MANAGING ANTARCTIC DATA—A PRACTICAL USE CASE

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ABSTRACT

Scientific data management is performed to ensure that data are curated in a manner that supports their qualified reuse. Curation usually involves actions that must be performed by those who capture or generate data and by a facility with the capability to sustainably archive and publish data beyond an individual project's lifecycle. The Australian Antarctic Data Centre is such a facility. How this centre is approaching the administration of Antarctic science data is described in the following paper and serves to demonstrate key facets necessary for undertaking polar data management in an increasingly connected global data environment.

Keywords: International polar data management, Scientific data curation, Data administration, Preservation, Data reuse

1 INTRODUCTION

The Australian Antarctic Data Centre (AADC), which has been operating for 16 years as the primary data repository for the Australian Antarctic Science program (AAp), has been gradually refining its policy base, working to integrate data services into the science program workflow, and continuously developing underpinning data infrastructure. Each of these activities is designed to improve data management services available to Antarctic researchers and to lift the volume and types of science data that are publicly accessible for reuse.

The AAp is a competitive research program involving scientists from the Australian Antarctic Division (AAD), the Commonwealth Scientific and Industrial Research Organisation, Australian state/federal government agencies, the university sector, and international institutions. The AADC coordinates the archiving and publication of data derived from AAp Antarctic and Southern Ocean-based research according to the open data principles of the Antarctic Treaty System (Antarctic Treaty Secretariat, 1959). In performing its functions, the centre works as part of the international network of Antarctic Data Centres, co-ordinated under the auspices of SCAR (the Scientific Committee on Antarctic Research), and was admitted to the International Council for Science – World Data System (ICSU-WDS) in 2011. ICSU-WDS is an international federation of global data centres and data service providers. Australia's ability to contribute to such global systems and to reuse data within the AAp and beyond is dependent upon scientists paying adequate attention to data management tasks that need to be performed within individual science projects and upon easy researcher access to core data management infrastructure. This paper describes how the AADC has been approaching polar data administration and how it is developing infrastructure to support AAp science. Whilst there is still much room for improvement, the combination of activities, practices, and policy described here present a useful example of how polar data management can be coordinated to scientific and national advantage.

2 SCIENCE APPLICATION PROCESS AND AAP DATA POLICY

In 2010, the AADC conducted an audit of the data it had received from past science projects implemented under the umbrella of the Australian science program in all of its previous guises, since the establishment of the AAD in 1980. In this audit there was a specific focus on those projects that commenced after the creation of the AADC (in 1996). Not surprisingly, it was found that a large number of projects had not submitted any data for archiving, despite a long-standing policy (first formalised in writing in 2004) that 'all data should be deposited with the AADC'. Three critical issues were identified as contributing to this poor level of compliance:

1. A lack of implemented penalties for non-compliance (even though sanctions, such as the right of the chief scientist to deny a chief investigator access to AAD logistical support, were informally touted within the program).
2. No prior understanding by the AADC of specifically what datasets should be delivered from approved AAp projects and hence a limited ability to chase outstanding data submissions.
3. An inadequate set of utilities available for the AADC to administer policy compliance and too few tools and assistance for scientists to comply with many of the (post 2006) data policy obligations.

Recognising that reforms were necessary, development of the new 2011–2021 Antarctic Science Strategic Plan (Australian Antarctic Division, 2011) offered an opportunity to revise and strengthen the current AAp data policy (AADC, 2013) to more closely align it with the science project assessment process and to begin targeted upgrading of the AADC toolset. These policy changes and science project assessment alignments are described in the next few sections and characterise the AADC's approach to scientific data administration.

2.1 Data submission history assessment criterion

Since the introduction of the 2011 Science Strategic Plan and the drafting of the new data policy, a public call is made every two years for science proposals. Submitted proposals are subject to peer review using a new ministerial-approved assessment process that now includes specific reference to the AAp data policy. Within this process, project proposals are rated based on a range of criteria associated with the quality and relevance of the proposed science and the competence of the listed research team. An important change in the new assessment criteria is that a chief investigator's previous history of data submission is now taken into account in the scoring. Although only three points (out of one hundred) are allocated to data submission history, because the program is highly competitive, these relatively few points have the capacity to influence the assessment outcome. Research scientists with no previous history of participation in the AAp as a chief investigator and those with an excellent data submission history get allocated the full three points. Those with a particularly poor track record of data and metadata submission are allocated zero points. Performance variations in between are assigned either one or two points.

It is already evident from the number of people who have contacted the AADC to submit old datasets since the policy was marketed that this approach provides a good incentive for scientists to make sure that they have sustainably archived their data. It is however readily acknowledged that by applying penalties anchored to the proposal assessment process, we are really mainly affecting those researchers who have a repeat history of working in Antarctica (or within the AAp grant scheme). Because the majority of chief investigators in the Australian program do have a long and active connection to the AAp, most will have a vested interest in maintaining a good data management record.

By including data submission history as part of the assessment criterion used to judge the competence of the chief investigator and his/her team to conduct the science proposed, we are reinforcing the expectation that science professionalism involves maintaining good data management practice.

2.2 Data management planning

The newly strengthened data policy also includes a provision that successful AAp projects must now submit a data management plan, to be delivered to the AADC by a chief investigator within the first six months of receiving project approval. Assistance with producing these plans is provided by AADC staff (in their roles as Science Project Liaison Officers: SLOs), and plan creation is standardised and made easy by using an online tool. Plans, once submitted, are versioned and reviewed to ensure they meet guidelines and then remain active for the duration of the project. Development of these plans is considered to be the first milestone in all approved AAp projects, and implementation progress is tracked through a formal project monitoring and review process conducted annually by a science review committee (the Antarctic Research Assessment Committee; ARAC), which has an independent chair, external to the AAD (Australian Antarctic Division, 2012).

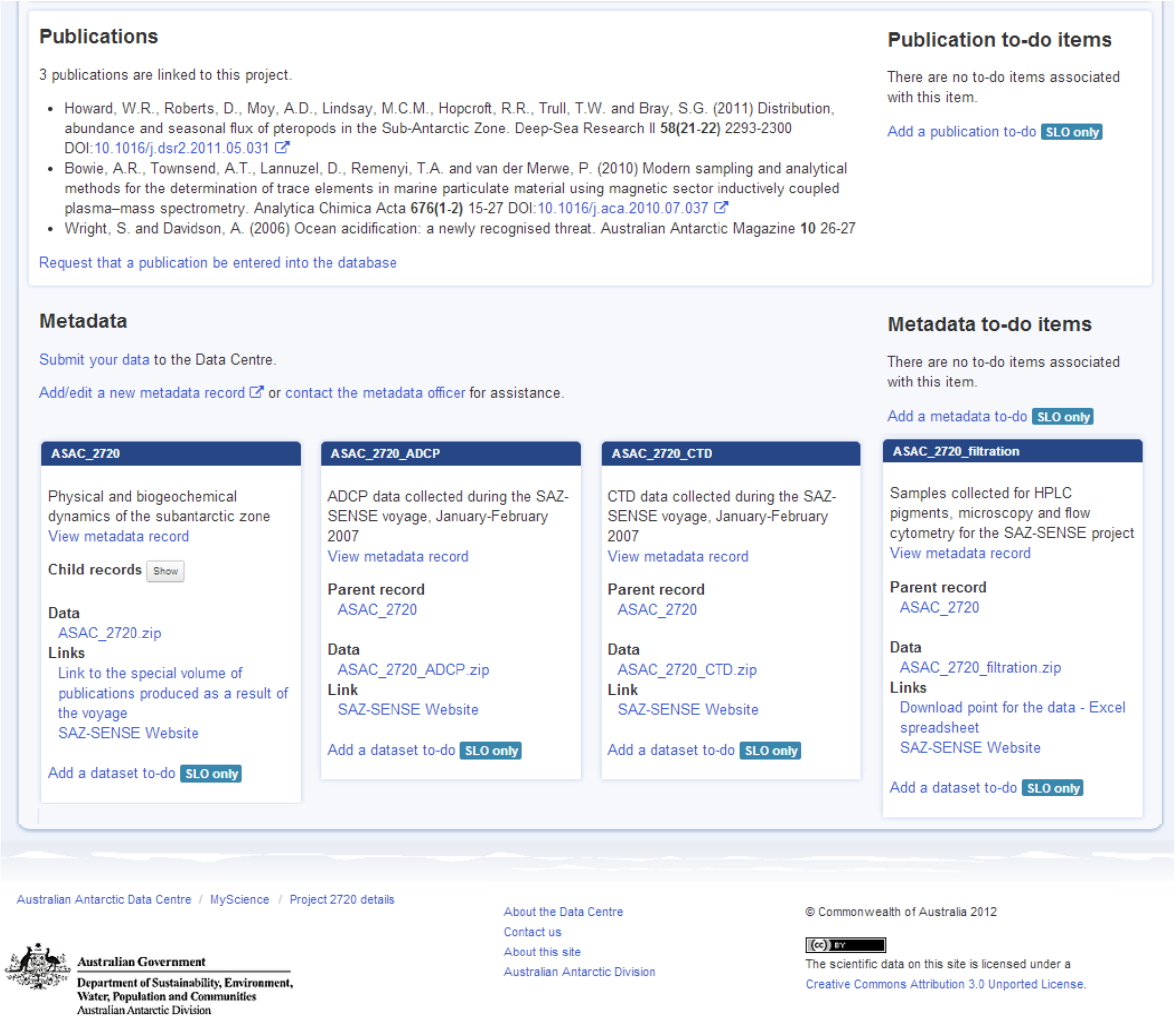
Within the plan, project team members must identify what datasets will be collected, when these data will be ready for submission to the AADC, who in the team will be responsible for their submission, and the likely volume of data that will be deposited. Under normal circumstances investigators must submit all project data to the AADC (or an alternate sustainable repository) by a project's end date. For the first time since the centre's inception in 1996, it is now possible to forecast the type and approximate quantity of data that will be generated annually from Australian Antarctic research. This information enables the AADC and its parent institution, the AAD, to improve the management and growth of expensive information technology infrastructure (e.g., digital storage area networks) and science facilities (e.g., on and offsite storage for biotic and geologic specimens/samples and ice cores). Better facilities planning should lead to enhanced services for research projects.

2.3 Data citation

Whilst it is not yet mandatory in the AAp Data Policy for AAp scientists to formally cite data in authored research publications, it is now strongly encouraged. If scientists cite their own data it becomes more visible and more widely accessible, and options for using both datasets and paper publications as measures of professional achievement become possible. For many scientists, particularly those engaged in observational and monitoring science, a significant proportion of their life's work is invested in capturing and collating datasets whose value becomes more apparent through time. The number of publications possible from such data may be limited in the early phases of their research due to the need to establish temporal trends, variability, and baselines before publishing. Being able to demonstrate the various uses of their data (through reviewing citations) should be an important factor in determining the impact of researchers' scientific activity in conjunction with their publication history. But most fundamentally, citation involving online, accessible data provides an open mechanism for scientific verification and validation (The Economist, 2013).

Compliance with this relatively new citation policy element is being monitored by ARAC, with input from the AADC. The AADC is able to supply persistent addressing for formal dataset citations, namely, digital object identifiers (DataCite, 2013) minted by the Australian National Data Service (ANDS, 2012), and provides guidance for scientists on emerging citation standards (Kotarski, Reilly, Schrimpf, Smit, & Walshe, 2012) by automatically marking-up deposited data for online publication using these standards. Recognising that there is a strong cultural element to this policy principle, and because global 'systems' are not yet in place either within many existing repositories or within the publishing sector, a 'soft' approach is being taken to shepherd AAp scientists into citation as a practice.

3 MYSCIENCE



Publications

3 publications are linked to this project.

- Howard, W.R., Roberts, D., Moy, A.D., Lindsay, M.C.M., Hopcroft, R.R., Trull, T.W. and Bray, S.G. (2011) Distribution, abundance and seasonal flux of pteropods in the Sub-Antarctic Zone. Deep-Sea Research II **58(21-22)** 2293-2300 DOI:10.1016/j.dsr2.2011.05.031
- Bowie, A.R., Townsend, A.T., Lannuzel, D., Remenyi, T.A. and van der Merwe, P. (2010) Modern sampling and analytical methods for the determination of trace elements in marine particulate material using magnetic sector inductively coupled plasma–mass spectrometry. Analytica Chimica Acta **676(1-2)** 15-27 DOI:10.1016/j.aca.2010.07.037
- Wright, S. and Davidson, A. (2006) Ocean acidification: a newly recognised threat. Australian Antarctic Magazine **10** 26-27

Request that a publication be entered into the database

Publication to-do items

There are no to-do items associated with this item.

Add a publication to-do SLO only

Metadata

Submit your data to the Data Centre.

Add/edit a new metadata record or contact the metadata officer for assistance.

Metadata to-do items

There are no to-do items associated with this item.

Add a metadata to-do SLO only

ASAC_2720

Physical and biogeochemical dynamics of the subantarctic zone
View metadata record

Child records Show

Data
ASAC_2720.zip
Links
Link to the special volume of publications produced as a result of the voyage
SAZ-SENSE Website

Add a dataset to-do SLO only

ASAC_2720_ADCP

ADCP data collected during the SAZ-SENSE voyage, January-February 2007
View metadata record

Parent record
ASAC_2720

Data
ASAC_2720_ADCP.zip
Link
SAZ-SENSE Website

Add a dataset to-do SLO only

ASAC_2720_CTD

CTD data collected during the SAZ-SENSE voyage, January-February 2007
View metadata record

Parent record
ASAC_2720

Data
ASAC_2720_CTD.zip
Link
SAZ-SENSE Website

Add a dataset to-do SLO only

ASAC_2720_filtration

Samples collected for HPLC pigments, microscopy and flow cytometry for the SAZ-SENSE project
View metadata record

Parent record
ASAC_2720

Data
ASAC_2720_filtration.zip
Links
Download point for the data - Excel spreadsheet
SAZ-SENSE Website

Add a dataset to-do SLO only

Australian Antarctic Data Centre / MyScience / Project 2720 details

Australian Government
Department of Sustainability, Environment, Water, Population and Communities
Australian Antarctic Division

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Figure 1. Screen snapshot showing a portion of a MyScience project record

To successfully implement the new data policy, the AADC rearchitected some of its infrastructure so that: (a) the AADC could monitor policy compliance and feed this information into the governance framework established for monitoring AAp projects and (b) AAp research scientists had utilities that enabled them to readily comply with policy directives. With a keen desire to minimise application maintenance overhead, it was decided that the primary tool used by the AADC to administer policy compliance would also be a utility that could be used by AAp scientists to manage their individual project-based resources (i.e., metadata records, datasets, associated documentation, publications, and Data Management Plans). The Web-based application developed to fulfil this function is called MyScience (see Figure 1).

3.1 Resource administration through MyScience

MyScience is accessible via secure login and is available to any scientist with an internet connection, a browser, and one or more registered AAp projects (past or current). It provides a single interface for scientists to access functionality and content from separately developed, mainly pre-existing AADC systems and data stores. The system is project-centric in that each MyScience record relates to a single AAp project that is usually associated with multiple scientists and support staff. MyScience accesses information from corporate databases of registered AAp scientists, project proposals and progress reports, publications, metadata, and data. From this interface an investigator can:

1. Create metadata records
2. Deposit datasets and associated resources and link these to existing metadata records
3. Register publications
4. View summaries of project activity timelines, team composition, and project resources that have been registered with the AADC
5. Access metadata and data associated with the project

AADC staff, in their roles as SLOs, can also insert annotations anchored to various elements of the MyScience record (i.e., 'to-do' messages, see Figure 1) as data administration reminders for project team members. This messaging facility is only activated when logged into MyScience using an SLO role. Since most AAp research teams are from institutions outside of the AAD and are distributed across Australia, this communication channel, centred on a compendium of a project's resources, has proven an effective way to reach project members regarding data administration issues.

Apart from functioning as a portal for project resource management, MyScience can produce reports for the AADC that are used in governing the AAp (e.g., information for the AAp science project review and assessment processes and program performance monitoring activities). The remaining functionality inherent in MyScience pertains to the creation and management of data management plans.

3.2 MyScience and data management planning

AAp data management plans are designed to assist project teams in thinking about likely data flows and any associated 'within-project' data management early on in their project's life-cycle. The plan's function is to educate project teams about available services, facilities, and obligations under the AAp data policy. It is also a vehicle for encouraging teams to identify, before field work commences, what data 'agreements' might need to be put in place with collaborators who are external to the AAp. Explicitly performing this particular task can prevent the conflict over data access and publication that often arises in science programs due to misunderstandings over implicit agreements about data application and ownership.

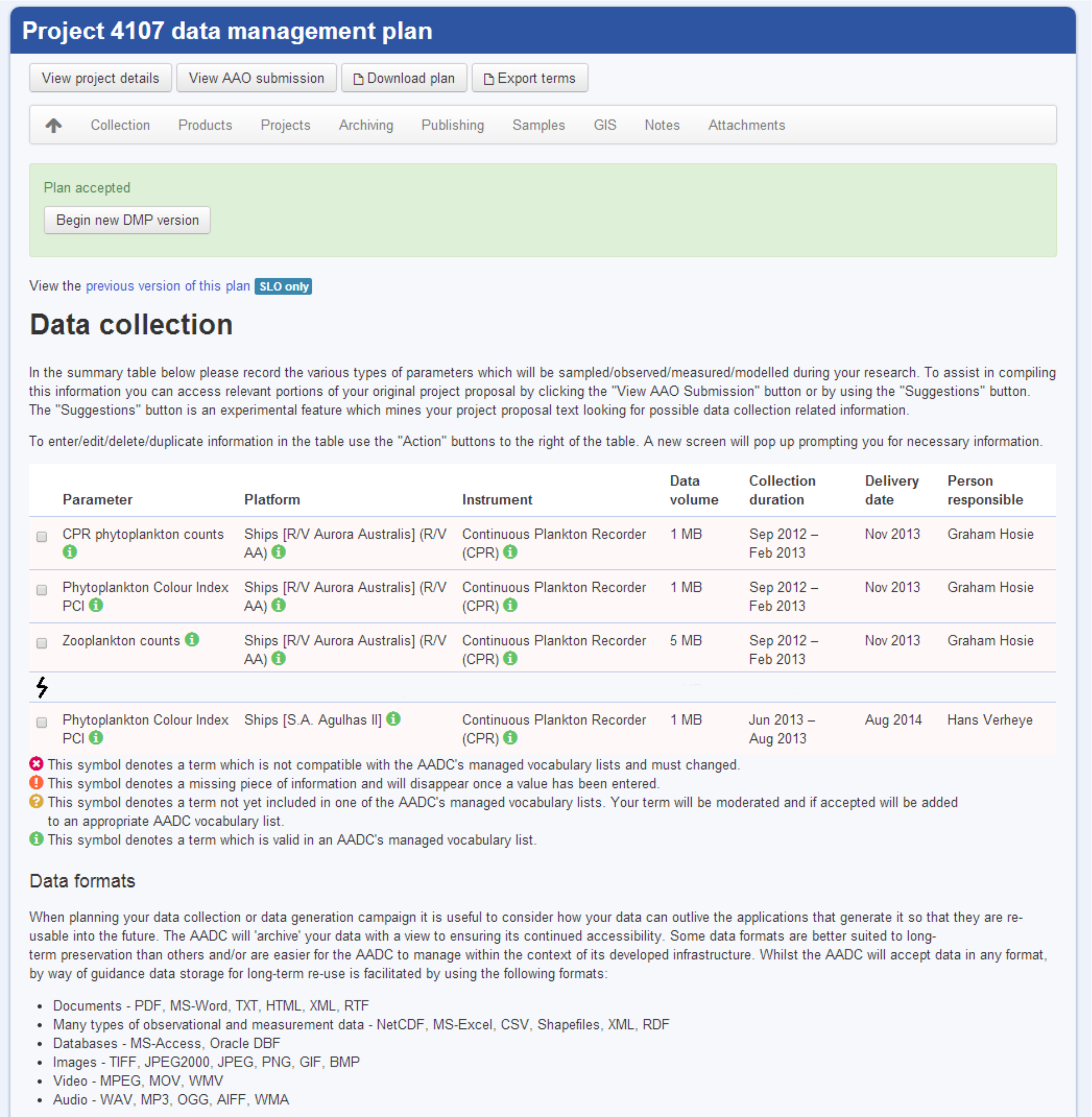
The online data management planning utility, accessible from within the MyScience application, is essentially a planning template. It contains three different types of information:

1. Project-based information already registered in other AAD systems
2. Preformulated text that the AADC automatically inserts into the plan (usually basic guidance on data management issues)
3. Information provided by project team members in response to data management questions

Questions in the planning template contain pick-lists and checkboxes where possible, and information being sought through the plan has been winnowed down to only those things that the AADC considers essential in order to reduce the administrative burden on those developing plans.

The template uses a range of controlled vocabularies for inserting content in specific sections (see Figures 2 and 3). Investigators are encouraged to supply new vocabulary terms when there are deficiencies in seed lists, and AADC staff then receive automatic notifications to moderate terms. Unmoderated terms can still be used to populate the plan template in real time, but if a term is later changed after moderation, the term is updated in the plan (and the plan creator is notified if he/she has not already been contacted during the term moderation process). The plan's vocabulary seed lists are pre-populated, where possible, with terms reused from existing domain vocabularies. The data management planning process is, however, being used by the AADC to build comprehensive and relevant vocabularies for AAp science because there are currently no vocabularies available that fulfil all of the program's requirements.

The vocabulary terms captured are being reused in other AADC core infrastructure to mark-up AAp metadata and data that are exchanged within global data networks. The ultimate benefit of these activities for scientists is that datasets described using rich, standardised, and mapped vocabularies can be discovered and accessed with much higher precision and recall than poorly and inconsistently described data. Domain vocabulary development and harmonisation is a relatively new activity within scientific data administration and is currently being pursued across many scientific disciplines globally. This is because formalising the description and definition of scientific concepts facilitates other desirable activities such as automated data extraction, integration, and manipulation. The AAp data management planning process provides a very structured way for the AAp to fill gaps in existing polar science vocabularies.



Project 4107 data management plan

Plan accepted

View the previous version of this plan SLO only

Data collection

In the summary table below please record the various types of parameters which will be sampled/observed/measured/modelled during your research. To assist in compiling this information you can access relevant portions of your original project proposal by clicking the "View AAO Submission" button or by using the "Suggestions" button. The "Suggestions" button is an experimental feature which mines your project proposal text looking for possible data collection related information.

To enter/edit/delete/duplicate information in the table use the "Action" buttons to the right of the table. A new screen will pop up prompting you for necessary information.

	Parameter	Platform	Instrument	Data volume	Collection duration	Delivery date	Person responsible
□	CPR phytoplankton counts ℹ	Ships [R/V Aurora Australis] (R/V AA) ℹ	Continuous Plankton Recorder (CPR) ℹ	1 MB	Sep 2012 – Feb 2013	Nov 2013	Graham Hosie
□	Phytoplankton Colour Index PCI ℹ	Ships [R/V Aurora Australis] (R/V AA) ℹ	Continuous Plankton Recorder (CPR) ℹ	1 MB	Sep 2012 – Feb 2013	Nov 2013	Graham Hosie
□	Zooplankton counts ℹ	Ships [R/V Aurora Australis] (R/V AA) ℹ	Continuous Plankton Recorder (CPR) ℹ	5 MB	Sep 2012 – Feb 2013	Nov 2013	Graham Hosie
ϟ							
□	Phytoplankton Colour Index PCI ℹ	Ships [S.A. Agulhas II] ℹ	Continuous Plankton Recorder (CPR) ℹ	1 MB	Jun 2013 – Aug 2013	Aug 2014	Hans Verheye

⊗ This symbol denotes a term which is not compatible with the AADC's managed vocabulary lists and must changed.
❗ This symbol denotes a missing piece of information and will disappear once a value has been entered.
❓ This symbol denotes a term not yet included in one of the AADC's managed vocabulary lists. Your term will be moderated and if accepted will be added to an appropriate AADC vocabulary list.
ℹ This symbol denotes a term which is valid in an AADC's managed vocabulary list.

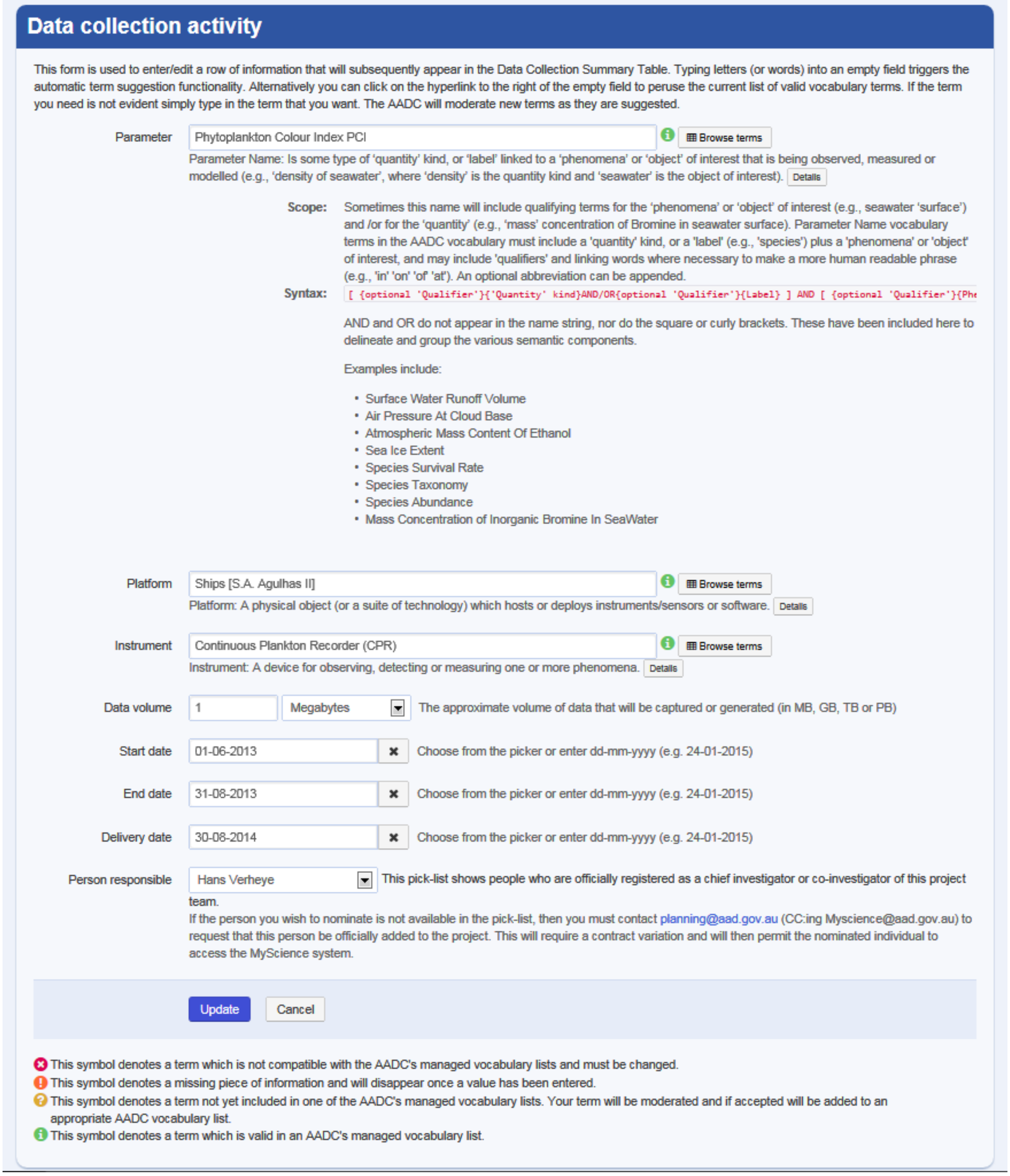
Data formats

When planning your data collection or data generation campaign it is useful to consider how your data can outlive the applications that generate it so that they are re-usable into the future. The AADC will 'archive' your data with a view to ensuring its continued accessibility. Some data formats are better suited to long-term preservation than others and/or are easier for the AADC to manage within the context of its developed infrastructure. Whilst the AADC will accept data in any format, by way of guidance data storage for long-term re-use is facilitated by using the following formats:

- Documents - PDF, MS-Word, TXT, HTML, XML, RTF
- Many types of observational and measurement data - NetCDF, MS-Excel, CSV, Shapefiles, XML, RDF
- Databases - MS-Access, Oracle DBF
- Images - TIFF, JPEG2000, JPEG, PNG, GIF, BMP
- Video - MPEG, MOV, WMV
- Audio - WAV, MP3, OGG, AIFF, WMA

Figure 2. Screen snapshot showing a portion of the data management planning tool

Finally, all submitted plans are considered fluid, in that they can be added to or changed over time. This fits with the dynamic nature of scientific research and the ever-changing logistics of operating in a harsh Antarctic environment. Plans are versioned and logged, and old and new versions are permanently accessible online.



Data collection activity

This form is used to enter/edit a row of information that will subsequently appear in the Data Collection Summary Table. Typing letters (or words) into an empty field triggers the automatic term suggestion functionality. Alternatively you can click on the hyperlink to the right of the empty field to peruse the current list of valid vocabulary terms. If the term you need is not evident simply type in the term that you want. The AADC will moderate new terms as they are suggested.

Parameter: Phytoplankton Colour Index PCI

Parameter Name: Is some type of ‘quantity’ kind, or ‘label’ linked to a ‘phenomena’ or ‘object’ of interest that is being observed, measured or modelled (e.g., ‘density of seawater’, where ‘density’ is the quantity kind and ‘seawater’ is the object of interest).

Scope: Sometimes this name will include qualifying terms for the ‘phenomena’ or ‘object’ of interest (e.g., seawater ‘surface’) and /or for the ‘quantity’ (e.g., ‘mass’ concentration of Bromine in seawater surface). Parameter Name vocabulary terms in the AADC vocabulary must include a 'quantity' kind, or a 'label' (e.g., 'species') plus a 'phenomena' or 'object' of interest, and may include 'qualifiers' and linking words where necessary to make a more human readable phrase (e.g., 'in' 'on' 'of' 'at'). An optional abbreviation can be appended.

Syntax:

```
[ {optional 'Qualifier'}{'Quantity' kind}AND/OR{optional 'Qualifier'}{Label} ] AND [ {optional 'Qualifier'}{Phe
```

AND and OR do not appear in the name string, nor do the square or curly brackets. These have been included here to delineate and group the various semantic components.

Examples include:

- Surface Water Runoff Volume
- Air Pressure At Cloud Base
- Atmospheric Mass Content Of Ethanol
- Sea Ice Extent
- Species Survival Rate
- Species Taxonomy
- Species Abundance
- Mass Concentration of Inorganic Bromine In SeaWater

Platform: Ships [S.A. Agulhas II]

Platform: A physical object (or a suite of technology) which hosts or deploys instruments/sensors or software.

Instrument: Continuous Plankton Recorder (CPR)

Instrument: A device for observing, detecting or measuring one or more phenomena.

Data volume: 1 Megabytes — The approximate volume of data that will be captured or generated (in MB, GB, TB or PB)

Start date: 01-06-2013 — Choose from the picker or enter dd-mm-yyyy (e.g. 24-01-2015)

End date: 31-08-2013 — Choose from the picker or enter dd-mm-yyyy (e.g. 24-01-2015)

Delivery date: 30-08-2014 — Choose from the picker or enter dd-mm-yyyy (e.g. 24-01-2015)

Person responsible: Hans Verheye — This pick-list shows people who are officially registered as a chief investigator or co-investigator of this project team.

If the person you wish to nominate is not available in the pick-list, then you must contact planning@aad.gov.au (CC:ing Myscience@aad.gov.au) to request that this person be officially added to the project. This will require a contract variation and will then permit the nominated individual to access the MyScience system.

✖ This symbol denotes a term which is not compatible with the AADC's managed vocabulary lists and must be changed.

! This symbol denotes a missing piece of information and will disappear once a value has been entered.

? This symbol denotes a term not yet included in one of the AADC's managed vocabulary lists. Your term will be moderated and if accepted will be added to an appropriate AADC vocabulary list.

i This symbol denotes a term which is valid in an AADC's managed vocabulary list.

Figure 3. Screen snapshot showing a portion of the data management planning tool that enables a user to enter rows into the data collection table (as shown in Figure 2)

4 CONCLUSION

The data administration changes, facilities, and activities outlined in this paper have already resulted in long-outstanding datasets being deposited within the AADC. These previously hidden data are now available for reuse. The centre is currently a far better placed to administer the AAp policy, and scientists are being supported to comply with policy obligations. Investigator co-operation is helping to build better infrastructure, which is more closely meeting scientific data publication, discovery, and access requirements. Our experience has shown that data policy, promulgated through a resourced governance framework that is tied into science program and project administration, can lead to better data management outcomes. In the long term this can only be beneficial for scientists and national science endeavours, particularly in disciplines such as Polar Science, where data capture is such an expensive activity.

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