

## **G7 Future of the Seas and Oceans Working Group: Progress since May 2016**

September 2017

The oceans and seas connect the world's population and form an important part of our natural and cultural heritage. They supply nearly half of the world's oxygen, absorb over a quarter of the carbon dioxide produced, play an integral part in shaping our weather, the water cycle and the climate system, and are an important source of the planet's biodiversity and ecosystem services. From poverty eradication, food security and nutrition to trade, transportation, jobs and livelihoods, the oceans and seas play a vital role in the well-being and prosperity of all the world's inhabitants. Oceans can also generate some of the most destructive conditions like tropical cyclones and tsunamis and we must monitor the oceans to prepare and warn for these potential natural disasters.

At the G7 Science Ministers' meeting in Tsukuba (Japan) in May 2016, Ministers recognised that the seas and oceans are changing rapidly, with overuse and destruction of marine habitats, warming, increased ocean acidity and depleted oxygen. They agreed that the health of the seas and oceans has rightly been recognised as a crucial environmental and socioeconomic development issue through the adoption of a specific United Nations Sustainable Development Goal (SDG 14 – to “*conserve and sustainably use the oceans, seas and marine resources for sustainable development*”). In support of achieving this goal, and other relevant goals, including the closely related SDG 13 (to “*take urgent action to combat climate change and its impacts*”), Ministers supported further action to develop the far stronger scientific knowledge necessary to assess ongoing ocean changes and their impact on economies. Working together to enhance our understanding of the changes taking place will enable the development of more appropriate and coordinated policies that ensure increased understanding and the sustainable use of the oceans and seas both now and in the future.

Following the mandate given by the G7 Science Ministers in May 2016, technical experts<sup>1</sup> (marine scientists and specialists from across the G7), with considerable support for the initiative from G7 policy experts (Government Ministries and Funding Agencies), developed strategies for each of the five action areas that were outlined in the [Tsukuba communiqué](#) and its second attachment.

This report provides a detailed update on Working Group activities since May 2016 and builds on the executive summary document that annexes the 2017 G7 Science Ministers' communiqué.

In November 2016, a G7 'Future of the Seas and Oceans' Working Group workshop (which also had representatives from independent bodies<sup>2</sup>) was held in the UK to discuss and further refine recommendations that address the five action areas. This document outlines these refined action recommendations and includes a list of action area leads (annex 1), as agreed at the workshop.

The technical experts recommend the G7 nations use the 'Future of the Seas and Oceans' Working Group to strengthen international collaboration. To this end, the goal of the recommendations outlined in this document is to realize a more efficient and effective network of scientific ocean observing that supports the improved monitoring, conservation and sustainable use of the seas and oceans and their resources. G7 members do a considerable amount of work in ocean observation, both at a national and international level. The G7 is therefore in a strong position to add value by galvanising momentum in ocean monitoring and observations, as well as working with and supporting existing initiatives to increase cohesion, advance technologies, and reduce the duplication of activities.

The following recommendations from the technical experts address the five action areas agreed by the G7 Science Ministers in 2016 and fit together in the following narrative:

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<sup>1</sup> Technical experts act in their own capacity and do not represent the political views of their nation.

<sup>2</sup> The Global Ocean Observing System (GOOS), Global Earth Observations (GEO) Blue Planet initiative, Scientific Committee on Oceanic Research (SCOR), Intergovernmental Oceanographic Commission (IOC), World Oceans Assessment (WOA), Intergovernmental Panel on Climate Change (IPCC) and Partnership for Observation of the Global Oceans (POGO).

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The challenges identified in building a scientifically robust assessment and consensus view of the state of ocean to inform policy (Action 2) and address SDGs 13 and 14 and others, highlights the need for an extension of routine observations into yet under-sampled key geographical regions (Actions 1 and 4) as well as expanding our global ocean observing capacity using the full range of existing and emerging technologies and capabilities (Action 1) if SDG 13 and 14 are to be robustly addressed.

This extension of observations (including into new areas such as the deep sea) needs to be linked to a coordinated, state-of-the-art means of data transmission, sharing, processing and integration into models to provide ocean reanalyses, analyses and forecasts (Action 3 and 4), all extending in a manner respecting national and international agreements (Action 5). Furthermore, collaboration with other international actors, such as GEO and Global Earth Observation System of Systems (GEOSS), will be sought.

### Action 1

#### Tsukuba Communiqué commitment:

*“Support the development of an initiative for enhanced global sea and ocean observation required to monitor inter alia climate change and marine biodiversity, e.g. through the Global Argo Network and other observation platforms, while fully sustaining and coordinating with ongoing observation.”*

#### Recommendations:

To better understand and predict natural phenomena as well as the impact of human activities on ocean chemistry and ecosystems, their resilience and the effect that they have on the Earth's climate, we need a deeper understanding of our oceans and seas, including how and why they are changing. This requires the continuation and improvement of existing observations (via ships and autonomous instruments) that are augmented by new observations using new technologies in a more integrated, coordinated and consistent way that also helps to close existing gaps. Therefore, G7 technical experts recommend:

- The initial primary policy drivers should be climate, sea-level, chemical state of the ocean and ecosystem health/biodiversity variability and change.
- G7 cooperation to establish sustained funding mechanisms that are essential to maintain and extend the existing global ocean monitoring and observing systems in accordance with national research priorities and budgets.
- G7 members establish a Global Ocean Observing System (GOOS) Implementation group to liaise with and support GOOS whilst coordinating enhancements to G7 observing.<sup>3</sup>
- G7 members establish a research vessel coordination group to improve the global efficiency of the use, development and deployment of their oceanographic fleets.
- Development of a strategy for extending both ship-based and autonomous vehicular exploration to enhance discovery through monitoring and observations focussed on the high-priority areas listed below. As a first step to take this work forward, the G7 could develop road maps for the next five years for each of the following<sup>4</sup>:

<sup>3</sup> In doing so, the G7 would affirm the importance of GOOS and other internationally coordinated programmes coupling physics, chemistry and biology. This is considered important as it would benefit from, build on and complement, but not compete with or duplicate, the UN GOOS framework. This would allow the G7 to focus its actions within a GOOS context and, at the same time, overcome some of the weaknesses and under-resourcing currently affecting GOOS.

<sup>4</sup> These priorities are chosen to address the above policy drivers, focussing on currently under-sampled key areas. This collaboration would: develop a system capable of providing enhanced environmental intelligence by monitoring the effect of climate change on biological productivity, ocean acidification, oxygen depletion (hypoxia) and ocean uptake of CO<sub>2</sub> (BGC-Argo, underway data, sensors and gliders); monitor ocean temperature and salinity changes below 2000 metres and their role on the Earth energy budget and global sea level rise (Deep Argo); further sea level observations for assessing sea level risk in coastal regions (GLOSS); enhance the use of Ships of Opportunity, including the long-running CPR plankton survey and CO<sub>2</sub> measurements; coordinate under-ice measurements using Autonomous Underwater Vehicles (AUVs) in order to better understand and document ocean changes in the Arctic and Southern oceans; utilise 'augmented observatories' and ocean process studies as foci of more detailed studies and as sites to test the new technology (e.g. sensors on gliders and floats); and, use the high quality research vessels observations for reference (e.g. GO-SHIP). All of the above

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- Bio-Geochemical Argo (BGC-Argo);
- Deep Argo;
- Gliders in polar and boundary regions;
- Underway data (e.g. climate relevant data and Continuous Plankton Recorder (CPR) data);
- Sensor development (particularly biological/biogeochemical sensors);
- Augmented observatories (to allow deeper investigation of marine biology);
- Global Sea Level Observing System (GLOSS); and,
- Efficient network of research vessels (including Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP)).

### Activities completed by September 2017 (please see annex 2 for full list of actions):

To help fulfil action 1, G7 technical experts have carried out a number of activities under 10 sub-groups (sustained financing; Global Ocean Observing System (GOOS) Liaison; Bio-Geochemical Argo (BGC-Argo); Deep Argo; Gliders in polar and boundary regions; Underway data (e.g. climate relevant data and Continuous Plankton Recorder (CPR) data); Sensor development (particularly biological/biogeochemical sensors); Augmented observatories (to allow deeper investigation of marine biology); Global Sea Level Observing System (GLOSS); and, Research vessels (including the Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP)).

Activities have ranged from coordinating with existing initiatives (e.g. the Atlantic Ocean Research Alliance (AORA), AtlantOS and the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), amongst others) and holding Workshops (e.g. GOOS, Research Vessels and Gliders in polar and boundary regions) to preparing roadmaps for future activities (all sub-groups) and reviewing existing frameworks and resources (e.g. sustained financing).

## **Action 2**

### Tsukuba Communiqué commitment:

*“Support an enhanced system of ocean assessment through the UN Regular Process to develop a consensus view on the state of the oceans, working to a regular timescale which would enable sustainable management strategies to be developed and implemented across the G7 group and beyond.”*

### Recommendations:

To support the fulfilment of the United Nations’ SDGs 13 and 14 (and others) and the maintenance of healthy oceans, and to support efforts of the United Nations Regular Process to produce a scientifically robust and well-respected second World Ocean Assessment, G7 technical experts recommend:

- G7 underline of the importance of the UN Regular Process to develop a scientifically robust World Ocean Assessment-II (WOA-II) as a vital international source of authoritative knowledge and analysis on the state of the oceans.
- G7 commitment to raise the profile of the WOA-II in G7 countries and elsewhere as appropriate.
- G7 commitment to proactively supporting the Regular Process and WOA-II.
- Identification of each G7 country’s UN Regular Process national focal point (if not already identified) and relay their appointments to the Secretariat of the UN Regular Process.

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- Once the UN regular budget for the process is finalized, the G7 could discuss any budgetary shortfalls and options for ensuring the Regular Process has the resources it needs to be effective in the long term.

### Activities completed by September 2017 (please see annex 2 for full list of actions):

To help fulfil action 2, G7 technical experts continue to work closely with G7 Ministries to help raise the profile of the WOA-II to their marine science communities and will continue to do so beyond September 2017. Over the last few months, respective G7 UN Regular Process national focal points were identified and details were relayed to the Secretariat of the Regular Process as well as to each country and each G7 nation's scientific community.

### **Action 3**

#### Tsukuba Communiqué commitment:

*"Promote open science and the improvement of the global data sharing infrastructure to ensure the discoverability, accessibility, and interoperability of a wide range of ocean and marine data."*

#### Recommendations:

The ability to seamlessly link data collected from the new observations with existing but under-exploited marine data such that it can be quickly and widely located, shared, compared and interoperated is needed. It is critical to train and enable researchers and others in developing countries to utilise the rich suite of ocean observations. This will help us to address the key policy drivers set out above, enable the World Ocean Assessment and support the achievement of SDGs 13 and 14. It would also support current work in the wider G7 in open science. Cloud technologies and pre-existing cloud environments should be used where appropriate. Therefore, G7 technical experts recommend:

- The G7 member states increase interoperability and discoverability through G7 cooperation towards sharing best practices for marine open data, including in-situ, satellite and model data to achieve integration of observing systems and, where needed, developing a limited set of common data sharing standards and data integration translators. This should build on existing and globally agreed WMO/IOC data management and sharing standards as well as GEOSS data sharing and management principles as promoted by GOOS and the GEOSS Common Infrastructure (CGI).
- Collaboration amongst G7 national ocean institutes in advance of the next Science Ministers' meeting to, amongst other things:
  - Identify primary ocean science and service needs to find the key drivers;
  - Identify specific societal challenges and policy questions identified under Actions 1 and 2 that a seamless data integration translator could be applied to as demonstration projects;
  - Identify the relevant data required to meet these challenges; and,
  - Consider what existing ocean science community structures exist (including, GEOSS, the International Oceanographic Data and Information Exchange (IODE), WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), Commission for Basic Systems (CBS) and Commission for Instruments and Methods of Observation (CIMO), Copernicus Marine Service, GOOS, etc.) that could define the appropriate standards-based marine data interfaces and integration translator as well as implement the marine data interfaces and integration translator through demonstration projects.
- Building on the suggested implementation of the standard marine data interface (the connection between the data integration translator and the data source), the G7 should coordinate to provide access to the data and resulting data products produced to address the key policy questions identified under Actions 1 and 2 as open data.

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- In parallel, the G7 should support and reinforce international collaboration on ocean reanalysis, analysis and forecasting both for physics and biogeochemistry (GODAE OceanView, World Climate Research Programme's project on Climate Variability and Predictability (WCRP-CLIVAR), GEO Blue Planet, Copernicus Marine Service) as this is a fundamental data integration step required for ocean state and ocean health assessments.

Activities completed by September 2017 (please see annex 2 for full list of actions):

To help fulfil action 3, G7 technical experts started discussing a *G7 Ocean Data Accord*<sup>5</sup>, which is based on the basic policy for open data. Several initial end-to-end demonstrators (i.e. from data to integrated products) have already been identified (e.g. Dias platforms and Copernicus Marine Service in Europe). Using this, technical experts will be able to create a list of best practices for the *Data Integration Translator*, which enables users to access the single site, search for data and download gathered data from diverse data repositories in a uniform format.

### Action 4

Tsukuba Communiqué commitment:

*"Strengthen collaborative approaches to encourage the development of regional observing capabilities and knowledge networks in a coordinated and coherent way, including supporting the capacity building of developing countries."*

Recommendations:

Scientific capacity for ocean science issues across the world need to be developed to ensure a relevant and authoritative assessment that supports coordinated policy and governance decisions. This needs to be done by building networks of talent and technical skills, such as the use of new autonomous observing systems, as well as ensuring the provision of necessary infrastructure and modelling capacity in developing countries and the currently under-monitored regions. The first objective of this must be to protect lives; the second, to support sustainable use of ocean resources, including the preservation of the health of the seas and oceans; and, the third, to enhance social knowledge of the state of the global ocean through comprehensive observing. Therefore, G7 technical experts recommend:

- Support the development of a programme to promote sustainable coastal ocean observing systems for marine management in support of sustainable Blue Economies and the protection of life and property from severe weather, tsunamis, tropical cyclones and storm surges. These systems would provide the effective acquisition and translation into action of coastal ocean data, and equip marine managers and policy-makers with tools that enable them to plan, promote and encourage the sustainable development and protection of ocean, seas and coastal assets supporting their Blue Economies. The programme would develop and enhance regional and coastal ocean observing systems, building on existing activities, developing local capacities, and also working in new partnerships with developing countries to co-design new systems. Any programme addressing Blue Economies should have three linked activities:

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<sup>5</sup> The purpose of the Open Marine Data Accord is to publically demonstrate a G7 commitment to Open Data in the marine environment. This will encourage a wider adoption of Open Data principles and thereby enable greater levels of access to marine data. By publishing a clearly articulated explanation of the value of open marine data and through the action of publicly endorsing Open Data by signing up to the Accord, the G7 could help encourage other nations to adopt a similar open marine data policy. Other nations adopting the Accord will encourage more countries establish relevant open access mechanisms and policies to encourage sharing of marine data.

Marine science representatives of the G7 nations would draft the Accord, which would be a short document outlining how the world could benefit from open Marine data and how Open data applies to marine science. This Accord would include a declaration that commits to making marine data openly accessible. There could then be an event where G7 representatives sign the Accord. The responsibility to solicit other nations to sign up would then be allocated to an organization, who would engage with each nation to encourage them to sign up. One suggestion is for this to be carried out by the IOC/IODE, which is the network of national oceanographic data centres.

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- Stakeholder engagement and identification of user needs. A key milestone would be a symposium on observing system requirements, best practices, tools and technologies for coastal management. Outcomes would direct the co-design and delivery of improved coastal ocean observing systems, including the identification of appropriate innovative technologies and strategies.
- Collaboration with the World Meteorological Organisation (WMO) and Intergovernmental Oceanographic Commission (IOC) to identify pilot project locations (e.g. through GOOS Regional Alliances) which co-design, implement and deliver site-specific coastal ocean observing systems that (a) provide a bespoke solution to regional sustainable management of marine resources; (b) build on best practices in coastal observing; (c) link and build upon existing international activity (e.g. AtlantOS, GEO/GEOSS); (d) demonstrate capability for translation to other regions; and, (e) contribute to wider global processes including the World Ocean Assessment, achievement of United Nations SDGs (including SDG14) and the Sendai Framework for Disaster Risk Reduction.
- Capacity development and system sustainability, including technical, practical and transferrable skills training, and region-specific training. This activity would also promote opportunities for the creation of new “blue jobs” through technological innovation linked to coastal observing systems and the use of the information they generate.

### Activities completed by September 2017 (please see annex 2 for full list of actions):

To help fulfil action 4, G7 technical experts held a Workshop, *“Co-designing a cost-effective, sustainable system for coastal ocean observing in developing countries”*, which resulted in a complete set of proposals in respect of the recommendations above that can be taken forward by the G7 Working Group. These full proposals build strongly on existing G7 capabilities and will form a Policy Brief for G7 Ministries, laying out a cost-effective, sustainable approach to regional/coastal ocean observing for countries with developing blue economies but with restricted access to large infrastructure. The proposals will also be published fully as a white paper for the global ocean observing community (at OceanObs 2019).

## **Action 5**

### Tsukuba Communiqué commitment:

*“Promote increased G7 political-cooperation by identifying additional actions needed to enhance future routine ocean observations.”*

### Recommendations:

To facilitate the international collaboration necessary to carry out an enhanced system of ocean observation, we need to (where possible) remove political, legal and economic barriers to effective and coordinated observation, including in the new activities and practices outlined through Actions 1-4. Therefore, G7 technical experts recommend:

- Continued consideration of ways to provide further support in the areas of policy, funding and regulation to address the identified issues arising from the work of the technical experts in Action Areas 1-4, and the implementation of the agreed roadmaps.
- Collaboration of the G7 with Blue Growth initiatives, such as the OECD’s Project on ‘the Ocean Economy and Innovation’, amongst others, to assess the economic potential of public investments in ocean observing and data collection.

### Activities completed by September 2017 (please see annex 2 for full list of actions):

To help fulfil Action 5, G7 technical experts completed a review of the existing legal and policy analysis already undertaken across the four other Action Areas. This involved creating a consolidated list of legal and policy actions to be addressed by the G7 Working Group. To help drive and monitor the delivery and implementation of the action proposals, G7 technical experts have begun

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considering the policy, funding and regulatory issues that could act as a barrier to the Working Group's activities. Alongside this, G7 technical experts completed a study requirement to look at the economic aspects of delivering the outcomes of the four Actions and a cost benefit to the global community of sustained global observations (by all observation techniques in general as well as those using marine autonomous systems specifically).

### **Conclusion**

The impact of a G7 initiative on ocean monitoring and observations can be maximised by ensuring the most significant challenges are met by the major marine science nations collaborating in a coordinated way. This is intended to lead to a step-change in realising more rapidly and cost-effectively the potential of international ocean science to support achievement of SDGs 13, 14 and others.

The G7 political and technical work-streams agree to meet before the end of 2017 to progress on the action plans for the five action areas to ensure sustainable and substantial impacts and monitor progress in 2018.

**Annex 1: A detailed breakdown of G7 Technical Leads to take forward Working Group activities (as agreed in November 2016)**

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Action Area	Co-leads	Active	Informed
1	Italy, UK, US (please see below)	Canada, EC, France, Germany, Japan	
2	UK, US	Italy, Japan	Canada, EC, France, Germany
3	France, Japan	Canada, EC, Germany, Italy, UK, US	
4	Italy, UK	Germany, Japan, US	Canada, EC, France
5	Italy, US, UK	EC, Germany, Japan	France, Canada

Action Area 1 sub-action areas	Lead country	Assistance
Sustainable funding	Germany	UK
G7-Global Ocean Observing System (GOOS) liaison	UK	US, Germany
Biogeochemical ARGO (BGC-Argo)	France	US, Japan
Deep ARGO	Japan	US, France
Gliders in polar and boundary regions	UK	US, France
Underway data (e.g. climate relevant data and CPR)	UK	Germany
Sensor development (particularly biological/biochemical sensors)	UK	Japan
Augmented observatories (to allow deeper investigation of marine biology)	Italy	Germany, UK
GLOSS sea level network	US	
Research vessels (including GO-SHIP)	Germany, France	



## **Annex 2: Activities completed by G7 technical experts by September 2017**

### **Action 1**

#### Sustained Financing

The “Atlantic Ocean Research Alliance (AORA)-AtlantOS Exchange of Ideas on the Sustainability of Ocean Observing in the Atlantic Ocean Region” meeting that took place in Washington in April highlighted the need to identify where resources are most needed and to avoid duplication of effort. The analysis described in the section on G7-GOOS liaison has been valuable in this regard. A similar analysis across ongoing national and multi-national observational programmes would also be of value but may require resourcing. This information continues to inform the development of the 2 and 5 year roadmap.

#### Global Ocean Observing System (GOOS) Liaison

A review and analysis of how the current GOOS components are resourced has been undertaken revealing significant under-resourcing in virtually all areas. A virtual workshop involving representatives of all G7 members discussed how G7 and GOOS may best collaborate (a briefing summary is available). G7 members subsequently engaged in internal discussion to identify national priorities within the current GOOS structure, ahead of a second virtual workshop. This second workshop put forward preliminary national priorities for GOOS enhancement for discussion and was timed to allow input to be provided to the annual GOOS Steering Committee (Singapore 11-13 September). The G7 initiative received strong support at the GOOS Steering Committee and a draft statement was prepared describing how GOOS and G7 may most effectively interact. This information continues to inform the development of the 2 and 5 year roadmap. The importance of G7-GOOS collaboration was noted at the 29th Session of the Intergovernmental Oceanographic Commission (IOC) Assembly in June. A session was run at the IOC Assembly to provide information on the G7 initiative to IOC members. Attendees included Prof Peter Haugan (IOC Chairperson), Dr Albert Fischer (Head, Ocean Observations and Services Section, Chief of GOOS Project Office) and Dr Toste Tanhua (GOOS Steering Committee co-chair) in addition to national IOC delegates.

#### Bio-Geochemical Argo (BGC-Argo)

The international research community had previously developed an [implementation plan for BGC Argo](#). This defines a target for a global BGC Argo array: about 1000 BGC profiling floats would provide the needed resolution to greatly advance our understanding of biogeochemical processes and to enable significant improvement in ecosystem models. With an endurance of four years for a float, this system would require the procurement and deployment of 250 new floats per year to maintain a 1000 float array. A global BGC Argo system would cost about US\$25,000,000 annually. The full-scale implementation of a global BGC Argo system with 1000 floats is feasible within a decade. Successful, ongoing pilot projects (e.g. Remocean and NAOS in France, Soccom in the US) have provided the foundation and start for such a system. This information continues to inform the development of the 2 and 5 year roadmap.

#### Deep Argo

The 18<sup>th</sup> Argo Steering Team meeting held in Hobart (March 2017) was used to share and discuss plans for Deep Argo (including the status of Deep Argo pilot arrays and float technical updates). On the basis of discussion at the meeting, 28 Deep Argos have been deployed by G7 countries (France 2, Italy 1, Japan 2 and the USA 23). Some Deep Argos were newly equipped with a biogeochemical sensor. The international research community is actively addressing how best to share the data and improve the sensor accuracy, as well, to develop data synthesis techniques. This information continues to inform the development of the 2 and 5 year roadmap, which includes analysis and discussion of quality control and data sharing in conjunction with Action 3.

#### Gliders in polar and boundary regions

A workshop was held to develop the 2 and 5 year roadmap, which was coordinated with JCOMM-OPS OceanGlider's steering team. A briefing note summarising current sustained boundary

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monitoring with gliders has been produced, listing 9 current observing sites and a further 7 sites where there is an aspiration to deliver sustained monitoring when resources permit. A survey of polar ocean glider deployments is underway and the results of this will be reported to the G7 soon. The current major priority in this area of work is to explore what resources are available to support an office for the coordination of the global glider observation effort in the framework of the GOOS.

### Underway data (e.g. climate relevant data and Continuous Plankton Recorder (CPR) data)

Coordinating with JCOMM (Ship Observations team) and IOCCP, technical experts created an outline of requirements to furthering the development of underway ocean observations as a contribution to the global ocean and climate observing systems. They also reviewed observational assets and infrastructure for underway observing within G7 states, and more widely as appropriate. This analysis shows that, although there are many examples of excellent co-ordination and data dissemination, the underway observing system (measuring near ocean surface meteorological, physical oceanographic, biogeochemical and biological parameters) is fragmented: by country, by discipline, by parameter and by research cruise. Responsibility for specification of requirements, observation, data, and dissemination is divided across many national and international bodies. Each element is currently running at capacity and focussed on delivering for national, or program priorities. By integrating activities across G7, the effectiveness and efficiency of the underway sampling could be significantly improved. This is a low-cost way of significantly improving our ability to collect data to address e.g. SDG13 and SDG14. However, while people have given time to perform the above analysis, given the currently overstretched system and without additional funding, it has not been possible to make further progress toward realising the major benefits of a full integration of the underway observing system across the G7 and across disciplines.

### Sensor development (particularly biological/biogeochemical sensors)

Through the AtlantOS EU project, a roadmap for sensors and instrumentation that charts current technology development trajectories with a ten year horizon has been produced and mounted on the NOC website. The above road-mapping initiative and the wider sensor development agenda, underpinning mechanisms and international coordination were discussed at 8th session (May 2017, Qingdao, China) of the Observation Coordination Group (OGC) of the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM). This resulted in wide-ranging discussion and the creation of a scoping group to further international engagement of existing observing networks in technology development and adoption. A joint AtlantOS-AORA workshop was held to investigate the shared use of ocean observing infrastructure, including for the testing of new sensor technologies. A proof of concept structure was proposed. Building on the outputs of the EU Oceans of tomorrow projects, OCG-JCOMM, AtlantOS and the G7 sensors initiative a special session has been arranged for 2018 Ocean Sciences Meeting (11-16 February 2018 in Portland, Oregon “*New Platform and Sensor Technologies: Advancing Research, Readiness and Transitioning for Sustained Ocean Observing of Essential Ocean Variables*”). The above activities have been coordinated with AtlantOS, SenseOCEAN, NEXOS, OGC, IEEE and JPI Oceans. As a direct result of the G7 initiative the UK (NERC) and Japan (JST) have created a bi-lateral joint fund for innovative biogeochemical sensor technology development and have solicited applications from teams that must comprise developers from both countries. Successful applications will be selected and announced later in 2017.

### Augmented observatories (to allow deeper investigation of marine biology)

After forming a sub working group that was made up of drawing members from across G7, a workshop was held in Naples (June 13-15), which was generously hosted by the Stazione Zoologica Anton Dohrn. This workshop was used to prepare a 2 and 5 year roadmap for a fully multidisciplinary approach to the study of marine ecosystems delivered through augmented observatories (a briefing summary on this workshop is available). Discussions also focused on locations and the design of future augmented observatories. Technical experts also agreed that there needs to be a holistic approach – one that makes full use of existent technology and techniques, including developing

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optical methods, whilst recognizing and planning for the major contribution that omics technology will make to the study of marine biology and monitoring.

### Global Sea Level Observing System (GLOSS)

The GLOSS Group of Experts met in July in conjunction with the WCRP Sea Level Conference (July 2017). They agreed to work with G7 points of contact to discern a set of actions that could be considered by G7 Science Ministers by the end of the year. This information continues to inform the development of a 2 and 5 year roadmap.

### Research vessels (incl. the Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP))

By April 2017, the participants of a sub working group were identified to provide a perspective for each country both of the logistical organization (ships and other means at sea, international collaborations etc.) and of the scientific organization (national structures and programs, international collaborations etc.). A workshop was held, which was coordinated with ERVO, EUROFLEETS, OFEG and IRSO, which resulted in a report that: (i) reviews the international collaboration agreements on infrastructures (ships and other means at sea); and, (ii) analyses gaps in scientific cooperation agreements (observation, research, data...). This draft document was sent to participants in May in order to incorporate further national information, contributions, comments and suggestions. This information continues to inform and shape the 2 and 5 year roadmap.

### **Action 2**

1. Raised the profile of the WOA-II to their marine science communities and will continue to do so beyond September 2017.
2. Identified respective G7 UN Regular Process national focal points and relayed these details to the Secretariat of the Regular Process. These national focal points were then advertised to each country and each G7 nation's scientific community.

### **Action 3**

1. Start of discussion on the *Ocean Data Accord* and created a list of best practices for the *Data Integration Translator*. This enables users to access the single site, search for data and download gathered data from diverse data repositories in a uniform format:
  - To evaluate the practices we gather information below;
  - Target variables;
  - Metadata schema and vocabulary; and,
  - Query protocol, amongst other things.
2. Evaluation of marine data standards in regards to whether they should be adopted as a limited set of standards (which are metadata schema, vocabulary, data format etc.).
3. Commitment of G7 nations on a limited list of seamless data integrator demonstration projects (from data to information, assessment and societal challenges).

### **Action 4**

1. Held a G7 technical expert workshop titled "*Co-designing a cost-effective, sustainable system for coastal ocean observing in developing countries.*"
2. Started developing a Policy Brief for G7 Ministries, which lays out a cost-effective, sustainable approach to regional/coastal ocean observing for countries with developing blue economies but with restricted access to large infrastructure. This also includes an extended summary that reviews existing capabilities and best practice in coastal observing networks (including ongoing initiatives) and identifies the minimum requirements, tools and infrastructure for non G7 countries.

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3. Contributed to the AtlantOS meeting (Brussels, June 2017) to promote the objectives of the G7 Future of the Seas and Oceans initiative within the *Task Transatlantic cooperation and sustainability*.
4. Conducted the GEOSS-Asia Pacific working group (the Asia-Oceania GEOSS initiative) of *Ocean and Society* in Vietnam for the purpose to improve capability of ocean data exchanges amongst countries in the Asia-Oceania region to support community development activities in the Group on Earth Observations' (GEO) Blue Planet Initiative.

### **Action 5**

1. Reviewed the existing legal and policy analysis already undertaken across the four other Action Areas.
2. Created a consolidated list of legal and policy actions to be addressed by the G7 Working Group.
3. Are considering the policy, funding and regulatory issues that could act as a barrier to the Working Group's activities.
4. Completed a study requirement to look at the economic aspects of:
  - Delivering the outcomes of the four Actions; and,
  - The cost benefit to the global community of sustained global observations by all observation techniques in general and using marine autonomous systems specifically.