Proceedings

Defining Essential, Executable Ocean Observing

A Workshop of the OceanObs
Research Coordination Network
February 16, 2020
San Diego, California

Editors
Pearlman, J., Muller-Karger, F., Pearlman, F., Rome, N., Desai, K., Murphy, S., Rahman, S.

May 1, 2020

Defining Essential, Executable Ocean Observing

OceanObs Research Coordination Network Meeting

February 16, 2020, 8:30 am - 5:30 pm | San Diego, California

I. Executive Summary

The OceanObs Research Coordination Network (RCN) organized a meeting of national and international members of the ocean research and observation communities that was held 16 February 2020, in San Diego, CA, immediately prior to the Ocean Sciences Meeting. The objective of the RCN meeting was to provide a venue for these communities to discuss and advance outcomes and priorities that emerged from the OceanObs'19 Conference of September 2019. The challenge following the OceanObs'19 Conference is to integrate the diverse activities of the ocean research and application communities into focused and sustained efforts that address important societal priorities, and that help inform international initiatives such as the UN Decade of Ocean Science for Sustainable Development and others, as well as important national priorities such as those highlighted in the *US decadal vision to promote American security and prosperity* and in the *White House Summit on Partnerships in Ocean Science and Technology* held in November of 2019.

The February 2020 RCN meeting was structured to encourage dialogue and clear definition of next steps. In one day, the meeting could address only a subset of the OceanObs'19 themes and outcomes. Five Breakout Sessions were organized for the community during the RCN meeting. Each of the breakouts defined specific actions and identified leads to carry these forward. Some of these actions are substantive new directions, and some are expansions of current efforts.

Three major themes emerged from the February 2020 OceanObs RCN meeting;

1. Expansion of coordinated observing systems and global scale measurements.
2. Cross-cutting efforts that underpin the value chain from observations to applications and policy.
3. Resources, the blue economy, and collaboration across the research, industry, sponsors and policy communities.

The RCN meeting produced specific actions with assigned leads in areas covered at the meeting. The OceanObs RCN is working to manage expectations in the community and focus on a process where members of the community become engaged to fill these expectations. Participants recognized that major international ocean research efforts need to better link research and operations. OceanObs RCN seeks to facilitate consensus for paths to operationalizing research.

Following the meeting, the international COVID-19 pandemic has placed a substantial burden on the traditional forms of communication in the science and operational communities. The OceanObs RCN will continue to help the community to organize itself and define priorities for implementation. Further OceanObs RCN meetings are anticipated in 2020 and another RCN meeting on the topic is being planned for December 2020 immediately prior to the AGU meeting in San Francisco. The organizers of the OceanObs RCN will continue moving this process forward under whatever conditions are presented.

II. OceanObs RCN: Introduction

The Ocean Observation Research Coordination Network (RCN) seeks to advance links between observation networks, modeling and operational users to facilitate the delivery of critical information to stakeholders. The RCN is a forum for dialogue on regional and global ocean observing that, in the aggregate, constitute a global observing system. There are many facets to this objective as it can reflect new technologies, observations issues in areas such as biology/ecosystem assessments, or interdisciplinary collaborations. Discussions help identify new technologies and promote their cost-effective development, identify policy priorities, and highlight capacity building requirements for the next decade. This includes the 2020 workshop, which was focused on advancing the outcomes from the OceanObs'19 Conference and on preparations for the Decade of Ocean Science for Sustainable Development (2021-2030). The RCN provides a forum for the ocean research, observing, and applications community to discuss strategies and to coordinate actions.

There is a continuing need for balancing ocean observations, science, applications, and conservation requirements as we plan for the next decade. There is also a need to understand priorities for key observations, analytical methods and applications in addressing societal goals of various national and international initiatives, including, among many:

- US decadal vision to promote American security and prosperity (NSTC, 2018; NAS, 2019);
- The White House Summit on Partnerships in Ocean Science and Technology (Summit; Nov. 14, 2019);
- UN Agenda 2030 (the UN Sustainable Development Goals or SDGs;
- The Strategy Framework Directive;
- The Sendai Framework for Disaster Risk Reduction 2015-2030;
- The Convention on Biological Diversity;
- and others.

The RCN dialogue included linking members of the US community to the international community, and identifying roles and priorities for participants to bodies like the Group on Earth Observations (GEO), including programs to look for solutions for societal benefit areas through GEO Blue Planet, the Marine Biodiversity Observation Network (MBON) of GEO BON, and to various programs of the Intergovernmental Ocean Commission. The process also sought to bring in various national agencies and programs.

The OceanObs RCN was fully involved in the planning and implementation of the OceanObs'19 Conference, held in Hawaii in September 2019. The OceanObs'19 Conference was part of the decadal series that was started in 1999. Each ten years, the ocean research and operations communities come together to identify the key issues for the coming decade and plan ways to address these. For 2019, the major theme of the conference was *Connecting Science and Society*. OceanObs'19 outcomes and actions focused on improving the response to scientific and societal needs of a fit-for-purpose integrated ocean observing system for better understanding the environment of the Earth, monitoring climate, and informing adaptation strategies as well as the sustainable use of ocean resources. The conference agenda was built around the subjects of information, innovation, and integration. Overall, the OceanObs'19 objective was to improve the governance of a global ocean observing system, including advocacy, funding, and alignment with best

practices. It also addressed responsibility for product definition, including production and timely delivery of data and information at the appropriate scales (global, basin, regional, national) to serve user needs.

The primary goal of the February 2020 RCN meeting in San Diego was to synthesize threads and recommendations that emerged from the OceanObs'19 Conference. The process by which the RCN does this is by helping the dialogue within and across communities. This is a challenging task, and similar to the efforts to prepare the OceanObs'19 Conference, it is a global effort to engage and link the US community with the international community. OceanObs'19 gathered 135 Community White Papers with 1551 authors. These were published in Frontiers in Marine Science (Ocean Observations Section). The RCN is now facilitating the organizing of these inputs, which cover 24 topics discussed in OceanObs'19 breakout sessions and which are captured in over 120 recommendations for the next decade. The OceanObs RCN has worked closely with the Consortium for Ocean Leadership (COL) to coordinate post-OceanObs'19 activities.

The February 2020 RCN meeting in San Diego sought to identify key steps to move forward in five broad areas: impacts and applications, observing systems, technology and interoperability, governance, and data management. The OceanObs RCN meeting was organized for one day during which participants had breakout sessions and sixteen short and focused talks.

The meeting identified key steps to continue moving the OceanObs'19 outcomes forward, and to inform the various national and international processes mentioned above. The OceanObs RCN plans to continue organizing virtual and in-person meetings to follow up and track progress. This report outlines next steps.

A. Acknowledgements

The organizers would like to thank NSF for their support for the workshop under grant 2500-1710-00, GEO Blue Planet for their technical contributions, the Consortium for Ocean Leadership for their support in organizing the meeting.

Any opinions, findings, and conclusions or recommendations expressed in these proceedings are those of the contributors only.

B. Recommended citation

Pearlman J., Muller-Karger F., Pearlman, F., Rome, N., Desai, K. Murphy, S., Rahman, S., 2018. Proceedings of the OceanObs Research Coordination Network – February 2020.

C. Attendance

One hundred and fifteen people attended the meeting. During a short tour around the meeting room, each attendee gave a brief introduction, including name, organization, and discipline/interest in the meeting. See **Appendix I** for a list of participants.

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OceanObs Research Coordination Network Meeting

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III. Agenda

09:00 – (20 mins) **| Welcome and Charge for Meeting**

a. RCN Context and Meeting Objectives (F. Muller-Karger) (5 mins)
b. UN Decade on Ocean Science for Sustainable Development (Updates) (M. Leinen) (10 mins)
c. Q&A (5 mins)

09:20 – (15 mins) **| Briefing from The National Ecological Observatory Network (NEON)**

a. Models for short-term achievements in Earth observing (T. Gulbransen)

09:35 – (45 mins) **| OceanObs Priority Initiatives – Part I**

a. Introduction and objectives (5 min)
b. Post-OceanObs'19 community action (3 mins each)
   - Integrated Ocean Observations - Coastal to Global (S. Kim)
   - Integrated Ocean Observations – Multidisciplinary (M. Cronin)
   - Governance (T. Tanhua)
   - Interoperability (J. Pearlman)
   - Data Integration with User Products (J. Hausman)
   - Tech Infrastructure (B. Howe)
   - Marine Debris (N. Maximenko)
   - HABs (C. Anderson)
c. Q&A (15 minutes)

10:20 – (10 mins) **| Breakout Introductions**

a. Goal of the sessions (E. Lindstrom, M. Visbeck, et al.)
   1. Anticipated goals of the OceanObs enterprise
   2. Focus on achievable tasks over 6-12 months & identify champions
   3. All sessions should discuss interoperability and best practices

10:30 – (15 mins) | BREAK & DISPERSE

10:45 – (75 mins) | Breakout Sessions I [Parallel] – ***Develop Specific Plans and Coordination Needs***

Impacts and Applications
- Marine Debris
- Harmful Algal Blooms
- Marine Extreme Events and Hazards

Governance & Engagement
- Governance
- Capacity Development
- Community Building/Ocean Partnerships
- Blue Economy

Ocean Observing Systems
- Coastal to Global Observing
- Integrated Surface Ocean Observing
- Deep Ocean
- Ecosystems and Biodiversity

Data Management, Products, and Interoperability
- Modeling and Assimilation
- Open Data Science
- Data Integration with User Products
- Best Practices

Technology & Interoperability
- Tech Infrastructure
- Interoperability
- Powering OceanObs
- Other Technology Innovations

12:00 – (60 mins) | LUNCH [ON YOUR OWN]

1:00 – (60 mins) | Breakout Sessions Report-out and Discussion

a. 5 min report-outs on each session (25 mins)
b. Sponsors feedback (10 min)
c. Q&A (15 min)

2:00 – (40 mins) | OceanObs Priority Initiatives – Part II

a. Post-OceanObs'19 community action (3 mins each)
   - Blue Economy (R. Rayner)
   - Powering OceanObs (C. Schmaus)
   - Deep Ocean (P. Heimbach)
   - Ecosystems and Biodiversity (M. Estes)
   - Open Data Science (C. Gentemann)
   - Capacity Development (A. Valauri-Orton, B. Arbic)
   - Community Building/Ocean Partnerships (J. White)
   - Modeling and Assimilation (S. Akella)

a. Q&A (15 minutes)

02:40 – (75 mins) | Breakout Sessions II [Parallel] – ***Finding commonalities, cooperation, and integration***

Impacts and Applications
- Marine Debris
- Harmful Algal Blooms
- Marine Extreme Events and Hazards

Governance & Engagement
- Governance
- Capacity Development
- Community Building/Ocean Partnerships
- Blue Economy

Ocean Observing Systems
- Coastal to Global Observing
- Integrated Surface Ocean Observing
- Deep Ocean
- Ecosystems and Biodiversity

Data Management, Products, and Interoperability
- Modeling and Assimilation
- Open Data Science
- Data Integration with User Products
- Best Practices

Technology & Interoperability
- Tech Infrastructure
- Interoperability
- Powering OceanObs
- Other Technology Innovations

4:00 – (15 mins) | BREAK

4:15 – (45 mins) | Breakout Sessions Report-out and Discussion

a. 5 min report-outs on each session (25 mins)
b. Sponsors feedback (10 min)
c. Q&A (10 min)

5:00 – (15 min) Open Discussion

5:15 – (15 mins) | Summary and Next Steps

a. Review Major Outcomes (F. Muller-Karger)
b. Actions and Follow-on Activities (E. Lindstrom, J. Newton)
c. Concluding Remarks (M. Visbeck)

5:30 – Workshop Concludes

IV. ***Welcome + Charge for Meeting*** **| F. Muller-Karger, University of South Florida**

A. RCN Context and Meeting Objectives

F. Muller-Karger opened the meeting and explained the charge of the day. The goal of the meeting is to help find a way to move forward from OO19. The community will define priorities and integrate disciplines by bringing different groups together over the long-term. He noted the importance of community leaders to volunteer to take initiative for selected priorities.

B. ***UN Decade on Ocean Science for Sustainable Development (Updates)*** **| M. Leinen, Scripps Institution of Oceanography**

M. Leinen provided a summary of the 2018-2020 preparatory phase for the UN Decade and discussed the high-level goals identified. The IOC has designed a "roadmap" and will begin communicating with the community about the decade and developing basic plans starting January 2021. The Ocean Decade will serve as a framework for international collaboration and will rely on the community to help develop specific activities. This should include input from philanthropic societies and the private sector. People can start getting involved by attending the Ocean Science Meeting 2020 town halls, reviewing the science plan that will be released in April of 2020, and by proposing ideas nationally and internationally. M. Leinen noted the importance of incorporating capacity development initiatives and early career scientists into the decade.

C. Discussion:

- A question was asked--For the draft coming out in April and the final plan presented in June in Lisbon, will the comments still be integrated?
    - M. Leinen noted that they will do their best. M. Visbeck also noted that there are many more meetings that can be used to elevate ideas to community and fill the framework, and that comments do not have to be submitted right away to be integrated.
- A question was asked-- Is the capacity development plan on the same timeline?
    - M. Leinen confirmed it will be part of the implementation plan as well as the communications plan. The IOC wants the world to know that it is the UN Decade of Ocean Science. It was also noted that the community is very aware of the fact that most of the senior people in planning might not be active in doing research at the end of decade. This indicates that it is really the decade of Early Career individuals and IOC plans on incorporating members of that community into the planning group.

V. ***Briefing from The National Ecological Observatory Network (NEON)*** **| T. Gulbransen, Battelle**

T. Gulbransen provided a briefing on the National Ecological Observatory Network (NEON). NEON is an NSF-funded large facility project operated by Battelle Memorial Institute. NEON comprises terrestrial, aquatic, atmospheric, and remote sensing measurement infrastructure and cyberinfrastructure that

deliver standardized, calibrated data to the scientific community through a single, openly accessible data portal. NEON infrastructure is geographically distributed across the United States, including Alaska, Hawaii and Puerto Rico, and will generate data for ecological research over a 30-year period. In summary, the NEON is a continental-scale ecological observation network that collects and provides open access data and archival samples from 81 field sites across the United States that characterize and quantify how our nation's ecosystems are changing.

There has been dialogue among regional and global ocean observers on how to effectively bring together a coherent process of traceable (and perhaps even standardized) ocean observations and use these to understand, analyze and predict the state of the ocean. The NEON presentation by T. Gulbransen was invited to provide insight into how interoperability was created for ecosystem monitoring. Guiding the efforts (under NSF funding) is a Science, Technology and Education Advisory Committee, which provides strategic advice to Battelle, the NEON Principal Investigator (PI), and NEON Project staff on the planning and operation of the NEON Project. In addition, there are 25 Technical working groups consisting of volunteers. Keys to interoperability are the use of a controlled vocabulary, varied ontological maps to express state and data, outreach and education to promote and build leaders and a single portal that provides access to all of the information from NEON's 175 data products from instruments and observers. These products, which may support understanding of one or more of the NEON seven Grand Challenges and the related Key Questions, derive from coordinated sampling across disciplines. The observatory design framework is driven by identified societal issues that then guide the requirements decisions. The design framework uses a flow down process, where the high-level requirements are parsed into which phenomena to observe, what to measure, the scales of location and time that are most important and the feasibility of making the measurements in a practical and consistent manner. Overall, there are decisions on quality assurance, consistency of processes and instruments and the degree of data FAIRness that should be core to the system from observations to products.

T. Gulbransen addressed parallels between NEON and ocean observing. He illustrated commonalities of the NEON challenges and questions with the societal considerations of the Framework for Ocean Observing (FOO). NEON uses the fitness for use via the Traceability Framework. T. Gulbransen then drew parallels between US IOOS and NEON and identified 11 annual operational tactics in common. These are:

- Further develop a unified approach to ingest/standardize/publish biological data;
- Build communities of practice around components of the observing system to provide recommendations and guidelines for measuring & QAQC EOVs;
- Sponsor community workshops to promote new data stewardship services and train data practitioners;
- Set criteria for regional certification and conduct regular reviews and audits to ensure compliance with government data standards;
- Implement the Data Management and Communications (DMAC) core capacity requirements with IOOS RAs and interagency partners through webinars and annual DMAC meetings;
- Enable more standardized interdisciplinary and integrated products across regions;
- Develop tools that integrate data across networks and regions;
- Promote IOOS products and services;

- Represent IOOS on agency, interagency, and international committees leveraging IOOS expertise and investments to build capacity;
- Continue co-development of DMAC tools; and
- Support outreach and education efforts in NOAA and the regions.

There are differences also between NEON and IOOS. The former is a more monolithic "system" across its 81 sites. Using the NEON model, T. Gulbransen suggested areas that would increase interoperability:

- Feature successes of "Measure once, use at many scales"
- Incentivize interoperable outcomes via Contract/Grant Terms
- Science Summit for large teams, coding, broader engagement
- Centers of Excellence to bridge expertise
- O&M continuance beyond grant or monitoring campaign

Many of these may apply to the ocean communities and looking at what NEON has been able to do for ecological sciences addressing complex issues may be a stimulus for increased dialogues in ocean research about interoperability.

VI. General Themes: Short Plenary Statements on OceanObs Priority Initiatives [AM SESSION]

A. Integrated Ocean Observations - Coastal to Global | S. Kim, KAIST

S. Kim provided an update from the Coastal to Global community. After the initial gathering at OceanObs'19, participants and leads focused on key efforts such as the expansion of the Essential Ocean Variables (EOVs) with the integration of collocated sampling of biological and biogeochemical parameters [e.g., Ocean Gliders Boundary Ocean Observing Network (BOON)]. A second key effort included capacity building and the opening of a 2020 PICES Spring School in Japan focused on coastal observations and analysis of physical, biological, and biogeochemical variables. A third effort was focused on predicting the Global Coastal Ocean. Prediction was described as improving ocean sampling design, advancing data management, and improving forecast skill with ocean modelling systems. This effort was initiated and discussed at the UN Decade Regional Workshop in Venice, Italy in January 2020. S. Kim described the community goals for the meeting which included sharing on-going observations, capacity building, and data services from coastal to global scale. The second goal included identifying the synergy of observations which comes from using ocean modelling systems and theories.

B. Integrated Ocean Observations – Multidisciplinary | M. Cronin, NOAA

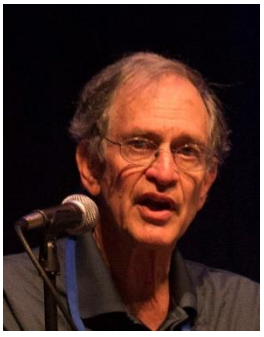
M. Cronin provided an update from the multidisciplinary, integrated ocean observation community. After the initial gathering at OceanObs'19, participants and leads focused on the creation of an "Integrated Surface Ocean Observing System" (ISOOS). This idea was generated on the principle recommendations which emerged from the OceanObs'19 Breakout session "Integrated Ocean Observing Systems: Meeting Diverse Stakeholder's Needs." The three recommendations developed were: (1) Observation systems should be multipurpose and multidisciplinary, (2) Data should be FAIR, open, and free, and (3) Communication among stakeholders should be strengthened and new stakeholders engaged. M. Cronin described the community goals for the meeting which included the identification of stakeholders and champions

for expansion of observations for multi-disciplinary and multifunctional ISOOS. The second goal included identifying relevant OceanObs'19 Community White Papers (CWP) and Common Recommendations and developing a roadmap of activities across the different communities (e.g. weather, climate, carbon, biology and ecosystems). The final goal was to vet a draft proposal for a Task Team which would report to GOOS OOPC, IOCCP, and Biology & Ecosystem Panels. The proposal included a terms of reference, list of potential members, 1-2-year deliverables, and a proposed budget.

C. Governance | T. Tanhua, GEOMAR

T. Tanhua emphasized the need to harmonize gaps and principles, improve learning, sharing, conflict resolution, and develop a network of actors. Currently, governance is very much in the middle of the governance spectrum, and community discussions indicate that regional governance and stakeholder communication is key. T. Tanhua suggested the commissioning of a working group to develop a revised governance system. The discussions should now focus on community engagement and the "collective impact" theory and how it influences multi-level, polycentric systems. He emphasized that the RCN discussion should be a continuation of engagement with the community.

D. Interoperability | J. Pearlman, IEEE, FourBridges

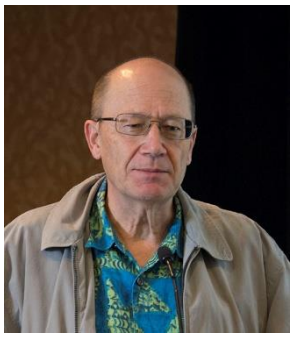


J. Pearlman presented on Interoperability, as it was a major theme in the OO19 conference and was addressed by many breakout sessions. Interoperability has many facets that go beyond the use of Best Practices. The resulting message was that action should be taken. The challenge moving forward is to tie together various aspects of interoperability, involving the entire value chain (multidimensional). For example, one of the elements must deal with interfacing systems of platforms. Another facet relates to modeling. For modeling, a concept was raised if it is possible to have a baseline or reference model outcome that all modelers can test against in their application to oceans. Other elements of importance include data quality, and training. J. Pearlman defined interoperability as a characteristic of a product or system (whose interfaces are understood) to work with other products or systems. A list of efforts following OceanObs'19 was reviewed. An international workshop on "Evolving and Sustaining Ocean Best Practices" (OBP) was held in December in Ostend and an OBP session was conducted at the India Regional Decade meeting in early January. Capacity Development will evolve and make use of the IOC Ocean Teacher Global Academy (OTGA) for web-based Interoperability training. An initial discussion about a possible Working Group on Interoperability was conducted in Brussels in early February. The goals for this RCN meeting included defining areas where improved interoperability will have the greatest impact (for multi-disciplinary efforts) and documenting benefits and impacts of a multi-disciplinary interoperability working group.

E. Data Integration with User Products | J. Hausman, NASA JPL

J. Hausman provided an update from the Data Integration for User Product community. Recommendations addressed at OceanObs'19 described how the science community can be made to understand the long-term benefits of data stewardship and management. Additionally, it was noted that data providers should enhance the quality of user products and be made interoperable. Efforts after OceanObs'19 include working with Earth Science Informatics Partners (ESIP) Marine Data Cluster and planning a workshop at the ESIP summer meeting to strategize on how to better connect the informatics communities to the science communities. The goals of today's meeting include determining funding agencies that can incentivize management and get low level centers to distribute data and make it more accessible.

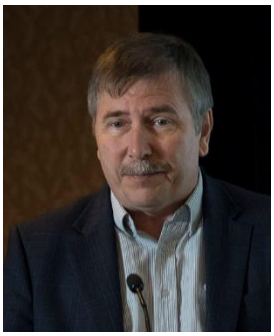
F. Tech Infrastructure | B. Howe, University of Hawaii



B. Howe provided an update from the Technology infrastructure community. After the initial gathering at OceanObs'19, participants and leads focused on key efforts surrounding SMART cables, acoustics, and international working groups. Developments in SMART cables include an Indonesia cable-based tsunami warning system, partial funding of a New Caledonia-Vanuatu cable system, a cable industry SMART roundtable, and a JTF SMART workshop planned for June 3, 2020 in Lisbon, Portugal. Acoustic developments include a submission of "Future Arctic Ocean Observing System'' to EU NFRADEV-Design studies, a proposed INTAROS follow-on, and a continuation of IQOE efforts. B. Howe noted that little progress had been made on the technology infrastructure international working groups.

B. Howe described the community goals for the meeting which included the identification of modeling, simulations, OSSEs, integration of science, cable reuse, and increased engagement of governments, banks, NOAA, NSF, OSB, NAS, etc. for SMART cables. The second goal which focused around acoustics included collecting information for a terms of reference for the Arctic Observing Workshops. The third goal focused on identifying a strategy forward for international working group engagement.

G. Marine Debris | N. Maximenko, University of Hawaii



N. Maximenko provided an update from the Marine Debris community. After the initial gathering at OceanObs'19, participants and leads focused on a number of key efforts. The first effort included the continuation of work with the G7 and G20, UNEP, and national legislature with the marine debris community acting as experts and reviewers. The second effort included building interdisciplinary science via large-group reviews of marine debris physics and remote sensing. The third effort included developing information systems with GOOS-appointed representatives and building a presence in scientific and engineering (SCOR, PICES, ICES, EU/TGML, IEEE, etc.) and science teams

(e.g., ESA & NASA Earth satellite missions). N. Maximenko described the community goals for the meeting which included coordinating an observing system to assess the baseline and monitor trends in response to measures (e.g. single-use plastic reduction, improved waste management, production and recycling) planned during the UN Ocean Decade. The second goal included planning the setup of data centers, repositories, and infrastructure, harmonization and optimization of protocols, and use of best practices to facilitate interoperability among stakeholders and with other Priority Initiatives. Final goals were the identification and implementation of mature observational technologies (e.g., satellites and in situ sensors) to obtain consistent global coverage and long-term monitoring as well as identifying sponsors and securing funding.

H. HABs | C. Anderson, Scripps Institution of Oceanography

C. Anderson reported on post OceanObs'19 HAB efforts. There was a successful proposal to create a comprehensive HAB observing and early warning network in California under the sponsorship of the CA Ocean Protection Council. Ten Imaging FlowCytobots (IFCB) will be positioned on piers and moorings. An IFCB is an imaging-in-flow instrument that combines video and flow cytometric technology to capture high resolution images for plankton identification (typically on the scale of 1micrometer). It also measures chlorophyll fluorescence associated with each image. Since HABs are organism dependent, the ability of IFCB to identify to genus and, in some cases, to species can contribute to HAB management.

The California IFCB network will serve as a prototype for scaling technology and data management strategies to other areas (Priorities _#1-3 from OO'19). Another step is to create a national resource for HAB data. This was proposed to NOAA recently. This would benefit from automation of in situ observations and a workshop is planned on this subject later in the year in Sweden. Another area needed for effective management is better modeling. There is a GlobalHAB Modeling and Prediction Workshop planned for Glasgow in May 2020.

Looking forward to supporting HAB activities, several actions are envisioned which were raised at the RCN workshop. Identify programs where HAB sensors can be integrated into existing platforms and have real time data available. To leverage this and existing measurements, the linking of observations and models into an effective early warning framework is needed. This includes funding opportunities in both areas and the expansion of alliances with key partners to provide a sustained environment. An example could be the HABON (HAB observation network) in the US.

I. Discussion:

- A comment was provided-- N. Maximenko's description of marine debris activities fit into functions of the observing system that would be multidisciplinary.
    - J. White noted that a multidisciplinary observing system called for collaboration with funding agencies. The NAVY is very visibly absent from this conversation; the community needs to get them excited again and consider them in breakout sessions moving forward.
        - A question was asked--How can we bring other nation's Navies into the conversation?

- J. White answered that we need senior cabinet level leadership to make ocean observations a priority in their topics. M. Leinen suggested the IOC as a forum to activate the Navy as they are all governmental representatives.

- M. Visbeck noted that other stakeholders, such as the private sector, need to be discussing ocean observations. It could be amazing if shipping vessels had sensors that provided researchers with data. It is important to bring all the stakeholders into the conservation and mobilize them.
  - T. Gulbransen asked how to improve marketing and storytelling.
    - A suggestion to improve this community wide gap included the development elevator talks and integrated stories.
  - T. Tanhua responded to M. Visbeck's comment. We have to work with other nations to find ways to make a marine research application framework and have it operate in various countries.
  - H. Sagen commented that the US Office of Naval Research (ONR) has had many years of collaboration with Scripps in the US and doing acoustics in the Arctic. How can we propose further collaboration for the Arctic? Arctic research and observations are strongly dependent on the funding and development of an acoustic system. It is vital to synchronize funding which can be done with ONR. Funders in the US, Norway, Europe need to come together and discuss real collaboration options.

  - M. Visbeck noted another important set of actors--citizens. They want to engage in a productive way. We need to engage citizens and colleagues by developing global technology that is simple to use and can help those individuals partake. Low-cost sensing and other emerging technologies can help with this.
  - J. Newton responded to T. Gulbransen's question on marketing and noted the importance of citizens/end users. The IOOS system has emphasized working and connecting with users, providing quotes from fishers, city planners, etc. Stories and quotes from these collaborations have been published on the IOOS website and these make a huge difference when advocating.
  - A question was asked regarding stakeholders--WMO will be restructuring and want to have a more service-oriented approach. Will the IOC adjust to that?
    - M. Visbeck noted there is a process. There is a very strong partnership between IOC and WMO and there are a lot of ocean observing committees vital to WMO missions which are

also part of the IOC. We need to be actively participating in that dialogue and identify other partnerships that would really help us.

- T. Tanhua also responded that in the reform process, FAO is a partner we should reach out to.
- M. Leinen commented that the executive planning group has been highlighting the need to IOC for partnerships. It is also important to consider the open data issue. They would like to see something developed for ocean data that has incentives built into it as WMO is restructured.

VII. *Preparing for Breakouts: Breakout Outline, Goals and Introductions*

A. Goal of the sessions | M. Visbeck, GEOMAR and E. Lindstrom, Saildrone

M. Visbeck and E. Lindstrom introduced the five, overarching breakout sessions and the associated goals. E. Lindstrom noted that resources migrate towards the best organized and most executable plans that have demonstrable impact. With the amount of competition in the community, just going to DC with lofty words doesn't work. Testimonies and other methods of communication are vital for an organized approach and to not be a "dog's breakfast." We need to surface information, synthesize it, and move it up the system to create a GOOS that is more than just the sum of its moving parts. M. Visbeck noted that now is the time to benefit from lofty words and turn it into action. The system is looking for concrete plans and ideas which support integration and not just serve your own purpose.

VIII. *Breakout Sessions: Report Out + Discussion in Plenary [AM SESSION]*

A. Impacts & Applications

F. Muller-Karger reported on the outcomes of the Impacts and Applications breakout session. The report out template asked the session participants to develop specific plans and coordination needs for the subtopics within the session organization. The subtopic milestone identified for *Marine Debris* was the creation of a catalog global marine debris observations (regional to global). This catalog would encourage the finding the linkages between different marine debris organizations/programs (i.e. EMODnet, NOAA Marine Debris, GOOS, US IOOS, others). The POC for this milestone action is N. Maximenko. The subtopic milestone identified for *HABs* was finding the linkages with different HABs organizations, programs, and observers (GlobalHABs/IOC/FAO/IOCCG/COCLIME). The POCs for this milestone action are C. Anderson, H. Moustahfid, and D. Turk.

B. Ocean Observing Systems

Participants discussed gaps, primarily the idea that as a community, we need to "sing from the same song sheet." We need to sell the value of the ocean to every stakeholder/user in a language that resonates with them. This can be accomplished by getting in touch with science communicators and social scientists, creating a pitch team that includes these communicators as well as scientists, and engaging stakeholders

to understand how these initiatives will affect them. M. Leinen and E. Lindstrom are the proposed leaders of this action. Participants also offered some specific actions around the surface ocean observing system— identify a task team, pitch that idea to GOOS and across disciplines (biology, chemistry, and physics). A process study was suggested to inform observing system design related to the Southern and Surface Ocean, to be led by S. Gille. This study should look at issues including scaling, coverage, and platform interoperability. Other participants spoke to the value of academia and industry connections. These groups don't want to be seen as funders with deep pockets, but as partners. Vessels of Opportunity was suggested as an example partner. Others remarked that research proposals should always include data and communications components.

C. Technology & Interoperability

B. Howe and C. Schmaus reported on the first technology and interoperability session. The session attendees addressed specific areas and technologies reflecting the breakout participant interests. These included the smart cable initiative, acoustic monitoring in the arctic, marine renewable energy for observing systems, and interoperability.

SMART Cables:

The smart cable initiative is focused on building a global constituency for use and interoperability of seabed communication cables for ocean observation. In moving forward, they plan to hold meetings, to work with the world technical standards association with the goal of getting a resolution proposed at an international assembly. The interactions include various ministries in some governments, development banks (funding), research and education networks (moral support). There is consideration of writing a white paper on cable reuse. In support of all these activities, there is a need to understand the benefits and impacts of smart cable observations. Thus, there is a need for modeling and operational simulations for smart cables.

Multipurpose Acoustics in Arctic:

Acoustics in the Arctic provide a wide range of ecological and physical information including undersea measurement of physical conditions, positioning, noise monitoring, etc. There is a need to set up working groups to explore and specify acoustic and energy requirements for different classes of Arctic services. The initial work can be in observation demonstrations and the expansion of modeling and OSSEs that address the Arctic environment.

Marine Renewable Energy:

The Water Power Technologies Office at the Department of Energy is launching the DEVELOP (design and build) Competition of the Ocean Observing Prize – a prize that challenges innovators to pair marine renewable energy with ocean observing technology – this summer. This prize specifically focuses on technology relevant to end users of ocean observing and aims to provide commercialization pathways for competitors following the conclusion of the prize. In support of this prize and the Powering the Blue Economy Initiative, the Water Power Technologies Office

will host a special session at the IEEE Oceans Fall 2020 conference. They will also stay engaged with OceanObs'19 activities.

Interoperability:

As new sensors and technologies become available, best practices and standards should become available for their calibration, operations and interfaces with platforms and data repositories. This work can be provided to the ocean observing community through the Ocean Best Practices System.

D. Governance & Engagement

T. Tanhua reported on the breakout session for governance and engagement. The group identified four subtopics at the first stage of governance systems and discussed potential for integration. The first subtopic, governance, involves the need to map the current ocean observing government system to realize changes. POGO has started and GOOS may work with them on furthering the initiative. The economic value of a well-functioning observing system on a basin scale should be considered. Participants identified the second subtopic as capacity development. A draft prospectus has been circulated and the plan is to finalize that draft into a white paper on how to engage different actors and create synergies. The community building and partnerships subtopic discussion identified some best practices in building partnerships and noted the need to develop more. It would be valuable to examine the idea of a Collective Impact Organization and how it would look in the ocean observing world. Perhaps initiate a task team to look at these kinds of things. The final subtopic identified was the blue economy. The whole value chain of ocean observing should be mapped to put in this context. It was recommended to develop a business case and build a repository of examples and case studies. Other ideas not grouped into subtopics included creation of an ocean reward system and having a group look at funding of ocean observing systems through means other than traditional science funding.

E. Data Management, Products, and Interoperability

C. Gentemann and A. Waite reported on the data management, products and interoperability session. The group noted that everything we do is to enable transformative science, underpinning almost every other group at this meeting. Several different subtopics were discussed and a strategy for formalizing initiatives was developed. In the subtopics, many of the same issues were encountered, and development of best practices through production of infographic/document, and training via training camps, summer schools, and networking international consortiums were considered as a path forward. The strategies for action for formalizing initiatives included a four-point plan designed to move all sub areas forward in substantial and consistent fashion and identifying linkages that are going to enable interdisciplinary science in the next decade. It was noted that reducing obstacles to getting data where it needs to be and in the right format. It is key to organize communities into data informatics communities, policy communities, funders, etc. – making some of those types of data management systems mandatory from the

funders. Data management should have their own budget line within the project. There are actions to get data transferred between scientists and data scientists; map the system in how data flows and identify pinch points; remind people that utility of data can be harnessed as proof of impact; improve academic culture (some systems in Europe and elsewhere encourage setting up proper data systems from the get go).

F. Sponsor's Feedback:

- C. McLean noted that everyone is inspired by ideas of marketing, finding sponsors, associating names with leadership of groups. The approach is a successful way to move forward and C. McLean noted that regional workshops are nowhere near this strategic. Here, we are looking at how you get there (important). He also highlighted that at a decadal level, it is important to push a little more aggressively on data. Requiring the deposition of data and tying it to financial assistance awards from funding agencies can be a strategic move. Overall, the community needs to change academic culture a little and consider how we translate the latest additions as well as bridging successful ideas to sustainable mechanisms.
- E. Lindstrom commented that the Framework for Ocean Observing was completed about 10 years ago. It is a great guide with common language about the system, but at the time this outcome was envisioned too soon to have an actual definition of a global ocean observing system. The community needs to develop a complete definition of the capabilities and functions of such a global system. Ten years later, we still don't have a perfectly crystal-clear definition of what we're trying to manage. He noted that some of the sub-bullets need to really must flow down from a precise definition of what is in the system. We, as a community, are struggling with and need to come to grips with it soon.

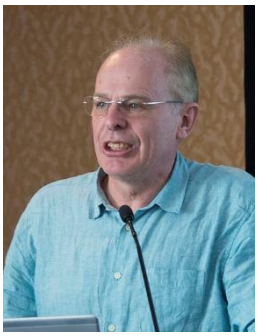
  - T. Gulbransen noted that some community members see GOOS as a platform, not a system that is delineated with boundaries. It was noted that if making a system, we need to first pick clients/stakeholders/end users.
  - J. Pearlman added that no uniform, consistent request for capabilities (sensors, platforms, etc.) has come from the community that can allow for mass production and lower costs. We need feedback from industry in this respect.
- M. Visbeck noted that what was missing after OceanObs'19 was one-two overarching recommendations. He asked if there was something that brings us together or connects us all, that would be attractive to a funder.
  - C. Gentemann noted that interoperability and open science is a theme that comes across. Other commenters noted that an ocean observing integrated system is a big idea to get behind. A. Waite noted that the UN has made huge efforts to connect with communities. The community needs to get these agenda points to workshops more clearly. We need to step up to a regional scale and

match that UN scaling so we can have a proper conversation with them via a volunteer system.

- J. White commented that a part of engagement that has been discussed is with resource funders. Many funders/sponsors look at ocean observing as a research-driven business. Meteorological funding is an operations-driven business. It is important to think about this in crafting and impacting decision makers who are also funders. He also asked when the community looks at building a collective impact organization, what are the types of partnerships needed and who has been successful in bringing in industries and other sponsors/stakeholders.
- T. Tanhua noted that we should be looking at examples of where/how that's been done and turning that into best practices approaches.

IX. General Themes: Short Plenary Statements on OceanObs Priority Initiatives [PM SESSION]

A. Blue Economy | R. Rayner



R. Rayner provided an update on the Blue Economy developments. Over the last few years, the community has developed a good understanding of the scale of blue economies at global and national levels. Now we need to understand, articulate, and value how observations will support that. We need to bring together disciplines/connections for impact; develop standardized methods for mapping the value chain; create a repository to capture the resulting case studies, and we have made good progress on all three items. We have had quite a lot of individual workshops/meetings about valuation in different disciplines. Initiatives are ongoing about mapping the value chain and standardizing approaches to that purpose. OECD is about to launch a substantial survey on this topic. We have scoped out what a catalog might look like, and what support, and engagement would allow us to build a prototype.

B. Powering OceanObs | C. Schmaus, DOE

C. Schmaus provided an update from the US Department of Energy's Water Power Technologies Office and their Powering the Blue Economy Initiative, specifically, activities related to the Ocean Observing Prize. At OceanObs'19 and later at the Oceans 2019 Conference in Seattle, NREL/PNNL presented an article entitled "Enabling Power at Sea: Opportunities for Expanded Ocean Observations through Marine Renewable Energy Integration"[Green, et al. 2019]. In October 2019, WPTO opened the Ocean Observing Prize, a challenge to pair marine renewable energy with ocean observing platforms, across five themes: unmanned/uncrewed vehicles; buoys, floats, and tags; underwater communications; extreme environments; and blue sea ideas. The DISCOVER (concept/ideation) phase closed on February 12, 2020 and the DEVELOP (design and build) phase will be focused on one theme. PNNL/NREL explored five use cases of powering various ocean observing devices with marine energy. C. Schmaus described the community goals for the meeting which included continued strengthening of the tie between the marine energy and ocean

observing community, identifying high potential, near-term areas of collaboration, and envisioning the future ocean observations without energy constraints.

C. Deep Ocean | P. Heimbach, University of Texas, Austin

P. Heimbach explained that the Deep Ocean Observing Strategy (DOOS) is a project within GOOS that observes deep ocean effectively. The science of why this project is needed is clear, and pointed to the Community White Paper from Ocean Obs'19 on the topic [Levin et al 2019]. Since OO19, there have been contributions to the UN Decade at a global scale through four goals: extend capacities to global scale, improve standardization of data, facilitate partnerships, and focus on observations needed for improving/developing ocean modeling for predictive capabilities. P. Heimbach also noted the NSF Accelnet iDOOS proposal to address grand challenges in science and observing deep ocean is very important. Four themes have been identified: understanding requirements needed for models/platforms and how they can communicate better; FAIR data; interoperability; and stakeholder uses. P. Heimbach commented this is an appropriate and timely endeavor.

D. Ecosystems and Biodiversity | M. Estes, NASA Ecological Forecasting & Biodiversity

M. Estes provided an update from the Ecosystems and Biodiversity community. At OceanObs'19, the community provided recommendations to advance plans for a global observing system that integrates biology, biodiversity, physical and biogeochemical observation; implement available technologies now to quantify, explain and forecast biodiversity changes; and support IOC, GEO and national programs to identify information requirements to guide ocean observing. To support these recommendations, several actions are underway through the following efforts: create a manuscript documenting needs, priorities and implementation plans; advance existing networks that integrate animal movement with other information to identify hotspots; align e-DNA with other approaches, apply acoustic technologies to evaluate health and biodiversity of reef systems; characterize plankton communities, and deep sea ecosystems; and identify regional networks to serve as hubs for implementation.

The manuscript is focused on lessons learned from the OceanObs19 conference with the target journal "Nature Communications". The bulk of the paper will be a summary of current status and needs and will build on the OO19 community white papers. Recommendations will include research that needs to be done to support ongoing development of the integrated monitoring system, including scientific research to improve understanding which will lead to new opportunities for adaptation and policy advice plus applications research. This should include both in situ and recommendations for future satellite missions and then link these data as applicable to our priorities. M. Estes noted that the goal for the meeting is to refine the list of actionable priority recommendations and develop a plan to link air-sea flux and biological observations.

E. Open Data Science | C. Gentemann, Farallon Institute

C. Gentemann provided an update from the Open Data Science community. After the initial gathering at OceanObs'19, participants and leads focused on a number of key efforts. The first major effort included a 2019 ACCESS A.46 call which aims at providing support to existing widely used open source tools and libraries. It is important to provide software management plans so that work completed is sustainable, documented, and reproducible. The second effort is the continuation of working with NASA, NOAA, and lawmakers around open data. The last effort is the publication on Open Data Science for *Oceanography.* C. Gentemann described the community goals for the meeting include discussion of overarching themes such as Open Data Science, interoperability, and Cloud Computing, understanding barriers in communities, technology, and funding, and the integration of OceanObs efforts with open science platforms.

F. Capacity Development | A. Valauri-Orton, The Ocean Foundation and B. Arbic, University of Michigan

A. Valauri-Orton provided an update on the Capacity Development initiatives. After OceanObs'19, the community has been setting priorities and establishing funding for capacity development during the decade of ocean science. Priorities include working on the initial OceanObs'19 recommendations proposed the creation of a community of practice, align efforts with community needs and realities, and create venues and opportunities for dialogue about capacity development. A prospectus has been developed outlining a strategy for the community, the first draft will be presented at an upcoming Town Hall at Ocean Sciences (Feb '20). The Town Hall will provide an opportunity for community feedback. Following initial feedback, the prospectus will be presented at the UN Ocean Conference (June '20) and deliver the consensus document to global leaders and funders as well as aim to have an initial pledge of funding announced. The prospectus will contain a Google survey to collect feedback on the draft being presented at the Ocean Science Meeting so that a second draft can be delivered at the conference in June.

G. Community Building/Ocean Partnerships | J. White, Consortium for Ocean Leadership

J. White provided an update on community building and partnership activities following OceanObs'19. A Town Hall has been scheduled for Ocean Science Meeting 2020. The session will focus on what a "collective impact organization" could look like and what partnerships does it include. The following discussion points will be addressed: matching and examining needs and priorities, showing funders/resource sponsors the community priorities, and identifying engagement opportunities with resource funders. A collective impact organization would address scientific needs, economic analyses & expertise, priorities, best practices, and end user partnerships. J. White noted that the goal for today's meeting is to identify how to sustain ocean observing and determine best practices through the examination of scientific needs,

identification of community priorities and best practices, and enhancement of partnerships and identification of new stakeholders/end users.

H. Modeling and Assimilation | S. Akella, NASA

S. Akella reminded the participants that one of the important things agreed upon was to organize workshops/meetings. These sessions help us connect models and observations, for example, the case of biogeochemical observations that need to be gathered and assimilated into models. It would be useful to connect the Ocean Predict and OceanObs Communities and synthesize best practices and interoperability requirements.

I. Discussion:

- M. Visbeck commented going into OceanObs'09 there was a hope that an outcome would be informing what a good observing system looks like. We haven't seen an organized effort since, so is that something we can see as a major initiative, to have coordinated effort?
    - C. Anderson noted that we need to engage with stakeholders to determine the right steps and have a feedback process. We can't just generate stakeholder requirements; it is a give and take. This kind of collaboration is important in observing systems, for example doing west coast reanalysis to get the modeling community on board with the observational community helps with fully integrating the system.
    - A. Waite noted that for engaging with industry, they are bringing the Economist Ocean Summit to Halifax, Canada. One of white papers from the summit is called the Digital Ocean which is a completely industry driven initiative. This could be an opportunity to fund research. If anyone is interested in helping with the efforts surrounding the summit, please reach out to A. Waite. The business community is up front and center in the conversation, and we need well-thought out conversation with industry.
    - M. Smit noted that one of the conditions of the project is to contribute to building a cluster, specifically to identify ways to build credits by sharing data with the regional community. The Canadian community has been proactive with the open sharing of data.

- J. White asked about "collective impact organizations" and if the WMO is considered a collective impact organization.
    - M. Visbeck noted that for meteorologists, many would say yes. The WMO is trying to embrace oceans/oceanography to provide services and look at the next set of capabilities.
    - T. Tanhua added that WMO has more of a regulatory framework than any collective impact organization would have.

X. Breakout Sessions [Participants broke out into separate rooms for the PM Sessions]

XI. Breakout Sessions Report Out + Discussion [PM SESSIONS]

A. Impacts & Applications

F. Muller-Karger reported on the outcomes of part two of the Impacts and Applications breakout session. The report out template asked the session participants to find commonalities, cooperation, and areas of integration within the subtopic milestones and develop actionable items which could be achieved with a 6-12-month timeframe. The first integrated action item identified was mapping ocean hazards and ocean uses in collaboration with ESRI. The initial resources needed would be student and postdoctoral support, a pilot project, and ESRI engagement. The POC for this action is Frank Muller-Karger. The second integrated action item identified was developing an integrated observing system (i.e. ISOOS) for co-located observations, joint data management, and interpretation. The initial resources needed would be working group support to engage with the Surface Ocean Observations planning meeting. The POC for this action is the Marine Ecology Working Group which included M. Estes and G. Canonico. The third integrated action item was to converge technology development across topics (example DOOS-omics). The initial resources needed and POC are to be determined. The fourth integrated action item was cataloging impacts of debris on protected species (via debris info system). The initial resources needed and POC are to be determined. The fifth and final integrated action item identified was to synthesize recommendations of the OO19 community white papers and OceanObs RCN meetings to map to the Decade of Ocean Science for Sustainability. The initial resources needed would be $500K for an expert synthesis group. The POC for this action is to be determined.

B. Ocean Observing Systems

M. Roughan reported on the second set of observing recommendations. The first sub-topic identified was the coastal to global continuum. Participants recommended long term sustained observations (map of spatial and temporal coverage by EOV / EBV), starting with the North Pacific. This action was assigned to J. Barth and S. Kim. The second subtopic listed was ISOOS. M. Cronin will create a proposal for a task team to GOOS (joint panel), requesting feedback from the community. She will also author a paper on water, energy, heat, and momentum for the March Special Issue of Frontiers, due September of 2020. Under the deep ocean subtopic, P. Heimbach and L. Levin were proposed to investigate how to leverage existing efforts (e.g. TPOS2020). This will include coordination with Ocean Modelers – OSE/OSSE and surveying existing data portals on deep ocean needs. Requirement setting, FAIR data, Demonstration sites, stakeholder use cases will be leveraged as well. Under the ecosystem and biodiversity subtopic, it was proposed that M. Estes

would lead a paper, including satellite remote sensing (SRS), on new metrics of change. This would require around a $25K investment. M. Estes also was assigned to lead a workshop that would inventory existing infrastructure, including platforms and Ships of Opportunity, to enhance our observing system EBVs and colocation of assets. This task would also require an investment of $25-50K. M. Roughan was assigned to lead fisheries observing initiatives and M. McCammon was assigned to lead Arctic/polar initiatives. B. Howe was proposed to lead acoustics observing initiatives. Under the omics/eDNA subtopic, it was proposed that a working group should be identified to scale up current biological observing. K. Goodwin was proposed to lead this team. Under the economics subtopic, it was proposed that JPL and others could articulate the operational value of GOOS. This would require a $450-600K investment. Under the satellite remote sensing subtopic, it was proposed that GOOS would lead an inventory of their assets. The final subtopic was data warehousing. It was proposed that A. Fischer would lead an initiative to expand JCOMMOPS and create a database that would be a guide to all other databases, observing systems, and best practices.

C. Technology & Interoperability

B. Howe and C. Schmaus reported on the second session of technology and interoperability. For autonomous systems, there is a community white paper which will be issued soon in Frontier in Marine Science by C. Whitt, et al. There are strong recommendations for the next five to ten years relating to technology and interoperability. The first step is to Identify enabling technologies, starting with geolocation. IEEE will help disseminate current work in geolocation to new stakeholders and to set a framework/precedence for sharing information about other enabling technologies (eventually: autonomy) contact: C. Whitt.

For SMART cables, there is an essential need to make observations relevant for everyone. The SMART cables community needs to support NOAA and IOC's emphasis on tsunami detection and storm surge for the UN Decade of Ocean Sciences for Sustainability and plans include meeting attendance and participation in major events (Lisbon, WTSA, AGU Town Hall) contact: B. Howe/JTF and Governance Group from this event.

To make progress for technology advances for an Integrated Arctic System, there is a need to communicate both the difficulties and importance of this work. To create an Integrated Arctic System, start by raising difficulties and sharing importance around polar acoustics. We need to work with other ocean observing systems to share lessons learned and best practices. The next steps are participation in international meetings – Antarctic and Southern Ocean Forum; Arctic Observing Summit already scheduled. contact: H. Sagen and others will attend to discuss these challenges.

For Marine Energy, the breakout participants will help to disseminate information, particularly at the International Conference on Ocean Energy which is scheduled for May in Washington DC. A much larger scale effort (outside 6-12 months) is to have a catalog of what ocean observations are needed across the board and what technologies exist to address OceanObs needs. This can eventually help sponsors with knowing what to fund. For this there needs to be coordination with the Ocean Observing Systems and the Ocean Partnership groups to generate additional applications and opportunities like the Ocean Observing Prize. contact: for marine energy: J. Garson & C. Schmaus at DOE.

D. Governance & Engagement

The governance and engagement group reported on new ideas related to commonalities, cooperation, and integration that were generated during their session. Under the integration recommendations, it was proposed that J. Pearlman would lead an interoperability working group. B. McKenzie was assigned to promote a Ship-of-Opportunity Programme (SOOP) working group, to integrate the Ship Observation Team (SOT), Volunteer Observing Ships (VOS) and SOOP networks. K. Juniper was suggested as a lead to develop an observing system in response to climate engineering and adaptation needs. Under the independent actions, it was proposed that J. White would lead development of best practices for end user engagement. For advocacy efforts, it was proposed that GEO Blue Planet would help promote the benefits of an observing system by bringing together a group to implement means and methods.

E. Data Management, Products, and Interoperability

C. Gentemann and A. Waite reported on the following integrated actions for the 6 to 12 months' time span:

- Guidance document (checklist) for funding agencies
  - Initial Resources Needed: Certified Data Repository
  - Identified Champion/contact: A. Benson
- Define core competencies in ocean data science that are necessary for graduate training.
  - Initial Resources Needed: Ocean Best Practices System (student component)
  - Identified Champion/contact: M. Smit and A. Waite
- Build a bridge between technology and science
  - Initial Resources Needed: many small steps
  - Identified Champion/contact: S. Akella and M. Smit

F. Discussion:

- E. Lindstrom noted that it is vital to keep some momentum going after OceanObs'19. As a co-chair for the National Academies of Science workshop team, an opportunity to keep the momentum up is the sustained ocean observing workshop which is being planned for early fall of 2020. The workshop will be similar to the size of this RCN meeting. The secret sauce is to get people to present posters and information that can be part of a report to be presented to the government or internationally.
- F. Muller-Karger noted that it would be good to come up with a cohesive idea to unify the various threads of these different discussions. How do you organize an observing system that includes animals? Is there something that we can propose that can really bring several of these ideas together?

- T. Tanhua mentioned that a lot of concepts should connect with organizations which are not represented in this room. We must be very careful, do outreach, and see what's there.
- F. Muller-Karger noted that the whole community was not at OceanObs'19 and we need to represent their needs moving forward.

- C. Gentemann noted that a lot of the science seen at OceanObs'19 was based on two decades of open data policies that have allowed researchers to work together. Something to note which is coming in the next decade is the concept of open data science which encompasses interoperability, brings scientists together and allows them to be more open about their science, brings the whole community forward, and provides a chance for oceanography to lead the science community.

  - F. Muller-Karger noted that we should have a concrete action to help this happen.
  - J. White mentioned that in the US, there is legislation that should embrace this concept.
  - C. Gentemann agreed and noted that this discussion needs to include the international community.
  - F. Muller-Karger noted that the potential intermediate OceanObs meeting (South Africa in 2024) could be useful for this cause.
  - A comment was provided to have an action item on defining best practices and standards.

XII. Summary and Next Steps

The OceanObs'19 Conference of September 2019 was a platform to bring the community together for visioning the next ten years. The organizers grouped activities into daily themes of information, innovation and integration, which allowed addressing the board array of ocean activities within a coherent framework. The Conference Statement reflected the key points highlighted during the conference. The challenge in the months (and possibly years) following the conference is to integrate the diverse activities of the ocean research and application communities into focused efforts which can create changes in the way we do business.

The "convergence" efforts were started two months after the conference (i.e., November 2019) with the first of what is expected to be a series of virtual OceanObs RCN meetings of the OceanObs'19 organizing committee and leads of the breakout and special sessions. In this meeting, the teams reviewed their activities and goals. This set the foundation for the February 2020 RCN meeting in San Diego. The February 2020 RCN meeting was structured to encourage dialogue and clear definition of next steps. This was

successful. In one day, the meeting could address only a subset of the OceanObs'19 themes and outcomes (See **Appendix 2** for list of all OceanObs'19 recommendations). Five Breakout Sessions were organized for the community during the RCN meeting. Each of the breakouts defined specific actions and identified leads to carry these forward. Some of these actions are substantive new directions, and some are expansions of current efforts.

Three major themes emerged from the February 2020 OceanObs RCN meeting;

1. Expansion of coordinated observing systems and global scale measurements relevant to a Global Ocean Observing System. Some of these are the Deep Ocean Observing System, Surface Ocean Observing System, Seabed mapping, a HABs Initiative and Smart Cables and integration across parallel observing capabilities (e.g. VOS, SOT and SOOP, all ship observing efforts). There are some that have not yet fully emerged such as a coordinated global effort for biological observations.
2. Cross-cutting efforts that underpin ocean observing across the value chain from observations to applications and policy. Examples of there are data management, interoperability, community building, best practices, open science/open access and capacity development.
3. Resources, the blue economy and the need for expanding collaboration across the ocean research community and engagement with industry, sponsors and policy organizations.

The RCN meeting was successful in furthering the dialog within the community. It produced specific actions with assigned leads in areas covered at the meeting (See **Appendix 3** for list of actions).

One of the major issues raised during the discussions are partnerships. There were many examples where partnerships are happening in a successful manner: across international organizations (e.g. IOC and WMO), across research and the private sector (e.g. maritime operators), with research science and citizen science and across national funding agencies. Further efforts are needed as the ocean community takes a global perspective.

There are still gaps in addressing expectations in the community leading up to OceanObs'19 and the outcomes of the OceanObs'19 Conference. The OceanObs RCN is attempting to manage these gaps and focus on a process where members of the community become engaged to fill these expectations.

Reflecting on this from a decade ago, M. Visbeck commented that going into OceanObs'09, there was a hope that an outcome would be informing what a good observing system looks like. These efforts for organization are a continuing process that is ongoing. C. McLean noted that at a decadal level, it is important to push aggressively on data, its availability, and openness.

Overall, the OceanObs RCN is attempting to change the academic culture of the community, considering how we translate expectations into actions and sustainable implementation mechanisms. Participants recognized that major international ocean research efforts need to better link research and operations,

such as for example support agreements such as UN Agenda 2030 (the UN Sustainable Development Goals). OceanObs RCN seeks to facilitate consensus for paths to operationalizing research.

The participants recognized that the successful outcomes of this meeting are another step in shaping the research for the next decade.

The present national and international COVID-19 pandemic has placed a substantial burden on the traditional forms of communication in the science and operational communities. The OceanObs RCN will continue to help the community to organize itself and define priorities for implementation. Further OceanObs RCN meetings are anticipated in 2020 and another RCN meeting on the topic is being planned for December 2020 immediately prior to the AGU meeting in San Francisco. The organizers of the OceanObs RCN will continue moving this process forward under whatever conditions are presented.

Defining Essential, Executable Ocean Observing

OceanObs Research Coordination Network Meeting

February 16, 2020, 8:30 am - 5:30 pm | San Diego, California

APPENDIX 1. Attendees

1. Santha Akella -- NASA -- santha.akella@nasa.gov
2. Clarissa Anderson -- Scripps Institute of Oceanography / SCCOOS - clrander@ucsd.edu
3. Brian Arbic -- University of Michigan -- arbic@umich.edu
4. Carlos Barrera -- PLOCAN -- carlos.barrera@plocan.eu
5. Fiona Beckman -- Plymouth Marine Laboratory -- fbe@pml.ac.uk
6. Nina Bednarsek -- Southern California Coastal Water Research Project -- ninab@sccwrp.org
7. Abby Benson -- USGS -- albenson@usgs.gov
8. Agnieszka Beszczynska-Möller -- University of Maine -- abesz@iopan.gd.pl
9. Debora Borges -- CIIMAR -- debora.borges@ciimar.up.pt
10. Lance Braasch -- University of California San Diego -- lbraasch@ucsd.edu
11. Mark Bushnell -- NOAA -- mark.bushnell@noaa.gov
12. Rob Cavagnaro -- Pacific Northwest National Laboratory -- robert.cavagnaro@pnnl.gov
13. Fei Chai -- University of Maine -- fchai@maine.edu
14. Lisa Clough -- NSF -- lclough@nsf.gov
15. Andrea Copping -- Pacific Northwest National Laboratory -- andrea.copping@pnnl.gov
16. Isabel Costa Azevedo -- CIIMAR -- iazevedo@ciimar.up.pt
17. Meghan Cronin -- NOAA PMEL -- meghan.f.cronin@noaa.gov
18. Kruti Desai -- Consortium for Ocean Leadership -- kdesai@oceanleadership.org
19. Richard Dewey -- Ocean Networks Canada --rdewey@uvic.ca
20. Frank C. DiMaria -- Ocean Networks -- frank.dimaria@oceannetworks.com
21. Marcel du Plessis -- Southern Ocean Carbon and Climate Observatory -- marceldpl10@gmail.com
22. Maury Estes -- UAH/NASA Ecological Forecasting & Biodiversity -- maury.ests@nsstc.uah.edu
23. Santos Fernandes -- Instituto Hidrografico -- santos.fernandes@hidrografico.pt
24. Vicki Ferrini -- Columbia University -- ferrini@ldeo.columbia.edu
25. Peer Fietzek -- Kongsberg -- Peer.Fietzek@km.kongsberg.com
26. Nelly Florida Riama -- BMKG -- nelly.florida@bmkg.go.id
27. Hayley French -- Consortium for Ocean Leadership -- hfrench@oceanleadership.org
28. Francois Galgani -- IFREMER -- francois.galgani@ifremer.fr
29. Jenn Garson -- Department of Energy -- jennifer.garson@ee.doe.gov
30. Chelle Gentemann -- Farallon Institute -- cgentemann@faralloninstitute.org
31. Florian Geyer -- Nansen Environmental and Remote Sensing Center -- florian.geyer@nersc.no
32. Jonatha Giddens -- University of Hawaii Manoa -- jonatha@hawaii.edu
33. Sarah Gille -- University of California San Diego -- sgille@ucsd.edu
34. Kelly Goodwin -- NOAA -- kelly.goodwin@noaa.gov
35. Carl Gouldman -- NOAA - carl.gouldman@noaa.gov
36. Patrick Gorringe -- Stockholm University -- Patrick.Gorringe@smhi.se
37. Tom Gulbransen -- Battelle -- gulbransen@battelle.org
38. Michelle Harris -- NOAA -- michelle.harris@noaa.gov
39. Jessica Hausman -- PO. DAAC -- jessica.k.hausman@jpl.nasa.gov
40. Patrick Heimbach -- University of Texas Austin -- heimbach@oden.utexas.edu
41. Megan Hepner-Medina -- University of California San Diego -- mhepner@ucsd.edu

42. Peter Hill -- WHOI -- phill@whoi.edu
43. Verena Hormann -- University of California San Diego -- vhormann@ucsd.edu
44. Bob Houtman -- NSF -- bhoutman@nsf.gov
45. Bruce Howe -- University of Hawaii Manoa -- bhowe@hawaii.edu
46. Kim Juniper -- University of Victoria -- kjuniper@uciv.ca
47. Maria Kavanaugh -- Oregon State University -- maria.kavanaugh@oregonstate.edu
48. Sandra Ketelhake -- GEOMAR -- sketelhake@geomar.de
49. Sung Yong Kim -- Korea Advanced Institute of Science and Technology (KAIST) -- syongkim@kaist.ac.kr
50. Jennie Knopp -- Oceans North -- jknopp@oceansnorth.ca
51. Marjolaine Krug -- CSIR --mkrug.deff@gmail.com
52. Meredith Kutz -- NOAA -- meredith.kutz@noaa.gov
53. Wu-Jung Lee -- APL UW -- leewujung@gmail.com
54. David Legler -- NOAA -- david.legler@noaa.gov
55. Margaret Leinen -- Scripps Institution of Oceanography -- mleinen@ucsd.edu
56. Alan Leonardi -- NOAA -- alan.leonardi@noaa.gov
57. Eric Lindstrom -- Saildrone -- ericlindstrom56@gmail.com
58. Bev Mackenzie -- IMAREST -- bev.mackenzie@imarest.org
59. Andreas Marouchos -- CSIRO -- andreas.marouchos@csiro.au
60. George Matsumoto -- mage@mbari.org
61. Hanne Mauriello -- UCAR, CPAESS -- hanne@ucar.edu
62. Nikolai Maximenko -- University of Hawaii -- maximenk@hawaii.edu
63. Craig McLean -- NOAA - craig.mclean@noaa.gov
64. Michelle McClure -- Pacific Marine Environmental Lab, NOAA -- michelle.mcclure@noaa.gov
65. Andrea McCurdy -- Consortium for Ocean Leadership -- amccurdy@oceanleadership.org
66. Chris Meinig -- NOAA -- Christian.Meinig@noaa.gov
67. Jerry Miller -- Science for Decisions -- Jerry.L.Miller@sciencefordecisions.com
68. Patricia Miloslavich -- SCOR -- patricia.miloslavich@scor-int.org
69. Peter Minnett -- RSMAS, University of Miami -- pminnett@rsmas.miami.edu
70. Cliff Miyake -- Ocean Networks -- cliff.miyake@oceannetworks.com
71. Hassan Moustahfid -- NOAA -- hassan.moustahfid@noaa.gov
72. Monica Muelbert -- Federal University of Sao Paulo -- monica.muelbert@unifesp.br
73. Frank Muller-Karger -- carib@usf.edu -- University of South Florida
74. Stephanie Murphy -- Consortium for Ocean Leadership -- smurphy@oceanleadership.org
75. Kakha Nadiradze -- IATRC -- nadiradzekakha@gmail.com
76. John Orcutt -- University of California San Diego -- jorcutt@ucsd.edu
77. Klas Ove Möller -- Helmholtz-Zentrum Geesthacht -- klas.moeller@hzg.de
78. Jan Newton -- NANOOS, UW -- janewton@uw.edu
79. Terri Paluszkiewicz -- Octopus Ocean Consulting LLC -- etpaluszkiewicz@gmail.com
80. Francoise Pearlman -- FourBridges -- jsp@sprintmail.com
81. Jay Pearlman -- FourBridges, IEEE -- jay.pearlman@fourbridges.org
82. Lindsey Peavey Reeves -- NOAA -- lindsey.peavey@noaa.gov
83. Sheri Rahman - Consortium for Ocean Leadership -- srahman@oceanleadership.org
84. Ralph Rayner -- ralph@ralphrayner.com

85. Susan Roberts -- National Academy of Sciences -- sroberts@nas.edu
86. George Robertson -- Orange County Sanitation District -- robbiegeo@gmail.com
87. Nick Rome -- Consortium for Ocean Leadership -- nrome@oceanleadership.org
88. Moninya Roughan -- UNSW Sydney -- mroughan@unsw.edu.au
89. Hanne Sagen -- NERSC -- hanne.sagen@nersc.no
90. Richard Sanders -- NORCE, ICOS -- rsan@norceresearch.no
91. Stein Sandven -- NERSC -- stein.sandven@nersc.no
92. Erin Satterthwaite -- University of California -- satterthwaite@nceas.ucsb.edu
93. Carrie Schmaus -- U.S. Department of Energy -- carrie.schmaus@ee.doe.gov
94. Virginia Selz -- NOAA -- virginia.selz@noaa.gov
95. George Shillinger -- Upwell -- george@upwell.org
96. Jan Van Smirren -- Ocean Sierra -- janvansmirren@oceansierra.com
97. Mike Smit -- Dalhousie University -- mike.smit@dal.ca
98. Andreea Strachinescu -- European Commission -- magdalene-andreea.stranchinescu-olteanu@ec.europa.eu
99. Espen Storheim -- Nansen Environmental and Remote Sensing Center -- espen.storheim@nersc.no
100. Adrienne Sutton -- NOAA -- adrienne.sutton@noaa.gov
101. Sebastiaan Swart -- University of Gothenburg -- sebastiaan.swart@gu.se
102. Toste Tanhua -- GEOMAR -- ttanhua@geomar.de
103. Maciej Telszewski -- IOCCP -- mtelszewski@ioccp.org
104. Brendal Townsend -- Dalhousie University -- brendal.townsend@dal.ca
105. Alan Turchik -- National Geographic Society -- aturchik@ngs.org
106. Daniela Turk -- Dalhousie University -- daniela.turk@dal.ca
107. Alexis Valauri-Orton -- The Ocean Foundation -- avalauriorton@oceanfdn.org
108. Nathalie Valette-Silver -- NOAA -- nathalie.valette-silver@noaa.gov
109. Martin Visbeck -- GEOMAR -- mvisbeck@geomar.de
110. Anya Waite -- Dalhousie University -- anya.waite@dal.ca
111. Christoph Waldmann -- Universität Bremen -- waldmann@marum.de
112. Rik Wanninkhof -- NOAA -- rik.wanninkhof@noaa.gov
113. Jon White -- Consortium for Ocean Leadership -- jwhite@oceanleadership.org
114. Christopher Whitt -- cwhitt@ieee.org
115. Dawn Wright -- ESRI -- dwright@esri.com

APPENDIX 2. OceanObs'19 Session Recommendations

OceanObs'19 Breakout Session	Key Recommendations
A Sustainable, Fit-For-Purpose Ocean Observing System: Responding to User Needs	● Feedback processes with identified users and resource stakeholders are needed from the beginning and should be reviewed on an ongoing basis to identify what is fit-for-purpose for users and societal benefit (and to adjust as needed). ● Case studies can highlight the value of ocean observing information products so that nations will want to commit to sustained ocean observing activities. ● Take into account existing pieces, commitments and regulations for developing a fit-for-purpose ocean observing system.
An Ocean of Data: NOAA's Roles in Marine Extreme Events and Hazards	● Bring in core mission stakeholders earlier on in the development of research and technology so that we are developing around needs and, in tandem, providing the necessary communication and education from the onset. ● The architecture of ocean observations is changing. Be more adaptive to changing technology and focus efforts on transitional systems while maintaining data records. ● Research to operations transitions are key in developing systems with broad reaching impacts and societal benefits and should be a focus from the onset of research questions to support issues and needs on multiple scales.
Arctic Observing Systems	● By 2029 the Arctic should prominently demonstrate it has a fully developed, implemented and sustained ocean observing system that meets – at a minimum, earth system prediction needs – but also meets other critical Arctic societal benefits. ● Development of an Arctic node or regional alliance under the umbrella of a global observing framework such as GOOS should be given serious consideration by the Arctic community. ● Arctic observing planning and implementation should draw on the principles of co-production, co-design and co-management of observing systems, with inclusion of Indigenous and local communities from the outset.
Blue Economy and Sustainable Development	● Fostering transdisciplinary research – active cooperation between economists, other social scientists and the ocean scientific communities. ● Mapping ocean observations' value chains in cooperation with interested data repositories, as to inform practitioners and policymakers with original evidence-based analysis on the growing links between ocean observations and many sectors of the economy. ● Establishing a catalogue of case studies of the socioeconomic benefits of ocean observations, measurement and forecasting, so that they can be readily accessed, grouped and extracted.

Building an international Transparent Ocean Community	● Transparent Ocean Initiative will greatly contribute to the UN Decade of Ocean Sciences for Sustainable Development by providing vital information relevant to the development goals. ● It is essential to integrate observations, process studies and prediction/projection, to meet multiple demands of end users. ● Strengthened effort is needed to meet challenges of effective communication between the science and research community and the general public.
Capacity Building	● Create a community of practice for those working in capacity development to share resources, catalogue existing efforts, create a unified agenda and funding request, obtain funding, and ensure sustainability of efforts. ● Align efforts with community needs and realities – make sure training matches available equipment, create regionally specific best practices including for import/procurement of equipment, ensure easy and sustainable maintenance. ● Create venues and opportunities for dialogue about capacity development between scientists, high level decision makers, local implementers, and other stakeholders.
Climate Change and Variability	● Augmentation and refined definition of the Global Climate Indicator framework: towards a comprehensive Earth system view ● Achieve accuracy targets for EOVs / ECVs to provide ocean related global climate indicator at required accuracy ● Reduce capability gaps for EOVs / ECVs measurements under the ocean related global climate indicator framework
Community Building and Dialogue	● Develop common principles and best practices for user engagement, which are tailored to the different target audiences (e.g., specific demographics, indigenous communities, industry sectors, regulators, emerging service sector, etc.) ● Co-develop tailored value propositions and use cases for ocean observing with user groups ● Increase level of funding & resources available for strategic user engagement & outreach activities, including economic studies to identify & prioritize engagement and co-development needed for highest societal impact observations and products/services
Data Integration With User Products	● Funding agencies of ocean observing systems need to align funding to meet the demands of data management, long-term stewardship, and training by participation in e.g., IODE, ESIP, E2SIP, CODATA, RDA. ● To qualify user products, a quantified measurement uncertainty should be added to each measurement result entered into ocean observation systems. ● Data providers should strive to use web services with well described and open APIs to distribute and make their data accessible to human and machine consumers to enable data products downstream
Design and Implementation of a Global Harmful Algal Bloom Observing System	● The ocean observing community must advance an end-to-end global observing system that responds to marine related societal needs and provides improved, advanced warnings of harmful algal blooms (HABs), in particular. ● The integrated observing system should fill the need for sustained, automated, near

	real-time information on biology, including HAB species & toxins, and improved forecast systems that address the HAB-risk warning requirements at global & regional levels ● The system will scale up from regional networks to global framework through interregional technology & product development to address societal needs while sustaining multidisciplinary and climate-quality datasets to ascertain long-term trends in HABs
Ecosystem Health and Biodiversity	● Integrate biological observations into the global observing system as an integral and necessary component of ocean ecosystem science and understanding. ● Implement available technologies for biological observing now, maximizing access to biological data and information to quantify, explain, and forecast biodiversity changes. ● Advance decadal plans for a fully encompassing global ocean observing system that integrates biology, biodiversity, physical and biogeochemical observations.
End-User Engagement: A Perspective from China	● Improve coordination at and across different levels of ocean observing through enhanced dialogue with observers and users, for example through a consolidated network or portal. ● Support tailored best practices for technological innovation, particularly at local and regional levels. ● Create coordination/collaboration network or portal as a mechanism to facilitate regional, institutional, and thematic partnerships.
Environmental DNA in Ocean Observing	● Build a coordinated, distributed eDNA monitoring network leveraging existing programs; include acoustic, optical, traditional and other environmental measurements when possible ● Develop internationally accepted practices for marine eDNA collection, analysis, processing, sample archival and data management ● Greatly expand current genomic reference libraries for marine species prioritizing groups based on user needs (EOVs, commercially important, invasive, etc.)
Fostering an Ocean-Literate Generation: An Approach at the Interface of Science Outreach and Communication	● Promotion of ocean literacy in order to engage people on the pathway to a sustainable interaction with the ocean ● Need to encourage ocean science outreach and communication activities and funding opportunities relevant to formal and informal educational environments in order to increase ocean literacy. ● Implementation of “marine-friendly” curricula in terms of school courses and textbooks as well as teacher training (at all levels, from primary to tertiary; in all countries; in an understanding-based manner).
Global Observing System for Marine Debris	● A comprehensive global observing & information system is necessary to evaluate sources/sinks, abundance, trends, risks and the efficiency of reduction measures and finally to get the problem under control. ● To achieve fundamental understanding of the issues of marine debris, develop efficient in situ observation technology, remote sensors, models and monitoring strategies, involving citizen scientists when possible. ● Build an integrated, standardized and harmonized collaborative network, using commonly accepted methods & definitions, whose structure (variables, coverage,

	and products) answers fundamental scientific questions and societal demands.
Governance Needs	● We recognize that OO governance is multi-level with many centers (polycentric). Engage them all to analyze gaps, harmonize principles, improve learning & sharing, and conflict resolution, and develop the network of actors. ● We want to have collective impact with our stakeholders; let's build a common agenda, ways to measure it, mutually reinforcing activities, continuous communication, and backbone support (collective impact model). ● Commission a working group, including ocean observers, and governance experts, to develop a revised governance system based on ideas presented at OceanObs'19.
How Research Institutions Will Enable Innovation for the Global Ocean Observing System (GOOS) Over the Next Decade	● Strengthen relationships between federal entities and research institutions to improve overall observing systems. ● Increase lifetime of floats and increase accuracy and stability of sensors. ● Support science-based research during the development and sustained phase of platform-based observing systems.
Indigenous Ocean Governance	● Formally recognize the traditional knowledge of Indigenous peoples worldwide as well as the articles within the United Nations Declaration on the Rights of Indigenous Peoples. ● Establish meaningful partnerships with Indigenous communities, organizations, and Nations to learn and respect each other's ways of knowing; ● Negotiate paths forward to design, develop, and carry out ocean observing initiatives; and share responsibility and resources.
Innovation in ocean observing platforms and infrastructure	● Establish international working groups to address key infrastructure areas including: ASVs, AUVs, Moorings, Cable systems, Acoustic Systems, assets of opportunity and Data systems. ● Pilot a sustained multipurpose acoustic network for passive monitoring, tomography, underwater positioning and communication in an integrated Arctic observing system, with eventual transition to global coverage. ● Transition telecom+sensing SMART subsea cable systems from present pilots to trans-ocean and global implementation, to support climate, ocean circulation, sea level monitoring, and tsunami and earthquake early warning and disaster risk reduction.
Integrated Ocean Observations I	● Make sure we're measuring the same, important EOVs in comparable ways across geographic scales to inform societal, management and scientific needs. ● Expand colocated EOV measurements to include biological and biogeochemical parameters. ● Improve observational capacity by making sensors and platforms more affordable and best practices universal.
Integrated Ocean Observations II: Diverse Stakeholder Needs	● Develop new mechanisms within the FOO to ensure that the observing system is truly multipurpose and multidisciplinary and serves diverse stakeholders. This may include developing new categories of EOVs connected to human activities. ● Develop incentives to reward data providers, and invest in Data Assembly Centers and Integrated Data Services with expert curation, to ensure that data from stakeholders are FAIR, open, and free, contributing to the ocean observing system

	value chain. ● Develop tailored communication strategies for the integrated observing system, to encourage stakeholder feedback and engagement processes. The strategies should include prioritization of ocean information and ocean observation needs.
Integrated Ocean Observations III: Across Disciplines	● Increase regional & global coordination throughout the next decade, focusing on partnerships & improved communication; observational capacity including improved data sharing; an expanded funding base for sustained observations. ● Report progress towards the desired global ocean observing system through biennial reporting to the United Nations using EOVs as a reporting framework ● Ensure that observing networks contributing to the global ocean observing system provide updated metadata on progress towards full maturity under the FOO, as well as their data to the relevant open and FAIR regional and global databases
Modeling and Assimilation Innovation	● Promote investment for organizing workshops, training programs, and targeted meetings in order to enhance the communication between observational and modeling/Data Assimilation (DA) communities. ● Encourage Observation System Experiments (OSEs) and Observation System Simulation Experiments (OSSEs) to identify best practices ● Utilize model/DA for designing/redesigning observation network, and for planning observation field campaigns to improve modeled physical processes.
NASA's Decade for Ocean Observation from Space	● Feedback processes with identified users and resource stakeholders are needed from the beginning, and should be reviewed on an ongoing basis to identify what is fit-for-purpose for users and societal benefit (and to adjust as needed). ● Case studies can highlight the value of ocean observing information products so that nations will want to commit to sustained ocean observing activities. ● Take into account existing pieces, commitments and regulations for developing a fit-for-purpose ocean observing system.
Observing Needs in the Deep Ocean	● Extend deep-ocean observing capacities to the global scale as part of the UN Decade – addressing all deep-ocean-relevant EOVs and building on existing assets and networks. ● Improve standardization of and access to deep ocean observing data, samples, and derived products ● Facilitate partnerships, collaboration, integration and capacity building across deep-ocean observing communities, including deep-ocean exploration, seafloor mapping and private sectors, through the Deep Ocean Observing Strategy.
Observing Technology Innovation: Platforms and Technology	● Stakeholders & funding agencies need to promote early & consistent connection & dialogue amongst researchers, engineers/technologists & data science communities at the inception of observing programs to ensure that objectives and requirements are met. ● The ocean observing community must establish a stronger pipeline for innovators from engineering, computer science, data science, and material science. ● Distributed and extensive ocean obs platforms/systems are required to increase community emphasis on turning prototype tools & individual sensors into integrated platforms & production systems using best practices in systems engineering & data management

Observing Technology Innovation-Satellite	● Enhance high-resolution coverage in space and time of satellite observations extending into the polar regions, coastal and regional seas, and in the equatorial band, whilst maintaining long-term continuity in the satellite observing system. ● Fly Missions to cover Gaps in observed ocean ECVs/EOVs where the technology exists: total surface currents, wave spectra, vertical plankton distribution, …. ● Promote synergy and coordination between agencies for (1) multiple sensors, platforms and disciplines for an integrated virtual constellation to observe the ocean's small rapid scales globally, and (2) for in-situ Calval infrastructure.
Ocean Best Practices	● The OBPS, as a sustainable, scalable system for best practices, is important for ocean observing and should be capable of evolving with new technologies. ● Establish community-based review capability for best practices. ● There is a need for a convergence of best practices with similar objectives.
Ocean Partnerships for Sustained Observing	● Identify willing champions and experts to facilitate a network of advisors and collective impact organizations that help with trans-sector partnership development and maintenance at national to regional to global scales. ● Design and implement an international, organizational structure for the development and resourcing of global partnerships around Capacity Building and maintenance in ocean observations (and larger ocean science). ● Create a framework for partnership building that provides guidance for research institutions, countries, philanthropies, etc. that wish to establish programs around ocean observations, products, and/or services.
Ocean, Weather, and Climate Forecasting	● Develop in partnership with the observational community a framework to perform observational impacts studies ● Enable a regular ocean observation impact forum for all applications, including user/sector needs ● Align strategies of groups along ocean obs value chain: e.g. GOOS, OceanPredict, and BluePlanet
Open Source Software Revolution	● Resources aimed at developing the knowledge & experience necessary to use & develop open source software will enable more scientists to benefit from the advantages of open source software. ● Identification of existing & development of new methods that provide credit for publishing open source software is important for acceptance of open source software. These include inclusion of software digital object BinderHubs, reporting GIThub activity. ● Support & further development of existing open source libraries that enable oceanographers to advance their science, including federal employees working on open source projects, funding work on libraries, or funding add-ons for grants.
Powering the Blue Economy: Energy Innovation for Ocean Observations	● Overcoming power limitations in ocean observing could provide tremendous value by providing new data streams and enabling new capabilities: proactive monitoring; high res BGC data; gliders that run climatology lines; further discussion ● Reducing the timescale of design cycles is a major challenge for further innovation to integrate marine energy and observing platforms. Solutions include: linking communities; improving access to testing sites; more time for deep thinking

Traditional Knowledge Building	● Build up capacity within the scientific community to understand and value indigenous and other knowledge systems ● Connect initiatives and exchange success stories and challenges to develop a framework for Community Supported Observation and to give Community Supported Observations a voice in the Global Ocean Observing Community ● Partnering with communities to develop mutual beneficial interdisciplinary projects with social sciences and indigenous knowledge systems
UN Decade of Ocean Science for Sustainable Development	● Ocean Observing ● Knowledge of ecosystems ● Ocean data and information system
UN Sustainable Development Goals	● Capacity building for students and early career professionals to understand the Agenda 2030, the SDGs and the international momentum of the oceans in a more holistic and integrated way considering the oceans as a socio-ecological system ● Increase the capacity of developing countries to produce continued observations that are fit-for-purpose of their policy concerns but at the same time useful to inform at the global level ● Enforce national and international efforts to connect scientists and statistical offices to ensure that the best available data and information are reported to support the achievement of the SDG targets.
Uncertainty Quantification: Recommendations	● We should train ocean observers and modelers in statistical terminology and techniques for the purpose of uncertainty quantification. ● Building on existing efforts, we should produce a series of peer-reviewed and open-access documents that define and recommend strategies and best practices for uncertainty quantification in ocean observing. ● Research programs should require and fund routine uncertainty estimates on ocean observations and derived products, and should fund dedicated efforts to develop freely available resources (software and databases) for uncertainty quantification.

Defining Essential, Executable Ocean Observing

OceanObs Research Coordination Network Meeting

February 16, 2020, 8:30 am - 5:30 pm | San Diego, California

APPENDIX 3. OceanObs RCN Breakout Groups: Key Actions and Responsible Parties

OceanObs RCN Breakout Group ***(Lead Names)***	**Key Actions + Volunteers**
Impacts and Applications *(F. Muller-Karger, N. Maximenko, C. Anderson)*	● Catalog global marine debris observations (regional to global). Find linkages between different marine debris organizations/programs (i.e. EMODnet, NOAA Marine Debris, GOOS, US IOOS, others). ○ Category: Marine Debris ○ Responsible Parties: N. Maximenko ● Establish Working Group (thematic: address regions (like Arctic), extreme events, biology impacts, economic consequences, food safety); ○ Category: Marine Debris ○ Responsible Parties: N. Maximenko ○ Resources Required: Two meetings ● Find linkages with GlobalHABs/IOC/FAO/IOCCG/COCLIME ○ Category: HABs ○ Responsible Parties: C. Anderson, H. Moustahfid, D. Turk ● Engage to develop an integrated observing system (i.e. ISOOS) for co-located obs, joint data management, and interpretation. ○ Category: Integrated ○ Responsible Parties: M. Estes, G. Canonico ○ Resources Required: WG support to engage with Surface Ocean Obs planning meeting ● Mapping ocean hazards and ocean uses in collaboration with ESRI. ○ Category: Integrated ○ Responsible Parties: F. Muller-Karger ○ Resources Required: students, post-doc support, pilot project and seek Esri engagement ● Converge tech development across topics (example DOOS-omics). ○ Category: Integrated ○ Responsible Parties: TBD ● Cataloging impacts of debris on protected species (via debris info system). ○ Category: Integrated ○ Responsible Parties: TBD ● Synthesize recommendations of the OO19 community white papers and OO RCN meetings to map to Decade ○ Category: Integrated ○ Responsible Parties: TBD ○ Resources Required: $500K Expert synthesis group
Ocean Observing Systems *(M. Roughan, J. Newton, M. Cronin, L. Levin, M. Estes)*	● Map spatial and temporal coverage by EOV/EBV of long-term sustained observations focused on North Pacific initially ○ Category: Coastal to Global ○ Responsible Parties: J. Barth and S. Kim ● Submit proposal for a task team to GOOS (joint panel); Requesting feedback from the community (p11), and input from sci comm. ○ Category: ISOOS

	○ Responsible Parties: M. Cronin ● Submit articles to Special Issue of Frontiers in MarSci, deadline Sept 2020 Carbon, water energy heat momentum ○ Category: ISOOS ○ Responsible Parties: M. Cronin ● Coordinate with Ocean Modelers – OSE/OSSEs; Survey existing data portals on deep ocean needs. Requirement setting, FAIR data, Demonstration sites, stakeholder use cases. ○ Category: Deep Ocean ○ Responsible Parties: L. Levin, P. Heimbach ● Submit Paper including SRS and new metrics of change ○ Category: Eco and Biodiversity ○ Responsible Parties: M. Estes, et al. ○ Resources Required: $25K ● Inventory of existing / Platforms / Ships of Opportunity to enhance Bio observing system EBVs and colocation of assets. ○ Category: Eco and Biodiversity ○ Responsible Parties: M. Estes, et al. ○ Resources Required: $25-$50K for workshop ● Assemble an OceanObs Pitch Team that includes communicators, social scientists, etc. who communicate the importance of the ocean to everyone off a single song sheet ○ Category: Integrated ○ Responsible Parties: E. Lindstrom, C. Whitt, M. Leinen ● Plan a process study to inform obs system design: coverage issues and scientific measurement type issues ○ Category: Integrated ○ Responsible Parties: S. Gille ● Working Group for Omics / eDNA Link to EBS – How to scale up and quantify ○ Category: Integrated ○ Responsible Parties: K. Goodwin ● GOOS Definition of components and elements ○ Category: Integrated ○ Responsible Parties: JPL, etc. representative TBD ○ Resources Required: $350K ● Include remote sensing in GOOS inventory ○ Category: Integrated ○ Responsible Parties: GOOS SC ● Data warehousing - The database to point to all databases / OOS / Best practices - expand JCOMMOPS! ○ Category: Integrated ○ Responsible Parties: A. Fischer
Technology and Interoperability *(B. Howe, C. Schmaus)*	● Meetings – UN Oceans/JTF/150y/Lisbon, WTSA, UN-ESCAP, AGU Town Hall – Community ● Building support from inter-ministry Gov’ts, Banks, Insurance, RENs, GOOS/iDOOS ○ Category: SMART Cables ○ Responsible Parties: B. Howe/Joint Task Force ○

	● SMART cables: community needs to support NOAA and IOC's emphasis on tsunami detection and storm surge for the UN Decade – helps make ocean observations relevant to all stakeholder ○ Category: SMART Cables ○ Responsible Parties: B. Howe/JTF and Governance Group from this event ○ Resources Required: meeting attendance and participation (Lisbon, WTSA, AGU Town Hall) ● Consider cable re-use - white paper ○ Category: SMART Cables ○ Responsible Parties: OceanNetworks (F. DiMaria) ● Work with gov't as part of permitting – governance – incentives, multinational ○ Category: SMART Cables ○ Responsible Parties: B. Howe/Joint Task Force ● Modeling/OSSEs ○ Category: SMART Cables ○ Responsible Parties: B. Howe/Joint Task Force ● Meetings (AOS April, Workshop (NSF, EU, NOAA, USARC, etc.) ○ Category: Acoustics in Arctic ○ Responsible Parties: H. Sagen, S. Sandven, INTAROS teams ● WG: Working group for technical specification (acoustic and other instruments) and energy demands – classes of "service" ○ Category: Acoustics in Arctic ○ Responsible Parties: A. Marouchos, C. Whitt, H. Sagen, M. Dzieciuch ● WG: Design of Multipurpose Ocean & Acoustic System using evaluation of ongoing and previous experiments, modeling, and OSSEs ○ Category: Acoustics in Arctic ○ Responsible Parties: H. Sagen, M. Dzieciuch, B. Howe ● Creating an Integrated Arctic System: start by raising difficulties and sharing importance around polar acoustics; need to work with other ocean obs systems to share lessons learned and best practices ○ Category: Integrated ○ Responsible Parties: A. Marouchos, H. Sagen, etc. ○ Resources Required: Antarctic and Southern Ocean Forum; Arctic Observing Summit already scheduled ● Launch design and build competition this summer including commercialization pathway ○ Category: Marine Renewable Energy ○ Responsible Parties: J. Garson, C. Schmaus ○ Resources Required: ● IEEE Oceans Fall 2020 Conference – Special session on Marine Renewable Energy ○ Category: Marine Renewable Energy ○ Responsible Parties: J. Garson, C. Schmaus ● Marine energy integration with ocean observing devices: need help with disseminating this information ○ Category: Integrated ○ Responsible Parties: J. Garson & C. Schmaus, DOE; for engagement and dissemination – this community ○ Resources Required: Ocean Observing Systems group: engage with marine energy community; Ocean Partnerships group: help disseminate information to

	generate additional applications to opportunities like the Ocean Observing Prize ● Define best practices/standards – White paper Ex: EOV's, Mooring systems, ASV's, AUV's ○ Category: Interoperability ○ Responsible Parties: A. Marouchos, C. Whitt, J. Pearlman ● Define energy needs ○ Category: Interoperability ○ Responsible Parties: J. Garson, C. Schmaus, A. Marouchos, C. Whitt, J. Pearlman ● Define interfaces with sensors/platforms ○ Category: Interoperability ○ Responsible Parties: A. Marouchos, C. Whitt, J. Pearlman ● Identify enabling technologies: will start with geolocation. IEEE will help disseminate current work in geolocation to new stakeholders and to set a framework/precedence for sharing information about other enabling technologies (eventually: autonomy) ○ Category: Integrated ○ Responsible Parties: C. Whitt ● Catalogue: what ocean observations are needed across the board (tied to EOVs), what is status of technologies currently in use, and what technologies would it take to address the ocean obs needs – so sponsors know what to fund, industry knows what to create ○ Category: Integrated
Governance *(T. Tanhua, A. Valauri-Orton, B. Arbic, J. White, R. Rayner)*	● Map the current Ocean Observing System and its Governance system, map vs. its purpose ○ Category: Governance ○ Responsible Parties: GOOS/POGO/GEO-BP joint project ● Look at the(economic) value of a well functional OO system governance on different levels (basin scale?) ○ Category: Governance ○ Responsible Parties: AtlantOS / S. Ketelhake ● Finalize the draft of the prospectus ○ Category: Capacity Development ○ Responsible Parties: B. Arbic, A. Valauri-Orton ● Formalize the group (governance system), include partners from the developing countries, two-way learning ○ Category: Capacity Development ○ Responsible Parties: B. Arbic, A. Valauri-Orton ● Establish and populate the best practices of community building and partnerships ○ Category: Community Building ○ Responsible Parties: J. White, N. Rome, K. Desai ● What does a good Collective Impact Organization look like? A task team to look at this ○ Category: Community Building ○ Responsible Parties: NAS Study Group ● Map the value Chain ○ Category: Blue Economy ○ Responsible Parties: C. Jolly (OECD) ● Build the business case. Build a repository of caste studies demonstrating the value of Ocean Observing

	○ Category: Blue Economy ○ Responsible Parties: R. Rayner and IOOS ● Create a reward system for "the Ocean Observer" of the year – or similar. TOS? GOOS? ○ Category: Other ○ Responsible Parties: M. Visbeck ● A group to look at funding of the OO system other than the traditional science funding. ○ Category: Other ○ Responsible Parties: M. Visbeck ● Establish Interoperability WG ○ Category: Integrated ○ Responsible Parties: J. Pearlman ○ Resources Required: WG support ● Promote SOOP WG ○ Category: Integrated ○ Responsible Parties: B. McKenzie, SOT, SOOP, VOS networks) ● OO in response to climate engineering and adaptation ○ Category: Integrated ○ Responsible Parties: K. Juniper ● Best practices for end-user engagement ○ Category: Integrated ○ Responsible Parties: J. White ● Advocacy, promote the benefit of OO – group to identify means and methods ○ Category: Integrated ○ Responsible Parties: E. Smail, GEO Blue Planet
Data Management, Products, and Interoperability *(C. Gentemann, A. Waite, S. Akella, J. Hausman, M. Bushnell)*	● Training camps, summer schools, networking international consortium ○ Category: Independent ○ Responsible Parties: C. Gentemann ● Development of best practices through production of infographic/document ○ Category: Integrated ○ Responsible Parties: D. Wright, V. Ferrini, A. Benson ○ Resources Required: Existing boundary orgs in https://dusk.geo.orst.edu/ec-story/ ● Guidance document (checklist) for funding agencies ○ Category: Integrated ○ Responsible Parties: A. Benson ○ Resources Required: Certified Data Repository ● Define core competencies in ocean data science that are necessary for graduate training. ○ Category: Integrated ○ Responsible Parties: M. Smit, A. Waite ○ Resources Required: Ocean Best Practices System (student component) ● Build a bridge between technology and science ○ Category: Integrated ○ Responsible Parties: S. Akella, M. Smit