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Evolving and Sustaining Ocean Best Practices IV OBPS Workshop 18; 21-25 & 30 Sep 2020 [Online]

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Executive Summary

The 4th Evolving and Sustaining Ocean Best Practices Workshop was held online during the period 17-30 September 2020, addressing community needs for advanced method development and implementation in ocean observations, data management and applications.

Thu	Fri	Mon	Tue	Wed	Thu	Fri	Wed
17 Sep	18 Sep	21 Sep	22 Sep	23 Sep	24 Sep	25 Sep	30 Sep
2020	2020	2020	2020	2020	2020	2020	2020
ECOP	P1	WG	WG	WG	WG	P2	Mini P

Framework of Workshop Sessions

ECOP = Early Career Ocean Professionals; WG = Working Group; P = Plenary

The WG working sessions may occur any time during the four day period indicated.

The workshop consisted of three plenary sessions and eleven Working Group meetings. These Working Groups, who met multiple times during 21-24 September, included topics in:

- Convergence of methods and endorsement of best practices
- Data and information management: towards globally scalable interoperability
- Developing community capacities for the creation and use of best practices
- Ethics and best practices for ocean observing and applications
- Fisheries
- Marine Litter/Plastics
- Omics/eDNA
- Partnership Building
- Sargassum
- Surface Radiation
- Uncertainty Quantification

The workshop participants came from across the globe (see **Error! Reference source not found.**) and had a wide range of interests relating to the ocean.

The workshop focused on ways that ocean observing across the value chain (from observations to end user decisions) can use best practices to improve interoperability and our knowledge of the oceans. Ocean practitioners collaboratively addressed best practices as well as recommendations for the Ocean Best Practices System (OBPS) which will guide its next implementation phase.

The recommendations (see Section 8) will broaden community engagement and help the OBPS serve the community and advance efforts along the following key dimensions:

- Data, Information, Knowledge
- Endorsement of methodological documents by communities
- Uptake of methodologies by communities
- Convergence of methods across scales (thematic, local, regional, global)
- Development paths how does a region/community build best practices? What does your region need? How can the OBPS better support that?

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1 Introduction and Objectives

"Standards are like toothbrushes. Everybody wants one but nobody wants to use anybody else's" Connie Morella

Commonly accepted, widely used methods provide a foundational element when designing, building and operating an integrated global system [Pearlman et al, 2019]. When methods are both commonly accepted and widely used in a consistent manner, they may be termed best practices. A more formal definition of a best practice is: a best practice is a methodology that has repeatedly produced superior results relative to other methodologies with the same objective. To be fully elevated to a best practice, a promising method will have been adopted and employed by multiple organizations. [Simpson et al., 2018]

The OBPS, a UNESCO Intergovernmental Oceanographic Commission project, includes a repository of ocean best practices and is implementing new technologies and solutions to facilitate the development and discoverability of best practices [Buttigieg et al, 2019]. The OBPS also includes a Research Topic in *Frontiers in Marine Science* for peer-reviewed publications on best practices¹ as well as an element for training in the creation and use of best practices². As the need for best practices and their use has expanded, the ocean-focused communities have made recommendations for OBPS improvements through a series of annual workshops [Simpson, et al 2020]. The Evolving and Sustaining Ocean Best Practices Workshop IV 2020, was the first OBPS workshop conducted in a virtual environment; there were many unique elements to the workshop in this new and challenging environment.

The workshop participants came from all continents except Antarctica (see Figure 5), and the conversations covered 24 hours each day, accommodating local time zone considerations. The objectives of the workshop were for these participants to offer thoughts on the creation and use of best practices as well as recommending how the OBPS should evolve to better fulfil its vision and mission with respect to their community's needs. The workshop consisted of three plenary sessions and was the first OBPS workshop to incorporate multiple themes through inclusion of eleven thematic Working Groups (WGs), who met multiple times during 21-24 September.

- Convergence of methods and endorsement of best practices
- Data and information management: towards globally scalable interoperability
- Developing community capacities for the creation and use of best practices
- Ethics and best practices for ocean observing and applications
- Fisheries
- Marine Litter/Plastics
- Omics/eDNA
- Partnership Building
- Sargassum
- Surface Radiation
- Uncertainty Quantification

¹ https://www.frontiersin.org/research-topics/7173/best-practices-in-ocean-observing

² https://www.oceanteacher.org

Each WG was self-organized under the leadership of senior leads, and one or more Early Career Ocean Professionals (ECOP) co-leads. The important contribution of the ECOP was recognized by the workshop.

The workshop used many digital techniques and tools to make the virtual system more user friendly and actively engage participants (see Section 2).

Participants reinforced the need to address the full spectrum of practices from ocean observations to societal decisions, incorporating the needs of diverse cultures.

2 Workshop in a Virtual Environment

Virtual meetings offer some unique advantages. These include broader participation, schedule flexibility, reduced conflict with other meetings because travel time is not required, and increased accessibility for the participation of experts. There are some disadvantages; time zones are hard to address and informal encounters and shared lunches for discussion are harder to arrange, if they occur at all.

As with many of our colleagues, given travel limitations due to COVID-19, in the space of three months, we transitioned from a planned face-to-face, two-day, 50 participant workshop to be conducted at the University of Maryland, near Washington DC to a virtual event gathering about 450 international participants who met over 2 weeks across multiple time zones and multiple domains. In addition to the order of magnitude growth, and associated logistics, we wanted to offer an environment where our attendees could easily navigate between a dozen "virtual rooms', make use of emerging technologies during the Working Group meetings and Plenaries, as well as simulate the in-person workshop environment of informal chats and chance meetings.

2.1 Tools for a virtual environment

The main platform was <u>QiqoChat</u> (Qiqo) which complements the selected virtual meeting platform (Zoom), allowing participants to move in and out of different virtual spaces, and to use chat within each space. QiqoChat also served a firewall for net security. In addition, we used Eventbrite for registration and used a Google <u>Teamup</u> calendar to provide an overview of all meetings, and how to access them; Google Documents was used for collaborative note taking and material development; and Slack expanded communications with channels for each of the working groups that were interested. The OBPS Workshop IV technology configuration is summarized in Figure 1. Several orientation sessions were offered to workshop attendees prior to the start of the workshop. These were necessary to have participants comfortable with the array of tools being used.



Figure 1 OBPS Workshop Technology Stack

2.1.1 Zoom

Zoom is a video conferencing and messaging system which operates across many devices. We chose this because of the flexibility that the platform offers in terms of navigation, breakout sessions and the convenience of the interface for the size of meetings being planned. Meetings were recorded locally with searchable transcripts. Attributes such as screen sharing, polls, hand raising, and management of participants were used. Zoom allowed enhanced security because of the controls it has over participation. We did not experience significant bandwidth limitations even with many participants using video images.

2.1.2 QiqoChat

<u>QiqoChat</u> (Qiqo) provides a social wrapper around Zoom meetings so that participants can move themselves in and out of different sessions (each with their own zoom access). This creates a vibrant and empowering online event/conference experience that replicates the freedom of movement to enter and leave a session available at in-person events. Participants made choices in real time about which breakout, panel, or workshop they wished to attend. QiqoChat also integrated Google Documents, background descriptions of the working groups and other tools. For some, the use of computer video enhanced the interactions.

2.1.3 Open Space and Cafe

To stimulate in-person interactions in our workshop environment, and as much as possible to facilitate informal chats and chance meetings, we experimented with the concepts of Open Space and Café (see Figure 2). The Cafe provided a hosted venue for workshop participants and organizers to connect informally. It generally had a menu of topics that were available for discussion. Participants were welcome to drop in and out of the Cafes at any time during the two hours each session was open.



Figure 2 Did we achieve this virtually?

The approach for OBPS Workshop IV offered rooms for open space discussions. Generally, these allowed people to join together for an impromptu discussion or join a discussion in progress.

This informality worked well in small groups and was used but was not widely understood. Time must be allowed for open space human interactions to work and this occurred in "off times" during the meeting week. Because this was an innovation, our facilitator offered the following:

Principles³:

- Whoever comes are the right people.
- Whenever it starts is the right time.
- · Whatever happens is the only thing that could have.
- When it is over, it is over.

We used <u>Teamup</u> calendar (see Figure 3) which is a free software that enables groups to manage their shared schedule. The tool was used to set up the workshop calendar and allowed workshop and working group organizers to enter relevant schedule information which was shared openly. All participants were given access to the calendar.



Figure 3 Teamup Calendar

³ https://medium.com/virtual-teams-for-systemic-change/fearless-experimentation-5a8695bbd10e

See also our Teamup calendar for the workshop in Section 8. Plenaries, individual Working Group meetings and ad-hoc open space/cafe opportunities were color-coded, and shown on a 24-hours per day calendar covering from 17-30 September.

2.1.4 Polling Tools

Building on the basic conferencing capabilities provided by Zoom and Qiqochat, we used real time polling tools such as Mentimeter and Co-Digital to generate, prioritize and refine ideas from participants. In addition, some interesting and innovative tools were suggested by our Facilitator and Tech Host, Ben Roberts. They included <u>unsplash.com</u> (free open-source pictures) and <u>Jamboard</u> (a photo scrapbook).

<u>Mentimeter</u> is a free, live polling tool for engaging audiences of all sizes to get feedback from participants with straightforward question and answer polling on subjects such as community priorities. It was easy to use and no training was required. It offers features such as a quantitative output but shows response weightings.

<u>Codigital</u> is a real-time polling device which is more complex than Mentimeter. It poses a series of comparative questions which are repeated in different ways. This allows a more subtle analysis of responses and is harder to create a bias in the responses. It was primarily used in Plenary 2 during breakout sessions which were looking at options and recommendations for OBPS evolution.

3 Workshop Agenda

The workshop consisted of three plenary sessions and eleven Working Group meetings. These Working Groups, who met multiple times during September 21 – 24, included topics in:

- Convergence of methods and endorsement of best practices
- Data and information management: towards globally scalable interoperability
- Developing community capacities for the creation and use of best practices
- Ethics and best practices for ocean observing and applications
- Fisheries
- Marine Litter/Plastics
- Omics/eDNA
- Partnership Building
- Sargassum
- Surface Radiation
- Uncertainty Quantification

The agenda for the meeting is provided in *Table 1 - Plenary 1 Agenda, September 18, 2020, Table 2 – Plenary 2 Agenda, September 25, 2020*, and *Pre-Plenary dialogue and Min-Plenary Agenda, September 30, 2020*

Plenary 1 was conducted on September 18 for 4.5 hours. WGs online working sessions took place from 21 through 24 September. The detailed schedules for the WG sessions, "Cafes" and "Open Space" were on the <u>Teamup Calendar</u>. General information for the Cafe and Open Space activities were found in the applicable rooms on QiqoChat.

Table 1 - Plenary 1 Agenda, September 18, 2020

Plenary 1	Introduction							
Time UTC	Торіс	Leads and Co-leads						
18:00	Welcome and workshop overview; background and capabilities of OBPS	Johannes Karstensen Jay Pearlman						
18:20	Panel discussion: Decade implementation with respect to Best Practices	Lead Elva Escobar Co-lead Fangli Qiao						
19:00	Transition to Breakout Session	ns						
19:10	Breakouts WGs will meet in their dedicated QiqoChat rooms where participants will be introduced, and will discuss the direction of each WG during the following week							
	Working Groups	Leads and Co-leads						
	WG1 - Convergence of methods and endorsement of best practices	Lead: Juliet Hermes Co-lead: Johannes Karstensen Co-lead: Jordan van Stavel* Co-lead Rebecca Zitoun*						
	WG2 - Data and information management: towards globally scalable interoperability	Lead: Pier Luigi Buttigieg Co-lead: Cem Serimozu*						
	WG3 - Developing training and guidance materials as well as mechanisms for the submission (to the OBPS) and use of OBPS best practices	Lead: Johanna Diwa Co-lead: Peter Pissierssens Co-lead: Sheri Rahman Schwartz* Co-lead: Abbie Akinyi Allela*						
	WG4 - Ethics and best practices for ocean observing and applications	Lead: Michele Barbier Co-lead: Frederick Whoriskey Co-lead: Tobias Hahn Co-lead: Mackenzie Mazur*						
	WG5 - Fisheries	Lead: Peter Haugan Co-lead: Cisco Werner Co-lead: Marino-O-Te-Au Wichman*						
	WG6 - Marine Litter/Plastics	Lead: Artur Palacz Co-lead: Rene Garello Co-lead: Ngozi Margaret Oguguah* Co-lead: Frolence Jovinary Peter*						

	WG7 - Omics/eDNA	Lead: Neil Davies Co-lead: Kathleen Pitz Co-lead: Robyn Mairin Samuel* Co-lead: Raïssa Meyer*
	WG8 - Ocean Partnership Building	Lead: Andrea McCurdy Co-lead: Jon White Co-lead: Maya C. Delaney* Co-lead: Nelly Isigi Kadagi*
	WG9 - Sargassum	Lead: Emily Smail Co-lead: Cesar Toro Co-lead: Shelly-Ann Cox*
	WG10 - Surface Radiation	Lead: Meghan Cronin Co-lead: Elizabeth Thompson Co-lead: Laura Riihimaki Co-lead: Maria Teresa Guerra*
	WG11-Ocean Uncertainty Quantification	Lead: Mark Bushnell Co-lead: Donata Giglio Co-lead: Christoph Waldmann Co-lead: Regina Easley Co-lead: Kimberlee Baldry*
19:10	Break	
20:30	WG Presentations of Breakout Sessions (3 minutes each)	Moderator: Pauline Simpson with WG leads or representatives
21:15	Discussion on WG presentations, integration across WG inputs and other topics	Moderator: Emma Heslop and Panel of WG leads or representatives
22:00	Close and Preview of following days	Jay Pearlman

* indicates ECOP co-lead

On September 25, there were two instances of Plenary 2 to accommodate global participation. The first one accommodated the Pacific regions starting at 1:30 UTC. The second, was focused on the Atlantic region, and starts at 14:30.

Discussions covered working group recommendations and participant interventions.

Plenary 2 Pacific	Plenary 2 Atlantic	Торіс	Presenter				
01:30 UTC	14:30 UTC	Virtual Plenary Access opens 30 mir in smal	nutes early for impromptu networking I groups				
		Introduction	Jay Pearlman (Pacific) Johannes Karstensen (Atlantic)				
02:00 UTC	15:00 UTC	Session 1: Reports from each WG (7 minutes each)	WG leads or delegates Atlantic 1 Moderator: Cora Hörstmann* Pacific 2 Moderator: Kimberley Baldry				
02:45 UTC	15.55 UTC	Br	eak				
02:55 UTC	16.00 UTC	Session 2: Reports from each WG (7 Minutes each), continued plus Mentimeter poll	WG leads or delegates Atlantic 1 Moderator: Rebecca Zitoun* Pacific 2 Moderator: Pip Bricher				
03:40 UTC	16.50 UTC	Breakout Discussion among Participants					
04:00 UTC	17.10 UTC	Key Message Synthesis using " <u>Codigital</u> "					
04:10 UTC	17.20 UTC	Br	eak				
04:25 UTC	17.35 UTC	Session 3: Synthesis discussion	Atlantic 1 Moderator: Mark Bushnell Pacific 2 Moderator: Rachel Przeslawski				
05:10 UTC	18.20 UTC	Pictures at an Exhibition (Jamboard)	Moderator: Ben Roberts				
05:15 UTC	18.25 UTC	Plenary Recommendations	Atlantic 1 Moderator: Anya Waite Pacific 2 Moderator: Ana Lara-Lopez				
05:40 UTC	18.50 UTC	Close	Atlantic 1 Johannes Karstensen Pacific 2 Jay Pearlman				

Table 2 – Plenary 2 Agenda, September 25, 2020

* indicates ECOP co-lead

On September 27 & 28 selected "Cafes" and "Open Space" sessions were conducted (see schedule on the <u>TeamUp calendar</u> and general information in the Cafe and Open Space rooms on QiqoChat.

A pre-plenary dialogue was held on September 30 at 02.00 UTC, followed by the Mini-Plenary at 15:00 UTC. The Workshop Committee presented a synthesis of the collected Working Group documents, stressing the resonance across Working Group recommendations considering areas of key strategic focus. Discussions covered Working Group recommendations, interventions, and answers to questions.

The outcome of the Workshop is a Final Report on Recommendations and Synthesis for community development of best practices and strategy for OBPS.

Table 3 Pre-plenary dialogue and Mini-Plenary Agenda – September 30, 2020

Mini Plenary	Торіс	Presenter
02.00 UTC	Pre-Plenary Dialogue	Moderators: Ana Lara-Lopez Rachel Przeslawski
15:00 UTC	Discussion on the most significant and final recommendations from the workshop for the community and OBPS	Bob Houtman with OBPS-SG Panel
	Community discussion on key priorities and directions for the community and OBPS	Moderator: Peter Pissierssens
	Close	Johannes Karstensen, Jay Pearlman

4 Workshop Participation

For a list of participants, refer to Volume 2 (see Annex 12)

Participants Profession

Participants were predominantly observers and data managers (see Figure 4) where the bar indicates number of respondents for each profession during the first workshop session).

Due to the virtual nature of the workshop, close to 30% of participants lived outside of Europe and North America (see Figure 5).



Figure 4 Participants' profession



Figure 5 OBPS Workshop IV global distribution of participants and screenshots of some attendees

Attendance Patterns

Attendance was measured based on the following information: 1) For plenaries, we used visual observation of count in participant tab, with particular attention to peak count, after most attendees have arrived and the figures have stabilized; and 2) During the week of WG meetings, unique sign-ons by individuals to QiqoChat, as computed over each 24-hour period from 21-24 September. The resulting daily count is summarized in Table 4 below.

	Plenary 1	WG	WG	WG	WG	Plenary 2	Plenary 2	Mini-
								plenary
	18-Sep	21-22-Sep	22-23-Sep	23-24-Sep	24-25-Sep			
		noon to	noon to	noon to	noon to			
		noon	noon	noon	noon			
Peak	169					37	90	80
number of								
participants								
Unique		284	227	181	136			
participants								
over 24 hrs								

Table 4 Attendance Patterns

5 Early Career Ocean Professionals (ECOP)

When entering the field, early-career ocean professionals (ECOPs)⁴ receive a high degree of training and are repeatedly challenged with learning, applying, and designing new methods. Naturally, they are thus able to identify gaps and challenges in the training or method application itself, or - even more importantly - challenge the field to improve systems, methods, and documentation as their needs evolve.

In preparation for the Workshop, the OBPS Organizing Committee called on ECOPs to become session co-leads to actively participate in workshop discussions. Further, ECOPs were invited through several ECOP networks to participate in the workshop sessions. Through an active engagement of ECOPs in leading a session and session discussion, ECOPs had the opportunity to represent their generation's needs and help develop recommendations for their field.

During the OBPS Workshop IV several ECOPs from all over the world shared valuable perspectives, and thus supported a fruitful intergenerational exchange in all workshop sessions. Additionally, ECOPs benefited from the informal environment of the Cafe and Open Space Sessions (see section 2.1). This was an opportunity to get valuable insights from seniors and discuss a large variety of topics. For instance, ECOPs organized an open space session about barrier breaking to improve diversity in ocean disciplines.

The participation and contributions from early career co-leads and participants were repeatedly highlighted and appreciated and ultimately identified as a goal itself to sustain a strong intergenerational exchange within the OBPS. Future objectives are to include ECOPs in the OBPS community to strengthen the collaboration, community- building, learning from past trial and error, and

⁴ Early-career professionals were defined as: 1) an MA/MSc student, 2) a PhD candidate, 3) an early postdoc (no more than two years after their PhD graduation) or 4) any junior professional (e.g., engineers, technicians, programme specialists) with at most 2 years of professional experience. We note that this definition was not inclusive in international standards and will be revised for upcoming events.

exchange of methods and ideas to accelerate the process of co-development and co-design of methods and practices.

6 Plenaries

6.1 Plenary 1

Plenary 1 was held on Friday 18 Sep 2020. It covered OBPS, the UN Decade of Ocean Science Sustainable Development (2021-2030) and reports from all the Working Groups (WG) following the WG Breakouts. A zoom image of some of the Plenary 1 participants is shown in Figure 6.



Figure 6 Plenary 1, Part 1 – screenshot of some of the participants

Recordings Plenary 1

- Part One -- Welcome, Overview, and panel on The Decade
- Part Two -- Working Group Breakout reports and Panel Discussion with leads/reps

[WG Breakout reports also available under individual WG Section 7 below]

6.1.1 Welcome and Workshop Overview

Jay Pearlman, Co-Chair of the OBPS, opened Plenary 1 and welcomed participants to the workshop, highlighting the fact that it was the first large online workshop that OBPS had hosted.

Johannes Karstensen, also a Co-Chair of the OBPS, then provided an overview of best practices and the OBPS including an introduction to the Steering Group for the OBPS.

Background and Capabilities of OBPS Johannes Karstensen and Jay Pearlman

This is the fourth workshop in an annual series of Ocean Best Practices Workshops. Previous workshops addressed best practices and modalities that can contribute to the broad needs of ocean observing. A best practice is a methodology that has repeatedly produced superior results relative to other methodologies with the same objective. Methods documents used in ocean research and applications have many formats: standard operating procedures, manuals, guidelines, etc. To be fully elevated to a best practice, a promising method will have been adopted and employed by multiple organizations.

Workshop objectives: At the IOC Ocean Best Practices System (OBPS) Workshop IV, ocean practitioners collaboratively addressed design and creation of best practices. An important outcome was recommendations for the OBPS to assist the Community in developing and improving common and recognized methodologies for all areas of ocean observation and applications. The outcomes of the workshop will guide the next implementation phase of the IOC Ocean Best Practices System.

The impacts of best practices adoption are manifold; areas include improved quality and consistency of observations, improved efficiency (don't reinvent the wheel), improved transparency and reproducibility, seamless linkages between data, model and applications, and resources for training and capacity development. These benefits come with overhead, as best practices must be well and consistently documented as well as accessible through a sustained global repository. The repository is available as part of the Ocean Best Practices System (see Figure 7).



Figure 7 Components of the Ocean Best Practices System

6.1.2 Decade Implementation with respect to Best Practice

Lead: Elva Escobar Co-lead: Fangli Qiao Panelists: Claudia Barón; Edem Mahu; Wenxi Zhu; Elva Escobar and Fangli Qiao and panelists provided perspectives on the UN Ocean Decade. Frank Muller-Karger's summary provided not only comments on the Ocean Decade, but a broader framing of our mission.

The Decade of Ocean Science for Sustainable Development is an important opportunity to address growing social and economic issues. This will require using best practices in both social and natural sciences to change the paradigm of ocean observing. One is understanding the needs of society and implementing an observing system that is responsive and responsible. The next 10 years are our opportunity to include people of all backgrounds: women, young investigators, and indigenous people in marine science and ocean observing. Inclusion will provide new, unique, and valuable insights to solve the problems of humanity that require understanding the ocean. Common best practices in all facets of ocean observing are part of the foundation for this vision.

The Workshop programme and its Working Groups are relevant to the objectives of the UN Decade of Ocean Science for Sustainable Development 2021-2030. The linkages are complex and samples are shown in Figure 8.



Figure 8 Linkages: UN Ocean Decade and OBPS Workshop IV Working Group

6.1.3 Working Group Breakout Reports

Working Group Sessions started with Plenary 1 Breakouts which introduced participants to each other and discussed the directions and planned sessions of each working group during the following week. After the one-hour WG Breakout Session each Working Group provided a report out which was followed by a panel discussion moderated by Emma Heslop. Breakout presentations are also included under Section 7.

6.2 Plenary 2 - Reports of Working Group Sessions 21-24 Sep 2020

Atlantic Recording

Pacific Recording

To accommodate global participation, there were two instances of Plenary 2 (Plenary 2 Pacific with approximately 30 participants, followed by Plenary 2 Atlantic with 75 participants). Discussions covered Working Group recommendations and participant interventions. Each working group provided a summary of the week's deliberations. WG presentations generally included logistics, scope of WG, three-point summary from workshop, and key aspects that came out of the discussions (see Section 7 for more details). The presentations were followed by an open forum where prioritization of the recommendations was addressed. See section 8 for further information on recommendations.

6.3 Pre- Plenary Dialogue for the Mini-Plenary

30 Sep: 02.00 UTC: Pre-Plenary Dialogue

Recording

Attended:

Jay Pearlman, Rachel Przeslawski, Pauline Simpson, Frank Muller-Karger, Mark Bushnell, Cathryn Wynn-Edwards, Johanna Diwa, Virginie van Dongen-Vogels, Ana Lara-Lopez, Ben Roberts

The Pre-Plenary Dialogue was conducted in the Pacific time zone, as a precursor to the Mini-Plenary. Discussion was focused on the recommendations from Plenary 2.

On Decision Trees to what and how will they be implemented:

- They are a process and the community will drive their development and implementation with the OBPS facilitating the process.
- Dialogue with two potential pilots already underway: Omics and Sargassum, with a possibility of a third one with GOA-ON.

On communication channels with OBPS:

- Users outside of the OBPS SG have mixed experience with the use of Slack, currently the one created for the workshop has 160 people subscribed out of more than 600 registrants
- Advantages of using the OBPS Forum will be that there is an easy and open community dialogue, users can make/join networks and even find mentoring opportunities.
- There will be a forum on Uncertainty Quantification headed by Mark Bushnell where people interested in this topic can connect.
- Need to communicate better on how different people can link with the OBPS community and the SG. The integration of OBPS ambassadors will be beneficial and worth pursuing.

On community engagement:

• The OBPS will discuss forming another layer in the program, for example the formation of task teams or working groups that are linked to each of the work packages. This will improve engagement and will allow the participation of the broader community

• There is a need for sufficient outreach to enable a better engagement with the BP community including having ambassadors for OBPS.

On Capacity Development:

- Add some of the recommendations and discussions from the Training WG in the new survey
- Visibility of what training activities are happening and their scope will be a very good asset for people involved in capacity development activities in ocean science BP
- Information on how people can better link with the training WP will be important
- Suggestion for OBPS to become an academic society would attract more people including early career professionals to be involved, but it will mean membership fees need to be charged and may disadvantage people with less resources.

Engagement with the UN Decade in Ocean Science

- OBPS, as an IOC project, may answer the first open call. UN organizations may submit according to a timing of their choice.
- Strategically OBPS should take both approaches, as an OPBP group, but also as part of other Decade Programmes/Projects/Actions.

6.4 Mini Plenary

30 Sep: 15.00 UTC: Mini-Plenary (1.5 hours)

Recording

The Mini-Plenary had two sessions.

- 1. Discussion on the most significant and final recommendations from the workshop for the community and OBPS with Moderator: Bob Houtman with OBPS-SG Panel
- 2. Community discussion on key priorities and directions for the community and OBPS with Moderator: Peter Pissierssens

Recommendations from participants were synthesized in a consensus approach where ideas were collected from all of the workshop discussions and presentations and were then adapted, grouped and prioritized. For that purpose, the key messages arising out of the themes, patterns and synergies from the workshop and the WG reports, also referred to as the "recommendations", were collected and analyzed. Looking at the process in more detail, the relevant steps are detailed in sections 8 below.

7 Working Groups (Sessions 21-24 Sep)

Working Groups met over 21-24 Sep in their dedicated QiqoChat rooms and session. All WGs met according to the schedule shown in the TeamUp calendar (see Figure 9).

Recordings are available on the OBPS WS IV YouTube Channel : http://bit.ly/obpsivyoutube



Figure 9 TeamUp Calendar indicates the number of WG sessions each day

Many of the Working Groups also identified their meetings during the Workshop as an opportunity for cross-community dialogue (see **Error! Reference source not found.**). The desire for such fora, where community discussions can occur and where an intergenerational mix can stimulate opportunities for learning (and mentoring), was highlighted. Extending beyond the workshop, the OBPS has a forum where communities can have their own continuing sessions. This capability was received with enthusiasm. Please contact Mark Bushnell for more information (<u>obpcommunity@oceanbestpractices.org</u>).

There were many ideas that appeared in multiple Working Group reports such as training, data, convergence, and decision trees. In addition, the need for the development of new virtual learning capabilities was discussed as well as the importance of effectively engaging multiple cultures as educators and trainees. Indigenous knowledge was recognized as an important element for addressing a comprehensive ocean data and information system. Participants also noted the value of increasing collaboration among existing initiatives and the importance of defining the role of ocean best practices in support of the upcoming UN Decade of Ocean Science for Sustainable Development ("Ocean Decade"). (https://oceandecade.org/)

It was particularly encouraging to see cross-WG interactions, where challenges and ideas were being shared and discussed. The opportunity for cross-WG dialogue was identified in many WG reports. Figure 10 below identifies if a WG indicated interest in collaborating with another WG in the workshop, or if several WG held a joint session (e.g. data and ethics). The table reflects the cross-working group interests of each working group named at the top of a column (interest shown in either green or yellow). Green indicates that both relevant working groups indicated the cross interest, while yellow indicated that the interest was in one direction only.

	Convergence & endorsement	Data & info management	Ethics	Training & guidance	Fisheries	Marine litter & plastics	Omics/ eDNA	Ocean partnership	Sargassum	Surface radiation	Uncertainty quantification
Convergence & endorsement											
Data & info management											
Ethics											
Training & guidance											
Fisheries											
Marine litter & plastics											
Omics/eDNA											
Ocean partnership											
Sargassum											
Surface radiation											
Uncertainty quantification											

Figure 10 Cross Working Group Interests.

Green indicates that both relevant working groups indicated cross interest, while yellow indicated that the interest was in one direction only. White means not addressed. Grey relates to self-interest in a working group.

In the following sections, a distillation of elements of Working Group Reports are provided and the full reports are available in Volume 2: Annexes of the proceedings.

7.1 Convergence and Endorsement from a Global Perspective Working Group

Co-leads:

Johannes Karstensen Juliet Hermes Rebecca Zitoun GEOMAR SAEON NIOZ



Plenary 1: Convergence & Endorsement Breakout Presentation

Plenary 2: Convergence & Endorsement Summary Presentation

Working Group Sessions: <u>Convergence & Endorsement Presentations</u>

Monday 21 September - Global Approach

Speakers: Andrew Dickson (IAPSO), Eric Achterberg (GEOTRACES), Sam Wilson (SCOR WG 143), Emmanuel Boss (SCOR WG 154)

Tuesday 22 September - Regional Approach

Speakers: Kim Currie (NZOA-ON), R Venkatesen (GOOS RA and INDOOS), Mark Bushnell (IOOS QARTOD), Brad de Young (AtlantOS), Sarah Fawcett (SOOS)

Wednesday 23 September - Organizational Approach

Speakers: Rachel Przesławski (Geoscience Australia), Ruth Anderson (ICES), Xiaoyan YU (NCOSM)

Open Presentation Forum: Patricia Miloslavich SCOR

Thursday 24 September – Discussion and synthesis

7.1.1 Scope of Working Group

Convergence and Endorsement - on the creation and disseminating of Best Practices. This cross-cutting session can be separated into two areas of importance:

Convergence - the alignment or synthesis of emerging and recognised documentation of various types (manuals, standard operating procedures, publications...) into Best Practices documentation and material.

Endorsement - focusing on the procedures of identifying recommended or even compulsory Best Practice documentation within practitioner groups and expectations on how such "endorsed" documents should be presented and disseminated within the OBPS.

During the course of the week, the following global, regional and organizational approach will be taken to the following questions: What was your motivation to create an SOP or a BP? How did the group that created the documents come together/were defined? • What was the approach you took to synthesize the knowledge? • Are you happy with the results? • Where were the bottlenecks in the process? How did you carry out a public review process? Do you plan/see a potential for a 'global' convergence? Which opportunities through the OBPS (repository and search engine) can facilitate the convergence processes? • What is the intention for communities to have access to endorsed/labelled best practice documents? • How should the current OBPS technology be modified (repository access, keywords etc) to serve the Endorsement needs/intentions? Go to www.menti.com and use the code 40 58 47 6 Which topic do you think is the most important to cover during the WG 1 session ? 23% Endorsement of BP 16% Initiating and Organizing the Convergence Proc 16% International Strategy and 7.1.2 Three-point summary from workshop - Convergence and **Endorsement requires** 1. Improved web services - established in a close dialogue of our user communities including an "OBPS convergence tool server", improved commenting functions on documents, keywords wishlist, document flagging, better analytics etc. 2. Improved user dialogue (e.g., through the annual OBPS workshops) to improve awareness, promote convergence and support champions, while also fostering collaborations with key communities/initiatives. Through this, the sustainability of the BPs and their update will be ensured as the reliance will be on groups rather than single authors. 3. Endorsement creates trust and thus uptake by the community. Enhance visibility of endorsed documents through search functionality, newsletter articles etc. Provide examples of how communities can endorse BP, e.g., hosting documents of endorsement processes/guidelines (what a BP must adhere to, to be endorsed) of individual organizations such as GOOS. 7.1.3 Key aspects that came out of discussions • It doesn't matter if it is of lesser quality as long as it is of known quality. We really need to know the uncertainty behind measurements.

- Standards or certified reference materials can be critical and have to be exact, although they do not have a thought about their underlying uncertainty to be ISO standard, BP are recommendations
- Enhanced training thanks to more online workshops
- Authorship on BP documents can be difficult, can be resolved by editors or naming it after the organisation driving it.
- It is difficult to balance input on BP. The hard part about too much input is about using it to its best and the resources required to the person trying to bring it all together. Trade off with the benefit that it becomes clearer and easier for people to use. Need an incentive to review. Authors need to balance the perceived value vs resource requirement.
- Can national BP be applied to the basin level or even global level, can there be global convergence? Sometimes if you can't converge you have to compromise, it really comes down to being fit for purpose. Discussion around adaptation of BPs - which led to action item 12
- Incentivize people to use BPS give them ownership and the knowledge they are contributing to national and international needs. How do you police them you have to trust.
- People don't want to change their practices When you're running a time series and you change/update equipment or new SOP or a different way of measuring the same parameter you have to take the same measurement using 2 different systems for (recommended) at least 3 years.
- We cannot endorse specific branded equipment but a way to get an idea of how good it is, is to look at the number of uses of that piece of equipment versus others
- Useful to document worse methods!
- Continue to foster engagements with regional groups and GRAs (eg SOOS) who may not develop BP but adapt them or are part of the community review process
- IMOS and IOOS are far ahead with their BP and the convergence process, look to them for what works and what doesn't
- Getting word out re new BP via conferences and social media and also by training early career ocean professional
- Bottlenecks: Assembling working group, reaching consensus, identifying long-term oversight and governance, making people aware of OBPS and understanding the BP can be a variety of documents and don't have to be published articles, they can even be videos
- Need to balance giving regulations with being overly prescriptive
- Very important that to be a BP it needs to be updated
- Are there legal implications of endorsing a BP
- Ensure you have a wide range of diverse stakeholders when creating and reviewing a BP
- Help starting up new observing systems or understanding BP. The forum isn't immediate enough but no-one person can help. Useful to have a helpdesk that links people up with the author of the BP. This again feeds into action item 12 as well as 2
- Be able to include in the metadata of a dataset the BP that was followed
- Is it possible to get around certain aspects of BPs without damaging the quality of the data - i.e., find compromises?

Additional information for Convergence and Endorsement is available in Volume 2 (see Annex 1).

7.2 Data and Information Management Interoperability Working Group

Co-leads:

Pier Luigi Buttigieg,GEOMAR Helmholtz Center for Ocean ResearchCem Serimozu,METU Institute of Marine Sciences



Plenary 1: Data and Information Management Breakout Presentation

Plenary 2: Data and Information Management Summary Presentation

Monday 21 September - The OBPS and the digital ocean ecosystem (two sessions)

Tuesday 22 September – Aligning Digital Strategies and Best Practices (two sessions)

Wednesday 23 September – From Data, to Information, to (Digital) Knowledge (two sessions)

Thursday 24 September – Synthesis (two sessions)

7.2.1 Scope of Working Group

We are facing a flood of new methods and standards concerning ocean data, information, and digital knowledge. Digital stores and streams need to be connected to the methods that generate them and the standards they comply to track provenance and boost transparency, reproducibility, interoperability, and trust. In this working group, we'll think about how the OBPS can better interface with the global digital commons, and catalyse the evolution of methods into best practices across scales.

During the course of the week, we will take a global, regional and organizational approach to the following questions:

- How can OBPS be used to help your community discover existing methodological documentation?
- How can the OBPS support your community in aligning related methods and, eventually, converging them into more global best practices?
- What additional functions can the OBPS provide to support your community in evolving methods into global best practices?
- 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?
- 7.2.2 Three-point summary from workshop Data and Information Management
 - 1. Linking human and machine narratives: Interlink OBPS document management with digital content. Persistently identified versions of documents should be linked with 1) versions of

data and information artifacts via dereferenceable and persistent IRIs 2) code holdings via popular management platforms (e.g. GitHub)

- 2. Humanize the digital: 1) Highlight documents which show how data and information streams and holding (of varying quality and type) can be efficiently channeled towards solving overlapping scientific questions and societal issues. 2) Elevate guidance on the communication of the highly technical to broader communities 1#3) Enhance the OBPS UI/UX to suggest linked data and information holdings and streams which may be relevant to a document being viewed.
- 3. Digitize human foci: 1) Upgrade (through co-development) and socialize the OBPS templates to have dedicated, machine-readable sections capture what users care about or should be more aware of. 2) Enhance the OBPS UI/UX to leverage these structure with natural language/semantic technologies to enhance search across OBPS holdings and FAIR data and information holdings and streams

7.2.3 Aspects that came out of the discussions

Linking methods, standard specifications, guidelines, policies, or other methodological artifacts to the zoo of data and information out there:

- Stress the importance of persistent Identifiers for methodology, guidelines, etc.
- Provide easy-to-follow templates/guides to link data to methodological documents
- Upgrade version control to push updates of OBPS documents to data and information systems
- Enhance convergence of data quality control methods by supporting training and discussion in centralized forums
- Bring together and help train the people that can make this happen

Bridging the ultra-technical communities and policy-developers/decision-makers via greater methodological transparency and communication

- Elevate dedicated resources for those working at the interfaces (e.g. more digitally literate policy makers and program managers)
- Highlight/call for content that focuses on digital communication skills
- Highlight/call for content that supports data managers in taking an active role in researchfocused conferences those distant from the data taking more active roles in digital design and activity

How do we best integrate code archives and automated workflows?

- Support the linkage of the OBPS document version control systems to code archives, making these a joint living resource
- Ensure that licensing and access/read/write controls respect IP/CARE/OCAP concerns where appropriate to prevent methodological and digital colonialisation

What's not on our radar but will take central stage in the next 5-10 years?

- "Fake data" we need more communities to be aware of this and implement protections
- Strong geopolitical negotiation around data sharing data as a new form of power and thus intersecting with residency, localisation, and sovereignty concerns (links to the Ethics WG)

Key ECOP perspectives - the OBPS should elevate content which:

- Addresses the reluctance to share data due to out-of-date reward structures
- Focuses on managing the human element of digital stewardship
- Leverages automated and interoperable systems to fast-track delayed-mode data flows and link them to near-real-time flows

In addressing data to information to knowledge relations, OBPS to elevate content which:

- Recognises the differing views on what these levels mean
- Recognises that varying degrees of QC/QA can lead to informative content for different stakeholders
- Clearly shows the maturation of data into information and knowledge
- Clearly shows how stakeholder consultation is needed to decides what is informative, to whom, and when
- Clearly distinguish "Knowledge first", "information first", and "data first" approaches

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 decisionmaking thinking), and dynamic suggestions offered at each step.

For fisheries, 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? 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 and form one CoP. Some of this will take digital knowledge management vs digital info or data

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 practices for dialogue. E.g. users of best practices have a means to get in touch with the submitters and ask questions.

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)o

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

Additional information for Data and Information Management is available in Volume 2 (see Annex 2).

7.3 Developing Community Capacities for Best Practices Working Group

Co-leads:

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



Developing Community Capacities Recordings

Plenary 1: Developing Community Capacities ... Breakout Presentation

Plenary 2: Developing Community Capacities ... Summary Presentation

Monday 21 September - Challenges and Priorities

Tuesday 22 September - Challenges and Priorities

Wednesday 23 September - Summary Session

7.3.1 Scope of Working Group

This breakout group discussed methodology to provide training in the development and documenting of best practices, their submission to the OBPS and to identify any challenges and potential pitfalls. The Working Group considered how to ensure global and equitable use of OBPS as "an evolving system which fosters collaboration, consensus building, and innovation by providing coordinated and global access to best practices and standards across ocean sciences and applications". In this scope, the following questions are examples of what was addressed.

- Are there existing training programs related to ocean best practices that you are currently engaged with or aware of?
- Who are the target users of OBPS training?
- What Capacity Development (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?

7.3.2 Three-point summary from workshop

- 1. Create dedicated training packages tailored to specified user groups. For example, 'cheat sheets' for each EOV (developed with the EOV Panels), elaborated as decision trees etc.
- 2. Develop best practices on Stakeholder Engagement

7.3.3 Key aspects from Working Group Discussions

The Working Group identified CD methodologies that can promote the wider use of OBPs examining online courses, face to face training, summer schools, internships, etc. The recommendations, looking forward, include:

- MOOCs
- Mentoring and peer-to-peer training.
- Courses and content need to be provided in languages relevant to the target audience;
- Face-to-face courses are limited to few participants and are expensive
- Internships in laboratories and field work
- Reaching out to non-scientific communities and establish what tools and resources are specifically needed for their situation

With the increasing potential of e-learning, recommendations for best practices in this area, addressed many aspects that should be considered:

- Training offering needs to be more than just the lectures
- Pre-course involvement, post-course communication and assessments: communicating through email, giving an assignment, certificates; implementing practical projects at the end of the learning
- OceanExpert as a tool to keep track of experts as lecturers or students
- Provision/distribution of equipment maintenance and regular follow-up training (Continuous professional development)
- BPs are not static and will change with time historic trail of evolution in the course platform
- A description for each EOV highlighting different methods (an imperfect vs perfect example or cost-effective vs. non-cost-effective)
 - Highlight basics of measurement technique, quality control currently implemented, and references for additional reading
 - Easily distributed and low-cost
- A "decision tree"/flowchart laying out different methods depending on the intended application

Another aspect for consideration are the options for effectively engaging non-scientific communities and practitioners in the creation, adoption and routine employment of best practices. Recommendations included:

- Engaging with Citizen science initiatives such as coastal surveys, secchi disc measurements
- Innovative creative ways for young people to contribute building a CTD for 100 euros, 3D printing of sensor models, etc.
- Involving in scientific NGO's, scientific societies like Ocean Society of Indian Geophysical Union Society of Earth Scientists, etc.
- Community engagement events, e.g., public talks, community science events
- Co-design some best practices with policymakers including how to present and communicate data, how to serve data to end users, etc.
- An important hurdle 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
- Develop data and information delivery mechanisms suited for the target audience (eg make it possible to use cellphones to receive data and information)

• Highlight local champions in smaller countries - very relevant to the discussion on inclusion and taking into consideration the local knowledge/communities to create best practices around them (also discussed in the ethics WG)

The challenges and pitfalls in moving forward with OBPS training were noted:

- 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
- Lacking resources Internet connectivity, platforms, and language to fully engage in this effort
- Understanding where certain BPs 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"

Recognizing that these recommendations are challenging and represent a long-term view, the working group identified actions that can be addressed as part of a foundation for the coming years. These include:

- Create toolkit: summary sheets for each EOV hosted in OBPS (start with a trial run in connection with Convergence of Methods WG or Uncertainty Quantification WG?)
- Model datasets for each EOV to help train on how to handle data, as well as a model for metadata.
- Decision trees that help by laying out different methods specific to different applications
- OBPS can support by providing access to science communicators/digital designers and citing DOI of resources available
- Develop best practices on stakeholder involvement in the process with regards to developing training targeted to members of various communities
- 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 Centres (RTCs) or Specialized Training Centres (STC)
- Include courses on 'Applied Ethics' in marine science
- More funding is needed to support OBPS training and CD

Additional information for capacity development is available in Volume 2 (see Annex 3).

7.4 Ethics in Ocean Observation Best Practices Working Group

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



Plenary 1: Ethics ... Breakout Presentation

Plenary 2 :Ethics... Summary Presentation

Working Group Sessions: Ethics... Presentations

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

Tuesday 22 September – 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 – Ethics and fisheries; Mackenzie Mazur from the Gulf of Maine Research Institute (USA)

Thursday 24 September – Optimizing infrastructure; Frederick Whoriskey from Dalhousie University (Canada).

7.4.1 Scope of Working Group

This working group held separate sessions on four topics. Each of these had a defined scope. These are summarized here, with more details available in Annex 4.

Session 1: 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. 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. 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.

Session 2: 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.

Session 3: 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.

Session 4: 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.

7.4.2 Three-point summary from workshop

1. Define a statement that addresses the efforts and key core-values for the ocean observation community.
- 2. Develop online training courses as a series on ethics, organised by topic (e.g., Collaboration with indigenous communities, collaboration with fishermen etc) focussed on ocean obs and application communities.
- 3. Design a flow chart easy to read for each observer to identify what are the potential ethical issues related to research activities with the related ethical recommendations related to these issues.



7.4.3 Key aspects from Working Group Discussions

The following are high level recommendations.

- Design a flow chart that Observers can consult to identify what are the potential ethical issues related to their research activities. To 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 overcome the first barrier and get people engaged even without previous knowledge of ethics. The flow chart should at least list types of questions.
- Support the implementation of an ethics committee in the ocean observing community linked to the UN Ocean Decade with different expertise.
- Design a statement for Ocean Observers to highlight responsibility of observers
- Organize online courses on Applied Ethics specifically dedicated to ocean observation (and not only to research integrity).
- Open a clearinghouse where we can find non-scientific information including legal aspects, agreements and permissions needed.
- Approaches to transparency and collaboration: clear science communication, stakeholders take part in the knowledge productions, knowledge scores, address internal conflicts between stakeholders, preparatory modelling, value and pedigree matrices, surveys on transparency.
- 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.

• Include more ECOP (PhD's, Early PostDocs) in this process through a training programme dedicated to ECOP exchange or a mentoring programme to favor exchange among different research groups.

Recommendations for the IOC OBPS

- Fora/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 highperformance observing technology', 'science-industry collaboration')

Additional information for Ethics is available in Volume 2 (see Annex 4).

7.5 Fisheries Working Group

Co-leads:

Peter Haugan, Institute of Marine Research, Norway Cisco Werner, NOAA USA Marino-O-Te-Au Wichman, Secretariat of Pacific Community, New Caledonia

Fisheries <u>Recordings</u>

Plenary 1: Fisheries Breakout Presentation Recording

Plenary 2 : Fisheries Summary Presentation

Working Group Sessions: Fisheries Presentations

Monday 21 Sep - Data Collection; Sven Kupschus (UK), Cisco Werner (USA)

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

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

Thursday 24 Sep - Review & Summary – and emerging topics

7.5.1 Scope of Working Group

Fisheries include a host of topics e.g. wild-capture fisheries and aquaculture, as well as our changing - non-stationary - oceans and their ecosystems. These changes include natural and/or climatechange related forcing, or changes related to the increased multi-sectoral use of the oceans. In the commit OBPS sessions we will focus on discussions on wild-capture coastal and offshore fisheries while acknowledging the importance of aquaculture in seafood sustainability. We will consider three topics: (1) Data Collection (2) Stock Assessments (3) Management Advice with the fourth day being a Review and Summary.

7.5.2 Three-point summary from workshop

Fisheries are scale and region dependent. Novel technologies (satellite, unmanned systems, genetics, Big Data, etc.) and collaboration may serve to diminish differences between data poor and data rich areas. Recommendations:

- 1. Involve the fisheries community more actively in OBPS and ensure interoperability of observations and models including by using metadata template.
- 2. Continue the conversation and include aquaculture session in next OBPS workshop
- 3. Improve regional implementation and capacity building within the framework of Ocean Decade actions.



7.5.3 Key aspects from Working Group Discussions

Commentary on Ocean Best Practices - what can be achieved in defining and using them?

- Give people 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)
- Convergence of methods (Create efficient integrated working methods, BUT consider needs and opportunities)
- Develop a standardized 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)
- Not tell people what they must or must not do!
- For data collection, fisheries should position itself to leverage the diverse and large quantities of data that could be available to evolve from a local to regional to global assessments and management. Key features include:
- Use of various systems (modeling, novel methods, etc.) to work towards stitching together these different measurements or estimates to construct a more complete, e.g., global picture [Links between 'Omics, Unmanned Systems, and Fisheries WGs]
- 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
- In addition to data, stock assessment models (SAM) are needed. 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 MSE best practices should be encouraged. Stakeholders' interests and scientific objectives need to be taken in concert.

The Fisheries Working Group also addressed Management Advice as part of their discussions and had the following recommendations:

- Dialogue between scientists, managers, and stakeholders about their challenges & expectations for advice
- Clarify management objectives & acceptable risk at start/through 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 social factors) is best practice
- Can no longer ignore climate change: check robustness / build resilience

Overviewing the Working Group discussions, four key points were seen:

- Fisheries is complex and diverse ranging from industrialized high tech to artisanal subsistence, but some common messages for BPs seem to emerge
- 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

The final observations considered what to do next. The four recommendations included:

- 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 in Marine Science to help stimulate follow-up of the above actions
- Consider appropriate steps for aquaculture specific aquaculture session at next OBPS workshop?

Additional information for Fisheries is available in Volume 2 (see Annex 5).

7.6 Marine Litter/Plastics Working Group

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	



Other co-leads of individual sessions:

Sanae Chiba (JAMSTEC, Japan), Jillian Campbell (CBD, Canada), Heidi Savelli-Soderberg (UNEP, Kenya), Francois Galgani (Ifremer, France), Alexander Turra (Univ São Paulo, Brazil), Yannick Lerat (SeaCleaners, France), Anne Bowser (Wilson Center, USA), Shungudzemwoyo Garaba (Univ Oldenburg, Germany), Paolo Corradi (ESA, the Netherlands), Christophe Maes (LOP-IRD, France), Audrey Hasson (LOCEAN-IPSL, France), Thierry Huck (LOP-IUEM), Hans-Peter Plag (Old Dominion Univ, USA), Dan Martin (Old Dominion Univ, USA)

Marine Litter Recordings

Plenary 1: Marine Litter Breakout Presentation and Recording

Plenary 2: Marine Litter Summary Presentation and Recording

Working Group Sessions: Marine Litter Presentations and Recordings

Monday 21 Sep -

Session 1. Global Frameworks for selecting priority indicators and variables for monitoring

Session 2. Towards standard sampling protocols

Tuesday 22 Sep -

Session 1. Towards best practices for remote sensing of marine debris

Session 2. Best practices for citizen science monitoring

Wednesday 23 Sep -

Session 1. Global frameworks (continued)

Session 2. Best practices for modeling

Thursday 24 Sep -

Session 1. Global platform for monitoring marine litter and informing actions - how does it work?

Session 2. Global platform for monitoring marine litter and informing actions – best practices

7.6.1 Scope of Marine Litter/Plastics Working Group

The OBPS Marine Litter/Plastics Working Group (WG) will 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 <u>Integrated Marine Debris System</u> (IMDOS) and <u>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, the Marine Litter/Plastics Working Group set up the following objectives for the group.</u>

- Identify criteria for selecting variables and methods for which we require guidelines, best practices and standard protocols as a priority.
- Recommend a process to globally harmonize and standardize methods for monitoring and assessment, and to promote their adoption.
- Decide on the scope of best practice documentations/resources needed for (i) remote sensing observations (ii) modelling, and (iii) citizen science components of marine litter monitoring; and other aspects.
- Identify short-term actions to implement recommendations from this WG.

7.6.2 Three-point summary from workshop

Recommendations for the community:

- 1. Establish global coordination of marine litter monitoring under the UN Ocean Decade for Sustainable Development, by implementing the community visions for a Global Platform for Marine Litter Monitoring and Information Action, and an Integrated Marine Debris Observing System.
- 2. Through dedicated technical workshops, harmonize approaches and protocols for each of the relevant global scale indicators (expanded beyond the list of SDG indicators), and define the best possible approaches to manage data.

For community and OBPS:

Develop and promote the use of the following resources for the marine litter community:

- 1. open-access datasets in standardized formats with traceable uncertainties to enable consistent and comparable training of remote sensing algorithms to detect marine litter,
- 2. technical training courses and capacity building initiatives for citizen scientists,
- 3. a framework for global marine litter model intercomparison.

7.6.3 Key aspects from Working Group Discussions

There is a significant need across Global frameworks for setting priority variables and indicators. The following steps are recommended:

- Reconcile existing global (environmental-based) monitoring frameworks (SDG and CBD indicators) with science-based ocean observations framework (EOV, Essential Ocean Variables).
- IMDOS view. Monitoring of marine litter expanded beyond the current list of SDG indicators. Developing Marine Plastics Debris as an Essential Ocean Variable.
- UN Platform view. Roadmap for establishment of marine microplastics monitoring and data hub.
- Establish and fund a global coordination of marine litter monitoring under the UN Ocean Decade for Sustainable Development.

Consider scientific, methodological, environmental, technical and ethical constraints when recommending and adopting common methodologies for marine litter monitoring and assessments.

There are initial steps which the WG recommends to move forward:"

- Shortlist the most relevant indicators for global scale monitoring
 - Possible suggestions: 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
- 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)
 - Role of OBPS to not only make BPs available but to help promote their adoption and use, especially at the QC and database integration step of the process?
- Consider technical workshops to harmonize approaches/ protocols for each of the relevant global scale indicators, and define the best possible approaches to manage data

Remote sensing for marine litter and plastics have many facets – from satellites to air vehicles to ships. This diversity drives a wide range of best practices with different levels of maturity. Consistency across protocols is important and was addressed in the session on remote sensing. The following considerations were considered:

- Remote sensing of marine litter is an emerging research field and consequently still focused on research and demonstrations. Factors impacting remote sensing include large amounts of information on a large scale ("the big picture"); need to improve quantification of concentrations globally and locally; 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 evolving.
- Big challenge for remote sensing due to the size continuum and composition mix.
- The community is establishing, adapting and updating operating protocols, e.g. in the optical domain it is utilizing the OBP from Ocean Color remote sensing (International

Ocean Color Coordination Group) and adapting them to establish updated protocols relevant for remote sensing of marine litter.

The Working Group goal (recommendation) is to standardize methodologies for obtaining consistent high-quality datasets that have traceable uncertainties and are comparable among the scientific community, ultimately having open-access datasets in standardized formats for algorithms training.

Citizen Science (CS) offers significant opportunities to further data collection, but there are challenges in defining practices (best practices) to encourage consistent data quality and interoperability with other measurements. The question is how to optimize the potential to produce robust information for scientific research and policy-driven responses; The keys for advancement focus on the:

Potential to share knowledge and promote engagement of society to combat marine litter; 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 ensure the right data quality;
- Feedback, as a form of acknowledgement, and to support data quality.

In addition, there needs to be a platform view: requiring standardized CS data collection may impede the flexibility needed to face different issues, goals and realities related to marine litter.

It may be easier to achieve data interoperability through post-collection harmonization (demonstrators of that in place). This approach will make it possible to assess general trends, if not specific and granular research questions.

Thus, 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 for monitoring and also training people and building capacity to understand and act.

As mentioned above, modelling of the ocean circulation is an important part of managing marine litter and plastics. The working group discussions focused around key questions:

What are the scales of motion needed for the floating dispersion?

How to estimate the scenario for the sources entering into the oceans?

How to reconcile model predictions with data-derived global trends?

How to constrain the mass balance of marine litter in global models?

Need to consider uncertainties due to mismanaged plastic wastes, lack of data on ocean interior, etc.

The discussions around these questions led to some preliminary recommendations:

- Intercomparison of global marine litter models (based on general ocean circulation models) is important.
- More collaborative efforts to develop plastics life cycle models to constrain the global budget of plastics.

Finally, returning to the discussion of global platforms for marine litter monitoring, the working group recognized that there needs to be a movement to integrate existing marine litter data bases and improved methods (e.g., though the use of artificial intelligence) to mine the outputs of citizen science. Some preliminary recommendations include:

- 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

How can best practices play a role in improving the understanding of marine litter ?

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.
- 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). Role of OBPS to not only make BPs available but to help promote their adoption and use, especially at the QC and database integration step of the process?
- Consider technical workshops to harmonize approaches/ protocols for each of the relevant global scale indicators, and define the best possible approaches to manage data.

Additional information for Marine Litter/Plastics is available in Volume 2 (see Annex 6).

7.7 Omics and eDNA Working Group

Co-leads:

Gump South Pacific Research Station, University of
California Berkeley, USA
Alfred Wegener Institute, Helmholtz Center for Polar
and Marine Research, Germany
Monterey Bay Aquarium Research Institute, USA
National Oceanography Centre, U.K



Plenary 1: Omics and eDNA Breakout Presentation

Plenary 2 : Omics and eDNA Summary Presentation

Working Group Sessions: Omics and eDNA Presentations

Working Group : Full Report

The working group sessions reflect the challenges of a rapidly emerging technology. In order to maximize outreach, the sessions are conducted in 3 time zones. Topics are listed below

Monday 21 September: Samples - Collection (in situ), Handling and Storage (field to lab), Processing (material to digital), Archiving (collections; futuromics)

Tuesday 22 September: Bioinformatics and analysis - Quality Assurance, Curation/Taxonomy, Reference Database, Modeling

Wednesday 23 September: Data and information stewardship - Data Lifecycle, (Meta)Data Standards, FAIR principles

Thursday 24 September: - Policy Interface, Ethical Legal & Social Issues, Education & Training

Omics/eDNA and Society.

The last 2 sessions were held in conjunction with Ethics WG and the Data and Information WG respectively.

7.7.1 Scope of Omics/eDNA

This global online workshop brought together representatives of the "Omics and eDNA" community under the umbrella of IOC-UNESCO Ocean Best Practices System (OBPS) (Pearlman et al. 2019) to explore how to align and improve the methods we use, and how the OBPS can best interface with our research community. For the purposes of the workshop, 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.

Broadly speaking the subject of our community is Biodiversity Observation at the Molecular Scale. It is a field that builds on the genomics revolution in DNA sequencing that accelerated after the Human Genome Project. Genomics soon expanded to a vast array of microbial and multicellular species, and began to include other types of molecules, particularly those derived directly or indirectly from genomes, (e.g., RNA, proteins, and metabolites). This broadening field has become known as "Omics" and includes a range of approaches, such as metagenomics, transcriptomics, proteomics, and metabolomics. In parallel with the acceleration of Omics, another innovation was to begin sequencing DNA directly from environmental samples (water, soil, air, etc.). Labelled 'environmental DNA' (eDNA), this approach has the potential to identify organisms - microbial or multicellular - that have interacted with a given environment. Total eDNA contains both cellular DNA (living cells or organisms) and extracellular DNA (resulting from natural cellular death and subsequent destruction of cellular structure). eDNA has received great attention from both research and management communities because it might offer a cost-effective single approach for characterising the full spectrum of biodiversity from microbes to megafauna. Furthermore, it is non-invasive and has less reliance on in-field taxonomic expertise than conventional methods for biological observation. In this workshop, the questions addressed by the community include:

- How can OBPS be used to help your community discover existing methodological documentation?
- How can the OBPS support your community in aligning related methods and, eventually, converging them into more global best practices (BPs)?
- What additional functions can the OBPS provide to support your community in evolving methods into global best practices?
- What additional functions can the OBPS provide to encourage the broad use and updating of any best practices your community produces?

7.7.2 Three-point summary from workshop

- 1. Establish a network of networks to promote coordination (e.g. hosting in-person workshops and online forums) and to harmonize national initiatives into global synergies.
- 2. Promote activities that develop metadata standards and that provide the tools needed to ease the implementation of those standards (e.g. version control, decision trees, templates) and the incentive mechanisms that motivate the sharing of protocols, samples, data and code.
- 3. Support training/documentation in ethical concerns and provide guidance on ethically, legally and socially appropriate protocols in different situations

7.7.3 Key aspects from Working Group Discussions

Discussions during the workshop were divided into four key topics: Samples, Bioinformatics & Analysis, Data & Information Stewardship, and Society. Collectively, we aimed to support the OBPS mission of sustaining and evolving a system that fosters collaboration, consensus building, and innovation by providing coordinated and global access to best practices and standards across ocean sciences and applications.

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

• Help users navigate the landscape of Protocols and Best Practices by offering a decision tree that will guide them to a collection of the most relevant resources for their research. The most commonly suggested intersections include: Resource and equipment availability, target, assumptions of algorithms/analysis, replication, data type, and experience level of the user.

Such a decision tree could also flag when a decision will reduce the usability of the sample along the line (e.g., using a certain preservative may not allow ...), and flag ethical concerns. The value of the decision tree will lie in the diversity and accuracy of the data provided to the OBPS about the real limitations and strengths of different protocols and BPs.

- Link to other protocol repositories and documentation on other platforms (e.g. github, protocols.io)
- Offer training resources on how to navigate the platform
- Raise awareness that the OBPS exists
- Standardize terminologies used within Omics/eDNA

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

- To facilitate discovery of appropriate protocols, work with appropriate partners (e.g., standards organizations) to support a review of the terminology used to describe the field of "Omics and eDNA" and related fields / subfields, how these terms have been and are currently used, and where differences in usage might be confusing, and could or should be harmonized.
- Raise awareness for the importance of method development and sharing. You need to provide an opportunity for recognition/incentive/career progression/citation to have the capacity for thinking about BP development. Support from the side of the IOC in such a culture change will be valuable.
- Provide a capacity building platform for the development of best practices.
- Encourage open discussions on methods, protocols, standards, and updates through a forum.
- Ensure users are aware of and open about strengths and weaknesses of BPs.
- Create a sense of common mission within the community to foster collaboration.
- Establish interoperability between OBPS standardized terms and comparable terminologies.

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

- The OBPS should constitute a centralized & trusted resource with links to:
 - Targeted outreach and communication material and simple introductory guides as educational material for scientists, policy makers, society
 - o Ethical principles
 - o Legal obligations (e.g., Nagoya Protocol)
 - o Metadata standards
 - Host standard compliant metadata templates to go with BPs
 - Link to services that can help with metadata submission (e.g. GFBio)
 - Data standards and principles
 - o Software/Docker container needed for protocol
 - o Repositories
- Offer functions for version control.
- Provide templates to publish protocol (otherwise very time consuming) and add compulsory fields/guidelines that need to be filled for metadata (e.g., needed for decision tree).
- Enable collaborative protocol development through offering functions to fork and merge to improve a protocol.
- Add a function to point out potential errors/issues directly on the protocol.
- Offer multimedia support for training users in using the platform and associated services, in writing and uploading best practices.

- Offer routes for continuous community review and endorsement of new or updated Practices as well as for competition to decide on the current Best Practices.
 - Part of the community endorsement would be to offer a rating system to add a badge of approval to a method that you have used and been satisfied with, or a badge of disapproval for any methods that were not satisfiable. Linking to publications using the protocols and auto-tracking the number of citations would be an additional feature to portrait the community uptake of a certain method.
 - Testing of protocols could be promoted by encouraging awareness and conversation between providers and users of similar methods and thus spark studies conducting performance tests of one against the other. Such comparative studies to discover which method produces superior results and under which conditions would be immensely valuable to make a decision on which protocol to use. To keep this information connected to the OBPS, such studies should be automatically linked.
 - To track any such activities, we need unique and persistent identifiers for each protocol and require it being mentioned in any publication that uses it.
- Add a section about Failed (Worst) Practices to prevent duplicating effort on something that has already been shown not to work (encourage publication of these experiences).
- Provide a platform to coordinate reference dataset exchange to standardise between observatories and laboratories.
- Give each version of a protocol a citable, globally unique and persistent identifier.
- Integrate Field Information Management Systems (FIMS) (Deck et al. 2012) and Laboratory Information Management Systems (LIMS) with methods for digitised and user-friendly logging of changes and modifications.
- Have Standard Operating Procedures (SOPs) running in parallel to validate the Omics approaches.
- Add a disclaimer function about readiness level of protocol (if we want to have them on there early for collaborative development).
- Work with journals, funders and other stakeholders to promote the Best Practices and to provide them with services (e.g., source of potential reviewers)

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

- Host forum discussions that can be directly linked to every protocol.
- Offer the function to modularise protocols and allow a mix and match of those modules to compose workflows.
- Support Wikis for narrative documentation.
- Highlight protocols and Best Practices that include specific guidance on FAIR and standards, particularly compliant Omics/eDNA (meta)data.

As a result of this meeting, our community hopes to move toward the following:

- Transparency and convergence of methods globally where applicable
- Provide visibility for standards, tools, and protocols as they emerge
- Mechanism for comparing and surfacing Best Practices globally
- Promote principles to exchange and compare data (e.g., FAIR + CARE)
- Enable more global analyses incorporating multiple regional datasets
- Pathway to operationalize genOmic biodiversity observations at scale in all regions (local to global)

Additional information for Omics and e-DNA is available in Volume 2 (see Annex 7).

7.8 Partnership Building Working Group

Co-leads:

Andrea McCurdyConsortium for Ocean Leadership, USAJon WhiteConsortium for Ocean Leadership, USAMaya C. DelaneyAlbright Stonebridge GroupIsigi KadagiEducation for Nature Program and
Conservation Leadership, WWF-USA,
BILLFISH-WIO, African Billfish Foundation



Plenary 1: Partnership ... Breakout: Presentation; Recording

WG Report: Partnership Building

Wednesday 23 September - Community consultation

7.8.1 Scope of Partnership Building Working Group

The Partnership Building WG focuses on the importance of partnerships among ocean observing practitioners in addressing both social and scientific challenges especially in the Blue Economy (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 to toward 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 OceanObs '19, RCN Annual Meeting, and OSM 2020:

- OceanObs 19 CWP: "Challenges of Sustaining Ocean Observations" (Weller et al., 2019)
- OceanObs 19 session, RCN session, OSM Town Hall
- Discussed duringrecent (Sept 16-18) National Academies Ocean Studies Board Meeting (Report to follow in early 2021).

These sessions 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:

Common Agenda

- Deemed as essential to developing a common approach
- Differences discussed and facilitation mechanisms put in place

Shared Measurements

Should be part of the collaboration from the beginning

• Should include qualitative and quantitative evaluations

Mutually Reinforcing Activities

- Activities should be chosen and scheduled to avoid competition
- Some of this coordination may reduce the duplication of effort within regions and organizations

Continuous Communication

- The cornerstone of all collaborations
- Important to see a balance of informal dialog and ensuring formalized reporting on activities and outcomes

Backbone Support

- This is absolutely necessary, and ideally operates as an independent entity
- This will require resources that are often lacking and lead to the failure of ocean observing efforts in time

7.8.2 Three-point summary from workshop

- 1. The panel of experts recommends that a best practice framework be explored featuring the five components of a Collaborative Organization Model as critical elements.
- 2. We recommend a more formalized group be formed to discuss the viability of this aspect of the Model also as part of a framework for collaboration.
- 3. Use Cases could readily be developed from the examples listed in this Report and demonstrate how the Collaborative Impact Model could be used to develop and build organization, programs and projects of all sizes to bring disparate groups together toward the achievement of a a shared agenda

7.8.3 Key aspects from Working Group Discussions

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 this session is reflected in the 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.

- Explore expanding the work being done during this Workshop into a manager's guide or workbook that includes activities for people to undergo when entering into collaborations or partnerships. This can ensure that each of these five areas have specific recommendations for people to consider. This may prove helpful particularly in the context of the UN Decade where there is a strong possibility that various organisations will be working together, establishing new partnerships, that may otherwise be formed in an ad hoc manner. A simple guide could help to ensure that these partnerships/collaborations are as successful as possible.
- As part of the IOC, we encourage the OBPS to further endorse the Collective Impact approach and encourage its promotion through groups such as GOOS, enhancing its impact on the ability for groups to come together toward a common agenda and sustain collaboration.

• During the working sessions, we explored possible solutions to the four obstacles to sustained Partnerships to Support Blue Economic Growth. These include setting common expectations, closing communication gaps, establishing trust, and building relationships based on an appropriate timeline.

Additional information on partnerships is available in Volume 2 (see Annex 8)

7.9 Sargassum Working Group

Co-leads:

Emily SmailNOAA, USAShelly-Ann CoxCERMES, BarbadosCesar ToroUNESCO, Paris, FranceLeah SeguiNOAA, USA



Sargassum Recording

Plenary 1: Sargassum Breakout Presentation

Plenary 2 : Sargassum Summary Presentation

Working Group Sessions: Sargassum Presentations

Monday 21 September – Science and Technology. This session covered the current status of Sargassum science and technology. Frank Muller-Karger (USF) and Rick Lumpkin (NOAA AOML) shared their perspectives on the state of these fields followed by breakout group discussions by working group participants.

Tuesday 22 September - UNEP Webinar on West Africa Perspective. This webinar featured leading experts from affected countries in the region (Benin, Côte d'Ivoire, Ghana, Guinea, Liberia, Nigeria, Senegal, Sierra Leone, and Togo) including local and international organizations working on marine and coastal biodiversity management to share information, build knowledge on the phenomenon, promote best practices and develop ocean governance arrangements in combating the Sargassum phenomenon in West Africa.

Wednesday 23 September – Monitoring and Forecasting. This session covered best practices on the monitoring and forecasting of Sargassum. Mengqiu Wang (University of South Florida) and Joaquin Trinanes (NOAA) shared the state of the field followed by breakout group discussions by working group participants.

Thursday 24 September – Management. This session covered best practices on the management of Sargassum. Patrick McConney (UWI-CERMES) and Ileana Lopez (UNEP) shared their perspectives on management and policy frameworks followed by breakout group discussions by working group participants.

7.9.1 Scope of the Sargassum Working Group

The Sargassum ocean best practices working group collaboratively addressed best practices as well as recommendations for the OBPS to meet community needs for advanced method development in ocean observations and applications.

The questions addressed include:

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

7.9.2 Three-point summary from workshop

- 1. Documents under OBPS repository should be easily sorted as there are a variety of documents in the repository and not all are protocols/procedures. We recommend a labeling process so there is a way to sort documents by category.
- 2. Allow version updates of best practices based on feedback. Include a functionality where community members can comment/rate a best practice and a procedure for producing and approving updated.
- 3. Strengthen public-private partnerships to share data and information and provide coordination and collaboration for science for management and entrepreneurial endeavors.

7.9.3 Key aspects from Working Group Discussions

Questions addressed

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

- Define "best practice" and explain how they are collated to get community buy-in.
- There are a lot of unused, unshared data and having a repository with rules on publication may help make data more available.

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

- Include "what practices not to do"
- "Best practice" will depend on the capacity and the priorities of those using the practice. This system can help the community recommend various approaches to municipal authorities.
- We suggest Including the cost of a best practice for things like equipment for analysis.

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

- Can OBPS be used to highlight information gaps, including major gaps that are fundamental to commercial development, and help create collaborations around these gaps?
- There is a need to not only identify information gaps, but identify which gaps prevent us from moving forward
- Advertise OBPS to the private sector since they are the ones interacting with sargassum and implementing solutions.
- OBPS can share training and guidelines for authorities and other stakeholders.

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

- Yes, provide specific labeling of Best Practice documentation because the current format is purely a repository of practices.
- Can OBPS develop a labelling process so that users can see which practice has been vetted and which community has vetted it?
- One suggestion is to make a traffic light approach for the label good, better, best practices.
- It can help combat misinformation and get vetted information to government official and the general public.

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.

- Groups that were mentioned include: IOC UNESCO, UNEP-CEP, FAO, CARICOM agencies such as Caribbean Regional Fisheries Mechanism (CRFM) and the Caribbean Institute for Meteorology Hydrology (CIMH).
- SargNet, CERMES, and GEO Blue Planet could help derive the vetting process.

Recommendations from the Sargassum community organized by session

Science

- The science of sargassum needs to be related to sargassum's impacts on people. Understanding information needs will help focus research.
- The community needs a consensus on activities to keep sargassum from beaching and on harvest impacts on biodiversity.
- There is no formal environmental impact for harvesting or for booms and other mitigation equipment.
- Many basic science questions are not answered, such as biodiversity associated with the mats, levels and proportions of contaminants in the mats, sargassum's effect on fisheries, and the chemical characteristics of the morphotypes.
- Methods for analyzing heavy methods and measuring volume of sargassum should be standardized.

Monitoring and Forecasting

- Results in one place may not be applicable in another place, like movement within coral reefs versus open ocean.
- While forecasting and monitoring sargassum is well underway, there are still information gaps on how much sargassum is moving. Photos and drone videos do not capture volume well as tides and other environmental factors change the volume of sargassum.
- The community needs recommended methods for estimating coastal sargassum influx and volume.
- There is a need for more information on coastal mapping of sargassum, nearshore monitoring and forecasting, and the use of far field forecasting.

Coordination

- The story of sargassum may be too complex. A simple message with recommended actions may be effective at reaching decision makers.
- Funding for sargassum favors studies in the pharmaceutical industry. Instead of competing for funding, build partnerships with the pharmaceutical industry to fund basic research.
- Hotels have money to fund clean ups but surrounding areas like mangroves and sea grass beds continue to be impacted.
- The Sargassum Information Hub can help facilitate sharing of information.
- Hotels have information as they have invested in sargassum removal, but their information is not readily available. Other unpublished sources come from other clean up events, national park groups.
- There is a need to develop data sharing policies.
- The private sector wants to participate in management but needs support from scientists and international/national organizations.
- Integrate more social science to incorporate community engagement and local knowledge into best practices.

Management

- There are questions as to who owns Sargassum and what are the regulations.
- The community needs best practices on thresholds for management (i.e. how much sargassum needs to be present to enact management protocols).
- The community needs best practices/regulations on how much sargassum can be collected, who can collect it, and other practices for a sargassum economy (extraction for alginates, equipment sharing, etc.).
- There is a need to identify legal frameworks and enforcements in different countries.
- Inundation events can favor some businesses (game fishing) than others.

Additional information on Sargassum is available in Volume 2 (see Annex 9)

7.10 Surface Radiation Working Group

Co-leads:

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Plenary 1: Surface Radiation Breakout Presentation

Plenary 2: Surface Radiation Summary Presentation

Working Group Sessions: <u>Surface Radiation Presentations</u>

Tuesday 22 September – ocean and land-based surface radiation networks (Summarize Best Practices)

Panel: Laura Riihimaki, Anthony Bulchotz, Chris Fairall, Patrick Berk, R. Venkatesan

Wednesday 23 September -

Panel: Christian Lanconelli, Alcide di Sarra, Jim Edson, Tom Farrar Plan the way forward -- Best Practice Report and potential peer-reviewed paper for submission to BAMS or Frontiers in Marine Science.

Thursday 24 September- Synthesis of Recommendations, plans for going forward

7.10.1 Scope of the Surface Radiation Working Group

The surface radiation working group is focused on developing best practices for making high quality surface radiation observations from moving platforms. 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. Surface radiation challenges include:

- Shadows & Reflection on Solar. Warm/cold object(s) in the field of view for IR.
- Moving platform changes effective zenith angle of solar direct beam. Motion due to wind (--> mean tilt), wave rocking, and platform navigation (--> mean tilts).
- Need to modify electronics and housing, e.g. amplification and digitization of small voltages for accurate measurement of thermistors.
- Environmental contamination of optics: Dust, dew, ice crystals, sea salt, guano, bird butts
- Calibration reference is not always available or may be of poor quality

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 by answering the questions below, describing challenges faced, and solutions to these challenges. During the final third session, a strategy was developed by 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.

As a starting point, the briefings addressed the following questions regarding surface radiation:

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

7.10.2 Three-to-four-point summary from workshop

- 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 electronics 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 Lampadusa Oceanographic Observatory, which is 15 km from the Lampadusa Atmospheric Observatory (Di Sarra et al. 2019), or the Air-Sea Interaction Tower (ASIT) offshore of Martha's Vineyard (Edson et al. 2016).

7.10.3 Key aspects from Working Group Discussions

Decision Tree for primary and ancillary sensors selection process which would include the following questions:

- Is this a biological application?
 - Choose PAR and UVB sensors accordingly
 - Is this a heat budget application? If so, the following additional decision trees apply:
 - Downwelling solar and IR radiation instrument choice:
 - Is power limited (by how much)?
 - Is platform stable (to what degree)? or not?
 - Does platform have a mean tilt (e.g. due to wind or setup)?
 - Does platform have a variable tilt (e.g. due to navigation or waves)?
 - Does sensor experience cold temperatures (how cold?) or ice?
 - Upwelling IR (i.e skin surface temperature) from direct observation or calculations from other in-situ measurements
 - Upwelling Solar (i.e., albedo) from observations, models, or parameterizations

Develop best practices for all aspects of the measurement, including:

- Sampling: The Baseline Surface Radiation Network (BSRN) does 1-minute averages of 1-Hz data
- Sensor/system modifications that could be transferred to industry, e.g. signal amplification, housing,
- Handling, setup, maintenance, e.g. refurbishing, cleaning, installation placement, field of view
- Motion correction, e.g., mean tilt versus fast response, type of motion sensors
- Calibration strategy, e.g. outdoor intercomparison vs. factory calibrations
- Post-processing to filter out or flag bad data, corrections to effective zenith angle, corrections for calibration biases, etc.
- Surface sanity checks and tests for goodness of data

Bridge ocean and land-based surface radiation communities

- Compile list of papers showing performance statistics for different sensors, written primarily by land-based networks
- Develop Decision Tree for choice of sensors and calculations
- Develop best practices for Surface Radiation observations
- Propose expanding land-based calibration facilities to handle ocean-based sensor systems
- Propose intercomparison experiments at ocean-land testbed sites nearshore & land-based tower references
- Write report & peer-review paper.
- It is Urgent that these best practices be developed. The ocean network of Surface Radiation is expanding rapidly. Through TPOS-2020, the surface radiation network is expected to expand from 4 stations to more than 50 in the next couple of years.

Additional information on Surface radiation is available in Volume 2 (see Annex 10).

7.11 Ocean Uncertainty Quantification Working Group

Co-leads:

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Uncertainty Quantification Recordings

Plenary 1: Uncertainty Quantification Breakout Presentation

Plenary 2 : Uncertainty Quantification Summary Presentation

Working Group Sessions: Uncertainty Quantification Presentations

Shane Elipot – University of Miami / RSMAS Steffen Seitz – German National Metrology Institute (PTB) Christoph Waldmann - University of Bremen Annie Wong – University of Washington Mikael Kuusela - Carnegie Mellon University Patrick Heimbach – University of Texas Adrienne Sutton – NOAA / PMEL Brian Emery- University of California, Santa Barbara Matthew Mazloff - University of California, San Diego Kyla Drushka – University of Washington / APL Rick Lumpkin – NOAA / AOML Robert Heitsenrether – NOAA / CO-OPS

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

7.11.1 Scope of Ocean Uncertainty Quantification (UQ)

Goal for the session

- Identify
 - o The different components or sources of ocean UQ
 - o The challenges involved with UQ, and their existing solutions
 - The importance of UQ to different applications (eg. data assimilation)
 - o Best practices for gridded fields
 - Ways OBPS can help further UQ efforts
- Select use cases for UQ for parameters that appear to have high priority like CO2 or O2
- Reach consensus that uncertainty quantifications are necessary and feasible for all ocean parameters
- Summarize ocean UQ for a general audience, to promote the importance of its quantification and broaden understanding of methods. In addition to the WG report, produce an easily digestible infographic or fact sheet.
- Propose a strategy to convey our outcomes to international organizations like IOC and GOOS. Thinking about the concept of maturity levels mentioned in the FOO, UQ should be considered as crucial for related considerations.

Overarching concepts and efforts

- The U.S. CLIVAR Ocean UQ Working Group
- Metrological concepts for ocean uncertainty quantification
- Metrology discussion

UQ in gridded products

- Uncertainty quantification in spatio-temporal mapping of Argo float data
- An end-to-end uncertainty quantification framework in ocean state estimation
- Signals & Noise: Commission & Omission Errors in Uncertainty Quantification of Mapped
 Products

UQ in measured variables

- Argo CTD data and their uncertainties
- Uncertainty in autonomous ocean carbonate chemistry observations: status and next steps
- Uncertainty estimates for ocean currents from **HF Radars**

- How variability can masquerade as uncertainty: representation errors in satellite salinity
- Evolving uncertainties in Global **Drifter** Program data
- Water level UQ discussion

Discussion Outcomes

- Terminology is highly variable
- Create a culture of OceanUQ by using existing knowledge from the field of metrology and our own developed practices.
- Many challenges with case-specific solutions (e.g. discrete measurements, autonomous platforms, data products)

OceanUQ is essential for data reuse, gridded data, data assimilation, and forecasting

7.11.2 Three-point summary from workshop

- 1. Plan for coordination/collaboration between OBPS and the US CLIVAR OceanUQ working group.
- 2. Create a general "Requirements of UQ in Oceanography" Best Practice and develop UQ best practices (use-cases) starting with one or two to serve as an example.
- 3. 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.

7.11.3 Key aspects from Working Group Discussions

Each speaker provided recommendations including topics such as variable specific, general UQ, OBPS specific. These are summarized in the following points:

- Plan for coordination/collaboration between OBPS and US CLIVAR OceanUQ
- SOOS Observing system design (OSD) WG Develop user tools to help with 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.

Additional information on uncertainty quantification is available in Volume 2 (see Annex 11)

8 Outcomes and Recommendations

8.1 Community Dialog (including polls)

8.1.1 Common Framework.

A common set of high-level questions was provided to the working group co-leads, and session participants. These questions, when taken together with WG specific themes, provided a common framework to start WG discussions. These included:

- **Best Practices Recommendations:** Did your group identify a need to highlight or recommend existing practices as being *the current Best Practices the community should follow* to ensure the highest standard and improved interoperability? Did your group come to the conclusion that key Best Practices and their documentation is missing in your area of discussion?
- Best Practices and their Documentation: Did you identify the need to generate a new or updated set of Best Practices for topics in your area? Is a "convergence" of existing documentation required?
- 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? Do you think that Best Practices (and documentation) will play an important role in the "Decade"? Do you have specific expectations on the Ocean Best Practices System for your area in the "Decade"?
- **OBPS Use Cases**: Are there use cases which illustrate the benefits and impacts of best practices. If so, can you document them?
- **Other:** Which international groups/working bodies would you consider asking to 'endorse' your BP, or who would you trust as an endorsement entity?

WG sessions were conducted to answer these high-level questions, address the multiple themes, allow participation across many time zones, and support joint meetings where appropriate. The WG recommendations were integrated across their sessions and then prioritized into the "top 3" recommendations specific to each WG (see three-point summary paragraphs in section 7). Outcomes were captured, and organized into individual WG presentations for Plenary 2 and summarized into the WG reports of section 7. The recommendations were extensive and are not duplicated here; see Annexes 1-11 in addition to section 7 for details. These recommendations were incorporated in formulating the integrated recommendations provided later in this section.

8.1.2 Multiple approaches to prioritization.

Recommendations were prioritized during discussions of Plenary 2, separately in the Pacific and Atlantic sessions. The first poll was a request asking participants to identify three words reflecting their priority recommendations for the OBPS. From these keywords, a "wordle" was created as a participant consensus of priorities (which is qualitative) (see Figure 11).



Figure 11 Wordle from key words identified by participants

In each session of Plenary 2, in addition to the Wordle above, the participants provided poll inputs through two commonly available tools, Mentimeter and Codigital. (see section 2.1: Tools for a virtual environment).

Mentimeter Description

Mentimeter gave a direct ranking by participants, who voted on their preferences in priority. The polls for the Atlantic and Pacific sessions are given in Figure 12 and Figure 13 respectively.



Figure 12 Mentimeter Poll for BP recommendation of focus areas for OBPS from Plenary 2 - Atlantic



Figure 13 Mentimeter Poll for BP recommendation of focus areas for OBPS from Plenary 2 - Pacific

These two polls were compared and recurring themes were identified in order of priority from the two polls. The results are:

- Interoperability
- Decision Trees
- Outreach and Communication
- Capacity Development
- Technology (OBPS)
- Convergence
- Intercomparison Experiments
- Ethics
- UN Ocean Decade

Codigital description:

As indicated in section 2.1, <u>Codigital</u> is a more complex polling device than Mentimeter. It poses a series of comparative questions which are repeated in different ways. This allows a more subtle analysis of responses and is harder to create a bias in the responses. It was primarily used in Plenary 2 during one of the plenary sessions, looking at options and recommendations for OBPS evolution. The high-level priorities identified in the Codigital analytics are shown in Table 5. The words highlighted in green demarcate the key topic of each recommendation. In some cases, two themes may have been included in a single recommendation.

Table 5 Prioritized recommendations resulting from Codigital analysis for Plenary 2 - Atlantic and Pacific (italics identify key words in each statement)

Atlantic Session	Pacific Session	
1 Facilitate interoperability among standards and best	1 Test mining and semantics technology behind the	
practices	OBPS should be a theme/pattern across similar stores	
	of documents to make them interoperate	
2 Provide more "practical best practices" options that	2 Education at many levels, training, resource	
are cost effective and can ensure more global	availability	
adoption of best practices		
3 Facilitate training and collaboration	3 Creating templates in a common theme to improve	
	standardization and boost interoperability	
4 Improve linking of documents between disciplines	4 Provide decision trees/templates	
(e.g., sampling of manual to ethics check list and		
education resources) avoiding false positives		
5 Need to support community commenting on	5 Decision trees to guide users to the right practice for	
documents in the OBPS that can be used to	their needs	
accelerate convergence		
6 Decision trees to manage when and where	6 We need more synergies, shared methods and	
standards and BPs are used	standards to make things interoperate between	
	communities	
7. Supporting the emergence of global protocol that	7. Global convergence and standards	
are sensitive to differences between regions and		
sectors		

A list of prioritized themes from Plenary 2 Codigital analytics was generated for both the Atlantic and the Pacific sessions. The lists were then merged by taking into account the initial prioritization within each list and the frequency of occurrence of the keywords across lists. The result is shown below:

- Interoperability
- Technology
- Capacity Development
- Decision Trees
- Global Adoption
- Convergence
- User Feedback

8.2 Recommendation compilation and analyses for Workshop IV

In section 8.1, various polling approaches were presented. As these have different methods of coalescing participants inputs, the results of these polls were compared. Table 5 shows the side-by- side comparison between the Mentimeter and Co-digital outcomes, and the resulting prioritized themes.

The lists from the two poll types were merged by taking into account the prioritizations within each list and whether the same recommendation topic was in each poll. The result is the synthesis shown in the right column Table 6. Examining the qualitative Wordle results discussed in Section 8.1, similar prioritization of recommendations is seen.

Mentimeter	Co-digital	Synthesized
Interoperability	Interoperability	Interoperability
Decision Tree	Technology	Capacity Development
Outreach/communication	Capacity Development	Decision Trees
Capacity Development	Decision Tree	Technology
Technology (OBPS)	Global Adoption	Convergence
Convergence	Convergence	Outreach/communiccation
Intercomparison	User Feedback	Global Adoption
experiments		
Ethics		User Feedback
UN Ocean Decade		Intercomparison Experiment
		Ethics
		UN Ocean Decade

Table 6 Synthesis of polling results

In a continued analysis, Workshop IV outcomes from each of the eleven WG were reviewed prior to the mini plenary and natural groupings were identified. To conclude Workshop IV, a set of high-level questions reflecting these prioritized themes was matched together with answers from the Top 3 recommendations from each of the WG. The questions used in the final session follow:

- 1. What are the key additional capabilities for the repository (more powerful search, multi-language support, multi-cultural engagement)?
- 2. How can OBPS collaborate with, and support the ocean observing and applications communities?
- 3. What are the key areas for training and education (online) and how do we deal with regions of limited infrastructure?
- 4. What outreach would be most effective community engagement, partnerships?
- 5. How should we implement new capabilities such as decision trees and best practices convergence?
- 6. What aspects of global support should be engaged by the OBPS and best practices more generally?

Answers to one of these questions (as an exemplar - question 1) are given below:

- 1. Documents under OBPS repository should be easily sorted as there are a variety of documents in the repository and not all are protocols/procedures. We recommend a labelling process so there is a way to sort documents by category [*Sargassum group*]
- Humanise the digital: 1) Highlight documents which show how data and information streams and holdings (of varying quality and type) can be efficiently channelled towards solving overlapping scientific questions and societal issues. 2) Elevate guidance on the communication of the highly technical to broader communities 3) Enhance the OBPS UI/UX to suggest linked data and

information holdings and streams which may be relevant to a document being viewed - 2021-2023 developments [*D&IM WG*]

- Digitize human foci: 1) Upgrade (through co-development) and socialise the OBPS templates to have dedicated, machine-readable/minable sections capture what users care about or should be more aware of 2) Enhance the OBPS UI/UX to leverage these structures with natural language / semantic technologies to enhance search across OBPS holdings and FAIR data and information holdings and streams 2021-2023 developments [*D&IM group*]
- 4. Allow version updates of best practices based on feedback. Include a functionality where community members can comment/rate a best practice and a procedure for producing and approving updated versions. [*Sargassum group*]
- 5. Endorsement creates trust and thus uptake by the community. Enhance visibility of endorsed documents through search functionality, newsletter articles etc. Provide examples of how communities can endorse BP, e.g., hosting documents of endorsement processes/guidelines (what a BP must adhere to, to be endorsed) of individual organizations such as GOOS. 2020 endorsement [*Convergence group*]

For the full set of participant responses to the six questions, see Peter Pissierssens' <u>Presentation</u> The result of this dialogue is a series of outcomes and priorities for the workshop.

8.3 Looking to the future

Many of the ideas discussed here will be presented to the OBPS-SG for incorporation in the OBPS strategic plan. Further analyses will be conducted. This will include outcomes from Workshop IV and community inputs from other workshops and events. New areas such as pilot demonstrations of decision trees will be considered. In addition, OBPS recognizes the importance of getting continuing inputs from the community – for the repository, the training, and the outreach and collaboration.

9 Citations [not exhaustive]

Bonney, R., H. Ballard, R. Jordan, E. McCallie, T. Phillips, J. Shirk, and C. Wilderman. (2009). Public participation in scientific research: defining the field and assessing its potential for informal science education. A CAISE Inquiry Group Report. Center for Advancement of Informal Science Education (CAISE), Washington, D.C., USA.

Bonney, R., C. B. Cooper, J. Dickinson, S. Kelling, T. Phillips, K. V. Rosenberg, and J. Shirk. (2009). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience* 59(11), pp.977–984.

Bradley, E.F. and Fairall, C.W. (2007) A guide to making climate quality meteorological and flux measurements at sea. Boulder, CO, NOAA, 109pp. (NOAA Technical Memorandum OAR PSD-311). Available: ftp1.esrl.noaa.gov/BLO/Air-Sea/wcrp_wgsf/flux_handbook/

McArthur, L.J.B. (2005) Baseline Surface Radiation Network (BSRN) Operations Manual Version 2. Geneva, WCRP, 188pp. Available:

<u>bsrn.awi.de/fileadmin/user_upload/bsrn.awi.de/Publications/McArthur.pdf</u>.BSRN Operations Manual Version 3 [under review],

Bushnell, M; Buttigieg, P.L.; Hermes, J; Heslop, E; Karstensen, J; Muller-Karger, F; Muñoz Mas, C; Pearlman, F; Pearlman, J; Simpson, P; (2018) Sharing Best Practices Among Operators and Users of Oceanographic Data: Challenge, Status, and Plans of the Ocean Best Practices Project. *Marine Technology Society Journal,* Volume 52, Number 3, May/June 2018, pp. 8-12(5); DOI: https://doi.org/10.4031/MTSJ.52.3.11

Buttigieg, P. L., Caltagirone, S., Simpson, P. and Pearlman, J. S (2019) The Ocean Best Practices System-Supporting a Transparent and Accessible Ocean, OCEANS 2019 MTS/IEEE SEATTLE, Seattle, Washington, USA, 27 October 2019 - 31 October 2019. doi: <u>10.23919/OCEANS40490.2019.8962680</u>

Cox, C. J., Morris, S. M., Uttal, T., Burgener, R., Hall, E., Kutchenreiter, M., McComiskey, A., Long, C. N., Thomas, B. D., and Wendell, J. (2021) The De-Icing Comparison Experiment (D-ICE): A study of broadband radiometric measurements under icing conditions in the Arctic. *Atmospheric Measurement Techniques*, 14, pp.1205–1224. DOI: <u>https://doi.org/10.5194/amt-14-1205-2021</u>

Deck, J., Gross, J., Stones-Havas, S., Davies, N., Shapley, R. and Meyer, C. (2012) Field Information Management Systems for DNA Barcoding. *Methods in Molecular Biology*, 85, pp.255–267.

di Sarra, A., et al., (2019) Assessing the Quality of Shortwave and Longwave Irradiance Observations over the Ocean: One Year of High-Time-Resolution Measurements at the Lampedusa Oceanographic Observatory. *Journal of Atmospheric and Oceanic Technology*, 36, pp.2383–2400, DOI: <u>https://doi.org/10.1175/JTECH-D-19-0018.1.</u>

ECSA 10 Principles of Citizen Science. Available: https://osf.io/xpr2n/

Fairall, C. W., Persson, O.P.G., Payne, R. E., and Bradle, E. F. (1998) A new look at calibration and use of Eppley precision infrared radiometers. *Journal of Atmospheric and Oceanic Technology*, 15, pp.1230-1243.

Flügge, M., Paskyabi, M. B., Reuder, J., Edson, J. B., and Plueddemann, A. J. (2016) Comparison of Direct Covariance Flux Measurements from an Offshore Tower and a Buoy, *Journal of Atmospheric and Oceanic Technology*, *33*(5), pp.873-890. Available: https://journals.ametsoc.org/view/journals/atot/33/5/jtech-d-15-0109 1.xml

Foltz, G.R. et al. (2013) Dust Accumulation Biases in PIRATA Shortwave Radiation Records. *Journal of Atmospheric and Oceanic Technology*, 30, pp.1414-1432. <u>https://doi.org/10.1175/JTECH-D-12-00169.1</u>

Habte, A., Sengupta, M., Andreas, A., Wilcox, T., Stoffel, S. (2016) Intercomparison of 51 radiometers for determining global horizontal irradiance and direct normal irradiance measurements. *Solar Energy*, 133, pp.372-393, <u>https://doi.org/10.1016/j.solener.2016.03.065</u>.

Long, C.N., Bucholtz, A., Jonsson, H., Schmid, B., Vogelmann, A.M., and Wood, J. (2010) A method of correcting for tilt from horizontal in downwelling shortwave irradiance measurements on moving

platforms. *The Open Atmospheric Science Journal*, 4, pp.78–87. DOI: <u>https://doi.org/10.2174/1874282301004010078</u>.

Long, Chuck N., and Shi, Yan (2008) An automated quality assessment and control algorithm for surface radiation measurements. *The Open Atmospheric Science Journal*, 2, pp.23-37.

Meloni, D., Di Biagio, C., di Sarra, A., Monteleone, F., Pace, G.and Sferlazzo, D. M. (2012) Accounting for the solar radiation influence on downward longwave irradiance measurements by pyrgeometers. *Journal of Atmospheric and Oceanic Technology*, 29, pp.1629-1643. DOI :10.1175/JTECH-D-11-00216.1

Michalsky, J.J., Harrison, L.C., and. Berkheiser, W.E. (1995) Cosine response characteristics of some radiometric and photometric sensors. *Solar Energy*, 54, pp. 397-402. DOI: <u>https://doi.org/10.1016/0038-092X(95)00017-L.</u>

NREL Tech Report (2012): https://www.nrel.gov/docs/fy12osti/56540.pdf

NREL Tech Report (2017): https://www.nrel.gov/docs/fy18osti/68886.pdf

Pearlman, J., Bushnell, M., Coppola, L., Karstensen, J., Buttigieg, P. L., Pearlman, F., et al., (2019) Evolving and Sustaining Ocean Best Practices and Standards for the Next Decade. *Frontiers in Marine Science*, 6:277, 19pp. DOI: 10.3389/fmars.2019.00277

Perini, F., Bastianini, M., Capellacci, S., Pugliese, L., DiPo, E., Cabrini, M., et al., (2019) Molecular Methods for Cost-Efficient Monitoring of HAB (Harmful Algal Bloom) Dinoflagellate Resting Cysts. *Marine Pollution Bulletin*, 147, pp. 209–18.

Shirk, J. L., Ballard, H. L., Wilderman, C. C. et al (2012) Public participation in scientific research: a framework for deliberate design. *Ecology and Society* **17**(2): 29. <u>http://dx.doi.org/10.5751/ES-04705-170229</u>

Simpson, P., Pearlman, F., and Pearlman, J; (eds) (2020) Evolving and Sustaining Ocean Best Practices Workshop III, 02– 03 December 2019, UNESCO/IOC Project Office for IODE, Oostende, Belgium: Proceedings, Oostende, Belgium, IOC- IODE: GOOS and IEEE Oceanic Engineering Society, 37pp. DOI: 10.25607/OBP-788

Stoeckle, M. Y., Das M, M., and Charlop-Powers, Z. (2020) Improved Environmental DNA Reference Library Detects Overlooked Marine Fishes in New Jersey, United States. *Frontiers in Marine Science*, 7:226. <u>https://doi.org/10.3389/fmars.2020.00226</u>.

Vignola, F., Michalsky, J., and Stoffel, T. (2017) Solar and Infrared Radiation Measurements, Energy and the environment. CRC Press, ISBN 9781138075528.

Vuilleumier, L., Hauser, M., Félix, C., Vignola, F., Blanc, P., Kazantzidis, A. and Calpini, B. (2014) Accuracy of ground surface broadband shortwave radiation monitoring, *Journal of Geophysical Research: Atmospheres*, 119, pp.13,838–13,860. DOI:<u>http://dx.doi.org/10.1002/2014JD022335</u> Vuilleumier, L., Félix, C., Vignola, F., Blanc, P., Badosa, J. et al., (2017) Performance Evaluation of Radiation Sensors for the Solar Energy Sector. *Meteorologische Zeitschrift*, 2017, DOI 10.1127/metz/2017/083 (preprint)

https://hal-mines-paristech.archives-ouvertes.fr/hal-01615641/file/metz_Performance_Evaluation_of_Radiation_Sensors_for_the_Solar_Energy_Sector_8 8057.pdf

Wieczorek, J., Bloom, D., Guralnick, R., Blum, S., Döring, M., Giovanni, R., et al., (2012) Darwin Core: An Evolving Community-Developed Biodiversity Data Standard. *PloS One* 7 (1): e29715.

Wilkinson, M., Dumontier, M., Aalbersberg, I. J. J., Appleton, G., Axton, M., Baak, A., et al. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*, 3:160018. doi: 10.1038/sdata.2016.18 Scientific Data 3 (1): 1–9.

WMO Specifications: Available:

https://library.wmo.int/doc_num.php?explnum_id=3153https://library.wmo.int/doc_num.php?explnum_id =3153

Yilmaz, P., Kottmann, R., Field, D. et al. (2011) Minimum Information about a Marker Gene Sequence (MIMARKS) and Minimum Information about Any (x) Sequence (MIxS) Specifications. *Nature Biotechnology* 29(5), pp.415–420.

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