Marine Biodiversity Hub

National Environmental Science Programme

Enhancement, connectivity and interoperability of spatial portals

Linking of science communication products to spatial metadata records within GlobalArchive

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Project D2: Standard Operating Procedures (SOP) for survey design, condition assessment and trend detection

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Important Disclaimer

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EXECUTIVE SUMMARY

Enhancement, connectivity and interoperability of data between map-based portals was recognised as a key challenge in the Marine Biodiversity Hub workshop on Map-Based Portals for Marine Science Communication and Discovery (Langlois et al. 2020). That workshop also highlighted how map-based portals are increasingly being recognised for their utility in marine science communication, and have the potential to provide an immersive biodiversity discovery and exploration experience. However, the workshop also highlighted that to operate and maintain such services requires the adoption of data standards between portals.

This report outlines the results of consultations with metadata and data experts on a pathway for map-based portals to adopt Open Geospatial Consortium (OGC) and ISO compliant standards to enable the discovery of raw data, summarise and curated data products. As a case study, a pathway to implement these standards on the GlobalArchive.org platform are presented.

This report then presents two case studies of how to enhance map-based portals with immersive data exploration. These case studies are presented in a development testing environment and are designed to be integrated into existing map-based portals such as GlobalArchive.org, an archive of fish and shark video survey metadata and annotation designed to improve the quality and accessibility of these annotations and their summaries.

The first case-study, 'FishNClips' Version 1 and Developmental version, presents the spatial discovery of marine imagery for science communication through an easily navigable spatial interface. The second case study, 'Visualiser' Version 1 and Developmental version, presents a data exploration tool to visualise summarised fish annotation data.

This report provides a pathway for the future enhancement, connectivity and interoperability of map-based portals to meet standards to enable the discovery of raw data, summarise and curated science communication data products such as interactive imagery and data visualizations.

1. INTRODUCTION

1.1 Background

There has never been a more important time for marine researchers to communicate their findings and make their data discoverable in a useful and understandable form for both data synthesis and science uptake.

Map-based portals are being increasingly recognised for their utility in marine science communication and data discovery. Previous Marine Biodiversity Hub workshops on Marine Imagery Discoverability & Accessibility (Przeslawski et al. 2019) and Map-Based Portals for Marine Science Communication and Discovery (Langlois et al. 2020) highlighted the value of raw and curated marine imagery for science communication.

The workshops recognised that the enhancement and connectivity of Findable Accessible Interoperable and Re-usable (FAIR) data (Wilkinson et al. 2016) between map-based portals was a key challenge, and that in part, this should be addressed by establishing pathways for map-based portals to adopt compatible Open Geospatial Consortium (OGC) and ISO compliant data standards to enable the discovery of raw data, summarised and curated data products.

The above workshops also recognised map-based portals have great potential to be enhanced to provide an immersive science discovery experience. Recommendation from Przeslawski et al. (2019) and (Langlois et al. 2020) are given in Appendix 1, and the specific recommendations relevant to this report include:

- Specify a metadata/data format for organisations to submit information about marine imagery, including image URL, location and annotation method that can be aggregated by AODN for discoverability and visualisation without having to store the imagery.
- Develop design protocols for spatial portals to enable immersive data exploration accessible to a wide variety of users.

1.2 Objectives

The objectives of this report were to:

1. Consult with experts to provide a pathway for map-based portals to adopt compatible Open Geospatial Consortium (OGC) and ISO compliant data standards.
2. Demonstrate how map-based portals can be enhanced to provide immersive science discovery experience using both:
    a. Interactive imagery (+open-source software-code)
    b. Data visualisation (+open-source software-code)

3. Identify how these development activities can be achieved for map-based portals using a case study of GlobalArchive, a web portal of fish and shark video survey metadata and annotation designed to improve the quality and accessibility of these annotations and their summaries.

2. OGC PATHWAY

The previous Map-Based Portals workshop (Langlois et al. 2020) recommended that map-based portals should adopt Open Geospatial Consortium (OGC) compliant standards to enable the discovery of raw data, data summaries and curated data products and to meet FAIR data standards (Wilkinson et al. 2016).

Using the GlobalArchive map-based portal as a case study of a community developed portal that is not OGC compliant, we consulted with experts on a pathway to adopt OGC compliant standards (Table 1). These experts included Peter Walsh (UTas), Melanie Barlow (ARDC) and Nichola Burton (ARDC).

Table 1 Pathway for GlobalArchive to become Open Geospatial Consortium (OGC) compliant

Recommendation	Proposed action	Implication	Completed in GlobalArchive.org
Use established vocabulary standardisation and validation	use World Register of Marine Species: WoRMS	aligns with workflows for the emerging field of automated image annotation	98% - there are minor inconsistencies between existing Australian standards
Implement Spatial Data Infrastructure to make data discoverable	adopt Geonetwork/Geoserver	enable data to be discoverable by existing services e.g. AODN, NationalMap, magda	0%
Use persistent identifiers	adopt DOI	to meet FAIR principles	0%
Use metadata standards	Establish cross-walk from community standards to ISO-19115-3	enable data to be interoperable existing services e.g. AODN, Seamap Australia	50% - cross-walk has been completed but need to be implemented in data capture
Use web feature services (WFS)	adopt WFS	enable open annotation data to be shared with existing annotation services e.g. FishID and summary data to be shared with existing data services e.g. AODN, ALA; will also allow linking from these services back to GlobalArchive	0%
Use web map services (WMS)	adopt WMS	enable map layers to be shared with existing services e.g. AODN, Seamap Australia; will also allow linking of these services back to GobalArchive	0%

The pathway to adopt OGC compliant standards includes:

- adopting existing services (Geonetwork/Geoserver) and metadata standards (ISO19115-3) to enable syndication of metadata, imagery, annotation data and summaries with other platforms;
- adopting established vocabulary standardisation and validation to align with workflows for the emerging field of automated image annotation;
- adopting persistent identifiers (DOI's) and metadata standards (ISO19115-3) for imagery, annotation data and data synthesis summaries (Table 2).

These changes represent a complete re-development of the GlobalArchive platform and so are beyond the scope of the current project, but this pathway provides a clear development agenda for GlobalArchive and other non-compliant portals for the future. It is useful to note that these recommendations are consistent with the National Environmental Information Infrastructure Reference Architecture (Bureau of Meteorology, 2015), which recommends OGC, ISO, Geonetwork and Geoserver to enhance the discovery, access and use of environmental information.

Importantly, the experts consulted identified that GlobalArchive held different forms of data that were needed to be shared with different services. For example, metadata containing positional and methodological information might want to be shared with spatial discovery services such as Seamap Australia; whereas fish image annotation data would want to be shared with image annotation services such as FishID; whereas summaries of annotation data would want to be shared with data services such the AODN or ALA (Table 1).

3. ENHANCEMENT OF SPATIAL PORTALS WITH IMMERSIVE DATA EXPLORATION

The FishNClips add-on of GlobalArchive was developed to demonstrate the functionality to create live science communication products where marine imagery can be displayed spatially to provide an immersive biodiversity discovery and exploration experience. The Visualiser add-on to GlobalArchive is designed to enable interactive plotting of summarised annotation data. Both FishNClips and Visualiser are built using the Shiny: Web Application Framework for R (Chang et al. 2019) that can be easily scaled up using available NCRIS infrastructure in the Nectar Cloud. Both add-ons are currently hosted on small resource "Tiny (t3)" virtual machines on the Nectar Cloud which contributes to their delayed responsiveness. For scaling up and wide use of these add-ons, we recommend large "RAM Optimised (r3)" should be used.

3.1 Interactive imagery 'FishNClips'

FishNClips currently exists as a Nectar Cloud hosted and development version. FishNClips uses imagery collected within Geographe Marine Park, the South-west Corner Marine Park and Ningaloo Marine Park (Commonwealth) from existing baited remote underwater stereo-

video (stereo-BRUV), Autonomous Underwater Vehicle (AUV) and towed-video surveys, that were conducted according to Hub best practice field manuals.

3.1.1 Landing page

The FishNClips landing page provides an easily navigable spatial interface, where the user can select the marine park to be viewed, and a check-box to select the types of imagery to be displayed (fish highlight clips, habitat imagery or towed video 3-D models, Fig. 1). Clips are indicated by coloured markers on the map and nearby clips are clustered together as indicated by the numerals on the markers.

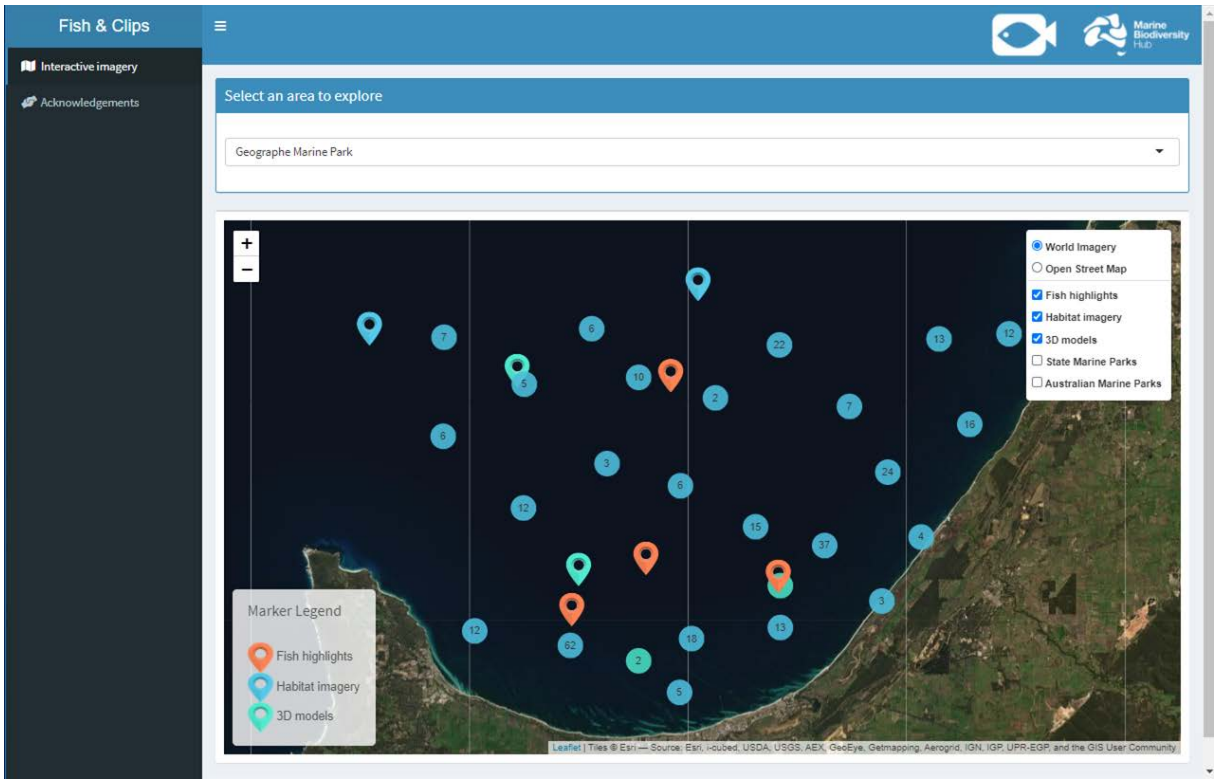


Figure 1 FishNClips landing page

3.1.2 Using FishNClips

Marine park zoning maps for both Commonwealth and adjacent State networks can be displayed by selecting the checkbox (Fig. 2) to discern which zone the imagery occurs in.

Fish highlight clips are located in the centre of each Commonwealth marine park zone (Fig. 3). These curated video clips are created using the '*MBH Guide for Producing Science Communication Videos of Video Surveys of Fish and Benthic Assemblages*'. The position of these clips is not spatially correct to avoid FishNClips becoming a tool for locating fishing spots. These clips are played by clicking on the orange markers on the map.

Habitat clips, from stereo-BRUVs, are displayed spatially providing an immersive science discovery resource (Fig. 4). A new habitat clip plays when a blue marker on the map is clicked. Where available, 3-D models from stereo-image reconstructions from AUV and towed video systems can be displayed (Fig. 5). Currently these 3-D models are only displayed for the Geographe Marine Park case-study.

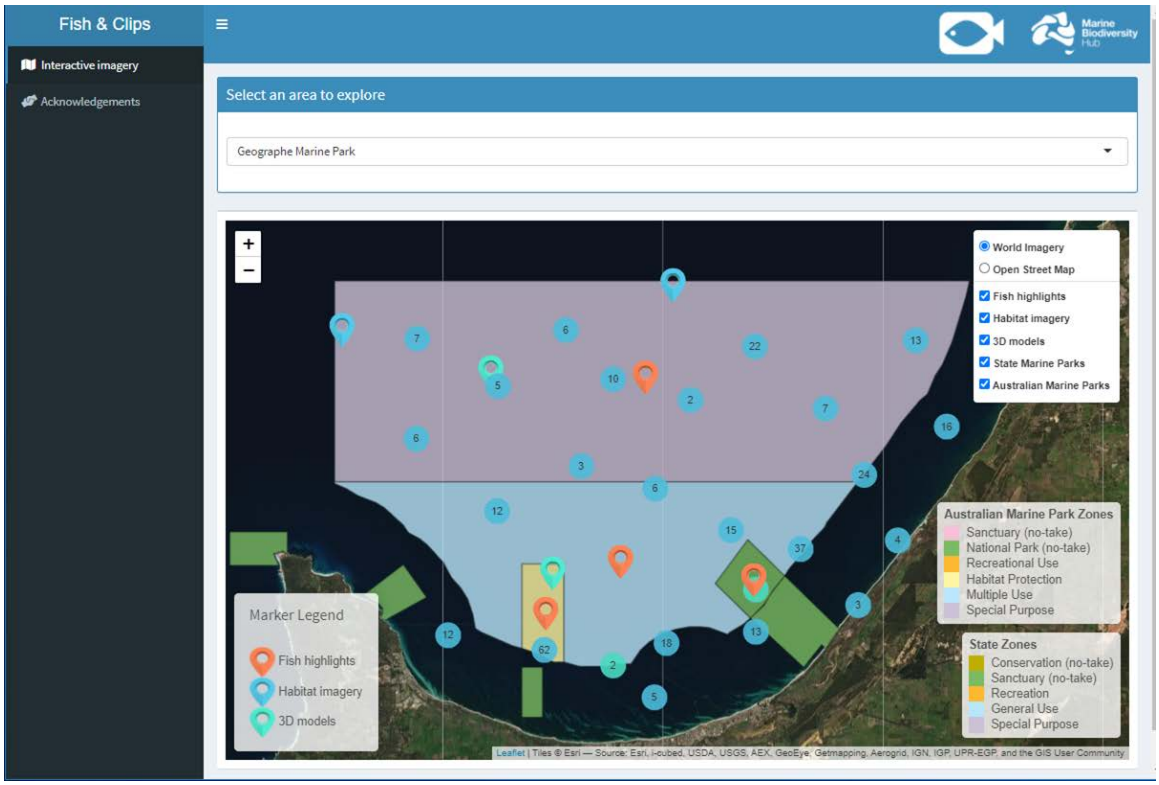


Figure 2 Commonwealth and State marine park zoning

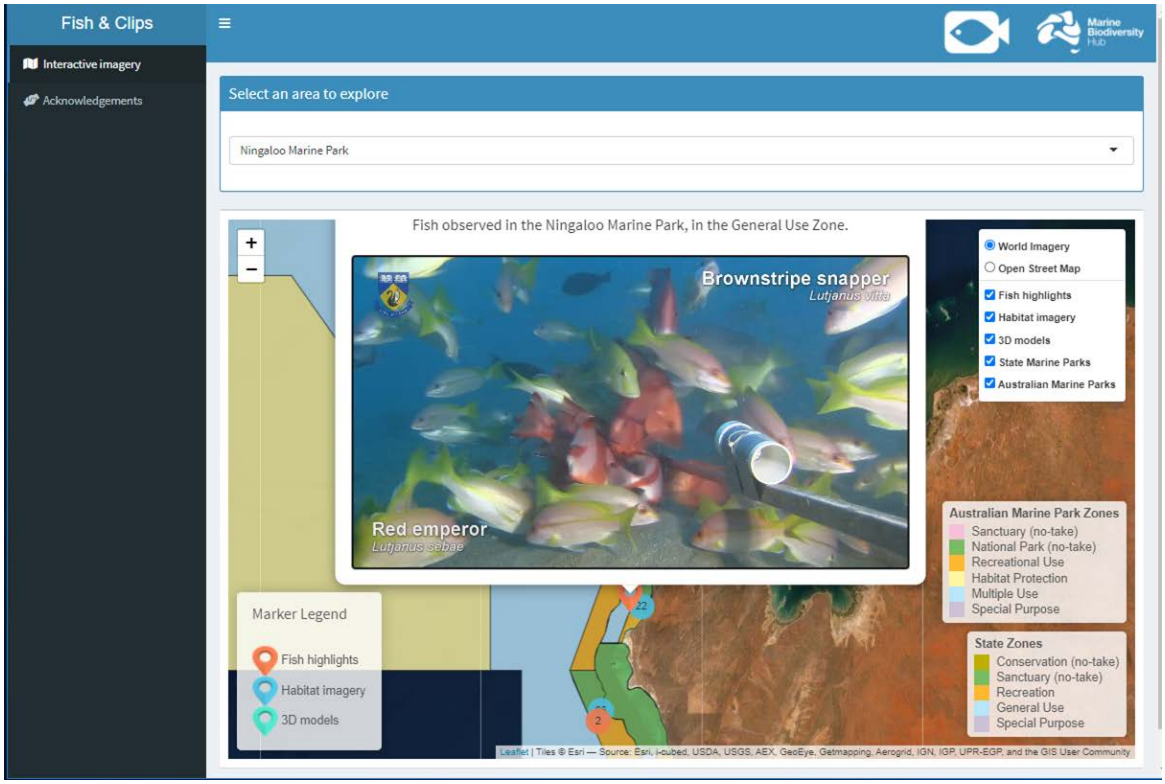


Figure 3 Fish highlights.

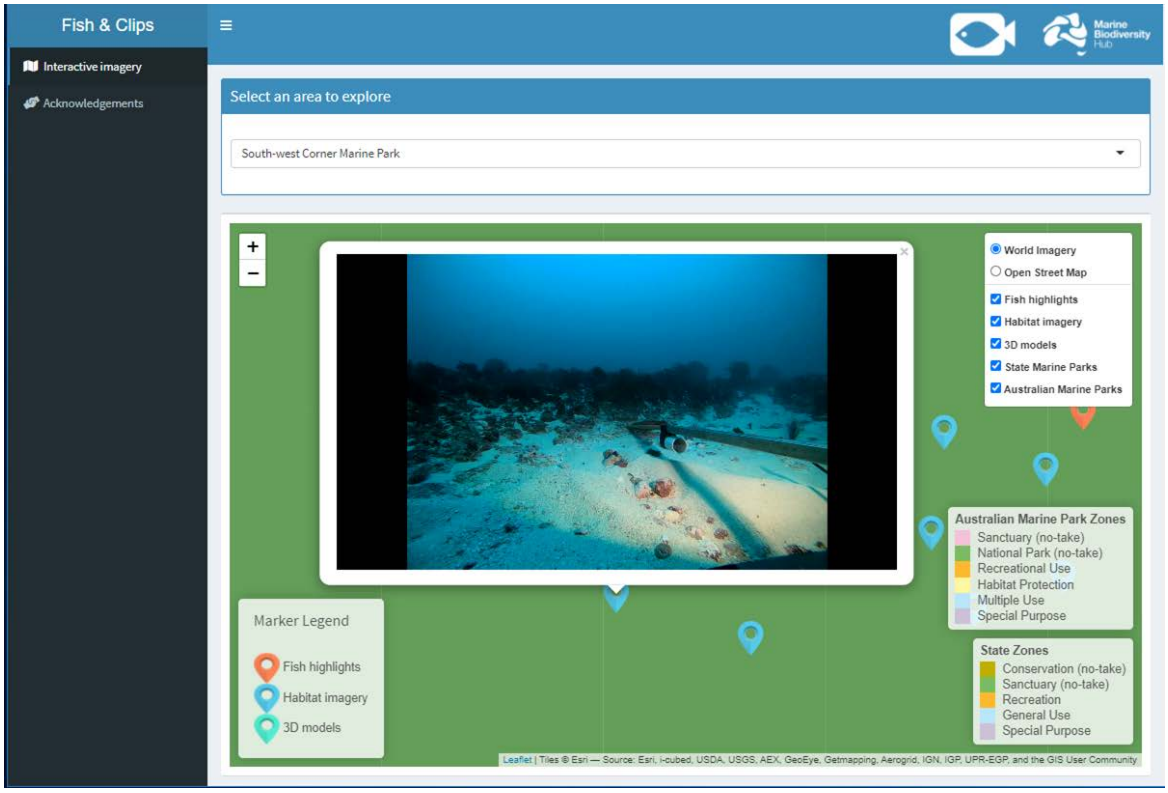


Figure 4 Habitat clips.

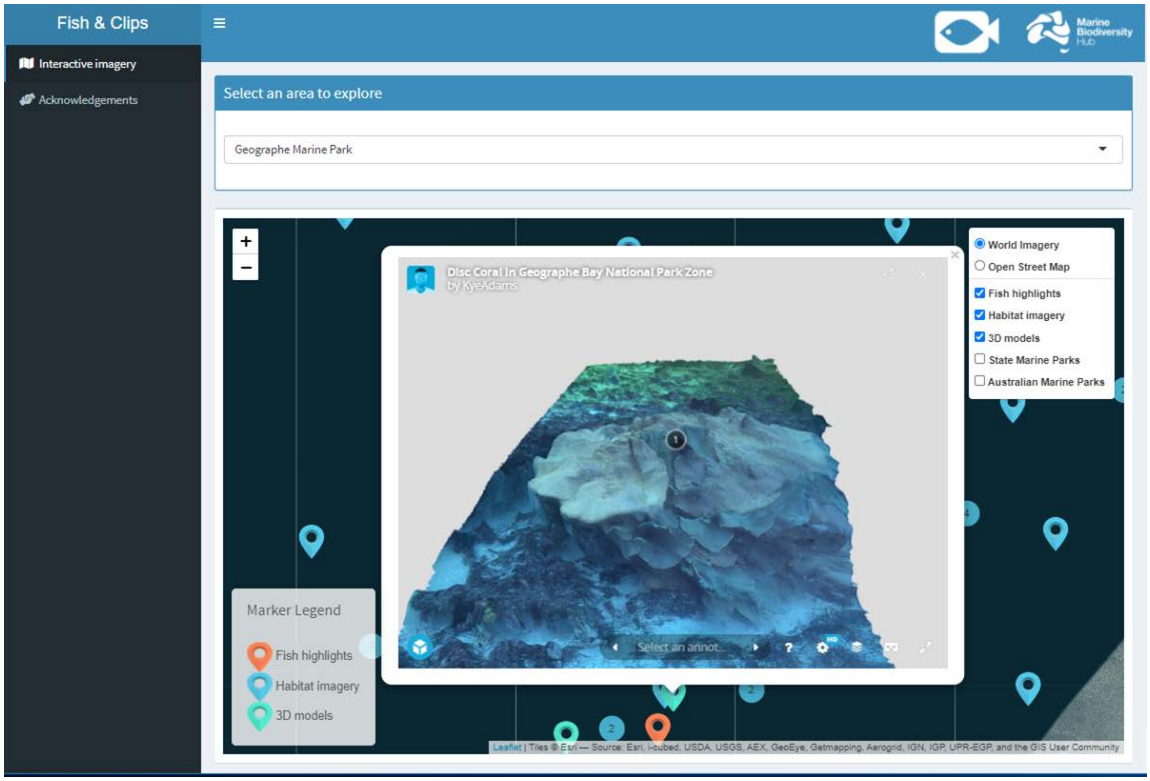


Figure 5 3-D models

3.1.3 Feedback from end-users

During the development of FishNClips feedback was sought from key end-users (Table 2), including Parks Australia and the Marine Science team at the Western Australian Department of Biodiversity Conservation and Attractions (DBCA). All suggestions were actioned by the development team. An important point was raised by DBCA-Marine Science, which was that the geo-referenced 'Habitat clips' on FishNClips could be used as a map to locate good fishing spots. The development team made every effort to select 'Habitat clips' that did not show fished species aggregations, but this is not possible to automate so implies a cost in the future preparation of 'Habitat clips'.

Table 2 Feedback from end-users on FishNClips

End-user	Suggestion	Action
Parks Australia	Simplify zone names and match to IUCN categories	Done
Parks Australia	Cluster points on map	Done
DBCA-Marine Science	Choose habitat clips to not show where aggregations of fished species are to prevent imagery being used as a tool for locating fishing spots	Done - but needs careful consideration

Open-source software-code to reproduce the functionality of FishNClips is provided here: github.com/GlobalArchiveManual/FishNClips.

3.2 Data exploration 'Visualiser'

The 'Visualiser' component of GlobalArchive was developed to demonstrate the functionality to create interactive plotting of summarised fish and shark image annotation data. 'Visualiser' is currently deployed on the Nectar Cloud and as a development version.

The implications of sample design on the suitability of data exploration and visualisation tools 'e.g. Visualiser' need to be understood and biases accounted for. If truly spatially balanced sample designs have been used to collect data, the mean and standard error plots presented will be representative. Representative data visualisations of typical ecological data, typically biased, will require model-based analyses and predictions to be conducted to create representative visualisations. However, such sampling designs are rarely employed and therefore data presented in the 'Visualiser' is intended for data exploration only and not designed to be representative.

3.2.1 Landing page

The 'Visualiser' landing page provides an easily navigable interface, where the user can either use the demonstration data or upload their own summarised data from fish annotations either accessed through GlobalArchive or created using the GlobalArchive-CheckEM (Fig. 6). The infographic displays the GlobalArchive workflow prior to using 'Visualiser'.

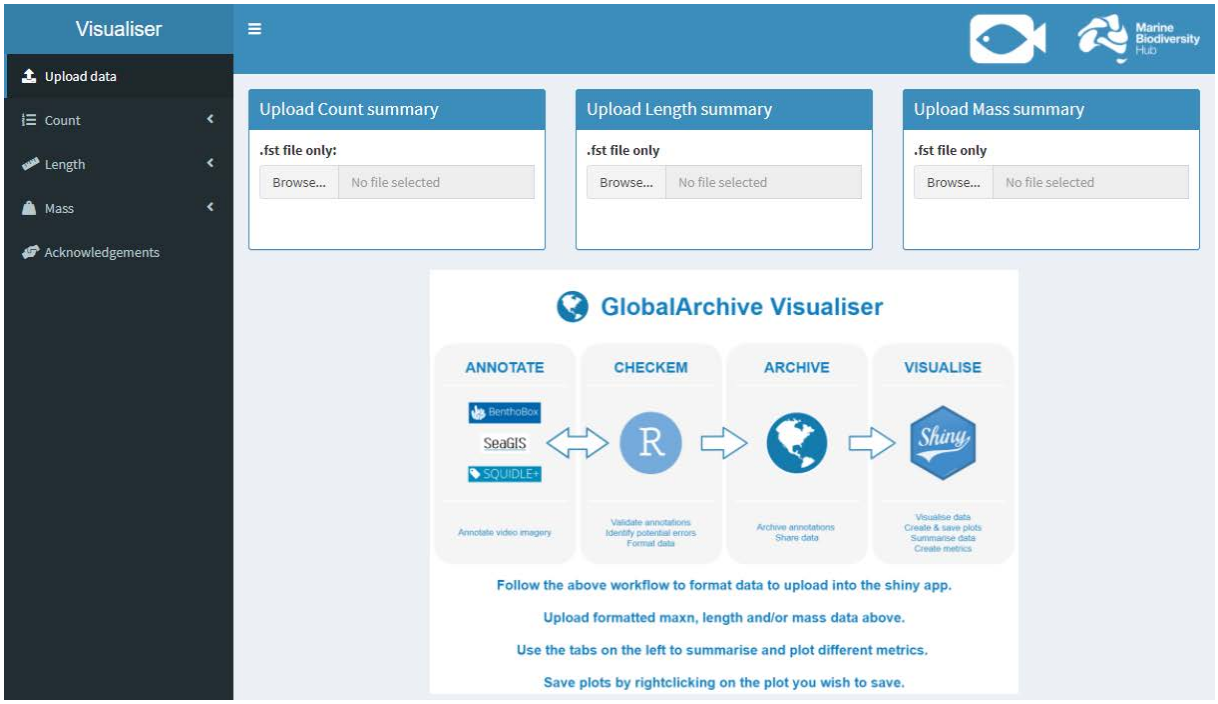


Figure 6 Visualiser landing page

3.2.2 Using 'Visualiser'

The navigation bar on the left of the application allows the user to explore the Count, Length or Mass data. Once the 'Count' or 'Length' tab is clicked, a second dropdown containing 'Summary', 'Plot species trends' and 'Plot metrics' is displayed (Fig. 7).

Once the 'Count' > 'Summary' tab is chosen, two tables are displayed, the first is a campaign level summary, which shows the calculated total abundance, species richness, family richness and genus richness and number of samples for each campaign (Fig. 7). The second table is a summary of the data by *Species*, *Trophic Group* or *Target Group*. The summarising variable can be changed from the dropdown, where multiple Campaigns have been summarised (e.g. a data synthesis) individual campaigns can be selected (Fig. 7).

The 'Count' > 'Plot species trends' tab allows the user to look at individual species trends (Fig. 8). The species of interest can be selected from the dropdown which then populates the four plots. The spatial plot is interactive, when the user hovers their mouse over the blue and white markers the species abundance is displayed, the user can also zoom in and out and change the extent of the plot (Fig. 8). The three bar charts display the abundance by Status (Fished versus No-take), Location and Site, metadata fields that are required for upload into GlobalArchive (Fig. 9).

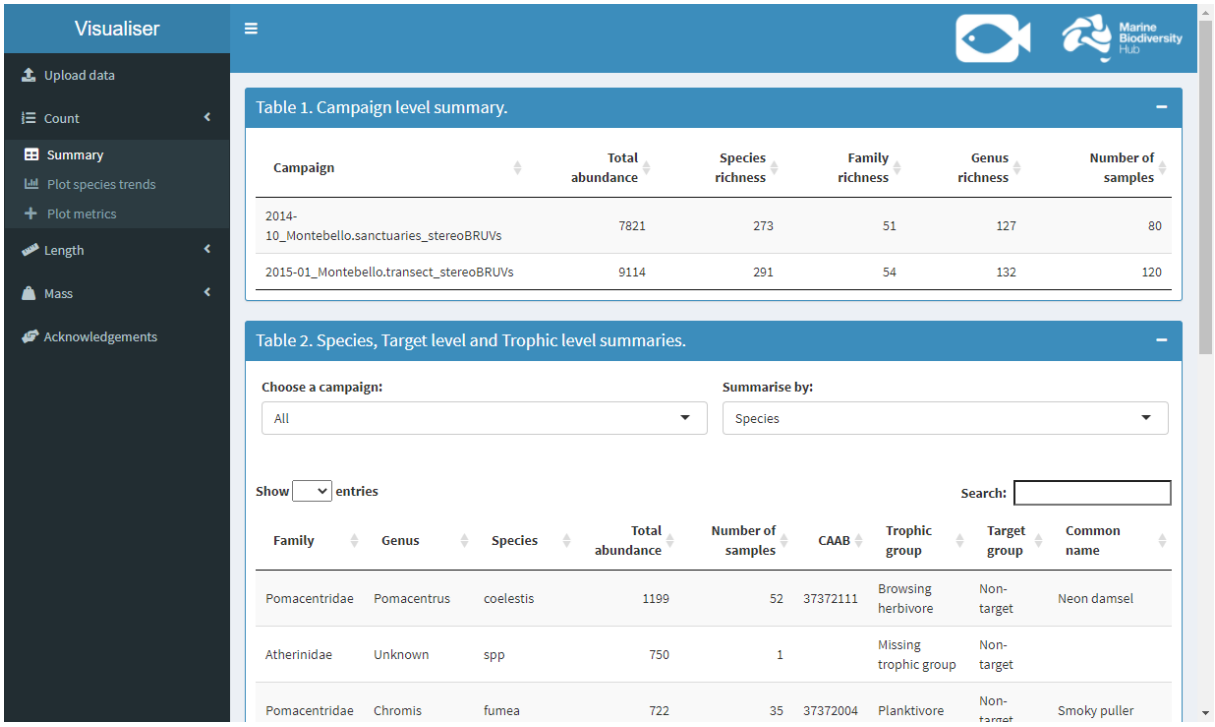


Figure 7 Count summary

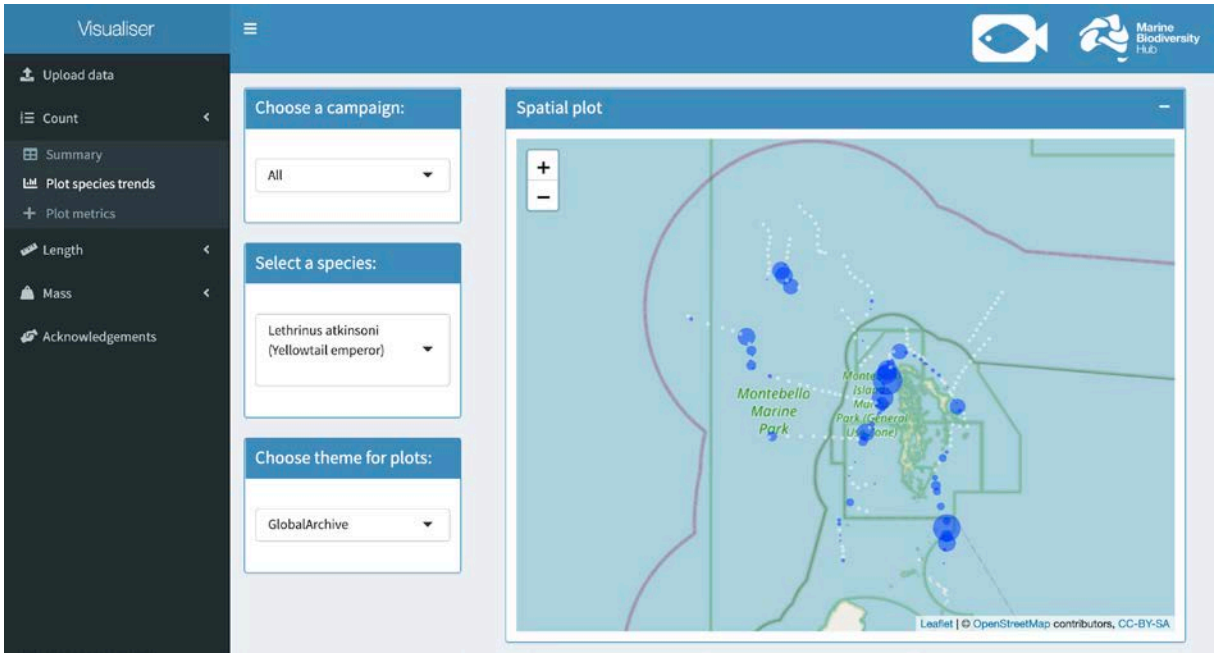


Figure 8 Count species trends by spatial plot

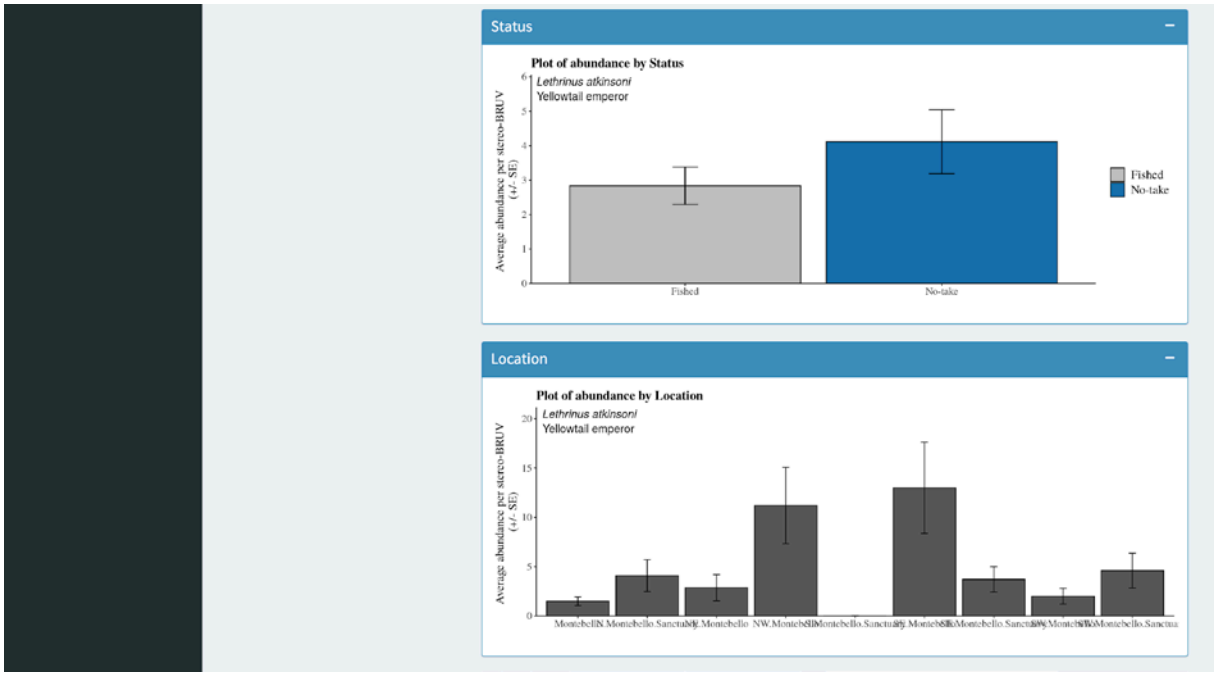


Figure 9 Count species trends by factors, including Status and Location

The ‘Count’ > ‘Plot metrics’ tab, summarises the count data into total abundance, family richness, genus richness and species richness metrics (Fig. 10). These metrics can then be explored using the interactive spatial plot (Fig. 10) or the three bar charts by Status, Location and Site as above.

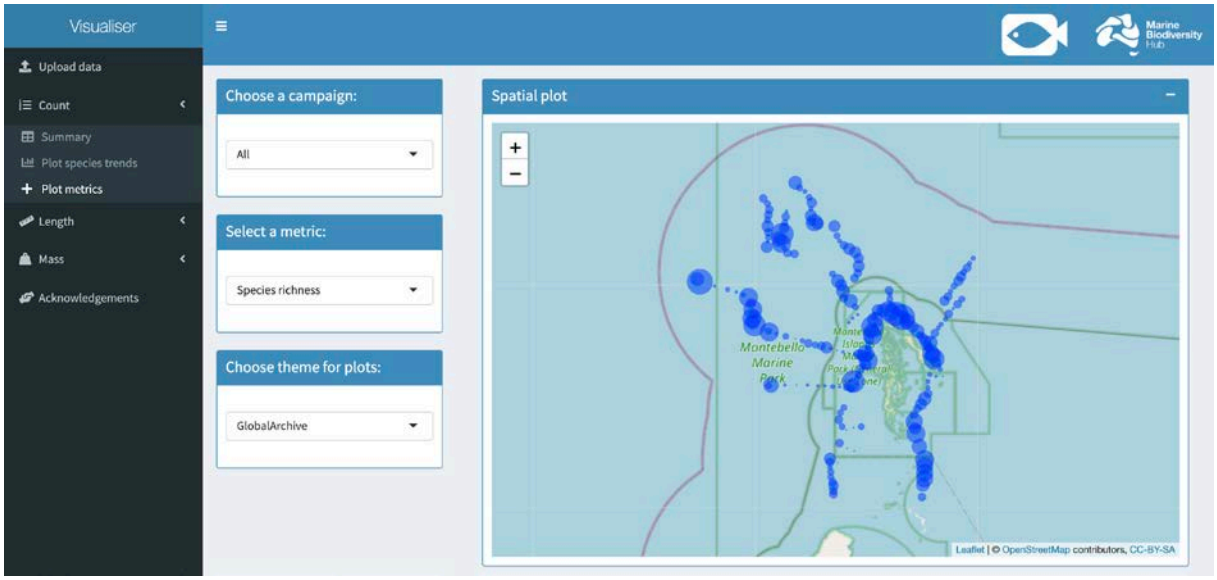
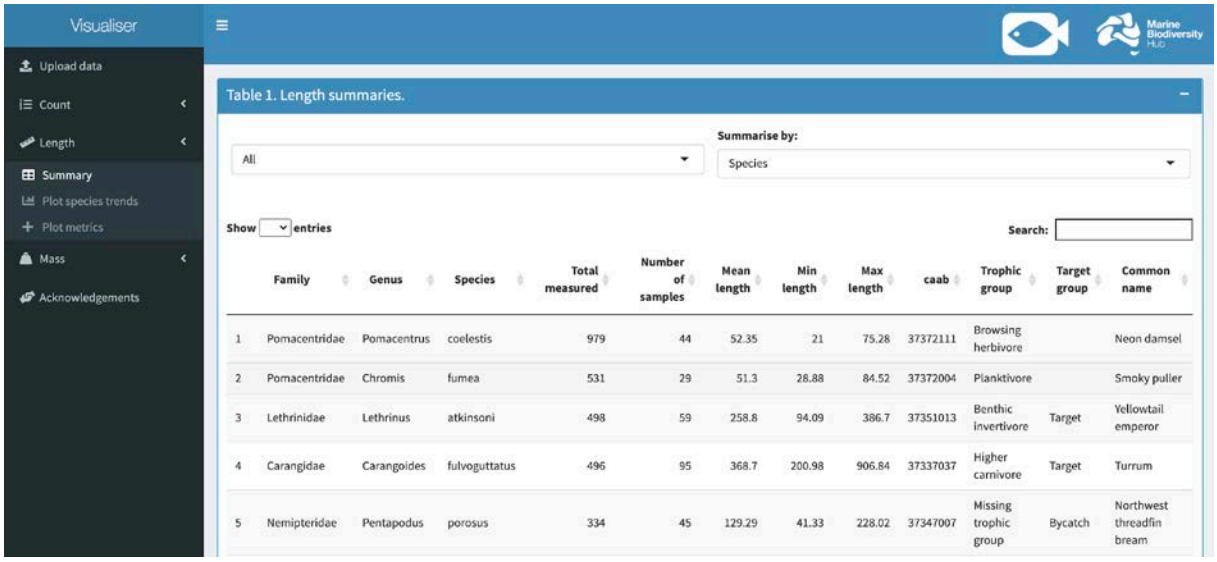


Figure 10 Count metrics

The 'Length' > 'Summary' tab shows the user a summary table of the length data (Fig. 11). The user can filter the campaigns (by selecting the desired CampaignID in the dropdown) and choose to view the summary by *Species*, *Trophic Group* or *Target Group*.



	Family	Genus	Species	Total measured	Number of samples	Mean length	Min length	Max length	caab	Trophic group	Target group	Common name
1	Pomacentridae	Pomacentrus	coelestis	979	44	52.35	21	75.28	37372111	Browsing herbivore		Neon damsel
2	Pomacentridae	Chromis	fumea	531	29	51.3	28.88	84.52	37372004	Planktivore		Smoky puller
3	Lethrinidae	Lethrinus	atkinsoni	498	59	258.8	94.09	386.7	37351013	Benthic invertivore	Target	Yellowtail emperor
4	Carangidae	Carangoides	fulvoguttatus	496	95	368.7	200.98	906.84	37337037	Higher carnivore	Target	Turrum
5	Nemipteridae	Pentapodus	porosus	334	45	129.29	41.33	228.02	37347007	Missing trophic group	Bycatch	Northwest threadfin bream

Figure 11 Length summary

The 'Length' > 'Plot species trends' tab allows the user to look at individual species trends (Fig. 12). The species of interest can be selected from the dropdown which then populates the histogram and boxplot. The bandwidth of the histogram can be adjusted by using the numeric input on the left hand side (Fig. 12).

The ‘Length’ > ‘Plot metrics’ tab, summarises the length data by target and trophic group. These metrics can then be explored using the two box plots (Fig. 13).

The ‘Mass’ > ‘Plot metrics’ summarises the mass data into total mass of fish, mass of fish greater than 200 mm and mass of fish greater than 300 mm (Fig. 14). These plots can be explored by Target or Trophic groups derived from life-history information based on the Codes for Australian Aquatic Biota (CAAB).

Figure 12 Length species trends

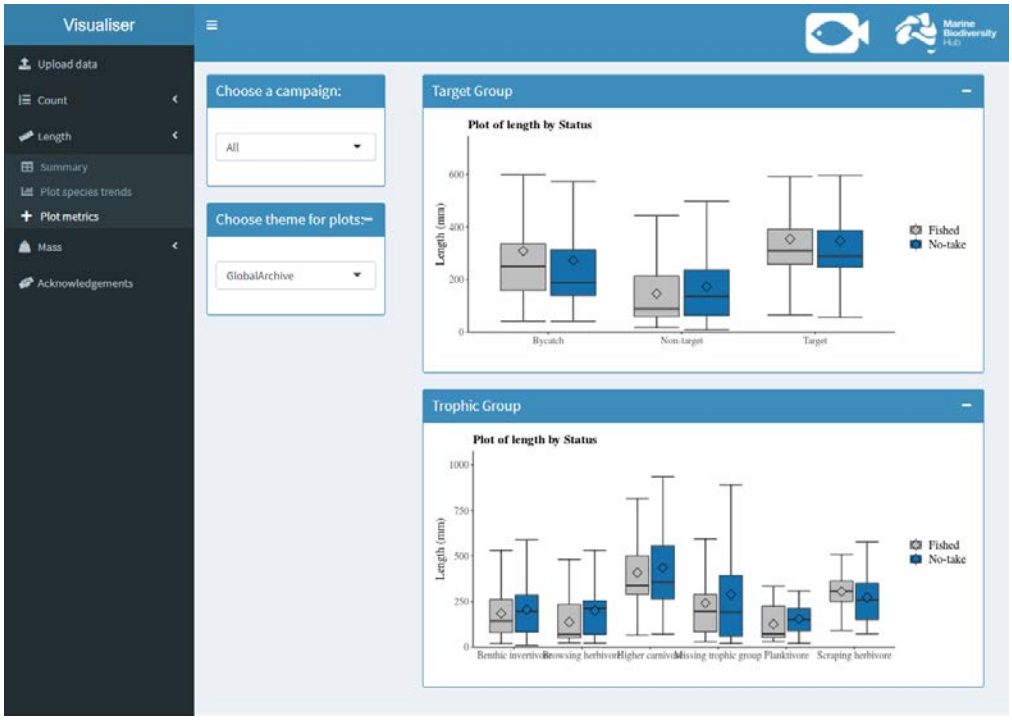


Figure 13 Length metrics

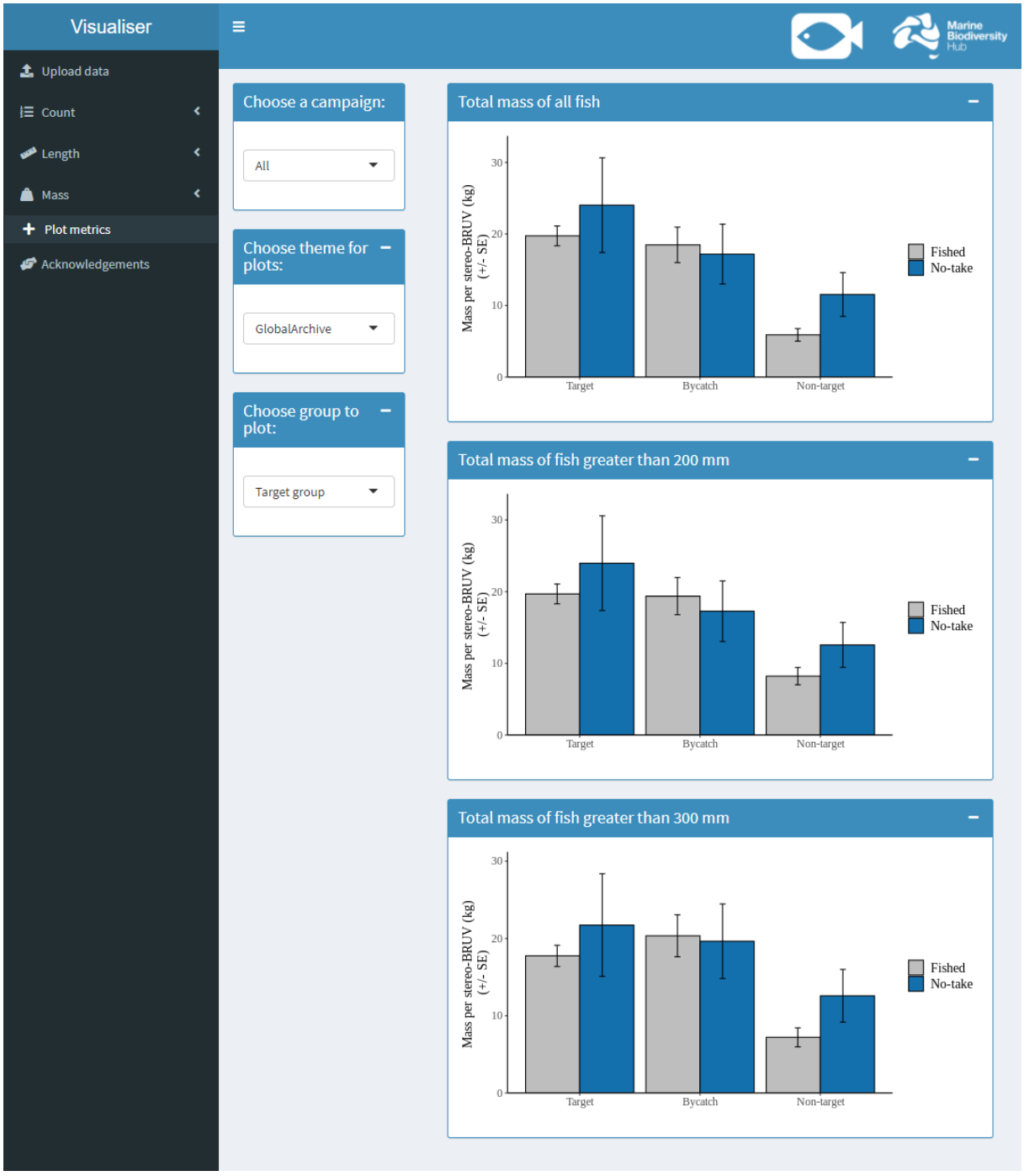


Figure 14 Mass metrics

3.2.3 Feedback from end-users

Table 3 Feedback from end-users on functions

End-user	Suggestion	Action
Parks Australia	Add functionality to automatically name plots saved once right click > “Save image as” is clicked.	Users can type name of plot easily. We suggest using screen shots and saving these as named files.
Parks Australia	Add functionality to automatically generate a complied report of typical plots to be used for reporting.	Add this functionality in the future after further feedback on the content of these plots required by end-users.
DBCA-Marine Science	Should this be publicly available, as it could be used to show where aggregations of fished species are and potentially be used as a tool for locating fishing spots	This needs careful consideration by end-users.

Open-source software-code to reproduce the functionality of FishNClips is provided here: github.com/GlobalArchiveManual/Visualiser.

4. CONCLUSION

The report has provided a pathway of how to enhance the connectivity and interoperability of data between map-based portals by adopting Open Geospatial Consortium (OGC) and ISO compliant standards and provided working examples of how marine imagery and data can provide an immersive science communication experience.

Adopting the above pathway would ensure data derived from the collection and analysis of marine imagery is FAIR (Wilkinson et al. 2016), but also provide a mechanism where the sharing and discovery of data and science communication products can be 'linked' rather than 'duplicated'- relying on there being one 'source' of the data on a specific geoserver and that all other sites link to.

The OGC pathway presented meets the main recommendations of the previous Marine Biodiversity Hub workshop on Map-Based Portals for Marine Science Communication and Discovery (Langlois et al. 2020). For web-based portals such as GlobalArchive.org, that were built on research community defined standards, the adoption of these standards will require consultation and re-development of the platforms to enable OGC compliance. This work is currently underway via an Australian Data Partnership Project funded by the Australian Research Data Commons.

The two case studies present how to enhance map-based portals with immersive data exploration. These case studies are presented in a development testing environment and are designed to be integrated into existing map-based portals such as GlobalArchive.org. Adoption of OGC standards, ISO 19115-3, and the widely used geonetwork and geoserver software are the key components of this project that could be more widely applied in the Australian marine data landscape.

The first case-study, 'FishNClips', presents the spatial discovery of marine imagery for science communication through an easily navigable spatial interface. The second case study, 'Visualiser', presents a data exploration tool to visualise fish annotation data summaries.

This report provides a pathway for the future enhancement, connectivity and interoperability of map-based portals to meet standards to enable the discovery of raw data, summarise and curated science communication data products such as interactive imagery and data visualizations.

In particular for the data exploration and visualisation tool 'Visualiser', we need to understand the biases involved in sample designs for the visualisations to be representative. Representative data visualisations of, typically biased, ecological sampling data will require model-based analysis and predictions that account for these biases. The data currently presented in 'Visualiser' is intended for data exploration only and not designed to be representative.

A key lesson from the previous Marine Biodiversity Hub workshop on Map-Based Portals for Marine Science Communication and Discovery was that the appropriate data must be available for the different users of marine imagery data (Langlois et al. 2020). In the adoption of OGC and ISO compliant standards, it should be recognised that different users require access to different forms of the data.

5. RECOMMENDATIONS

We recommend that Open Geospatial Consortium (OGC) and ISO compliant standards should be adopted by map-based portals such as GlobalArchive.org in future development activities. GlobalArchive is part of a project that is being further developed with support from the Australian Research Data Commons (ARDC) to build on existing and novel data partnerships of fish and shark imagery data. Development activities that implement OGC and ISO compliant standards should be prioritised to increase the accessibility and interoperability of existing and new datasets.

We recommend that before interactive imagery (e.g. 'FishNClips') and data exploration (e.g. 'Visualiser') features are implemented in map-based web portals (e.g. GlobalArchive), a targeted workshop should be held to present and evaluate alternative strategies, that is led by science communication experts. This workshop should also provide a forum for end-users to provide feedback on the proposed science communication enhancements.

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APPENDIX 1

Table 1. Marine Imagery Discoverability & Accessibility Recommendations

Developed at preceding Marine Imagery Discoverability & Accessibility workshops from 2018 and 2019 (Przeslawski, et al. 2019).

Bold items are the focus of the current report.

	Task
1. Governance, oversight, and working group(s)	1.1 Present to NMSC on state of Australian marine imagery data
	1.2 Define and promote the role of the NMSC or relevant working group as an oversight committee to provide broad strategic guidance on marine imagery and data accessibility.
	1.3 Establish a marine imagery collective (or revisit ToR for an existing group) to develop a strategy for moving forward as a united community (vision, communicate value, risk and mitigation, funding), including progression of action items detailed in this report
	1.4 Identify leader of this collective who can progress recommendations in this report. Establish support (e.g. funding) for this leader, as this will involve a lot of work.
	1.5 Develop and apply communication strategy between implementation group (e.g. marine imagery collective) and oversight group (e.g. NMSC)*
	1.6 Ensure future versions of NESP field manuals 1) define clear data release workflows, including minimum meta data requirements and consistent vocabularies and 2) articulate the oversight and implementation groups related to marine imagery
	1.7 Continue to promote field SOPs and data standards
2. Long-term or institutional support	2.1 Develop a transparent prioritisation of preferred funding priorities, including: requirements of users regarding data acquisition and product delivery, capacity to contribute to impact, international context (UN SDGs, EOVs), cost-effectiveness and operating scale. Collaborate and communicate this to marine imagery collective.
	2.2 Encourage larger partners in the collective to provide contributions to base funding to ensure resilience and demonstrate buy-in
	2.3 Ensure successful funding proposals address multiple recommendations in this report
	2.4 Develop and apply communication strategy between implementation group (e.g. marine imagery collective) and oversight group (e.g. NMSC)
3. Centralised repository and tracking system	**3.1 Specify a metadata/data format for organisations to submit information about marine imagery, including image URL, location, annotation method. This can be aggregated by AODN for discoverability and visualisation without having to store the imagery.**
	3.2 Use above framework to characterise current holdings and adapt organisational workflows to ensure appropriate meta data for marine imagery
	3.3 Scope long term sustainable federated repository (including both images AND annotation, georeferencing, backups, security/sharing, and citation system) or centralised harvesting service with ARDC and other major agencies that have invested in their own appropriate repositories (e.g. geoserver).
4.	4.1 Address bottlenecks relevant to the objectives of funding proposals, such that a user-friendly and practical national workflow is achievable (see red parts of Figure 4)

Bottlenecks	4.2 Prioritise funding proposals that address the bottlenecks and underdeveloped links.
	4.3 Meet with NCRIS to discuss speed-of-access issues with big data
	4.4 Develop workflows (including bottlenecks and undeveloped links) for each of the major imagery sampling gear (AUV, BRUV, Towed imagery, ROV, UVC/DOV).
5. Communication and collaboration	5.1 Develop image analysis workflows
	5.2 Hold annual meetings to ensure continued dialogue and collaboration
	5.3 Adopt a collaborative approach in funding proposals seeking to develop marine imagery capability, such that a clear national workflow(s) is developed and communicated to the marine community
	5.4 Demonstrate how a funding proposal is gear- and platform-agnostic or clearly identify its association with a particular gear type (e.g. AUV).
	5.5 Prioritise funding proposals that adopts a collaborative approach to develop marine imagery capability between the main groups.
6. Other	6.1 Each organisation take responsibility for ensuring their data abides by FAIR principles, including funding, input, and support for infrastructure
	6.2 Scope the need, scale, and cost of digitising legacy data at risk of being lost (e.g. VHS imagery)
	6.3 Funded projects should clearly identify the intended user of the proposed infrastructure or research, ideally addressing diverse end-user case studies.
	6.4 Set targets for Open-data and encourage use of time-locks or embargoes on data, but avoid mandating. In particular, this will promote industry data sharing. Note that all other recommendations detailed in this report will also promote industry data sharing by developing the practical infrastructure that encourages data input into safe repositories.
7. Marine science communication and discovery	**7.1 Develop design protocols for spatial portals to enable immersive data exploration accessible to a wide variety of users.**
	7. 2 Hold a follow up workshop with professional educators to further develop concepts for immersive marine science communication.

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