The Pole to Pole Marine Biodiversity Observation Network of the Americas (P2P MBON) gathered researchers and managers from Canada to Patagonia and experts from other parts of the world, to discuss and converge on strategies for biodiversity monitoring and conservation in rocky intertidal areas and sandy beaches. This process continues to build the foundations of the P2P MBON network in the GEO context, in a partnership between various GEO elements (GEO BON/MBON, AmeriGEOSS, Blue Planet) and the Intergovernmental Oceanographic Commission (IOC).

The P2P MBON workshop took place at the Centro de Biologia Marinha da Universidade de São Paulo (CEBIMar/USP) during the 2018 AmeriGEOSS Week. P2P MBON is a central element of the GEO Biodiversity and Ecosystem Societal Benefit
Area. It represents the marine environment and biodiversity focus within AmeriGEOSS.

The August 2018 P2P MBON workshop focused on capacity building and applied science for conservation and management of living resources. The goal was to develop the capacity to sustain critical ecosystem services for communities in the region. Instructional modules focused on four key areas: 1) field data collection in rocky shore and sandy beach habitats using existing, standardized protocols; 2) manipulation of tabular and spatial data for standardized data formats, such as Darwin Core; 3) publish datasets to the Ocean Biogeographic Information System (OBIS, IOC) using established tools for data sharing; and 4) training on data science tools (R, Rmarkdown, Github) to mine data, conduct data discovery and analysis, and produce reproducible research documents with interactive visualizations on the web. The effort included discussion of remote sensing observations, and strategies to develop indicators for Sustainable Development Goals and Aichi Biodiversity Targets.

The P2P MBON activity was led by the Institute for Marine Remote Sensing (IMaRS), College of Marine Science of the University of South Florida, and the Centro de Biologia Marinha (CEBIMar) & Instituto de Biociências (IB) of the University of São Paulo in coordination with OBIS, the Global Ocean Observing System for Biology and Ecosystems, and EcoQuants. This workshop was a first step for the implementation of a global P2P MBON network.
The main goal of the P2P MBON network is to develop a community of practice that helps nations to improve conservation planning and environmental impact mitigation, serve the scientific community, and satisfy commitments to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Aichi Targets of the Convention of Biological Diversity (CBD), and the UN 2030 Agenda for Sustainable Development Goals (SDGs). The approach of the P2P for achieving this goal is through: 1) enhancement of coordination of data collection among nations; 2) improved collection of harmonized data, and the development of data standards and methodologies for data management and dissemination without compromising national concerns; 3) integration of physical and chemical data over time with biodiversity information to characterize status and trends; and 4) generation of products needed for informed management of the ocean.

Workshop Activities at a Glance

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Day 1:

Participants were introduced to international frameworks and initiatives relevant to P2P activities. Frank Muller-Karger (University of South Florida – USF) introduced the 2030 Agenda of the UN Sustainable Development Goals (SDGs), specifically SDG #14 and Aichi Targets and indicators of the Convention of Biological Diversity. Patricia Miloslavich (University of Tasmania - UTAS) introduced the Assessment Reports of the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES), the World Ocean Assessment of the UN, intersections between GOOS Essential Ocean Variables (EOVs) and GEO BON Essential Biodiversity Variables (EBVs), and an overview of the South American Research Group in Coastal Ecosystems (SARCE).

Patricia Miloslavich and Eduardo Klein presenting the EBV/EOV frameworks of GOOS and GEO BON.

Eduardo Klein (Ocean Biogeographic Information System – OBIS) provided an overview on data and visualization and analysis tools available in OBIS to set the stage for guided practical exercises that were conducted in the following days by participants. This included a summary of the general architecture and use of Darwin Core (DwC) data schema as a tool for registering data in internationally-accepted biodiversity data repositories.

Ben Best (EcoQuants) provides a tutorial on using R and Github for project management and data analysis.
Workshop participants presenting their research projects (e.g. GBIF and OBIS) and sharing data and metadata via OBIS through the Integrated Publishing Toolkit (IPT; http://iobis.org/manual/ipt/). Frank Muller-Karger provided the context with an overview of the GEO BON Marine Biodiversity Observation Network (MBON).

Each workshop participant had the opportunity to share their research projects during 3-minute presentations during the afternoon.

Afternoon activities were followed by a lecture on Data Wrangling with R software and Rstudio, Rmarkdown, Git, and GitHub as reproducible research tools led by Benjamin Best (Ecoquants).
Day 2:

The second day of the workshop was dedicated to developing a framework for biodiversity monitoring of sandy beaches as a central activity of the P2P MBON. This is an area of priority of the P2P MBON program as sandy beaches were identified as overlooked habitats where critical biodiversity information gaps exist along the east and west coastlines of the Americas. Lectures and field data collection exercises were conducted on beaches around CEBIMar.

Maikon Di Domenico, professor at the Universidade Federal do Paraná, Brazil, conducted a lecture on physical features, beach morphodynamics, animals on sandy beaches, and their adaptations to these environments. This also included a summary of sandy beach monitoring programs around the world, and those implemented in Brazil. Carlos Barboza and Guilherme Corte, workshop participants studying sandy beach biodiversity, led lectures on interocean comparisons of macrofaunal diversity and effects of extreme events (i.e. storms) on intertidal invertebrate diversity in sandy beaches.

Di Domenico, Corte and Barboza conducted a field demonstration of physical characterization of sandy beaches, e.g. slope and temperature distribution patterns and macrofaunal diversity sampling using sediment coring techniques along parallel transects. Collected samples were sieved immediately after collection to recover, identify and register macro-invertebrates.

During this practical exercise participants registered biotic and abiotic field observations. As part of the computer lab work participants learned to match species names of

Example data file from the sandy beach sampling exercise.
organisms identified in collected field samples with the World Register of Marine Species (WoRMS) catalog using R and the WoRMS online platform. Species name matching with WoRMS is a requirement to upload biological observations to OBIS. Data sheets containing biodiversity data collected during this exercise were formatted according to Darwin Core formats and data was uploaded to the OBIS/GBIF IPT for public use.

In a parallel session, USF Ph.D. students Cara Estes and Savannah Hartman conducted a training session with participants interested in rocky shore intertidal communities on the use of photo-quadrats as tools for documenting field observations in these environments through collection of imagery and footage. During this activity, participants assembled 12 photo-quadrats prepared by CEBIMar and manipulated GoPro cameras mounted on the frames of photo-quadrats using the GoPro app previously installed in their smart phones. Photo-quadrats were later tested in the field during the third day of the workshop.

Day 3:

Training sessions of the third day of the workshop were dedicated to lectures and hands-on laboratory and field activities focused on rocky shore intertidal habitats. Gil Rilov (Israel Oceanographic and Limnological Research), Brian
Helmuth (Northeastern University, USA) and Fernando Lima (University of Porto) presented lectures on lessons learned from ongoing rocky shore monitoring programs studying the ecology of these environments around the world (e.g. Multi-Agency Rocky Intertidal Network [MARINe], Global Rocky Intertidal Ecology Network [GRIEN], and Partnership for the Interdisciplinary Studies of Coastal Oceans [PISCO]). Topics included patterns of biodiversity, environmental drivers of these communities, and status and trends observed over multiple rocky shore areas, where sustained biodiversity monitoring has been occurring. Instructors shared insights into the effects of temperature on behavior of rocky shore invertebrates, the mosaic of thermal environments and their relationship with spatial distributions of biodiversity, thermal tolerance of rocky shore invertebrates and mass mortality events, and experimental and analytical approaches for detecting and understanding biodiversity patterns in the intertidal zone.

Augusto Flores (Dir. CEBIMar and SARCE investigator) conducted a field demonstration on sampling techniques for biodiversity assessments in rocky intertidal areas described in the protocol developed by the SARCE program (http://sarce.cbm.usb.ve/for-scientists/).

Lima introduced participants to novel technological tools being developed by his group to measure intertidal body temperature of sessile intertidal animals. The model organism selected was intertidal limpets, a common mollusk within these habitats. Lima demonstrated how a model of an animal with a thermal sensor embedded inside the shell (i.e. Robolimpets) can be used to monitor physical conditions on the rocks where
live animals exist. The activity included the preparation and deployment of sensors, and data recovery using an app available for smartphones. Robolimpets will be provided by the manufacturer (http://www.electricblue.eu/) at no cost to the project to be deployed at multiple sites from Canada to Patagonia (also possibly Antarctica) as testbeds for developing a regional network for monitoring thermal stress of rocky shore communities with regional scope. These sensors will be deployed at these sites before the end of 2018 in areas where biodiversity monitoring currently exists.

Other technological demonstrations included the use of biomimetic and heartbeat loggers in local invertebrates recovered from nearby rocky shores.
Day 4:

Before the start of the morning session, participants and instructors Rilov, Helmuth, and Lima conducted a field expedition to nearby areas as tidal conditions were optimal for biodiversity assessments in the rocky intertidal. This activity included brief talks on the ecology and diversity of the local rocky intertidal zone, demonstrations of the use of photo-quadrats and discussions about field sampling strategies, i.e. stratified random sampling design, site selection criteria, transect distribution, and structural complexity considerations.

Classroom activities started at 9 AM with Flores sharing information about academic and professional opportunities offered by CEBIMar and USP for early career and senior scientists. Miloslavich followed with a presentation on international opportunities for capacity development as visiting scholars offered by the Scientific Committee on Ocean Research (SCOR; http://www.scor-int.org/SCOR.htm) of the International Council for Science (ICSU) and Partnership for Observation of the Global Oceans (POGO) of the Nippon Foundation, and highlighted similar opportunities and various scholarships advertised on the MARINE-B listserv.

MarineGEO PanAmex Experiment: Predation and fouling community development, exotic invasions and biodiversity - an experimental approach

Emmett Duffy (Smithsonian Institution) presented the PanAmex initiative from MarineGEO aimed at understanding the effects of fishing pressure on fouling community development, exotic invasions and biodiversity based on predator exclusion cage experiments. The PanAmex experiment is currently being deployed at multiple sites in North America and thus the workshop provided an opportunity for extending to possible sites in Latin America and the Caribbean. Duffy made a full demonstration of
the experimental design of this effort and showed equipment that will be provided by MarineGEO to interested participants. At least 10 workshop participants from Argentina, Brazil, Colombia, Ecuador, Costa Rica, US Virgin Islands, Chile and Uruguay have already expressed interest in deploying the PanAmex at their study sites during the austral summer, i.e. before March 2019.

Frank Muller-Karger continued the morning session with a 45-min presentation about indicators from the Sustainable Development Goal framework of the UN 2030 Agenda, and indicators for the Aichi Targets of the Convention of Biological Diversity. This presentation was intended to raise awareness among P2P MBON participants about these international mandates and discuss future plans for the development of indicators that can help AmeriGEOSS countries report progress on SDG #14 (Life Below Water) specifically related to targets on biodiversity.

The day continued with five hours of hands-on computer exercises guided by Eduardo Klein and Ben Best. Computer training exercises were dedicated to the use of R routines that allow the transformation of spreadsheets of raw data into a Darwin Core-formatted file. This included the use of a more advanced learning module for matching lists of observed species with species catalogs in the World Register of Marine Species (WoRMS) and
obtaining WoRMS species identifiers, a required field in the DwC schema and OBIS. Best led a practical session on Github workflows and creation of Rstudio Projects with the Git Repository using Rmarkdown as tools for collaborative research. During these exercises, participants developed experience with these tools with their own computers through a step-by-step process. Best also conducted a data wrangling demonstration for preparing datasets for submission to OBIS using a raw data spreadsheet in Excel format containing rocky shore invertebrate observations from example data provided by Rilov. Best introduced participants to R Tidyverse tools for reading and wrangling data using the “dplyr” function and freely available “Cheatsheets” for Rstudio found online.

Workshop outputs, commitments and next steps

The final three hours of the workshop were dedicated to an open discussion about commitments, specific action items and next steps. A summary of these agreements with the corresponding P2P MBON activity lead is shown as follows:

- **P2P MBON kick-off**: initial efforts will be devoted to establishing a biodiversity monitoring program in two key habitats: rocky shores and sandy beaches. This includes developing new sampling protocols and reviewing existing ones, e.g. SARCE. Commitments from participants were gathered during this discussion. Eighteen P2P MBON members formalized their commitment to start (or continue in the case of previous SARCE members) a monitoring program aimed at detecting changes biodiversity at their study sites following this set of essential principles: 1) use of common methods, 2) repeated sampling at the same sites, 3) similar seasonal and temporal sampling resolution, 4) data formatting following DwC schema, and 5) open data sharing via OBIS. Participating countries include Canada, USA (mainland and US Virgin Islands), Costa Rica, Colombia, Brazil, Ecuador (mainland and Galapagos Islands), Chile, Brazil, Uruguay and Argentina.

The first step will be for P2P MBON members to carry out at least one biodiversity survey at three sites in selected localities before the end of 2018 and contribute raw data to the Data Management and Communication Github repository administered by Klein, Montes and Best. Sampling sites will be separated from each other by at least 100 km, and each one must have three sites within a 10 km radius where surveys will be conducted. All data spreadsheets will be uploaded to the P2P Repository by the end of February 2019. These datasets will be formatted to be DwC-compliant and uploaded to OBIS in the next workshop tentatively scheduled for the spring of 2019. During this follow-up event the P2P team will use these datasets to carry out spatial analysis to identify biodiversity patterns in the region.
• **Sandy Beach Biodiversity Monitoring**: Maikon Di Domenico volunteered as P2P MBON team lead of the sandy beach biodiversity monitoring program (SB). The SB team agreed to distribute a first draft of the sampling protocol by August 13, 2018, among regional experts and colleagues participating in the Brazilian ReBENTOS program (http://rebentos.org/) and prepare a final version of the sampling protocol by August 31 of this year. Di Domenico will compile information about locations and dates for the first SB surveys by September 30. Representatives of all countries agreed to contribute to SB.

• **Rocky Shore Biodiversity Monitoring**: Erasmo Macaya (University of Concepción) volunteered as P2P MBON team lead of the rocky shore monitoring program (RS). The RS team will review the SARCE protocol and provide recommendations by August 31, 2018. Macaya will collect information about localities and sites where RS surveys will be carried out by September 30. Representatives of all countries agreed to contribute to RS. The RS team will provide guidance on deployment of the SARCE protocol to P2P members with no present rocky intertidal sampling programs, i.e. US Virgin Islands. They will also support in locality and sites selection using satellite imagery available in Google Earth Engine; Rilov will aid in this process. Imagery will be collected during RS surveys with photo-quadrats provided during the workshop. The RS team will provide recommendations for the use of photo-quadrat imagery for biodiversity estimates.

• **Miniaturized temperature logger - Robolimpets**: P2P MBON will contribute to the development of a global network that monitors body temperature of sessile organisms in rocky intertidal habitats by deploying Robolimpets. The plan is to deploy one temperature logger in an area fully exposed to the sun and another in a shaded area at each locality to measure the entire dynamic thermal range to which organisms are exposed on a diel cycle and across seasons. Lima offered up to two temperature loggers for each locality where rocky shore biodiversity surveys will be conducted at no cost to the project. Robolimpets will be distributed to P2P MBON teams in different countries by September 2018 and deployed in the field before the end of the year. Data will be collected from sensors using the smartphone app from the manufacturer (http://www.electricblue.eu/) available on the Android app store.

• **Data Management and Communications (DMAC)**: All P2P data products, protocols, survey schedules, web presence, and workshop outputs will be managed through the P2P MBON Github domain: https://github.com/marinebon/p2p (under construction). Best, Klein and Montes are responsible for managing all DMAC elements of the P2P and will flesh out a DMAC plan, including tool development for data QC/QA, to be presented in the
next P2P workshop. The DMAC team will also ensure the flow of P2P MBON resources, products and data, into OBIS, GBIF, OTGA, and GOOS.

- **Indicators**: One of the primary goals of the P2P MBON team will be to discuss the development of biodiversity indicators relevant to national contributions to international policy frameworks such as Aichi Biodiversity Targets and UN Sustainable Development Goals. Successful conservation and management of marine biodiversity requires informative indicators to holistically assess biodiversity and detect changes in distribution and status. The objective is to propose new indicators based on sets of Essential Biodiversity Variables (EBVs) and Essential Ocean Variables (EOVs) related to species distribution. The effort links with MBON efforts to develop a web service to enable extraction of OBIS data and corresponding environmental values from satellite data (color, temperature, seascapes), etc., for predefined areas of interest such as jurisdictions (EEZ, LME, MEOW, EBSA, WDPA, etc.) or arbitrary polygons.

- **Upcoming workshops**: P2P MBON will hold annual workshops focused on the advancement of the network’s objectives and output production. Inti Keith and Maritza Cardenas will provide support with the logistics and organization of these events, and work hand-in-hand with Habtes and Grimes for communication elements. The agreed tentative date for the next workshop is March 12-14, 2019 and will be confirmed after consultation with all team members.

- **P2P MBON E&O and social media**: Development of the P2P MBON Education & Outreach strategy will be led by Juan Azofeifa (CIMAR, Costa Rica), Kristin Grimes (UVI, USVI), and Yasmina Shah Esmaeili (Universidade Estadual de Campinas, Brazil). This includes creating a communication strategy via traditional social media outlets, e.g. Facebook, Twitter and Instagram. Azofeifa will work in collaboration with CJ Reynolds (USF; P2P E&O coordinator). Helmuth will facilitate linkages between P2P MBON and similar programs in the US like MARINe (https://www.marine.gov/) and PISCO (http://www.piscoweb.org/rocky-shores). Grimes proposed to use the P2P MBON network as an opportunity to examine the value of diverse collaborations in science and will lead the writing of a manuscript on this topic.

- **P2P MBON internal communications**: Sennai Habtes and Kristin Grimes (UVI) will be responsible for leading the development of the internal communication infrastructure of the P2P MBON network, including the coordination of multiple listservs (i.e. rocky shores, sandy beaches, all P2P MBON), and communications among P2P MBON members related to biodiversity assessments in the region and funding opportunities for P2P MBON activities, including participation in future workshops.
• **P2P MBON Scientific Advisory**: Patricia Miloslavich and Gregorio Bigatti (IBIOMAR-CONICET, Argentina) will coordinate the generation of scholarly products from the P2P MBON, oversee the advancement of biodiversity survey protocols, provide support in hypotheses testing to determine regional biodiversity baselines and change in coastal habitats, and provide advice for the achievement of scientific objectives of the project. They will also guide the P2P MBON in the integration of the network with GOOS and the implementation of the EOV framework.

• **P2P MBON workshop materials**: All workshop materials, including agenda, presentations, programming code and notes are available at the workshop website: https://marinebon.github.io/p2p-brazil-workshop/. All workshop participants registered with the IODE OceanExpert network (https://oceanexpert.net/event/2284) and the Ocean Global Teacher Academy (OTGA). All workshop materials (presentations, Dwc, R and OBIS resources, contact information, etc) are also available in the OTGA platform (https://classroom.oceanteacher.org/course/view.php?id=349). The P2P MBON website is under construction at https://marinebon.github.io/p2p/. All workshop and project outputs will be available upon completion.

• **P2P MBON biodiversity monitoring timeline**: Activities described above will take place according to the timeline below.
Aug 7-10: 2nd P2P Biodiversity Workshop

Aug 13: First SB protocol draft

Aug 31: Final SB protocol ready, Robolimpets (temp loggers) list completed

Sep 31: Robolimpets (temp loggers) sent to all participating P2P countries. List of biodiversity indicators are defined. Next workshop dates are agreed.

Dec 31: End of biodiversity surveys. Field data is fully processed and raw data is reported on spreadsheets to the P2P DMAC.

January 31: SB data is DWC formatted and sent to P2P DMAC. First Robolimpet dataset is sent to DMAC.

February 28: SB data is DWC formatted and sent to P2P DMAC. 2019 P2P workshop agenda is ready.

March 12-14, 2019

3rd P2P Biodiversity Workshop

Spring

Biodiversity surveys

Increased coverage of Robolimpets

Summer

Fall

4th P2P Biodiversity Workshop

Date and venue TBD
MBON Pole to Pole of the Americas: using OBIS as data sharing and integration platform

Introduction

Overview
The MBN Pole to Pole (MBNP) project is a multi-disciplinary initiative that seeks to advance our understanding of marine biodiversity across the Americas. The project focuses on three main aspects:

1. Collecting data on marine biodiversity across multiple habitats, including coral reefs, mangroves, seagrass beds, and sandy beaches.
2. Utilizing OBIS (Ocean Biogeographic Information System) to share data and facilitate research collaborations.
3. Training visionaries on data science tools (e.g., coding) to analyze and interpret data.

Dates: 06-10 August 2018
Venue: Centro de Biologia Marinha (CEBAM), Universidade de São Paulo, Praia do Sargento, São Sebastião, São Paulo, Brazil

Marine Biodiversity Workshop: from the Sea to the Cloud

Summary
This workshop will engage participants in marine biodiversity activities in the field and behind the computer, promoting a community of best practices. Specifically, the activities will focus on:

1. Collecting data across multiple habitats, such as coral reefs and sandy beaches.
2. Archiving data in a spatial database for standardized data formats, such as Darwin Core.
3. Publishing data to OBIS, utilizing tools for sharing and analysis.
4. Training on data science tools (e.g., coding) to analyze and interpret data.

Organizers
- Instituto Nativo de Biodiversidade (INB) and MBNP (Pole to Pole Marine Biodiversity Observation Network)
- Instituto de Pesquisas Científicas e Tecnológicas do Estado de São Paulo (IPCT-UNESP)
- ICMBio (Instituto Chico Mendes de Conservação da Biodiversidade)
- UNESCO/IOC Project Office for IODE

Website: https://nathanhan.github.io/pole-to-pole-workshops/

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