GOOS – Biology & Ecosystems Panel

2019 Activity Report

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GOOS Report #241

Prepared by Patricia Miloslavich (IPO)

Chairs: Nic Bax and Daniel Dunn

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SUMMARY
The Biology and Ecosystems Panel of GOOS (GOOS BioEco) works since 2015 in developing and coordinating efforts in the implementation of a global ocean observation system to include essential biological and ecosystem variables to contribute to enhance global ocean observations and inform policy development and management decisions on ocean and coastal resource sustainability and health. The highlights of GOOS BioEco in 2019 are framed within the following activities:

(1) Advancing EOV implementation and building the networks
(2) Mapping the global network of biological ocean observations through the PEGASuS project
(3) Capacity development and EOV monitoring training
(4) Contributions to OceanObs19 – publications and breakout sessions
(5) Providing a vision and a roadmap for implementation of observations in the next decade
(6) Contributions to policy and to global assessments - publications
(7) Contributions to the GOOS and GCOS programs (across disciplines)
(8) Securing future funding – the EuroSea project
(9) Panel composition renewal

The highlights report contains four appendices with: (1) legacy of publications in 2019, (2) GOOS BioEco partnerships, (3) funding needs, and (4) a list of acronyms used in the report.

GOOS BioEco highlights of 2019

(1) Advancing EOV implementation and building the networks

1.2. Mangrove and seagrass EOVs:
The "Coordinated Implementation of Mangrove and Seagrass Essential Observations workshop" (or Sea Plants Workshop for short) to facilitate the development and implementation of the mangrove and seagrass EOVs was held on the 9-10th of June 2019 in Washington DC at the Consortium for Ocean Leadership (COL). The goal of the workshop was to discuss the implementation plans for sustained observations of the seagrass and mangrove EOVs and their related Essential Biodiversity Variables (EBVs) to support biodiversity and health status assessments of these two ecosystems. The workshop was funded by NASA, with funds administered by COL.

The full meeting report is GOOS Report #236 and can be found at:

A short summary of the goals, outcomes and recommendations of the meeting was published in Eos:
Figure 1. Coordinating the Implementation of Mangrove and Seagrass Essential Observations: A joint GOOS/MBON community outreach workshop to implement EOV/EBVs (Sea Plants Workshop), Consortium for Ocean Leadership; Washington, D.C., 10–11 June 2019.

Additionally, a SCOR Working Group to establish a “Coordinated Global Research Assessment of Seagrass System (C-GRASS)” was approved in September. This will be SCOR’s WG #158 and will be chaired by Emmett Duffy (Smithsonian Marine GEO) and Lauren Weatherdon (WCMC, UK). Goals and terms of reference can be found at:


1.2. Ocean Sound EOV:
A one day workshop was held on the 15th of September 2019 within the framework of OceanObs19 chaired by Jesse Ausubel (Rockefeller University) and with the participation of Nic Bax and Patricia Miloslavich from GOOS BioEco and Ed Urban from SCOR among other participants including NOAA, University of New Hampshire, and the Office of Naval Research of the US among others. Sound was recognized as a cross-cutting topic that could support all biological EOVs. It was agreed that the IQOE would draft a proposal to organize a workshop aimed at defining intermediate goals (e.g. how effectively can acoustics be used to manage marine biodiversity and abundance in MPAs). The proposal will be revised by the GOOS BioEco chairs and the GOOS SC. Jesse Ausubel has offered some funding for this workshop. Ed Urban will continue to be the SCOR liaison to the IQOE.

Ocean Sound was also featured in a special issue of the ECO Magazine:

The journal Nature also featured an article about ocean noise and consulted members of the panel for content. The article is available through the link below and mentions GOOS as a "lauded UN project" (https://www.nature.com/articles/d41586-019-01098-6).

![Figure 2. Special issue of ECO Magazine on ocean sound highlights the need for ocean acoustic observatories to the rescue of marine life](image)

1.3. Macroalgal EOV:
A four-day workshop was held on the 1-4th of October 2019 at the Institute for Marine and Antarctic Studies, University of Tasmania, in Hobart, Australia to develop the data architecture (data processing and workflow) for the different Standard Operating Procedures (SOPs) by which the macroalgal EOV data is collected. The workshop was supported by the Australian Research Data Commons (ARDC) Data and Services Discovery Activity program on Transformative data. The building components of the plan included the SOPs for 5 different methods (visual surveys, genetics, acoustics, remote sensing and AUV/BRUV imagery), the data upload, data transformation, and the data flow to both OBIS-Australia and OBIS-international.

Outcomes of this workshop include the drafting of the SOPs for the different survey methods, a proposed data pipeline to transform the data obtained from the SOPs into OBIS along with a successful proof of concept data upload using data from Tasmanian belt transect surveys to monitor benthic community structure (https://obis.org/dataset/c83d85a5-0308-4d95-b129-7a3d32f473ce), the establishment of a Global Ocean Macroalgal Observing Network (GOMON) along with its terms of reference and governance structure and membership, and a draft agreement on data sharing policies.

See event documents including workshop report (GOOS-238) in the GOOS website:
http://goosocean.org/index.php?option=com_oe&task=viewEventRecord&eventID=2538

Outcomes of this workshop include:
• The drafting of the SOPs for the different survey methods
• A proposed data pipeline to transform the data obtained from the SOPs into OBIS along with a successful proof of concept data upload using data from Tasmanian belt transect surveys to monitor benthic community structure: https://obis.org/dataset/c83d85a5-0308-4d95-b129-7a3d32f473ce
• The establishment of a Global Ocean Macroalgal Observing Network (GOMON) along with its terms of reference and governance structure and membership, and a draft agreement on data sharing policies. The chairs of the GOMON network are Lisandro Benedetti-Cecchi (University of Pisa) and Jarret Byrnes (University of Massachusetts in Boston).

![Figure 3. Macroalgal EOV data processing workshop - developing the data architecture (data processing and workflow) for the macroalgal EOV of GOOS.](image)

1.4. Plankton EOV:
The SCOR WG #154, Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs or P-OBS (https://scor-int.org/group/154/ P-OBS) led by Emmanuel Boss (University of Maine) and Anya Waite (Dalhousie University) completed the draft report with the recommendations for plankton measurements on the GO-SHIP program with relevance to other sea-going expeditions. The report provides the necessary materials to incorporate routine biologically-relevant measurements on GO-SHIP, which is likely to inform other operational, routine oceanographic expedition programs. It provides an inventory of validated plankton-related measurements and commercial sensors that could be implemented / installed on board research vessels, describe the associated effort involved (personnel...
The report is posted at the P-OBS website and is publicly available for review:
https://sites.google.com/maine.edu/p.obs/final-draft-report-data

1.5. Turtle-Bird-Mammal EOV:
Aiming to form an animal tagging emerging network, a workshop was organized in from the 19-22nd in Hobart to establish “PROTEUS”, the global animal-borne oceanographic observing network. The primary goal of PROTEUS is to provide a cost-effective and complimentary real-time capability for measurement of temperature and salinity through the upper 1000 m of the ocean and contribute to a global description of the seasonal cycle and interannual variability of the upper ocean thermohaline circulation. Each animal borne sensor is expected to gather on average at least 500 temperature-salinity profiles annually in; the high polar latitudes, coastal shelves and tropics, regions that are currently poorly serviced by traditional observing platforms. These observations in remote areas of the ocean will help fill the large gaps that presently exist in the global observing network, and provide crucial information for ocean state estimation and when integrated with other elements of the climate observing system, will greatly enhance studies of climate variability and deliver information to inform climate prediction estimates. Emma Heslop (OCG-JCOMM OPS) and Dan Costa (University of California in Santa Cruz) attended the meeting. Discussions were focused on how this network may be incorporated into JCOMM-OPS. While initially only providing data on physical variables, the idea is that it will be expanded to include animal data as well.

On the other hand, based on the variability in the information across the three taxonomic groups for the specification sheet, the TBM specification sheet will be split into three spec sheets, one for each group (marine mammals, seabirds and marine turtles). Sam Simmons and Roxanne Carini from the Marine Mammal Commission, Karen Evans (CSIRO) and Daniel Dunn (formerly at Duke University, currently at University of Queensland), have been working on updating the specification sheet for marine mammals. They have agreed to solidify a list of observations and to obtain more information from the observing networks about abundance, distribution, species presence/absence, age (year, age class, life history stage), count data, repeated individual presence (tracking/resights/photo-id). They have compiled an initial list of networks to reach out to obtain this extra information. This list includes all networks from the BioEco panel original survey that reported observing marine mammals in any format, as well as networks that reported using methods that can be used for marine mammal observations. The survey to these networks is in progress and the list of networks contributed to the inventory of the Pegasus project.

1.6. Hard coral EOV:
The Global Coral Reef Monitoring Network (GCRMN) has engaged in the new Implementation and Governance Plan for the GCRMN adopted by the ICRI General Meeting in December 2018 and endorsed by GOOS and MBON. The plan defines a common global strategy for coral reef monitoring and reporting. The key elements of re-design include: (1) applying the principles of the Framework for Ocean
Observations, (2) applying the Drivers Pressures Status Impact Responses (DPSIR) model used in many convention processes, and (3) adopting the Essential Ocean Variable (EOV)/Essential Biodiversity Variable (EBV) frameworks to identify the priority variables for understanding and reporting on the health of coral reefs, and mechanisms to improve and expand their delivery.

(2) Mapping the global network of biological ocean observations through the PEGASuS project

The first Pegasus project workshop was carried out between the 5-7th of March 2019 at the NCEAS in Santa Barbara, California. The event documents and full meeting report can be found at:

http://goosocean.org/index.php?option=com_oe&task=viewEventRecord&eventID=2435

A meeting report was also published in Eos:

https://eos.org/meeting-reports/designing-the-global-observing-system-for-marine-life

The story about the project was disseminated through the NCEAS and Future Earth websites:


Two of the main outcomes of the workshop were the definition of biological network attributes based on the Observation Coordination Group (OCG) of JCOMM-OPS, and the timeline of activities leading to the implementation of all biological EOVs into the next two decades.

Mission – fit for purpose - science, policy and management needs

Spatial scale – local and national needs, contributing to global - reporting to relevant indicators

Sustainability – trends over time - repeatability

Best practice – global accepted standards - new technologies (SOPs, data management and delivery)

FAIR and open data standards – data attribution and provenance - open data, metadata supporting interoperability, data aggregation and reuse

Capacity development and technology transfer – supports extension of SOPs and best practices supporting local/regional and/or global needs and priorities

Figure 4. Attributes of fully contributing observing networks
Figure 5. Synthesis of the combined EOV timelines for 1-5, 10- and 20-year timeframes

The second Pegasus project workshop was carried out between the 2-5th December 2019 at the NCEAS in Santa Barbara, California. The event documents and full meeting report can be found at:

http://goosocean.org/index.php?option=com_oe&task=viewEventRecord&eventID=2577

The final report is being drafted and will be uploaded on the GOOS website as GOOS report #241
Figure 6. Participants of Pegasus workshops #1 and #2 – NCEAS, Santa Barbara, California.
(3) Capacity development and EOV monitoring training

The IPO contributed to two major regional capacity/research efforts aimed at training and collecting data on EOVs. The first of these efforts is the MBON Pole to Pole of the Americas (MBON P2P) project aimed at building a regional Community of Practice for understanding and conserving life in the ocean. The second is through a grant from the Lounsbery Foundation to provide training in monitoring to Venezuelan and South American students and involve US researchers.

3.1. The Marine Biodiversity Observation Network – Pole to Pole (MBON P2P)

The MBON P2P aims more specifically to build capacity to: (1) expand our knowledge of biodiversity and its services, (2) coordinate disaggregated biodiversity monitoring, share data, experiences, knowledge, and protocols, (3) increase understanding of physical and biological connectivity, and (4) develop biodiversity indices needed for future assessments and science-based decisions.

The second MBON-P2P workshop, “From the Sea to the Cloud”, was held in Puerto Morelos (Mexico) in April 2019. In this second workshop, participants brought their data for further QA/QC analysis and to discuss several issues regarding the protocol implementation including the environmental loggers, issues on data sharing, image analysis (including the use of the GigaPan), use of data for biodiversity indicators, and how to support partner networks. Training in the use of satellite data tools and the SquidPop (from MarineGEO) field protocol for fish assessments were also provided (Figure 10).

Figure 7. Field (SquidPop deployments and GigaPan panoramic filming) and data analysis activities during the MBON P2P second training workshop – Puerto Morelos, Mexico, April 2019

The MBON P2P has sampled in 41 rocky shore sites (20 localities, from the northern coast of the USA to the Antarctic Peninsula, Figure 11) and is contributing 10450 records of 293 taxa (208 at species level). These records add to the 19253 records of 672 taxa (512 at species level) provided by the SARCE project (https://obis.org/dataset/81db945e-d319-4237-b49e-cd3e78937393)
Data from each of the sites is being synthesized and visualized using a Biodiversity Explorer file (file://D:/biodivExplorer_rocky_v2.html) developed by Eduardo Klein which includes (1) general information (e.g. local SST from satellite measurements, climatology, taxonomic rank distribution, species frequency per sampling strata in the intertidal and the number of quadrats where the taxa were found), and (2) information on indicators (e.g. number of species for each taxonomic group, distribution of classes, % of live cover, etc.) (See example for Arraial do Cabo in Brazil in Figure 9).
Figure 9. Biodiversity Explorer developed to visualize the MBON P2P data

Event in the GOOS website:
http://www.goosocean.org/index.php?option=com_oe&task=viewEventRecord&eventID=2382

3.2. The Lounsbery Foundation training workshops

With funding from the Lounsbery Foundation, two workshops were organized to train Venezuelan and South American early career scientists in biological EOV monitoring in collaboration with US professionals and to connect them with ongoing regional initiatives such as the MBON Pole to Pole project. Both courses contributed to the Ocean Teacher Global Academy (OTGA) platform.

The first workshop took place at the INVEMAR in Santa Marta, Colombia (13-17th May, 2019). The course consisted on lectures, field and lab activities, data QA/QC to learn on standard and innovation methods to: (1) assess cover and biomass of seagrasses, (2) assess abundance and composition of fish associated to seagrasses, (3) assess fish predation rates, (4) extract satellite data on sea surface temperature and chlorophyll, and (5) quality assess and control data and register in OBIS. Background information, agenda and other course material including presentations and photos is publicly available at: https://diodon.github.io/seagrassWorkshop/workshopProgram.html#introduccion
The second workshop was held at the IBIOMAR, formerly the CENPAT in Puerto Madryn, Argentina from the 25-30th of November 2019. The course consisted on lectures, field and computer lab activities, data QA/QC to learn on standard and innovation methods to conduct research and monitoring in rocky shores (focusing on the macroalgal EOV), and exercises on climate change communication.

Lectures, photos, data, and presentations are all uploaded in a shared Google Drive, accessible to the course participants:

https://drive.google.com/drive/folders/1zLiBsse6il8sGTTSZ5-m4Qb0RAkhliy6?usp=sharing

The final report is also in the GOOS website at:

http://www.goosocean.org/index.php?option=com_oe&task=viewEventRecord&eventID=2593
Figure 11. Lab and field work at Puerto Madryn and Valdes Peninsula, Argentina during the second Lounsbery training workshop on rocky shore ecosystems (November 2019).

(4) Contributions to OceanObs19

Sanae Chiba (JAMSTEC) was one of the four co-chairs of the Program Committee (PC) of OceanObs19 and Frank Muller-Karger (University of South Florida) was one of the members of this Committee. The PC coordinated the community white paper input for conference, built the program, and provided communications and outreach guidance.

4.1. Community White Papers
The BioEco Panel contributed to the following OceanObs19 papers in the Journal Frontiers of Marine Science:


4.2. Breakout sessions

The BioEco Panel contributed to organize the breakout sessions on Integrated Ocean Observations I, II and III and directly led (Nic Bax and Patricia Miloslavich) the breakout on Integrated Ocean Observations III. These breakout sessions were aimed at providing recommendations on how to achieve integration of ocean observations across scales, stakeholders, disciplines and networks. Patricia Miloslavich was also a speaker at the Panel on Interoperability and Governance and a contributor to the organization and recommendations of the Breakout session on Ecosystem Health and Biodiversity (chaired by Maury Estes) and on Capacity development (chaired by Bryan Arbic) and to the Harmful Algal Blooms special session (chaired by Melissa Anderson). The IPO produced all background documents for the third breakout session of the series including a roadmap with the priority goals and milestones to be achieved in the next decade and the attributes that observing networks should have in order to make this possible.

Integrated Ocean Observation III: Across disciplines and networks

Breakout Session
Thursday 19th September (2-4 pm / Room 316A)

Session organizers

Patricia Miloslavich
University of Tasmania
Universidad Simón Bolívar
pmilos@usb.ve

Nic Bax
CSIRO
Nic.Bax@csiro.au

Rapporteur

Samantha Simmons
U.S. Marine Mammal Commission

Session co-organizers

Jack Barth Oregon State University, Sung Yong Kim KAIST, Eitarou Oka University of Tokyo, Meghan Cronin NOAA, Artur Palacz IOCOP, Kim Currie NIWA

Figure 12. Invitation material to join the Integrated Ocean Observation III: across disciplines and networks breakout session at OceanObs19.

This goal of this third breakout session was to provide recommendations on how to fully integrate biological observations into a truly multidisciplinary observing system across all coastal and ocean domains. It brought together representatives of the major global organizations and programs carrying
out and individually coordinating observations to, building from recommendations of the CWPs to agree on (1) collaborating on a two-year process to develop an implementation strategy and (2) delivering a unified 10-year roadmap focusing on how to advance these strategic objectives to the best of each group’s capabilities. A follow-up paper merging the recommendations on this breakout with those on Ecosystem Health and Biodiversity is being outlined.

Several members of the BioEco Panel attended OceanObs19 and were involved in a variety of breakout sessions, panels, and special sessions: Emmett Duffy, Pier Luigi Buttigieg, Sam Simmons, Sonia Batten, Dan Costa, and Raphael Kudela).

(5) Providing a vision and a roadmap for the implementation of observations in the next decade

Based on the panel’s discussions within the framework of the Pegasus project, a roadmap of goals and milestones to achieve the implementation of biological observations, along with the attributes of the contributing networks, the societal applications of sustained biological observations and some key recommendations to achieve the building of an integrated ocean observing system were prepared. This information is communicated in a 4-page flyer which was distributed at several of the above-mentioned workshops, at OceanObs19, and at training workshops. It can be downloaded at the GOOS website:


Figure 13. The Global Ocean Observing System for Marine Life – flyer 2019
Members of the BioEco Panel contributed to the following policy activities and global assessments:

- Contribution to the IPBES Global Assessment: (approved by the IPBES GA, Paris, May 2019)(*)
  Chapter #2: status and trends, drivers of change (David Obura, CLA)
  Chapter #3: progress towards meeting international agreements (Miloslavich, CLA)
  Chapter #4: Exploring future scenarios to 2050 (Yunne Shin, CLA)
- Contribution to the WOA-2:
  Sub-chapter 7c: Intertidal zones (Miloslavich)
  Group of Experts (Karen Evans)
- Contribution to the IOC Capacity Development Working Group (Nic Bax)
- Contribution to the CBD-SBSTTA and CBD Post 2020 Aichi Targets processes (Nic Bax)
- Contribution to the BBNJ process (Biodiversity Beyond National Jurisdiction) / UN process (Daniel Dunn)
- Contribution to the Expert Panel on a Sustainable Ocean Economy on biodiversity (14 Head of States): Blue Paper 10 - Critical habitats and biodiversity: Inventory, thresholds and governance (Miloslavich)

In addition, a live google document linking Aichi targets and SDGs and their indicators and the potential contribution from EOVs along with ECV/EOV/EBV products can be found in:

https://drive.google.com/drive/u/1/my-drive

(*) A version of the SPM was published in Science: Díaz, S. et al. (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. Science 366, eaax3100.

(7) Contributions to the GOOS, GCOS and OBP programs (across disciplines)

7.1. Contributions to the GOOS program
The BioEco Panel contributed to the GOOS 2030 strategy:


BioEco also provided the first live mapping case phenomena using coral bleaching as the example phenomena. See live map at:

7.2. Contributions to the climate GCOS program

Nic Bax attended the GCOS SC meeting held in Morocco during the 18-22nd of March 2020. Two major areas within the meeting were of potential interest for BioEco contributions: the biosphere and the coastal breakout session. Following the discussions, a paper is in preparation by the “Biosphere” group focusing on the sufficiency of the observations to explain climate-induced changes in the global biosphere. The aim of this paper is to review available ECVs and their subvariables to identify where existing monitoring systems are sufficient to measure climate-induced biotic changes, where changes have been measured but an ongoing monitoring system is lacking, and where changes are anticipated and there is, or could be, accurate measurement sufficient to distinguish climate-induced changes from other anthropogenic or natural changes.

We had email exchanges with Simon Eggleston from the GCOS terrestrial panel (and interested in engaging in marine coastal issues with our panel), informing them of our activities related to the coastal
zone. For the coastal breakout we thought useful to get an overview of what observations, products etc. are available for Biological ECVs (see full list of ECVs here: https://gcos.wmo.int/en/essential-climate-variables). Particularly what requirements can be deduced from satellite products and what in addition could be needed (coverage can be collected from satellite, but what can also be deduced from e.g. spectral signatures).

Finally, the BioEco Panel was requested by the Global Climate Observing System (GCOS) to complete some product requirements for our biological EOVs that are also ECVs (Plankton and “Marine Habitat Properties”). This is a work in progress. The idea is that once completed by the EOV experts, GCOS will issue an open call for review of these product requirements that will be open for 3 months (From the 13th of January 2021). In addition to the usual GOOS/GCOS community, the IPCC and other communities will also be invited for this public review. Tables can be found at the following link:

https://drive.google.com/open?id=1VqT47Mn7xS6_7k_DE4ErLNKcJnoxyFPM

7.3. The Ocean Best Practices platform: https://www.oceanbestpractices.net/

The panel agreed that best practices for biological EOVs are to be identified by BioEco experts and recommended to the OBP platform. Other agreements were:

1) Set an endorsement mechanism to consider scientific validity (e.g. papers published using that method, contained in a recognized manual or paper) and applicability (e.g. used consistently across observing networks) among the criteria.

3) Endorsement channeled through the OBP WG but to come as a recommendation from the expert community (GOOS Panels, OCG Global Networks, and some potential GOOS partners such as for example IMBER)

4) For most EOVs there will be a “collection of best practices” (e.g. for coral reef monitoring, different plankton survey methods / technologies)

At each of the implementation plan EOV workshops, participants are informed about the OBP platform and are encouraged to submit their protocols. Some protocols have already been included in the platform and have a DOI and for some others, discussions have been initiated (e.g. the AIMS/GBR and the NOAA-PacificRamp coral reef monitoring).

7.4. The POGO Working Group on Biological Observations

Miloslavich and Benedetti-Cecchi are members of the POGO WG on biological observations led by Margaret Leinen (SCRIPPS). The WG has regular conference calls for the planning of training workshops. The first was to introduce attendees to on Machine Learning/Artificial Intelligence (ML/AI) techniques currently being applied in three broad areas: acoustics, imaging, and genomics. During 2019, planning was underway for a second workshop on eDNA to be held in 2020.

(8) Securing future funding – the EuroSea project

The BioEco panel will be contributing to the recently approved “EuroSea” project. EuroSea is about improving and integrating European Ocean Observing and Forecasting systems for Sustainable use of the oceans under the “The Future of Seas and Oceans Flagship Initiative” and funded by the Horizon 2020 Blue Growth (BG-07-2019-2020) program. The goal is to achieve ocean innovation and exploitation through observation and forecasting. EuroSea will bring together European stakeholders (providers and
key users of ocean observations and forecasting) in an interdisciplinary consortium (55 partners) for 4 years to work in 9 Work Packages (WPs). The budget is of about ~€ 12.3M and it will be coordinated at GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany by Toste Tanhua (coordinator) and Andrea Franke (project manager). The project had a kick-off Meeting on the 27 – 29 November 2019, at the Royal Belgian Institute of Natural Sciences (RBINS), Brussels.

GOOS Bio will be co-responsible of Work Package #1 on governance and coordination of ocean observing and forecasting systems, but it is expected to contribute to other work packages. EuroSea will support part of the time of the BioEco IPO.

Figure 15. The EuroSea vision: moving from fragmented and dispersed ocean observing efforts (left) to that of a coordinated European Observing System Framework (right) – based on the EOOS strategy.

(9) Panel composition renewal

Currently the panel is composed by Nic Bax (CSIRO, Australia) and Daniel Dunn (University of Queensland, Australia; formerly Duke University) as co-chairs and by Valerie Allain (Pacific Community, New Caledonia), Sonia Batten (Marine Biological Laboratory, Canada / UK), Lisandro Benedetti-Cecchi (University of Pisa, Italy), Pier Luigi Buttigieg (Alfred Wegener Institute, Germany), Sanae Chiba (JAMSTEC, Japan), Dan Costa (University of California in Santa Cruz, USA), Emmett Duffy (Smithsonian, USA), Raphael Kudela (University of California in Santa Cruz, USA), Frank Muller-Karger (University of South Florida, USA), David Obura (CORDIO, Kenya), Lisa Maria Rebelo (The International Water Management Institute, IWMI, Lao), and Yunne Shin (Institute for Research and Development, France) as panel members representing the biological EOVs.

Valerie Allan and Yunne Shin will be rotating off and new panel members to develop the fish EOV are Rick Stuart-Smith (University of Tasmania, Australia) and Anthony Bernard (University of Cape Town, South Africa). Dan Costa will be rotating of and the new panel member to develop the marine mammal EOV is Karen Evans (CSIRO, Australia). Daniel Dunn will be stepping down from co-chair and a call of interest to take the role of panel co-chair will be issued in early 2020. Sonia Batten will be stepping
down in April 2020. A new panel member to link to Seabird International is under consideration, as well as a member of the DOOS network to develop the benthic invertebrate EOV.

APPENDICES

Appendix 1. Legacy of publications in 2019


Appendix 2. GOOS BioEco PARTNERSHIPS

Since its establishment in 2015, GOOS BioEco has interacted with several institutions, organizations, programs, projects, and groups in general to advance the implementation of these biological EOVs. The nature of these interactions has been quite variable and include formal collaboration and support/funding, discussions on how to establish such formal ways of collaboration, participation and reporting on BioEco activities in their meetings, and contributing and/or reviewing to their strategies and plans.

Using the UN Decade stakeholder classification of: (1) science and technology, (2) policy and sustainable development, (3) business and industry, (4) civil society and NGOs, and (5) funders and donors, we summarize here the main partnerships that GOOS BioEco has either initiated (or is in the process) to support the implementation of the EOVs globally.

PARTNERSHIPS

(1) Science and technology

<table>
<thead>
<tr>
<th>PARTNER</th>
<th>NATURE OF PARTNERSHIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCN/NSF</td>
<td>Provided support for the BioEco IPO to travel in representation of GOOS to relevant events (e.g. the Ocean Sciences meeting in Portland and the RCN workshop) and co-supported the plankton EOV implementation plan workshop (June 2018)</td>
</tr>
<tr>
<td>MBON</td>
<td>Signed collaboration agreement – Pole to Pole project of MBON has supported airfares and/or accommodation for IPO to provide training in MBON-P2P workshops in Latin America. MBON of IOOS provided funding for the plankton EOV implementation workshop (June 2018). Represented in the panel by Frank Muller-Karger.</td>
</tr>
<tr>
<td>SCOR</td>
<td>The BioEco IPO is a member of the SCOR Executive Committee in representation of IABO. Regardless of the BioEco Panel not being affiliated to SCOR, the IPO takes advantage of the SCOR ExCom meetings to inform on progress of the BioEco panel and to use the SCOR WG platform to build global networks around the biological EOVs. SCOR is mainly funded by the National Science Foundation (NSF) and by country memberships. It provides funding to three-year duration Working Groups, to three large scale research projects (the IOCCP, SOOS and GlobalHABs), it sponsors other five research projects (IMBER, SOLAS, GEOTRACES, IQOE and the IIOE-2), and has several affiliated programs which benefit of no funding but still have reporting obligations to SCOR. One of the current working groups, P-OBS is directly linked to GOOS BioEco.</td>
</tr>
<tr>
<td>GCRMN</td>
<td>Collaboration to develop and implement the coral EOV (represented in the panel by David Obura)</td>
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</tr>
<tr>
<td>IOC – Ocean Sciences</td>
<td>Potential collaboration and synergies in topics related to blue carbon and other related projects ran by the Ocean Sciences section: e.g. ocean acidification (GOA-ON), eutrophication (GlobalHABs), the Blue Carbon initiative (distribution of blue carbon ecosystems), IGMETS, and the global oxygen network.</td>
</tr>
<tr>
<td>IMOS</td>
<td>Provides office space to the IPO</td>
</tr>
</tbody>
</table>
| DOOS       | Collaboration to develop and implement deep sea EOVs  
DOOS provided airfare and accommodation to BioEco IPO to attend strategic planning workshop (December 2016) |
| GLOMICON   | Collaboration to develop and implement the microbial EOV (represented in the panel by Pier Luigi Buttigieg) |
| IMBER      | Collaboration to develop and implement the turtle-bird-mammal EOV (through Karen Evans from CLIOTOP, a project under IMBER) |
| IGMETS     | Collaboration to develop and implement the plankton EOVs – data contribution model               |
| POGO       | Collaboration to develop and implement the macroalgal EOV (through Craig Johnson from IMAS/UTAS)  
Collaboration with the POGO WG in Biological Observations (through Patricia Miloslavich, member of the WG chaired by Margaret Leinen) |
| SOOS       | Discussions on potential collaboration (with Louise Newman)                                       |
| GACs       | Collaboration to develop and implement the zooplankton EOV (represented in the panel by Sonia Batten) |
| GlobalHABs | Collaboration to develop and implement the phytoplankton EOV (represented in the panel by Raphael Kudela) |
| MarineGEO  | Collaboration to develop and implement the seagrass EOV (represented in the panel by Emmett Duffy) |
| IndiSeas   | Collaboration to develop and implement the fish EOV (represented in the panel by Yunne Shin)       |
| IQOE       | Collaboration to develop and implement the sound EOV (through Peter Tyack)                        |

(2) Policy and sustainable development

<table>
<thead>
<tr>
<th>PARTNER</th>
<th>NATURE OF PARTNERSHIP</th>
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<tbody>
<tr>
<td>UNEP</td>
<td>Contributed to support the Coral EOV workshop in Tanzania (November 2017)</td>
</tr>
<tr>
<td>CBD</td>
<td>Discussions on potential collaboration (with Jihyun Lee who now moved to ISA, and with Joseph Appiott)</td>
</tr>
<tr>
<td>Future Earth</td>
<td>Collaborator in PEGASuS project supported by NCEAS on mapping the biological observing network</td>
</tr>
</tbody>
</table>
| OBIS          | Signed collaboration agreement – OBIS staff (Ward Appeltans was partially allocated to GOOS BioEco between 2015-2018)  
OBIS participates in all EOV implementation workshops to provide guidance and encourage biological monitoring data to be uploaded into the database |
| IPBES         | The BioEco IPO is one of the Coordinating Leading Authors (CLAs) for the IPBES global assessment (securing that information from the oceans is included in the assessment). The global assessment will be discussed at the General Assembly in April 2019. IPBES has supported all travel of the IPO for IPBES related activities. |
The BioEco IPO is contributing to one of the WOA-2 chapters (Chapter 7c on intertidal zones).

LME Discussions on potential collaboration

FAO Early discussion on potential collaboration through FAO funded project on “Marine Monitoring Network”. The point of contact is Piers Dunstan. FAO may have some funding capacity in the next 6 months for deep sea work, BioEco proposing that some be used to help develop a global network map, with explicit links to the data.

(3) Business and industry

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<thead>
<tr>
<th>PARTNER</th>
<th>NATURE OF PARTNERSHIP</th>
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(4) Civil society and NGOs

<table>
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<tr>
<th>PARTNER</th>
<th>NATURE OF PARTNERSHIP</th>
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</thead>
<tbody>
<tr>
<td>ICRI</td>
<td>Contributed to support the Coral EOV workshop in Tanzania (November 2017)</td>
</tr>
<tr>
<td>WCMC</td>
<td>Discussions on potential collaboration (with Lauren Weatherdon)</td>
</tr>
</tbody>
</table>

(5) Funders and donors

<table>
<thead>
<tr>
<th>PARTNER</th>
<th>NATURE OF PARTNERSHIP</th>
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</thead>
<tbody>
<tr>
<td>AIMS</td>
<td>Contributed AUD 50 K/year since 2015 and committed until 2021 to support salary of IPO (Additional AUD 16,742 were contributed to pay for 2015-2017 budget deficit)</td>
</tr>
</tbody>
</table>
| CSIRO  | Contributed AUD 75 K from 2015-2019. In 2019 committed to contribute with AUD 50K/year for 3 years to support salary for IPO  
Contributes airfare for Nic Bax to attend BioEco Panel meetings |
| MMC     | Contributed US$ 25 k (AUD 34,559) for the 2017-2019 period to support salary for the IPO. Sam Simmons was co-chair of the panel from 2015-2017 and the MMC contributed with her airfares and accommodation to attend BioEco panel meetings |
| UWA     | Contributed AUD 100 K for the 2015-2017 period to support salary of IPO (Additional AUD 16,742 were contributed to pay for 2015-2017 budget deficit) |
| IOC     | Contributed US$ 65k in 2015 and US$ 50k in 2019 to support salary of IPO  
Co-supported the coral and macroalgal EOV implementation workshops (airfare and accommodation of some participants)  
Major funder for the 3 BioEco Panel meetings (February 2016 in New Orleans; November 2016 in Oostende, and November 2018 in St. Petersburg, Florida) |
<p>| NCEAS /PEGASuS | Contributing US$ 111,490 in 2019 to support two workshops plus 40% salary of a Postdoc to support project activities |
| Lounsbery Foundation | Contributing US$ 100k in 2019 to support training workshops in Latin America on marine biodiversity monitoring methods (Colombia and Argentina) |
| NASA    | Contributed US$ 10k to organize special session on biological observations at the 4th WCMB (2018) and is contributing US$50k to organize the seagrass/mangrove implementation plan workshop in June 2019 |</p>
<table>
<thead>
<tr>
<th>Organization</th>
<th>Funding Contribution and Workshop Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>POGO</td>
<td>Contributed €10k to support the macroalgal EOV implementation workshop (Hobart, September 2018)</td>
</tr>
<tr>
<td>NESP-MBH</td>
<td>Contributed AUD 1k to support the macroalgal EOV implementation workshop (Hobart, September 2018)</td>
</tr>
<tr>
<td>IMAS/UTAS</td>
<td>Contributed AUD 2k to support the macroalgal EOV implementation workshop (Hobart, September 2018)</td>
</tr>
<tr>
<td>IOOS</td>
<td>Co-supported the plankton EOV implementation plan workshop (June 2018)</td>
</tr>
<tr>
<td>NIPPON FOUNDATION</td>
<td>Potentially (to be approached by Daniel Dunn): Daniel to broker a discussion with Nippon Foundation on how it could contribute to support the activities of BioEco, including the IPO. BioEco activities could be focused on developing capacity (to use Nic’s and Patricia’s papers on capacity as outline for this conversation)</td>
</tr>
</tbody>
</table>

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### Appendix 3. GOOS BioEco FUNDING NEEDS

At the current level of salary of the IPO, the Panel’s funding needs (in US$) for coordination, workshops and other activities are:
The chart shows the budget needs in US$ per year to support the coordination of biological observations within the global ocean observing system by the GOOS BioEco Panel. Such coordination requires a full-time position for an International Project Officer as well as some other core activities to meet the panel’s tasks and to develop the implementation plans of the biological essential ocean variables within the global observing system. This budget does not include the resources to actually carry out the observations.

**Level I:** is the minimum amount required to support the salary for the international project officer (IPO), including travel (two trips/year) and office support.

**Level II:** adds to level I by including one full panel meeting per year with the participation of 12-16 people.

**Level III:** adds to level II by including (a) salary for 50% of the time of an assistant to the IPO to support coordination activities around the EOV networks and (b) approximately US$ 100 k to organize three EOV Implementation Plan workshops aimed at building the networks around EOVs and drafting detailed implementation plans to develop these EOVs.

**Level IV:** adds to level III by including (a) capacity development workshops to help advance the EOV implementation plans especially in regions where these are needed the most and (b) costs of data services to develop the EOV data management structure (e.g. within OBIS) for product delivery as part of the implementation (within or similar to JCOMM-OPS).

**Level V:** adds to level IV by including three EOV data workshops to work on data standards, data processing (QA/QC), data archiving, data provenance and traceability, and data access. This should include salary for a “data-officer” to coordinate metadata from all biological EOVs with JCOMM-OPS (metadata center).
Appendix 4. List of acronyms

AIMS (Australian Institute of Marine Science), AWI (Alfred Wegener Institute), CBD (Convention on Biological Diversity), CORDIO (Coastal Oceans Research and Development – Indian Ocean), DOOS (Deep Ocean Observing Strategy), EOVs (Essential Ocean Variables), FAO (Fisheries and Agriculture Organization), GACs (Global Alliance of Continuous Plankton Recorders), GCOS (Global Climate Observing System), GCRMN (Global Coral Reef Monitoring Network), GEOTRACES (International Study of Marine Biogeochemical Cycles of Trace Elements and their Isotopes), GlobalHABs (Global Harmful Algal Blooms project), GOOS (Global Ocean Observing System), GOOS BioEco (GOOS Biology and Ecosystems Panel), IABO (International Association for Biological Oceanography), ICRI (International Coral Reef Initiative), IGMETS (International Group for Marine Ecological Time Series), IIIOE-2 (International Indian Ocean Expedition-2), IMAS (Institute for Marine and Antarctic Studies), IMBER (Integrated Marine Biosphere Research Project), IMOS (Integrated Marine Observing System), IOC (Intergovernmental Oceanographic Commission), IOCCP (International Ocean Carbon Coordination Project), IOOS (Integrated Ocean Observing System), IPBES (Intergovernmental Platform for Biodiversity and Ecosystem Services), IPO (International Project Officer), IQOE (International Quiet Ocean Experiment), IRD (Institut de recherche pour le développement), ISA (International Seabed Authority), IWMI (International Water Management Institute), JAMSTEC (Japan Agency for Marine-Earth Science and Technology), LME (Large Marine Ecosystem), MarineGEO (Marine Global Earth Observatory - Smithsonian's Tennenbaum Marine Observatories Network), MBL (Marine Biological Laboratory, UK), MBON (Marine Biodiversity Observation Network), ML/AI (Machine Learning/Artificial Intelligence), MMC (Marine Mammal Commission), NCEAS (National Center for Ecological Analysis and Synthesis), NESP-MBH (National Environmental Science Programme – Marine Biodiversity Hub/Australia), NGOs (Non-Governmental Organizations), NSF (National Science Foundation / USA), OBIS (Ocean Biogeographic Information System), P-OBS (Integration of Plankton-Observing Sensor Systems to Existing Global Sampling Programs), POGO (Partnership for the Observation of the Global Ocean), RCN (Research Coordination Network), SARCE (South American Research Group in Coastal Ecosystems), SBSTTA (Subsidiary Body on Scientific, Technical and Technological Advice for the CBD), SCOR (Scientific Committee on Oceanic Research), SOLAS (International Surface Ocean - Lower Atmosphere Study), SOOS (Southern Ocean Observing System), UP (University of Pisa), USCS (University of California at Santa Cruz), USF (University of South Florida), UTAS (University of Tasmania), UNEP (United Nations Environment Program), UWA (University of Western Australia), WMO (World Meteorological Organization), WCMB (World Conference on Marine Biodiversity), WCMC (World Conservation Monitoring Center), WOA (World Ocean Assessment).