

Hermann Neumann

NOAA

# 1 THE YEAR IN 23 NUMBERS













Partnership for Observation of the Global Ocean



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e Ocean-Insurance

Nexus



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#### INNOVATION **IN OCEAN** OBSERVING



FOREWORD





# CAPACITY DEVELOPMENT

# OUTREACH AND ADVOCACY

### ANNUAL REPORT September 2022 – August 2023





















### FOREWORD

In my Foreword last year, I briefly discussed stepping down as Chair of POGO. Unfortunately, the Chair Elect, Prof Kim Juniper, was unable to assume the role due to personal reasons. The POGO community was saddened by this turn of events, but I was willing to serve as interim Chair until a new permanent Chair could be elected. However, due to circumstances, this process took longer than expected. Nevertheless, I am pleased to announce that Capt. Francisco Arias will be assuming the role of Chair starting in January 2024. I wish him success in his new position.

Staying on for an extra year has been a pleasure and has given me the opportunity to witness first-hand the progress we continue to make in our three main areas of focus: innovation in ocean observing, capacity development, and outreach and advocacy. As I have previously mentioned, there is much to be proud of in these areas.

It is difficult to highlight specific events or activities because we have achieved a wide range of accomplishments, many of which are detailed in this excellent report. However, there are two that I find particularly noteworthy. First, our membership continues to grow, and this is not just about increasing numbers. The addition of new members enhances our diversity and brings various benefits to POGO in terms of opportunities and experiences. Comparing our current membership to that of just a few years ago highlights these positive changes. Second, the Nippon Foundation has agreed to fund a new Centre of Excellence hosted by the Ocean Frontier Institute, in partnership with the Faculty of Open Learning and Career Development, Dalhousie University; the Fisheries and Marine Institute of Memorial University; and Hakai Institute. The Nippon Foundation's generous support has allowed us to run Centres of Excellence for a number of years, all of which have proven to be highly successful. The alumni from these training programmes have gone on to influential positions worldwide, spanning industry, academia, and national governments. Through the support of the Nippon Foundation, this remains one of POGO's flagship achievements, with global impact.

POGO is a wonderful organization, and I hope all our members find this informative report, prepared by our excellent secretariat, enjoyable; I have thoroughly enjoyed working with them for the past five years. Although changing roles, I will remain active in POGO as the Director of a longstanding member organization. For non-members reading this report, I hope you find it interesting, and please do not hesitate to contact us if you would like to learn more about POGO. There are many ways to get involved beyond becoming a member.

Lastly, I would like to express my gratitude for all the support I have received over the years.





Michala J. Chens.

Professor Nicholas J P Owens POGO Chair Executive Director, Scottish Association for Marine Science











As you will discover in the following pages, 2022-23 has been another very busy year for POGO, and as a result we have had to add more pages relative to last year's report, to allow all of our activities to be showcased! From training programmes to intergovernmental meetings, low-cost technologies to global partnerships, POGO has worked tirelessly towards achieving its objectives. Our membership has grown, and we were extremely pleased to welcome two new countries: Egypt and Indonesia.

POGO would not exist without its members, and we strive to reflect the benefits of membership back to those institutions, by enabling collaborations between members that make POGO greater than "the sum of its parts", and by offering opportunities either funded by POGO or from external sources. We are particularly grateful to our long-term partners the Nippon Foundation and the Richard Lounsbery Foundation for funding programmes such as the NF-POGO Centre of Excellence and the Citizen Observation of Local Litter in coastal ECosysTems (COLLECT) project.

In 2024, we are looking forward to celebrating POGO's 25th anniversary and to POGO's first external review, as well as to a long-awaited annual meeting in Ensenada, Mexico. It will be sad to see Nick Owens stepping down as POGO Chair after a record 5 years of service, during which time POGO has flourished under his leadership and dedication to the role. On behalf of the Board, membership and Secretariat, I would like to thank Nick for his leadership, hard work, and patience. I also look forward to working with Francisco Arias (INVEMAR, Colombia) as the new Chair, and to new projects and partnerships - 2024 is already looking to be an exciting year for POGO!











Dr. Sophie Seeyave **POGO** Chief Executive Officer





















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Working group on Capacity building for biochemical observation of anthropogenic pollution in tropical, transitional waters (BEACON)

**Open Access Marine Observation** Devices (OpenMODs)

Action for Sustainable Ocean Acidification Research (ASOAR)



#### CAPACITY

NF-POGO Centre of Excellence in Observational Oceanography hosted by the Alfred Wegener Institute, Germany

**Regional Training Programme** 

POGO-SCOR fellowships

Shipboard training

The 2022 North-South Atlantic Transect (NoSoAT) Floating Summer School cruise

POGO-funded member training initiatives

NANO Global Project "A global study of Deoxygenation, Ocean Acidification and Productivity at selected coastal sites" (NANO-DOAP)



#### OUTREACH AND ADVOCACY......43

Citizen Observations of Local Litter in Coastal ECosysTems (COLLECT)

South East Asia project for General Regional Awareness of Seagrass by Society (SEAGRASS)

Collaborations with other organisations





















# THE YEAR IN NUMBERS

#### MEMBERSHIP





nstitute for Sustainable Developmen











# TRAINING



**16** Shipboard Training fellowships

OUTREACH Side events at major international events attended by a combined total of >36,000 people

OCEANS LIMERICK 5-8 JUNE **BLUE OCEAN PLANET EARTH** 

ocean observing case studies published

#### 



Countries represented

scholarships awarded to attend NF-POGO Centre of Excellence 2022-23

fellowships

#### Funding provided for training courses held in Bangladesh (22), Cabo Verde (1), China (3), India (19), and UK (3)





Shipboard outreach project launched a fleet of "miniboats" that travelled a combined total of

>20,000 km

Sponsorship of Oceanography magazine supplemental issue including 31 articles by 211 co-authors

MAJOR ACHIEVEMENTS

### 91 students 28 countries 1,280 Trainees 1,280 since 2001







#### **OBSERVATIONS**

Time-series measurements conducted during

sampling events at

stations in

countries

(NANO-DOAP project)





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# **MAJOR ACHIEVEMENTS**

POGO was one of the founding members of the first Ocean Pavilion to feature at a UNFCCC COP Meeting (COP27)



#### **POGO obtained UN Ocean Decade Implementing Partner** status in March 2023



United Nations Decade **2030** of Ocean Science for Sustainable Development



#### **POGO sponsored the first West African Marine Science** Symposium in partnership with National Geographic in Ghana



**Ocean Sound Essential Ocean Variable** Implementation Plan finalised and ready for publication

























# **MAJOR ACHIEVEMENTS**

**COLLECT** project successfully completed in July 2023 and outcomes published in peer-reviewed publications, in a poster and video created for the participating schools and general public



#### **4th Polarstern Atlantic Training Transect completed**





Seascape: the state of our oceans Oceans the guardian .org About this content Alice Hutton Ion 15 May 2023 06.00 (f) 🎔 🖾

2-week Regional Training **Programme in Bangladesh held** as part of the NF-POGO Centre of Excellence programme, back to back with an International Management in March 2023

**Symposium on Marine Resource** 



**IQOE Science Committee** Meeting and GLUBS Workshop at WHOI, April 2023, attract media attention with an article published in the Guardian





















# MEMBER ENGAGEMENT





involved in observation-related activities (Projects, Working Groups)



involved in training and capacity development initiatives



20

40

60

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involved in POGO outreach (case studies, COP27, Oceanography supplement) and communications (newsletter)

80



actively engaged in at least one area of POGO activity







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Toulon, France

Photo credit: E Buffier, Ifremer

















# PARTNERSHIPS

#### **Nippon Foundation**

This year saw the arrival of the 10th and final batch of scholars attending the NF-POGO Centre of Excellence (CofE) in Observational Oceanography at the Alfred Wegener Institute in Germany. 2023 also marks 15 years since the programme was first initiated in partnership with, and generously funded by, the Nippon Foundation. This year, a call was issued to the POGO members to host the next Phase of the CofE. The NF-POGO partnership has continued to support shipboard training fellowships and activities of the NF-POGO Alumni Network for the Ocean (NANO), in addition to the NF-POGO CofE.

See Pillar 2 section



#### **Deep Ocean Stewardship Initiative (DOSI)**

POGO partnered with DOSI and the University of Southampton for a Side Event on "Observing" and understanding climate change and biodiversity from the coast to the deep ocean" at COP27 in Sharm el-Sheikh, Egypt (Nov 2022).









#### Scientific Committee on Oceanic **Research (SCOR)**

POGO has continued to co-sponsor with SCOR the International Quiet Ocean Experiment (IQOE), particularly on the development of the Ocean Sound Essential Ocean Variable (EOV) Implementation Plan. POGO also provided financial support for the First Southern Ocean Observing System (SOOS) Symposium. SCOR is one of the governing bodies that oversee SOOS.

POGO and SCOR partnered for the 22nd year running on the joint POGO-SCOR Visiting Fellowship programme.







See Pillar 1 section

See Pillar 3 section

See Pillar 2 section







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## PARTNERSHIPS

The Trends, Reflections, Evolution, and Visions in Ocean Research (TREVOR) Symposium was a collaboration with the International Ocean Colour Coordinating Group (IOCCG), Copernicus, the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Space Agency (ESA), the Nansen Scientific Society, NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS), Plymouth Marine Laboratory, SCOR, Trevor Platt Science Foundation, and the Western Indian Ocean Marine Science Association (WIOMSA). It represented a celebration of the scientific life of Trevor Platt, former Executive Director of POGO, who was passionate about teaching the next generation.





#### **IOC-UNESCO**

POGO has continued to work closely with IOC, for example on the Ocean Info Hub project and its connection to Oceanscape, collaboration with the Global Ocean Observing System (GOOS), the Ocean Best Practices System, and capacity development via the Ocean Teacher Global Academy (delivery of a joint module on data management at the NF-POGO Centre of Excellence, POGO funding for a training course at the International Training Centre for Operational Oceanography at INCOIS, India).









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# **OBJECTIVES**

Our goal is to have by 2030, world-wide cooperation for a sustainable, state-of-the-art global ocean observing system that serves the needs of science and society. To achieve this, we will:

- Lead innovation and development of the crucial components of the ocean observing system.
- Identify and contribute to the development of the key skills, capabilities and capacities needed to achieve the vision.
- Work with governments, foundations 3. and industry, to articulate the benefits to society and required funding to build and sustain the system.

Read and download POGO's full Strategy in several languages

### **OUR VISION AND MISSION** Ocean observations available on-line to all

























#### **OBJECTIVES**

#### **WORKING FOR THE PUBLIC BENEFIT**

The charity brings together the world's major oceanographic institutes to plan joint actions to advance sustained ocean observations for societal benefit. POGO institutes believe that advancing scientific understanding of the ocean is rooted in making systematic, high quality measurements. This understanding and its wise use are critical to enabling humanity to develop a sustainable relationship with a healthy, productive and biologically diverse ocean. Our vision can only be realised by working together across the world, to achieve together what none of us could do alone.

The ocean produces half of the world's oxygen, most of its fresh water and much of its food. It regulates climate and weather, is critical to the cycling of heat, water and carbon. It is the source of huge biodiversity. However, far too little is known about the state and functioning of the ocean. Accordingly, scientifically sound study of the ocean and support and advocacy for such study is of vital importance to humankind. POGO seeks to expand international support for ocean observing, through innovation of the ocean observing system, capacity development and outreach/advocacy.























#### OBJECTIVES

#### STRATEGIES FOR ACHIEVING OUR OBJECTIVES

In terms of innovation, POGO members are at the forefront of oceanographic methods and technology development, often in partnership with industry, as they are the future "users" of such new technologies. Thus, POGO is in a critical position to identify the emerging methods and technologies that POGO members are developing and using, and highlighting those that can be expanded and deployed on a global scale to achieve global datasets of specific parameters measured using comparable methods. POGO also focusses on the affordability issues associated with ocean observing, particularly for developing countries, and is therefore engaged in projects to develop low-cost sensors and systems for coastal ocean observing.

POGO also recognises that the expertise for conducting ocean observations is not evenly distributed between countries, and therefore the ocean is unevenly observed, with a much higher density of observations conducted in the North Atlantic and North Pacific, than in, for example, the South Atlantic, South Pacific and Indian Oceans. POGO therefore provides professional training opportunities for early-career scientists, mainly from coastal developing countries, to expand the worldwide capacity for conducting sustained ocean observations, data collection, analysis and management, and interpreting the scientific results for the benefit of society.

POGO highlights the societal need for ocean observations, as well as the key issues facing global ocean observing, and the obstacles hampering the completion of a global ocean observing system, and brings these issues to relevant public and policy fora.





National Oceanography Centre



















#### OBJECTIVES

#### SHORT-TERM AND LONG- TERM OBJECTIVES

In the short term, POGO aims to provide training for early-career scientists, to develop the next generation of scientists and ocean observers, as well as to raise the levels of awareness and education about the importance of the ocean and ocean observing for society. Measures of success include numbers of trainees, numbers of countries having received training, numbers of website visits and downloads of outreach materials, mentions on social media and other statistics.

The longer-term vision is to develop the capacity of research institutions in developing countries to conduct ocean observations, by (1) integrating the trained scientists and their institutions into the POGO network and having them actively participate in POGO projects, (2) sharing best practices among POGO member institutions, and (3) contributing to the development and dissemination of low-cost instrumentation for coastal ocean observing. Measures of success include numbers of POGO members and numbers of new (developing) countries being added to the network, establishment of new ocean observing systems in those countries, and demonstrated long-term impacts of the training programmes (e.g. >5 years after the training, on institutional capacity and continued knowledge-transfer).





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# **INNOVATION IN OCEAN OBSERVING**

#### **OCEAN BIOMOLECULAR OBSERVING NETWORK**

POGO is the lead organisation for OBON, a UN Decade programme endorsed in June 2021, which aims to utilise biomolecular technologies to monitor, research and understand life in the sea at every trophic level and scale, how life varies in response to climate and anthropogenic impacts, including fisheries, and how these changes impact society. This high-level objective is broken down into the following four more detailed objectives:

- To build a coastal-to-open ocean multi-omics biodiversity observing system over the Ocean Decade.
- To develop and transfer capacity so as to initiate additional marine and philanthropy.
- generate 4D multi-omic biodiversity seascapes.
- and those affected by other pressures.

biomolecular observation activities through training programs combined with funded equipment programs supported by development/aid agencies

To enhance marine ecosystem models (including new modelling based on machine learning) by adding biomolecular components so the models can utilize data collected from the coordinated molecular observations and

To address pressing scientific, management, and policy questions linked to the state and dynamics of life in the ocean, including exploited resources

This year POGO has continued to support the development of OBON, through Secretariat support, as well as the provision of salary for a part-time Programme Officer (Sept-Dec 2022) and Programme Assistant (July-Aug 2023) and financial support for a hybrid meeting of the OBON Science Advisory Council (SAC) and OBON projects in Sept 2022 (mostly funded by a grant from the Richard Lounsbery Foundation).

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#### **INNOVATION IN OCEAN OBSERVING OCEAN BIOMOLECULAR OBSERVING NETWORK**

#### **Highlights:**

- Transition from interim SAC to permanent SAC, totalling 18 members with additional geographical representation from Brazil and Japan.
- Establishment of a smaller Executive Committee in July 2023.
- Endorsement of another 2 UN Decade Projects (see www.oceandecade.org/ actions/ocean-biomolecular-observingnetwork-obon/)
- Project meetings were held in hybrid mode in Plymouth, UK (Sept 22) and in virtual mode in April 2023.
- Side event at COP27 in collaboration with the Deep Ocean Stewardship Initiative (DOSI)
- Podcast on the "Ocean Decade Show" released in January 2023.
- New website under development and newsletters issued in Nov 2022 and Aug 2023.

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### **INNOVATION IN OCEAN OBSERVING INTERNATIONAL QUIET OCEAN EXPERIMENT**

POGO and SCOR have been co-sponsoring the International Quiet Ocean Experiment (IQOE) since 2011, with seed funding from the Sloan Foundation and subsequent support for activities provided by the Richard Lounsbery Foundation. IQOE is an international scientific programme to promote research, observations, and modelling to improve understanding of ocean soundscapes and effects of sound on marine organisms.

IQOE is nearing the end of its 10-year life span and the IQOE Science Committee (SC) has been focussing this year on assessing IQOE's progress against the original objectives, as well as discussing what IQOE should aim to achieve in its last 2-3 years, and what the project's legacy should be.

#### **Highlights:**

- the next several years of IQOE implementation.
- being formatted and copy-edited prior to publication.

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The IQOE SC met on 26–27 April 2023, at WHOI, USA, chaired by Peter Tyack. All 10 SC members participated either in person or remotely. Meeting participants reviewed ongoing IQOE activities, evaluated the progress of IQOE after 8 years, and planned for the coming year. The meeting concluded with a discussion of future activities of IQOE. Participants agreed that IQOE has provided a unique framework for developing international cooperation on ocean acoustics and bioacoustics, and has built a foundation that will be important for

Following the development of the **Ocean Sound Essential Ocean** Variable (EOV) Specification Sheet by a POGO-IQOE Working Group and its acceptance by the Global Ocean Observing System (GOOS), IQOE was given the responsibility for the implementation of this EOV. A committee was formed in 2020 to write an Implementation Plan for the Ocean Sound EOV, with support from POGO and SCOR. During 2022-23, the Implementation Plan was made publicly available for community review and underwent several rounds of editing and internal review, before approval by POGO and SCOR. As of Sept 2023, the Plan was

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#### **INNOVATION IN OCEAN OBSERVING INTERNATIONAL QUIET OCEAN EXPERIMENT**

**A Virtual IQOE Workshop on Low-Cost**, **Self-contained Underwater Acoustic Recording Systems** was held in Dec 2021 to discuss how to develop and deploy lower cost hydrophone systems worldwide. As a follow-up to the workshop, a Working Group has been established on Low-Cost Hydrophones for Research, Education and Citizen Science, chaired by Lucille Chapuis (University of Bristol, UK).

### **COVID-19 Pandemic Noise**

**Observations and Publications**: The list of papers on the IQOE website related to COVID-19 impacts on ocean sound has been updated with 5 publications, bringing the total to 20. The IQOE SC is seeking funding to hire a postdoctoral fellow to analyze ocean sound observations to determine if, when, and where the pandemic affected ocean sound. Approximately 150 records in the IQOE Hydrophone Metadatabase span an appropriate time period to conduct such an analysis.

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**Global Hydrophone Network:** The number of records in the IQOE Hydrophone Metadatabase continues to grow, now surpassing 5,000 unique recordings. The number of observing days has reached around 300,000. The metadatabase has been used to (1) identify for the Worldwide Soundscape project cabled networks that provided public metadata and (2) connected a Ph.D. student with data sources for a specific area and a specific day, to study acoustic propagation modeling and seismic event detection related to his dissertation research. The IQOE SC is in the process of forming a IQOE working group to carry on the work of identifying new records and preparing the metadatabase for public access.

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#### **INNOVATION IN OCEAN OBSERVING INTERNATIONAL QUIET OCEAN EXPERIMENT**

- **Global Library of Underwater Biological Sounds (GLUBS)**: GLUBS is a project of the IQOE WG on Acoustic Measurement of Ocean Biodiversity Hotspots, led by Miles Parsons (AIMS, Australia). The GLUBS mission is to develop and merge novel technologies with sounds more accessible to researchers, managers, educators, and was held at WHOI in April 2023 to discuss plans to develop an machine learning training databases for as many identified and deadline of 24 November 2023.
- as a tool to discover archived, qualitycontrolled passive acoustic spectrograms and power spectrum plots.

existing bioacoustics resources to make the exploration of biological enthusiasts. A two-day workshop, funded by the Lounsbery Foundation, integrated platform to facilitate building reference dictionaries and unidentified underwater sounds as possible. A news release about GLUBS was issued in April 2023, which was picked up and reported on by media worldwide. A GLUBS-inspired Research Focus has been opened in Frontiers in Remote Sensing, with a manuscript submission

**Open Portal to Underwater Soundscapes (OPUS)**: OPUS is designed monitoring data to promote public recognition of underwater sound. There are currently six observation sites available through OPUS (87 data sets), from Alfred Wegener Institute (AWI) PAM observations, and OPUS is already adding recordings from sources beyond AWI. OPUS will be launched for public use in the coming year (without log-in requirements) and additional products will be developed, such as 2-min

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#### WORKING GROUP ON BUILDING CAPACITY IN OCEAN **ACIDIFICATION MONITORING IN THE GULF OF GUINEA (BIOTTA)**

#### **Grant awarded to University of Ghana**

The BIOTTA working group was set up to equip graduate students, early career ocean scientists and other marine science professionals in the GoG region with skills on sustainable OA data acquisition to expand our understanding of the threats, risks and impacts to marine ecosystems and chart pathways for sustainable management of marine resources at risk to ocean acidification (OA) in the GoG region. This working group hopes to also bridge national, regional and international data gaps in ocean acidification.

BIOTTA aims to complement global efforts such as the Global Ocean Acidification Observing Network (GOA-ON) and the International Ocean Carbon Coordination Project (IOCCP) by convening a series of virtual regional workshops and webinars to train young and professional scientists in setting up and maintaining OA observation systems in the GoG and other African coastal waters.

The BIOTTA working group objectives are to:

- Develop a coordinated network for observing OA in the GoG
- Develop capabilities to undertake analysis of seawater OA parameters using low-cost, readily available and easy-to-use equipment.
- Map OA hotspots in BIOTTA member countries for long-term OA monitoring.
- Initiate OA monitoring activities in BIOTTA member countries after successful mapping of hotspots in these countries, making use of OA observation kits developed by GOA-ON and the International Atomic Energy Agency (IAEA).
- Integrate into global OA observing networks, such as GOA-ON, with the goal to share and make data available to the global ocean observing community.

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#### **Members** Involved

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für Marine Tropenforschung

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#### WORKING GROUP ON BUILDING CAPACITY IN OCEAN **ACIDIFICATION MONITORING IN THE GULF OF GUINEA (BIOTTA)**

#### **Highlights:**

- The network has been formed, with partners from new countries (Benin, Cote d'Ivoire and Cameroon) added to the original group of country representatives from Ghana and Nigeria.
- 100K USD obtained from The Ocean Foundation (TOF) to purchase equipment to set up the monitoring stations. Surveys have been sent to the OA kit beneficiaries (in Benin, Cameroon and Nigeria) to assess their requirements ahead of ordering the equipment and consumables.
- The Ocean Foundation is funding a Coordinator at the University of Ghana to support BIOTTA.
- Regular on-line meetings have been held between representatives of GOA-ON, TOF, IOC-UNESCO, and IAEA, to discuss and coordinate ongoing and planned OA activities in the GoG/West Africa region.
- On-line training course developed by TOF and IOC-UNESCO and trialled in the Pacific Islands. This is due to be implemented in the BIOTTA countries in 2024, in conjunction with an in-person training course.

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Read more about BIOTTA

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#### **INNOVATION IN OCEAN OBSERVING**

#### **WORKING GROUP ON ACQUISITION OF OCEANOGRAPHIC DATA FOR** SUSTAINABLE RESOURCES MANAGEMENT IN THE GULF OF GUINEA

#### **Grant awarded to Nigerian Institute of Oceanography and Marine Research** (NIOMR)

The initiation of an oceanographic network and a regional databank is a very important project to be embraced by all countries within the West African sub region. Sea surface temperature in the Gulf of Guinea varies at seasonal and interannual time scales, and thus may have a strong impact on climate (West African monsoon onset and intensity), precipitation (water resources), and fisheries. The WG aims to obtain data on seawater characteristics up to the 500m isobath within the Gulf of Guinea region. This will provide salient information for physical, chemical, biological and geological description of the water column and sediment characteristics within this region. The main objectives are to collect oceanographic data to complement the completed and ongoing international programs within the Gulf of Guinea region, establish and maintain a long-term network of measurements within the Gulf of Guinea, and also incorporate training and local capacity building.

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To fulfil one of the goals of POGO in building a community of ocean scientists, this WG brings together marine scientists from five African countries within the Gulf of Guinea region (Nigeria, Benin, Togo, Ghana and Côte d'Ivoire), in partnership with oceanographers from GEOMAR, Germany (5 out of these 6 institutions are POGO members). The main goals are:

- To establish a regional oceanographic databank needed for studies on the analysis and monitoring of ocean and climate conditions within the Gulf of Guinea, their influence on the regional climate, and sustainable management of living and non-living resources (e.g. identification of potential fishing zones).
- To promote regional capacity building through academic/research institutions and shipboard trainings.
- To develop and maintain a long-term ocean monitoring network within the Gulf of Guinea region.
- To assist governments through research and development in implementing sustainable economic policies on living and non-living resources, which are geared towards sustainable societal livelihood.

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### **WORKING GROUP ON ACQUISITION OF OCEANOGRAPHIC DATA FOR** SUSTAINABLE RESOURCES MANAGEMENT IN THE GULF OF GUINEA

#### **Highlights:**

- Following the completion of the first leg of the cruise, which included 6 shipboard training fellows (January 2021), the WG worked on the analysis and compilation of the comprehensive dataset that was collected.
- The complete data report has been submitted to POGO.
- A data analysis workshop was held at NIOMR, Nigeria, in Sept 2022, attended by WG members from Benin, Cote d'Ivoire, Ghana, and Nigeria. The workshop was reported on in the local media.
  - The final WG report has been submitted to POGO.

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#### **Members Involved**

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Read more about Acquisition of Oceanographic Data for Sustainable Resources Management in the Gulf of Guinea

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### **WORKING GROUP ON CAPACITY BUILDING FOR BIOCHEMICAL OBSERVATION OF ANTHROPOGENIC POLLUTION IN TROPICAL, TRANSITIONAL WATERS (BEACON)**

#### **Grant awarded to University of Ghana**

There is a need to build capacity to monitor human activities (e.g., pollution) on benthic communities and chemical tracers within the biota and sediment in the coastal waters of the Gulf of Guinea. This will increase access to state-of-theart sampling methodologies, laboratory processes, and instrumentation useful for expanding the knowledge of benthic biodiversity and chemical tracers in biota coupled with the sediment in West Africa. As the aquatic environment is a source of food, its pollution is a global health concern. Mercury is a toxic element occurring in low concentrations, but its by-product, methylmercury, is highly toxic, and can accumulate in the sediment and biota (e.g., bivalves and fish). This can lead to human health concerns, such as increased risk of circulatory system disorders and cancers, through consumption of contaminated food.

Benthic organisms are good bioindicators for investigating anthropogenic environmental disturbances such as pollution. Transitional waters (e.g., estuaries) are complex systems that are regional in scale. There is limited information on transitional tropical waters and their biota in the spatial inventory of benthic fauna from West Africa. Increasing human population coupled with growing demand for resources and generation of waste put coastal lagoons and estuaries at risk of collapse. Continuous monitoring of these systems is necessary for understanding changes in their ecosystem structure and functioning. Yet, there is inadequate information on biota as chemical tracers of contaminants from the tropical West Africa coast. Information on species occurrence, habitat, and spatial-temporal distribution will allow local and regional distribution of indicator species to understand pollution and environmental change.

The BEACON working group objectives are:

To organise a workshop for interdisciplinary scientists on benthos sampling with bottom grab and Multi-Parameter Probe to observe the conditions of the coastal waters and use of a Direct Mercury Analyzer to measure chemical tracers such as analysis of total Hg in sediment and biota.

To contribute spatial knowledge on benthos and contaminant of Hg in biota and sediment from coastal waters in the Gulf of Guinea.

The preliminary findings can support decision-making, policy development for biodiversity conservation, future coastal benthic research, and understanding of pollution in tropical transitional coastal waters.

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#### **WORKING GROUP ON CAPACITY BUILDING FOR BIOCHEMICAL OBSERVATION OF ANTHROPOGENIC POLLUTION IN TROPICAL, TRANSITIONAL WATERS (BEACON)**

#### **Highlights:**

- The BEACON working group has fostered a scientific network among interdisciplinary scientists in Sub-Saharan Africa for biochemical pollution assessment of transitional waters.
- BEACON has established membership among participating countries (Ghana, Côte d'Ivoire, Nigeria, Togo and Benin) through the Biochemical Observation Network (BON) for field training for graduate students in pollution studies.
- The BEACON Hybrid Workshop, held in Ghana in March 2023, contributed to scientific knowledge sharing (both in-person and online), and delivered field and practical hands-on experience on biological sampling and mercury analysis in sediment via Direct Mercury Analyser (DMA).
- The preliminary results show contamination of coastal waters in West Africa through unavailable living biological organisms but the presence of empty shells and Hg in sediment.
- The group proposed "BEACON West Africa Research Clusters" for further scientific collaboration.

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#### **Members** Involved

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Read more about BEACON

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### **OPEN ACCESS MARINE OBSERVATION DEVICES (OPENMODS)**

#### Grant awarded to National Institute of Oceanography and Applied Geophysics (OGS), Italy, Alfred Wegener Institute (AWI), Germany, and Instituto do Mar (IMar), Cabo Verde

This project has the overarching goal "to devise ocean sensors and monitoring" devices, globally available to all and not just to a privileged few". The 2nd phase of the project was completed in Dec 2022. The objective of Phase 2 was to realize a prototype of a versatile low-cost ocean observing platform ready to be tested and equipped with a variety of sensors, to consolidate and enlarge the potential user community and to narrow the data and knowledge gaps between "advanced" and "developing" countries. Phase 3 of the project was initiated in Jan 2023, with the following objectives:

- produce their own system to be used in their waters.
- the effectiveness of the instrument in following the currents.
- To take advantage of 3D printing technology and create a threeproduce independently.

To continue working on the platform (drifter mode) to produce a system to deploy during the 2023 NF-POGO CofE training, to instruct the scholars on the use of the platform and give them all the tools and elements to

To produce, for demonstration purposes, a completely disassembled drifter platform and a 1:10 scale drifter to be used in an aquarium to demonstrate

dimensional file of these components that the end user will be able to

**Highlights:** One OpenMODs platform was sent to Cape Verde for offshore tests in the Tropical waters with different characteristics with respect to that of the Adriatic and North Seas where the platform was tested before. An intensive test at sea was carried out, using two vessels: a 13-meter pleasure craft and a 4.5-meter zodiac. Several drifter deployments and recoveries were performed adopting different methodologies and using different tools. A document describing the best practices for the deployment and recovery of the OpenMODs platform was delivered by the IMAR/OSCM Ocean Science Centre.

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#### **Members Involved**

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FRED-WEGENER-INSTITUT

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#### **INNOVATION IN OCEAN OBSERVING OPEN ACCESS MARINE OBSERVATION DEVICES (OPENMODS)**

- Between 10 and 14 July 23, the OpenMODs platforms were used within the NF-POGO CofE 2023 at the AWI (Helgoland) to introduce the topic of low cost sensors in observational oceanography. The scholars assembled a platform from scratch, understanding the principles of hydrostatic force and centre of mass. They also used the 1:10 drifter model in an aquarium to appreciate the resistance opposed by the drifter to artificial wind generated at the surface, learning the importance of the drag coefficient of different shapes.
- The scholars then set up a GPS tracker with satellite transmission and a self-recording CTD sensor and equipped the OpenMODs platforms with these devices. The platforms were deployed at sea and successfully recovered in three occasions.
- After the experiment at sea, the collected data were downloaded and processed. A preliminary version of dedicated videos on the platform assembling, the set-up of the GPS-satellite tracker and of the CTD, together with power point presentations of the analysed data were presented during the training. These products will be formatted and made available for the community.

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### **ACTION FOR SUSTAINABLE OCEAN ACIDIFICATION RESEARCH (ASOAR)**

#### Grant awarded to Plymouth Marine Laboratory, UK

Ocean acidification (OA) is a global issue, with the driver being global emissions of carbon dioxide. However, regional and local seawater conditions affect the rate of acidification, making it more difficult to predict local impacts and consequences of OA. Coordinated monitoring efforts are required to gather informative and scaleable data on the progress of OA and to support positive action for protecting the marine environment. Over recent years the Global Ocean Acidification Observing Network (GOA-ON), a network set up to establish universal principles for monitoring OA, bring together data access, and to share and exchange knowledge, has formed regional 'hubs' to allow specific regions to coordinate activities, data and projects.

The UN Decade of Ocean Science for Sustainable Development has endorsed a 10-year programme of coordinated OA research proposed by GOA-ON. The Ocean Acidification Research for Sustainability (OARS) programme sets out 7 outcomes that need to be delivered by the global OA community (see www.goa-on.org/ oars/overview.php.) A large part of this delivery will be through activities and engagements planned and executed through the GOA-ON regional hubs. The Action for Sustainable Ocean Acidification Research (ASOAR) POGO working group will consider how the North-East Atlantic hub will deliver on the outcomes of OARS. The working group also includes participation from other regional hubs to ensure the benefits of the group discussions are disseminated beyond the NE Atlantic region and facilitate cross-hub collaborations and interactions.

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### **INNOVATION IN OCEAN OBSERVING ACTION FOR SUSTAINABLE OCEAN ACIDIFICATION RESEARCH (ASOAR)**

#### **Highlights:**

- The first working group meeting took place online on 28th September to define the aims and objectives of the group as well as start to make an assessment of known activities and how they relate to the objectives of OARS.
- A hybrid meeting was held in March 2023 at PML, UK, to review and build on the draft implementation plans (Outcome White Papers) produced by the OARS outcome champions, to identify the activities and engagements that can be delivered for the Atlantic region and more broadly.
- Over two days, the Workshop participants discussed the OARS implementation plans (Outcome White Papers) to assess the needs and align these with the known OA activities both in the Atlantic and more globally, and made recommendations for delivering action for the Atlantic region, and more broadly.
- The Workshop outputs were (1) Documented action plan for participants to take back to their hubs as ways to move the OARS outcomes forward, and (2) Documented action plan for cross-hub activities with suggested funding routes and recommendations on how these activities can be delivered.

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#### **Members** Involved Plymouth Marine Laboratory PML

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Read more about ASOAR

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#### NF-POGO CENTRE OF EXCELLENCE IN OBSERVATIONAL OCEANOGRAPHY HOSTED BY THE ALFRED WEGENER INSTITUTE, GERMANY

Funded by the Nippon Foundation since 2008, the 10-month, postgraduate-level training programme concluded its 9th year of hosting by the AWI in Germany, where the programme is hosted on two different islands in the North Sea (Helgoland and Sylt), as well as on the mainland and, this year, on-board the RV Polarstern. The training, provided each year to a group of ten scholars from ten different countries, consists of a series of 1- to 2-week modules on all aspects of observational oceanography (e.g. physical, chemical, biological, remote sensing, modelling) as well as key skills (scientific writing, presentation skills, scientific communication, research ethics) and a 3-month individual research project.

The 10 scholars from the 2021-22 cohort (postponed to Jan – Oct 22) successfully graduated in Nov 22. Although the scholars' arrivals were somewhat staggered, all scholars were able to physically join the programme by Feb 2022 and the course has been able to return to its usual in-person teaching format. The ten CofE scholars also had the opportunity to join the North-South Atlantic Training transect (NoSoAT) a dedicated month-long training expedition on-board the German ice-breaker RV Polarstern. In addition to the 10-month programme in Germany, a 2-week Regional Training Programme was conducted in Bangladesh.

"The training I received at NF-POGO CofE was world-class, and it has equipped me with the necessary knowledge and skills to be a successful oceanographer. Furthermore, the NF-POGO CofE training programme offers a supportive and collaborative learning environment. The small class size allows for personalized attention, and the interactions with other students from diverse backgrounds and countries fostered a sense of community and collaboration. Overall, I would highly recommend the NF-POGO CofE training program to anyone who is interested in pursuing a career in observational oceanography. The program has truly exceeded my expectations, and I am grateful for the opportunity to have been a part of it". Anonymous testimonial CofE scholar 2021-2022

The final year of the NF-POGO CofE to be hosted by AWI commenced in June 2023, welcoming scholars from Argentina, Brazil, India, Lebanon, Madagascar, Philippines, Portugal, Somalia, Sri Lanka, and Tanzania.

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ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR-

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#### REGIONAL TRAINING PROGRAMME

The NF-POGO Regional Training Programme on Marine Resource Management was hosted by the Department of Oceanography of the Shahjalal University of Science and Technology (SUST) between 12th and 23rd March 2023. The training was organised by Dr Subrata Sarker, a former CofE scholar, NANO member and head of the Oceanography department at SUST. The training was endorsed as an activity of UN Decade of Ocean Science through INCOIS. 22 participants (12) Female and 10 Male) from Bangladesh, Malaysia, India and the Phillipines had a 12-day intensive training that included theoretical and practical lectures on fisheries resource management, marine spatial planning and conservation, climate change and marine resources, remote sensing for resource management and data science in marine resource management. The training included a field trip to Cox's Bazar where participants visited different mariculture sites, shrimp hatchery and planted mangrove trees. The training was followed by the International Symposium on Marine Resource Management, also organised by SUST, on 24th and 25th March 2023. Training participants attended the Symposium and presented their research work orally or as posters.

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#### **POGO-SCOR FELLOWSHIPS**

During this period, seven POGO-SCOR Visiting Fellowships were awarded to early-career scientists from developing countries to spend up to 3 months at another research institute receiving individual training and supervision on a research topic of their choice. (including 1 that had been postponed from 2020 due to Covid).

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"The training fellowship gave me the opportunity to do my PhD (which I start now in my parent institution) in partnership with the University of East Anglia. Thus, further strengthening the ties between the two institutions and enabling for a long-term collaboration between Federal University of Rio Grande, Brazil and University of East Anglia, UK" -Brendon Damini.

#### Mahi Mankeshwar

**Parent institution:** n/a (independent researcher)

- Host Institution: Lamont Doherty Earth Observatory at Columbia University, USA
- **Training topic:** Changing habits with changing seas: habitat study of marine megafauna in the Arabian Sea

**Duration:** 3 months (Aug–Nov 2022)

#### **Brendon Damini**

Parent Institution: Universidade Federal do Rio Grande -FURG, Brazil

**Host Institution:** University of East Anglia, UK

**Training topic:** Autonomous underwater vehicles as a tool to improve Antarctic shelf regions studies: From acquiring to understanding SeaGlider data.

**Duration:** 1 month (Oct–Nov 2022)

#### Maria Emilia Bravo

**Parent Institution:** CONICET (National Scientific and Technical Research Council), Argentina

Host Institution: Scripps Institution of Oceanography, USA

**Training topic:** First taxonomic (molecular/morphological) analysis of polychaetes associated with recently discovered methane seeps off-Argentina (SW Atlantic Ocean)

**Duration:** 2 months (Nov–Dec 2022)

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#### **POGO-SCOR FELLOWSHIPS**

#### **Isabelle de Oliveira**

**Parent Institution:** Universidade Federal de Pernambuco, Brazil

Host Institution: University of Bergen, Norway

**Training topic:** Ocean-Atmosphere processes in response to climate change in the tropical South Atlantic

**Duration:** 3 months (Dec 22–Feb 2023)

Country Host of origin country

Maya Sinurat **Parent Institution:** IPB University, Bogor, Indonesia **Host Institution:** Biophysics Operating Unit, Italy **Training topic:** Altimetry data processing

training for sea level trend and variability studies

**Duration:** 2 months (Jan–Mar 2023)

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#### Sangeeta Naik

**Parent Institution:** Goa University, India. Host Institution: Cardiff University, UK. **Training topic:** Bacterial farming by mixoplankton in the global ocean; an integrated in vivo & in silico training programme.

"I am currently working on starting my own lab once I am back to India. The training provided me with an opportunity to learn best practices in setting up labs, conducting experiments and putting together ideas. I feel enriched as a scientist, and I hope to put these practices in place in my own setup. I am going to work toward maintaining these collaborations and learn more in the future." - Anwesha Ghosh

#### Anwesha Ghosh

Parent Institution: Indian Institute of Science Education and Research, Kolkata, India.

Host Institution: Plymouth Marine Laboratory, UK

**Training topic:** Integrating coastal observations to explore the biological impacts of climate change

**Duration:** 3 months (Mar–May 2023)

Country

of origin

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Host

country

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#### **SHIPBOARD TRAINING**

This year, a total of 16 fellowships were awarded for training onboard research ships, thanks to funding from the Nippon Foundation, and the invaluable collaboration and support of

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partner institutions from around the world. The fellowships provide hands-on training in sampling and analysis techniques, and in many cases a onemonth stay at the host research institute prior to the cruise and a further month after the cruise to analyse the data and interpret the results. In addition, this year saw the 4th edition of the "Floating Summer" School" on-board the German ice-breaker Polarstern, for which the 10 NF-POGO Centre of Excellence scholars were joined by 3 additional scholars from Germany, South Africa and Spain.

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Verynice Herman Temu (Tanzania) received training on-board the CCMAR (Portugal)-run SINES cruise in Sep-Oct 2022.

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Dec 2022.

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#### CAPACITY DEVELOPMENT CONTINUED

Salim Kabbara (Lebanon) and Yaovi Zounon (Benin) were awarded fellowships to receive training as part of the RADMED programme, run by the Instituto Español de Oceanografía (IEO), Spain, from Oct to

> Vanessa Contreras Pacheco (Mexico) joined the Atlantic Meridional Transect (AMT) cruise on-board RRS Discovery, from the Falkland Islands to UK and received training for one month before and after the cruise at the National Oceanography Centre, UK (total fellowship Jan-Apr 2023).

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#### **CAPACITY DEVELOPMENT SHIPBOARD TRAINING**

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Mayara Lourenco (Cabo Verde) received training during the **GEOMAR-led RV Polarstern** cruise PS135/2 in April 2023, from Cabo Verde to Germany.

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Lisandro Ariel Arbilla (Argentina) received training at the IEO, Spain, as part of the RADPROF campaign (June-Aug 2023).

Namibia.

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Founi Mesmin Awo (Benin) received training during the **GEOMAR-led RV Meteor cruise** M189 in April-May 2023, off

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Australia, in June-July 2023.

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Luiz Gustavo Rodrigues de Sa Valle (Brazil) received a NF-POGO-SeaNetwork fellowship to join a University of Ghent cruise on-board RV Belgica in June 2023.

Raul Rodrigo Costa (Brazil) and Paula Bermejo (Argentina, right) received fellowships to join the International Nutrient Intercomparison Voyage (INIV) cruise, on-board RV Investigator, and received training before and after the cruise at CSIRO,

> Nazirahmed Abdulgaffarbhai (India) and Salma Abdoussalam (Morocco) were hosted by the IEO, Spain, and received training as part of the RADMED campaigns, between June and Sept 2023.

> Maria Luz Torres Alberto (Argentina) received training on-board the DANA-IBTS cruise run by DTU Aqua, in Aug-Sep 2023.

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#### THE 2022 NORTH-SOUTH ATLANTIC **TRANSECT (NOSOAT) FLOATING SUMMER SCHOOL CRUISE**

The Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), has embarked upon the next North-South Atlantic Training Transect (NoSoAT) on-board the ice-breaker Polarstern. The floating summer school, a UN Ocean Decade Endorsed Activity, ran from 30 August to 29 September 2022 as the research vessel travelled from Bremerhaven, in Germany, to Cape Town, in South Africa.

Due to Covid requirements, instead of the usual 25 inernational trainees, the cohort of the 4th edition of the Floating Summer School was composed of the 10 NF-POGO Centre of Excellence scholars and three additional NF-POGO trainees: Maria Coscolla (Spain), Philile Mvula (South Africa) and Maximilian Owen (Germany). During the expedition, the 13 scholars were trained in four oceanographic topics (Atmosphere and Climate; Physical Oceanography; Microbiology; Bathymetry) by a team of international scientists in a rotating scheme.

In addition to the number of participants, another peculiarity of NoSoAT 2022 was the outreach campaign. NF-POGO purchased 4 miniboats (a 1.5 m long uncrewed sailboat, with satellite transmitter and sensors for air and water surface temperature) and worked with local partners in Ireland (University of Galway - formerly known as National University of Ireland), Germany (AWI), Spain (Spanish Institute of Oceanography) and South Africa (South African Environmental Observation Network) – in addition to miniboat fabricant Educational Passages, to have them assembled and decorated by local children.

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Schnelle Welle (Fast Wave), Spiorad na Gaillimhe (Spirit of Galway) and El Cisne Alto (The Tall Swan) were deployed by the RV Polarstern during the NoSoAT while Yemaya was deployed by the Department of Forestry, Fisheries and the Environment -Oceans & Coasts Research' RV Algoa, during the SAMBA cruise. Live calls from the NoSoAT allowed the children to chat with the trainees onboard and ask questions about the ocean, daily life on a cruise and the launching of their miniboats.

The NF-POGO miniboats fleet was the first ever deployed in the South Atlantic and, combined, they travelled 364 days and over 20000 km. The miniboats are designed to be recovered, refurbished and relaunched by a 'finder' school, creating further international connections like a modern day 'message in a bottle'. Unfortunately, two miniboats landed in remote areas, unable to be recovered, while the other two were recovered, but not in full working order. POGO and Educational Passengers are working with the finders of El Cisne Alto to attempt a relaunching with a local school.

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Grants were awarded to 3 member institutions to support the following training programmes:

#### **Training course on Ocean Observations to Societal Applications** (30 Oct-5 Nov 2022, India) **Grant awarded to Indian National Centre for Ocean Information Services** (INCOIS)

The training was held in hybrid mode, with all the students joining the training physically and some faculty members teaching remotely. A keynote talk on "Ocean Observations and their role in the Society" was delivered by Dr. Toste Tanhua, GEOMAR Helmholtz Centre for Ocean Research Kiel and Vice-Chair, Global Ocean Observing System (GOOS). Each faculty member's talk focused on a service theme in which the faculty members covered the observational requirements, principles of equipment used to measure the geophysical parameters, data analysis and utilization to that respective service/ theme. Another talk showcased the heterogeneous data available in the Indian Ocean and its applications.

To make the trainees ready for action at their respective institutions, practical lab sessions were imparted with demonstration of the data collection and lab analysis of water samples collected. The theory sessions were held at e-class room facilities of International Training Centre for Operational Oceanography (ITCOOcean) at INCOIS, Hyderabad including the demonstration of various ocean instruments and show case of wet & dry labs, IRMS, HPLC, etc. The field trip onboard the vessel was conducted at Centre for Studies on Bay of Bengal (CSBOB) of Andhra University in Visakhapatnam. Different types of equipment were operated onboard for collection of the data and water samples. The water samples were analyzed at the laboratory of CSBOB. In addition, the participants were introduced to (i) POGO and its activities in brief, (ii) the IndOOS-2 activities towards the climate services and the need for sustained ocean observations and (iii) coastal observations in under-resourced countries – a portable and economical platform.

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#### **POGO-FUNDED MEMBER TRAINING INITIATIVES**

#### 2023 Surface Ocean Lower Atmosphere Study (SOLAS) Summer School (June 2023, Cabo Verde) Grant awarded to GEOMAR Helmholtz Centre for Ocean Research Kiel, **Germany (funds remaining from support of 2022 Virtual Summer School)**

The 9th SOLAS summer school brought 66 young researchers and 30 lecturers, practical demonstrators, and organisers to the Ocean Science Center Mindelo (OSCM) on the island of São Vicente, Cabo Verde. The summer school is a well-established activity of SOLAS, which gives participants the opportunity to expand their knowledge in the fundamentals of ocean and atmosphere sciences and trains practical methods of experimentation, remote sensing, modelling and science communication. The participants – master and doctoral students as well as recent postdocs – came from 25 countries and various fields of oceanography and atmospheric science. The lecturers were experts on SOLAS science from around the world.

It was the first time that the SOLAS summer school took place in an African country, highlighting the importance of marine research in the region. SOLAS recognizes that globally relevant science needs global participation, which means targeting regions that have so far been underrepresented in the SOLAS network. Early career scientists in many African nations are performing or would like to perform pertinent research on SOLAS topics, so SOLAS needs a presence within their communities. Cabo Verde, and specifically the OSCM, provide a wonderful stepping stone into these communities. The courses were supported by the on-site team of the OSCM as well as past summer school alumni and the SOLAS International Project Offices in Ireland and China. The school was generously supported by: China SCOR, GEOMAR, BMBF, CNC-SCOR, Gordon and Betty Moore Foundation, IMar, the International Assoc. of Meteorology and Atmospheric Sciences, iCACGP, ICOS, IUGG, MaCID, NSF, PICES, POGO, OCB, SCOR, UTA, WASCAL, and the Xiamen Marine International Cooperation Center.

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# **POGO-FUNDED MEMBER TRAINING INITIATIVES**

#### Training course on Subsurface Mooring Design, Recovery and Deployment (July 2023) **Grant awarded to the Institute of Oceanology Chinese Academy of Sciences (IOCAS)**

POGO member, the Institute of Oceanology of the Chinese Academy of Sciences (IOCAS), successfully hosted a Training Course on Subsurface Mooring Observation in Qingdao from July 16 to July 22. Fan Wang, Chair of Training, Director of IOCAS, Chair of Northwestern Pacific Ocean Circulation and Climate Experiment (NPOCE) Program, Sophie Seeyave, CEO of POGO, Kentaro Ando, Chair of IOC/WESTPAC, Janet Sprintall, Chair of IOC-GOOS Indian Ocean Region Panel, and Jae Hak Lee, a researcher from the Korea Institute of Ocean Science and Technology, attended the opening ceremony and delivered opening remarks respectively. 60 trainees from 22 countries/regions around the world, as well as renowned experts and early career scientists, participated in the training.

During the training, a series of highly professional lectures relating to ocean observations and research were presented. Scientists from IOCAS provided trainees with detailed instructions on the design, deployment, and recovery process of subsurface mooring observations, and also the data processing, analysis methods, and scientific interpretations of both subsurface mooring data and other in-situ observations in ocean circulation, internal waves, and climate research. IOCAS also organised field training for all trainees on the deployment and recovery of subsurface mooring, which was conducted on a scientific research vessel in the surrounding waters of Qingdao.

Fan Wang noted that this is the beginning of concerted efforts by IOCAS, in collaboration with scientists from all over the world, to support long-term subsurface ocean observations in open oceans, which is the key for ocean and climate community to understand the climate variability better and to gain sustainable development of the ocean. IOCAS will continue to host such training courses in the future to promote global ocean observing research, and warmly welcomes cooperation and support from research institutions or universities worldwide.

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### **POGO-FUNDED MEMBER TRAINING INITIATIVES**

#### **Training Course on Satellite-based** tools for investigating Aquatic Ecosystems

The "Satellite-based tools for investigating" aquatic ecosystems" training course consisted of 2 components: an open 17-week online course (whose lectures are now available online at https:// www.youtube.com/@trevorfoundation), and an inperson 2-day training course (7-8 August) attached to the TREVOR symposium. The online training had hundreds of attendees and 42 students from over 20 countries were present at the in-person training event hosted by PML.

In addition to teaching and exercises on satellite data processing, water quality and human health, primary production and the carbon cycle, and machine-learning and AI, the in-person training also gave students the opportunity to network and collaborate on areas of possible future research with input, guidance and discussion from experts and senior scientists.

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Group shot of the Students and some of the instructors/ supporters of the training. Credit: **Plymouth Marine** Laboratory

Students working on coding exercises. Credit: Plymouth Marine Laboratory

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### NANO GLOBAL PROJECT "A GLOBAL STUDY OF DEOXYGENATION, OCEAN **ACIDIFICATION AND PRODUCTIVITY AT SELECTED COASTAL SITES" (NANO-DOAP)**

NANO members conduct coastal monitoring of Essential Ocean Variables in 33 stations in: Argentina, Bangladesh, Brazil, Colombia, Ecuador, Ghana, India, Indonesia, Kenya, Lebanon, Mexico, Nigeria, Pakistan, Peru, Senegal, Thailand, Togo and Tunisia

Research grants awarded to 17 participating institutions in the following countries: Argentina, Bangladesh, Brazil, Colombia, Ghana, India, Indonesia, Kenya, Lebanon, Mexico, Nigeria, Senegal, Thailand, Togo and Tunisia.

The NANO global project has three major components:

- ocean acidification and deoxygenation;
- biogeographic distribution of the stations.

Field work was conducted in 2022-23 in all countries, for a set of variables (e.g., temperature, chlorophyll-a, pigments, bio-optical variables, conductivity, nutrients, total alkalinity, pH, dissolved oxygen, phytoplankton) varying from station to station. The budget was allocated depending on the local sampling costs, so as to enable each country to sample on a bimonthly basis (up to a maximum of 3K EUR per station).

Promote in situ and remotely sensed observations of the ocean at selected coastal sites in order to contribute to the global effort of monitoring the levels of

Provide opportunities to the project participants for: i) capacity building to strengthen their efforts to monitor levels of acidification and oxygenation; ii) join larger observation networks of ocean acidification and deoxygenation;

Organize workshops and webinars dedicated to share experiences in i) monitoring levels of productivity, acidification and oxygenation; ii) training on marine data management; iii) compare results from fieldwork and produce a

- Project participants also develop outreach activities to raise awareness of the importance of the ocean.
  - Twenty project participants attended a workshop at Plymouth Marine Laboratory, UK, in August 2023, to discuss their results, the future of the project, and specifically to work on a joint manuscript presenting the initial project results.

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### NANO GLOBAL PROJECT "A GLOBAL STUDY OF DEOXYGENATION, OCEAN **ACIDIFICATION AND PRODUCTIVITY AT SELECTED COASTAL SITES" (NANO-DOAP)**

#### **Ghana Fishing Vessel Sensor Network Pilot**

The Ghana Fishing Vessel Sensor Network Pilot is an innovative initiative which integrates oceanographic sensors onto fishing nets and canoes, capturing crucial data during routine fishing activities. By turning fishing gears into data collection platforms, it may revolutionize coastal ocean observation. This approach empowers local fishers to contribute to scientific research seamlessly and aids marine scientists in unraveling the complex processes influencing fish distribution.

This project is set to establish a proof Photo: Abeeku of concept, paving the way for scalable fishing vessel-based observation networks. This collaboration merges local knowledge with cutting-edge technology, fostering sustainable fisheries management and enhancing our understanding of marine ecosystems.

The pilot initiative is a collaboration between Ocean Data Network (ODN) and the University of Ghana's MarCNoWA project and receives support from Environmental Defense Fund (EDF) for travel, and funding from POGO and NANO-DOAP project for sensor acquisition.

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Maritime Safety

**Climate monitoring** 

**Tropical Cyclone** 

Offshore energy

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Public outreach is normally conducted through participation in international exhibitions, and 2022/23 saw a gradual return to face-to-face exhibitions, meetings and conferences. During this year, POGO participated in various events both in-person and virtually.

All of POGO's brochures, leaflets and other written products are available as digital versions online. POGO has now moved away from printed (paper) materials, with the exception of small quantities of postcards to distribute, otherwise favouring the display of laminated 'hard copies' of leaflets on our booths, and of QR codes on our promotional banners to give mobile device users quick and easy access to digital copies. We are also limiting the production and handing out of branded USB Flash Drives.

Continuing to pursue our goals for an inclusive and truly international organisation, we have translated and published our first interactive annual report (2021-22) in French. Due to budgetary constraints, other language translations were not possible on this occasion.

The Secretariat has continued to add to the POGO Case Studies illustrating the socioeconomic benefits of ocean observing. The case studies are designed for use in a variety of settings - website, social media, print, etc - to help those outside the ocean observing community to understand the value of such observations in the wider societal context, and the critical need for GOOS.

A freelance science writer was contracted once again to work on the project and to interact directly with researchers at POGO institutions. From the call for story ideas issued to all POGO members in 2021, the second phase of the project has focussed on the theme of Climate-critical observing, with case studies from China, Japan and UK. The third phase focussed on Geohazards, with case studies from France and India. We have created an Interactive Map on the POGO website, with links to each example, and printable PDFs.

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#### OUTREACH AND ADVOCACY CONTINUED

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#### **CITIZEN OBSERVATIONS OF LOCAL LITTER IN COASTAL ECOSYSTEMS (COLLECT)**

Project funded by the Richard Lounsbery Foundation, led by Dr. Ana Catarino from the Flanders Marine Institute (Belgium) and Dr. Edem Mahu from the University of Ghana, 100K USD, Jan 2021 – July 2023. Funds provided to the University of Ghana, NIOMR, University of Calabar, CURAT, IRHOB, IMAR and INRH.

The COLLECT project aimed at empowering students to become citizen scientists, by acquiring data on plastic litter distribution in sandy beaches, in West/North-African countries and in one South-East Asian country. In this project, students and school teachers collaborated closely with local experts in Benin, Cabo Verde, Côte d'Ivoire, Ghana, Morocco, Nigeria and Malaysia. The COLLECT project consisted of training local students (15 -18 years old) from ten high schools on sampling and analyzing macro-, meso- and microplastics in beach sediments, using a quantitative assessment protocol. The project further aimed to measure the impact of the citizen science intervention in ocean literacy, pro environmental behavior, and wellbeing of the participating students.

All documents and materials resulting from this project are (/will be) open access and available according to the FAIR Principles (Findable, Accessible, Interoperable, and Reusable). The results and outcomes from COLLECT contribute to expanding knowledge and establishing baseline information on coastal plastic pollution, with citizen science being an enabler of open science, allowing

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data to be freely available to the public, academics and policymakers. Expected results from the use of the COLLECT protocol globally will further contribute to the identification of hotspots of coastal plastic litter, and bring awareness to local communities on the potential consequences of plastic pollution. The COLLECT project contributes with data suitable to survey plastic litter to the United Nations' Sustainable Development Goals (UN SDGs), in particular to SDG 14, on the sustainable use of the ocean.

#### OUTREACH AND ADVOCACY CONTINUED

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#### **CITIZEN OBSERVATIONS OF LOCAL LITTER IN COASTAL ECOSYSTEMS (COLLECT)**

COLLECT has reached over 400 students from ten different schools, of which nearly 240 participants answered a social sciences questionnaire. Students attended two sampling seasons (November/December 2021, March/April 2022), and collected relevant data on litter distribution which will be submitted to The European Marine Observation and Data Network (EMODnet) central beach litter database, operated by EMODnet Chemistry (www.emodnet-chemistry.eu). The initiative impact assessment, led by Marine Severin (PhD student), demonstrated that, in general, the students had a very high baseline for knowledge of the "plastic litter" issue and its impact, and that after participating in the project, their well-being was positively impacted. Students demonstrated also increased pro-environmental behaviours, and the project had a positive impact on their ocean literacy.

The project has currently led to two peer-reviewed papers so far, a methodology paper (Catarino et al 2023, Frontiers in Marine Science), and a paper analysing the impact of the project on the well-being and pro-environmental behaviours of the participants (Severin et al 2023, Frontiers in Psychology). A third scientific manuscript is currently under preparation, where the data on marine litter distribution and abundance acquired during the project will be analysed. The Data management Plan (DMP) of the project, as well as all sampling procedures are available (open access) and findable using a digital object identifier.

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COLLECT vcée Techniqu Riverside Colleg Jniversitv of Calab Secondary School 'Kg drv sedimen Mean items/m² erved in season 2 ere single-use items **AFTER COLLECT** perceived to be ncrease in behaviours **Higher well-being** that help reduce litter +12% happines bad for tourism **1 %** understandir +19% nature packaging +5% understanding rivers discharging wastes in the sea

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#### **CITIZEN OBSERVATIONS OF LOCAL LITTER IN COASTAL ECOSYSTEMS (COLLECT)**

All developed educational materials were made available in the project working languages: English, French, Portuguese and Spanish. This included simplified and illustrated sampling procedures and video animations. Letters, information and consent forms are also available in all project working languages. COLLECT was featured in the media of participating countries and a complete list of TV reports, newspaper mentions, blog posts etc is available in the publication Catarino et al 2023, Frontiers in Marine Science. The complete list of presentations in scientific conferences (nine posters or oral presentations) and meetings is also available in the same publication.

In April 2022, COLLECT submitted a commitment that aims to accelerate and contribute to the implementation of Sustainable Development Goal 14 (life below water). In August 2023, COLLECT has further submitted an "activity" to the Ocean Decade programme (UNESCO, currently under evaluation), where the COLLECT Team aims to produce a Frontiers for Young Minds article (simplified scientific articles, peer-reviewed and edited by kids).

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#### SOUTH EAST ASIA PROJECT FOR GENERAL REGIONAL AWARENESS OF SEAGRASS BY SOCIETY (SEAGRASS)

Grant awarded to the Centre for Marine and Coastal Studies (CEMACS) of Universiti Sains Malaysia (USM) to cover field trip expenses, production of videos and pamphlets, and expenses for international speakers.

The Straits of Malacca is the second busiest ocean maritime trade route in the world. Naturally, this brings with it a lot of environmental pressure and risks to existing natural habitats. However, there are still pockets of marine habitats that possess high diversities of marine life such as shallow seas, intertidal mudflats, uninhabited islands and seagrass beds. As the only extensive and established seagrass area in the northern Straits of Malacca, Middle Bank seagrass meadow serves as nursery ground for many commercially important fish and mollusc species. the Centre for Marine and Coastal Studies (CEMACS) has been working closely with Penang State Government to gazette this area as ecologically important, serving as a carbon sink (complementing adjacent mangrove area) to mitigate climate change and offset the state's carbon emission.

The proximity of the Middle Bank to a World Heritage Site can be exploited to drive awareness and education on the value of these marine habitats to the general public. We hope this will encourage the local government and agencies to set up a marine protected area for research, monitoring and education.

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Through this project, CEMACS has started creating environmental awareness of the Middle Bank seagrass bed (Penang, Malaysia) as an important cultural and natural heritage to the various stakeholders. Among the first and earliest activities were the field trips to the seagrass bed for the collection of photographic and video materials for teaching and production of learning materials for biodiversity conservation at the Middle Bank. Simultaneously, scientific training and capacity development programmes for university students were also successfully conducted.

#### OUTREACH AND ADVOCACY CONTINUED

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#### SOUTH EAST ASIA PROJECT FOR GENERAL REGIONAL AWARENESS OF SEAGRASS BY SOCIETY (SEAGRASS)

As part of the awareness, outreach, and advocacy programme, several stakeholder engagement activities with the local government agencies, community representatives, and the public were conducted to promote the protection of the Middle Bank seagrass bed. We have also engaged with international schools on the idea of a marine protected area as a natural and cultural heritage - providing early sensitisation to seagrass beds' benefits and importance and marine conservation through a virtual tour.

Along with that, CEMACS, with the collaboration of Ocean Best Practices Systems (OBPS), held a successful workshop on 'Best Practices of Seagrass Monitoring' during OBPS Workshop IV on 7th October 2022. This workshop aspired to introduce protocols for seagrass monitoring that have been

adopted in seagrass areas across different countries. The team also had the opportunity to share their findings during the 6th International Congress of Fisheries and Aquatic Research (ICFAR) which was held virtually.

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#### Milestones and Deliverables: Field programme

Awareness, outreach and advocacy programme

- Preparation of video material -completed
- Virtual video creation of the Middle Bank -in progress
- Engagement with local/international schools and virtual tour of Middle Bank environment -in progress

#### Publication programme

- Preparation of photographic material -completed Pamphlet 1: The natural heritage of the Middle Bank -in progress Pamphlet 2: The animals and plants of the Middle Bank -in progress **Opportunistic Publications -completed**

#### Scientific training and capacity development

- Stake holder training on the ecology of the Middle Bank (national and international) -completed
- Stake holder training on seagrass mapping and ecology (national and international) -completed.

Seagrass field trip programmes for schools at CEMACS 1 - in progress Seagrass afield trip programme for schools at CEMACS 2 - in progress

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### **OUTREACH AND ADVOCACY COLLABORATIONS WITH OTHER ORGANISATIONS COP27**

The UN climate summits, i.e. so called COP (Conference of the Parties) are global conferences, in the course of which action for climate policy is negotiated. Almost 50,000 people from 195 countries took part in COP27, including politicians, representatives of non-governmental organizations, scientific community and business sector. The COP takes decisions which are necessary to ensure the effective implementation of the provisions of the Convention and regularly reviews the implementation of these provisions. POGO became an Observer NGO to UNFCCC in 2017. The conferences attract a variety of delegates – policy makers, business leaders, research institutes, NGOs, media – giving POGO a wide potential audience.

POGO joined forces with PML and the International Coastal and Ocean Organization (ICO) to co-host an exhibition stand entitled "Why the Ocean Matters in the Climate Negotiations", drawing attention to the major stressors on the world ocean and giving delegates the opportunity to learn more about the causes, effects, impacts and options for action. POGO also submitted a successful proposal for a Side Event on "Observing and understanding climate change and biodiversity from the coast to the deep ocean", jointly with the University of Southampton/Deep Ocean Stewardship Initiative (DOSI). This year, POGO was also a partner in the first physical Ocean Pavilion to have a presence at COP. The Ocean Pavilion was an initiative led by WHOI and Scripps, with other partners including several other POGO Members: CNRS, IFREMER, PML, and NOC. The exhibit was in place for 1 week, with POGO, NANO and PML representatives interacting with delegates in multiple languages.

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The POGO-OBON-DOSI Side Event focussed on how developing capacity for observing and understanding marine ecosystems will support tracking, forecasting and stewardship of these ecosystems to address the intertwined threats of climate change and biodiversity loss from the coast to the deep ocean. More details can be found on the POGO website, including a YouTube link to a recording of the session. The Ocean Pavilion was a hub for those interested in Ocean matters throughout the two weeks of COP, hosting networking events, meetings and a packed schedule of side events. POGO co-hosted two side events, (1) "Ocean observations for climate change: From local observations to a global system" (with GOOS) and (2) "Ocean observations for climate change: How do we train and educate the next generation of scientists and citizens?".

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#### **COLLABORATIONS WITH OTHER ORGANISATIONS**

In addition, POGO representatives were invited to participate in a number of other side events and panel discussions:

- Sophie Seeyave was a panellist for the UK Pavilion side-event co-hosted by the UK government and PML "Sea View: Enhancing ocean observations for climate action", and also for the side-event "Seabed 2030 - Mapping for People and Planet", organised by the NF-GEBCO project Seabed 2030.
- Fiona Beckman participated in a panel in the UNESCO pavilion, entitled 'Communicating Ocean Science for Climate Action'.

Margaret Leinen spoke about OBON in a side-event organised by Delta Electronics Foundation on "Science and Practice in Ocean Resilience".

#### West Africa Marine Science Symposium

The West Africa Marine Science Symposium (WAMSS) took place in Ghana from 18 to 20 August 2023, with 163 participants from 18 countries - both within the region and overseas. It was an Ocean Decade endorsed activity that brought together marine and coastal experts, storytellers, youth, government bodies, non-governmental organisations, funders, and National Geographic Society Explorers from and working in West Africa in order to: Foster critical knowledge exchange and cross-pollinate perspectives on the challenges and opportunities in the region; share successes and lessons learned with practitioners across sectors as well as the broader public; and engage early-career professionals and youth to inspire and equip the next generation of marine and coastal scientists, managers, and conservationists with key knowledge and skills. WAMSS highlighted career paths and funding opportunities, offered grant writing workshops, and forged critical connections, identifying successful marine research and conservation models.

The symposium was chaired by POGO trustee Dr. Edem Mahu, organised by University of Ghana and supported by National Geographic Society, POGO, NEWF and COESSING.

The POGO Secretariat was represented in-person by Scientific Coordinator, Dr Lilian Krug, who delivered a talk on opportunities for capacity development in ocean observations. The audience for her presentation also included participants of the Coastal Ocean

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**Environment Summer School In Nigeria and** Ghana (COESSING) training, which overlapped with the Symposium.

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#### **COLLABORATIONS WITH OTHER ORGANISATIONS**

#### Trends, Reflections, Evolution, and Visions in Ocean Research (TREVOR) Symposium

This international symposium was hosted by the Plymouth Marine Laboratory and attended by some 140 participants from around the globe.

The symposium was organised as a celebration of the scientific life of Prof. Trevor Platt, former Executive Director of POGO. Prof. Nick Owens, Chair of POGO, delivered the keynote lecture on "The Ocean as a Common Weal". The oral sessions were organised around a series of themes – physical and biological interactions; marine optics and ocean colour; physiological ecology of marine phytoplankton; water quality and human health; and size and ecosystem structure of aquatic communities – reflecting the broad scientific interests of Prof. Platt. There were also three networking session that dealt with capacity building and sustaining it; the United Nations Sustainable Development Goals relevant for water; and the concluding session that examined lessons learned and the way forward. The symposium also included two poster sessions. Former POGO Chair Prof. John Field presented Dr. Venetia Stuart, formerly the Project Scientist of the International Ocean Colour Coordinating Committee, the first TPSF Lifetime Achievement Award for her contributions to capacity building.

The symposium was organised with capacity building very much at the heart of it, and was designed as a continuation of the preceding online and in-person training course on Satellite-Based Tools for Investigating Aquatic Ecosystems. Students and Early Career Researchers were prominent in the agenda as speakers, session co-chairs and poster presenters. Support from POGO, and the juxtaposition of a NANO meeting at PML just prior to the symposium were instrumental in significantly enhancing developingcountry participation in the event.

The organising committee included Sophie Seeyave and Lilian Krug from the POGO Secretariat, and Dr Shubha Sathyendranath, former POGO Executive Director, along with many TPSF members from around the world. The success of the symposium is a testament to what can be achieved when many like-minded organisations come together and work jointly towards a common goal, with many volunteers working tirelessly to achieve that goal.

The feedback from the participants was uniformly positive, and by popular demand, the organisers are considering the possibility of organising a similar event three years from now.

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#### **COLLABORATIONS WITH OTHER ORGANISATIONS**

### Southern Ocean Observing System (SOOS) Symposium

The Southern Ocean Observing System (SOOS) hosted its inaugural SOOS Symposium, "Southern Ocean in a Changing World", from the 14th to 18th of August 2023 in Hobart, Australia. The Symposium was attended by 300 scientists from 25 nations for a week of plenary presentations, parallel sessions and workshops covering a wide spectrum of Southern Ocean research. In light of the escalating climate crisis, a community statement calling for an urgent expansion of Southern Ocean observations was released. Funding support from POGO and the Scientific Committee on Oceanic Research (SCOR) allowed SOOS to provide travel scholarships to eight early career researchers from developing countries to assist with their travel to attend the SOOS Symposium. The ECRs supported from the POGO travel funding are introduced in the POGO newsletter. The full Symposium report can be accessed here.

#### **OCEANS 2023 Limerick**

OCEANS is the bi-annual event for global marine technologists, engineers, students, government officials, lawyers, and advocates. It is the flagship event of the Marine Technology Society (MTS) and the IEEE Oceanic BLUEBE Engineering Society (OES). The 2023 meeting was hosted by **PLANET EARTH** the University of Limerick, Ireland, with Marine Institute as a key partner/organiser, and took place from 5-8 June. OCEANS 2023 was a UN Ocean Decade endorsed activity.

This meeting is dominated by marine industry and engineering, and provides an opportunity for POGO to interact with a subset of the Ocean Observing community who do not generally attend the same events as the secretariat. The programme was focused on three main themes: (1) Offshore Wind, Carbon Neutral Energy by 2050; (2) Sustainable Commercial Use of Seas and Oceans; and (3) Ocean Health and Resilience, with the morning plenary sessions tackling on one theme per day. Former POGO Chair, Karen Wiltshire (AWI) was honorary chair of the conference.

Fiona Beckman attended the meeting on behalf of POGO and staffed an exhibition booth. She also represented POGO in a special panel session, entitled "Fair solutions" in Engineering for sustainable oceans", chaired by Niall McDonough (Marine Institute). Other panellists were Eva-Maria Brodte (AWI), Prof Karen Wiltshire (AWI), and Toste Tanhua (GEOMAR/GOOS). The panel discussed the global need for low cost/ affordable observing devices, and shared examples of existing projects. Audience engagement was good, and the panel agreed to explore this topic further within the framework of the UN Ocean Decade.

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#### **UN Decade of Ocean Science for Sustainable** Development

In March 2023, we were pleased and proud to receive endorsement as one of three new UN Ocean Decade Implementing Partners (DIPs) announced by the IOC Executive Secretary.

POGO has been designated as a DIP for its commitment to supporting the Decade by coordinating existing Decade Actions, catalyzing new initiatives, leading targeted communications and outreach, and mobilizing resources.

Ocean Decade-endorsed activities supported by or involving POGO include:

- Ocean Biomolecular Observing Network (OBON) (2021 onwards)
- West Africa Marine Science Symposium (2023)
- International Nutrient Inter-comparison Voyage (INIV) (2023)
- North-South Atlantic Training Transect (NoSoAT) (2022)
- COP27 Ocean Pavilion (2022)

Find out more about our UNOD involvement on our dedicated page on the POGO website.

The POGO Communications Officer has continued to serve on the UN Ocean Decade Communications Advisory Group, recently renamed the Strategic Communications Group. The Decade is bringing together diverse stakeholders, including civil society, private industry, and science, to tackle the major challenges facing the ocean, and by association, facing our society.

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NF-POGO Regional Training Programme on Sustainable Marine Resource Management (2023)

OARS - via the POGO WG, "Action for Sustainable Ocean Acidification Research (ASOAR)"

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### **United Nations Decade** of Ocean Science **2030** for Sustainable Development

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# Frontiers in Ocean Observing Supplemental Issue of Oceanography magazine

POGO partnered once again with the US National Oceanic and Atmospheric Administration (NOAA) and Ocean Networks Canada to sponsor a second supplement of Oceanography magazine on "Frontiers in Ocean Observing". The purpose of the supplement was to widely disseminate information about the many different ways in which scientists observe the ocean to improve our understanding and support the sustainable management of the ocean and its resources. One of the aims of the supplement is to help explain the scientific and societal importance of ocean observing to funders, policymakers, and the general public.

The POGO Secretariat was represented on the Executive Committee, and contributed to defining the scope and themes of the supplement, issuing the call for contributions, and selection of invited articles. For this issue, specific themes were selected under each of the overarching themes that had been chosen for the first issue: (1) Observations for Marine Carbon Dioxide Removal (mCDR); (2) Patterns and Trends in Ocean Biodiversity Under Climate Change; (3) The Economic Consequences of Ocean Acidification on Marine Food and Tourism; (4) Assessing the Damage Caused by Marine Plastic Pollution; Ocean Observations for Coastal Hazard Warning; and (6) Environmental DNA Technology. The supplement, entitled "Emerging Technologies for Understanding and Managing a Changing Ocean" was published in March 2023 and is available as an open-access publication.

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2023 Oceanography Supplement

FRONTIERS IN OCEAN OBSERVING EMERGING TECHNOLOGIES FOR UNDERSTANDING AND MANAGING A CHANGING OCEAN

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Partnership for Observation of the Global Ocean