



National Environmental Science Programme

Data Discoverability and Accessibility

Report from July 2019 Workshop on Marine Imagery

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

Milestone 33 – Research Plan v5 (2019)



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EXECUTIVE SUMMARY

There are increasing incentives for marine researchers to share their data, but the will of the marine community to share data has often not yet caught up with our capabilities. Marine imagery and associated annotation, for example, can be collected and analysed with various gear and digital platforms, and there is a large body of legacy imagery and an increasing rate of image collection due to technological advances. As the volume of marine imagery grows, so has the need to establish a national workflow for making it discoverable and accessible. To meet this need, a series of workshops on data discoverability and accessibility were coordinated by the NESP Marine Hub in 2018 and 2019. This report focuses on the *Marine Imagery Discoverability & Accessibility Workshop II* held on 25 July 2019 at CSIRO, Hobart. The overarching aim of the 2019 marine imagery workshop was to 1) assess the progress made in the past year regarding the discoverability and accessibility of marine imagery and 2) to refine the 2018 recommendations to specify priority, feasibility, and responsibility.

The workshop included a range of presentations, activities, and discussions designed to shift participants' thinking to end users, rather than their own perspectives based on their roles in the marine imagery pipeline. Workshop participants identified the top five barriers to making marine imagery discoverable and accessible:

- Limited institutional support or long-term funding for some digital platforms,
- Lack of a centralised image and annotation repository or tracking system to ensure FAIR (findable, accessible, interoperable, reusable) data,
- No governance or oversight for the entire marine imagery community,
- Bottlenecks during processing, imagery upload, and annotation in digital platforms,
- Limited communication between major Australian marine imagery groups.

For each of the challenges, a set of revised recommendations and actions was developed. The highest-priority actions were to 1) establish a governance body or oversight group to provide broad strategic direction as related to the general marine science community, and 2) establish an ongoing marine imagery node to develop a national workflow to ensure the discoverability and accessibility of marine imagery (i.e. progress the actions listed in the current report). All other recommendations listed in this report are underpinned by the establishment, operation, and collaboration between an oversight group and an implementation group.

Importantly, marine imagery and annotation are means to an end, and the primary focus needs to be on understanding and meeting requirements for science and management, not on the sampling gear or digital platforms themselves. There appears much to be gained by AIMS and the IMOS community (which includes AIMS) working closely together to ensure that workflows and infrastructures across their initiatives (e.g. Squidle+, Benthobox/ReefCloud) are compatible and interoperable as required.

It is now evident that marine imagery acquisition and annotation, for still and video and for both mono and stereo imagery, is reaching a level of maturity within Australia that would benefit from a more facilitated national approach. The recommendations listed in this report provide such a way forward, but they will require sustained effort and drive to progress, at both the individual and organisational level.

1. INTRODUCTION

1.1 Background

The FAIR principles state that data should be findable, accessible, interoperable, and reusable (Wilkinson et al. 2016). These principles are often used in parallel with what has been coined ‘open data’, although there are some differences, namely that open data are accessible to everyone while FAIR data are not necessarily so. There are increasing incentives for marine researchers to share their data, with many funding bodies and research institutions now requiring that all collected data is publicly accessible, unless a strong justification can be made otherwise. Data sharing enables large scale synthesis, at a scale that no individual research group could sample, thereby facilitating biodiversity reporting at national and international scales (e.g. GlobalFinPrint Project). Increasingly, the FAIR data principles are considered a requirement to contribute to the growing global monitoring network. In addition, FAIR data and open data may benefit researchers by increasing citations, media attention, collaborations, jobs and funding opportunities through the development of large-scale and impactful data synthesis (McKiernan et al. 2016).

Despite these noble intentions, the will of the marine community to share data has often not yet caught up with our capabilities, with the notable exception of datasets provided by IMOS and the AODN. For example, marine imagery has long been collected with various sampling gear and analysed or curated with various digital platforms to understand the habitat, communities, and species in our oceans (Table 1). We have a large body of legacy imagery and an increasing rate of image collection due to advances in technology, including data storage, robotics, and camera systems. As the volume of marine imagery grows, so too has the need to establish a national workflow for making it discoverable and accessible.

Table 1 The main imagery sampling gear and targeted habitat, communities, and species covered in the 2018 and 2019 Data Discoverability and Accessibility Workshops

Gear	Habitat, communities, and species
<ul style="list-style-type: none"> • Diver operated still and video • Towed Video • Remotely Operated vehicle (ROV) • Autonomous Underwater Vehicle (AUV) • Baited Remote Underwater Video (BRUV) 	<ul style="list-style-type: none"> • Fishes • Mobile invertebrates • Coral (soft and hard) • Kelp and other large macroalgae • Seagrass/Algae • Sponge • Rocky Reef • Canyon • Seamount

The need for a national workflow for imagery became particularly obvious to many marine scientists with the release of a package of field manuals by the NESP Marine Biodiversity Hub in early 2018 which aimed to promote national standard operating procedures (SOPs) for

marine monitoring (Przeslawski et al 2019a, www.nespmarine.edu.au/field-manuals). In developing the 'Data Release' section of each field manual, we were unable to advocate a national standard for data release for many data types including marine imagery and annotation because we either do not yet have suitable digital infrastructure or links between existing infrastructure are not clear.

1.2 2018 Workshops

To meet this need, two workshops on data discoverability and accessibility were coordinated by the NESP Marine Hub in September 2018: one focussed on biological specimen data and the other on marine imagery. Participants briefly characterised their respective agency's data holdings, described current and ideal workflows, and identified key challenges and recommendations to help make marine imagery and annotations discoverable and accessible.

The 2018 marine imagery workshop found that the major challenges for making data discoverable and accessible are related to digital platforms for data storage, annotation, and visualisation. Specific barriers include: i) poorly defined characteristics and linkages between existing digital platforms for marine imagery annotation which results in confusion over which digital platforms should be used, and ii) lack of optimised and FAIR workflows for these digital platforms. Although some organisations within the Australian marine community are attempting to address these issues, the geographic focus of these organisations (i.e. tropical and temperate) mean that several groups are undertaking similar but independent initiatives. The workshop report identified an opportunity for these groups to collaborate and to develop a clear national standard and workflow for marine imagery and annotation with the end goal of an open national library of both still and video imagery and annotations from mono and stereo systems that could be applied to a range of research questions and management needs.

The full report for the 2018 data discoverability and accessibility workshops can be found in [Przeslawski et al 2019b](#).

1.3 2019 Workshop

A follow-up workshop (*Marine Imagery Discoverability & Accessibility 2019*) was planned for 25 July 2019, the day after a workshop on spatial portals (*Map-based Portals for Marine Science Communication and Discovery*). There was some coordination among workshop leaders, but each workshop was separately managed with a discrete report.

The overarching aim of the 2019 marine imagery workshop was to 1) assess the progress made in the past year regarding the discoverability and accessibility of marine imagery and annotation and 2) to refine the 2018 recommendations to specify priority, feasibility, and responsibility. We didn't attempt to drill down to technical detail or focus on individual gear or digital platforms; these will need to be done with follow-up proposals and activities.

The workshop began with several presentations on the progress of key agencies and programs regarding marine imagery and annotation over the past year. Workshop participants then broke

up into groups to discuss different user cases related to marine imagery and annotation (Figure 1, left). After this activity, participants discussed the key challenges defined in the 2018 workshops and voted on the top five challenges (Figure 1, right). These were then used in the afternoon session to refine the 2018 list of recommendations, including action items. Throughout the workshop, participants were encouraged to provide input to two online documents: one addressing challenging questions and potential sticking points and another articulating current recommendations regarding marine imagery. These documents were later integrated into the current report in Sections 4 and Section 5, respectively. More details on the workshop format can be found in the Agenda in Appendix A.

1.4 Terminology

Throughout this report, **data discoverability** refers to whether a particular dataset or associated meta data is findable as defined by the FAIR principles, such as its inclusion in a known spatial portal that allows a user to search a region of interest (e.g. Australian Ocean Data Network). **Data accessibility** refers to the actual dataset itself (not just the meta data) being available to the public. This may include direct inclusion or links to spatial portals or a standalone collection. It does not include datasets available only upon request to an individual or agency.

Marine imagery is used in its broadest definition to refer to all information or data directly collected or extracted from marine sampling gear. This includes raw images (i.e. as collected), processed image files (i.e. after image QA/QC), annotations (i.e. extracted data from individual images), and annotation summaries (i.e. pooled data (e.g. averages) from annotations).

To describe the various collection and analysis methods involved in the marine imagery workflow, **gear** refers to equipment used for collection of raw images (e.g. BRUV, AUV, Towed video) while **digital platform** describes the software or digital infrastructure used to store or process marine imagery, annotate raw or processed images, or visualise meta data.



Figure 1: Workshop participants in break-out groups (left) and voting on key challenges (right)

2. PROGRESS SINCE 2018 WORKSHOPS

The goal of the morning presentations was to describe the progress made in the year since the original 2018 workshops. For descriptions of key marine imagery agencies and programs refer to the 2018 workshop report (Przeslawski et al 2018). Figure 2 shows a general summary of the main gear and habitats targeted by the major agencies that acquire marine imagery.

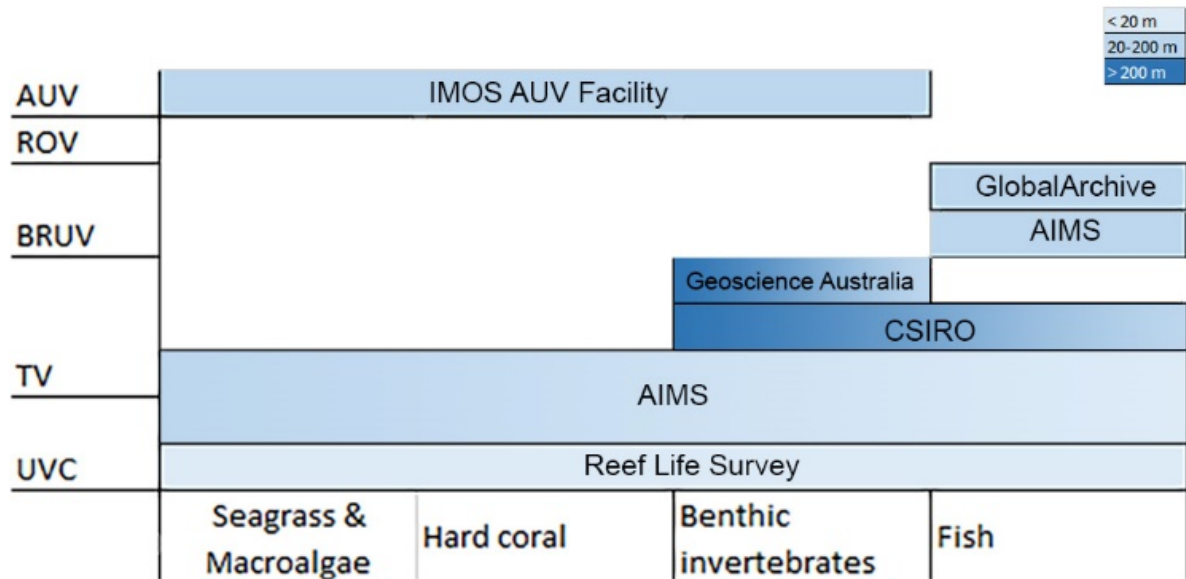


Figure 2 The focus areas of key organisations and programs that acquire and manage marine imagery at a national scale. Focus areas include imagery sampling gear (left axis) and Essential Ocean Variable (horizontal axis). This is a generalisation based on current operating practices and does not reflect full or future capability (e.g. GlobalArchive and IMOS AUV can include deep-sea data, but there is currently very little of such data from BRUVs and AUVs), nor state-based programs (e.g. NSW OEH seabed mapping program).

2.1 FAIR data principles and case study

Alan Williams (CSIRO) provided an overview of the FAIR data principles based on his recent presentation at the international Marine Imagery Workshop in Canada. He used a 2018 survey of deep-sea Tasmanian seamounts as a case study to explore data issues with towed imagery, particularly poorly defined workflows and poor data discoverability. He described a summary of a FAIR self-assessment using a deep-sea towed camera survey, which had good findability, conditional accessibility, and reasonable interoperability and reusability. Alan identified some ways of addressing issues and improving discoverability and accessibility to deep-sea data (and improved metadata for provenance).

2.2 IMOS and AODN update

Cameron Moloney (AODN) summarised the steps in publishing data to the AODN and described the current data workflows for the IMOS-AUV facility, including the limited access to

annotated data. As of July 2019, the AODN hosts 246 dataset collections and 12462 metadata records. Although these are dominated by IMOS data, the Marine Research Data Cloud project has improved links for better data integration with other organisations. Cameron described the national service for the underwater imagery project, including the proposed conceptual workflow for marine imagery. He summarised a list of challenges including the practicality of combining annotations from many sources, what user case are we trying to achieve, and the storage of raw and processed images. He also identified the need to embrace diversity while developing standards for outputs from various annotation systems.

2.3 Understanding Marine Imagery (UMI) Proposal

Stefan Williams (USyd) described the current IMOS-AUV facility, including an archive of 5 million seafloor images, the Integrated Benthic Monitoring Program (2018-22), and scientific outputs. He then summarised a proposed infrastructure for Understanding Marine Imagery (UMI), including existing infrastructure (e.g. Squidle+), planned activities, system architecture and workflow. The project would require a developer, data engineer, on-going user support, and a project benthic ecologist, as well as co-investment. Stefan also gave an overview of the national automated UMI (NAUMI) and developments in machine learning. He concluded by identifying the opportunity to develop the infrastructure needed to address national imagery workflow.

2.4 GlobalArchive

Tim Langlois (UWA) highlighted how GlobalArchive was designed to improve the application of FAIR principles to video annotation of mobile fauna. GlobalArchive is currently being used to synthesise Australian stereo and mono BRUV data, but is also being used to manage stereo-video data from diver operated video (DOV) and ROV. Tim described the development of the new SyncTool workflow which was developed via the Marine RDC and has improved the FAIR principles self-assessment score for stereo-video data, and in particular stereo-BRUVs. A GlobalArchive steering committee has been formed with representatives from research institutions and with representatives from a range of State and Commonwealth organisations. GlobalArchive is ready to spread the workflows it has developed to the fish and mobile fauna video annotation community nationally and internationally.

2.5 State program case study

Alan Jordan (NSW-DPI) provided an overview of the NSW marine mapping and monitoring program which taps into various data management and storage facilities. This includes a BRUVs program that feeds into GlobalArchive (490 reef BRUVs drops) with data currently stored on NAS drives; AUV surveys accessible through IMOS; historical towed video data that's not publicly accessible; recent ROV and towed imagery and annotations currently stored locally; and threatened and protected species (grey nurse sharks & black cod) data currently stored on NAS drives. Ongoing challenges include prioritisation of legacy towed video data, implementation of data management workflows for core funded projects, archiving of BRUV

video files, lack of capacity to manage data delivery in a non-scientific based agency (scientist represent 1.8% of staff), and the poor use of marine imagery in communication and engagement material.

2.6 Benthobox and ReefCloud

Mat Wyatt (AIMS) gave an update on work from the AIMS related to analysing BRUVS, diver-operated imagery, and towed imagery. They adopt a 5-point annotation approach, using deep learning algorithms for coral classification. Millions of images are fed into the machine-learning algorithms. Imagery data from some sites are now processed in an automated workflow, allowing rapid reporting of hard coral cover for change detection. Codes have been developed that are semi-resistant to movement of species labels on the taxonomic tree. Benthobox is the public face of this work. Mat summarised insights and learnings, and said they are now quantifying error and moving towards finer scale automation: ReefCloud is a public open source aggregation of shared annotated data. Bayesian modelling allows for integration of disparate datasets and development of reliable coral cover estimates. Funded by DFAT and working with Palau and Fiji, ReefCloud aligns with AIMS marine strategy and the Global Coral Reef Monitoring network.

3. USER CASE STUDIES

To keep the focus on the end use cases that require marine imagery to be discoverable and accessible, break-out sessions were held in which each group was assigned a particular use case and asked to present potential solutions to the main group. Case studies were developed by the workshop coordinator and Parks Australia as follows:

1. A PhD student has collected time-series towed and drop cam imagery from several locations over two years. Where does she put the images so they're discoverable and accessible?
[i.e. Where should the images go?]
2. A marine manager wants to understand fish community changes in a marine park. How can she access data summaries based on imagery annotations (e.g. species abundance and length summaries for a set location and time period)?
[i.e. How can data summaries from image annotations be produced?]
3. An energy company is submitting an Environmental Plan for petroleum exploration activity. They want to know the location of all imagery previously collected in their proposed area of activity. How do they find this information?
[i.e. How can you access imagery meta-data for a defined spatial area?]
4. An ecologist annotating deep-sea imagery wants to see images from particular taxa to aide in their own annotations and species identifications. How does he access multiple images of the same taxon?
[i.e. How do we link annotations, particularly species identifications, back to original images and make this searchable?]
5. A communications officer wants to be able to quickly find a range of high quality habitat and species images from a particular marine park for use in an article. She wants to be confident that the images come from that location, what the image shows (i.e. suitable caption), and the credits.
[i.e. How do we store and search for images with appropriate meta-data for communication purposes?]

Importantly, most of the user case studies didn't have straightforward solutions. The main intent for this activity was to shift participants' thinking to end users, rather than their own perspectives based on their roles in the marine imagery pipeline.

4. KEY CHALLENGES

Workshop participants were each given three votes to determine which of the challenges identified in the 2018 workshop they thought were most important to resolve. We then focussed the remainder of the workshop on the top five challenges (Table 2) and recommendations to address them (Section 5).

Table 2 The top five challenges (in bold) to making marine imagery data discoverable and accessible, as voted by workshop participants

<i>Challenge [from 2018 workshop]</i>	<i>Number of Votes [from 2019 workshop]</i>
Limited institutional support or long-term funding for some digital platforms	20
No centralised image repository or tracking system	17
No governance or oversight for entire marine imagery community	15
Bottlenecks during processing, imagery upload, and annotation on digital platforms	11
Limited communication between Australian marine imagery groups	9
Difficulties mapping between annotation methods of between classification schemes	6
Few or unclear incentives to change the current paradigm	6
No clear workflow to accurately capture and upload meta data for many marine imagery types	4
No champions for some imagery gear and data types and no one to drive national synthesis	1
Poorly defined links and characteristics between existing digital platforms	0

In addition, participants were asked to contribute to an online questionnaire about potential sticking points. These questions (*italics*) and responses (normal text) are summarised below:

Where should universities, private consultants and others without an agency-specific repository upload their imagery and annotations?

Responses:

- Repositories for annotations exist, with Global Archive hosting BRUV annotations and Squidle+ able to store annotations from other imagery gear including AUVs and towed videos. However, we still need clear national workflows and justifications for people to use a given repository and follow FAIR principles.
- There are still no national repositories for imagery itself, although many individuals and institutions are making their imagery and annotations available through agency-specific systems. However, there are still some exceptions (e.g. much of AIMS Long-Term Monitoring Program imagery and annotations are not accessible).

- Ideally, all national and established repositories will have long-term security for data, with possible certification.

What do we do about the vast amounts of legacy data out there (e.g. Figure 3) particularly with towed video? Is this a lost cause?

Responses:

- There were conflicting initial discussions about the need to prioritise legacy data. Some workshop attendees thought this was a rich source of historical baselines with potential to contribute to large spatiotemporal coverages, and as such it should be prioritised. It was also noted that data at risk of being lost should be protected (e.g. punch card data), possibly through a new designated capability to digitise legacy data and make it discoverable. Others thought that effort should be expended developing digital infrastructure and ensuring its uptake for recent and newly acquired data. All agreed that we shouldn't create tomorrow's legacy today.
- Ultimately, most workshop attendees agreed that if there's no management or research need, then we shouldn't bother investing in legacy data. However, this clearly requires guidance from management and policy to inform what's actually needed to be compared with resourcing (e.g. legacy data may be more important in areas with access limitations, e.g. sanctuary zones or deep-sea locations). Regardless, we need appropriate and georeferenced meta data such that it could be included in the AODN. Users could then track down legacy data as needed.

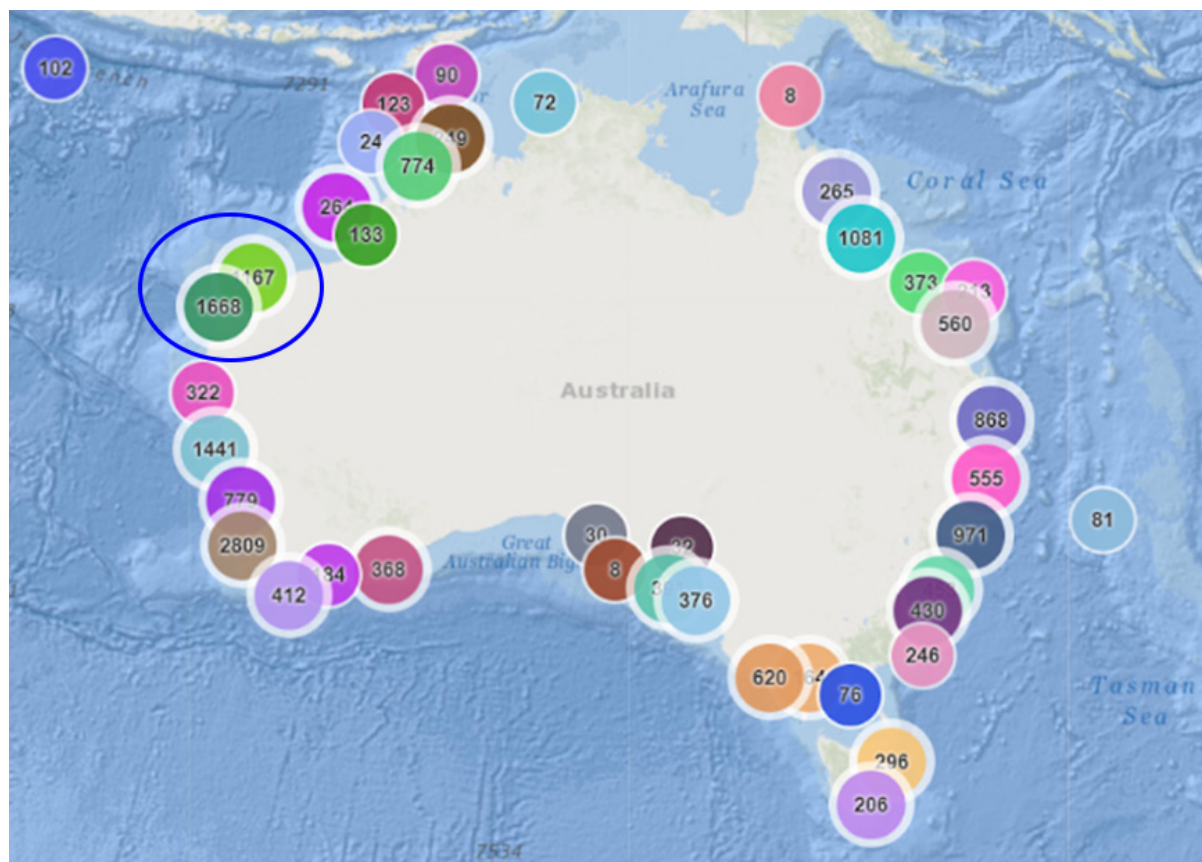


Figure 3 Locations of BRUV legacy imagery. With the exception of the two campaigns circled in blue, all other datasets are not currently in a national repository. Taken from GlobalArchive.

How do we work towards nationally collatable and comparable benthic image annotations for key datasets (e.g. reef imagery from AIMS Long Term Monitoring Program and Reef Life Survey)?

Response:

- Each program has its own method for annotation used for years to detect trends, and it is not realistic to expect one program to adopt the methods of the other, thereby negating the historical value of their data. Rather, it may be more realistic to accept regional or program-specific SOPs for annotation. Projects that require a national scale would then be required to either i) re-annotate images from one program using the method from another, or ii) apply an appropriate statistical method to account for variation in the different annotation methods. A statistical adjustment approach will require appropriate information within the data to estimate the relevant difference between the annotation schemes. Statistical adjustments also require assumptions and therefore could be seen as an inferior approach.
- Regardless, the images and annotations from each program should be made publicly accessible so that these national-scale projects integrating data from multiple programs

are feasible. If annotations and associated x-y-coordinates of the image annotation-points are publicly accessible, the need to re-annotate full images is greatly reduced. While methods to collect the data might still differ, at least the annotation libraries can then be used to compare labels between programs.

What are the intended links or collaboration between UMI proposal and Reef Cloud (DFAT + AIMS), as there seems to be high levels of overlap?

Responses:

- These are currently unknown since Reef Cloud is just starting, and UMI is unfunded. As such, this is the perfect time to discuss links and complementary approaches.
- Some attendees suggested that ReefCloud is initially focused on a specific user case (e.g. eAtlas), while UMI and its constituents (Squidle+) have a national focus.

Where is funding best directed to refine a national workflow that enables collectors of marine imagery to easily abide by the FAIR data principles?

Response:

- Some attendees suggested that UMI is essential to advance the national program development and integration, including support for sharing of national morphospecies image collections and codes. However, there is significant opportunity to share some components (e.g. Synch tools) and develop a common architecture.

What else can we can do to get industry to share their marine imagery and other data?

Response:

- It was agreed that we need to get our own house in order before we approach industry, as they will require a clear and functional workflow. Once this is done, we lead by example and articulate the incentives, particularly that this will ultimately save time and money and work towards shared blue economy goals to conserve biodiversity and sustainable economies of scale.

5. UPDATED RECOMMENDATIONS

Appendix B summarises the current status of the recommendations from the 2018 workshop. None of these original recommendations were initially assigned responsibility by an individual or agency so any progression is based on independent actions outside of the workshop series.

One of the goals of the 2019 workshop was to refine those original recommendations associated with the key challenges identified in Section 0 and develop new ones as needed. We particularly wanted more tangible actions, and these are detailed in the current section based on discussions at the workshop and subsequent contributions to an online document listing recommendations. Recommendations are grouped below by five key challenges, such that a researcher or organisation could concentrate their efforts on a given issue(s) (e.g. in a funding proposal).

For ease of use, we have also compiled these updated recommendations into a single table in Appendix C.

CHALLENGE: There is a lack of governance and focused working group(s)

Previous Recommendation

- Identify existing groups (e.g. IMOS Benthic Monitoring Group, NMSC Baselines WG) to support funding proposals, revisit Terms of Reference, and develop a strategy document for moving forward as a united community (vision, communicate value, risk and mitigation, funding).

Current Status

This recommendation has not progressed since the 2018 workshop and is associated with ***the most immediate actions in order to progress the other recommendations made in this report***. There is a strong need for governance and oversight, particularly since the NESP Marine Hub has no immediate plans to coordinate subsequent workshops on marine imagery or take long-term custodianship of marine imagery data accessibility.

Importantly, there are existing groups that could form an oversight group and implement plans and recommendations (e.g. IMOS Benthic Monitoring Group, NMSC Baselines WG), but their Terms of Reference and objectives may need to be expanded or shifted to clearly identify accessibility of marine imagery as a focal point in a gear-agnostic manner.

Revised recommendations are listed in Table 3Table 3.

Table 3 Revised recommendations and actions based on the challenge of lack of governance and focussed working group(s)

Task	Responsibility	Timeframe
Present to NMSC on state of Australian marine imagery data	NESP Marine Hub workshop coordinator	Mid 2020
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.	NMSC (or relevant working group) Chair	Mid 2020
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	NMSC (or relevant working group) Chair	Late 2020
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.	NMSC (or relevant working group) Chair	Late 2020
Develop and apply communication strategy between implementation group (e.g. marine imagery collective) and oversight group (e.g. NMSC)*	NMSC, marine imagery collective	Early 2021
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	NESP D2 project leaders, future NESP theme leaders	Early 2020 (version 2), ongoing (version 3+)
Continue to promote field SOPs and data standards	All Australian organisations, individuals, and committees related to marine science	Ongoing

* This recommendation is shared with another challenge (Table 4)

CHALLENGE: There is limited long-term support or institutional backing for some digital platforms

Previous Recommendation

- Scope a marine imagery collective and links to high level committees (NMSC) through to researchers and end-users to inform funding priorities. Potential funders are IMOS/AODN, government and universities (GA, CSIRO, UTAS, AIMS), ARC LIEF, SOI, Industry Partners (e.g. APPEA).

Current Status

This recommendation has not progressed since the 2018 workshop. The 2018 and 2019 workshops have assembled an expert group of marine imagery users familiar with the diverse needs of the marine science community, and the time has come to formalise this consortium in a gear- and platform-agnostic manner. This group can then inform an oversight committee who will be responsible for long-term strategic guidance (and enforcement) of activities (see challenge on governance below).

Revised recommendations are listed in Table 4.

Table 4 Revised recommendations and actions based on the challenge of limited long-term support or institutional backing

Task	Responsibility	Timeframe
Develop a transparent prioritisation of preferred funding priorities, as informed by this report, 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.	NMSC Baselines Working Group, IMOS Benthic Monitoring Group	Mid 2020
Encourage larger partners in the collective provide contributions to base funding to ensure resilience and demonstrate buy-in	Marine imagery collective leader	2021
Ensure successful funding proposals address multiple recommendations in this report	IMOS, ARDC, ARC and other funding agencies	Ongoing
Develop and apply communication strategy between implementation group (e.g. marine imagery collective) and oversight group (e.g. NMSC)*	NMSC, marine imagery collective	Early 2021

* This recommendation is shared with another challenge (Table 3)

CHALLENGE: There is a lack of a centralised marine imagery repository and tracking system; meaning some data may not be able to be harvested by data aggregators, whereas other data may have multiple copies;

Previous Recommendations

- Provide a framework within which meta data, including version history, can be formally compiled, characterised, and visualised.
- Apply this framework to characterise marine imagery holdings for major institutions and gear.
- Explore the possibility of a permanent marine imagery repository (including backups and security/sharing) with ARDC and other major agencies.
- Apply a data citation system (e.g. DOI) to facilitate tracking of data usage in any such image repository, as this would increase uptake by recognising contributors for their input to the repository.

Current Status

Some of these recommendations have been explored in agency-specific projects (e.g. Reef Cloud) and funding proposals (e.g. UMI), but have not yet progressed in an open and nationally supported manner. Free online storage and streaming are available for images and video through platforms like Google pics, or YouTube, but these are risky for the archival of national resources because there is no guarantee of their longevity or policies.

The revised recommendations and actions below depend in large part on the establishment of a marine imagery collective, including an identified leader to progress them.

Revised recommendations are listed in

Table 5.

Table 5 Revised recommendations and actions based on the challenge of lack of centralised imagery repository and tracking system

Task	Responsibility	Timeframe
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.	AODN	Late 2020
Use above framework to characterise current holdings and adapt organisational workflows to ensure appropriate meta data for marine imagery	Organisation leads in marine imagery	Early 2021
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).	Marine imagery collective leader, organisation leads in marine imagery	Early 2021

CHALLENGE: Bottlenecks exist during processing, imagery upload, and annotation on platforms

Previous Recommendations

- See points above regarding storage.
- Scope global solutions for large file size sharing, streaming, viewing, and access as related to Australian marine imagery (e.g. YouTube).
- Since the speed-of-access problem transcends marine imagery and likely applies to other data types (e.g. satellite imagery, bathymetry), NCRIS should be approached to see if they can develop a solution.

Current Status

There has been substantial progress on the major marine imagery platforms (GlobalArchive, Squidle+, Benthobox) in the past year. The most progress has arguably been made with Benthobox and the new Reef Cloud platform funded by DFAT to AIMS. However, this has been managed in-house, and broader connection with the marine science community remains limited, possibly due to the early stages of the project. As such, the bottlenecks and underdeveloped linkages remain broadly unchanged since the 2018 workshop (Figure 4).

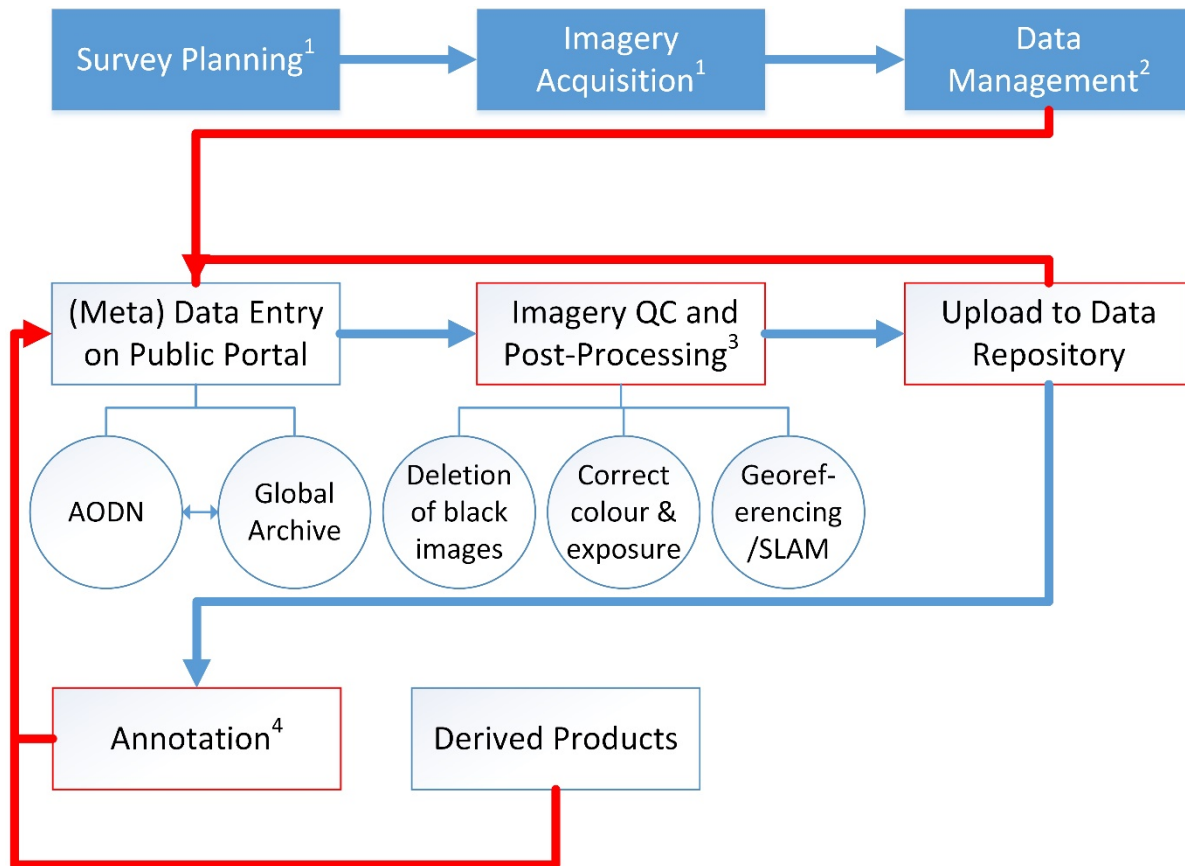
Notably, each collection platform (e.g. AUV, UVC, etc) and user group (e.g. indigenous rangers) have their own collection methods and set of issues that act as bottlenecks.

As mentioned above, free online sharing and streaming are available for imagery, but these are risky for the archival of national resources because there is no guarantee of their longevity or policies. A more prudent course of action is to explore options with NCRIS, as the issue of sharing and viewing large datasets is not exclusive to marine imagery (e.g. satellite imagery, bathymetry).

Revised recommendations are listed in Table 6.

Table 6 Revised recommendations and actions based on the challenge of bottlenecks

Task	Responsibility	Timeframe
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)	Principal Investigators	Ongoing
Prioritise funding proposals that address the bottlenecks and underdeveloped links shown in red in Figure 4.	IMOS, ARDC, ARC, other funding agencies	Ongoing
Meet with NCRIS to discuss speed-of-access issues with big data	Marine imagery collective leader	Late 2020
Develop workflows based on Figure 4 (including bottlenecks and undeveloped links) for each of the major imagery sampling gear (AUV, BRUV, Towed imagery, ROV, UVC/DOV).	Marine imagery collective leader	Late 2020



¹ Follows national SOPs in Przeslawski and Foster 2018

² Includes back-ups

³ Semi-automated or automated

⁴ Includes manual (e.g. Event Measure), semi-automated (e.g. Squidle+, Benthobox), and in-house (e.g. CSIRO) annotation platforms

Figure 4 A proposed workflow for general marine imagery from Przeslawski et al 2018, noting more detailed and tailored workflows are needed for specific gear. Blue boxes represent activities undertaken during the survey, and white boxes represent post-survey activities. Red boxes and lines indicate activities and linkages that require further development to achieve an effective national workflow.

CHALLENGE: There is limited communication and integration between the main Australian groups working on marine imagery data management and analysis;

Current Status

There has been good progress against these recommendations since the previous workshop, including the workshop upon which the current report is based which involved all the major organisations collecting marine imagery at a national or bioregional scale. There was an obvious intention and good will by participants to ensure their marine imagery abides by the FAIR principles. However, the translation of this individual intent to the broader organisation

remains unarticulated from some organisations; and the means to ensure this occurs remains uncertain.

Revised recommendations are listed in Table 7.

Table 7 Revised recommendations and actions based on the challenge of limited communication and collaboration.

Task	Responsibility	Timeframe
Develop workflows based on Figure 4 (including bottlenecks and undeveloped links) for each of the organisations listed in Figure 2.	Marine imagery collective leader, organisation leads in marine imagery	Late 2020
Hold annual meetings to ensure continued dialogue and collaboration	Marine imagery collective leader	Ongoing
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	Principal Investigators	Ongoing
Demonstrate how a funding proposal is gear- and platform-agnostic or clearly identify its association with a particular gear type (e.g. AUV).	Principal Investigators	Ongoing
Prioritise funding proposals that adopt a collaborative approach to develop marine imagery capability between the two main groups working on marine imagery in Australia (AIMS and the rest of IMOS community).	IMOS, ARDC, ARC, other funding agencies	Ongoing

During the course of the workshop, other valuable recommendations were made that weren't tied to the key challenges. These are details in Table 8 below.

Table 8 Recommendations and actions outside of the key challenges identified in the workshop

Task	Responsibility	Timeframe
Each organisation take responsibility for ensuring their data abides by FAIR principles, including funding, input, and support for infrastructure	CEOS, Directors, Lead Data Custodians of organisations collecting and using marine imagery	Ongoing
Scope the need, scale, and cost of digitising legacy data at risk of being lost (e.g. VHS imagery) through a new designated capability	Researchers working in organisations collecting and using marine imagery	2021
Funded projects should clearly identify the intended user of the proposed infrastructure or research, ideally addressing diverse end-user case studies (see Section Error! Reference source not found.).	Principal Investigators IMOS, ARDC, ARC, other funding agencies	Ongoing
Set targets 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.	CEOs and Directors of organisations collecting and using marine imagery Marine imagery collective NMSC	Early 2021

6. CONCLUSION

This second workshop on data discoverability and accessibility in marine imagery brought together the main researchers and users within Australia and helped us all to understand similarities and differences across marine imagery initiatives focused on different combinations of gear and digital platforms.

The following key points were made at the conclusion of the workshop:

- Seemingly simple user case scenarios are anything but simple. When developing digital infrastructure and workflows, the marine science community must keep these end user needs in mind.
- We need to prioritise efforts, collaborate to maximise efficiencies, and clearly communicate with those on the outskirts of the marine imagery community.
- We have a dynamic and enthusiastic community of marine imagery researchers and users. This will make possible the development of a national system to ensure FAIR marine imagery.

Importantly, marine imagery is a means to an end, and the primary focus needs to be on broader goals, such as understanding and meeting requirements for science and management, not on the gear or digital platforms themselves. There appears much to be gained by AIMS and the IMOS community (which includes AIMS) working closely together to ensure that workflows and infrastructures across these initiatives are compatible and interoperable as required.

There was a surge of activity to develop marine imagery infrastructure and research programs between the 2018 and 2019 Data Discoverability and Accessibility Workshops, particularly at the AIMS with the start of the Reef Cloud project and associated research on automation and deep learning for marine imagery. It is now evident that marine image analysis capability is reaching a level of maturity within Australia that would benefit from a more facilitated national approach. The recommendations listed in this report provide such a way forward, but they will require continued effort and drive to progress, at both the individual and organisational level. The next step should be to establish a marine imagery collective and its governance, perhaps as part of the Marine Baselines and Monitoring Working Group of the National Marine Science Committee.

REFERENCES

Przeslawski R, Foster S, Monk J, Barrett N, Bouchet P, Carroll A, Langlois T, Lucieer V, Williams J and Bax N. 2019. A Suite of Field Manuals for Marine Sampling to Monitor Australian Waters. *Frontiers of Marine Science* 6:177. doi: 10.3389/fmars.2019.00177.

Przeslawski R, Falkner I, Foster S, Mancini S, Bainbridge S, Bax N, Carroll A, Flukes E, Gonzalez-Riviero M, Langlois T, Moore K, Rehbein M, Tattersall K, Watts D, Williams A, Wyatt M. 2019b. Data Discoverability and Accessibility: Report from Workshops on Marine Imagery and Biological Specimen Data. Report to the National Environmental Science Program, Marine Biodiversity Hub. Geoscience Australia.

McKiernan EC, Bourne PE, Brown CT, Buck S, Kenall A, Lin J, McDougall D, Nosek BA, Ram K, Soderberg CK, Spies JR, Thaney K, Updegrave A, Woo KH, and Yarkoni T. 2016. How open science helps researchers succeed. *eLife* 5:e16800.

Wilkinson MD., Dumontier M, Aalbersberg IJ, Appleton G, Axton M, Baak A, Blomberg N, Boiten J-W, da Silva Santos LB, Bourne PE, Bouwman J, Brookes AJ, Clark T, Crosas M, Dillo I, Dumon O, Edmunds S, Evelo CT, Finkers R, Gonzalez-Beltran A, Gray AJG, P. Groth P, Goble C, Grethe JS, Heringa J, 't Hoen PAC, Hooft R, Kuhn T, Kok R, Kok J, Lusher SJ, Martone ME, Mons A, Packer AL, Persson B, Rocca-Serra P, Roos M, van Schaik R, Sansone S-A, Schultes E, Sengstag T, Slater T, Strawn G, Swertz MA, Thompson M, van der Lei J, van Mulligen E, Velterop J, Waagmeester A, Wittenburg P, Wolstencroft K, Zhao J, and Mons B. 2016. The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data* 3:160018.

APPENDIX A – AGENDA & PARTICIPANTS

Marine Imagery Discoverability & Accessibility Workshop II
25 July 2019
CSIRO Auditorium, Hobart TAS

Objective: The aim of the workshop is to 1) assess the progress made in the past year regarding the discoverability and accessibility of marine imagery and 2) to refine the 2018 recommendations to specify priority, feasibility, and responsibility.

9:00	Workshop opening and introductions		Rachel Przeslawski
9:15	Purpose and scope of workshop		Rachel Przeslawski
9:30	Current developments		
	9:30	FAIR data principles and case study	Alan Williams
	9:45	IMOS / AODN update	Cameron Moloney
	10:00	UMI / AUV update	Stefan Williams
	10:15	GlobalArchive update	Tim Langlois
10:30	MORNING TEA		
	11:00	NSW mapping and marine imagery	Alan Jordan
	11:15	Benthobox and Reef Cloud update from AIMS	Matt Wyatt
11:30	Marine imagery – a user perspective [discussion/activity]		Rachel Przeslawski Cath Samson
12:15	Revisiting the 2018 challenges and recommendations		Rachel Przeslawski
12:45	LUNCH		
13:30	Update the key challenges		All
14:00	Assess recommendations [individual]		All
14:15	Assess recommendations [group]		All
14:45	Present group assessment of recommendations		All
15:15	AFTERNOON TEA		
15:45	Refine recommendations		All
16:45	Where to from here?		Rachel Przeslawski
17:00	Close of workshop		

PARTICIPANTS	ORGANISATION
Alan Jordan	NSW DPI
Alan Williams	CSIRO
Andrew Carroll	GA
Ari Friedman	Grey Bits
Brooke Gibbons	UWA
	Parks Australia
Chris Jackett	CSIRO
David Miller	SA DEW
Donna Audas	GBRMPA
Eric Lawrey	AIMS
Franzis Althaus	CSIRO
Indi Hodgson-Johnston	IMOS
Jacqui Pocklington	Parks Victoria
Jacquomo Monk	UTAS
Jan Jensen	UTAS
Julia Martin	ARDC
Katherine Tattersall	CSIRO
Mark Rehbein	AIMS
Mat Wyatt	AIMS
Narissa Bax	CSIRO
Nev Barrett	UTAS
Nic Bax	NESP
Pamela Brodie	CSIRO
Paul Hedge	NESP
Peter Walsh	UTAS
Rachel Przeslawski	GA
Rick Stuart-Smith	UTAS
Roger Beeden	GBRMPA
Scott Foster	CSIRO
	Parks Australia
Tim Langlois	UWA
Tim Moltmann	IMOS
Vanessa Lucieer	UTAS

APPENDIX B – STATUS OF 2018 RECOMMENDATIONS

The status of recommendations made from the 2018 marine imagery discoverability and accessibility workshop. These have now been refined into more tangible actions focussed around five key challenges (Section • of main report).

2018 Recommendation	Status in 2019
Hold a follow-up workshop on marine imagery data in 2019 with key staff from institutions with major marine imagery collections.	Completed
Document the workflows from each group, as well as their bottlenecks and internal challenges. Identify differences in these workflows and assess whether these would affect marine imagery as nationally collatable and comparable data.	In progress
Incorporate appropriate workflows into the NESP SOPs through the next version of the towed imagery, AUV, BRUV, and ROV field manuals.	In progress, due for release in early 2020
Promote data-sharing best practice (FAIR).	Ongoing
Consider AusSeabed and similar initiatives as models for partnering between institutions to integrate data.	Complete, currently no funding or institutional support for such a program
Focus on improving consistency in annotation data and metadata rather than the gear and platforms themselves	Ongoing

2018 Recommendation	Status in 2019
Develop an infographic to articulate current digital platforms for marine data	In progress, due for release in late 2019
Provide a framework within which meta data, including version history, can be formally compiled, characterised, and visualised.	No progress
Apply this framework to characterise marine imagery holdings for major institutions and gear	No progress
Explore the possibility of a permanent marine imagery repository (including backups and security/sharing) with ARDC and other major agencies.	In progress, addressed at 2019 workshop
Scope global solutions for large file size sharing, streaming, viewing, and access as related to Australian marine imagery (e.g. YouTube).	No progress
Since the speed-of-access problem transcends marine imagery and likely applies to other data types (e.g. satellite imagery, bathymetry), NCRIS should be approached to see if they can develop a solution.	No progress
Conduct a census of current annotation methods and schemes in relation to their purposes, including an online survey to gauge level of data quality, QA/QC methods, extent (spatial/temporal), biological resolution needed and applied	No progress, could be undertaken as part of CATAMI update
Scope the adoption of a framework (e.g. software system) that allows the marine imagery community to cross-walk between schemes. It is important to facilitate mapping between CATAMI and other annotation schemes, as it seems unlikely that a single annotation system will be applied by everyone.	No progress

2018 Recommendation	Status in 2019
Revisit and update the CATAMI national classification scheme, including morphospecies catalogue, including the development of a shared morphospecies library for national standardisation, all to be managed by a technical working group.	No progress
Identify international initiatives in this space.	Ongoing
Propose a national standard for QA/QC of marine imagery, including quantification of observer bias in annotations	In progress, due for release in early 2020
Encourage scoring of imagery at the finest level possible so it can map up to all schemes (refer to NESP SOPs)	Ongoing
Scope a marine imagery collective (e.g. IMOS marine imagery node) and links to high level committees (NMSC) through to researchers and end-users to inform funding priorities	Ongoing
Standardise metadata, preferably using automated software to reduce human error and to increase efficiency. Develop a semi-automated process to reduce scoping time and human errors (ideas from Robotic Process Automation may apply). For example, semi- automated in-fill process to populate metadata.	In progress by AODN, but no progress on automation
Enforce meta data standards (e.g. via permits or through vessel systems).	No progress
Update next version of NESP field manuals to define minimum requirements for metadata (reduce prescriptiveness), ensure consistent formats and vocabularies (define), establish working groups by gear to develop standards and ensure uptake and compliance.	In progress, due for release in early 2020

2018 Recommendation	Status in 2019
Compile a list of common requirements across these gear nad platforms to inform the design of tools that will support marine imaging around the country (data upload, storage, annotation, etc.)	Completed in 2019 workshop
Identify champion(s) for each imagery gear to focus on the national data products	Completed
Identify existing groups to support funding proposals, revisit Terms of Reference, and develop a strategy document for moving forward as a united community (vision, communicate value, risk and mitigation, funding).	In progress, addressed at 2019 workshop
Describe why a researcher should make his/her data accessible/discoverable and abide by standards (and what happens when you don't). Promote this information.	In progress, will be included in V2 SOP introduction
Develop automated high-level reporting that researchers can use	No progress
Liaise with funding agencies and regulators so they insist on best practices, including meta data standards and data accessibility.	Ongoing
Avoid insistence on one-size-fits-all approach for all gear and agencies; instead focus on bringing gear-specific and agency-specific workflows together so that data is, at the very least, accessible and discoverable and ideally comparable and collatable.	Ongoing
Invest in user-friendly digital platforms that make it easy for researchers to submit appropriate meta data and data.	In progress

APPENDIX C – CURRENT RECOMMENDATIONS (2019)

	Task	Responsibility	Timeframe
1. Governance, oversight, and working group(s)	1.1 Present to NMSC on state of Australian marine imagery data	NESP Marine Hub workshop coordinator	Mid 2020
	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.	NMSC (or relevant working group) Chair	Mid 2020
	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	NMSC (or relevant working group) Chair	Late 2020
	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.	NMSC (or relevant working group) Chair	Late 2020
	1.5 Develop and apply communication strategy between implementation group (e.g. marine imagery collective) and oversight group (e.g. NMSC)*	NMSC, marine imagery collective	Early 2021
	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	NESP D2 project leaders, future NESP theme leaders	Early 2020 (version 2), ongoing (version 3+)

	Task	Responsibility	Timeframe
	1.7 Continue to promote field SOPs and data standards	All Australian organisations, individuals, and committees related to marine science	Ongoing
2. Long-term or institutional support	2.1 Develop a transparent prioritisation of preferred funding priorities, as informed by this report, 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.	NMSC Baselines Working Group, IMOS Benthic Monitoring Group	Mid 2020
	2.2 Encourage larger partners in the collective provide contributions to base funding to ensure resilience and demonstrate buy-in	Marine imagery collective leader	2021
	2.3 Ensure successful funding proposals address multiple recommendations in this report	IMOS, ARDC, ARC and other funding agencies	Ongoing
	2.4 Develop and apply communication strategy between implementation group (e.g. marine imagery collective) and oversight group (e.g. NMSC)	NMSC, marine imagery collective	Early 2021
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.	AODN	Late 2020
	3.2 Use above framework to characterise current holdings and adapt organisational workflows to ensure appropriate meta data for marine imagery	Organisation leads in marine imagery	Early 2021

	Task	Responsibility	Timeframe
	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).	Marine imagery collective leader, organisation leads in marine imagery	Early 2021
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)	Principal Investigators	Ongoing
	4.2 Prioritise funding proposals that address the bottlenecks and underdeveloped links shown in red in Figure 4.	IMOS, ARDC, ARC, other funding agencies	Ongoing
	4.3 Meet with NCRIS to discuss speed-of-access issues with big data	Marine imagery collective leader	Late 2020
	4.4 Develop workflows based on Figure 4 (including bottlenecks and undeveloped links) for each of the major imagery sampling gear (AUV, BRUV, Towed imagery, ROV, UVC/DOV).	Marine imagery collective leader	Late 2020
5. Communication and collaboration	5.1 Develop workflows based on Figure 4 (including bottlenecks and undeveloped links) for each of the organisations listed in Figure 2.	Marine imagery collective leader, organisation leads in marine imagery	Late 2020
	5.2 Hold annual meetings to ensure continued dialogue and collaboration	Marine imagery collective leader	Ongoing
	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	Principal Investigators	Ongoing

	Task	Responsibility	Timeframe
	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).	Principal Investigators	Ongoing
	5.5 Prioritise funding proposals that adopt a collaborative approach to develop marine imagery capability between the two main groups working on marine imagery in Australia (AIMS and the rest of IMOS community).	IMOS, ARDC, ARC, other funding agencies	Ongoing
6. Other	6.1 Each organisation take responsibility for ensuring their data abides by FAIR principles, including funding, input, and support for infrastructure	CEOS and Directors of organisations collecting and using marine imagery	Ongoing
	6.2 Scope the need, scale, and cost of digitising legacy data at risk of being lost (e.g. VHS imagery) through a new designated capability	Researchers working in organisations collecting and using marine imagery	2021
	6.3 Funded projects should clearly identify the intended user of the proposed infrastructure or research, ideally addressing diverse end-user case studies (see Section Error! Reference source not found.).	Principal Investigators IMOS, ARDC, ARC, other funding agencies	Ongoing
	6.4 Set targets 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.	CEOs and Directors of organisations collecting and using marine imagery Marine imagery collective NMSC	Early 2021



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