Pilot Marine Spatial Assessment Tool

Evaluating options for assessing and balancing marine use change within Tasmanian coastal waters using a spatial assessment tool

Pilot Study – South and West of Bruny Island

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Non-technical Summary

Evaluating options for assessing and balancing marine use change within Tasmanian coastal waters using a spatial assessment tool: Pilot Study – South and West of Bruny Island. IMAS Technical Report. IMAS, Hobart, Tasmania.

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Project Objectives

The main aim of the project is to develop and trial a spatial assessment decision support tool that identifies potentially competing resource uses which may pose challenges under different development scenarios within the marine environment. In doing so the main objectives include:

- Identification of the types of uses and values present within the marine environment based on existing knowledge and understanding;
- identifying areas which may be most appropriate for given marine uses based on marine use suitability and the least number of conflicts with other uses.
- identifying relevant information gaps to assist in the development of marine spatial assessment tools and processes.

Abstract

This project captures the process of developing a spatial assessment decision support tool for marine waters in the south east of Tasmania using existing data in conjunction with GIS mapping and Marxan. The decision support tool provides a starting point for stakeholders within the decision-making process by identifying potential marine users who may have conflicting values in association with locating sites for new developments or relocating existing ones. By undertaking this project within the pilot study region, we demonstrate a process that is applicable and could be replicated in other regions.

Outcomes achieved

The project has identified a method for developing a decision support tool that could be replicated in other regions. In doing so, the project has collated relevant spatial information on marine users for the pilot study region and used this in conjunction with GIS and Marxan to produce map outputs which highlight areas which may be more likely to experience marine user conflicts together with areas which may be more suitable for potential developments. In carrying out this process, assessment of data suitability was undertaken and where relevant methods of using surrogate data were developed.

Acknowledgments

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Thank you to the support and direction provided by project Steering Committee, Dr. Ian Dutton, Director Marine Resources (DPIPWE), Chair; Prof. Caleb Gardner, IMAS, University of Tasmania; Mr. Andrew Gregson, Tasmanian Salmonid Growers Association (TSGA); Mr. Julian Harrington, CEO Tasmanian Seafood Industry Council; Mr. Mark Nikolai, CEO, Tasmanian Association for Recreational Fishing Inc. (TARFish).

The spatial assessment would not have been possible without the data and metadata provided from the following departments and organisations: NRM South, Information and Land Services Tasmania, University of Tasmania, IMAS, Seamap Australia, Tassal, Huon Aquaculture, IMOS, Geoscience Australia, DPIPWE, MAST, Natural Values Atlas, CSIRO, CAPAD, AMSA and the Tasmanian Parks and Wildlife Service.

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Introduction and Background

1.1. Need

Tasmanian coastal waters are highly valued, offering significant social, economic and environmental benefits to society. The way in which the coast is valued and used is dynamic, changing over time and space. It is realised that there is a need to balance the values of different marine users to ensure social, economic and environmental sustainability for future generations and to meet the objectives of the Tasmanian Resource Management and Planning System (RMPS), as enshrined in Tasmania's resource management legislation (for example, the Living Marine Resources Management Act (1995) and the Marine Farming Planning Act (1995)). This project was initiated to address this need with the specific purpose of developing and trialling a spatial assessment decision support tool to assist in the assessment of future planning for fisheries and aquaculture and related industries within the marine environment.

To do this a wide variety of spatial data needed to be identified and incorporated within a platform that enabled improved understanding of the values which exist and their distribution throughout the region. This information provided a starting point for assessing competing use and resource challenges associated with different future marine use scenarios.

1.2. Objectives

The main aim of this project was to develop and trial a spatial assessment decision support tool that allows for identification of potential competing resource uses which may pose challenges under different development scenarios within the marine environment in support of the objectives of the RMPS.
The decision support tool will help to:

- identify the types of uses and values present within the marine environment based on existing knowledge and understanding;
- provide a starting point for identifying areas which may be most appropriate for given marine uses based on marine use suitability and the least number of conflicts with other uses.
- identify relevant information gaps to assist in the development of marine spatial assessment tools and processes.

As such the tool offers the potential to address specific considerations relating to planning developments.
For example, it may be used to assist in:

- identifying suitable areas for additional aquaculture development (based on biophysical constraints) while minimising impacts on other values.
- identifying areas of high value for wild harvest fisheries (both recreational and commercial).
- redistributing existing finfish farms within the study area to maximise biosecurity outcomes, with minimal additional impact on other values.
- identifying areas of high social and conservation value in order to retain these in balance while supporting other marine uses (e.g. industries).

It is hoped that the decision support tool will offer valuable insight for decision makers and stakeholders in the early stages of marine development planning processes by highlighting any competing use and resource challenges associated with potential future developments. In this context the tool will be a starting point to help guide decision makers and proponents on where to focus the more detailed and rigorous aspects of planning processes (i.e. more detailed data collection, environmental impact studies and community engagement) needed to inform good decisions. It is hoped that the tool will help to initiate and support 'good neighbour' practices by identifying some of the wide variety of coastal and marine users, encouraging fair consideration of those uses, and therefore maximise the benefits and minimise the risks associated with potential developments.

The project was not designed as a participatory planning process or to generate a spatial plan per se. It has considered a range of scenarios and it is anticipated that project outputs may contribute to the development of future spatial plans for the region as well as more localized marine farm development plans by supporting the process of engagement with diverse stakeholder groups.

Finally, lessons from this pilot will inform whether such a decision support tool is an appropriate approach for fisheries and aquaculture and related industry development in other regions of Tasmania. For the tool to remain relevant it is important that it is used as a 'living resource', being updated regularly as further information is made available or existing information is updated.

1.3. Project oversight

The project was undertaken by IMAS staff in collaboration with DPIPWE staff under the Sustainable Marine Research Collaboration Agreement (SMRCA). The project team worked under the direction of a project Steering Committee, comprised of:

- Dr. Ian Dutton, Director Marine Resources (DPIPWE), Chair;
- Prof. Caleb Gardner, IMAS, University of Tasmania;
- Mr. Andrew Gregson, Tasmanian Salmonid Growers Association (TSGA);
- Mr. Julian Harrington, CEO Tasmanian Seafood Industry Council;
- Mr. Mark Nikolai, CEO, Tasmanian Association for Recreational Fishing Inc. (TARFish).

The Project Team and Steering Committee was supported by DPIPWE Marine Farming Branch staff Mr John Adams, Ms Bronagh Kelly and Mr Graham Woods. Initial project findings were also shared with the Marine Farming Planning Review Panel at a work session on 3 July 2019.

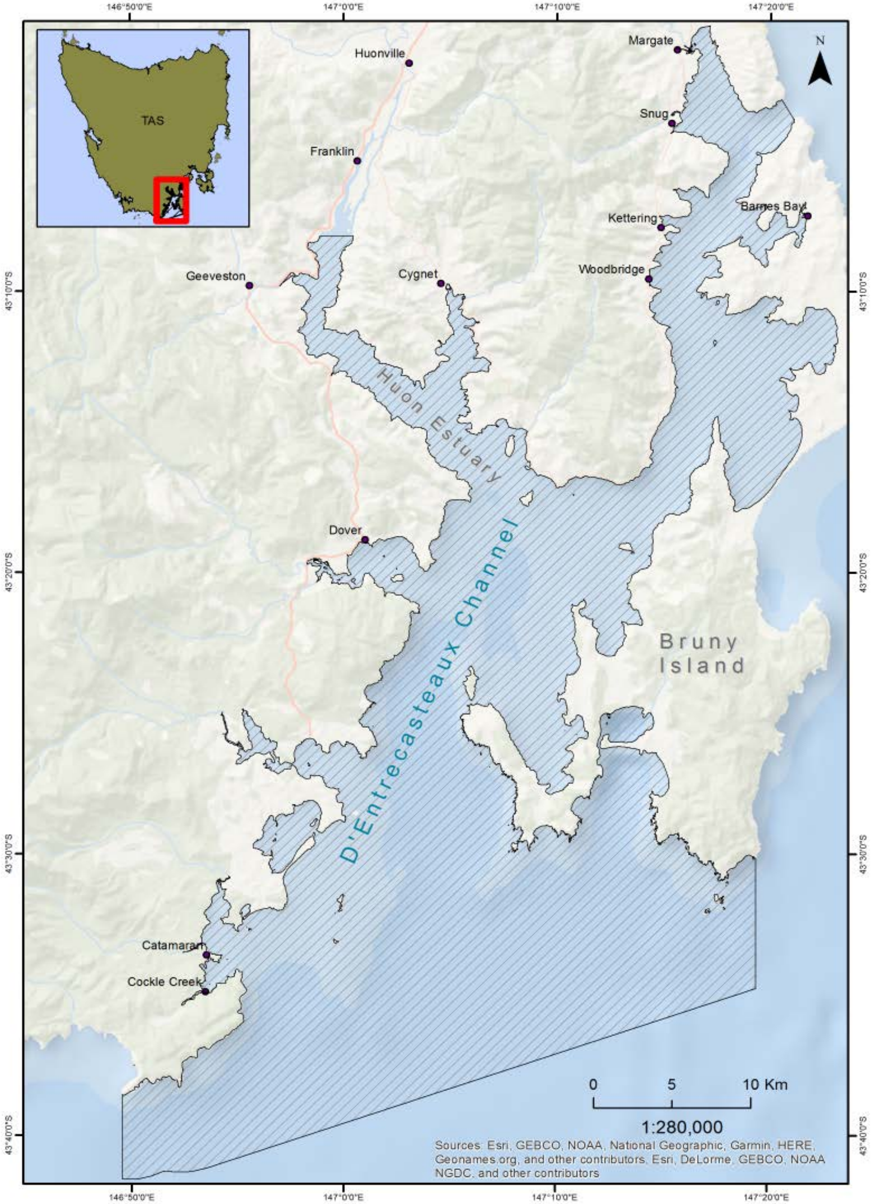


Figure 1: Pilot project study region – the D'Entrecasteaux Channel, SE Tasmania

Methods

2.1. Rationale

To assess the effectiveness of the spatial decision support tool, it was considered important to apply it in the context of a relevant pilot study region. The location of a study region must have the potential to facilitate industry developments (e.g. expansion of fisheries, aquaculture, tourism, etc.), a variety of potentially competing marine users and have enough information and data available to undertake the process.

The marine waters to the west and south of Bruny Island in South-East Tasmania, Australia were chosen as the study region to develop and trial the spatial decision support tool (Figure 1). This region is largely made up of the D'Entrecasteaux Channel and the Huon Estuary which are drowned river valleys that were inundated when sea level rose after the last glacial (Butler 2006). The Channel is bordered by Bruny Island to the east and mainland Tasmania to the west and opens into the Tasman Sea to the south. The study area is a very popular residential area, with over 50,000 residence dispersed throughout the Kingborough and Huon Valley council areas representing a mix of rural communities, commuters, retirees and shack owners. The area is also popular for recreational use by locals and people from Hobart and further afield in addition to attracting interstate and international visitors as a major Tasmanian tourist destination. The study area was chosen because it is identified as an important region for existing aquaculture and fisheries within Tasmania, with the potential for further aquaculture expansion and a reasonable amount of information available.

The pilot region includes two Marine Farming Development Plan (MFDP) areas and is currently home to 22 active finfish lease areas and 42 shellfish farming lease areas. An area within the southern part of the pilot region has been identified within the Tasmanian Government's 'Sustainable industry growth plan for the salmon industry' (the Salmon Plan) as having potential for future release, particularly where the D'Entrecasteaux Channel meets the Tasman Sea.

In Tasmania marine and coastal environmental planning and management is underpinned by the RMPS from which several laws, policies and procedures structure the planning system. The RMPS is based on a set of common objectives which hinge around the principals of sustainable development (RPDC. 2003):

'The objectives of the RMPS are to:

- *promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity*
- *provide for the fair, orderly and sustainable use and development of air, land and water*
- *encourage public involvement in resource management and planning*
- *facilitate economic development in accordance with the objectives set out in the above paragraphs*
- *promote the sharing of responsibility for resource management and planning between the different spheres of government, the community and industry in the State*

In the objectives "sustainable development" means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well-being and for their health and safety while:

- *sustaining the potential of natural and physical resources to meet the reasonably foreseeable needs of future generations;*
- *safeguarding the life-supporting capacity of air, water, soil and ecosystems; and*
- *avoiding, remedying or mitigating any adverse effects of activities on the environment.'*

In undertaking this project, one of the key aims was to identify and assess the suitability of available data for developing a spatial decision tool in support of the 5 objectives of the RMPS, and to identify any data gaps that may limit its ability to achieve this.

2.2. Project components

The project was comprised of four main components to assess the costs and benefits of alternative spatial scenarios in marine resource development (Figure 2):

1. **Information gathering:** Marine users and values were identified for the study region. A spatial inventory of available information associated with existing marine uses and values was developed in addition to potential future uses where relevant. Data constraints, gaps and limitations were identified in relation to the needs of spatial planning within the region.
2. **Select relevant layers:** Relevant information were integrated within a Geographic Information System (GIS) allowing for visual layer exploration and analysis. Where data gaps were observed, surrogate measures were used as relevant.
3. **Suitability analysis:** Where necessary information from multiple data layers was synthesised into one using suitability analysis to provide data layers of optimal suitability for different marine uses.
4. **Marxan analysis:** A Marxan based network analysis of options was undertaken to identify optimal locations and possibly configurations of current and future fisheries and aquaculture development zones.

These components can be loosely fitted to the approach set out in the UNESCO marine spatial planning guidelines (Table 1) (Ehler & Douvere 2009).

The following sections describe the steps required to develop a decision support tool and provide an overview of the types and variety of information that can support good decision making within the marine environment.

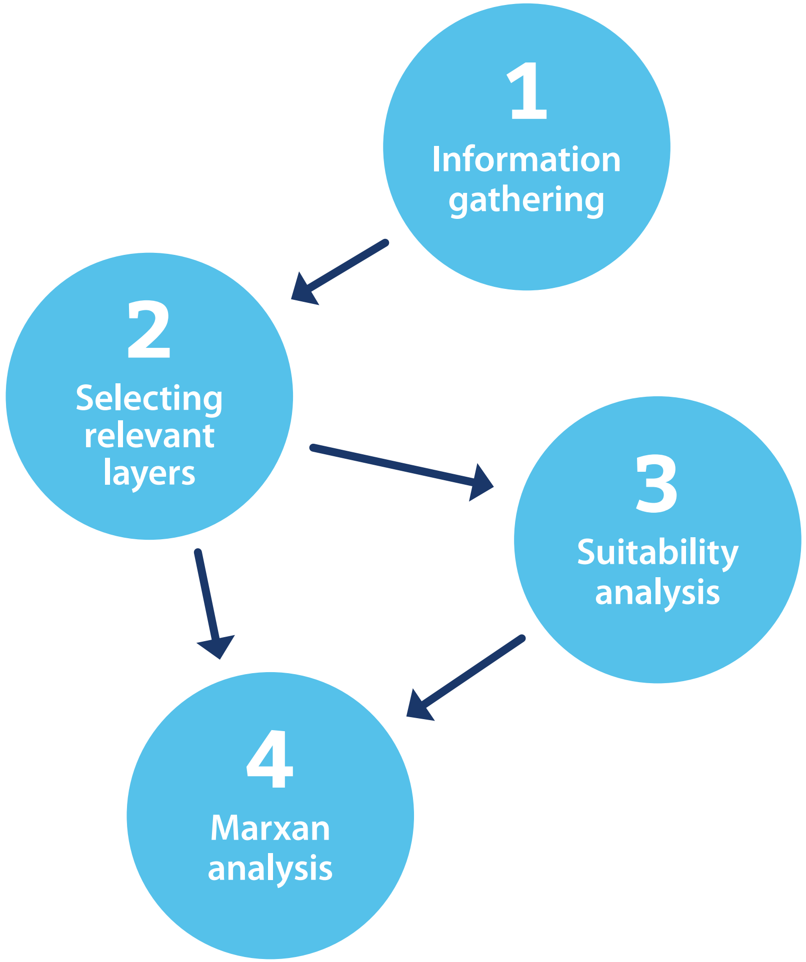


Figure 2: Steps taken to develop the spatial assessment tool

2.2.1. Task 1 & 2 — Information gathering and selection of relevant layers

In order to develop a spatial decision support tool that adequately considers the needs of future developments alongside the needs of all existing (and potential future) marine users and values, a wide variety of information was needed (Figure 3):

1. **information relating to the consideration of all existing marine users:** Within the context of the RMPS (RPDC. 2003) definition of sustainable development, the 2013 Your Marine Values report (Ogier & Macleod 2013) and the 2015 Storm Bay salmon expansion pilot study (Macleod et al. 2015), three marine use and value categories to be considered in order to undertake sustainable decision making were defined for this pilot project:
   - Economic information: data and information which provides insight into the current needs of economic values and users (commercial enterprise and industry e.g. fisheries and aquaculture) within the marine environment and its resources.
   - Social information: data and information which provide insight into the current needs of recreational, cultural, heritage and lifestyle values and users within the marine environment.
   - Environment and conservation information: data and information which provides insight into the state of the environment and its value from an ecological function and integrity perspective.
2. **information relating to the needs of proposed or potential future developments:** This required both an understanding of the environmental parameters and the conditions needed for the sustainability of future developments (economic, social, and environment and conservation) and the spatial variability of these parameters across the study area (e.g. biophysical data) to identify areas suitable for expansion (from the perspective of the development).

In the initial stages, an inventory of all the marine users and values were defined for the study region and available information and data to spatially represent these were identified. The information search was broad, largely identifying existing databases (publicly available or available on request; see Appendix A), however where necessary, information was extracted and compiled from publications or directly from data sources on request, to overcome data gaps.

Data-sets from the pilot region were assessed for relevance for inclusion within the decision tool based on source reliability, spatial extent and resolution. Suitable data-sets were explored in ArcGIS to determine the most appropriate way of illustrating and analysing the information for the purposes of the decision tool. For each dataset, the advantages and disadvantages of different approaches were outlined. Maps displaying the available datasets for each of the information categories defined, were produced together with any significant data omissions or assumptions as relevant (see Section 3.1).

Values and marine uses vary over time and space and as such, the specific emphasis of a spatial decision tool and the data required will also vary in line with the prevailing marine users and development interests. While the data required to inform the process will change, the framework (Figure 3) and steps followed in this pilot project will remain applicable to any region and/or proposed development to support good decision making:

- **Step 1:** to scope and describe all values and users of the sea region;
- **Step 2:** to identify data needed to spatially represent these values and users and to use existing data where possible to represent these;
- **Step 3:** to fill data gaps where needed with surrogate measures of values;
- **Step 4:** to engage in more detailed creation of data or combinations of existing data to provide a highly resolved understanding of marine uses as needed.

<table>
<tr><th>UNESCO tasks</th><th colspan="3">Pilot project components</th></tr>
<tr><td rowspan="5">Task 1:
Projecting current trends in the spatial and temporal needs of existing human activities — maximum extent</td><td colspan="2">Identify the coastal/marine use users and develop a spatial inventory of datasets from existing information to map these:</td><td rowspan="8">Identify critical information gaps which need further consideration and/or field research in order to support a more detailed development planning process.</td></tr>
<tr><td>Needs of proposed developments</td><td>To inform understanding on the general state of the environment and its operational suitability for development</td></tr>
<tr><td>Social information</td><td rowspan="3">To inform understanding of the needs of coastal, land and sea values and users that share/ compete for space</td></tr>
<tr><td>Economic information</td></tr>
<tr><td>Environment and conservation information</td></tr>
<tr><td>Task 2:
Estimating spatial and temporal requirements for new demands of ocean space</td><td colspan="2">Quantify the likely expansion of all coastal/marine users and values over a given period of time:
• social, cultural and heritage values (e.g. recreational and lifestyle uses and values)
• economic values (e.g. all industry sector users)
• environment and conservation values (e.g. protected areas)</td></tr>
<tr><td>Task 3:
Identifying possible alternative futures for the planning area</td><td colspan="2">Develop a spatially representative method of displaying options for optimal siting and configuration of multiple marine uses using a MARXAN based analysis of options approach to present alternative spatial scenarios based on costs and benefits</td></tr>
<tr><td>Task 4:
Selecting the preferred spatial sea use scenario</td><td colspan="2">Deliver 11 possible future use scenarios to decision makers and proponents to assist in the planning and decision making processes.</td></tr>
</table>

Table 1: Relating pilot project components with UNESCO marine spatial planning tasks

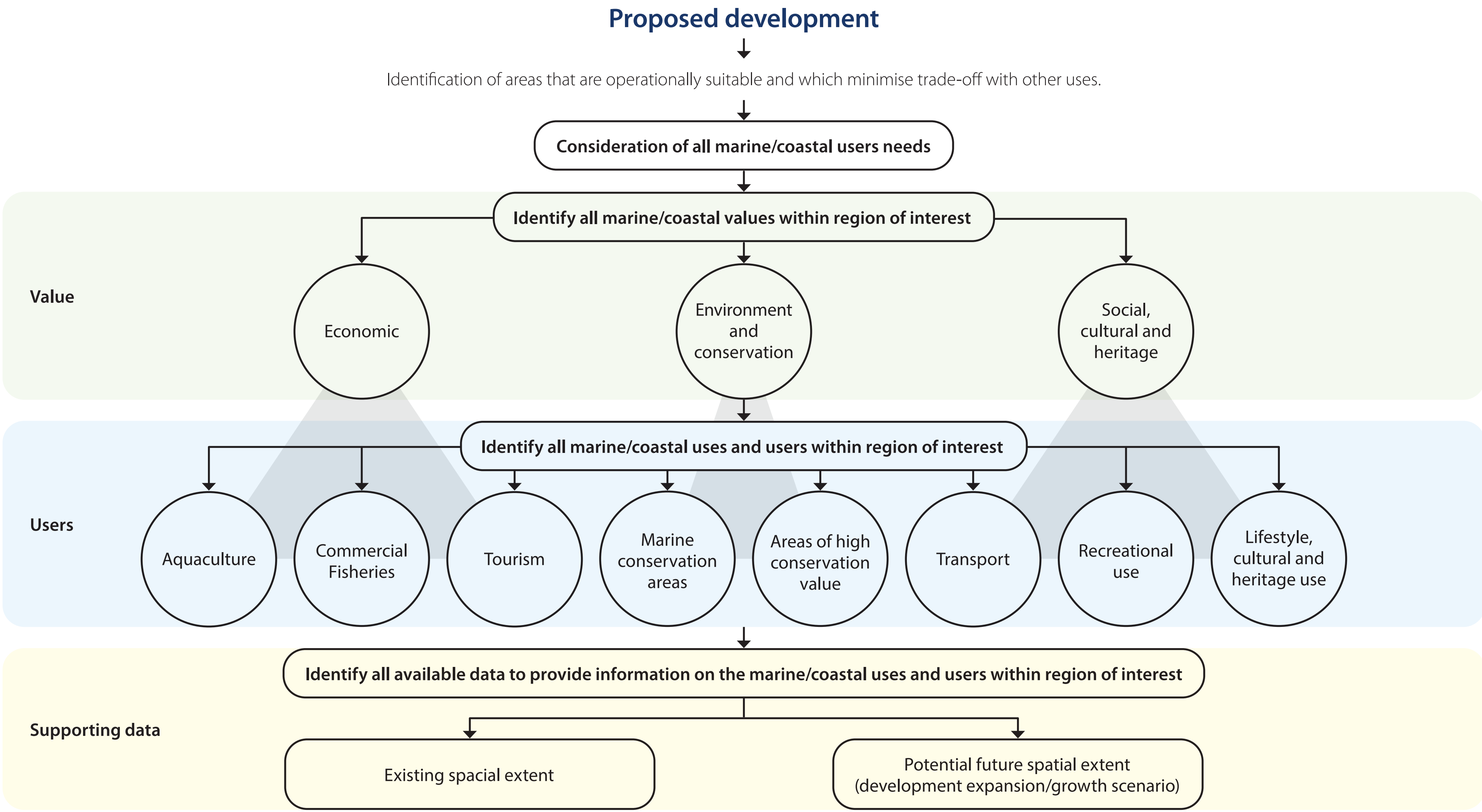


Figure 3: Structural model to illustrate the relationships between values, users, and information sources when developing a decision support tool.

2.2.2 Task 3 — Suitability analysis

In some instances, it is appropriate to produce suitability layers which incorporate data from multiple data layers to determine the spatial suitability for a given marine use. In these cases, suitability analyses (also known as spatial multicriteria decision analysis) can be used in GIS to determine the relative suitability of locations for particular activities or developments. In this project this technique was used for two marine uses:

- To find the most suitable areas to grow salmon (as the main finfish species under cultivation within the region): creating suitability layers for salmon growing reduced and summarised the number of bio-physical layers to include in Marxan while considering environmental features and operational restrictions for salmon aquaculture.
- To find most suitable areas for recreational activities (i.e. recreational fishing, diving, kayaking, etc): since there was not enough data available on recreational usage at the required spatial scale in the region, this layer was a first principals attempt to develop a surrogate for these activities.

In order to perform the analysis, a standard set of steps was undertaken following Malczewski (1999):

1. Define the question/problem
2. Define constraints and criteria
3. Identify relevant data layers
4. Reclassify layers values from 1 (less suitable) to 9 (most suitable) based on known information
5. Define weights for the layers
6. Calculate suitability layer by combining layers using a linear equation

2.2.3 Task 4 — Marxan analysis

Marxan with Zones is a multiple-use planning version of the Marxan software platform used to identify configurations of land or water uses that achieve specified planning objectives while minimizing trade-offs. It uses a simulated annealing approach to return good solutions to planning objective problems by assigning qualitative goals and quantitative targets to each marine use zone and solving to meet these with the least costs/trade-offs (Ball et al. 2009).

Marxan with Zones (herein referred to as Marxan) (Watts et al. 2009) was used to generate alternative marine use zone configurations that meet the planning objectives set for the purposes of the pilot project in collaboration with the Steering Committee:

- identifying suitable areas for additional aquaculture development (based on biophysical constraints) while minimising impacts on other values.
- identifying areas of high value for wild harvest fisheries (both recreational and commercial).
- redistributing existing finfish farms within the study area to maximise biosecurity outcomes, with no additional impact on other values.
- identifying areas of high social and environment and conservation value in order to retain these in balance while supporting and expanding other marine uses (e.g. industries).

Relevant marine use zones for the pilot region were also identified in agreement with the Steering Committee which may have competing values or uses (Table 2). Marine use zones include economic uses such as aquaculture (i.e. finfish, shellfish and seaweed, with finfish considered separately given the planning objectives of the pilot) and commercial fisheries; social uses such as recreational, cultural, heritage and lifestyle uses; and environment and conservation uses such as designated sites, in addition to a zone which is available for use by any user, particularly for navigation (available zone).

For each marine use zone, qualitative goals with associated quantitative targets were defined (Table 2). The aim was to meet the qualitative goals for each marine use zone by maximising quantitative targets while also meeting any constraints set within the pilot project planning objectives (e.g. biosecurity zone constraints). Broadly, targets were set as high as possible while minimizing trade-offs across zones to reflect the aim of maximising values for all marine uses in the region.

As an indicative example, for social values the qualitative goal was to maximize retention of all existing uses and to minimize interaction with economic uses (e.g. noise and light pollution from industry uses such as aquaculture operations or from high traffic vessel navigation lines for commercial fishing).

Six non-overlapping and possibly competing marine use zones were identified in the pilot region and therefore must be planned for in non-overlapping exclusive use zones (Table 2). Where there were overlaps in uses that did not result in competition (i.e. users can happily share the same space), we attributed these goals to a single zone. For example, rocky reefs are important for recreational and commercial fisheries, and so we allowed the assignment of these reefs to the commercial fisheries zone to contribute to recreational values in the social zone as well. Similarly, for scenarios that consider potential reef buffers, these buffers are beneficial to commercial, environment and conservation, and social values and thus these zones take into account targets met for these zones but we attribute them to the social zone for mapping purposes (Table 2).

Eleven planning scenarios were developed with the Steering Committee which were used to explore different ways of meeting the pilot project planning objectives (see Box 1 for a description of each). For each of the scenarios regular square grid planning units of 25ha (500m grid) (5,304 planning units) and Marxan's 'best' solution (i.e. a near-optimal configuration of zones that achieved objectives with the least amount of area) was used. The maps of spatial solutions across scenarios and the total area allocated to each zone per scenario were compared.

Marine use zones			Non-overlapping zones	Spatial data used	Qualitative goals and related actions	Quantitative objectives
Available			Available	Major channels and navigation lines	Maintain existing navigation channels for safe navigation by all marine users	100% existing navigation channels
Economic	Aquaculture	Shellfish and seaweed	Other aquaculture	Aquaculture leases	Maintain existing economic activities - existing shellfish aquaculture	100% existing leases
		Finfish	Finfish aquaculture	Finfish aquaculture leases	Maintain existing economic activities - existing finfish aquaculture	100% existing leases
				Salmon suitability	Grow the finfish aquaculture industry in suitable areas	Target high suitability (≥7 suitability values, 60% values of 7-8 and 80% values >8)
	Commercial fisheries		Commercial fisheries	Commercial fishing (abalone, rock lobster, reef scale fish)	Maintain existing commercial fisheries[1]	100% rocky reef areas
Social	Lifestyle, cultural and heritage		Social	Distance to residential buildings	Minimise noise and light pollution to residents	90% 1km buffer to residential buildings
				Distance to high human use value areas	Maintain high human use value areas	90% high human use value areas buffered by 1km
				Aboriginal land	Protect aboriginal land and sea areas	100% aboriginal land
	Recreation			Moorings and popular anchorages	Maintain moorings and popular anchorage areas	90% of moorings and popular anchorages
				Important sailing course areas	Maintain sailing areas	80% of important sailing course areas
				Recreational suitability	Maintain recreational marine areas (boating, fishing, diving, etc)	Target high suitability (≥7 suitability values, 70% values of 7-8 and 90% values >8)
				Rocky reef substrate with buffer: 1km to reef (variable buffer to high value reefs considered: 2km buffer and 5km buffer)	Reduce impacts to reefs as significant recreational (and commercial habitats)[2]	95% of 1km (2km or 5km as relevant) rocky reef buffers
Environmental conservation	Designated areas		Environmental conservation	Existing marine conservation areas and exclusion zones	Protect environmentally significant areas	100% of conservation areas and exclusion zones
	Areas of high biological value			Distance to high biological value areas	Protect environmentally significant areas	90% high biological value areas buffered by 1km

Table 2: Qualitative goals and associated quantitative objectives used for the Marxan planning scenarios.

1 Due to limitations around data resolution for non-reef fish spatial distribution of these species could not be adequately mapped within the pilot region and as such commercial non-reef fishery species were not included in Marxan runs. To overcome this, non-reef fisheries spatial data (Map 10) can be overlayed across Marxan output maps and the species representing the top 10% of catch identified for each fisheries block (Table 6).

2 Protection of rocky reef is important for both social (recreational), economic (commercial fisheries) and arguably environmental conservation (high biological value) uses which are largely considered to be capable of sharing the same space. To ensure that separate areas of rocky reef protection were not unnecessarily selected for by applying qualitative goals and quantitative objectives to each of the relevant social, economic and environmental non-overlapping zones (commercial fisheries, social and environmental conservation), the qualitative goal and quantitative objective around rocky reef protection was arbitrarily assigned to only one: the social non-overlapping zone.

Box 1: Planning Scenarios

In line with the pilot objectives, the following planning scenarios were defined with the steering committee:

Default scenarios

Scenario 1 — Baseline: This scenario reflects the basic goal of maximizing values across all zones while minimizing trade-offs. This scenario can be used as a default scenario from which to measure spatial changes for all other scenarios which consider a range of additional constraints or goals. A 1km buffer is applied to all reefs.

Scenario 2 — Blank slate: This scenario deviates from Scenario 1 as the location of existing finfish leases are not considered (locked in) and instead, it explores the most suitable locations for finfish leases based on highest suitability for finfish farming together with the least conflicts with other marine use zones.

Reef buffer scenarios

Scenario 3 — Baseline + 2km reef buffer: In addition to Scenario 1 criteria, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 2km reef buffer to high value reefs.

Scenario 4 — Blank slate + 2km reef buffer: In addition to Scenario 2 criteria, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 2km reef buffer to high value reefs.

Biosecurity and reef buffer scenarios

Scenario 5 — Baseline + 2km reef buffer + biosecurity: In addition to Scenario 3 criteria, this scenario requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area.

Scenario 6 — Blank slate + 2km reef buffer + biosecurity: In addition to Scenario 4 criteria, this scenario requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area.

Scenario 7 — Baseline + 5km buffer + biosecurity: In addition to Scenario 1 criteria, this scenario explores the additional constraint of protecting social-cultural and economic values associated with reefs by applying a 5km reef buffer to high value reefs and also and also requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area.

Scenario 8 — Blank slate + 5km buffer + biosecurity: In addition to Scenario 2 criteria, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 5km reef buffer and also requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area.

Future use finfish suitability scenarios

Scenario 9 — Alternative technology: This scenario used the same targets and zones as Scenario 1, with the exception of the targets for finfish aquaculture and the salmon suitability layer was adapted to reflect potential 'future' suitability (see section 3.1.1.2 – Salmon suitability layer), taking account of technological and operational advances which may support farming in higher energy environments in the future.

Scenario 10 — Alternative technology + 2km reef buffer + biosecurity: In addition to Scenario 9, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 2km reef buffer to high value reefs and also requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area

Scenario 11 — Alternative technology + 5km reef buffer + biosecurity: In addition to Scenario 9, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 5km reef buffer to high value reefs and also requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area.

3

Results

3.1. Information availability and application

A wide variety of marine users and values were identified within the pilot study region together with data sources to inform our understanding of their spatial distribution (see Figure 4).

Information relating to the consideration of all marine users and values are varied and diverse. In addition to understanding the variety of marine uses and values within the study area, this information is also important to provide an understanding of their spatial extent and potential for future expansion through better understanding the likelihood of spatial conflicts.

The variety of marine zone uses, and values will vary between regions but can be broadly separated into three categories: economic, social, and environment and conservation.

- Economic information provides insight into the economic values and uses within the study area, this will include the values of commercial enterprise and industries operating within the region.
- Social information provides insight into the recreational, cultural, heritage and lifestyle users and their values within the region
- Environment and conservation information provides insight into the ways in which the environment is valued from an ecological function and integrity perspective.

The breadth and depth of available information for these categories is likely to vary considerably between areas.

Where there is likely to be future development or expansion of a marine use, it is important to identify additional areas of suitability for expansion. As such it is necessary to understand the spatial constraints around the proposed development and match these to suitable areas within the study region. The variables of interest are likely to change depending on the type, scale, and intensity of development in addition to any regulatory requirements.

For the purposes of applying this decision support tool to the pilot project study region, the expansion/redistribution of the finfish industry has been used as a proposed future development case study given the potential for industry growth identified in the Salmon Plan (DPIPWE 2019a). As such, specific information around the environmental requirements of successful finfish aquaculture has been collated for this pilot project to identify new areas of suitability for finfish while optimizing the spatial distribution for all marine users and values.

It is acknowledged that other industries or values may experience growth and expansion within the pilot project study region in the future. In these instances, other additional information may be required to understand their projected growth and areas suitable for expansion.

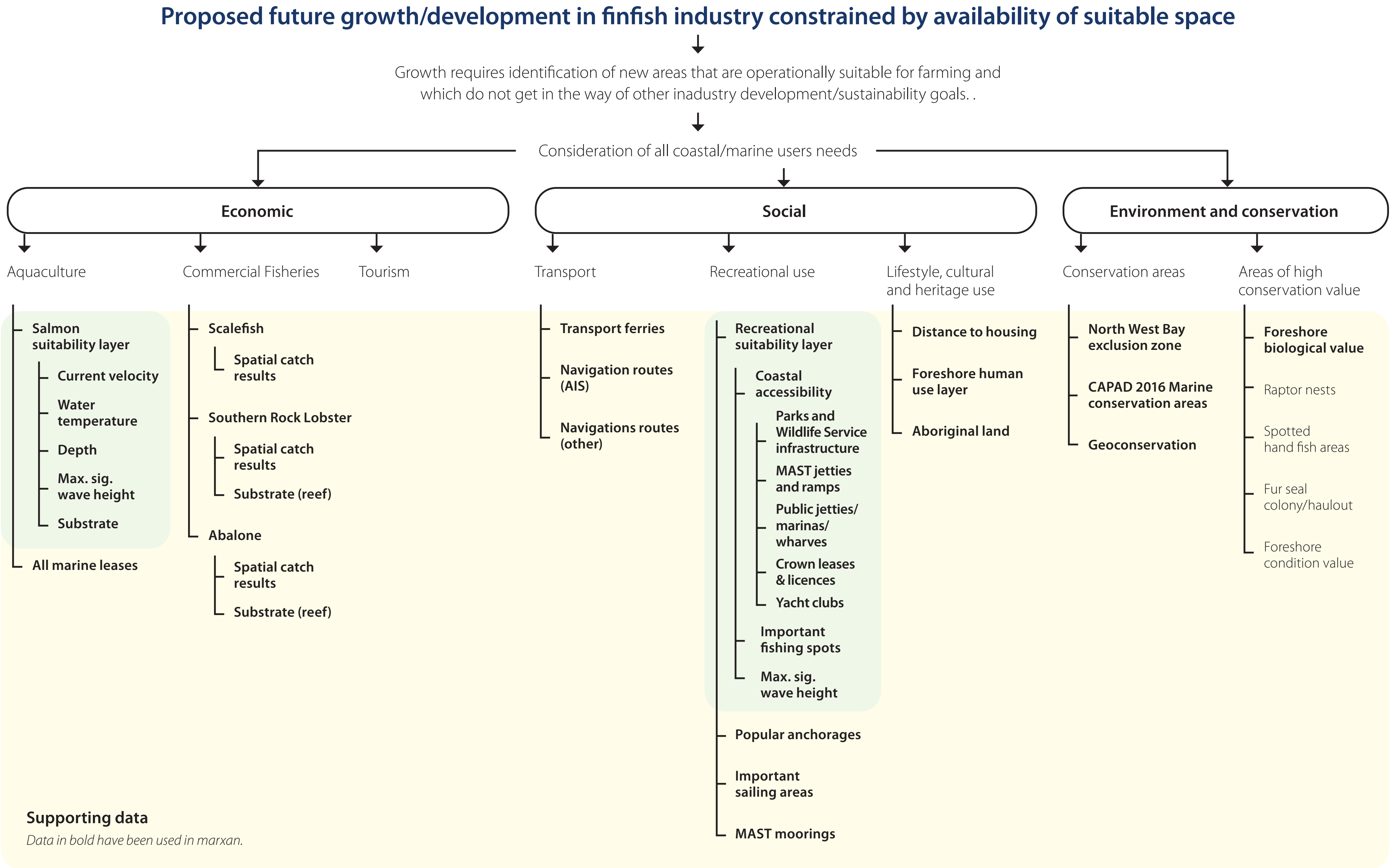


Figure 4: Pilot Case study: Structural model to illustrate the relationships between values, users, and the supporting data identified for this pilot project

3.1.1 Economic

Within the study area, three main marine and coastal industry groups were identified: aquaculture, fisheries and tourism. While the scope of the project was limited to these three groups, other industries of economic value which could be considered include resource extraction and renewable power production.

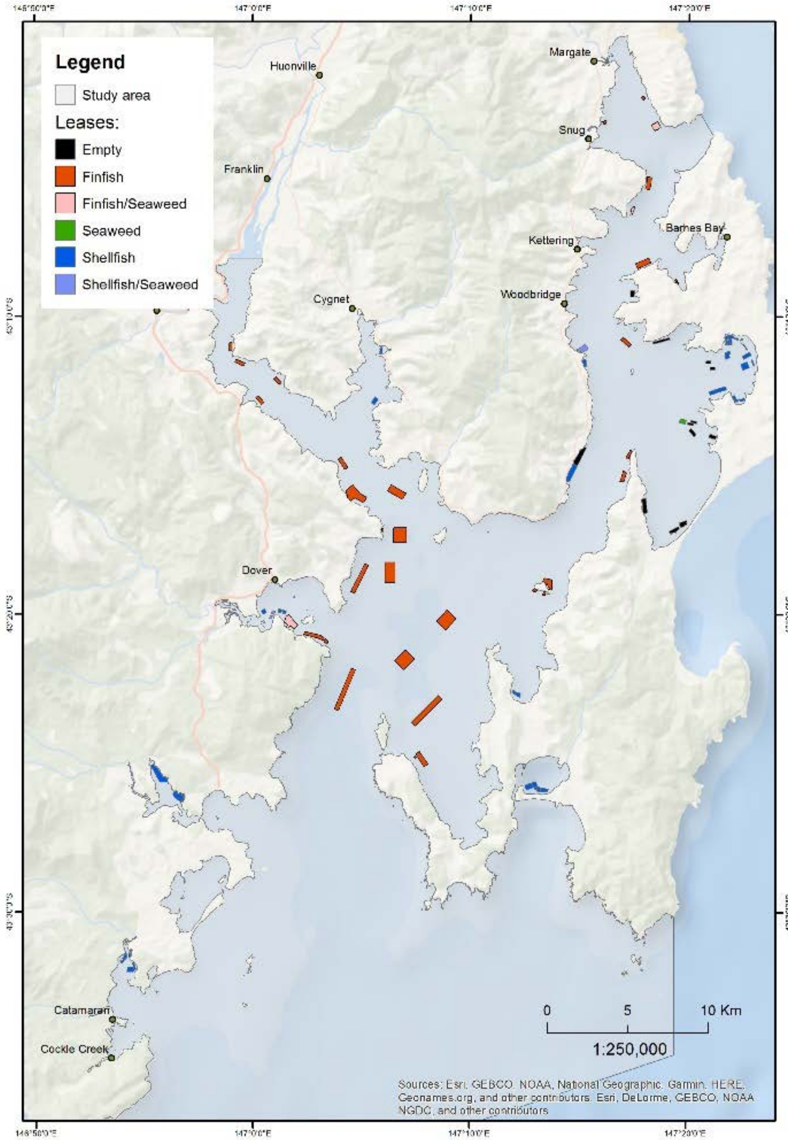
3.1.1.1. Existing aquaculture

Within the study area finfish and shellfish aquaculture are both important industries. It is important that new developments do not infringe on existing aquaculture operations, and that emerging industries are considered. Different distances may be appropriate between any proposed and existing industries depending on the type of operations being carried out and the local hydrodynamic setting.

Data source: *Data on the location, spatial extent of existing aquaculture leases (areas of land registered as marine farm leases from the Crown within Tasmania) and authorised species is available from the marine farm leases dataset on LISTmap (www.theLIST.tas.gov.au) © State of Tasmania. Marine farm leases are issued under the Marine Farming Planning Act 1995 for a period of 30 years. The lease describes the area in which marine farming activities are permitted to take place in accordance with the Act.*

Post processing: *The marine farm lease data set from LISTmap was combined with information provided by DPIPWE to include the type of farming carried out at each lease.*

Data limitations: *The marine farm lease data set provides a complete list of all marine farming leases, including those which have active licences but are not currently operational and leases which do not have any current marine farming licences associated. Sites with no marine farming licences have not been designated any particular species and have been classified as 'Empty Lease' within the post processed data set (see Map 1).*



Map 1: Existing marine leases within the study region.

3.1.1.2 Future growth and/or redistribution of aquaculture

Because the planning objectives of the pilot project considered the expansion and/or redistribution of the finfish industry within the study area, additional information was needed to identify which areas within the study region meet the requirements to operate a sustainable finfish industry. The key environmental variables which influence the location of viable salmon aquaculture using existing farming techniques in Tasmania include water depth, water temperature, substrate type, and the energy of the environment (current velocity and wave height). A data layer incorporating all these parameters was produced as a spatial representation of the operational suitability for salmon aquaculture within the study area (see below).

Water depth

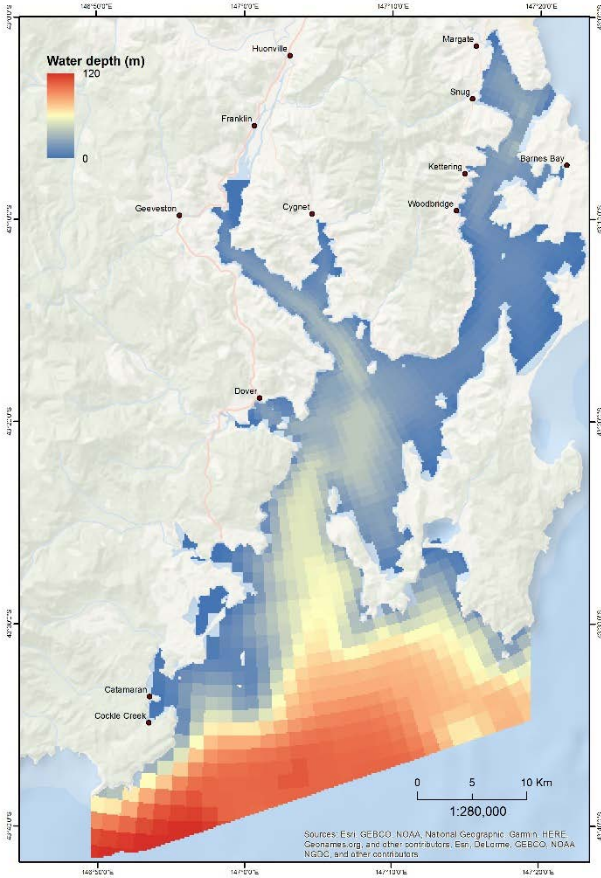
Water depth is an important parameter in determining the viability of a given site for salmon aquaculture. In Tasmania circular sea cages with suspended nets are used by the salmon industry. These rely on good water exchange between the inside of the fish cages and the surrounding sea to maintain a clean and oxygenated environment for the culture fish (Forrest et al. 2007). The greater the volume of water around and below the cages the greater the capacity for water exchange. A distance of at least 5m between the bottom of a net cage and the sea floor is considered essential for salmon farming sites while it is preferential to have at least twice the depth of the net-pen to allow for sufficient water exchange and solid waste dispersal into the surrounding environment (Forrest et al. 2007, Sim-Smith & Forsythe 2013). As such, taken in isolation deeper sites are generally more suitable for salmon farming than shallower sites, while some shallower sites may be suitable for growing smolt. It is therefore, important to consider sites in relation to specific farming purpose rather than applying a blanket approach to depth suitability.

Study area depth range: *0 to 135m*

Data source: *Detailed single beam echo sounder water depth (bathymetry) information is available for the study region from Seamap Australia, but this is only available up to a depth of 40m or a maximum of 1.5km from the shore. Geoscience Australia provide bathymetry data, but this is only available at a resolution of 250m. Georeferenced bathymetry chart data is also available for the study area, however large discrepancies were identified between it and Seamap Australia data. For the purposes of this project we used the same bathymetry data as that used for the SETAS (South East Tasmania) SHOC hydrodynamic model system produced from the INFORMD (Inshore Network for Observation and Regional Management of the Derwent-Huon) project. This consists of a compilation of data from a number of sources including DPIPWE measurements, the Huon River Study (Griffin), Australian Hydrographic Office charts (AUS 173) and Geoscience Australia 2km gridded 2002 bathymetry for the pilot project study area which is available at: http://data1.tpac.org.au/thredds/catalog/tascem/setas/catalog.html (Margvelashvili et al. 2009).*

Post processing: *The data was clipped to the pilot project study area and re-gridded to provide a regular grid of ~145m cell size. The land was masked out. Some shallow areas with no available data were gap filled by taking values from the nearest cells (see Map 2).*

Data limitations: *Data are the compilation of several different data sources which have been mapped at different resolutions: hydrographic measurements of some of the shallow and deeper regions are limited in resolution.*



Map 2: Water Depth (meters)

Water temperature

Water temperature is a critical variable dictating the health, survival and growth rates of Atlantic salmon (Pankhurst & Munday 2011, Wang & Russell 2016). Increasing water temperature increases the metabolic rates of fish resulting in greater oxygen demand, in conjunction with lower oxygen availability as higher water temperatures also result in lower oxygen solubility (and thus lower dissolved oxygen: DO) (Stehfest et al. 2017).

For salmon in sea cages, the preferred temperature range is between 16°C and 18°C with an upper critical limit between ~20°C and ~34°C (Battaglene et al. 2008, Anttila et al. 2013). Variability in thermal tolerance is observed between families of Atlantic salmon (Anttila et al. 2013).

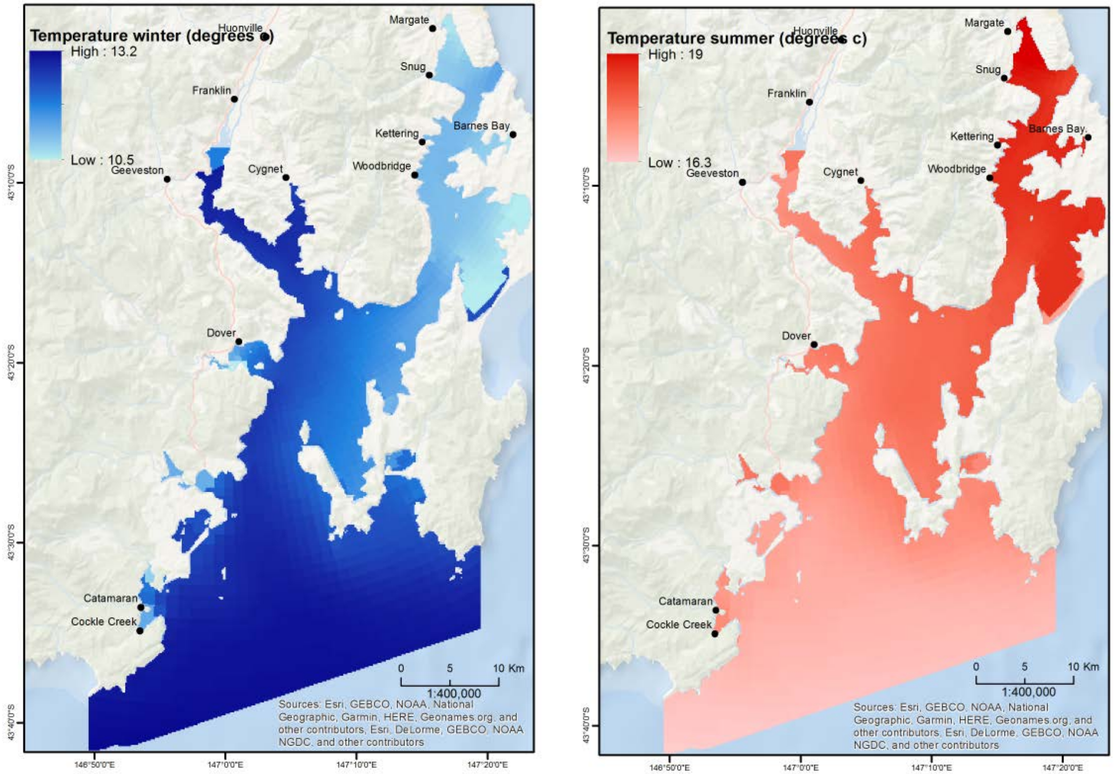
Growing salmon in areas outside the preferred temperature range may result in the stress of caged fish and increased incidence of disease with negative effects on overall salmon health (Battaglene et al. 2008). Summer water temperatures within Tasmania do exceed the optimum temperature range for Atlantic salmon occasionally, emphasising the need to consider variability in temperature across the study region when determining suitability for salmon operations.

Study area average temperature range:
Summer: 16°C to 19°C
Winter: 11°C to 13°C

Data source: *Modelled water temperature data for the study region is available from the SETAS SHOC hydrodynamic regional model (CSIRO). Water temperature is modelled at hourly timesteps for the period August 2014 to May 2019 at water depths of 0.25m, 5.3m, 15.5m and 23m and monthly data files are available for download (1.8GB) at a 100m resolution within the estuaries to 2km resolution offshore. Data is available at http://data1.tpac.org.au/thredds/catalog/tascem/setas/catalog.html. A range of empirical water temperature data sets are also available in the study region. This includes data collected directly by the finfish industry as part of the Broadscale Environmental Monitoring Program (BEMP), a statutory requirement of licenced finfish marine farming lease holders, which collects monthly water quality data (including temperature) from 15 sites across the region (since 2009; https://epa.tas.gov.au/regulation/salmon-aquaculture/dentrecasteaux-channel-huon-and-port-esperance/bemp-monitoring). The modelled data has been used for the pilot given its greater spatial and temporal resolution.*

Post processing: *The data was clipped to the pilot project study area and re-gridded to provide a regular grid of ~145m cell size. The land was masked out. Some shallow areas with no available data were gap-filled by taking values from the nearest cells. Average water temperature at a depth of 5.3m was calculated for summer 2017/2018 (January – February) and winter 2017/2018 (July – August) across the grid however alternative depths and time ranges are available and could be used in future projects (see Map 3).*

Data limitations: *Data is based on model outputs. The reliability of model outputs is dependent on validation against field observations. Validation is an ongoing process.*



Map 3: Modelled mean winter (July-August 2017/2018; left) and summer (January-February 2017/2018; right) water temperature (°C) at 5.3m depth.

Current velocity

Current velocity within the marine environment varies over time and space and plays a key role in maintaining a healthy growing environment for caged fish and effects the assimilative capacity of the surrounding environment to additional nutrients. Higher current velocity results in greater water exchange between the inside of the cage and the surrounding water, allowing for more waste dispersal and greater oxygen supply (Forrest et al. 2007), critical to produce good quality salmon. Greater waste dispersal and dilution can also reduce the localised deposition under cages as waste materials are carried further away. This can reduce the impact of waste products on the local environment with additional secondary benefits on the salmon growing environment as organic matter breakdown products like hydrogen sulphide are less likely to develop and build up (Sim-Smith & Forsythe 2013).

As such, areas with current velocities high enough to disperse solid wastes are generally considered to be more suitable for salmon farming (>9.5cm s^{-1}) than areas with lower velocities, however stocking density and cage design/layout are also important factors (Sim-Smith & Forsythe 2013). Furthermore, where fish are continually exposed to current velocities above their preferred swimming speed animal welfare concerns have been raised (Johansson et al. 2014).

Study area average effective current velocity:
Summer: 0 to 0.15m/s
Winter: 0 to 0.21m/s

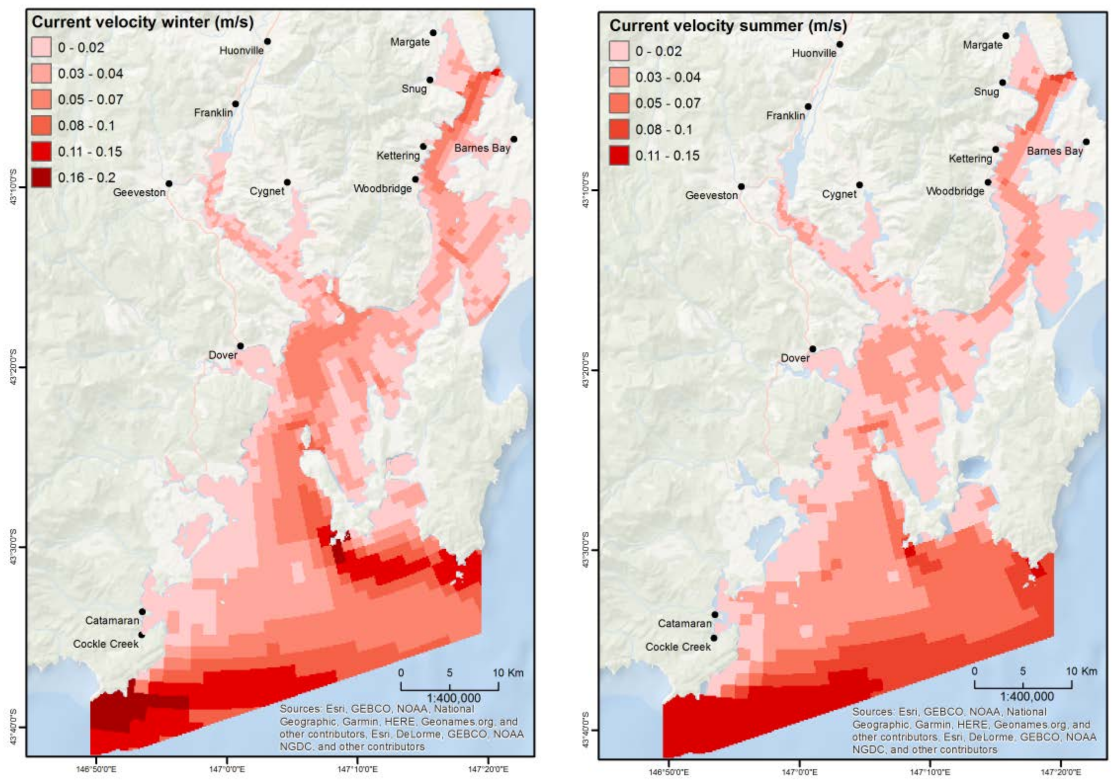
Data source: *Modelled current velocity data for the study region is available from the SETAS SHOC hydrodynamic regional model (CSIRO). Current velocity is modelled at hourly timesteps for the period August 2014 to May 2019 at water depths of 0.25m, 5.3m, 15.5m and 23m and monthly data files are available for download (1.8GB) at a 100m resolution within the estuaries to 2km resolution offshore.*

Data is available at: http://data1.tpac.org.au/thredds/catalog/tascem/setas/catalog.html. A range of empirical sets on current profiles from ADCP deployments are also likely to be available in the study region for comparison and validation.

Post processing: *Effective current velocity was derived from its linear components (direction and speed). Average effective current velocity at a depth of 5.3m was calculated for summer 2017/2018 (January – February) and winter 2017/2018 (July – August) across the grid however alternative depths and time ranges are available and could be used in future projects.*

The data was clipped to the pilot project study area and re-gridded to provide a regular grid of ~145m cell size. The land was masked out. Some shallow areas with no available data were gap-filled by taking values from the nearest cells (see Map 4).

Data limitations: *Data is based on model outputs. The reliability of model outputs is dependent on validation against field observations. Validation is an ongoing process.*



Map 4: Modelled mean winter (July-August 2017/2018; left) and summer (January-February 2017/2018; right) current velocity (m/s)

Substrate type

Substrate type can vary markedly over short distances within the marine environment and generally provides a good reflection of the energy of the environment. Increasing sediment grainsizes are associated with increasing current speeds and waste dispersal potential (see section on current velocity above). While increasing the dispersal of waste results in lower enrichment within the local environment, it may be associated with low levels of enrichment over a greater area. Ecosystems in areas with low current velocity are generally pre-adapted to times of enrichment, while communities in higher energy environment may be more susceptible to even low levels of sustained enrichment with longer associated recovery times (Macleod et al. 2007). As such, sediment type will often influence the length of fallowing required.

Temperate rocky reefs often exist in high energy environments and have shown susceptibility to nutrient enrichment from a variety of sources (Stuart-Smith et al. 2015). Rocky reef ecosystems can collapse where external pressures exceeds resilience and nutrient enrichment is sustained. Recovery is complex, as the collapse of the reef ecosystem often results in a phase shift from a macroalgal canopy dominated ecosystem to an environment dominated by turfing species, which exclude the reformation of the canopy (Folke et al. 2004, Fowles et al. 2018a, Fowles et al. 2018b). Therefore, while high energy environments may offer many benefits for salmon production, the risks associated with the receiving environment need to be considered.

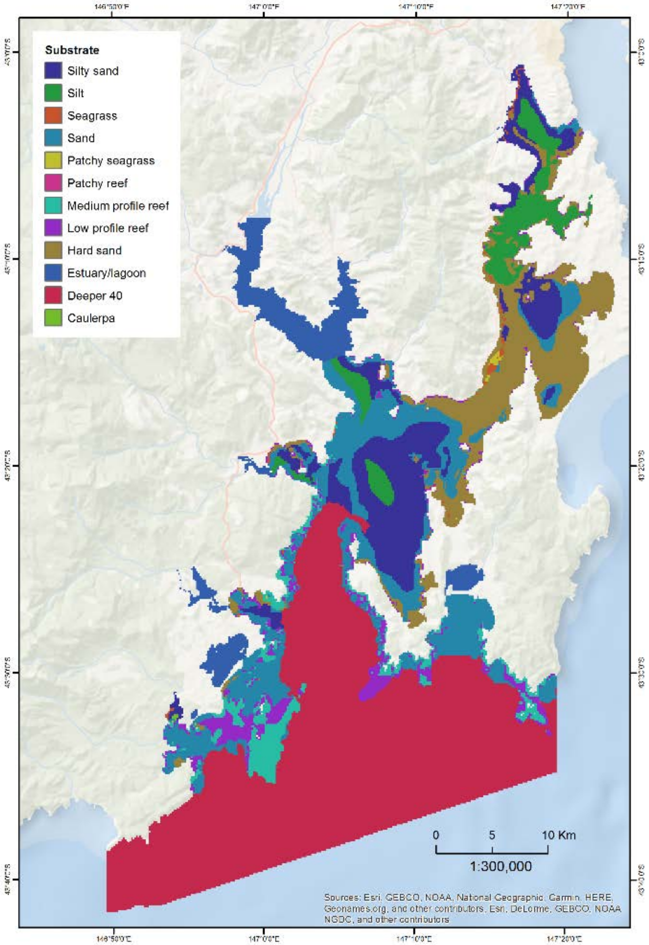
In addition, areas of seagrass and *Caulerpa* may be important nursery habitats for fish and can be negatively impacted by nutrient enrichment and smothering (Jackson et al. 2001, Apostolaki et al. 2007). As such seagrass and *Caulerpa* beds are not considered to be a suitable substrate below salmon aquaculture for the purposes of this pilot.

Study area habitat categories: *Silty sand, silt, seagrass, sand, patchy seagrass, patchy reef, medium profile reef, low profile reef, hard sand, Caulerpa and areas unmapped (estuary/lagoon and areas deeper than 40m)*

Data source: *Detailed data on substrate and habitat type is available for the study region for depths <40m excluding estuaries (mapped using underwater camera equipment, echo sounder and differential GPS as part of the Southeast Tasmania Marine Habitat Project) from the marine habitat mapping layer in Seamap Australia. Data is available at: https://seamapaustralia.org/.*

Post processing: *The data was clipped to the pilot project study area and gap-filled with two new categories to account for the areas not mapped (estuaries and lagoons and areas deeper than 40m) (see Map 5).*

Data limitations: *Data is missing for areas which have not been mapped (areas of depth >40m and within estuaries).*



Map 5: Substrate type; Seamap Australia marine habitat data showing substrate types.

Wave height

The maximum and average wave height for a proposed salmon farm location is an important consideration, for both the ease of day to day operations and maintenance and the structural integrity of infrastructure (Beveridge 1996). The operational limits set by different wave heights are highly dependent on the cage design and technology being used to farm salmon. Globally, designs are being developed to withstand higher energy environments with associated increases in maximum wave heights (e.g. Scott & Muir 2000, Kim et al. 2014, Drach et al. 2016). Current farming practice in Tasmania however use the more traditional circular cages with sizes ranging from 120 – 240m circumference which were originally developed for more sheltered coastal waters and are now being adapted for higher energy environments.

While higher energy environments (with larger wave heights) may offer other advantages for salmon production (better flushing and oxygenation), more sheltered areas are generally more suitable from a purely operational perspective.

Study area maximum significant wave height: *1m to 12m*

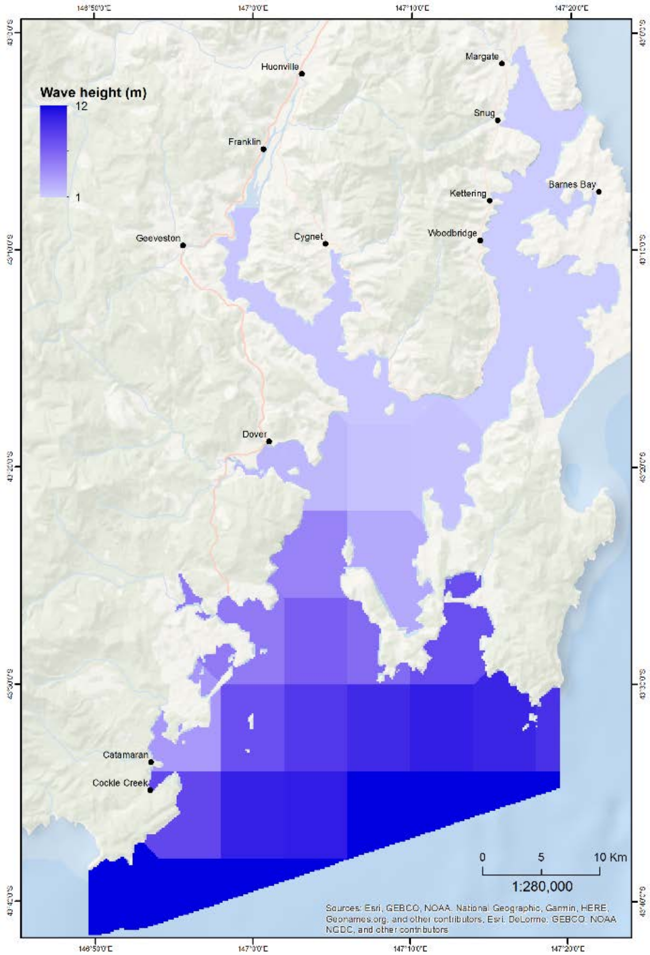
Data source: *Modelled wave height data can be obtained at a resolution of 200 m for specific regions using MARVL (available at: http://imos.org.au/facilities/aodn/imos-data-management/marvl/) however model runs can take several days to weeks depending on the temporal resolution, spatial extent and computer power (high performance computer capability is required).*

For this project, modelled wave height data based on outputs from the CAWCR global wave hindcast (Hemer et al. 2018) was used (available for the study area at Australian Wave Atlas (https://nationalmap.gov.au/renewables/#share=s-gGd5ztFcxe2ysy9f). Data outputs have a lower resolution than MARVL outputs (~7km) however they cover a larger temporal range. Measures of wave height including hourly time series, 50th and 90th percentiles of significant wave height, monthly averages are available, from the Wave Atlas and may offer useful insight into expected conditions in the area. For the purposes of the pilot, maximum significant wave height from archived hourly data from 1 January 1979 to 31 December 2012 was used to ensure consistency with the wave metrics used in other information sources for the broader region (e.g. in Storm Bay).

Maximum significant wave height over the time period 1979-2012 will provide the worst-case scenario, and thus a conservative measure in relation to suitability for salmon aquaculture.

Post processing: *The data was clipped to the pilot project study area and re-gridded to provide a regular grid of ~145m cell size. The land was masked out. Some shallow areas with no available data were gap-filled by taking values from the nearest cells (see Map 6).*

Data limitations: *Data is based on model outputs at 7-km resolution. The reliability of model outputs is dependent on validation against field observations. Validation consisted of observational data from historical wave in-situ buoy data and satellite altimetry observations (Hemer et al. 2017).*



Map 6: Modelled maximum significant wave height (meters)

Finfish suitability layer

Using the data sets informing the future growth and/or redistribution of aquaculture (water depth, temperature, current velocity, wave height and substrate type), a suitability analysis was used to produce a spatial representation of variability in operational suitability for salmon aquaculture across the study area. Suitability analysis was carried out separately for summer (Map 7) and winter (Map 8) conditions to provide an understanding of temporal variably in suitability across the region.

To undertake the suitability analysis, suitability classifications for the development of salmon aquaculture (1 to 9, where 1 is unacceptable and 9 more suitable) for each operational information variable was defined from literature and consultation with the Tasmanian salmon industry based on current practice (Table 3). To accommodate a future scenario where technological and operational advances may open up higher energy environments for finfish farming, suitability classifications for wave height and depth were amended (Table 4).

An operational salmon suitability equation was developed, considering the relative importance of the five information variables (weights) based on literature review and consultation with Tasmanian salmon industry representatives. Suitability classifications were used as a numerical representation of suitability for each information variable within the equation to calculate:

> Operational salmon suitability = (0.2 x temperature classification) + (0.2 x bathymetry classification) + (0.2 x current velocity classification) + (0.3 x maximum significant wave height classification) + (0.1 x substrate type classification)

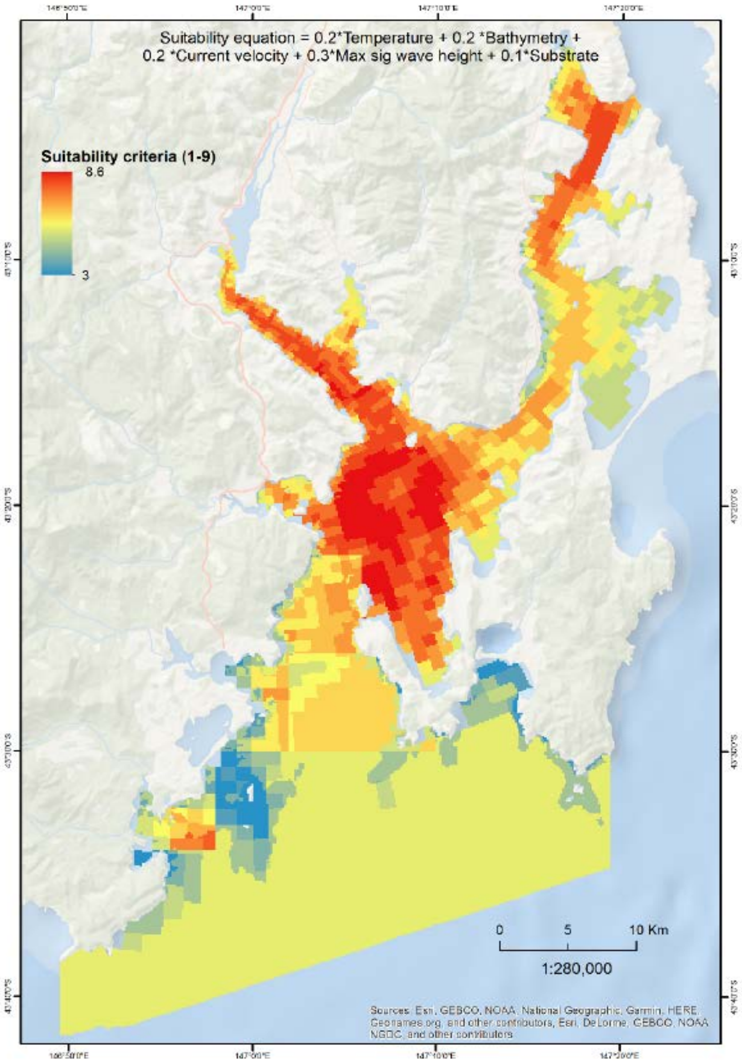
Maximum significant wave height was assigned the highest weight because under current Tasmanian salmon farming practices, operational activities will be increasingly limited with increasing wave exposure. It should be noted that the way in which information variables are classified and the weights applied to them in the suitability equation will directly affect the spatial suitability within the study region.

		Suitability classifications				
		Unacceptable →				More suitable
		1	3	5	7	9
Operational information variables	Temperature (°C)	>22	20-22	19-20	18-19	10-18
	Water depth (m)	<10	10-15	15-18	18-22	>22
	Current velocity (m/s)		0.00-0.01	0.01-0.02	0.02-0.80	
	Substrate type	Rocky Reef; Seagrass and Caulerpa				Sand; silty sand; hard sand; silt; estuaries; areas >40m depth
	Maximum significant wave height (m)	>7	5-7	4-5	3-4	<3

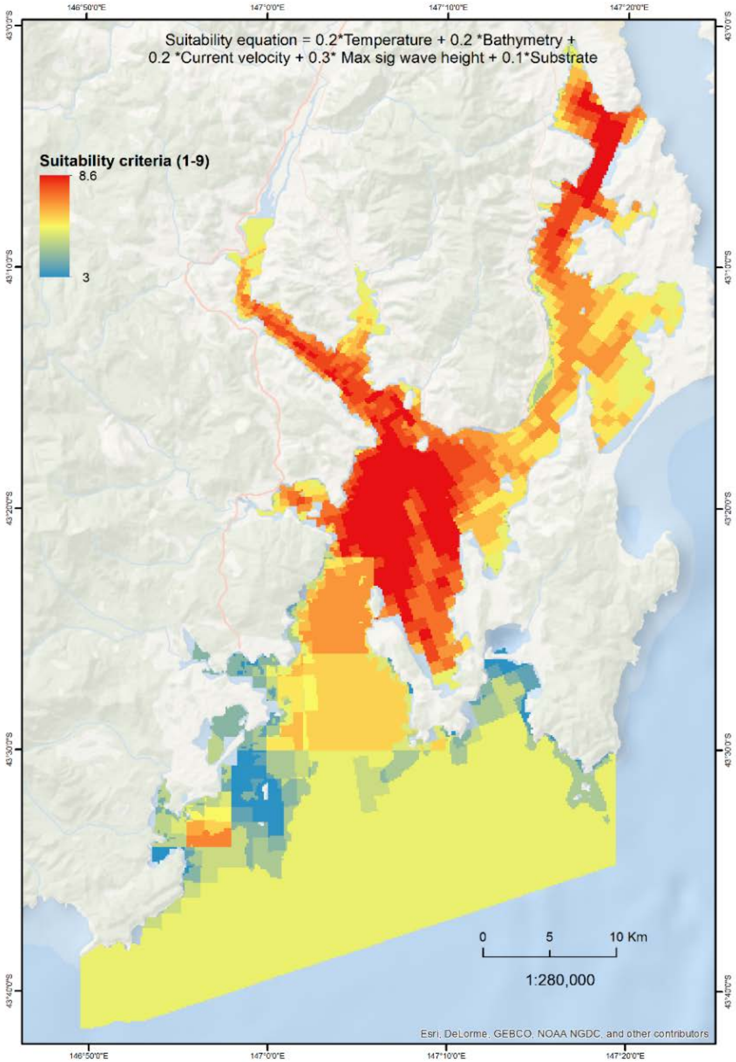
Table 3: Suitability classification for current salmon aquaculture practices.

		Suitability classifications				
		Unacceptable →				More suitable
		1	3	5	7	9
Operational information variables	Temperature (°C)	>22	20-22	19-20	18-19	10-18
	Water depth (m)	<15	15-20	20-25	25-30	>30
	Current velocity (m/s)		0.00-0.01	0.01-0.02	0.02-0.80	
	Substrate type	Rocky Reef; Seagrass and Caulerpa				Sand; silty sand; hard sand; silt; estuaries; areas >40m depth
	Maximum significant wave height (m)	>9	7-9	5-7	3-5	<3

Table 4: Suitability classification for future salmon aquaculture practices.



Map 7: Suitability areas with the potential to grow salmon in summer (where 1 is unacceptable and 9 is most suitable)



Map 8: Suitability areas with the potential to grow salmon in winter (where 1 is unacceptable and 9 is most suitable)

3.1.1.3 Commercial fisheries

Within the study area there are several important commercial fisheries. These include scalefish, abalone and southern rock lobster fisheries. These industries rely on the maintenance of ecosystems with good functional integrity to sustain stock levels.

Commercial scalefish fishery

The scalefish fishery in Tasmanian state waters includes several species (Table 5) which are caught using a variety of fishing methods. It is managed under the regulatory framework of the Scale Fishery Management Plan (amended in 2015) (Moore et al. 2019) and includes sharks and cephalopods in addition to scalefish. Since the 1990's annual commercial catches of the major species have seen a decline from 1,000 t to 300 t due to changes in fishing practices, market demand and management approaches (Moore et al. 2019).

In addition to sustainable catch rates, the fishery relies on healthy functioning ecosystems to support all life history stages and to maintain healthy stock levels. Different habitat types are important for different species, with some species considered to be predominantly reef fish while others are associated with soft sediment areas or within the water column (Table 5). As such, the scalefish industry requires access to a range of important fishing grounds and that the broader ecosystem be managed to maintain the functional integrity of a range of habitat types to support existing and/or improving stock levels into the future.

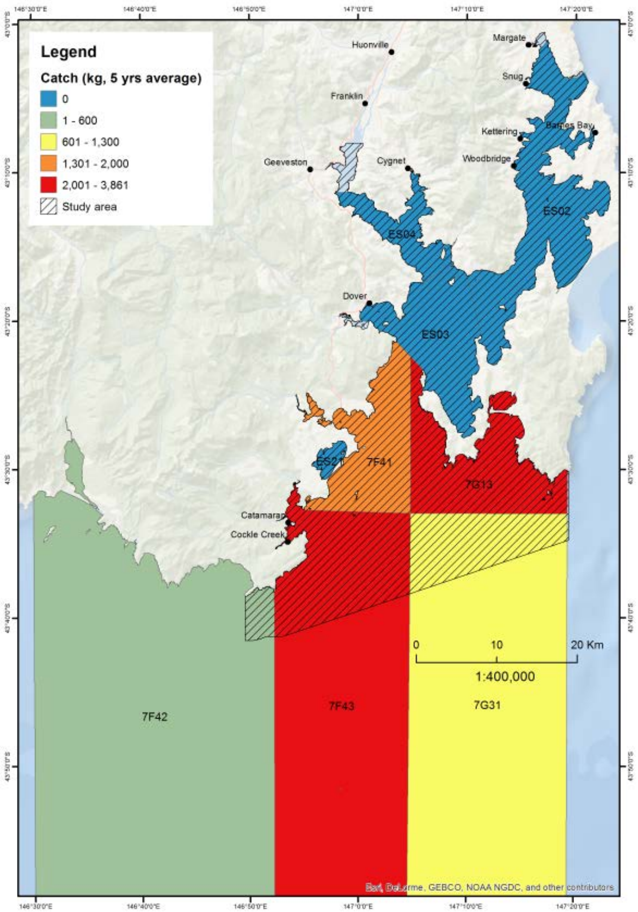
Data source: *Data on the commercial catch (in kilograms) for fishing blocks is available from the DPIPWE Fisheries Integrated Licensing and management System (FILMS) data base on request subject to privacy and public reporting limitations. This provides some understanding of the relative importance of different fishing blocks in terms of the total commercial catch.*

Data includes 146 species which are predominantly associated with reefs and non-reef species, in addition to those species which are associated with both reef and non-reef habitats. The data is available for a period of 23 years (reported as fishing years from July to June to reflect the seasonality of fisheries and fish biology).

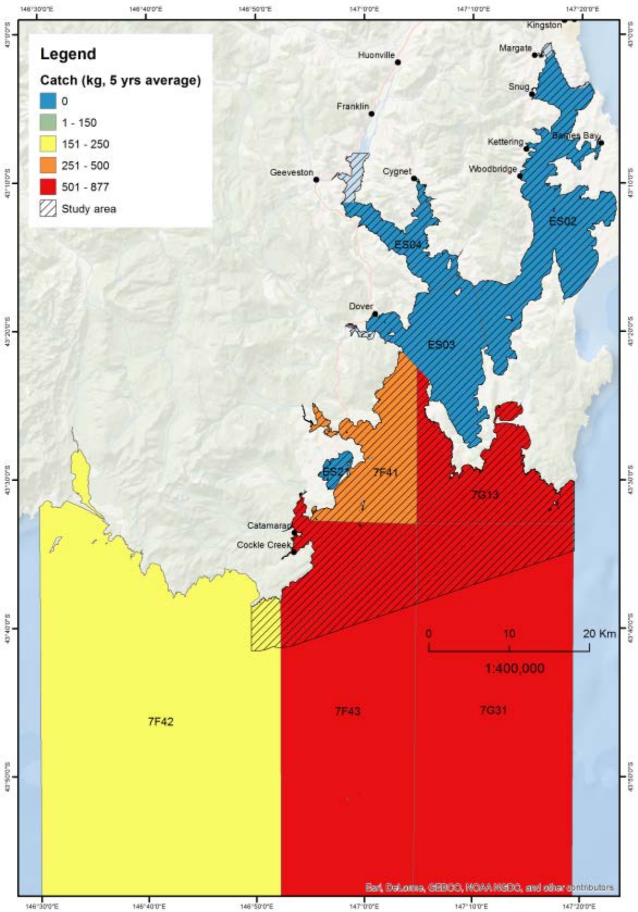
Post processing: *A map of total catch per fishing block was produced (see Map 9) and to provide more meaningful information around the spatial importance of different areas for different commercial species, the 53 species which are caught within the pilot study area were classified according to their habitat preferences (both habitat types, non-reef or reef) and mapped separately (see Map 9, Map 10 and Map 11 respectively). For species that are associated with both reef and non-reef habitats, the catch was divided equally between habitats as a first approximation). Separation between species with different habitat preference allows the potential for greater spatial distinction between areas within blocks by overlaying habitat mapping data (see Map 5) onto scale catch data to identify the areas which are more or less important for a given fishery (i.e. allocating catch data to the relevant habitat area within the block). To avoid confidentiality restrictions, mean annual catch was calculated for a five year period (2013/2014 to 2017/2018).*

To better understand which species are the most important by catch volume (kilograms) for each block, the percentage of total catch per block was calculated for each species. Species with catches over 10% of the total catch per block are reported in Table 6.

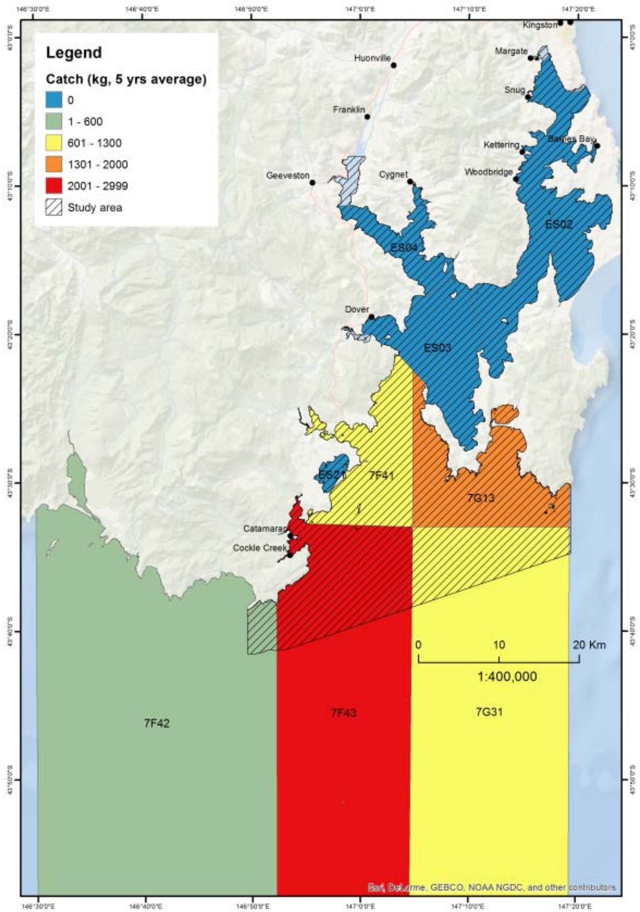
Data limitations: *Data is collated from catch and effort logbooks kept by commercial fishers. Due to reporting inconsistencies some catch data has not been identified to species level (e.g. 'Shark unspecified') and in some instances catch has been allocated to larger fishing blocks than illustrated within this pilot project.*



Map 9: Average annual total catch of scale fish fisheries per block aggregated over a 5 year period (kg)



Map 10: Average annual catch of non-reef scale fish fisheries per block over 5 years (kg)



Map 11: Average annual catch of reef scale fish fisheries per block over 5 years (kg)

Reef species	Non-reef species	Both
Long-snouted Boarfish	Barracouta	Red cod
Calamari	Conger eel	Gurnard
Bearded rock Cod	Sand flathead	Gurnard perch
Herring cale	Tiger flathead	Ocean perch
Leatherjacket	Greenback flounder	Short-finned pike
Rock Ling	Garfish	School shark
Luderick	Latchet	Seven gilled shark
Marblefish	Blue mackerel	Arrow squid
Banded Morwong	Jack mackerel	Bastard trumpeter
Red Mullet	Yellow-eye mullet	Striped trumpeter
Barber Perch	Australian salmon	
Long-finned Pike	Elephant shark	
Snapper	Gummy shark	
Sweep	White trevalla	
Silver Trevally	Ocean wild trout	
Blue throated Wrasse	Albacore tuna	
Purple Wrasse	Blue warehou	
	King George Whiting	
	School whiting	

Table 5: List of species reported in study region catch data (separated by habitat preferences)

	Block number				
Species	7F41	7F42	7F43	7G13	7G31
Banded morwong	✓	✓	✓	✓	×
Gummy shark	✓	✓	×	×	×
Arrow squid	×	×	×	×	✓
Bastard trumpeter	×	×	×	✓	×
Striped trumpeter	×	✓	✓	×	×
Blue warehau	×	×	×	✓	×
Blue throated wrasse	✓	×	✓	✓	×
Purple wrasse	✓	×	✓	✓	×

Table 6: Scalefish species which represent catches > 10% of total catch for each block within the study area

Commercial abalone fishery

The Tasmanian abalone fishery is the largest wild abalone fishery in the world, providing 25% of the global annual harvest and is a major contributor to the local economy (DPIPWE. 2019a). The current exported revenue generated by the industry is around $100 million per annum, generating about $300 million in associated economic activity and $30 million in wage income across the state (Tasmanian Abalone Council Ltd, 2019). Both blacklip (*Haliotis rubra*) and greenlip (*Haliotis laevigata*) abalone are caught in Tasmania following a fisheries management plan, with blacklip abalone making up about 95% of the total harvest. Catch data is recorded and reported annually in industry specific fishery assessment reports (e.g. Mundy & McAllister 2018).

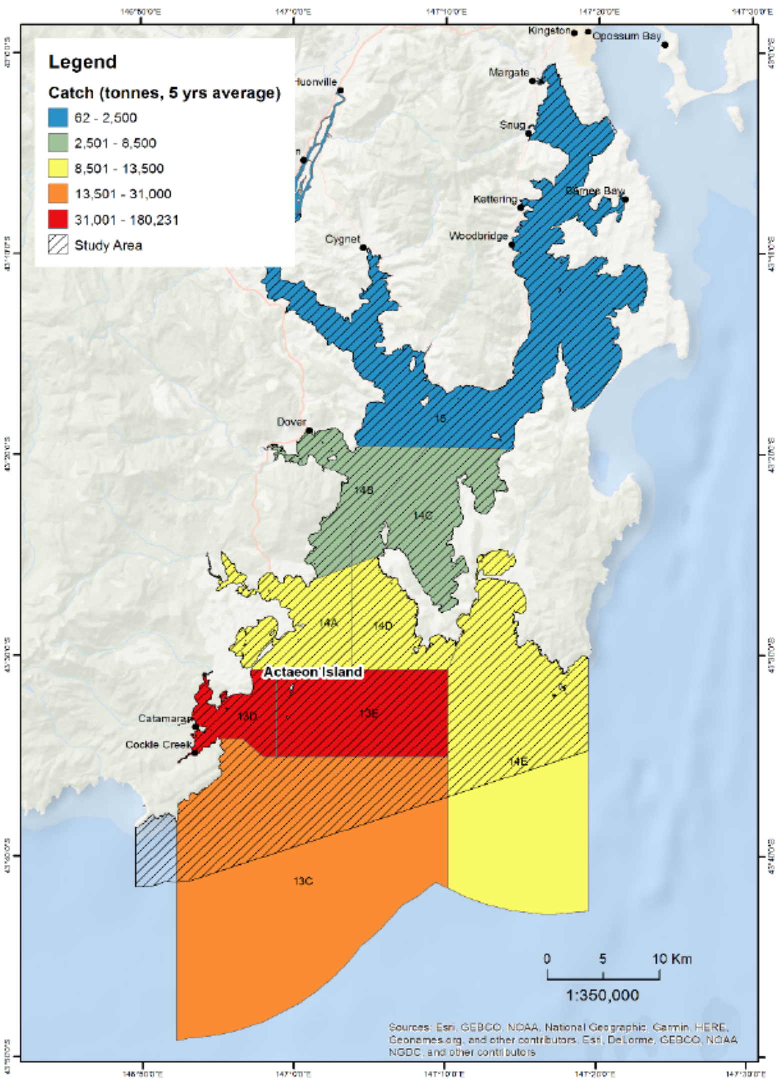
Abalone populations are limited to rocky reef habitats. The Actaeon reef system, considered to be one of Australia's most valuable regions in terms of economic yield from the abalone fishery is located within the pilot study area. This small region is thought to yield an average production comparable to the whole Western Australian and New South Wales abalone catches combined (Marine Life Network n.d.). While the importance of the Actaeon reef system is well understood, other rocky reefs within the area also provide important habitat that help to maintain abalone populations.

The abalone fishery therefore requires access to important abalone harvesting grounds and the maintenance of functioning rocky reef ecosystems more broadly for the recruitment and continuity of healthy abalone populations which can support a sustainable commercial abalone fishery.

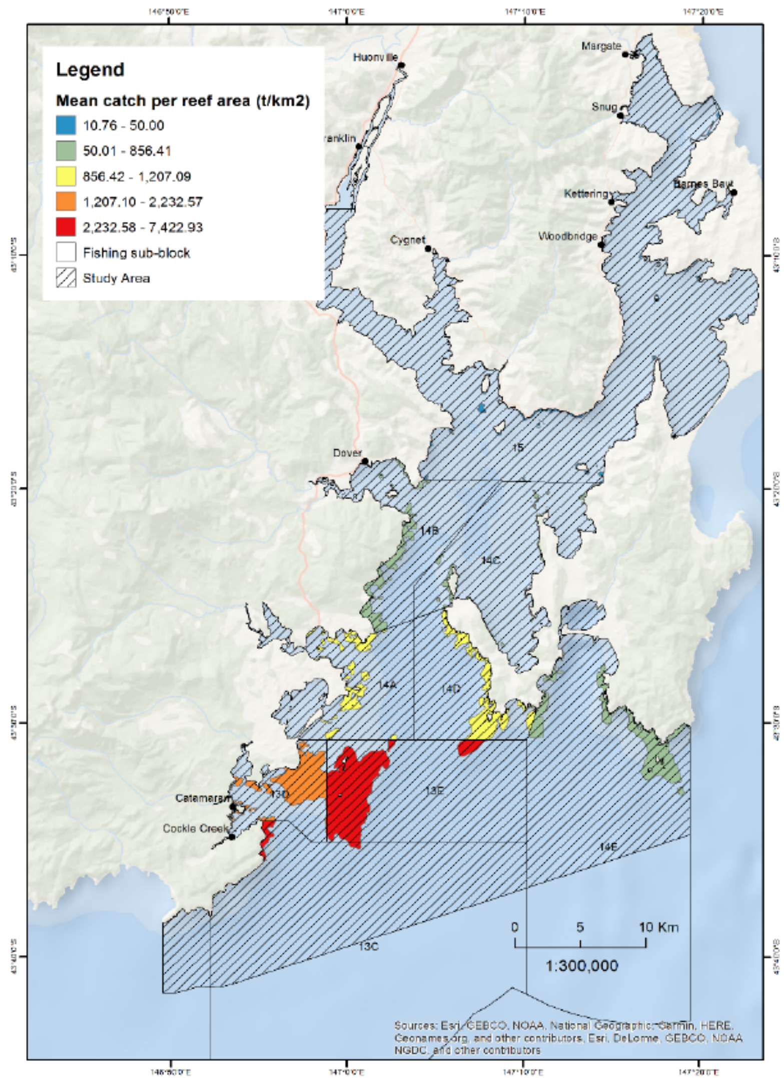
Data source: *Data on the commercial catch (in tonnes) for the south east sub-blocks is available from the IMAS Fisheries and Aquaculture Oracle catch and effort data base on request. Catch data provides an understanding of the relative importance of different fishing blocks in terms of commercial catch contribution. To overcome confidentiality concerns, data is provided as an aggregation over five years (see Map 12).*

Postprocessing: *The five-year aggregated catch data was divided by five to provide an average annual catch over the five year period. While catch data is assigned to a whole fishery block, the ecological preference of abalone dictate that the fishery is focused around rocky reef habitats. Therefore, to make the data more spatially meaningful and better represent the important abalone fishery locations, catch data for each block was assigned to mapped areas of rocky reef (see section 3.1.1.2 — Substrate, for data source information) within the block (see Map 13).*

Data limitations: *Data is collated from catch and effort logbooks kept by commercial fishers. Data must be checked for reporting inconsistencies before use.*



Map 12: Average annual abalone catch per fishing block over 5 years (in tonnes, 2014-2018)



Map 13: Average annual abalone catch per reef area within each fishing sub-block (in tonnes/km^2, 2014–2018)

Commercial southern rock lobster fishery

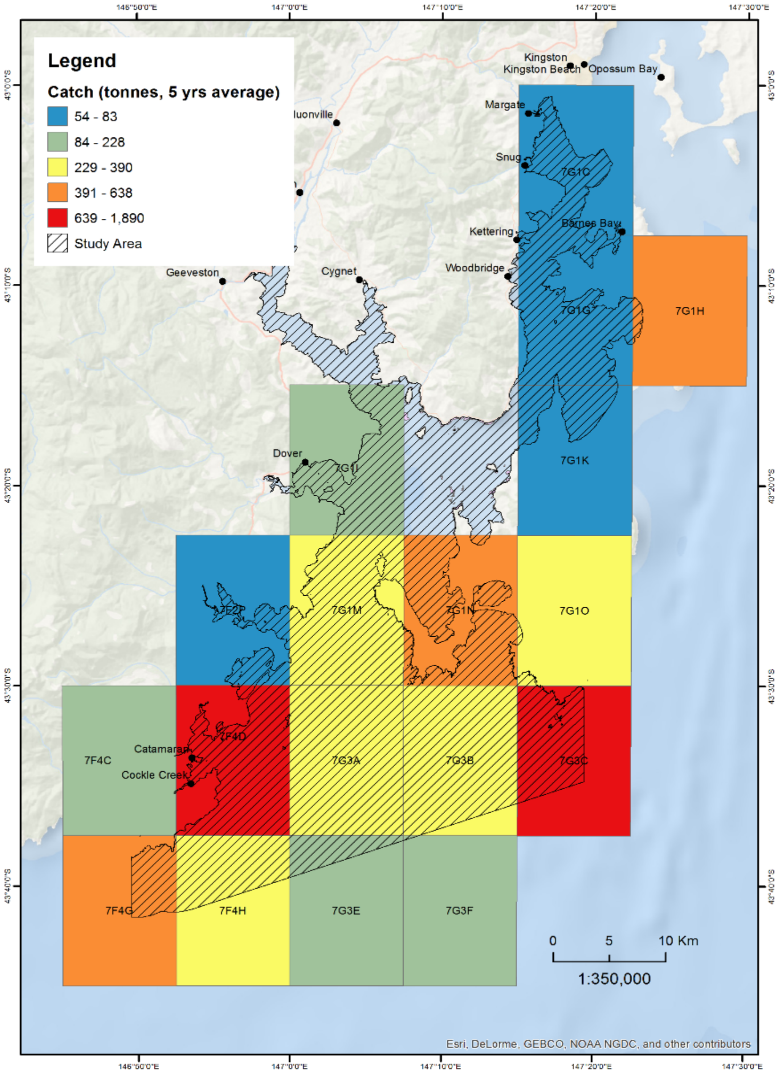
The rock lobster industry has supported rural coastal communities around Tasmania for generations. Due to observed decreases in the rock lobster stock around Tasmania (Hartmann et al. 2019) strategies have been put in place to help rebuild numbers. In 2013, the East Coast Rock Lobster Stock Rebuilding Strategy was put in place to limit the total annual commercial catch (DPIPWE. 2019b, Hartmann et al. 2019). The East Coast Stock Rebuilding Zone is a designated area between Eddystone Point in the north-east of Tasmania and Tasman Head on Bruny Island, and includes the Huon Estuary and the D'Entrecasteaux Channel. This rebuilding zone overlaps a significant portion of the pilot project study area. In addition, recreational fishing restrictions have been put in place for marine reserves and fisheries research areas within the pilot project study area and areas designated as 'no rock lobster pot areas' have been specified within the D'Entrecasteaux Channel.

Like abalone, southern rock lobster (*Jasus edwardsii*) are also restricted to rocky reef habitats and as such the commercial rock lobster industry requires access to important rocky reef harvesting grounds in addition to the maintenance of functioning rocky reef ecosystems more broadly to replenish and maintain southern rock lobster populations in support of the industry.

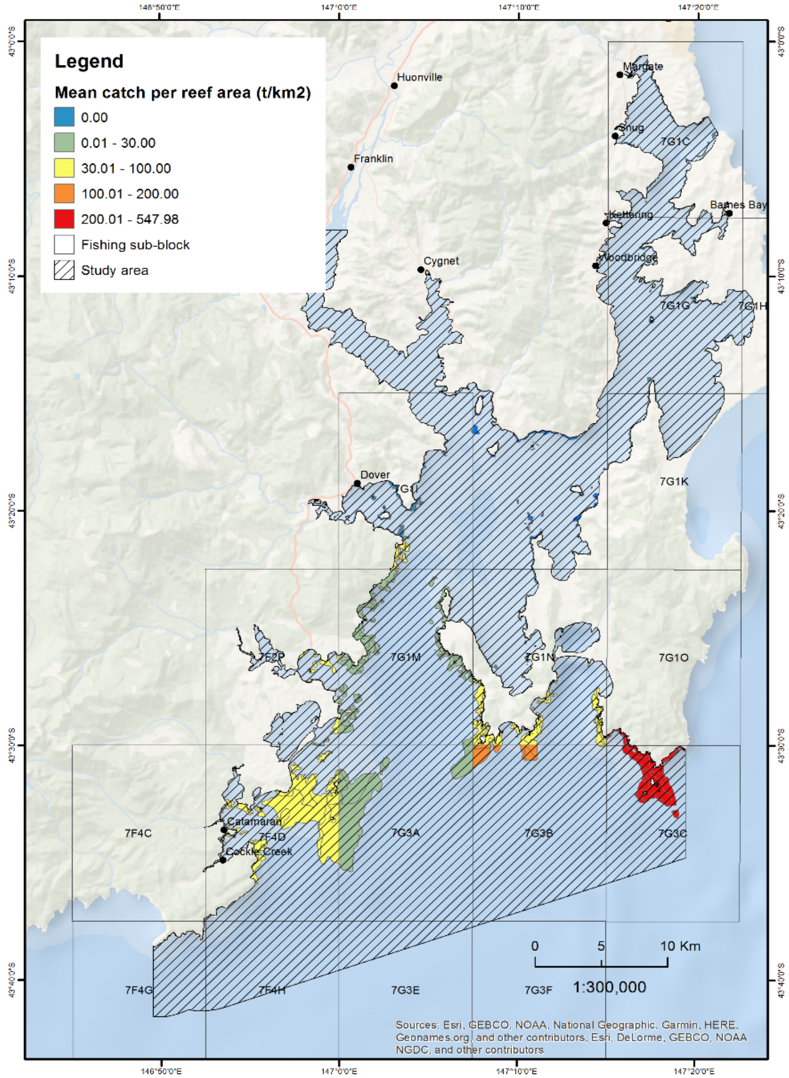
Data source: *Data on the commercial catch (shot weight in tonnes) and effort for the south east is available from the DPIPWE Fisheries Integrated Licensing and management system (FILMS) data base on request subject to privacy and public reporting limitations. Monthly catch and effort totals are provided for each fishing block for each quota year for a twenty-one year period (1999 – 2019). Catch data provides an understanding of the relative importance of different fishing blocks in terms of commercial catch contribution.*

Postprocessing: *To overcome confidentiality concerns, mean annual catch over a five year period (2014-2018) was calculated for each block (Map 14). While catch data is assigned to a whole fishery block, the ecological preference of southern rock lobster dictate that the fishery is focused around rocky reef habitats. Therefore, to make the data more spatially meaningful and better represent the important southern rock lobster fishery locations, catch data for each block was assigned to mapped areas of rocky reef (see section 3.1.1.2 – Substrate, for data source information) within the block (Map 15).*

Data limitations: *Data is collated from catch and effort logbooks kept by commercial fishers. Data must be checked for reporting inconsistencies before use.*



Map 14: Average annual catch of Southern Rock Lobster per fishing block over 5 years (in tonnes, 2014–2018)



Map 15: Average annual Southern rock lobster catch per reef area within each fishing sub-block (in tonnes/km^2, 2014–2018)

3.1.1.4 Tourism

In Tasmania the tourism industry has shown rapid growth over the last decade with increasing numbers of visitors to the state each year. A variety of tourism ventures have developed within the region, including a growing marine tourism sector (e.g. locally operated (sightseeing, fishing, diving, kayaking) tours in addition to increasing visitations by international cruise ships.

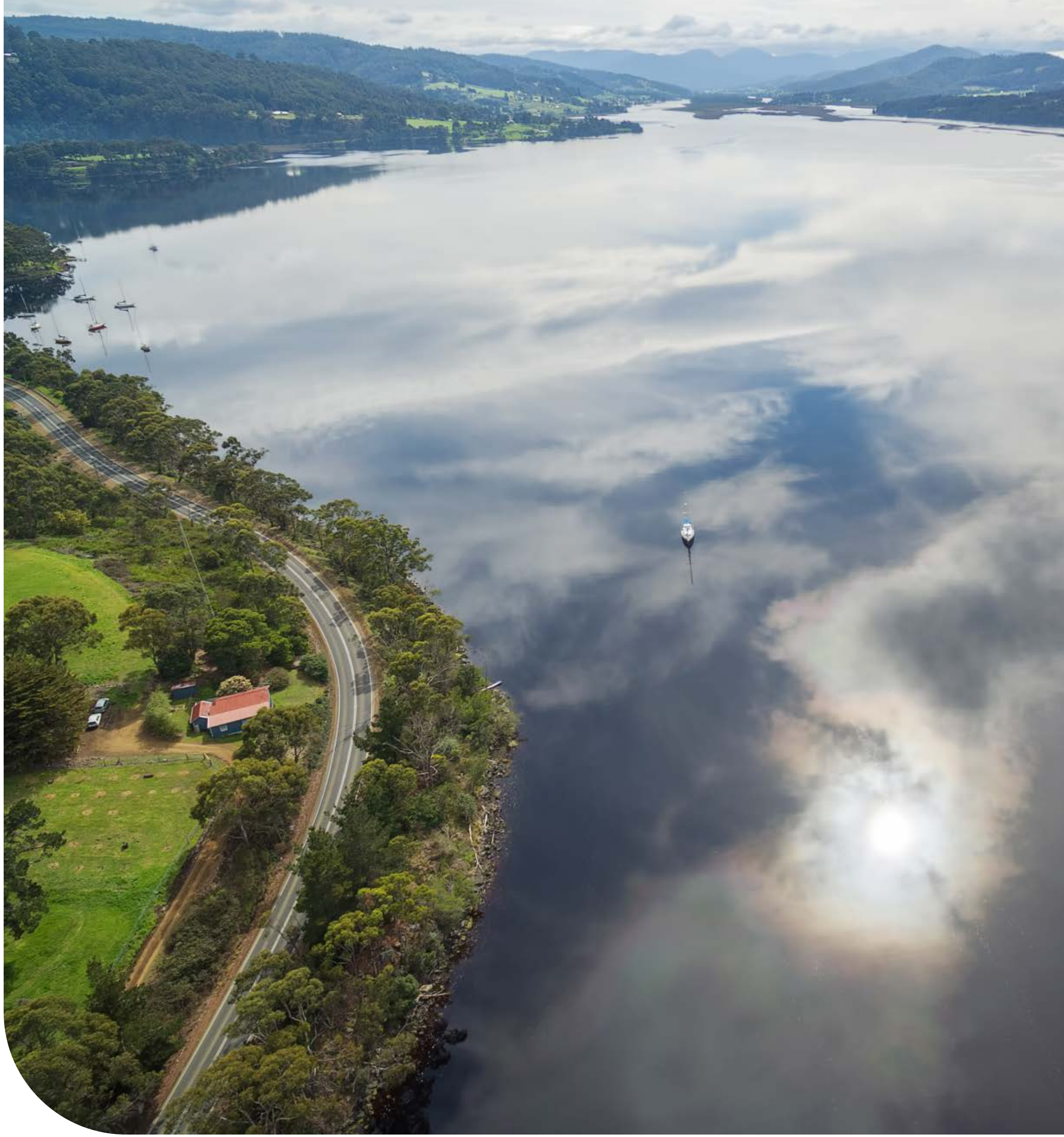
Because of the dynamic nature of the tourist industry and the way in which people perceive the environment it is difficult to determine which are the most important or essential criteria to sustain the industry. As a rule, however, in Tasmania, the industry is based around the 'clean green' image and as such accessible areas of wilderness and high wildlife richness are of high importance.

Data source: *For an overview of data that may be of interest in understanding of the spatial distribution of areas of wilderness and wildlife importance for the marine tourism industry see Section 3.1.3: Environment and Conservation information*

For an overview of data that provides an indication of coastal accessibility (e.g. presence of coastal access points and recreational facilities etc.) see Section 3.1.2.2: Recreational use and section 3.1.2.3: Lifestyle, cultural and heritage use.

3.1.2 Social

While it is important to maintain a strong economy from a society perspective, it is also important that the social values enjoyed by the population (recreation, transport (marine traffic), lifestyle, culture and heritage) are also considered around any proposed development (Ogier & Macleod 2013). As a sheltered waterway near Hobart, the D'Entrecasteaux channel and Huon Estuary attract many residents who live along the coast in addition to visitors who use the area for a wide variety of uses from fishing to bird watching.



3.1.2.1 Marine traffic

While the whole region is a popular area for navigation by recreational and commercial marine vessels, there are several routes which are particularly important for marine traffic. Data from several sources were combined to create a marine traffic map (Map 16):

Data sources:

1. Ferry routes

Data on the location of ferry routes is available from the Huon Valley and Kingborough Municipality Tracks/ Ferry Routes layers on LISTmap (http://listdata.thelist.tas.gov.au/opendata/index.html#LIST_Transport_Segments). This layer includes a variety of transport routes including vehicular and ferry routes, walking tracks and railways.

Post processing: *Ferry routes were extracted from the Tracks/ Ferry Routes layers and combined for both the Huon Valley and Kingborough municipalities.*

Data limitations: *The Tracks/ Ferry Routes layer was produced in the early 1980s and as such may be out dated.*

2. Navigation routes (AIS)

Aggregated automatic identification system (AIS) data was accessed from the Marine Traffic website (https://www.marinetraffic.com/en/ais/home/centerx:147.0/centery:-43.3/zoom:9), representing higher frequency routes used by marine vessels with AIS.

Post processing: *AIS data was digitised and traffic between marine leases was excluded from the spatial layer.*

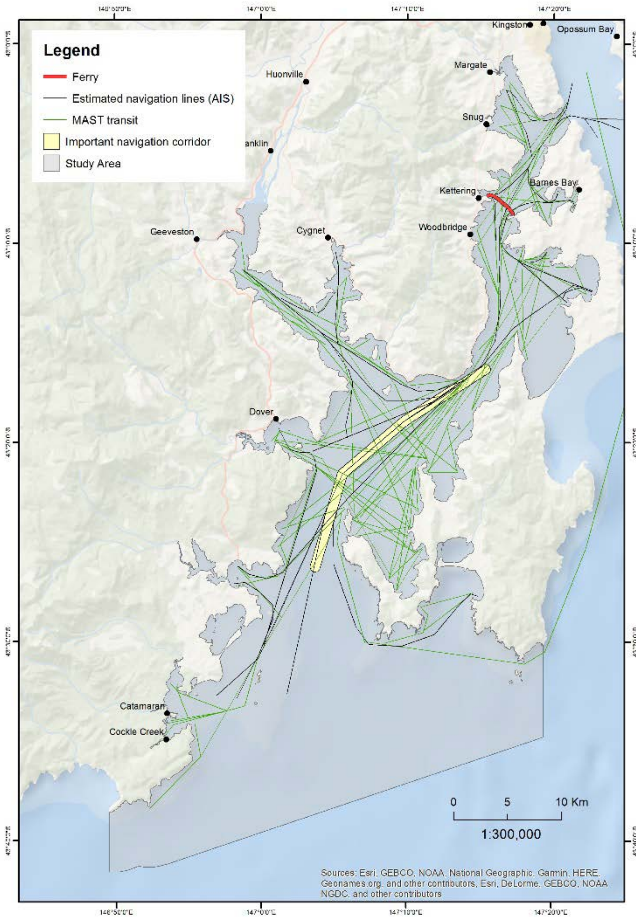
Data limitations: *AIS navigation routes are representative of the highest traffic routes and have been manually digitised from an image of AIS routes.*

3. Navigation routes (other)

The main navigation routes used by recreational vessels can be accessed on request from the Marine and Safety Tasmania (MAST). Tas ports can provide information on navigation routes for large shipping. A navigation corridor historically provided by Tas ports to DPIPWE was used for this pilot project.

Post processing: *No post processing of the recreational vessel routes was needed.*

Data limitations: *Recreational vessel navigation routes are the shortest route between areas of recreational vessel use and do not necessarily represent the actual routes taken by recreational traffic.*



Map 16: Outline of aggregated marine traffic corridors

Note: while transport has been placed within social values within this report, it could also be included within the economic values section as it is of both economic and social importance.

3.1.2.2 Recreational use

The study area is a very high recreational use area, with a wide variety of recreational activities taking place in and around the water including boating, kayaking, swimming, sailing, fishing and diving. While the whole area is a valuable resource for recreational activities, some areas are likely to be more used than others due to accessibility and the recreational and ecosystem services available.

While there is limited information available on spatial utilisation for recreation within the study area, a spatial representation of the recreational suitability was built based on coastal accessibility and knowledge of key recreational attractions.

A data layer incorporating a number of these layers was produced as a spatial representation of the recreational suitability within the study area (see below).

Coastal accessibility

Coastal accessibility in this context is the ease of access to the marine environment from the coast by road for the deployment of a vessel into the water. There are several types of access points in Tasmania that are publicly and privately available, including pontoons, jetties, boat ramps, marinas, wharfs, yacht clubs, beach sheds and public beaches. While marine vessels will at times travel considerable distances from access points, for the purposes of this pilot project, it has been assumed that the highest recreational activity is likely to occur in closer proximity to access points, with decreasing recreational activity with distance from these points. A coastal accessibility data layer including data from multiple sources was prepared in GIS (with Euclidean distance calculated) to create a coastal accessibility map (see Map 17).

Data sources:

1. Parks and Wildlife coastal access

Data on the location of Parks and Wildlife Service marine access infrastructure is available from the Parks and Wildlife marine structures GIS layer on request.

Post processing: *None*

Data limitations: *The dataset is an incomplete list of Parks and Wildlife infrastructure.*

2. MAST infrastructure

Data on the location of Marine and Safety Tasmania (MAST) infrastructure is available from MAST on request.

Post processing: *Errors in the location of some infrastructure were identified (e.g. located in the northern hemisphere). Where possible, data was corrected by comparison with satellite imagery.*

Data limitations: *The dataset contains some location errors.*

3. Private coastal access infrastructure

Data on the location of privately-owned (commercial and non-commercial) coastal infrastructure is available from the crown leases and crown licences layers on LISTmap (http://listdata.thelist.tas.gov.au/opendata/index.html). These layers also include both coastal access infrastructure in addition to other leases and licences e.g. pipeline outfalls.

Post processing: *A subset of the original datasets was compiled by assessing the location of leases and licences with satellite imagery and extracting only leases and licences which appeared to be coastal access points (i.e. excluding pipeline outfalls etc).*

Data limitations: *Some coastal access points may have been miss-identified against satellite imagery. Inconsistencies and errors within the leases and licences layers may be present and are currently awaiting cleaning by DPIPWE.*

4. Public boat ramps

Data on the location of all public access boat ramps is available from the boat ramp layer in LISTmap (https://maps.thelist.tas.gov.au/listmap/app/list/map) on request.

Post processing: *None*

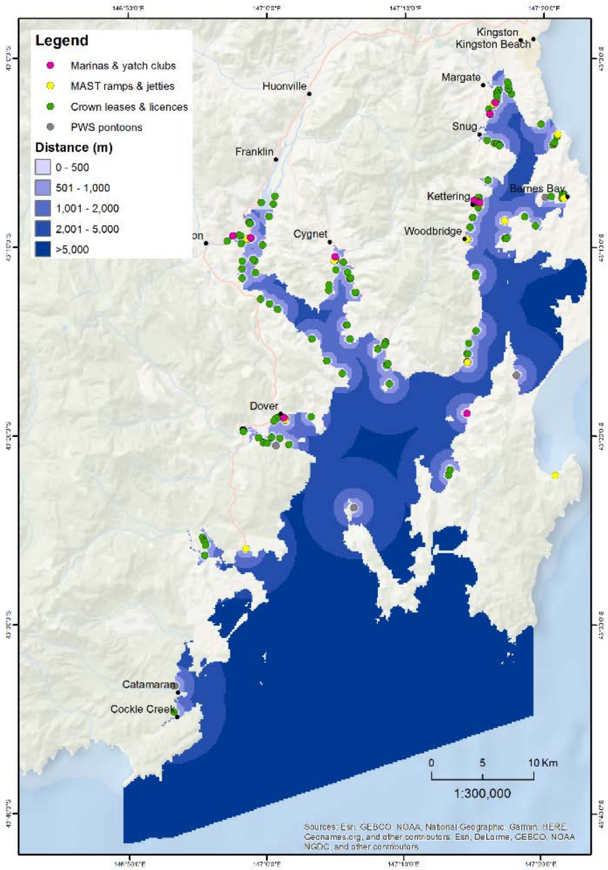
Data limitations: *None identified*

5. Marinas, jetties and wharves

The location of several marinas, jetties and wharves that allow boats to tie up (i.e. hours to days) together with the location of boat/yacht/sailing clubs in the area were identified by internet search and local knowledge. Larger yacht clubs are associated with marina's however a number of smaller clubs rely on public or private boat ramps for coastal access.

Post processing: *None*

Data limitations: *Non identified*



Map 17: Coastal accessibility

Recreational attractions

Some attributes which are appealing for recreation will draw people to specific locations for different purposes (e.g. sheltered bays will be popular as anchorages). As with coastal accessibility, several information sources were identified that provide some indication of which specific areas may be recreationally important.

Data sources:

1. Sheltered areas

Sheltered marine areas were considered to offer more potential for recreational activities than more exposed areas. Data on maximum wave height (see section 3.1.1.2 for data source details) was used to identify the more sheltered locations of greater suitability for recreational use.

2. Habitat type

Substrate and habitat type (see section 3.1.1.2 for data source details) may provide an indication of the types of recreational activities which are popular in different areas. For example, rocky reefs will be particularly popular for recreational snorkelling and diving in addition to fishing, while sandy areas will be more appropriate for fishing for species like flathead (see Table 5 and Map 5).

Post processing: *None*

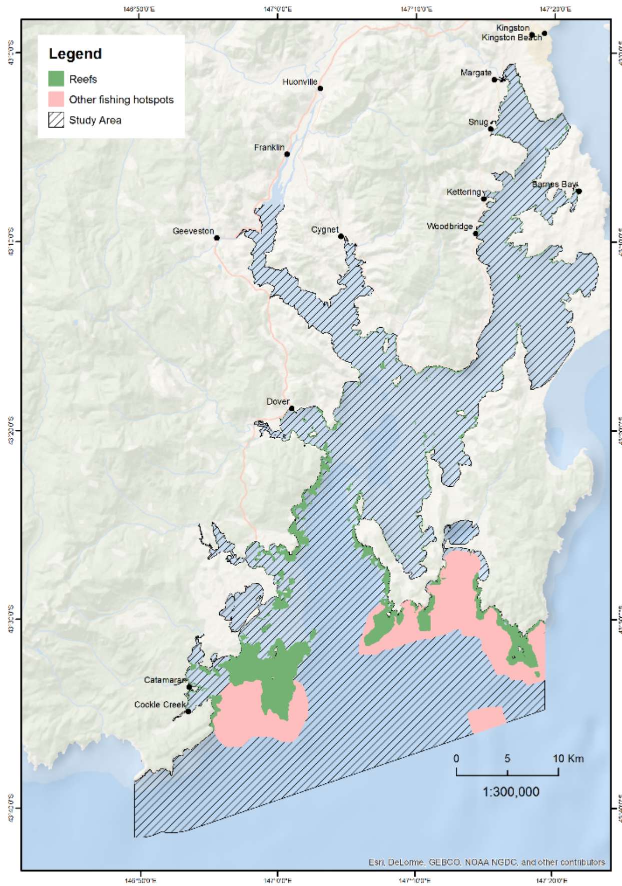
Data limitations: *Substrate and habitat type will only provide an indication of the types of recreational activities which are possible within the area however maps will not document all the spatial heterogeneity in substrate and habitat type.*

3. Fishing hotspots

While recreational fishing occurs across the whole study area, particularly in closer proximity to coastal access points within sheltered areas, areas of reef (see section 3.1.1.2 for data source details on substrate type) are known to be very important and a number of fishing hot spots at greater distances from the coast in deeper (>40m) more exposed locations have been identified from existing local knowledge (see Map 18).

Post processing: *Rocky reef areas were extracted from the substrate and habitat data (see section 3.1.1.2 for data source details on substrate type) while local knowledge of popular fishing areas >40m were digitised.*

Data limitations: *While this layer provides insight into important recreational fishing grounds, other areas may exist which have not been identified. It is also important to note that habitats >40m have not been mapped for most of the study area.*



Map 18: Recreational fishing hotspot areas

4. Organised sailing courses

The location of existing regular sailing routes was identified from local sailing club websites (Kettering Yacht Club, Port Cygnet Sailing Club, Port Huon Sailing Club) (Map 19).

Post processing: *Information was digitised*

Data limitations: *No consultation was undertaken in establishing this dataset, and as such may not be exhaustive.*

5. Registered moorings

The location of registered moorings (not including marine farming boundary markers) is available from Marine and Safety Tasmania (MAST) on request (see Map 19).

Post processing: *Information relevant to the study area was extracted.*

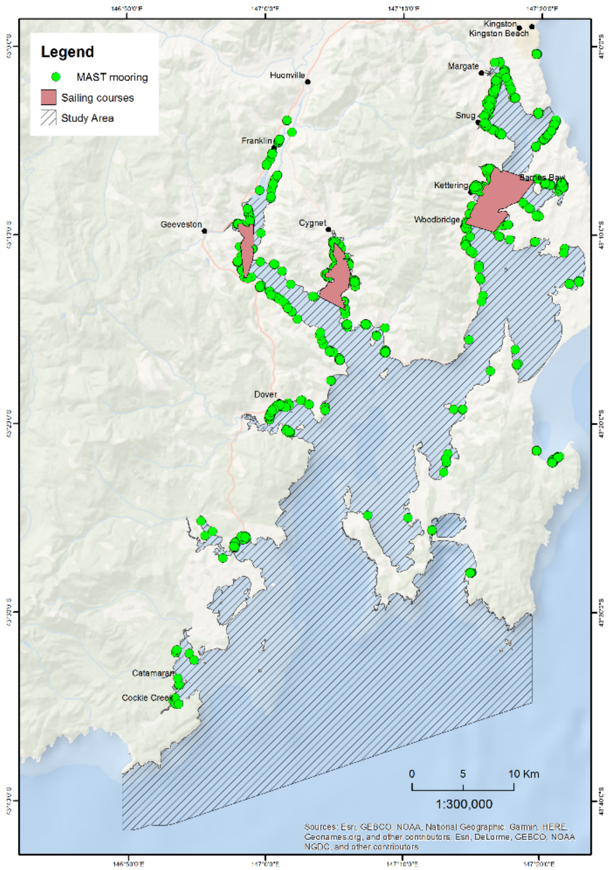
Data limitations: *None identified.*

6. Popular anchorages

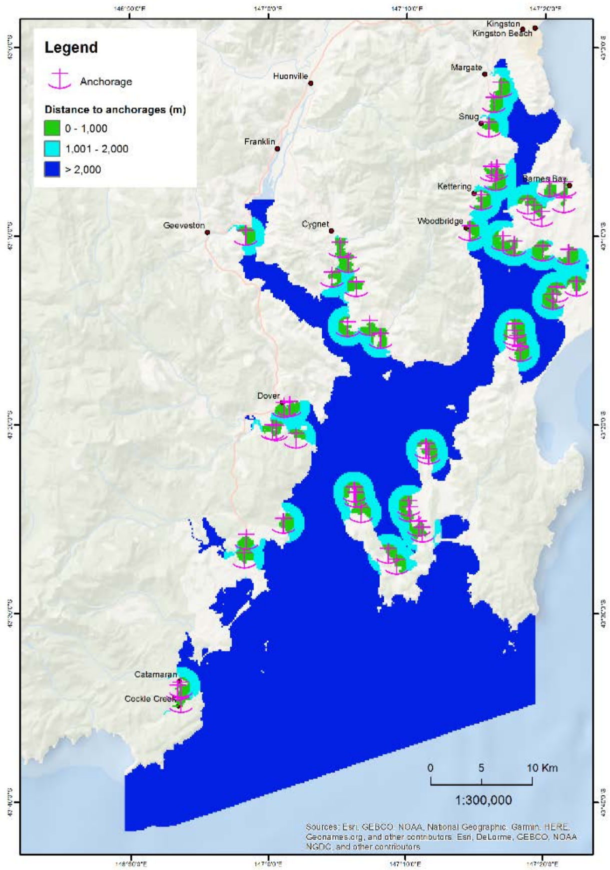
The D'Entrecasteaux Channel in general is a very popular area for boaters, however there are many sheltered embayment's which are especially important as overnight anchorages and areas to shelter during inclement weather. The location of popular anchorages is available from the 'D'Entrecasteaux waterways: a guide to the waterways of the D'Entrecasteaux Channel and its tributaries' booklet (see Map 20).

Post processing: *Information from the booklet was digitised.*

Data limitations: *While the information provides the location of popular anchorages, it is unlikely to be an exhaustive list of all the places which people enjoy anchoring.*



Map 19: MAST moorings and Important sailing areas



Map 20: Distance to popular anchorages

Recreational suitability layers

Using a selection of recreational information data sets (coastal accessibility, important fishing spots and maximum wave height), a suitability analysis was undertaken to produce a spatial representation of variability in recreational suitability across the study area (Map 21).

To undertake the suitability analysis, suitability classifications for each of the recreational data sets used in suitability analysis were defined (see Table 7).

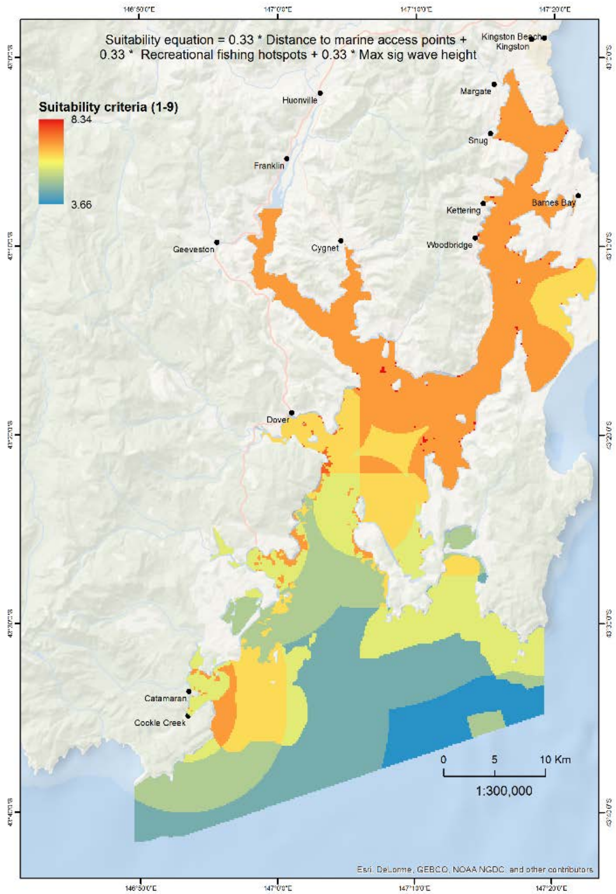
A recreational suitability equation was developed, considering the relative importance (weight) of the three information variables based on local knowledge. Suitability classifications were used as a numerical representation of suitability for each information variable within the equation to calculate:

> Recreational suitability = (0.33 x coastal accessibility) + (0.33 x fishing hotspots) + (0.33 x maximum significant wave height classification)

All variables were assigned the same weight; however, this could be altered where relevant. It should be noted that the way in which information variables are classified and the weights applied to them in the suitability equation will directly affect the spatial suitability within the study region.

		Suitability classifications			
		Less suitable → More suitable			
		3	5	7	9
Recreational suitability variables	Coastal accessibility (km)	>20	10-20	5-10	0-5
	Fishing hotspots		Other		Areas of extended reef and reef
	Maximum significant wave height (m)	>3	2-3	1-2	0-1

Table 7: Suitability classification for recreational activities



Map 21: Recreational suitability (based on marine accessibility, fishing hotspots and wave height), where 3 is less suitable and 9 is more suitable.

3.1.2.3 Lifestyle, cultural and heritage use

The whole study area is highly valued for its lifestyle qualities, cultural and heritage attributes however some areas can be identified as having particular significance and should be considered during any proposed development.

While there are no data sources which provide direct information on the spatial variability of lifestyle, cultural and heritage use within the study area, a variety of data sources can be used together to provide information on areas of particular importance:

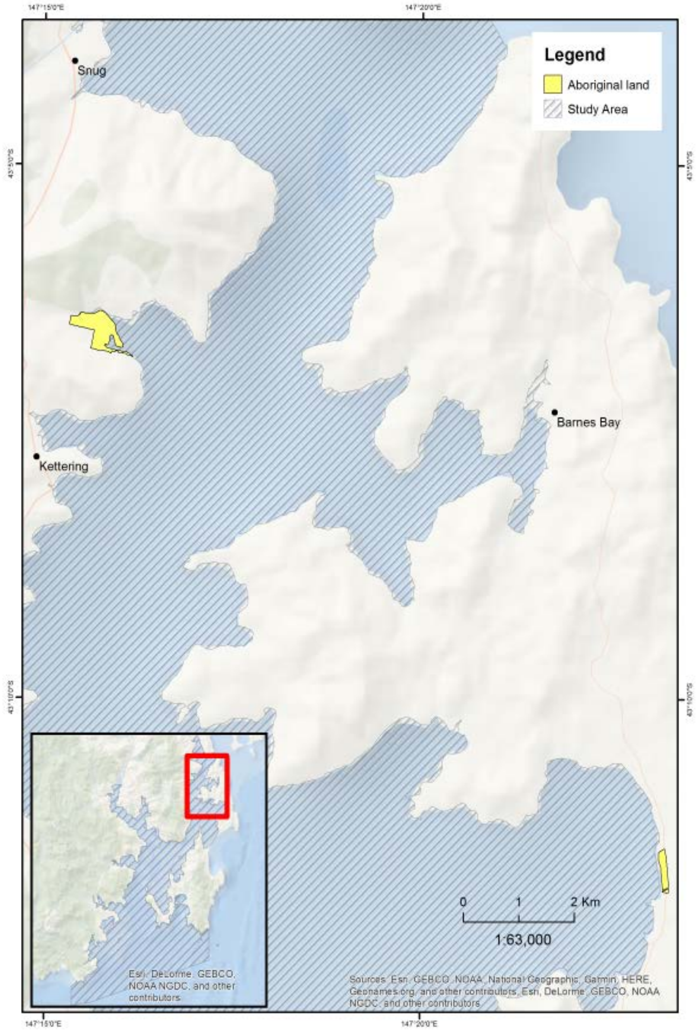
Aboriginal land

Aboriginal land is highly significant from both a cultural and heritage perspective. Within the study area, there are two areas designated as Aboriginal land. The location of proposed developments should be considered in relation to Aboriginal land to ensure that cultural and traditional practice is not negatively impacted, and that heritage values are not undermined.

Data source: *Data on the location of aboriginal land can be accessed from the Aboriginal land layer on LISTmap (https://maps.thelist.tas.gov.au/listmap/app/list/map).*

Post processing: *Areas of aboriginal land within the study area were extracted and Euclidean distance calculated (see Map 22).*

Data limitations: *While areas of Aboriginal land are of high cultural and heritage importance, these areas are not a representation of every area of Aboriginal cultural and heritage significance within the region and any proposed development should consider Aboriginal values through a participatory process in order to account for them.*



Map 22: Aboriginal land

Residential dwellings

The location of residential buildings is important from a lifestyle perspective, to allow for the consideration of disturbance (noise and visual pollution from proposed developments) on existing values which people may hold around the location of their home (e.g. solitude, serenity, wildlife, and wilderness). A distance of 1km was suggested by the EPA sound specialists as a suitable buffer between new salmon aquaculture developments and existing residential buildings.

Data source: *Data on the location of houses within the study area can be accessed from the Huon Valley and Kingborough Councils building points and building footprints layers on LISTmap (www.theLIST.tas.gov.au © State of Tasmania).*

Post processing: *Building points and building foot print layers include buildings classified as residence, feature (those shown in red on the Tasmanian Towns Street Atlas), sheds, ruins, hothouses, silo, commercial, and industrial. Residential building points and residential building footprints (polygons) within 500m from the coast were extracted from the LISTmap building points and building footprint layers. For the building footprints layer, centroids for each polygon were produced and extracted. Both layers (residential building points and residential building polygon centroids) were merged and the Euclidean distance calculated (see Map 23). To provide an understanding of the areas which are least likely to cause impact on residential buildings (from new developments), distance buffers around each building point were added to the layer at distances of 1km and 2km.*

Data limitations: *New houses may be excluded from the data layer.*

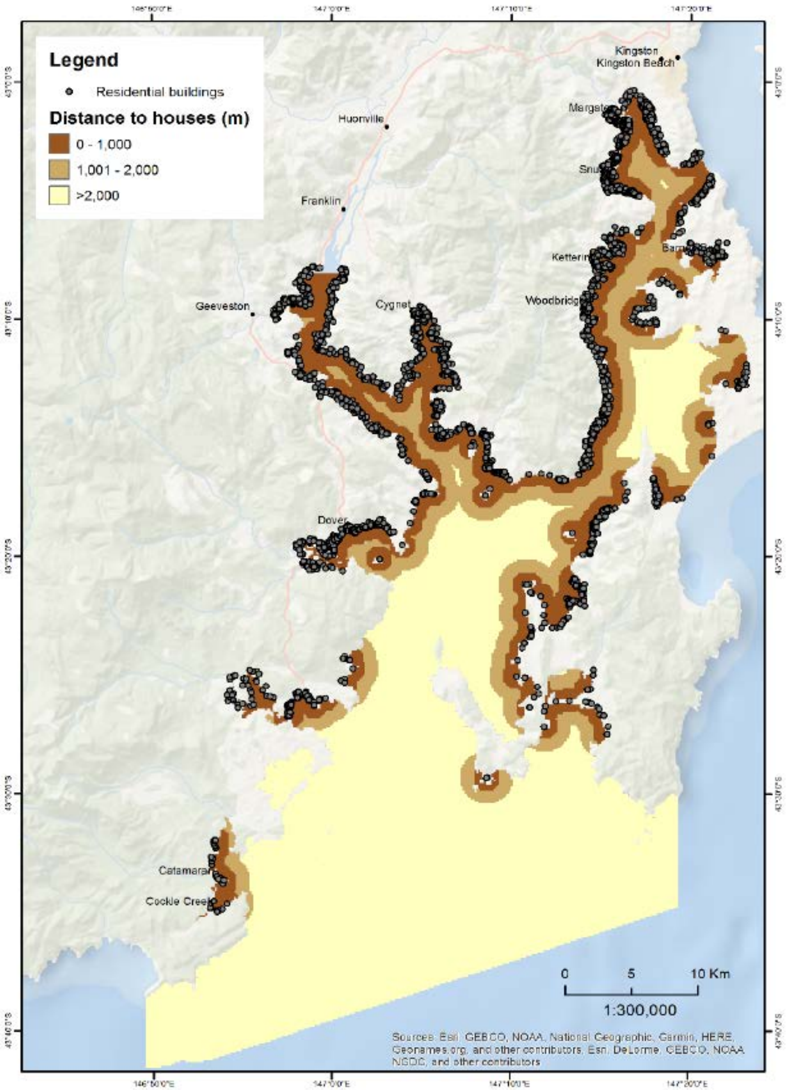
Human use values

The Foreshore project undertaken by Aquenal (Migus, 2008) assigned values to 100m segments of the coast around the south-east of Tasmania based on existing datasets, expert consultation, inferred data and aerial images to produce spatial data on the value, condition and pressures of the foreshore. Within this project, a layer called the 'human use value' layer was produced from information on the level of human use along the coast.

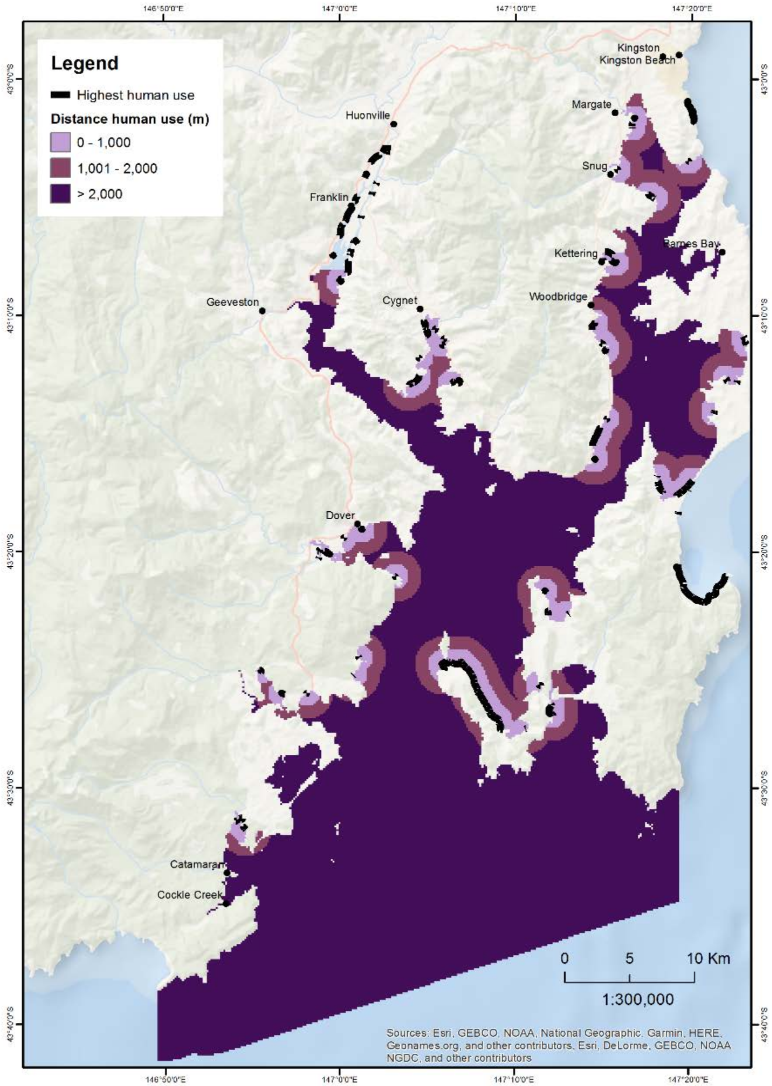
Data source: *The human use value layer can be viewed on LISTmap (https://maps.thelist.tas.gov.au/listmap/app/list/map) and is available for download on request from DPIPWE.*

Post processing: *Coastal segments of the highest human use value were extracted and Euclidean distance was calculated. To provide an understanding of the areas which are least likely to cause impact to highest human use value (from new developments), distance buffers around the highest human use segments were added to the layer at distances of 1km and 2km (see Map 24).*

Data limitations: *The human use value layer is not a measure of the aesthetic or qualitative values humans place on the foreshore but provides some indication of which areas are more frequently used than others (based on the on the frequency of use of amenities along the foreshore, recreational use, tourism value, land classification and European heritage values). No aboriginal values were included within this layer as requested by the Tasmanian Aboriginal community.*



Map 23: Distance to houses (residential buildings)



Map 24: Distance to foreshore highest human use value

3.1.3 Environment and conservation

Within any region, it is important to balance the economic and social needs with the need to manage and conserve healthy supportive environments. Environment and conservation values can be associated with designated or non-designated areas which are considered to have high conservation value due to their environmental attributes.

Designated conservation areas

Within the pilot study region, a number of areas have been identified for protection through the designation of conservation areas, nature reserves and exclusion zones. The environmental conservation values and aims of designated areas have the potential to be jeopardised by changes to the balance of an ecosystem. As such it is important to consider the reasons for a designation and how it may be affected by proposed developments. The ways in which these will interact will vary depending on the characteristics of both.

Data from multiple sources was used to compile information on the location of the different designated sites within the pilot study area (see Map 25 and Map 26).

Data sources:

1. ***Marine protected areas***

Data on the location of marine protected areas which meet the IUCN (1994) definition of protected areas ('an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means') is available from the Collaborative Australian Protected Areas Database (CAPAD) 2016 (http://www.environment.gov.au/fed/). These include marine nature reserves and marine conservation areas (see Map 25).

Post processing: *Non required*

Data limitations: *None identified*

2. ***Exclusion zones***

The location of the NW Bay exclusion zone (an area where no marine farming/transport vessels are allowed) is available from DPIPWE on request (see Map 25).

Post processing: Data was digitised, and a spatial layer was created.

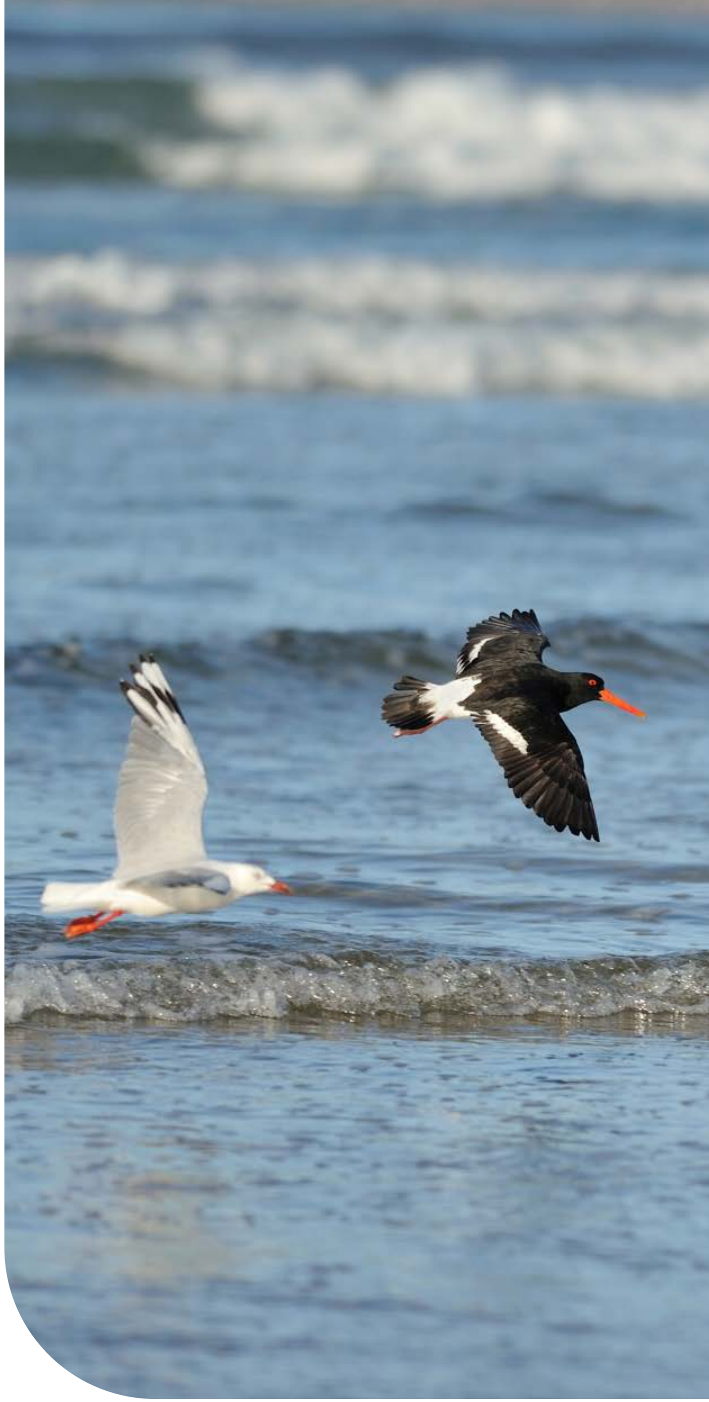
Data limitations: None identified

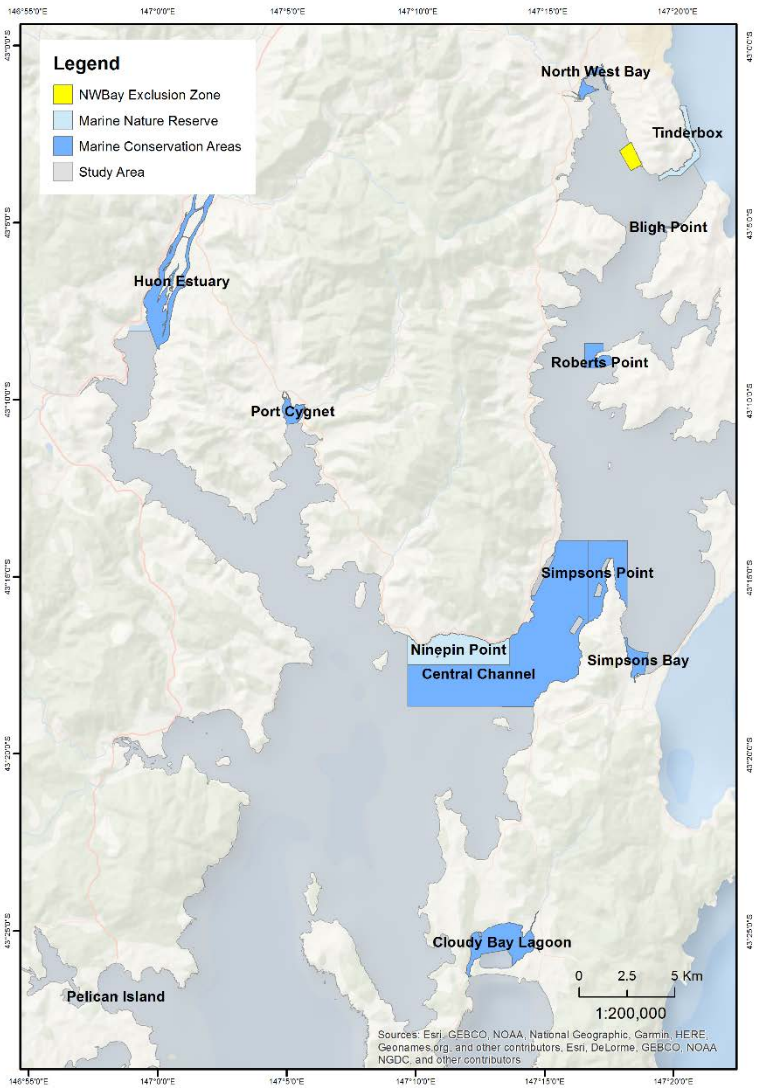
3. ***Geoconservation sites***

The location of geoconservation sites (geological, geomorphological and pedological sites, features, areas and systems of conservation, scientific or heritage significance) is available from LISTmap (https://maps.thelist.tas.gov.au/listmap/app/list/map) on request (see Map 26).

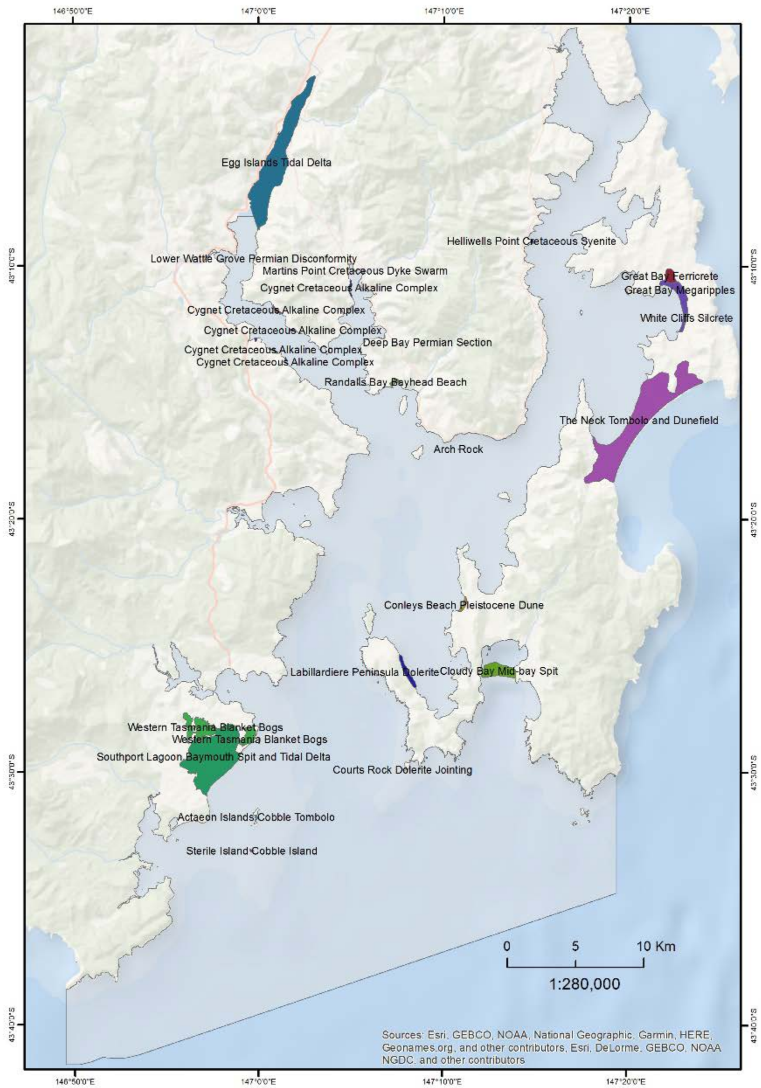
Post processing: None required

Data limitations: Highly sensitive sites are unavailable for public disclosure. A spatial search will identify the presence of highly sensitive sites however the user is required to contact the custodian to obtain further information.





Map 25: CAPAD Marine conservation areas and the NW Bay Exclusion Zone



Map 26: Geo-conservation sites

Other areas of high environmental and conservation value

While designated areas receive specific protections, other areas within the study area may also have high environmental and conservation value due their attributes (e.g. wilderness and presence of significant species or habitats) which also require consideration.

Data from multiple sources were used to provide information on the spatial variability of areas with high environmental and conservation value (see Map 27, Map 28 and Map 29).

Data sources:

1. Foreshore project

The Foreshore project undertaken by Aquenal (Migus 2008) assigned values to 100m segments of the coast around the south-east of Tasmania based on a number of existing datasets, expert consultation, inferred data and aerial images and produced seventeen data layers which can be viewed on LISTmap (https://maps.thelist.tas.gov.au/listmap/app/list/map) and are available for download on request from DPIPWE. Layer outputs from this project which have been used to provide information on the spatial distribution of areas with high environmental and conservation value include the foreshore biological value layer and the foreshore condition layer:

a. Foreshore biological value layer – this layer provides a representation of biological value based on the presence/absence of significant species (e.g. rare, threatened or endangered species), significant fauna habitat, areas directly adjacent to protected natural areas and introduced marine species or beach weeds.

b. Foreshore condition layer – this layer provides a representation of how close the environment is to a pristine state based on ecological disturbance (land clearing and condition of adjacent habitat, land classification, land zoning, presence of foreshore structures, pollution sources), geomorphological disturbance and the presence/absence of introduced species.

Post processing: *Segments of the coast with the highest biological value and highest condition were selected from each of the data layers and Euclidean distance was calculated (see Map 27 and Map 28).*

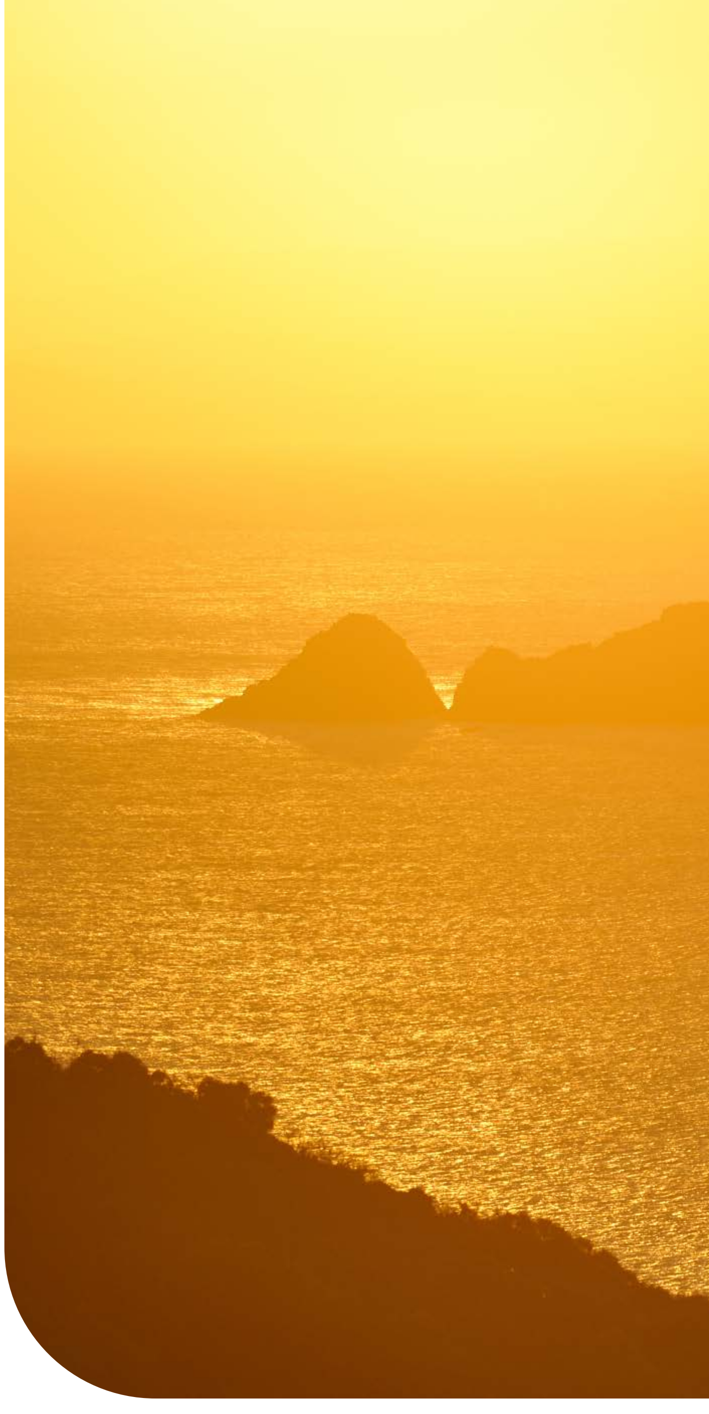
Data limitations: *Both biological value and condition have been determined from a composite of multiple data sources using arguments and criteria to define values. The arguments and criteria used will affect value characterisation. Data sources are from pre 2008 and information may be outdated.*

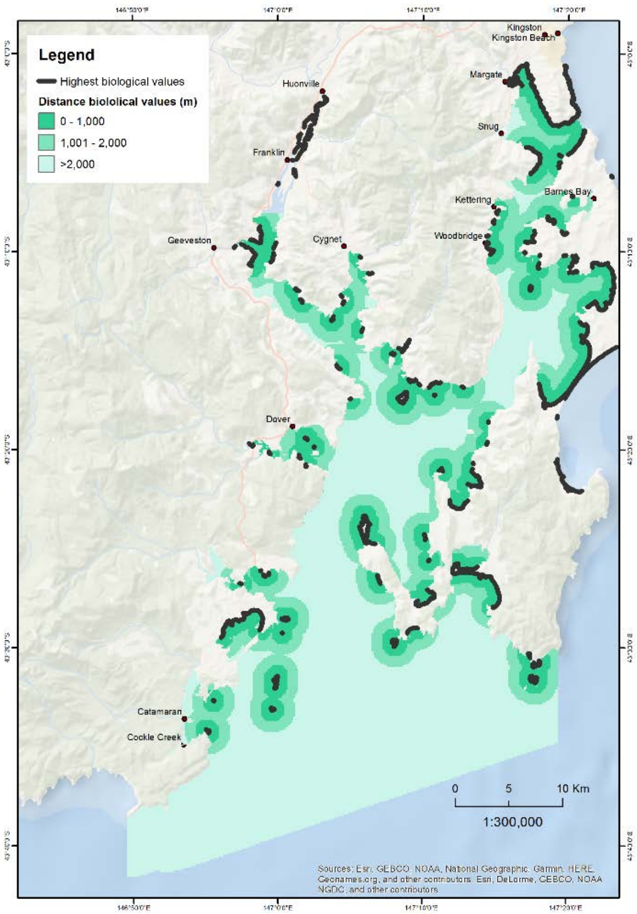
2. Wildlife observations

Additional information on important locations for protected and sensitive species and habitats is available from wildlife observations (e.g. spotted handfish, fur seal colonies and haulout areas, and raptor nests) on the Natural Values Atlas (https://www.naturalvaluesatlas.tas.gov.au/).

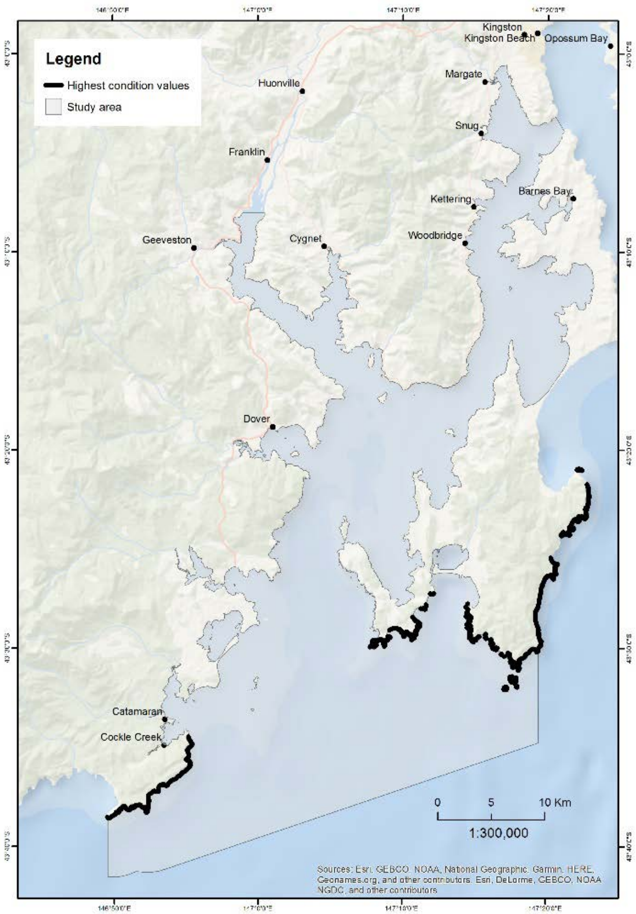
Post processing: *Data layers for spotted handfish, furseal colonies and haulout areas and raptor nests were merged to create one map (see Map 29).*

Data limitations: *Recorded observations are largely opportunistic sightings reported by interested parties. Records include sightings over time; older sightings may no longer be relevant.*

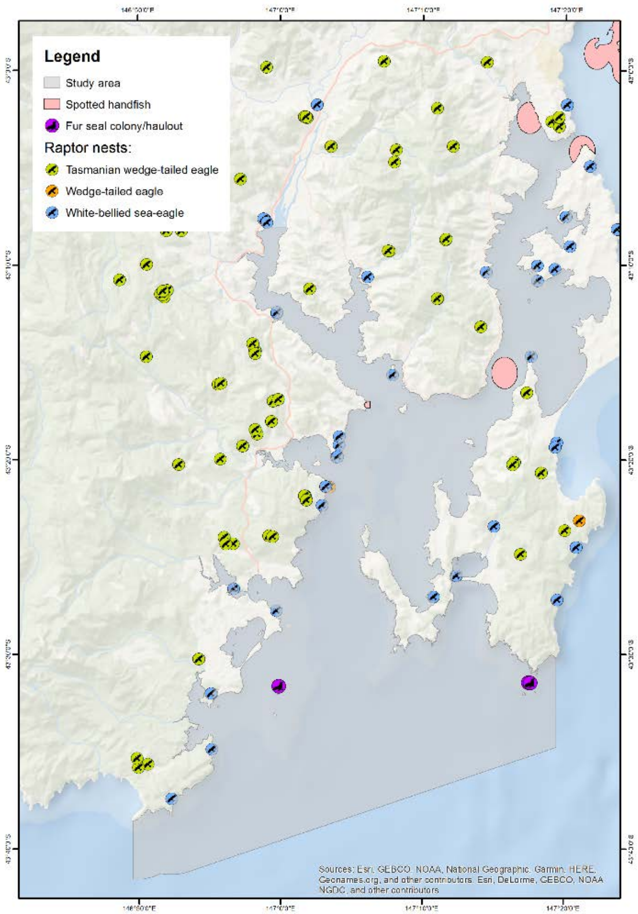




Map 27: Distance to coastal segments of highest biological values as determined by Migus (2008)



Map 28: Areas of highest foreshore condition as determined by Migus (2008)



Map 29: Wildlife observations recorded in the Natural Values Atlas

3.2. Marxan analysis

We explored a range of Marxan scenarios to demonstrate the changes in spatial solutions depending on constraints including: locking in existing leases or allowing for blank slate configurations, inclusion of potential biosecurity zones, and consideration of additional social values such as variable reef buffer sizes (0km, 2km, and 5km reef buffer scenarios for high value reefs and 0km and 1km reef buffers for other reefs). Marxan provides a range of good spatial solutions that meet the defined objectives for each zone. We present and discuss the best solution for each scenario – the Marxan run with the least cost.

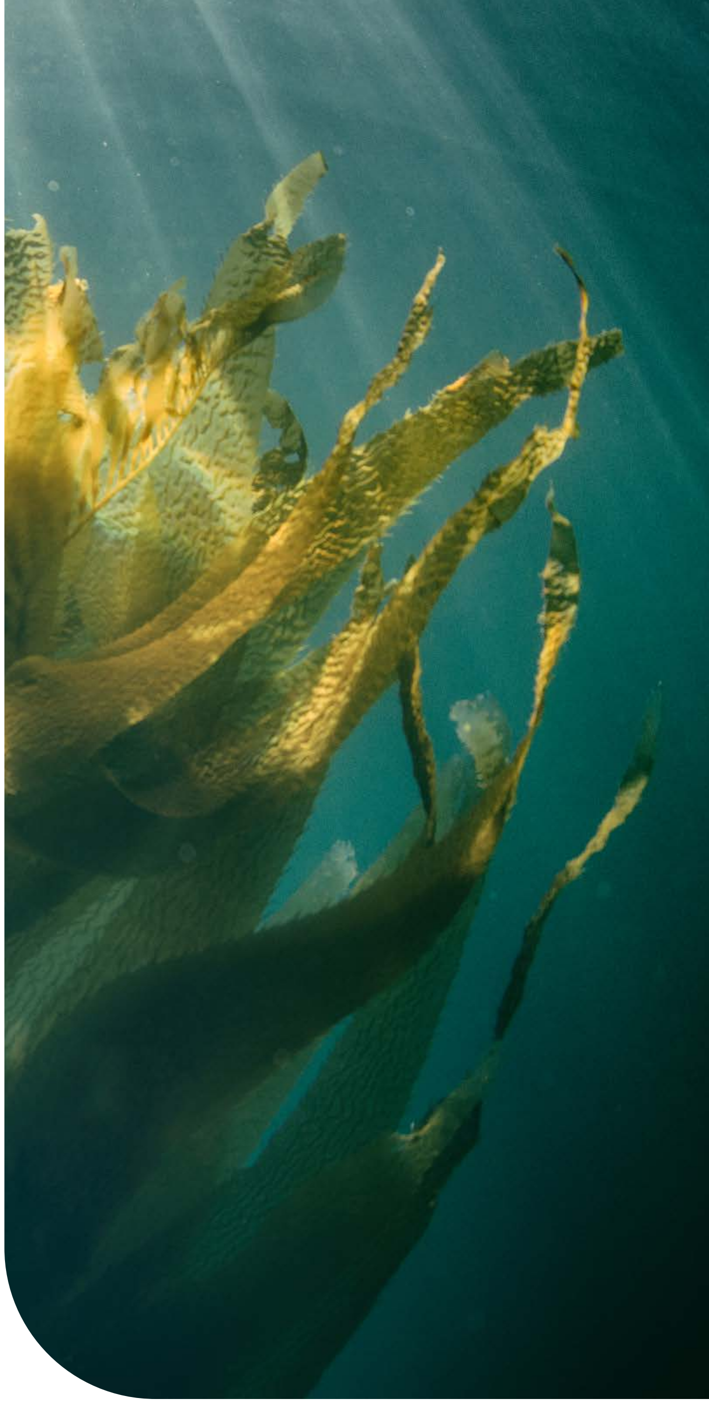
The spatial area allocated to commercial fishing, social values, environment and conservation values and other aquaculture are robust across scenarios with the main variation to these being the expansion of the social zone when a reef buffer is included in the targets. In contrast, the finfish aquaculture zone is sensitive to scenario assumptions. The baseline scenario (Scenario 1; Map 30) demonstrates the spatial allocation of marine values with no additional constraints. It has the largest area allocated to the finfish aquaculture zone. In contrast, a fully constrained scenario (Scenario 6; Map 35, including biosecurity constraints and a 1km reef buffer, in addition to a 5km high value reef buffer constraint) has the smallest area allocated to the finfish aquaculture.

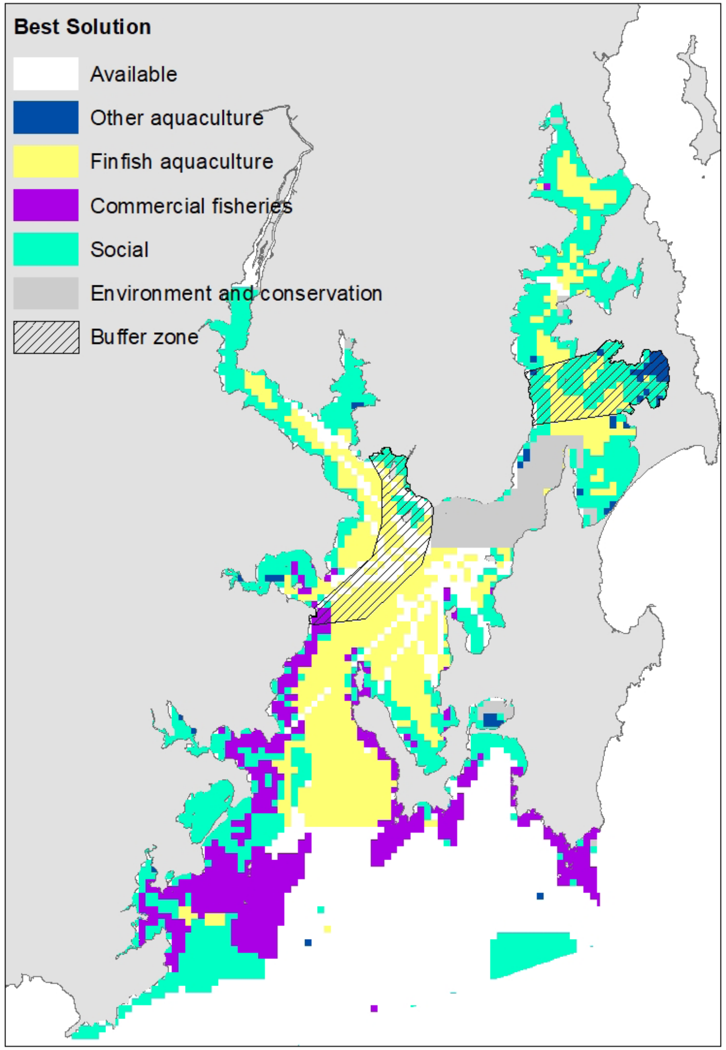
To examine what areas are robust or sensitive to different assumptions, we considered selection frequency of sites across scenarios (the number of scenarios out of which a particular planning unit is selected).

Across scenarios there are some regions that are consistently included in the finfish aquaculture zone, namely the upper and lower D'Entrecasteaux Channel (Map 41). Sites in the Huon estuary are selected less frequently in the blank slate scenarios (Map 43) compared to when they are locked in (baseline scenario; Map 44). Inclusion of biosecurity constraints predictably intensifies areas selected to the upper and lower channel and removes sites from the biosecurity 'separation' buffer area (Map 42).

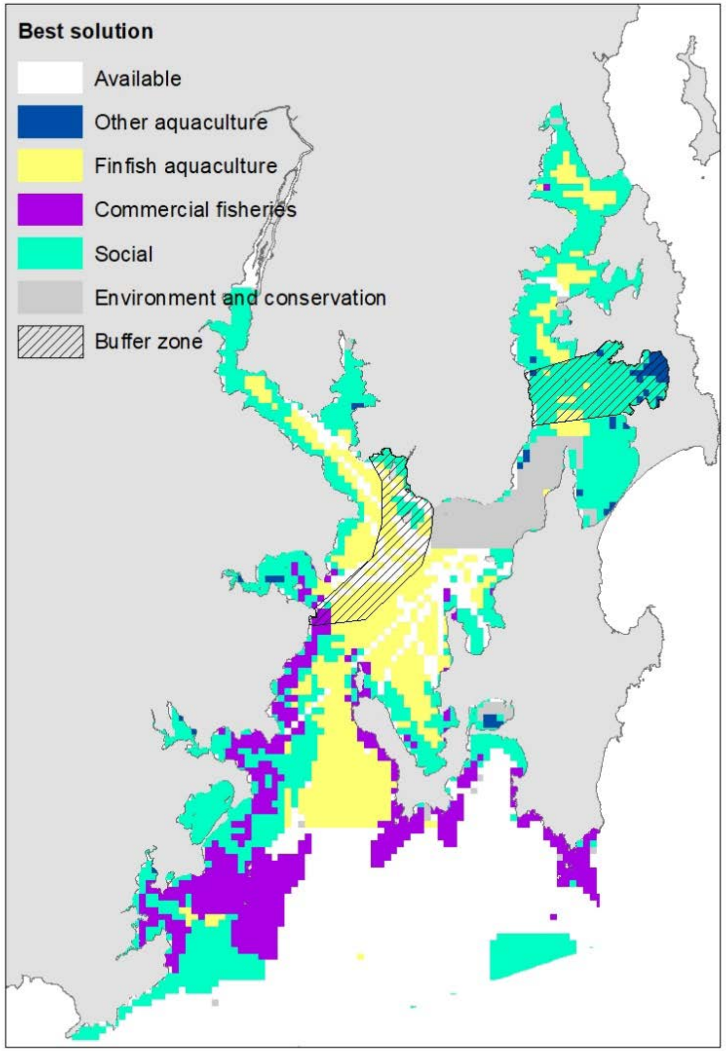
Including the reef buffers constrains areas selected, in particular in the 1km reef and 5km high value reef, scenarios. The area selected for finfish aquaculture off the southern end of Bruny just outside the D'Entrecasteaux Channel (west of the Labillardiere Peninsular) is only selected for no buffer and 1km reef, 2km high value reef scenarios (Map 41). This area is excluded from the finfish zone and instead allocated to the social zone in the 1km reef, 5km high value reef scenarios (e.g. Scenario 6-8; Map 35,Map 36, and Map 37).

The future technology scenarios open up high energy environments in the southwest of the study region for the baseline and 1km reef, 2km high value reef scenarios (Scenario 9 and 10; Map 38 and Map 39). However, with a 1km reef, 5km high value reef scenario these areas that are available in a future technology scenario are allocated to the social zone (Scenario 11; Map 40).

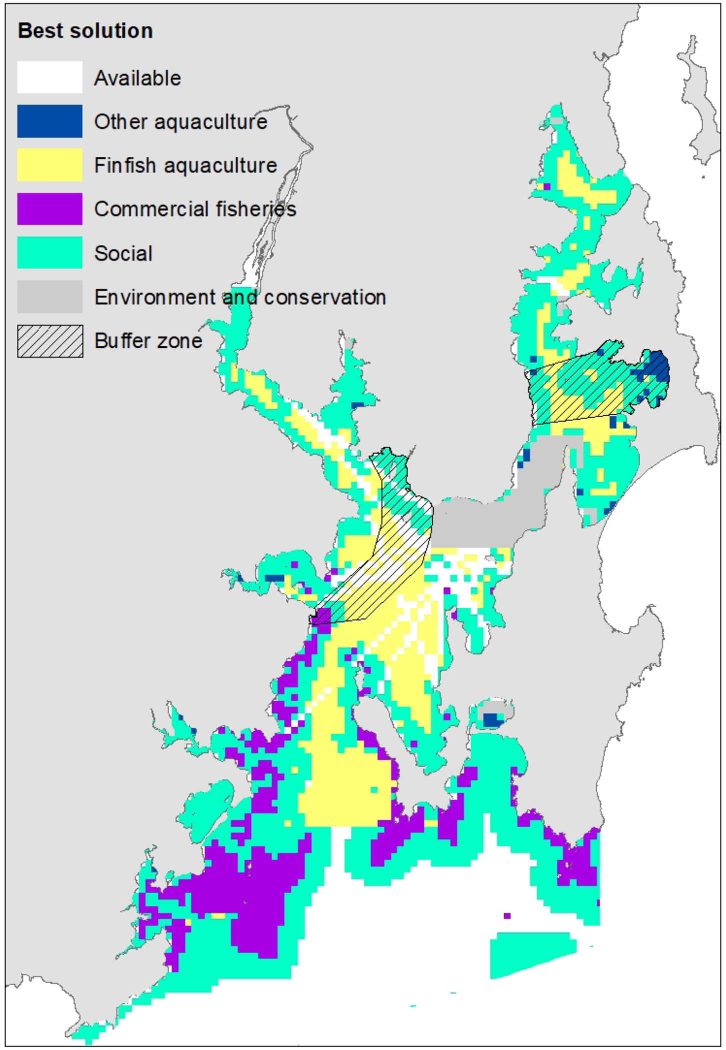




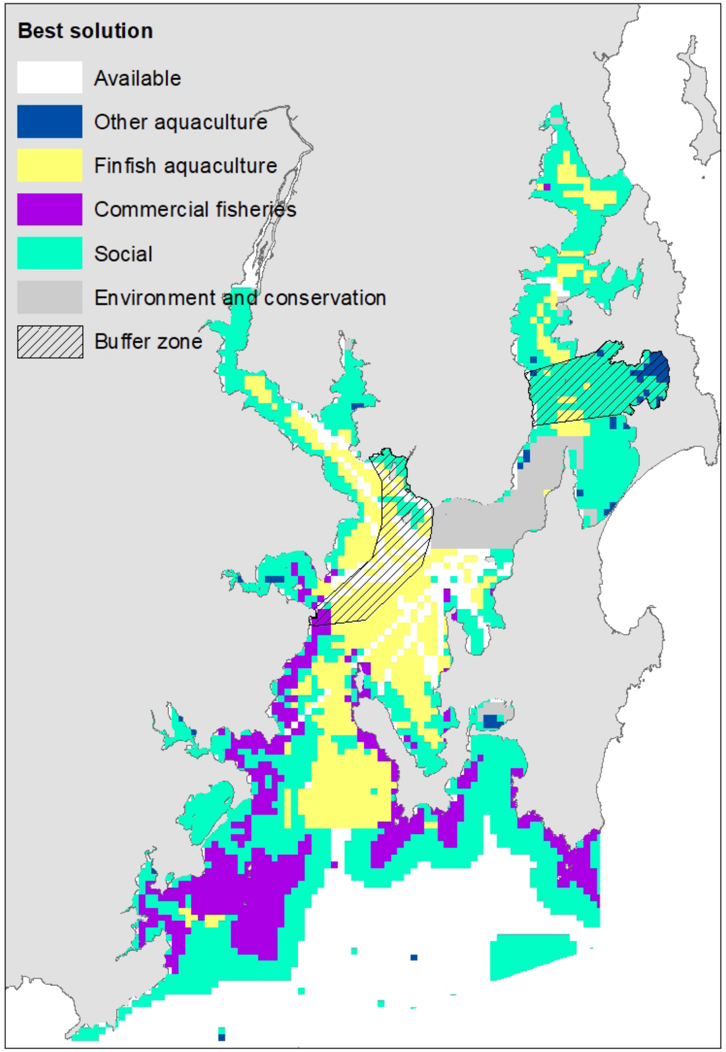
Map 30: Scenario 1 – baseline (this scenario reflects the basic goal of maximizing values across all zones while minimizing trade-offs. This scenario can be used as a default scenario from which to measure spatial changes for all other scenarios which consider a range of additional constraints or goals. A 1km buffer is applied to all reefs.)



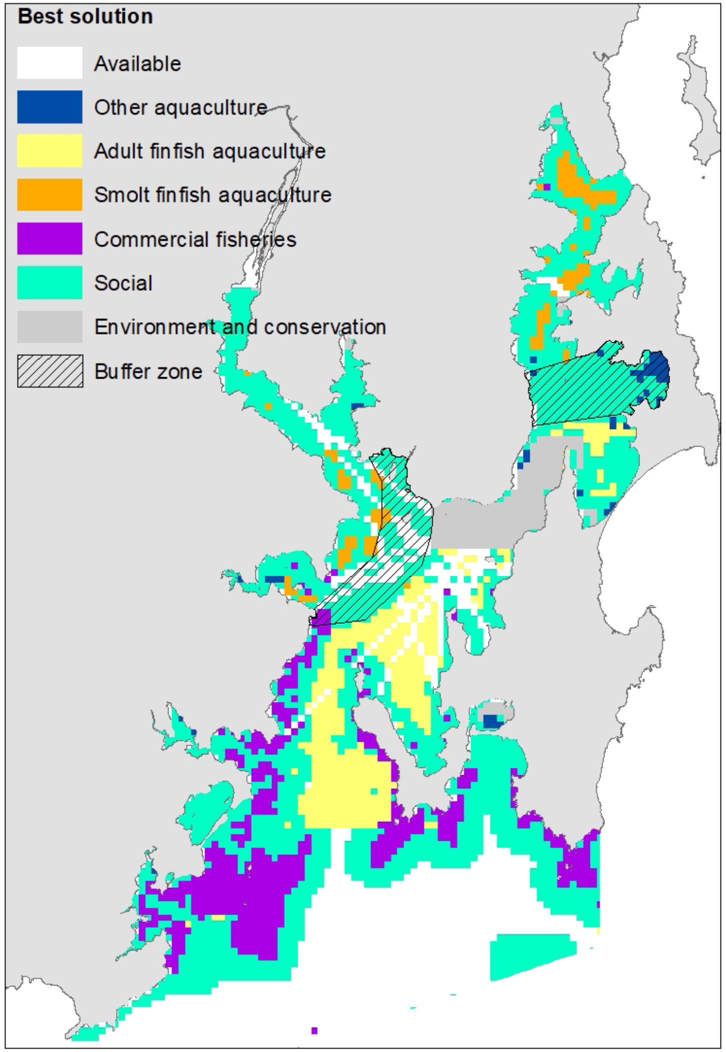
Map 31: Scenario 2 – Blank slate (this scenario deviates from Scenario 1 as the location of existing finfish leases are not considered (locked in) and instead, it explores the most suitable locations for finfish leases based on highest suitability for finfish farming together with the least conflicts with other marine use zones.)



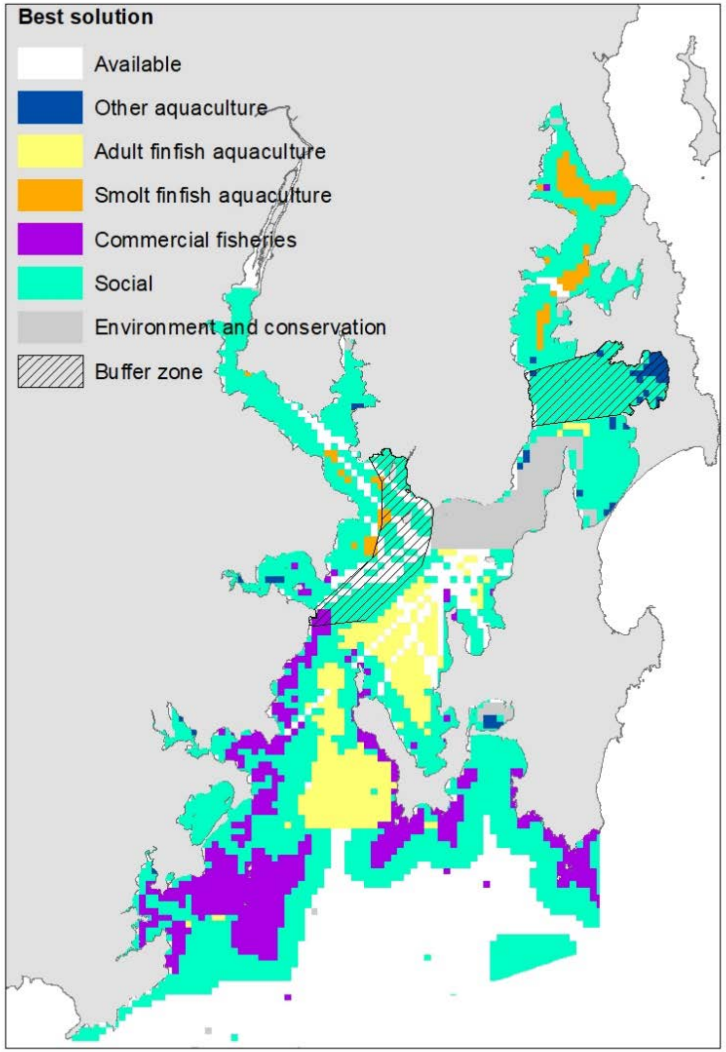
Map 32: Scenario 3 – Baseline + 2km reef buffer (in addition to Scenario 1 criteria, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 2km reef buffer to high value reefs).



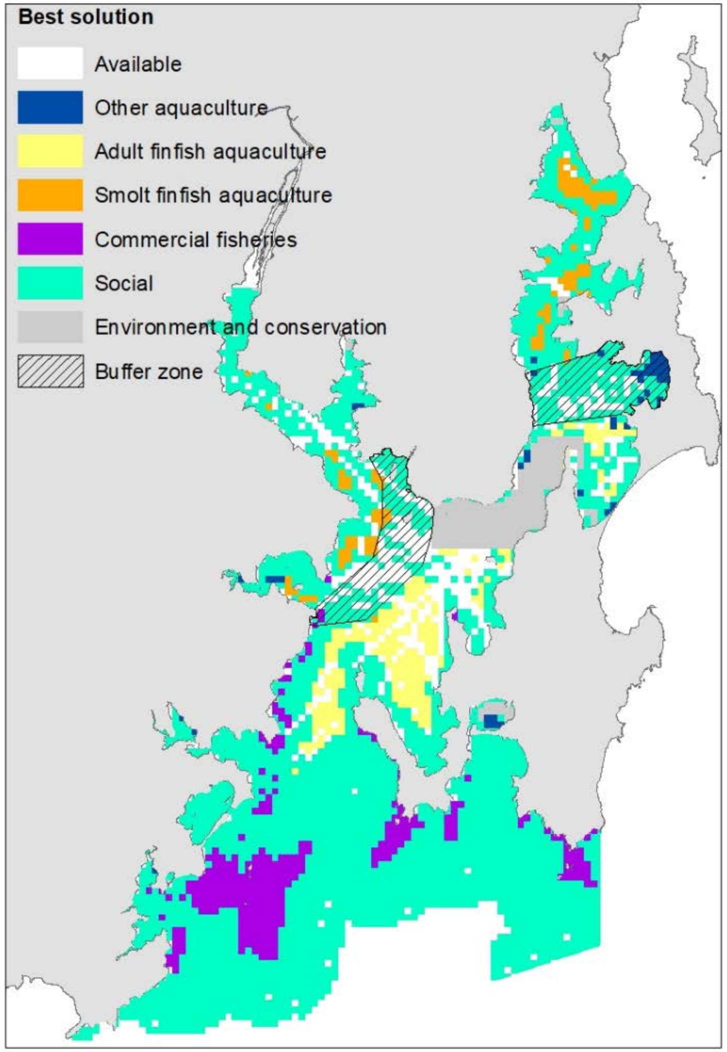
Map 33: Scenario 4 – Blank slate + 2km reef buffer (in addition to Scenario 2 criteria, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 2km reef buffer to high value reefs).



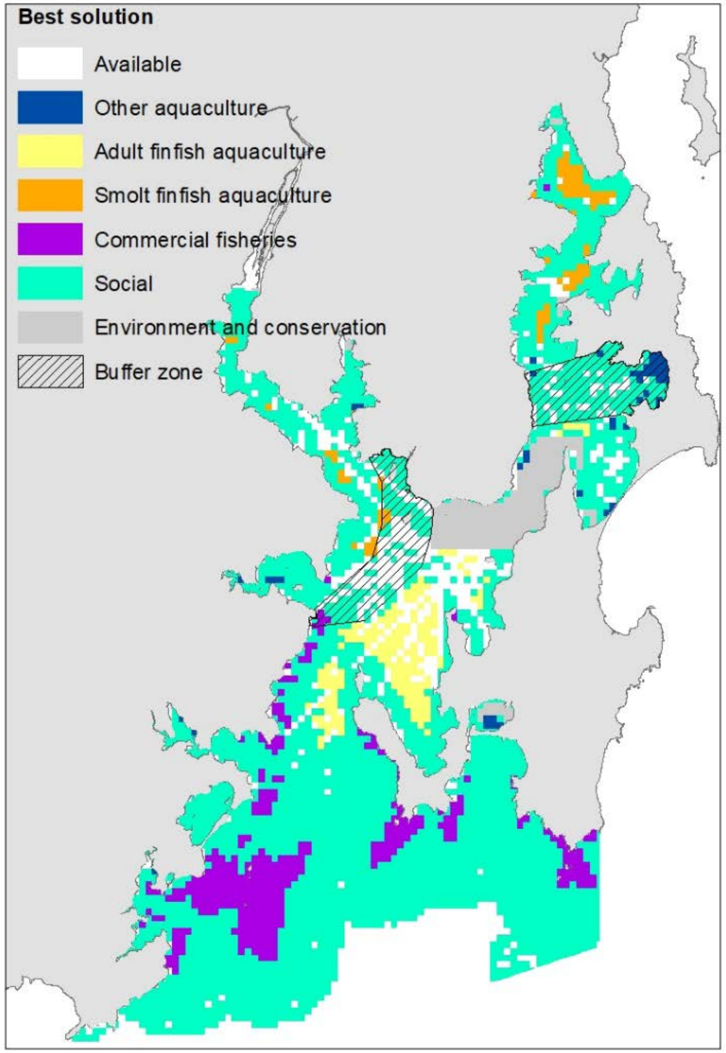
Map 34: Scenario 5 – Baseline + 2km reef buffer + biosecurity (in addition to Scenario 3 criteria, this scenario requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area).



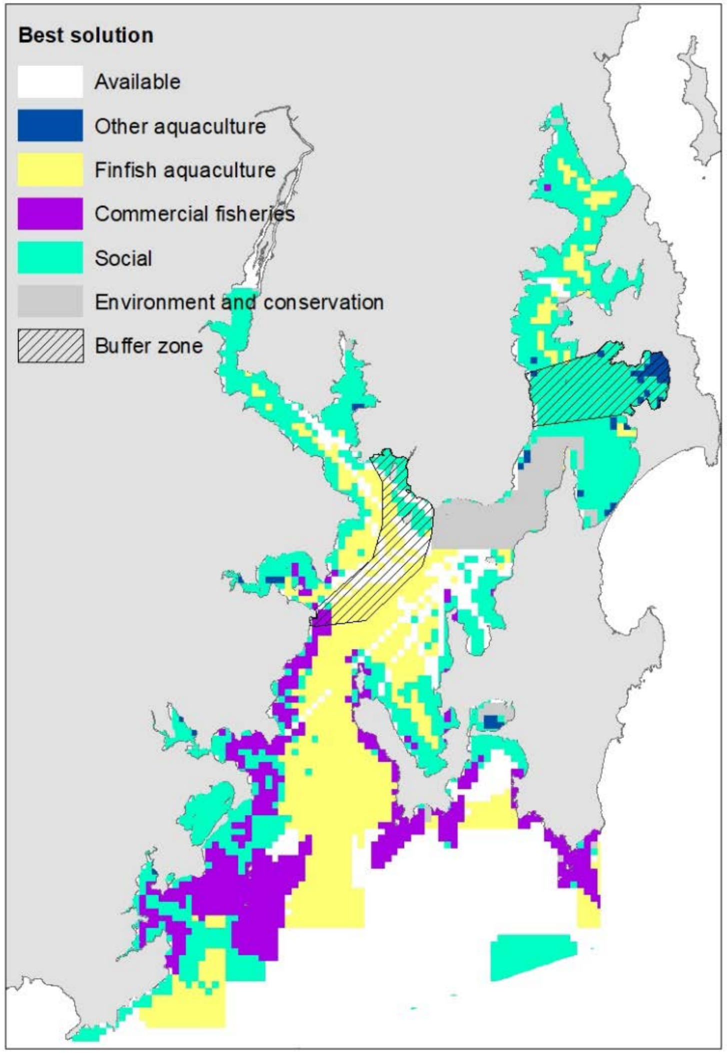
Map 35: Scenario 6 – Blank slate + 2km reef buffer + biosecurity (in addition to Scenario 4 criteria, this scenario requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area).



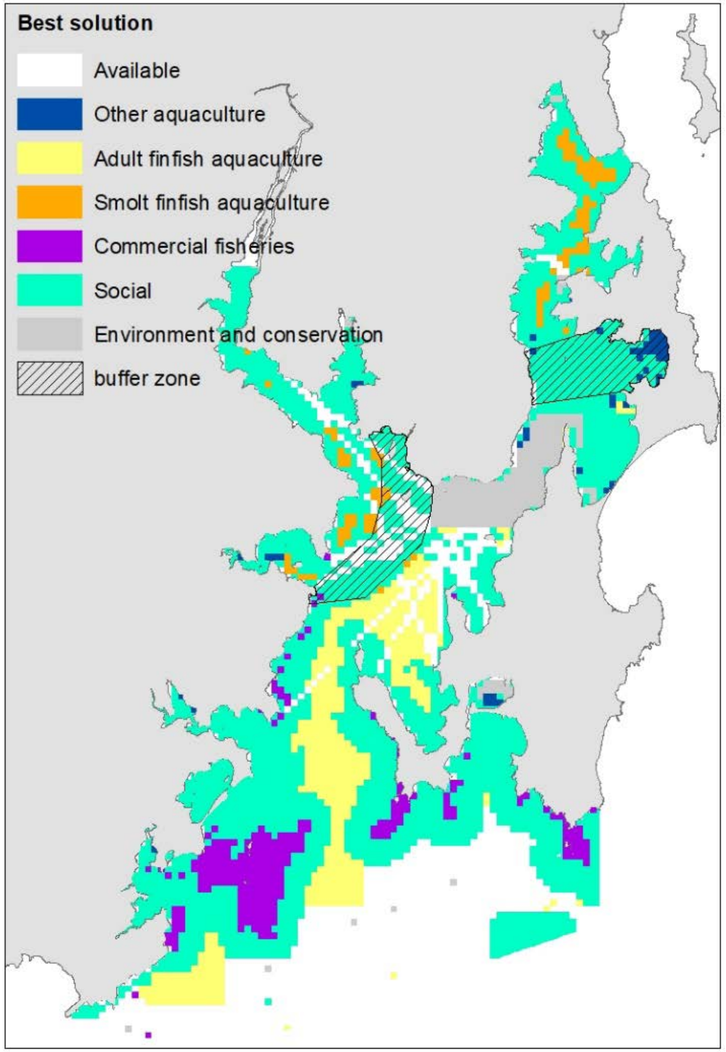
Map 36: Scenario 7 – Baseline + 5km reef buffer + biosecurity (in addition to Scenario 1 criteria, this scenario explores the additional constraint of protecting social-cultural and economic values associated with reefs by applying a 5km reef buffer to high value reefs and also and also requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area).



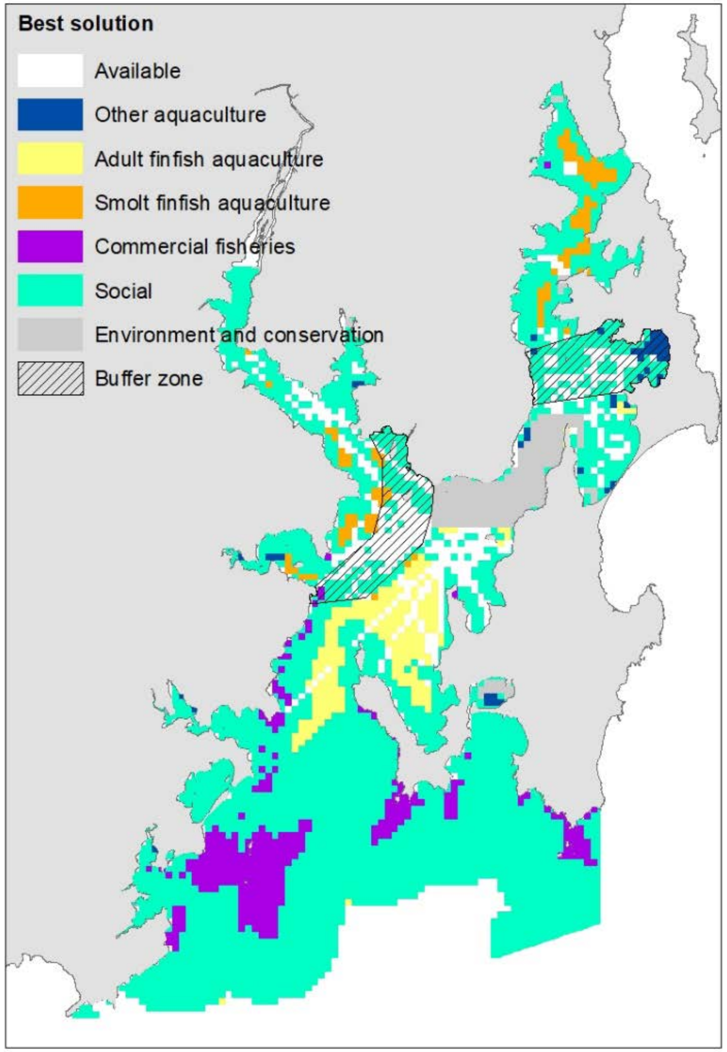
Map 37: Scenario 8 – Blank slate + 5km reef buffer + biosecurity (in addition to Scenario 2 criteria, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 5km reef buffer and also requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area).



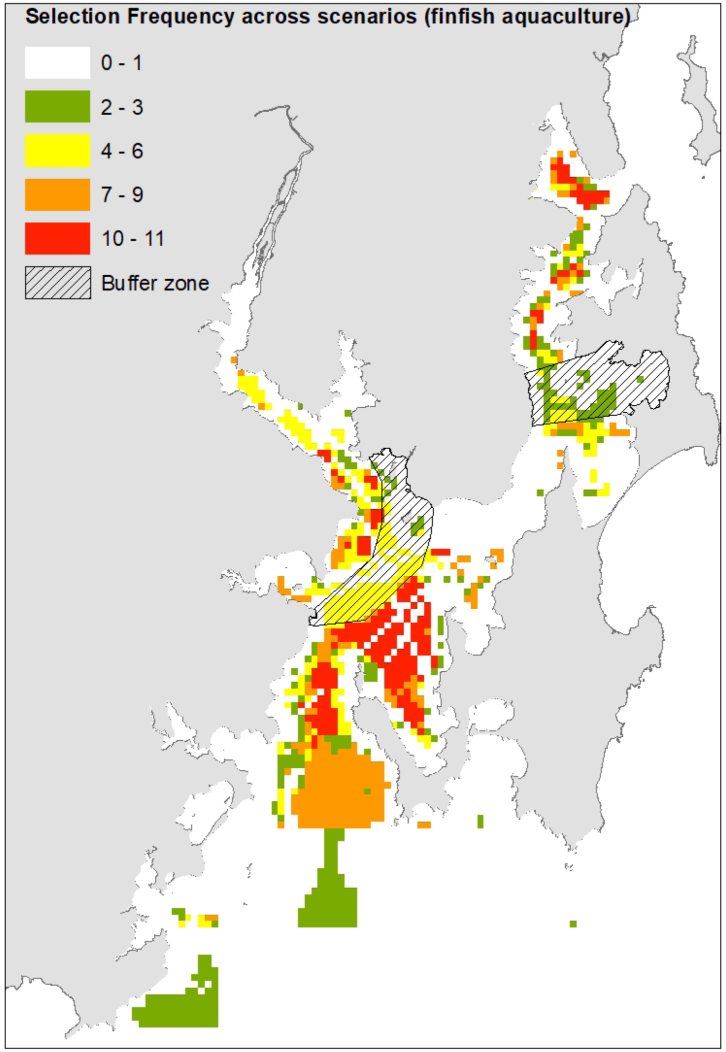
Map 38: Scenario 9 – Alternative technology (this scenario used the same targets and zones as Scenario 1, with the exception of the targets for finfish aquaculture, and the salmon suitability layer was adapted to reflect potential 'future' suitability (see section 3.1.1.2 – Salmon suitability layer), taking account of technological and operational advances which may support farming in higher energy environments in the future).



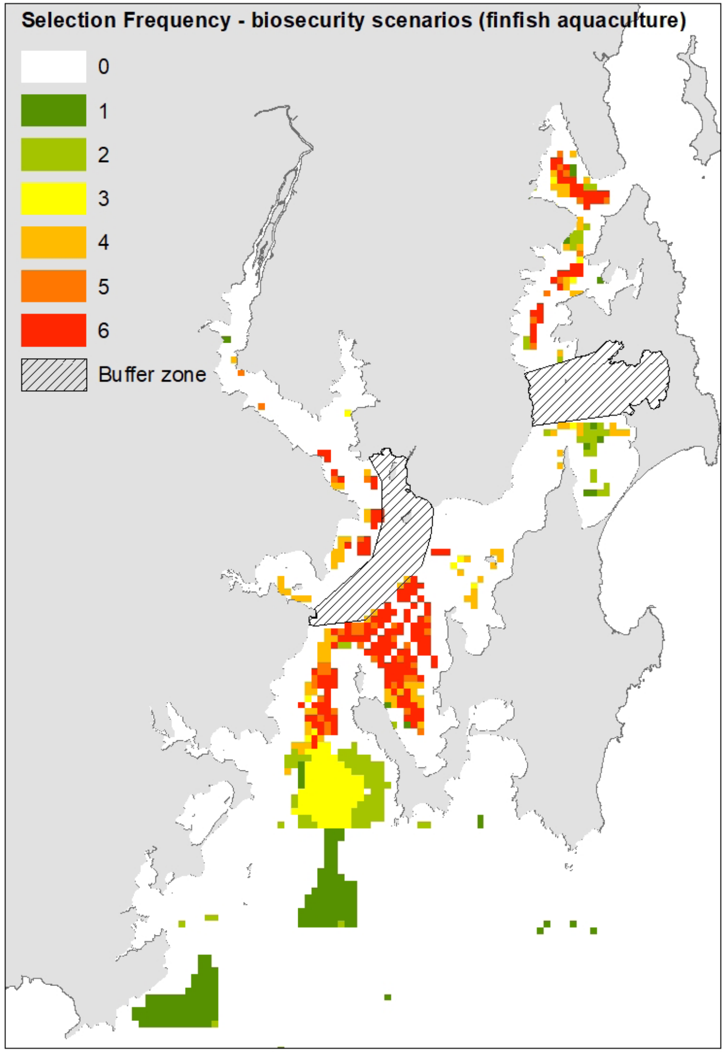
Map 39: Scenario 10 – Alternative technology + 2km reef buffer + biosecurity (in addition to Scenario 9, this scenario also explores the constrain of protecting social-cultural and economic values associated with reefs by applying a 2km reef buffer to high value reefs and also requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area).



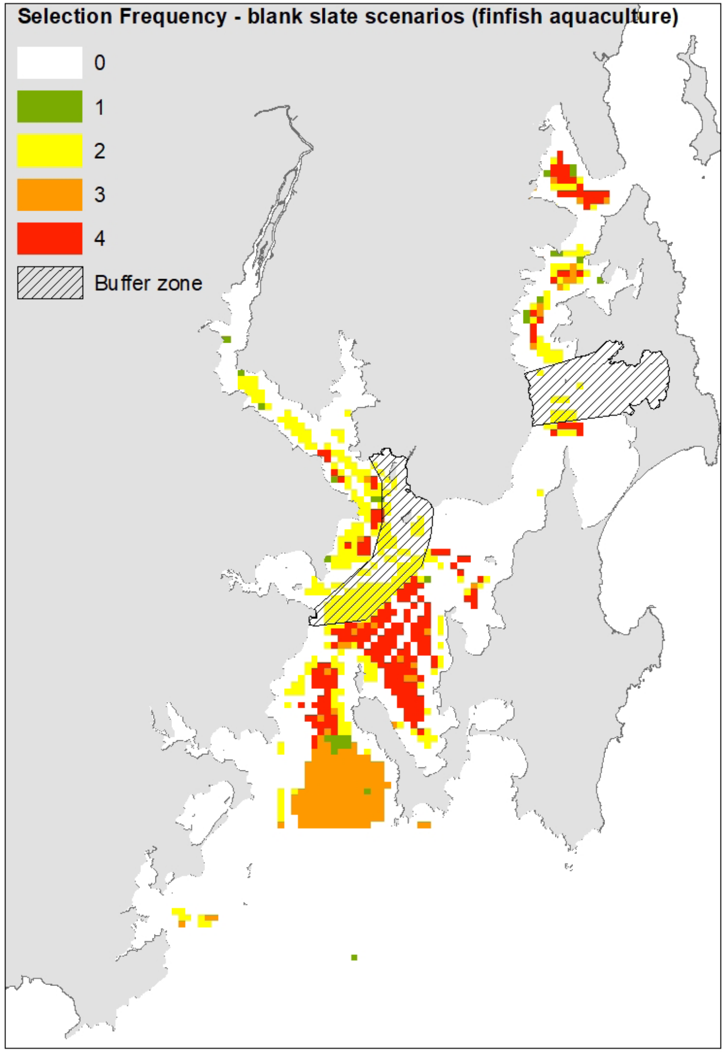
Map 40: Scenario 11 – Alternative technology + 5km reef buffer + biosecurity (in addition to Scenario 9, this scenario also explores the constraint of protecting social-cultural and economic values associated with reefs by applying a 5km reef buffer to high value reefs and also requires smolt finfish to be constrained to a defined smolt zone and adult finfish to be constrained to an adult grow zone separated by a biosecurity 'separation' buffer area).



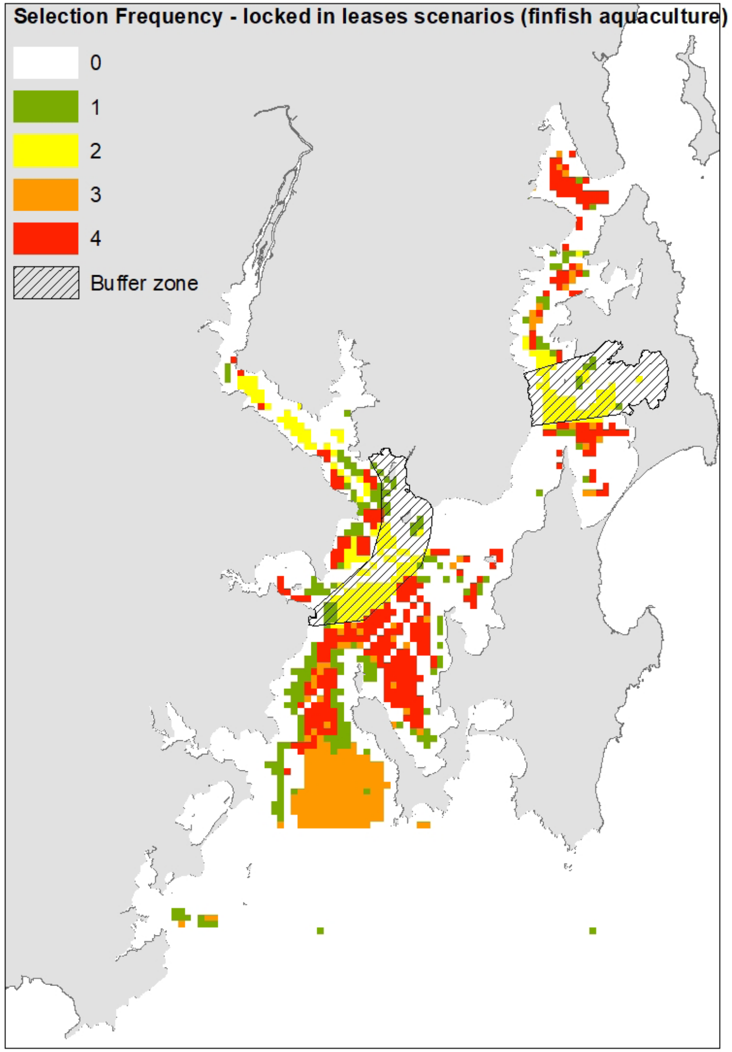
Map 41: Finfish aquaculture selection frequency across all scenarios



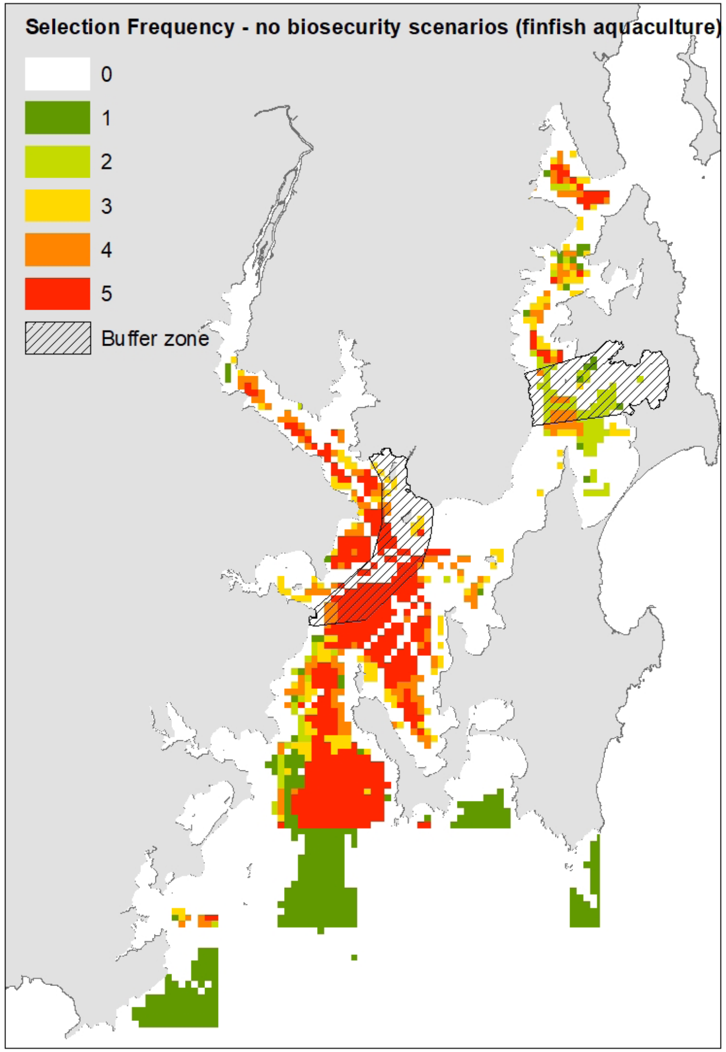
Map 42: Finfish aquaculture selection frequency for biosecurity scenarios



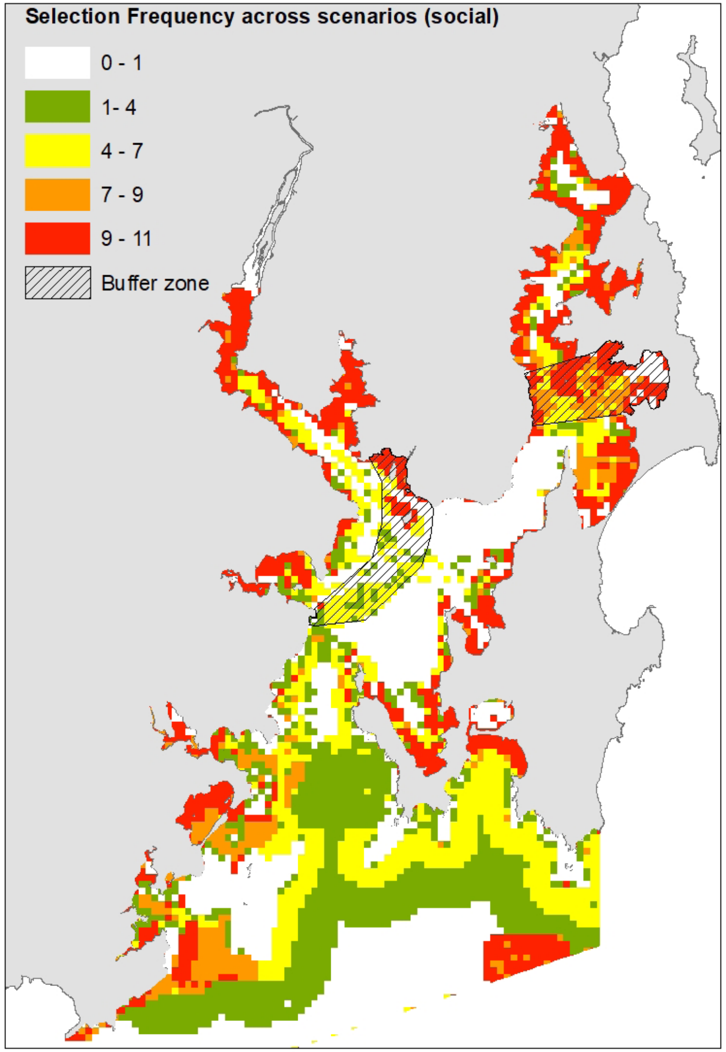
Map 43: Finfish aquaculture selection frequency for blank slate scenarios



Map 44: Finfish aquaculture selection frequency for baseline scenarios.



Map 45: Finfish aquaculture selection frequency for scenarios with no biosecurity



Map 46: Social use zone selection frequency for all scenarios

4

Discussion

The first part of this pilot project involved identifying the marine users and values within the study region that require consideration prior to implementing new developments. These users can be classified broadly as economic, social, or environment and conservation with each user group valuing different aspects of the environment for different reasons. As such, there are some marine uses which may have competing needs and from a planning perspective it is advantageous to seek spatial zonings of the marine environment that meet each user's needs while spatially separating uses. In other instances, multiple marine users can inhabit the same space with values that are synergistic and spatially overlapping. Thus, identifying users and their values also required mapping which uses shared values, and which had potentially conflicting or competing values.

The second part of the project was focused on identifying available data which can inform understanding of the existing spatial distribution of marine uses in addition to any planned developments (e.g. expansion/redistribution of the finfish industry within the pilot study region). The results of the pilot project highlighted the large availability of data within the study region which can be accessed from a variety of sources. A large proportion of these are publicly available, with some available on request subject to privacy and public reporting limitations.

Choices around data inclusion were necessary throughout the project and are important considerations as they affect the interpretation of mapping outputs. Data identified was collected in a variety of ways (from modelled time series data (e.g. water temperature) to one off snap shots of the environment (e.g. substrate type) while in other instances it may be the compilation of opportunistic sightings (e.g. natural values atlas wildlife sightings). For time series datasets (e.g. wave height), choices around the time range and metrics selected can also have significant impacts on the data mapped and interpretation.

Additional data sets which were not mapped within this pilot project, but which may offer potential insight for the purposes of the project could include dissolved oxygen, wind velocity, hydrodynamics, biochemistry, the location of underwater infrastructure (e.g. cables) and measures of tourism such as metrics around the frequency of geolocated pictures (e.g., tourism hotspots derived from sources such as Instagram).

Where desired data sets were not available but there were reasonable surrogate measures for the values in question, we used the relevant surrogate data sets. For example, viewsheds from coastal homes is the relevant dataset for understanding the visibility and likely sound impacts of aquaculture. However, viewshed data is not currently available. Therefore, a 1km buffer from mapped domiciles was used as a surrogate measure. Similarly, where information on areas of relative importance were not available for particular users, but measures of suitability were possible to construct, we created these suitability layers as a measure of relative spatial importance. This was done for recreational use as well as finfish aquaculture. Decisions around surrogate measures or suitability proxies for relative importance will ultimately affect the spatial solutions for each user zone in Marxan, but they reflect commonly made assumptions in similar decision making situations and match the best available data for each use to avoid making decisions in the absence of information.

To identify areas which may be suitable for the expansion of the finfish industry, a static 'salmon suitability layer' was developed incorporating key operational requirements for the industry. This layer does not evaluate the interdependence of each planning unit suitability relative to whether the neighbouring planning units are farmed or not. Thus, while environmental variables were considered in relation to the ability for the farm to operate (including regulatory restrictions), the carrying capacity of the environment to assimilate farm outputs was not assessed. Furthermore, no connectivity measures were used to assess the overall carrying capacity of the pilot region for additional finfish aquaculture.

While a given location may be identified as highly suitable within the suitability layer, in practice farming there may cause an unacceptable environmental response (e.g. algal blooms within nearby sheltered bays) and as such the area may be unviable. Therefore, while areas of higher and lower suitability have been identified, any location will still need to be assessed on its own merit and its capacity to accommodate new developments from an environmental perspective, in particular taking into account hydrodynamics, connectivity and the carrying capacity of regions to support multiple farms. In light of this limitation, the biosecurity separation scenarios are based on hypothetical separation between areas to enable the assessment of Marxan as a decision support tool. The hypothetical separation does not consider hydrological or operational connectivity.

Compiling and mapping data is a critical step in gaining insight into the likely spatial distribution of marine use and values within the study region. However, even in this relatively data rich region, a number of constraints have been identified. While best efforts were made to use up-to date and relevant information, some information used within this pilot project was compiled before 2008 (e.g. foreshore value data layers; Migus 2008)) and for some marine uses it is difficult to accurately map the spatial extent of marine use and values (e.g. lifestyle, cultural and heritage values and navigation). While measures of value and spatial extent of these marine uses are hard to define, efforts to incorporate surrogate data to inform understanding on these has been made. In addition, for several data layers (e.g. scalefish fisheries), the data resolution is coarse. Based on these constraints, it is worth noting that planning processes using such data are best interpreted as producing coarse filter recommendations – i.e. identifying areas for further investigation and fine grain analysis with relevant local high-quality data (sometimes acquired specific to the area of interest). Thus, any areas identified as areas of interest for a particular use in this process would be subjected to further analysis and possible acquisition of data and assessment (e.g. environmental impact assessment and community engagement).

The third element of this project was the integration of the relevant users and associated data into a spatial decision support tool - Marxan (with Zones) - to identify near optimal spatial zonings that meet targets for all users while minimising costs to each user. The scenarios we explored with Marxan focused on possible expansion and/or relocation of finfish aquaculture while meeting other user values and minimizing impacts to other marine users. Eleven Marxan scenarios were used to illustrate different priorities, producing output maps which highlight the alternative solutions for identifying new space for finfish aquaculture industry expansion within the pilot region based on different planning assumptions and constraints (e.g. whether existing leases are retained or moved to new locations (baseline vs. blank slate approaches) and whether reef buffers are targeted in the social zone). Different scenarios identified slightly varying locations for most suitable finfish expansion, however through exploring selection frequency it was possible to identify a number of key locations which are important across all scenarios (Map 41). While outputs are helpful in informing explicit and transparent decision making around potential future locations, it is important to understand that Marxan outputs are only as good as the data that is used to build them.

Assumptions around the use of data in Marxan as well as what values to target is an integral component of building Marxan scenarios and emphasizes that Marxan is a decision support tool not a decision maker. The process by which users are identified, data is collated, goals are set, and scenarios are built is as important, or more so, than the decision support tool which is then used to identify possible spatial solutions. Investing in appropriate planning processes is thus critical for successful integration of any decision support tool in the decision making process.

For example, while our scenarios are focused on identifying areas for future expansion of the finfish industry (as per Steering Committee guidance), other marine uses are considered to be static (e.g. commercial fishing and social uses and values) as no metrics for growth are available. Thus, our scenarios are inherently built to inform future changes in one user group while minimizing impacts to others but do not support decision processes that would address dynamic changes in other user groups. While Marxan could be used to answer these questions, its success would rely on building the relevant data sets and goals and integrating stakeholders to support these processes.

While a large number of data layers were used within Marxan, some could not be included (e.g. non-reef scale fish for which spatial distribution could not be defined due to data resolution). While these layers could not be used to produce Marxan outputs, the data layers can be used to overlay on Marxan maps and thus can be considered together by developers and decision makers to identify potential trade-offs and conflicts during a decision-making process. For example, while the non-reef scale fish data could not be mapped at a resolution relevant for inclusion in Marxan, it could be overlaid with Marxan outputs to identify whether there is likely to be possible overlap in commercial fishing and future finfish farms to then guide relevant stakeholder engagement and negotiations with user groups relevant to the decision making process.

The application of these software approaches (ArcGIS and Marxan with Zones) to the pilot study region has highlighted their potential in optimising the value of existing data in supporting sustainable decision making. Their use together can help to visualise the spatially complex coastal land and sea uses, their interactions and potential conflicts. It is important however, to interpret results within the context of associated assumptions and limitations of the tools and data sources.

While spatial mapping and optimisation can support good decision making, these should be used to focus resources in undertaking environmental impact assessment and community engagement and should not be considered as a replacement for these within the planning process. Furthermore, their use relies on relevant data being available. As our pilot project demonstrates, even in data rich regions of Tasmania there are still data gaps or data quality issues. Thus, Marxan may not always be the most appropriate decision support tool. Instead, simply visualizing available data through a GIS system alongside participatory decision making with relevant user groups might be a viable alternative in regions with less data availability. The process within which a decision support tool is embedded should reflect the relevant decisions being made and the planning context.

Conclusion

Conclusions from this pilot project are:

- That there is a wide variety of data and information available that can be used to support good decision making within the context of marine planning in the pilot study region.
- That spatial mapping tools (e.g. ArcGIS) can be used to illustrate spatial data, making it more accessible and relevant to decision makers.
- That decision support tools (e.g. Marxan with Zones) can provide an effective method of rationalising multiple data layers by using these to create optimisation maps of marine use zones which meet defined planning objectives.

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Appendices

APPENDIX A: Initial assessment of available information

Table A1: A summary of the LISTMap data layers of interest for south and west of Bruny Island.

LISTMap Data Layer Title	Online Category	Online Contact for data	Mapped in report
Public land classification	Reserves and administrative boundaries (Reserves)	Information & Land Services, DPIPWE	No
World Heritage Area	Reserves and Administrative Boundaries (Reserves)	Commonwealth of Australia, Department of Environment and Energy	No
RAMSAR wetlands	Reserves and Administrative boundaries (Reserves)	Information & Land Services, DPIPWE	No
Aboriginal Land	Land Parcel and Property (Cadastre)	Land Tasmania	Yes
Land Tenure	Land Parcel and Property (Cadastre)	Client Services, Land Tasmania	No
Authority Land	Land Parcel and Property (Cadastre)	Client Services, Land Tasmania	No
Crown Leases	Land Parcel and Property (Cadastre)	Client Services, Land Tasmania	Yes
Crown Licences	Land Parcel and Property (Cadastre)	Client Services, Land Tasmania	Yes
Tracks/Ferry Routes	Infrastructure & Utilities (Transportation)	Information & Land Services, DPIPWE	Yes
Building Footprints	Infrastructure and Utilities (Structures)	Client Services Land Tasmania	Yes
Building Points	Infrastructure and Utilities (Structures)	Client Services Land Tasmania	Yes
Boat Ramps	Infrastructure and Utilities (Structures)	Marine and Safety Tasmania	Yes
MAST Mooring Points	Infrastructure and Utilities (Structures)	Marine and Safety Tasmania	Yes
MAST Navigation Aids	Infrastructure and Utilities (Structures)	Marine and Safety Tasmania	No
TasWater: Sewer Main, Sewer Network Structures and Sewer Pressurised Main	Infrastructure and Utilities (Water and Sewer)	TasWater	No

LISTMap Data Layer Title	Online Category	Online Contact for data	Mapped in report
Geo-conservation sites	Geology and Soils (Geoscientific Information)	Resource Management & conservation (NRM)	Yes
Foreshore recreation – Tourism value NRM south	Coasts, Oceans and Estuaries (Coastal vulnerability)	Dep. Environment, Parks, Heritage & the Arts	No
Foreshore biological value	Coasts, Oceans and Estuaries (Coastal vulnerability)	Dep. Environment, Parks, Heritage & the Arts	Yes
Foreshore condition NRM south	Coasts, Oceans and Estuaries (Coastal vulnerability)	Dep. Environment, Parks, Heritage & the Arts	Yes
Foreshore human use NRM south	Coasts, Oceans and Estuaries (Coastal vulnerability)	Dep. Environment, Parks, Heritage & the Arts	Yes
Foreshore pollution pressure NRM south	Coasts, Oceans and Estuaries (Coastal vulnerability)	Dep. Environment, Parks, Heritage & the Arts	No
Ecological Disturb. And Foreshore Cond. NRM South	Coasts, Oceans and Estuaries (Coastal vulnerability)	Dep. Environment, Parks, Heritage & the Arts	No
Foreshore European heritage value NRM south	Coasts, Oceans and Estuaries (Coastal vulnerability)	Dep. Environment, Parks, Heritage & the Arts	No
Coastal Vulnerability	Coasts, Oceans and Estuaries (Coastal vulnerability)	Strategic Policy & Planning Division, project manager, climate change	No
Macrocystis surveys	Coasts, Oceans and Estuaries (Oceans)	SeaCare Tasmania, UTAS	No
Seagrass beds	Coasts, Oceans and Estuaries (Oceans)	Dep. Environment, Parks, Heritage & the Arts	No
Submerged Reef	Coasts, Oceans and Estuaries (Oceans)	Information & Land Services, DPIPWE	No
Marine habitat mapping /Seamap Australia	Coasts, Oceans and Estuaries (Coasts)	Seamap Australia website: https://seamapaustralia.org	Yes
Marine Leases	Primary Industries (Aquaculture)	Client Services, Land Tasmania	Yes
Marine Farming Licences	Primary Industries (Aquaculture)	Marine Farming Branch, DPIPWE	Yes
Marine farm zones	Primary Industries (Aquaculture)	Food, Agriculture and Fisheries	No
Proposed Finfish Zones in Tasmania	Primary Industries (Aquaculture)	Food, Agriculture and Fisheries	No
Fishing Block (DPIPWE)	Primary Industries (Aquaculture)	Food, Agriculture & Fisheries	No
Scale Fishery Fishing Blocks	Primary Industries (Aquaculture)	Wild Fisheries Management Branch	Yes
Mining Leases	Primary Industries (Mining)	Mineral Resources Tasmania	No

Table A2: An inventory of the potential data sources available on the IMOS Australian Ocean Data Network within the south and west of Bruny Island region detailing the pathway to access the files, parameters measured, and the distribution of sites/data points.

IMOS Australian Ocean Data Network			
Platform	**Online Pathway to File**	**Parameters Measured**	**Distribution**
IMOS (Integrated Marine Observing System)	IMOS-SRS Satellite – SST L3S – composites across different time periods	Temperature	Multiple blocks within pilot study region
	IMOS – SRS Satellite – SST L3C composites across different time periods	Temperature	1 section in the mid-channel, and a large area south of Bruny island heading towards the south-west coast
	IMOS-SRS- MODIS – 01 day – Chlorophyll-a concentration (OC3 model)	Chlorophyll	1 region south of Bruny
	IMOS – SRS – MODIS – 01 day – Chlorophyll-a concentration (GSM model)	Chlorophyll	1 region south of Bruny
	IMOS – SRS – MODIS – 01 day – Ocean Colour – SST	Temperature	1 region south of Bruny
	IMOS – SRS Bio-optical database of Australian Waters (SRS-OC-BODBAW) Sub-Facility	Chlorophyll, Optical properties, Pigment, Suspended particulate material	53 sites in the Huon and channel
	IMOS – OceanCurrent – Gridded sea level anomaly – Delayed mode	Current, Sea surface height	Huon Estuary and South of Bruny
	IMOS – OceanCurrent – Gridded sea level anomaly – Near real time	Current, Sea surface height	Huon Estuary and South of Bruny
	IMOS – SOOP – Air Sea Flux (ASF) sub-facility – Meteorological and Flux Products	Air pressure, Air temperature, Air-Sea Fluxes, Humidity, Optical properties, Precipitation and evaporation, Temperature, UV radiation, Wind	1 line across Huon and another in the south of the Channel (these appear to be inaccurate as they cross land).
	IMOS – SOOP Underway CO2 Measurements Research Group – delayed mode data	Air pressure, Carbon, Salinity, Temperature, Wind	A couple of tracks south of Bruny
	IMOS – Autonomous Underwater Vehicle (AUV) Facility	Chlorophyll, Optical properties, Salinity, Temperature	1 location near the Fryers and another further south of there.
Reef Life Survey (RLS)	RLS: Global reef fish dataset	Ocean Biota	47 sites in the Channel
	RLS: Invertebrates	Ocean Biota	47 sites in the Channel
	RLS: Habitat Quadrats	Ocean Biota	31 sites in the Channel
	RLS: Cryptic Fish	Ocean Biota	36 sites in the Channel

IMOS Australian Ocean Data Network			
Platform	**Online Pathway to File**	**Parameters Measured**	**Distribution**
CSIRO Oceans and Atmosphere	SST Atlas of Australian Regional Seas (SSTAARS) – Daily climatology fit	Temperature	1 section in the mid-Channel, and a large area south of Bruny island heading towards the south-west coast
	CARS 2009 – CSIRO Atlas of Regional Seas – Australian Weekly	Density, Nutrient, Oxygen, Salinity, Temperature	Entire area? Looks coarse.
	CARS 2009 – CSIRO Atlas of Regional Seas – World Monthly	Density, Nutrient, Oxygen, Salinity, Temperature	Entire area? Looks coarse.
	CAMRIS Marine Benthic Substrate Database - Marsed	No parameters listed	Blocks covering most of the Channel and some of the Huon
	CAMRIS Seagrass Dataset	No parameters listed	Blocks covering most of the Channel and some of the Huon
Multiple Groups including CSIRO, IMAS & IMOS	The Australian Phytoplankton Database (1844 – ongoing) – abundance and biovolume	Ocean biota	36 sites in the Channel and Huon
	The Australian Phytoplankton Database (1844 – 2016) – abundance and biovolume (superseded by ongoing collection)	Ocean biota	36 sites in the Channel and Huon
	The Australian Chlorophyll-a Database (1965-2017)	Pigment	57 sites
Multiple Groups including CSIRO, IMAS & AIMS	MARVL3 – Australian shelf temperature data atlas	Temperature	3 sites
	MARVL3 – Australian shelf salinity data atlas	Salinity	3 sites
Clean Ocean Foundation, IMAS/ UTAS	National Outfall Database	Alkalinity, Salinity, Suspended particulate material, Turbidity	4 sites
NOAA	NOAA – Australasian Surface Drifting Buoys	No Parameters listed	1 track south of Cloudy Bay

IMOS Australian Ocean Data Network			
Platform	**Online Pathway to File**	**Parameters Measured**	**Distribution**
IMAS	Condition of rocky reef communities around Tasmania: fish surveys	Ocean Biota	12 sites
	Reefs on the Australian continental shelf (NESP MB D3)	No parameters listed	Multiple locations throughout region
	Nearshore temperature monitoring in Tasmanian coastal waters	Temperature	2 sites outside of Recherche Bay
	Tracking of Short-tailed shearwaters	No parameters listed	Multiple tracks across the Channel, Huon and south of Bruny
	Pollution markers at ecological monitoring sites (NESP MB C2)	Bathymetry, Optical properties	5 sites in the Channel
	Redmap – sightings of range shifting marine species	Ocean Biota	1 site south of Southport
	Estuarine Health in Tasmania, status and indicators: water quality	Nutrient, Oxygen, Pigment, Salinity, Temperature, Turbidity	2 sites in Recherche Bay
	Baseline coastal and estuarine condition assessment of the southern NRM region, Tasmania	Alkalinity, Nutrient, Ocean Biota, Oxygen, Pigment, Salinity, Temperature, Turbidity	Sites in NW Bay and Port Cygnet
	Condition of rocky reef communities around Tasmania: algal surveys	Ocean Biota	15 sites
Geosciences Australia	Australian coastal waterways geomorphic habitat mapping (national aggregated product)	No parameters listed	NW Bay, Huon, Cloudy Bay, Port Esperance, Hastings Bay, Southport Lagoon, and Recherche Bay
	Australian Seagrass distribution (2005 – Polygons + Points Datasets) as subsetted from Global Distribution of Seagrasses	No parameters listed	NW Bay, Great Bay, Kettering/Woodbridge, Port Esperance, Hastings Bay, and Recherche Bay

Table A3: Summary of the IMAS data of interest for the pilot study region which is available on the IMAS Data Portal and which is not available from the IMOS data portal. It is worth noting therefore, that this table does not represent the breadth of IMAS data which is available online, furthermore, additional data of relevance which is not available on the IMAS data portal may exist and be made available on request.

IMAS Data Portal			
Dataset	**Type**	**Parameters Measured**	**Distribution**
Video surveys of long spined sea urchin barrens habitat, eastern Tasmania	Video surveys	Substrate and habitat type	Sites around the Actaeon islands and Recherche
Recreational scallop fishery	Dive surveys	Species, size structure and abundance	D'Entrecasteaux channel
Abundance and distribution of coastal, inshore Zooplankton in the Huon Estuary and D'Entrecasteaux Channel	Sampling	Mesozooplankton community composition and structure	Huon Estuary, North West Bay and D'Entrecasteaux channel
Eastern Tasmania Heatwave Atlas & the ETAS Ocean Model Version 2 – Monthly means	3 dimensional estimates of monthly means	Temperature, salinity and circulation	Entire region

Table A4: A summary of datasets available from a mixed range of resource groups

Other datasets for the region South and West of Bruny Island, Tasmania				
Source	**Dataset/Type**	**Parameters Measured**	**Distribution**	**Link**
DPIPWE	Water Information Tasmanian Web Portal	Operational surface and groundwater locations (discharge, ground water level, reservoir level). Flow, nutrients, oxygen, turbidity, conductivity, temperature, pH.	State wide	https://portal.wrt.tas.gov.au/
	Natural Values Atlas	Species observations and geodiversity conservation sites (including threatened species, species of significance, weeds, geodiversity, Tasveg, threatened communities and reserves).	State wide	www.naturalvaluesatlas.tas.gov.au
EPA	Splashback	Not assessed within scope of project	Not assessed within scope of project	Internal database
AMSA	Spatial Portal. Digital data and map products for download, also assisted information requests (including vessel tracking data analysis).	Vessel tracking, administrative data, operational data, navigational data	Not all is relevant to the study region.	https://www.operations.amsa.gov.au/Spatial/
Marine Traffic	AIS density maps	Provides map showing density of AIS routes within the marine environment	State wide	https://www.marinetraffic.com/en/ais/home/centerx:146.8/centery:-43.3/zoom:10
MAST	Moorings and Navigation Aids	Locations	State wide	https://maps.mast.tas.gov.au/
BOM	Spatial climate datasets	Rainfall, temperature, humidity, evaporation, wind, sunshine/radiation/cloud, cyclones/thunderstorms, climate classifications, atmospheric circulation.	State wide	http://www.bom.gov.au/climate/data-services/maps.shtml
	Ocean maps and data – marine observations & forecasts and model data.	Sea temperature, waverider buoy observations, sea surface temperature anomalies, sea level and meteorological statistics, coastal observations (wind, waves and swell).	State wide	http://www.bom.gov.au/climate/data-services/ocean-data.shtml

Other datasets for the region South and West of Bruny Island, Tasmania				
Source	**Dataset/Type**	**Parameters Measured**	**Distribution**	**Link**
Department of Defence	Electronic Navigation Chart (ENC). Doesn't appear to be Open Access and seems there is a charge involved.	It provides more information that you can get from MAST (e.g. Anchorage area, Navigation, Buoys, etc.).	Block AU444147 covers the study area.	http://www.hydro.gov.au/prodserv/digital/ausENC/enc.htm
Department of the Environment & Energy	National Shipwreck Database	Location, vessel details, year wrecked, and general historical information.	Many sites present in the region. Would require identification of which sites have infrastructure present.	https://dmzapp17p.ris.environment.gov.au/shipwreck/public/maps/shipwreck-map-search-load.do
CSIRO	CSIRO Hydrodynamic Model – STORM (nested in the regional SETAS Model)	3-dimentional monthly data on Temperature, Salinity, Wind, Current	Huon, Derwent, Channel, Storm Bay	http://cem.csiro.au/thredds/catalog/storm/hydro/nrt/catalog.html https://data.csiro.au/dap/landingpage?pid=csiro%3A19072 https://research.csiro.au/cem/projects/completed-projects/tasmania/informd/project-description/
	CSIRO Wave Data	It provides data on wave characteristics (CAWCR Wave Hindcast).	Australian wide	http://data-cbr.csiro.au/thredds/catalog/catch_all/CMAR_CAWCR-Wave_archive/CAWCR_Wave_Hindcast_aggregate/gridded/catalog.html?dataset=allDatasetScan/CMAR_CAWCR-Wave_archive/CAWCR_Wave_Hindcast_aggregate/gridded/ww3.aus_4m.201807.nc https://data.csiro.au/dap/landingpage?pid=csiro:7309
Australian Renewable Energy Agency	Australian Wave Energy Atlas	Provides modelled wave height data based on outputs from the CAWCR global wave hindcast	Australia wide	https://nationalmap.gov.au/renewables/#share=s-gGd5ztFcxe2ysy9f
Aboriginal Heritage Tasmania	Heritage sites	Heritage sites	Available on request	https://www.aboriginalheritage.tas.gov.au/propertysearch/
Department of the Environment and Energy	CAPAD database 2018	Provides a complete list of marine protect areas	Australia wide	https://www.environment.gov.au/land/nrs/science/capad/2018

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