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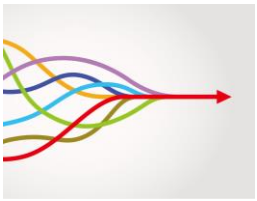
1.1 Logistics



Topic of Session:
Convergence and Endorsement from a Global Perspective
Co-leads:
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Rebecca Zitoun

Participants are listed in Table 1

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Session recording(s) available: here

Locations of WG Presentations: here

Date and time of sessions:
21/09/2020 06.00-08.00 (CEST)

22/09/2020 12.00-14.00 (CEST)

23/09/2020 06.00-08.00 (CEST)

24/09/2020 07.00-09 :00 (CEST)

24/09/2020 15.00 :17.00 (CEST)

A daily summary of the 4 days can be found here.

For the first 3 days, we had 30 participants from all over the globe - China, South Africa, Brazil, Australia, America, Canada and Europe. On the fourth day we had 20 participants in the morning and 20 in the afternoon.

1.2 Links to other WGs

There were no joint sessions, however the following subjects for working with other WGs were identified:

- Create BP4BP template
- Improve User dialogue
- Add features to the OBPS interface and to the Repository (keywords wish list) categorize

1.3 Key Points and developments

1.3.1 Key Points

BP4BP template (as a tool for the Convergence and Endorsement process)

- Including guidelines on how much detail a BP should have (e.g. uncertainty, CRMs) - NEED to be/“fit-for-purpose”, i.e. practical BP
- Improve transparency of BP processes, e.g., details on convergence, endorsement, review process, updates etc. Follow the best practices of people who have carried out convergence (eg IMOS) and learn from their process, include this in the BP4BP
- Worst practices section, including Long and Shi, 2008 in references experiences with convergence!

User dialogue (as a tool for the Convergence process)

- The targeted user dialogue for OBPS is needed for many elements of the OBPS search interface (tree search, keywords)
- Keyword wish list - for the repository we have to learn what good keywords are. We need approved keywords for documents. How were the original list of keywords on the OBPS defined?
- Continue to advertise the OBPS as a primary data base for the literature/methods review
- Foster improved relationships between OBPS and communities such as SOOS etc. to improve uptake, encourage convergence and promote endorsement

Interface - Add features to OBPS that help the convergence process:

- Review Platform/website; very different levels of complexity can be envisioned and need to be defined (in dialogue with the potential users)
- From OBPS repository - provide contact addresses from OBPS expert database (for review, for working groups)Groups must provide a long term.
- Could we create an OBPS central server which posts new documents which want to converge or are a process of recent convergence and allow for feedback (i.e. facilitate the convergence

process for global acceptance of new and updated BP). How would we do that? E.g., as per the IPCC
- Could OBPS perform automated update check after e.g. 3-5 years? Does it make sense? (e.g., who to contact? consequences)
- An actual search button on the homepage (landing page) of OBPS to search directly BP
- We need frequently asked questions directly associated with each BP
- Implement a way to measure the uptake of a BP, downloads is not good enough
- Implement different users that are tested to see their needs and how they navigate the OBPS - students, early career, members of a community e.g. an observing network, etc.?

Endorsement

- Convergence and endorsement linked to “Community”; (no need that this is always global!) - ie if IMOS converges their BP then the endorsement may be done by IMOS but not necessarily at a global level. Whereas if endorsed at the GOOS level then the BP needs to have had a global convergence.
- To be endorsed Review/Update of BP’s need permanent contacts (e.g., GOOS panels/ OCG as link to “current expert teams”
- OBPS could ‘endorse’/highlight particular BP which use certified references or ISO standards
- “Public endorsement” (via website) shall be discussed?

Convergence

- Needs Champions - how to motivate? Endorsement, as a carrot. Look at examples of successful convergence (e.g. through the Dickson bible and update) and how authorship has been handled
- Creating “ownership” and trust to ensure BP uptake - how to ensure community is taking the document on trust
- Collaborate with organizations that support the Convergence process (SCOR, IAPSO, ICES)
- Synthesize existing BPs into one more globally relevant document with spatial/temporal specifics in the annex

1.3.2 Open questions

- Should we have a BP on virtual meetings?
- Should OBPS endorse instruments or provide a platform to give reviews?
- Would you do the convergence of BP per discipline, per facility/observing network, per region, per variable?
- Would an open BP document (representing the core BP) that can be added to, especially regarding specifics of BP for distinct subregion/locality, spatial and temporal scale, etc. advantageous?
- Would a workflow system of the repository help to narrow down which BP is/are feasible for a certain objective?
- How can the OBPS help and support your convergence and endorsement process
- How important are BP for the UN Decade?
- Are BP only reasonable for abiotic variables since bitc ones are too variable, too dynamic, too diverse?!
- Do you start the convergence process of BP by region, variable, facility etc.
- How much detail is necessary for BP/SOPs?
- What is the best structure of BP/SOPs?
- How to ensure people follow SOP/BPs?
- How do we know which BP is the best one for a certain application/objective?

- Should OBPS endorse instruments or provide a platform to give reviews?
- Would you do the convergence of BP per discipline, per facility/observing network, per region, per variable?
- Would an open BP document (representing the core BP) that can be added to, especially?
- regarding specifics of BP for distinct subregion/locality, spatial and temporal scale etc., be
- advantageous?
- Would a workflow system of the repository help to narrow down which BP is/are feasible for a certain objective?
- Should we have a BP on virtual meetings?

Which opportunities through the OBPS (repository, and search engine) can facilitate the convergence processes?

- Repository and workshops can facilitate community review and endorsement (e.g, ranking system) and identify similar BPs
- What is the intention for communities to have access to endorsed/labelled Best Practice documents?
- Efficient use of limited funding and research expertise, increased comparability among national and global datasets

How should the current OBPS technology be modified (e.g., repository access, keywords, etc) to serve the Endorsement needs?

- Not sure, but whatever we do it should be as transparent as possible (e.g. no anonymous ratings, but identities could perhaps be known only to a committee)

1.3.3 Recommendations for the IOC OBPS

Community-specific guidance for the creation, use and updating of Best Practice documentation addresses the following questions:

How can OBPS motivates communities to converge existing methodological documentation and knowledge into best practices documents?

- Better incentives
- Funding needs to be available
- Cheaper instruments, standards and CRMs
- Inclusive process, i.e., personal investment and feeling of ownership
- Initiate/support the process following successful examples (e.g. IMOS)

What additional functions can the OBPS provide to facilitate the convergence of methods into BP documents?

- Ranking system of BP, i.e., Feedback feature for OBPS documents
- More training

Which objective/question can be resolved with which BP has to be clear (e.g., decision tree)?

- Involvement of citizen scientists
- Facilitate exercises of intercomparisons and intercalibration
- Implement consumer/user reports
- Highlight use of Certified Reference Material in OBPS repository docs (global approach with uncertainty well defined)

What additional functions can the OBPS provide to encourage the broad use and updating of best practice documents?

- Better advertisement of OBPS, i.e., better visibility
- Use OBPS ambassadors to get the word out
- Keep BP flexible and broad (not too prescriptive), i.e., need for more practical BP
- Transparent review processes of BP
- Engage more ECR

Is a specific labelling (endorsement) of Best Practices documentation required?

- Yes, endorsement creates trust which in turn ensures uptake and identification with BPs and thus ensure use and hence interoperability
- Endorsement can be based on institutions, organizations, or even on a “public
- endorsement” (via “likes”, comments, etc.)
- Regional endorsement through groups such as IMOS, IOOS etc
- Global endorsement through GOOS, SCOR

After discussion on our WG we thought that an interesting question to ask would be which international groups/working bodies would you consider asking to ‘endorse’ your BP, or who would you trust as an endorsement entity.

- The answer would depend on the kind of endorsement (as highlighted above) but would include regional organisations - SOOS, IMOS, IOOS, AtlantOS and global ones - GOOS, SCOR

1.4 OBPS use cases

The OBPS is interested in “use cases” which helps us to scope future services but also demonstrate the benefit and impact of Best Practices and of he OBPS. These use cases may address the implementation of a best practice or consider creation of a new or the update of an existing Best Practices. Please share your “Use case” examples or potential use cases with us. We are more than happy to follow up on an implementation with your group. Particular interest from OBPS is in how we can serve the communities in collaborating on creation and adoption of Best Practices.

1.5 UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

In this section, please comment on how your community will be responding to the Ocean Decade. Please see the latest implementation plan for guidance on the UNDOS high-level aims and rationale.

Did you discuss the “Decade” in relation to your working group scope and current and future activities?

- Endorsement is important for document uptake and use and hence is key for ensuring interoperability which in turn is a major topic in the Ocean Decade.

Do you think that Best Practices (and documentation) will play an important role in the “Ocean Decade”?

- This was not a focal point of discussion (see poll)

Do you have specific expectations on the Ocean Best Practices System for your area in the “Decade”? and in general for the Decade?

This was not a focal point of discussion (see poll)

1.6 Plans for follow up discussion and future collaborations

No plans were specifically made for follow-up discussions, but good connections were established such that we will be able to contact people. Future collaboration between OBPS and SOOS as well as SCOR may be considered.

2 Annex 2 Data and Information Management Working Group

1.1 Logistics

Topic of Session:
Data and Information Management
Co-leads:
Pier Luigi Buttigieg (Co-Lead)
Cem Serimozu (Co-lead)

Participants are listed in Table 2

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1.2 Links to other WGs

In this section, if your WG discusses themes that could be relevant to another WG in this workshop (e.g. sargassum, fisheries), please identify them here and indicate where your report mentions their theme.

Fisheries

Discussions on modularising methods (requires writing them differently) to allow mix-and-match to create manuals suited for different scenarios and to maximise reuse. The compilation will get its own DOI - OBPS should be able to make this easier.

Some form of metric or metadatum on how comparable the data coming from one methodological doc is to another one - can the data be compared? What caveats? Maybe include a method on conversion/integration in between.

Notes from the Pacific Tuna side, indicate that many paper-based methods are now being digitised to speed up transfer to national reporting systems – this provides new opportunities to link to OBPS records.

In the context of versioning - note that all the converging best practices are formed in a world with changing climate - the stable point is continuously moving as distributions change along with oceanographic conditions. How can the OBPS version control this (meta versioning with climatic parameters) and link it to data?

Coping with different communities - e.g., fisherfolk vs scientific missions vs commercial reports - all can do things the others can't, but use different standards and conventions. Need methods to map across these communities as they are major sources of data error. QC / validation / coded lists are encouraged.

Omics/eDNA

It was suggested to add a section to the templates (described in BP4BPs) that list the ethical reviews / evaluations the document has gone through, perhaps with a field for "passed" and a link to the document that describes the review process and outcomes. Include the respect for ethics principles as a checklist for submissions of BPs, and create a BP on ethics principles and include in the OBPS and also promote it for inclusion in training courses. Text-mining and Natural Language Processing (NLP) can have a dedicated routine for this and we can plug that in as a search filter. This can then be linked to the data and information that comes out of that methodological document (and that's linked to it in a provenance metadata section), so we know that the generating method has been ethically evaluated. The need for "boundary spanners" (noted in Mackenzie Mazur's presentation) was also articulated in the data WG, to bridge the technical communities to policy makers etc - we need those that are trained in both, with the interface space understood (and rewarded) as a field in itself.

Trust

The discussion then addressed trust. Some data and information are not easy to open up to all, but are auditors and ethics boards working confidentially a sufficient signifier of trust? Selective transparency applied to mutually trusted / neutral groups, which use fully transparent methods and share outcomes (similar to the logic of a credit check) provides a potential approach.

Is there a solid meta-analysis / in-depth review of how inclusion of stakeholders in scientific processes improves the outcomes? Cross stakeholders that aren't ready to open up their data completely to one another, thus would need a moderating/mediating third party,

Ethics & Uncertainty

There was strong agreement that better communication revealed that the strength of science comes from acknowledging and evaluating uncertainty.

2.1 Key Points and developments

2.1.1 Decision tree support

Cesar, Alexis, and Jens: I'll put that into our data and information WG report - some decision trees have to have strict outcomes to respond to emergencies/disasters (no margin for error). We can augment that with more dynamic suggestions, if desired.

For less high-stakes situations, a more relaxed and discovery/exploration-oriented approach is more suitable.

Merging of both a rigid decision tree and a dynamic discovery/exploration-oriented approach is also a powerful tool - an expert panel can create a static tree (so others can learn from their decision-making thinking), and dynamic suggestions offered at each step.

We can also crowdsource decision trees (as Jens suggested) from the community at large: we can then compile a library of these trees, allowing us a glimpse into different community's minds and priorities.

Allow also narrative text / stories to go in - apply text-mining and NLP to derive and extract a decision tree from that! Exciting challenge to put to the community as a project. The corpus of documents in the OBPS will strongly flavor this.

2.1.2 What can be done to bridge the mismatch of practice between the field/lab and the in silico workbench to reduce time loss and errors?

- Electronic measurement system linked to database concept extended to the vessel which provide near-real-time QC and data visualisation increases buy-in
- Reluctance of working groups to integrate local FIMS/LIMS system is a challenge. Maybe if the OBPS makes clear that changing this in favour of integrated systems is an organisational best practice, we can catalyse more change in this direction

2.1.3 Enabling feedback and dialogue

- There are ways of enhancing the existing OBPS portal and the tools already in use. E.g. by interlinking submitted best practices with the forum on the site would open up the practises for dialogue. E.g. users of best practices have a means to get in touch with the submitters and ask questions.
- Ultimately, further personalisation could be built on this - allowing users to create their own chain/decision trees/wizards, and expose them to the rest of the community. Using usage statistics already in place can allow exposure to users of most used/read practices - possibly subdivided into disciplines or similar.

2.2 OBPS use cases

A relatively simple pilot project could be established, distributing the bulk of the task. E.g. 10 scenarios for which we would want some decision trees/flows/wizards could be built. With a few volunteers for each

scenario to simply provide a set of steps and links to BP's these could act as a demonstrator on which to develop a visual/functional element for the portal itself.

Potential scenarios:

- Conducting Temperature and salinity measurements (added context for volunteer context would be beneficial - areas worked, coastal/offshore, equipment, budget)
- Recording abundance of species in biological sampling and readying it for further analysis.
- Recording human activities in oceans (spatial/economics/sociological)
- Oil spill incident response or other environmental disaster
- Collecting anecdotal or non-quantifiable data from indigenous populations or industry activities (fisheries might be a good example).

.

OBPS should welcome more content and lower the barrier with submission. E.g. rather than putting up the demand for more metadata or review processes, it should be democratically enabled by using technology to harvest the relevant terms and expressions from the submitted documents, and allow user metrics to show what is the most used/discussed practices.

Initial

2.3 UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

As an IOC resource, the OBPS is well positioned to help build methodological bridges between your community and the UNDOS - please let us know how we can support your method. Please see the latest implementation plan for guidance on the Ocean Decade high-level aims and rationale.

3 Annex 3 Developing Community Capacities for the Creation and use of Best Practices Working Group

3.1 Logistics

Topic of Session:

Developing Training and Guidance Materials

Co-leads:

Abbie Akinyi Allela	Stockholm Environment Institute. Sweden
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Peter Pissierssens	UNESCO/IOC/IODE, Belgium
Sheri Rahman Schwartz	Consortium of Ocean Leadership, USA.

Working Group Sessions:

Monday 21 September – Challenges and Priorities

Tuesday 22 September - Challenges and Priorities

Wednesday 23 September – Summary Session

3.2 Key Points and developments

3.2.1 Points of Discussion

- What capacity development programmes currently include training and awareness about the OBPS??
- What are possible entry points as defined in the needs, opportunities or challenges related to collaboration, participation or innovation that could be approached using BP methods and/or tools?
- Which of the methodologies for capacity development on BP should we capitalize, given the existing resources and available platforms? And what other methodologies which were previously not considered can optimize development and dissemination of BPs? How to configure viable e-learning tools/MOOCs for different user groups?
- How can we link isolated individuals, communities and networks? What strategies can be used to ensure new techniques in training and capacity development are capable of reaching across regions, cultures, and resources? How can the community ensure user groups with diverse backgrounds and experiences are also included in the creation of materials?
- As different users utilize the best practice methodologies, the identification of training methodologies that adapt to different communities and end-user groups becomes more imperative. Within these groups, how should community-review capabilities for trainings and guidelines be established? How can non-specialized practitioners contribute to discussion of methodologies in the creation, adoption and routine employment of best practices?

Further points of discussion at the working group summary meeting on Wednesday, September 23.

- Are there existing training programmes related to ocean best practices that you are currently engaged with or aware of?
- Who are the target users of OBPS training?
- What CD methodologies can promote the wider use of OBPs? e.g. online courses, face to face training, summer school, internship, etc.
- What existing tools, resources or platforms can be utilized for training on the development and dissemination of ocean best practices? e.g., toolkits, manuals, handbooks, videos, etc.
- What best practices on e-learning (online courses, webinars, MOOCs, etc.) can contribute to the effectiveness and success of OBPS training?
- How can non-scientific communities and practitioners get engaged in the creation, adoption and routine employment of best practices?
- What are the potential challenges and pitfalls in delivering and supporting OBPS training across diverse user groups?

3.2.2 Results of the discussions

Are there existing training programmes related to ocean best practices that you are currently engaged with or aware of?

- The Group noted (i) the OceanTeacher Global Academy, (ii) POGO fellowships; (iii) UNOLS RVTEC Technician Training Sub-Committee that works to provide marine technician training to UNOLS technicians. (iv) Another programme in the US is MATE internship program that provides students with hands-on shipboard intern experience; (v) IOCCP Biogeochemical sensor training course; (vi) ITIC (International Tsunami Information Center).
- Reference was made to an online survey that attempted to map existing OBPS-relevant training and CD programmes around the world. Preliminary results revealed that most initiatives offer short courses, workshops, courses towards BSc, MSc and PhD degrees, followed by ship-based training. In terms of subject areas most courses related to Data management, followed by Sensor use and QC/AC, and Product development. Looking at EOVs course focused mainly on subsurface temperature, subsurface salinity, phytoplankton mass and diversity, oxygen.

Who are the target user groups of OBPS training?

- The Group noted that the target audiences are mainly: students, educators, professionals working in the ocean, ECOPs, national and state government officials, disaster management authorities, industry, local communities, ocean-going technicians. In addition, it was felt that also Regional Information Centers, (RMICs), GOOS Regional Alliances (GRAs), Programmes and Projects such as IODE (Ocean InfoHub), AtlantOS, ODIP (Ocean Data Interoperability Platform) should be considered as target audiences.

What Community development (CD)methodologies can promote the wider use of OBPS (e.g., online courses, face to face training, summer school, internship, etc.)?

There was an overwhelming preference for online learning (probably caused by Covid-19). Online courses can reach large audiences across geographic boundaries. The group noted however that for topics that require hands-on laboratory or technical work a fully online approach will not work. Especially

hands-on experience onboard a research vessel is essential and is not easily replaced. However, in this regard the use of Virtual Reality was mentioned.

- It was concluded that a variety of methodologies needs to be considered depending on the subject and expected results of the training
- There should be some best practice development on how to be successful online
- It might be an option to do an online course with theory/background and then 1-on-1 coaching sessions for each group, which allows trainers to address research goals/objectives.
- Have been piloting these types of coaching sessions with different research groups and might be able to provide them with funding to purchase equipment and someone who has experience with that equipment can do a 1-on-1 session to show them how to set it up. OTGA is also an example of a model that can be used for online training in a formal course
- MOOCs are a great resource, supported by a suite of resources (papers, SOPs, open-source software etc.)
- Also mentoring and peer-to-peer were mentioned as relevant
- methodologies.
- Courses need to be provided in languages and educational level relevant to the target audience.
- Face-to-face courses were considered but limited to few participants if
- these can travel and are relatively expensive.
- Internships in lab and field work are very important and should be encouraged
- Field work should be considered an important way to apply sampling Best Practices

What existing tools, resources or platforms can be utilized for training on the development and dissemination of ocean best practices? e.g. toolkits, manuals, handbooks, videos, etc.?

- Infographics, videos, manuals, toolkits, handbooks, games, guidelines and virtual reality products
- It was noted that various monitoring networks have established best practices
- It was noted that OBPS could contribute to the development of “toolkits” that include BP guidelines, manuals, videos etc.
- It was recommended to also consider ethics courses in OBPS
- It was recommended to the SG-OBPS to consider the issue of how to review/recognize the quality of courses developed by a wide range of entities

In this regard the Group was informed that the IOC Project Office for IODE is ISO-29990 certified as Learning Services Provider and applies a well-defined set of protocols to plan, deliver and evaluate its courses.

What best practices on e-learning (online courses, webinars, MOOCs, etc.) can contribute to the effectiveness and success of OBPS training?

- The training offering needs to be more than just the lectures. There has to be pre-course involvement as well as post-course communication and assessments: communicating through email, giving an assignment, certificates; implementing practical projects at the end of the learning
- In this regard the importance of OceanExpert was also mentioned as a tool to keep track of experts as lecturers or students
- While training in itself does not constitute capacity development: the provision of equipment, maintenance and regular follow-up training (Continuous professional development) is also

important. In this regard, BPs are not static and will change with time. Trainees should be informed about these changes and the course platform should provide a historic trail of course evolution
- A cheat sheet for each EOV could potentially be of use by highlighting different methods (an imperfect vs perfect example or cost-effective vs. non-cost-effective). This would highlight basics of measurement technique, quality control currently implemented, and provides some references for additional reading. It would be easily distributed and low-cost.
- A “decision tree”/flowchart can help by laying out different methods and how the data that comes from it could mean or be applied

How can non-scientific communities and practitioners get engaged in the creation, adoption and routine employment of best practices?

- Citizen science initiatives such as coastal surveys, secchi disc measurements, biodiversity images. Innovative creative ways of getting involved in ocean science for young people such as building a CTD for 100 euros, 3D printing of sensor models, inexpensive communicating buoys with Android cards and PVC pipes etc.
- They can also become involved in scientific NGO's, scientific societies like Ocean Society of Indian Geophysical Union Society of Earth Scientists etc.
- Networking in diverse networks for ECOPs, general public, acquaria, etc.
- Community engagement events, e.g. public talks, community science events
- The research community should reach out to those communities and establish what tools and resources are specifically needed for their situation
- It is important to co-design some best practices with policymakers. This could include how to present and communicate data, how to serve data to end users, etc.
- An important hurdle to involving the non-scientific communities is access to the technology needed to access data and information
- Need to engage traditional knowledge holders from indigenous communities, their data will be important to their best practices.
- It is important to develop data and information delivery mechanisms that are suited for the target audience (eg make it possible to use cellphones to receive data and information)
- It is important to highlight local champions in smaller countries. In the process of creating best practices in coastal communities, local community is engaged in the process because the process is designed to involve them throughout the project. This is very relevant to the discussion on inclusion and taking into consideration the local knowledge/communities to create best practices around them. This point was also discussed in the ethics working group.

What are the challenges and potential pitfalls in delivering and supporting OBPS training across diverse user groups?

Challenges

- Sustainability of the training effort and related availability of funding
- Agreement and consensus on best practices and their community engagement
- The challenge may be "the need to identify the "best for who" and "best for what" for every "best" that is encountered to prevent discrepancies and confusion
- Many developing nations and ECOPs don't always have the needed Internet connectivity, platforms, and language to fully engage in this effort.

· Pitfalls

- We need to be careful not to force BPs as defined by some of our community members on everyone as they may be insensitive to local conditions, indigenous communities, available technology
- People can become very overwhelmed with best practices. It may be appropriate to identify “practical best practices” - other versions of best practices that allow people to feel confident they're doing high quality work with perhaps a less-perfect design.

In addition, the Working Group identified the following action items:

- Create a toolkit that includes a variety of resources: cheat sheets for each EOV and host them on OBPS. model datasets for each EOV to help train on how to handle data, as well as a model for metadata.
- Can start with a trial run in connection with Convergence of Methods WG or Uncertainty Quantification WG.
- Decision trees that help by laying out different methods and how the data that comes from it could mean or be applied
- OBPS can support by providing access to science communicators/digital designers and citing DOI of resources available.
- Develop best practices on stakeholder engagement involvement in the process
- regarding developing training targeted to members of various communities.
- Develop best practices compendium on the subject of Virtual Reality (VR).
- Develop best practices on Stakeholder Engagement.
- OceanTeacher Global Academy can contribute to OBPS through its platform, hosting
- OBPS training materials, and by assisting with the organization and implementation of training events either online or through its network of Regional Training Centers
- (RTCs) or Specialized Training Centers (STC).
- Include courses on 'Applied Ethics in Marine Science.
- More funding is needed to support OBPS training, CD initiatives and internship
- programmes (shipboard training).
- Improve face-to-face courses for sharing experiences and building new networks on OBPS CD initiatives.

PLENARY 2 DISCUSSIONS

- One-on-one coaching is a good idea, but a blended model would need to address specific issues for the topic.
- OBPS can house videos/documents necessary and somehow work to identify individuals who can provide the initial coaching/hand-holding to encourage them.
- Some BP's can almost act as training (e.g., includes background info, rationale, written in approachable language) - while others will be accessible only to experts. Maybe tagging some BP's as "Good training resource"
- standards will come, however the infrastructure to support standards in this area needs to develop and further convergence in ocean observing

- Create a board of mentors and advisors
- Forum could be the location of 1-on-1 opportunities or consultation opportunities

4 Annex 4 Ethics in Ocean Observations Best Practices Working Group.

4.1 Logistics

Co-leads:

Michèle Barbier,	Institute for Science and Ethics, France
Tobias Hahn,	GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
Mackenzie Mazur,	Gulf of Maine Research Institute, USA
Fred Whoriskey,	Ocean Tracking Network, Dalhousie University, Canada

Working Group Sessions:

Monday 21 September – Session 1: Ethics in ocean observation overview; Michèle Barbier from the Institute for Science & Ethics (France)

Tuesday 22 September – Session 2: Ocean observations and indigenous groups; Shelley Denny, Dalhousie University (Canada) and the Aquatic Research and Stewardship at the Unama'ki Institute of Natural Resource (UINR)

Wednesday 23 September – Session 3: Ethics and fisheries; Mackenzie Mazur from the Gulf of Maine Research Institute (USA)

Thursday 24 September – Session 4: Optimizing infrastructure; Frederick Woriskey from Dalhousie University (Canada).

4.2 Session 1: Ethics | Ethics in ocean observation: Overview

Speaker: Michèle Barbier from the Institute for Science & Ethics (France)

Scope of the Session WG

The aim of this session was to highlight the core values applicable to ocean observation, which could then be improved and adopted to become an integrated part of best practices in ocean observing methods and systems. Ethics are the sum of all elements that will enable equitable and sustainable research and monitoring endeavors and include elements drawn from philosophical, social and natural scientific dimensions.

Autonomy, dignity, integrity and vulnerability are the four law and public policy values that guide ethical decision-making in human health care and technology development (European Commission's

Fundamental Ethical Principles on Bioethics and Biological Law. Autonomy, Dignity, Integrity and Vulnerability, 2000).

In research, fundamental ethical values such as honesty, integrity, transparency and reliability, as well as accountability should be promoted. Responsibility is one of the values that the human community universally accepts as representative of individual and social good because it promotes honesty, justice and respect for life and the environment. It is important in research to emphasize the responsibility of scientists to take the necessary steps to ensure a healthy working environment, to keep society safe, and to promote good international relations. Awareness of the issues of mistrust and risks (diplomatic, geopolitical and environmental) can prevent or mitigate undesirable impacts and ensure environmental protection. This in turn enhances the resilience and well-being of societies. Accordingly, as scientists we have a responsibility in our work to apply fundamental ethical values consistent with the UN's sustainable development goals.

All research activity must comply with the legal obligations of the producing country and in some cases with international laws. While sampling operations must, as a minimum, comply with national and local laws, to meet recently established sustainability goals, more ambitious voluntary actions that go beyond those required by law must be developed.

Michèle Barbier from the Institute for Science & Ethics (France) gave a presentation on the topic, followed by a 90 min lively discussion.

4.2.1 Logistics

Lead, Co-leads, Rapporteur(s) present at session

Role	Given Name	Family Name	Affiliation	Country	email	ORCID if available
Lead	Michele	Barbier	Institute for Science and Ethics	France	mbarbier@sciencethics.org	https://orcid.org/0000-0003-3845-6233
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Monitor for chat/hand-raised & security monitoring for disrupters	Mackenzie	Mazur	Gulf of Maine Research Institute	United States	mmazur@gmri.org	https://orcid.org/0000-0001-8615-4702
Monitor for time	Fred	Whoriskey	Dalhousie University	Canada	fwhoriskey@dal.ca	https://orcid.org/0000-0001-7024-3284

Locations of WG documents: Google Drive Folder

Date and time of session: September 21st at 12:00 UTC - 13:55 UTC

Participants are listed in Table 3.

Table 3 Participants to Ethics WG session 1

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Abigail	Wells	NOAA Fisheries Northwest Fisheries Science Center	USA	abigail.wells@noaa.gov	

4.2.2 Links to other WGs

All WGs, especially: WG 'Data and Information', WG 'Training and guidance', WG 'Omics-eDNA', and WG 'ECOP/early-careers'.

4.2.3 Recommendations for your community needs and for development of methods and best practices

Ocean Observers should feel responsible for what they are doing and think about the long-term impact of their research activities.

Applied Ethics define how to implement principles and core-values related to one domain. Applied Ethics provide guidance and assure long-term global impact. Guiding principles address past power imbalances.

To embrace ethics principles in ocean observation (Ocean Observation Ethics Statement) In your research activities, ensure that you are:

- Respecting human freedom, dignity, equality and solidarity, citizens' rights and justice
- Respecting cultures and differences when engaging local people/indigenous communities in research activities and engage them at the outset of the research
- Working with the goal of global benefit for you and for your partners and collaborators (strive to understand the interests of others)

    - Negotiating fairly to reach agreements
    - Applying transparency and reciprocity, explaining the objectives of your research, identifying who are the third parties, and updating everyone on changes that occur to the research program
    - Compliant with international AND national legislation
    - Sharing data: acquire once, use multiple times but respect regional/national imperatives- - (e.g., OCAP - Ownership, Control, Access, Possession - First Nation's data principles)

- Maximizing the efficiency and quality of observations in research activities
- When engaging with society, ensure transparency and offer feedback
- Minimizing impacts from research and monitoring on ocean ecosystems, for example by applying Life Cycle Assessment or multi-risk assessment, or providing means of restoration for damage done by your work if needed
- Ensuring animal welfare (Adherence to the Three R's principle: Replacement – Reduction – Refinement)
- Communicating with and advising policymakers, providing feedback, decomplexifying the topic (engage discussion on applications rather than on scientific objectives)
- Encouraging learning.

When an ethical issue arises, first check existing legislations or rules (i.e., the Convention on Biological Diversity (CBD), the United Nations Convention on the Law of the Sea (UNCLOS), Nagoya Protocol, Antarctic Treaty, etc.) **AND specifically national legislation for all jurisdictions that apply.**

Whatever the ethical issue is, scientists should think about potential long-term impacts (positive and negative) to help make a decision. Difficult ethical issues such as the use of existing data stemming from oil drilling, whale hunts or 'unethical' experiments have to be carefully considered. Institutional ethics committees could help here.

OBPS existing infrastructure: Integration can take place through terminologies, ontologies, text-mining technology, links and labels. Metadata can also be published if raw data are embargoed or not yet finalized. Add a dedicated section. Matches can then trigger suggestions. Documents can be uploaded.

A tracking system is necessary when sharing information (who, what, where) and a labelling system for data and technology will help ease the handling of ethical issues when implementing CARE-principles (CARE stands for Collective benefit, Authority to control, Responsibility and Ethics). It is important to share the information regarding the participation of all third parties involved in a project or using data/samples.

Traditional and indigenous knowledge input and exchange in the development of Best Practices (BP) is a pressing and important issue. Consolidation of traditional knowledge and 'our' knowledge benefits all parties.

Innovation and technology drives and shapes legislation, but before a legal framework is established, ethics is a powerful guiding tool to prevent unwanted damage by both technology and legislation to humans, the environment and society.

Violation of ethics/agreements can be pursued and penalized via community pressure (reputational risk). Connections to the FAIR data principles (Findable, Accessible, Interoperable and Reusable) will help here. How can we define which actors (e.g., individual persons or institutions) are unethical?

Gender diversity issues and imbalances need more attention and solutions, especially during oceanographic cruises!

Data Sharing Agreements are very hard to negotiate. Wherever possible, it is much easier to use w3c standard Data on the Web Best Practices and publish data to open data catalogs and let anyone use the data for any purpose without permission.

Unethical people may adapt to changing ethics by hiding their behaviors with new tools. It will be a challenge to hold such individuals accountable.

Interesting links to make the community aware of previous work on data and ethics:

https://theodi.org/event/data-ethics-an-introduction/
https://theodi.org/article/data-ethics-canvas/

4.2.4 Recommendations for the IOC OBPS implementation of ethics in the OBPS:

1) Design a flowchart to guide researchers in identifying potential ethical issues that could affect their work (draft: see here)
   This tool will create awareness among researchers and end-users and provide key points to be answered when best practice documents are submitted. Furthermore, this will help to engage people in considering ethical issues, including individuals without a previous knowledge of ethics. The flowchart should at least list types of questions (better: with boxes and arrows) and can be completed/complemented with artificial intelligence tools cued to keywords. Helpful information is available here: https://theodi.org/article/data-ethics-canvas/

2) Implementation of a permanent Ethics Working Group in the ocean observing community composed of diverse memberships, perspectives, and expertises

3) Organise online courses on Applied Ethics specifically dedicated to ocean observation

4) Design a statement or a charter for Ocean Observers (to be endorsed by credible community sources) and highlight individual responsibilities (first draft: See here)

5) **Implement a clearing house** providing information on what kind of permission/legislation is related to your research activities, where to find the information, and whom to contact for help or more information.

4.2.5 The UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

- The UN Decade of Ocean Science is based on ethical principles. A direct link between an ethics WG or committee and the Decade would be effective.
- A**n ethics committee for ocean observation/ocean sciences** with appropriate diversity and expertise would be beneficial.

4.2.6 Future collaborations

A first draft of an Ethics Statement needs collaborative participation from the community.

A core-group has been gathered to provide a first draft of this statement. The group is composed of: Michele Barbier, Frederick Whoriskey, Mackenzie Mazur, Johannes Karstenssen, Frank Muller-Karger, Pier-Luigi Buttigieg, Raissa Meyer, Carmen Grados, Nick Roden, Yi-Ming Gan, Jörn Schmidt, Lydia Ross, and Carol Ana Carolina de Azevedo Mazzuco.

The Slack platform could be a tool to continue discussion. A Google Drive to share documents will also be used.

Interactions with Observers might be needed, and the OBPS can help.

A special Issue on Ocean Sciences & Ethics in Frontiers is open for contribution until 31 May 2021.

4.3 Session 2: Ethics | Ocean observation and Indigenous groups

Invited speaker: Shelley Denny, Dalhousie University (Canada) and the Aquatic Research and Stewardship at the Unama'ki Institute of Natural Resource (UINR)

Scope of the Session WG

As society moves to incorporate new knowledge systems/streams into science-based decision making, and especially to embrace indigenous knowledge streams, new ethical issues are arising. In Canada and other jurisdictions, moves are now occurring to bring indigenous participation into all facets of many new research programs in meaningful ways. However, as western science moves towards an open access for research data, indigenous peoples are seeking ways to correct historical injustices that resulted when they could not protect their knowledge and maintain ownership and control of data that would affect them and influence their relationship with the environment. One indigenous model to address this is the Ownership, Control, Access and Possession (OCAP) framework. It is important that western researchers understand and embrace the ethical basis of indigenous concerns and adjust in ways that also permit us to meet ethical obligations to western research.

Shelley Denny from the Dalhousie University (Canada) and the Aquatic Research and Stewardship at the Unama'ki Institute of Natural Resource (UINR) gave a presentation on this topic, followed by a 1h 30 min debate.

4.3.1 Logistics

Lead, Co-leads, Rapporteur(s) Present at session

Role	Given Name	Family Name	Affiliation	Country	email	ORCID if available
Speaker	Shelley	Denny	Dalhousie University	Canada	sdenny@dal.ca	
Leader	Fred	Whoriskey	Dalhousie University	Canada	fwhoriskey@dal.ca	https://orcid.org/0000-0001-7024-3284
Rapporteur/ Monitor for time and for security	Michele	Barbier	Institute of Science and Ethics	France	mbarbier@sciencethics.org	https://orcid.org/0000-0003-3845-6233

Monitor for chat/hand-raised	Mackenzie	Mazur	Gulf of Maine Research Institute	United States	mmazur@gmri.org	https://orcid.org/0000-0001-8615-4702

Locations of WG documents: Google Drive Folder

Date and time of session: September 22nd at 12:00 UTC

Participants are listed in Table 4

Table 4 Participants to Ethics WG session 2

Given Name	Family Name	Affiliation	Country	email	ORCID if available
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Christina	Macdonald	Coastal and Ocean Information Network Atlantic	Canada		
Claudia	Baron-Aguilar	University of South Florida	USA		
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R	Venkatesan	National Institute of	India		

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Niels					
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4.3.2 Links to other WGs

All WGs.

4.3.3 Recommendations for your community needs and for development of methods and best practices

The Two- Eyed seeing model: “learning to see from one eye with the strengths of Indigenous knowledges...and from the other eye the strengths of Western knowledges...and using both these eyes

together, for the benefit of all." - Albert Marshall. To this end, Indigenous communities could teach non-indigenous communities about the indigenous perception of western scientific research.

Trust: It is crucial that both groups know each other, and exchange knowledge extensively. This also includes creating relationships between scientists and indigenous communities where both sides have a mutual benefit of the relationship. In this type of relationship, scientists should give back to the Indigenous communities in a way that helps communities grow.

Participatory and co-designed approaches are essential for indigenous community participation. Collective expertise is more valuable than individual expertise. Mutual respect, reciprocity, dialogue, listening, and understanding guide the interests of the indigenous community to participate in a project and where there are differences between Indigenous and other groups, negotiations are welcome to find solutions. The Indigenous community can apply some restriction or limitation on participation in research and the use of research results to ensure the respect of their culture (i.e. in one project an Indigenous nation established an agreement that when tagging fish for research, the accidental mortality would not be above 10 animals. If this number was exceeded, the project would stop.

When engaging into a participatory project with western scientists, indigenous communities want to be involved from the earliest stages of the work. Indigenous groups will help other participants to understand their culture, and show what is important to them. Research involving Indigenous groups must generate outputs that are of interest to Indigenous communities.

OCAP principles: Ownership, Control, Access and Possession: The Mi'kmaw communities apply the OCAP principles regarding the outcomes of research in projects that implicate them. Ownership refers to the relationship of First Nations to their cultural knowledge, data and information. Control affirms that First Nations, their communities, and representative bodies are within their rights in seeking to control over all aspects of research and information management processes that impact them. Access refers to the fact that First Nations must have access to information and data about themselves and their communities regardless of where it is held. Possession or stewardship is more concrete and refers to the physical control of data. **OCAP is a basis for negotiation; it refers to standards and is a protection mechanism.**

Mi'kmaw Ethics Watch: a committee established 10 years ago with a diversity of expertise, knowledge, and cultural practices. They review projects to ensure the preservation of indigenous knowledge.

The Mi'kmaw culture is respectful of animals and of the environment. The Mi'kmaw community builds strong relationships with society through mutual interactions; in many collaborations with local populations, they always provide feedback to society on their research and results. They collaborate efficiently with local governments. They also regularly consult within their communities, asking the opinion and needs of their people.

In the Mi'kmaw community, scientists interested in conducting research implicating the community can and should contact the local Mi'kmaw government, as there is a strong interaction between scientists and local government. They are actors in Ocean Observation and call for the respect of their knowledge and values. Trustful relationships lead to open negotiation and agreements.

In some other Indigenous communities, it is important for a member of an indigenous community to be the one that first introduces a non-indigenous scientist to the indigenous community

Learn community-based approaches from social sciences. A new set of guidelines can be created for natural sciences.

4.3.4 Recommendations for the IOC OBPS

- When working with Indigenous communities, create collaborative projects and implement and encourage knowledge sharing with these communities.
- Ensure that researchers respect indigenous cultures.
- Ensure that researchers are aware of the OCAP Principles.

4.3.5 The UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

The UN Decade of Ocean Science is based on ethical principles. A direct link would be effective. An ethics committee for ocean observation/ocean sciences with diverse relevant expertise would be beneficial.

4.3.6 Future collaborations

A draft of an Ethics Statement would need collaborative participation from the community.

A core-group has been struck to provide a first draft of this statement. The group is composed of: Michele Barbier, Frederick Whoriskey, Mackenzie Mazur, Johannes Karstenssen, Frank Muller-Karger, Pier-Luigi Buttigieg, Raissa Meyer, Carmen Grados, Nick Roden, and Yi-Ming Gan, Jörn Schmidt, Lydia Ross, and Carol Ana Carolina de Azevedo Mazzuco.

4.4 Session 3: Ethics | Ethics & fisheries

Speaker: Mackenzie Mazur from the Gulf of Maine Research Institute (USA).

Scope of the session WG

Fisheries are complex and involve a variety of stakeholders that are strongly impacted by the process and outcome of fisheries science. Fisheries science also depends on information and often participation from a variety of stakeholders. As a result, transparency in data and methods is an important ethical issue in fisheries science that needs to be addressed. Indeed, FAO's ethical approach to fisheries calls for data transparency. However, transparent data and methods are not easily accessible in fisheries science. Fisheries often come with large amounts of data that are not centrally stored and as a result, not accessible to many. Additionally, the methods used in assessments are often not clearly communicated or available to all stakeholders. Including fisheries stakeholders in data collection and methods and clear science communication are two approaches to address this ethical issue. Satisfying a broad range of stakeholders with the process of fisheries science is difficult but necessary for ethical science. The discussion was undertaken to help define best practices on that topic.

Mackenzie Mazur from the Gulf of Maine Research Institute (USA) gave a presentation on the subject, followed by a 1h 30 min debate.

4.4.1 Logistics

Lead, Co-leads, Rapporteur(s) Present at session

Role	Given Name	Family Name	Affiliation	Country	email	ORCID if available
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Monitor for chat/hand-raised, time and security	Michele	Barbier	Institute for Science and Ethics	France	mbarbier@sciencethics.org	https://orcid.org/0000-0003-3845-6233

Locations of WG documents: Google Drive Folder

Date and time of session: September 23rd at 12:00 UTC

Participants are listed in Table 5

Table 5 Participants to Ethics WG session 3

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Veronica	Kapula				
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Franck	Muller-Karger	University of South Florida	USA		
Ana-Carolina	Mazzuco	Universidade Federal do Espírito Santo	Brazil		

4.4.2 Links to other WGs:

WG on fisheries.

4.4.3 Recommendations for community needs and for development of methods and best practices

Fisheries are social-ecological systems as they include economy, ecology, natural resources and governance. Many stakeholders are affected by fishery sciences and the fishing industry should have a greater influence in fisheries science and management. To sustain scientific collaboration with fishers, there is a need for processes that build trust and foster openness and

Transparency. Transparency is the openness of information that allows others to readily see what actions are, or are not, being conducted and the process of participation in obtaining, sharing, and creating knowledge.

Fishers provide data that can be used to analyse the status of the resource. Collaboration with scientists is thus essential. Transparency and collaboration with fishers is important because if successful, it improves relationships between scientists and fishers, which improves the resulting science. In result, this improves agreement with the resulting fisheries management.

For a successful collaboration, transparency is needed during the process of participation, and to ensure the openness of the information. Openness of information allows others to readily see what actions are, or are not, being conducted. The process of participation refers to obtaining, sharing, and creating knowledge.

The benefits of adopting transparency are multiple: increase quality of the data, provide room for constructive criticism, develop trust, help to resolve conflicts early and increase collaboration with stakeholders. Examples of the consequences of distrust among fisheries and scientists (Atlantic Cod fisheries), and alternatively of trust between stakeholders (Maine American lobster fishery) were presented for consideration during the session.

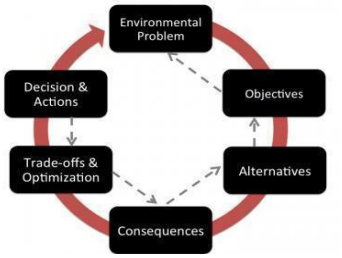
Transparency is now popular but the incorporation of fisher's knowledge into scientific results is still limited. The challenges are:

- Lack of trust
- Difficulty of communicating uncertainties
- Mismatch of objectives

There are approaches that require and will increase and improve transparency and collaboration if done effectively. Many of these approaches stem from social science methods. The approaches recommended to foster and improve collaboration are:

- Clear scientific communication
- Address early existing or potential internal conflicts among stakeholders
- Ensure extensive discussion
- Stakeholders take part in knowledge production
- Knowledge scores
- Participatory modelling

Conduct a survey on transparency which develops a general understanding of issues in the community by asking questions such as: Where would you go to get information you wanted/needed? How aware are you of the science going on that is relevant to you? How confident are you that you can get the information on science you want/need? How often do scientists give your community information about their research? Do you think science is generally open and transparent?



Structured decision-making which tends to flow as follows:

The purpose of this framework is to promote a logical and transparent process for making informed management decisions. Such an approach clearly distinguishes the components of the decision process that are inherently subjective (management objectives, potential management actions) from those that are more objective (models of system behavior, estimates of system state).

Ethical matrices (Kaiser and Forsberg 2000)A filled-in ethical matrix can help ensure that fishers' values are being considered. Ethical matrices acknowledge the multitude of interests represented by different stakeholders and that different ethical concerns may all be relevant.

	Justice	Dignity	Wellbeing
Fishermen	Equal right to professional practice for different categories of fishermen	Right to control of their work situation and respect for their occupation	Safe and secure workplace and income, as well as stable social situation
Fishing industry	Equal terms for this industry as for the fisheries and other marine occupations	Acknowledgement for their place in the value chain; being heard in negotiations	Stable deliveries from the fisheries; a part of the welfare goods obtained in the value chain
Other users of the sea and coast	Equal access to the resources	Respect for their needs and their use of the coast and sea	Access to welfare goods directed at marine activities as other users
The society as a whole	Equal living conditions for urban and rural societies	Freedom to manage resources for the best for the society as a whole	Income from marine activities
Consumers	Fish products of good quality available for different consumer groups	Opportunity for the consumer to chose and influence the production of food products	Guaranties for healthy food in adequate amounts
Future generations	The conservation of marine environment and resources so that future generations will have the same opportunities we have	Knowing that earlier generations acted with respect for their welfare	No activities that threaten their health or living conditions
The biosphere	The diffusion to a viable level of environmental burdens over a variety of ecosystems	Harm and abuse of nature as limited as possible	That fish and other animals are not exposed to unnecessary pain

Pedigree matrices (Issaris et al. 2012)

A pedigree matrix describes aspects of data quality influencing the reliability of the overall result

and assists different stakeholders in understanding each other.

Indicator Score	1	2	3	4	5
Reliability	Measured Data	Verified data partly based on assumptions	Non-verified data partly based on qualified estimates	Qualified estimate (e.g. by scientific expert)	Non-qualified estimate
Completeness	Representative data from all sites relevant for the study area considered over an adequate period to even out normal fluctuations	Representative data from >50% of the sites relevant for the study area considered over an adequate period to even out normal fluctuations	Representative data from only some sites (<50%) relevant for the study area considered OR >50% of sites but from shorter periods	Representative data from only one site relevant for the study area considered OR some sites but from shorter periods	Representa-tiveness unknown or data from a small number of sites AND/ OR from shorter periods
Temporal correlation	Less than 3 years of difference to year of study	Less than 6 years difference	Less than 10 years difference	Less than 15 years difference	Age of data unknown or more than 15 years of difference
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar environmental conditions	Data from area with slightly similar environmental conditions	Data from unknown area or area with very different environmental conditions
Data collection process quality	Data from targeted research conducted by the team involved in the case study	Data from targeted research conducted by other teams not involved in the case study	Data from targeted research conducted with different methodologies	Data from common research conducted with a standard methodology	Data from common research conducted with different methodologies

Management strategy evaluation

Management strategy evaluation (MSE) is similar to structured decision-making. MSE is a simulation-based approach to evaluate management strategies with consideration of uncertainties and stakeholder objectives.

Collaborative monitoring

Collaborative monitoring includes monitoring programs designed and conducted by scientists and fishers.

The working group considered the successful example of the on-going Eastern Gulf of Maine Sentinel Survey, which is co-designed and conducted by scientists and fishers interested in managing groundfish. In this survey, fishers' boats are used.

The concept of Boundary Spanners was introduced. A Boundary Spanner is a person that can link different groups together and can lead successful collaborations. The role requires trust with different groups and sharing of both data and results. There is a need in many fisheries for boundary spanners, and the relevant training should be provided. In Canada, in the past, the role of a boundary spanner was undertaken by volunteers with limited preparation, and the process has not improved.

Boundary spanners must have skills in:

- Conflict resolution
- Listening
- Recognizing the value of fishers and their knowledge
- Scientific communication

The need for a boundary spanner/moderator raises the question of the funding for the role. In Brazil, as well as in the U.S., federal agencies are currently providing such funding.

Scientists face the interesting challenge of collaborating with both large fishing companies and local traditional fishers. Traditional coastal fisheries can provide daily monitoring of stocks at local scales.

In Peru, there is active participation by commercial entities, engaged with the national society of fisheries, who use data from remote sensing instruments to guide their fishing activity and improve catches. The Ministry of Fisheries also launched an information and education campaign to help sustain and protect fisheries.

4.4.4 Recommendations for the IOC OBPS

- Increase the amount of collaboration and transparency in fisheries science
- Improve the quality of collaboration in fisheries science
- **Develop best practices** to assist in this effort
- Ensure the recognition of all fisheries stakeholders (can use a variety of media to do so)
- Regularly communicate with the engaged stakeholders (fishers and all actors of the value chain)

4.4.5 The UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

- **Recognize the importance of Boundary spanners/mediators.** This role can create new jobs which require specific training and funding.
- Data obtained from fishers are useful for fisheries scientists but also to climatologists and many other ocean scientists. Within the framework of the UN Decade, **recognizing fishers' and other stakeholders' contributions and engagement should occur.**
- Support the participation of fishers in research cruises.
- **Scientific information must be disseminated at all levels**, from the organization responsible for management to the fishers.

4.4.6 Future collaborations

A core-group has been created to provide a first draft of a statement on research ethics. The group is composed of: Michele Barbier, Frederick Whoriskey, Mackenzie Mazur, Johannes Karstenssen, Frank Muller-Karger, Pier-Luigi Buttigieg, Raissa Meyer, Carmen Grados, Nick Roden, Yi-Ming Gan, Jörn Schmidt, Lydia Ross, and Carol Ana Carolina de Azevedo Mazzuco.

4.5 Session 4: Ethics | Optimizing infrastructure

Speaker: Frederick Woriskey from Dalhousie University (Canada).

Scope of the session WG

Most ocean research infrastructures depend mostly or wholly on public funding to maintain their development, operations and maintenance. This potentially confers on the scientists who operate and use them an ethical responsibility to maximize benefits from these expensive investments. Many ocean observation infrastructures are established for unique, single purposes. Currently, the ocean science community does not systematically evaluate whether particular deployments could serve multiple purposes and more cost-efficiently bring bigger benefits to society. Figuring out how to do this should be a priority of the science community. The discussion was intended to help stimulate definitions of best practices to maximize scientific value from infrastructure investments.

Frederick Whoriskey from Dalhousie University (Canada) gave a presentation followed by a 90min debate.

4.5.1 Logistics

Lead, Co-leads, Rapporteur(s) Present at session

Role	Given Name	Family Name	Affiliation	Country	email	ORCID if available
Lead	Fred	Whoriskey	Dalhousie University	Canada	fwhoriskey@dal.ca	https://orcid.org/0000-0001-7024-3284
Rapporteur	Michele	Barbier	Institute of Science and Ethics	France	mbarbier@sciencethics.org	https://orcid.org/0000-0003-3845-6233
Monitor for chat/hand-raised	Mackenzie	Mazur	Gulf of Maine Research Institute	United States	mmazur@gmri.org	https://orcid.org/0000-0001-8615-4702
Monitor of time and security	Tobias	Hahn	GEOMAR Helmholtz Centre for Ocean Research Kiel	Germany	thahn@geomar.de	https://orcid.org/0000-0002-9001-5753

Locations of WG documents: Google Drive Folder

Date and time of session: September 24th at 1pm UTC

Participants are listed in Table 6

Table 6 participants to Ethics WG session 4

Given Name	Family Name	Affiliation	Country	email	ORCID if available
Jenny	Bortoluzzi	Trinity College Dublin	Ireland	bortoluj@tcd.ie	https://orcid.org/0000-0002-0496-5358
Yi-Ming	Gan	Royal Belgian Institute of Natural Sciences	Belgium	ymgan@naturalsciences.be	
Carmen	Grados	Instituto del Mar del Perú	Peru		
Cora	Hoerstmann	AWI	Germany	cora.hoerstmann@awi.de	https://orcid.org/0000-0002-0097-2454
Ana-Carolina	Mazzuco	Universidade Federal do Espírito Santo	Brazil		
Jay	Pearlman	IEEE	USA	jay.pearlman@ieee.org	
Nick	Roden	University of Bergen	Norway	Nicholas.Roden@uib.no	
Robyn Mairin	Samuel			robynsam145@gmail.com	
Jörn	Schmidt	International Council for the Exploration of the Sea	Denmark	joern.schmidt@ices.dk	https://orcid.org/0000-0002-4420-6532

4.5.2 Links to other WGs

All WGs.

4.5.3 Recommendations for community needs and for development of methods and best practices

In ocean observation there are broadly two kinds of approaches: the international ocean observing programmes (such as GOOS and Argo to address already defined societal needs; these are well coordinated, long-term, nationally endorsed and hence more easily sustainable programs) and punctual observations (related to local needs; tend to be short-term, coastal, independent and uncoordinated).

As one group cannot measure everything to ensure a sustainable ocean, there is benefit in sharing platforms for monitoring, and for a mechanism to coordinate a sharing structure.

Known obstacles for optimizing infrastructure include: time issues, incentives (who benefits from the optimization effort), too many tasks, customs regulations, data processing, organizing effective communication channels, language barriers, and cultural differences. However, access to observational platforms among scientists so far face no insurmountable legal hurdles.

Researchers can communicate more to make their research more visible. Depending on your target group, there are a variety of mechanisms to showcase research:

- OBPS platform
- OceanExpert forum: https://oceanexpert.org/
- Radio/TV
- Your own institutes' home website
- JCOMMOPS
- The clearing house: https://absch.cbd.int/
- Social media (use with care and pay attention to the rules): Facebook, Twitter, Instagram

The reputation of a Working Group is also relevant for sharing/optimizing infrastructure, but an individual sometimes has little influence within a Working Group. Dealing with breakdown issues and failures require individual solutions.

It is necessary to include more ECOP (PhD's, Early PostDocs) in this process as they have a strong desire for collaboration. Senior scientists can be less eager because they might have been 'burnt' before. A recommendation to address this is a training programme dedicated to ECOP exchange or a mentoring programme to favour exchange among different research groups.

Collaboration of industry and science can be promising, but it may only be sustainable via local collaborations. Low cost-technologies are of great interest to many parties.

Optimizing infrastructure comes with sharing knowledge and expertise (give and gain process) between scientists and stakeholders. This might build the momentum to overcome single-discipline thinking.

Integration of platforms will cascade the process of optimizing infrastructure. GOOS (Global Ocean Observing System) may provide platforms that meet their key objectives (measure EOVs/ECVs - Essential Ocean Variables and Essential Climate Variable).

The value to be accrued from the possibility of integrating new programmes must be developed (such as the Ocean Tracking Network connecting fisheries). Disciplinary boundaries are real and central mechanisms to share infrastructure that could help to create interdisciplinary links and foster discussion. Perhaps these could be organised at the government level. Focusing on a geographic area may enhance exchanges for sharing platforms, infrastructure, sensors, and monitoring instruments. An example of a platform for integration of platforms at a specific geographic area is the Arctic Best Practice System (ABPS), which is currently under development.

Better connection of international, mostly offshore, sustained observing systems to regional, coastal observing infrastructures and smaller communities are also needed. This scientific outreach of products will give confidence to communities to further engage.

4.5.4 Recommendations for the IOC OBPS

OBPS can be a helpful tool to communicate an individual's own research and increase its visibility. Methods (puzzles pieces) to accomplish this within the OBPS can be:

- **Forums/common spaces** (e.g., regional workshops) = trustful, neutral place where people can share.
- Promoting fellowships/exchange programs (like POGO) as OBPS.
- **Mentor-program** (i.e.. PhD candidates will guest visit with scientists of their own choice during the PhD training time). This allows networks to develop beyond existing working groups or projects. Metrics are needed to capture the value of these exchanges to OBPS.
- **Additional sections/working groups in the OBPS** (e.g., 'shared infrastructure', 'low- cost high-performance observing technology', 'science-industry collaboration').

4.5.5 The UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

The UN Ocean Decade emphasizes: "The science we need for the ocean we want" and "you can manage what you can measure".

- **Organisation of regional workshops** to gather the different observers in a region would help discussion about technology, sensors, scientific topics, and geographic location and would enhance the optimisation of platforms.
- Launching calls on low-cost technology and science-industry cooperation

4.5.6 Future collaborations

A core-group has been created to provide a first draft of a statement on research ethics. The group is composed of: Michele Barbier, Frederick Whoriskey, Mackenzie Mazur, Johannes Karstensen, Frank

Muller-Karger, Pier-Luigi Buttigieg, Raissa Meyer, Carmen Grados, Nick Roden, Yi-Ming Gan, Jörn Schmidt, Lydia Ross, and Carol Ana Carolina de Azevedo.

4.6 Three final recommendations

1- Develop an Ocean Observation Statement defining community core ethical values

As an Example: https://wcrif.org/montreal-statement/file

The Ocean Observation Statement will be guided by the following activities/principles/responsibilities, which investigators should ensure to incorporate into their research activities:

- Respect human Freedom, Dignity, Equality and Solidarity, and Citizens' rights and Justice.
- Respect different cultures and their values when engaging local people/indigenous communities in research activities. This requires engaging early and often during research activities.
- Design and execute research activities in a way that all parties meet their needs and derive their anticipated benefits.
- Negotiate to reach mutually agreeable terms for the conduct of research (including management and processing of data).
- Apply transparency and reciprocity to all interactions; explain clearly the objectives of the research; identify all of the participating parties; and update everyone on changes to activities and personnel in a timely manner.
- Ensure all research activities are compliant with international AND national legislation.
- Share data (raw data and metadata) as much as possible: acquire once, use multiple times but respect regional/national decisions (OCAP principles: Ownership, Control, Access, and Possession).
- Maximize both the efficiency of data collection and the quality of research observations.
- When engaging with the public, ensure transparency and offer opportunities for feedback.
- Minimize any potentially negative impacts from the research and monitoring of ocean ecosystems; apply Life Cycle Assessment or Multi-Risk Assessment procedures when planning and executing the work; if harm is unavoidable, provide the means for restoration.
- For studies involving animals, ensure animal welfare is properly addressed (Adhere to the Three R's principle: Replacement – Reduction – Refinement), and respect cultural values with regards to animals.
- Communicate with and advise policymakers with regards to the significance of the research activities. Decomplexify the topic (engage discussion on applications rather than on scientific objectives).
- Encourage learning, education and knowledge exchange.

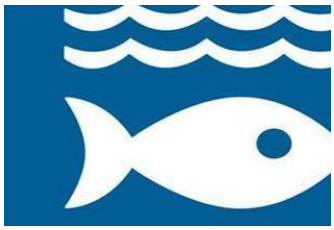
2- Develop a series of online training courses on Ethics specifically for ocean observation, organised by topic (e.g., collaboration with indigenous communities, collaboration with fishers, etc.), and if possible, link these with existing massive open online courses (MOOCs).

3- Design an easy-to-use and intuitive flow chart that identifies potential ethical issues related to proposed and existing research activities, and which leads investigators to ethical recommendations related to these issues.

Draft here: https://docs.google.com/document/d/11BTTBxvkXAEmsfUy9Kvk1lArNM4hiijj/edit

5 Annex 5 Fisheries Working Group

5.1 Logistics



Co-leads:

Peter Haugan, Institute of Marine Research, Norway

Cisco Werner, NOAA USA

Marino-O-Te-Au Wichman, Secretariat of Pacific Community (SPC), New Caledonia

Working Group Sessions:

Monday 21 September – Data Collection; Sven Kupschus (UK), Cisco Werner (USA)

Tuesday 22 September - Stock Assessments; Manuela Azevedo (POR), Rick Methot (USA)

Wednesday 23 September - Management Advice ; Mark Dickey-Collas (DK), Éva Plagányi (AUS)

Thursday 24 September - Review & Summary – and emerging topics

Lead, Co-leads, Rapporteur(s) Present at session

Given Name	Family Name	Affiliation	Country	email	ORCID if available
Christine	Bassett				
Katherine	Dziedzic				
Peter	Haugan				
Ana Lara	Lopez				
Kaitlyn	Lowder				
Cristian	Munoz				
Nikos	Nikolioudakis				
Grace	Roskar				

Spencer	Showalter				
Francisco	Werner				
Marino	Wichman				

Session recording(s) available at: https://www.youtube.com/playlist?list=PLkuDz7rC6Mb9p-xIXqmJ8iKfVoazIa5Tr

Locations of WG documents: https://drive.google.com/drive/u/0/folders/1U3lyRSHRsRuAMfR0ZIfkay8KkZICQLfY

Date and time of session: 21/22, 21/22, 23/24, 24/25 September 2020

Participants to Fisheries WG are listed in Table 7

Table 7 Participants to Fisheries WG

Given Name	Family Name	Affiliation	Country	email	ORCID if available
Manuela	Azevedo				
Joana	Beja				
Anthony	Bernard				
Pier Luigi	Buttigieg				
Matthew	Campbell				
Mark	Dickey-Collas				
Fernando	Esposito				
Ian	Freeman				
Greg	Hinks				
Chuanmin	Hu				
Nicole	Kostner				
Lindsey	Kraatz				

Sven	Kupschus				
Mackenzie	Mazur				
Rick	Methot				
Krista	Nichols				
Ngozi	Oguguah				
Terry	Opa				
Marta	Ottogalli				
Jay	Pearlman				
Éva	Plagányi				
Ana	Ramon-Laca				
Jens	Rasmussen				
Ian	Salter				
Edward	Sencondo				
Megsie	Siple				
Vardis	Tsontos				
Alison	Watts				
Abi	Wells				
Chris	Werner				
Justine	Whitaker				

5.2 Links to other WGs

- Convergence
- Data and Information Management
- Ethics
- Partnership

- Omics
- Uncertainty Quantification

5.3 Key Points and developments

Recommendations for your community needs and for development of methods and best practices

Describe key steps to making progress in your community including creating and evolving methods and maturing these to best practices for the Working Group focus area(s).

What are the challenges?

- Fisheries is complex and diverse ranging from industrialized high tech to artisanal subsistence, but common messages for BPs emerged
- Transparency is key: Data, methods and models need to be accessible through metadata
- Continue developing BPs for ecosystem-based management
- Novel technologies (satellite, unmanned systems, genetics, Big Data, etc.) may serve to diminish differences between data poor and data rich areas
- Fisheries is scale and region dependent (local, regional, global)

Where are there gaps?

- Best evidence
- Compiled data
- Traditional knowledge
- Access and participation
- Restore biomass
- Environmental and Socio-economic
- Transparent decision-making
- Management plans
- Agreed objectives

What are the success stories?

- Data collection
- Stock Assessment
- Management and Adv

What ae the recommended steps to move forward?

- Invite the fisheries community to join the OBPS family and evolve its engagement as it begins to upload its BPs
- Ocean Decade implications – actions on UN level and regionally
- Write short Perspective paper soon to *Frontiers* to help stimulate follow-up of the above actions
- Consider convening a dedicated aquaculture session at the next OBPS workshop.

Please include other topics and recommendations as covered in the WG meeting

- Use of various systems (modeling, novel methods, etc.) to work towards stitching together different measurements or estimates to construct a more complete, e.g., global picture
- Importance of metadata [Important for connecting across data sets (interoperability); consider furthering fisheries metadata standards/templates]
- Big data – we are collecting increasing amounts of data; what do we do with it? [Links to satellite community for BPs]
- Reinforced importance of data findability, availability … FAIR principles
- There are a host of stock assessment modeling (SAM) approaches... Best practices for SAMs should make use of repositories (such as OBPS), and follow FAIR principles.
- Just as important is to ensure capacity development on how to use these models.
- "Community modeling" approaches offer alternatives to building on existing models systematically, e.g., via GitHub. This is important as we collect more data and more diverse data (eDNA, AIS, satellite, random effects, etc.). This would allow for deliberate and systematic approaches to be included in future generation SAMs.
- Continued development of Management Strategy Evaluation (MSE) best practices should be encouraged. Stakeholders' interests and scientific objectives need to be taken in concert.
- Dialogue between scientists, managers, and stakeholders about their challenges & expectations for advice
- Clarify management objectives & acceptable risk at start and throughout the process
- Accessible and timely documentation of framework & procedures
- Use best available science & peer review of methods & approaches
- Strive for advice for consensus & independent of managers
- Stakeholder buy-in is key including consideration of traditional knowledge
- Ecosystem approaches (which includes socio-economic factors) is best practice
- We can no longer ignore climate change: check robustness / build resilience

5.4 Recommendations for the IOC OBPS

Your Community-specific guidance for the OBPS – items for inclusion in the OBPS strategic plan for updates and expanded capabilities 2020 – 2025.

How can OBPS be used to help your community discover existing methodological documentation?

- Give the community a leg up, shortcuts (Knowing and evaluating what works for others helps make the right decisions, BUT Science improves only through challenge of conventional thinking)

How can the OBPS support your community in aligning related methods and, eventually, converging them into more global best practices?

- Provide guidance for creating efficient integrated working methods (BUT consider needs and opportunities)

What additional functions can the OBPS provide to support your community in evolving methods into global best practices?

- Support development of a standardised and transparent quality assured process (Clear scientific reasoning and well documented practices, BUT requirements vary regionally and societal focus changes constantly therefore must remain adaptive)

What additional functions can the OBPS provide to encourage the broad use and updating of any best practices your community produces?

Are there any groups within your community whose endorsement of a method/standard/etc would inspire confidence/trust across the community? Why?

- FAO
- National agencies: NOAA Fisheries, Canada DFO, etc.
- ICES, PICES
- RFMOs: ICCAT, IATTC, WCPFC, IOTC, etc.

5.5 The UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

In this section, please comment on if (and how) your community will be responding to the Ocean Decade. Please see the latest implementation plan for guidance on the Ocean Decade high-level aims and rationale.

As an IOC resource, the OBPS is well positioned to support your Ocean Decade efforts and to bridging of methods between your community and other Ocean Decade activities - please let us know how we can support your efforts.

5.6 Plans for follow up discussion and future collaborations

Is there a plan for follow-up discussion after the Workshop IV?

- Those discussions would address the body of existing BPs available for fisheries.

Please indicate possible collaborations between your community and other activities in the ocean community. Specific recommendations for working with the OBPS are also welcome.

–

6 Annex 6 Marine Litter/Plastics Working Group

6.1 Logistics

Co-leads

Artur Palacz International Ocean Carbon Coordination Project/ Institute of Oceanology of the Polish Academy of Sciences, Poland

René Garello IEEE Oceanic Engineering Society, France

Ngozi Oguguah Nigerian Institute for Oceanography and Marine Research, Nigeria

Florence Jovinary Peter Institute of Marine Sciences, Tanzania

The goal of the OBPS Marine Litter Working Group was to foster community discussions on aspects of developing guidelines and best practices for coordinated collection, quality control, streaming and management of marine litter data. The need for standardized monitoring and research on marine litter underpins the development of globally coordinated observing and information systems the visions for which were recently described in community white papers on an Integrated Marine Debris Observing System (IMDOS) and A Global Platform for Monitoring Marine Litter and Informing Action. In line with some of the white paper recommendations and the overall goals of the OBPS workshop, we have set the following objectives for the Marine Litter WG:

- Identify criteria for selecting variables and methods for which we require guidelines, best practices and standard protocols as a priority
- Establish a process towards developing first standard protocols for high impact and feasibility elements of marine debris monitoring
- Decide on the scope of best practice documentations/resources needed beyond standard monitoring, i.e. for (i) remote sensing observations, (ii) modelling, and (iii) citizen science components of marine debris monitoring
- Identify short-term actions to implement a Global Platform for Monitoring Marine Litter and Informing Action and IMDOS as its backbone

Below is a summary of the scope and proceedings of the individual sessions as well as the key recommendations identified for the marine litter community and OBPS. Based on the success stories and lessons learnt from past and ongoing initiatives, each thematic session identified gaps and challenges related to the aspect of methods, how they can evolve to meet the scientific and societal requirements, and where already established, how they can mature into best practices and standard protocols. Ongoing attempts to establish global coordination of marine litter research and monitoring aim to harmonize and streamline planning and execution of the key steps to making progress in addressing the gaps and challenges through the recommendations put forward during this workshop.

The Marine Litter WG convened six thematic sessions on 21-24 September (each 2 or 4 hours long), and joined three OBPS workshop plenaries on 18, 25 and 30 September.

Each WG session was prepared and chaired by at least two session leads identified prior to the workshop. A rapporteur was assigned to each session as well.

Attendance at WG sessions varied from approximately 15 to over 75, with a broad geographical distribution. Priority during most sessions was given to open discussions, with a limited number of presentations introducing the session topics and providing perspectives on lessons learned and future needs of best practices. Participants were interacting through chat but were encouraged to make direct interventions.

Video recordings from most sessions are available from the OBPS YouTube playlist here: https://www.youtube.com/playlist?list=PLkuDz7rC6Mb9p-xIXqmJ8iKfVoazIa5Tr

6.2 Links to other OBPS WGs

During the workshop, the Marine Litter WG identified a number of links to other WGs. During the plenary sessions, we have highlighted a couple of recommendations which we think could benefit from being addressed across more than one WG. Below we provide a few specific examples:

Marine Litter WG & Data and Information Management WG

Through a series of technical workshops aimed primarily to harmonize existing methodological approaches and/or protocols of selected global scale marine litter indicators and variables, we also recommend **defining the best possible approaches to manage data**.

We recommend OBPS to optimize means of promoting global adoption and use of guides, best practices and standard protocols, especially at the QC and **database integration** step of their implementation process.

Marine Litter WG & Ethics WG

We recommend considering **ethical requirements** (e.g. acknowledgement, health safety of volunteers) in formulating best practices for engaging citizen scientists in marine litter monitoring.

Marine Litter WG & Training and Guidance WG

When considering the role of citizen science in tackling marine litter pollution, we recommend creating adequate **training resources** to build technical capacity (to meet data quality requirements) as well as capacity to understand and act.

When promoting the use of best practices on marine litter, potential collaboration with IOC-UNESCO Ocean Teacher Global Academy is envisaged.

6.3 Session 1: Global frameworks for selecting priority indicators and variables for monitoring

6.3.1 Logistics

Date & Time:

Part 1: Monday, 21 September 2020, 11:00-12:30 UTC

Part 2: Wednesday, 23 September 2020, 11:00-13:00 UTC

Session leads:

Heidi Savelli-Soderberg (UNEP, Kenya), Jilian Campbell (CBD, Canada), Sanae Chiba (JAMSTEC, Japan), Artur Palacz (IOCCP/IOPAN, Poland)

Rapporteur:

David Marquis (UNEP, Kenya)

Objective:

To discuss requirements for best practices to monitor marine litter in the context of the SDG indicator framework and the Essential Ocean Variables framework.

6.3.2 Summary

During Part 1 of this session, there were three presentations given by the session leads to introduce the two global frameworks currently used in environmental monitoring and sustained ocean observations.

Jillian Campbell (UN Convention on Biological Diversity) introduced the SDG indicator 14.1.1 of which UNEP is the custodian. The subject has been recognized in different UN Environment Assembly resolutions, most recent of which (UNEA Res. 4/6) includes specific requests to harmonize monitoring, reporting, and assessment methodologies. Approach for SDG indicators has 3 levels: first level is globally available data, models, citizen science. Second level is national data collected directly from countries. Third level has additional indicators that countries may want to consider but that most countries may not want to consider yet. For harmonized monitoring GESAMP methodologies are proposed.

Artur Palacz (IOCCP / IOPAN) gave a brief introduction on developing an Essential Ocean Variable for marine plastics debris as support offered by the Global Ocean Observing System (GOOS) for developing global coordination of marine litter observations. GOOS relies on the Framework for Ocean Observing (FOO) to coordinate a system of multi-platform and multi-disciplinary observations, across the whole value chain of ocean observations: from setting societal and scientific requirements, through coordination of ocean observations, to managing data and information products, and their evaluation by end users. Central to the FOO are the concepts of Essential Ocean Variables and readiness levels which GOOS uses to set priorities for what to measure and how on a global scale.

Sanae Chiba (JAMSTEC) called for strengthening of ties between GOOS and UNEP to reconcile the differences between indicator-based monitoring and EOV-based sustained ocean observations, in the marine litter domain in particular. Development of indicators can be political and mismatched with

scientists' needs, as was the case with Aichi biodiversity targets where the marine community was not sufficiently consulted in the process of developing indicators. With the launch of the UN Decade of Ocean Science for Sustainable Development, there is an opportunity to fill this gap across a number of societal issues related to the ocean.

Discussions focused on the future prospect of coordinated global marine litter monitoring, pointing at the main role of UNEA in the process. AHEG has been established with the mandate to coordinate the issue of marine plastics, and has been successful in bringing governments on board.

In response to the question to what extent there are gaps in the SDG indicators that could be filled by opportunistic sampling, it was mentioned that while sampling of macroplastics was well covered, different technologies were needed for microplastics and that they are less used and developed. Gaps in knowledge in microplastics, especially in the open ocean, would benefit from new monitoring initiatives. There are also regional differences in level of development of technologies and skills for macro v micro sampling.

Plastics in marine biota were discussed as another challenging indicator in the SDG framework. Though initially proposed, entanglement and ingestion were not included as indicators due to feasibility issues. Global indicators require comparability, and thus samples from similar if not same species across the globe. If looking at migratory species we lose information on where the plastic came from. We also don't want to propose lethal sampling at large scales so sampling would be biased by commercial species. It was suggested that microplastics could be included in the Mussel Watch Program, pointing at studies which revealed that mussels of different but related species can be used to compare information, and that this would be easier to accomplish than for fish.

During Part 2 of this session, Heidi Savelli (UNEP) presented on International Policy Responses and Processes. After UNEP was asked to review global frameworks in 2017 and found that none have marine litter as primary reduction and no international targets specifically to reduce marine litter, a stocktaking of all activities was mandated by UNEA through an Ad Hoc Open Ended Experts Group. There are many actions being undertaken on a global level related to the Basel amendment, IMO action plan, 12 Regional Seas action plans, G20 and G7 activities, ASEAN, EU all with activities where monitoring is extremely important. A fragmented picture can be drawn considering activities and resources at a regional level with Regional Seas, where there are important platforms but which don't cover all regions. Already 10 marine litter action plans adopted by 2017, more in progress.

Stock taking overview: submissions through narrative reports and a survey. Outputs are shown in a database and an interactive dashboard, both will be online soon. Actions were submitted globally by numerous member states. Types of actions: 17% were on monitoring. Most actions reported were on macroplastics, showing gaps in microplastics coverage. Several submissions showed that product bans are a favourite approach.

Several SDGs are linked to marine litter monitoring: 6, 11, 12 and 14. Opportunities for indicator development between these. There has been lots of work on pathways, accumulation zones and flows of waste to the ocean, and UNEP has a role in coordinating these. UNEP has also been asked to provide guidance on prioritization of interventions, including policy guidance and risk-based prevention measures to prevent marine litter and microplastics.

Sanae Chiba (JAMSTEC) presented Japan's support for global coordination of marine microplastic monitoring. Japan is willing to take the lead on surface microplastics research and monitoring, as discussed in the G20 meeting. Japan wishes to be the global hub for microplastics data used by all. Many data portals exist (Litterbase, NOAA, etc), and Japan would provide a focused one, limited to surface quality-assured microplastics data for scientific users. A roadmap for establishment of the marine

microplastics data hub has been prepared by the Ministry of the Environment Japan (MOEJ), but a crucial step is to receive the endorsement of an international/intergovernmental body.

An open question was posed as to whether surface microplastics abundance and mass can be variables to inform global marine litter indicators. Critics of its readiness say the knowledge gap remains too large, but this applies more to it being a variable, not an indicator. Currently data coverage for surface microplastics is patchy, although over 7000 data points and number of observations is increasing. GOOS, IOC-WESTPAC, UNEP-NOWPAP could play roles as data collectors/providers to the MOEJ data hub. Ocean Race,

VendeeGlobe, eXXpedition have all proved the concept of microplastic data collection by seafaring sailboats. Sampler systems were semi-autonomous and allowed for continuous sampling.

In the third presentation, Artur Palacz (IOCCP/IOPAN) highlighted the challenges and opportunities for establishing global coordination of an Integrated Marine Debris Observing System (IMDOS) according to the vision presented in an OceanObs'19 Community White Paper by Maximenko et al. (2019). It was noted that establishing a globally coordinated IMDOS would fill the need for a coordinated and sustained observation platform which would also provide authoritative guidance on how to continuously enhance and optimize an observing system for marine debris. Along with regular monitoring efforts, IMDOS would provide adequate data and information on marine debris in response to diverse stakeholder needs, and as such serve as a backbone structure behind another proposed construct, namely that of a Global Platform for Marine Litter and Informing Action.

A proposed draft GOOS Action Plan to establish global coordination of IMDOS was presented. The objectives, scope and approach were listed, along with a number of specific actions proposed over the next 2-3 year timeline. Examples of existing coordinated networks were presented as possible demonstrations of how the governance of IMDOS could look like. It was recommended that a collective impact model be considered, with an international steering group and project office of IMDOS to ensure IMDOS acts as a suitable backbone structure.

Selecting those parameters or indicators which we want to measure on a global scale, considering both their impact and feasibility, is a necessary prerequisite for taking further steps in setting up IMDOS. A possible shortlist of these, as discussed during previous sessions, needs to receive feedback from the remote sensing and modelling communities.

6.3.3 Conclusions and recommendations:

- There is a need to better communicate between and reconcile existing global (SDG and CBD indicators) and regional (e.g. MSFD) environmental-based monitoring frameworks with the primarily science-based sustained ocean observations framework centered around the concept of Essential Ocean Variables.
- It is recommended that global monitoring of marine litter be expanded beyond the current list of SDG indicators considering those indicators and methodologies with potential for global upscaling and addressing gaps in current knowledge (e.g. seafloor litter, microplastics, ingestion by sea turtles). Further consultations and final recommendations on the expanded list of these indicators will take place in the coming months.
- A roadmap for establishment of the marine microplastics monitoring and data hub was presented as an initiative by Japan and the G20 group. The initiative seeks endorsement and support from the UN and other organizations.
- The International Hydrographic Organization (IHO) expressed willingness to assign national hydrographic offices of IHO members to the regular duty of microplastic monitoring under the

proposal of Japan and G20. The EU Mission Board Healthy Ocean would also be interested in supporting and collaborating on this initiative.
- An issue to develop further is how to ensure that surface microplastics data collection is comparable between manta trawls and sailing samplers.
- Developing Marine Plastics Debris as an Essential Ocean Variable is intended as support for global coordination efforts, in particular the open-ocean and research-based components of the envisioned Integrated Marine Debris Observing System (IMDOS). Surface microplastics are recommended as one of the sub-variables to be included in the new EOV framework.
- Exploring the potential for other basin-scale operations via established GOOS-coordinated observing networks is recommended.

During the workshop there was a clear recommendation to establish global coordination of marine litter monitoring under the UN Ocean Decade for Sustainable Development. This is envisioned by operationalizing the community visions for a Global Platform for Marine Litter Monitoring and Informing Action, as described in the GEO Blue Planet white paper, and through an Integrated Marine Debris Observing System, as described in the OceanObs'19 Community White Paper. Developing best practices and standard methodologies will be an inherent part of the process.

6.3.4 Recommendations for OBPS:

Successful coordination of global monitoring efforts will depend on the development and promotion of the use of best practices applied all along the monitoring value chain. The Ocean Best Practices System, through its repository and future capabilities, is expected to provide a valuable resource to the marine litter community. OBPS is recommended to consider GESAMP WG 40 as the leading authority for producing guidelines and recommendations for global marine litter monitoring, and make sure that relevant reports are included in the OBPS repository.

6.4 Session 2: Towards standard sampling protocols

6.4.1 Logistics

Date & Time:

Monday, 21 September 2020, 12:45-15:15 UTC

Session leads:

Francois Galgani (Ifremer, France), Alexander Turra (Oceanographic Institute, University of São Paulo, Brazil)

Rapporteur:

Artur Palacz (IOCCP/IOPAN, Poland)

Objectives:

To discuss the prospects for establishing first standard sampling protocols for marine litter while considering many challenges and types of constraints when recommending and adopting common methodologies.

6.4.2 Summary

The session built on GESAMP monitoring guidelines, UN Regional Action Plans, and other documents which addressed the challenge to consider environmental, technical or even ethical constraints when recommending and adopting common methodologies.

The Session Chairs started with an overview of the status and future prospects of global marine litter monitoring, including issues of governance, platforms, methods, etc. It was mentioned that knowing what to measure, where and how is critical to discussions about global ocean indicators for marine litter, and development of best practices. Alexander Turra (University of São Paulo) gave an overview of the GESAMP Report #99 on "Guidelines for the Monitoring and Assessment of Plastic Litter in the Ocean." This document, which is so far the most comprehensive overview of various strategies and available methods for marine litter monitoring and assessment, can already be found in the OBPS repository. This was followed by a presentation by Francois Galgani (Ifremer) on the main constraints for the implementation of Marine Litter monitoring. There are many constraints and criteria which have to do with best practices including:

- Scientific:
    - Scientific information must be accessible and accepted/recognized by the scientific community
    - Possible interferences are managed
- Methodological:
    - Protocols have been referenced, tested, compared and validated by the community of specialists
    - The existence of bias in the measurement (natural fibers, contamination, etc.) must stop the use of a protocol
    - Data is collected according to recognized and validated procedures
    - Reproducibility and representativity must be guaranteed (standard operational procedures with quality assurance and guides)
    - Standardization must be reached for regular monitoring
- Logistical:
    - The existence of good logistical practices and common approaches must favour the comparability and harmonization of results

Through an open discussion, participants emphasized which challenges and constraints were critical from the perspective of their work, and how the different constraints and criteria discussed can be considered when selecting new global scale indicators of marine litter. Participants supported the need to clearly define the question and purpose of monitoring prior to deciding on what to monitor. They also supported the need to prioritize areas and applications of monitoring programs on a global scale but at the same time insisted that efforts should also promote the development in greater detail for local scales. This means harmonized approaches and methods to enable informing local/regional policy and combating actions.

Feasibility of globally scaled operations need to consider costs as many nations don't have access to the expensive equipment required for some measurements. Effort vs. gain from data will be considered. Feasibility of global upscaling was discussed, for example with respect to seafloor litter. While bottom trawling provides very good data from optimal sampling schemes, there is no capacity globally to use these methods. Instead, opportunistic ROV or diver imagery could be the recommended method for global scale measurements of seafloor litter.

A major discussion point concerned the impact and feasibility of reporting mass/weight and not just abundance of specific fractions of marine litter. Though challenging to measure in a standard way, information on weight was seen as essential to close the overall budget of plastics in the ocean, and thus also better inform global models used to inform current global SDG indicators. The criteria for separating size fractions, and inability to measure nanoparticles at all, were also mentioned.

A part of the discussion was devoted to possible global indicators related to marine biota, such as marine turtles or mussels. It was clarified that monitoring of entanglement is at the moment not feasible even though it is a major and common form of interaction between biota and marine litter.

An idea of a tiered approach to monitoring impacts was raised with (i) compliance monitoring (trends & distribution) aimed at following progress of measures and with a certain threshold which when triggered leads to (ii) investigative monitoring (in depth questions such as impact to specific species).

The importance of terminology was also brought up, for instance with regard to hotspots which are used interchangeably between studies but with very different meanings from one location to another. Scaling this idea to global levels (with similar indicators) requires transparent and harmonised approaches as well.

An urgent issue to solve is the fact that approaches used in the sampling and analysis are still very different even in the same sea area. This includes surface microplastics for which basin scale efforts have been undertaken, but which still don't allow for basin-to-basin comparisons. This is despite the fact that global harmonization efforts have been initiated by Japan.

In addition, it was concluded that the proposed Marine Plastics Debris EOV should be complementary to the SDG global indicators framework. The EOV could consider those variables and methods which are not feasible to scale up globally due to individual nations capacity to report, but which would have the potential for being globally coordinated especially in the open ocean, e.g. ships of opportunity, sailing.

The need to manage pollution due to fishery operations was also discussed, both from the aspect of how to track fishing gear litter (majority of seafloor litter from nets) but at the same time safeguard the fishing industry.

The session also initiated discussions on thresholds and targets, and the challenges behind setting them. An example of successfully setting a threshold for beach litter in the EU was mentioned, in reference to a recent publication: "A European Threshold Value and Assessment Method for Macro Litter on Coastlines."

Finally, the session discussed the general concept of best practices and how it applies to marine litter monitoring. While this session discussed general recommendations for what to measure and how globally, more technical details need to be resolved through dedicated discussions and technical workshops to develop best practices and protocols which are indicator/parameter and/or method specific.

6.4.3 Conclusions and recommendations for the community

The following five key recommendations were put forward as an outcome of this session:

- Shortlist the most relevant indicators for global scale monitoring. Possible suggestions included: Beach litter; Sea floor litter by diving (MPAs) / ROV; Microplastics (floating & sediments); Ingested litter by sea turtles/mussels.
- Elaborate formal guidelines for global Marine Litter indicators
- Recommend and support research for methods enabling large scale assessments (models, remote sensing, etc.)
- Elaborate best practices dedicated documents for each of the relevant indicator with consideration to the various steps of implementation process (strategy, protocols, analysis, data check, database, baseline, thresholds, reporting)
- Consider technical workshops to harmonize approaches/ protocols for each of the relevant global scale indicators, and define the best possible approaches to manage data.

6.4.4 Recommendations for OBPS

The role of OBPS is seen as not only to make best practices available but to help promote their adoption and use, especially at the quality control and database integration step of the process.

The community would approach OBPS with outcomes of technical workshops to harmonize approaches and protocols for global scale variables and indicators of marine litter. Relevant new documents and resources should be made available via the OBPS.

6.5 Session 3: Towards best practices for remote sensing of marine debris

6.5.1 Logistics

Date & Time:

Tuesday, 22 September 2020, 11:00-13:00 UTC

Session leads:

Paolo Corradi (European Space Research and Technology Centre, European Space Agency, the Netherlands), Shungudzemwoyo Garaba (Institute for Chemistry and Biology of the Marine Environment, University of Oldenburg, Germany)

Rapporteurs:

Paolo Corradi, Shungu Garaba

Objective:

To discuss first steps towards developing best practices for remote sensing of marine debris, e.g. through comparable spectral reference libraries.

6.5.2 Summary

The session, attended by 75 participants, was introduced by Paolo Corradi and Shungu Garaba who started with an introductory talk on the state-of-the-art, the challenges and the actual limitations of remote sensing of marine litter. This was followed by a presentation by Nikolai Maximenko (University of Hawai'i) who stressed the need of remote sensing in combination with marine debris transport models in the context of an envisioned Integrated Marine Debris Observing System. He also suggested caution when adopting standardization to avoid risks in limiting data collection, e.g., as needed by models.

The session followed with a series of talks by invited speakers who shared lessons learnt and recommendations in the spectral data collection:

- Remote sensing of marine plastic from public satellites: From field measurements to satellite retrieval: understanding our errors - Manuel Arias (Argans Ltd)
- Remote sensing of microplastic/plastic in water and macroplastic on shore: Measurements and algorithms for marine plastics detection from aircraft and satellite - Victor Martinez Vicente (PML), Lauren Biermann (PML)
- Laboratory based hyperspectral measurements: VNIR-SWIR hyperspectral measurements of dry, wet and submerged plastics in a controlled environment - Els Knaeps (VITO), Sindy Sterckx (VITO)
- Plastic litter targets and spectral drone/satellite measurements: Plastic litter targets for calibration / validation of remote sensing products Konstantinos Topouzelis (MRSG, University of the Aegean)
- Drone surveys: Monitoring marine debris in protected coastal areas: an UAV approach - Marco Paterni (CNR-IFC), Silvia Merlino (CNR-ISMAR)
- Microwaves remote sensing and databases: Marine litter signatures in SAR images, and presentation of a new database for remote sensing and artificial intelligence studies - Laia Romero (isardSAT)

6.5.3 Conclusions and recommendations for the community and/or the OBPS

- Remote sensing of marine litter is an emerging research field and consequently still focused on research and demonstrations.
- Remote sensing technologies have the potential to offer large amounts of information on a large scale ("the big picture"), improve quantification of concentrations globally and locally, and support the identification of transport dynamics and thus of the sources, sinks and fluxes of marine litter.
- Different technologies and techniques to generate imagery and spectral data from handheld devices, drones, aircrafts and satellites are still being investigated and are evolving.
- The target, i.e., marine litter, poses a big challenge for remote sensing due to the size continuum and composition mix.
- Current technologies demonstrated detection of large accumulations or aggregated litter at sea and beaches/coastal areas.
- Windrows and fronts can be used as proxies for plastic marine litter pollution.
- The community is establishing, adapting and updating operating protocols, e.g., in the optical domain it is utilizing the best practices from Ocean Colour remote sensing (International Ocean Colour Coordination Group) and adapting them to establish updated protocols relevant for remote sensing of marine litter
- Standardise methodologies for obtaining consistent high-quality datasets that have traceable uncertainties and are comparable among the scientific community.

- Such standards shall include the definition of e.g., materials/targets of reference, standardised-formats for metadata to be collected in field experiments, open-access datasets in standardised formats for algorithms training.

As this community is really centered on the upstream part of the observation methods, the role of OBPS is gaining a slow but rising interest. Nevertheless, many of the observation campaigns (especially for drones and airplanes) need to be coupled with in situ information and activities. It would require the definition (best practice) for selecting the zones of marine debris search.

6.6 Session 4: Best practices for citizen science (CS) monitoring

6.6.1 Logistics

Date & Time:

Tuesday, 22 September 2020, 15:15-17:15 UTC

Session leads:

Anne Bowser (Woodrow Wilson International Center for Scholars, USA), Yannick Lerat (SeaCleaners, France), Alexander Turra (University of São Paulo, Brazil)

Rapporteurs:

Alex Turra

Objectives:

To review existing guidelines for citizen science (CS) monitoring in light of new developments and initiatives from around the globe.

6.6.2 Summary

This session, attended by around 20 participants, consisted of a series of 5 short introductory presentations on the approaches to citizen science monitoring and role of best practices in addressing challenges identified.

- Alexander Turra (GESAMP Report)
- Martin Thiel (types of scientific questions CS may answer)
- Metis Meloche (challenges of data aggregation),
- Natalia Pirani Ghilardi-Lopes (dimensions of citizen science- the citizen and the science)
- Hans-Peter Plag (the role of the citizen and science in society and platform for connecting them)

A subsequent discussion focused on the major concerns, considerations, and developments for citizen science monitoring of marine litter (e.g., data quality, ethical aspects, data user/users, scientific questions

etc.). Conclusions from this session were grouped under several questions raised during the presentations as well as the discussions, and ultimately synthesized into recommendations.

How is CS data already being used to monitor marine debris?

CS has been used in many scientific fields since decades, for instance animal observations. Marine Litter field is different as observations are often linked with cleanup actions and people's education on their consuming practices at home to avoid plastic pollution. So the willingness to help in scientific projects can be very high.

Different projects have different monitoring needs. To what degree is it possible to standardize citizen science monitoring?

Several speakers shared the point that Integration of CS in scientific projects is very important to consider. Anonymous data gathering through mobile applications is not the best way to motivate people and it also opens the door to fake data. Opportunistic app data is also only fit for limited purposes.

What are the scientific questions that can be answered by CS? Is data quality appropriate for science? What about policy?

Any question or scientific question can be answered, but it must be a question of interest for citizens to get motivation and implication. Regarding marine litter, there is an urgent need for ground truthing to help validate remote sensing detection systems. Having ready to use monitoring systems is critical to evaluate new regulations on plastics and to organize cleanup actions. Citizens can help bridging science and politics and so be part of decision making (and holding parties accountable for adhering to decisions).

What would be the major concerns, considerations, and best practices? Are there ethical obligations to citizen science volunteers? (Reference ECSA 10 Principles of Citizen Science) (Bonney et al., 2009; Shirk et al. 2012). What are good practices for fostering data quality (e.g., training citizen science volunteers)?

Ethical obligations to citizen science volunteers is important. Ethical best practices should be present in project proposals aiming to use CS. It has to be integrated in project selection beside scientific interest. Feedback results and knowledge generated from CS data is very important to keep citizens integrated and motivated to help.

Training and certification should be considered at a level appropriate to the expertise required for data collection. There is a direct impact on data quality. Data falsification was discussed. The more anonymous

data gathering is (i.e. mobile application), the higher the risk is. To integrate validation step is one way to minimize the risk, another way is to integrate people in the project team so they understand the critical aspect of data quality.

To what degree is it possible to standardize citizen science monitoring?

Outcome: Discussing pros and cons of a CS "standardized" approach.

During the discussion, a consensus was reached on the requirement for high level standardized methods, or considerations related to project design, that should be included across CS projects. Key points to consider are:

- Ethical requirements (e.g., acknowledgement, attribution, protecting volunteers);
- Facilitating different levels of participation (e.g., integration in the project at a level depending of their interest);
- Training, to support data quality; and,
- Feedback, as a form of acknowledgement or attribution, and to support data quality.

6.6.3 Conclusions and recommendations for the community

- Citizen Science (CS) is an important aspect of marine litter monitoring. It has the potential to produce robust information for several purposes, including scientific research and policy-driven responses;
- CS has the potential to share knowledge and promote engagement of society to combat marine litter;
- There are several CS projects with different goals and governance models, with a higher or smaller involvement of citizen scientists in different steps of the CS process (e.g., co-created, collaborative, contributory; e.g., Shirk et al., 2012). All are relevant to achieving different scientific and societal goals.
- Important aspects to consider to foster the citizen and the science dimensions of citizen science are:
    - Ethical requirements (e.g., acknowledgement, protecting volunteers);
    - Facilitating different levels of participation (e.g., integration in the project at a level depending of their interest);
    - Training, to support data quality; and,
    - Feedback, as a form of acknowledgement, and to support data quality.
- Requiring standardized data collection may impede the flexibility needed to face different issues, goals and realities related to marine litter. It is possible to consider harmonization to achieve data interoperability after the fact. This approach will make it possible to assess general trends, if not specific and granular research questions.
- Citizen science should be fostered in several ways, including top-down policy accelerators (e.g., recommending that UN member states integrate CS in their monitoring schemes); and, facilitating funding, including for monitoring but also training people and building capacity to understand and act.

6.6.4 Recommendations for the OBPS

Some of the recommendations listed above could be picked up by OBPS in a potential broader pursuit of harvesting existing and developing new guides and best practices for citizen science engagement in ocean sciences, going beyond just marine litter. Resources made available in the OBPS could include methodologies addressing the following issues:

- Ensuring ethical requirements are met when engaging citizen scientists? This includes proper acknowledgement or certification of volunteer contributions, ensuring safety and protection during field work, among other issues.

- Providing universal access to training courses and resources which adhere to common methods and best practices recommended by the scientific community for engaging citizens.

Addressing these recommendations requires involving other OBPS WGs: Ethics and Training.

6.7 Session 5: Best practices for modelling

6.7.1 Logistics

Date & Time:

Wednesday, 23 September 2020, 14:00-16:00 UTC

Session leads:

Christophe Maes (LOP-IRD, France), Thierry Huck (LOP-IUEM, France), Audrey Hasson (LOCEAN-IPSL, France), René Garello (IEEE, France)

Rapporteurs:

Audrey Hasson

Objectives:

To initiate discussions on what best practices for modelling marine litter would entail, and how to overcome numerous challenges in their development.

6.7.2 Summary

This session, with a peak attendance of 27, started with three talks focused on:

- Remote Sensing & Ocean circulation models - René Garello
- Pollution of sea waters: Ocean modelling - Christophe Maes
- Modelling Ocean Plastic Pollution: Sources Uncertainties - Thierry Huck

It was followed by a discussion around 2 main questions:

- What are the scales of motion needed for the floating dispersion?
- How to estimate the scenario for the sources entering into the oceans?

In addition the group discussed several other issues such as:

- To what extent ground-truthing in machine learning interpretation of data collected by citizen scientists is similar to the process used in remote sensing? Examples of solutions were given such as from: https://www.litterati.org/ or https://www.sciencedirect.com/science/article/pii/S0141113614000634

- A point was raised to ask what should be prioritized in a subnational scale considering the monitoring of the sources of marine litter, such as rivers.
- It is a challenge for the modelling community to resolve the apparent discrepancy between the increasing sources of plastics used to drive global ocean plastic model simulations and the lack of increasing long-term trends in plastics being reported by repeated measurements, except in remote regions of the oceans such as the Arctic. Most numerical experiments implement an increasing amount of plastic input with time, following the total production of plastics or other proxy like Gross Domestic Product. Maybe the input trend is wrong, and changes in waste management practice have reduced the total amount of plastics getting to the ocean. Maybe some processes are still overlooked. One of the less known compartments remains the ocean interior, that is not well monitored. Sinks for plastics at the ocean surface are not well known, biofouling for example is a complex process to account for, as well as the effect of particle ingestion and defecation by living organisms. Nevertheless, there is clearly a physical contradiction between increasing sources and constant concentrations in most ocean compartments (sediments, beach, ocean surface).

6.7.3 Conclusions and recommendations for the community

- A global model intercomparison project was recommended to better understand the differences between model simulations as a function of their structures, parameterizations, assumptions, etc.
- It was recommended that future model developments should also focus on simulating the life cycle of plastics in the ocean, e.g. to better understand their fate. To this end, new collaborative efforts need to be developed.

6.7.4 Recommendations for the OBPS

Considering the rapidly developing field of marine litter modeling and the arising need for intercomparisons, the community would benefit from access to OBPS resources which describe standard protocols and frameworks for global model intercomparisons or evaluations.

6.8 Session 6a: Global Platform for Monitoring Marine Litter and Informing Action - how does it work?

6.8.1 Logistics

Date & Time:

Thursday, 24 September 2020, 11:00-13:00 UTC

Session leads:

René Garello (IEEE OES, France), Emily Smail (NOAA / GEO Blue Planet, USA), Heidi Savelli-Soderberg (UN Environment Programme, Kenya), Jillian Campbell (UN Convention on Biological Diversity, Canada)

Rapporteurs:

David Marquis (UNEP, Kenya)

Objectives:

This session aimed to introduce the concept of a multi-stakeholder Global Platform for Monitoring Marine Litter and Informing Action described in a white paper by Smail et al. A brief report was shared from a meeting jointly held by GEO Blue Planet and IBM on the potential to implement the Global Platform. It also aimed to foster further discussions on the concept and its potential implementation, emphasizing the critical role of developing and adhering to best practices in marine litter data collection and management.

6.8.2 Summary

Heidi Savelli, UNEP: The Platform is a request from UNEA and it should be used to coordinate action, it should centralize data and information available on the topic (it's a busy space with many actors). It should facilitate target-setting and aim to match needs with resources. It can be used to increase transparency and tracking of voluntary commitments. The intention is not to take over other websites. For users, the source of the info is less interesting (although credit will be given) but rather the user wants the information to solve their problem.

Emily Smail, GEO Blue Planet/NOAA: The GEO Blue Planet Initiative has coordinated the preparation of a white paper on this global platform. There is a section giving an overview of existing technologies and assess their readiness levels. There is an inventory of marine litter databases and major datasets. There is a summary of other platforms that exist and could be brought in, and an overview on what types of features would be needed. There is a section on a digital ecosystem for the subject, and some ideas on the use of AI.

In order to bring in the platform tools for managing data from observations, there is a need for some additional understanding.

Eric Chassignet, Florida State University: For instance, marine litter oceanographic modeling and simulation tries to answer simple questions: once you have waste put out at sea, where does it go? And when you find waste, where does it come from? One should start by trying to address key challenges: fragmented origins of datasets, and some places well sampled, most not. Often opportunistic data collection, like apps and citizen science.

How can we come up with estimates of marine litter density?

Kunal, IBM: Trying to address these we came up with a pipeline for establishing marine litter density. We used Watson Knowledge Catalogued Dataset, combined with Marine Litter Watch, MDMAP, TIDES, and tried to come up with a common baseline. This provides a flexible framework that can be used by the marine litter community for future approaches.

Anne Bowser, Wilson Center: As cited above, Citizen science is well established in marine litter. It includes any form of public participation in data collection. This work unfolds at community-level, it promises to spark action, and there is an opportunity to re-use local data in national and larger assessment. We mapped the top 10 types of plastic pollution in each country using a few datasets. Knowing the top items is useful to inform local bans. We mapped the effort of cleanup events as well.

The talks were followed by a discussion on several aspects. The first issue concerned the concept of assigning a technical readiness level (TRL) to marine litter indicators. The TRL concept has been used mainly in the private sector. It ranges from 1 to 9, with 9 being a final product, and 1 meaning a conceptual upstream idea. But this was never accepted by the academic community. In Europe, in Horizon 2020

projects from 2015 onwards people were asked to set technical readiness levels. The Global Platform white paper presents a numerical assessment of readiness for each indicator, but mainly for monitoring technologies. True that we could apply this to some of the indicators. And indeed, we need more efforts in the sensitivity of modeling experiments. Not only basic data but also basic physics. Intercomparison of various models would be interesting, as there are many uncertainties, sources, lifecycle, breakdown, windage, etc. We need to have a discussion framework that would identify all uncertainties.

Talking about some tools based on these efforts, such as extended country responsibility or a global market on marine litter (like the CO_2 market). Would bring the responsibility of countries to the forefront. Would be interesting to think about. Question: how can photographs of beach litter be transformed into usable information?

Another discussion focused on transforming beach litter photographs into usable information. The idea of image forensic analysis was presented to assess the authenticity of the image. Secondly the labelling of the image is important. Third, what is relevant, some photos might not be relevant at all. We are working with the US government and UNEP to solve these challenges and determine the reliability we can have in these. On the count/mass question, this was more about the data availability, most datasets collect data by count. In terms of the framework plugging in the size is easy. Using machine learning and citizen science data we did some proof of concept to combine image recognition using box wise segmentation and estimate volumes. It worked but we need more data and time to work on it.

A question asked many times is about the lifecycle of plastics. In many models and measurements, lifecycle is a knowledge gap. Some plastics disappear, we don't know where. Global budget of plastics would be very useful.

6.8.3 Recommendations for the community

- Continue the ongoing efforts to evaluate existing marine litter databases and how they can be integrated into the global platform.
- Plan a series of follow-up meetings/workshops to address themes which have cut across several sessions of the Marine Litter WG, e.g.: quantification of model uncertainty, use of AI in analyzing photographic data from citizen scientist campaigns, harmonization of methods and protocols related to global scale indicators.

The meetings would lead up to the 7th International Marine Debris Conference in 2022.

6.9 Session 6b: Global Platform for Monitoring Marine Litter and Informing Action - best practices

6.9.1 Logistics

Date & Time:

Thursday, 24 September 2020, 14:00-16:00 UTC

Session leads:

Hans-Peter Plag (Old Dominion University, USA), Dan Martin (Old Dominion University, USA)

Rapporteurs:

Dan Martin

Objectives:

This session aimed to discuss other aspects of best practices related to developing a proposed Global Platform, such as the need for best practices in gap analyses, identification and prioritizing of knowledge needs, including life cycle analyses and impact assessments.

It also aimed to comment on best practices in engaging with stakeholders, including participatory modeling; and co-usage of knowledge, i.e., the delivery of knowledge to decision and policy makers and for the engagement of scientists and researchers in policy making, including ethical considerations.

6.9.2 Summary

This session, attended by 22 participants, consisted of three short introductory presentations by the session leads followed by interactive discussions on each of the three questions/issues put forward as discussion points to all participants:

- What data and knowledge are needed? Best practices in gap analyses, identification and prioritizing of knowledge needs, including life cycle analyses and impact assessments;
- Co-creation of research agendas and knowledge: best practices in engaging with stakeholders, including participatory modeling;
- Co-usage of knowledge: best practices for the delivery of knowledge to decision and policy makers and for the engagement of scientists and researchers in policy making, including ethical considerations.

6.9.3 Conclusions and recommendations for the community

What data and knowledge are needed?

The spectrum of futures for marine litter in the ocean could skew in a number of directions, based on certain natural drivers and pressures, as well as human responses and solutions to the problem.

The scientific community must make a decision whether to focus on avoiding Type 1 errors to avoid alarmism, or focus on avoiding Type 2 errors, and avoid overlooking warning signs.

Currently, plastic production produces as much CO_2 emissions as 40 million cars, and impacts the lives of 500 billion to 1 trillion people to be born in the next 5,000 years, in many cases violating their rights. Interventions must be developed to guide the system towards a desirable future and to devise and achieve reasonable and effective sustainability goals. For these interventions to be well informed and effective, there must be a good understanding of adaptation science, developing and validating

transformation knowledge. We must have a good understanding of what we don't know before we can try to learn it. Currently, there is no consistent method for conducting gap analyses that is universally accepted.

Cocreation of research agendas and knowledge.

A primary goal for this research should be to create knowledge that can be used by societal agents to produce effective change. Knowledge can be defined as information that is justified, true, and believed. Belief requires trust. Participatory creation of knowledge creates trust and knowledge usage.

There is a spectrum of methods for engaging societal agents that range from maintaining a diversity of views, to converging to a shared viewpoint; and from sharing existing knowledge to reacting to new scenarios.

Co-usage of knowledge

Integrating science into society and improving scientific literacy is crucial for the developed interventions to be successful. One way this can be achieved is through developing pathways through which the gap between experts and the general public can be closed.

7 Annex 7 Omics and eDNA Working Group

7.1 Logistics

Co-leads:

Neil Davies, Gump South Pacific Research Station, University of California Berkeley, USA

Raïssa Meyer, Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research, Germany

Katie Pitz Monterey Bay Aquarium Research Institute, USA

Robyn Samuel, National Oceanography Centre, U.K

Participants (65 in total) are listed in Table 8.

Table 8 Participants to Omics and eDNA WG

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The properties of eDNA mean it is likely to be a significant component of high-throughput and large-scale biological observations - addressing a key need for monitoring biodiversity status and changes by governmental monitoring programs. The cost-efficiency and taxonomic resolution of Omic data enables high resolution time-series which will improve our ability to detect changing communities across trophic levels. Ecological forecasting based on Omic and eDNA data, combined with other data, can help provide decision-makers with the foresight they need to manage ecosystems for resilience. Omic data have great power to characterise functionality of organisms, which in combination with environmental (meta)data can be used in biogeochemical models.

Workshop Methodology

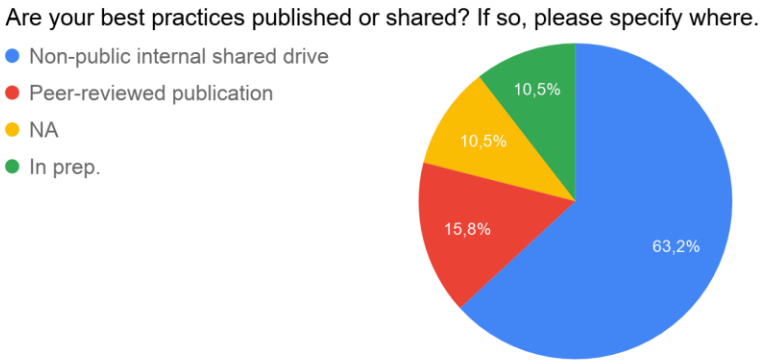
For the purposes of the workshop, and this document, we consider all products of the genome (from DNA, RNA, proteins, to metabolites and chemical products such as lipids) to be included in the scope of the Omics/eDNA community. We acknowledge that this workshop included mainly participants involved in DNA and RNA analyses but consider our findings to be beneficial and broadly applicable to the larger Omics community.

Over the four days of working group meetings, we divided meeting discussions into four themes:

- Samples (including physical handling of molecular samples, from collection to archiving),
- Bioinformatics & Analysis (including *in-silico* pipelines and analysis),
- Data & Information Stewardship (including the sharing of data and metadata),
- Society (including ethical, legal and social issues within Omics/eDNA).

Prior to the working group meeting we surveyed participants to ask if any further topics should be covered and to find out what time zones participants would be joining from. Based on 29 respondents, we found that these four topics would sufficiently cover the breadth of omics/eDNA ocean research and three

replicate meetings at 09:00, 17:00 and 00:00 UTC would allow all participants across the globe to take part at a reasonable hour, although limit interactions between participants across time-zones



In the pre-workshop survey, we also asked participants if they or their group have adopted a set of best practices. Half of the participants had not. When asking those that did whether their best practices were published or shared, out of 19 responses 12 said that their best practices were currently only shared in internal shared drives, three respondents had best practices shared in peer reviewed publications, two were in prep and another two were not applicable (see Figure). Having these best practices (or protocols) publicly available is essential for establishing best practices across research groups and regions. Consequently, in the WG meetings for Samples and Bioinformatics & Analysis, we decided to initiate discussions around why groups were not publishing protocols and what would motivate the community to publicly share their protocols and best practices.

7.2 Links to other Working Groups

Joint sessions were held with the Data and Information WG and the Ethics WG.

7.3 Key points and developments

In communicating outside the field of Omics and eDNA (including to the other fields in the OBPS), it is unclear what term best represents the science covered. “Genomics” may be the most widely recognized term among scientists. The term DNA is also widely understood, which might help explain how Environmental DNA (eDNA) has gained such traction. Even within the Omics and eDNA community, however, terminologies are diverse, can be roughly defined, sometimes interchangeably used, and are often debated over. While some differences in terms are inevitable and might not matter significantly (e.g., they can be mapped through ontologies), substantial disagreement creates a barrier for communication and can impede findability of data, protocols and best-practices. Therefore, a general recommendation for the OBPS community is to support a review of the terminology in this field and its subfields, to identify how terminologies have been changing, and where differences in meaning might be confusing. Such a review would aim to build consensus for a consistent set of terminologies going forward.

The International Nucleotide Sequence Database Collaboration (INSDC) is the major player (public repositories) in the Omic community, and has achieved an impressive degree of harmonization across a vast and dynamic field (going well beyond ocean science). The Genomic Standards Consortium represents an important partner for OBPS with strong links to INSDC as well as to the broader Data community. However, Omics and eDNA cover such a broad range of research, that no individual group endorsement would inspire confidence/trust across the scope of Omics/eDNA research. However, a badge of OBPS community endorsement would convey trust in that method. To make sure that this initial

trust will not be lost, it would require a transparent framework behind the endorsement process. Aspects to consider for this are testing of methods and thus proven superiority over other protocols in the same field, assurance by independent groups, and traceable up-/ downvoting by the community of concern. Especially in a field as quickly evolving as the Omics/eDNA research, a valuable endorsement process would require very regular updates.

7.4 Summary of Findings for each theme.

34 participants

Omics/eDNA is important for ocean science and sustainable development because Genetic variation is the fundamental layer of biodiversity and DNA is the universal code (standard) underpinning all life. Omic and eDNA derived data can:

- Augment other biological monitoring tools offering new indicators of ecosystem status and/or health (e.g., provide early warning of threats by detecting presence of potential alien invasive species, pathogens, harmful algal blooms).
- Provide additional information for understanding intraspecific population structure, gene flow, and environmental associations.
- Provide estimates for biodiversity that are quicker, cheaper and less invasive than traditional biodiversity monitoring. However, it does not currently (and might never) provide some data collected through traditional methods such as species size, health, and life stage.

During the WG meetings we discovered that the majority of participants would be willing to share protocols but time constraints and a lack of recognition for the work means that publishing detailed protocols is a relatively low priority for most researchers. Ideas for how to motivate the community to publish protocols included adequate recognitions for protocols and technicians (e.g., facilitated via DOI citations), training on the existence and use of protocol repositories, requirements for publishing, templates to facilitate the process, and forums to discuss and catch errors and/or improvements. It was expressed that a sense of a common mission and working together to establish a range of best practices are good enough motivation, but that there needs to be visibility and credit for all those contributing in order to stop “scooping” by high-capacity groups. The platform most commonly used to publish protocols is currently protocols.io, although the site has recently introduced fees for downloading them. Other platforms include Github, ISO, Integrated Publishing Toolkit - Global Biodiversity Information Facility (IPT-GBIF) and JoVE-Scientific Video Journal.

Participants indicated that an OBPS endorsed best practices should be reviewed by the community with a vote system and ideally be part of a comparative study (e.g., GLOMICON style comparison). Best practices should include sufficient details to allow replication, training materials, a forum to discuss potential improvements/alternative applications, cost estimates, time estimates, automated metadata templates and links to other research using the protocol. It was also discussed that OBPS best practices should be modularised to enable mix and match workflows. The OBPS could provide a platform in which best practices are incorporated into decision trees to allow for a variety of best practices dependent on

the specific research goals. Incorporating automated metadata based on the outcomes of such decision trees would not only facilitate research but also increase the interoperability of sample metadata through use of consistent categories.

Omics/eDNA technologies are rapidly evolving and participants agree that sampling protocols and analyses will also need to evolve rapidly to make use of improving technologies. Therefore, best practices cannot remain static. Routine annual reviews are needed, as established by the eDNA Society for their manual for eDNA research (Minamoto et al. 2020) Comparative reviews are needed to establish how the progression of best practices are likely to bias time-series studies which adhere to current OBPS endorsed best practices. Biobanking of samples to enable such reviews was suggested and discussed in further detail during an additional thematic meeting led by participant Chris Meyer.

7.4.1 Bioinformatics & Analysis

45 participants

Bioinformatic and analysis protocols are more consistently shared than sampling and lab protocols (e.g., through platforms like Github); however there is often insufficient auxiliary information that limits their utility. There is a need for more detailed commenting to explain functions within the code and comprehensive metadata including versions of software and dependencies, licenses, system requirements, versions of reference databases used, and links to test and/or real datasets to conduct the code with known outcomes.

There are already a number of initiatives which promote standardisation of bioinformatics and analysis pipelines:

The Ocean Sampling Day (OSD), Earth Microbiome Project (EMP), and TARA oceans are prominent examples of activities which, within their respective project, supported globally standardised approaches from sampling to analysis. Besides such global initiatives, there are outstanding regional or national initiatives such as the Australian Microbiome Initiative and Australia's Integrated Marine Observing System (IMOS), the US National Oceanic and Atmospheric Administration (NOAA) Omics Working Group, the Government eDNA Working Group (GEDWG), the Southern California Coastal Water Research Project (SCCWRP), the California Water Quality Monitoring Council - Molecular Methods WG, the Fisheries and Oceans Canada (DFO) eDNA and Bioinformatics WG, and the UK Environmental Observation Framework (UKEOF) - UKDNA WG. Apart from projects that focus on standardized methodology in regional areas, there are also projects which focus on research targets. An example for this would be the Microbiome Quality Control Project (MBQC) which focuses on the human microbiome.

With the aim to connect efforts from around the world, umbrella initiatives such as the Global Omics Observatory Network (GLOMICON), the Genomics Observatory (GO) Network, DNAquaNet, or the Marine Biodiversity Observation Network (MBON) under the Group on Earth Observation (GEO) have developed and taken hold. Resources including the Ocean Biodiversity Information System (OBIS) and GBIF provide valuable services by collecting, classifying and distributing related marine biodiversity data and information. MGnify by the European Molecular Biology Laboratory's European Bioinformatics Institute (EMBL-EBI) is a global resource for microbiome data analysis and an example of resources in our field moving towards operational grade.

Additionally, certain tools, software, and packages have been highlighted which, through their wide adoption, increase standardisation: the open-source bioinformatics pipelines QIIME and QIIME2 for analysing raw sequence data, visualisation and statistics, the cloud-based data storage and analytics platform Multiplex Barcode Research And Visualization Environment (mBRAVE) with standardised pipelines for metabarcoding data, the Anacapa Toolkit to easily process eDNA sequence data, and the R package Phyloseq for data analysis and visualisation.

OBPS endorsed best practices for Bioinformatics & Analysis would benefit from many of the same suggestions as discussed in the Samples session. However, many more platforms are used for bioinformatics and analysis. The platforms used within the Omics/eDNA community include GitHub, GitLab, Docker, ReadTheDocs, Googlelabs, Jupyter notebooks, Snakemake, Conda, QIIME/QIIME2, Anacapa Toolkit, FigShare, Primer7, and the Journal of Open Source Software. Developing OBPS compatibility with these platforms would facilitate uptake of OBPS platform by the Omics/eDNA community.

Having the OBPS as a central link to these initiatives, efforts, and tools would facilitate alignment between previously independent/siloed efforts.

The development of decision trees for Omics/eDNA sampling, laboratory, and bioinformatics protocols was well supported during the first day of the WG meeting therefore at the end of the second day sessions we spent some time discussing what a decision tree for bioinformatics protocols could look like.

7.4.2 Data and Information Stewardship

45 participants

One of the most relevant guidance for data and information stewardship are the FAIR data principles (Wilkinson et al. 2016). These focus on improving the Findability, Accessibility, Interoperability, and Re-usability of (meta)data and include valuable sub-specifications for each of these four components. To further contextualise sequence data, the Genomic Standards Consortium (GSC) has developed standards such as the Minimum Information about any (x) Sequence (MIxS) (Yilmaz et al. 2011). For more general biological observations, the Biodiversity Information Standards (TDWG) organization has developed the DarwinCore standard (Wieczorek et al. 2012).

While the INSDC and journal requirements have promoted the FAIRness of sequence data in our community, awareness and adoption of the principles and standards above is still especially lacking for contextual metadata. Thus, we encouraged focused discussions in the WG about how to improve that. Training on and outreach about the importance of accurate and extensive metadata records have emerged as preconditions for the broad and correct use of the standards. The German Federation for Biological Data (GFBio), Biodiversity.aq (Antarctic), the QIITA metadata wizard (template production), and the Genomic Observatories Metadatabase (GeOMe) have been noted as resources to support accurate metadata records. To further facilitate the adoption of standards, data standards have to align and become interoperable with one another to reduce work for the end user. Along with that, we also

established the value of community-based extensions of these standards to be able to accurately enter contextual data from any domain. As we investigate mature, new or previously ignored elements, such as novel types of genetic data, we will be confronted with new challenges on how to accurately represent and preserve this information. Best practices should address how to include novel (meta)data and address limitations of current standards moving forward.

To promote data and information stewardship, we additionally recognised a prevailing need for a culture change towards giving appropriate funding and recognition to FAIR data providers by offering career progression metrics. One way of achieving this would be the adequate crediting of data publications, which would additionally serve the purpose of training when the data is reviewed as part of the review process (as seen in the recently introduced Omics Data Paper in Pensoft's Biodiversity Data Journal). This would be essential to allow the thinking space for researchers to consider data and information stewardship. Only then, would a (perhaps necessary) top-down enforcement through the requirement of FAIR and standard compliant data for publishing, funding, and reporting. be meaningful. The provision of templates and links to (meta)data standards and data & information stewardship principles that are relevant to the method a user is searching for from the side of OBPS would be a valuable resource. Additionally, it would lead to a timely coordination with data and information stewardship: simultaneous to the selection of protocols and thus during the initial phase of conducting an experiment.

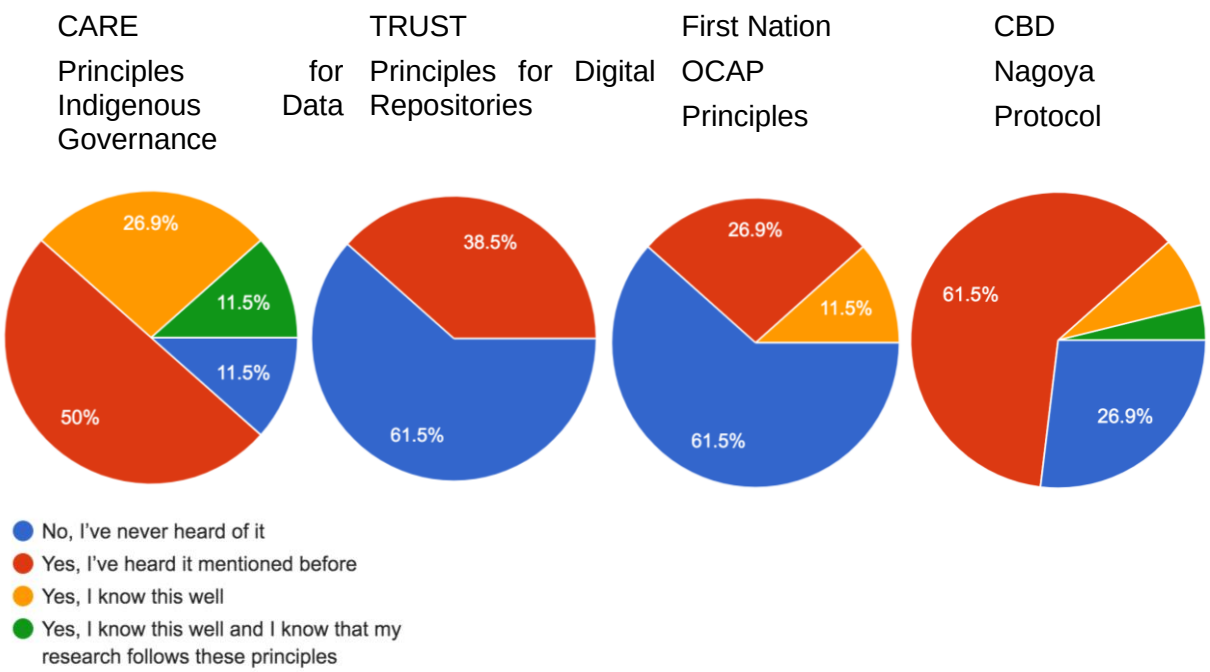
We next asked the participants to provide an overview of the repository landscape they encounter in the Omics/eDNA community. The established repositories for DNA and RNA sequence data in FASTA or FASTQ formats are the INSDC resources (ENA, Genbank, DDBJ), which provide gravity to our quickly evolving field. Further mentioned were UNITE for rDNA ITS sequences of Eukaryotes (including Fungi), BOLD for barcode sequences, PRIDE for proteomics data, the Dryad Digital repository, Pangaea, FigShare and Zenodo. Many of those databases, however, face the challenges of becoming a dumping ground for any kind of data that do not yet have a dedicated repository. For example omic biodiversity data (ASV contingency tables) do have a standard format (BIOM format) but a dedicated repository is lacking. The Atlas of Living Australia (www.ala.org.au/) and Global BIodiversity Information Facility (www.gbif.org) have started efforts to release interpreted eDNA data alongside conventional biodiversity records. This means that the (much larger) non-research community can take advantage of this revolutionary way to measure biodiversity. As we realise the sheer amount of diverse data we are producing in this community, we recognise the need for specific repositories and face the additional challenge of linking different data types together, e.g., sequence data to intermediate data products to contextual data, each in its own repository. This brings us back to a core concept of FAIR data practices, improving the Findability of data. The OBPS could provide regularly updated guidance on which repositories are the best for different types of data. This would ensure that users anticipate sharing their data in a certain format and location from the beginning.

Barriers in FAIRness and standard applicability and compliance will impede our understanding of the world around us. Especially in the light of the upcoming UN Decade of Ocean Science and Sustainable development, we bear the responsibility of using our resources to the best of our abilities to provide valuable data, information and knowledge about the processes and players that shape the world we live in.

7.4.3 Society

37 participants

Within the discussion on Omics/eDNA and Society we covered topics ranging from ethical concerns across the entire Omics pathway from sampling to data sharing, as well as discussing how Omics relates to policy, education and training. For the 09:00 UTC session we teamed up with both the Ethics WG and Data & Info WG. Each session started with a poll to see how many participants had heard of the CARE (Collective benefit - Authority to control - Responsibility - Ethics) principles for Indigenous Data Governance, TRUST (Transparency - Responsibility - User focus - Sustainability - Technology) Principles for Digital Repositories, First Nation OCAP (Ownership - Control - Access - Possession) principles for the Convention on Biological Diversity - Nagoya Protocol. These principles have all been designed to ensure ethical data stewardship. However, the majority of the 26 respondents, in the Society WG meetings, had either never heard of the principles (especially TRUST and OCAP), or had heard of the principles but were unsure if their research practices followed the principles (see Figure). This highlights a need to promote these principles within the Omics/eDNA community and provide guidelines on how to ensure that research follows these principles. Both, the provision of training resources, or the inclusion of ethical principles in protocol decision trees, would help to ensure that researchers take steps to fulfill ethical requirements early on in their research.



Ethical values should always be promoted, such as honesty, integrity, transparency, reliability and accountability. Ultimately, responsibility is one of the core values universally accepted as representative of individual and social good in terms of honesty, justice and respect for life and the environment. It is important to emphasize the responsibility of scientists to take the necessary steps to ensure a healthy working environment and a safe society, as well as good international relations.

The basic requirement for any research activity must be in accordance with the legal obligations of the producing country or international laws. While sampling operations must, as a minimum, comply with national and local laws, more ambitious sustainability requirements and voluntary actions beyond those required by law must be developed. Scientists would benefit from an awareness of diplomatic issues and the risks of mistrust in the region of study. Guidance for scientists is needed on diplomatic issues and how to prevent and mitigate such geopolitical issues. Incorporation of these ethical considerations to an OBPS decision tree could facilitate the adoption of relevant ethical guidelines from the outset, flagging any potential diplomatic or

mistrust issue as well as linking to initiative aimed at mitigating such problems, like the Biocultural Label Initiative.

The Access and Benefit Sharing principles have been defined in the Convention of Biological Diversity recalled in the Nagoya Protocol. This includes the Essential core values, such as fair and equitable sharing of benefits, with transparency, traceability and reciprocal relations to foster the sharing of scientific knowledge with concerted handling of data, traceability, nature conservation and environmental respect. The OBPS can play a key role in improving the accessibility and traceability of Omics/eDNA data. Ensuring transparency in research, which is needed for early engagement and trustful relationships with collaborating indigenous communities. Scientists should also not be afraid of negotiating when signing agreements on sharing data or collaborating on research activities. As defined by the First Nations' community, OCAP principles are a start for exchanging and agreeing on activities with respect of indigenous culture and knowledge.

The ethical, legal, and social issues that may impact Omics/eDNA research include:

- Chain of custody for samples and sequence data - How to decide on chain of custody in international waters and in regions where these ethical principles apply?
- Terms of use for open access data - FAIR principles encourage open access data but what are the terms of use for these data? Will sequence data be used by companies with commercial interests and how can we ensure ethical use of these data and prevent copyright of genes?
- Omics/eDNA can be seen as a cheaper, less invasive alternative to more conventional marine biomonitoring - We have an ethical responsibility to make clear the limitations of Omics/eDNA research so that governmental monitoring schemes can include Omics research without replacing valuable conventional marine biomonitoring. There is a potential conflict between using eDNA/Omics with conventional methods of sampling (e.g., trawling) in protected areas - can we ethically trawl through protected areas with sensitive benthic habitats, or risk losing information on species sex, size, and other traits if we replace trawling with eDNA in these protected areas?
- Omics/eDNA in the court of law for biodiversity impact assessments - How/who will establish benchmarks for competent Omics/eDNA assessments that can be used in court?

The Omics/eDNA community would benefit from clear guidelines or checklists on how to adhere to ethical principles, and from training resources for ethical data management within the Omics/eDNA fields. As Omics/eDNA is increasingly being used to inform policy, resources need to be available for policy makers with simplified details on Omics/eDNA surveys which also make clear the limitations. Boundary spanners are needed to navigate the maze of national and international laws that may be relevant to Omics/eDNA research and impact assessments. Institutional review boards (IRB) can be used to address ethical

issues and we could look to archeological/anthropological communities for examples on how to address such issues.

7.5 UN Decade of Ocean Science for Sustainable Development

The UN Decade of Ocean Science for Sustainable Development (Ocean Decade) aims for:

- A clean ocean where sources of pollution are identified and reduced or removed.
- A healthy and resilient ocean where marine ecosystems are understood, protected, restored and managed.
- A productive ocean supporting sustainable food supply and a sustainable ocean economy.
- A predicted ocean where society understands and can respond to changing ocean conditions.
- A safe ocean where life and livelihoods are protected from ocean-related hazards.
- An accessible ocean with open and equitable access to data, information and technology and innovation.
- An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development.

Development of Omic and eDNA approaches within OBPS will facilitate comparisons enabling biodiversity monitoring at global scales with greater temporal, spatial and taxonomic resolutions. Omic and eDNA approaches will thus play an integral role in achieving outcomes [2] and [4] of the seven desired outcomes at the end of the Ocean Decade. Monitoring with Omic and eDNA methods has the potential to provide biodiversity data at scales previously only achievable for physio-chemical data, advancing the greater understanding of marine ecosystems desired in outcome [2]: 'A healthy and resilient ocean where marine ecosystems are understood, protected, restored and managed.' These data can then be used to develop more comprehensive models for ecological forecasting, helping to achieve outcome [4]: 'A predicted ocean where society understands and can respond to changing ocean conditions.' Harmonizing Omic and eDNA approaches within OBPS will contribute to outcome [6] 'An accessible ocean with open and equitable access to data, information and technology and innovation'. For outcome [3] 'A productive ocean supporting sustainable food supply and a sustainable ocean economy' - eDNA methods are already being developed to monitor commercial fish stocks (Stoeckle, Das Mishu, and Charlop-Powers 2020). Furthermore, Omic and eDNA methods can be used for the early detection of harmful algal blooms (Perini et al. 2019) ("Molecular Methods for Cost-Efficient Monitoring of HAB (harmful Algal Bloom) Dinoflagellate Resting Cysts" 2019), providing early warning systems that can benefit both aquaculture and tourism, contributing to outcome [5] 'A safe ocean where life and livelihoods are protected from ocean-related hazards'. Furthermore, methods to collect samples for Omic and eDNA research are relatively simple, making them suitable for citizen science, as demonstrated already by efforts such as Ocean Sampling Day, encouraging public engagement

with ocean sciences, and promoting [7] 'An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development".

Implementing the recommendations for OBPS to support the Omic and eDNA community will take a concerted effort over the coming decade. The UNDOS provides an opportunity to rally efforts, including those that already exist, to help develop solutions and then scale them globally with the support of OBPS.

7.5.1 Ocean Decade Actions: 'Programmes, Projects, or Activities'

We considered potential “actions” and “ocean shots” that the community could rally around over the next decade (during UNDOS) to advance the objectives identified above. We present one of these ideas below.

A Decade **programme** is typically global or regional in scale and will contribute to the achievement of one or more of the Ocean Decade Challenges. It is long-term (multi-year), interdisciplinary and will consist of component projects, and potentially enabling activities.

A Decade **project** is a discrete and focused undertaking. It may be regional, national or sub-national and it will typically contribute to an identified Decade programme.

A Decade **activity** is a one-off standalone initiative (such as an awareness-raising event, a scientific workshop, or a training opportunity). It will enable a programme or project or directly contribute to an Ocean Decade Challenge.

For each action, the following will need to be developed in subsequent discussions:

- **Coordinators:** Potential partners/champions:
- **Partners:** Existing/funded programs that might contribute:
- **Equity:** How to make globally accessible to all regions and inclusive to all people
- **Sustainable Development Goals (SDGs):** How does it advance sustainable development - society beyond research

Global Ocean Microbiome and Genomic Observatory (eDNA) Network?

As an Ocean Decade *action: program*, the community might propose a **Global Ocean Microbiome and Genomic Observatory (eDNA) Network (GLOMIGON)** [an Ocean OMIC BON] would promote coordinated Omic and eDNA sampling of the global ocean.

- Potential Coordinators: IOC/UNESCO via national/regional efforts with organizations such as Partnership for the Observation of the Global Ocean (POGO), World Association of Marine Stations (WAMS), et al.
- Potential Partners: Australia Microbiome, EMBRC, Smithsonian, … ?
- Equity: Include Small Island Developing States (SIDS) et al. in scope, including access to high seas research; training and education
- SDGs: Link to Law of the Sea (UNCLOS), Biodiversity Beyond National Jurisdictions (BBNJ) as well as IPCC and IPBES

The GLOMICON Program could also address a “Futuromic Ocean Shot” consisting of three core components:

- **Futuromic Ocean Biobank** - build a distributed repository (Biobank) of samples conforming to best practices and accessible (e.g., via GGBN) for future ‘omic analyses that could be used to

test and calibrate new protocols and practices by providing a reference set of time-series “omic-grade” samples. **[Samples]**

- **FAIR Ocean Omic Data (FOOD) -** Developing pipeline of Omic and eDNA data that feed into ecological models, help train ML/AI, and contribute to efforts to build digital twin ocean and support scenario-based decision-making at nested social-ecological scales from coastal seas to the global ocean **[Data/Bioinformatics]**
- **FAIR Ocean Omic Resources & Training Center** - developing capacity in all regions for Omics research, Omics-driven management, and Omic literacy to benefit from data/knowledge stemming from new omic technologies; and including references/materials for Ethical Legal and Social issues **[Society]**

7.6 Plans for follow up discussion and future collaborations

There are many initiatives in Omics and eDNA. The Omic BON (stemming from the merger of GLOMICON and Genomic Observatories Network) is an opportunity to federate these (Network of Networks), linking OBPS and GEO BON (particularly MBON) through Omics toward the objectives of the Decade (convergence) including the potential UNDOS actions listed above.

We aim to prepare and execute the plans introduced above in: UNDOS activities and Future Collaboration. For this we plan to continue using the OBPS slack workspace (Omics-eDNA Channel) and set up an OBPS subforum for Omics/eDNA. Working group participants have suggested that follow up meetings should be held every 6 months and 14 participants, including the working group leads, have volunteered to help coordinate these meetings.

Acknowledgements

The following participants contributed comments and edits to the final draft:

Michèle Barbier, Jodie van de Kamp, Nick Jeffery, Oliver Berry, Christina Pavloudi, Ian Salter, Alison Watts, Carol Stepien

8 Annex 8 Partnership Building Working Group

8.1 Logistics

Co-leads:

Andrea McCurdy Consortium for Ocean Leadership

Jon White Consortium for Ocean Leadership

Maya C. Delaney Albright Stonebridge Group

Isigi Kadagi Education for Nature Program and Conservation Leadership, WWF-USA, BILLFISH-WIO, African Billfish Foundation

Community Consultation Working Group Session:

Wednesday 23 Sept. 2020

On a global scale, nations are increasingly focusing on harnessing the potential of the ocean economy, also referred to as “Blue Economy” (BE). This growing interest has attracted a significant body of knowledge on the guidelines to achieve a balanced BE, one that accounts for economic development while ensuring environmental sustainability and community involvement. Acknowledging the complexity of BE, various stakeholders (e.g., governmental, non-governmental, and intergovernmental agencies) are developing initiatives that aim to bring together diverse public and private partners to catalyze the investment into

long-term development of BE sectors. Ocean partnerships are critical for providing an integrated approach for addressing challenges and creating opportunities for sustainable blue growth, based on ocean observing data and capable of scaling to meet the prevailing demand for goods and services.

In 2018, the global Sustainable Blue Economy Conference, held in Nairobi, Kenya, focused on the sustainable development of oceans, seas, lakes, and rivers as stipulated by the 2030 United Nations Agenda. Following the Nairobi Blue Economy Conference, similar events have been held in other regions across the globe, with participants ranging from heads of states and representatives of national and international agencies, communities, business sectors, and the scientific community. Given the significance of ocean partnerships for strategic blue growth, there is a need for collaborative efforts to bring diverse groups to leverage best practices for sustainable oceans.

The Ocean Partnership Building Working Group (WG) was convened during the Evolving and Sustaining Ocean Best Practices IV OBPS Workshop 2020. This WG focused on the importance of partnerships among ocean observing practitioners in addressing both social and scientific challenges especially in the BE arena. During the last decade with the adoption of a multi-disciplinary approach to project design and the adoption of open data policies, partnerships are critical for sustained successful impact of observing projects and programs. These partnerships can be formed to address a wide range of needs, from highly localized endeavors to cross-regional systems, to technology and data maturation, to national and international policy.

This WG will launch from work done previously at Ocean Obs '19, RCN Annual Meeting, and OSM 2020. These sessions have discussed various partnership and collaborative groups and the role of Collaborative Impact Approach to cooperation and organization. The Approach was introduced in 2011 from the Stanford Social Innovation Review [Kania, Kramer] and has been adopted by a wide range of groups globally. These organizations have five conditions that set them apart:

- A common agenda
- Shared measurements
- Mutually reinforcing activities
- Continuous communication
- Backbone support

The WG brought together experts that have experience working on intrinsically collaborative projects ranging from local, regional, national, and global to those that are geographic in scope, and those thematic in nature. Panel Members included:

- Brad deYoung (Professor Memorial Univ / AtlantOS)
- Michelle Heupel (Director / IMOS)
- Jerry Miller (President / Science for Decisions)
- Sophie Seeyave (CEO / Partnership for Observation of the Global Ocean)
- Louise Newman (Executive Officer / SOOS)
- George Petihakis (Chair / EuroGOOS)
- Carlie Wiener (Director of Communication and Engagement Strategy / Schmidt Ocean Institute).

8.2 Key points and developments

Panelists discussed how the keys to strengthening partnerships involves a granular understanding of each stakeholder's respective barriers to greater participation and exploring data solutions that begin to address those challenges.

Organizations that manage a plethora of collaborative ocean projects and programs, such as the Consortium for Ocean Leadership, based in Washington, D.C. discussed how partnerships across all sectors and around the globe have been essential to the advancement of ocean observing for many years. And how the ability to observe the ocean and gain the requisite knowledge to support future growth of a sustainable, global adoption of BE practices will rely on transformational partnerships across all maritime sectors that transform "stakeholders" to "shareholders" of ocean knowledge.

The Partnership for Global Observation (POGO) is a partnership in and of itself, of around 50 oceanographic research institutions that work together globally to identify ocean observing priorities and to support these through a concerted effort. Beyond this POGO also partners with other international and regional organizations, where mutual interests have been identified and complementarities can be leveraged.

Groups that have as their mission to sustain national and regional scales will also discuss the importance and the role of partnerships to their success. For example, the Integrated Marine Observing System

(IMOS) coordinates observing assets and resources for Australia. This organization will discuss how partnerships are essential to every element of their program and underpin every aspect of their success to date.

In addition, the European Global Ocean Observing System (EuroGOOS), a long-standing partnership between major operational oceanographic actors in Europe, in its 2030 strategy will leverage co-design with a much broader range of ocean observing stakeholders, spanning ocean disciplines, as well as the social sciences. There will be a discussion of how partnerships are a cornerstone of a successful delivery of sustained ocean knowledge and information for society and allow separate nations to speak with one voice promoting and jointly setting out the agenda for ocean science and observations across Europe.

Blue Economy specialists and policy analysts provided insight into partnerships for investment in natural capital solutions, including fisheries, or aquaculture in developing countries. Comments explored the obstacles to further investment and methodologies to sustained capital development and what are methods that lead to enhanced understanding along with long-term investment.

This group discussed the Collaborative Impact Approach and examined to what degree it

is sufficient as a framework for bringing disparate groups together to solve common ocean observing, BE and other broader impact goals in a sustainable way. The outcome of the session is a recommendation to the OBPS on what are next steps toward the achievement of a best practices organizational and partnership framework that will better ensure the achievement of long-term impacts related to commonly agreed to scientific and societal goals; and maximize the value of ocean observations to an expanding community of BE shareholders.

9 Annex 9 Sargassum Working Group

9.1 Logistics

Co-leads:

Emily Smail	NOAA, USA
Shelly-Ann Cox	CERMES, Barbados
Cesar Toro	UNESCO, Paris, France
Leah Segui	NOAA, USA

- Link to google drive: https://bit.ly/SargWGrp
- Contact information for co-leads: Emily Smail (emily.smail@noaa.gov), Shelly-Ann Cox (shellsalc@gmail.com), Cesar Toro (c.toro@unesco.org)
- Contact information for rapporteur**:** Leah Segui (leah.segui@noaa.gov)

Participants to Sargassum WG are listed in Table 9

Table 9 Participants to Sargassum WG

Given Name	Family Name	Affiliation	Country	Email	ORCID if available
Debbie	Bartlett	University of Greenwich	United Kingdom	D.Bartlett@greenwich.ac.uk	
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Sabine	Engel				
Fernando	Esposito	UMV	Brazil		
Mar	Fernández-Méndez				
Brigitte	Gabio				
Tristan	Harmel				
Maren	Headley				
Philip-Neri	Jayson				
Don	Johnson				
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Kalim	Shah				
Emily	Smail	GEO Blue Planet	USA		
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Martin	Thiel				
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Fabien	Vedie				
Chrstianne	Walcott	UWI		christianne.walcott@cavehill.uwi.edu	

9.2 Links to other Working Groups

The working group did not have any direct exchanges with other working groups established for this meeting.

9.3 Key Points and developments

Many participants were unaware of OBPS. On the second meeting, we started our discussions by giving an overview of OBPS and reiterating the goal of the workshop which is to provide suggestions to OBPS from our community.

9.4 OBPS use cases

The OBPS is interested in “use cases” which helps us to scope future services but also demonstrate the benefit and impact of Best Practices and the OBPS. These use cases may address the implementation of a best practice or consider creation of a new or the update of an existing Best Practices. Please share your “Use case” examples or potential use cases with us. We are more than happy to follow up with your group on an implementation. Particular interest from OBPS is in how we can serve the communities in collaborating on creation and adoption of Best Practices.

The Sargassum Uses Guide: a resource for Caribbean researchers, entrepreneurs and policy makers is now available.

9.5 UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

Did you discuss the “Decade” in relation to your working group scope and
current and future activities?

- The IOC Sargassum group will lead a proposal for the Decade to make sargassum a program action.
- Sargassum affects both the east and west Atlantic. The Decade can be used to bring the two communities together.
- The sargassum community could use the decade to engage citizens and drive political will
- Coordinate with ethics discussions related to the decade - could you harvest a portion of the sargassum without destroying the offshore ecosystem? How does this relate to the societal need to deal with the sargassum issue? Do we know the safety of sargassum-derived products?

- Public-private partnerships may be the way forward. Commercial sector is leading sargassum efforts and it is interested in creating a market for sargassum. This may create an opportunity to create partnerships with the agriculture and energy sectors.

Do you think that Best Practices (and documentation) will play an important role in the “Decade”?

- OBPS can help with information sharing in the Caribbean and West African regions.

9.6 Plans for follow up discussion and future collaborations

Do we plan to continue discussions either with the whole or subgroup after this meeting?

Yes, SARGNET listserv offers an opportunity to continue discussions and explore synergies with existing projects.

10 Annex 10 Surface Radiation Working Group

10.1 Logistics

Co-Leads

Meghan Cronin (NOAA/PMEL, meghan.f.cronin@noaa.gov)

Laura Riihimaki (NOAA/GML, laura.riihimaki@noaa.gov)
Elizabeth Thompson (NOAA/PSL elizabeth.thompson@noaa.gov)
Maria Teresa Guerra (Trinity College Dublin guerram@tcd.ie)

Sessions

Tuesday Sep 22 13:00-14:30 UTC (15' each block)

1. Laura Riihimaki Briefing
2. Anthony Bulchotz Briefing
3. Chris Fairall Briefing
4. Patrick Berk Briefing
5. R. Venkatesan Briefing
6. Summarize Best Practices

Wednesday Sep 23 13:00-14:30 UTC (15' each block)

1. Christian Lanconelli Briefing
2. Alcide di Sarra Briefing
3. Jim Edson Briefing
4. Tom Farrar Briefing
5. Summarize Best Practices
6. Plan way forward -- Best Practice Report and potential peer-reviewed paper for submission to BAMS or Frontiers in Marine Science.

Thursday Sep 24 16:00-17:00 UTC Synthesis of Recommendations, and plans for going forward.

Briefings addressed the following questions:

- What components of Surface Radiation are you measuring? and Why?
- How are you measuring Surface Radiation? What is your setup, including platform, & sensor sampling strategy?
- What is your calibration strategy?
- What particular challenges do you face making these measurements?
- What are your practices for overcoming these challenges and ensuring high
- quality measurements?

Working Group Leads and Participants

Given Name	Family Name	Affiliation	Country	email	ORCID if available	Contribution to Report (i.e. Section #, Cleanup, All)
Meghan	Cronin	NOAA PMEL	USA	Meghan.F.Cronin@noaa.gov	0000-0002-4703-8132	Workshop co-lead, All
Elizabeth	Thompson	NOAA PSL	USA	Elizabeth.Thompson@noaa.gov		Workshop co-lead, Rapporteur
Maria Teresa	Guerra	Trinity College Dublin	Ireland	guerram@tcd.ie		Workshop co-lead, Section 5.4
Laura	Riihimaki	NOAA GML	USA	Laura.Riihimaki@noaa.gov		Workshop co-lead, All

Elizabeth Thompson acted as the Workshop Rapporteur

Panelists at session are listed in Table 10

Table 10 Panelists for Surface Radiation WG

Given Name	Family Name	Affiliation	Country	email	ORCID if available	Contribution to Report (i.e. Section #, Cleanup, All)
Patrick	Berk	NOAA PMEL	USA	patrick.berk@noaa.gov		Section 4.2, 6.2, 7, 9
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Alcide	di Sarra	ENEA	Italy	alcide.disarra@enea.it	0000-0002-2405-2898	Section 4.2, 6.2, 6.3, 9

James	Edson	Woods Hole Oceanographic Institution	USA	jedson@whoi.edu		Sections 4.2, 5.3, 6.2, 6.3, 9
Chris	Fairall	NOAA PSL	USA	chris.fairall@noaa.gov		Section 4.2, 6.2, 6.3, 9
Tom	Farrar	Woods Hole Oceanographic Inst	USA	jfarrar@whoi.edu		Section 6.2, 6.3, 9
Christian	Lanconelli	European Commission Joint Research Centre (for BSRN)	Italy	christian.lanconelli@ec.europa.eu	0000-0002-9545-1255	Sections 6.1, 6.3, 7, 8
Laura	Riihimaki	NOAA GML	USA	laura.riihimaki@noaa.gov	0000-0002-1794-3860	All
R	Venkatesan	NIOT	India	dr.r.venkatesan@gmail.com	0000-0001-7386-1539	Section 6.2, 6.3

Other Participants are listed in Table *11*

Table 11 Other Participants to Surface Radiation WG

Given Name	Family Name	Affiliation	Country	email	ORCID if available	Contribution to Report (i.e. Section #, Cleanup, All)
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Gary	Hodges	NOAA GML	USA	gary.hodges@noaa.gov		Section 7
Kathleen	Lantz	NOAA GML	USA	kathy.o.lantz@noaa.gov		Section 4.4, 5.2, 5.4, 6.3, 9
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Sebastiaan	Swart	U. Gothenburg	Sweden	sebastiaan.swart@marine.gu.se	0000-0002-2251-8826	Section 6.2, 6.3, 9
Jim	Wendell	NOAA GML	USA	jim.wendell@noaa.gov		Section 7

10.2 Links to other WGs

Developing Training & Guidance WG – Our goal to expand the community of surface radiation observers, including from developing countries, is a driver for all of our recommendations. Our WG could benefit from this WG's best practice recommendations.

Uncertainty Quantification WG -- This WG could help us define useful uncertainty specifications that are at the core of metrology in all our above recommendations.

Fisheries WG, etc. – We will include decision trees for surface radiation observations for biological applications, as well as for heat budget applications.

Convergence WG – We welcome feedback and advice from this WG on how we present our best practice recommendations. Should these be part of the Ocean Best Practice System website? Or part of a new www.airseaobs.org website that is currently under development? This website is intended to help galvanize and highlight post-OceanObs19 activities (including development of best practices) related to

improving and expanding air-sea interaction observations for the UN Decade of the Ocean Science for Sustainable Development.

Note: we expect that there are other synergies too.

10.3 Scope of Surface Radiation Community Consultation Working Group

Understanding and simulating cloud processes and their effect on the Earth's energy balance represents one of the major challenges for weather forecasts and climate predictions. Improved understanding of the surface radiation budget within models and from satellite observations will require direct observations of surface radiation over the ocean from the equator to polar latitudes, and from coastal to open ocean. Over the next decade the network of ocean surface radiation observations is expected to greatly expand as programs like Tropical Pacific Observing System (TPOS)-2020 are implemented and the use of novel surface platforms grows. In addition, surface radiation technology has rapidly advanced as solar power has gained wide-spread usage. It is thus critical to consider the challenges and best practices for making high quality surface radiation measurements from moving platforms, whether they be moored or drifting buoys, ships, autonomous surface vehicles, drones or aircraft.

As part of the Ocean Best Practices "Evolving and Sustaining OBPS Workshop IV: 18; 21-25 & 30 Sep 2020" a Community Consultation Working Group (WG) for Surface Radiation was formed. Panelists and participants included Surface Radiation practitioners of all levels from novices to gurus, and from both ocean and land-based surface radiation networks. During the first two sessions, panelists described their individual setups, challenges faced, and solutions to these challenges. During the final third session, a strategy was developed for the WG that would lead to consensus best practices for making Surface Radiation measurements from ocean platforms.

This report describes the workshop, the strategy developed by the WG for improving surface radiation measurements from moving platforms, and some consensus best practices. We hope that this WG will help bridge the ocean and land-based surface radiation networks so that ultimately the surface radiation reference station network can extend over the entire globe -- land, sea and ice.

10.4 Recommendations and Background

The following were deemed the top three-four recommendations for development of surface radiation methods and best practices. While this workshop report lists some of the best practices discussed during the workshop, further work will be needed to develop the best practices for submission in the OBPS repository.

10.4.1 Three-to-four top recommendations

1. Develop a decision tree for different surface radiation applications that provide recommendations for

a. choice of sensors,

b. best practices for handling of sensors and installation setup,

c. best practices for calibrating sensors and processing/post-processing data, and

d. sanity checks and tests for goodness of data.

2. Develop plans to expand land-based calibration facilities to handle ocean-based radiation sensors

3. (tie with 4) Develop recommendations for standardizing modifications to sensor electronic and housing for marine application. Share these recommendations with industry to allow for broader usage of sensors for marine applications

4. (tie with 3) Develop plans for field intercomparisons of different surface radiation platforms at testbed sites that can act as high-quality reference time series. Example testbed sites might include the Lampedusa Oceanographic Observatory, which is 15 km from the Lampedusa Atmospheric Observatory (Di Sarra et al. 2019), or the Air-Sea Interaction Tower (ASIT) offshore of Martha's Vineyard (Edson et al. 2016).

These consensus recommendations, and the key steps for making progress for creating and evolving methods and maturing these to best practices, are described in more detail in the following sections.

10.4.2 What are the challenges?

- If the sensor is not level, error in solar radiation is introduced due to the effective zenith angle of the solar direct beam.
- Moving platform changes effective zenith angle of solar direct beam. Waves (rocking) leads to high frequency variance in the tilts, while wind and currents, and platform navigation can lead to mean and variable tilts.
- Shadowing and reflection introduce errors in the solar irradiance
- Warm/cold objects in the field of view introduce errors in the IR irradiance.
- Condensation on the inside of the dome occurs when the desiccant is saturated. This leads to errors similar to dew formation, a particular problem for IR sensors because the condensation is not visible.
- Environmental contamination of the optics leads to errors, including from: Dust, dew, ice crystals, sea salt, guano, bird butts
- Input for data loggers must be amplified before digitization in some systems. As a result, "plug and play" sensors are not available, leading to a serious impediment for widespread usage by new groups.
- Lack of calibration "facilities" -- Calibration reference not always available or may be of poor quality.

10.4.3 What are the success stories?

Tilt correction:

Some success has been achieved using active leveling platforms to provide stability on moving platforms, primarily used on ships and aircraft (presentations by Chris Fairall & Anthony Bucholz)

A post-processing tilt correction methodology using the SPN1 radiometer to measure direct and diffuse components (Long et al. 2010) has been deployed on aircraft, ships, and autonomous vehicles (presentations by Laura Riihimaki, Anthony Bucholz, and Patrick Berk)

When averaging over longer time periods some sites show little overall bias (di Sarra et al., 2019; presentation by Alcide di Sarra)

Cleaning:

Two methodologies under development for automated cleaning which could help solve this challenge (presentations by Alcide di Sarra and James Edson)

10.4.4 List of papers showing performance of different sensors

One of the discussions of lessons learned from the land-based radiometer community is the potential to choose sensors that minimize the problems of a solar zenith angle response to instrument sensitivity, that have accurate spectral response sensitivity to wavelength region of interest, and a thermal offset caused by infrared loss to improve the accuracy of measurements. This collection of papers includes comparisons of the performance of different sensors as a first step towards creating decision trees for sensor choice in different environments.

10.5 Decision Trees for Choice of Sensors

In this section, we lay out the basic framework for the decision trees for different applications. A table of possible sensors with accuracies and sensor sampling frequency etc. could be very useful as a quick guide. While there are sensitivities to naming manufacturer products, the goal is to be practical about sensor recommendations based on actual performance as identified in the literature. Overall, it was recognized that technology has improved and newer technology has advantages over older technology. The land-based surface radiation community has also done studies verifying the specifications of different radiation sensors. Thus, rather than duplicate this work, our WG will try to identify these studies and incorporate their lessons into the Ocean Best Practices.

10.5.1 Decision Tree for downwelling solar and IR radiation for heat budget applications

This section describes the decision tree for the choice of both primary and ancillary sensors for measuring downwelling solar and IR radiation specifically for heat budget applications. The choices depend upon the following considerations:

Is power limited?

Typically, power is not a limiting factor for large platforms such as ships or aircrafts, but is a limiting factor for smaller platforms such as buoys. In some cases, power is harvested from the sun or wind so that power is limited for some sensor choices but not for others. Thus, it is important that the decision tree for the sensor choices specify the power requirements.

- Active gimbal can be used to stabilize sensor
- Leaves room for new potential technologies like automated washing or heating/ventilation in environments that may require it.

Is the platform stable or not?

Longwave Radiation is relatively isotropically distributed so its sampling is less sensitive to platform motion. However, this is not the case with shortwave radiation, except under very diffuse conditions. Most ocean platforms are not stable. In some cases, however, such as with ships and aircraft, shortwave radiation sensors can be leveled using active gimbaling. This section will describe recommendations for gimbals and shortwave radiation sensors when it is not possible to keep the sensor level. These decisions will depend upon not only the degree of tilt, but also in some cases, the sensor’s motion characteristics.

For example, a buoy rocking in waves is less of an issue than a persistent tilt due to wind, currents or navigational changes to the platform. In general, when the sensor is not level and is moving, shortwave radiation should be measured with:

- Fast response shortwave irradiance sensors that also measure diffuse component (from which can derive and correct for platform motion) may be effective
    - IMU for measuring platform motion -- pitch and roll should be measured with accuracy of a few tenths of a degree at no slower than 1 Hz
- Check solar radiation leakage of IR sensors

Does the sensor experience extreme cold temperatures (or extreme heat)?

In extreme cold environments, ice can form on the domes, leading to measurement errors.

In land-based networks, this is often

- mitigated by ventilation and sometimes heating
- Some sensors, such as the SPN1 have internal heaters which mitigate this problem in some environments

Lessons can be learned from an Arctic radiometer comparison campaign held in Utqiaġvik, Alaska (Cox et al. 2020)

Decision Tree for Upwelling solar (i.e., albedo) Albedo is a challenging measurement to make over oceans, but needed for direct evaluation of satellite data and parameterization-based approaches for estimation. Aircraft measurements may be an effective approach to provide these measurements and evaluate the quality of surface-based measurements made from buoys or other platforms.

Decision Tree for Upwelling IR (i.e., Skin temperature)

Ideally, the skin temperature is measured directly with downward looking radiometers that are corrected for reflected radiation by a separate upward looking device or the same device that is occasionally rotated to look upwards. More typically, a thermistor is used to measure the temperature at some depth. Thermistors that can be towed very close to the sea surface (i.e., a sea-snake) require an adjustment for cool skin. Thermistors at depth (i.e., from a surface mooring) often require correction for diurnal warming and then adjustment for cool skin. A vertical array of temperature sensors may help with the warm layer but not the cool skin.

Downwelling solar radiation for biological application

The biological community is also in need of high-quality observations of surface radiation with wavelengths in a spectral range critical for photosynthesis, e.g. PAR and UVB sensors. These types of sensors differ from those used for heat budget analyses and therefore a separate decision tree.

10.5.2 Other Best Practices

These best practices typically apply to all applications and therefore are not included in the decision trees for different applications. It is emphasized that throughout this section, the best practices described here should be considered as preliminary. Further work is needed to determine the consensus best practice.

Recommended Sampling

- 1-minute averages of 1-Hz data is standard for the Baseline Surface Radiation Network (BSRN)
- Perhaps different frequency and averages for different variables (Tom Farrar mentioned the various averaging that can take place 10 second values into 1 min averages versus an instantaneous sample per minute, etc.)
- Also, the working group may recommend for the minimum sampling requirement i.e. Sample Rate, Sample Period, Sample Time (UTC), and Stored Data Interval for radiation measurement. Globally, each buoy operator follows their own sampling technique, this needs to be standardized.
- Sampling for tilt correction should be high, at 1 Hz or greater in order to adequately capture the range of motion of the platform. If tilt correction is not performed, then ranges of uncertainties could be calculated for different averaging times as a guide to how to use the data.

Recommended sensor/system modification

One of the major recommendations was to develop recommendations for standardizing modifications to sensor electronics and housing for marine application. Share these recommendations with industry to allow for broader usage of sensors for marine applications. Currently, modifications are performed to:

- Provide custom gain stages to amplify Thermopile sensor.
- Provide highly accurate thermistor readings on case & dome (PIR only).
- Minimize self-heating through low-power circuitry.
- Provide digital serial communications between the sensor and control systems.
- Custom sealed plastic housing (vs metal) to minimize thermal absorption and ensure sensor is ocean-ready (IP68+).
- The use of radiation shields and aspiration on accuracy is still an open question.
- Allow data to be logged. Manufacturers should be encouraged to give inbuilt data logger along with radiometer, although this may lead to larger power requirements. In some cases, sensors are part of a larger met system and don't require independent logging. Both options should be possible.

Capacity building needs to be undertaken as a priority. Field expertise is too often developed in a hard way. For new users the collection of additional or auxiliary data is very unclear. Many don't know that collecting a particular extra data can be used later to correct for issues with the target shortwave or longwave radiation observation. The WG hopes to clarify these best practices and recommendations.

Recommended Handling, Setup and Maintenance

Best practices for handling, setup and maintenance form part of the top major recommendations of the WG (#1b: Develop a decision tree for different surface radiation applications that provide best practice recommendations for handling of sensors, installation setup and maintenance). Here we provide some thoughts raised during the workshop. Further work is needed to determine the consensus best practices.

- Needs to change desiccant, pack very carefully, Galvanic corrosion and damage to fragile radiation shield
- Sensor output voltages can be very small, so selection of data loggers (sensitivity, stability, calibration requirements) and electronics for signal conditioning and digitizing requires some care.
- Aspiration in moist environments: not ventilated on ship, but someone physically cleans them every day. Ventilation removes dew, which may be an issue in coastal regions where fog can develop.
- Position on highest point to avoid shadows, but there are more subtle, yet important recommendations on this - e.g., if space constraints make it impossible to avoid having objects in the field of view of the radiometer, consider the cosine response of the sensor (i.e., have the object as low in the radiometer's field of view as possible) and consider the reflectivity/emissivity of the object.
- Clean with soft cloth, if possible.
- Cleaning in general… very interesting discussions yesterday on the apparent lack of dirt impact on SW versus the LW sensors. Of course, we could clean as much as possible but sometimes this is very tricky due to numerous reasons (e.g. cannot access ship met-mast due to weather/radar etc.). If we had some recommendations, we could better estimate the frequency of cleaning (at the moment I'm not sure if this should be daily versus weekly versus even monthly!). In land-based networks we clean daily when possible, and weekly, if possible, at more remote sites where daily cleaning is not feasible. On a ship I suspect the instruments would benefit from a daily cleaning given the challenging conditions.

10.6 Recommended Calibration Strategy

Best practices for calibration strategies form part of the top major recommendations of the WG (#1c: Develop a decision tree for different surface radiation applications that provide best practice recommendations for calibration strategy and post-processing). In addition, the second major recommendation (#2) of this WG is to expand land-based calibration facilities to handle ocean-based radiation sensors.

- Ideal: Outdoor calibration against sensor traceable to the World Radiometric Reference (WRR)
    - This calibration can be performed whenever the sun reaches an elevation of 45 degrees or solar-zenith angle is less than 45 degrees. This limits the time of year/location for acceptable high quality outdoor calibrations.
- Comparison with shaded pyrgeometer for LW irradiance
    - The LW should be calibrated against three standards of the same model that have been calibrated at the World Radiation Center in Davos
- Pre, during and post deployments calibration procedures/opportunities.
    - The ideal is to calibrate using the component sum of direct normal (DNI) and diffuse horizontal (DHI) measured separately: DNI*cos(Solar Zenith Angle) + DHI to compare to sensor under calibration
- Can anything be done during the actual deployment to get a reference to something (e.g. on a ship cover a certain radiometer for a period of time to get a zero count?)

    - Measurements should be acquired 24/7 and the nighttime can be used to get a rough estimate of the zero offset
- For moving platforms where cleaning can't be done, should post calibration be done pre-cleaning?
    - Yes, however, the calibration for a sensor that is subject to salt spray and rain will be constantly changing. See thoughts below.

The post-cal-before-clean idea requires responses to two questions:

1. Do salts and contaminants build up at a measurable rate over time, and
2. Do salts reach a quasi-steady-state fairly quickly in a deployment?

If these answers are not known then a post-calibration should be performed before cleaning. Formalizing further, it should be rolled into an experiment. To answer the above questions, it is recommended that instruments are removed from buoys at, say, 1, 2 ,3...12-month intervals and then calibrated pre- and post-cleaning. If a general relationship with time deployed vs attenuated signal can be developed that is a reasonable outcome. This assumes that the outcome of the post-cal-before-cleaning effort could be dropped and the relationship applied as a general correction for all instruments.

- How important is calibrating case/dome temp on PIR? To what precision (1.0C,0.1C, 0.01C?). Calibration should be better than 0.1 C. A 0.1 C error in dome T is about 2.5 W/m^2. Generic calibration formulae often yield temperature errors of 0.5 C with Eppleys.
    - The thermistors are 0.1 degree C interchangeable. The original manufacturer (YSI) specified this down to -40 C, but the new manufacturer changed the spec to -20 C.
- The question about precision should refer to the deviation from the curve that we use to calculate temperature from the thermistor resistance.

10.7 Recommended Sanity Checks and Post-Processing

The following sanity checks and post-processing tips were discussed during the workshop. Further work is needed to develop community consensus.

- Filter out sample when tilt > 10 degrees.
- Zenith angle correction for moving platform
- Fairall et al. "fix" for cosine issue when using Eppley factory calibrations: Calibration coefficient is set at 45 deg incidence. But when the sun is directly overhead, the instrument is 3% more sensitive; you get a slight over estimation of solar flux at noon. This correction however was not clear to all and might be two different things. One issue is that the Eppley factory calibration doesn't necessarily match a calibration at 45 degrees, and a calibration factor could be added to adjust for that. The second is that the cosine response of an Eppley PSP (particularly the older model over the newer SPP) is not flat. This can be corrected for somewhat if characterized, though most folks in the land-based community don't do that correction because PSP measurements are usually a secondary measurement. Further information is needed for a full understanding of this proposed correction.
- QC/QA to be implemented, as far as the radiation components needed to perform a certain test are available (see Long and Shi, 2008 in references). At least PPL/ERL.
- Pyranometer offset correction using NetIR (at least). For modern instruments it may not be necessary but check nighttime offset signal. Further information can be found in the 2018 BSRN presentation:

https://www.esrl.noaa.gov/gmd/grad/meetings/BSRN2018_documents/Th3_Pyranometer_intercomparison_Wang.pdf

- Sensitivity as S(T), dependence of S from air/body temperature
- "Sanity Checks" should be performed, including comparison to climatological expectations. For solar radiation, a semi-theoretical estimate of clear-sky solar radiation provides a good constraint, and it can often reveal the existence of mean tilts in the radiometer (because radiation will be systematically higher or lower than expected, with a dependence on time of day).
    - Someone mentioned an SWR sanity check against top-of-atmosphere incoming radiation (although OCS has seen some reflection/refraction cases).
    - For LWR, the Stefan-Boltzmann equation can provide a possible upper limit. I'd be interested in opinions here, as it may not be a hard threshold -- if a warmer layer exists above the sensor, values over sigma*T^4 (T as measured by sfc inst) may be realistic?
- Could we recommend the top priority studies we can undertake with existing or new data to deal with radiometer quality/uncertainty etc.? The long WHOI datasets can already test many things in this area... like cleaning/dirt impacts on different radiation measurements, etc etc. Maybe this is out of scope to propose?

10.8 Interoperability Experiments

The WG recommends that plans be developed for field intercomparisons of different surface radiation platforms at testbed sites that can act as high-quality reference time series. Example testbed sites might include the Lampedusa Oceanographic Observatory, which is 15 km from the Lampedusa Atmospheric Observatory (Di Sarra et al. 2019), or the Air-Sea Interaction Tower (ASIT) offshore of Martha's Vineyard (Edson et al. 2016).

Some of the potential experiments that could help determine uncertainties for measurements in the field are tests for:

- The impact of buoy motion on data quality, what are the long-term
- The impact of lack of cleaning on data quality
- The quantitative effect of buoy structures on the measurements due to shading in the SW and emission in the LW
- Testing the effectiveness of potential automated cleaning and ventilation systems and their reliability in unattended ocean-based systems
- Testing our ability to measure albedo from buoys and technical challenges to doing so

10.9 The UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

SCOR Working Group #162 for the development of an Observing Air-Sea Interactions Strategy (OASIS) has recently been formed to harmonize nearly 3-dozen OceanObs19 Community Strategy Papers relevant to air-sea interaction. One goal of this strategy will be to work through the UNDOS to massively expand the surface radiation network (as well as other surface variables). Developing Best Practices is part of this strategy. At present net surface heat flux is measured at only 20 OceanSITES reference stations. This is in part because there are fewer long-term measurements of downwelling longwave

radiation than downwelling solar radiation. Part of the expansion will occur through enhancement of existing moorings. For example, through efforts such as the Tropical Pacific Observing System (TPOS)-2020, all TPOS moorings will be enhanced, thereby expanding the TPOS network of surface radiation from 4 sites to more than 50. Likewise, if a network of Unmanned Surface Vehicles and other mobile and drifting platforms is developed through UNDOS, we hope that these platforms will carry surface radiation sensors.

10.10 Future collaborations

Surface Radiation WG thanks the organizers of the IOC OBPS Workshop IV for giving us the forum to develop these best practices. The Surface Radiation community has been fractured, with little overlap between land-based and ocean-based groups. This is now changing. We hope that through working with IOC OBPS, ocean surface radiation will move towards being a standard measurement and ultimately part of a global network of air-sea interaction observations. Interoperability, through standardized best practices, is a fundamental premise of having a network of observations. Therefore, the Surface Radiation community would like to continue working with the IOC OBPS for development of a global network of surface radiation observations.

We envision this Community Consultation WG continuing as an ongoing WG, with growing membership. Organization can be provided through the newly forming Observing Air-Sea Interaction Strategy (OASIS) and the Baseline Surface Radiation Network (BSRN). The OASIS website: www.airseaobs.org is currently under construction.

One of the first tasks of this WG will be to share these recommendations for best practices widely by drafting a peer-reviewed manuscript (for example a BAMS article) based upon this report. We hope that this WG will also act as a bridge between the land-based and ocean-based surface radiation communities. We note that most of the literature showing performance statistics for different sensors is written primarily by land-based networks. Likewise, the existing calibration facilities at present have been developed to serve the land-based community. Our recommendation for intercomparison experiments at ocean-land testbed sites will bridge the ocean-land divide by using nearshore and land-based tower reference stations. At present, sensors and packaging are often modified by the individual groups. This is a barrier for many smaller groups, particularly in the developing world. After the best practices are standardized, it would be helpful to have industry adopt these modifications so that the sensors and packaging could be used off the shelf. Ultimately, we hope that the network of surface radiation reference stations will extend across the entire globe.

10.11 Relevant References

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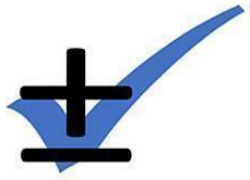
11 Annex 11 Ocean Uncertainty Quantification

11.1 Logistics



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Working Group Sessions

Plenary breakout September 18-19

Shane Elipot - The U.S. CLIVAR OceanUQ Working Group

Steffen Seitz - Metrological concepts for ocean uncertainty quantification

Monday 21 September – Uncertainty Q -Metrology

Christoph Waldmann - Metrology discussion
Annie Wong - Argo CTD data and their uncertainties
Mikael Kuusela - Uncertainty quantification in spatio-temporal mapping of Argo float data
Patrick Heimbach - An end-to-end uncertainty quantification framework in ocean state estimation

Tuesday 22 September –

Adrienne Sutton - Uncertainty in autonomous ocean carbonate chemistry observations: status and next steps
Brian Emery - Uncertainty Estimates for Ocean Currents from HF Radars
Matthew Mazloff - Signals and Noise: Commission and Omission Errors in Uncertainty Quantification of Mapped Products
Kyla Drushka - How variability can masquerade as uncertainty: representation errors in satellite salinity

Wednesday 23 September –

Rick Lumpkin - Evolving uncertainties in Global Drifter Program data
Robert Heitsenrether - Water level UQ discussion

All co-leads were present at all sessions

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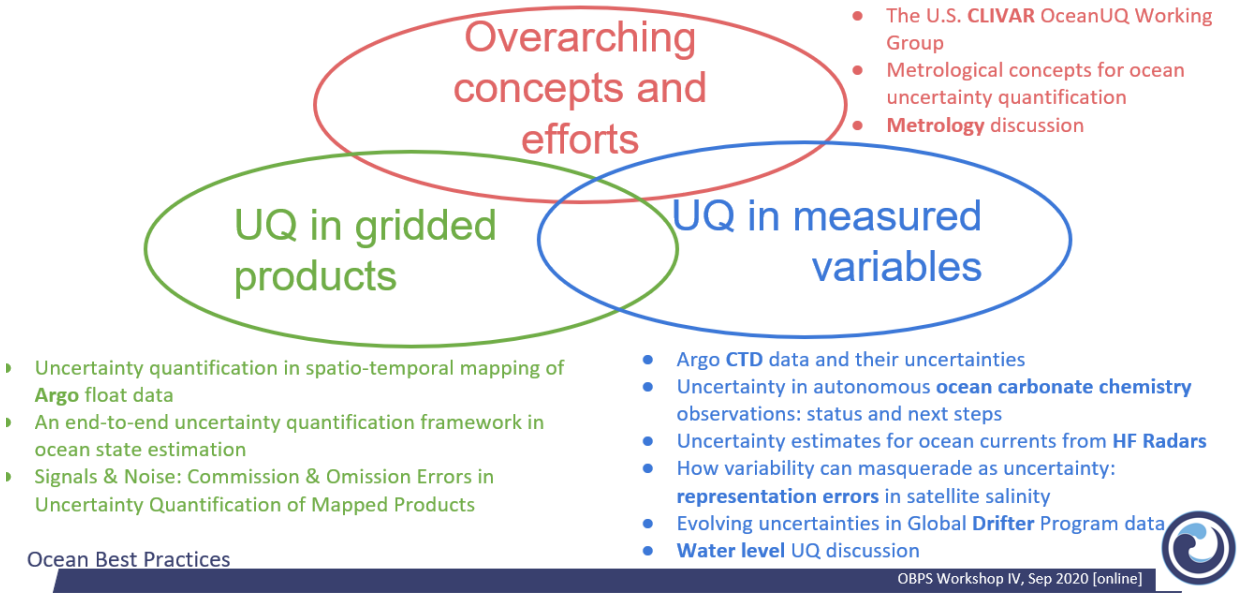
Session Information

During our sessions we heard from speakers about 1) Overarching concepts and efforts 2) OceanUQ in measured variables and 3) OceanUQ in gridded products. See Figure YY



Key topics of working group discussions were 1) Overarching concepts and efforts 2) OceanUQ in measured variables and 3) OceanUQ in gridded products.

Our main discussion outcomes were:

- OceanUQ terminology is highly variable
- Creating a culture of OceanUQ by using existing knowledge from the field of metrology and our own developed practices
- There are many challenges for OceanUQ, with cas-specific solutions (e.g. discrete measurements, autonomous platforms, data products)
- OceanUQ is essential for data reuse, gridded data, data assimilation and forecasting

Plenary breakout 2020 09 18 19:10 UTC

- Shane Elipot - The U.S. CLIVAR OceanUQ Working Group
- Steffen Seitz - Metrological concepts for ocean uncertainty quantification

Session 1 2020 09 21 15:00 UTC

- Christoph Waldmann - Metrology discussion
- Annie Wong - Argo CTD data and their uncertainties
- Mikeal Kuusela - Uncertainty Quantification in Spatio-Temporal Mapping of Argo Float Data
- Patrick Heimbach - An end-to-end uncertainty quantification framework in ocean state estimation

Session 2 2020 09 22 15:00 UTC

- Adrienne Sutton - Uncertainty in autonomous ocean carbonate chemistry observations: status and next steps
- Brian Emery - Uncertainty Estimates for Ocean Currents from HF Radars
- Matthew Mazloff - Signals and Noise: Commission and Omission Errors in Uncertainty Quantification of Mapped Products
- Kyla Drushka - How variability can masquerade as uncertainty: representation errors in satellite salinity

Session 3 2020 09 23 15:00 UTC

- Rick Lumpkin - Evolving uncertainties in Global Drifter Program data
- Robert Heitsenrether - Water level UQ discussion

Session notes available at : https://docs.google.com/document/d/1n6gMdkigWwJJAdunC02tH6ORHGryzeKaRlM4EnvXVQQ/edit#

Participants to Ocean Uncertainty Qualification WG are listed in Table 12

Table 12 Participants for Ocean Uncertainty qualification WG

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11.2 Synergies with other WGs

Convergence of Methods

- "Faster, cheaper, better methods"
  - **Build accessible methods** to enhance the ability of institutions with low resources to contribute to ocean observations
  - **OK, if uncertainty is properly quantified** so statistical comparisons can be made. This puts less pressure towards a single "best practice" method and SOP
  - Important to **enhance adaptability to climate variability and change** in SIDS and institutions with low resources
- **An uncertainty focused approach towards SOPs** is an interesting perspective put forward by Andrew Dickson
- There should be **SOPs for OceanUQ** and OceanUQ within all method-based SOPs

Data and Information Management

- Uncertainty should be **reported alongside ALL ocean obs.** with clear metadata to communicate what uncertainty is reported - ie. standard error, standard deviation, confidence interval, or statistical methods used to determine combined uncertainties.
- Ocean UQ is **essential** for data assimilation and accurate/robust modelling.
- Quality flags are highly variable, qualitative, and will often vary based on application. A more quantitative approach to **OceanUQ allows user-specific decisions**. QF should be used for the identification of qualitative uncertainty (ie. noise/interferences identified visually)
- How can we perform OceanUQ on historical data, which has no uncertainty reported alongside it? Is OceanUQ being performed on historical data for different EOVs? Legacy datasets are not a bad thing.

Training and Development WG

- We want to develop online training and education resources for OceanUQ. This is also an aim of the US CLIVAR OceanUQ WG.
- Need to convey complex statistical concepts in a digestible format.
- Change the culture. Make OceanUQ straight-forward.
- **Cheat sheets/decision trees** proposed for EOVs should include OceanUQ
- **Model datasets (must include UQ reporting)** are needed for each EOV (collaboration between T+G, DM and UQ)
- OceanUQ can be done by anyone and should be done by everyone!

11.3 Key Points and developments

Discussions will continue with QARTOD (Regina Easley and Christoph Waldmann are members of the board), U.S. CLIVAR OceanUQ (Donata Giglio is a WG member) and the SOOS OSD WG (Kimberlee Baldry is a WG member). A presentation on our WG outcomes has already been delivered to U.S. CLIVAR OceanUQ. Other identified efforts include leveraging established metrology efforts in other fields (e.g., at WMO and PTB). Thinking about the concept of maturity levels mentioned in the FOO, UQ should be considered as crucial for related considerations.

11.4 Recommendations for the IOC Ocean Best Practices System

After working group discussions, we have established four strong recommendations for the IOC OBPS:

- Plan for coordination/collaboration between OBPS and US CLIVAR OceanUQ
- Create a general “Requirements of UQ in Oceanography” Best Practice
- Develop UQ best practices (use-cases) starting with one or two to serve as an example.
- Encourage the development of training materials and/or collate existing OBPS to outline effective OceanUQ for each EOV. These efforts would be led by disciplinary experts.

The questions asked below guided the discussions:

How can OBPS motivate communities to converge existing methodological documentation and knowledge into best practices documents?

What additional functions can the OBPS provide to facilitate the convergence of methods into best practice documents?

What additional functions can the OBPS provide to encourage the broad use and updating of best practice documents?

Is a specific labelling (endorsement) of Best Practices documentation required?

After discussion on our WG we thought that an interesting question to ask would be which international groups/working bodies would you consider asking to 'endorse' your BP, or who would you trust as an endorsement entity.

- U.S. CLIVAR OceanUQ WG
- SOOS OSD WG
- WMO
- NIST
- PTB
- NOAA
- Argo

Recommendations:

- Plan for coordination/collaboration between OBPS and US CLIVAR OceanUQ
    - Contribute to US CLIVAR OceanUQ blog-posts and web-platform
- Create a general "Requirements of UQ in Oceanography" Best Practice
    - Don't reinvent the wheel! Leverage other metrology efforts
    - Break OceanUQ into components/chunks
    - Best practice for communicating and evaluating uncertainties
    - Define and teach terminology
        - Strictly adhere to metrological concepts (e.g., GUM) for best results
        - Follow EuroMet
        - Harmonize existing and upcoming procedures with related disciplines like Meteorology.
        - Assess what other organisations are doing
    - Advocate that all data products (inc. gridded, state estimation) should contain uncertainty information (and supplemented with covariance information)
    - Promote the production of formal uncertainty estimates by data providers
- Develop UQ best practices (use-cases) starting with one or two to serve as an example.
    - Set-up task teams to develop UQ quantification procedures for all EOVs and come up with SOPs
    - Work within EOV communities to reach consensus
    - Well worked examples for the requirement and rooted in sound statistics
    - Get authors of BP material to self-select and submit OceanUQ procedures

- Encourage the development of training materials and/or collate existing OBPS to outline effective OceanUQ for each EOV (also an aim of US CLIVAR OceanUQ). These efforts would be led by disciplinary experts.
    - Change the culture, make OceanUQ more straightforward with training materials
    - Data assimilation is needed in data analysis courses
    - OceanUQ is not integrated into oceanographic courses well

** note: GOOS EOV sheets have a “good enough” error on them, this could be improved and leveraged as a guide

Thinking about the concept of maturity levels mentioned in the FOO, UQ should be considered as crucial for related considerations.

US-CLIVAR OceanUQ WG (future outputs of this WG include peer-review lit, summer school, web-platform)

- Collaborate with manufacturers to engineer dynamic errors from data
- Further the interaction between the oceanography and statistics community
- Collaboration with computational and computer scientists
- The computational challenge is sufficiently difficult, yet important to tackle, that dedicated efforts are needed and a range of methods should be explored (ensemble-based, derivative-based, emulator-based)

SOOS OSD WG (future outputs of this WG include tools for OSD and publications)

- Observing system design (OSD) is a powerful approach to assess uncertainty reduction. Develop user tools to aid this.

11.5 OBPS use cases

The OBPS is interested in “use cases” which helps us to scope future services but also demonstrate the benefit and impact of Best Practices and the OBPS. These use cases may address the implementation of a best practice or consider creation of a new or the update of an existing Best Practices. Please share your “Use case” examples or potential use cases with us. We are more than happy to follow up with your group on an implementation. Particular interest from OBPS is in how we can serve the communities in collaborating on creation and adoption of Best Practices.

We recommend working with the U.S. CLIVAR OceanUQ WG on use-cases to leverage resources. As outlined above, we have 3 use-case recommendations:

1) Create a general “Requirements of UQ in Oceanography” Best Practice

- Don’t reinvent the wheel! Leverage other metrology efforts
- Break OceanUQ into components/chunks
- Best practice for communicating and evaluating uncertainties
- Define and teach terminology
    - Strictly adhere to metrological concepts (e.g., GUM) for best results

    - Follow EuroMet
    - Harmonize existing and upcoming procedures with related disciplines like Meteorology.
    - Assess what other organisations are doing
- Advocate that all data products (inc. gridded, state estimation) should contain uncertainty information (and supplemented with covariance information)
- Promote the production of formal uncertainty estimates by data providers

2) Develop UQ best practices (use-cases) starting with one or two to serve as an example.

- Set-up task teams to develop UQ quantification procedures for all EOVs and come up with SOPs
- Work within EOV communities to reach consensus
- Well worked examples for the requirement and rooted in sound statistics
- Get authors of BP material to self-select and submit OceanUQ procedures

3) Encourage the development of training materials and/or collate existing OBPS to outline effective OceanUQ for each EOV (also an aim of US CLIVAR OceanUQ). These efforts would be led by disciplinary experts.

- Change the culture, make OceanUQ more straightforward with training materials
- Data assimilation is needed in data analysis courses
- OceanUQ is not integrated into oceanographic courses well

** note: GOOS EOV sheets have a “good enough” error on them, this could be improved and leveraged as a guide

11.6 UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

While we did not openly discuss the link to UNDOS during our OceanUQ session, there are extensive areas of overlap between the goals of OBP Ocean UQ WG and the sustainable development goals. Particularly, Ocean UQ helps to ensure that the quality of data which is used to manage ocean ecosystems is understood. These efforts will support the UNDOS goals of managing ecosystems with multiple stressors (14.1, 14.2, 14.5), understanding the impacts of ocean acidification (14.3), sustaining the ocean economy and fisheries (14.4 and 14.7), and for increasing capacity development and transfer of marine technology (14.A). 9.1

11.7 Plans for follow up discussion and future collaborations

The following recommendations were provided in looking forward to actions on uncertainty quantification

- Engage with stakeholders involved with OceanUQ
- Engage with the US CLIVAR OceanUQ WG by contributing to blog-posts and web-platform.
- Define and teach terminology
- Strictly adhere to metrological concepts (e.g., GUM) for best results
- Follow European Metrology Network (EMN) for Climate and Ocean Observation
- Collaborate with manufacturers to engineer dynamic errors from data
- Advocate that all data products should contain uncertainty information
- Gridded products - all pointwise uncertainties should be supplemented with covariance information

- Covariance parameters can, and should be, estimated from observations themselves
- Try to go beyond Gaussian uncertainties
- Further the interaction between the oceanography and statistics community
- Extend data assimilation to incorporate formal UQ
- The computational challenge is sufficiently difficult, yet important to tackle, that dedicated efforts are needed and a range of methods should be explored (ensemble-based, derivative-based, emulator-based)
- Collaboration with computational and computer scientists
- Ocean system design (OSD) is a powerful approach to assess uncertainty reduction
- An iterative process to improve observing systems and models
- Assess how other organizations dealing with environmental observations like WMO are addressing this topic
- Set-up task teams to develop UQ quantification procedures for all EOVs and come up with SOPs
- Harmonize existing and upcoming procedures with related disciplines like Meteorology
- Work within EOV communities to reach consensus
- Use of the term “representation error” to describe the differences resulting from time/scale mismatches
- When referring to near-surface data, explicitly specify the measurement depth rather
- Don’t reinvent the wheel!
- Promote the production of formal uncertainty estimates by data providers
- Data Assimilation - use P and R - already termanology consensus reached in history. Don’t just use observation error for R, omission error.
- WMO provides support to surface measurements and the process can be adopted to oceanography - adopt methods
- Reach a common understanding that OceanUQ is important
- Carbonate system may be a good use-case to begin with
- Best practice for communicating and evaluating uncertainties (particularly in the field)
- “Requirements for UQ in Oceanography” BP
- well worked examples for the requirement and rooted in sound statistics
- multiple examples from each core sub-discipline would be included. Two examples are Eurachem Guide to Quality in Analytical Chemistry (https://www.eurachem.org/images/stories/Guides/pdf/Eurachem_CITAC_QAC_2016_EN.pdf) and Eurachem Guide to Quantifying Uncertainty in Analytical Measurement (https://www.eurachem.org/images/stories/Guides/pdf/QUAM2012_P1.pdf)
- Data assimilation is needed in data analysis courses.
- Break OceanUQ

12 Annex 12 Participants (495)

Participants to the Workshop are listed in Table *13*.

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