Toitū Te Whenua
Land Information
New Zealand

Enabling Integrated Marine Management

Part 1: Technical Proof-Of-Concept

Partner Agencies

Te Papa Atawhai | Department of Conservation
Ministry for Primary Industries
Te Arawhiti
Toitū Te Whenua LINZ

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Te Kāwanatanga o Aotearoa
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13-10-2022	1.2	Ashley Schischka	Final updates following review and endorsement by Governance Group

Contents

Executive Summary

This executive summary provides strategic findings and recommendations from the marine data innovation technical Proof-Of-Concept (POC) project funded through the Department of Internal Affairs (DIA) Digital Government Partnership fund. The project was a collaboration between Toitū Te Whenua LINZ (LINZ), Te Arawhiti, Te Papa Atawhai | Department of Conservation (DOC) and the Ministry for Primary Industries (MPI).

1. An Integrated marine geospatial system should be progressed as an essential national data asset

This project was undertaken to determine the feasibility of connecting marine geospatial data from various platforms and understanding the value of improved access to data and tools for marine management in Aotearoa.

This project delivered four specific marine management use case applications which proved the value of an integrated marine data system. An integrated marine geospatial system can enable:

- **Consistency in mapping areas of ecological significance** regionally and nationally, by sharing and connecting disparate marine datasets and enabling the development of innovative open-source tools.
- **Increased understanding on fisheries impacts across protected species**, by connecting data across multiple species for a wider, more holistic approach to understanding at risk areas.
- **Increased awareness on the location of customary marine and coastal areas,** by incorporating more relevant information in the customary rights application process and providing greater visibility of customary areas to a wider set of stakeholders.
- **Improved response to maritime disasters,** through efficient sharing and connecting of data from multiple sources to develop a common-operating-picture for emergency response.

While the system demonstrated value in these specific marine management applications, the value is not limited to these applications.

2. Technology and shared information can enable integrated marine management

Aotearoa New Zealand's marine management system is fragmented. This project concluded that cloud-based technology can enable an integrated approach to marine management, by providing access and reuse of marine geospatial data and analysis tools from a single interface.

An integrated marine geospatial system would improve marine management in the following ways:

1. create efficiencies in accessing data and responding to new environmental issues as they arise,

2. improve prioritisation in data collection investments,
3. support a broad range of marine management applications and enable decision makers to understand and consider cumulative impacts,
4. create greater consistency in marine management process and decision making across organisations and regional jurisdictions,
5. stimulate innovation through data reuse, new research design and capability building,
6. effective and efficient analytical computation through closer integration between cloud-based data and cloud-based application tooling,
7. enable wider and more competitive input from external researchers by sharing analytical tools,
8. increase public trust, confidence, and agreement in decision-making, enabled by transparency in what/how data is used and processed.

The findings from this POC provide a sound basis for pursuing an integrated marine data system.

3. A lead agency is required, however an integrated marine geospatial system should be developed and governed collaboratively

The marine management system in Aotearoa is complex, with responsibilities spread across many organisations[1]. The success of a decentralised, integrated marine geospatial system will require collaboration from the agencies and organisations that have a role in the wider marine management system[2]. However, leadership will be required to drive the project and ensure the establishment of the system and ongoing management of the system is successful. One of the key challenges identified through this POC was identifying a natural lead agency. The project team recommend an agency with a key role in marine management leads the development of a business case and is supported by other key marine agencies in identifying a preferred option/approach. The preferred option should be endorsed by the wider marine agency group[3], and the NZ Marine Geospatial Information Working Group (NZMGI WG).

Data should continue to be managed and maintained by the organisation which has created or captured it. This data steward should be responsible for connecting their data to the integration system.

[1] In 2021 Minister David Parker establish the Ocean Secretariat to strengthen coordination of marine management in New Zealand. The Ocean Secretariat is made up of DOC, MPI and MFE. Each of these agencies has key responsibilities relating to marine management.

[2] There is a wider marine agency group consists of central government agencies with a role and interest in the marine environment. It includes DOC, MFE, MPI, LINZ, NZDF, DIA, MOT, Treasury, Te Arawhiti, Te Puni Kōrkiri, Maritime NZ.

[3] The NZMGI WG est. 2019 by LINZ, to facilitate national collaboration and leverage opportunities to grow the value of marine geospatial information investments and benefits for all NZ. The NZ MGI WG has over 150 representatives from both the public and private sectors. https://www.linz.govt.nz/sea/marine-geospatial-information/nz-marine-geospatial-information-working-group

The integrated marine geospatial system should be governed by a Board consisting of representatives contributing agencies. The Board would be responsible for managing the service suppliers' contract, reporting on the ongoing value and performance, and identifying and prioritising system improvements.

Any specific marine management application development should be scoped, resourced, and managed by the organisation or group for which the application benefits. Applications should where possible be developed using open-source tools and be independent of the data integration infrastructure.

4. The findings from this POC research should be used to inform a business case and any future technical requirements

The strategic and financial findings should be used to inform the future state and business case development. The technical findings set out in the body of this report should be used to inform the technical system requirements.

The data integration infrastructure should be procured as-a-service and use open-source code where possible. This approach would reduce Government capital investment, reduce the risk of vendor lock-in and enable ongoing innovation from the private sector.

Based on the POC research the indicative costs of establishing and operating an integrated marine geospatial system as a service are thought to be:

	Set-up Cost	**On-going costs** Out years
TOTAL Shared system cost	$600k	$400k
TOTAL Internal resource cost	$100k - $400k	$70k - $170k

5. A marine spatial system could be expanded to support other domains in the future

Challenges with disparate spatial data are not unique to the marine domain. While this technical POC considers the value of an integrated data system in marine management, it should be noted, an integrated data system could be extended to other domains in the future.

6. Te ao Māori perspective on Aotearoa's marine data must inform any business case

Iwi/Māori have diverse rights and interests in the marine environment and play an extremely important role in marine management decisions. This technical POC will be followed by an additional workstream: a te ao Māori perspective on integrated marine management. Securing a partner for this work has been a challenge. It is proposed the innovation funding be used to explore how Iwi Māori can inform integrated marine management, including the value of an integrated marine geospatial system, via an Iwi Māori Ocean Advisory Group.

Project Background

Overview

Aotearoa's marine environment supports recreational and economic activities, it is of significant spiritual and cultural value to our people and is high in unique biodiversity. It is also under immense pressure from human activities and climate change. Good marine management has never been more important.

Geospatial information can help ensure decisions about the oceans are well informed and evidence based, so the oceans continue to support the activities required today while preserving the health of marine and coastal ecosystems.

In 2021 Toitū Te Whenua LINZ (LINZ) partnered with Te Arawhiti, Te Papa Atawhai | Department of Conservation (DOC) and Ministry for Primary Industries (MPI), to successfully secure funding through Department of Internal Affairs (DIA) Digital Government Partnership Innovation fund (the DIA fund), to explore how spatial data can enable integrated marine management.

The Enabling Integrated Marine Management Project has two core components:

1. **A technology Proof-Of-Concept (POC)** – testing the value of a cloud-based Datamesh[4] infrastructure in connecting existing data platforms, tools, and systems from various agencies.
2. **Te ao Māori perspective** – working with Iwi/Māori to develop a te ao Māori view on marine data governance and data sovereignty.

A total of $442,300 was provided through the DIA fund (see Appendix 1 – Financial Performance for detailed project financials).

Purpose

This report provides details, findings and recommendations relating to the technology component of the project. The te ao Māori component of the project will be reported in late 2023.

The Problem

In Aotearoa New Zealand the responsibilities, interests, and decision-making powers for managing the marine environment belong to a wide and diverse range of central and local government agencies with overlapping mandates and spatially nested jurisdictional responsibilities. In 2021 the Minister for Oceans and Fisheries noted in a Cabinet paper

[4] A datamesh is based on distributed architecture for data management. It enables data consumers to directly connect and interact with data from different data sources.

that because our "marine management system is fragmented, it is difficult to respond to pressures in a holistic, timely fashion".

This problem is exacerbated by the disjointed nature of marine geospatial data and tools required to inform decision-making. Organisations collect, manage, and produce various types of marine geospatial data with singular and sometimes divergent outcomes or purposes (e.g., environmental, scientific, economic, commercial). This creates silos of data that are inaccessible or not easily integrated, resulting in:

- narrowly focused decision-making processes in one jurisdiction which often fails to consider the objectives and constraints of other overlapping jurisdictions generating conflicts that often end up in Court (e.g., the Northland coastal plan proposing marine protected areas potentially in conflict with fisheries management constraints at the larger scale),
- a lack of transparency about what data are already owned by government which discourages a competitive market for innovative analyses from outside of government that builds upon previous work, and increases the cost of government research contracts,
- a lack of transparency regarding what data is informing the decision-making process generating mistrust among iwi partners, stakeholders, and the public.

The Opportunity

The Innovation Fund provided an opportunity to bring agencies together, leverage new technologies and test the feasibility of an Integrated Marine Data System. To understand if the system could help resolve the disjointed nature of marine geospatial data and help inform decision making.

An existing cloud based Datamesh system (the Datamesh) developed by NZ based company Oceanum Ltd. was chosen for the POC[5]. The system was originally developed to share very large oceanographic and climate datasets, and the POC aimed to test its value more broadly in the marine geospatial domain.

The Datamesh enables users to find, connect, subset, extract and use marine data across multiple platforms. Some marine datasets are incredibly large and can include multiple dimensions e.g., time. The Datamesh enables users to manage and use data efficiently.

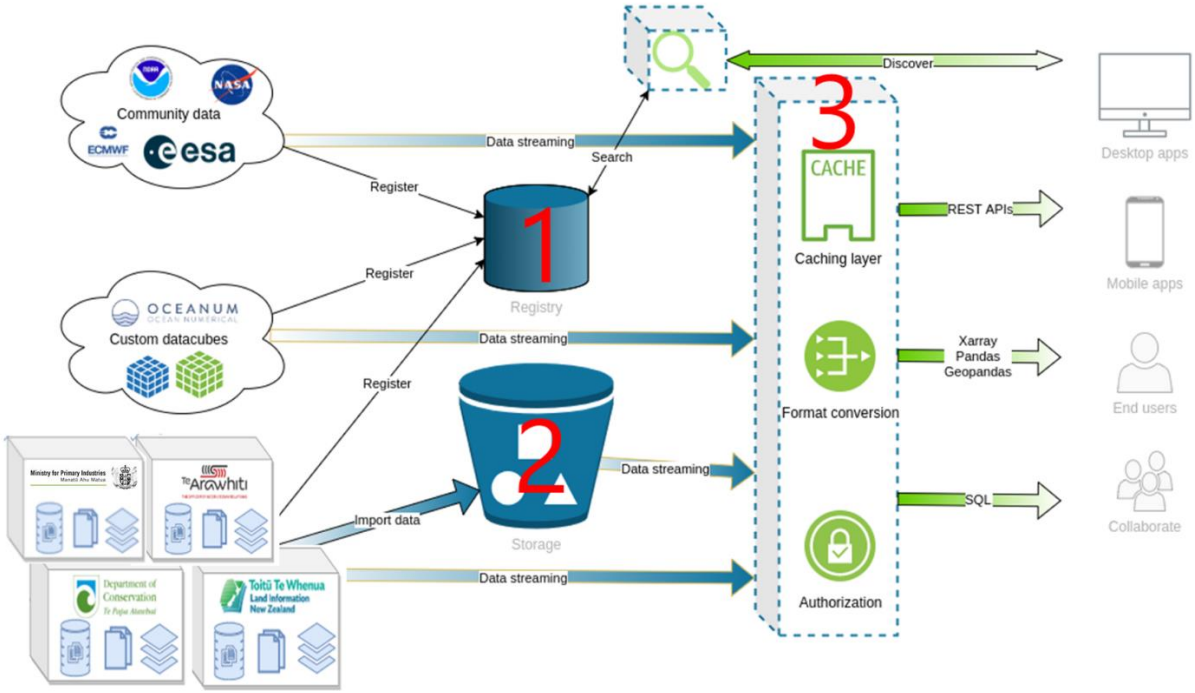
The Datamesh connects existing data platforms and systems from various organisations allowing data stored and managed by different organisations to be searched and discovered from one interface. It includes format conversion tools which deal with the variability of data and connecting data based on spatial location and time range.

There are three key components to the Datamesh. Each work together to provide a unified service:

[5] More information is available via https://oceanum.science/

1. **The registry:** All data sources are entered in a registry, which stores metadata including: a unique ID, connection details, storage location, spatial geometry, temporal extent, tags, or key words.
2. **The Datamesh storage system** allows for data to be uploaded and stored directly in the Datamesh cloud, if required. The preference is that data remains with the source provider.
3. **The Datamesh gateway** is the access point for all data on the Datamesh. All data is accessed through the Datamesh APIs. The gateway takes a user request for data and authenticates, authorises, and executes the request query, and delivers the data in the specified format.

The gateway query engine carries out several functions including spatial and temporal sub setting, and selection by attribute. It has a high-performance caching layer which optimises the internal access of data, improving access speed, and reducing load on external downstream data services.



Project Objectives and Deliverables

The objective of the POC was to increase understanding of the feasibility of creating an across government integrated marine geospatial system, including the risks, costs, and benefits.

The POC was delivered using four marine management use cases:

i. DOC used the Datamesh to identify areas of key ecological significance.

ii. MPI used the Datamesh to assess the impact of fisheries on Aotearoa New Zealand protected species, considering different spatial scales.
iii. Te Arawhiti used the Datamesh to access and share data to better support marine customary rights applications.
iv. LINZ used the Datamesh to connect data required in an emergency exercise – oil spill response.

Each use case, assessed the value of the system across eight specific criteria:

1. connections between existing GIS web services and/or datasets (without replicating the data across to this system) from the four partner organisations supporting faster and lower-cost computation of bulk data than existing systems,
2. interoperability of various data formats, standards, and scales,
3. a web service (conforming to OGC API standards) enabling users to query and stream data into their own GIS systems and analysis platforms,
4. safe and secure access to sensitive data repositories,
5. a spatial catalogue viewer with query functionality such as searching and filtering,
6. access to analytical tools (source code) using open formats,
7. insights/models from analytical queries run across multiple datasets,
8. performance of the system meets partners' and users' needs.

Marine Management Use Case Summaries

The four partner agencies tested the value of the Datamesh through real use case scenarios. They have worked with Oceanum to make data connections to the Datamesh, tested linkages, and run analysis tools where needed, to test the system performance and assess the system benefits. The full findings reports are attached as appendix, this summary provides an overview of each use case and the key findings obtained through this POC.

1. Te Papa Atawhai Department of Conservation: Mapping Marine Key Ecological Areas

Aotearoa New Zealand is nationally and internationally committed to manage its marine biodiversity; however, there is currently inconsistency on how different government bodies apply regulatory frameworks for managing marine and coastal biodiversity. One of the fundamental aspects to solve is how to effectively share existing data and allow potential users (e.g., regional councils, government agencies, etc) to analyse it in consistent ways. Te Papa Atawhai Department of Conservation (DOC) has been developing a set of criteria for identifying Key Ecological Areas (KEAs) that can inform decisions related to the management of marine biodiversity.

The DOC use case developed an online tool to delineate candidate KEAs within the marine environment using a set of criteria thresholds through the Datamesh. The use case explored how the Datamesh technology can support the development of an open-access analytical tool to delineate KEAs at national and regional scales. DOC, the National Institute of Water and Atmospheric Research (NIWA) and Oceanum collaborated during the use case to: (1) identify a series of test KEA criteria and sample of datasets to generate analyses; (2) link all required input datasets for the analyses to the Datamesh; (3) develop the analytical tool; and (4) conduct user testing internally and with regional councils (see Appendix 3 – DIA Marine Data Innovation – DOC Final Report for full description of each step).

The main output of the use case was a prototype online application, the 'KEA App.' The KEA App is Datamesh-enabled and fully performs the mapping of KEAs. The KEA App brings together data from multiple source servers (including the partner agencies' data portals) via the Datamesh without requiring downloading the data. The KEA App and Datamesh were extensively tested with key stakeholders such as regional councils, which showed strong interest and support for future development of these tools.

Key Findings

The Datamesh provides an intuitive and innovative solution to access standardised data from different organisations and enable the DOC use case purpose of mapping KEAs.

The DOC use case showed how a Datamesh can be transformational in how marine geospatial data are accessed in Aotearoa New Zealand providing a single access point to a range of data held on different data servers. The flexible and functional data

architecture provided by the Datamesh could save time and resources if fully operationalised, which ultimately could help create efficiencies in marine management.

The Datamesh also provided a platform for the development of the prototype KEA App which represents an innovative way of running analyses on spatial data, while maintaining the data on source servers. The KEA App can improve coastal planning initiatives with a user-friendly interface to map KEAs.

The two significant limitations identified during the use case were: (1) The Datamesh only partially incorporated metadata from the linked datasets, and (2) The owners of datasets need good data management discipline, including having complete metadata, in source portals. The DOC use case noted that these can be overcome with proper planning and governance in place to drive the implementation of the Datamesh.

Overall, the DOC use case provided an excellent test of the functionality of the Datamesh. The use case goals were achieved, as all data were successfully linked and the mapping of KEAs was successful, with the additional achievement of building the prototype KEA App. The use case also demonstrated that the Datamesh or a similar solution can provide a range of benefits to government departments, including regional councils, and improve marine management in Aotearoa New Zealand.

2. Ministry for Primary Industries: Protected species spatial risk assessment

Ministry for Primary Industries (MPI) and Fisheries New Zealand (FNZ) used the Datamesh to spatially display and manage fisheries impacts across all NZ protected species (e.g., seabirds and marine mammals). To date, fisheries risk has been managed one species at a time and usually only at the national scale. The Datamesh technology allowed evaluation of fisheries impacts across all species simultaneously and empowered users to access data about fisheries risk at whatever spatial scale is required, informing local and regional scale planning processes in harmony with national objectives.

Key Findings

The Datamesh provides several benefits for MPI. Having an integrated marine geospatial system raised awareness of the ability to access and analyse internal datasets without silos, and we are now able to access other agencies data in the marine space in a single location.

A key strength is the now open dialog between agencies involved in the Marine Geospatial data space, another is the clearer picture we now have of what works and what does not while potentially moving to the second phase for the Datamesh. The concept of a single collection location for marine data is a good one, and what functionally that offers can now be determined.

Weaknesses are uncertainly around vendor, vendor services, and administration functionally. Agencies need to have a clear picture of what needs to be delivered at the start of any next phase. Initially streamlined searching, catalogue functionally with enhanced display should be a priority. If this includes any analytical functions, then a clear approach on how these will be delivered in a technical sense should be determined as the approach has an impact on agency geospatial platforms and will allow the technical team to build sound use cases.

A risk for MPI relates to the level of ongoing involvement and sits in the data security space. Currently the Datamesh does not offer any more functionality that our existing open data portal offers and if MPI were to share more secure data there would need to be appropriate sign off from senior managers with the appropriate delegations.

3. Te Arawhiti: Visualising Applications and Orders made under the Marine and Coastal Area (Takutai Moana) Act 2011

Te Arawhiti administrates the Marine and Coastal Area (Takutai Moana) Act 2011 (the Act). This act provides for a legislative framework to recognise Māori customary rights around the coast of Aotearoa.

Under the Act, Māori were invited to apply to have their rights recognised over a specific geographic area. These applications are then subject to various tests relating to tikanga, historical use, occupation, and the possibility that customary rights may have been extinguished or interrupted. These tests are administered either through a High Court hearing, or by direct engagement with the Crown.

Successful applicants may receive recognition by way of two types of customary rights: Customary Marine Title (CMT) and Protected Customary Rights (PCRs). CMT constitutes recognition of general customary rights over a given area of the takutai moana. PCRs recognise an activity, typically undertaken in a specific location or locations, which is recognised as culturally and historically important.

Various rights and obligations flow on from the Act. Applicants under the Act must be notified of any proposed resource consents in their application area. Holders of CMT and/or PCRs receive a right of veto over resource consents in their customary area, as well as a right to contribute to local authorities' environmental planning.

Te Arawhiti maintain publicly available spatial data describing the location and extent of these area on its own platform, Te Kete Kōrero a Te Takutai Moana Information Hub, or Kōrero Takutai. To ensure that the rights described above are respected, it is vital that local and national government, as well as the public and other interested parties have access to relevant information.

The aim of the Te Arawhiti use case was to import its data into the Datamesh, making it available and searchable. The application areas in the Datamesh will be the most up to date which will reduce the risk of using outdated application areas.

Key Findings

The Datamesh allowed Te Arawhiti to link its data directly to an external platform, ensuring that it has a higher profile. Anyone working the Marine and Coastal Area space would be able to easily find spatial information on customer rights that have been applied for and/or recognised.

It will also provide a one-stop shop for related data. Administering the tests involves assessing a breadth of evidence, some of which can be easily collated thanks to the other data available on the Datamesh provided by partner agencies.

Once Te Arawhiti's data was imported into the Datamesh it was viewable by the partner agencies and could be used to support their use case tested.

4. Toitū Te Whenua LINZ: Supporting Emergency Response through Data Integration

During an emergency event the LINZ Geospatial Incident Management team can be contacted to help monitor and provide geospatial data to support a response. The LINZ use case aimed to test the value of the Datamesh technology in responding to a maritime emergency incident.

LINZ ran an oil spill emergency response exercise (the exercise), working primarily with Maritime New Zealand (MNZ), and alongside other organisations who have a role in marine pollution responses.

As well as testing LINZ' Coordinated Incident Management System (CIMS) processes, the exercise included a live test of the Datamesh, its performance in linking and sharing numerous big data sets between response agencies and enabling the development of a common-operating picture.

Prior to the exercise LINZ worked with MNZ to identify the key datasets that would be required in a maritime emergency. Approximately ten different LINZ Data Service (LDS) dataset were linked to the Datamesh prior to the exercise. Other datasets were requested and linked from Oceanum (Predict Wind), Te Arawhiti, DOC, MPI to support the emergency exercise.

Key Findings

The Datamesh proved beneficial throughout the exercise, increasing the speed agencies were able to find and share new data upon request.

Shared workspaces were created within the Datamesh (by supplier Oceanum) enabling multiple agencies (LINZ, MNZ, DOC, and MPI) to access a secure space, to share data, and build a common operating picture. A future instance of the Datamesh would allow user to create their own workspaces which could be shared with other agencies. This set up would benefit agencies building a common operating picture in an emergency event.

Feedback on Datamesh testing was positive, with data import, data selection, search functionality, Datamesh display, and metadata functionality tested. Current limitations of some functionality were noted and have been developed into future requirements, including a minimum metadata schema, previewing of datasets, and bulk data import functionality. Recommended future requirements are set out later in this report.

POC Findings

Overview

The purpose of this POC project was to increase understanding of the feasibility of creating an across government integrated marine geospatial system.

Through the four use cases the project concludes the cloud based Datamesh technology was effective in connecting and integrating marine geospatial data. The data was managed in various formats, on multiple different platforms, by different organisations from a single user interface. The technology proved a more holistic approach to marine management could be supported through improving data access and data integration.

An integrated marine geospatial system would provide a range of benefits including:

1. Improving the quality of marine management decisions, by considering wider cumulative impacts.
2. Creating greater consistency in marine management process and decision making across organisations and regional jurisdictions,
3. Increasing public trust, confidence, and agreement in decision making, enabling transparency in what and how data is used and processed.
4. Create efficiencies in accessing data and responding to new environmental issues as they arise.
5. Access to open-source analytical tools will enable a wider and more competitive field of external research providers capable of delivering government needs.
6. Providing effective and efficient analysis computation by having closer integration between cloud-based data and application tooling.
7. Stimulate innovation through data reuse, new research design, and capability building.
8. Improve prioritisation in data collection investments.

Challenges with disparate spatial data are not unique to the marine domain. While this technical proof of concept considers the value of an integrated data system in marine management, it should be noted, an integrated data system could be extended to other domains in the future e.g., earth observation data[6].

[6] In 2021 LINZ, MBIE, MFE, Stats worked with Frontier SI on a scoping study for Earth Observation data, including the need for a technology platform.

Functional Criteria

Eight functional criteria were used to test and measure the success of the Datamesh in enabling integrated marine management. The criteria were agreed as part of the early project planning. Each criterion was assessed for each use cases. Six of the eight output criteria were achieved, the two remaining criteria were partially achieved.

Functional Criteria	Result	Findings
1. Connections between existing GIS web services and/or datasets (without replicating the data across to this system) from the four partner organisations supporting faster and lower-cost computation of bulk data than existing systems,	**Achieved**	• All data for the KEA analysis was successfully linked to the Datamesh. • The Datamesh allowed analysis to run directly from the data source via the Datamesh, providing lower-cost computation of large datasets. • The Datamesh provided more flexibility for data architecture, allowing better searching and downloading capabilities, therefore saving time. • The Datamesh consumed existing open vector feature services easily. Raster images were also consumed with some configuration development. • Datasets from a variety of organisations were connected to the Datamesh. • Existing web service data is connected to the Datamesh, and the data is streamed to the Datamesh. • The Datamesh allowed for quick sharing of data during the emergency exercise. • Package building and exporting took less than 10minutes however a data package requires re-downloading if data is updated. • The Datamesh was connected to Te Arawhiti's existing REST API service and datasets linked.
2. Interoperability of various data formats, standards, and scales	**Achieved**	• A wide variety of data formats were ingested, including met ocean formats, GIS formats, and time series data. Data was ingested from various platforms, in several formats, • Data can be downloaded from the Datamesh and analysis in GIS tools. • Vector and raster format rest services were both supplied which fit under the ESRI rest service "umbrella." These follow the open geospatial services standards from the OGC guide. • The Datamesh provides the option to create data packages for export to common operating platforms. • Scales were tested when utilising the zonal statistic tool which work at a variety of spatial extents. • Metadata is fully customisable and populated by the data owner/steward however, metadata standards need to be clearly defined to support user searching and informing. • There are limitations on file sizes and visualisation, particularly with raster datasets. This limitation is due to the way the Datamesh is interfaced through to web browsers.

		• While Te Arawhiti's data was relatively simple it was compatible over variable formats. Te Arawhiti were able to integrate Datamesh data with their own software and platform.
3. A web service (conforming to OGC API standards) enabling users to query and stream data into their own GIS systems and analysis platforms	**Partially achieved**	• The DOC KEA App developed in the use case is Datamesh-based and queries, streams, and uses datasets through the Datamesh. • All the data MPI supplied is open and can already be consumed by any users of the ESRI suite, both web based and desktop. • QGIS can be connected to the Datamesh via API without having to go through the Datamesh. • Further work is required to connect ArcGIS to the Datamesh via API. There is currently no obvious mechanism for this function. • Further thinking required on which OGC specifications should be supported if a Datamesh project moved forward • While this output was not directly related to the Te Arawhiti use case, it was tested, and Te Arawhiti found it work well as part of the POC.
4. Safe and secure access to sensitive data repositories	**Achieved**	• The level of security was not defined in the PoC scope, however the PoC aimed to prevent agencies from viewing other agencies data. Function was successfully tested during development. • Datasets are natively locked down to the data owner. Owners can edit their data permissions and share with another user group. • Sensitive data can be secured and restricted in the Datamesh. • A full C&A would be required if an Integrated marine geospatial system was stood up.
5. A spatial catalogue viewer with query functionality such as searching and filtering,	**Partially Achieved**	• The Datamesh interface provided a useful and user-friendly spatial catalogue with good search, filter and download functions. • Search function efficiency relies upon correct metadata being imported with datasets. If metadata are not well curated in the source servers, a manual step to edit metadata and tags in the Datamesh will be required. • Data portals for spatial data normally contain a mapping component that allows users to view data and toggle information on and off, it would have been preferable to see this as a feature. • The ability to visualise the data through the Datamesh would be additionally advantageous. • Viewing all dataset extents created an overly busy map interface. The ability to group data by theme or type layers and turn layers on/off would be useful. • Te Arawhiti testing showed these functionalities were working with some future requirements noted.
6. Access to analytical tools (source code) using open formats	**Achieved**	• Successful development of a prototype KEA analytical tool (the KEA App). Open-access and web-based, using data through the Datamesh. • The MPI tool requires a spatial licence to operate in a desktop environment. MPI is restricted by the ESRI platform which has a proprietary format that is restricted, this is not a limitation of the Datamesh but would need to be included in any new requirements. *Note: Outcome 6 was not applicable for the LINZ and Te Arawhiti use cases.*
7. Insights/models from analytical queries run across multiple datasets	**Achieved**	• KEA analyses use multiple large datasets from different sources, which are run and visualised using the KEA App. • The tool was run against MPI's raster datasets, it would provide a complete picture of the system if another agency could test model and analytical functionality against our datasets.

		Note: Outcome 7 was not applicable to the LINZ and Te Arawhiti use cases.
8. Performance of the system meets partners' and users' needs.	**Achieved**	• The Datamesh provides an excellent platform to improve marine and coastal management, using data from different sources through a single portal. • The Datamesh enables the use of data from their original source, maintaining version control by data custodians. • DOC user testing found that regional councils highlighted the need for a tool like the KEA App for regional planning and management. There is a strong interest in the Datamesh technology with some identified improvements. • MPI tested the zonal statistic tool against 6+ layer. The tool seems to run faster in the UI that on desktop. Further comprehensive load and stress testing is required. • The Datamesh provides a quick and straightforward way for sharing datasets between organisations in an emergency event. Data exported from the Datamesh was imported into ArcGIS during the emergency exercise event. • Building of data packages and export was successful. Individual layers are easy to download but a good understanding of the package download process is required. • There are benefits to using the Datamesh to find and locate original data sources during an emergency event. • Met the need of Te Arawhiti's use case with future requirements noted.

Future Requirments and Considerations

The insights gained through the POC project have been used to consider requirements and consideration for any future integrated marine geospatial system.

Insight	Future Requirement / Considerations
System Administration	
Administration functions: System Administrative functions were all performed by the Datamesh Supplier (including integrating new datasets), this created inefficiencies.	• Data providers should be able to add, modify, or grant access to specific datasets. • Bulk datasets import functionality. • Data providers should be able to perform certain admin functions including being able to create shared workspace environments. A workspace enables users to see a selected subset of the Datamesh that is customisable.
Data providers: The Datamesh technology enables data to be integrated from multiple platforms and providers. The system will become difficult to administer and use as it grows.	• More consideration is required to ensure a growing system can remain functional – one option may be to have different instances.

Data Management	
Metadata: The Datamesh does not require comprehensive metadata making it easier for data provider to add data however this creates challenges for users when searching for data.	• Comprehensive metadata is required for good data management. A minimum metadata schema could align with the schema of the NZ Marine Geospatial Working Group. • Efficient, automated importing of metadata is required. • Data providers need adequate data management systems and complete metadata. • Contributing agencies need more information on how the search function retrieves datasets based on metadata and information tags.
Data attribution: The data is downloaded directly from the Datamesh without customers understanding the source or permissions.	• Data requires clear descriptions of the owner, sharing permissions, and attributions (ideally included as part of metadata to be read automatically in the Datamesh). • A Datamesh facilitated prompt when ingesting new datasets, for data license and access permissions. • The Datamesh needs to identify if a dataset is the authoritative data source (i.e., the valid or trusted data that is recognised by government agencies) to limit use of non-authoritative data for management. • Some level of data curation in the Datamesh may be required to ensure authoritative datasets are well identified and limit duplication of data.
Security: Some marine data sets are highly sensitive, and access needs to be restricted.	• Extensive security testing signoff from the security team and sign off potentially to a DDG level would be required to ensure sensitive data could be integrated into the system.
Storage: The Datamesh architecture enables data to be integrated from different sources. Data hosted in the cloud has improved performance.	• Large (greater than 100mb) datasets should be hosted in the cloud and then connected to the Datamesh.
End-user Functionality	
Searching and filtering: The Datamesh enables users to search and filter data in multiple ways, however users require some knowledge of what is available in a free text search.	• A catalogue of types of data layers accessible via the UI. • Additional filtering options, e.g., 'by source repository,' 'by owner.'
Data visualisation: The Datamesh user interface (UI) displayed the spatial extents of datasets however not all data types could be visualised through the UI. The UI is busy with large number of datasets	• Data should be previewed on the user interface before it is exported or packaged. • Visualisation of raster data. • Group/ layer dataset, so layers can be turned off/on. This prework has been done by NZ Marine Geospatial Working Group.
Integration with analytical tools: The Datamesh was able to integrate and connect data with analytical tools however, it was	• Open standards and tools should be encouraged / required by public organisations. • Identify any commonly used proprietary tools – explore opportunities to integration with common tools e.g., ArcGIS.

unable to integrate some large raster datasets with some tools. Some proprietary tools do not unable easy integration. Browser limitations also a limitation.	• Consider alternative interface options to negate limitations of browsers constraints for large datasets.
Usability: The Datamesh was relatively easy to use for those involved in the project however it requires some experience with spatial data systems. The currently user interface would not be suitable public users.	• An application should be developed to enable the public to visualise connected marine data through the Datamesh. • Guidance documents for those new to the Datamesh; particularly for building and exporting packages, describing functionality of the Datamesh.
Exporting data: The Datamesh enables user to export data however the by grouping data for an export package a copy of the data is created rather than a link to the data. Projection options are also not supported.	• Automated notifications/alert when source datasets used in analyses or selected in a package are updated. • Additional option for the user to select the projection for the export function.

Supplier Findings

Overall, the Oceanum involvement in the POC confirmed the pressing need for enabling technologies that allow meaningful outcomes to be derived from environmental data in a robust and efficient manner, and this finding has validated the company's vision and purpose to build and deliver such services. Oceanum noted that it would be desirable for Government Agencies and CRI's to better access open-source data science community libraries, tools, and solutions in addition to the current proprietary services. In this way they could benefit from rapid advancements in technology, innovative cloud-native architectures and collaborative frameworks that adhere to transparent standards. For more detail see Appendix 8 – Oceanum DIA insights, lessons, and recommendations for the full supplier report.

Risks

If an integrated marine geospatial system is progressed the below risks should be reviewed and monitored.

Risk
Lead agency: For this initiative to be successful, leadership is required. If no agency (with key marine management responsibilities) is prepared to lead this work, it will not progress. - Discussions are needed by senior leaders within key agencies to identify an appropriate lead.
Continued involvement of current agencies: If an agency that is currently involved in the POC decides to step back from development in the future the knowledge could be lost, and support could drop. - A working group agreement should be established and Datamesh responsibility should be formalised.
Onboarding new marine agencies: Agencies that have not been involved in the POC are keen be involved, provide data links to the Datamesh, and use the Datamesh. - A process for onboarding new agencies to become Datamesh administrators will require development.
An alternative supplier is selected: When a future system is set up, the project will need to go through a procurement process, including RFP and a different supplier may be selected. - Considerations around ongoing vendor support for the platform should be discussed with agency members at the beginning of any future development so that they are aware of any limitations.

Future Resourcing and Financials

The project partners considered future resource requirements for an integrated marine geospatial system, based on the insights from the POC. Consideration from project partners include:

Agency	Resource Allocation
DOC	- General administration of an integrated marine geospatial system could be part of an already established BAU role. However, this would depend on the metadata functionality provided in the system. - Extra FTE would need to be considered to support the development and implementation of an integrated marine geospatial system and related improvements in data management and metadata.
MPI	- Administration of an integrated marine geospatial system could be part of an already establish BAU role. - The system would require updates to allow for administration to be completed by individual agencies. - A higher FTE may be required if bulk data uploads or new development work were required. This would ideally be identified as soon as possible to allow for time resourcing backfills/secondments/recruitment etc. - To establish context and continuity, the same agency members should be involved, at least in the initial stages, of any further development.
Te Arawhiti	- As part of BAU we already maintain our data an ArcGIS Online-based web application and the necessary REST API services used by the Datamesh. - As such, we anticipate that no significant further resourcing will be required.
LINZ	- Full time person required for establishment, approx. 3months. - Ongoing .25 FTE resource once set up is completed.

The indictive costs in the table below are based on a shared infrastructure as-a-service model. In this funding structure, contributing organisations would be responsible for managing and hosting their own data, and developing any specific marine management applications they require. The base integration infrastructure would be contracted as a service. The costs below also include a Product Owner and Customer Engagement as a shared cost. Organisations with marine management responsibilities would contribute to a governance board and be responsible oversight of the service suppliers' contract, reporting on the ongoing value and performance, and identifying and prioritising system improvements.

	Indicative System Set up Costs Year 1		Indicative On-going operational costs Outyears	
Shared System Costs	**Quantity**	**Cost**	**Quantity**	**Cost**
Service establishment – Supplier	1 FTE	$200k		
Annual administration – Supplier				$50k
Annual enhancements – Supplier			1 FTE	$200k
Product owner / lead	1 FTE	$200k	0.5 FTE	$100k
Customer engagement lead	1 FTE	$200k	0.25 FTE	$50k
TOTAL Shared System Cost**		**$600k**		**$400k**
Internal Cost per agency	**Quantity**	**Cost**	**Quantity**	**Cost**
Data management	0.25 FTE	$50k	0.25 FTE	$50k
System integration / security		$0-$200k		
Governance contribution	0.25 FTE	$50k	0.1 FTE	$20k
Application development – Supplier		$0 - $100k		$0 - $100k
Data storage*		nil		nil
Total Internal Cost**		**$100k - $400k**		**$70k - $170K**

**It is assumed agencies will use their existing data storage; however, cloud storage can be provided to as an add-on if required. Costs would need to be investigated in a future business case.*

***Estimated costs include corporate overheads.*

Strategic Recommendations

Based on the POC findings, the partner agencies recommend:

1. **Progressing an integrated marine geospatial system beyond this POC.** The POC demonstrated value of an integrated marine geospatial system in four specific marine management applications, however the value is not limited to these applications.

2. **The findings and insights from this POC should be used to inform a business case and the technical requirements of any future system**. There were many learnings across the four use cases which provided valuable insights into the requirements of data providers and system users. Insights and requirements have been summarised in the body of this report however details relating to each use case are included as appendices.

3. **Identifying a lead agency and developing a multi-agency business case for an integrated marine geospatial system**. The business case should be led by an agency with a key role in marine management and be supported by other key stakeholders. The POC project partners should contribute as required. Input from other organisations with a role in marine management should also be sort. Support from the Wider Marine Agency Group[7] and NZ Marine Geospatial Information Steering Group members should also be sought.[8]

4. **A te ao Māori perspective on marine data must inform any business case**. Iwi/ Māori have diverse rights and interests in the marine environment and play an extremely important role in marine management decisions. The technical POC will be followed by an additional workstream to build a te ao Māori perspective on marine data and integrated marine management. This work must also inform any integrated marine geospatial system business case and requirements. The project has been challenged by finding a partner for this workstream. We now plan to engage a consultant with strong relationships in the Māori Marine space to facilitate this work. It is proposed the innovation funding be used to explore how Iwi Māori can inform integrated marine management, including the value of an integrated marine geospatial system, via an Iwi Māori Ocean Advisory Group. This work is envisaged to be completed by June 2023.

[7] The Wider Marine Agency group consists of agencies with a role and interest in the marine environment. It includes Agencies making up the Ocean Secretariat (DOC, MFE, and MPI), and LINZ, NZDF, DIA, MOT, Treasury, Te Arawhiti, Te Puni Kōrkiri, Maritime NZ.

[8] NZ MGI Steering Group consists of representatives from LINZ, DOC, MPI, MFE, MBIE, NZDF, Local Government, NIWA and GNS.

5. **Infrastructure as-a-service should be considered as an approach to establishing a shared service**. This approach would reduce Governments capital investment, reduce the risk of vendor lock-in, and enable ongoing innovation from the private sector.

6. **A future integrated marine geospatial system is governed collaboratively.** The success of an integrated marine geospatial system will be reliant on the uptake of use. This would include both data owners/stewards making data available and end users being aware of the system and its functionality. Contributing organisations with a marine management responsibility should form a governance board and terms of reference to provide management oversight of the shared system.

Appendices

Appendix 1: Project Financial Performance

Appendix 2: Te Papa Atawhai Department of Conservation Use Case Summary

Appendix 3: Te Papa Atawhai Department of Conservation use case: Mapping Marine Key Ecological Areas

Appendix 4: NIWA Key Ecological Areas report

Appendix 5: Ministry of Primary Industries Use Case Summary

Appendix 6: Te Arawhiti Use Case Summary

Appendix 7: Toitū Te Whenua LINZ Use Case Summary

Appendix 8: Oceanum insights, lessons, and recommendations report

Appendix 1 – Project Financial Performance

How the project performed against baseline budget for overall spend.

Project Budget		FY 21/22	FY 22/23	Total
Allocated funding				$442,300
Budget for POC				$245,000
Supplier	Project Management	$20,000	$0	$20,000
	POC Technical Development	$100,000	$0	$100,000
DOC	Marine Geospatial Project Lead	$19,775	$11,515	$31,290
DOC	Contract with NIWA	$50,200	$28,500	$78,700
DOC change of scope 22/23	Scoping to progress additional testing od DOC Use Case		$15,010	$15,010
Te ao Māori budget	Original Budget Te ao Māori Scope		$47,300	$47,300
	Rediverted from MPI IT Support and system testing to Te Ao Māori Research		$150,000	$150,000
Actual Spend to date		$189,975	$40,015	$229,990
Total		$189,975	$252,325	$442,300