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The Threatened Marine Taxa (TMT) tool: software design and feasibility considerations

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The Threatened Marine Taxa (TMT) tool: software design and feasibility considerations

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Prepared for Nelson City Council, Environment Southland, Canterbury Regional Council. Ministry of Business, Innovation and Employment Envirolink Grant: 2442-NLCC130

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Glossary

Term	Definition
AOI	Area of interest
API	Application programming interface; a set of rules that allows software applications to communicate and share data
app	Application (software that performs a specific task)
CMA	Coastal marine area
CRC	Canterbury Regional Council
CSIG	Coastal Special Interest Group
CSIGSK	Coastal Special Interest Group Species Key tool
CSV	Comma-separated values file; a text file that uses commas to separate values and new lines to separate records
Datamesh	An advanced cloud service that allows a decentralised data architecture. Within this type of architecture, different entities can own and manage their data as products, using a shared infrastructure. A datamesh facilitates the discovery, management and use of different types of datasets
DOC	Department of Conservation
ES	Environment Southland
ESRI	Environmental Systems Research Institute (GIS software company)
GBIF	Global Biodiversity Information Facility
GIS	Geographical Information System
HBRC	Hawke's Bay Regional Council
IUCN	International Union for Conservation of Nature
KML	Keyhole Markup Language (XML notation developed for Google Earth)
LAWA	Land, Air, Water Aotearoa
m/s	Metres per second
MBIE	Ministry of Business, Innovation and Employment
MfE	Ministry for the Environment
MPI	Ministry for Primary Industries
NABIS	National Aquatic Biodiversity Information System
NCC	Nelson City Council
NIWA	National Institute of Water and Atmospheric Research
NZTCS	New Zealand Threat Classification System
OBIS	Ocean Biodiversity Information System
PDF	Portable document format file; presents documents independent of application software, hardware and operating systems

POC	Proof of concept
Python	A computer programming language often used to build software, automate tasks and conduct data analysis
Shapefile	A data format for geographic information systems that stores the shape, location and attributes of features
Stats NZ	Statistics New Zealand
Software stacks	A collection of components that work together to support the development of an application. The components are 'stacked' on top of one another
Taonga	Māori word, analogous to treasure
TMT	Threatened marine taxa
UI	User interface
VME	Vulnerable marine ecosystems

Contents

Executive summary

Cawthron Institute (Cawthron) was contracted by Nelson City Council, Environment Southland and Canterbury Regional Council through an Envirolink advice grant (2442-NLCC130) to review the feasibility of designing and developing a cross-referencing software analysis tool that will identify and locate existing records of threatened indigenous marine taxa in Aotearoa New Zealand, i.e. the Threatened Marine Taxa (TMT) tool. It is anticipated that better access to threatened taxa records and associated geospatial information will improve the ability of councils to identify the presence / absence of threatened or at-risk marine taxa in their coastal management areas, to meet their New Zealand Coastal Policy Statement 2010 requirements and to enable more informed coastal management. For this initial project (Stage 1), we have undertaken market research, identified desirable design features, discussed software considerations, presented a proof of concept (POC) and made final recommendations for the next steps in the TMT tool development.

Market research for the tool was informed by a primary user questionnaire (councils and Department of Conservation [DOC]) and reviews of potential user organisations and current online tools. Through this, it was identified that:

- Making the tool public would reduce some of the information request strain on council, and possibly national, regulators.
- Externally sourced taxa records have no data management requirements and are of no cost to council to maintain.
- Data from external sources need to be filterable (e.g. by time frames), and have metadata, source attribution and measures of data quality control.
- Users would also like to be able to input taxa records of their own and have them cross-referenced by the TMT tool.
- Geospatial data should be displayed on a map viewer and be exportable in comma-separated values (CSV), shapefile and portable document format (PDF) formats.
- The tool needs to be a long-term, cost-effective (< $15,000/yr shared cost), ongoing solution with the potential for data archiving. It is possible that Regional Sector Holdings Limited could cover the costs of ongoing support and development, with statutory agencies (with obligations in the coastal marine area) also financially supporting the tool.
- User uptake was best via conference presentations, top-down approaches (where government feeds information to councils), word of mouth and Teams group chats, with training modules to be provided for the new software.

A review of other potential users showed that the TMT tool would likely be a useful asset to several other organisations (primarily DOC, but also Ministry for the Environment, Statistics New Zealand and Land, Air, Water Aotearoa), environmental consultants, resource consent applicants / submitters, students (universities, schools and learning resources), researchers, iwi and conservation groups.

The design of the TMT tool application (app) should consider two main functions: identifying TMT from selected or uploaded records / databases, and predicting where TMT might be present, based on species distribution layers.

To help undertake these functions, we identified three external threat classification data source

inputs (NIWA-VME 2016; IUCN 2024; NZTCS 2024) and five taxa record database inputs (eBird 2023; GBIF 2024; iNaturalist 2024; MPI-NABIS 2024; OBIS 2024) that contain relevant data. We also recommend, as an initial quality control mechanism, that taxa record names are cross-referenced / checked against taxonomic nomenclature (e.g. using WoRMS 2024). These data inputs (and controls) are a starting point for the tool development, with the potential to add further data sources to the tool over time.

The most desirable data output format identified in the review was CSV files. However, the ability to create Environmental Systems Research Institute (ESRI) shapefiles and Keyhole Markup Language–type files (KML, e.g. Google Earth-compatible files) through the TMT tool is likely to be advantageous for users and should be considered.

The software development approach should be divided between the operator (owner), the developer (engineer and host manager) and the designer (Cawthron). We also recommend hosting the tool within Aotearoa New Zealand to improve networking and downloading times and ensure there is data sovereignty protection.

Our preliminary software POC, designed by Cawthron using Shiny (2024), is a prototype of the TMT tool demonstrating that the basic tool functions are feasible.

The next steps for the development of the tool are listed below:

- *Phase 2a: Envirolink tool centralisation*

  Ministry of Business, Innovation and Employment (MBIE) / Coastal Special Interest Group to consider centralising Envirolink tools software and providing guidance for selecting the software owner (operator), software developers and web hosts.

- *Phase 3a: Build the final prototype*

  The designer (Cawthron) should review the preliminary POC and refine the app, increasing functionality. The final prototype should be provided to the developer to engineer the required data architecture to make the software.

- *Phase 3b: Select the development team*

  The software owner, developer and platform should be selected using MBIE guidance (as per Stage 2a, if available). If guidance is not available, then selection should be by recommendation of the designer.

- *Phase 4a: Build the TMT tool software*

  The selected developer should use the final prototype and this report to inform the build of the TMT tool software (front and back ends), using the agreed / appropriate data platform. A complete record of the design process information and software coding is to be recorded (e.g. via GitLab).

- *Phase 4b: Test the TMT tool software*

  A selection of engineers and potential users should test the tool and provide feedback on the user experience and any software bugs to the developer for fixing.

- *Phase 4c: Roll out the tool to SCIG and DOC*

  The tool should initially be opened to internal users. Tool access / collaboration and distribution of running costs to be negotiated with other GOs and NGOs (as identified in this report).

1. Introduction

Cawthron Institute (Cawthron) was contracted by Nelson City Council, Environment Southland and Canterbury Regional Council through an Envirolink advice grant (2442-NLCC130) to review the feasibility and software considerations for developing a tool capable of identifying and locating existing and predicted records of threatened indigenous marine taxa in Aotearoa New Zealand – i.e. the Threatened Marine Taxa (TMT) tool. This review considered aspects related to designing, developing and implementing the TMT tool into a fully functional cross-referencing analysis software application. In this context, 'threatened' is used as an umbrella term to include any species identified from 'threat-type' classification lists (e.g. IUCN 2024; NZTCS 2024, etc.). The general aims for the TMT tool are to:

- be designed for use by regional and unitary councils, government departments, consent applicants, educators, researchers, environmental consultants and the public
- be able to identify the presence / absence of threatened or at-risk marine taxa in a given area using existing available geospatially referenced taxa lists (e.g. GBIF 2024; MPI-NABIS 2024; OBIS 2024.)
- provide regional councils with data for the mandatory identification of threatened or at-risk marine taxa presence / absence under the New Zealand Coastal Policy Statement 2010 and to enable more informed coastal management
- provide regional councils with key threatened taxa data inputs to inform the Marine Habitat Assessment Decision Support Tool (MacDiarmid et al. 2011).

At present, no efficient method or tool is available for doing this, which makes managing potential ecological risks to threatened and at-risk marine taxa difficult. Currently, regulators, planners, consultants and researchers are required to build up project-specific species lists from available sources and then cross-reference them manually with threatened taxa lists to see if any threatened taxa are known to exist in certain areas of the coastal management area (CMA). Alternatively, they go through each species on the threatened taxa lists to see if they could 'potentially' exist in a specific habitat of interest, which is especially labour intensive. Both methods run the risk of human error, are not standardised and are time-consuming.

1.1 Scope

Software design and feasibility considerations of developing the TMT tool software were reviewed through:

- understanding the potential user market for the tool (through a user questionnaire and review) and summarising the users' desired software features
- reviewing the preliminary design concept, and identifying the key data input and output requirements, software and hosting considerations, and the potential design (look and function)
- providing a basic proof of concept (POC) to demonstrate software development feasibility
- planning the next development phases.

2. Method of assessment

2.1 Market research / user engagement

Primary users

The key input / output requirements and expected functionality of the tool were determined through focused questioning of potential council and DOC users via a questionnaire (see Appendix A1.1). The digital questionnaire was developed using the Environmental Systems Research Institute (ESRI) ArcGIS Survey123, with input from Harry Allard (leading council scientist, Nelson City Council [NCC]), and was circulated for 2 months to all councils via the Coastal Special Interest Group (CSIG) working group.

Identifying potential non-council users and collaborators

Other organisations and professionals that might be interested in using and / or hosting the tool were identified via a Google web search for 'New Zealand threatened marine taxa'.

2.2 Preliminary design concepts

Preliminary design concepts were initially informed by reviewing existing web-based tools. The review identified their hosting mechanisms, inputs / outputs, positive and negative characteristics, and functionality. The tools and web applications (apps) reviewed were those that were known to us, or were found through subsequent internet searches (for 'web-based marine taxa tools'), specifically those:

- previously commissioned through Envirolink, e.g. CSIGSK (2024), NIWA-SCENZ (2024)
- already used by councils e.g. LAWA (2024)
- internationally recognised e.g. OBIS (2024).

All review results were presented / summarised in table format. The summary of the web-based tools review helped to inform much of the software considerations, technical specifications and user interface design presented in this report (see Section 3).

2.3 Proof of concept

A basic POC app was developed using R Shiny (Chang 2024; R Core Team 2024). The functionality of this POC was limited to two external data sources, OBIS (2024) as an external database of taxa distribution, and NZTCS (2024) for the threatened taxa list information. Ensuring that taxa names are consistent across different datasets should be a key component of the TMT tool. For the POC, the WoRMs application programming interface (API)[1] was used to check and correct taxa names from the external data sources and the taxa entered by the user. The aim of this exercise was to show that the automation of the process can be achieved with technologies that are relatively easy to implement and can be used as a prototype for future development.

[1] https://www.marinespecies.org/rest/

3. Results

3.1 Market research / user engagement

Primary users

Following circulation of the questionnaire to the CSIG, the councils that responded (singularly) were NCC, Hawke's Bay Regional Council (HBRC), Environment Southland (ES) and Canterbury Regional Council (CRC). The Department of Conservation (DOC) also completed the questionnaire. The findings from the questionnaire (Appendix A1.1) are summarised below.

How would the tool help?

The questionnaire participants thought the tool would be helpful for councils and environmental regulators alike, enabling them to identify the presence / absence of threatened taxa and the vulnerability of certain species and ecosystems / habitats, inform monitoring planning and design, assess impact assessments and undertake impact assessments. It was also identified that making the tool public would reduce some of the strain on councils (and possibly national regulators) to provide the public with this information.

Current data-sourcing practices

Internal databases are limited for most councils, with the storage of threatened species data largely in report format or stored in spreadsheets (Microsoft Excel). Internal data sources benefit councils in terms of ease of access / analysis and records where the samples were collected, but can be limited in terms of effort and subsequent species records (both spatially / temporally). In contrast, DOC has some internal at-risk species distribution data that are used internally to predict the potential for threatened taxa presence (Enrique Pardo, Marine Science Advisor, DOC, pers. comm., 15 November 2024).

External databases (eBird 2023; GBIF 2024; iNaturalist 2024; MPI-NABIS 2024; OBIS 2024) were also used by some councils to source marine taxonomic data. In these cases, councils noted that the external databases were generally clear and up to date, and typically included threat classifications with the organism description. As the data are housed externally, there are no data management requirements for the councils, which was seen as a cost saving. The inclusion of non-empirical observation data was also seen by the councils as acceptable, as it is often peer reviewed and is of no cost to council. DOC used similar external databases to the councils, finding the accessibility of these to be a benefit. However, there appears to be a disjunct between DOC and the councils about the quality of the data available, with DOC noting that external data sources can have inconsistent metadata, data standards, quality assurance processes and quality control.

Data inputs and outputs

All users require the taxonomic data input to be in comma-separated values (CSV) file and / or shapefile formats. Generally, users also wanted a map viewer (displaying the records) and the option to have data reports exported as a portable document format (PDF). Metadata were also identified as an important

output by 2/5 of the users questioned. Being able to sort / filter data based on the time of observation was identified by DOC as a requirement for outputs.

Storage and retrieval of data
Some of the users that do not already have a data management system would like the user data to be stored after they are inputted (2/5), while other users (including DOC) felt this was not necessary (3/5). DOC would like the tool to be a long-term, ongoing solution.

Data accuracy
The expectation around the accuracy and reliability of the data in the tool was that historical data and public data (citizen science data) should be included. The proviso to this is that all data included should be 'tagged' or filterable to show what sort of data it is, and reviewed to give it a measure of uncertainty, similar to the iNaturalist (2024) data verification process.

Service costs
Most participants (3/5) responded that the lower end of budget would be reasonable for the data service (<$15,000/year, TMT tool software costs only), and that there are limited budgets for the service. The other two questionnaire participants were unsure how to answer this question.

For ongoing costs, one participant suggested that Regional Sector Holdings Limited (RSH 2024) could cover the expense of ongoing support and development (for this tool). Another mentioned that statutory agencies (with obligations in the CMA), such as Fisheries New Zealand and DOC, should also contribute. Overall, the users believe the costs (approximately $15,000/year) could be reasonably split over 5–10 users / subscribers, resulting in lower individual costs.

Methods of tool uptake, training and feedback
The best-ranking methods of uptake were conference presentations, top-down approaches (where government feeds information to councils), word of mouth and group chats (via team collaboration apps). Special interest groups and workshops were ranked as less effective methods of uptake by the participants.

Almost all the participants were accustomed to undergoing training for new software tools and the majority of users felt an email to the host/manager was a useful method of providing feedback about the tool performance/issues.

Potential non-council users and collaborators

A number of organisation websites were identified that reference or discuss Aotearoa New Zealand 'threatened' taxa online (Table 1). Given these websites already incorporate threatened taxa or council environmental data, it is possible that links to the tool itself, or possibly hosting of the tool (via collaboration), could be managed through their websites.

Other potential TMT tool users could include environmental consultants, resource consent applicants / submitters, students (universities, schools and learning resources), researchers, conservation groups and the general public.

Table 1. Non-council organisations that may have an interest in hosting or using (linking to) the TMT tool.

Potential user	Why
Department of Conservation (DOC) New Zealand Threat Classification System (NZTCS 2024)	National threatened taxa classification web platform that provides up-to-date threatened taxa lists. Has no provision for mapping locations of threatened taxa records
DOC Marine Data Portal (DOC-MDP 2024)	National platform that provides a wide range of marine taxa records that can be displayed on ArcGIS web maps. Has no provision for mapping locations of threatened taxa records
Ministry for the Environment (MfE 2019)	National web platform, linked to the Stats NZ (2023) threatened marine taxa summary (see below). Recognises that threatened species are a compulsory value within the National Objectives Framework. Provides the public with tools for assigning threat classifications to freshwater species and guidance around the available tools, databases and resources relating to the distribution of threatened freshwater species and their habitats in NZ
Land, Air, Water Aotearoa (LAWA 2024)	National ecological data web platform with aspirations to add more topics over time. Currently, presents information on freshwater quality, groundwater quality, water quantity, air quality, land cover and estuary health. Initially a collaboration between NZ's 16 regional councils and unitary authorities, LAWA is now a partnership between the Te Uru Kahika – Regional and Unitary Councils Aotearoa, Cawthron Institute, MfE, DOC and Stats NZ, and has been supported by the Tindall Foundation and Massey University
Statistics New Zealand (Stats NZ 2023, 2024)	National data web platform that summarises threatened taxa lists. Has no provision for mapping locations of threatened taxa records

3.2 Preliminary design concepts

A review of 17 mapping-style web-based tools was undertaken (DOC 2021, 2024; EnviroSatTools 2021; Stats NZ 2023, 2024; CSIGSK 2024; GMTDS 2024; iNaturalist 2024; LAWA 2024; MBIE 2024; MPI-NABIS 2024; MPI 2024; NIWA-SCENZ 2024; NZTCS 2024; OBIS 2024; SWA 2024), identifying the design approach used, the desirable and undesirable features, access, data use terms, hosting and management / maintenance approaches. These are discussed below (and summarised in Appendix A1.2).

Concept

We aim to develop a cross-referencing software analysis tool that can identify and locate existing and predicted records of threatened indigenous marine taxa in Aotearoa New Zealand, i.e. the TMT tool. The basic steps / functionality for the TMT tool app would be:

Identifying threatened taxa records

1. Select area of interest (AOI) on a map.
2. Select external databases (e.g. OBIS, iNaturalist), with the option to upload a user taxa record.
3. Apply filters for external databases (record time range, species type, threat class, etc.).
4. Check and fix all (user and external) taxa names using WoRMs services.
5. Check and merge all (user and external) duplicate records using data validation rules.
6. Cross-reference the taxa list with the threatened taxa lists (e.g. NZTCS, IUCN, VME).
7. Return the list of taxa selected by user (user and / or external) with the designated threatened status.
8. Return a map showing the selected taxa and allow the user to download data for AOI.

Predicting threatened taxa presence

The ability to include predicted species distribution layers (e.g. from the DOC Marine Data Portal and NABIS annual distributions) of threatened taxa can be used to identify threatened species that *may* occur in the AOI. These layers can be overlaid on the map, but should also be a summarised as a table, so the user can also be provided with a list of taxa that could potentially occur within the AOI

Hosting

Almost all Aotearoa New Zealand-based tools reviewed were hosted overseas (e.g. Amazon 2024; Google 2024; Microsoft 2024). The four Aotearoa New Zealand-based tools that were hosted locally used the following hosting companies: Catalyst.net (2024), Redshield Security Ltd (2024), Solarix Networks Ltd (2024) and Vodafone (2024). Hosting a tool and the data associated with it locally can have benefits, including networking efficiencies, faster downloading times and data sovereignty protection (TMR 2024). If possible, we recommend hosting the website locally in Aotearoa New Zealand – for example, the CSIG species guide (CSIGSK 2024, appendix 1) is a previously funded Envirolink tool that is hosted by Aotearoa New Zealand-based Solarix Networks Ltd (Solarix 2024) via the AtlasMD (2024) platform.

The cost of hosting can vary slightly depending on the provider but is typically based on the amount of traffic to the app, how much data storage is required, specific services, security support, performance and other factors. If the tool is of complex design and open to the public, there is a risk that tool ownership becomes expensive, especially if there are more users than anticipated. However, the amount charged per month by hosts (and host managers) is typically not linear or exponential and can be capped. Therefore, it may be worthwhile to restrict access to the tool, at least until funding mechanisms, tool owners (operators) and the final software architecture are decided.

Key data inputs, outputs and permissions

For the TMT cross-referencing tool to work, at least two data input types are required: (1) threat classification taxa records, and (2) geospatially defined taxa records. We have identified three potential threat classification data input sources (NIWA-VME 2016; IUCN 2024; NZTCS 2024) and five taxa record input databases (eBird 2023; GBIF 2024; iNaturalist 2024; MPI-NABIS 2024; OBIS 2024) that contain relevant data (Table 2, with a more detailed review in Appendix A1.3). The ways in which the two different data sources (taxa records and threat classes) are to be cross-referenced with each other are presented in Table 2. Note that a WoRMS (2024) check is also included as an initial quality control mechanism, to ensure all records (both taxa record and threat class data) have the most up-to-date nomenclature.

Table 2. Cross-referencing matrix for taxa records against current taxa names and threat class data sources.

Cross-check data sources	**Taxa record data sources**					
	OBIS (2024)	**MPI-NABIS (2024)**	**GBIF (2024)**	**iNaturalist (2024)**	**eBird (2023)**	**User records (data imports)**
WoRMS (2024)	Check names	Check names	Check names	Check names	Check names	Check names
NZTCS (2024)	NZTCS matches	NZTCS matches	NZTCS matches	NZTCS matches	NZTCS matches	NZTCS matches
IUCN (2024)	IUCN matches	IUCN matches	IUCN matches	IUCN matches	IUCN matches	IUCN matches
NIWA-VME (2016)	VME matches	VME matches	VME matches	VME matches	VME matches	VME matches
	TMT tool potential data outputs: e.g. shapefiles (ESRI), KML (Google Earth), CSV files					

The majority of outputs identified in the review were CSV files (Appendix A1.3). However, the ability to create shapefiles (ESRI) and Keyhole Markup Language–type files (KML, e.g. Google Earth-compatible files) is likely to be advantageous for users who access online mapping resources such as Google Earth (2024) maps and ArcGIS Online (ESRI 2024).

Data access and permissions

Of the potential data sources identified in Table 2, NABIS, OBIS and DOC have already provided written terms of use for the TMT tool (see Appendix A1.3 for API instructions). The other data managers have not yet responded to our requests. The majority of the potential taxa record data sources have clear data sharing terms available through their websites, these largely being governed by the Creative Commons Attribution 4.0 International licence, with some restrictions on commercial use of the data. Most sites also have instructions for communicating and sharing data via API connections (Appendix A1.3). It is noted that written permission from each data provider (a data sharing agreement) will need to be obtained, given the potential restrictions on commercial data use.

Data limitations and challenges

There are several limitations on using other organisations' data, including:

- Maintenance of datasets and APIs are the responsibility of the host organisation. If changes are made to the structure of the datasets or the responses of the APIs, the tool using these services will be affected, and fixes could be costly in terms of time.
- Data ownership and responsibilities, and the type of use permitted, should be tracked and displayed for each organisation's datasets. This could be complicated depending on the number of reference datasets used and the complexity of the original data itself.
- Data sharing agreements might need to be set up for each organisation, and maintained, with regular revisions as ownership of data or permissions for their use may change.
- Data sovereignty should be taken into account when deciding which datasets to use. The position of the organisation around respecting sovereignty of original data sources might need to be included in the metadata or description of the datasets.
- Some external data services will have overlapping data points, potentially causing record duplication during the data merge process. These should be addressed using data matching and / or validation rules (criteria or conditions to determine if data are valid).

Software considerations

The majority of the tools we reviewed (Appendix A1.2) used websites embedded with apps (e.g. GEE 2024; R Core Team 2024; Shiny 2024) to manage data selection and data inputs, and / or interactive web maps to display and select the data (e.g. ArcGIS Online [ESRI 2024); QGIS 2024; Leaflet 2023). Where the development information was publicly shared, the software appears to have been created and / or maintained by third-party software developers (e.g. AtlasMD 2024; Dragonfly 2024; GitLab 2024; MapLarge 2024; SHD 2024) or, in the case of large collaborative regional council software tools (such as LAWA), the websites were managed and operated by Regional Software Holdings Limited (RSH 2024).

We recommend a similar design approach, with the tool management divided between the owner / operator (e.g. RSH 2024), the designer (Cawthron 2024) and a developer (e.g. AtlasMD 2024; Cawthron 2024; Dragonfly 2024; MapLarge 2024; SHD 2024). With the exception of the tool design, which is being driven collectively by Cawthron with input from the Ministry of Business, Innovation and Employment (MBIE), CSIG and DOC, the final software engineering roles (the build of the app; Table 3) can be managed in a number of ways by any reputable developer (see a comparison of three representative software developers in Table 3). Hosting locations (for the app itself and the data inputs) are usually specific to the developer (who have their own preferred hosting providers), and preference should be given to those developers that have the capability to use Aotearoa New Zealand-based hosting (as discussed earlier).

Table 3. Key software development roles and the capabilities of three representative service providers.

Key roles	Cawthron (2024)	AtlasMD (2024)	Oceanum (2024)
Tool designer: Provides the tool design idea, and defines functionality, inputs and outputs	✓	x	x
Developer / engineer (front end): Builds the web app	✓	✓	✓
Developer / engineer (back end): Designs and maintains architecture. Typically manages hosting	✓	✓	✓
Host: For the app and user data inputs	✓ *NZ-based hosting anticipated 2024 (Microsoft 2024)	✓ *NZ-based host (Solarix 2024)	✓ *International host (Google 2024)

We note that when more developers / engineers (across organisations) are involved with software development (with different stacks and programming design languages[2]), the development can be slower and result in more work than if it is managed fully by one organisation. To avoid these difficulties, our recommendation is to use a single developer for the full software development (front and back ends, and hosting management), rather than dividing tasks.

How to choose a developer and platform?

Developers are also linked to their own software platforms / data architecture. For previous Envirolink tools, the developers and platforms have varied – for example, some software tools are managed by NIWA (NIWA-SCENZ 2024), AtlasMD (CSIGSK 2024) and Google (EnviroSatTools 2021). However, following feedback from the MBIE tool committee (Bill Dyck, Envirolink Coordinator, pers. comm., 18 November 2024) we understand there is a desire to move towards a centralised platform for all Envirolink marine tools. Given this, there are two possible approaches for selecting a developer / engineer for the TMT tool:

1. MBIE Envirolink specify a preferred software development provider (and any guidelines for software development) for centralising and managing Envirolink tools software.
2. The designer (Cawthron) identifies a developer based on their merits and experience and the cost to deliver the tool.

[2] E.g. Python, Java, JavaScript.

The approach / position on centralisation should be clarified with MBIE / CSIG prior to selecting a developer.

Desirable and undesirable software features / functions

Based on the tool software review findings (Appendix A1.2), a number of desirable and undesirable features and functions were identified (summarised in Table 4 and Table 5, respectively). Desirable features and functions that were identified included a fast-loading interactive map that can display the threatened taxa record matches (along with all species records), with integrated filterable data; and simple, bulk data download processes. The inclusion of some functions for comparison of data and statistics from different locations and / or time periods was also identified as a useful feature. To make the tool as easy to use and reference as possible, the data search, selection and filtering process needs to be intuitive and have clear data use terms and tool user guides.

Many of the undesirable features encountered stemmed from slow-loading apps and web maps, broken links, incorrect or outdated taxa record names (resulting in non-matches), and the onus and expense of data hosting. The majority of these collective problems with online biodiversity tools can be managed through excellence in software design, clear archivable system queries and rapid response, simple registration and regular software maintenance (e.g. software like GitLab [2024], as used for EnviroSatTools [2021]), can be used to help achieve this). To avoid potential record-matching issues involved with species name changes or naming errors, we recommend a similar process as that used by OBIS (2024), where the taxa records are first cross-referenced against WoRMS (2024).

Table 4. Desirable software features that should be considered for incorporation into the TMT tool design.

Desirable features from tool review (Appendix A1.2)	Features to incorporate
Almost all sites used maps to display data (with the exception of DOC 2021; NZTCS 2024; Stats NZ 2023). Maps that had the functionality to select and view sample / site information from an interactive map (Stats NZ 2024) were helpful for seeing data at a glance	Interactive web map Select sample / site for data export and visualisation / pop-out
Tools that were easy to navigate generally had simple layouts and were developed using Shiny (2024). More complex mapping was undertaken using ArcGIS (ESRI 2024) or QGIS (2024) platforms. However, we note that complex mapping did not always correlate to more complex data. The fastest-loading maps were on the Global Marine Traffic Density Service (GMTDS 2024) via MapLarge (2024)	Simple apps with fast-loading maps using efficient web architecture that makes best use of multiple APIs and best practice for mapping integration (Dimitris et al. 2013; Google Cloud 2024)
Some tools allowed the downloading of data, e.g. CSV, geoTIFF, GridFloat or NetCDF (GMTDS 2024; OBIS 2024)	Allow for downloading of data
Data summary graphs for visualisation (Stats NZ 2024)	Include summary statistics
The ability to download multiple months of data as zip files (GMTDS 2024)	Allow for downloading of large volumes of data for specific time frames
The ability to select regions and look at data from those regions (MBIE 2024)	Include CMAs as a default AOI for selection
A summary of key statistics for each selection (MBIE 2024)	Include summary statistics / graphs
The ability to compare data between designated areas / regions (EnviroSatTools 2021; MBIE 2024)	Enable comparison of statistics between areas of interest. Include all species records for area comparisons (i.e. non-threatened species)
The ability to select / filter data by AOI (MPI-NABIS 2024; NIWA-SCENZ 2024; OBIS 2024)	Allow for selections of areas of interest on interactive map
The ability to filter data by time and various categories. e.g. 'all species', 'invertebrates', 'fish', 'birds', 'mammals' and 'plants' (MPI-NABIS 2024)	Allow for downloading of filtered data for specific time frames, species groups, databases, etc.
The ability to add (upload) geospatial data to the tool to display on the web map (EnviroSatTools 2021; MPI-NABIS 2024)	Enable shapefile inclusion as an alternative to selecting an AOI (drawn polygon)
Data processing (software design) workflow clearly shown in a diagram (EnviroSatTools 2021; NIWA-SCENZ 2024)	Include information about system design
User guides (EnviroSatTools 2021; GMTDS 2024; MPI-NABIS 2024; OBIS 2024)	Include an online and downloadable user guide
Almost all sites had a contact email for maintenance, data queries and troubleshooting	Include an email enquiry form to sort and archive queries, for future quality control reviews
Open sharing of data APIs and instructions for ease of sharing / scraping data (EnviroSatTools 2021; GBIF 2024; iNaturalist 2024; OBIS 2024)	Include API and sharing instructions, as well as clear terms and conditions for data use

Table 5. Undesirable software features and how they will be avoided in the TMT tool design.

Undesirable features from tool review (Appendix A1.2)	How to avoid
Slow-loading apps (NIWA-SCENZ 2024)	Use good cloud architecture, programming languages that allow efficient use of data, and appropriate programming practices to avoid latency issues
Web maps that are slow to load or do not load (MPI-NABIS 2024; NIWA-SCENZ 2024)	Use good cloud architecture, programming languages that allow efficient use of data, and appropriate programming practices to avoid latency issues
Broken links (DOC 2021) and registration requirements (CSIGSK 2024), making navigation to the tool difficult and slow	Carry out regular, ongoing site maintenance. Include automatic registration
Some tools do not allow for the download of data, or it's difficult to navigate (LAWA 2024; Stats NZ 2024)	Allow for simple downloading of data
Some tools do not clearly display terms around data sharing (DOC 2021; SWA 2024)	Include clear terms of data use
Some tools were complicated for the user to navigate, with a number of steps rather than automated processes. While this allows for more flexibility with data interpretation and use for the experienced user, it can be difficult for the novice user to navigate (NIWA-SCENZ 2024)	Use intuitive single-page processes only, e.g. select area on mapper tool, filter data (using an automatic pop-out), view data, have option to see statistics and compare areas of interest, download data
Inability to upload external data to ArcGIS web maps	If ArcGIS web maps (ESRI 2024) are used, they will need to be integrated with another app or widget to enable data uploads, e.g. the 'add data' widget
The datasets used in large biodiversity tools like OBIS, NABIS and GBIF.org, typically have to be transformed by the publisher into a standardised format, which is then submitted to the tool as a standalone database. This work may include additional processing, content editing and mapping a dataset's content into one of the available data transfer formats. Updates are not automatically linked to the publishers API	Use a datamesh-type linked app where the data are automatically updated from the original database
As databases are only intermittently updated, species names are not always current	Ensure a species name (synonyms) cross-reference check with WoRMS (2024) is undertaken

A final undesirable feature is that all the software designs investigated (Appendix A1.2) obtain datasets from data providers and host the data themselves (e.g. centralised software platforms). This is undesirable because the expense and effort of hosting data in this (more traditional) way is significant, as datasets must be manually followed up and revised continually. To manage this issue, it may be possible to use a 'datamesh'-style architecture in the TMT tool design, whereby direct links to the databases (from data contributors) are used. In this way, a datamesh spreads out taxa record data storage and maintenance responsibilities to the data contributors. The data contributors are then linked together through cloud platforms so that data can still be shared and / or interpreted using apps. The feasibility of the datamesh approach to sourcing information for biodiversity data, as well as integration of prototype apps (e.g. the KEA app) to interpret the data, has been investigated by DOC (Bennion et al. 2022; Pardo et al. 2022), partnered with Oceanum (2024), e.g. the KEA app successfully used R code (R Core Team 2024), translated into Python (by Oceanum 2024), to source habitat suitability index models (DOC Marine Data Portal) and fish spawning areas (MPI Open Data Portal) in order to delineate key ecological areas (KEA). The box below presents further discussion on suitable approaches for the TMT tool platform.

Datamesh vs standard centralised software platforms

The main difference between datamesh and a standard software platform is that datamesh is decentralised, while standard software platforms are centralised. In other words:

- **Centralised platforms** are scalable and promote standardisation, governance and scalability. However, they can lead to bottlenecks, slower responsiveness and dependency on a centralised team.
- **Datamesh platforms** are decentralised and distribute data ownership and governance to the original host. This can lead to improved responsiveness, scalability and agility. However, it can also lead to inconsistent data practices and coordination challenges.

User interface design

User interface (UI) design is the process of creating the visual and interactive elements of a product's interface to improve the user experience. To make sure the user has a good experience with the tool, we suggest the tool web page / app is designed to be fast and intuitive, with the following UI design features (as illustrated in Figure 1):

- Opening page designed as a mapper tool app, with sequential data import filters (for taxa records, classification records and user taxa lists).

- WoRMS (2024) taxa name check included as part of the database cross-reference process.
- Map layer options and export file selections.
- Metadata file with the export file downloads, including WoRMS (2024) name corrections.
- A download countdown, so that users know when to expect their export to be completed.
- Visible header links to the tool user guide, data use terms (and API instructions), information about the tool and contact details for queries.
- Public searchability for the tool via web search engines and links to relevant organisation websites (as per Table 1).
- Data use disclaimer (i.e. explaining how users' personal information, data imports, etc., might be used) as a simple pop-up on page opening.
- A data storage / archive option as a possible add-on to the 'import own taxa record data' option.

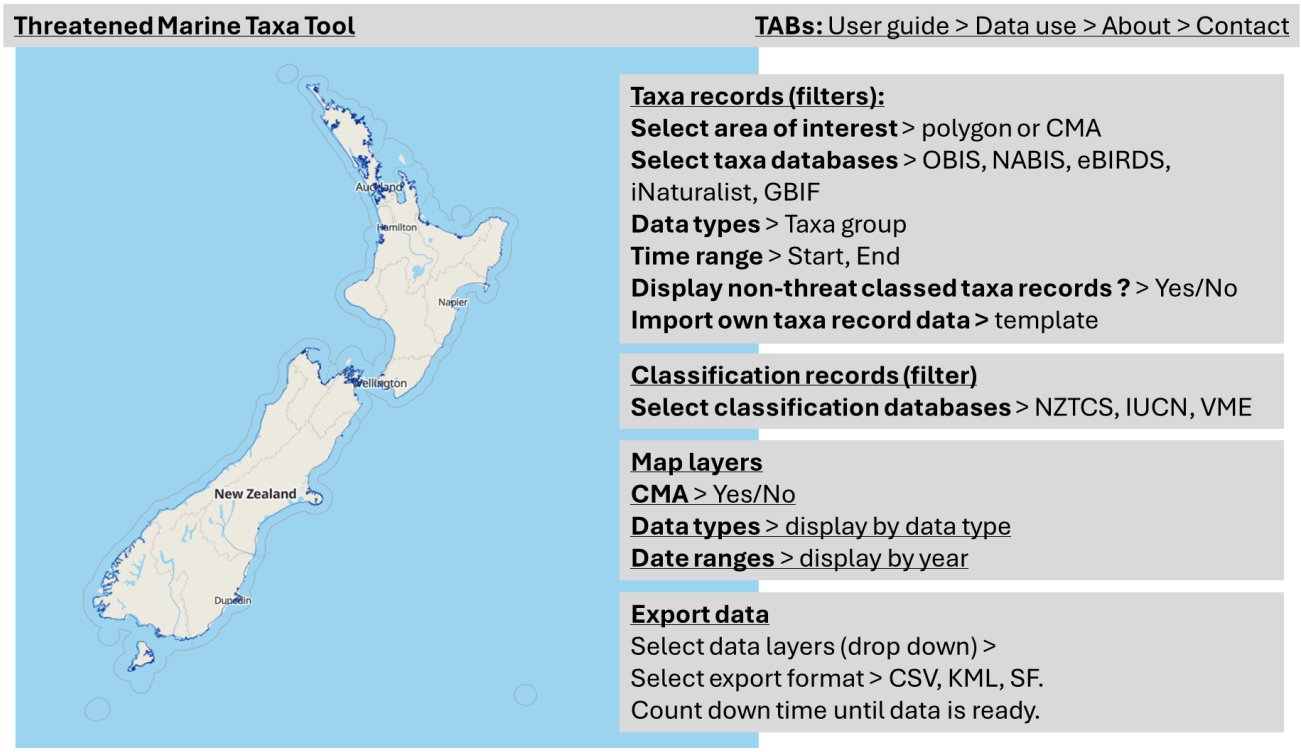


Figure 1. Schematic example of the TMT web tool look and key functions (see Glossary for definitions of abbreviations).

3.3 Proof of concept: tool usability

The POC TMT Tool app showed that it is possible to achieve the desired functionality, including an easy and intuitive user interface. This very preliminary app can be found at https://cawthron.shinyapps.io/18842_TMT_tool_concept/ and Figure 3 illustrates the POC user interface.

The POC app was developed with a centralised architecture. All reference datasets were downloaded, curated (including checking taxa names against WoRMS [2024] records), appended and merged. The new combined and compiled dataset is being hosted in the shinyapps.io server alongside the web app. This approach will need a scheduled call and update of the reference databases to keep the tool up to date.

The tool also checks the taxa names from user lists against WoRMS (2024) using their APIs. For this POC, functionality is undesirably slow. However, there are many ways of optimising this step, including parallelising the process and using appropriate cloud infrastructure to take advantage of this method (i.e. running the app in an environment that allows multiple cores to operate simultaneously).

The final dataset and app are both hosted by shinyapps.io, currently in Amazon's AWS US-East region. However, it is possible to containerise the app using Docker and then deploy it elsewhere. Containerising ensures the longevity of the app by deploying the app and its dependencies (e.g. libraries, configuration files, frameworks, etc.) together as a package, so it can run on any host operating system. This is standard practice at Cawthron when apps are finalised and developed for external use.

The TMT POC code and documentation are kept with version control in Cawthron's GitLab (Git) account. Git is a development tool for source code management. In addition to a distributed version control based on Git, some Git software packages (e.g. GitLab) include other features such as access control, task management, issues tracking, bug reporting, software feature requests and wikis (with documentation about the software development and user manuals).

Overall, we showed that the basic desired functionality of the TMT tool can be achieved with relatively basic software development technology (using R Shiny and hosting the tool in the R Shiny server: shinyapps.io). This could be a viable option if the resources are limited and there is willingness to compromise on query response times, hosting environment and time management for the underlying reference datasets.

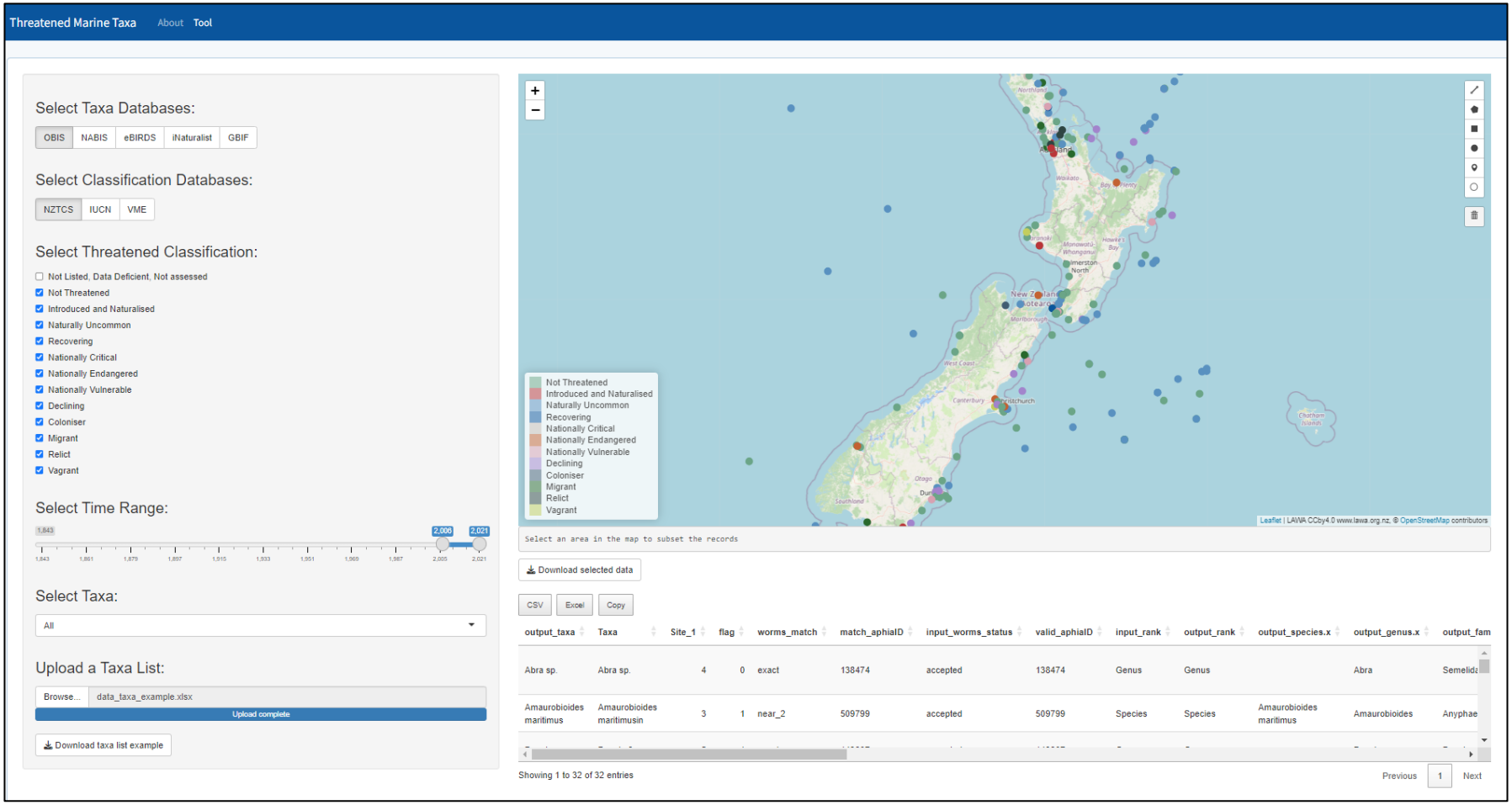


Figure 2. User interface for the proof-of-concept TMT Tool application.

4. Discussion

To improve councils' ability to identify the presence / absence of threatened or at-risk marine taxa in their coastal marine areas (CMAs), to meet their New Zealand Coastal Policy Statement 2010 requirements and to enable more informed coastal management, an open-access cross-referencing software analysis tool will be developed to identify and locate existing records of threatened indigenous marine taxa in Aotearoa New Zealand, i.e. the Threatened Marine Taxa (TMT) tool. Here, as the first stage of development, we present the findings of market research, preliminary design concepts and considerations, and a proof of concept to test the tools usability.

4.1 Market research

We undertook market research via user questionnaire (councils and DOC), a review of potential (non-council) organisations that might use the tool and a review of online tools currently available. The questionnaire participants (council and DOC staff) thought a TMT tool would be helpful for councils and other environmental regulators alike, enabling them to identify the presence / absence of threatened taxa and the vulnerability of certain species in ecosystems / habitats, to carry out state of the environment monitoring and monitoring design, and to assess and undertake impact assessments. The market research also identified that making this information public would reduce some of the strain on council (and possibly national regulators such as DOC) to provide public with this information.

The users questioned considered externally sourced taxa records (e.g. OBIS, NABIS, iNaturalist, GBIF, eBird) to be helpful, including historical and citizen science type data, as they have no data management requirements and are of no cost to council to maintain. However, any data from these sources would need to include metadata and source attribution, with measures of data quality assurance and control. The users would also like to be able to input taxa records of their own and have them cross-referenced by the TMT tool. The data input template preference was a csv file and / or shapefile format, with all geospatial data available for viewing on an online map viewer. Users also preferred exported data (both user supplied and from externally sourced databases) to be in csv and shapefile formats, with the addition of PDF reporting options. All data exports will require the inclusion of metadata and source attribution, and the ability to be sorted based on the time range of observation.

Overall, the questionnaire participants felt the tool needed to be a long-term, cost-effective (< $15,000/yr), ongoing solution with the potential for data archiving. It is possible that Regional Sector Holdings Limited could cover the costs of ongoing support and development (RSH 2024), with statutory agencies (with obligations in the CMA) such as Fisheries New Zealand and DOC, as well as regional councils, approached for maintenance contributions.

The best-ranking methods of user uptake were conference presentations, top-down approaches (where government feeds information to councils), word of mouth and Teams group chats, with training modules provided for the new software. User feedback about the tool performance / issues should be made via email to the asset / app manager.

Based on a separate review of online resources, the TMT tool would likely be a useful asset to a number of other organisations (e.g. DOC, MfE, Statistics New Zealand and LAWA), environmental consultants, resource consent applicants / submitters, students (universities, schools and learning resources), researchers, conservation groups and individuals.

4.2 Preliminary design

The app should have two main functions: (1) identifying the TMT from selected taxa records / databases, and (2) predicting where TMT might be present, based on species distribution layers.

To identify TMT from selected taxa records / databases, the app will need to be designed so that it can select external databases for inclusion (e.g. OBIS, iNaturalist), with the option to upload a user file with a list of taxa names (user taxa records). This process will also need to be able to check and fix all (user and external) taxa names using WoRMs services, and then compare the taxa list from the user with the online lists of threatened taxa (e.g. NZTCS, IUCN, VME). Finally, the cross-referenced list will be returned to the user with the designated threatened status and the record locations on a web map, allowing the user to download data for the area of interest (AOI).

The ability to include predicted species distribution layers (e.g. from the DOC Marine Data Portal and NABIS annual distributions) of threatened taxa may also be useful for identifying threatened species that may occur in the AOI, rather than where records are known to have occurred (e.g. from OBIS, iNaturalist, etc.). Rather than overlaying these species distribution layers on the map (making then difficult to read / select), the layer overlaps could be provided as a summary table.

4.3 Inputs / outputs

We have identified three threat classification data sources (NIWA-VME 2016; IUCN 2024; NZTCS 2024) and five taxa record databases (eBird 2023; GBIF 2024; iNaturalist 2024; MPI-NABIS 2024; OBIS 2024) that contain data relevant to Aotearoa New Zealand oceans (Table 2, review provided in Appendix A1.3). A WoRMS (2024) check will also be included as an initial quality control mechanism, to ensure all records (both taxa record and threat class data) have the most up-to-date nomenclature. The majority of outputs identified in the review were CSV files. However, the ability to create shapefiles (ESRI) and KML-type files (e.g. Google Earth-compatible files) is likely to be advantageous for users.

4.4 Software considerations

We recommend that the website management is divided between the operator (owner), a developer and the designer (Cawthron). We also recommend that the website is hosted locally to avoid data sovereignty issues.

Software centralisation appears to be something that MBIE wants to work towards for the Envirolink software tools. Given this, there are two possible approaches for selection of a developer / engineer for the TMT tool: (1) the developer can be designated by MBIE / CSIG as the preferred provider, or (2) the developer can be identified by Cawthron. Either option is feasible. Although advice around software centralisation is outside of the scope of this assessment, Cawthon experts are available to provide possible approaches to this if required.

The ongoing costs of the software tool, once rolled out, will depend on the complexity of the design, the user base, the maintenance requirements and the functionality. Given that councils have limited available resources to support the tool, we suggest containerising the software and restricting access to the tool, at least until software development guidance (platform and hosting preferences), tool owners (operators) and the final software architecture are decided.

4.5 Preliminary proof of concept (POC)

Our preliminary POC (software prototype) was designed using R Shiny (2024) and provides a basic representation of the TMT tool. The simplified POC showcases the desired tool functionality (as informed through the user questionnaire and software review). This preliminary POC will be available as a starting point for future development. The code and underlying compiled datasets are also available if needed (upon request), and version control has been kept with Git.

4.6 Next phase planning

The next phase for the tool development is to clarify the tool platform approach, identify the key development team members, draft a final prototype tool, and then build, test and roll out the TMT tool software. Specifically, the next steps for the development of the tool are (Figure 4):

- **Phase 2a: Envirolink tool centralisation**

  Given there is some desire to centralise (and more easily manage) Envirolink tools software, we recommend that MBIE / CSIG first consider how this might be achieved. A wide range of developers and different types of platforms can be used to bring the TMT tool to life. However, to ensure the tool is of long-term benefit, easy to manage and cost-effective to the owner, the selection of the developer and platform (to create and share the tool) should made strategically. Cawthron is available to provide expertise and advice on software management approaches if required.

- **Phase 3a: Build the final prototype**

  The designer (Cawthron) should review the preliminary POC and refine the app, increasing functionality. The final prototype should be provided to the developer to engineer the required

data architecture to make the software. Written permission from each data provider (a data sharing agreement) will need to be obtained, given the potential restrictions on commercial data use.

- **Phase 3b: Select the development team**

  The software owner, developer and platform should be selected, using MBIE / CSIG guidance (as per Stage 2a) if available. If guidance is not available, then the final team should be selected by recommendation of the designer (Cawthron). Using the final prototype, development cost estimates could be obtained from a selection of providers, with the final developer chosen based on merits, experience and cost.

- **Phase 4a: Build the TMT tool software**

  The selected developer should use the final prototype and this report to inform the build of the TMT tool software (front and back ends), using the agreed / appropriate data platform. A complete record of the design process information and software code is to be recorded (version control should be kept via Git).

- **Phase 4b: Test the TMT tool software**

  A selection of engineers and potential users should test the tool and provide feedback on any software bugs to the developer for fixing.

- **Phase 4c: Roll out the tool to CSIG and DOC**

  The tool should initially be opened to internal users. Tool access / collaboration and distribution of running costs should be negotiated with other GOs and NGOs (as identified in this report).

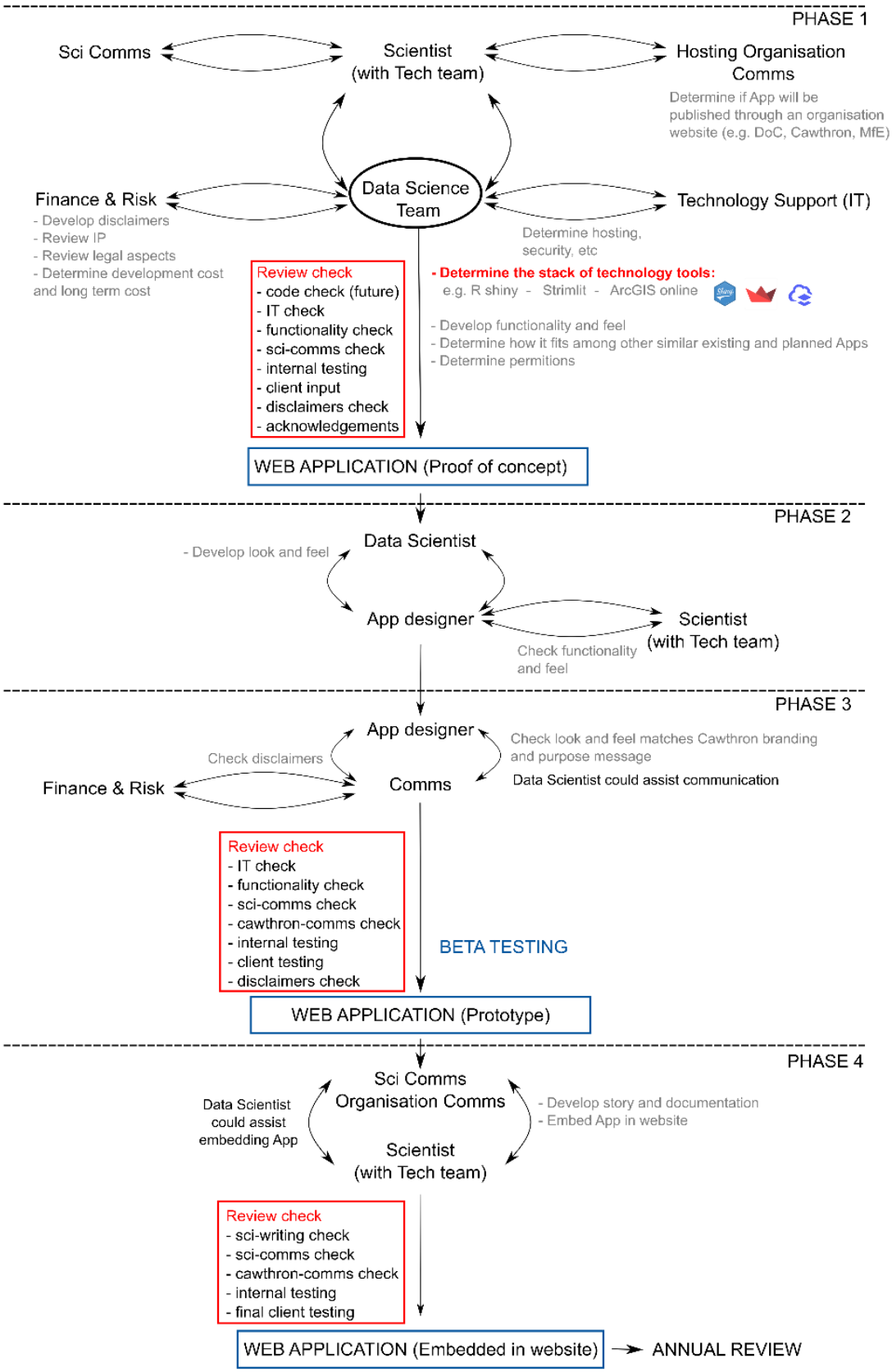


Figure 3. Diagram of TMT tool application development workflow and phases.

5. Appendices

Appendix 1. Market research

A1.1 TMT tool user questionnaire

TMT tool questionnaire

Which council or government organization are you affiliated with?

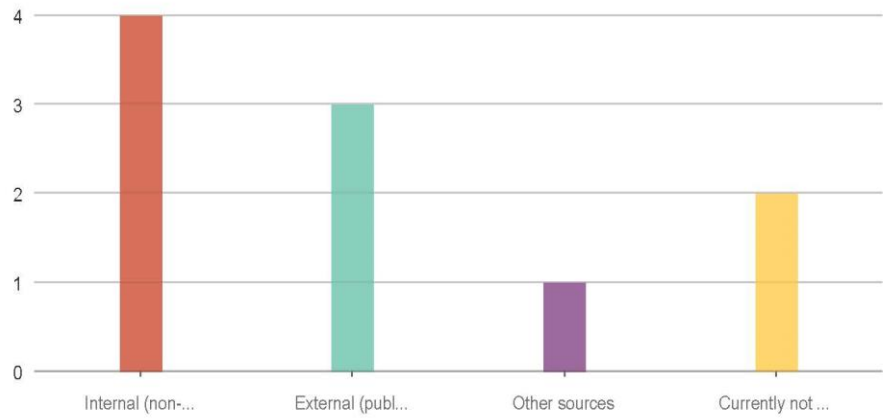
The word cloud requires at least 20 answers to show.

Response	Count
Nelson City Council	1
HBRC	1
Environment Southland	1
Environment Canterbury	1
Department of Conservation	1

Answered: 5 Skipped: 0

1. Current Data Sourcing Practices

How do you currently source data on threatened and at-risk marine taxa in areas ...



Answers	Count	Percentage
Internal (non-public) taxonomic record databases, checked manually against NZTCS and IUCN lists	4	80%
External (public/online) taxonomic record databases (e.g. OBIS, NABIS, iNaturalist, eBirds etc), checked manually against NZTCS and IUCN lists	3	60%
Other sources	1	20%
Currently not something we do / have time for	2	40%

Answered: 5 Skipped: 0

1. Current Data Sourcing Practices > Internal Data Source Details

Please provide additional details for internal databases:

The word cloud requires at least 20 answers to show.

Response	Count
Species list stored in spreadsheets	1
Our significant conservation areas have species lists from DOC in the 90s that were used as a basis to create them. Work hasn't been repeated since.	1
Not particularly databases as we're working through that stuff, but in internal reports etc.	1
DOC-held threatened and at-risk species data, including GIS layers	1

Answered: 4 Skipped: 1

1. Current Data Sourcing Practices > External Data Source Details

Please provide additional details for external databases:

The word cloud requires at least 20 answers to show.

Response	Count
OBIS, NABIS, iNaturalist.	1

OBIS, NABIS, iNaturalist, GBIF (if I have to), eBird - you nailed the list.	1

Answered: 2 Skipped: 3

1. Current Data Sourcing Practices > Other Data Source Details

Please provide additional details for 'Other' sources:

There are no answers to this question yet.

What are the benefits of these data sources?

The word cloud requires at least 20 answers to show.

Response	Count
Up to date, held externally (no data management requirements), peer-reviewed observations, no cost to council	1
Some are clear and moderately well updated and have threat classifications included with the organism description.	1
Highlights hotspots in our region	1
Accurate record of where we sample (estuary infauna) and ease of analysis and access	1
Accessibility	1

Answered: 5 Skipped: 0

What are the disadvantages of these data sources?

The word cloud requires at least 20 answers to show.

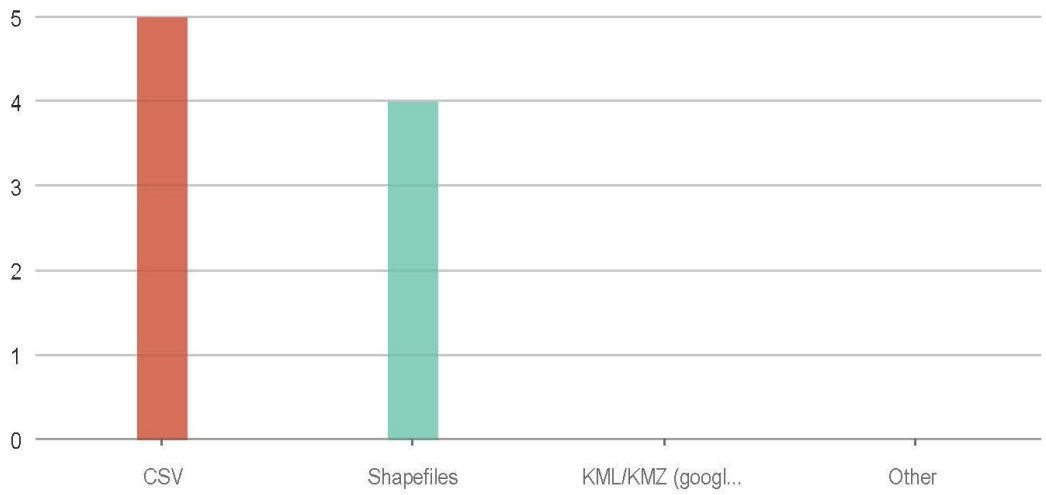
Response	Count
Very limited information as only records for ECan monitored sites (8 estuaries) and one ecosystem	1
Pretty old	1

IUCN over NZTCS for some pages. Having to go between all of them to double check, and in some instances, no clarity of observation date.	1
Inconsistent meta data, data standard, QA and QC	1
Ad-hoc sampling by public, may need to reference several sources, underrepresentation of fully marine taxa	1

Answered: 5 Skipped: 0

2. Desired Functionality, Expectations and Requirements

If you were to use the TMT tool to cross-reference your taxonomic records, what...



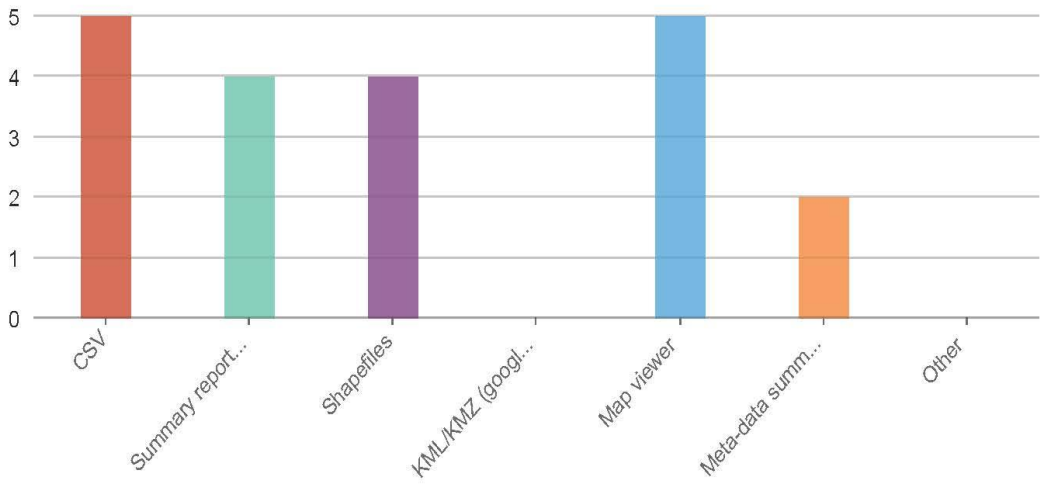
Answers	Count	Percentage
CSV	5	100%
Shapefiles	4	80%
KML/KMZ (google earth)	0	0%
Other	0	0%

Answered: 5 Skipped: 0

If 'Other', please provide additional details

There are no answers to this question yet.

What specific outputs or reports would be most valuable to you?



Answers	Count	Percentage
CSV	5	100%
Summary reports (PDF)	4	80%
Shapefiles	4	80%
KML/KMZ (google earth)	0	0%
Map viewer	5	100%
Meta-data summaries	2	40%
Other	0	0%

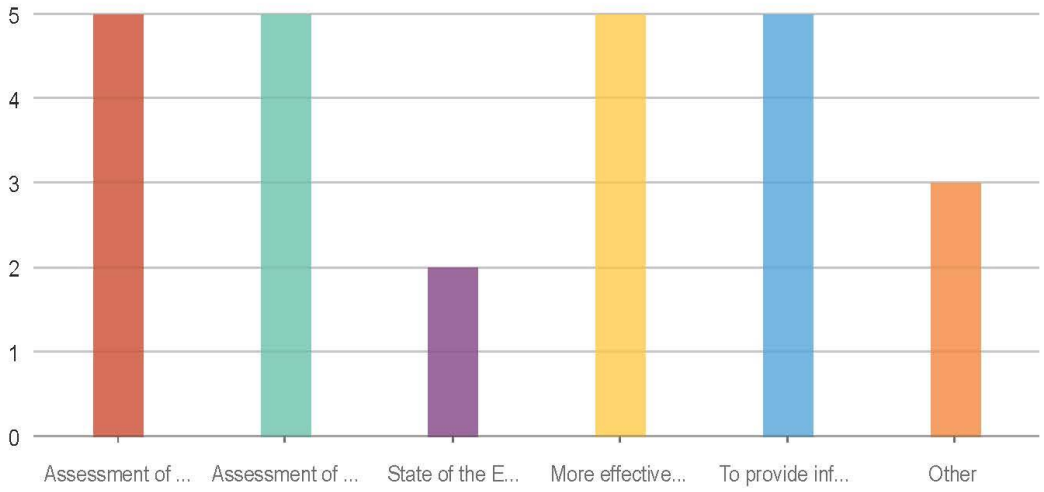
Answered: 5 Skipped: 0

If 'Other', please provide additional details

There are no answers to this question yet.

3. Objectives of the tool

How could the tool assist in meeting your requirements?



Answers	Count	Percentage
Assessment of presence/absence/distributions of threatened (nationally critical, endangered and vulnerable), at-risk (declining, recovering, relict and naturally uncommon), data deficient indigenous marine taxa (NZTCS) within a spatially defined area (to fulfil NZCPS 2010 requirements)	5	100%
Assessment of presence/absence/distributions of IUCN red-list indigenous marine taxa within a spatially defined area (to fulfil NZCPS 2010 requirements)	5	100%
State of the Environment (SOE) monitoring design	2	40%
More effective, targeted monitoring and management of marine habitats and resources, to protect indigenous biological diversity in the coastal environment, as per the NZCPS (2010) requirements	5	100%
To provide information to support the development and review of resource consent applications and associated assessment of environmental effects (AEE)	5	100%
Other	3	60%

Answered: 5 Skipped: 0

- **If 'Other', please provide additional details**

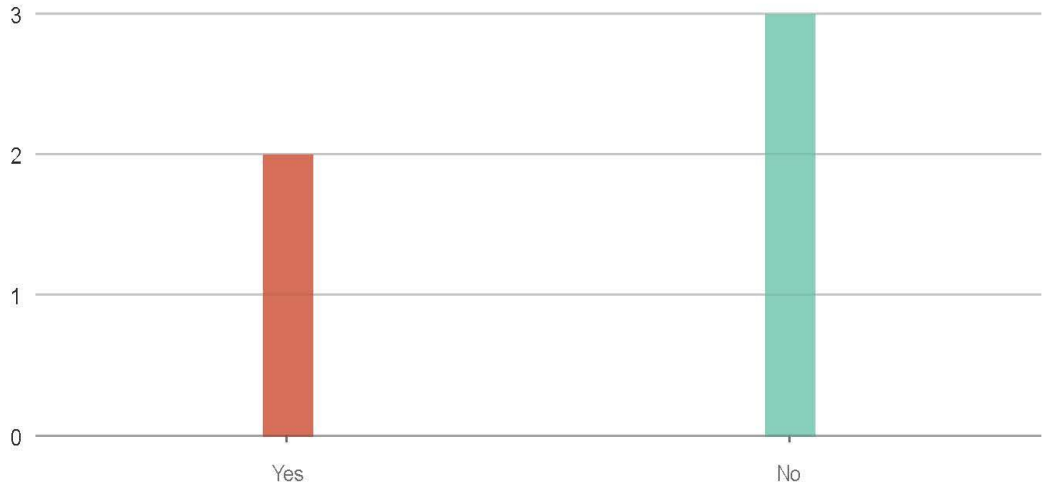
The word cloud requires at least 20 answers to show.

Response	Count
If provided for public use, then indefinitely. I would not need the tool to hold NCC records for future NCC retrieval.	1
I would hope in perpetuaity, although there needs to be a mechanism to disaggregate data by time of observation	1

Answered: 2 Skipped: 3

4. Data Storage and Retrieval

Would you expect the tool to be able to store and retrieve your inputted taxonomi…



Answers	Count	Percentage
Yes	2	40%
No	3	60%

Answered: 5 Skipped: 0

4. Data Storage and Retrieval > Data storage requirements

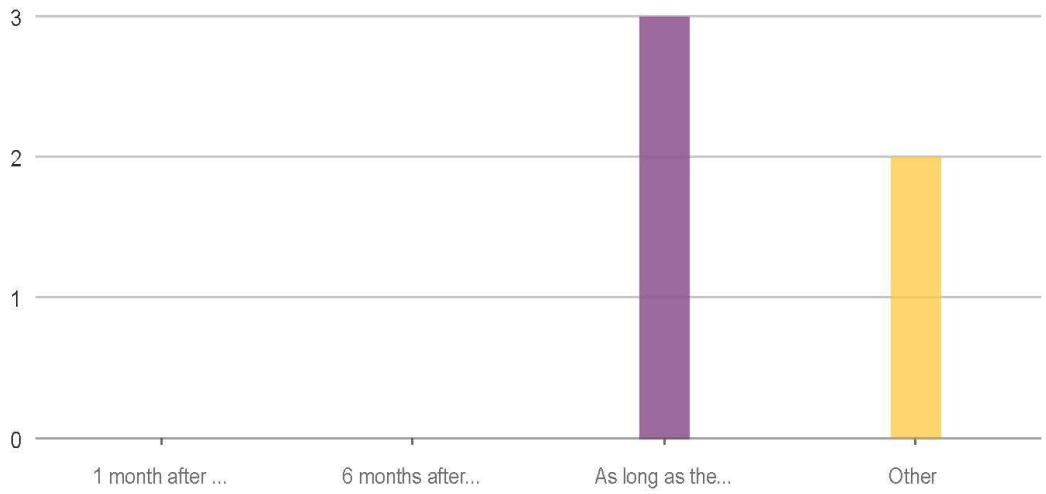
If you do need the tool to support data storage and retrieval, what are your specif…

The word cloud requires at least 20 answers to show.

Response	Count
We don't know sorry	1

Answered: 1 Skipped: 4

For how long do you expect the data to be stored for?



Answers	Count	Percentage
1 month after input	0	0%
6 months after input	0	0%
As long as the organisation has an active account with the t ool	3	60%
Other	2	40%

Answered: 5 Skipped: 0

If 'Other', please provide additional details

There are no answers to this question yet.

5. Budget Considerations

What would be a reasonable annual cost for this data service, considering its…

Answers	Count	Percentage
$15,000 (divided between user councils/GOs)	3	60%
$20,000 (divided between user councils/GOs)	0	0%
$30,000 (divided between user councils/GOs)	0	0%
Other	2	40%

Answered: 5 Skipped: 0

If 'Other', please provide additional details

The word cloud requires at least 20 answers to show.

Response	Count
unsure	1
Preferecne would be for the Regional Sector Holdings Limited to cover the costs of ongoing suppo rt and development. But if not, minimal costs as we have limited budgets at present.	1
Haven't had the time to consider	1

Answered: 3 Skipped: 2

What is a reasonable number of user councils to cover this cost?

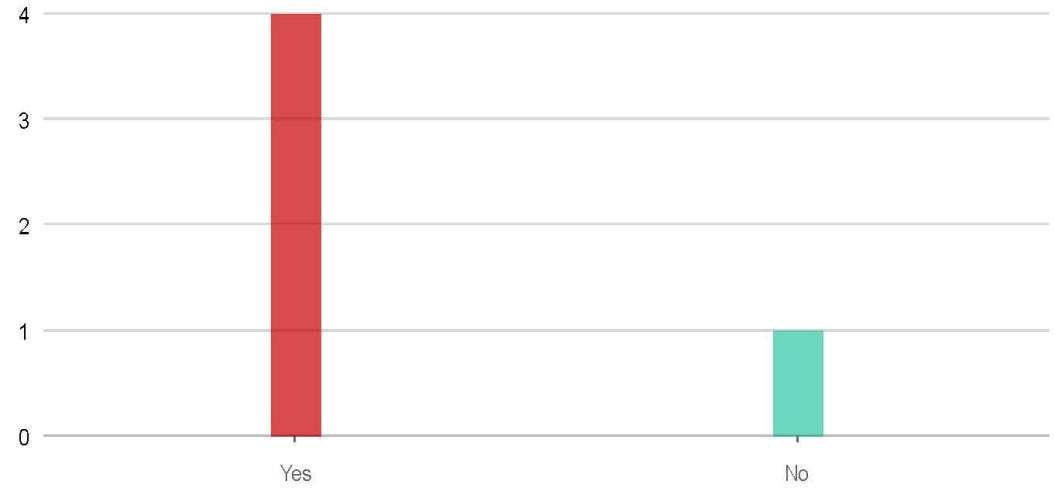
The word cloud requires at least 20 answers to show.

Response	Count
unsure	1
If all use it, then the cost is pretty small.	1
I would presume most, if not all, as well as other agencies with statutory obligations in the CMA, e.g. Fisheries & DOC	1
5+	1
10	1

Answered: 5 Skipped: 0

6. User Experience and Training

- **Do your staff typically undertake workshops/training for new software or tool use?**

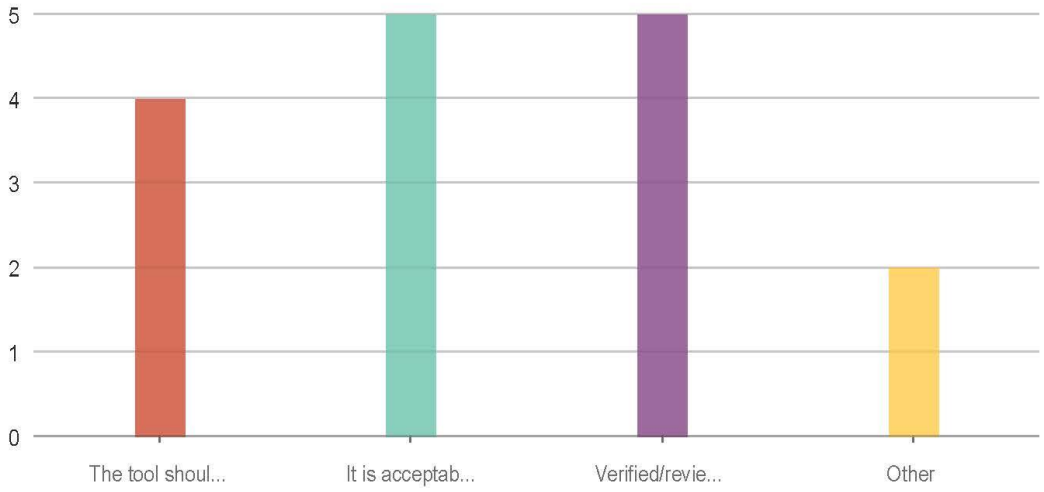


Answers	Count	Percentage
Yes	4	80%
No	1	20%

Answered: 5 Skipped: 0

7. Data Accuracy

- **What are your expectations regarding the accuracy and reliability of the data…**



Answers	Count	Percentage
The tool should include public (citizen science) observation data	4	80%
It is acceptable to include historical species data that is over 20 years old	5	100%
Verified/reviewed data (more robust) should be identifiable/filterable	5	100%
Other	2	40%

Answered: 5 Skipped: 0

If 'Other', please provide additional details

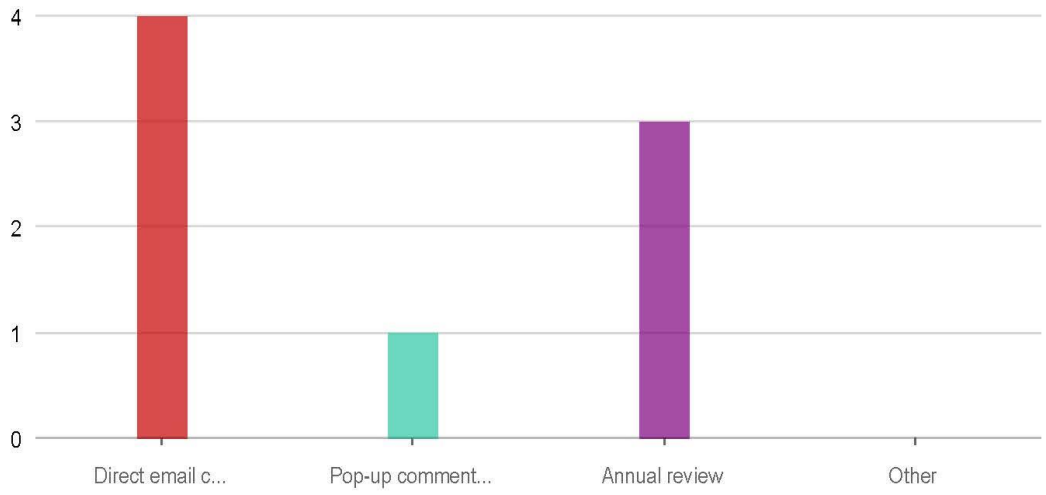
The word cloud requires at least 20 answers to show.

Response	Count
data should be tagged to identify the three options above, it should also ideally be tagged with a measure of certainty	1
Citizen science could be ok to include if verified	1
As long as it's clear around where the observation came from, then happy to include public and historic data (both have their uses)	1

Answered: 3 Skipped: 2

8. Feedback Mechanism

How would you prefer to provide ongoing feedback about the tool's performance...



Answers	Count	Percentage
Direct email contact	4	80%
Pop-up comments box on application	1	20%
Annual review	3	60%
Other	0	0%

Answered: 5 Skipped: 0

- **If 'Other', please provide additional details**

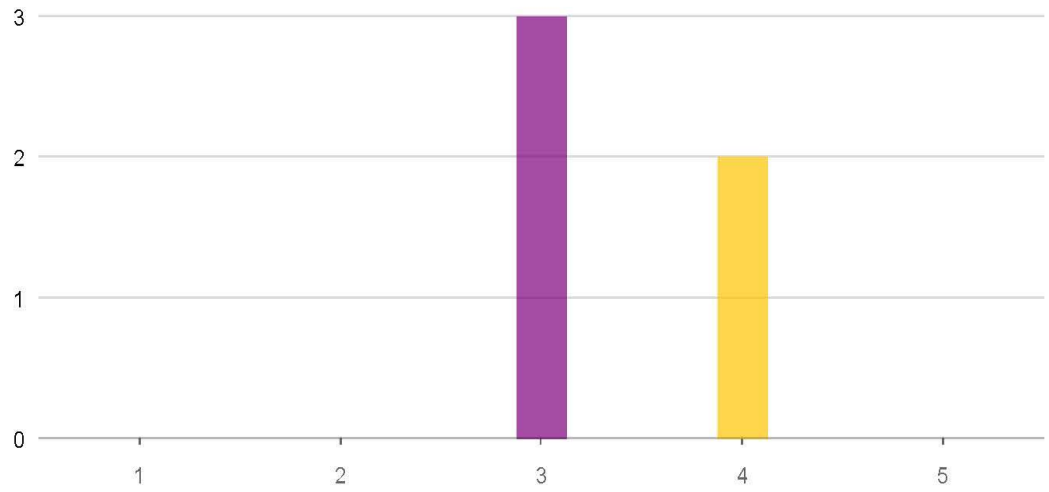
There are no answers to this question yet.

9. Effective Mechanisms for Tool Integration by Councils

- **What are the best mechanisms for tool uptake by councils? Please rank each option from 1 (bes…**

There are no answers to this question yet.

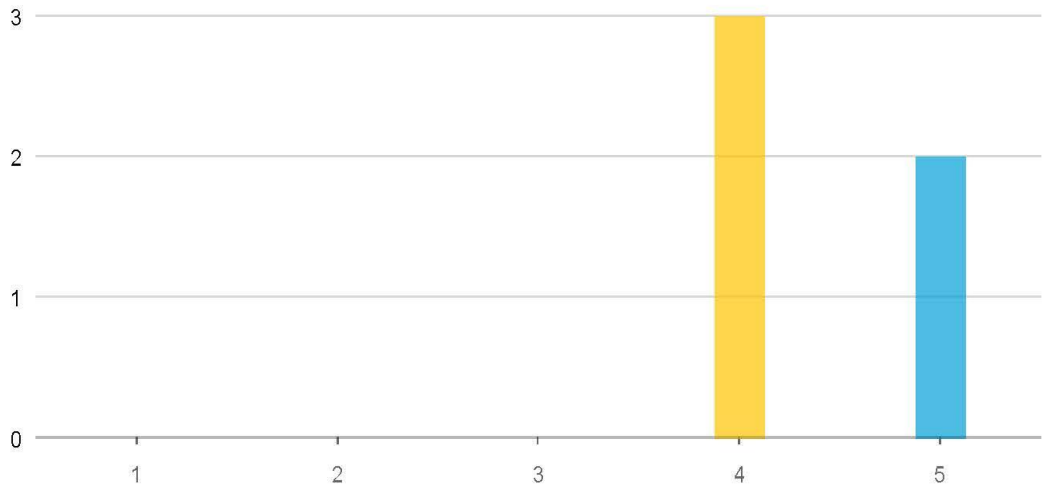
- **Word of mouth (emails/meetings)**



Answers	Count	Percentage
1	0	0%
2	0	0%
3	3	60%
4	2	40%
5	0	0%

Answered: 5 Skipped: 0

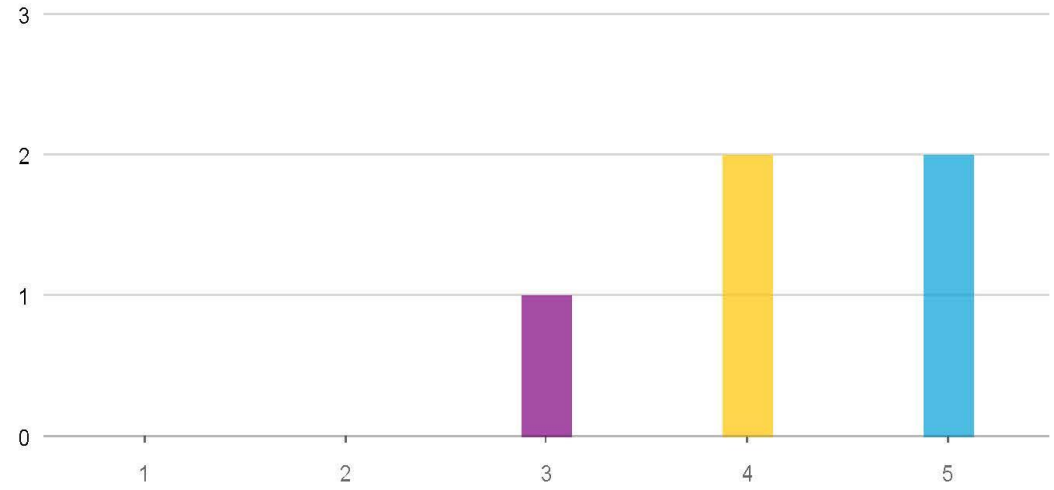
Special interest groups



Answers	Count	Percentage
1	0	0%
2	0	0%
3	0	0%
4	3	60%
5	2	40%

Answered: 5 Skipped: 0

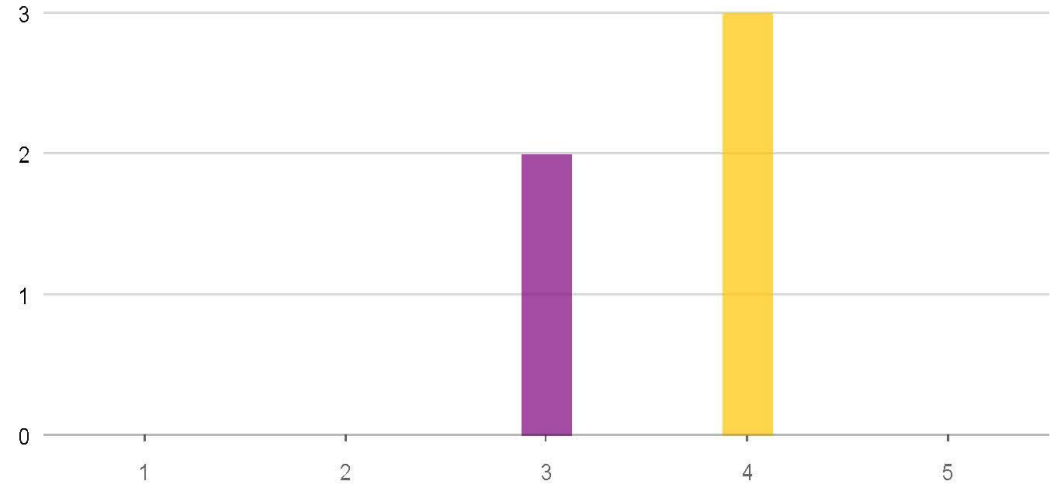
Workshops



Answers	Count	Percentage
1	0	0%
2	0	0%
3	1	20%
4	2	40%
5	2	40%

Answered: 5 Skipped: 0

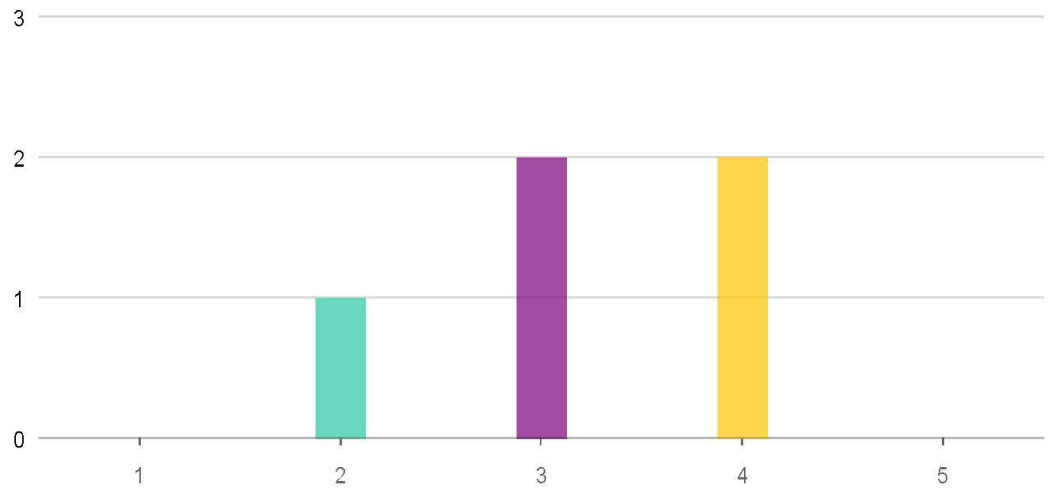
Microsoft Team establishment (for all users) and group chat functions



Answers	Count	Percentage
1	0	0%
2	0	0%
3	2	40%
4	3	60%
5	0	0%

Answered: 5 Skipped: 0

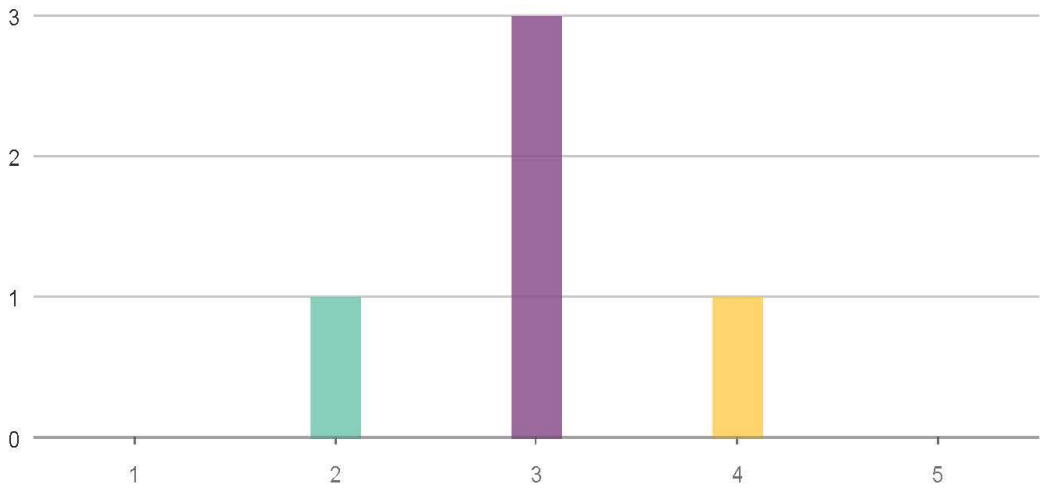
Top down: information provided from government to councils (DOC or…



Answers	Count	Percentage
1	0	0%
2	1	20%
3	2	40%
4	2	40%
5	0	0%

Answered: 5 Skipped: 0

Conference presentations



Answers	Count	Percentage
1	0	0%
2	1	20%
3	3	60%
4	1	20%
5	0	0%

Answered: 5 Skipped: 0

Thank you for your time and participation in this survey. Your feedback is greatly appreciated!

There are no answers to this question yet.

A1.2 Software design review. Hosting status checked via: https://hostingchecker.com/

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
CSIG Species Key	Taxonomic ID tool (Envirolink Tools Project)	• No map	• Easy to navigate • Free to use	Restricted access requiring registration, took 2–3 days to get access	When using images from this tool please credit the source	Solarix Networks Limited. IP address: 103.160.159.6. City: Auckland. Country: New Zealand	https://atlasmd.com/ For queries email specieskey@niwa.co.nz
EnviroSatTools	Satellite Data Workspace for Regional Councils (Envirolink Tools Project)	• Hosted internationally	• Shows full development process online using wiki space and Git software (Gitlab.com) • Links to Google Earth Engine (GEE) applications / tool outputs • Fast-loading maps	API: https://developers.google.com/earth-engine/guides/ui	https://earthengine.google.com/terms/	Git software (gitlab.com) is hosted by Cloudflare, Inc. IP address: 172.65.251.78 City: Toronto Country: Canada GEE is hosted by: Google LLC	Rogier Westerhoff, GNS Science. Gitlab.com

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
			• Can import and export data • Includes pilot studies • Web forum to share findings and ask technical questions			IP address: 142.250.80.78 City: Malvern Country: United States	
LAWA	Environmental data portal	• Can no longer download data?	• Integrated mapping, with ability to select and view sample information and regions • Free	Public access to all data without restriction	The copyright in this site and its contents is owned by the contributing regional councils and their licensors. (https://www.lawa.org.nz/terms)	Microsoft Corporation IP address: 20.211.64.0City: The Rocks Country: Australia	Regional Software Holdings Limited on behalf of the LAWA partners. For general enquiries go to the website or email info@lawa.org.nz

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
NZTCS	Threatened taxa lists for NZ	• No map	• Has up-to-date threat classification specific to NZ species • Can download data as CSV files and has links to reports • Free	Public access to all data without restriction	Unless indicated otherwise, all content on the NZTCS website is licensed for reuse under Creative Commons Attribution 4.0 International	Amazon.com, Inc. IP address: 3.25.12.131 City: Sydney Country: Australia	Department of Conservation For enquiries email threatstatus@doc.govt.nz
Stats NZ	Summary of NZTCS list	• No map • Data used are not updated regularly (must be done manually), last updated 2022 (data download in 2022) • The accuracy of the data source is defined as being of medium quality	• Adapts NZTCS 2022 data to develop 'extinction threat to indigenous marine species' indicators • Can download data as CSV files • Lists marine taonga species (and has link to supporting report), which could be included as a filterable threat class in the TMT tool • Free	Public access to all data without restriction	Unless otherwise specified, content we produce is licensed under the Creative Commons Attribution 4.0 International licence. Except for photos, graphics or logos, or anything with a specific copyright statement, you may copy, distribute and adapt the work, as long as you attribute it to Stats NZ and obey	Incapsula Inc. IP address: 45.60.11.134 City: New York Country: United States	https://www.govt.nz/ To ask permission to reuse a photo, graphic or logo, email info@stats.govt.nz

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
					the other licence terms. To ask permission to reuse a photo, graphic or logo, email info@stats.govt.nz		
Stats NZ	NZ STATLAS (ArcGIS web map platform)	• Cannot download data from web map; instead, have to go to Stats NZ 'datafinder' page (difficult to navigate / search)	• Has maps • Easy to select sampling sites and hover over information • Clear map and icons • Free	Public access to all data without restriction	All web maps, web applications and data on this web page are made available under CC BY 4.0	https://www.amazon.com/ Organisation name: AWS EC2 (us-east-1) IP address: 44.215.202.167 City: Ashburn Country: United States	Built with ArcGIS Hub Managed by Stats NZ

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
GMTDS	Vessel density mapping tool. Across-platform application (including AI)	• Finest time-series resolution is in months	• Fast-loading maps • Time-series data available • Easy to select variables / filters • Clear definitions of data types / meta data and map user guide • Easy to download data as CSV, geoTiff, GridFloat or NetCDF • Can download multiple months of data • Free	Public access to all data without restriction	Authorised downloads from GMTDS are subject to the terms of the Creative Commons Attribution 4.0 International Public License and shall be attributed to: Global Maritime Traffic, a service of MapLarge 2021: https://www.globalmaritimetraffic.org	Amazon.com, Inc. Organisation name: AWS CloudFront (GLOBAL) IP address: 2600:9000:247b:6e00:1a:db3e:a680:93a1 City: Seattle Country: United States	Produced by MapLarge. Feedback can be provided to GMTDS@maplarge.com
NIWA-SCENZ	Satellite water quality images. Shiny app and ArcGIS web map	• Shiny app is slow • Difficult to navigate	• Uses ArcGIS to display maps • Shiny-R Studio tools • Data can be extracted for an AOI (all products), saving it as a file (CSV) to your	• Public access to all data without restriction • Limits to commercial use	Creative Commons License (CC-BY-NC-SA) Creative Commons Attribution NonCommerical ShareAlike 4.0 International Public License. Free for	American Registry Internet Numbers Organisation name: American Registry Internet Numbers IP address: 104.22.54.253 City: Chantilly	Development and maintenance involved the following NIWA staff: Simon Wood (satellite processing, SeaDAS); Matt Pinkerton

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
			computer. The user can draw a polygon and use it to extract data within its extent ('eDraw' widget) or with 'Add Data' use one of those polygons to extract data. The file can then be uploaded into Shiny-SCENZ for analysis (summary statistics) • Clearly shows data processing workflow in a diagram • Free		non-commercial use. You must acknowledge the source of this information and, where possible, provide a link to this licence. For commercial use, users must contact NIWA	Country: United States	(algorithm development, netCDF file generation); Tilmann Steinmetz (Imagery Services, ArcGIS); Mark Gall (website design, Shiny-R Studio interactive graphical and analysis tools). Email niwascenz@niwa.co.nz for further information about commercial use

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
Regional Economic Activity Web Tool	Interactive data map	• Cannot select location using a polygon, only via region • Cannot download data	• Can select regions and look at data from those regions • Can select indicators that are listed below the interactive map and interactive data graph • Key statistics are summarised for each selection • Can compare areas • Free	Public access to all data without restriction	Crown copyright ©. Copyright material on the Regional Economic Activity interactive visualisation is protected by copyright owned by Ministry for Business, Innovation and Employment. Unless indicated otherwise, this copyright material is licensed for reuse under a Creative Commons Attribution 4.0 International Licence. Please note that this licence does not apply to any logos, design elements or photography	VODAFONE IP address: 116.89.228.153 City: Auckland Country: New Zealand	The Regional Economic Activity data visualisation is a collaboration between Dragonfly Data Science, Salted Herring and MBIE. A single source of data flows through to the report, the website and the apps, to ensure the integrity of the data across all the presentations. Charts and maps were drawn using the statistical software R, and the tool uses the EmberJS web framework

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
Protected species data map	Data display map and table, Shiny app	• Map points not interactive • Cannot select areas of interest	• Easy to navigate • Simple data download tab (for zip file of all data) • Can explore data tab with graphical displays and selection of data for download	Public access to all data without restriction. Limits to commercial use	Data are made available for reuse by the Ministry for Primary Industries, under a Creative Commons 3.0 New Zealand attribution licence, following the recommendations of NZGOAL. This licence allows the data to be used for any other purpose and be republished, provided that attribution is given to the source	Catalyst.Net Ltd Organisation name: Catalyst.Net Ltd IP address: 150.242.42.22 City: Wellington Country: New Zealand	Dragonfly Data Science (NZ company). Team included: MPI, FNZ, Dragonfly, Abacusbio

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
Antipodean albatross population model	Open-access modelling tool, Shiny app	• DOC link to simulation tool does not work (error), so could not use or view the Shiny app	• The accessibility of the app also supports transparency and agreement between stakeholders about which actions should be prioritised	NA	NA	Amazon.com Organisation name: AWS EC2 (us-east-1) IP address: 204.236.235.245 City: Ashburn Country: United States	Dragonfly Data Science (NZ company) and DOC

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
Reporting of accidental catch of protected species in recreational fisheries	Open-access fisheries bycatch tool, Shiny app. and ArcGIS map (interactive map)	• No form to add data; must be added via DOC • Some of the graph text is cut off (not visible) • Slow to load • Cannot download data	• Simple tool • Can click on map records and see metadata • Summary graph included • Searchable / filterable data (species, region, fishing methods, data quality and date range)	Public access. Cannot find data use terms on tool	Cannot find data use terms on tool	Amazon.com Organisation name: AWS EC2 (us-east-1) IP address: 204.236.235.245 City: Ashburn Country: United States	Managed by Dragonfly Data Science (NZ company) and DOC Leaflet | Powered by ESRI | © OpenStreetMap, ODbL, USGS, NOAA Leaflet: https://leafletjs.com (an open-source JavaScript library for mobile-friendly interactive maps) Email queries to csp@doc.govt.nz

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
Cyclone Gabrielle impact map. Social Wellbeing Agency, NZ.	QGIS web map, with Google Earth Engine for analysis Cloud Optimised GeoTIFF	• Cannot download data	• Simple tool • Interactive graphics	Public access. Cannot find any data use terms on tool	Cannot find any data use terms on tool	Amazon.com, Inc. Organisation name: AWS CloudFront (GLOBAL) IP address: 13.249.91.23 City: Ashburn Country: United States	Created by Dragonfly Data Science (NZ company) Commissioned by Social Wellbeing Agency The cyclone impact visualisation was generated from Sentinel-2 data by comparing the most recent pre-disaster imagery and the oldest available post-disaster imagery across the North Island. Email feedback and suggestions to: info@swa.govt.nz

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
National Aquatic Biodiversity System (NABIS), Ministry for Primary Industries (MPI)	Web map that displays selected data, which is linked to further ArcGIS web maps	• Complicated navigation • Difficult to work out how to download the data (Layer list>attributes table>filter by map extent> options>DL CSV) • For various reasons, some attribute tables are not made available in the map and need to be requested via nabis@mpi.govt.nz • No time-based data filters • There is a known download issue in the open data portal, and a link to a work-around is provided on the MPI geospatial data portal	• Can add your own data (CSV/Shapefile or GPX) into the NABIS map • Has a user guide • Can filter data: Search available data on 'all species', 'invertebrates', 'fish', 'birds', 'mammals' and 'plants' • Can limit search to map extent	Public access to all data without restriction. Limits to commercial use	Obtained from the MPI spatial data webpage link – nothing listed on the NABIS map link. Except where otherwise stated, all material on this website is subject to Crown copyright, and that material is licensed for use under the Creative Commons Attribution 4.0 New Zealand licence	Webpage map: Redshield Security Limited IP address: 185.71.230.98 City: Auckland Country: New Zealand Data download location: Amazon.com Organisation name: AWS EC2 (us-east-1) IP address: 23.23.51.121 AS name: AMAZON-AES City: Ashburn Country: United States	NIWA, Geosciences Australia, ESRI, GEBCO, Garmin, NaturalVue. NABIS is an interactive web-based mapping tool. Users can map and display information about NZ's marine environment, species distributions and fisheries management. The data can be downloaded from the MPI open data site. For feedback / questions about the site, email nabis@mpi.govt.nz

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
Ocean Biodiversity Information System (OBIS)	Online atlas. Mapper browser embedded in website with data links	• Cannot scroll through all datasets • Dataset selections default as heat map of records rather than points. Have to navigate to layers and toggle field codes to points	• Can search for key words to identify datasets • Can filter by a number of parameters, including time range and depth range • Can style the map • Can select geometry / AOI • Simple to download data (CSV files) • Metadata for data exports are available to view but not downloadable • The robis R package has been developed to facilitate connecting to the OBIS API from R. The package can be installed from	Public access to all data with minimal restriction	Data use policy: https://iode.org/resources/ioc-data-policy-and-terms-of-use-2023	DigitalOcean, LLC IP address: 146.185.135.41 City: Amsterdam Country: The Netherlands	Contact form available from the mapper For T&Cs and guidance around APIs: https://manual.obis.org/access.html#mapper

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
			CRAN or from GitHub (latest development version) • Includes conservation status (IUCN Red list) • Free				

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
iNaturalist	Observation records displayed on web map	• Some of the verified map records in the marine areas seem to be inaccurate locations	• Can upload observations • Can download records • Includes conservation status (IUCN Red list) • Free	Public access to all data with minimal restriction	Data use policy (T&Cs): https://www.inaturalist.org/pages/terms	Microsoft Corporation Organisation name: Microsoft Azure Cloud (westus2) IP address: 51.143.92.118 City: Quincy Country: United States	Member of the iNaturalist Network. Powered by iNaturalist open-source software. Developer information: https://www.inaturalist.org/pages/developers API: https://www.inaturalist.org/pages/api+reference

Name	Type	Limitations	Positives	Access	Data use terms	Host	Managed by
Cawthron tools, including: **c-state** **BeNeZe** **CawthronEye: Daily Satellite Images** **Home - ExPAT** **doc-j4n**	Centralised location for all Cawthron's online tools	• Currently being updated • Currently hosted internationally, but Microsoft is planning to provide NZ-based hosting in 2024	• Centralised location for all tools • Each tool can be developed and managed separately but linked to a central location • Digestible marine science data	Public access with minimal restriction	Each tool has different data-sharing terms	Varies depending on tool; majority through Microsoft Azure services (Microsoft 2024). Host manager is Cawthron	Cawthron (2024)

A1.3 Potential data providers. Includes both threat classification providers (red highlight) and taxa record providers (not highlighted)

Database	Data sources	Data input	Data output	Data access	Data export options	Permission?	Contact details	Terms of use
NZTCS (2024) (Threat classification lists)	Databases, scientific publications, public information, expert knowledge	Search by species name (scientific or common name), risk category, environment, taxonomic status, species type, or reports	Basic species information with threat status (no abundance or spatial data)	NZCTS home page, MfE (full list)	Excel spreadsheet	Yes	threatstatus@doc.govt.nz	The data are primarily intended for non-commercial use. Any commercial use requires explicit permission from DOC. Users can redistribute the data, provided the same terms of use are applied and proper attribution to NZTCS is maintained
WoRMS (2024) (Species name check / synonyms)	Databases, scientific publications, public information, expert knowledge	Search by species name (scientific or common name), import of species list (CSV)	Basic species information (no spatial data)	Home page, API		No response	Home page: https://www.marinespecies.org/usersrequest.php	Redistribution of the entire database is not permitted, unless by prior written agreement. This is mainly to avoid circulation of (quickly) outdated copies of WoRMS, accessible through different pathways, which can lead to confusion for the many users. Users are requested to provide detailed information relating to the planned usage of the data. Partial or incomplete

Database	Data sources	Data input	Data output	Data access	Data export options	Permission?	Contact details	Terms of use
								applications will not be considered. Data downloads include taxonomic data only and are provided in Darwin Core (CSV) format
IUCN (2024) Red List (Threat classification lists)	Databases, scientific publications, public information, expert knowledge	Search by species name (scientific or common name), risk category, environment, taxonomic status, species type, land regions, biogeographic realm If with R: csv. Species table import possible	Presence / absence data, spatial data of species occurrences With R: upload of Red List categories for the species list. Mapping of species distributions based on location data for species of interest	Home page, R membership	Home page: export of species lists on home page possible; however, membership necessary R: export of species list and additional information such as threat status and location data possible; however, API key necessary	No response	Red List Unit Biodiversity Assessment and Knowledge Team Centre for Science and Knowledge IUCN David Attenborough Building, Pembroke Street, Cambridge CB2 3QZ, United Kingdom Tel: +44 (0)1223 331178 Email: redlist@iucn.org	Users must attribute the source of the data to the IUCN Red List of Threatened Species. Proper citation formats are provided by the IUCN for different types of use (e.g. scientific publications, general reports, websites) The data from the IUCN Red List is intended primarily for non-commercial use. Any commercial use requires explicit permission from the IUCN. Anyone wishing to use the information obtained from the IUCN Red List for commercial purposes must contact IUCN directly. Anyone wishing to provide a service through which IUCN Red List Data are otherwise made available for reposting or otherwise made

Database	Data sources	Data input	Data output	Data access	Data export options	Permission?	Contact details	Terms of use
								available for redistribution should contact IUCN directly
Vulnerable Marine Ecosystem indicators (VME) (NIWA-VME 2016) (Vulnerable class lists)	OBIS, NIWA, CSIRO, MPI, AFMA	Only list download by area possible	Presence / absence location data	Account necessary	CSV. File, KML, shapefile, DwC-A file	No response	Kevin Mackay Metadata Provider Originator, Marine Data Manager, NIWA, Private Bag 14-901, 6241 Wellington, New Zealand http://www.niwa.co.nz Ashley Rowden Point of Contact, Principal Scientist – Marine Ecology NIWA, Private Bag 14-901 6241 Wellington, New Zealand http://www.niwa.co.nz	

Database	Data sources	Data input	Data output	Data access	Data export options	Permission?	Contact details	Terms of use
OBIS (2024) (Taxa list)	MPI, NIWA, WoRMS, reports	Search species name, common name, area, datasets, nodes, institutes, provider country If with R: csv. species table import possible	Abundances and distribution maps (location data). With R: will give information on species distributions (location data). Maps of species distributions for species of interest possible	Home page, R, API. Email submission API link: https://api.obis.org	CSV. File per species. With R: export of whole species list	Yes	Contact the secretariat at helpdesk@obis.org	Open access, citation of OBIS and original data contributors necessary. Review any specific terms associated with individual dataset if for commercial use. Users can redistribute OBIS data, but they must include the same terms of use and ensure proper attribution to the original sources
NABIS **(MPI-NABIS 2024)** (Taxa list)	MPI – open geospatial data portal	Search by species name > data by report	Geospatial data. Presence / absence location data	ArcGIS links (REST): /MARINE	CSV. File per species	Yes	GISHub@mpi.govt.nz	

Database	Data sources	Data input	Data output	Data access	Data export options	Permission?	Contact details	Terms of use
iNaturalist (2024) (Taxa list)	IUCN Red List	Only species name		API link: https://www.inaturalist.org/pages/api+reference		No response	help@inaturalist.org	
GBIF (2024)				API link: https://techdocs.gbif.org/en/openapi/				

Database	Data sources	Data input	Data output	Data access	Data export options	Permission?	Contact details	Terms of use
eBird (2023) (Taxa list)		Search by species name	Species distribution data, species hotspots			No response	Email: cornellbirds@cornell.edu	Users are not permitted to reproduce, distribute, modify, repost on another site (regardless of the server on which the content is stored), or sell any content without specific written authorisation from Cornell Lab of Ornithology, unless such use is pursuant to educational use

6. Acknowledgements

We would like to acknowledge the driving support and championing of Harry Allard from Nelson City Council, Ash Rabel from Environment Southland and Kate Schimanski from Canterbury Regional Council, and the interest and input from the wider Coastal Special Interest Group (CSIG).

We would also like to thank MBIE for funding this project through the Envirolink grant platform, and the tool committee for providing us with feedback on potential tool platform options.

This project has in-kind support from the Department of Conservation (DOC), with helpful advice and support from Enrique Pardo.

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