Data Management for 21st Century Ocean Research

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Data Management

• Has always been essential to the scientific process
• Much has changed in my lifetime with respect to data management
• Those changes represent challenges and opportunities
• I have been managing field research data since I was 8 years old
The Data Harvest

Recently published report from RDA Europe (December 2014)

Research Data Alliance - Europe
The Data Revolution

“[The data revolution] isn’t just about the volume of scientific data; rather, it reflects a fundamental change in the way science is conducted, who does it, who pays for it and who benefits from it. And most importantly, the rising capacity to share all [these] data – electronically, efficiently, across borders and disciplines – magnifies the impact.”

The Data Harvest: How sharing research data can yield knowledge, jobs and growth (RDA Europe, December 2014)
Eight Global Sustainability Challenges

- Delivering water, energy, and food for all.
- Decoupling carbon emissions from economic growth.
- **Safeguarding** land, freshwater and marine natural assets.
- Building healthy, resilient and productive cities.
- Promoting sustainable rural futures.
- Improving human health by incorporating global change concerns.
- Encouraging sustainable consumption and production patterns.
- Improving governance and early warning systems to respond to complex future threats.
All photo images courtesy of Woods Hole Oceanographic Institution personnel or those who have sailed on one of our vessels.

Marine research themes are varied, so the data are as well.
Cavolinia uncinata  (photo by Karen Osborn, Smithsonian Institution, 2012)
in situ biogeochemistry data
Sea floor bathymetry

Illustration by Jack Cook, WHOI
water column data
data from mooring deployments
data from sediment traps
deep ocean ecosystem dynamics studies
laboratory and mesocosm experiments
When the data have been collected ... how will the data be managed and will the data be truly available?
when the research is complete ... what about the data?
Big Challenges & Big Opportunities

• Complex, large scale research questions
• Infrastructure (people, machines, systems) must be updated to support new research requirements
• Increased need for explicit declaration of machine–actionable information
• Standards-compliant metadata
• Documenting open-access data
Connectivity Challenges

- **Goals:**
  - linking content at distributed repositories
  - improved interoperability (machine-to-machine)

- **Technical strategies/solutions:**
  - metadata content standards
  - controlled vocabularies
  - Brokering, Linked Data

- **Not just technical**
  - cultural conditions, behaviors
  - research data lifecycle
  - “proposal to preservation”
Connecting ALL Research Products

• DATA (raw/original and final form)
• Original proposal, science plan
• Cruise reports
• Conference abstracts and presentations
• Traditional publications
• Social media
• Citizen science
Thoughts at this point?

This seems like a Sisyphean task ...

... with ever increasing moments when you realize there is so much to do, that you should probably just nap instead.
• funded by US NSF to provide data management support at no cost to researchers funded by the program managers who fund BCO-DMO

• data from current, hypothesis-driven research projects, and legacy data from large coordinated research programs (e.g. US GLOBEC and US JGOFS)
EXAMPLE: OPEN ACCESS CRUISE DATA

1. NSF funds a research cruise.  
2. R2R serves the original underway data.  
3. BCO-DMO manages the post cruise data.  
4. meeting abstracts and  
5. formal publications (data and peer-reviewed papers) complete the research data life cycle.

Resources are discoverable at each repository, but what if we could connect them?
Create templates that describe the important aspects of each concept.
R2R and BCO-DMO both:

define what cruise, platform (e.g. vessel) and instrument are; match them to NVS terms

Use ICES platform codes

“R/V OCEANUS” [link](http://vocab.nerc.ac.uk/collection/C17/current/32OC/)

Terms from the NERC Vocabulary Server (NVS) are important for federating content from distributed systems ([Leadbetter et al. 2013a](#)).
All of these repositories share a common definition of cruise (from NERC Vocabulary Server), published out with the data resources when they are expressed as Linked Data.
An example

• A researcher reads a paper
  ▪ We have already assumed they have found and are able to retrieve the paper

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Significance

Phosphorus is scarce in many subtropical ocean regions, and phytoplankton in these regions adjust their biochemical composition such that they require less of it. We show here that phytoplankton in

Footnotes

\textsuperscript{1}Present address: Earth Observatory of Singapore, Nanyang Technological University, Singapore 639798. See Commentary on page 7880.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1321719111/-/DCSupplemental.
there is a data supplement

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Known Facts

• Publication: PNAS, has a DOI, has data suppl.
• Person name (author): Benjamin Van Mooy
• Dates of activity: 2010 and 2012
• Location keywords: Sargasso Sea
• Cruise: on vessel Knorr
• Data keywords: plankton, polyphosphate, lipid
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Recommended Goal

• Each fact is explicitly declared and described by terms from (or linked to) community or global vocabularies

• Each term is identified by a globally unique Persistent IDentifier (PID)

• Each PID resolves to a semantic representation of that term, with relationships to other terms

• Published as standards-compliant & open access
THE DATA LIFE CYCLE
(Chandler et al., EGU 2013)
context matters

Semantic Web technologies can help
Modern data infrastructure requires:

- information integration
- interoperability
- conceptual modeling
- intelligent search
- data-model intercomparison
- data publishing support

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*inspired by* Pascal Hitzler, WSU; Krzysztof Janowicz, UCSB (2013)
Challenge

• Very limited resources (funds, time, personnel)

Solution

• Strategic partnerships to develop, share & adopt common strategies and solutions
  ✤ Regional
  ✤ Domain-specific
  ✤ International
  ✤ Cross-domain
Research Data Alliance

- [https://rd-alliance.org/](https://rd-alliance.org/)
- supported by the European Commission, the National Science Foundation and other U.S. agencies, and the Australian Government; constructing the social and technical bridges that enable open sharing of data across technologies and between disciplines and nations with the ultimate goal of addressing the grand challenges of society.
RDA Vocabulary Services Interest Group (proposed Mar 2015)

- controlled vocabulary: representation; reuse; curation; linking ...

RDA Marine Data Harmonization Interest Group

- [https://rd-alliance.org/](https://rd-alliance.org/) -> Working and Interest Groups

OBJECTIVE: to promote the development of a common global framework for the management of marine data
• ODIP (Ocean Data Interoperability Platform) EU, Australia, USA marine data interoperability
• Develop a framework to support effective sharing of data across scientific domains and international boundaries
• [http://odip.org](http://odip.org)
Belmont Forum

• Belmont Forum:  http://www.bfe-inf.org/
• established in 2009, brings together environmental and geoscience funding agencies from 15 nations and seeks to build a coalition of national resources to advance global environmental change research.
Future Earth

- [http://www.futureearth.info/](http://www.futureearth.info/)

- Funding coordinated through the Belmont Forum, will be the platform through which many global change research programs will be coordinated, and the broad research themes, including the Earth Sciences, will require advanced information architectures to enable trans-disciplinary data-information-knowledge transfer
• IOC UNESCO IODE
  International Oceanographic Data and Information Exchange  http://iode.org
• community and capacity building
• Ocean Data Portal, OceanDocs, OceanTeacher, OceanTeacher, OBIS, Ocean Data Standards
A scholar’s positive contribution is measured by the sum of the original data that he contributes. Hypotheses come and go but data remain.”
from: Advice to a Young Investigator (Nobel Laureate Santiago Ramón y Cajal, 1897)