Marine Biodiversity Hub

National Environmental Science Programme

# Quality control and interoperability of fish annotation data

Case study of GlobalArchive-CheckEM service for validating stereo-BRUV annotations

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

*July 2021*

*Milestone 43 – Research Plan v5 (2019)*

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## Preferred Citation

Langlois T., Gibbons, B., Monk, J., Lucieer, V (2021). *Quality control and interoperability of fish annotation data: Case study of GlobalArchive-CheckEM service for validating stereo-BRUV annotations* Report to the National Environmental Science Program, Marine Biodiversity Hub. *The University of Western Australia.*

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## Acknowledgement

This work was undertaken for the Marine Biodiversity Hub, a collaborative partnership supported through funding from the Australian Government's National Environmental Science Program (NESP). NESP Marine Biodiversity Hub partners include The University of Western Australia, the University of Tasmania; CSIRO, Geoscience Australia, Australian Institute of Marine Science, Museums Victoria, Charles Darwin University, Integrated Marine Observing System, NSW Office of Environment and Heritage, NSW Department of Primary Industries.

We thank all end-users who contributed to CheckEM development and provided feedback. In particular scientists from the Western Australian Department of Biodiversity Conservation and Attractions-Marine Science (DBCA-Marine Science), New South Wales Department of Primary Industries (Fisheries NSW) and South Australian Department of Environment and Water-Marine Science (SA DEW-Marine Science).

## Important Disclaimer

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# EXECUTIVE SUMMARY

This report presents a case study of how to improve the quality control and interoperability of spatial data.

This case study focuses on the quality control of fish and shark annotations from baited remote underwater stereo-video (stereo-BRUV) imagery. The GlobalArchive-CheckEM service conducts a series of quality control checks on annotation data against life-history information, based on the Codes for Australian Aquatic Biota (CAAB). This report provides a 'how-to guide' for CheckEM and we propose that, in addition to review by expert fish biologist and ecologists, any fish and shark image annotations collected in Australia should be validated using CheckEM.

Data validation, quality control and interoperability of spatial data are key to enable data discovery and re-use for biodiversity reporting and science communication. This report provides two different case studies of how Findable Accessible Interoperable Reproducible (FAIR) aspects of marine data can be improved and implemented at a national scale.

# 1. INTRODUCTION

## 1.1 Background

Improving the quality control and interoperability of spatial data has been raised as a key challenge by a 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. 2020a). Without robust quality control and interoperability of this information data discovery and re-use is likely to be limited, and data will not meet FAIR standards (Wilkinson et al. 2016). Quality controlled and interoperable data is also key for creating more immersive science communication data products, as these are likely to rely on the consistency to enable different users to engage with the data at different scales (Langlois et al. 2020b).

Within this report, the definition of quality for fish annotation data is restricted to the validity of the spatial metadata, fish species identification, fish species abundance estimates and individual fish body-size estimate. These attributes of fish annotation data considered will have direct implications on the interoperability and re-use of this data for reporting and synthesis.

The above workshops also recognised map-based portals rely on effective quality control of data contributed. Recommendation from Przeslawski et al. (2019) and Langlois et al. (2020a) are given in Appendix 1, and the recommendations relevant to this report include:

- Develop workflows (including bottlenecks and undeveloped links) for each of the major imagery sampling gear (AUV, BRUV, Towed imagery, ROV, UVC/DOV)
- Develop image analysis workflows

This report presents a case study of how to improve the quality control and interoperability of spatial data, in the form of fish and shark annotations from baited remote underwater stereo-video (stereo-BRUV) imagery. Stereo-BRUV imagery has been recognised to produce essential information for the non-destructive monitoring of fish and shark assemblages within marine parks and for ecosystem-based assessments, and a best-practice field manual by the Marine Biodiversity Hub, as an internationally authored publication, has been endorsed by the Global Ocean Observing System (GOOS) Biology and Ecosystems Panel of Experts as a globally accepted best practice for conducting research with baited remote underwater video (Langlois et al. 2020c).

The long-term preservation of imagery collected by stereo-BRUV enables image annotations to be revisited and validated for quality control. GlobalArchive has been recognised as the national portal for fish and shark image annotations and a recent national synthesis of annotations from stereo-BRUV data from a broad range of institutions and agencies have highlighted that increased quality control of annotations is needed. The vast majority of fish and shark image annotation is done using the SeaGIS annotation software, EventMeasure (www.seagis.com.au) and existing best practice (Langlois et al. 2020c) call for review of any annotations by expert fish biologists and ecologists. Despite this best practice, an existing synthesis of Australian stereo-BRUV data has found a range of common errors that could be checked and validated against life-history and published occurrence information (Harvey, E. S. and others n.d.). The 'GlobalArchive-CheckEM' service conducts a series of quality control checks of annotation data from EventMeasure against life-history information based on the Codes for Australian Aquatic Biota (CAAB). CheckEM will also convert annotation data into summarised data suitable for biological reporting or for use in data exploration tools such as the 'GlobalArchive-Visualiser' (Langlois et al. 2020a). This report provides a 'how-to guide' for use of CheckEM.

The body of the report will present the 'GlobalArchive-CheckEM' service and provide a 'how-to guide' to validate fish and shark annotation data and to convert annotation data into summarised data suitable for biodiversity reporting or for use in data exploration tools such as the 'GlobalArchive-Visualiser' (Langlois et al. 2020a).

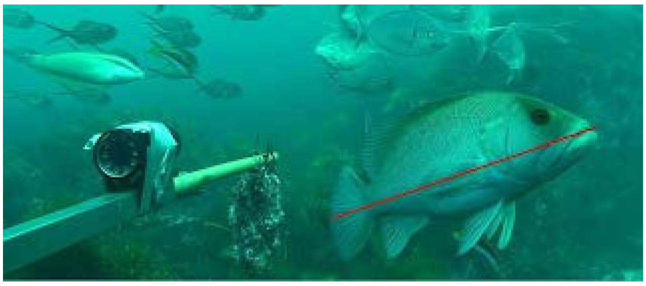

*Figure 1 Two 3-D point annotations on the nose and tail of a breaksea cod (Epinephelides armatus), joined by a predicted length estimate in EventMeasure.*

The vast majority of fish and shark image annotation is done using the SeaGIS annotation software, EventMeasure (www.seagis.com.au), and this software is recommended for the annotation of stereo-BRUV imagery (Langlois et al. 2020a). This point annotation data (Fig. 1) is typically summarised into count data and length data by species. For both un-baited and baited video station methods this count data is calculated as the maximum number of individuals of a species in the field of view at one time, often referred to as MaxN (Priede et al. 1994).

GlobalArchive was designed to ingest annotation data and both share and summarise this data into a format suitable for biodiversity reporting such as count (MaxN) and length data by species. To maintain the interoperability of these annotation data, any corrections or quality control procedures must be made to the annotation data. If corrections are instead made to the summarised data (e.g. the count and the length data by species), the interoperability of the annotation data is broken and it cannot then be used for biodiversity reporting or for other uses such as training image automation algorithms. It is therefore important that data validation and quality control checks are made on the annotation data and not the summarised count and length data by species.

## 1.2 Objectives for 'GlobalArchive-CheckEM'

The 'GlobalArchive-CheckEM' service presented here is designed to run validation and quality control checks on fish and shark stereo-imagery annotation data and their spatial metadata, within a specific Campaign. For GlobalArchive, a Campaign is defined as a discrete spatial and temporal set of samples collected by a single sampling platform method. Within GlobalArchive each Campaign has a CampaignID typically formed by the concatenated Year-Month_Location_Method (see the GlobalArchive user guide for further definition of terms).

'GlobalArchive-CheckEM' conducts validations and quality control by comparing the biodiversity data contained in these annotations against a life-history information based on the Codes for Australian Aquatic Biota (CAAB), including length-weight relationships, expected spatial distribution and body-size of fishes and sharks and makes suggestion of species names changes where species names have been changed historically (e.g. synonyms exist for species). In addition, CheckEM plots data by marine park zone type by joining the metadata with Australian marine spatial planning shapefiles. CheckEM also converts annotation data into summarised data (e.g. the count and the length data by species) suitable for biodiversity reporting or for use in data exploration tools such as the 'GlobalArchive-Visualiser' (T. Langlois, Monk, and Gibbons 2020). GlobalArchive-CheckEM was built using the Shiny: Web Application Framework for R (Chang et al. 2019).

# 2. GLOBALARCHIVE-CHECKEM

## 2.1 Upload and preview Metadata and annotations

Upload and preview the metadata and annotation files; including image annotation points, length and 3D points files (Fig. 2).

- Metadata contains a sample number joined with spatial, temporal and methodological information, and the name of the file will be formed as 'CampaignID'_Metadata.csv, see GlobalArchive user guide for more information on the format of this file.
- Points file contains single image annotations points by species, and will be used to generate count data using MaxN, and the name of the file will be formed as 'CampaignID'_Points.txt.
- Length file contains stereo image annotations of lengths by species, and will be used to generate length data, and the name of the file will be formed as 'CampaignID'_Lengths.txt.
- 3D point file contains stereo image annotations of 3-D point estimates of species, and will be used to generate count data standardised by range from the cameras, and the name of the file will be formed as 'CampaignID'_3DPoints.txt.

By default CheckEM displays data from a Marine Biodiversity Hub stereo-BRUV survey from the 2019 campaign to benchmark the Ningaloo Marine Park (Commonwealth) with the CampaignID of '2019-08-Ningaloo_stereo-BRUVS'.

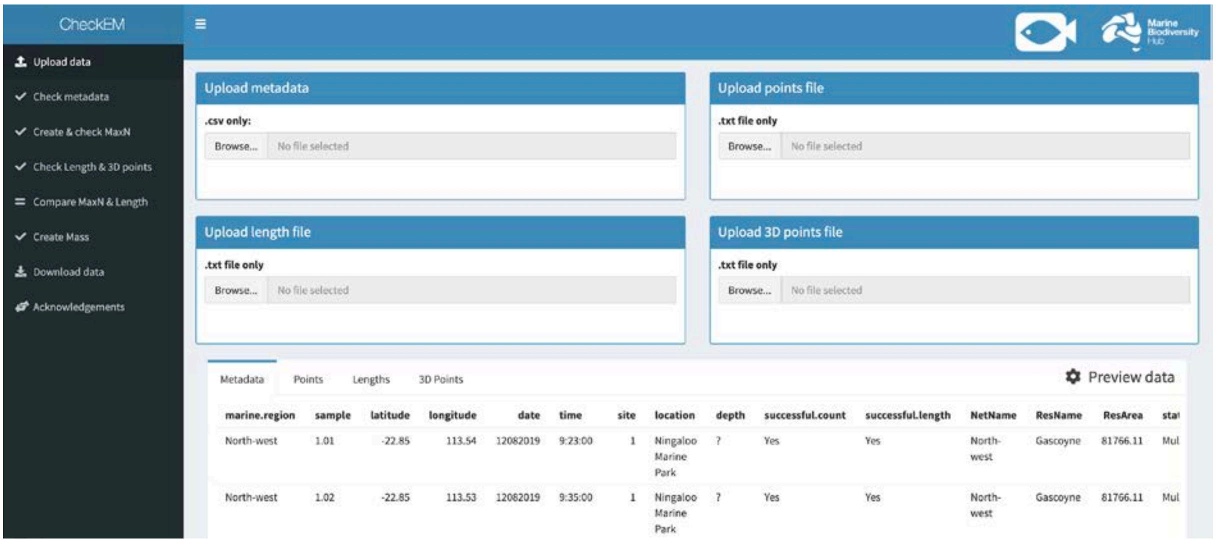


*Figure 2 CheckEM upload and preview page.*

## 2.2 Check Metadata

Validates the community metadata standards required for GlobalArchive (see globalarchivemanual.github.io)

- Counts the number of samples and displays them on an easily navigable spatial interface, to facilitate checking of the location (Fig. 3).
- Check that no metadata samples are missing annotation points and that no annotation points are missing metadata samples.
- Joins metadata to shapefiles of marine regions and marine parks (including the Australian Marine Parks, state and territory marine parks and the Great Barrier Reef Marine Park) to determine biogeographic region and marine park or management area zone type.
- The biogeographic region will be used to check observed versus expected species distribution.
- The marine park or management area zone type will be used to facet exploratory plots.

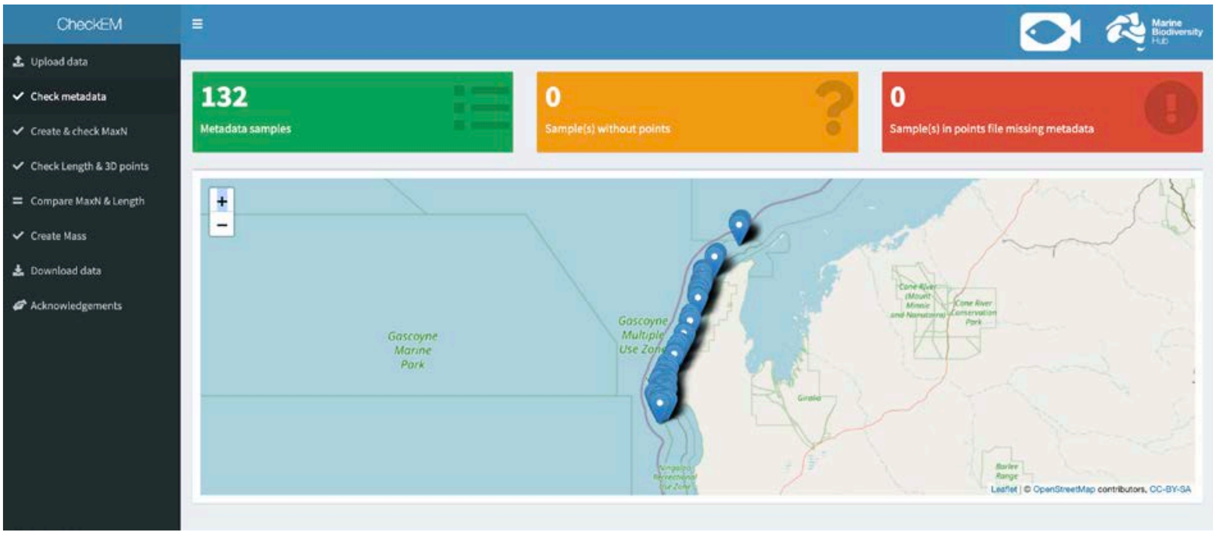


*Figure 3 Check Metadata.*

## 2.3 Create and check count data (MaxN)

Creates the count data (MaxN) from point annotation data and validates by biogeographic region.

- Creates count data (MaxN) from point annotation data.
- Counts the number of individual fish observed as a sum of MaxN by species.
- Change species names with outdated species names to current synonyms.
- Check species that haven't been observed in the area before.
- Interactive plot of the top most abundant species, the number of species to be displayed can be changed (Fig. 4)*.

*We suggest users zoom in and out using their browser zoom function to size the plots (e.g. zoom in to plot using 'Ctrl' & '+' and wait for plot to update).

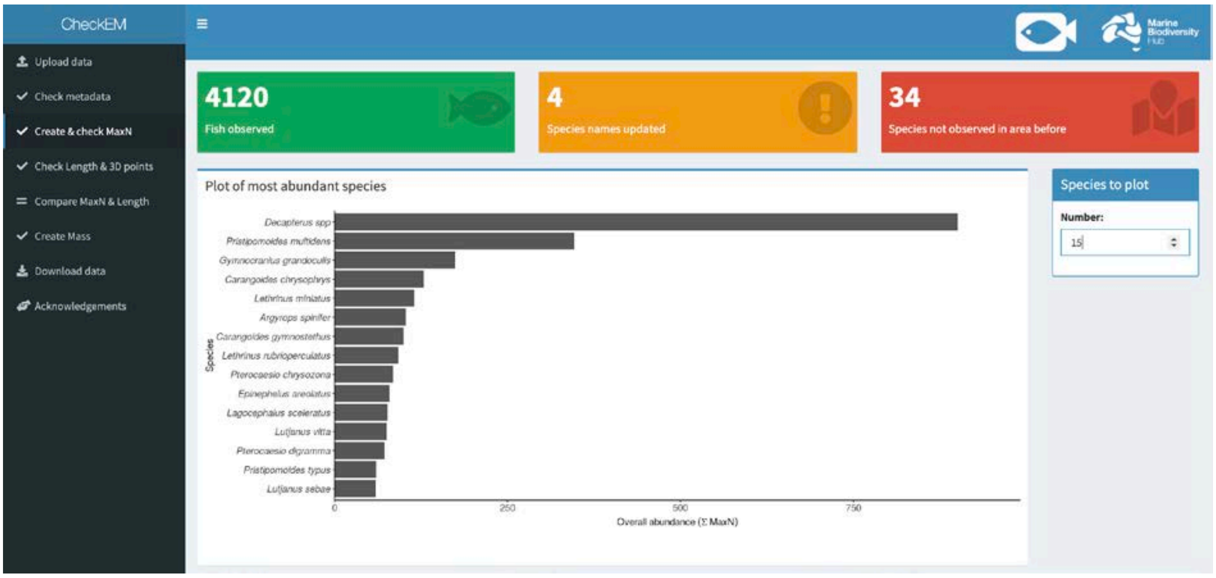


*Figure 4 Check Count (MaxN) data.*

- Interactive plots of any species can be chosen to show the spatial abundance distribution and by marine park or management Zone type (Fig. 5), and further plots by Status type, Location and Site (Fig. 6).

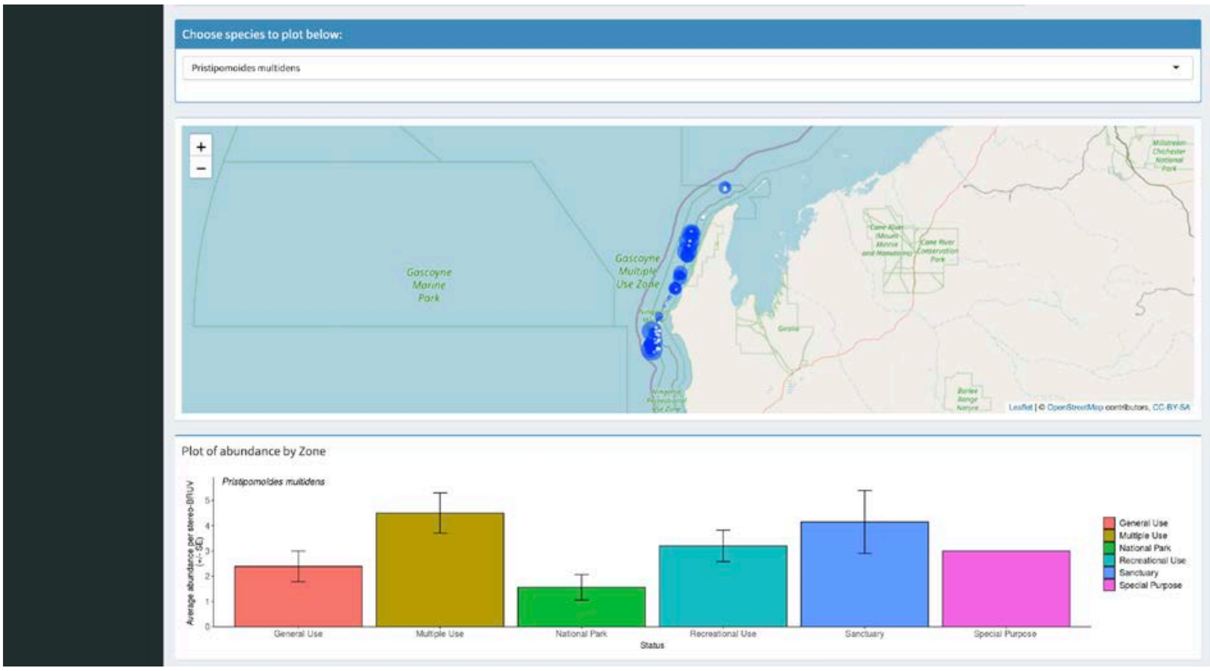


*Figure 5 Check particular species Count (MaxN) data: spatially and by zone type.*

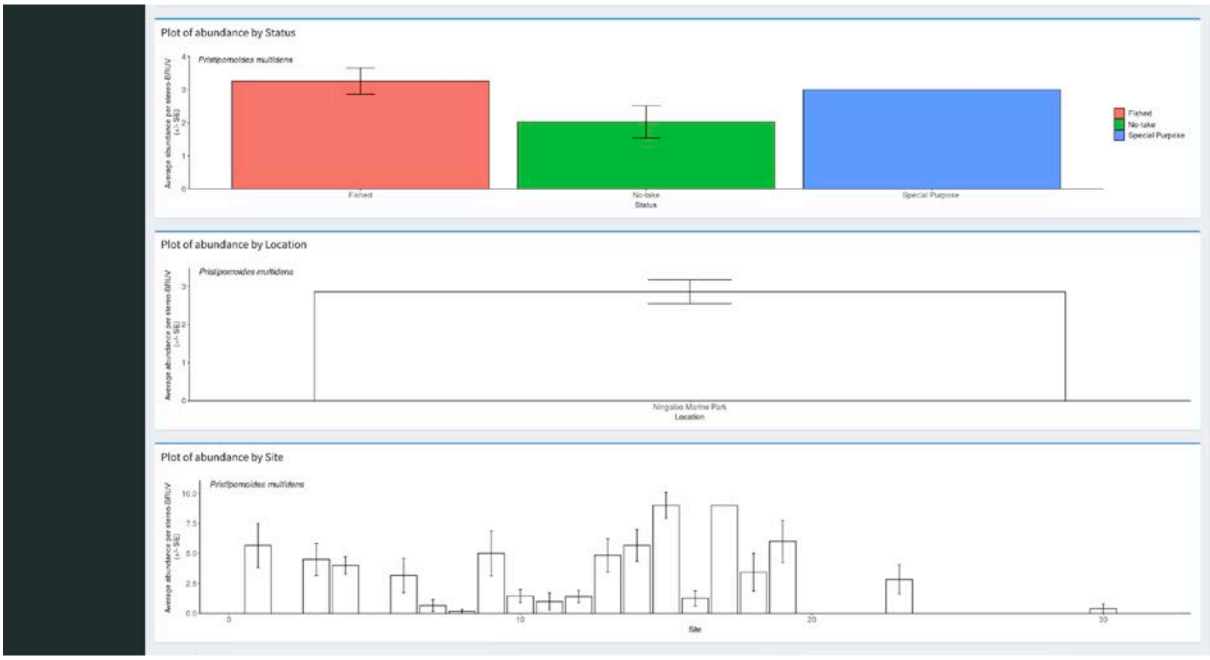


*Figure 6 Check particular species count (MaxN) data: by status type, location and site.*

## 2.4 Create and check length data

Creates the length and 3D point data from annotation data and validates by biogeographic region.

- Counts the number of individual fish length measurements made at MaxN by species.
- Counts the number of individual fish that had 3D points instead of length. 3D points suggest that those fish could not be measured.
- Change species names with outdated species names to current synonyms.
- Check species that haven't been observed in the area before.
- Counts the number of length measurements that are smaller than expected (i.e. lengths smaller than 15% of the maximum length for any species).
- Counts the number of length measurements that are larger than expected (i.e. lengths larger than 85% of the maximum length for any species).
- For a chosen range from the cameras, CheckEM counts the number of fish measured further from the cameras and therefore out of range.
- Interactive plots of any species can be chosen to show the length histogram, including validation points of length estimates (i.e. lengths smaller than 15% of the maximum length, lengths larger than 85% of the maximum length and the maximum length, Fig. 7), by Status type (Fig. 8) and boxplots of length by Zone and Status type (Fig. 9).

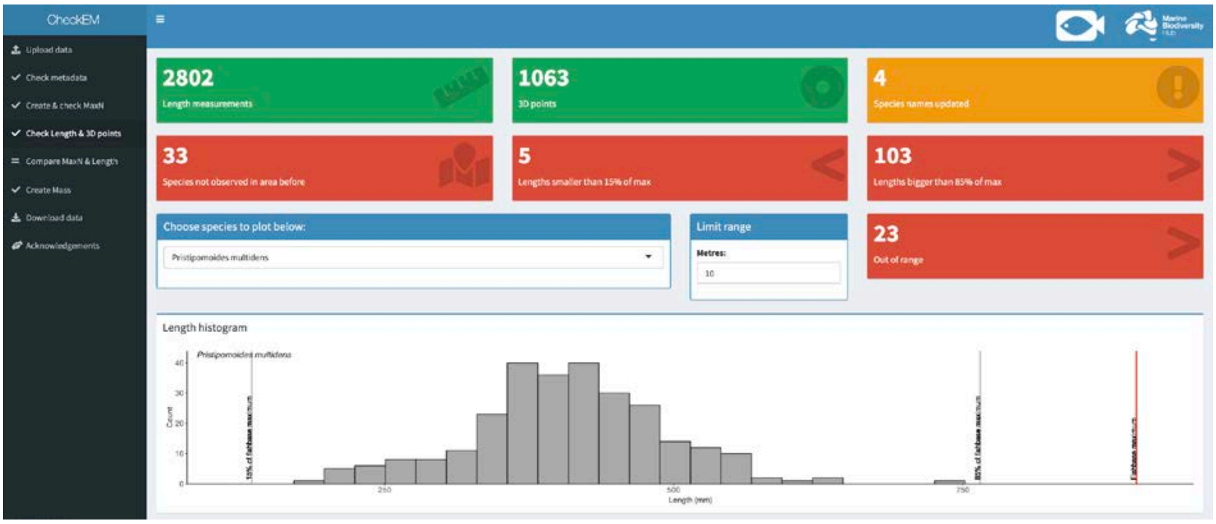


*Figure 7 Check Length data and particular species: histogram of length against expected minimum and maximum values.*

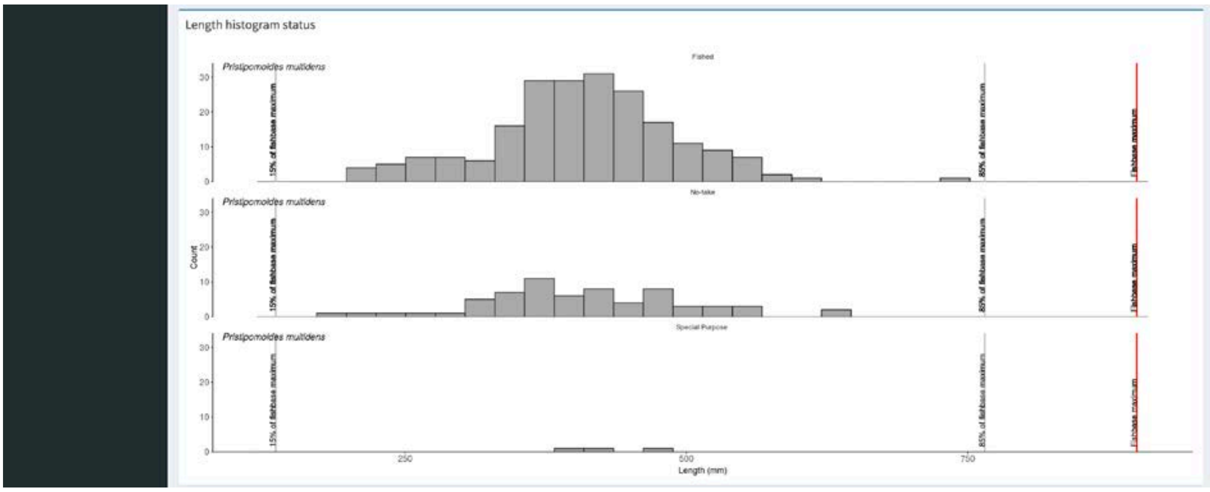


*Figure 8 Histogram of length of a particular species: by status against expected minimum and maximum values.*

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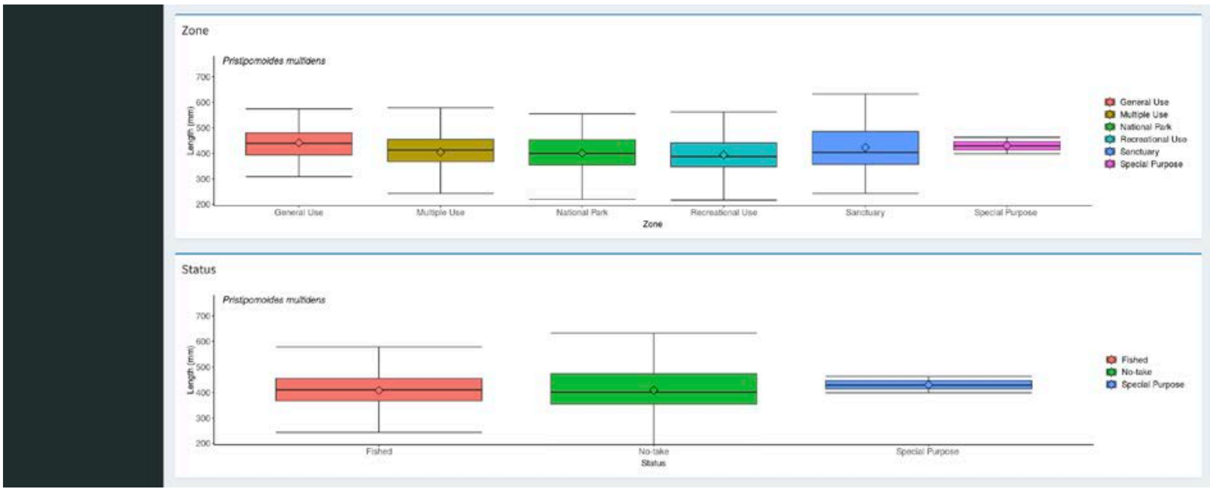


*Figure 9 Boxplot of length of a particular species: by zone and status type.*

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## 2.5 Compare count (MaxN) and count of length+3D points

Compares the count (MaxN) and count of length, including 3D points. For annotations to be complete, count from MaxN versus the count of length, including 3D points, should match.

- Comparison of the count of length, including 3D points, to the count (MaxN) and give the number of annotations that need to be completed (Fig. 10).
- Scatter plot with 1:1 line (red) of count (MaxN) versus count of length, including 3D points, by species.
- Counts the number of individual fish that had 3D points instead of length. 3D points suggest that those fish could not be measured.
- Interactive plots of any species can be chosen to show scatter plot with 1:1 line (red) of count (MaxN) versus count of length, including 3D points, by species, with the sample number shown for non-matching annotations (Fig. 11).


*Figure 10 Comparison of the count of length including 3D points, versus the count (MaxN). with 1:1 line shown in red. The number of annotations that need to be completed is given.*

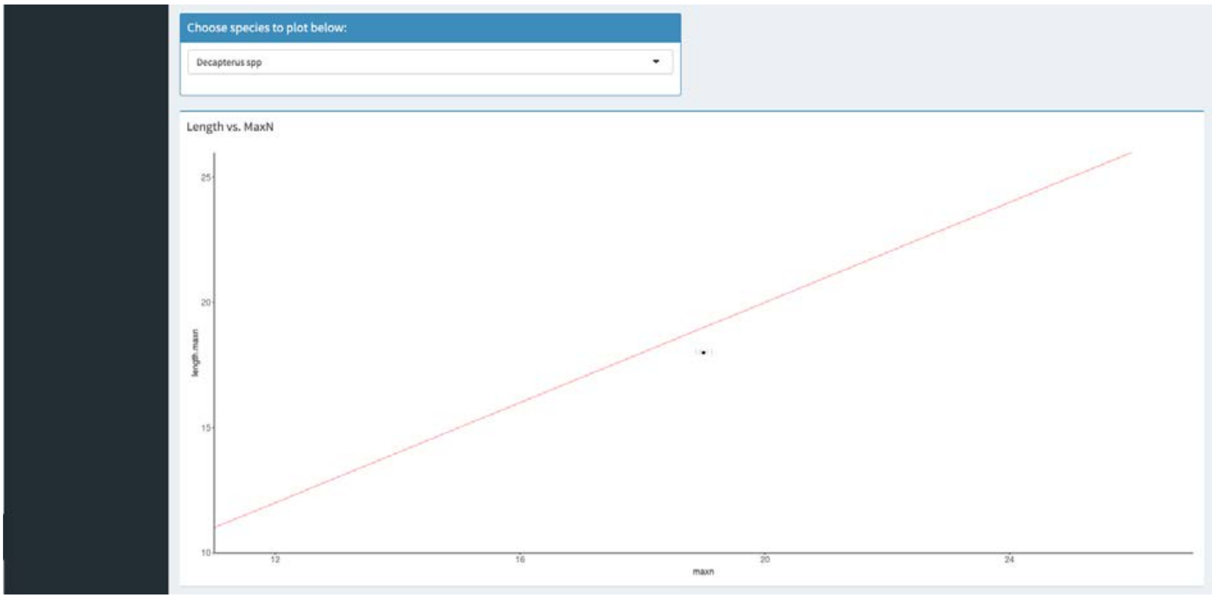


*Figure 11 Comparison of the count of length: including 3D points, versus the count (MaxN) for a particular species, with 1:1 line shown in red.*

## 2.6 Create and check Mass

Creates mass estimates for every species by sample using life-history information, including length-weight relationships.

- Creates mass data from length annotation data, 3D points are ignored.
- Interactive plot of the top highest species by mass, the number of species to be displayed can be changed and elasmobranchs can be filtered out or included (Fig. 12).
- Mass data for the chosen species can then be checked spatially, using an easily explorable map, and by marine park or management Zone and Status type (Fig. 13).

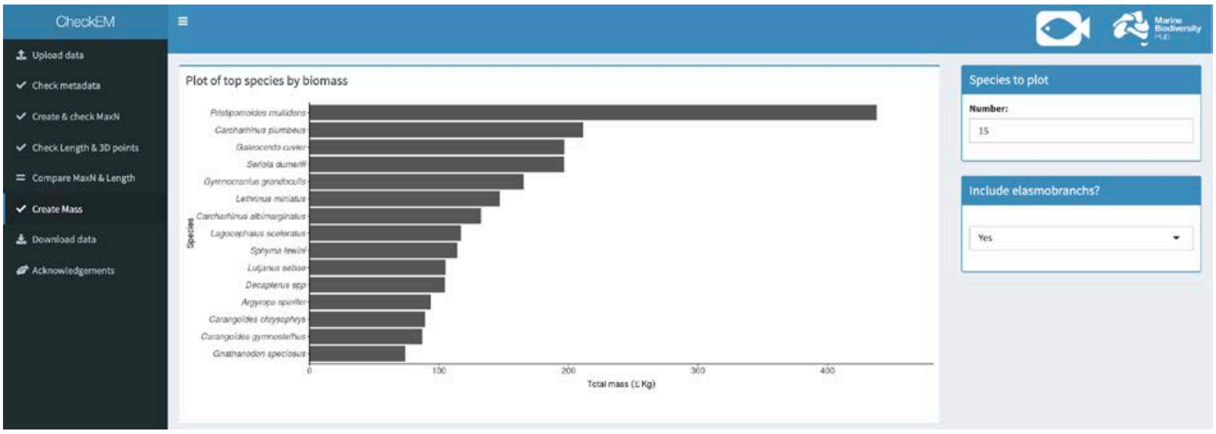


Figure 12 Check Mass data.

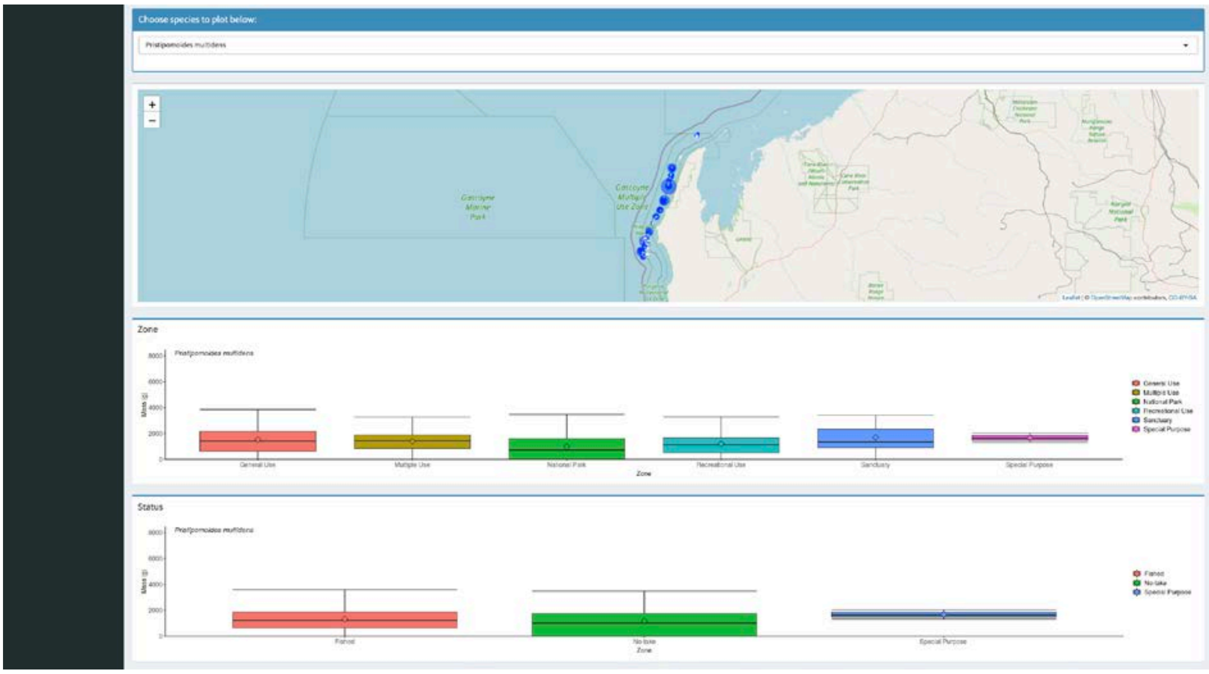


Figure 13 Check particular species mass data: spatially and by zone and status type.

## 2.7 Download the summarised data

During the validation process, the annotation data has been reformatted into summarised data. Once the CHeckEM data checks have been done and any required corrections made to the annotations and then passed through CheckEM again, summary data suitable for biodiversity reporting or interactive plotting in data exploration tools such as the 'GlobalArchive-Visualiser' (Langlois et al. 2020c) (Fig. 14).

- Creates count (MaxN), length with 3D points and mass data.
- Can filter to:
    - keep species names that have been updated with currently accepted synonyms.
    - remove species not previously observed in the bioregion previously.
    - filter length and mass data but a certain range from the stereo-cameras.
    - filter out length measurements larger than maximum expected length.
- Count, length and mass data files joined with metadata information can then be downloaded for biodiversity reporting or interactive plotting.

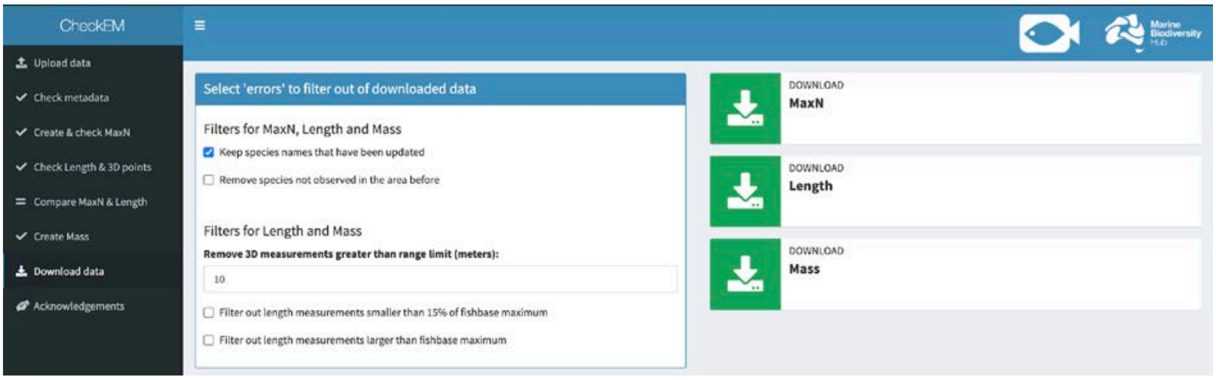


*Figure 14 Filter and download summary data.*

For biodiversity reporting or interactive plotting in 'Visualiser'.

## 2.8 Open-access code base

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

# 3. FEEDBACK FROM END-USERS

During the development of 'CheckEM' feedback was sought from key end-users (Table 1). All suggestions were either actioned by the development team or proposed for future development priorities.

*Table 1 Feedback from end users*

| End-user | Feature | Suggestion | Action |
|---|---|---|---|
| DBCA-Marine Science | Check metadata | Can it flag points that fall on the land? | That would be slow due to shapefile loading speed. Suggest you zoom in and have a look. |
| DBCA-Marine Science | Create and check count (MaxN) | Can the 'species not previously observed in the bioregion" also include the sample names? | Done. |
| NSW DPI-Marine Science | All plots | A 'quick save to PDF' would be useful. | Suggest you use your browser zoom (i.e. 'Ctrl' & '+') to size the plot and take a screen shot. |
| SA DEW-Marine Science | All checks | An overarching summary of all errors with sample number as a quick reference for checking the image annotations. | Great idea but will require further development. |

# 4. CONCLUSION

The ‘GlobalArchive-CheckEM’ workflow provides an example of how data must be validated and quality controlled before they can be useful and reliable for biodiversity reporting.

Data validation, quality control and interoperability of spatial data are key to enable data discovery and re-use for biodiversity reporting and science communication. This was raised as a major challenge by a previous Marine Biodiversity Hub workshop on Map-Based Portals for Marine Science Communication and Discovery (Langlois et al. 2020b). Without robust quality control and interoperability of this information data discovery and re-use is likely to be limited, and data will not meet Findable Accessible Interoperable Reproducible (FAIR) standards (Wilkinson et al. 2016). Existing best practice (Langlois et al. 2020a) calls for the review of any annotations by expert fish biologists and ecologists. Despite this best practice, an existing synthesis of Australian stereo-BRUV data has found a range of common errors (Harvey, E. S. and others n.d.), that CheckEM has been designed to check and validate published life-history and occurrence information.

Robust and easily-applied forms of data validation have been suggested to be key to enable data synthesis for marine park or ecosystem based reporting (Langlois et al. 2020a). We propose that the Seamap Australia workflow and ‘GlobalArchive-CheckEM’ provide exemplar case-studies of data validation. The ‘GlobalArchive-CheckEM’ workflow presented here has not yet contributed to any published large scale synthesis, but we suggest that all management agencies using stereo-video fish and shark data should take advantage of the CheckEM workflows provide a further validation check of their data.

# 5. RECOMMENDATIONS

We propose 'GlobalArchive-CheckEM' should be adopted as a standard by all data end-users of fish and shark annotation data conducted using EventMeasure software, and that management agencies commissioning or conducting stereo-video sampling should require data sets to be validated using CheckEM.

We propose that 'GlobalArchive-CheckEM' should be expanded to operate on data from other annotation software.

We propose that feedback should be sought from end-users of the service provided by 'GlobalArchive-CheckEM', and GlobalArchive itself, to provide refinement and an assessment of uptake, use and impact of these services.

We also reaffirm that the manual review of stereo-video annotation data by experienced fish biologists and video analysts is always essential and will not be replaced by CheckEM workflows.

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# APPENDIX 1

**Marine Imagery Discoverability & Accessibility Recommendations**
Developed at preceding Marine Imagery Discoverability & Accessibility workshops from 2018 and 2019 and workshop on Map-Based Portals for Marine Science Communication and Discovery.

**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) |

| | Task |
|---|---|
| 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. Bottlenecks | 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) |
| | 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 |

| | Task |
|---|---|
| | 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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