Tasmania's Marine Atlas

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Foreword

Marine groups in Tasmania expressed a need to better understand the distribution of ocean uses, ecosystems and species in Tasmanian marine waters, and to make that information readily available to stakeholders. The Tasmania's Marine Atlas project aimed to address this need by collating datasets relevant to marine resources and make this information available via a publicly available web-based mapping platform.

The Tasmania's Marine Atlas enables Tasmanian stakeholders to easily access relevant information on marine activities and ecosystems. The Atlas is designed for ease-of-use to foster opportunities for research through data discovery and data gaps, and facilitate engagement and extension with relevant stakeholders. The Atlas can support spatial planning to ensure fair access to the marine estate and the sustainable development of marine industries. The Atlas aims to appeal to a broad range of stakeholders and contains ocean literacy content to support engagement.

It is expected several groups will benefit from the development of the Tasmania's Marine Atlas, including the fisheries and aquaculture sectors, marine transport, recreational users, the Tasmanian Government, the general public, researchers and educators.

The Tasmania's Marine Atlas is a web-based mapping platform where users can easily access relevant datasets on the uses of Tasmania's marine waters and its ecosystems. The platform connects to online databases and repositories from state and federal government agencies and research organisations (e.g., University of Tasmania, CSIRO). The platform is hosted by a front-end accessible website that also contains targeted science communication products meant to foster ocean literacy in Tasmania. The Tasmania's Marine Atlas is now available at tasmarineatlas.org.

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Abbreviations

ABS	Australian Bureau of Statistics
AMSIS	Australian Marine Spatial Information System
AODN	Australian Ocean Data Network
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ESRI	Environmental Systems Research Institute, Inc.
GIS	Geographic Information System
IMAS	Institute for Marine and Antarctic Studies
IMOS	Integrated Marine Observing System
ITS	Information Technology Services
LISTmap	Land Information System Tasmania (map)
MSP	Marine spatial planning
NESP	National Environmental Science Program
NRM South	Natural Resource Management South
SMRCA	Sustainable Marine Research Collaboration Agreement
SQL	Structured Query Language
UNESCO-IOC	United Nations Educational, Scientific and Cultural Organization – Intergovernmental Oceanographic Commission
URL	Uniform Resource Locator (web address)

Executive Summary

What the report is about

Researchers at the Institute for Marine and Antarctic Studies (University of Tasmania) launched a web-based (online) mapping platform to visualize data on uses, ecosystems, and species in Tasmania's marine waters. This report details the development of the platform – the 'Tasmania's Marine Atlas' available at tasmarineatlas.org – between 2021 and 2024. The platform was developed to address a key stakeholder need to better understand ocean uses in Tasmanian marine waters, and collate and make that information more readily accessible to marine groups.

The development of the platform was based on a knowledge co-production model where the most impacted groups are involved in the research activities. This was combined with a systematic approach to uncovering relevant data. The project included a data audit and the development of a bespoke classification scheme for data collation, significant engagement with stakeholders and interested parties to guide the development of the content and format of the platform, the creation and launch of a web-based mapping platform, and the development of ocean literacy products to further support broad engagement with the Atlas.

Background

Tasmanian marine waters host many uses, activities, infrastructure, in parallel with unique species and ecosystems. Marine planning is a process by which decisions on marine activities are made within a regulatory and legislative context based on the distribution of species and ecosystems, socio-economic value of marine resources, and a cultural importance of place. It aims to balance the need for conservation of marine resources and protection of marine ecosystems, while promoting sustainable development of marine industries. Marine planning is also a key mechanism to ensure fair, equitable and accountable access to marine resources among different marine groups.

Marine *spatial* planning relies on relevant and reliable information on the distribution of marine resources, their uses, and interactions – potential or realized – with ecosystems and species. In Australia, several web-based tools exist to display and access that information, including Seamap Australia and the Australian Marine Spatial Information System (AMSIS) at the national level, and CoastKit (Victoria) and LISTMap (Tasmania) at the state level. In Tasmania, a need was expressed by stakeholders to further consolidate the available information on the uses, assets, species and ecosystems in an accessible format to facilitate evidence-based decision-making on resource allocation. The Tasmania's Marine Atlas project responds to this need.

Objectives

The Tasmania's Marine Atlas project aimed to:

- Identify data sources and datasets available for Tasmanian marine waters relevant to the management of marine resources.
- Consolidate relevant datasets and develop an accessible tool to make these datasets easily accessible by stakeholders with an appealing format.
- Determine the breadth of decision-support tools in Australia and overseas and develop the Tasmania's Marine Atlas in line with these tools.
- Conduct this process with a knowledge co-production model where the most stakeholders are involved in the research process and outcomes.

Methodology

Desktop analyses were conducted to guide the development of the Tasmania's Marine Atlas. A data audit aimed to identify the suite of potential datasets (from disparate data sources) that could be embedded in the Atlas. The development of a bespoke classification scheme for these datasets supported their systematic organisation in the final web-based mapping platform delivered through this project. The classification scheme was meant to facilitate ease-of-use of the Atlas, while reflecting other classification schemes for standard terminology. A second desktop analysis reviewed relevant web-based mapping platforms (nationally and globally) to situate the role and format of the Atlas.

Engagement with marine groups was undertaken to guide the development of the Atlas. Eight structured workshops and three focus groups in 2022 and 2023 elicited feedback on the content and format of the Atlas. The feedback was then incorporated into the Atlas, as relevant and within the capacity of the infrastructure. In addition to the web-based mapping platform, there was a need to augment and value-add the format and content of the Atlas to increase its accessibility and appeal. Feedback from engagement workshops and focus groups supported the development of ocean literacy and science communication content.

Based on the above, a web-based mapping platform was developed and deployed. Much of this development relied on the existing infrastructure of Seamap Australia, which reduced costs and increased efficiency throughout the project.

Results

The Tasmania's Marine Atlas is a web-based mapping platform with a primary purpose to share relevant datasets on the uses, assets, species, ecosystems, and socio-economic marine resources in Tasmania. The Atlas links to reliable data custodians; end-users can visualise information on the Atlas, at this stage data cannot be directly downloaded from the platform. A small subset of the spatial data layers are locally hosted at the University of Tasmania for the purpose of the Atlas. The features of the Atlas were designed for ease-of-use and include bespoke tools such as the 'Find Data in Region' tool – a key need from stakeholders – which allows users to uncover datasets in a user-defined geographic area. The structure of the Atlas is not unlike other similar platforms overseas and in Australia, its clear focus however being on providing datasets relevant to Tasmanian stakeholders. As of October 2024, the Atlas links to 305 individual spatial data layers, included in 116 datasets, from 14 external data custodians.

Spatial data sets embedded in the Atlas are organized in four main categories: biophysical dimension (e.g., bathymetry, species occurrences), human dimension (e.g., aquaculture and fisheries data), threats and pressures (e.g., climate change impacts, invasive species), and administrative boundaries (e.g., maritime boundaries).

The Atlas also contains ocean literacy resources: Theme Maps, Featured Maps and Story Maps. All these products are meant to provide context to the data, support engagement with and extension of the Atlas, and foster ocean literacy of complex socio-ecological topics, as well as a better understanding of how geospatial tools can support decision-making for these topics.

A longevity strategy was developed to ensure the future of the Atlas beyond this initial development phase. This strategy is formed around three pillars:

- Ongoing maintenance: ensuring continuing functionality of the core components of the Atlas
- Uptake by stakeholders and relevance: actions to keep the audience engaged
- Resource sustainability: securing adequate resources to maintain the Atlas and support further development as needed

Implications for relevant stakeholders

The Tasmania's Marine Atlas was designed to be used by all relevant marine groups: industry, government, researchers, and members of the community. It contains accessible features, tutorials and ocean literacy products to further guide end-users to relevant spatial datasets. It is hoped the Atlas has now become and will increasingly develop in the future as a tool for all stakeholders in the fisheries and aquaculture sectors, government, researchers, and community members. Users can:

- Navigate to or search topics of interest to uncover data and visualize them, as well as having access to comprehensive metadata linking to the data custodian;
- Search available datasets in a user-defined geographic area of interest;
- Uncover metadata when relevant: information on datasets that exist but may sensitive and/or proprietary.

The Atlas was designed to be a dynamic and flexible tool to absorb more relevant datasets in the future, as well as meeting yet-unknown stakeholder needs.

It is expected the Atlas can also be readily used as a conduit for relevant extension activities, either through data visualization or the development of communication tools, pending available resources.

Recommendations

Several sources of relevant datasets were identified during the project but not yet included on the platform. It is therefore recommended actions be taken to embed these datasets: publicly available catch data from Tasmanian commercial fisheries and oceanographic data products. The latter is increasingly of interest to stakeholders because of projected environmental change under climate change.

Further development to the Atlas could include:

- A bespoke and Indigenous-led (or co-led) approach to understand the relevance of the Atlas to Indigenous communities as it stands or in a different format.
- An emphasis of collecting and making available socio-cultural datasets. In the context of the Atlas, this emphasis is specifically on providing spatially-explicit attributes of socio-cultural values in Tasmania.
- The development of a mobile version and/or 'offline' version of the Atlas.
- The development of tools embedded in the Atlas allowing users to interact with the datasets – or a select subset of datasets – and simple analytical tools.

Keywords

Tasmania, marine, spatial data, portal, web-based, socio-ecological, planning, marine spatial planning

Introduction

Marine planning is a process by which decisions on marine activities within a legislative and regulatory context are made based on the distribution of ecosystems and species, the socio-economic value of marine resources, and the cultural importance of place. Marine *spatial* planning aims to optimize activities in the marine environment with fair resource allocation, while minimizing negative impacts on ecosystems and species, to ensure the continuing provision of ecosystem services for future generations. To support this process, evidence-based decision-making relies on information to guide actions, may such actions be from government or from a user perspective to ensure fair and sustainable resource allocation.

A critical step of evidence-based decision-making in the context of spatial planning is the collation and availability of relevant information in marine ecosystems (Ehler and Douvere 2009). In the fisheries and aquaculture sectors, several examples exist of tools and approaches to share data to guide spatial planning, particularly for aquaculture sitting (Falconer et al. 2019, Gangnery et al. 2021). Geospatial technologies and tools can support spatial planning through data acquisition, manipulation and storage. Mapping platforms in particular can act as data repositories and sharing mechanisms and include tools to manipulate the data to guide decision-making (e.g., Menegon et al. 2023). In Australia, such mapping platforms exist, namely Seamap Australia (seamapaustralia.org), the Australian Marine Spatial Information System (AMSIS; amsis-geoscience-au.hub.arcgis.com) at the national level, and at the state level and government-managed, CoastKit (Victoria; mapshare.vic.gov.au/coastkit/) and LISTmap (Tasmania; maps.thelist.tas.gov.au). These portals contain much information, but other sources of relevant information abound, particularly in the context of managing marine resources. This information is contained in disparate databases and online repositories, and often proprietary or sensitive.

The Tasmania's Marine Atlas project addresses a need expressed by marine groups in Tasmania to better document the spatial distribution of ocean uses and ecosystems and species at a scale relevant to Tasmania, including local datasets. In addition, making this information (and meta-information) easily accessible by stakeholders was a priority. To guide this effort, key principles shaped the activities and final outcomes and products of the research to meet this need:

- Format is accessible to a broad range of potential end-users, including researchers, industry, government and also interested members of the public when relevant;
- Flexible infrastructure to collate a diversity of datasets and information sources, and be responsive to upcoming, yet-unknown stakeholders needs;
- Technology-ready and progressive;
- Abide by the FAIR data principles (Findable, Accessible, Interoperable, Reusable);
- Relevant, suitable to stakeholders, and broadly appealing;
- Low-cost and efficient on resources to ensure sustainability.

The Tasmania's Marine Atlas project aimed to fill this gap. This was achieved through four key activities:

- Data discovery: What datasets are relevant and available in Tasmania?
- Synthesis and classification: How can we group and classify datasets for easy access while using consistent terminology?
- Access: what is the best, most appealing and appropriate approach to visualize and share data (and metadata)?
- Augment (value-add): what other tools and products can we develop to enhance the appeal of the platform, thus further supporting longevity?

Objectives

The project had four main objectives:

1- Identify, collate and create database of available spatially-resolved environmental, resource use, and cultural heritage data for Tasmania's state waters.

Amendment: A database was not created; instead, the Tasmania's Marine Atlas, as an online mapping platform, draws metadata and datasets from online repositories and databases via web-mapping services.

2- Develop an interactive web-based mapping service to display and download Tasmania's Marine Atlas data.

3- Analyse and compare existing trade-off tool(s), to be used in conjunction with Tasmania's Marine Atlas, for use in decision-making

4- Establish protocols for ongoing updates (automatic and manual) to, and management of, Tasmania's Marine Atlas database

In this report, project activities are divided into sections, each addressing one or several of the objectives of the project (see Table 1 below). Each chapter includes rationale, methods, outputs and/or findings, and when relevant, implications for the project. This documents the development of the Tasmania's Marine Atlas platform and looks ahead to ensure its relevance and longevity moving forward.

Table 1 Report structure: Mapping activities against the objectives of the Tasmania's Marine Atlas online mapping platform.

	Project objectives			
	1	**2**	**3**	**4**
Section 1: Classification scheme and data discovery				
Section 2: The Tasmania's Marine Atlas				
Section 3: Stakeholder engagement and extension				
Section 4: Longevity and future of the Atlas				

SECTION 1: Classification scheme and data discovery

1.1 Rationale

A critical component of marine spatial planning is the definition and analysis of existing conditions by collating background information relevant to the coastal and marine environment, including biological and ecological information, features of the physical environment, human activities, administrative and jurisdictional boundaries, and pressures (Ehler and Douvere 2009). It is also important to consider the economic and social factors which are relevant within the local context (Ehler and Douvere 2009).

Reliable datasets about the biophysical state of the ocean and coast and its human uses exist in the Tasmanian context; however, they are often not widely distributed, and/or not formatted with the capacity of interacting with other data layers or analytical tools. A study by Nicholson et al. (2020) conducted at the Institute for Marine and Antarctic Studies (University of Tasmania) highlighted the breadth of publicly available datasets, uneven spatial distribution of dataset coverage, gaps in the type of data identified and the challenges associated with data collation.

Disparate datasets require organization to be easily accessible by end-users and stakeholders, and recognizable across disciplines, practitioners, and government. A 'classification scheme' aims to arrange datasets by relevant topics and/or data custodians and should generally reflect expectations of end-users with regards to terminology and content. A classification scheme helps synthesise and understand the breadth of information available for spatial analysis, planning, and management, and to provide a foundation for ensuring that a comprehensive representation of datasets is compiled and available for use within Tasmania's coastal waters. It is therefore a critical initial component of data collation and eventual sharing of information through the web-based mapping platform.

In the Tasmania's Marine Atlas project, the data inventory built by Nicholson et al. (2020) was augmented with additional potential data sources and specific publicly available datasets relevant to marine socio-ecological systems in Tasmania's coastal waters to support the development of the web-based mapping platform. Further, a fit-for-purpose classification scheme for datasets to be embedded in the mapping platform was developed to organize the datasets to facilitate access by end-users.

1.2 Methods

Classification scheme

The classification scheme used in the Tasmania's Marine Atlas was developed based on published literature and engagement with stakeholders through structured workshops (engagement is detailed in Section 3). An initial classification scheme was derived from types of spatial data discussed by Ehler and Douvere (2009). This scheme additionally drew on the types of spatial data discussed by Stamoulis and Develaux (2015) and Shucksmith and Kelly (2014). At a finer scale the scheme was informed by data types used within decision-support research in Tasmania (e.g., Macleod et al. 2015, Ross et al. 2020). The classification scheme was designed to be hierarchical in nature, representing as broad overarching themes the human dimension, ecological dimension and datasets related to zoning (administrative boundaries). These broad themes then contained nested levels, with increasing level of specificity. This initial classification scheme was refined via engagement with stakeholders (see details in Section 3). The final classification used in the Tasmania's Marine Atlas is shown in Table 2.

Table 2 Classification scheme of linked datasets in the Tasmania's Marine Atlas online mapping platform (based on 'By Category' tab only).

Main category	Sub-category
Biophysical dimension	Bathymetry and seabed types
	Ecosystems
	Ocean properties
	Southeast Biologically Important Areas
	Species occurrences and distributions
Human dimension	Aquaculture
	Commercial Fisheries Blocks
	Commercial Fisheries
	Environmental Monitoring
	Marine & Coastal Infrastructure
	Marine Renewable Energy
	Marine Transport
	Oil & Gas
	Other Industries
	Recreation
	Recreational Fishing
	Restoration
	Recreational Fishing
	Restoration
	Scientific Research
	Social and cultural
	Socio-economic
Threats and Pressures	Climate change
	Coastal land use
	Combined pressures
	Invasive species
	Pollution
	Others
Administration	Administrative boundaries and names
	Australian Maritime Boundaries
	Protected Areas

Users can also navigate linked datasets by organisation (data custodian) using the 'By Organisation' tab.

Data discovery: Pre-existing inventory

Nicholson et al. (2020) initially identified 356 potential datasets. These stemmed from many data sources, from local to international databases. This effort was narrowed to four key data portals as most relevant to Tasmanian waters: the Australian Ocean Data Network (AODN), the IMAS data portal, the LIST (Tasmanian Government) and the CSIRO data portal. A few additional relevant datasets were acquired from different sources, e.g., boundaries of maritime jurisdictions in Australia. Overall, from this narrowed search, 100 datasets were acquired and categorized for visualization. The outcomes of this analysis are presented in Nicholson et al. (2020). This list of datasets formed the starting point of the data audit for the Tasmania's Marine Atlas.

Data discovery: Inventory for the Tasmania's Marine Atlas

In this project, an initial data inventory was developed using the datasets acquired and categorized for visualisation in Nicholson et al. (2020), and additional datasets discovered through searching data portals and other relevant local, national and international sources (Appendix 1). Key portals which aided in data discovery were the National Environmental Science Program (NESP); Australian Bureau of Statistics (ABS); Australian Government Department of Agriculture, Water, and the Environment; The

List (Land Information System Tasmania); National Map; Institute of Marine and Antarctic Studies (IMAS) Data Portal; Australian Ocean Data Network (AODN); and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) data portal.

From this inventory, a catalogue of 174 potential datasets was collated. This data catalogue prioritised spatially explicit accessible datasets to gain an initial understanding of the scope and distribution of coastal, marine, and land-sea interface datasets in Tasmania. This catalogue was used to initially populate the Tasmania's Marine Atlas (details in Section 2).

OUTCOMES

These project activities produced:

- A classification scheme by which datasets are discoverable on the Tasmania's Marine Atlas mapping platform.
- A catalogue of 174 relevant datasets that could be linked to the platform.
- An initial understanding of 'data gaps' (more details provided in Section 4).

SECTION 2: The Tasmania's Marine Atlas

2.1 Online mapping platform

This section details the key components and processes underpinning the operational functioning of the Tasmania's Marine Atlas (the 'Atlas'). The Atlas was developed in collaboration with the software development company Condense based in Hobart, Tasmania, and the support of the Seamap Australia team (Dr. Emma Flukes) and staff with data infrastructure expertise at the University of Tasmania (Mr. Peter Walsh). The Atlas was also developed through engagement with stakeholders and end-users (detailed in Section 3). The purpose of this section is to better understand the capabilities of the Atlas, as well as its limitations, and hence supporting the discussion on longevity, relevance to and uptake by end-users, and the possibility and needs for future updates, should opportunities arise (detailed in Section 4).

2.1.1 Key components and features

The Tasmania's Marine Atlas (the 'Atlas') consists of a front-facing website (Fig. 1, available at tasmarineatlas.org) and a web-based mapping platform which allows visualisation of a collection of spatial data layers. The website provides users access to the web-based mapping platform (detailed below), resources such as tutorials, a glossary and useful links, as well as 'Featured Maps', 'Theme Maps', and 'StoryMaps' (described in Section 3). The web-based mapping platform provides users with the capacity to visualise data layers and access the metadata and, in some cases, source data of these spatial layers. The front-facing website is configured using WordPress, and the web-based mapping platform data layers are catalogued in Microsoft SQL Server. This section focuses on the functionality and features of the web-based mapping platform for visualization of spatial data layers (available at tasmarineatlas.org/map/).

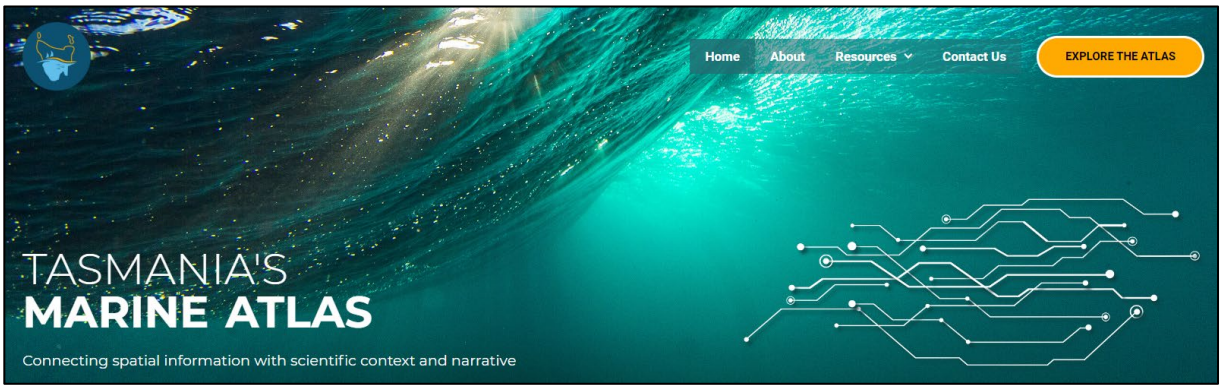

Figure 1 Landing page of the Tasmania's Marine Atlas (as of October 2024, tasmarineatlas.org).

As of October 2024, the web-based mapping platform contains a total of 305 individual spatial data layers from 14 external data custodians and the Atlas itself (locally hosted) across 116 datasets relevant to Tasmania's marine and coastal environment (Table 3). Navigation to specific data layers occurs via the left-hand side panel (Fig. 2). Spatial data layers are activated with tick boxes in the 'Catalogue' tab. Once activated, they appear in the 'Active Layers' tab (Fig. 3).

When in the 'Active Layers' tab, a legend is associated with each spatial data layer, the appearance of which is dictated by the data custodian (Fig. 3). Information on the content of each layer, its metadata, and source is accessible via the 'Layer info'. The opacity of each layer can be adjusted with a transparency slider. Layers with a temporal component – such as those related to catch of commercial fisheries in Tasmania - have additional features allowing users to navigate data at different time points. This is accessible via the 'Time' button in the 'Active Layers' for these layers (Fig. 4). A slider is used to switch time points. This feature is also available for layers with a probabilistic component.

Table 3 Summary of datasets embedded in the Tasmania's Marine Atlas as of October 2024.

Category [number of datasets]	**Examples of datasets**	**Data custodians**
Biophysical dimension [29]	Bathymetry, ocean properties, seabed types, species occurrence and distribution of seabirds, benthic species, and marine mammals	Department of Climate Change, Energy, the Environment and Water; Geoscience Australia; Institute for Marine and Antarctic Studies (University of Tasmania); Integrated Marine Observing System (IMOS); National Science Environmental Program, CSIRO, Department of Natural Resources and Environment Tasmania, SeaCare; Tasmania's Marine Atlas
Human dimension [55]	Fishing management zones, marine farming zoning, fisheries catch data, coastal infrastructure, recreation use (surveys), socio-economic data, marine infrastructure, oil and gas infrastructure, offshore renewable energy areas of declaration, monitoring programs and locations, scientific research sites, vessel tracks, restoration sites	Australian Bureau of Statistics; Australian Maritime Safety Authority; Department of Agriculture, Fisheries and Forestry; Department of Climate Change, Energy, the Environment and Water; Geoscience Australia; Institute for Marine and Antarctic Studies (University of Tasmania); Integrated Marine Observing System (IMOS); Marine and Safety Tasmania; National Offshore Petroleum Titles Administrator; National Science Environmental Program; CSIRO; Department of Natural Resources and Environment Tasmania; Tasmania's Marine Atlas
Threats & Pressures [14]	Climate change impacts (rainfall change, storm tides), invasive species surveys, coastal pressures, cumulative impacts in the pelagic environment	Department of Climate Change, Energy, the Environment and Water; Department of Natural Resources and Environment Tasmania; National Science Environmental Program
Administration [18]	Marine parks, reserves and conservation areas; geoconservation sites, maritime boundaries	Department of Climate Change, Energy, the Environment and Water; Department of Natural Resources and Environment Tasmania; Geoscience Australia

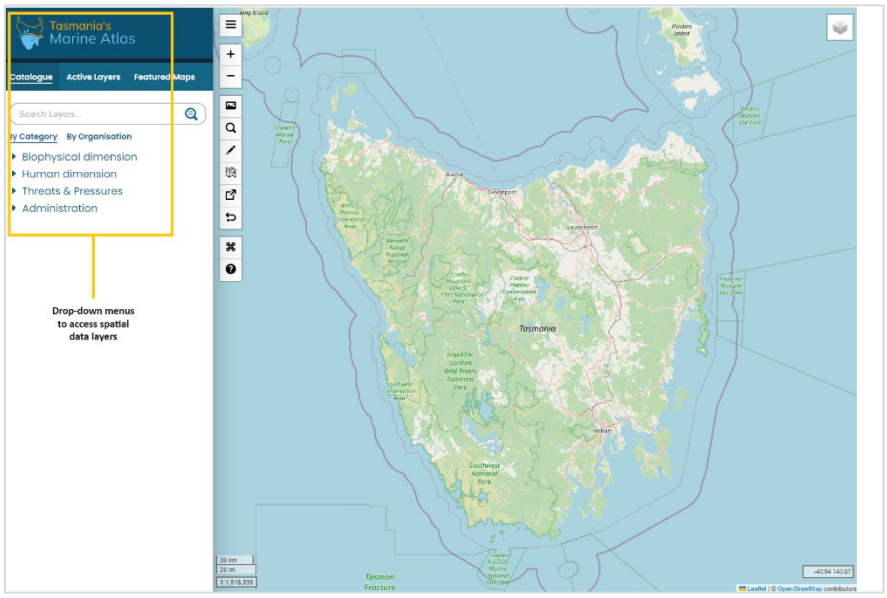

Figure 2 'Catalogue' view in the web-based mapping platform embedded within the Tasmania's Marine Atlas (available at tasmarineatlas.org/map/). End-users can access the spatial data layers via the drop-down menus (by category or organisation) via the left-hand side panel.

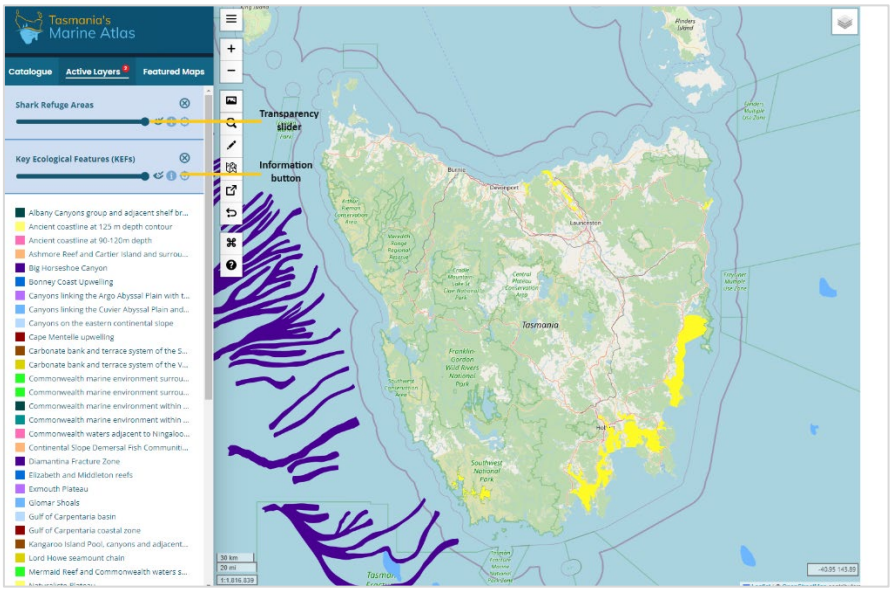

Figure 3 'Active Layers' view in the web-based mapping platform embedded within the Tasmania's Marine Atlas (available at tasmarineatlas.org/map/). End-users can access information on each layer via the 'Information button', and the opacity of each layer can be adjusted with the transparency slider.

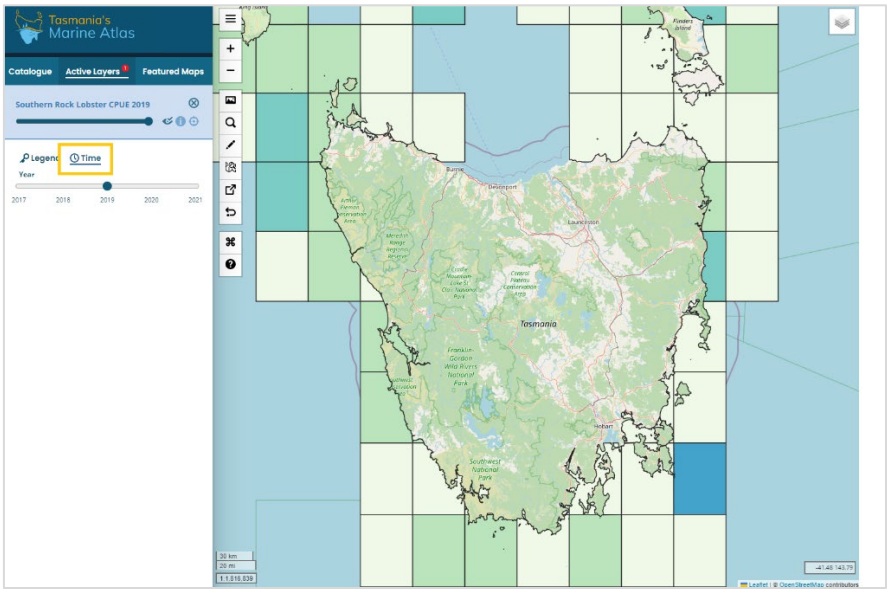

Figure 4 'Active Layers' view in the web-based mapping platform embedded within the Tasmania's Marine Atlas (available at tasmarineatlas.org/map/). Layers with a temporal component have a 'Time' slider where the user can adjust the time point of the spatial data layer.

Users can navigate as needed through the layers of the Atlas based on a particular topic of interest or data custodian (i.e., the 'By Category' and 'By Organisation' tab). Users can also search for data layers based on a spatial region of interest. The 'Find Data in Region' tool extracts all data layers contained within the Atlas with features in a user-defined area of interest (Fig. 5). This allows the user to rapidly examine the breadth of available data (and highlight data gaps, where relevant). When a region is selected, a right-hand panel appears with the available datasets within that region, with a similar structure (classification) as found in the 'Catalogue' tab.

The Atlas contains other user-friendly features such as exporting the current map to an image, creating a shareable URL with the defined set of layers that preserves the current user interface state, searching layers, and resetting the interface to remove all active layers.

There are currently 13 basemaps available to users of the Atlas. Open Street Map is displayed by default, but the basemap can be changed using the icon in the top right corner of the map view (Fig. 6).

Spatial data layers embedded in the Atlas cannot be directly downloaded via the web-based platform. Instead, users are directed to the metadata provided by the data custodian, which typically includes a description of how the data can be obtained. If downloads are available for the selected data layer the link to download may be provided within the metadata record. It is preferrable users obtain the data directly from the data custodian if they wish to do so. This directs site traffic to the data custodian, which may support their capacity to monitor dataset traffic and data usage. The Atlas is developed to link to other repositories and databases via web-mapping services for quick and easy access to an overview of the available data (or lack thereof) and visualization. This infrastructure is described in the following section.

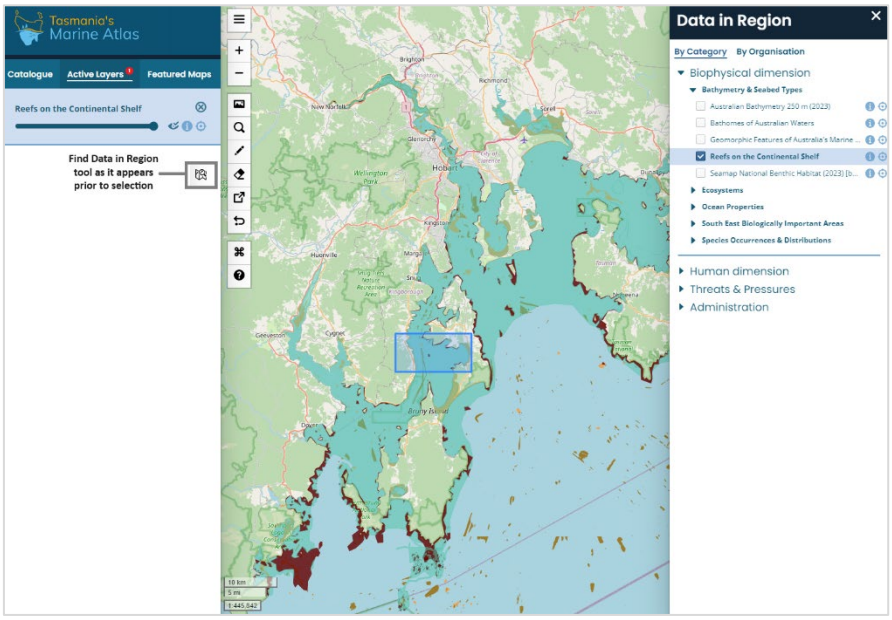

Figure 5 'Find Data in Region' tool in the web-based mapping platform embedded within the Tasmania's Marine Atlas (available at tasmarineatlas.org/map/). The user-defined selected area is shown in blue. Available datasets in the selected area are displayed in a right-hand side panel, the structure of which reflects the one found in the 'Catalogue' tab.

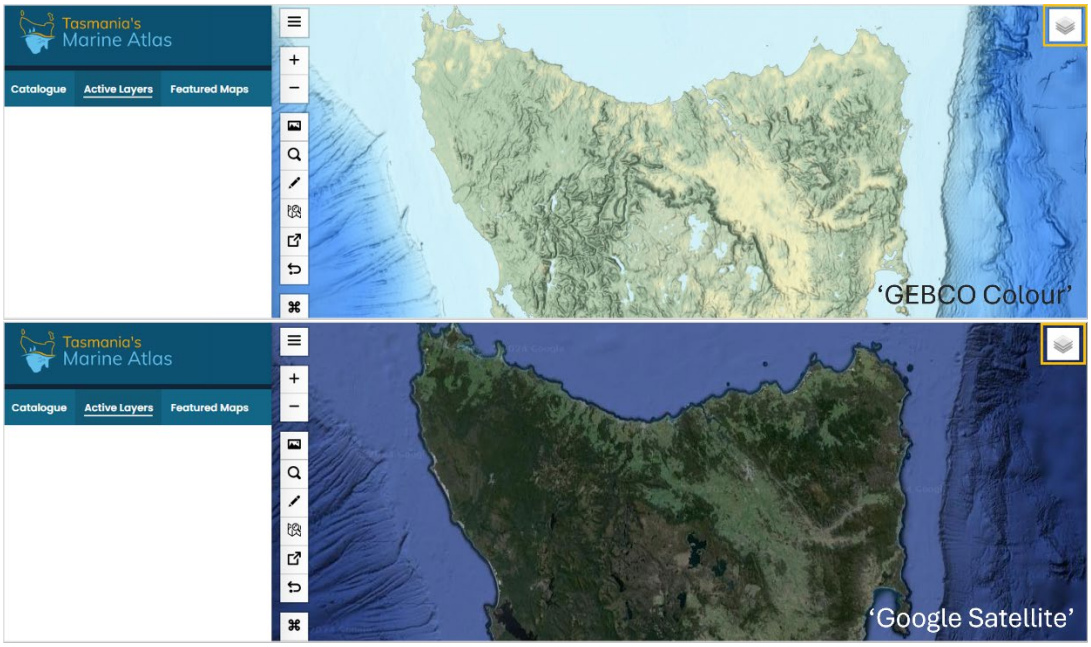

Figure 6 Thirteen basemaps are available in the Tasmania's Marine Atlas. Two examples are provided: 'GEBCO Colour' and 'Google Satellite'. Basemaps can be changed using the icon in the right-hand corner of the map view.

2.1.2 Geospatial Database

Spatial data layers in the Atlas are either locally hosted at the Institute for Marine and Antarctic Studies, University of Tasmania, or visualized through geospatial web-mapping services managed by external

data custodians. A web-mapping service provides a visual representation of geospatial data by dynamically rendering it as georeferenced images, enabling users to view and interact with maps over the web without needing to access the underlying data directly. The georeferenced images are then displayed on the Atlas map and allow for exploration of spatial data by non-expert users. Therefore, critically, for relevant spatial data to be embedded in the Atlas, web-mapping services must be made available by the data custodian.

Spatial data layers embedded within the Atlas are configured through a catalogue stored in Microsoft SQL Server, a relational database management system which allows data storage and management. Microsoft SQL Server also functions as a data store for locally hosting spatial data.

Individual data layers are catalogued in the main 'layer' table, which directs the Atlas software to the web-mapping service. This layer catalogue also collates the essential metadata used to display each mapping layer including a human-readable title (for display in the Atlas catalogue), metadata URL, categorical groupings, mapping server type, data custodian and spatial extent. Custom or bespoke classification of datasets – as shown on the Atlas – are made possible by connecting to secondary tables detailing options for data classification, category, server type, base layers and data custodian, as well as parameters for data layers with a temporal or probabilistic component. Searchable keywords and a brief metadata summary to aid interpretation of the spatial data are also included in the tables to enhance discoverability and user experience. The catalogue and layer details provided in the Atlas ensure users have ready access to information on data provenance and data owners are given attribution.

Most spatial data layers embedded in the Atlas are hosted by third-party data custodians, as this is the preferred option to reduce ongoing maintenance costs. However, some datasets not found in public online repositories are hosted locally by the Atlas (through the IMAS data infrastructure). These 'orphan' datasets are deemed of high importance to Tasmanian stakeholders, hence are worth the commitment to host them for the purpose of the Atlas. Examples of those datasets include: the Broadscale Environmental Monitoring Program sites, publicly-available commercial fisheries catch data, and sites of the Oysters Tasmania Sensor Network. Because this effectively transforms the Atlas into a data custodian, through the IMAS infrastructure, several steps need to be taken to embed these layers in the Atlas:

1- A **data agreement** needs to be put in place where original data owners agree the data be hosted and published by the Atlas (IMAS) on behalf of the data owners;

2- The creation of a single or several **spatial data layers,** if not currently available;

3- Publish spatial data layers with associated visual styling through the **IMAS GeoServer** web services;

4- The layer can be visualized in the Atlas by linking to the IMAS GeoServer's web-mapping service;

5- Since the dataset is now part of the IMAS data management infrastructure, a **metadata record** is created.

2.2 The Tasmania's Marine Atlas as a decision-support tool

2.2.1 Rationale

The Atlas is a web-based mapping platform where users can visualize information relevant to marine resources management, marine industries, and natural ecosystems in Tasmanian waters. As such, it is meant to provide support to industry, policymakers and the community when tackling marine issues by providing information and context and an evidence base for decision making. It is also meant to support and foster research in marine resource management, marine geography, and marine planning. Information relevant to marine resources is complex and varied, e.g., fisheries footprint and effort, distribution of marine ecosystems, spatiotemporal variability in distribution of species, underlying natural or anthropogenic change in the environment, socio-cultural values of communities interacting with the marine environment, etc. To address this, 'decision-support and trade-off tools' are developed to help synthesize and condense information when making decisions about the use – or lack thereof – of marine resources. The purpose of the analysis presented here was to investigate how trade-off and decision-support tools are generally used in marine resource management, specifically in a spatially-explicit context such as marine spatial planning, and contrast these uses against the format of the Atlas.

What are decision-support tools?

The expression 'decision-support tool' (DST) refers to a range of methods, processes, software and mathematical models used in spatial and other physical sciences to collate, condense and package complex information in forms that can be more easily accessed by decision-makers (Depellegrin et al., 2021; Sullivan, 2002).

DSTs account for the complexity of marine socio-ecological systems by considering conflicts, synergies and trade-offs among marine users, while ensuring ecological sustainability and resilience of the marine environment. DSTs provide transparency, are evidence-based, and aim to generate reproducible results to support decision-making processes. Some DSTs can also evaluate different management decisions through scenario modelling. Here, in the context of the Atlas as a web-based mapping platform, we focus on computer software-based tools. However, other tools/methods and techniques are available that can support the decision-making processes in marine resource management, such as surveys, participatory mapping, expert workshops, and serious gaming, to name a few (Gee et al., 2019; Pınarbaşı et al., 2019).

2.2.2 Methods

To determine the range of potential DSTs, a desktop analysis was conducted comprising of the analysis of articles on DSTs in the primary scientific literature. A systematic search using the SCOPUS database was conducted in early 2023 using the search terms 'decision support*' and 'marin*'. A total of 159 journal articles were identified from this search. After an initial review of abstracts, four review articles and 58 empirical articles (case studies) published since 2019 were identified as relevant for the purpose of this analysis. The date range was selected for two reasons: (i) the most recent review paper published in 2021 was assumed to include DSTs up to at least 2019; and (ii) restricting our analysis to the past five years ensured we focus on only the most recent and therefore relevant DSTs for practical application in the Tasmanian context (see Appendix 2 for the list of articles used in this analysis). To further ensure we did not miss any important themes from the pre-2019 literature we further included: three review articles which together provide a comprehensive summary of decision-support tools in a marine context since 2013, and one article identified through a focused literature search. Therefore, 66 articles in total were considered for this analysis.

In addition to the review of the primary scientific literature, an online search was conducted to identify other relevant web-based DSTs and mapping platforms for marine spatial planning. The range of tools identified were analyzed against four key aspects relevant to the Atlas:

1- **Format**, e.g., web-based application, modelling suite;

2- **Functionality**, which included:

- ability to display raw data,
- capability for enhanced data visualization (e.g., plots, 3D, animations, maps focused on specific topics)
- ability to perform basic tasks with the tool beyond visualizing raw data (e.g., drawing features, making maps, downloading data), label here as 'user experience',
- analytical capabilities (e.g., modelling, cumulative impact assessment, conflict analysis).

3 - **Knowledge** and **technical skills** required to use the DST;

4- **Access**, e.g., user authentication, open-access, mixed access.

2.2.3 Results

From the desktop analysis, we identified 37 DSTs which are summarized in Appendix 3. Four types of formats were present for the decision-support tools: web-based mapping application (n = 26, 65%), standalone software (n = 8, 20%), add-in/toolbox/library (n = 4, 10%) and methodology tools (n = 2, 5%). Some tools are available in different formats. For example, Marxan is available as a standalone software, as a plug-in and as a web-based mapping application.

Tools had varying levels of complexity in their functionality. A basic functionality was the display of raw data (e.g., all web-based mapping applications). More advanced functionalities included the creation of maps and sharing with other users, data access (i.e., download a local copy), drawing and editing tools, adding external data, and exploring model outputs and metrics. 'Enhanced' data display were provided in tools that explore time series data, modelled data, plots and graphs for different metrics, 3D visualization, animations, and shared workspaces. Finally, analytical tools were available in 21 decision-support tools, and they included ecosystem and food web modelling, economic analyses, cumulative impact assessments, particle tracking, trade-off analysis, conflict analysis, and the development of scenarios for management.

The use of web-based mapping applications required basic computer skills only to visualize data or perform basic tasks such as creating a map, drawing features or accessing enhanced visualization features. In contrast, most tools that included analytical functionality require intermediate to advanced Geographic Information Systems (GIS) and domain-specific skills (e.g., ecosystem modelling, marine resource economics). Two tools with analytical capabilities were more accessible: SeaSketch and PlanWise4Blue.

Most tools were openly available online either via an Internet browser (web-based) applications or accessible tools to be downloaded and used on a local computer. However, six tools required registration and/or paid access (licensing). Some tools required registration but no charge is asked to the user. Some tools required either partial licensing (e.g., Ecopath with Ecosim) or full paid access (e.g., SeaSketch). In one tool - Geoportal of the Adriatic-Ionian Region (GAIR) – access was restricted to project partners. In all cases where registration or paid access was required, this was meant to unlock more advanced analytical capabilities (e.g., 'particle tracking' application).

In this analysis, three web-based mapping applications tools were identified specifically in Australia (only) to compare/contrast against the Atlas (see Appendix 3): the Australian Marine Spatial Information System (AMSIS), CoastKit (Victorian Government), and Seamap Australia. Like other web-based mapping applications, the tools display primarily data (and act as data repositories), and each offers a distinct suite of enhanced data visualisation or user experience features. Importantly, each tool is focused either geographically (Victoria) or thematically (national seabed habitats, specific interest in Australian Marine Parks). AMSIS is hosted by the federal government (Geoscience Australia). Analytical capacity is included in CoastKit via the 'Feature Activity Sensitivity Tool' (FeAST); however, this may require domain-specific knowledge to use effectively. It is worth noting many 'decision-support tools' are either developed or applied in Australia (e.g., the ecosystem model Atlantis, CSIRO Connie, Marxan) but the focus here is on web-based mapping applications most similar in purpose and format to Atlas.

2.2.4 Outcomes

The definition of decision-support tools (DST) is varied across the literature. Decision-support tools are not designed to alone define optimal decisions. They rather provide synthesis and information, based on the data available, to make evidence-based decisions (Bolman et al., 2018). In many cases, DST refers to specific computer-based software, such as Marxan or Atlantis, that provide evidence-based products to support the decision-making process (Pınarbaşı et al., 2017). In some cases, the term also includes aspects beyond computer-based tools, for example stakeholder engagement and education (e.g., MSP Challenge Simulation Game; Gee et al., 2019). In other cases, the term is used interchangeably with 'decision -support systems' – i.e., 'an interactive computer-based system designed to help people use (computer) communication, data, documents, knowledge, and models to solve problems and make decisions' (Bolman et al. 2018; Stelzenmüller et al., 2013) -, 'decision- support processes' (technical, based on expert opinion, or participatory) where the outputs of a tool need to be developed in certain ways (Gee et al., 2019), or 'decision-support approach', which is broader and represents a framework that provides guidance for planning and decision-support (Gee et al., 2019).

It is therefore vital to define what a DST is in the context of the Atlas that is relevant to the stakeholders and end-users. Key aspects of effective decision-support tools are: 1) appropriate to decision-making context and questions; 2) appropriate quality data for the different decision support tools; 3) sufficient expertise to use the decision-support tool and convey outputs to non-experts.

The Atlas is primarily meant as a web-based mapping application (mapping portal) to convey complex (spatial) information on marine socio-ecological systems in Tasmania. In this context, we found that:

- Similar to the Atlas, all reviewed web-based mapping applications have been designed to support the decision-making process for marine resource management by providing available spatial data (information) related to the marine environment and uses in a specific area.
- End-users typically do not require advanced background knowledge and/or technical skills to visualize data, perform basic tasks and access enhanced visualization capability of web mapping portals.

As designed, the functionality of the Atlas therefore provides decision-support like other web-based mapping applications in Australia and overseas. Specifically,

- The Atlas displays 'raw' data from data providers in curated databases, including research data and metadata when relevant;
- The Atlas aims to provide enhanced data visualization capacity, such as:
    - Develop capacity for temporal data visualization beyond static layers, e.g., commercial fisheries catch data, ocean properties and vessel tracks (maritime transport);

- The Atlas hosts features to enhance the user experience based on end-users feedback, including:
    - Save a current 'workspace' (data layers and field of view) with a URL (to save or share);
    - Allow discovery of relevant place-specific datasets using the 'Find Data in Region' tool;
    - 'Featured Maps' and 'Theme Maps' to guide users to relevant topic-specific datasets (detailed in Section 3);

In terms of background knowledge and skills required, the Atlas is intuitive, easy-to-use, and designed to be used by a diversity of end-users with varying background knowledge and technical skills. It is also an open online platform, where user registration or paid license is not required.

Also like most reviewed web-based mapping applications, the Atlas does not currently contain advanced analytical capabilities. This is because:

- The Atlas acts as an online repository of data sets hosted in various databases, including research databases. Therefore, as an intentional design feature, few datasets are locally hosted to be displayed on the Atlas (despite the technical capacity to do so). This limits the potential for data analytics.
- The Atlas is meant to be easy-to-use, intuitive and open to all interested end-users. This is a design feature of the Atlas when interacting with datasets. This limits the complexity of the tools that are currently embedded within the Atlas.
- The Atlas has a diversity of potential end-users, including industry, community, researchers, government and non-governmental environmental organizations. Analytical capability and needs of these groups vary. Establishing clear methodology for the analytical tools based on robust science – and demonstrated stakeholder need – is vital prior to tool implementation. This diversity limits the breadth of the analytical tools that could be provided by the Atlas, including for more advanced users.

SECTION 3: Stakeholder engagement and extension

The Tasmania's Marine Atlas was developed using a participatory or knowledge co-production framework, where the most affected stakeholders are directly involved in guiding the research objectives and outputs. In this context, understanding and responding to end-user needs and ensuring accessibility was central to the approach taken to develop the Atlas. This is meant to:

- Ensure end users' data needs are met, they are aware of the project outputs and how to use them;
- Enable stakeholders to contribute relevant data products;
- Ensure usability of the primary research output (the 'platform') by key stakeholders.

The Atlas is meant to meet stakeholders' expectations and needs and appeal to a broader audience when needed to enhance its use and ensure its relevance and therefore its longevity. In this context, actions taken for stakeholder engagement and extension fell under two main streams:

1- Direct stakeholder engagement to guide the content and format of the Atlas;
2- Develop science communication products based on stakeholder interest to facilitate the use of the Atlas, and more broadly, to foster ocean literacy.

This section details how these two streams were implemented in the development of the Atlas, and the current features that can be found on the platform.

3.1 Direct stakeholder engagement

Direct stakeholder engagement was conducted using various means: the creation of a Project Advisory Group at the onset of the project, engagement through individual discussion with key stakeholders, and a series of structured engagement workshops.

Project Advisory Group

A 'Project Advisory Group' (PAG) was formed at the onset of the project. The purpose of the PAG was to support the research process and progress of the project by providing advice on: how to remove any obstacles as they arise, decision-support tool(s) the Atlas may contain and contribute to, and identifying financial support on the ongoing maintenance of the Atlas beyond this initial development phase. Additionally, the PAG was created to provide general advice and recommendations on the platform, and facilitate access to datasets, when relevant. Membership to the PAG included industry representatives (Seafood Industry Tasmania, and initially, the marine tourism sector), Natural Resources Management (NRM) South, government (Director Marine Resources, Department of Natural Resources and Environment Tasmania), a community representative, and an academic representative from IMAS (external to the project). The PAG met with the project team regularly (every ~3-4 months during the project).

Individual discussion with key stakeholders

Throughout the lifetime of the project, many direct discussions were had with key Tasmanian stakeholders. Initially, at the onset of the project, this was meant to introduce the objectives of the project and identify data users and potential data providers. In subsequent stages of the project, the

purpose of these discussions shifted to ensuring the content, format and functionality of the Atlas met stakeholders needs.

In addition to interactions with the PAG, which included industry representation, the research team directly engaged during the project with:

- **Potential end-users** in the Department of Natural Resources and Environment Tasmania (The LIST, Lands Tasmania, Invasive Species, Marine Conservation, Wild Fisheries, Aquaculture Branch), the Environment Protection Authority, Australia Institute, NRM South, Department of State Growth (Renewables, Climate and Future Industries Tasmania), Tasmanians for Marine Parks and Aboriginal Heritage Tasmania;
- **Collaborators and data providers** at IMAS (Fisheries Modelling Team, Human Dimensions Research Team, Marine Conservation, Salmon Environment Interactions Team), Integrated Marine Observing System (IMOS), Natural Values Atlas (Tasmanian Government), and Seamap Australia;
- **Advice**: Indigenous Science and Engagement (CSIRO)

Structured engagement workshops and focus groups

Eight structured engagement workshops were held with stakeholders in July and August 2022, and three focus groups were held in May 2023. These sessions were approved by the University of Tasmania Human Research Ethics Committee (reference H0026864). For all sessions, summaries of the findings were subsequently shared with participants. De-identified outcomes are reported here in line with consent sought from participants; outcomes are provided based on broad groups, whenever more suitable, e.g., aquaculture sector, research, government, community member.

In July and August 2022, eight structured workshops were held with a range of stakeholders in Tasmania. Eighty people participated in these workshops drawn from across the interested general public, community-based marine end-user groups, local government, Tasmanian aquaculture sector and representatives from science and government. Workshops were held in a hybrid format: in-person and online. This initial series of workshops was meant to elicit feedback on two main questions:

- Using the Atlas: How might the Tasmania's Marine Atlas be used?
- Populating the Atlas: What information is useful and important to you, and therefore should be included in the Atlas?

Features were included in the design of the platform based on the stakeholder input. Amongst these, the capacity for end-users to easily access all information associated with a specific valued place by drawing a transect/polygon was developed (now the 'Find Data in Region' tool, see Section 2). This represented a significant innovation in the platform technology to respond to this request.

In May 2023, three focus groups were held with the Department of Natural Resources and Environment Tasmania, key stakeholders in fisheries and aquaculture (i.e., seafood industry peak body and Tasmanian aquaculture sector) and researchers, and a general focus group for community members in Hobart. Forty-one people attended these focus groups. Focus groups were held in person. The objective of these focus groups was to test a beta version of the Atlas and elicit feedback from participants on strengths and weaknesses of the platform. Key points of the feedback provided during workshops and summary of design features developed from focus groups feedback are included in Appendix 4.

Engagement with Tasmanian Aboriginal people

Engagement with Tasmanian Aboriginal people was initiated during the second year of the project (2022). Contact was initiated with 28 Tasmanian Aboriginal organisations registered with the Office of the Registrar of Indigenous Corporations (ORIC)[1] to introduce the project and offering to provide briefings to any interested organisation. Of the three organisations that signalled initial interest, only one, the Tasmanian Aboriginal Centre, provided further input in the subsequent period of the project.

At the same time, a number of briefings and discussions were initiated with four Indigenous researcher leaders and Aboriginal Heritage Tasmania, the Tasmanian Government agency with responsibility for administering the Tasmanian *Aboriginal Heritage Act 1975*.

A follow-up round of contact was made with all registered Tasmanian organisations to discuss information they may have wished to include in the Atlas and provide feedback on the draft statement of Country (more details are provided below). Very low take-up resulted from this approach. At the same time, one-on-one discussion continued between the research team and the Tasmanian Aboriginal Centre (TAC) and with the newly-appointed (at the time) Aboriginal Cultural Fisheries officers at the Department of Natural Resources and Environment Tasmania.

Exploratory discussions continued between October 2022 and June 2023 and shaped the research team's understanding of what potential benefit for Aboriginal communities might be, and what was recommended to ensure Aboriginal interests and potential benefits can be taken into account in the process and final product in an ethical way. The following points were emphasised:

- No engagement with Tasmanian Aboriginal communities had been conducted in the development of the project proposal and feedback was given this was poor practice;
- Indigenous cultural intellectual property (ICIP) must be addressed before consideration of what Aboriginal knowledge might (or might not) be included;
- Building Aboriginal involvement in the Atlas will require dedicated and funded Aboriginal-led projects with interested and authorised Aboriginal organisations to address cultural knowledge that might be included in the Atlas;
- Develop a *Statement of Country* to be included in the Atlas, explaining *inter alia*: (1) all of Tasmanian waters and coasts are of significance to Tasmanian Aboriginal peoples; (2) an absence of data does not indicate an absence of connection and significance; (3) Tasmanian Aboriginal communities may at any time decide what information they wish to have included in the Atlas.
    - Include a communication piece (now in the form of an ESRI Story Map, details below) drawn from publicly available information to explain connection to Country and the significance of all marine waters to Tasmanian Aboriginal people.

In early 2023, concerns were raised about the accessibility of the Atlas for 'everyday' Aboriginal community members, and it was suggested that the Atlas should be tested through a focus group with community members, although not implemented over the course of this project. This remains a priority for the future of the Atlas. In addition, it was recommended that a community-led process be conducted to develop community specific interfaces with the platform to enable communities to access the range

[1] ORIC administers the *Corporations (Aboriginal and Torres Strait Islander) Act 2006*.

of data in community-relevant ways and formats, and to enable communities to develop, store and govern Indigenous Sea Country related data and information in the product.

It was acknowledged by respondents that, given the stage at which the engagement was conducted, these requirements may not be met during the initial development of the Atlas. It was also emphasised that it is essential to continue to building research team and Aboriginal organisations' understanding of what is possible, and how it could be governed in future projects.

Development of the statement of Country

The Atlas now contains a statement of Country which includes the suggestions made above. The statement is made visible in a pop-up window when first opening the web-based mapping platform. It reads:

The waters and coastlines represented in the Tasmania's Marine Atlas are of significance to Tasmanian Aboriginal people. We recognise the deep history and culture of the islands represented in this Atlas and acknowledge the traditional owners and custodians of Country. We pay respect to Tasmanian Aboriginal people, who have survived invasion and dispossession, and continue to maintain their identity, culture and Indigenous rights and honour their Elders, past and present.

Any absence of information about Tasmanian Aboriginal people's connection to Sea Country in the Tasmania's Marine Atlas does not indicate an absence of connection or significance. We respect the right of Tasmanian Aboriginal people to self-determination and affirm their right to decide what information is included in the Atlas.

After consultation on the wording, the statement of Country was workshopped with the Project Advisory Group. Aboriginal communities were given further opportunity to comment on the proposed final version and the statement of Country was reviewed and accepted by the Office of the Pro-Vice Chancellor for Aboriginal Leadership at the University of Tasmania in June 2023.

Launch of the Tasmania's Marine Atlas

The Atlas was publicly released in late December 2023. The platform was shared with collaborators, stakeholders, and participants in our engagement activities with a specific statement emphasizing the 'living' nature of the Atlas, hopefully continuously evolving to meet stakeholders' needs. Feedback was sought on this latest version of the platform. Over the following months, no feedback was received, which the research team interpreted the Atlas was working as intended. A public release was conducted on 28 May 2024, aided by a media release.

3.2 Fostering ocean literary and promoting engagement

The fundamental purpose of the Atlas is to collate and share available information on uses, ecosystems, and socio-cultural and economic values of Tasmanian marine waters. In addition to extensive engagement with stakeholders and the community, the Atlas team developed additional features to enhance the user experience – therefore increasing accessibility to a broader audience – and generally foster ocean literacy on topical issues in Tasmania. The purpose of this is to potentially increase traffic to the Atlas while improving science communications for marine uses, industry and conservation efforts in Tasmania. Described below are the key products and features now available on the Atlas – and meant to be updated as needed.

3.2.1 Rationale and purpose

Ocean literacy is a global movement to improve understanding of the influence humans have on the ocean, and the importance of the ocean to all humankind. It calls for education and engagement of the public through inclusive and accessible formats, to help people gain the knowledge, skills and values to support sustainable marine environments and "make informed and responsible decisions on ocean resources" (Santoro et al., 2017). Ocean literacy therefore plays a key role in effective marine spatial decision-making. The Intergovernmental Oceanographic Commission (IOC) has specifically emphasised ocean literacy as a mechanism to enhance stakeholder engagement and facilitate knowledge transfer in marine spatial planning (UNESCO-IOC, 2021).

Opportunities to increase participation in marine spatial planning

Identifying and engaging stakeholders throughout decision-making is considered one of the most crucial aspects of effective marine spatial planning (Collie et al., 2013; Frazão Santos et al., 2018; Pomeroy & Douvere, 2008; Ritchie & Ellis, 2010). Indeed, a participatory approach is one of the guiding principles of marine spatial planning (UNESCO-IOC/European Commission, 2021). Effective and broad participation benefits the planning process by identifying all relevant viewpoints and perspectives, providing local knowledge and alternative solutions, advancing justice and fairness, fostering legitimacy and trust, and ultimately leading to more durable decisions (Pomeroy & Douvere, 2008; Ritchie & Ellis, 2010; UNESCO-IOC/European Commission, 2021). Yet adequate engagement of stakeholders remains an ongoing criticism of marine spatial policy to date, with breadth of stakeholders and degree of involvement being the primary concerns (Flannery et al., 2018; Frazão Santos et al., 2018; Jacob et al., 2023; Ritchie & Ellis, 2010).

Engaging the public more broadly – and earlier – in marine spatial planning, requires building a sense of 'marine citizenship' or general 'sea interest' throughout the community, achieved largely through ocean literacy initiatives (Jacob et al., 2023; McKinley & Fletcher, 2010; Ritchie & Ellis, 2010). Initiatives such as education programs, citizen science, exhibitions, technology/apps, media and other modes of outreach help to mobilize potential stakeholders by promoting broad awareness of marine issues (Ashley et al., 2019; Kelly et al., 2022; Pomeroy & Douvere, 2008). Indeed, tailored ocean literacy education has been empirically shown to increase personal motivation to take action on marine issues (Ashley et al., 2019), thus harnessing broader participation in decision-making more generally.

By making information more accessible, ocean literacy can target non-technical/non-expert stakeholders who might otherwise be excluded from planning processes (Flannery et al., 2018; Jacob et al., 2023). For instance, storytelling has been identified as an effective technique to help engage typically marginalised stakeholder groups, such as youth and rural citizens, in marine policy (Lowery et al., 2020; Mannan et al., 2020). This is because storytelling can convey complex and potentially nuanced information through a familiar format that connects us at a human level. Such accessible ocean literacy content plays an especially important role in schools, where it can empower young people to participate in future decision-making – the consequences of which will affect them the most (Devenport et al., 2021; Evans et al., 2019; Mannan et al., 2020).

Promoting knowledge transfer for evidence-based decision-making

At its core, marine spatial planning relies on rigorous scientific and/or technical information to guide policy options and decisions (Shucksmith & Kelly, 2014; Stelzenmüller et al., 2013). Much of this information therefore requires translation and interpretation for effective transfer between all involved parties. According to the Intergovernmental Oceanographic Commission (IOC), the "ideal situation regarding data exchange in marine spatial planning" is that data be "easily understandable for/by everyone" (UNESCO-IOC, 2021). This reflects a wider call for scientists more generally to promote trust and understanding of their data – especially when it has policy implications – through accessible

communication and public outreach (Green et al., 2018; Kelly et al., 2018). Ocean literacy initiatives speak directly to these objectives because they help to interpret or 'broker' knowledge, ultimately connecting marine data more effectively with policy (Kelly et al., 2018, 2022; Larkin et al., 2022; UNESCO-IOC, 2021). For example, knowledge transfer can be enhanced through technology/apps, education and workshops, citizen science, social media and storytelling (Green et al., 2018; Kelly et al., 2018, 2022).

Coastal atlases have been specifically identified as a useful platform for knowledge brokerage via ocean literacy content (Barale et al., 2018; Larkin et al., 2022). They are widely accessible and lend themselves to interactive and educational content, to help interpret potentially complex information (Larkin et al., 2022; Longhorn, 2016). This empowers non-specialist users and decision-makers to explore and utilise marine data. The European Atlas of the Seas provides an example: hosting stories, 'thematic maps' and other interpretational content via its user-friendly interface, it is utilised in school classrooms, public engagement, workshops and decision-making, with thousands of users a month (Barale et al., 2018; Larkin et al., 2022).

3.2.2 Ocean literacy resources in the Tasmania's Marine Atlas

The Tasmania's Marine Atlas could provide fundamental support to marine spatial planning and decision-making by interpreting and explaining marine and coastal data through ocean literacy content, to help address the dual goals of knowledge transfer and stakeholder engagement.

Ocean literacy content was embedded into the Atlas with three key features: 'Featured Maps', 'Theme Maps', and 'ESRI StoryMaps'. These features enable us to engage users through appealing formats with different end-goals: Featured Maps are a guided map 'tour' explaining data layers available for a given topic, and how these layers may be navigated in the Atlas, Theme Maps are pre-selected layers on a given topic, while ESRI StoryMaps provide an interactive, storytelling layout to explore multifaceted marine 'issues' through knowledge co-production. Together, it is hoped these features will serve to educate and engage the Tasmanian public on a range of topics pertinent to the future of our shared marine resources.

Topic selection

The selection of topics for content development began by collating themes raised most frequently by participants at the structured stakeholder workshops in July and August 2022. Specific topics were further examined based on this collation. Topics included recreational fisheries, commercial fisheries, aquaculture, 'blue carbon', the development of marine renewable energy, citizen science, ecological restoration, maritime traffic, human impacts (and associated monitoring efforts), Tasmanian Aboriginal Sea Country and heritage, threatened species, invasive and range-shifting species, climate change, marine conservation and protected areas, and biodiversity spotlights. The prioritisation of these topics was then based on their interdisciplinarity, i.e., their relevance to economic, social and environmental/ecological spheres. This is meant to ensure any created products would be of interest to a wide range of stakeholders, therefore drawing an additional audience to the Atlas and supporting its longevity.

Once a topic has been deemed a priority for incorporation into the Atlas, one must select the most appropriate format for its delivery. This content was delivered through two key formats, Featured Maps and StoryMaps, with the addition of Theme Maps later in the project development. Details on these different formats are presented below.

The content featured in the Atlas is meant to be updated with the latest information; additional products are also meant to be developed in the future, depending on their relevance to stakeholders.

Theme Maps

Theme Maps are pre-defined sets of spatial data layers for key marine topics such species distributions, energy resources, aquaculture, and habitats. Theme Maps are only accessible from the landing page of the Atlas. Selecting a Theme Map opens the main mapping platform with the pre-defined set of layers (Fig. 7).

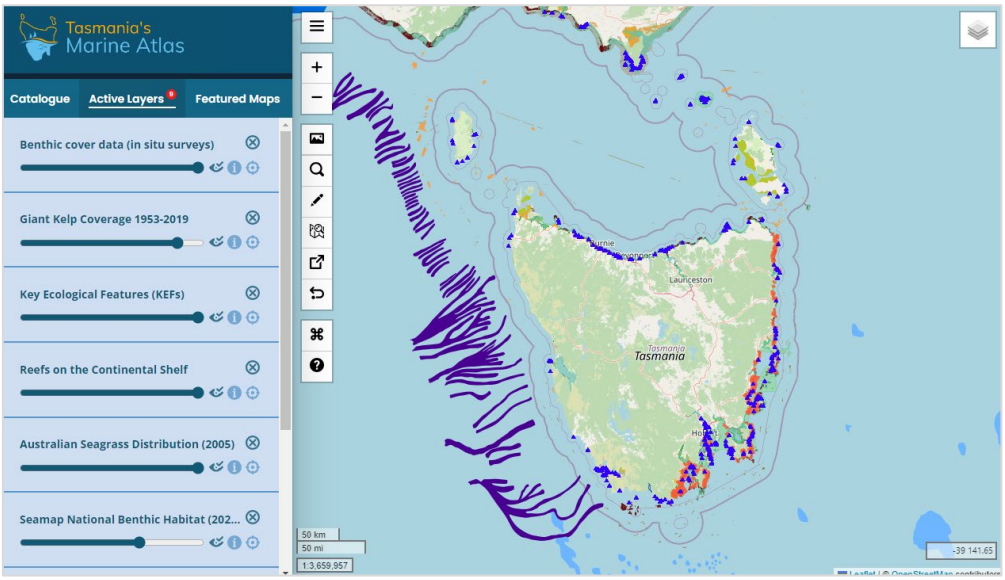

Figure 7 View of web-based mapping platform on the Atlas when selecting the 'Habitat' theme map. Theme Maps are accessible through the main landing page of the Atlas.

Featured Maps

Featured Maps help users unpack and explore the spatial information available in the Atlas pertaining to key marine and coastal topics, such as aquaculture planning and zoning, sea level rise, and maritime boundaries (Fig. 8). Featured Maps are accessible either from the main landing page of the Atlas or within the mapping platform as a 'tab' on the left-hand side panel (Fig. 8). When selecting a Featured Map, short sections of text appear in a right-hand panel, which guide the user with interactive 'Show Me' icons. These icons automatically select layers, basemap and zoom level appropriate to the information being provided. Simple figures and diagrams and links to further information are also provided in the text.

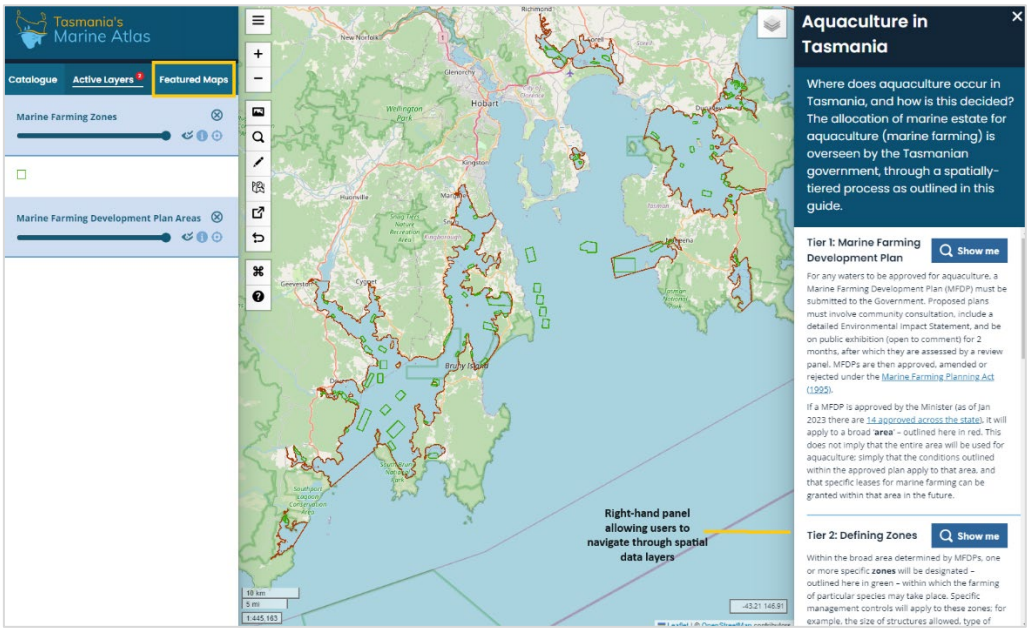

Figure 8 View of the 'Aquaculture in Tasmania' Featured Map in the Tasmania's Marine Atlas. Featured Maps can be accessed on the main landing page of the Atlas or via a tab on the left-hand side of the platform (shown with orange box).

ESRI Story Maps

ESRI Story Maps allow users to better understand complex socio-ecological topics pertaining to Tasmania's marine and coastal environment through interactive storytelling. ESRI Story Maps are only accessible through the main landing page of the Atlas. The initial Story Maps embedded in the current version of the Atlas were co-produced with collaborators to display the breadth of viewpoints on an issue, build legitimacy, and engage a wide spectrum of stakeholders. Collaborators that have already contributed to Story Maps on the Atlas include industry, non-governmental organisations, government, research and the general community. Current topics available on the Atlas were chosen based primarily on the priorities expressed by participants at the structured engagement workshops in July and August 2022 and focus groups held in May 2023. The development of future Story Maps is not currently funded, and will require additional resources (see Section 4: Longevity and future of the Atlas).

Story Maps are created using the ESRI ArcGIS® StoryMapsSM application. They launch in a separate window and allow the user to interact with video, imagery, sliders/temporal data, maps, buttons and links to further information. Language is intentionally simple as meant for a broad audience and navigation is aided by chapter and/or section headings. Throughout the content, links are embedded to directly connect with the spatial data layers in the mapping platform of the Atlas. This allows context to be provided with some layers, therefore augmenting the user experience. Topics currently included in the Atlas, include the impacts of the non-endemic range-extending long-spined sea urchin (*Centrostephanus rodgersii*) on Tasmanian ecosystems and industries, aquaculture monitoring, the development of offshore renewable energy, and marine ecological restoration (Fig. 9).

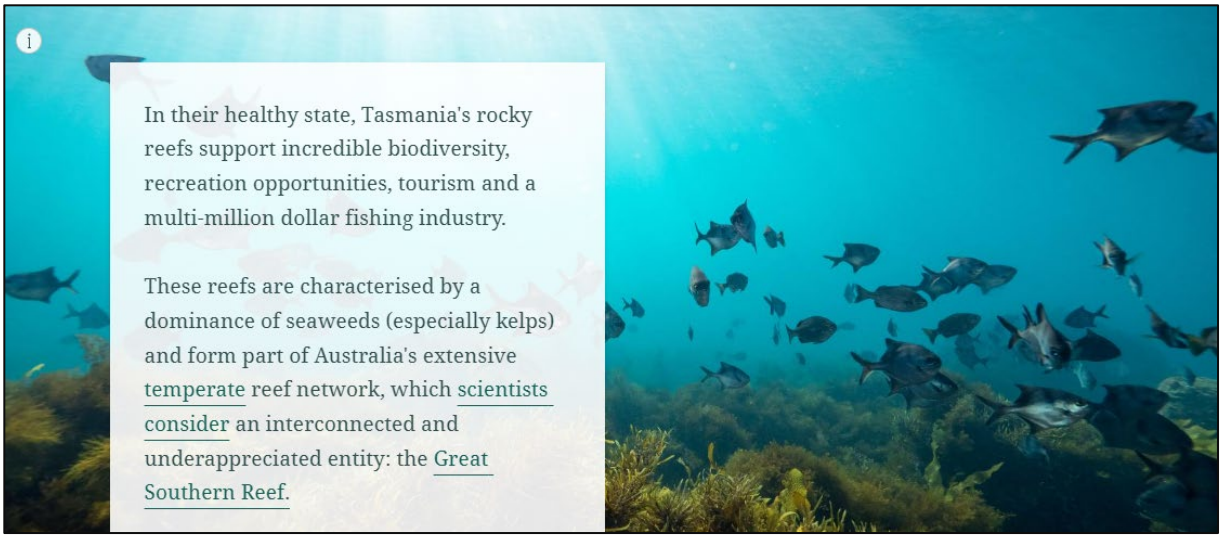

Figure 9 Excerpt view of the ESRI Story Map on the extension of longspined sea urchin (*Centrostephanus rodgersii*) and its impacts on marine ecosystems and marine industries in Tasmania. Story Maps are accessed through the main landing page of the Atlas.

3.2.3 Outcomes

Engagement and extension were a key aspect of the development of the Tasmania's Marine Atlas. To further widen the reach of the Atlas, and foster ocean literacy, several science communication products were embedded within the Atlas. These are meant to be updated as needed, also with new topics added as they arise. These research activities generated:

- 'Theme Maps' as pre-defined sets of spatial data layers relevant to a topic.
- 'Featured Maps' contained within the platform to provide further context and information on spatial data layers.
- 'Story Maps' located outside of the main platform to explore in rich details key socio-ecological issues in Tasmania.

SECTION 4: Longevity and future of the Atlas

4.1 Rationale

The Tasmania's Marine Atlas (the 'Atlas') is an accessible web-based (online) mapping platform to visualise relevant data and metadata on the uses and ecological value of Tasmanian marine ecosystems. The platform connects to multiple databases to display such information for use by researchers, government, industry, environmental non-governmental organizations, and anyone with an interest in the Tasmanian marine environment. In this context, the Atlas is both an IT infrastructure and a tool with a need for relevance to industry and research. Both these aspects require ongoing maintenance and attention to ensure longevity of the Atlas. Here, we detail a longevity strategy for consideration and implementation after this initial development of the Atlas. This is meant to ensure the ongoing maintenance, uptake and relevance of the Atlas moving forward. This strategy was developed in discussion with IT experts at the Institute for Marine and Antarctic Studies (IMAS; University of Tasmania) and members of the Project Advisory Group.

The strategy focuses on three key aspects:

1) addressing basic maintenance needs for the platform to function properly;

2) ensuring the uptake of the platform by stakeholders and other end-users thus reflecting its ongoing relevance;

3) securing the financial sustainability of the platform after this initial development of the Atlas.

4.2 Core maintenance of the Tasmania's Marine Atlas

To display data on the online mapping platform, the Tasmania's Marine Atlas primarily connects to publicly available online databases curated by recognized data custodians, in addition to the IMAS data infrastructure where the Atlas' datasets are hosted. As of October 2024, the Atlas connects to data layers from 14 external data custodians (organisations). This existing infrastructure must be maintained moving forward. Key aspects of the platform maintenance are detailed below.

Basic responsibilities of the Atlas custodian(s)

The Tasmania's Marine Atlas is permanently hosted at the University of Tasmania. It is overseen by a small group of academics and professional technical staff at the Institute for Marine and Antarctic Studies, in collaboration with professional data managers at the Institute for Marine and Antarctic Studies with dedicated expertise in web-based mapping platform management. The basic responsibilities of the custodian(s) of the Atlas are to:

1- Ensure data layers and metadata are properly connected to data providers, i.e., to avoid 'broken links'.
2- Add data layers either from external data custodians or meant to be locally hosted by the Atlas, as needed.
3- Respond to any enquiries raised by end-users.

This will require the following actions:

- Sporadic random checks and responding to user complaints.
- Adress any changes to data layers propagated to ocean literacy content.
- When necessary, creating new data layers and metadata records to host locally.

- Connecting data layers to the Atlas platform and updating organisations/data custodians (if needed).
- Staying informed on relevant stakeholders and end-users needs.
- Providing some basic support to end-users, primarily through enquiries received through the website.

Automated maintenance

The Atlas contains a tool identifying datasets with features present in a user-selected geographic area (i.e., the 'Find Data in Region' tool). This tool has been specifically crafted for the needs of the Atlas and is built to be robust against changes to data layers. Each data layer in the Atlas is meant to be indexed once a week to capture updates from data providers and new data layers added to the Atlas.

Maintenance undertaken by third parties (i.e., not directly by the Atlas custodians)

The Atlas is permanently hosted by Information Technology Services (ITS) at the University of Tasmania. As such, ITS personnel at the University – and more directly the Data and Information Management team at the Institute for Marine and Antarctic Studies – can perform:

- Basic ongoing maintenance of ICT infrastructure, which includes maintaining high standards of cybersecurity and resolving software 'bugs'.

- Maintenance of relevant software libraries for essential functioning of the infrastructure, and of the SQL Server database, data storage, metadata catalogue and mapping server (IMAS GeoServer).

- Financial management required to support the infrastructure and to accurately estimate costs of additional development of the Atlas.

4.3 Ensuring relevance and uptake of the Tasmania's Marine Atlas

Relevant content

It is important the Atlas remains relevant to end-users when meeting their needs and be flexible enough to meet future yet-undefined needs. The core aspects of responding to these needs revolve around providing access to: 1) data and metadata on key biological, ecological, socio-economic, and cultural aspects of the Tasmanian marine environment, and 2) administrative boundaries and other zoning boundaries relevant to marine planning. In addition to the provision of data and metadata, the Atlas promotes and supports ocean literacy - defined as an understanding of the influence of the ocean on people and in turn how people influence the ocean. The Atlas team also took a local knowledge co-production approach during its inception, which promoted the active engagement of local stakeholders. This approach will be maintained whenever possible moving forward. It is therefore expected the Atlas may be a suitable 'extension' infrastructure for future research projects – from the FRDC or other – by combining the availability of data and a knowledge co-production model.

Overall, it is important the Atlas distinguishes itself against other online platforms (in Australia), whenever possible. As part of a clear extension and communication strategy, the niche, role and capacity of the Atlas are detailed below.

Niche: The Atlas hosts multiple disparate datasets relevant to marine industries and marine planning in Tasmania. It has a broad mandate to serve multiple audiences – in addition to the fisheries and aquaculture sectors – to support sustainable use of the marine estate. This in turn can further support the core fisheries and aquaculture sectors by augmenting the breadth of

information found on the Atlas. It is also meant at its core to engage this broad audience – from the community member to the scientific expert – in collating and sharing information on the Tasmanian marine estate as it becomes available. In this context, it allows a diverse audience to engage with the information on complex socio-ecological topics to support decision-making. In addition, the Atlas is not government or industry-managed, but rather directly embedded in a strategic basic and applied research environment at the University of Tasmania.

Role: In its current form, the primary role of the Atlas is to share information. It acts as a central source for relevant datasets on Tasmanian marine uses and ecosystems. This information is vetted as it originates from reliable data custodians (e.g., state and federal agencies) and/or the result of scientific research. At this stage, the Atlas is not an analytical tool but rather forms the basis for analysis, as well as identifying data gaps, when relevant.

Capacity: The Atlas was developed as a flexible web-based mapping platform, able to respond to current needs, as well as future, yet-unknown needs from industry, government and research. There has been much emphasis on ensuring the Atlas is flexible enough to be resilient to changes in data needs. It is currently able to connect to online data repositories, including the IMAS infrastructure, where bespoke Atlas datasets are hosted (or could be stored). The current preference is for the Atlas to link to external datasets, but local hosting is also possible.

Suitable format

At its core, the Atlas is an online mapping platform linking to relevant data and metadata on the Tasmanian marine environment. Currently, this includes connections to datasets hosted by external custodians (for visualization purposes only). This requires ongoing maintenance (detailed above) and importantly presents limitations to perform analytics locally. The Atlas is also meant to locally host 'orphan' datasets. This is not the preferred way as it does require specific ongoing maintenance, however it allows for greater local analytical capacity. In this context, it is important the Atlas custodians details how the infrastructure (the platform itself) could be amended and improved upon in the future to seize opportunities as they arise.

Based on our stakeholder engagement, future development of the Atlas could include:

- Ability to interact with datasets (e.g., subset value);
- Ability to directly download select datasets from the platform;
- Development of 'modules' to interact with select datasets in an analytical capacity (e.g., summary assessments, cumulative impacts, potential for conflict, connectivity);
- Development of a mobile (app) version of the Atlas

Engaged audience

It is crucial the value of the Atlas is recognized by stakeholders, and in turn feedback from stakeholders is integrated in the Atlas on an ongoing basis. It is expected diverse audiences will interact with the Atlas: marine researchers, government, marine industries (e.g., fisheries, aquaculture, tourism), marine recreation (e.g., recreational fishing), environmental non-government organizations, and interested community members. As demonstrated during our engagement activities in 2022 and 2023, it is worthwhile for the Atlas custodians to better understand the perspectives and needs of these different audiences.

The Atlas contains video tutorials to help users navigate its basic features. Tutorials are accessible via the main landing page of the Atlas under the 'Resources' tab. These tutorials cover basic uses of the

Atlas, such as navigating the spatial data layers, a quick guide to Featured Maps, identifying available data in a specific region, and exploring spatial data layers with a temporal component.

In addition to understanding the profiles of end-users of the Atlas, there is a need to explicitly 'brand' and socialize the Atlas as a 'go-to' tool for marine practitioners in Tasmania. This includes researchers, government, and industry (including marine consultants). Marine spatial projects can benefit from the Atlas by:

- Quickly identifying relevant information in an area of interest
- Identifying data gaps
- Highlighting datasets relevant to a specific issue that might not have been previously considered
- Gaining an appreciation of spatial scale and resolution, as well as fostering basic skills in the handling of marine spatial data.

The content of the Atlas is already used to guide research projects on marine planning in Tasmania, for example, to support the management of the longspined sea urchin (*Centrostephanus rodgersii*).

Other products embedded in the Atlas – such as Theme Maps, Featured Maps, and ESRI StoryMaps – are potentially powerful mechanisms to help keep the audience engaged, while supporting ocean literacy by increasing accessibility for Tasmanians to understand complex marine socio-ecological topics. The ongoing maintenance and curation of these products will be critical to maximize such benefits. At a minimum, the following would need to be performed to maintain the ocean literacy content already embedded in the Atlas:

- Featured Maps rely on layers within the Atlas to function properly. Therefore, if any changes occur to spatial layers, then Featured Maps would also need to be altered to accommodate this and continue functioning.
- Similarly, StoryMaps often contain links to the Atlas portal, which may need to be maintained as layers within the Atlas are updated, removed or changed.
- More broadly, StoryMaps typically cover issues that are dynamic and constantly evolving. Therefore, they should be periodically updated to reflect developments in that respective space to stay relevant.

Ocean literacy content should continue to be developed for the Atlas to address new topical marine socio-ecological issues as they arise.

4.4 Resource sustainability to ensure the longevity of the Atlas

The Tasmania's Marine Atlas is permanently hosted by Information Technology Services (ITS) at the University of Tasmania. It is expected the Tasmanian Government – through the Sustainable Marine Research Collaboration Agreement (SMRCA) between the government and the University of Tasmania – will contribute to the ongoing (basic) maintenance of the Atlas via the provision of a modest fractional allocation of dedicated technical staff time for the duration of the Agreement, e.g., a mapping officer and academic research leader. Professional ITS personnel at the University of Tasmania also support the maintenance of the Atlas. It is expected the Institute for Marine and Antarctic Studies (University of Tasmania) will maintain sufficient trained academic and professional staff capacity for basic maintenance and support of the Atlas.

A Steering Committee will be formed in 2025, consisting of industry and state government representatives, and research leaders at the University of Tasmania. It is expected the Steering

Committee will be administered and chaired by the academic lead supporting the maintenance of the Atlas and meet twice per calendar year. The role of the Steering Committee will be to:

- Represent the needs of their respective organisation for content and format of the Atlas;
- Determine priorities for new content to be added to the Atlas or alternatively, retire irrelevant content;
- Identify and/or enable sources of funding to further the development of the Atlas, if needed;
- Act as conduit in their respective organisation to further the relevance and adoption of the Atlas.
- As the Atlas matures, enable and support the identification of evaluation metrics to gauge the uptake by stakeholders and effectiveness of the Atlas in supporting decision-making.

The Atlas can be used as a suitable data discovery and extension tool for marine research projects in Tasmania, including but not limited to projects funded by the FRDC. Costs (e.g., staff time) to support the development of spatial data layers, if needed, can be recovered via externally-funded research projects. It is expected these costs will be minimal but critical to help maintain the basic infrastructure of the Atlas. As noted above, the inclusion of datasets or other products (e.g., ocean literacy content) is dependent on its availability either via an external data custodian, or locally hosted at IMAS (or a bespoke database at IMAS, see 'Recommendations'). Costs are dependent on the level of engagement of the University of Tasmania in the research projects.

It is expected major additional features, updates or changes to the Atlas – for example, change in general IT infrastructure or additional analytical capacity – would require sporadic funding injections from external sources (e.g., government grants, industry partnerships). This will be overseen by the Atlas custodians and the Steering Committee, when formed.

4.5 Outcomes

A longevity strategy has been developed to ensure the maintenance and relevance of the Atlas moving forward beyond this initial development of the platform. This strategy will be overseen by the Atlas custodians at the Institute for Marine and Antarctic Studies (University of Tasmania) and the Steering Committee, when formed. A small contribution for staff time to cover basic maintenance of the Atlas is expected to be made available on an ongoing basis via the Sustainable Marine Research Collaboration Agreement (SMRCA) between the University of Tasmania and the Tasmanian Government for the duration of the Agreement. Any additional features or work to support the Atlas would require additional external funding. This strategy relies on three aspects:

- Ongoing maintenance: Ensuring the spatial data layers and content of the Atlas remain functional.
- Uptake and relevance: Actively seeking to engage the audience – end-users from industry, government and research – to ensure the content and format of the Atlas remain relevant.
- Resource sustainability: Secure adequate resources to maintain the Atlas and embed new spatial data layers as needed and seek alternative resources for major development.

Conclusion

This project saw the development and launch of the Tasmania's Marine Atlas, a web-based (online) mapping platform meant to collate and make available spatial data on the uses, ecosystems, and species of the Tasmanian marine environment. The platform was developed through desktop studies examining the most appropriate format and the breadth of relevant datasets, and through engagement with key stakeholders and interested parties, or future end-users of the Atlas.

Research activities aimed to determine a suitable format and content for the Tasmania's Marine Atlas. Through a data audit, a wide array of spatial data layers was uncovered with potential to support industry, government and research applications in Tasmania. We examined other examples of spatial decision-support tools in Australia and overseas to guide the development of the platform. Both format and content were developed in a knowledge co-production model involving engagement with key stakeholder groups through structured workshops and focus groups. Finally, science communication products aiming to foster ocean literacy for complex marine socio-ecological topics in Tasmania were developed based on the engagement activity and in close collaboration with relevant and impacted parties. This approach was taken as a means to further broaden the audience of the Atlas, and hence support its longevity.

Outcomes of this project include:

- A web-based (online) mapping platform that is easy to navigate and provide a robust initial suite of spatial data layers relevant to resources uses and management – including environmental management – in Tasmania. The Tasmania's Marine Atlas is available at tasmarineatlas.org.
    - As of October 2024, the Atlas connects to 305 individual spatial data layers from 116 datasets. This yielded an initial suite of potential spatial data layers to be included in the Atlas.
    - Like other platforms with the same objectives, the Atlas is a web-based mapping platform connecting to spatial datasets that are either hosted externally in reputable online agencies, or for a minority of datasets, locally hosted by the Atlas at the University of Tasmania on the local geoserver.
- Further support for spatial resource management in Tasmania by facilitating access to relevant datasets;
- A flexible platform to be further populated in the future by research data outputs and ready to use for extension on research projects and communication, as needed.

The Tasmania's Marine Atlas is permanently hosted at the University of Tasmania. A longevity strategy was developed for the Atlas focused on three pillars: minimal ongoing maintenance of the computing technology infrastructure, ensuring uptake and relevance of the Atlas, and maintaining resource sustainability with a low-cost and efficient platform. Resources needed to maintain the Atlas are designed to be flexible: a baseline is needed for basic maintenance, and additional resources will be needed for major development.

The Atlas is meant to be a dynamic and 'living' resource for stakeholders. It will be an ongoing objective to ensure the suite of spatial data layers available on the Atlas is current and continue engaging with stakeholders for extension and communication.

Implications

The Tasmania's Marine Atlas is an accessible web-based mapping platform meant to be used by researchers, industry, government and interested members of the public. When using the platform, end-users can:

- Navigate to or search topics of interest to uncover data, visualize datasets, and gain access to comprehensive metadata including how to acquire a local copy of the data if necessary.
- Search available datasets by specifying a geographic area (user-defined using a drawing tool). This provides a broad overview of an area, and highlights data gaps when relevant.
- In addition to datasets, the Tasmania's Marine Atlas can display metadata, i.e., locations where data exist but may be proprietary and/or sensitive. In these cases, the Atlas guides users to the relevant data custodian.

The Tasmania's Marine Atlas contains products meant to facilitate the use of the platform and appeal to a broad audience to support the longevity of the Atlas:

- 'How-to' tutorials and other resources are available from the landing page of the Atlas.
- Theme Maps, Featured Maps, and Story Maps can help end-users navigate the datasets contained in the Atlas.

The Tasmania's Marine Atlas was developed in a knowledge co-production model. In the future, the Atlas is meant to retain that model with updates and improvements:

- Flexible platform that can be built upon to meet current and future stakeholder needs.
- Ongoing engagement with stakeholders for datasets available on the platform to remain current and relevant. Basic maintenance of the Atlas includes this component of responding to requests to embed datasets as needed, depending on the complexity of the datasets.

The Tasmania's Marine Atlas, in addition to facilitating access to datasets, can be used in the future by stakeholders and rightsholders to:

- Visualize data generated by research projects.
- Act as a conduit for relevant extension activities, either through data visualization or through the development of communication tools (e.g., Featured Maps), pending available resources.
- Because of a strong relationship with Seamap Australia, hosted at the University of Tasmania, further socialize and reproduce in other contexts and jurisdictions in Australia a reproducible, low-cost mapping platform meant to meet local needs.

Recommendations

Several sources of relevant datasets were identified during the project but their inclusion in the Tasmania's Marine Atlas was not finalized. To progress this, it is recommended that further steps be taken to:

- Embed publicly available catch data from Tasmanian commercial fisheries in the Atlas. This is a high priority for stakeholders and was not achieved because this data is not yet centralized in Tasmania for the Atlas to efficiently display this information (see Section 2 of this report).

- Embed oceanographic data products. This information is increasingly relevant, particularly in the context of climate change and future climate scenarios, but again the Atlas as designed could not readily connect to many available sources of information. Some datasets could be included in the Atlas, but more steps need to be taken for a seamless integration, particularly with regards to data contained within the Australian Ocean Data Network (AODN) and other relevant sources of data.

Further development

The Tasmania's Marine Atlas project was not initially developed in a knowledge co-production model with Indigenous communities. This did not meet current expectations for engagement with these communities. Therefore, further development includes:

- Relevance to Indigenous communities and ethical inclusion of Indigenous data be further explored, specifically through Indigenous-led (or co-led) initiatives.

- The Atlas platform (i.e., the infrastructure) could be made available to Indigenous researchers and collaborators to support these initiatives.

- More broadly, support be provided to conduct research to better understand how Indigenous data sovereignty as it relates to the Tasmanian marine environment impacts how Indigenous data is shared, when appropriate and in an ethical way. In the context of the Atlas, this specifically addresses spatially-explicit data.

Datasets currently embedded in the Tasmania's Marine Atlas mostly reflects socio-economic uses, the distribution of species, ecosystems and physical properties, and zoning (administrative boundaries). A key data gap identified through this project is the description and availability of spatially-explicit datasets on socio-cultural values, when relevant. Describing these values – and their spatial patterns – would be beneficial to support sustainable and inclusive management of marine resources. Therefore, further development includes:

- Determining a baseline of such values, if not currently available, with consideration for explicit spatial attributes and appropriate resolution.

- Embed such datasets in the Atlas to further support the needs of stakeholders.

The Atlas was developed primarily as a web-based mapping platform to be used on a computer. The Atlas can be visualized on a mobile or tablet but its use is optimized on a computer. Based on our engagement with stakeholders, further development could include:

- Development of an app version of the Atlas
- Development of an 'offline' mode – in relation with app mentioned above – for use when beyond mobile coverage (e.g., on vessels).

The Tasmania's Marine Atlas is a web-based mapping platform designed to visualize datasets. At this stage, it is not possible to interact with or manipulate data or conduct analysis with the platform itself. Further development could therefore include:

- Developing tools to embed within the Atlas that would allow interaction with datasets – or a select subset of datasets - through simple operations, such as extracting a subset of values.
- Developing simple analytical tools to embed in the Atlas, such as connectivity (particle tracking), cumulative impacts metrics, and suitability modelling (site selection).

Extension and Adoption

The Tasmania's Marine Atlas was developed using a knowledge co-production model with significant engagement with those directly impacted by the project outcomes. These development activities are detailed in Section 3 and included:

- Direct engagement with potential end-users and collaborators in government, non-governmental organizations, and researchers.
- A project advisory group composed of representatives from government, industry, non-governmental organizations, Aboriginal liaison from the University of Tasmania, academia, and community members.
- Eight structured engagement workshops in July and August 2022 with community members, researchers, government, Tasmanian aquaculture sector, local government councils, non-governmental organizations, and educators.
- Three focus groups in May 2023 with government, seafood industry peak body, Tasmanian aquaculture sector, researchers, non-governmental organizations – including recreational fishing organizations and environmental organizations – and community members.

In addition to the activities detailed above, the Atlas team has had targeted interactions with:

- Indigenous Science and Engagement (CSIRO)
- Aboriginal Heritage Tasmania
- Tasmanian Aboriginal Centre
- Aboriginal Cultural Fisheries Officers (Tasmanian Government)
- Lands Tasmania (Aboriginal and Dual Naming Reference Group)
- Natural Values Atlas (Tasmanian Government)

The Tasmania's Marine Atlas was also featured at:

- Public event: Wooden Boat Festival, Hobart, Tasmania (2023)
- Public event: Festival of Bright Ideas, Hobart, Tasmania (2024)
- Public event: Centre for Marine Socioecology (University of Tasmania) Showcase, Hobart, Tasmania (2024)

Ongoing engagement and extension of the project outcomes – the web-based mapping platform – will be available through research advisory groups in Tasmania and through the Sustainable Marine Research Collaboration Agreement, the partnership between the Tasmanian Government and the University of Tasmania.

Project coverage

- Radio:
    - ABC Radio Evenings with Christopher Lawrence (July 2022)
    - ABC Radio Hobart Tasmania Afternoons with Joel Rheinberger (May 2024)

- Print/media:
    - The Examiner (July 2022)
    - Media Release (Public launch; May 2024)

- Newsletter/social media:
    - Showcase of the Tasmania's Marine Atlas project in FRDC newsletter (July 2023)

Project materials developed

The Tasmania's Marine Atlas: tasmarineatlas.org

Appendices

APPENDIX 1. Data portals relevant to Tasmanian marine waters uncovered during the data audit.

Name	Web link (URL)	Extent
The List	www.thelist.tas.gov.au/app/content/home	Local/State
Tasmanian Wild Fisheries Assessments	tasfisheriesresearch.org	Local/State
Tasmanian Museum and Art Gallery (TMAG)	www.tmag.tas.gov.au	Local/State
Tasmanian Natural Values Atlas	www.naturalvaluesatlas.tas.gov.au	Local/State
CSIRO Connie 3	connie.csiro.au	Local/State
NRE Tasmania Water Information Tasmania Web Portal	portal.wrt.tas.gov.au	Local/State
Tasmanian Salmon Farming Data (Salmon Portal)	salmonfarming.nre.tas.gov.au/the-environment	Local/State
Marine And Safety Tasmania (MAST)	maps.mast.tas.gov.au	Local/State
Parks and Wildlife Service Tasmania	parks.tas.gov.au/explore-our-parks	Local/State
Aboriginal Heritage Tasmania	www.aboriginalheritage.tas.gov.au	Local/State
Aboriginal Tasmania Story Map	www.arcgis.com/apps/MapTour/index.html?appid=8870d6229a93485b99b713d4435cc0a0	Local/State
Australian Marine Spatial Information System (Geoscience Australia)	maps.ga.gov.au/interactive-maps/#/theme/amsis	National
National Map	www.nationalmap.gov.au	National
Seamap Australia	seamapaustralia.org	National
Geoscience Australia	www.ga.gov.au/data-pubs	National
Australian Institute of Marine Science (AIMS)	apps.aims.gov.au/metadata/search	National
CSIRO Data Access Portal	data.csiro.au/collections	National
Bureau of Meteorology (BoM)	www.bom.gov.au	National
Southern Ocean Observations System (SOOS)	www.soos.aq	National
National Environmental Science Programme (NESP) Marine Biodiversity Hub	www.nespmarine.edu.au/data	National
Digital Earth Australia (Geoscience Australia)	www.ga.gov.au/dea	National
Tern Data Discovery Portal	portal.tern.org.au	National
National Outfalls Database	www.outfalls.info	National
Australian Antarctic Data Centre	data.aad.gov.au	National
Earth Observations Australia	www.eoa.org.au	National
Australian Region MArine Data Aggregation (ARMADA)	www.cmar.csiro.au/data/armada/	National
Australian Ocean Data Network (AODN)	portal.aodn.org.au/search	National
Australian Maritime Safety Authority (AMSA)	www.operations.amsa.gov.au/Spatial	National
Marine Traffic	www.marinetraffic.com	National
Institute for Marine and Antarctic Studies Data Portal	data.imas.utas.edu.au/portal/search	National
AusSeabed (Geoscience Australia)	www.ausseabed.gov.au	National
Atlas of Living Australia	www.ala.org.au	National
Australia Wave Energy Atlas	arena.gov.au/projects/australian-wave-energy-atlas	National
Department of Climate Change, Energy, the Environment and Water	www.dcceew.gov.au/environment/environmental-information-data	National
Department Of Defence AusENC (Electronic Navigation Chart)	www.hydro.gov.au/prodserv/digital/ausENC/enc.htm	National
Data.gov.au	www.data.gov.au	National
Australian Institute of Health and Welfare Data	www.aihw.gov.au/data	National

Name	Web link (URL)	Extent
Trove	trove.nla.gov.au	National
Australasian Underwater Cultural Heritage Database (DCCEEW)	environment.gov.au/shipwreck/public/maps/shipwreck-map-search-load.do	National
Research Data Australia	researchdata.ands.org.au	National
Museum Victoria	www.museumvictoria.com.au	National
Australian Bureau of Statistics (ABS)	www.abs.gov.au	National
NCMI Information and Data Centre (CSIRO)	research.csiro.au/ncmi-idc	National
Australian Marine Parks Science Atlas	atlas.parksaustralia.gov.au/amps	National
eAtlas	maps.eatlas.org.au/list.html	National
Copernicus & Copernicus Australasia	marine.copernicus.eu	International
National Oceanic and Atmospheric Administration (NOAA)	www.ncdc.noaa.gov/data-access	International
NASA	data.nasa.gov	International
PANGEA	www.pangaea.de	International
Permanent Service for Mean Sea Level (PSMSL)	www.psmsl.org	International
World Ocean Database (WOD)	www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html	International
Group on Earth Observations	www.geoportal.org/?m:activeLayerTileId=osm&f:dataSource=dab	International
Ocean Biodiversity Information System (OBIS)	obis.org	International
Moderate Resolution Imaging Spectroradiometer (MODIS)	oceandata.sci.gsfc.nasa.gov	International
Centre For International Earth Science Information Network	www.ciesin.org	International
Squiddle+	squidle.org	International
GlobalArchive	globalarchive.org	International
Bird Life International	maps.birdlife.org/portal/apps/opsdashboard/index.html#/754b32566bfa4f23ba7fa67942684553	International
Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC)	data.aad.gov.au/metadata	International
Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)	www.ccamlr.org	International
Marine Cadastre	marinecadastre.gov/data	International
The Nature Conservancy	maps.oceanwealth.org	International

APPENDIX 2. List of journal articles reviewed to guide the analysis on decision-support tools in (spatial) marine resource management. Review articles are highlighted in bold. Methods are detailed in Section 2.2.

1. Abramic, A., García Mendoza, A., & Haroun, R. (2021). Introducing offshore wind energy in the sea space: Canary Islands case study developed under Maritime Spatial Planning principles. Renewable and Sustainable Energy Reviews, 145. doi:10.1016/j.rser.2021.111119
2. Aporta, C., Bishop, B., Choi, O., & Wang, W. (2020). Knowledge and data: an exploration of the use of inuit knowledge in decision support systems in marine management. Governance of Arctic Shipping: Rethinking Risk, Human Impacts and Regulation, 151-169.
3. Basirati, M., Billot, R., Meyer, P., & Bocher, E. (2021). Exact Zoning Optimization Model for Marine Spatial Planning (MSP). Frontiers in Marine Science, 8. doi:10.3389/fmars.2021.726187
4. Bolman, B., Jak, R. G., & van Hoof, L. (2018). Unravelling the myth–the use of decisions support systems in marine management. Marine Policy, 87, 241-249.
5. Bonnevie, I. M., Hansen, H. S., & Schrøder, L. (2019). Assessing use-use interactions at sea: A theoretical framework for spatial decision support tools facilitating co-location in maritime spatial planning. Marine Policy, 106. doi:10.1016/j.marpol.2019.103533
6. Bonnevie, I. M., Hansen, H. S., & Schrøder, L. (2020). SEANERGY - a spatial tool to facilitate the increase of synergies and to minimise conflicts between human uses at sea. Environmental Modelling and Software, 132. doi:10.1016/j.envsoft.2020.104808
7. Bonnevie, I. M., Hansen, H. S., & Schrøder, L. (2021). Supporting integrative maritime spatial planning by operationalising SEANERGY–a tool to study cross-sectoral synergies and conflicts. International Journal of Digital Earth, 14(6), 678-695. doi:10.1080/17538947.2020.1865467
8. Bonnevie, I. M., Hansen, H. S., Schrøder, L., & Armoškaitė, A. (2022). Utilising MYTILUS for Active Learning to Compare Cumulative Impacts on the Marine Environment in Different Planning Scenarios. Sustainability (Switzerland), 14(19). doi:10.3390/su141912606
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11. DeMarco, K. E., Hillmann, E. R., Nyman, J. A., Couvillion, B., & La Peyre, M. K. (2022). Defining Aquatic Habitat Zones Across Northern Gulf of Mexico Estuarine Gradients Through Submerged Aquatic Vegetation Species Assemblage and Biomass Data. Estuaries and Coasts, 45(1), 148-167. doi:10.1007/s12237-021-00958-7
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13. Depellegrin, D., Hansen, H. S., Schrøder, L., Bergström, L., Romagnoni, G., Steenbeek, J., . . . Menegon, S. (2021). Current status, advancements and development needs of geospatial decision support tools for marine spatial planning in European seas. Ocean and Coastal Management, 209. doi:10.1016/j.ocecoaman.2021.105644
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Appendix 3. Decision-support tools used for (spatial) marine resource management identified through the desktop analysis detailed in Section 2.2. The tools are summarised based on their format, functionality, knowledge and technical skills required, and access. DSTs used in Australia are highlighted in blue.

		Functionality						
Decision-support tool	**Format**	**Raw data Display**	**Enhanced data Display**	**User experience**	**Analytical tools**	**Advice on skills required**	**Access**	**Reference**
AquaSpace Tool	GIS Toolbox	No	No	--	Site identification, mapping, economic analysis, & scenario analysis	Advanced ArcGIS	Open source, but ArcGIS required	Gimpel et al., 2018
Atlantis	Standalone modelling software	No	No	--	Ecosystem modelling tool considers all parts of marine ecosystems – biophysical, economic and socials	Advanced programming and modelling	https://research.csiro.au/atlantis/	Fulton et al., 2011
Australian Marine Spatial Information System (AMSIS)	Web map application	Yes	Offshore Renewable Energy map	Map creation and sharing	No	Basic computer skills	https://www.ga.gov.au/scientific-topics/marine/jurisdiction/amsis	
(IOW) Baltic Sea Atlas	Web map application	Yes	No	Drawing tool, map creation and sharing	No	Basic computer skills	http://bio-50.io-warnemuende.de/iowbsa/	
Baltic Explorer	Web map application	Yes	No	Collaborate in a shared workspace, draw and edit features	No, but works in conjunction with MYTILUS & SEANERGY DSToolboxes	Basic computer skills	http://balticexplorer.eu/	
Baltic Sea Impact Index (BSII) Cumulative impact Assessment Toolbox	Standalone software	No	No	--	Cumulative impacts; Identify areas with high ecological value and/or high potential for provision of ecosystem services	Advanced GIS and programming skills	https://github.com/helcomsecretariat/Cumulative-impact-Assessment-Toolbox	http://stateofthebalticsea.helcom.fi/cumulative-impacts/
BONUS BALTSPACE Spatial Economic Benefit Analysis (SEBA) tool	Methodology	No	No	--	Calculates the beneficiaries and the distribution of economic benefits associated with a given set of maritime uses	Resource economic knowledge	Mapping software required Used RegioGraph (paid access)	Weig & Schultz-Zehden, 2019
CoastKit (Victorian Government)	Web map application	Yes	Time slider for temporal data Theme maps GeoBibliography tool for displaying and searching marine and coastal ecological studies	Add data from other sources; Query data; Map creation and sharing; Drawing tools; Calculate area	Feature Activity Sensitivity Tool for environmental risk assessment	Basic computer skills Domain-specific skills for analytical tool	https://mapshare.vic.gov.au/coastkit/	

		Functionality						
Decision-support tool	**Format**	**Raw data Display**	**Enhanced data Display**	**User experience**	**Analytical tools**	**Advice on skills required**	**Access**	**Reference**
Coastal Resilience Mapping Portal	Web map application	Yes	With 'Apps' display tools for time series data and modelled data	Explore model outputs based on different parameters	No	Basic computer skills	https://maps.coastalresilience.org/	
COast to COast NETworks of marine protected areas (CoCoNet) WebGIS	Web map application	Yes	No	Add data from other sources, query and download data, map creation and sharing	No	Basic computer skills	http://coconetgis.ismar.cnr.it/	
European Marine Observation and Data Network (EMODnet) Map viewer	Web map application	Yes	Animated temporal data display, 3D view	Download data, map creation and sharing	No	Basic computer skills	https://emodnet.ec.europa.eu/geoviewer/#	
European Atlas of the Seas	Web map application	Yes	Explore topic maps, map stories, resources for educators	Map creation and sharing	No	Basic computer skills	https://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/mindmap_en.html	Barale et al., 2018
Ecopath with Ecosim (EwE)	Modelling standalone software	No	No	--	Modelling: food web, ecosystem, fisheries, spatial optimization for marine protected areas	Advanced programming and modelling	Open source Paid license available (https://ecopath.org/	Steenbeek et al., 2016
Geoportail	Web map application	Yes	No	Add data from other sources, download data, map creation and sharing	No	Basic computer skills	https://www.geoportail.gouv.fr/	
Geoportal of the Adriatic-Ionian Region (GAIR)	Web map application	Yes	No	For registered users only: Layer Editing, Layer Styling, Uploading layers, GeoDataBuilder	Widgets for summary data analytics; Series of modules for registered users only (e.g., cumulative impacts assessments, particle tracking, small-scale fisheries)	Basic computer skills for data exploration. More advanced GIS and domain-specific skills for analytical tools	Sign-in required for most functionalities (project partners only) https://www.portodimare.eu/	Menegon et al., 2023
HELCOM Map & data service (MADS)	Web map application	Yes	No	Query data, view attribute table, user satisfaction survey	No, but provides data to MYTILUS & SEANERGY DSToolboxes	Basic computer skills	https://maps.helcom.fi/website/mapservice/index.html	
Ireland's Marine Atlas	Web map application	Yes	Links to Users' stories of spatial layers	Add data from other sources, download data, map creation and sharing	No	Basic computer skills	http://atlas.marine.ie/#?c=53.9108:-15.9082:6	

		Functionality						
Decision-support tool	**Format**	**Raw data display**	**Enhanced data display**	**User experience**	**Analytical tools**	**Advice on skills required**	**Access**	**Reference**
MAGiC	Web map application	Yes	No	Add data from other sources, query and download data, map creation and sharing	No	Basic computer skills	https://magic.defra.gov.uk/home.htm	
Mapping Ocean Wealth Explorer	Web map application	Yes	With 'Apps' display tools for time series data and modelled data	Explore the apps and choose different metrics	No	Basic computer skills	https://maps.oceanwealth.org/	
MarineAtlas.be	Web map application	Yes	No	Download data	No	Basic computer skills	https://www.marineatlas.be/en/view	
Marine Integrated Valuation of Eco-system Services Tradeoffs (InVest) Workbench	Suite of models packed in a standalone software	No	No	--	Tradeoffs with management choices; identify areas where investment in natural capital can enhance human development and conservation	Intermediate GIS	https://naturalcapitalproject.stanford.edu/software/invest	
Marxan, including Marxan with zones & connectivity	Standalone software GIS interface Built plug-in	No	No	--	Design and evaluate conservation & zoning plans, Create & explore scenarios Conduct gap analysis Understand trade-offs between objectives Incorporate connectivity	Advanced GIS and domain-specific skills	https://marxansolutions.org/	
Marxan Planning Platform (MaPP) beta version	Web map application	--	Web map application to visualize the data and outputs	Team access & collaboration	Design and evaluate conservation & zoning plans Create & explore scenarios Conduct gap analysis Understand trade-offs between objectives	Advanced domain-specific skills	Open source; https://marxanplanning.org/	
Mid-Atlantic Ocean Data Portal and Marine Planner mapping tool	Web map application	Yes	No	Download data, map creation and sharing, storytelling, connect with other stake-holders via map groups	No	Basic computer skills	https://portal.midatlanticocean.org/	

		Functionality						
Decision-support tool	**Format**	**Raw data display**	**Enhanced data display**	**User experience**	**Analytical tools**	**Advice on skills required**	**Access**	**Reference**
MSP Challenge Simulation Platform	Standalone software Web map application	Yes	Consequences of decisions for energy, shipping and the marine environment are simulated and visualized in indicators and heat maps	Review raw and modelled data, and develop plans for future uses of the marine space	Integrates best available geo, maritime and marine data with simulation models for ecology, shipping and energy production using advanced game technology	Basic computer skills	https://www.mspchallenge.info/simulation-platform.html	
MYTILUS	Standalone software	No	No	--	Cumulative Impact Assessment Conflict-synergy analysis	Intermediate/ Advanced GIS	Open source	Hansen & Bonnevie, 2020
Northeast Ocean Data	Web map application	Yes	Visualization of curated maps and data on key topics	Add data from other sources, map creation and sharing	No	Basic computer skills	https://www.northeastoceandata.org/	
PlanWise4Blue	Web map application	Yes	Valuation metrics and future modelled data; dynamic graphs to assess sustainability of human uses	Explore different metrics through graphs and tables	Cumulative Effects Assessments for registered users	Basic computer skills. It does not require GIS knowledge	https://gis.sea.ee/planwise4blue	
Seamap Australia	Web map application	Yes	Descriptive statistics in defined regions	Map creation and sharing, draw transects to show depth profiles or habitat data	No	Basic computer skills	https://seamapaustralia.org/	
SEANERGY	ArcMap Toolbox	No	No	--	Analyze conflicts and synergies among marine uses to support assessment of co-location options	Intermediate/ Advanced GIS	Open source, but ArcGIS required	Bonnevie et al., 2020
SeaSketch	Web map application	Yes	Customised based on users' requirements	Stakeholder participation; Participatory mapping Drawing tools	Scenario planning; integrate Marxan, cumulative impact assessments and conflict analysis	Designed to be easy to use	Paid license https://www.seasketch.org/	
Symphony	Methodology		Heat maps of cumulative impact Calculation reports	--	Cumulative Impact Assessment Development of scenarios for planning and implementation Co-location	Advanced GIS Potentially modelling	Uses EcoImpactMapper (open source) and SeaSketch (paid) software	Hammar et al., 2020; Swedish Agency for Marine & Water Management, 2018

		Functionality						
Decision-support tool	**Format**	**Raw data display**	**Enhanced data display**	**User experience**	**Analytical tools**	**Advice on skills required**	**Access**	**Reference**
Tools4MSP	Standalone software	No	No	--	Marine use conflict analysis Cumulative Effects Assessment	Advanced GIS and programming skills	Open source	Menegon et al., 2018
Tools4MSP Geoplatform (previously ADRIPLAN data portal)	Web application including map platform	Yes		Map creation and sharing	For registered users: Maritime Use Conflicts Analysis Cumulative Effects Assessment Marine Ecosystem Services Threat Assessment DST for Blue Economy in MPA	Advance GIS and domain-specific for analytical tools	Sign-in required for most functionalities https://geoplatform.tools4msp.eu/	Menegon et al., 2018
WebGIS Application to Assess Conflicting Activities in the Framework of Marine Spatial Planning	Web map application	Yes		Drawing tools	Detection of areas of multiple conflicts Delineation of areas of conflict based on specific criteria	Intermediate GIS	Free, uses ArcGIS Enterprise portal https://sdi-portal.aegean.gr/portal/apps/sites/#/conflicts-assessment	Patera et al., 2022
Western Indian Ocean Symphony	Web map application	Yes	Heat maps of cumulative impact Calculation reports	Map creation Drawing tools	For registered users: Cumulative Environmental Impacts; Scenario testing for future use; Compare planning options; DST for Blue Economy in MPA	Advanced domain-specific skills Potentially advanced GIS skills	Sign-in required to access the portal http://www.nairobiconvention.org/wio-symphony/	

Appendix 4. Key points of feedback received through a series of eight workshops (July and August 2022) and summary of design features incorporated after three focus groups (May 2023) on the content, format and functionality of the Tasmania's Marine Atlas to support its development.

ENGAGEMENT SESSION	QUESTION OR FEEDBACK SOUGHT	KEY POINTS OR DESIGN FEATURES
Structured workshops (2022)	Using the Atlas: How might the Tasmania's Marine Atlas be used?	• Informing decision-making and providing evidence for decisions on uses of the Tasmanian marine estate • Supporting a wide range of planning processes from dive trips to inshore/offshore industries, and supporting coastal hazard risk assessment and planning • Understanding where science and research projects are or have been conducted and major findings and contact details for further information Understanding and assessing marine ecosystem processes and the effects of human uses for a wide range of interested parties, including local planners, commercial operators, state government regulators and decision-makers • Raising public awareness and interest about the marine environment, including threats and pressures to marine ecosystems and livelihoods, and supporting the development of ocean literacy (i.e., the understanding of how the marine environment works and its significance to people's lives) • Designing workshops aligned to educational curriculum and materials for Tasmanian schools, and for the general public • Supporting artistic practice
	Populating the Atlas: What information is useful and important to you, and therefore should be included in the Atlas?	• Ecological data • Ecosystem data • Coastal and marine processes • Coastal hazards • Human uses of the marine environment and their impacts (ranging from commercial and recreational activities, ownership status, economic information, Sea Country, and shipping traffic) • Marine areas and zones including bioregions, marine parks and conservation areas, aquaculture zones, fishing areas and seasons, mooring areas and areas in which terrestrial parks connect to marine areas • Information and results from research, citizen science, restoration projects and similar material • Climate and weather information • Temporal data, such as data that shows processes through time • Visual and video data including imagery and underwater video
Focus groups (2023)	Simplified navigation	• A user-friendly way to select a single theme or category and have all the relevant layers automatically selected • Clearer information and guides to aid Atlas navigation • Simplifying navigation back to the Atlas home page • Making StoryMaps easier to find including links from within portal as well as from the homepage • An 'educator portal' or featured map, which links to a simplified version of the Atlas, i.e. with a subset of layers available

ENGAGEMENT SESSION	QUESTION OR FEEDBACK SOUGHT	KEY POINTS OR DESIGN FEATURES
Focus groups (2023)	Explanation and guidance	• A 'Help' or 'FAQ' section, featuring common issues and questions such as how to contact the administrators, how the Atlas differs from related products • Legends with explicit explanation for some units • Improve landing page in general, i.e., graphics adjusted to ensure a balanced approach to marine industry, tourism and conservation • Simplified language for layers (if overly technical) • Glossary/ explanation of all acronyms used
	Explanation on datasets	• Contact information (to data custodians) for end-users struggling with contrast, colour blindness etc.
	Specific additional information	• Links and access to relevant legislation (e.g., EPCB Act of the Commonwealth) – perhaps from within the 'Resources' section • StoryMap addressing monitoring around marine farms in Tasmania (the highest voted priority)

Appendix 5. List of references

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