UNIVERSITY of TASMANIA

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Institute for Marine and Antarctic Studies

Statewide Finfish Aquaculture Spatial Planning Exercise

Investigating growth opportunities for finfish aquaculture in Tasmanian coastal waters

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ABBREVIATIONS

BRAN	Bluelink Re-ANalysis
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPIPWE	Department of Primary Industries, Parks, Water and Environment
EAC	East Australian Current
GIS	Geographic Information System
IMAS	Institute for Marine and Antarctic Studies
LIST	Land Information System Tasmania
MAST	Marine and Safety Tasmania
MFDP	Marine Farming Development Plan
NRM	Natural Resource Management
RMPS	Resource Management and Planning System
RPDC	Resource Planning and Development Commission
SMRCA	Sustainable Marine Research Collaboration Agreement
SRL	Southern rock lobster
TARFish	Tasmanian Association for Recreational Fishing Inc
TSGA	Tasmanian Salmonid Growers Association
TSIC	Tasmanian Seafood Industry Council
UTas	University of Tasmania

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ADVISORY COMMITTEE

The project was undertaken by IMAS in collaboration with the Department of Primary Industries, Parks, Water and Environment (DPIPWE) under the Sustainable Marine Research Collaboration Agreement (SMRCA). The project team worked with input from an Advisory Committee, comprised of:

- Ian Dutton, Director Marine Resources (DPIPWE), Chair;
- John Whittington, Blue Economy Cooperative Research Centre;
- Jen Fry, Tasmanian Salmonid Growers Association (TSGA);
- Mike Thomson, Natural Resource Management (NRM) - Cradle Coast;
- Jennifer Hemer, NRM South;
- Andrew Baldwin, NRM North;
- Jane Gallichan, Tasmanian Association for Recreational Fishing Inc. (TARFish);
- Julian Harrington, Tasmanian Seafood Industry Council (TSIC);
- Peter Hopkins, Marine and Safety Tasmania (MAST)

CONTENTS

NON-TECHNICAL SUMMARY

OBJECTIVES

The objective of this project is to carry out a sector-based spatial planning exercise to investigate potential sustainable growth opportunities for finfish aquaculture in Tasmania using existing information.

The project develops and applies a decision-support tool to identify these opportunities, should they exist. Decision-support tools promote transparency in decision-making by providing an approach where the input of information (data) is rigorously detailed, assumptions are explicit, and caveats are identified. These tools, which can be utilized by all stakeholders, can therefore form solid foundations to ensure the sustainable use of marine resources.

The choice of an adequate decision-support tool rests on the resource management problem to be solved. Here, multi-criteria decision analysis is used in a first instance to derive the biophysical suitability of the surrounding environment to host finfish aquaculture in Tasmania (referred to in this exercise as 'biophysical suitability'). Multi-criteria decision analysis is a common approach in environmental decision-making, the mechanics of which can be examined and challenged, if needed. In a second instance, optimization analysis with the software Marxan with Zones is used in local areas to identify contiguous areas where the potential for finfish aquaculture could be further assessed through a rigorous planning process. Marxan is a robust software used widely in multi-uses planning, including conservation planning. The utility of Marxan for sector-based planning where multiple stakeholders may interact with the sector of interest is an ongoing area of research. This also includes identifying specific planning situations, if they exist, where the utility of Marxan with Zones may be limited, such as in areas of reduced potential for conflict.

The project was initiated as part of the second review of the *Sustainable Industry Growth Plan for the Salmon Industry* and the spatial modelling process and outputs of the project will help inform Government policy (and/or decisions) about finfish aquaculture planning, including potentially leading to any revisions of the map of 'grow' and 'no grow' zones.

The project was comprised of two stages:

Stage 1:
The objective of Stage 1 was to undertake a statewide assessment of biophysical suitability of the surrounding environment to host finfish aquaculture within Tasmanian State waters (generally extending three nautical miles from the coast). Based on the statewide assessment of biophysical suitability and advice from the Advisory Committee, areas were identified for subsequent analyses in Stage 2. The statewide assessment excluded existing Marine Farming Development Plan (MFDP) areas, the east coast of Tasmania (the region between Tasman Island and Cape Portland), and waters shallower than 10 m.

Stage 2:
The objectives of Stage 2 were to:

a. Identify and collate relevant social, economic and environmental information for the areas identified in Stage 1.

b. Using the information collated in (a) and biophysical suitability for finfish aquaculture derived in Stage 1, undertake an optimization analysis in each area using the software Marxan with Zones .

OUTCOMES ACHIEVED

Biophysical suitability of the surrounding environment to host finfish aquaculture was generally relatively higher in southeast Tasmania (Tasman Island to South East Cape) and the north coast (west of Cape Portland, including King Island and Furneaux Group). In the southeast of Tasmania, relatively colder water temperature and deeper waters, especially offshore, indicated higher biophysical suitability. On the north coast, water temperature is generally higher than in the southeast, but a calmer ocean environment indicated overall higher biophysical suitability than along the west coast of Tasmania.

Two areas were assessed in Stage 2: the southeast and the north coast of Tasmania. In each area, four hypothetical scenarios for potential future finfish aquaculture development were implemented in the software Marxan with Zones. Scenarios considered other marine uses and activities, and areas of conservation and/or high ecological value. Other marine uses and activities included fisheries, coastal access and recreational boating, areas of high navigation density, marine infrastructure, and distance to coastal development (foreshore human use and residential dwellings).

When considering both biophysical suitability and other marine uses and activities, and areas of high ecological value, it was noted that opportunities for potential development of finfish aquaculture generally reside offshore in Tasmanian State waters.

By applying and further developing the methods used in the Pilot Marine Spatial Assessment Tool in the D'Entrecasteaux Channel (Ross et al. 2020), this project has refined the methodology for undertaking sector-based spatial planning at both statewide and local scales.

Introduction

1.1 Need

Tasmanian coastal waters offer a wide variety of economic, social and environmental benefits to society. In addition to the highly valued recreational and environmental services provided, Tasmanian coastal waters support several important local industries across the State, including tourism, wild-catch fisheries and aquaculture.

In 2017 the Tasmanian Government finalised the *Sustainable Industry Growth Plan for the Salmon Industry* (henceforth referred to as the Salmon Growth Plan). This document sets out the Government's vision and priorities for the salmon aquaculture industry, together with a map of 'grow' and 'no grow' zones around the state based on their availability for finfish aquaculture operations from a governance perspective.

This project was initiated at the request of the Tasmanian Government as part of the second review of the Salmon Growth Plan. The project's spatial modelling process and specific outputs were developed to help inform future Government policy and/or decisions about finfish aquaculture planning. This could include informing any potential revisions of the map of 'grow' and 'no grow' zones. This project does not provide recommendations on revisions to the map of 'grow' and 'no grow' zones.

The study area for this project excludes areas with existing Marine Farming Development Plans (MFDP). MFDPs delineate areas where and which types of marine farming can occur, up to a maximum leasable area set by individual Plans. Please see dpipwe.tas.gov.au for more information on existing MFDPs.

Adopting the Tasmanian Resource Management and Planning System (RMPS) objectives and definition for sustainable development (as set out in Tasmania's resource management legislation; **Box 1)**, this project aligned with Government targets for the sustainable growth of finfish aquaculture while also balancing other marine uses, activities and areas of high ecological value.

Box 1. RMPS objectives and definition of sustainable development as set out in Tasmania's resource management legislation.

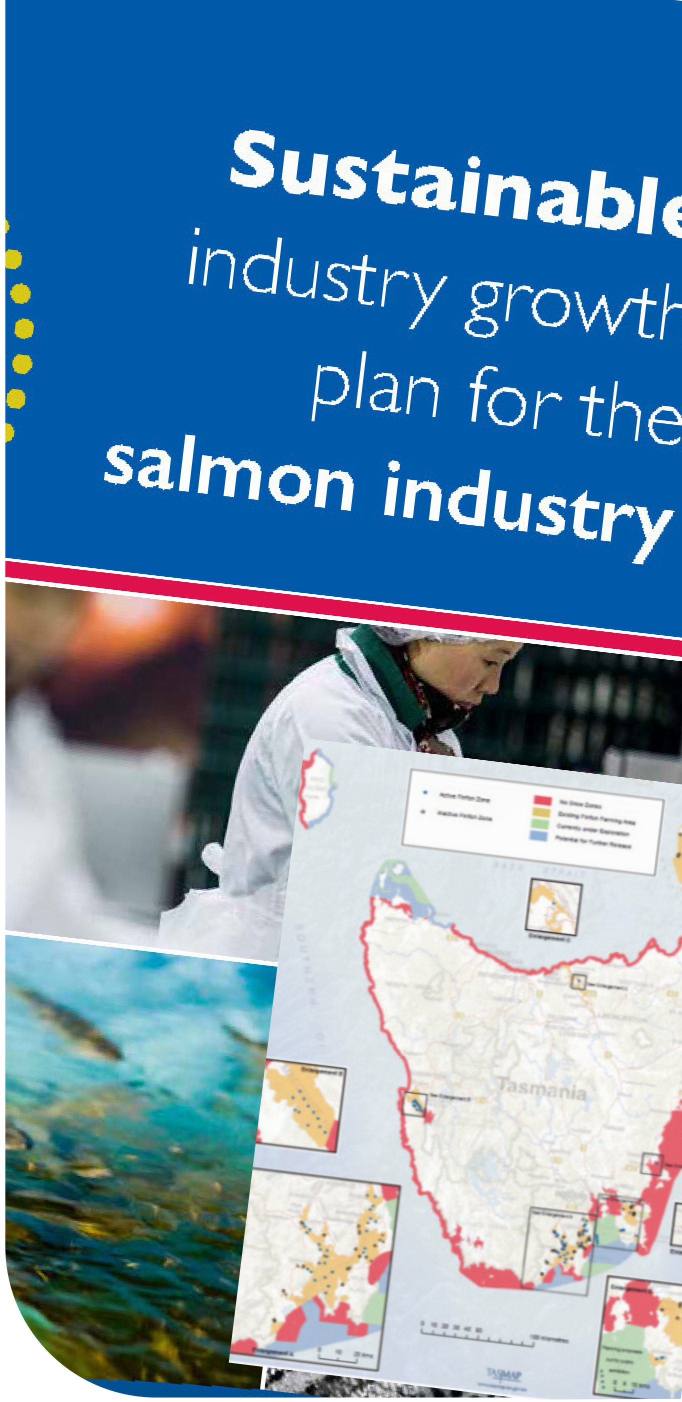
RMPS definition of 'sustainable development':
'managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well-being and for their health and safety while:

- 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.'

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.'

Resource Planning and Development Commission (2003)



1.2 Rationale and objectives

The Tasmanian marine finfish aquaculture industry has been growing since the first State trials into farming Atlantic salmon in 1985 and is set to continue to grow into the future (Crawford et al. 2002, DPIPWE 2017). While much of the existing finfish aquaculture has taken advantage of more sheltered inshore waters, there is growing momentum from industry to identify new areas for finfish farming, including moving into more exposed offshore and Commonwealth waters (DPIPWE, 2021; **Box 2**). The establishment of the Blue Economy Cooperative Research Centre in 2020 (Blue Economy CRC-Co Ltd. 2020) together with the National Aquaculture Strategy (Department of Agriculture and Water Resources 2017) mark a shift in this direction. Over the next ten years the Government is dedicated to supporting the sustainable growth of the industry in Tasmanian waters with an emphasis on moving into higher energy environments (DPIPWE 2021).

To achieve sustainable growth of finfish aquaculture, it is essential to find locations which meet the biophysical operational requirements for the industry while also balancing the values associated with the other diverse users of the coastal and marine environment. Societal support is a recognised component of achieving and/or maintaining sustainable economic development (Cullen-Knox et al. 2017, Cullen-Knox et al. 2019, Alexander & Abernethy 2019). The selection of sites is a critical step in achieving environmental, economic and socially sustainable development (Alexander & Abernethy 2019). In Tasmania, the principles of sustainable development have been integrated into marine and coastal environmental planning through the objectives of the RMPS (see **Box 1**), from which several laws, policies and procedures have been developed and which together structure the planning process (RPDC 2003).

The extent and variety of coastal environments around Tasmania have the potential to provide biophysically suitable areas to host finfish aquaculture.

This statewide project was initiated to carry out a spatial assessment to identify new areas for potential future expansion of the finish aquaculture industry (outside existing MFDPs and within 10 years) in Tasmanian State waters (generally extending to 3 nautical miles from the coast; **Figure 1**). Identified areas for potential expansion considered both biophysical conditions for operations (e.g., water temperature, seabed depth) in addition to minimised potential for conflict with other ocean users and areas of ecological value.

This project used a step-wise approach by:

- Carrying out a statewide assessment of biophysical suitability for finfish aquaculture operations in Tasmanian State waters to rule out any areas where finfish aquaculture is unlikely to occur given the biophysical environment;
- Identifying local areas for potential future finfish aquaculture (based on statewide biophysical suitability for operations and advice from the Advisory Committee) and undertake optimization analysis in these local areas using the software Marxan with Zones. Social, economic and conservation information are included in this step in addition to the biophysical suitability assessment.

Because the focus of this project is to identify areas with the most potential to support development of the finfish aquaculture industry within State waters, some areas not considered for future industry development have been excluded from the exercise (**Figure 1**). These include:

- **The east coast of Tasmania** extending from Tasman Island to Cape Portland: under current governance this area is not under consideration for additional finfish aquaculture development;
- **Existing MFDPs** (Blackman Bay, D'Entrecasteaux Channel and Huon River, Far North West, Furneaux Islands, Georges Bay, Great Oyster Bay and Mercury Passage, Macquarie Harbour, Pipe Clay Lagoon, Pitt Water, Port Sorell, Storm Bay North, Storm Bay off Trumpeter Bay North Bruny Island, Tamar Estuary, Tasman Peninsula and Norfolk Bay): because the purpose of this exercise is to identify areas within State waters which may offer potential for future finfish aquaculture, existing marine farming areas have not been included in the assessment;
- **Areas of < 10m water depth**: following State and National Government aspirations to grow finfish farming into offshore environments, areas with less than 10-m depth were excluded from the assessment.

Box 2. Finfish aquaculture governance in Tasmanian State waters and Commonwealth waters

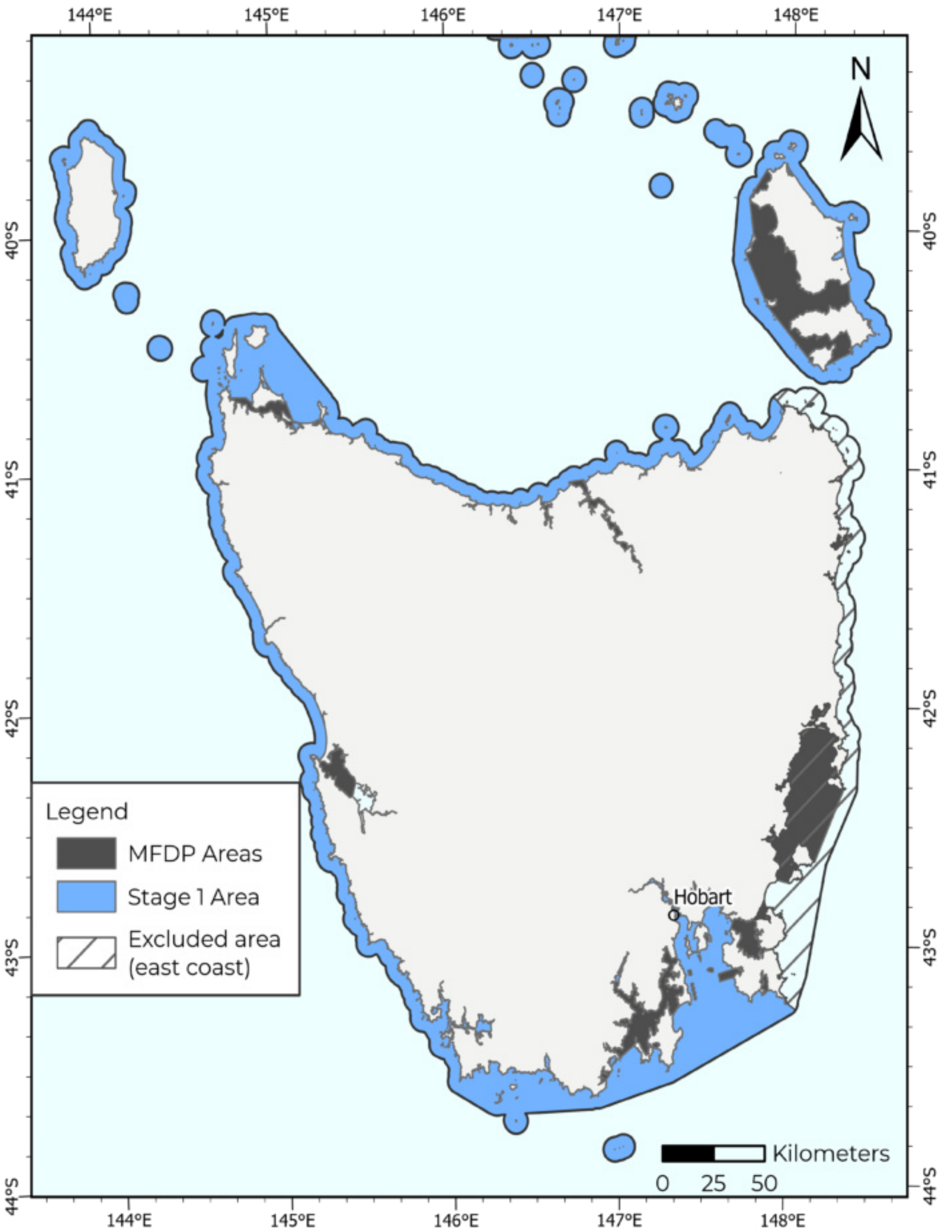
In Tasmanian State waters, finfish aquaculture is regulated under Tasmanian legislation including the *Marine Farming Planning Act 1995* and the *Living Marine Resources Management Act 1995*. This legislation ensures that any proposed finfish farms follow a planning and approval process, including preparation of environmental impact statements available for public review.

Historically, finfish aquaculture has not been developed in Commonwealth waters and as such, regulatory processes, including a rigorous planning and approval process have not been established under relevant legislation. In 2021, the Second Progress Report of the *Sustainable industry growth plan for the salmon industry* details the Government's outlook on future finfish aquaculture development in Tasmania (DPIPWE, 2021). Such development is favoured for offshore waters, including Commonwealth waters. A regulatory framework and processes are being developed to potentially enable the Tasmanian Government to regulate and manage aquaculture in Commonwealth waters.

The developed approach and derived outputs from this project are intended to help inform policy and decision-making around finfish aquaculture planning in Tasmania, while promoting transparency in decision-making. Importantly, the project was not designed as a participatory planning process or as a comprehensive marine spatial planning process. Rather, the approach is intended as a means of initiating constructive conversations around the placement of future finfish aquaculture sites in Tasmanian State waters.

In addition, it is hoped that the project will highlight the importance and promote the practice of undertaking rigorous case-specific investigations (i.e., detailed data collection, environmental impact studies and engagement with diverse stakeholder groups) to inform decisions within the marine planning and governance framework. As such, while the tool has been designed to provide a sector-based assessment (finfish aquaculture industry), it could be used for a range of activities and uses in the marine environment that utilize a given spatial footprint.

Figure 1. Study area within Tasmanian State waters considered in this project. The east coast region extending from Tasman Island to Cape Portland and existing Marine Farming Development Plans (MFDPs) areas are excluded. Please note: areas <10m water depth are also excluded from the assessment (not illustrated on the map).



1.3 Project outline

Building on the methods developed in the Pilot Marine Spatial Assessment Tool (Ross et al. 2020), the project followed a two-stage process (each comprised of a number of contributing steps) to develop a statewide assessment (**Box 3**):

Stage 1 – In this stage, statewide biophysical suitability of the surrounding environment to potentially host future development of finfish aquaculture operations in Tasmanian State waters was assessed (referred to in this exercise as 'biophysical suitability'). This excluded the east coast region from Tasman Island to Cape Portland, existing MFDPs and areas of less than 10m water depth. Outputs of Stage 1 ruled out areas where finfish aquaculture is unlikely to occur given the biophysical environment and were used to identify local areas for more detailed assessments in Stage 2.

Stage 2 – Focussing on the local areas identified in Stage 1, Stage 2 incorporated information on other marine uses, activities and areas of ecological value to explore trade-offs and opportunities for potential future finfish aquaculture development using the software Marxan with Zones (more information on this software is provided in Section 1.4).

The methods are adapted from the UNESCO marine spatial planning approach which is outlined in **Table 1** (Ehler and Douvere 2009).

Box 3. Overview of project methods

Stage 1: Statewide spatial assessment of biophysical suitability for finfish aquaculture operations

- **Information gathering:** Key biophysical requirements for future finfish aquaculture operations were defined with a literature review (detailed in Ross et al. 2020) and industry consultation. Available data sources were identified and data collated on a common grid at 1-km horizontal resolution.
- **Suitability analysis:** A single biophysical suitability assessment was derived by synthesizing individual biophysical suitability for each environmental parameter expressed with a categorical scale.
- **Output:** The statewide biophysical suitability assessment was reviewed by the project Advisory Committee to select local areas for potential future finfish aquaculture expansion that fed into Stage 2.

Stage 2: Develop and implement scenarios to explore options for potential expansion of finfish aquaculture that consider other existing marine uses in local areas

- **Information gathering:** Spatial information on marine uses and activities and areas of high ecological value was identified for each of the Stage 2 areas.
- **Optimization analysis:** For each local area, four hypothetical scenarios contrasting varying targets for other ocean uses (expressed as extent of area to be kept for these uses and activities) were developed and implemented into the software Marxan with Zones. This analysis was undertaken to identify optimal locations of potential future aquaculture developments based on costs and benefits of multiple marine uses and activities.
- **Output:** The marine estate in each local area was segregated into contiguous areas either labelled as potential for future development of finfish aquaculture based on underlying biophysical suitability determined in Stage 1 (expressed as 'medium', 'high' or 'very high'), or other uses. Other uses were pooled and no effort was made to distinguish among them, which was out of scope for this project. For each local area, a synthesis map of all four scenarios is presented.

Table 1. Relating finfish aquaculture spatial planning exercise project components with UNESCO marine spatial planning tasks

	UNESCO	Finfish Aquaculture Spatial Planning Exercise	
		Stage 1	Stage 2
Task 1	Projecting current trends in the spatial and temporal needs of existing human activities – maximum extent	N/A	Using available information, map the existing coastal/marine uses and values (social, economic and environment) and develop an inventory of relevant datasets
Task 2	Estimating spatial and temporal requirements for new demands of ocean space	Identify the key biophysical requirements for future development of finfish aquaculture and develop a spatial inventory of relevant and available datasets: • Water temperature • Seabed depth • Current speed • Significant wave height • Substrate type Identify the potential for finfish aquaculture development based on biophysical suitability	Using spatial data collected in Task 1 to determine potential spatial conflict, estimate contemporary requirements for social, economic and environment uses and values Focus on areas displaying 'very high', 'high' and 'medium' biophysical suitability for finfish aquaculture
Task 3	Identifying possible alternative futures for the planning area	N/A	Develop multiple scenarios, each of which with varying quantitative targets of a set of other uses to be implemented in the software Marxan with Zones Aim: Present alternative spatial configurations describing where finfish aquaculture could be developed in the future and where other uses would be prioritized
Task 4	Selecting the preferred spatial sea use scenario	N/A	Synthesize the outputs of scenarios used in the software Marxan with Zones into a single map to support decision-makers

1.4 Marxan with Zones

To explore different spatial configurations for future finfish aquaculture development within Stage 2 local areas, the software Marxan with Zones was employed.

Marxan with Zones is a multiple-use planning version of the software Marxan used to identify configurations of land or water uses that achieve specified planning objectives while optimizing 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 and trade-offs (Watts et al. 2009).

In each local area in Stage 2, four hypothetical scenarios which focused on different priorities for marine uses in the area were developed with the Advisory Committee. The scenarios were devised to demonstrate how altering priorities in other uses and quantitative targets would influence the spatial extent of the potential for finfish aquaculture development, and identify potential conflict with other users.

Scenarios differed by varying 1) the spatial extent of certain uses (e.g., extent of footprint of recreational activities) while maintaining the quantitative target (proportion of footprint of the activity to be maintained for that use), or 2) the quantitative target with a static spatial extent.

In each local area, the four scenarios were synthesized to demonstrate areas that were consistently identified as suitable for either finfish aquaculture or other uses.

For the purpose of this exercise four types of contiguous areas (defined as zones in the software) of marine use were defined:

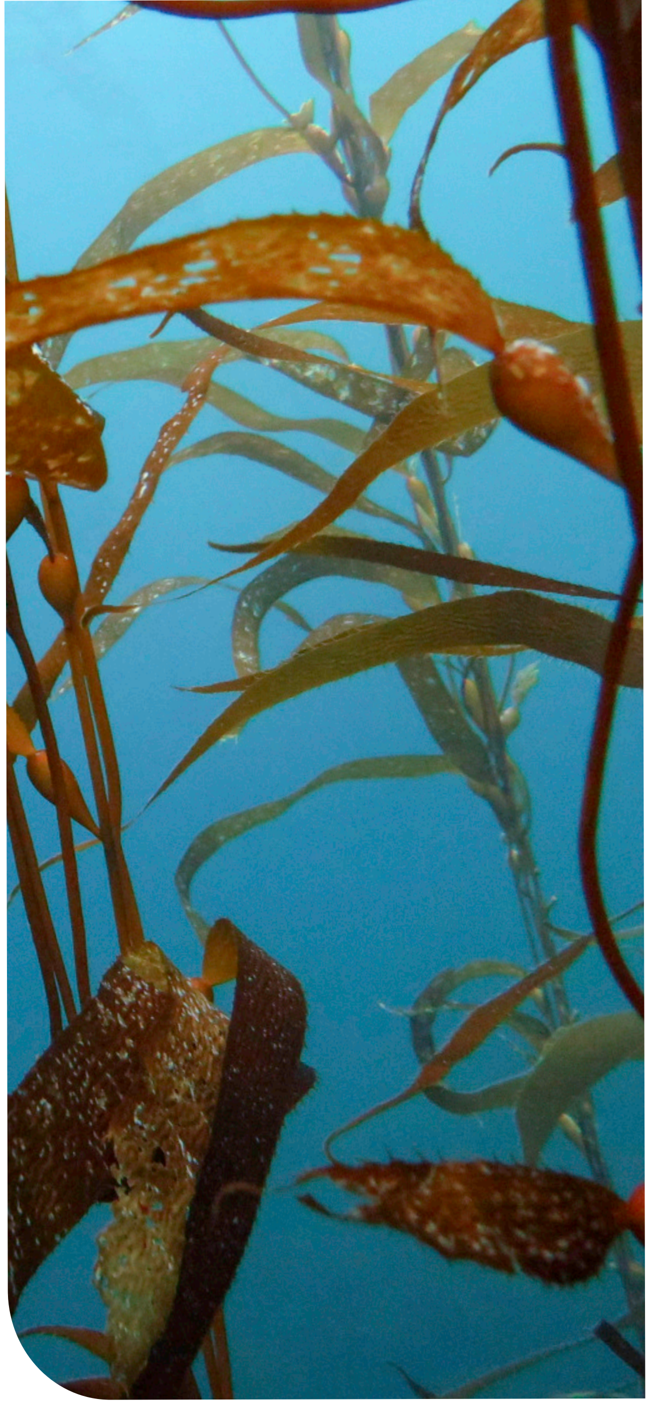
- Finfish aquaculture (very high biophysical suitability)
- Finfish aquaculture (high biophysical suitability)
- Finfish aquaculture (medium biophysical suitability)
- Other uses (which includes all other marine uses considered)

Areas attributed to finfish aquaculture were divided based on the underlying biophysical suitability determined in Stage 1, e.g., 'very high' biophysical suitability are areas where finfish aquaculture biophysical suitability exceeded 7 (out of a maximum value of 9), and where potential conflict with other users was minimized. Not all types of contiguous areas associated with finfish aquaculture occurred in each local study area.

The 'finfish aquaculture' and 'other' marine use contiguous areas (zones) were considered to be competing for marine space and were accommodated in non-overlapping exclusive use areas.

Within the context of this project, increase in spatial extent for any of the 'other' marine uses, as well as emerging uses, were not considered. As such, the qualitative goal for the 'other' marine use areas was to maintain all existing uses and activities (economic, social and environment) while minimising interaction with the areas assigned to 'finfish aquaculture' in the analysis.

Please note: Additional information on the use of the software Marxan with Zones in this project is available on the IMAS website.



Stage 1
Statewide biophysical suitability for finfish aquaculture

2.1 Study area

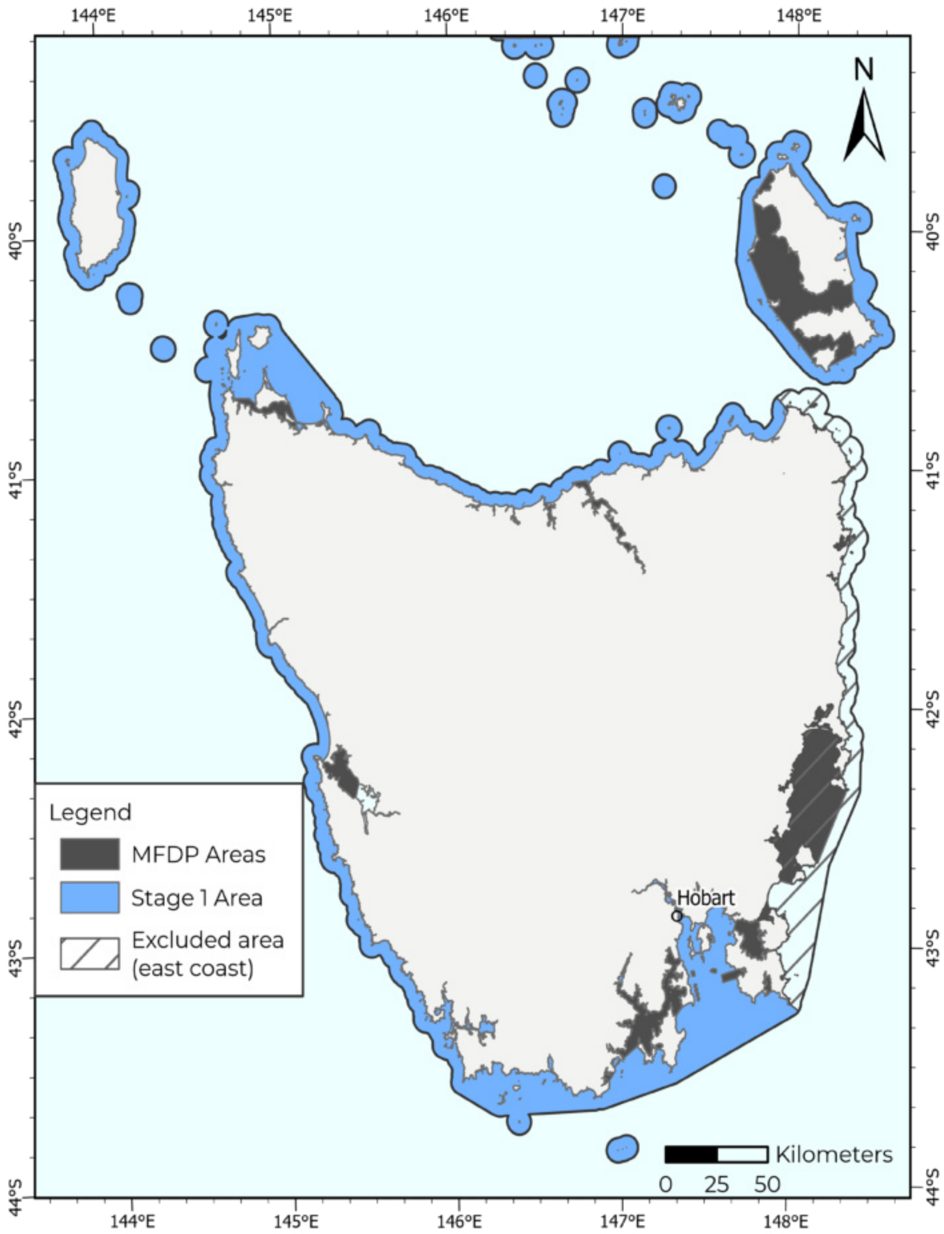
As an island State, Tasmania is surrounded by the ocean with a total coastline of 2237 km (excluding Macquarie Island) offering considerable opportunity for industry development in addition to a wide variety of other uses and values (Short 2020, **Figure 2**). To explore options for potential future expansion of finfish aquaculture in Tasmanian State waters, a statewide assessment of biophysical suitability was applied to all coastal waters (using a grid with 1-km horizontal resolution). Because of the focus on industry growth, some areas were excluded from this exercise. They include:

The east coast of Tasmania extending from Tasman Island to Cape Portland: under current governance this area is not under consideration for additional finfish aquaculture development;

Areas of <10m depth: following State and National Government aspirations to grow finfish aquaculture in offshore environments, areas with less than 10m water depth were excluded from the assessment;

Existing MFDPs (Blackman Bay, D'Entrecasteaux Channel and Huon River, Far North West, Furneaux Islands, Georges Bay, Great Oyster Bay and Mercury Passage, Macquarie Harbour, Pipe Clay Lagoon, Pitt Water, Port Sorell, Storm Bay North, Storm Bay off Trumpeter Bay North Bruny Island, Tamar Estuary, Tasman Peninsula and Norfolk Bay)**:** because the purpose of this exercise is to identify areas within State waters which may offer potential for future finfish aquaculture, existing MFDPs have not been included in the assessment. While existing areas with MFDPs are excluded from this study, their existence does not indicate that part or all that area is, or could be, authorised for marine farming development. Within MFDPs, areas or 'marine farming zones' where marine farming can occur are identified, up to a maximum leasable area within each marine farming zone. MFDPs also specify which types of marine farming can take place within each marine farming zone such as finfish, shellfish or seaweed. For more information, please see dpipwe.tas.gov.au.

Figure 2. Stage 1 study area. The east coast region extending from Tasman Island to Cape Portland and areas with existing Marine Farming Development Plans (MFDPs) areas are excluded. *Please note*: areas <10m water depth are also excluded from the assessment (not illustrated on the map).



The Tasmanian landscape including its coastline has been influenced by its geology, climate and changes in sea level (Seymour et al. 2006). As a result, the environmental and biophysical conditions in different coastal regions are diverse.

North coast (Woolnorth Point – Cape Portland): *The north coast is bordered to the north by the Bass Strait with King Island and the Furneaux Group (including Cape Barren and Flinders Islands) situated off the mainland coast at the most western and eastern edge of the region respectively (Short 2020). While the entire coast is affected by the prevailing westerly winds, the western region is more sheltered with increasing wind exposure towards the east. The coastline is largely sheltered from the westerly swell by King Island (Short 2020).*

South and west coasts (South East Cape – Woolnorth Point): *The south and west coastal region of Tasmania is exposed to the Southern Ocean and its prevailing westerly winds, waves and swell (average of 2-3m daily) resulting in a high energy environment with high rainfall (Short 2020). Rocky outcrops predominate (69% of the coast), interspersed with sandy beaches exposing a complex and varied geology (Short 2020). The south and west coasts are generally influenced by the Zeehan Current, an extension of the Leeuwin Current, which travels southward along the west coast of Tasmania (Ridgeway 2007).*

Southeast coast (Tasman Island to South East Cape): *The geography of the southeast coast of Tasmania is dominated by the presence of the Derwent and Huon Rivers and their submerged river valleys which make up the Derwent Estuary and the D'Entrecasteaux Channel (Short 2020). This creates an intricate coastline with a number of islands and peninsulas resulting in many sheltered embayments in addition to higher energy areas that are subjected to swells from the southwest. Within this region the upper D'Entrecasteaux Channel, Norfolk Bay, and Port Arthur exhibit lower energy environments being largely sheltered from ocean swell while the lower D'Entrecasteaux Channel and Storm Bay are significantly more exposed. The area is primarily influenced by the cooler Zeehan current as it rounds the southern tip of Tasmania and extends northward along the southeast coast. However in summer, the East Australian Current (EAC) off the east coast of Tasmania can extend further south, bringing with it warmer nutrient-poor waters (Cresswell 2000, Ridgway 2007). Research indicates increasing southward transport of the EAC extension resulting in more frequent influence in the southeast region, and delayed onset of the Zeehan current moving northwards in winter (Johnson et al. 2011, Oliver & Holbrook 2018).*

The differences in coastal water environments are reflected in the variety and distribution of uses which are observed around the state, including recreation, industry (e.g., tourism, wild-catch fisheries and aquaculture) and conservation.

The majority of Tasmania's residential population is located along the coast in a number of urban centres, including Hobart and Kingston in the southeast and Launceston, Burnie and Devonport in the north. The west coast region has a lower residential population with no large urban centres however a number of smaller towns scatter the coast (Strahan, Granville Harbour, Arthur River).

Although it is less populated, the west coast region is a popular tourist destination for interstate, international and local visitors, with tourism contributing significantly to the local economy (Nichol et al. 2013). Based on the Australian Bureau of Statistics 2011 census, around 14% of the total jobs in the west coast region were associated with tourism (Nichol et al 2013). It should be noted that these statistics do not represent absolute tourist visits to different regions, but rather the relative importance of tourism to the economy within the context of other industries.

Recreational fishing is very popular in Tasmania with most of it occuring in saltwater (Lyle et al., 2019). Statewide, important species for recreational fishing include southern sand flathead, trout, Australian salmon, gurnard, wrasse, southern calamari, gould's squid, southern rock lobster, abalone and scallops. A 2017-2018 survey indicated that half of recreational fishing effort within that period was undertaken in the east and southeast coast regions, especially in the Derwent Estuary, the D'Entrecasteaux Channel and the Norfolk-Frederick Henry Bay regions, 20% was focused along the north coast and only 1% on the west coast (Lyle et al., 2019).

2.2 Biophysical suitability for finfish aquaculture

Stage 1 focused on developing a statewide finfish aquaculture biophysical suitability layer. This was based on the biophysical requirements for potential future development of finfish aquaculture. Using the findings from the Pilot Marine Spatial Assessment Tool (Ross et al. 2020) five variables were identified to determine biophysical suitability for finfish aquaculture: water temperature, seabed depth, current speed, substrate type and significant wave height. Following consultation with industry and the Advisory Committee variables were given a classification between 0 and 9 where 0 is unsuitable and 9 is more suitable (**Table 2**). These were based on classifications from the Pilot Marine Spatial Assessment Tool (Ross et al. 2020) with minor modifications to make them applicable for a statewide assessment.

Relevant georeferenced biophysical datasets for the study area were identified. Each variable was gridded at 1-km horizontal resolution to conduct the suitability analysis (**Box 4**).

The presence of rocky reef (as a substrate type) was considered to be an unsuitable substrate for future finfish aquaculture development. The presence of rocky reef was also mapped to the grid, where grid cells with more than 20% of the surface area covered by rocky reefs cover were given a score of 0. It should be noted however that substrate type in State waters has not been fully mapped to this resolution. This may introduce uncertainty to biophysical suitability assessment in unmapped areas.

Table 2. Biophysical suitability classification for future finfish aquaculture operations.

		Biophysical suitability classification					
		Unsuitable	*Less suitable*				*More suitable*
		0	**1**	**3**	**5**	**7**	**9**
Biophysical suitability variables	Water temperature (°C) *Average summer temperature at 5m below the surface in January and February 2015-16*	>22	21-22	20-21	19-20	18-19	<18
	Water depth (m)	--	--	10-15	15-25	25-40	>40
	Current speed (m/s) *Average summer current speed at 5m below the surface in January and February 2015-16*	<0.01	0.01-0.02	0.02-0.04	0.04-0.08	0.08-0.2	>0.2
	Substrate type	Presence of reef	--	--	--	--	--
	Significant wave height (m) *Maximum monthly significant wave height between 2010 and 2020*	>11	9-11	7-9	5-7	3-5	<3

The relative importance of each variable was determined from a review of the literature and industry consultation and used to calculate biophysical suitability for finfish aquaculture in the study area:

Biophysical suitability =
(0.30 x water temperature class) +
(0.15 x seafloor depth class) +
(0.25 x current speed class) +
(0.30 x significant wave height class)

The suitability classifications of water temperature (**Figure 3**), depth (**Figure 4**), significant wave height (**Figure 5**) and current speed (**Figure 6**) were synthesized to create a single biophysical suitability layer for finfish aquaculture (**Figure 7**).

Significant wave height and water temperature were given higher relative weights to reflect the challenges of operating in high-energy environments and the critical requirement not to exceed physiological tolerance of salmonids, respectively. Overall, depth was considered a relatively less important defining factor, and it is often linked to other hydrographic variables such as current speed and wave height which have greater weightings. It must be noted that choices around the weight applied to each biophysical variable will directly affect biophysical suitability outcomes. These weights form parts of the overall decision model and are best elicited by a review of the scientific literature and/or expert advice (practitioners). Here, aquaculture operators provided critical input to ensure the weights reflected operational constraints as closely as possible.

Results of the biophysical suitability analysis were used together with advice from the Advisory Committee to identify local areas for a more detailed assessment in Stage 2 that incorporates other uses and activities and areas of high ecological value using the software Marxan with Zones.

Box 4. Steps of (biophysical) suitabilty analysis

Suitability analysis, as an application of **multi-criteria decision analysis**, can be used to determine the relative suitability of locations for particular activities or developments based on specified suitability criteria.

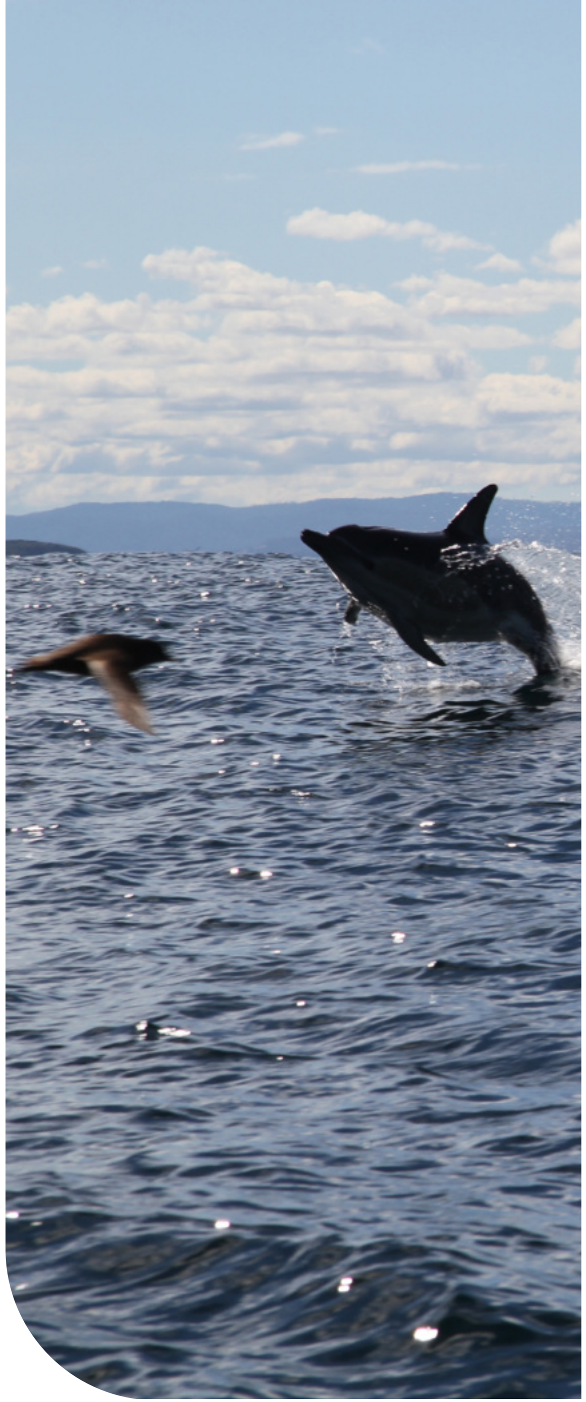
Suitability analysis has the capacity to use multiple criteria, from multiple data layers to determining spatial suitability for a given marine use.

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 0 (unsuitable) to 9 (most suitable) based on known understanding of the activity of interest;
5. Define weights for the layers;
6. Calculate suitability layer by combining layers using a linear equation.

In this project, suitability analysis was conducted solely to assess biophysical suitability (Stage 1). The software Marxan with Zones was used during Stage 2 to incoporate other uses and activities, and areas of high ecological value.

Please note: Additional information on the use of multi-criteria decision analysis to determine biophysical suitability in this project is available on the IMAS website.



Biophysical suitability based on water temperature

The restricted timeframe of spatiotemporal information was used as an indicator only for the purpose of this project and reflected data availability across outputs of ocean circulation models. More detailed analyses using longer time series could provide more information on the oceanographic regime in the region. Conducting such analyses was beyond the scope of this project.

Statewide

Average summer water temperature (°C) was derived from outputs of Bluelink ReANalysis 2016 (BRAN2016; daily averages; research.csiro.au). BRAN is a periodical re-analysis using observational data of the near-global Ocean Forecasting Australia Model (OFAM) resolved at 1/10th of a degree horizontal resolution. BRAN is made freely available by CSIRO Bluelink and is supported by the Bluelink Partnership: a collaboration between the Australian Department of Defence, Bureau of Meteorology and CSIRO.

Values were extracted at ~5m below the surface and averaged over the months of January and February in 2015 and 2016. Values were gridded at 1-km horizontal resolution using bilinear interpolation.

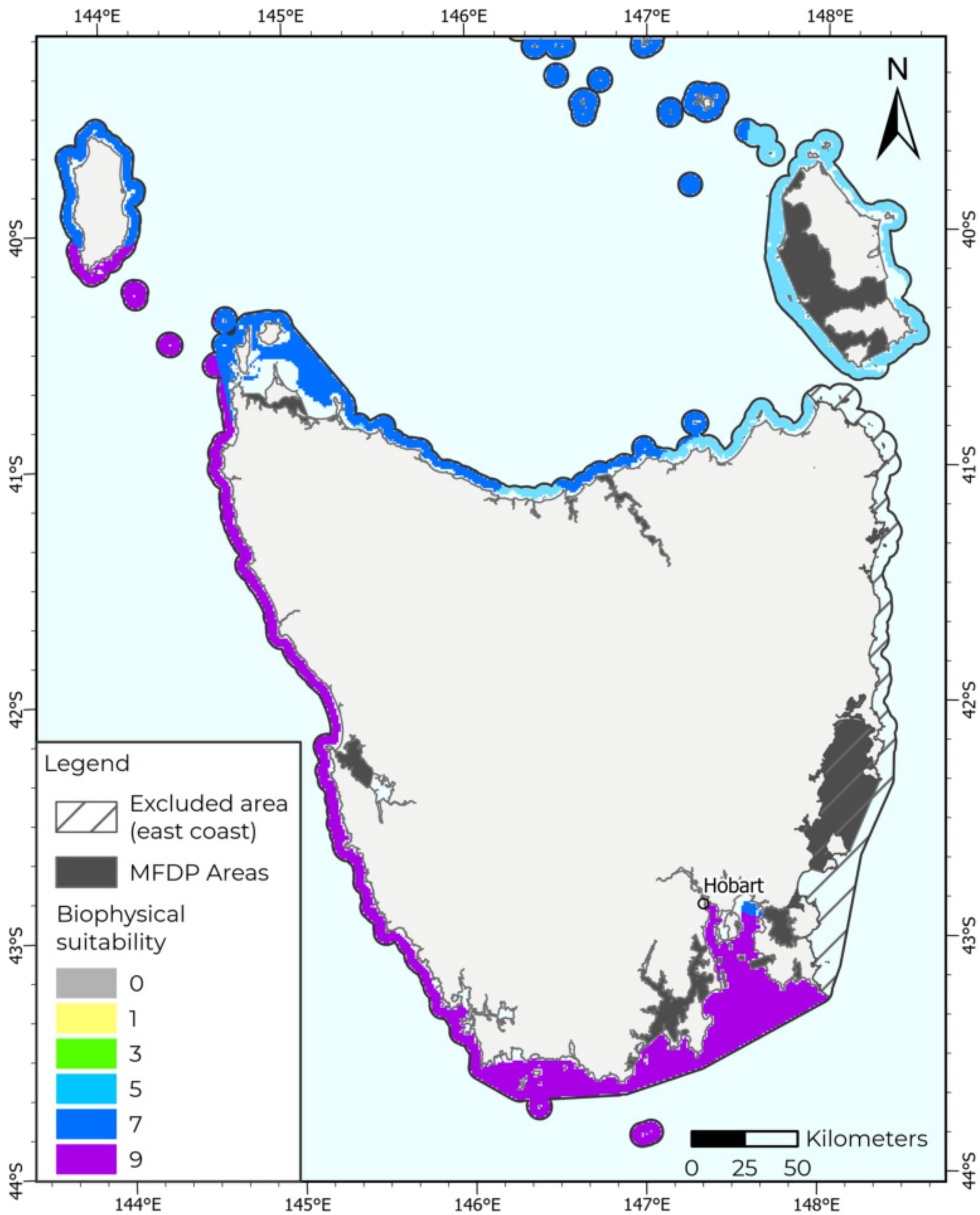
Southeast: Tasman Island to South East Cape

In the southeast, BRAN2016 water temperature values were superseded by the higher-resolution CSIRO Storm Bay hydrodynamic model (model run tasseH1p2; Wild-Allen et al., 2021). Please note this model is yet un-calibrated. The model was developed by Clothilde Langlais, Mike Herzfeld and John Andrewartha at the CSIRO.

Values were extracted at ~5m below the surface and averaged over the months of January and February in 2015 and 2016. Values were gridded at 500-m horizontal resolution using bilinear interpolation, and re-sampled at 1-km horizontal resolution for the statewide assessment.

Biophysical suitability based on water temperature alone is shown in **Figure 3**.

Figure 3. Biophysical suitability for potential future finfish aquaculture based on water temperature where 1 is less suitable and 9 is more suitable.



Biophysical suitability based on depth

Statewide
Bathymetry (depth; m) was obtained from the Australian Bathymety and Topography Grid resolved at 9 arc-seconds, equivalent to ~250 m at the equator, produced by Geoscience Australia (Whiteway 2009). The grid was last updated in June 2017. The depth values were resampled to 1-km horizontal resolution.

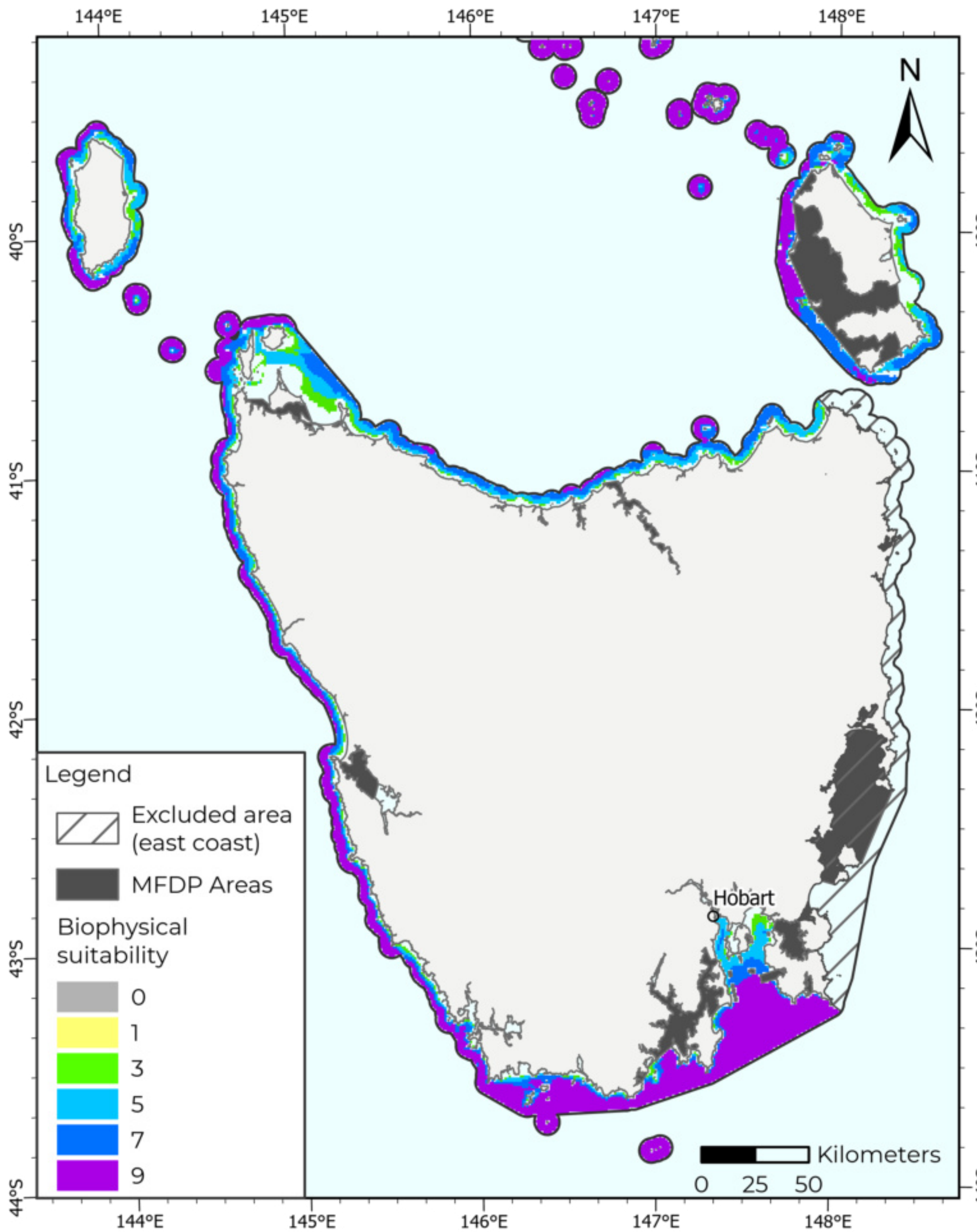
Depth values were corrected where necessary along the north coast of Tasmania (including King Island and Furneaux Group) using Nautical Charts (as AusGeoTIFFs) produced by the Australian Hydrographic Office (hydro.gov.au).

Southeast: Tasman Island to South East Cape
Because of its higher-resolution, depth values in the southeast were superseded by the bathymetry layer included in the CSIRO Storm Bay hydrodynamic model (model run tasseH1p2; Wild-Allen et al., 2021). The model was developed by Clothilde Langlais, Mike Herzfeld and John Andrewartha at the CSIRO.

Values were gridded at 500-m horizontal resolution using bilinear interpolation, and re-sampled at 1-km horizontal resolution for the statewide assessment.

Biophysical suitability based on depth alone is shown in **Figure 4**.

Figure 4. Biophysical suitability for potential future finfish aquaculture based on depth where 1 is less suitable and 9 is more suitable.



Biophysical suitability based on current speed

The restricted timeframe of spatiotemporal information was used as an indicator only for the purpose of this project and reflected data availability across outputs of ocean circulation models. More detailed analyses using longer time series could provide more information on the oceanographic regime in the region. Conducting such analyses was beyond the scope of this project.

Statewide

Average summer current speed ($m \cdot s^{-1}$) was derived from outputs of Bluelink ReANalysis 2016 (BRAN2016; daily averages; research.csiro.au). BRAN is a re-analysis using observational data of the near-global Ocean Forecasting Australia Model (OFAM) resolved at 1/10th of a degree horizontal resolution. BRAN is made freely available by CSIRO Bluelink and is supported by the Bluelink Partnership: a collaboration between the Australian Department of Defence, Bureau of Meteorology and CSIRO.

Values were extracted at ~5m below the surface and averaged over the months of January and February in 2015 and 2016. Values were gridded at 1-km horizontal resolution using bilinear interpolation.

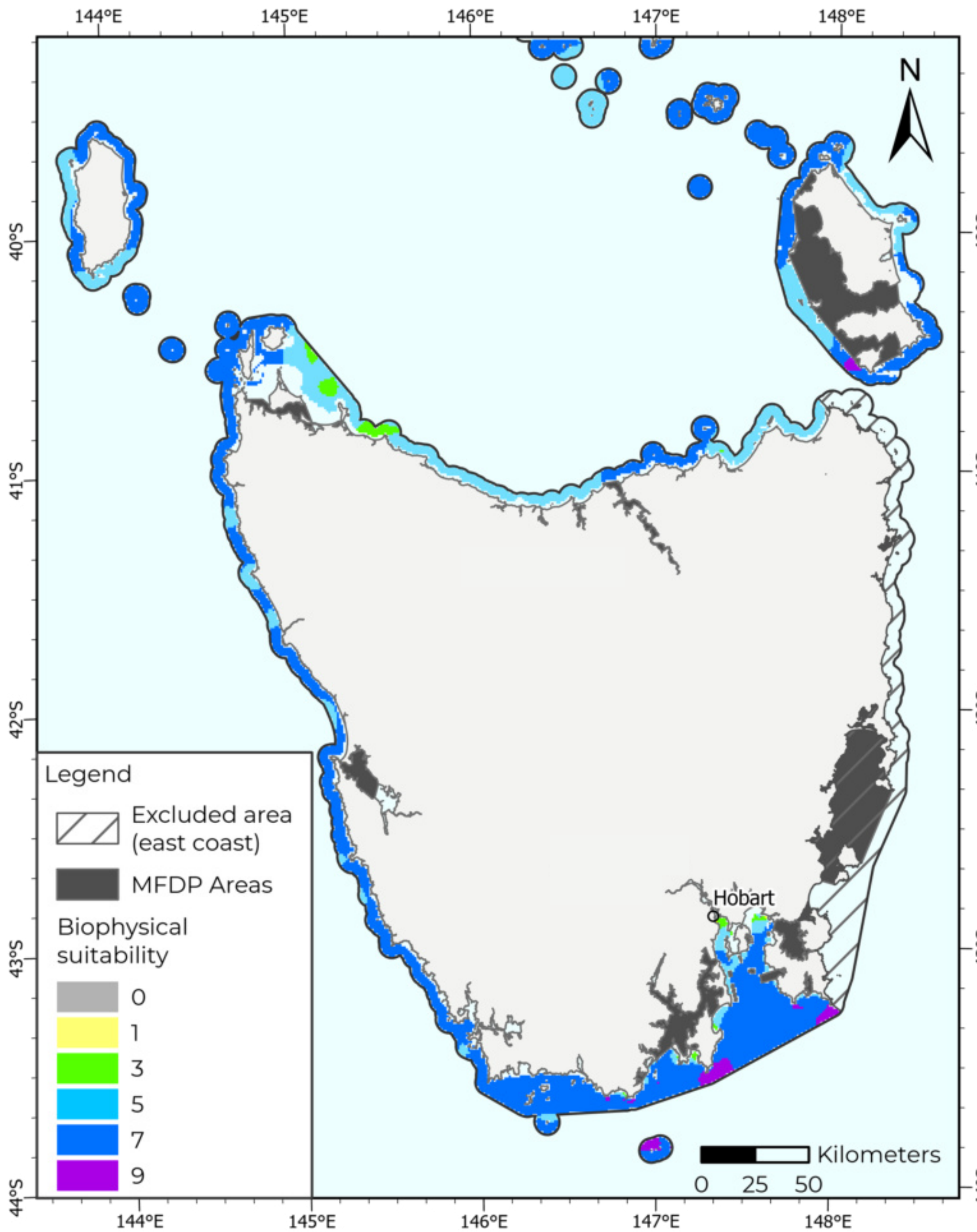
Southeast: Tasman Island to South East Cape

In the southeast, BRAN2016 current speed values were superseded by the higher-resolution CSIRO Storm Bay hydrodynamic model (model run tasseH1p2; Wild-Allen et al., 2021). Please note this model is yet un-calibrated. The model was developed by Clothilde Langlais, Mike Herzfeld and John Andrewartha at the CSIRO.

Values were extracted at ~5m below the surface and averaged over the months of January and February in 2015 and 2016. Values were gridded at 500-m horizontal resolution using bilinear interpolation, and re-sampled at 1-km horizontal resolution for the statewide assessment.

Biophysical suitability based on current speed alone is shown in **Figure 5**.

Figure 5. Biophysical suitability for potential future finfish aquaculture based on current speed where 1 is less suitable and 9 is more suitable.



Biophysical suitability based on significant wave height

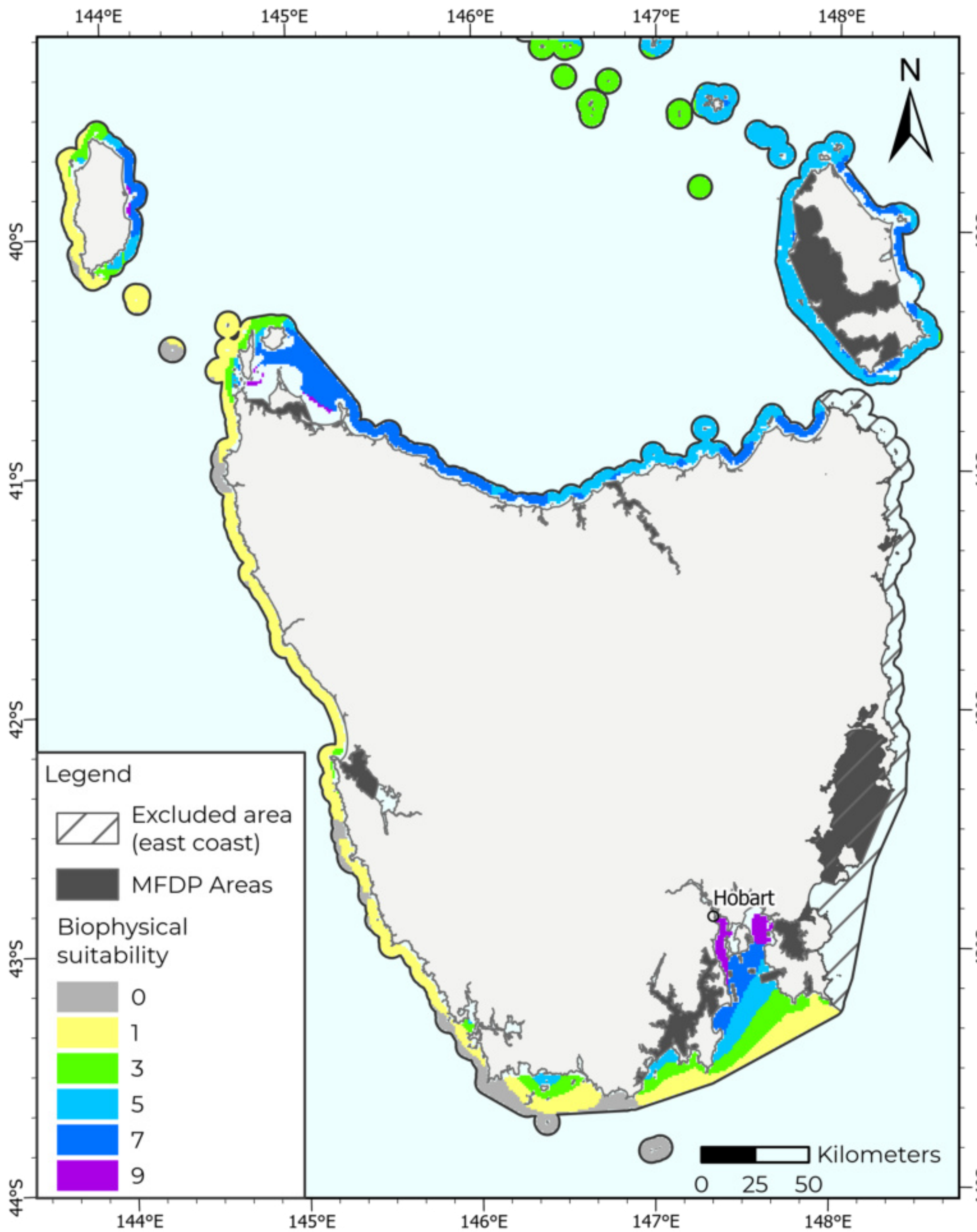
Significant wave height (m) was extracted from the Centre for Australian Weather and Climate Research (CAWCR) Wave Hindcast model (CSIRO, Bureau of Meteorology; cawcr.org.au; Durrant et al. 2014, Smith et al. 2021). The aggregated collection of hindcasts spans 1979 to present. The global model has a nested high-resolution grid covering Australian waters closest to shore at a resolution of 4 arc-minutes.

Monthly significant wave height was extracted from October 2010 to September 2020 (10-year period). Maximum significant wave height over this period was used in the statewide assessment. Values were resampled at 1-km horizontal resolution.

Maximum significant wave height was used rather than average significant wave height to reflect more extreme conditions in high-energy environments. A more detailed analysis of significant wave height over the same period could reveal windows of opportunity for operations. Such a detailed analysis was beyond the scope of this project.

Biophysical suitability based on significant wave height alone is shown in **Figure 6**.

Figure 6. Biophysical suitability for potential future finfish aquaculture based on significant wave height where 1 is less suitable and 9 is more suitable.



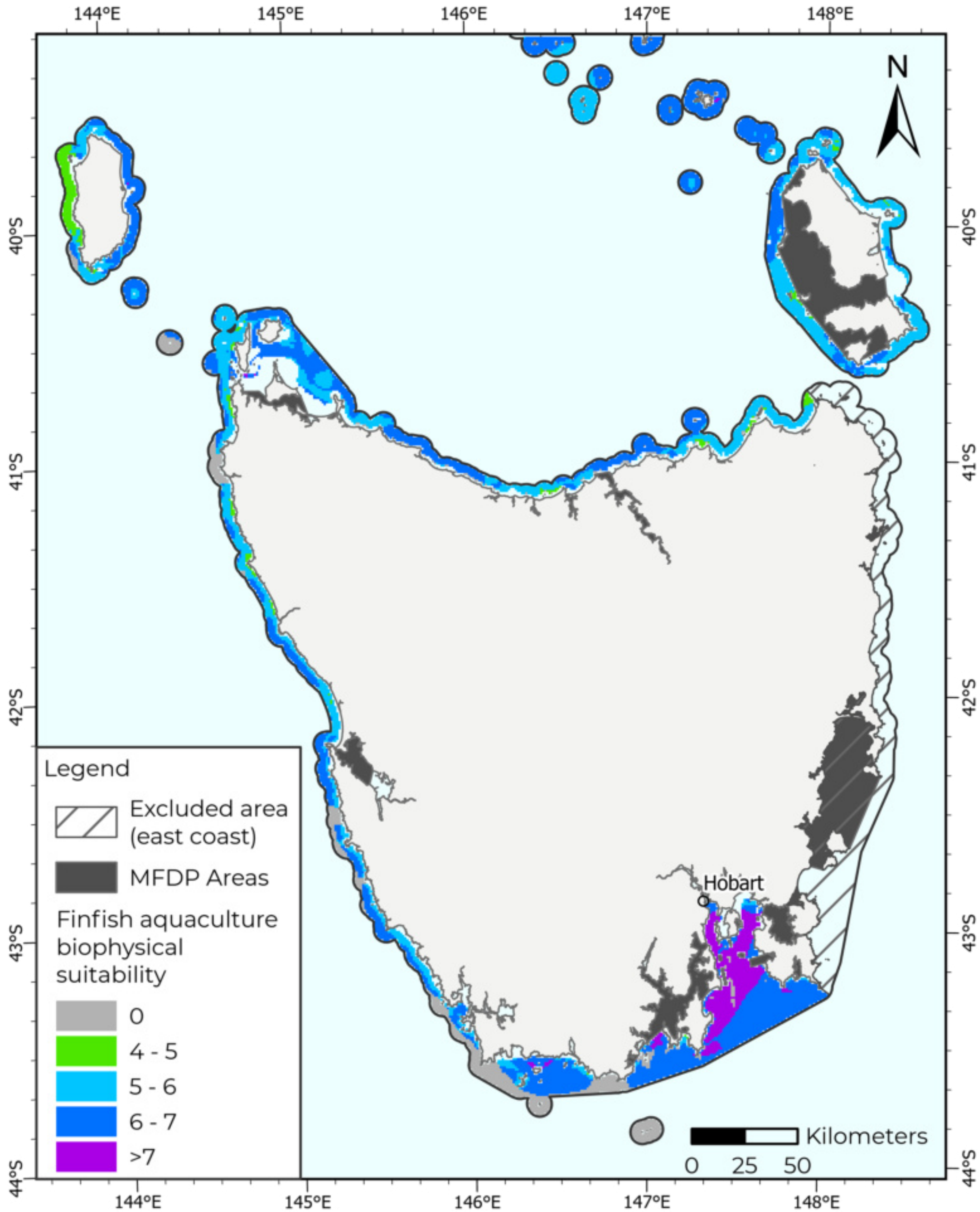
Statewide biophysical suitability for finfish aquaculture

Overall biophysical suitability was very high (above a score of 7 out of 9) and high (between 6 and 7) in the southeast of Tasmania, specifically in Storm Bay and south of the D'Entrecasteaux Channel (**Figure 7**). Spatial patterns of biophysical suitability in this region were largely driven by significant wave height (**Figure 6**), given overall very high variable-specific biophysical suitability for temperature (**Figure 3**), depth (**Figure 4**), and current speed (**Figure 5**).

The west coast of Tasmania (South East Cape to the northwest, excluding Macquarie Harbour) was less biophysically suitable for finfish aquaculture. The coast was interspersed with unsuitable areas (score of 0) due to large significant wave height (**Figure 6**). South of Macquarie Harbour, high biophysical suitability in coastal waters was present offshore at the limit of State waters. North of Macquarie Harbour, biophysical suitability was generally medium (score between 5 and 6), with sporadic areas closer to shore with relatively lower biophysical suitability (score of less than 5).

The north coast of Tasmania, including King Island and the Furneaux Group, was composed of areas of medium (score between 5 and 6) and high (score between 6 and 7) biophysical suitability. Biophysical suitability on the north coast was driven by the spatial variability of all considered variables. However, warmer water temperature on average was seemingly restricting biophysical suitability to relatively lower scores than in the southeast (**Figure 3**).

Figure 7. Biophysical suitability for potential future finfish aquaculture based on water depth, water temperature, current speed, significant wave height and substrate type (presence of reefs), where 4-5 is less suitable, >7 is more suitable and 0 is considered unsuitable.



2.3 Local areas for Stage 2

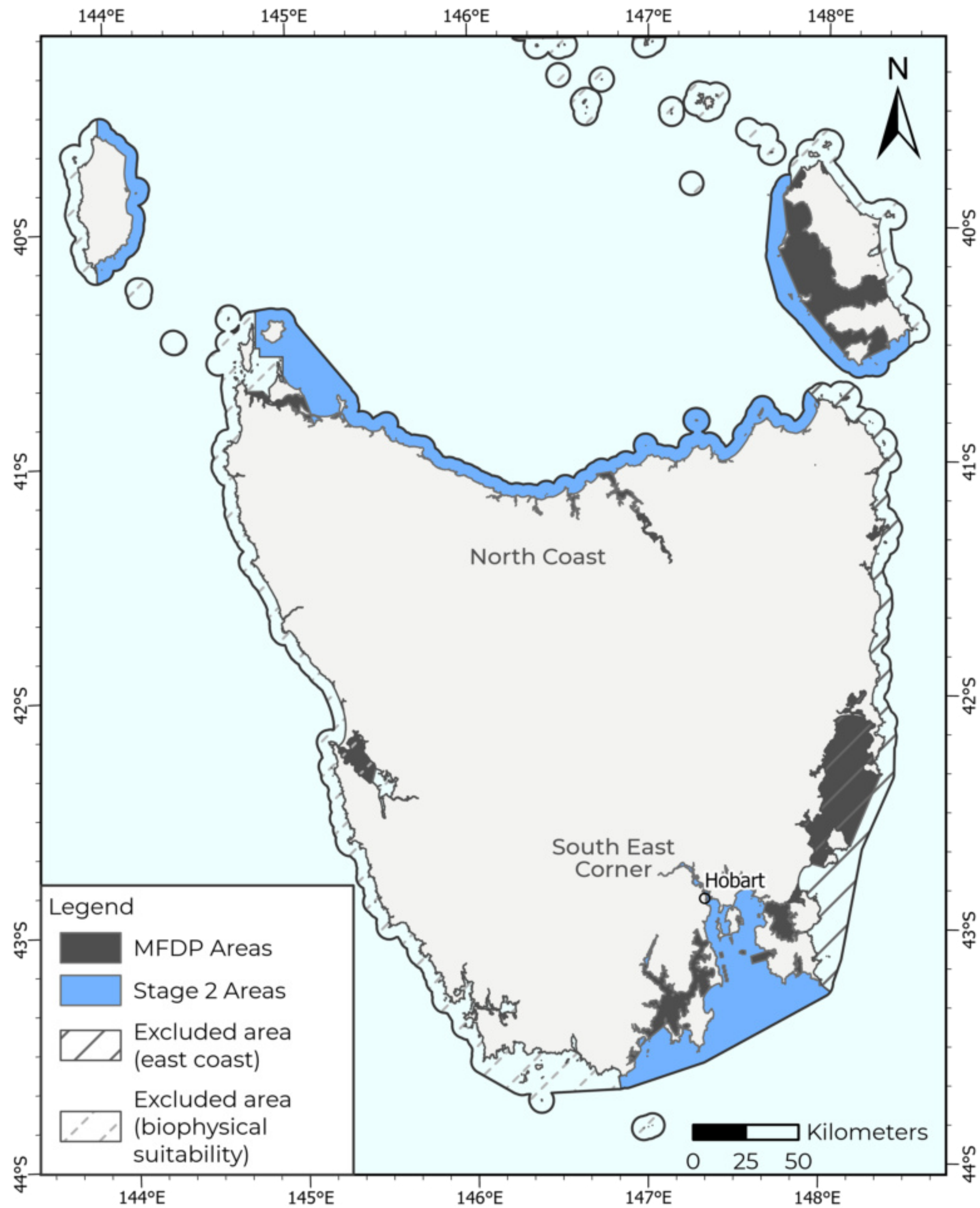
Based on the statewide assessment of biophysical suitability for finfish aquaculture from Stage 1 (**Figure 7**) together with advice from the Advisory Committee, two regions were identified for further investigation in Stage 2 (**Figure 8**). The west coast of Tasmania was not investigated further because of its overall lower biophysical suitability with a more dynamic ocean environment and advice from the Advisory Committee that finfish aquaculture is unlikely in this region in the near future.

The two regions for further investigation were considered separately in Stage 2.

Southeast Tasmania
This includes the area between South East Cape and Tasman Island, excluding existing MFDP areas (Tasman Peninsula and Norfolk Bay, Pitt Water, Pipe Clay Lagoon, Storm Bay North, Storm Bay off Trumpeter Bay North Bruny Island and D'Entrecasteaux Channel and Huon River). As in Stage 1, the area under investigation also excludes waters shallower than 10m.

The north coast of Tasmania
This includes the north coast between Three Hummock Island and Cape Portland, including west of the Furneaux Group (south of and including Flinders Island), and east of King Island. As in Stage 1, the area under investigation excludes existing MFDP areas (Tamar Estuary, Far North West, Furneaux and Port Sorell), and waters shallower than 10m.

Figure 8. Stage 2 local areas as identified from Stage 1 biophysical finfish aquaculture suitability assessment.



Stage 2
Optimization analysis: Southeast Tasmania

3.1 Southeast Tasmania

Study area

The study area in the southeast of Tasmania stretches from South East Cape to Tasman Island, including the area south of the D'Entrecasteaux Channel and Storm Bay, as well as part of the Derwent Estuary and Frederick Henry Bay (**Figure 9**).

In addition to finfish aquaculture biophysical suitability, available social, economic and environmental information was collated (summarized in **Table 3**). Information was included as activities, uses and ecological habitat, using input and review from the Advisory Committee. This information aims to be representative of the study area. However, additional relevant information may be warranted in the future, should a more detailed planning process be undertaken. The additional information included the distribution of inshore and offshore rocky reefs, and considerations on commercial fisheries, recreational activities and navigation density. Also considered was nearshore and onshore coastal development (including the presence of residential dwellings and other high human use), areas of high biological value, and geoconservation sites.

Details of all contributing data and associated figures for the area of interest in the southeast of Tasmania are presented in **Section 3.2**.

Finfish aquaculture biophysical suitability

Biophysical suitability for finfish aquaculture, based on Stage 1 outputs, is generally very high (score > 7 out of 9) in the southeast of Tasmania (**Figure 10**). This is due to relatively colder water temperature in the area relative to other regions. This area of 'very high' biophysical suitability is bordered offshore by a region of 'high' biophysical suitability (score between 6 and 7) due to increased ocean energy (**Figure 6**) restricting overall biophysical suitability for finfish aquaculture.

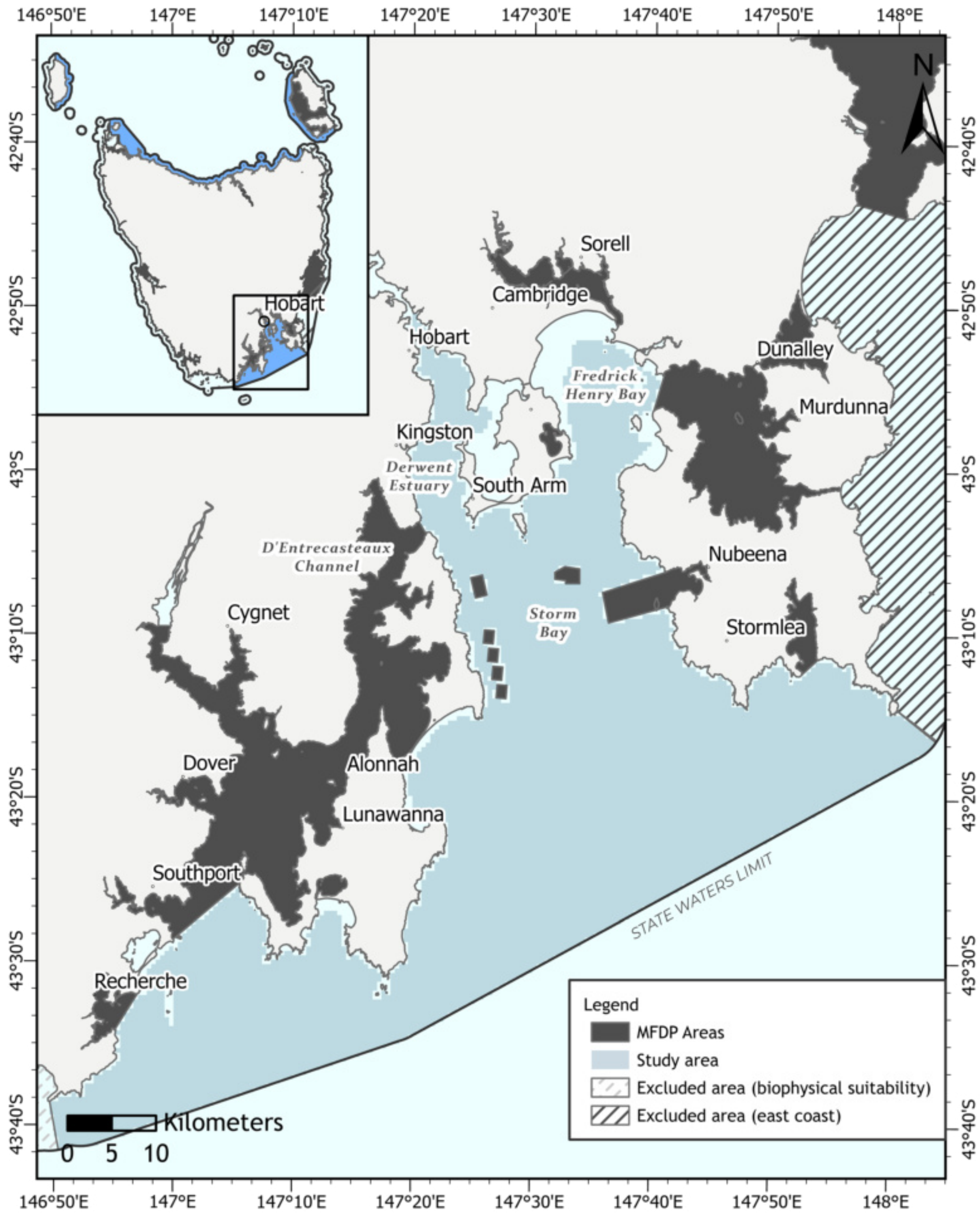


Figure 9. Study area in the southeast of Tasmania. The study area extends from South East Cape to Tasman Island.

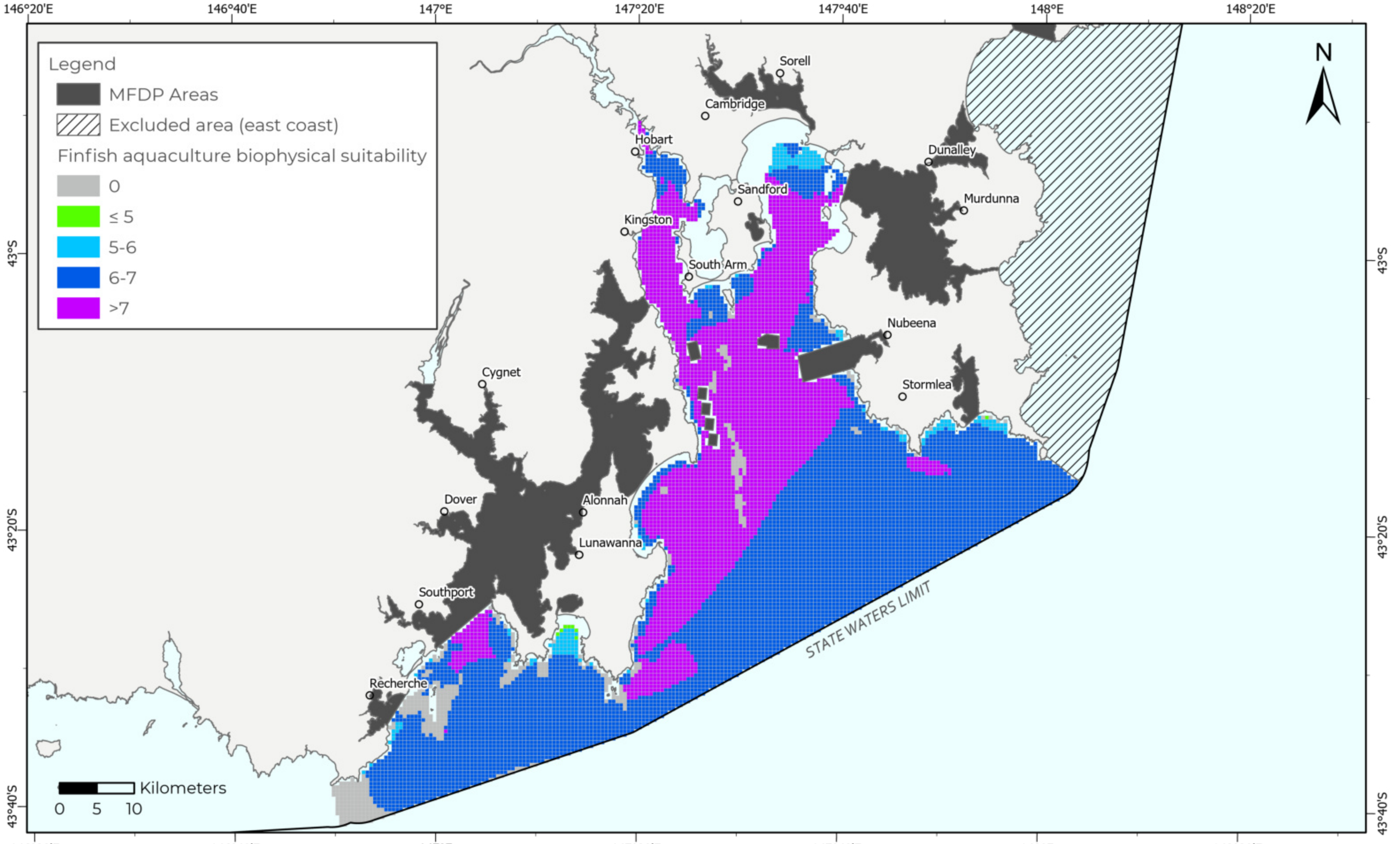


Figure 10. Finfish aquaculture biophysical suitability in the southeast of Tasmania with horizontal units at a resolution of 500m x 500m. The region west of South East Cape is not considered.

Table 3. Supporting data identified to provide information for marine uses, activities and areas of high ecological value in the southeast of Tasmania.

	Finfish aquaculture biophysical suitability	Social	Economic	Environment
Current speed	X			
Water temperature	X			
Depth	X			
Significant wave height	X			
Substrate (rocky reef)	X	X	X	X
Commercial scalefish – (Area in ES01 Derwent Estuary + Other area in Storm Bay)			X	
Distance from coastal access points (boat ramps)		X		
High navigation density corridor		X	X	
Moorings and popular anchorages		X	X	
Distance to residential dwellings		X		
Distance to high human use value areas		X		
Existing geoconservation sites (marine only)				X
Distance to high biological value areas				X

3.2 Social, economic and environmental values

3.2.1 Rocky reefs

Temperate rocky reefs in Tasmania hold social, economic and environmental value, being considered key marine ecosystems (White et al., 2021). In this project, areas over mapped reefs were considered unsuitable for finfish aquaculture (see **Section 2.2**). However, given the relative importance of reefs, buffered areas around them may also be considered to reduce the potential for detrimental ecological impacts to reefs and/or conflict with other ocean users.

Rocky reefs are a diving and snorkeling attraction, and support recreational fisheries in the southeast of Tasmania. Reefs host a diversity of fishes, invertebrates and macroalgae. They are key habitat for several species of commercial and recreational importance, such as southern rock lobster, abalone and some scalefish species, and generally hold high ecological value.

Some areas of rocky reef are particularly important for some commercial fisheries. In particular, the Actaeon reef complex (south of the D'Entrecasteaux Channel and west of Recherche Bay) is a highly productive habitat for abalone (Mundy and McAllister 2020). Similarly, the area in the vicinity of the Friars Islands is important for southern rock lobster and as a recreational fishing hotspot (Hartmann et al. 2019; personal communications).

The distribution of reefs was extracted from Seamap Tasmania (Barrett et al. 2001; available on LISTmap). In addition to Seamap Tasmania, the distribution of offshore deep reefs in Storm Bay was delineated using high-resolution multibeam data collected by IMAS in 2020 and 2021 (unpublished data).

Several options to delineate buffered areas around rocky reefs were considered in this project (**Figure 11**). A buffer of 500-m to 1000-m was considered around all rocky reefs, with the possibility of a 5-km buffered area around important rocky reefs, i.e. the Actaeon reef complex and the area in the vicinity of the Friars.

3.2.2 Commercial scalefish fisheries

Commercial scalefish catch data from the Tasmanian Scalefish Fishery Assessment over the previous five quota years (2015/16 to 2019/20) was used in this assessment (Krueck et al., 2020).

Areas of importance for commercial scalefish species primarily associated with rocky reefs were included when considering buffers around rocky reefs. This includes species such as the banded morwong, the bluethroat wrasse and purple wrasse. Scalefish species not exclusively associated with rocky reefs (herein referred to as 'non-reef species') are also fished in the southeast of Tasmania. Effort is spatially distributed. However, two areas of importance where catch is relatively higher were identified as part of this process.

Highest total catch per non-reef species in the southeast of Tasmania was the eastern school whitting (*Sillago flindersi*). This species is caught with Danish seine and in southeast Tasmania most of the catch occurs in a specific area at the mouth of the Derwent River (fishing block ES01). For more information, see 'Danish Seine Fishing Areas' at dpipwe.tas.gov.au. The area was digitized based on the description in the fishing license endorsement (**Figure 12**).

Another important commercial species in the southeast of Tasmania was the tiger flathead (*Platycephalus richardsoni*). The tiger flathead is the dominant species of flathead in commercial fisheries and is caught with Danish seine (Krueck et al. 2020). Based on information provided by DPIPWE (unpublished data), most of the catch occured in an area that could be delineated with available information. This area was therefore digitized based on this information and included in the analysis. However, because of commercial sensitivity, it is not displayed in this report.

Other scalefish species are commercially caught in the southeast of Tasmania, but specific areas of importance were not identified as part of this process. Similarly, areas of importance for multiple species were not identified.

3.2.3 Recreational use

Distance from boat ramps was used as a proxy for recreational use in this project, the assumption being that - with some exceptions - most recreational activities would occur in proximity of a point of coastal access.

The locations of 26 boat ramps in the southeast of Tasmania were extracted from LISTmap. Boat ramps outside of the study area were also included because of their potential influence in the study area.

The level of use for each boat ramp was determined based on the expert advice of the Advisory Committee. Scores from 1 to 10 reflecting use were tagged to each boat ramp. Twelve 'high-use' boat ramps (here defined as a score above 8) were identified: Margate, Southport, Adventure Bay (2), Cremorne, Dodges Ferry, Gypsy Bay, and Nubeena (3). Also added were Sandy Bay and Bellerive in the Derwent Estuary.

Two options of buffered areas (travel distance) are used in this exercise (**Figure 13**). The first option is a 1-km buffered area around all boat ramps. The second option is a 10-km buffered area around 'high-use' boat ramps and all others with a 1-km buffered area.

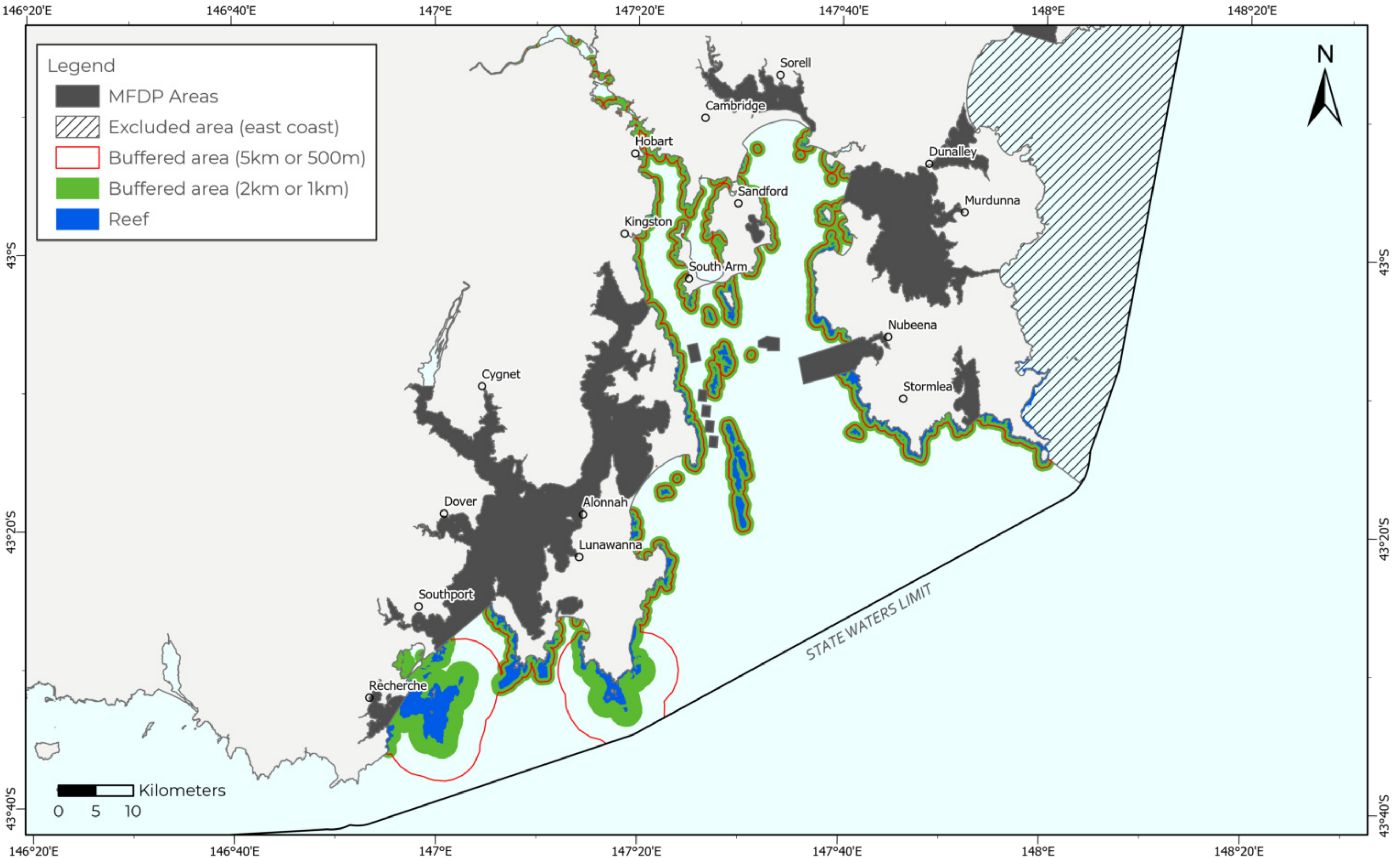


Figure 11. Distribution of mapped rocky reef habitat in the southeast of Tasmania with suggested buffered areas. Options included in scenarios include: option 1: a 5-km buffer around the Actaeon and Friars, and 500-m buffer around all other reefs; option 2: a 2-km buffer around Actaeon and Friars and 1-km around all other reefs; option 3: 5-km around Actaeon and Friars and 1-km around all other reefs. The region west of South East Cape is not considered.

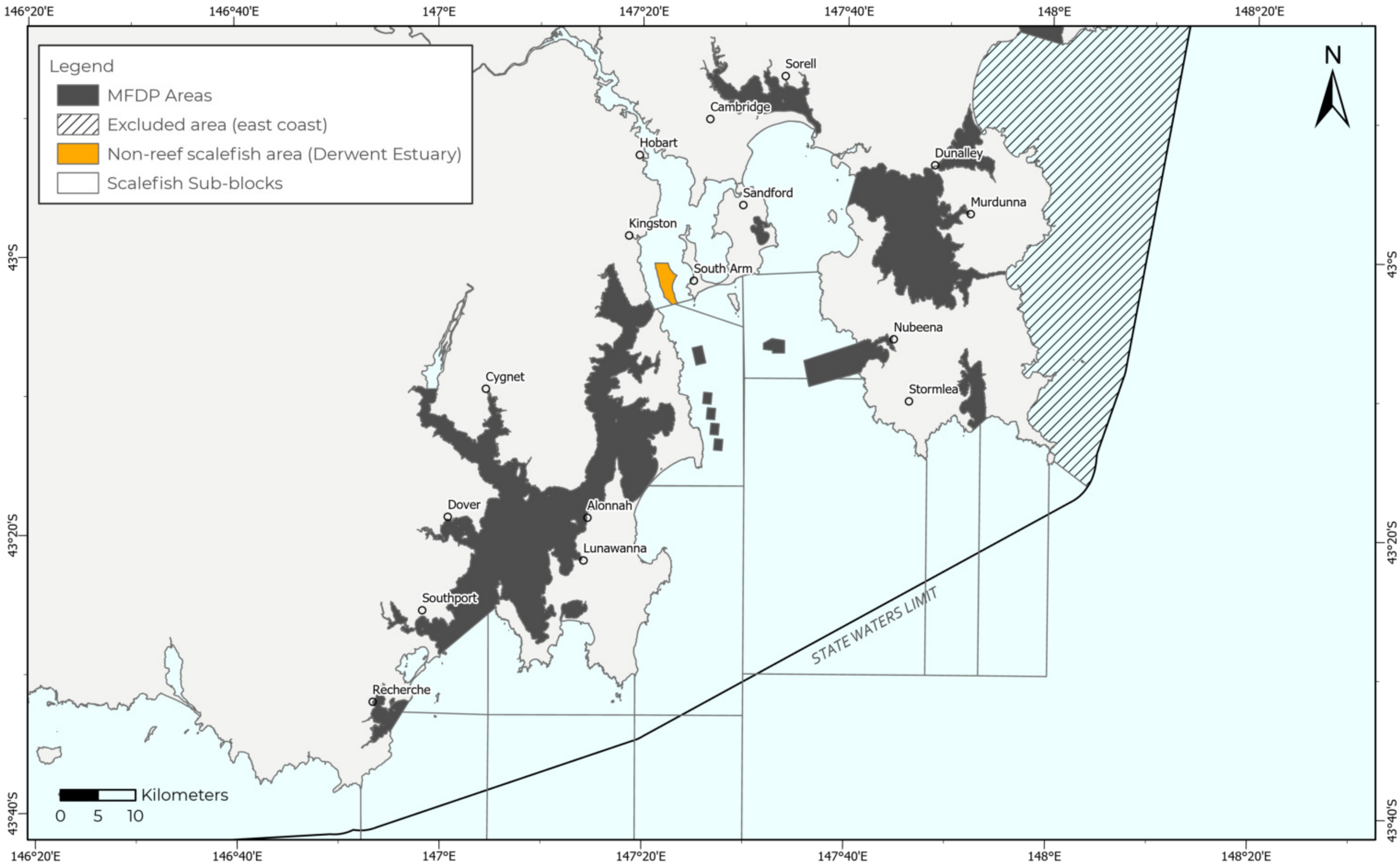


Figure 12. Identified area of importance for commercial non-reef scalefish fisheries in the southeast of Tasmania area of interest. The region west of South East Cape is not considered. A second area was included in the analysis but not shown due to commercial sensitivity.

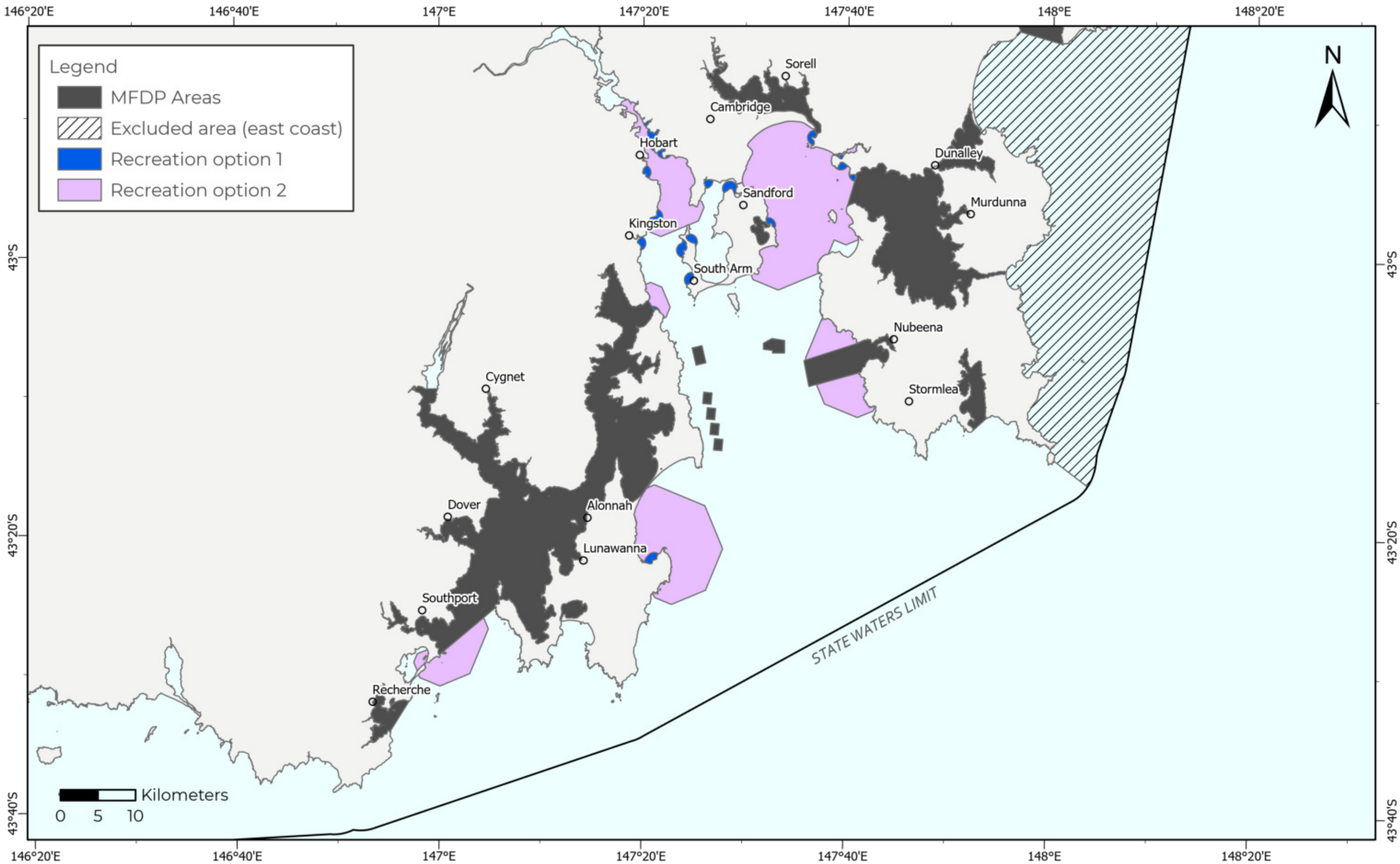


Figure 13. Areas of importance for recreational use (defined by buffered areas around boat ramps) in the southeast of Tasmania. Buffer option 1: a 1-km buffered area around all identified boat ramps; Buffer option 2: a 10-km buffer around 'high use' boat ramps and a 1-km buffer around all other boat ramps. The region west of South East Cape is not considered.

3.2.4 Other socio-economic uses

Navigation

Areas of high-density navigation were digitized from Automatic Identification System (AIS) information available on marinetraffic.com. While navigation occurs broadly in the southeast of Tasmania for commercial and recreational purposes, certain paths are clearly more in use. These included dense navigation in the Derwent Estuary, and corridors connecting the Derwent Estuary to to the tip of the Tasman Peninsula, crossing Storm Bay, and to Frederick Henry Bay, via the waters north of Betsey Island. Areas of high density navigation were expressed as full grid cells matching the grid of horizontal units (**Figure 14**).

Moorings and anchorages

Locations of registered moorings were obtained from Marine and Safety Tasmania (MAST) and information on additional popular anchorages was digitized from MAST (unpublished data). Registered moorings are mostly located in the Derwent River in the vicinity of Hobart, with additional ones in Frederick Henry Bay and Adventure Bay. Anchorages are located along north Bruny Island in Storm Bay. A buffered area of 1 km from moorings and anchorages was delineated from the point locations to include in the analysis (**Figure 14**).

Distance from residential dwellings

Locations of buildings (as points) were extracted from LISTmap for each Local Government Area with a coastal connection to the study area. Points identified as 'Residential Dwellings' were extracted from this dataset, focusing on buildings within 1 km of the coast.

A buffered area of 1 km from residential dwellings was delineated for the analysis (**Figure 14**). The 1-km limit was derived from the methodology of Ross et al. (2020), as suggested by sound specialists at the Environmental Protection Authority (EPA) as suitable buffer between residences and new finfish aquaculture development.

Foreshore human use

The value, condition and pressures on the foreshore in the southeast of Tasmania was described along 100-m segments using existing datasets, expert consultation, inferred data and aerial images ('Foreshore' project; Migus, 2008). The level of human use along the coast was a product of this project. Human use in this context refers to areas relatively more frequently used based on amenities along the foreshore, recreation and tourism, land classification and (non-Indigenous) cultural heritage. The layer does not necessarily equate to cultural value, for example the aesthetic or preferrence communities may place on certain areas.

Coastal segments labelled as 'high human use' were extracted from this dataset. A 2-km buffered area around the segments was delineated to be included in analyses.

3.2.5 Areas of conservation interest

Geoconservation sites

Geoconservation sites were extracted from LISTmap, focusing only on sites occurring in the marine environment (**Figure 15**). In the study area, this includes the vicinity of Southport Lagoon, the nearshore environment of Frederick Henry Bay, the southern portion of Ralphs Bay and the lower Derwent River.

Foreshore biological value

The biological value of the foreshore was assessed along 100-m coastal segments in the Foreshore project (Migus, 2008) based on the presence of significant species and habitat, areas directly adjacent to protected areas and introduced marine species or coastal weeds.

Coastal segments identified as 'high biological value' were extracted from this dataset. A 1-km buffered area around the segments was delineated to be included in the analysis (**Figure 15**).

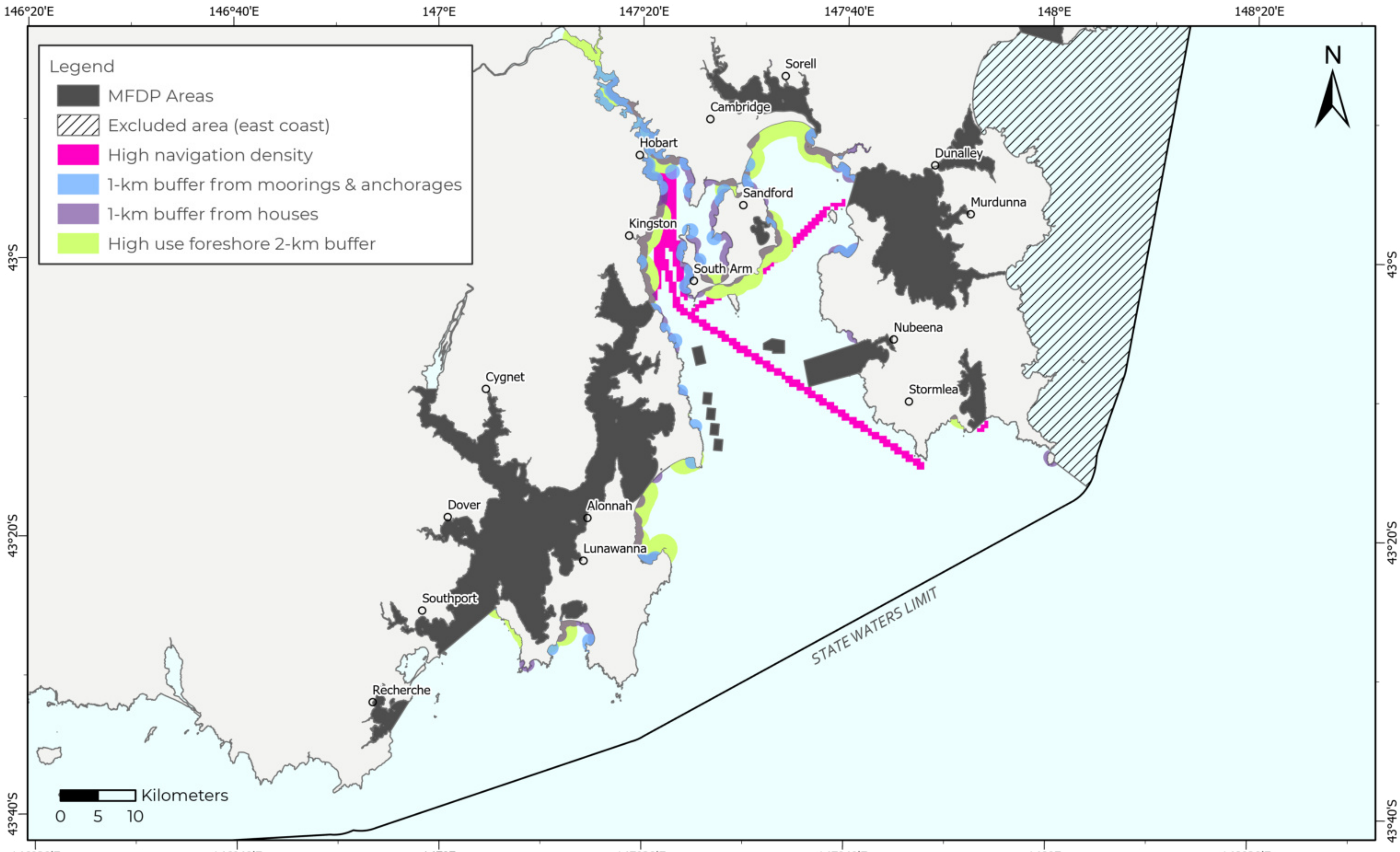


Figure 14. Important areas identifed for other socio-economic uses in the southeast of Tasmania. The region west of South East Cape is not considered.

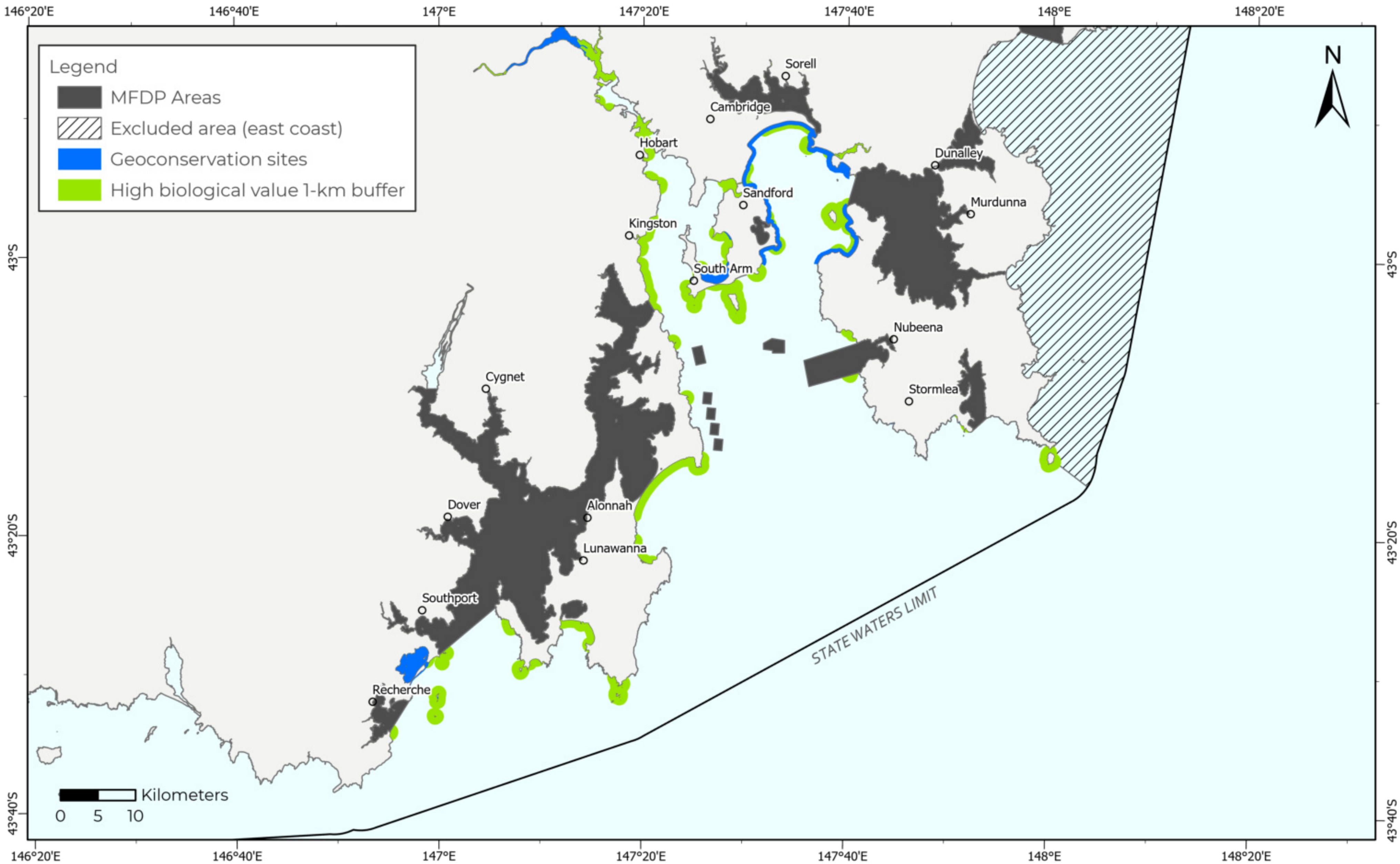


Figure 15. Geoconservation sites and 1-km buffered area around foreshore areas of high biological value. The region west of South East Cape is not considered.

3.3 Marxan with Zones scenarios

To explore various configurations for potential future finfish aquaculture within the southeast of Tasmania, four hypothetical scenarios were developed in agreement with the Advisory Committee for the software Marxan with Zones (**Box 5**). **Table 4** outlines the information used in each scenario, together with qualitative and quantitative goals (targets) for each marine use as applied in different scenarios.

The scenarios aim to define the distribution of three contiguous areas ('zones' in the software Marxan with Zones). The first two Marxan zones target different scores of biophysical suitability for finfish aquaculture, whereas 'very high' refers to overall finfish aquaculture biophysical suitability scores of > 7 (out of 9) and 'high' refers to overall finfish aquaculture biophysical suitability scores between 6 and 7 (out of 9). The third Marxan zone labelled 'other uses' encompasses all other uses and values (social, economic, environmental), making no attempt to refine the allocation of space to individual uses or values. This is because the focus of this project is to support sector-based spatial planning, rather than a more comprehensive marine spatial planning process where the delineation of these other uses and values would be warranted.

The scenarios were designed to illustrate trade-offs when altering assumptions underlying the spatial footprint of given activities and values. The focus is on buffered areas around rocky reefs and coastal access points (the latter as an indication of recreational use), and the extent of commercial non-reef scalefish fishing areas. Other socio-economic and environmental values are constant among scenarios.

Quantitative targets for finfish aquaculture were set prior to the analysis but adjusted during the analysis to ensure all horizontal units were assigned to a zone, where possible, while ensuring they did not compromise meeting quantitative targets for other uses.

Box 5. Hypothetical scenarios implemented in the software Marxan with Zones

In line with the project objectives, the following scenarios were defined for the southeast of Tasmania with the input and review of the Advisory Committee

Scenario 1 -- Baseline
Quantitative targets aim to reflect equal importance to finfish aquaculture and other marine uses. In this scenario, buffered areas around coastal access points extend to 1 km, while buffered areas around rocky reefs vary from 1 km for most reefs to 2 km for reefs of high importance. Out of the two identified commercial (non-reef) scalefish areas, only the one in the Derwent Estuary is included.

Scenario 2 -- Commercial fishing
In this scenario, more importance has been placed on areas of importance for commercial fishing. This includes a wider (5-km) buffered area around the Actaeon and the Friars Island (high importance for abalone and rock lobster fisheries), while minizing buffers around other reefs (500 m). It also includes the other area of importance for (non-reef) scalefish fisheries (based on information on tiger flathead catch).

Scenario 3 -- Recreation and conservation
In this scenario, more importance has been placed on recreational use and conservation by using a wider buffer (10-km) around 'high-use' points of coastal access. As in Scenario 1 ('baseline'), all reefs have a minimum buffered area of 1 km, with a wider 2-km buffered area around reefs of high importance

Scenario 4 -- All other marine uses
This scenario is a composite of Scenarios 2 and 3 and maximum importance is given to other marine uses. This scenario takes into account conservation, recreational use and commercial fishing by including: a wide (5-km) buffered area around the Acteaon and Friars Islands (and 500-m buffered areas around all other reefs), both areas of importance for non-reef scalefish fisheries, and wide (10-km) buffered area around 'high-use' points

Outcomes of individual scenarios are presented in **Figures 16-19**. A synthesis of all four scenarios is presented in **Figure 20**. The synthesis presents five types of contiguous areas. Three types indicate systematic assignment of horizontal units to finfish aquaculture (either 'very high' or 'high' biophysical suitability), or other uses (4 scenarios out of 4). A fourth type indicates where horizontal units were assigned 'finfish aquaculture' (either 'high' or 'very high' biophysical suitability) in 2 out of 4 scenarios, indicating uncertainty and potential for trade-off with other uses and values. A small area south of South East Cape was left unassigned during the analysis, i.e., the area was considered unsuitable for finfish aquaculture based on biophysical suitability and no other uses were identified in the area.

Table 4. Qualitative objectives and quantitative targets (%) used in the four scenarios implemented in the software Marxan with Zones (**Box 5**) for the southeast of Tasmania.

Marxan Zones	Data	Qualitative objectives	Quantitative targets			
			Scenario 1 'Baseline'	Scenario 2 'Commercial fishing'	Scenario 3 'Recreation and conservation'	Scenario 4 'All other marine uses'
Finfish aquaculture (very high biophysical suitability) **Finfish aquaculture (high biophysical suitability)**	Finfish aquaculture biophysical suitability (Stage 1)	Develop finfish aquaculture in biophysically suitable areas	Initial target: 60% of both very high biophysical suitability (score > 7) and high biophysical suitability (score between 6 and 7) Actual proportion of area assigned to finfish aquaculture varied during analyses between 50 and 85% depending on quantitative targets of other uses being met. Actual targets reached are inserted in captions of Figures 16-19.			
Other uses	Rocky reefs	Decrease the possibility of detrimental impacts to rocky reefs as habitat of significant commercial, recreational and conservation value	90%: 2-km buffered area around the Actaeon/Friars and 1-km buffered area around all other reefs	90%: 5-km buffered area around the Actaeon/Friars and 500-m buffered area around all other reefs	90%: 2-km buffered area around the Actaeon/Friars and 1-km buffered area around all other reefs	90%: 5-km buffered area around the Actaeon/Friars and 1-km buffered area around all other reefs
	Commercial (non-reef) scalefish – Derwent Estuary area	Maintain existing commercial fisheries	100% of area			
	Commercial (non-reef) scalefish – Tiger Flathead area	Maintain existing commercial fisheries	Not included	60% of area	Not included	60% of area
	Distance from coastal access points (boat ramps)	Maintain recreational marine areas (e.g., boating, fishing, diving)	90% of 1-km buffered area around boat ramps		90% :10-km (travel) buffered area around high-use boat ramps and 1-km buffered area around all other boat ramps	
	High navigation density	Maintain existing navigation channels for safe navigation by all marine users	100% of existing areas of high-density navigation			
	Registered moorings and popular anchorages	Maintain existing moorings and popular anchorage areas	90% of 1-km buffered area around registered moorings and popular anchorages			
	Distance to residential dwellings	Minimise noise and light pollution to residents	90% of 1-km buffered area around residential dwellings located within 1 km of the coast			
	Distance to high human use value area along the foreshore	Maintain identified high human use value areas	90%: 2-km buffered area around high human use foreshore areas			
	Existing (marine) geoconservation sites	Conserve environmentally significant areas	100% of (marine) geoconservation sites			
	Distance to high biological value areas along the foreshore	Decrease the possibility of detrimental impacts to environmentally significant areas	90% of 1-km buffered area around high biological value foreshore areas			

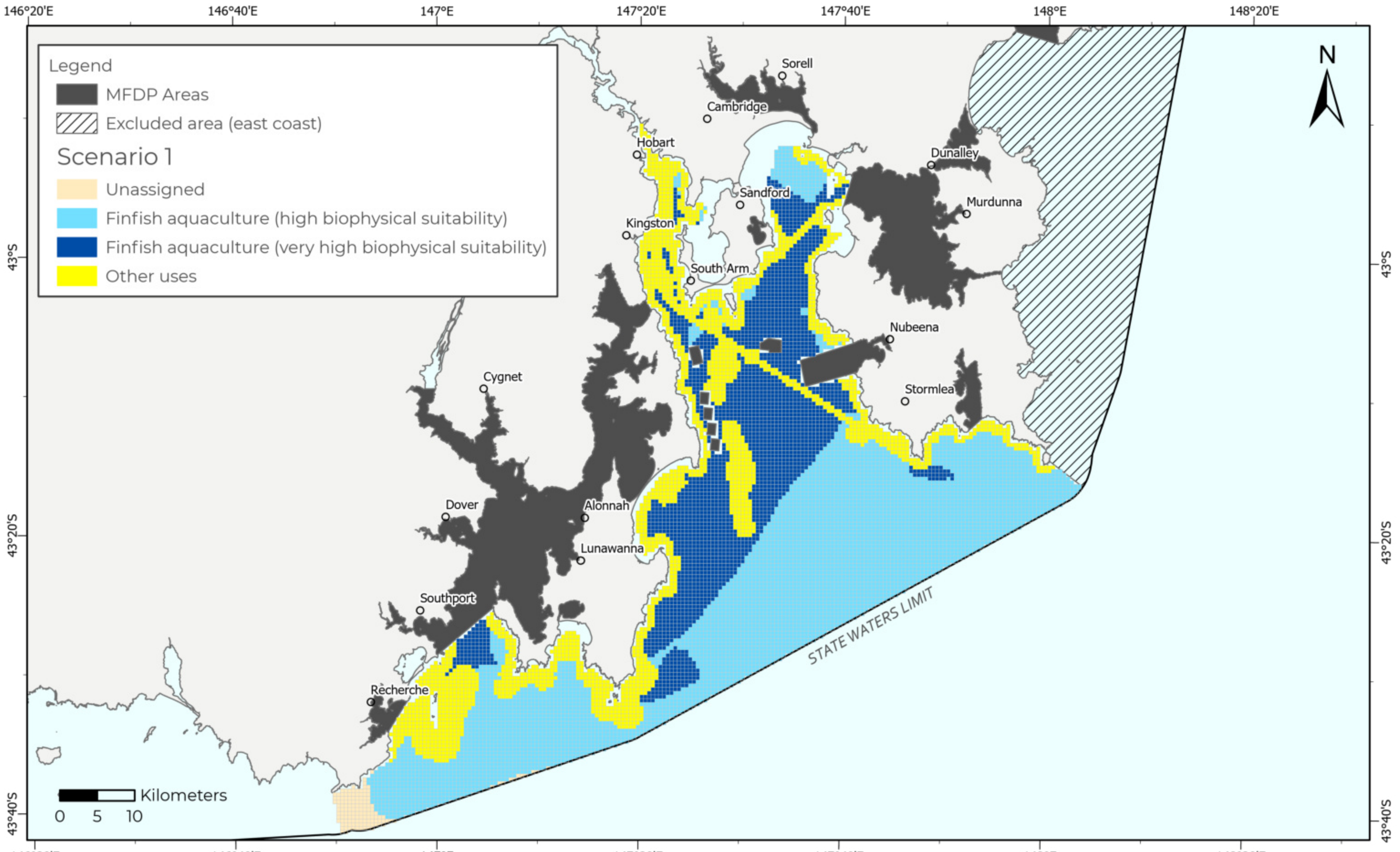


Figure 16. Output of Scenario 1 implemented in the software Marxan with Zones in the southeast of Tasmania. This scenario is considered a 'baseline' aiming to provide equal importance to finfish aquaculture and maintaining existing uses, activities and areas of high ecological value. Quantitative targets achieved for finfish aquaculture are 70% and 85% for high and very high biophysical suitability, respectively (see **Table 4**).

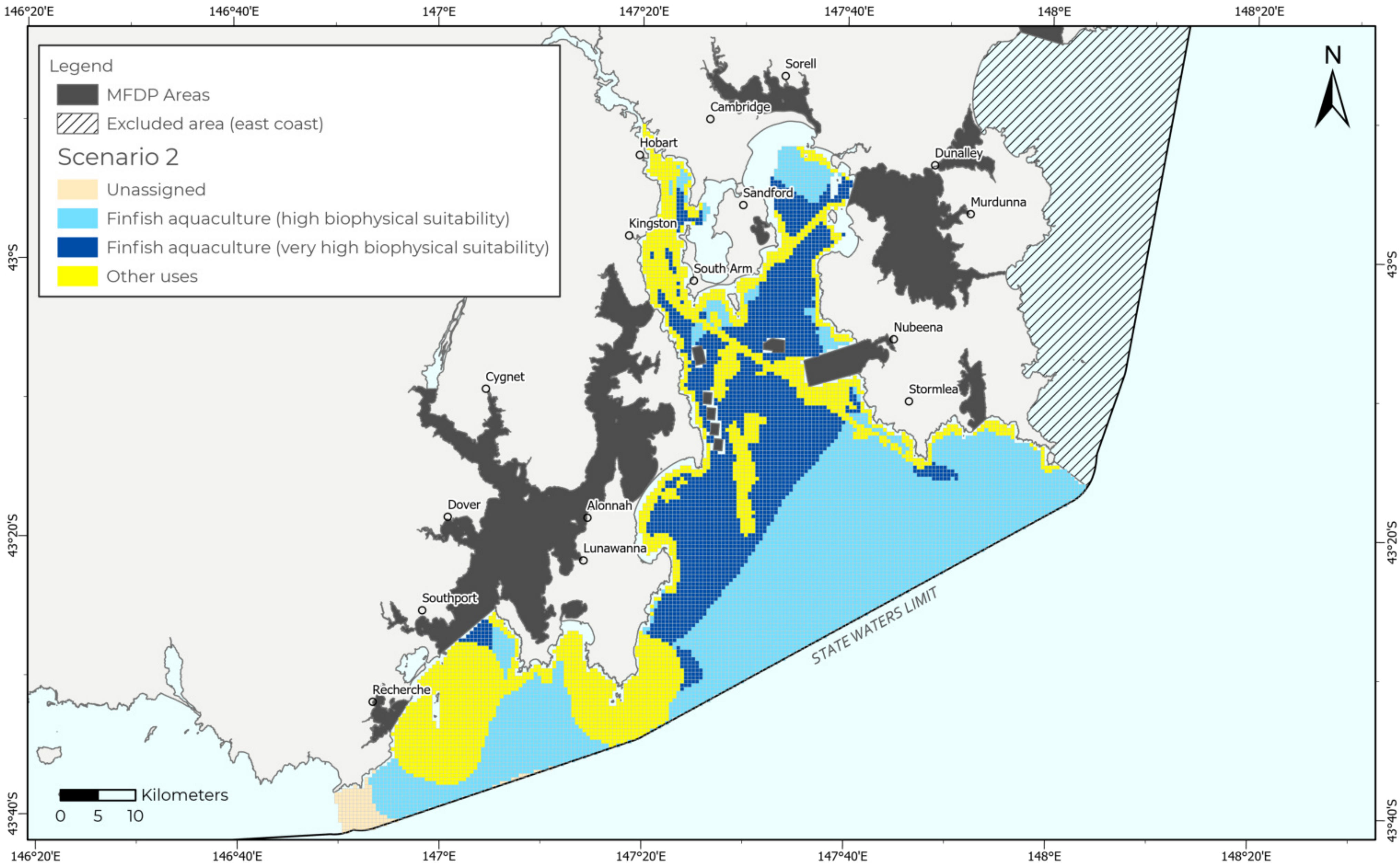


Figure 17. Output of Scenario 2 implemented in the software Marxan with Zones in the southeast of Tasmania. This scenario places greater emphasis on commercial fishing by extending the buffered area around some rocky reefs of high importance, and including an additional (non-reef) commercial scalefish fishing area. Quantitative targets achieved for finfish aquaculture are 65% and 80% for high and very high biophysical suitability, respectively (see **Table 4**).

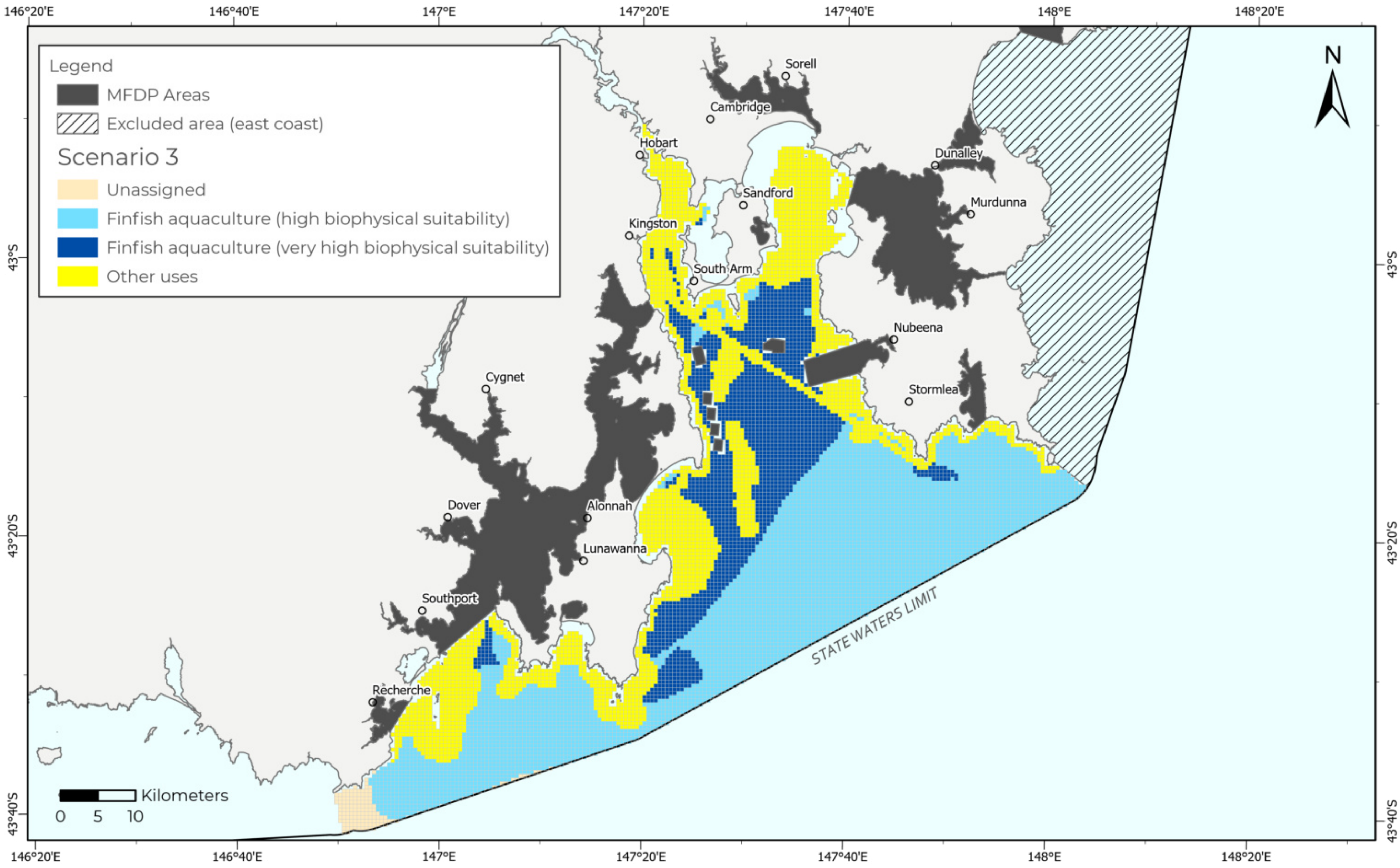


Figure 18. Output of Scenario 3 implemented in the software Marxan with Zones in the southeast of Tasmania. This scenario puts greater emphasis on recreational use, by considering 10-km buffered areas around high-use boat ramps, and conservation with a minimum 1-km buffered area is included around all rocky reefs. Quantitative targets achieved for finfish aquaculture are 55% and 85% for high and very high biophysical suitability, respectively (see **Table 4**).

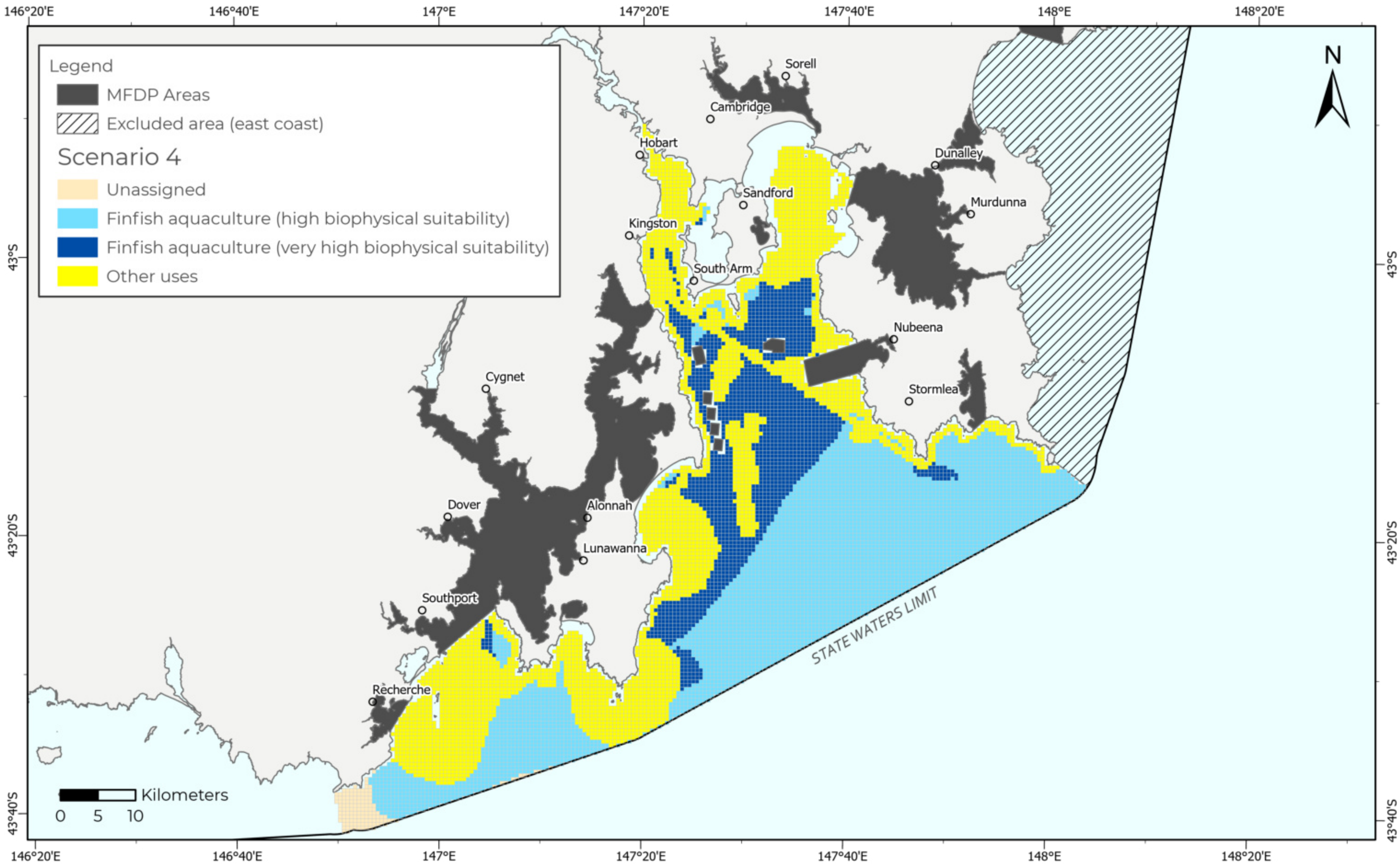


Figure 19. Output of Scenario 4 implemented in the software Marxan with Zones in the southeast of Tasmania. This scenario puts greater emphasis on all other marine uses, activities and areas of high ecological value, rather than finfish aquaculture. Quantitative targets achieved for finfish aquaculture are 50% and 75% for high and very high biophysical suitability, respectively (see **Table 4**).

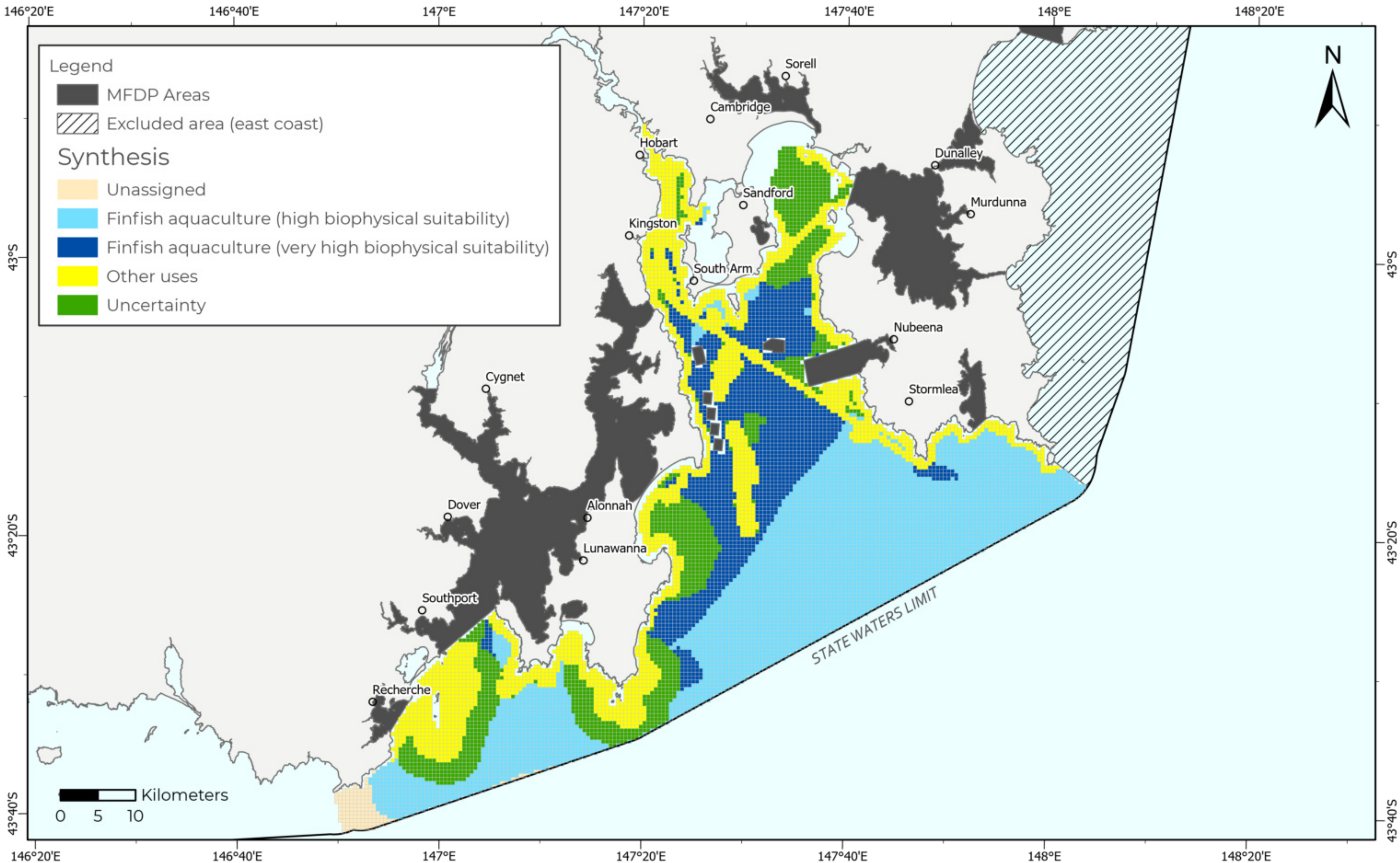


Figure 20. Synthesis of the four hypothetical scenarios implemented in the software Marxan with Zones in the southeast of Tasmania. Labels according to **Table 4** (Marxan zones) indicate consistent assignment across all four scenarios. Areas of uncertainty are indicated in green, whereas the software Marxan with Zones assigned these areas to finfish aquaculture (based on either high or very high biophysical suitability) in two out of four scenarios.

3.4 Potential for finfish aquaculture in the southeast of Tasmania

Horizontal units assigned to finfish aquaculture were overall located offshore in the southeast of Tasmania (**Figures 16-20**). The area based on 'very high' finfish aquaculture biophysical suitability was located primarily in the northern portion of Storm Bay, limited to the northwest by the Derwent Estuary and to the northeast by Frederick Henry Bay. The southern boundary of this area extended from south of Wedge Island to the tip of South Bruny Island. Offshore of this area at the mouth of Storm Bay, most horizontal units were assigned as 'finfish aquaculture' (based on biophysical suitability scores between 6 and 7) because of limited apparent conflict with other ocean uses.

The area south of the D'Entrecasteaux Channel is influenced by the presence of the Actaeon reef complex where large buffered areas restrict the potential for finfish aquaculture (Scenarios 2 and 4, **Figures 17, 19**). A similar pattern occurs south of South Bruny Island in the area around the Friars. A limited area could be available however for finfish aquaculture, between the Actaeon and South Bruny Island, and further offshore (**Figure 20**).

Generally, most of the Derwent Estuary is consistently assigned to other uses across all four scenarios. This is because of the dense existing uses in the area, especially navigation density and buffered areas around residential dwellings (high population density near the state capital Hobart), registered moorings, high foreshore human use and popular boat ramps in Sandy Bay and Bellerive (**Figures 13, 14**). This is augmented by the commercial (non-reef) scalefish area for eastern school whiting at the mouth of the Derwent Estuary (**Figure 12**).

In contrast, horizontal units in Frederick Henry Bay are assigned to other uses when considering wide buffered areas around popular boat ramps, reflecting the potential for recreational use in the area (**Figures 18, 19**). When recreational use is not emphasized, horizontal units are assigned to finfish aquaculture, with a combination of 'high' to 'very high' biophysical suitability being mostly limited by water temperature (**Figures 10, 16, 17**).

The area surrounding Adventure Bay connecting North and South Bruny Islands was overall assigned to other uses close to shore. Similar to Frederick Henry Bay, areas offshore are mostly dependent on the extent of the potential for recreational use through a wider buffered area (**Figures 18-20**).

Most of eastern Storm Bay straddling the Tasman Peninsula are assigned to other uses, with some uncertainty surrounding the existing Tasman Peninsula and Norfolk Bay Marine Farming Development Plan area (**Figures 12, 17, 19**).

Stage 2
Optimization analysis: North coast

4.1 North coast of Tasmania

Study area

The study area on the north coast of Tasmania extends from Three Hummock Island to Cape Portland, and includes the south and west of the Furneaux Group and the east of King Island (**Figure 21**). The area excludes existing Marine Farming Development Plans and focuses on water depth >10 meters within State waters. The area surrounding Hunter and Robbins Islands, west of Stanley, is excluded because of shallow depths in this region.

Because of the large spatial extent, the resolution of available data and the focus on the region as a whole, the resolution and grid of the horizontal units is the same as in Stage 1 (1 km x 1 km).

In addition to finfish aquaculture biophysical suitability, available information on social, economic and environmental values was collated (summarized in **Table 5**). Values were included as activities, uses and habitat, and were identified based on the advice of the Advisory Committee. These values aim to be representative of the study area. However, additional relevant information may be warranted in the future, should a more detailed planning process be undertaken.

The additional information included the distribution of coastal rocky reefs, and considerations of commercial fisheries, recreational activities and navigation density. Also considered was onshore coastal development (the presence of residential dwellings), and areas of high biological value. Geoconservation sites and other areas of conservation value (Ramsar wetlands) are shown here for completeness but were not included in analyses since they did not overlap with horizontal units.

Details of all contributing data and associated figures for the area on the north coast of Tasmania are presented in **Section 4.2**.

Finfish aquaculture biophysical suitability

In contrast to the southeast of Tasmania, the north coast of Tasmania displays overall relatively lower biophysical suitability for finfish aquaculture (**Figure 22**). This is mainly due to warmer water temperature (**Figure 4**) and shallower waters (**Figure 3**).

Most of the main coast extending from Cape Portland to Three Hummock Island is interspersed with regions of 'medium' finfish aquaculture biophysical suitability (scores between 5 and 6 out of 9) - for example, from Cape Portland to Bridport - and 'high' finfish aquaculture (scores between 6 and 7 out of 9) - for example, between Weymouth and the head of the Tamar River (**Figure 22**).

The east coast of King Island displays 'high' finfish aquaculture biophysical suitability, mainly between Wickham at the northern tip of the island and Grassy. In contrast, the area west of Flinders Island mostly shows 'medium' finfish aquaculture biophysical suitability, with an area to the northwest of Whitemark showing 'high' finfish aquaculture biophysical suitability.

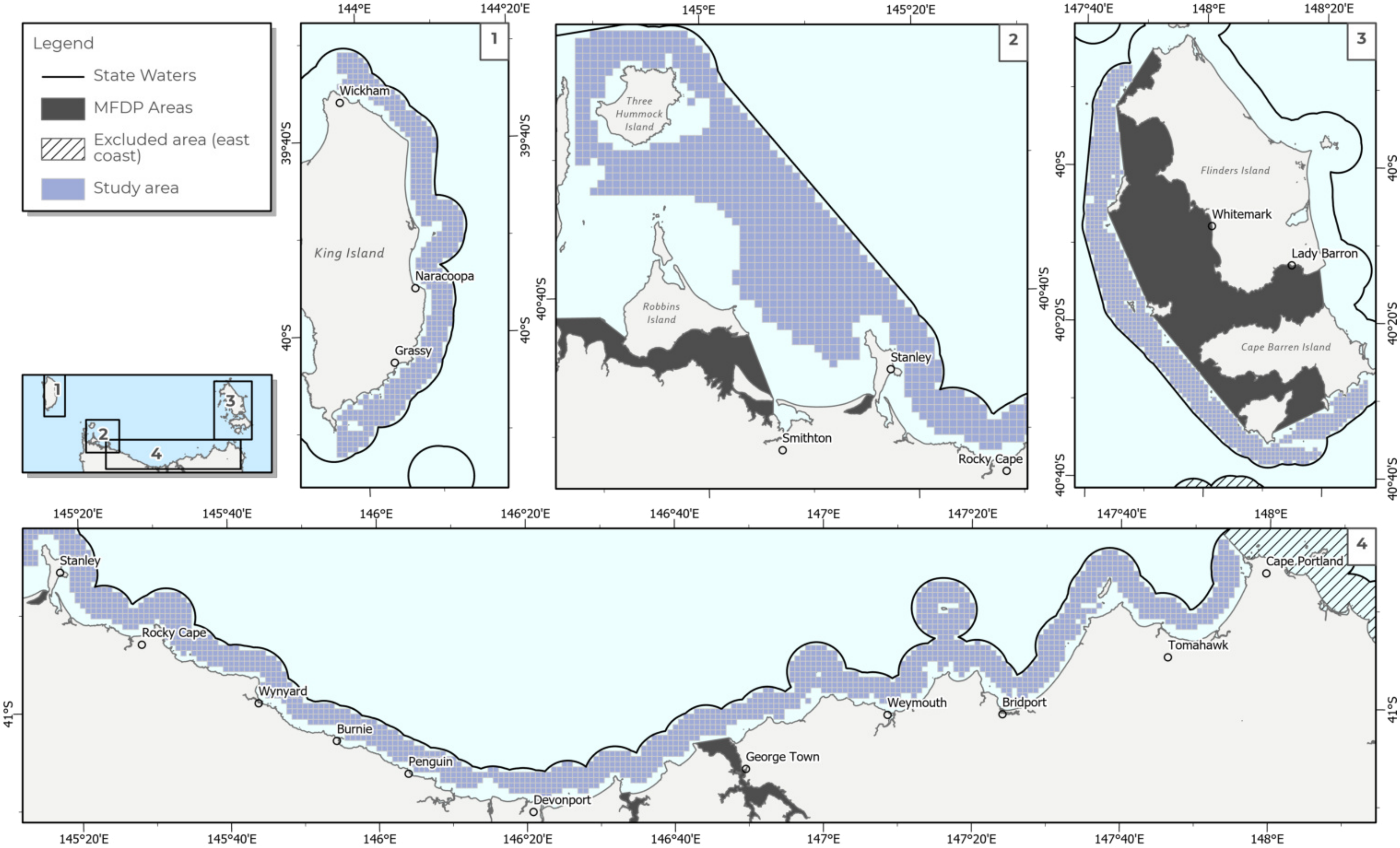


Figure 21. Study area on the north coast of Tasmania. A 1 km x 1 km grid of horizontal units is used for analyses. The area excludes existing MFDPs and waters shallower than 10 m.

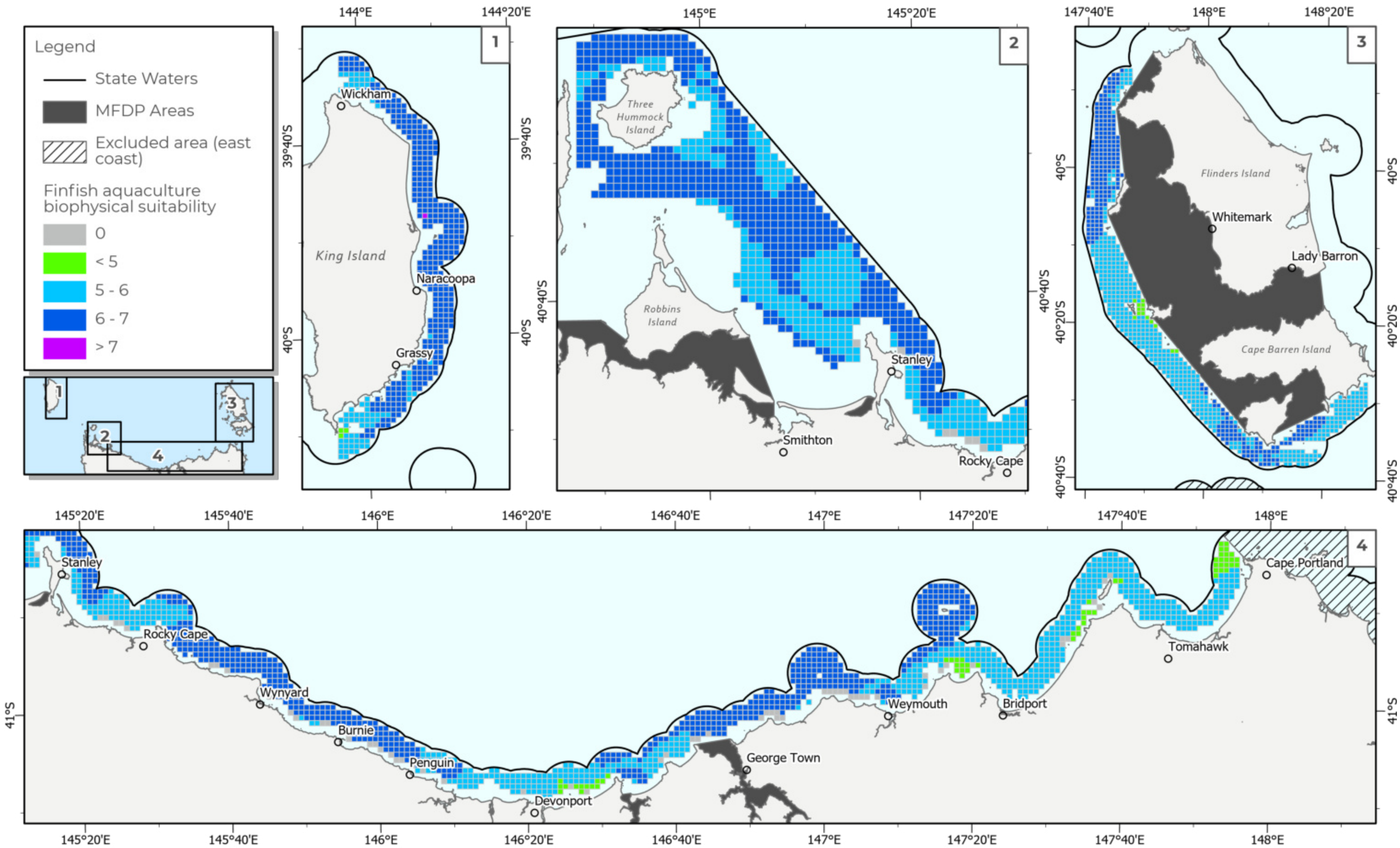


Figure 22. Biophysical suitability for finfish aquaculture in the north coast of Tasmania (spatial subset of Stage 1 analysis).

Table 5. Supporting data identified to provide information for biophysical suitability of finfish aquaculture, marine uses, activities and areas of high ecological value on the north coast of Tasmania.

	Finfish aquaculture biophysical suitability	Social	Economic	Environment
Current speed	X			
Water temperature	X			
Depth	X			
Significant wave height	X			
Substrate (rocky reef)	X	X	X	X
Commercial fisheries (Southern rock lobster and abalone)			X	
Commercial fisheries (Other)			X	
Distance from coastal access points (boat ramps)		X		
High navigation density corridor		X	X	
Submarine cables and pipelines			X	
Moorings and popular anchorages		X	X	
Distance to residential dwellings		X		
Distance to high foreshore human use areas		X		
Distance to high natural value areas				X

4.2 Social, economic and environmental values

4.2.1 Rocky reefs

As important habitat in Tasmania, the distribution of reefs on the north coast of Tasmania was extracted from Seamap Tasmania (Barrett et al. 2001; available on LISTmap). However, it is important to note that the known distribution of reefs included in this study may be incomplete. The distribution of seafloor habitat over a large portion of the north coast of Tasmania is currently not available. The coverage of Seamap Tasmania extends to the 40-m isobath or 1.5 km from shore, whichever comes first. In addition, the distribution of habitat in several areas, including most of the northwest waters, King Island and Flinders Island has not been documented at a high resolution. In contrast to the southeast, specific reef complexes or areas have not been identified as part of this project. Therefore, to account for the uncertainty in extent of reefs and the lack of spatial variability in importance, a 1-km buffered area was drawn around mapped reefs and included in analyses (**Figure 23**). This buffered area did not vary among scenarios implemented in the software Marxan with Zones.

4.2.2 Commercial fisheries

In the southeast of Tasmania, considerations for commercial fishing of southern rock lobster and abalone was included when varying buffered areas around rocky reefs, in some cases highlighting reefs of high importance (**Figure 11**). On the north coast of Tasmania, because the known distribution of reef is considered incomplete, commercial catch data was also used to delineate areas of potential importance. Commercial catch data was obtained for southern rock lobster over quota years 2014-2018 (K. Hartmann, personal communication, see Hartmann et al. 2019), and for blacklip/greenlip abalone over quota years 2016-2020 (C. Mundy, personal communication, see Mundy and McAllister 2020).

Commercial fishing for southern rock lobster and abalone occurs throughout the north coast of Tasmania. However, based on catch data, some areas seem more targeted.

For southern rock lobster (SRL), total commercial catch above 10 tonnes in a sub-block was considered very high in the region; these sub-blocks were therefore included (n = 14). One sub-block did not overlap with horizontal units and was removed. For blacklip and greenlip abalone, sub-blocks with total catch data (combining both species) above 20 tonnes, considered very high in the region, were included (n = 8). These thresholds were based on the distribution of catch data among sub-blocks, representing in both cases upper percentiles.

Taken together, areas of relatively high importance for these commercial species were indicated off King Island, in the northwest including Robbins and Three Hummock Islands, as well as areas south of Flinders Island and off Cape Portland. These sub-blocks were then overlayed on bathymetric navigational charts (AusGeoTiffs) to delineate inshore areas where seabed depth would suggest that fishing could occur. These areas were then snapped to the grid of horizontal units for inclusion in analyses ('Major SRL/Abalone Fisheries', **Figure 24**).

In addition to abalone and southern rock lobster, commercial scalefish catch data was also examined in the north coast of Tasmania to uncover potential areas of importance. Commercial scalefish catch data from the Tasmanian Scalefish Fishery Assessment over the previous five quota years (2015/16 to 2019/20) was used in this exercise (Krueck et al., 2020).

Scalefish fishing is recorded throughout the north coast of Tasmania. However, total catch over the time period is particularly high (> 100 tonnes) in the northeast of Tasmania in block 4G4 (sub-blocks 4G41 and 4G42). Fifty-seven taxa were recorded in these waters, with the most caught (by weight) being the Eastern Australian salmon (*Arripis trutta*), followed by the southern calamari (*Sepioteuthis australis*) and gummy shark (*Mustelus antarcticus*). While southern calamari is primarily associated with reefs, both the eastern Australian salmon and gummy shark are found in other habitats.

As in the southeast of Tasmania, a buffered area (1-km) was included around all mapped rocky reefs on the north coast, including the north east. The eastern Australian salmon is caught in diverse habitats ranging from coastal rocky headlands to offshore waters, while gummy shark are found over sandy areas inshore and offshore (see dpipwe.tas.gov.au for more information on these species). Therefore, the area in fishing block 4G was included in analyses as potentially important for commercial (non-reef) scalefish species ('Commercial Scalefish Fisheries', **Figure 24**).

Since 2017, Petuna Aquaculture has been gathering environmental information under their scientific permit in the far northwest of Tasmania. As part of this process, Petuna Aquaculture has consulted with local fishers to establish the footprint of existing activity. The information publicly shared from this consultation revealed large swathes of waters being utilized in the area west of Stanley and bordered to the east by Hunter and Three Hummock Islands. Several fisheries have been identified, including octopus, scallop, calamari, shark, green lip abalone, and southern rock lobster. While individual fisheries cover only a portion of the grounds, together they indicate the area is significantly harvested. To include this information in this exercise, the horizontal units in the far northwest were designated as 'fishery area' for inclusion in analyses ('Other Fisheries', **Figure 24**).

For the purpose of analyses, two sets of areas were considered separately because of their varying uncertainty: 1- the identified areas of importance for southern rock lobster and abalone, and 2- the identified areas of importance for all other fisheries based on scalefish commercial catch data and the outcomes of consultation in the northwest of the state by Petuna Aquaculture.

Please note: *These areas were delineated as proxies for inclusion in this exercise at the extent of the north coast and do not replace valuable information gained from local consultation or considerations for finer-scale georeferenced data should a more detailed planning process take place.*

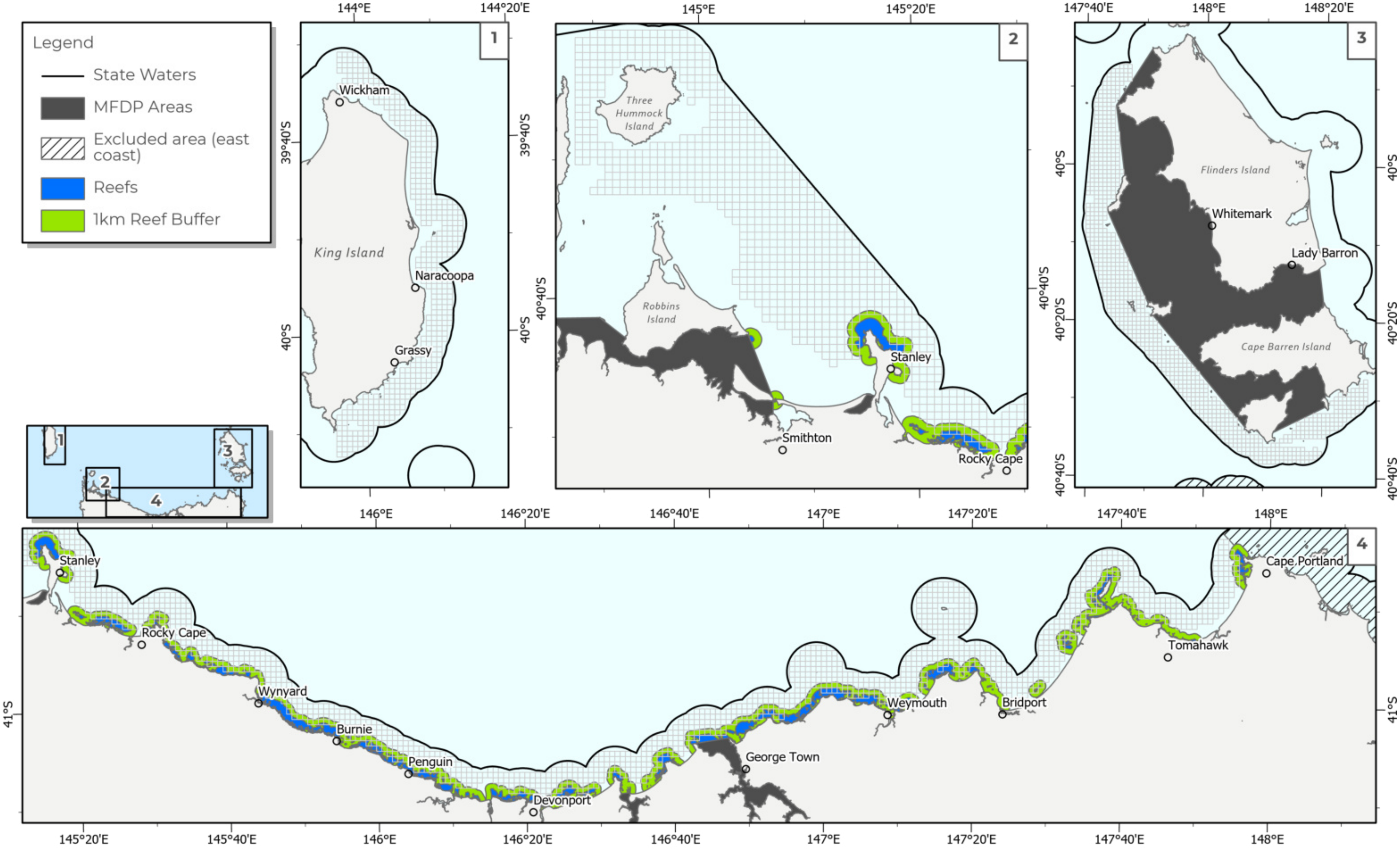


Figure 23. Distribution of mapped rocky reef habitat on the north coast of Tasmania with the buffered area included in analyses (extent of 1-km around all reefs). Grid of horizontal units is shown.

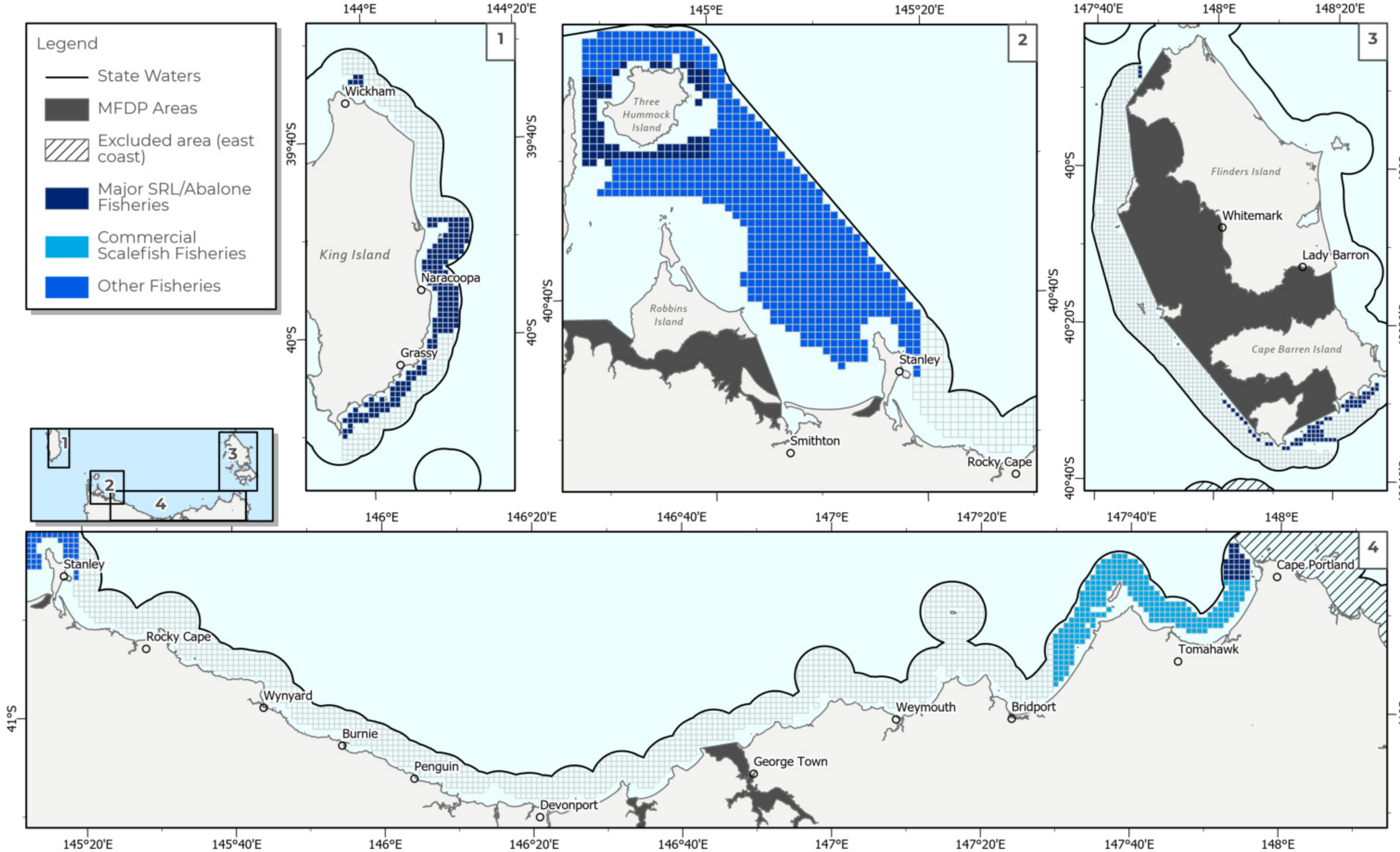


Figure 24. Identified areas of importance for commercial fisheries on the north coast of Tasmania. Areas associated with southern rock lobster and abalone (Major SRL/Abalone Fisheries) and those associated with scalefish and other species ('Commercial Scalefish Fisheries', 'Other Fisheries') were considered separately during analyses. Grid of horizontal units is shown.

4.2.3 Recreational use

Distance from boat ramps was used as a proxy for recreational use in this project, the assumption being that - with some exceptions - most recreational activities would occur in proximity of a point of coastal access. The locations of 31 boat ramps on the north coast of Tasmania were extracted from LISTmap. The level of use for each boat ramp was determined based on the expert advice of the Advisory Committee. Scores from 1 to 10 reflecting use were tagged to each boat ramp. Seven 'high-use' boat ramps (here defined as a score above 8) were identified: Bridport, Port Sorell, Devonport, Ulverstone, Burnie, Wynyard, and Stanley.

Three options of buffered areas (travel distance) are used in this project (**Figure 25**). The first option is a 1-km buffered area around all boat ramps. The second option is a 10-km buffered area around 'high-use' boat ramps and all others with a 1-km buffered area. The third option arose out of discussion with the Advisory Committee recognizing the geography of the north coast, and suggesting the majority of recreational use could spread alongshore but less likely to venture further offshore into Bass Strait. To represent this, the third option builds on the second option - i.e., 10-km buffered around 'high-use' boat ramps, 1-km buffered elsewhere - but restricts the buffered areas to 1 nautical mile from shore.

4.2.4 Other socio-economic uses

Navigation

Areas of high-density navigation were digitized from AIS information available on marrinetraffic.com (**Figure 26**). This included dense navigation off Devonport (mostly due to the path of the *Spirit of Tasmania* ferry), at the mouth of the Tamar River, off Bridport (path of ferry to Flinders Island) and off Burnie. Additional areas were also included because of marine traffic associated with annual yacht races. The areas were digitized from tracks available at race.bluewatertracks.com. This included an area off King Island between Naracoopa and Grassy (Melbourne to King Island Race), and an area off Stanley (Melbourne to Stanley Race).

Submarine cables and pipelines

Three areas were included as overlaying important submarine cables or pipelines (**Figure 26**). Areas were digitized based on the information contained in navigational charts (Australian Hydrographic Office). Areas were aligned to the grid of horizontal units and considered exclusion zones, i.e., 100% of area unavailable for finfish aquaculture. The Basslink cable lands east of Low Head at Four Mile Bluff. While no official exclusion zone is enforced, mariners are advised to be cautious within 500 m of the cable route. A submarine pipeline is also indicated on charts west of Five Mile Bluff in the same area. In the northwest, the Stanley and Boat Harbour cable routes are included, but not the Marinus Link (still in development and anticipated to land near Burnie).

Moorings and anchorages

Locations of registered moorings were obtained from Marine and Safety Tasmania (MAST) and information on additional popular anchorages was provided by DPIPWE (unpublished data). A 1-km buffered area was drawn around each registered mooring/anchorage. Buffered areas were aligned to the grid of horizontal units: areas included in analyses were units fully or partially overlapping with the 1-km buffered areas (**Figure 26**).

Distance from residential dwellings

Locations of buildings (as points) were extracted from LISTmap for each Local Governement Area with a coastal connection to the study area. Points identified as 'Residential Dwellings' were extracted from this dataset, focusing on buildings within 1 km of the coastline. A buffered area of 1 km from residential dwelling was delineated for the analysis (**Figure 26**). The 1-km limit was derived from the methodology of Ross et al. (2020), as suggested by sound specialists at the Environment Protection Authority as suitable buffer between residences and new finfish aquaculture development.

Foreshore human use

The value, condition and pressures on the foreshore on the North and Craddle Coast Natural Resource Management Regions of Tasmania was described along 100-m segments (available on LISTmap; produced by Aquenal). The line map used in this exercise represents the overall human use value of the foreshore. Human use in this context refers to areas relatively more frequently used based on amenities along the foreshore, recreation and tourism, land classification and (non-Indigenous) cultural heritage. The layer does not necessarily equate to the cultural value, for example based on aesthetic or preference, communities may place on certain areas. Coastal segments labelled as 'high' and 'very high' human use were extracted from this dataset. A 2-km buffered area around the segments was delineated to include in the analysis (**Figure 26**).

4.2.5 Environment and conservation

The value, condition and pressures on the foreshore on the North and Cradle Coast Natural Resource Management Regions of Tasmania was described along 100-m segments (available on LISTmap; produced by Aquenal). The line map used in this exercise represents overall natural value of the foreshore. The assessment is based on biological and geomorphic values. Coastal segments identified as 'high' and 'very high' natural value were extracted from this dataset. A 1-km buffered area around the segments was delineated to be included in the analysis (**Figure 27**).

Please note geoconservation sites (including terrestrial sites) and Ramsar wetlands are displayed in **Figure 27** but were not included in the analysis. This is because these areas do not overlap with the study area.

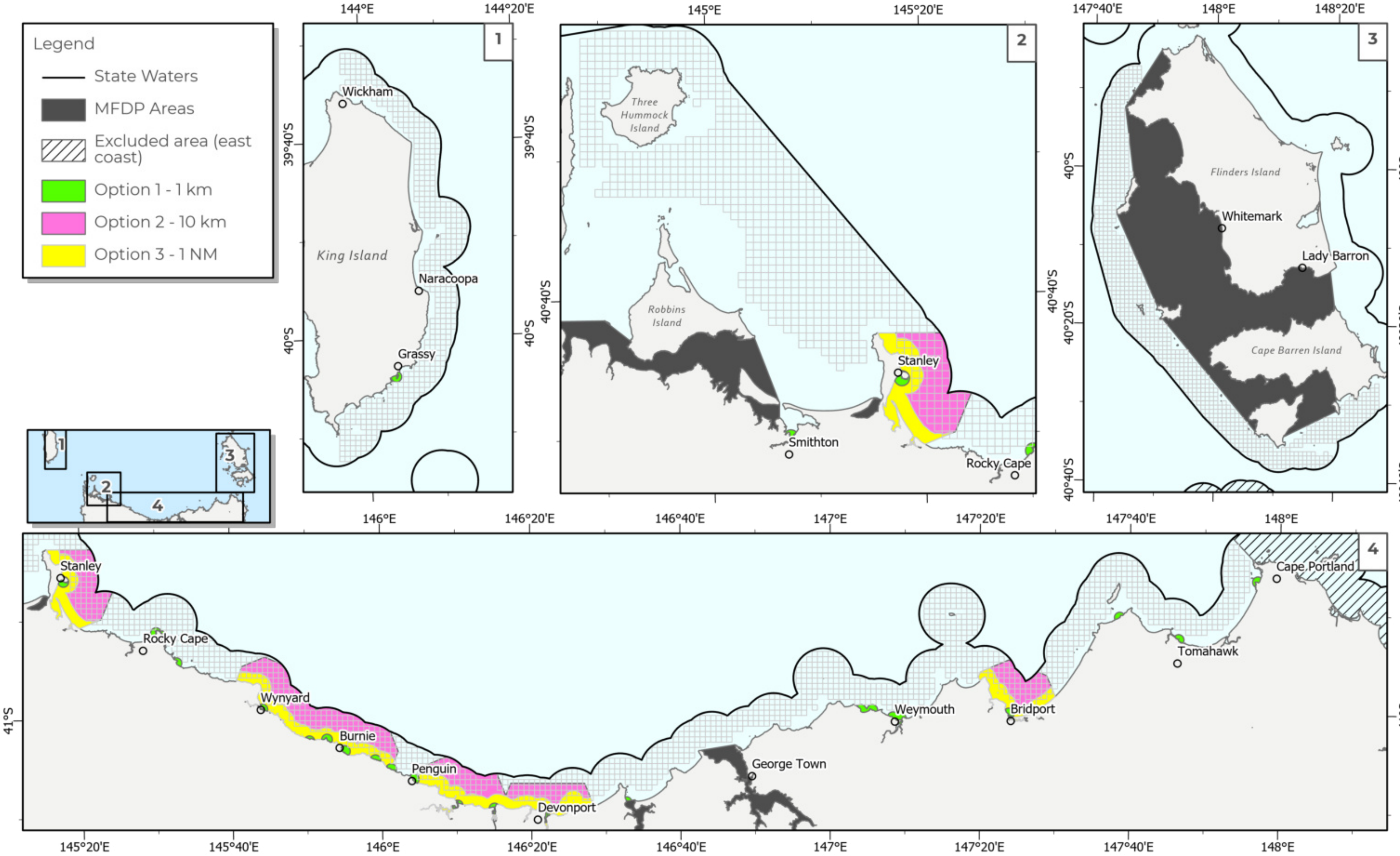


Figure 25. Areas of importance for recreational use (defined by buffers around boat ramps) in the north coast of Tasmania area of interest. Buffer option 1: a 1-km buffer around all identified boat ramps; Buffer option 2: a 10=km buffer around 'high use' boat ramps and a 1-km buffer around all other boat ramps; Buffer option 3: a 10-km buffer around 'high use' boat ramps and a 1-km buffer around all other boat ramps, within 1 nautical mile from the shoreline. Grid of horizontal units is shown.

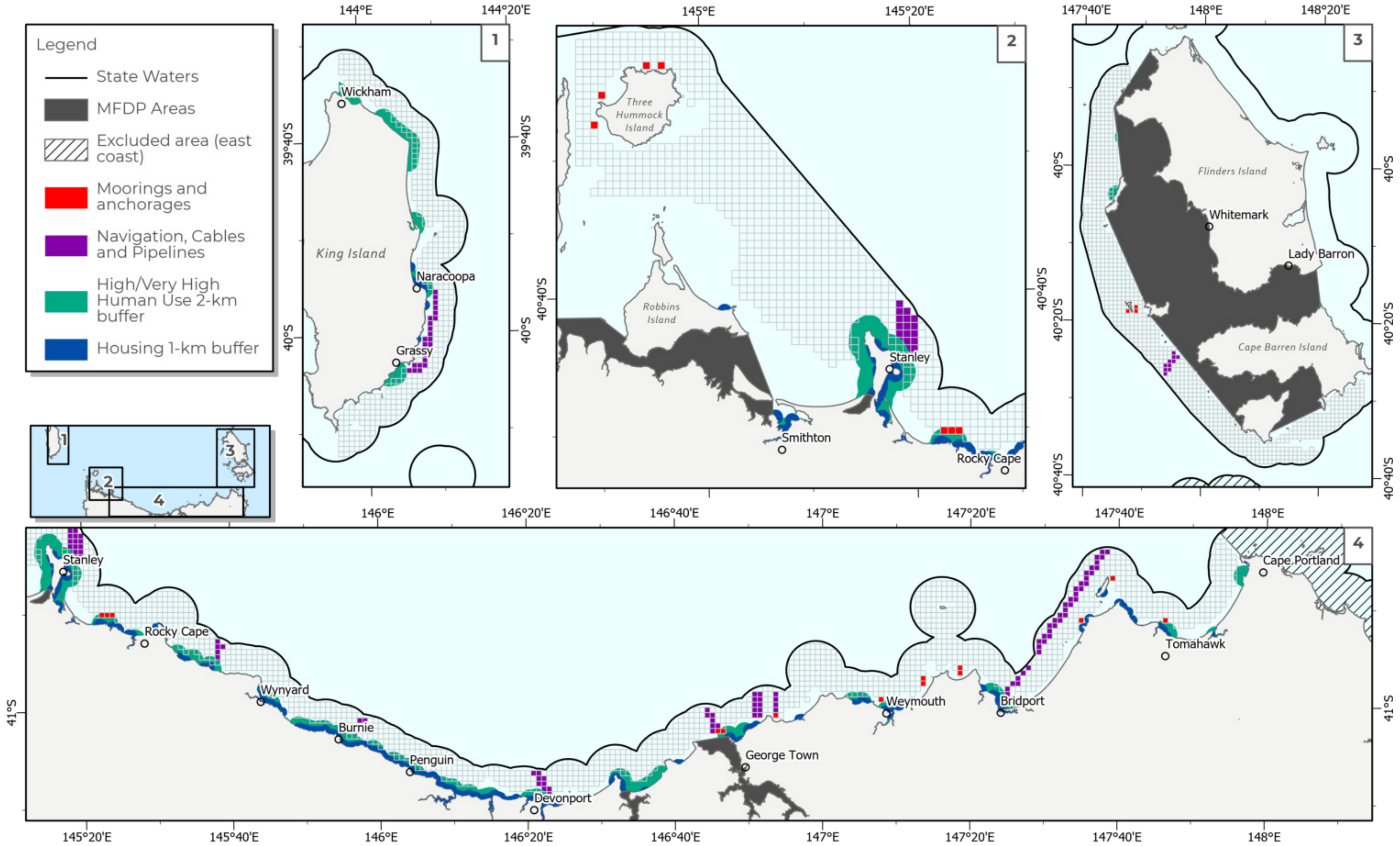


Figure 26. Important areas identifed for other socio-economic uses in the north coast of Tasmania area of interest. Grid of horizontal units is shown.

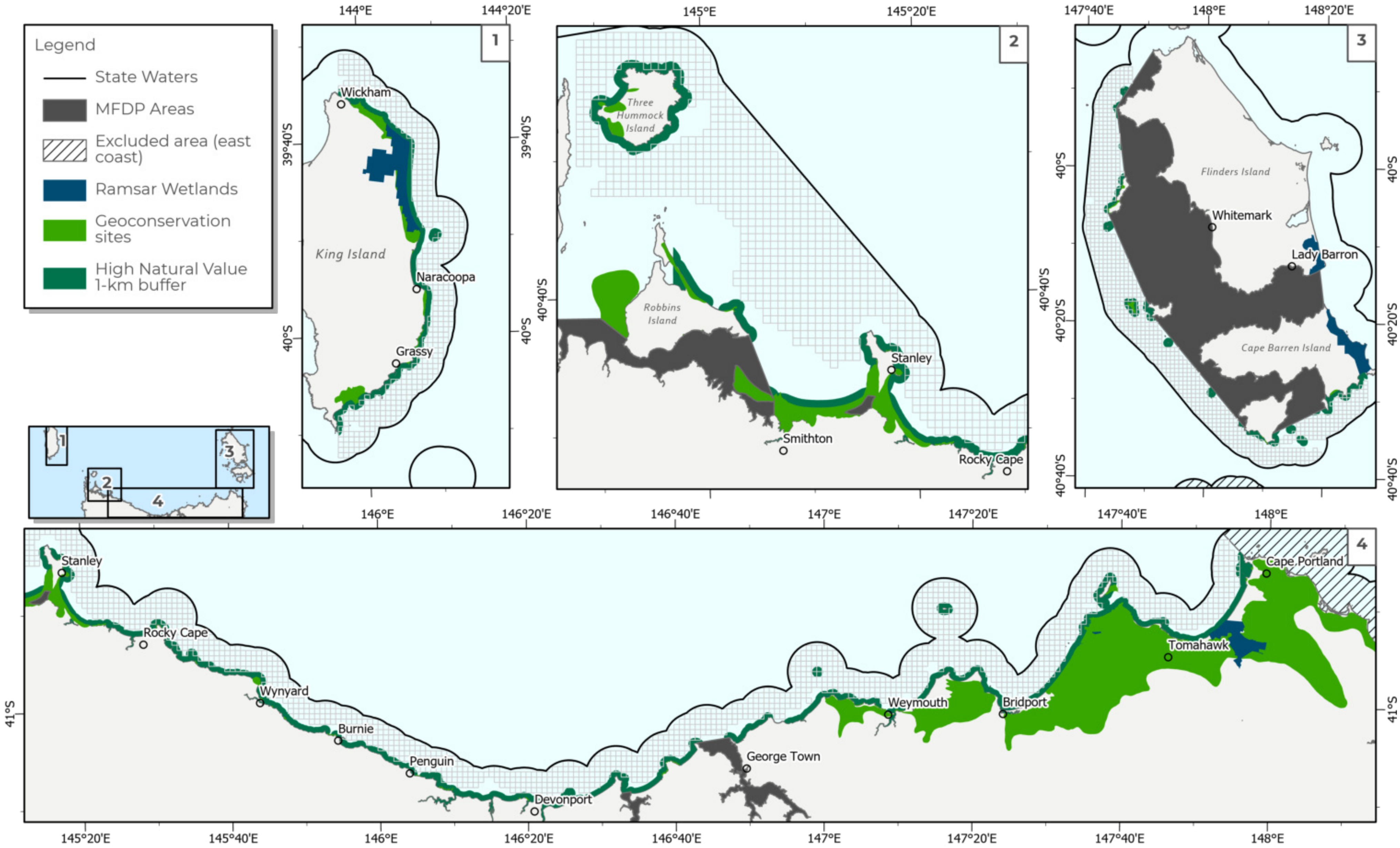


Figure 27. Coastal areas with conservation and high natural value on the north coast of Tasmania. Only the 1-km buffer to high natural foreshore value was included in the analysis. Ramsar wetlands and geoconservation sites are shown to provide context only; they were not included in the analysis since they do not overlap with the study area. Grid of horizontal units is shown.

4.3 Marxan with Zones scenarios

To explore various configurations for potential future finfish aquaculture development within the north coast of Tasmania, four hypothetical scenarios were developed with the input and review of the Advisory Committee for the software Marxan with Zones (**Box 6**). **Table 6** outlines the data used in each scenario, together with qualitative and quantitative goals (targets) for each marine use as applied in different scenarios.

The scenarios aim to define the distribution of three contiguous areas ('zones' in the software Marxan with Zones) The first two Marxan zones target different scores of biophysical suitability of finfish aquaculture, where 'high' refers to finfish aquaculture biophysical suitability scores of between 6 and 7 (out of 9) and 'medium' refers to finfish aquaculture biophysical suitability scores between 5 and 6 (out of 9). The third Marxan zone labelled 'other uses' encompasses all other uses and values (social, economic, environmental), making no attempt to refine areas based on individual uses or values. This is because the focus of this project is on sector-based spatial planning, rather than a more comprehensive marine spatial planning process where the delineation of these other uses and values would be warranted. The scenarios were designed to illustrate trade-offs when altering assumptions underlying the spatial footprint of specific activities and values. The focus is on buffered areas around coastal access points (as a proxy of recreational use), and the extent of other commercial fishing areas (i.e., commercial non-reef scalefish in the northeast and the area associated with other fisheries in the northwest). Other socio-economic and environmental values are constant among scenarios.

Quantitative targets were set prior to the analysis and adjusted during the analysis to ensure all horizontal units were assigned to a zone while ensuring targets for finfish aquaculture did not compromise meeting other targets. This included minor variability among scenarios in targets for finfish aquaculture and other uses.

Box 6. Hypothetical scenarios implemented in the software Marxan with Zones on the north coast of Tasmania.

In line with the project objectives, the following scenarios were defined with the input and review of the Advisory Committee. The scenarios take into consideration the geography of the study area (e.g., narrow stretch of State waters from the Cape Portland to Stanley) and the unique features of the area (i.e., the inclusion of the different commercial fishing areas and in contrast to the southeast, the coarser resolution of the distribution of seafloor habitats). Also considered is the lower resolution of the grid of horizontal units (1 km x 1 km).

Scenario 1 -- Baseline
This scenario is considered a 'baseline'. Quantitative targets aim to reflect equal importance of finfish aquaculture and other marine uses, activities and areas of high ecological value. For example, in this scenario, buffered areas around coastal access points are minimal (1 km in extent).

Scenario 2 -- Recreation and commercial fishing (both high)
In this scenario, greater emphasis is placed on areas of importance for recreational use and commercial fishing. In addition to the baseline 1-km buffered area around all boat ramps, a wider 10-km buffered area is included at popular boat ramps. The target for 'other' fishing activities (i.e., not southern rock lobster or abalone) is also significantly increased from the baseline.

Scenario 3 -- Recreation and commercial fishing (both moderate)
In this scenario, greater emphasis is placed on areas of importance for recreational use and commercial fishing, albeit more moderately than in Scenario 2. As in Scenario 2, the areas of high recreational value have been defined by a 1-km buffered area around boat ramps and a 10-km buffered area around popular boat ramps, however the area included has been limited to within 1 nautical mile from shore. This scenario also includes an intermediate quantitative target for 'other' fishing activities (i.e., not southern rock lobster or abalone).

Scenario 4 -- Moderate recreation and high commercial fishing
This scenario is a combination of Scenario 2 and Scenario 3. As in Scenario 3, the areas of high recreational value area defined by a 1-km buffered area around boat ramps and a 10-km buffered area around popular boat ramps, but the latter is limited to 1 nautical mile from shore. As in Scenario 2, this scenario includes a high quantitative target for 'other' fishing activities (i.e., not southern rock lobster or abalone).

Outcomes of individual scenarios are presented in **Figures 28-31**. A synthesis of all four scenarios is presented in **Figure 32**. The synthesis presents five types of contiguous areas. Three types indicate consistent assignement of horizontal units to finfish aquaculture (either 'high' or 'medium' biophysical suitability), or other uses (in 4 scenarios out of 4). Two categories illustrate uncertainty among scenarios where horizontal units were assigned 'finfish aquaculture' (either 'medium' or 'high' biophysical suitability) in 2 or 3 out of 4 scenarios, or where no clear outcome was determined ('Areas of uncertainty').

Table 6. Qualitative objectives and quantitative targets (%) used in the four scenarios implemented in the software Marxan with Zones (**Box 6**) for the north coast of Tasmania Stage 2 local area.

Marxan Zones	Data	Qualitative objectives	Quantitative targets			
			Scenario 1 'Baseline'	Scenario 2 'Recreation and commercial fishing (both high)'	Scenario 3 'Recreation and commercial fishing (both moderate)'	Scenario 4 'Moderate recreation and high commercial fishing'
Finfish aquaculture (high biophysical suitability); Finfish aquaculture (medium biophysical suitability)	Finfish aquaculture biophysical suitability (Stage 1)	Develop finfish aquaculture in biophysically suitable areas	Initial target: 65% of both high biophysical suitability (score between 6 and 7) and medium biophysical suitability (score between 5 and 6) Unlike the study area in the southeast of Tasmania, this target was reached in most scenarios (with some exceptions), which indicated a proper threshold for optimizing the potential for finfish aquaculture against other uses.			
Other uses	Rocky reefs	Decrease the possibility of detrimental impacts to rocky reefs as habitat of significant commercial, recreational and conservation value	90%: 1-km buffered area around identified reefs			
	Commercial fisheries (southern rock lobster and abalone)	Maintain existing commercial fisheries	80% of identified areas			
	Commercial fisheries: Other (non-reef scalefish and northwest area)	Maintain existing commercial fisheries	60% of identified areas	80% of identified areas	70% of identified areas	80% of identified areas
	Distance from boat ramps	Maintain recreational marine areas (boating, fishing, diving, etc)	90%: 1-km buffered area around all boat ramps	90%: 10-km buffered area around popular boat ramps and 1-km buffered area around other boat ramps	90%: 10-km buffered area around popular boat ramps and 1-km buffered area around other boat ramps (within 1 nautical mile from the shore)	
	Navigation: High navigation density corridor and marine infrastructure (cables/pipelines)	Maintain existing navigation channels for safe navigation by all marine users and protection of existing cables and pipelines	100% of identified areas			
	Moorings and anchorages buffer	Maintain moorings and anchorage areas	90%: 1-km buffered area			
	Distance to residential dwellings	Minimise noise and light pollution to residents	90%: 1-km buffered area			
	Distance to high human use value areas along the foreshore	Maintain high human use value areas	90%: 2-km buffered area			
	Distance to high natural value areas along the foreshore	Decrease the possibility of detrimental impacts to environmentally significant areas	90%: 1-km buffered area			

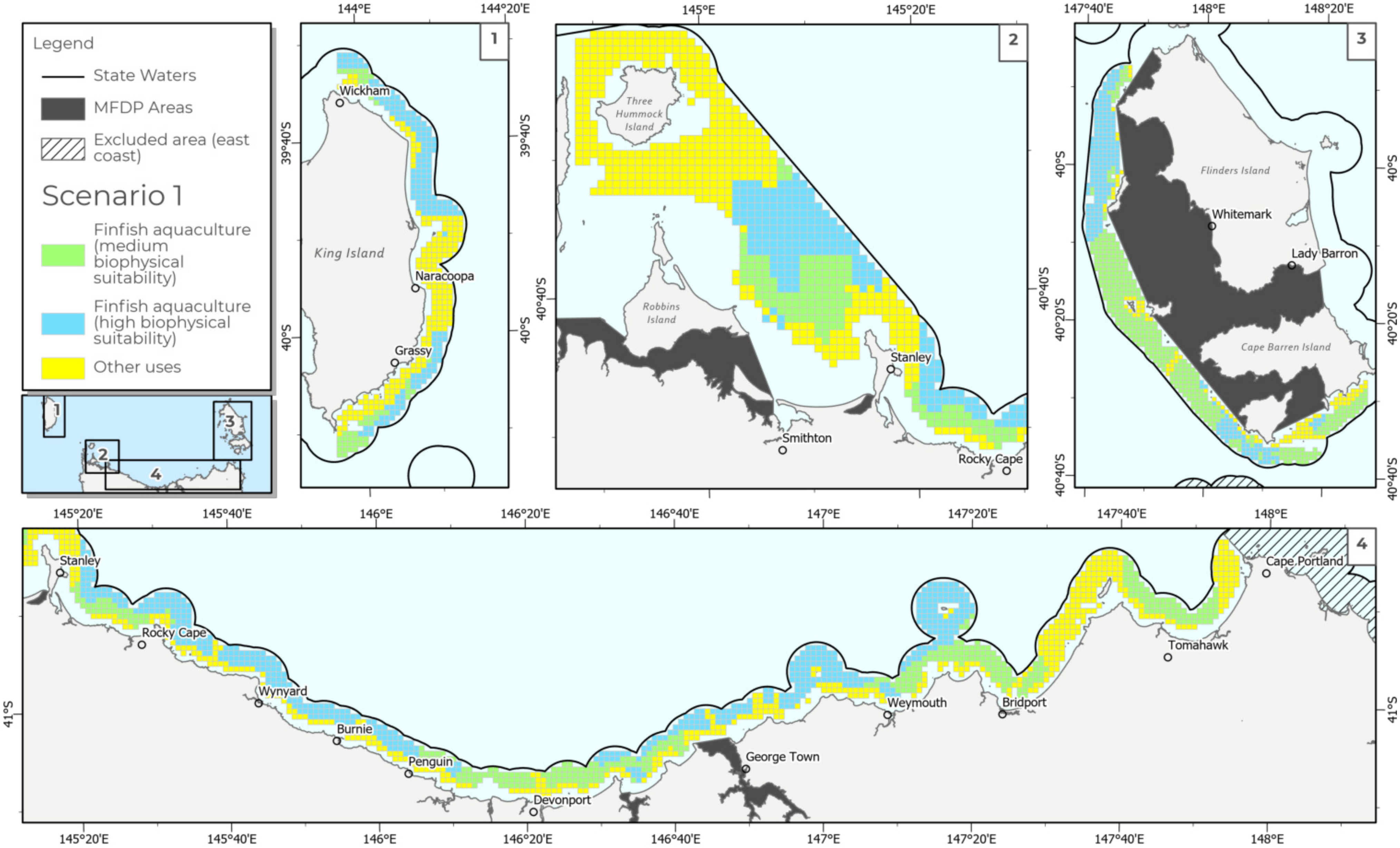


Figure 28. Output of Scenario 1 implemented in the software Marxan with Zones on the north coast of Tasmania. This scenario is considered a 'baseline' aiming to provide equal importance to finfish aquaculture and maintaining existing uses, activities, and areas of high ecological value. Actual targets reached (refer to **Table 6)**: 75% of commercial fishing areas ('other'), and 61% of area with high biophysical suitability for finfish aquaculture.

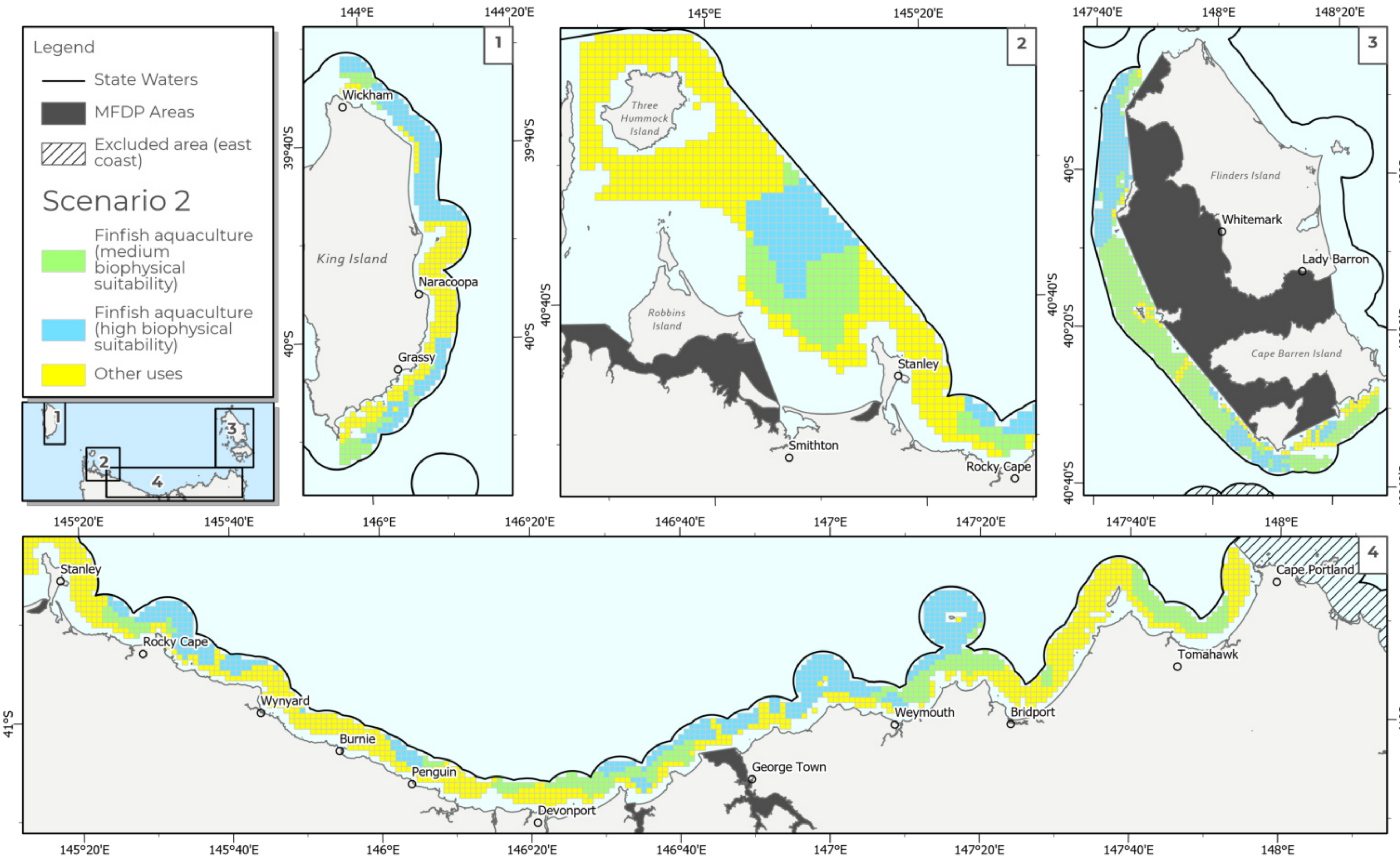


Figure 29. Output of Scenario 2 implemented in the software Marxan with Zones on the north coast of Tasmania. This scenario places greater emphasis on recreational use and commercial fishing (both at a high level).

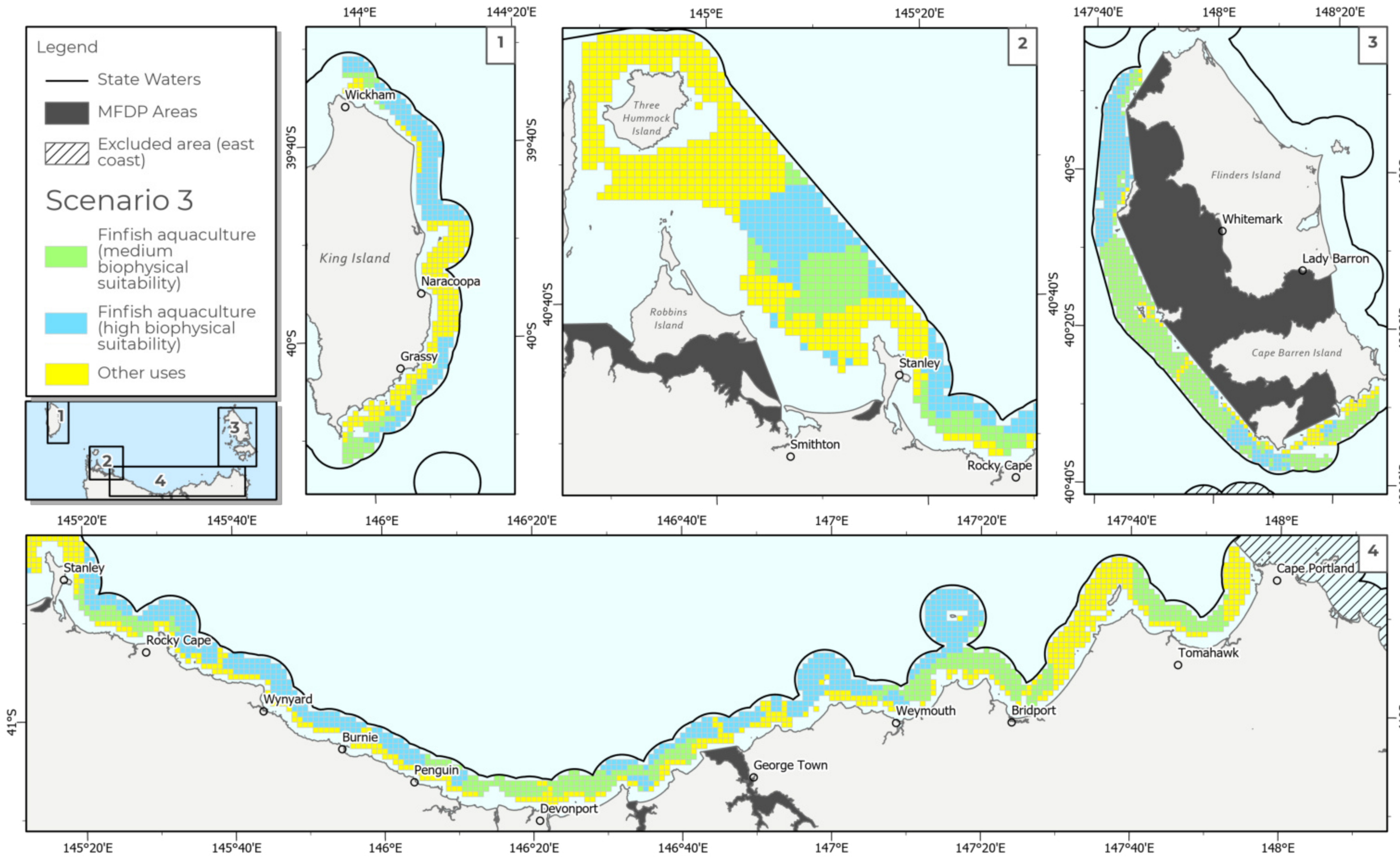


Figure 30. Output of Scenario 3 implemented in the software Marxan with Zones on the north coast of Tasmania. This scenario places greater emphasis on recreational use and commercial fishing (both at a moderate level).

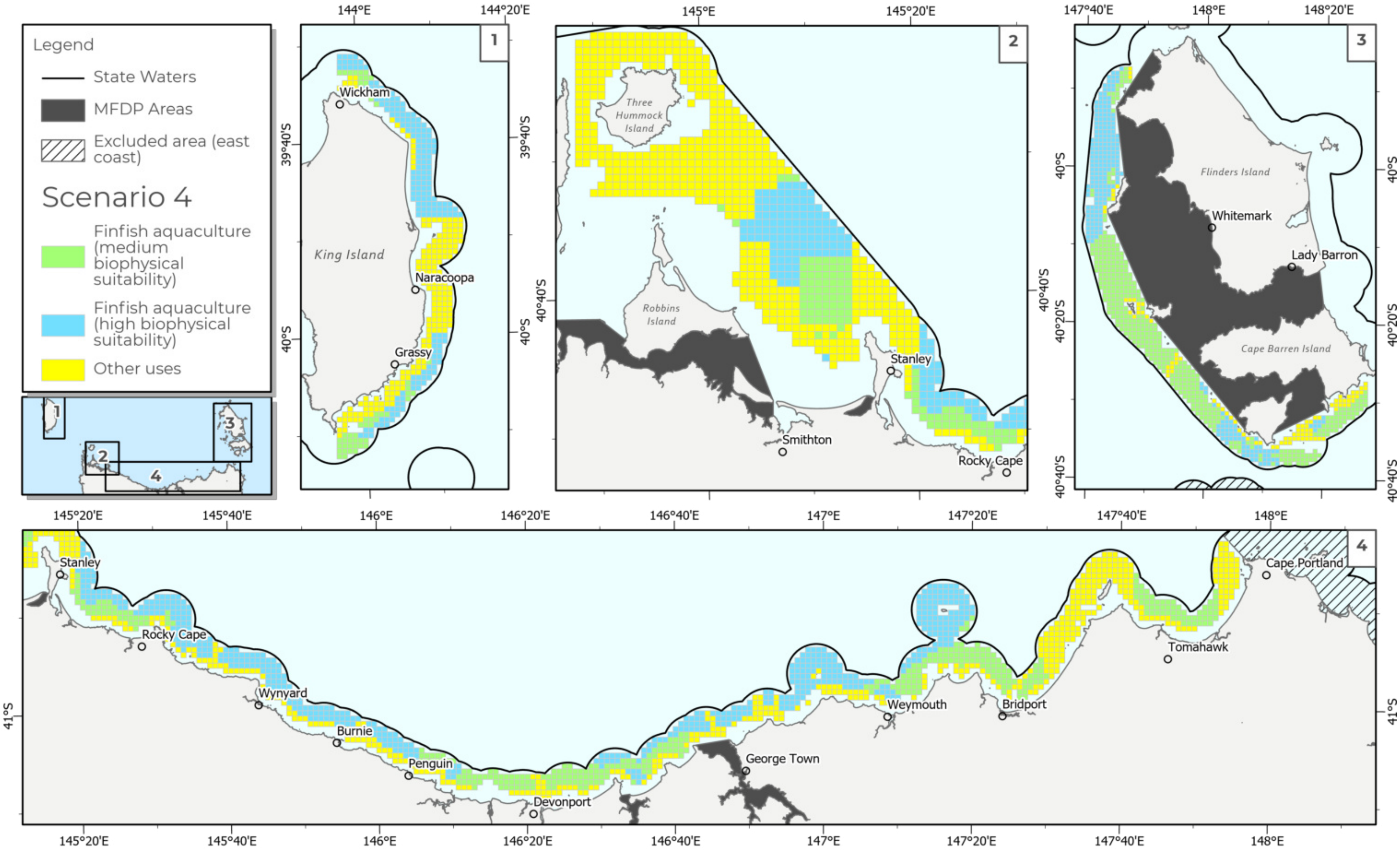


Figure 31. Output of Scenario 4 implemented in the software Marxan with Zones on the north coast of Tasmania. This scenario places greater emphasis on recreational use (at a moderate level) and commercial fishing (at a high level). Actual targets reached (refer to **Table 6)**: 75% of commercial fishing areas ('other'), and 61% of area with high biophysical suitability for finfish aquaculture.

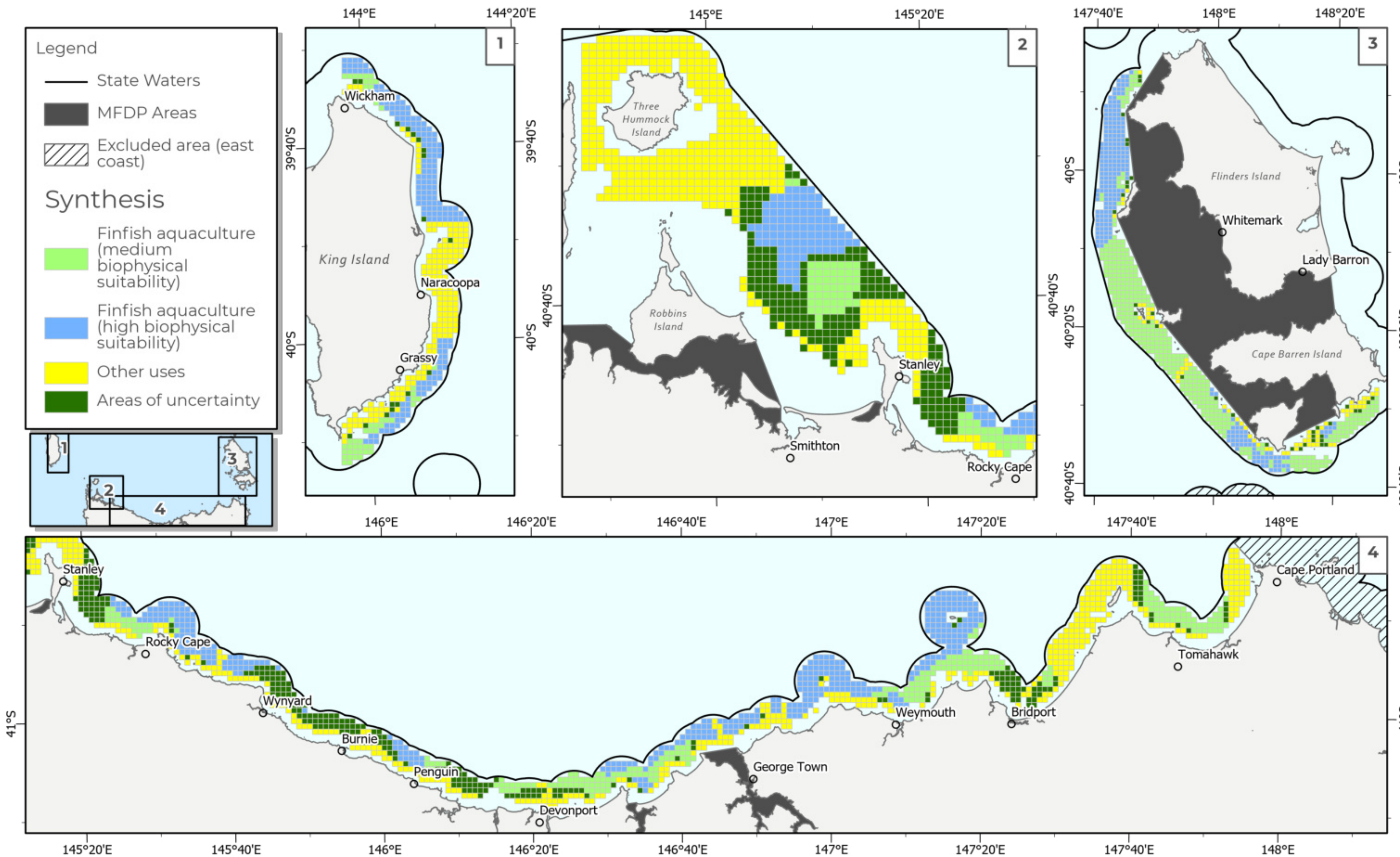


Figure 32. Synthesis of the four scenarios implemented in the software Marxan with Zones on the north coast of Tasmania. Labels according to **Table 6** (Marxan zones) indicate consistent assignment across all four scenarios. Areas of uncertainty are indicated in green, whereas the software Marxan with Zones assigned these areas to finfish aquaculture (based on either high or very high biophysical suitability) in some but not all four scenarios.

4.4 Potential for finfish aquaculture on the north coast of Tasmania

The potential for finfish aquaculture varied spatially on the north coast of Tasmania. Areas consistently assigned to finfish aquaculture during analyses were mostly confined offshore, with different spatial patterns along the northern coast and off the coasts of King and Flinders Islands.

Horizontal units were assigned to 'high finfish aquaculture biophysical suitability' along the northern coast of King Island, whereas other uses dominated the area around Naracoopa and the southern portion of the coast (**Figure 32**). This is mainly due to commercial abalone/southern rock lobster fisheries areas (**Figure 24**) and navigation traffic (**Figure 26**). Some offshore areas along the southern coast of King Island were also assigned to finfish aquaculture for both 'medium' and 'high' biophysical suitability.

In contrast, off the coast of the Furneaux Group (Flinders Island), little conflict was apparent with other ocean uses - with few exceptions such as the path of Flinders Island ferry - and most of the area was assigned to finfish aquaculture in areas with both 'medium' or 'high' biophysical suitability (**Figure 32**).

In the northeast, most of the area between Cape Portland and Bridport is assigned to other uses, with sporadic areas assigned to finfish aquaculture with 'medium' biophysical suitability, varying in size among scenarios (**Figure 32**). Horizontal units assigned to finfish aquaculture with 'high' biophysical suitability are found offshore east of Devonport, with some areas with 'medium' biophysical suitability (**Figure 32**). In general in the northeast, there is little variability among scenarios, which is reflected in minimal uncertainty, with the exception of the area around Bridport.

In the northwest, between Penguin and Stanley, areas for finfish aquaculture with 'high' biophysical suitability are found offshore, while areas with 'medium' biophysical suitability occur in the vicinity of Devonport (**Figures 28, 30, 31**). These areas are restricted in Scenario 2 by a wider buffered area around popular ('high-use') boat ramps extending offshore (**Figures 25, 29**).

In the far northwest, east of Stanley, the areas around Three Hummock Island and Stanley are largely assigned to other uses (**Figure 32**). The area northeast of Robbins Island is divided between areas with both 'high' and 'medium' biophysical suitability for finfish aquaculture. The configuration of this area changes among scenarios, which is reflected in uncertainty of its boundaries.

Overall, with few exceptions, most horizontal units assigned to finfish aquaculture on the north coast of Tasmania lie offshore (> 1 km from shore). The geography of the coastline and shallow coastal waters result in minimal overlap between some of the values considered (such as the 1-km buffered areas around either residential dwellings or high/very high foreshore natural value), thus resulting in low levels of trade-offs between these and areas where finfish aquaculture is biophysically suitable.

There was larger overlap in areas of commercial fishing and areas where finfish aquaculture is biophysically suitable.

5

Conclusion

5.1 Spatial planning for finfish aquaculture

Sector-based spatial planning

Marine spatial planning (MSP) is a public process aiming to allocate space, e.g., by creating a marine spatial plan, for different human activities in specified areas to satisfy social, economic and ecological objectives (Ehler and Douvere, 2008). A MSP process balances economic development with the needs to conserve marine ecosystems for future generations, ensuring sustainable use of marine resources.

In contrast to MSP, this assessment does not directly aim to support the creation of a marine spatial plan. Instead, it is a decision-support tool addressing the needs of a specific industry, the outcomes of which could be integrated into a more comprehensive MSP process. A similar decision-support approach could be taken on a single-sector basis or across multiple sectors and activities. For example, if needed and with appropriate information and description of objectives, the Marxan zone 'other uses' employed in this assessment could be further broken into specific activities as in Ross et al. (2020).

The assessment focused on exploring a number of options for the potential development of the finfish aquaculture industry in Tasmanian State waters, while considering other marine uses, activities and areas of ecological value. As such, the emphasis was to provide decision-makers with an understanding of the effects of varying trade-offs among scenarios on the potential for finfish aquaculture in the study area. The scenarios were designed with the advice of the Advisory Committee to capture a wide range of socio-economic uses and areas of environmental value, ranging from low to high value placed on finfish aquaculture and low to high value placed on other uses and values. As such, this assessment presents a robust spectrum of the possible extent of use for finfish aquaculture and for other uses.

Regulatory landscape for Tasmanian aquaculture planning

The sector-based assessment conducted in this exercise is meant to guide decision-makers in their understanding of the potential for growth of finfish aquaculture in Tasmania, and where such opportunities might lie. It must be stressed the outcomes of this assessment are potential foundations on which a rigorous regulatory approval process takes place (**Box 7**), and is not in itself a plan for the growth of the finfish aquaculture industry. The *Marine Farming Planning Act 1995* (MFPA) provides the basis to develop Marine Farming Development Plans (Plans).

Plans are developed over an area, and aim to integrate marine farming with other uses, minimize adverse impacts, and take into acccount both adjacent land uses and the community's right to show an interest in marine farming activities while meeting the objectives of the resource management and planning system of Tasmania (see dpipwe.tas.gov.au for more information). The planning process involves several steps, including an Environment Impact Statement (EIS), consultation, stakeholder engagement and public hearings and the review and recommendation of the draft Plan (or amendment to an existing Plan) by a Marine Farming Planning Review Panel to the Minister.

Box 7. Planning for aquaculture in Tasmania.
Please see dpipwe.tas.gov.au for more detailed information on the planning process for aquaculture in Tasmania, including for shellfish and seaweed (EIS: Environmental Impact Statement; MFPRP: Marine Farming Planning Review Panel).

Key State legislation

- *Marine Farming Planning Act 1995* (MFPA)
- *Environmental Management and Pollution Control Act 1984*
- *Living Marine Resources Management Act 1995*

The MFPA provides the statutory framework for establishing, amending and reviewing **marine farming development plans**.

Marine farming development plans (Plans):
Plans are developed or amended over a specific area, and specify types of fish (including shellfish or seaweed), maximum leasable area farmed in each zone, and management controls setting out the operational requirements of a marine farm.

Steps of planning process

[*Non-statutory process*]

Exploration: under permit, collection of data
Initial consultation with community
Submission of development proposal to DPIPWE
EIS guidelines issues by DPIPWE
EIS prepared by proponent with stakeholder engagement

[*Statutory process*]

Application to progress draft Plan (or amendment)
Consideration of proposal by the MFPRP
Public exhibition of draft Plan or amendment with public hearings
Final consideration by the MFPRP
Final consideration by the Minister

5.2 Limitations and future considerations

Biophysical suitability for finfish aquaculture

The first stage of this assessment focused on determining statewide biophysical suitability of the surrounding environment to host finfish aquaculture in Tasmanian State waters. Data limitations arose in this project. The analysis relied on modelled data of ocean properties over a short time window (summer 2015-2016), and for which the horizontal resolution varied between well-resolved areas (e.g., the southeast of Tasmania) and other areas where outputs of high-resolution ocean circulation models are not publicly available. In addition to this, much of the seafloor in Tasmanian State waters has not been mapped at a high resolution, e.g., by using acoustic technology. Therefore, broad statewide patterns are reliable but more detailed analyses, using higher-resolution data/information should be conducted if development is proposed.

This assessment was based on recent past ocean conditions (2015-16) and did not consider environmental change. Reliable forecasts of ocean conditions could augment analyses to ensure the sustainability of the industry in the future and minimize risks associated with anticipated consequences of climate change in the ocean.

Further, to determine biophysical suitability for finfish aquaculture, choices around suitability classification for finfish aquaculture were needed. This suitability scale was derived from a literature review and industry consultation but may be altered, for example, by using a risk-based approach. The overall weighting applied to the different biophysical variables reflected current operational requirements and anticipated challenges, and directly impacted outcomes. For example, the deployment of ocean infrastructure more robust to high-energy environment allows the development of offshore marine waters, but is contingent on the availability and reliability of such technology and the consideration of risks associated with emerging industrial practices. It is therefore important to carefully craft or construct the decision-support modelling approach and understand its implications.

Inclusion of other uses, activities and values

The inclusion of uses, activities and other values in a spatial planning exercise relies on access to both reliable information and its spatially-explicit depiction. In this assessment, while attempts were made to be comprehensive in determining these values, several caveats remain. This introduces uncertainty in the spatial footprint of activities with potential downstream impacts in the decision-support tools. Some datasets are dated; for example the foreshore human use assessment which is more than 10 years old. Other descriptions of spatial footprint would benefit from greater consultation in the event of a regulatory process taking place. This includes for example the intensity and distribution of recreational activities. In this assessment, we used distance from coastal access, and varied that distance according to level of use derived from expert opinion. This information, while suitable for the purpose of this assessment, should be reviewed and augmented in the event of a local-scale regulatory process.

Some sources of information could also be used in a local planning process, but may not be as useful at the broader spatial extent and resolution used in this assessment. This could include for example detailed information on threatened species, if available, and local activities such as tourism.

In addition, several decisions were made based on the advice of the Advisory Committee on the content and definition of targets for each use, activity and values. This affects outcomes of the analysis, and ideally, such objectives should be determined via a broader participatory process if undertaking a marine spatial planning process.

It must also be stressed this assessment did not include Aboriginal cultural values. This issue was initially considered by the project research team and raised by the Advisory Committee. Advice from Aboriginal Heritage Tasmania indicated these values would be best included through direct engagement via community consultation for specific developments at local scales.

More broadly, how to respectfully and meaningfully include cultural values in decision-support tools is an ongoing area of research.

Connectivity and carrying capacity

The analysis in this assessment is static and does not include connectivity between adjacent or distant areas. It is acknowleged that including connectivity as a proxy of the potential for adverse impacts on sensitive ecosystems or for biosecurity considerations among sites is necessary. It is assumed here that the scale of analysis is coarser (statewide and large areas of interest), and that connectivity would be included in a finer-scale assessment.

A similar argument is made for carrying capacity, i.e., how much production the recipient marine ecosystem could be resilient against. This consideration is important and can be best effectively estimated at a finer scale than the one used in this assessment.

5.3 Summary of outcomes

Spatial analysis in the decision-making process

- Existing data on the biophysical characteristics of the marine environment, marine uses, activities and areas of ecological value in Tasmanian State waters can be used to support decision-making in a marine planning context. However, some datasets are dated and may need to be updated.
- Computing statewide biophysical suitability for finfish aquaculture in Tasmania allowed the identification of areas where more detailed analyses were conducted, i.e, the southeast of the state, and the north coast.
- In local areas (southeast and north coast of Tasmania), outputs of scenarios fed into the software Marxan with Zones assisted in understanding and conceptualising data on multiple marine users by optimizing marine use zones which met defined planning objectives. However, caveats exist because the spatial footprint of many activities, such as recreational use, and the potential for conflict among uses are estimated.
- Outputs of sector-based spatial assessment can be a valuble first step in thinking around potential future growth for the finfish aquaculture industry in Tasmania, and can provide a basis to a detailed regulatory approval process conducted with local data, and stakeholder and community engagement.

Key findings

- Most opportunities for finfish aquaculture described in this assessment reside offshore in deep waters. This is because biophysical suitability for finfish aquaculture is higher in this environment, pending available infrastructure and cost-effective operations, and few conflicts with other marine users and values have been so far identified offshore.
- In the southeast of Tasmania, opportunities for offshore finfish aquaculture based on biophysical suitability appear constrained by the high-energy of the ocean (wave height). A gradient of suitability is present along an inshore-offshore axis with higher biophysical suitability found in the north of Storm Bay.
- In the north coast of Tasmania, opportunities for finfish aquaculture based on biophysical suitability appear constrained by relatively warmer ocean temperature and shallower depth. Opportunities in this region also mostly lie offshore, especially off the coast of the Furneaux Group, and offshore waters between Penguin and Three Hummock Island.
- Data limitations are more important on the north coast of Tasmania, especially off King Island and the Furneaux Group.

Key research gaps

- Most seabed habitats offshore of Tasmania have not been mapped to a high resolution. Filling these gaps would benefit any future planning process, other sectors and conservation efforts.
- Using ocean conditions at higher resolution could enhance our understanding of biophysical suitability for finfish aquaculture. Similarly, determining future conditions could benefit planning by ensure activities are resilient to anticipated environmental change.
- The spatial footprint of some uses and activities used in this exercise is coarse, for example recreational use and commercial fisheries. Consultation could alleviate this knowledge gap.
- Incorporating socio-cultural values in a spatially-explicit framework could augment this analysis by complementing how uses and activities are represented.
- The inclusion of connectivity - for example, for biosecurity - and carrying capacity in planning is lacking in this assessment and should be considered in future spatial planning exercises.
- The decision-support tool used here could be complemented by a risk-based approach, whereas a probability of suitability and successful operations could be assessed.
- Finfish aquaculture is considered here as a spatially exclusive activity. Decision-support tools for planning could help determine the potential for synergies among sectors and therefore opportunities for ocean multi-use.

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APPENDIX 1: Summary of datasets used in the project with data sources.

Data	Dataset	Data source
Annual yacht races (north coast only)	Annual yacht races (King Island to Melbourne, Stanley to Melbourne)	Estimated from race.bluewatertracks.com
Seabed depth (north coast only)	Navigational Charts	AusGeoTIFFs (Australian Department of Defence; https://www.hydro.gov.au/prodserv/digital/ausGeoTIFF/geotiff.htm)
Seabed depth (statewide)	Australian Bathymetry and Topography Grid (Whiteway 2009)	Data custodian: Geoscience Australia; data.gov.au
Seabed depth, current speed, water temperature (southeast only)	CSIRO Storm Bay hydrodynamic model (model run tasseH1p2)	Not publicly available; please contact Dr Karen Wild-Allen (CSIRO, Hobart)
Commercial abalone catch data	Tasmanian Abalone Fishery Assessment	Not publicly available; personal communications Dr Craig Mundy, IMAS/UTAS
Commercial scalefish catch data	Tasmanian Scalefish Fishery Assessment	Not publicly available; personal communications Dr Nils Krueck, IMAS/UTAS
Commercial scalefish sub-blocks	Scalefish sub-blocks	Available on LISTmap (maps.thelist.tas.gov.au; Scalefish Fishery Fishing Blocks)
Commercial southern rock lobster catch data	Fishery Assessment Report: Tasmanian Rock Lobster Fishery	Not publicly available; personal communications Dr Klaas Hartmann, IMAS/UTAS
Current speed, water temperature (statewide)	BRAN 2016	Credit: Bluelink Partnership (Australian Department of Defence, Bureau of Meteorology and CSIRO); research.csiro.au/bluelink/
Distance from residential dwelling	Buildings (points)	Available on LISTmap (maps.thelist.tas.gov.au; Building Points). Accessible for each Local Government Area, only considered 'Residential Dwellings' (https://listdata.thelist.tas.gov.au/opendata/index.html#LIST_Building_Points)
High foreshore biological value (southeast only)	Foreshore biological value	Available on LISTmap (maps.thelist.tas.gov.au; Foreshore biological value NRM South)
High foreshore human use	Foreshore human use	Available on LISTmap (maps.thelist.tas.gov.au; Foreshore human NRM South, Foreshore human use value NRM North-NW)
High foreshore natural value (north coast only)	Foreshore natural value	Available on LISTmap (maps.thelist.tas.gov.au; Foreshore Natural Value NRM North-NW)
Locations of boat ramps	Boat ramps	Available on LISTmap (maps.thelist.tas.gov.au; Boat Ramps)
Locations of geoconservation sites	Geoconservation sites	Available on LISTmap (maps.thelist.tas.gov.au; Geoconservation Sites)
Locations of rocky reefs (consolidated hard substrate)	Seamap Tasmania	Available on Seamap Australia (seamapaustralia.org; Seamap Australia National Benthic Habitat Layer) and LISTmap (maps.thelist.tas.gov.au; Seamap Tasmania Habitat)
Locations of registered moorings	Registered moorings	Available upon request by Marine and Safety Tasmania (MAST)

APPENDIX 1 (continued): Summary of datasets used in the project with data sources.

Data	Dataset	Data source
Marine Farming Development Plan Areas	Marine Farming Development Plan Areas	Available on LISTmap (maps.thelist.tas.gov.au; Marine Farming Development Plan Areas)
Navigation density	Automatic Identification System (AIS)	Estimated from marinetraffic.com
Ramsar wetlands	Ramsar wetlands	Available on LISTmap (maps.thelist.tas.gov.au; Ramsar Wetlands)
Significant wave height (statewide)	Australian Weather and Climate Research (CAWCR) Wave Hindcast model	Credit: CSIRO, Bureau of Meteorology; cawcr.org.au
Submarine cables and pipelines	Navigational Charts	Extracted from AusGeoTIFFs navigational charts (Australian Department of Defence; https://www.hydro.gov.au/prodserv/digital/ausGeoTIFF/geotiff.htm)