1. INTRODUCTION

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Background

Australia has one of the world's largest marine estates that includes many vulnerable habitats and a high biodiversity, with many endemic species crossing a wide latitudinal range. The marine estate is used by a variety of industries including fishing, oil & gas, and shipping, in addition to traditional, cultural, scientific and recreational uses. The Commonwealth government manages the Australian Marine Parks (AMPs), the largest network of marine protected areas in the world (Cochrane 2016). These marine parks complement existing networks in State and Territory waters.

Monitoring the impacts of these uses on the marine environment is a massive shared responsibility that can only be achieved by making the best use of all the information that is collected. Australia has a number of significant long-term marine monitoring and observing programs (Table 1), as well as a national ocean data network (aodn.org.au). Without some common and agreed standards, information collected may not be comparable with other areas or sectors. This may reduce its value to regional and national management, while the individual project or survey may lose the opportunity to interpret results in a regional or national context.

Australia is uniquely placed to develop standardised national approaches to monitor the marine environment. This objective integrates with one of the eight high-level priorities identified by the National Marine Science Plan (2015-25): the establishment of national baselines and long-term monitoring. Standardised national approaches will also contribute to the effective coordination across the marine science and observing community (including industry and citizen scientists). Such coordination has been recognised as integral to a governance system for sustained and effective monitoring in Australia's marine environment (Hayes et al. 2015) and yet was identified as highly variable and frequently inadequate in the 2016 State of the Environment Report (Evans et al. 2017). In order to facilitate objective and robust conclusions about the status and trends of the marine ecosystems, it is crucial that sampling methods are as consistent as possible while still allowing for practical differences among equipment, vessels, and weather conditions. This need for consistent methodology has been identified in several reports on regional and national marine monitoring frameworks (Hedge et al. 2013, Bowden et al. 2015, Hayes et al. 2015), and its contribution to supporting a blue economy is also recognised (Golden et al. 2017).

Although many biological monitoring programs focus on single elements of the marine environment (e.g. Wraith et al. 2013), several large-scale marine monitoring programs that include multiple areas are currently under development or implementation in Australian waters. Table 1 lists some of these programs, as well as the associated indicators to be measured or sampling platforms if specified. Standardised marine monitoring has been done successfully in Australian waters for shallow waters (e.g. underwater visual census in Reef Life Survey) and pelagic animals (e.g. acoustic tagging in IMOS Animal Tracking Facility), but it has yet to be developed, implemented, and adopted at a national scale for most other biological sampling platforms (but see IMOS AUV Facility in Table 1).

Table 1 Large-scale biological or ecological monitoring programs currently operating or under development in Australia as of Dec 2017. UVC = underwater visual census, DOV = diver-operated video, ROV = remotely operated vehicle, AUV = autonomous underwater vehicle, BRUV = baited remote underwater video, MBES = multibeam echosounder.

		Program	Region	Indicator	Sampling Platforms	Example Reference
PELAGIC		Continuous Plankton Recorder (CPR)	Global	Plankton assemblages, colour index	CPR	Hosie et al. 2003
		IMOS Animal Tracking Facility	National	Marine megafauna movement	Acoustic telemetry, satellite tracking	Taylor et al. 2017
		IMOS Ships of Opportunity	National	Temperature, salinity, water column backscatter, biochemistry	Bathythermograph, echosounder, biogeochemical and meteorological sensors	Alory et al. 2007
		IMOS National Reference Stations	National	Nutrients, microbes, phytoplankton, zooplankton, environmental factors	Moored sensors, water sampling	Sloyan and O'Kane 2015
	BENTHIC & DEMERSAL	RIMREP	GBR	Various	Various (TBC)	GBRMPA 2015
		Marine Estate Management Authority	NSW	Various	Aerial imagery, UVC, BRUVs, AUVs, towed imagery, grabs, DOVs, ROVs	NSW Government 2017
		WAMSI estuary science program	WA	Various	Various (TBC)	Thomson et al. 2017
		Reef Life Survey	Global	Demersal fish and benthic invertebrate assemblages	UVC	Stuart-Smith et al. 2017
		Long-Term Monitoring Program (AIMS)	GBR and NW Australia	Fish and benthic invertebrate assemblage, coral health and cover	UVC, DOV, Towed imagery	De'ath et al. 2012
		IMOS AUV Facility	National	Benthic invertebrate assemblages	AUV	Perkins et al. 2017
		VIC Signs of Healthy Parks monitoring program	VIC	Various	UVC, drone/UAV, AUV, BRUVS, ROV, towed video, aerial photography	Parks Victoria's Technical Series
		WA marine monitoring program	WA	Various	Various	Dept Biodiv Conserv Attractions 2017
		NESP field manual package*	National	Various	MBES, AUV, BRUV, Towed camera, Sled/trawls, Grab/corer, ROV	Current study

* Primarily benthic and demersal platforms, but also includes an emergent pelagic method (Pelagic BRUVs)

Due to the large geographic area, diverse flora and fauna, and range of environmental conditions represented by the Australian Marine estate, a single method of sampling is neither practical nor desirable (Bouchet et al. 2018, Przeslawski et al. 2018). For this reason, we present a standard approach for each of seven key marine benthic sampling platforms that were identified based on frequency of use in previous open water sampling and monitoring programs: Multibeam sonar (MBES), Autonomous Underwater Vehicles (AUVs), benthic Baited Remote Underwater Video (BRUVs), towed video, grabs and box cores, sleds and trawls, and remotely operated vehicles (ROVs). Each of these platforms targets a discrete data type (bathymetry, imagery, biological and sediment samples) within particular environments (consolidated, unconsolidated substrates) (Table 2), with specific advantages (Table 3). In addition, we provide a field manual for pelagic BRUVs as a concept sampling method in pelagic ecosystems due to its similarity to benthic BRUVs. Importantly, the inclusion of these sampling platforms in the current version is not an assessment of their value but instead an indication of their frequency of use and suitability for national monitoring (e.g. established methods, dedicated users, integration with existing national programs).

One of the main challenges in assessing marine biodiversity is the lack of standardised approaches for monitoring it (Duffy et al. 2013, Teixeira et al. 2016). As such, the overarching goal of these field manuals is to reduce the bias and variance in data from differences in sampling procedures, thereby ensuring that patterns in data are due to patterns in the community rather than patterns of how or when the community was sampled. If the measured ecological variable and the variation in sampling techniques are confounded, it is challenging if not impossible to objectively determine if observed changes are due to real ecological change or sampling technique. If variability is sufficiently high, real changes that would trigger appropriate management may not be detected in time, if at all. Importantly, many state marine monitoring programs use their own standard operating protocols (SOPs) relevant for wetland, estuarine, embayment, or intertidal habitats (Table 1). The current package of field manuals is not meant to replace them, but rather to complement them for deeper waters and national monitoring purposes. At the same time, we hope that individual state marine monitoring programs will also identify opportunities to adjust current practices to increase national consistency and that the SOPs will provide an opportunity for industry and industry consultants to contribute to national monitoring through standardising their ongoing activities (Teytelman 2018). To that end, marine managers from all states and territories in Australia were engaged in the process of developing these field manuals. This ensured that methods were similar whenever possible and differences were clearly explained in relation to marine monitoring in Commonwealth waters.

Table 2: Summary of prioritised benthic sampling platforms and their acquisition targets

	Data Type	Data Target	Spatial coverage	Environment	Chapter
MBES	Bathymetry, backscatter	Seafloor	Continuous	All	3
AUV	Imagery	Epifauna	Continuous	All	4
BRUV	Imagery	Demersal fish	Point (qualitative)	All	5
Towed	Imagery	Epifauna	Transect	All	7
Grab/Boxcore	Biological and sediment samples	Macrofauna, infauna	Point	Unconsolidated substrate	8
Sled/Trawl	Biological and sediment samples	Megafauna, epifauna	Transect (qualitative)	Consolidated substrate	9

ROV	Imagery*	Epifauna	Transect	All	10

* ROVs can collect biological and geological samples, but the focus of the manual in this package is on imagery.

Table 3: Advantages of prioritised benthic sampling platforms.

	MBES	AUV	BRUV	Towed	Grab/Boxcore	Sled/Trawl	ROV
Continuous (i.e. grid) broad-scale spatial coverage	X						
Continuous (i.e. grid) fine-scale spatial coverage		X					
Non-extractive	X	X	X	X			X
Able to revisit exact sites (repeatability)	X	X					X
Able to sample over variety of environments	X	X	X	X			X
Species-level identifications[1]					X	X	X[2]
Genetic, morphological etc analysis possible					X	X	X[2]
Behaviour observed			X	X			X
Cryptofauna included					X	X	
Quantitative	X	X	X	X	X		X
Concurrent physical and biological data		X		X	X		X
Minimal technical expertise			X	X	X	X	X[3]
Vessel flexibility			X	X	X		X[3]

[1] Refers to identifications able to be made with unknown or cryptic species (i.e. well-known, distinctive species can be identified via imagery)
[2] Only possible when the ROV is equipped with sampling capability. This is outside the focus on the ROV manual
[3] This only applies to small off-the-shelf ROVs, Working class ROVs require technical expertise and specific vessel specifications

Scope

This field manual package aims to provide a standardised national methodology for the acquisition of marine data from a prioritised set of frequently-used sampling platforms (below diver depths) so that data are directly comparable in time and through space. This will then facilitate national monitoring programs in Australian open waters and contribute to the design of an ongoing monitoring program for AMPs. The long-term goal is to produce a set of manuals that is applicable to a broad range of users and to be prescriptive enough that all data are collected without unnecessary technical variation.

We generally limit these platforms to benthic biological sampling, with a few exceptions (e.g. pelagic BRUVs included as a proof-of-concept due to its similarity to benthic BRUVs; water column, sedimentology, and geochemistry data included for comprehensiveness related to the relevant platform). These field manuals focus on data acquisition and post-processing including data management, particularly as applied to marine monitoring. Standardisation of sampling design is important to ensure rigor and reproducibility (National Academies of Sciences, Engineering, and Medicine 2019) and is addressed accordingly in Chapter 2. Data analysis and reporting are generally not included in the field manuals, although we direct users to useful methods or resources within each field manual.

For each field manual, a scope specific to that particular sampling gear and data type is presented in a separate section. Overall, these field manuals are meant to cover basics and important considerations, with agency- and gear-specific SOPs supplemented as needed by individual researchers. Detailed and gear-specific SOPs are outside the scope of this field manual package due to the large number of existing SOPs and the variety of gear currently employed by researchers. It is impractical that researchers would agree on detailed SOPs (and associated gear). Rather, we have developed these field manuals to find consensus about as many issues as possible, while noting the differences. These differences can then be assessed in the future (e.g. they may not correspond to large amounts of variation in data), and addressed if need be. Wherever possible, however, we have mandated or recommended specifications (e.g. imagery resolution) that should be used in future equipment upgrades or purchases.

This field manual package does not describe the decision to use a particular sampling platform, supporting previous recognition that a top-down, one-size-fits-all approach to monitoring is unlikely to be effective in systems with large environmental variability (Fancy et al. 2009). Ultimately, the decision to use particular marine sampling platforms depends on a variety of factors, including depth (e.g. reef vs slope), substrate (e.g. hard vs soft), purpose (e.g. voyage of discovery vs impact assessment), and resources (e.g. minimal expertise vs technologically complex) (Salvanes et al. 2018). In some instances, multiple platforms will yield higher observed diversity (e.g. BRUVS + a transect-based imagery platform), while data collected among other platforms are comparable (e.g. ROV, diver-operated video, towed video) (Schramm et al 2019). For a more detailed review of each sampling platform, as well as a comparative assessment among them, we refer readers to our companion reports on benthic (Przeslawski et al. 2018) and pelagic (Bouchet et al. 2018) sampling methods used in marine monitoring. There reports also relate marine sampling platforms to Essential Ocean Variables (Miloslavich et al. 2018, Muller-Karger et al. 2018). After the decision to use an appropriate sampling platform has been made, using the appropriate field manuals will help ensure that the collected data can be compared with data collected previously and in the future, thus contributing to national marine monitoring and reporting.

Format

In order to maximise uptake, methods in each field manual are usually presented as simple steps. All steps listed are considered essential unless they are clearly marked with brackets and italics as recommended (i.e. Use netsonde or bottom contact sensor to ensure sled or trawl is suitably deployed along the seafloor *[Recommended]*)

The field manual package is designed to be separated into its component chapters representing discrete sampling platforms, as needed. For this reason, the package can be downloaded in its entirety as a single pdf, or as standalone chapters representing discrete field manuals (Figure 1). References will be listed accordingly at the end of each chapter.

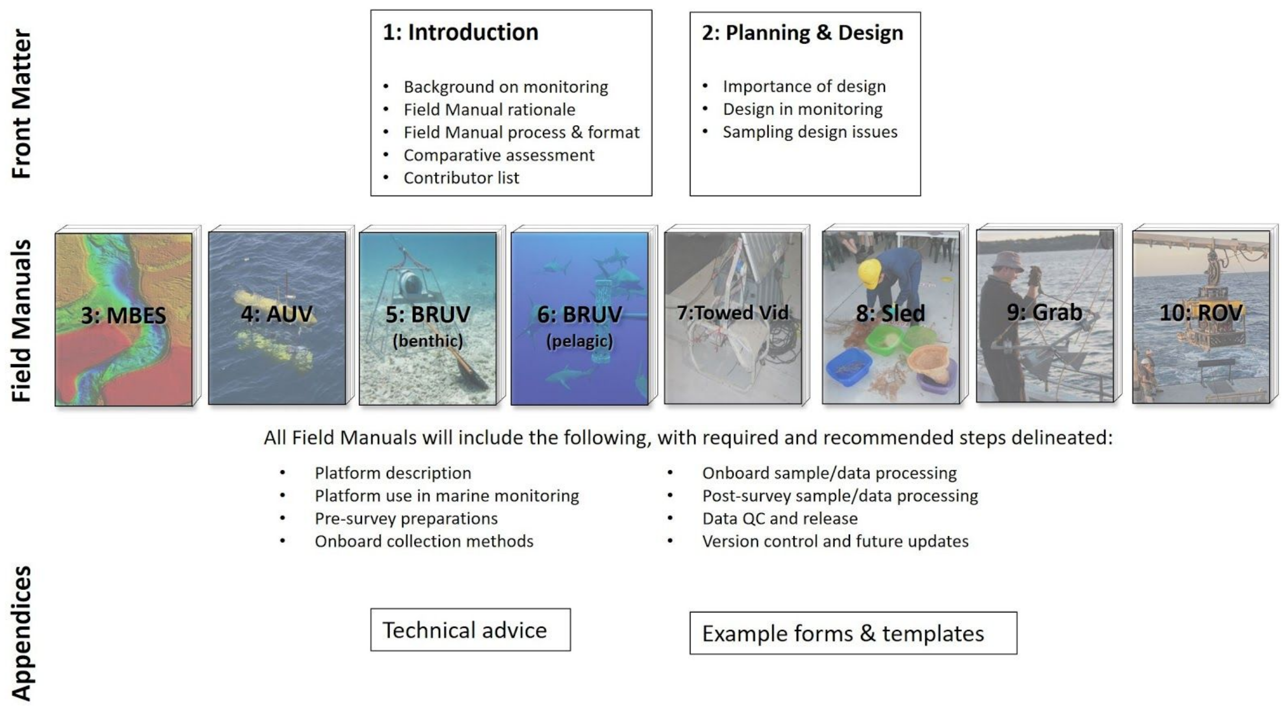

Figure 1 The structure of the NESP field manual package (version 2) with numbers indicating respective chapters.

Development of Field Manuals

The process of developing these field manuals has been detailed in [Przeslawski et al (2019a)].

The main challenge in the development of these manuals was to find a balance between being overly prescriptive (such that people prefer to follow their own protocol and ignore the manuals) and overly flexible (such that data are not consistent and therefore not comparable). A collaborative approach was therefore paramount to their development.

Ultimately, over 136 individuals from at least 53 organisations contributed to versions 1 and 2 of the field manual package (see Collaborators section in this introductory chapter). The increase in collaborators from Version 1 to Version 2 is due primarily to i) the new ROV manual, ii) expansion of the BRUV authors based on preparation of an associated manuscript to a journal, and iii) the merger of the V1 NESP field manual with AusSeabed's *Australian Multibeam Guidelines*. By engaging researchers, managers, and technicians from multiple agencies with a variety of experience, sea time, and subject matter expertise, we strove to ensure the field manuals represented the broader marine science community of Australia including real-world context, diversity of experiences, and candid acknowledgement of limitations and challenges. This not only improved the content but also increased the potential for adoption of the SOPs across multiple agencies and monitoring programs. After the release of the first version, input from additional stakeholders was actively sought and incorporated into the second version.

The process used to develop each field manual included in this package is shown in Figure 2, and the steps are listed below:

1. For each field manual, a working group was formed in which known users of the given sampling platform were invited. To be as inclusive as possible, we also extended more general invitations through email lists (e.g. Australian Coral Reef Society, Australian Marine Science Association (AMSA), NESP) and presentations (e.g. AMSA 2017 conference). Each working group was led by a coordinator(s) to develop content. Coordinators were identified as experts in their particular sampling platform and took on the role of lead author(s) for their respective field manual (Figure 3).
2. Content was developed by the coordinators based on meetings with the working group and associated input, including existing SOPs.
3. A draft field manual was distributed to the working group as a strawman for further discussion and refinement.
4. A complete field manual was submitted for internal review and approval by the editors, NESP, Geoscience Australia, and IMOS.
5. A complete field manual was submitted to an external reviewer who was not previously associated with the project.
6. A final revised field manual package was released as Version 1 on the Ocean Best Practice Repository (www.oceanbestpractices.net) and the website (www.nespmarine.edu.au).
7. Feedback was solicited through a questionnaire, particularly geared towards field testers.
8. Content of field manuals was revised based on feedback and new developments (e.g. data discoverability and accessibility). This was incorporated into Version 2, with the exception of the ROV manual which was a new addition to the Version 2 field package and thus has not yet been through a process of stakeholder feedback after release.

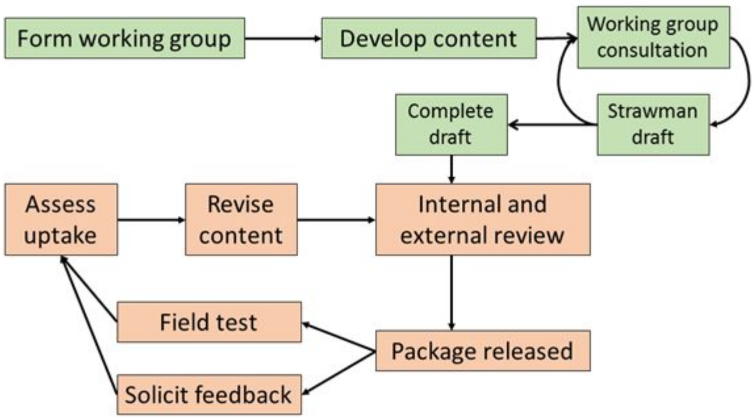

Figure 2 Flow chart showing the iterative process used in the initial development of this field manual package (version 1, orange and green), as well as version 2 and subsequent future versions (orange only).

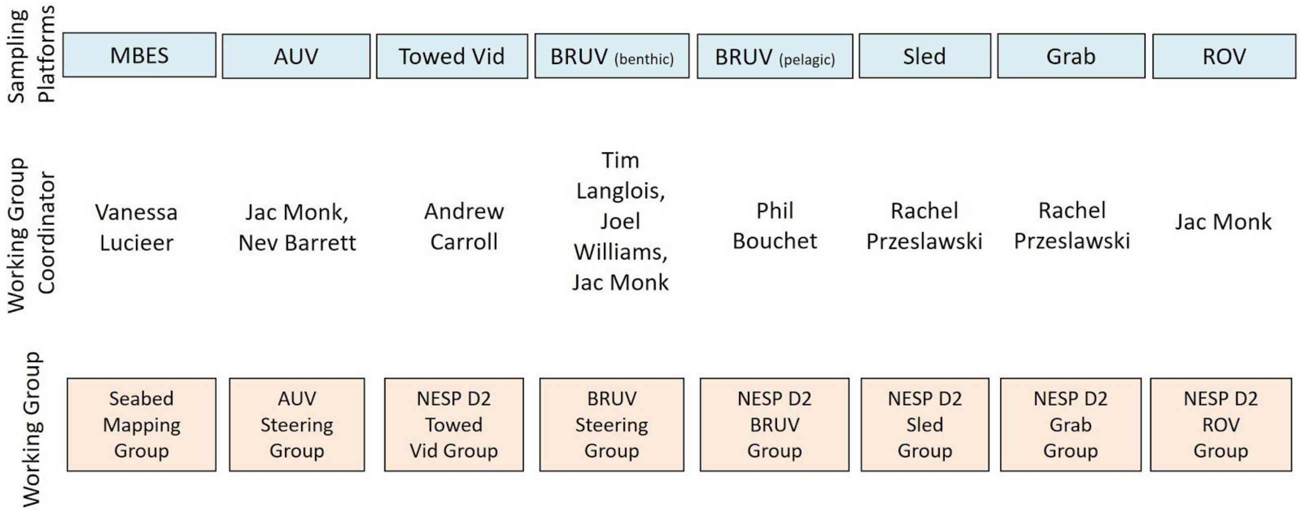

Figure 3 Collaborative network that developed the marine sampling field manuals. Working group members are listed in a table at the end of this chapter as authors or collaborators.

Universal Protocols

In this section, we generally describe some of the protocols that span all sampling platforms. Further detail on each of these is also provided in each chapter, as it is specifically relevant to a given sampling platform.

Sampling design

There are several overarching issues related to sampling design across all marine sampling platforms (e.g. randomisation, efficient designs, and uncertainty). We strongly encourage users of any field manual contained in this package to read Chapter 2 to familiarise themselves with these issues.

Permits

Prior to undertaking any marine survey, researchers are responsible for ensuring appropriate applications for permission are lodged, with subsequent relevant approvals obtained and documented. A list of potential permissioning documents relevant to marine sampling in Commonwealth waters are listed in Appendix A.

Risk Assessments

Risk assessments not only help quantify potential risks associated with planning and field activities, they can help make fieldwork safer and reduce costs. They may also be a requirement for some organisations. It is recommended that a risk assessment is completed during the survey planning phase and again prior to the commencement of fieldwork for any of the sampling platforms included in this manual:

- Planning risk assessment. The assessment during the planning phase identifies risks and mitigation strategies associated with attaining appropriate equipment, staff, finances and other resources. In addition, it should include potential reasons survey objectives may not be met. This provides an opportunity to develop contingency plans and prioritise objectives.

- Fieldwork risk assessment. This assessment identifies risks associated with onboard activities, including safety hazards, equipment damage or loss, inclement weather, and any other aspect that may compromise budget, survey objectives, or crew health and safety. There will be some overlap with the risks identified in the planning phase, but this risk assessment should explicitly address onboard risks. This provides an opportunity to ensure the survey is compliant with workplace health and safety issues, as well as optimising the potential for successful data acquisition.

Quality assurance and control

These field manuals define quality assurance (QA) as measures adopted before and during data acquisition, while quality control (QC) are measures adopted after data acquisition. Specifically QA represents the processes necessary to support the generation of high quality data and QC represents the follow-on steps that support the delivery of high-quality data, requiring both automation and human intervention. The documentation of the QA/QC process is arguably just as important as data acquisition itself. The QA/QC process can affect data analysis and interpretation (e.g. observer bias in marine imagery in Durden et al. 2016b) , and it is thus an integral part of standardisation to facilitate comparisons between datasets (Lara-Lopez et al. 2017). The appropriate methods for QA/QC depends on the data type (e.g. multibeam, underwater imagery, biological specimen). As such, further details on QA/QC are included in each field manual in the Data Release sections.

Data discoverability and accessibility

All marine metadata and data should be publicly released so that it is discoverable and accessible to the public, unless circumstances require otherwise (e.g. confidentiality clause or embargo for commercial work). Even in situations when data cannot be shared, the metadata should be made available so that future surveys are based on informed decisions about existing sampling locations. Refer to Stocks et al. (2016) for further information on appropriate information management including useful advice on data quality control and data sharing. Data can be licensed with the Creative Commons BY license which attributes the author but allows for free use of the data, including commercial applications. Some agencies may prefer to restrict commercial applications based on their data in which case Creative Commons BY-NC should be used.

Discoverable and accessible data contribute the following potential benefits to scientific, commercial, environmental, and social endeavours:

- Increased citations, media attention, and public engagement opportunities for researchers (McKiernan et al. 2016);
- More collaboration, funding, and job opportunities for researchers (Popkin et al. 2019);
- Larger and more useful datasets to address regional, national, and international issues (e.g. Cinner et al. 2020);
- Faster and more accurate development of analytical tools to inform important and emerging scientific and management questions (Zipkin 2019);
- Enabling artificial intelligence developments to improve the cost-efficiency of biodiversity monitoring (OzFish Dataset).
- Stronger capability to monitor environmental changes and develop appropriate management plans, including expedited capacity to appropriately respond to natural disasters (Donner et al. 2017);
- Increased potential for industry and commercial application of data products and information (e.g. Carroll et al. 2012);

All field manuals, excluding the manual on survey design, include a section titled "Data Release," which describes ways to ensure public discoverability and accessibility of collected data, thereby abiding by the FAIR (findable, accessible, interoperable, reusable) principles (Wilkinson et al., 2016). In the first version of the field manuals, these sections did not provide a clear national standard and instead refer to anticipated improvements in subsequent versions. This vagueness was due to the current lack of established national data infrastructure able to incorporate appropriate or comprehensive information produced from the sampling platforms.

To meet these challenges related to data discoverability and accessibility, a series of workshops were held in the months following the field manuals release (July – September 2018, July 2019), including focused workshops on bathymetry data, marine imagery, and biological specimen data. The bathymetry data release protocols are dependent on new digital infrastructure being developed as part of the AusSeabed program (www.ausseabed.gov.au). In contrast, marine imagery and biological specimen data are linked to existing digital platforms (Squidle+, GlobalArchive, OBIS Australia, Atlas of Living Australia) so priorities are to establish appropriate workflows linking these platforms with the data collection phase, and to find the resources needed to ensure they can be developed and maintained. Further recommendations the discoverability of marine imagery and biological specimen data can be found in the relevant workshop reports (Przeslawski et al. 2019c,d).

Regardless of the challenges described above, the appropriate methods for release of marine data depend on the data type (e.g. multibeam, underwater imagery, biological specimen). As such, further details on data management (including accessibility and discoverability) are included in each field manual in the Data Release sections.

Post-survey report

A post-survey report is highly recommended within a year of survey completion. Such a report is valuable documentation of the survey objectives, methods, and preliminary results. It is especially important because it is a single resource describing the multiple methods and data often acquired from a given survey, and it provides overarching context to a survey that is not found in the associated metadata or data. Many agencies have their own post-survey report template, and we have also included one with suggested headings and content in Appendix B for reference.

Outreach and Maintenance

After the release of the Version 1 of the field manual package in early 2018, efforts were focussed on outreach to increase the adoption of the field manuals by the broader marine science community in Australia, as well as industry, regulators, and policymakers. This was done initially through conference presentations and face-to-face meetings, with follow-up meetings and questionnaires to gauge the success of adoption. Outreach and engagement efforts were focussed on establishing institutional uptake of the field manuals, rather than just individual uptake. This ensures the continuity and long-term applicability of the SOPs even if advocating individuals leave an agency. Ultimately, institutional uptake will maximise the comparability of datasets from various surveys, thus increasing the amount of comparable data able to be applied to national products and syntheses.

The field manuals are not just applicable to the Australian community; they are also valuable to the international community, both regarding their content and the process used to develop them. The latter was addressed in a scientific journal paper (Przeslawski et al 2019a), while the content is available through the international searchable Ocean Best Practice Repository (www.oceanbestpractices.org) (Pearlman et al 2019).

Support was available to develop a Version 2 of this field manual package following additional community consultation and input. There will be a need to develop subsequent versions for the following reasons:

- Keeping up with technological advances to ensure uniformity of data acquisition across multiple agencies over time is a challenge for some platforms, particularly those that are based on rapidly advancing technology (e.g. AUV, MBES). In order to ensure that field manuals include relevant advances, they should be periodically checked and revised, lest they become superseded or obsolete.
- Over time, opportunities may arise for increasing the amount of standardisation between research providers. This may come from the acquisition of new sampling gear, changes in research staff, or development of new projects and monitoring programmes.
- The way in which the data are stored in aggregated databases will evolve over time. Currently, for many platforms, there is a competitive environment within this area. Competition is a force for change, and so change is likely to occur. The 'Data Release' sections of each manual will almost certainly need to be updated by 2025 to account for these developments and provide clearer and more definitive instructions (e.g. Przeslawski et al 2019d).
- Each field manual has a sub-section on uses of the sampling platform in marine monitoring. This will need to be periodically updated to include new research and monitoring outcomes.

- One of the strengths of this field manual package is the collaborative approach taken to ensure representation of a range of organisations and disciplines. As time passes, this representation will become increasingly outdated, and new and different researchers should be given the opportunity to contribute.
- Suggestions about standard vocabularies for metadata are currently lacking, and there is an opportunity to help guide the AODN and other programs regarding controlled metadata vocabularies in future versions.
- The new online platform managed through GitHub Pages was chosen partly due to the inherent version control features. Nonetheless, an update or new system to host these field manuals may be required in the future.

A long-term plan for managing the field manuals has not yet been developed, with the exception of the multibeam field manual which will be overseen by AusSeabed. Efforts are still needed to establish a high-level oversight committee to develop and implement actions needed for future versions and to strengthen institutional uptake. At the time of writing this introduction, the most likely groups for this responsibility are the National Marine Science Committee's Monitoring and Environmental Baseline working group, the AODN and/or a future iteration of the NESP Marine Hub.

Version 2 - Updates and Revisions

Version 1 of the field manual package was released in February 2018, and Version 2 was released two years later in June 2020.

All original chapters were updated in Version 2 with stakeholder feedback, corrections, and updates where applicable. The chapter 'Seafloor Mapping Field Manual for Multibeam Sonar' was substantially changed in Version 2 to amalgamate it with the *Australian Multibeam Guidelines* which were released in June 2018 by AusSeabed, a nationally seabed mapping coordination program. The unified multibeam manual in Version 2 addresses stakeholder concerns about maintaining two separate SOPs for multibeam sonar. In addition, a new manual on ROVs was developed for the Version 2 package. The ROV was chosen based on findings from a report titled Scoping of new field manuals for marine sampling in Australian waters (Przeslawski et al. 2019b).

All major changes related to a given sampling platform are logged in a version control table at the end of the relevant manual.

One of the most notable changes for Version 2 was the development of an online portal for the field manuals (https://marine-sampling-field-manual.github.io). While Version 1 was released as static pdfs through the NESP Marine Hub website, Version 2 was released through GitHub. This digital delivery system has the following benefits:

- The manuals are easily accessible in online or pdf formats, increasing the flexibility of user experiences and needs.
- The online system readily reflects minor corrections by harvesting through the source document maintained on Google docs.
- Updates and version control are easier to manage through permissions on GitHub and GoogleDocs.
- Analytics are easily generated to track downloads which can then be incorporated into impact assessments.

- A clearly documented user-friendly workflow (Figure 4) will help future contributors to maintain and update existing SOPs and to develop new ones.
- The online system will have more flexibility to embed imagery and other media (e.g. video tutorials) in future versions, thereby taking a much more modern approach than only static pdfs allow.

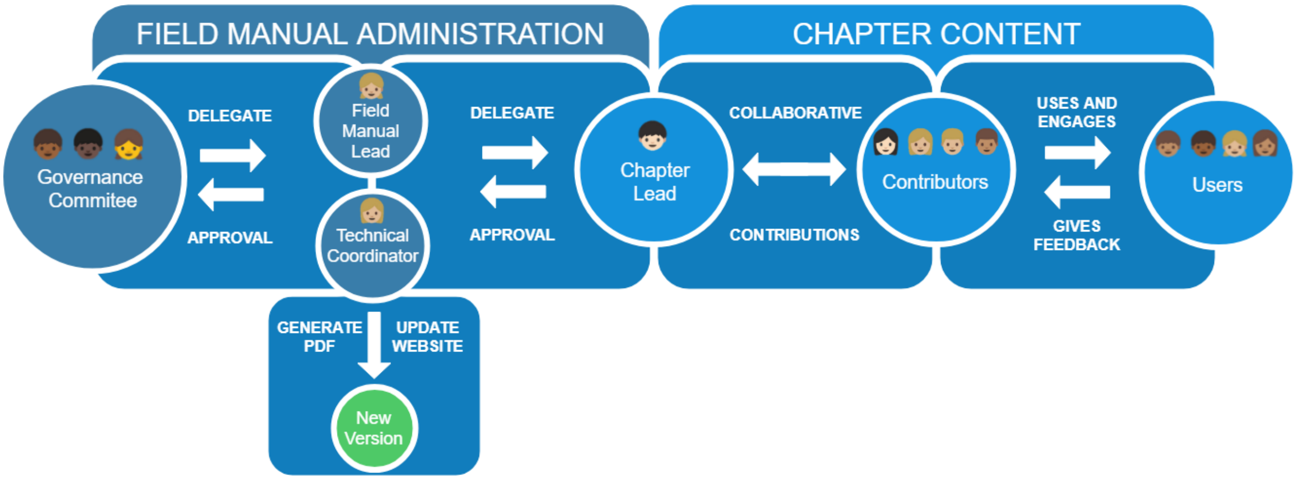

Figure 4 Workflow of version control and governance for the digital field manuals of Version 2 and future versions.

Collaborators

All individuals that contributed to versions 1 or 2 of this field manual package are listed below, with the following categories assigned based on their level of contribution:

- *Editors* oversaw production of the entire field manual package, ensuring fit-for-purpose content and consistent scope, style, and formatting throughout.
- *Lead authors* led working groups associated with discrete chapters or sampling platforms.
- *Authors* helped write chapters or provided crucial information to do so.
- *Contributors* participated in working group discussions.
- *Reviewers* provided assessments of draft chapters. In some cases, reviewers of Version 1 became co-authors of Version 2 due to their extensive contributions.

First name	Surname	Agency	Role	Chapter
Rachel	Przeslawski	Geoscience Australia	Editor, Lead author	All
Scott	Foster	CSIRO	Editor, Lead author	All
Neville	Barrett	UTas	Lead author	AUV, ROV, MBES
Phil	Bouchet	UWA	Lead author	P_BRUV, BRUV
Andrew	Carroll	Geoscience Australia	Lead author	Towed Vid, AUV
Tim	Langlois	UWA	Lead author	BRUV, P_BRUV, Introduction
Aero	Leplastrier	Geoscience Australia	Lead author	MBES (V2)
Vanessa	Lucieer	UTas	Lead author	AUV, MBES (V1)

Jac	Monk	UTas	Lead author	ROV, AUV, BRUV, TowVid, Stats
Kim	Picard	Geoscience Australia	Lead author	MBES (V2)
Joel	Williams	NSW Dept of Primary Industries	Lead Author	BRUV, ROV
Rene	Abesamis	Silliman University	Author	BRUV
Franzis	Althaus	CSIRO	Author	Sled, TowVid
Jacob	Asher	NOAA	Author	BRUV
Kam	Austine	EGS	Author	MBES
Robin	Beaman	James Cook University	Author, Contributor	TowVid, MBES
Penny	Berents	Australian Museum	Author	Grab
Anthony	Bernard	South African Institute for Aquatic Biodiversity	Author	BRUV
Matthew	Birt	AIMS	Author	BRUV
Todd	Bond	UWA	Author	ROV
Tom	Bridge	AIMS	Author	AUV
Mike	Cappo	AIMS	Author	BRUV
Malcolm	Clark	National Institute of Water and Atmospheric Research	Author	Sled, Grab
Jamie	Colquhoun	AIMS	Author	Sled
Richard	Cullen	RAN AHO	Author	MBES
Leanne	Currey-Randall	AIMS	Author	BRUV
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* An abridged version of the grab field manual was developed for the AHO for sedimentology, excluding geochemical and biological data.

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