The Global Ocean Observing System

marine technology SOCIETY

NOAA

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DIALOGUES WITH INDUSTRY

Report out from Dialogue 2

Multi-Sectoral Ocean Architecture: Integrating new observing networks and business models

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Dialogue 2 Description

The second Dialogue brought together twenty-four (24) participants representing key stakeholders from industry, government, and academia (see list of the participants in Appendix 1) to discuss the multi-sectoral ocean architecture, i.e., the integration of new observing networks and business models into the existing ocean observing the environment. In preparation, the participants were provided the Industry Dialog Background Paper and the Use Case paper (Appendix 2).

The Dialogue was moderated by Chris Ostrander, Executive Director Marine Technology Society (MTS). The Use Case was divided into three sections: (1) Building an integrated system with public and commercial networks; (2) Understanding a new paradigm of commercial data streams; and (3) Hybrid architectures - how are they shaping the landscape? Each section included a set of questions to help participants prepare for the dialogue, which acted as a base for the discussions. The participants provided feedback from an operational, technical, or policy perspective. The event was held on a non-attribution basis and this synthesis document is delivered correspondingly.

In addition, there were approximately sixty-five (65) observers. Both participants and observers were able to engage in the dialogue. The first two hours were a facilitated discussion among participants with the observers providing input through the Q&A functionality of the video conference tool that was brought into discussion by the facilitator. The last thirty minutes were an open question and answer session among participants and observers.

This was the second of four dialogues. The key takeaways and potential paths forward provide a foundation for subsequent dialogues.

Key Takeaways from the Dialogue

- Ocean data is the foundation needed to de-risk and grow the blue economy, but the new blue economy market is as yet too small and immature, it is fragmented and difficult to value, which slows investment into, and thus the development of, data solutions. There is not enough stability or future growth potential to support increased investment. There is a need to look at how to break this cycle and stimulate new blue and thus blue economic growth.

Three factors came out as key to stimulating growth in the new blue economy:

- Standards are vital, they play an important role in leveling the playing field, providing stability, and opening the market for technology and data. Businesses see standards as incentives, as they provide a clear target, and are a baseline from which businesses can calculate their returns. There is a more transparent market when the same standard is required regardless of whether the provider is a public, private or academic component of the Ocean Enterprise.

- The public and intergovernmental sectors (GOOS, national governments) have a role to play in aggregating demand.

- National funders have an additional role to play in sustaining and/or committing to a longer-term vision for funding recognized components of the global ocean observing system. For the private sector, this longer-term commitment or vision provides a greater level of stability and is a factor in creating an environment that is favorable to making investments in new technology, cost reduction, etc., it reduces risk and increases stability.

Ultimately there needs to be a critical mass for opportunity. The demand for ocean information products is disjointed and further, there is not a strong international framework for developing that demand.

- GOOS, private and public sectors need to work together to lower the barriers and to promote blue and new blue economy growth towards the critical mass that will create a more sustainable market for the private sector partners. Currently, the ocean observing system is fragmented and niche, with both public and private sectors too weak to materialize the ambition, and the data, required for the blue economy.

New models for observing:

- Hybrid public-private ocean observing architectures require a better understanding of the public, private and academic components and are not risk-free. These components operate on different time horizons and motivations and there is a lack of understanding of how to fully engage stakeholders to develop a hybrid architecture. Alignment can accelerate a hybrid architecture through incentives such as purchases, regulations, and sharing in discoveries.

- Data is an asset and understanding the licensing of these assets is complex. As we increase the number of private sector businesses that are offering data, missions, and services, there is not yet a consensus on data licensing models for commercially procured data. Although licensing is complex, the Ocean Enterprise can look to the Space Enterprise and Weather Enterprise for examples. Alignment of interest and partnership were identified as important to successful licensing agreements. Defining ownership of the data is critical for licensing.

- Private sector data acquired for private sector clients are often dense and limited in scale, this can provide a complimentary data set to the broader scale public sector acquired data. Those companies collecting this type of data could adopt the FAIR data principles, which will ready them for sharing this data, should clients, government, or the market demand develop.

- Addressing the obstacles related to a comprehensive and truly international ocean observing environment, i.e., regulation of global databases, data from coastal, national waters, etc., requires targeted and ongoing communication efforts.

The top options identified to accelerate change toward a dynamic, expanded, and hybrid ocean observing system were suggested:

- Speeding technological advances by combining collaboration, investment models, and standards. Focusing on agreed areas of 'issue' where public-private collaboration groups/hubs could work to solve technology issues. Seeing technology funding to do this.

- Developing a hub or focal point to work together on the issues raised in the Dialogues with Industry, WMO recently developed an example of how this could work.

- The public sector and GOOS should consider working to set standards and to develop aggregated demand.

- Changing the perception of ocean data from being an ancillary or peripheral item to being essential and mainstream in operating a country.

Dialogue Purpose

MTS, GOOS, NOAA, and industry partners have identified a significant need to improve and expand communication if we are to collectively face the demand for a resilient, and responsive global ocean observing, forecasting, and information delivery system.

To date, the ocean observing enterprise has been a largely research-focused effort driven by government investments, which has created a highly fragmented value chain. Increasing societal demands for ocean data for climate adaptation and mitigation, to sustainably manage ocean resources and improve the forecast of extreme events to reduce loss of life and property, require a more rapid expansion of the ocean observing enterprise. However, the immaturity of the market significantly inhibits the speed and efficiency of system development.
New commercial ocean observing services are finding opportunities to exploit, yet it remains unclear as to how these will interact with the established global and national observing operations, as coordinated under the GOOS. The observing system will continue to need new technology, but there remains no established way to fast-track promising technology candidates into existing systems.

GOOS, MTS, and NOAA, together with industry have co-designed these fora for compact and meaningful dialogues with new and established companies, academia, and government to dismantle barriers and highlight opportunities towards achieving a mature and vibrant Ocean Observing Enterprise, through a thriving mix of the public and private technologies and players. Working together will solve problems …faster.

Discussion Synthesis

Section 1: Building an integrated system with public and commercial networks

Underpinning this section is the reality that the global ocean observing system, historically funded by governments, and operated by government agencies and grant recipients, is being complemented by a rapidly growing landscape of commercial platforms and data providers.

Investment in 'blue' business is hampered by a lack of ocean data

Investments in sustainable 'blue' business models trail behind those in 'green' (land), the reason offered was that many serious investors perceived such investments as too risky, and further, these investors were looking for data/observations to reduce or de-risk these investments. This can be seen in new areas such as carbon credits and marine carbon storage, which need data on the carbon cycle, particularly in the ocean. The business community is looking to the ocean observation and ocean knowledge communities to help them de-risk these opportunities. Providing ocean observations is now at an intersection with the private sector. Digital twins of the ocean can present a modern way of providing information.

Market size, maturity, and stability impact investment in the new Blue Economy

Private sector technology investment and development in the new blue economy are vital for the blue economy, however, a significant barrier is the currently small market size of the new blue economy, which inhibits companies from investing. This is at least in part a 'chicken and egg' problem, in that the market will not grow without a lowering of cost and increased investment, and yet at the same time, it is not attractive for this needed investment. In addition, as noted above, growth in the blue economy is potentially hampered by the lack of new blue economy data to de-risk investments. The sectors, the customer needs, the scale, etc., are not yet well defined, which indicates that the market is not mature.

The lack of data on the new blue economy is a particular challenge for new market entrants in accessing private equity and capital. One example of success has been for several companies to ‘club’ together to solve an issue, each bringing part of the solution. This approach requires establishing agreements and trust but can be a way of sharing investment responsibility.

There are ocean networks (e.g. Ocean Tracking Network (OTN), Canada) that were established based on commercial technologies resulting in a growing commercial market for animal tracking, a specific niche. However, overall, this market is relatively small, so there has not been a growth in the number of companies in this field. OTN, beyond the mission of tracking, has provided benefits to businesses that provide tracking technology by beta testing new technologies.

Another market factor is the sustainability of the observing system and supply chain. Risk in this area is attributed to both the public and private components. For the public sector, public funding is variable and even large networks are underfunded. For the private sector, if there is not a stable market, a business can and has in the case of BGC Argo, decided that a sensor the network relies on will be discontinued, impacting the data available for public use. A lack of long-term, sustained funding for ocean observations adds further risk to any investment in sensor or platform development

Users in the private sector could be important to the sustainability of the ocean observing market, however, big private customers for ocean data do not exist yet, as they do in the weather sector. In the future, the potential exists for this to grow, for example as the new ocean climate/carbon markets will require verification and reporting.

The ocean community could do a better job of identifying a need that we are going to meet, defining the service, giving it a version number, and then identifying the requirements for enhancements and technology development for the next version of that service. More systematic planning and information feedback processes for user needs would aid co-development between the private and public sectors to meet these needs. For example, the United States Integrated Ocean Observing System's Regional Associations serve as innovation hubs and are connected to the users. These feedback loops exist within other GOOS Regional Alliances that could be used to develop the market.

For developers of platforms providing data streams is an opportunity, and it is important to follow standards in acquisition, where they exist. Offering this service can enable companies to engage with new customers, and so grow their base. It is not easy to deliver data services, but it is an important market segment and with future developments, such as digital twins, this could grow in new ways.

Standards

Standards, also discussed in Dialogue 1, were again raised as an important feature missing in the ocean market.

A lack of standards was highlighted as a barrier because when standards are not identified, set, and communicated, then private sector companies have no target point, and when reached the data is known to be fit for purpose. This also impacts those who set contracts in the public sector.

Setting standards would not necessarily impede excellence, since companies would still strive for higher quality/accuracy etc., above the standard, as a means of differentiation, but having standards de-risks investment in development. This set of standards and urging/monitoring of uptake was seen as potentially one of the most important barriers to market growth and integration of public-private networks.

Standards can also be viewed as an incentive if the same standard is being asked for by all consumers or users, whether they are in the public or private sector. Standards are driven by the fundamental needs of the providers or consumers who use these data to serve their clients or the public. Such users will typically pull data from different sources, so it is critical that data can be interoperable, in similar formats, and of a known minimal level of quality. If companies set different standards that potentially confound the client's use of the data, then market growth, particularly of services will falter. Companies will differentiate themselves based on the precision and accuracy of their measuring equipment, and in providing more reliable and precise information to the users who make better quality products.

Private enterprise has shareholders and stakeholders with limited resources and narrow interests, they will therefore not solve all the problems that occur. If the targets are not well defined, then this is even more difficult. Developing standards for data, and the formats associated with them, is important and reduces the risk for the private sector.

Having a global standard-setting organization levels the playing field and reduces uncertainty for the private sector by agreeing on for example ontology, accuracy, and best practice. Standards also reduce the barriers to entry for the private sector. Adhering to common standards is of huge benefit in delivering consistent data, from which insights and services can more easily be developed.

In the meteorology community, the World Meteorology Organization (WMO) through its mandate for weather and climate and 193 member countries, sets standards and urges the uptake of standards within the public and private sectors. In addition, the member states have legal obligations to share data. In practice, National Meteorological Services use standardized and non-standardized data, and there are many different examples of how this works. In some cases, private sector data is being used with quality control, and in other cases where the government has indicated to stakeholders that this data will be meaningful to their economy.

In the ocean community, the IOC of UNESCO GOOS, through its global community and networks, supports best practices and standards and urges the uptake of standards within the public sector. Further, GOOS supports the Ocean Best Practice System (GOOS-IODE Project), however, the arrangement is looser. GOOS works in this area, in endorsing best practices, and is in a good position to support dialogue with the public and private sectors on data needs and to set such standards. Adherence to standards is an important aspect of the expectation of the global enterprise around collecting observations today.

An additional risk is not engaging with the private sector and/or making standards too complex (i.e., putting up barriers). Creating standards should be carefully considered so that they are the right ones, ones that are helpful to the public and private sectors.

Private Network Business Models

In looking at the landscape for public-private interaction within the ocean observing community it is worth considering that there is a mix of models. Understanding these can help identify the different barriers. Different models for private networks have different barriers and thus need different solutions.

Three current models are: 1) public sector demand is outsourced to private sector delivery. Here the barriers include complex and lengthy public procurement contracts, and whether the public sector is willing to outsource vs approaching other public sector providers, 2) opportunistic participation by the private sector in ocean observations, for example, the ships of opportunity (SOT) program, where there are substantive contributions from the private sector companies. The barriers here relate to standards, and the marginal costs associated with the taking of the observations, and 3) a data service, where the private company owns the asset and simply provides the data service. Here some of the barriers to the take up of these services are about accessibility to the data, and the ability to re-use the data for multiple purposes by multiple stakeholders.

Making initially proprietary data public

There is no considered or adopted pathway for making public the data collected by the private sector for specific purposes. . Such private sector work is often done by the private sector for private sector clients, and the data remains private. Releasing such data could have a positive impact on managing risk in the marine environment and could generally help the growth of the sector.

There are various ways how initially proprietary private sector data can be made public, e.g., through a philanthropic sharing of collected data through existing portals, and there can also be co-design or co-investment in a public-private partnership for marine infrastructure e.g., instrumenting wind farms.

Private sector data and public data are often different but complementary; private sector obtained data can often be smaller in extent and high resolution, providing ground truth for the bigger picture. By contracts, the public sector data provides this bigger picture in which the high-resolution private data sits as a subset. We need to see this as an interconnected ecosystem of public and private sector actors and users.

The oceanographic community's Findable, Accessible, Interoperable, Reusable (FAIR) data principles are beneficial to companies and the ocean community could do more to promote the concept of FAIR data. Taking up the principles of FAIR data and implementing them within companies, has two impacts: first, that data is easily used and re-used internally, and second, this procedure leads to interfaces, that are ready to make data available in the public sphere, essentially readying companies for a mixed system of public/private data. It was noted that under the Ocean Decade there is a Corporate Data Group which is designed to create frameworks and mechanisms that will provide public access to data collected by the private sector.

Organizations like IOC and WMO could also help develop a hybrid architecture for data delivery by setting a common framework to meet user needs, thereby creating a common platform across which commercial entities could create products and services that meet a range of user needs.

Section 2: Understanding a new paradigm of commercial data streams

Ocean data exists along a spectrum of accessibility with two end members: data that are collected and held by organizations for private use; and that which is freely and publicly available. The landscape of data between these two points is changing – with a mission- and data-as-a-service offerings from industry presenting a new procurement opportunity for both commercial and government players.

Commercial Data are an Asset

The shift from government-owned and distributed data to a commercially procured model raises several questions and concerns. From a legal standpoint data are an asset, and how a company maximizes value and minimizes risk for this asset is how legal systems view this. The move to open data and sharing in an unrestricted way is at odds with the realities of how businesses work. For example, in entering a software license, we do not require that this software is free to everyone. In addition, different types of data and different types of data use, have different legal regulatory risks associated with them. If these are not reflected in the license agreements, then it will be difficult to share data, even under an open license. Open licenses are still licenses that allocate risk. In addition, and adding to this complexity, is that the laws around intellectual property, liability, and increase in privacy regulations differ around the world. The value of data may depend on your culture, in some parts of the world social benefit/community benefit is valued more highly than the data. Public and business lawyers must be in the discussion from the beginning, so a mutual understanding is reached. However, it is noted that in some instances there is a lack of expertise in matters of environmental data sharing within the law community, as this is not an area of focus at many law schools.

The scientific community has raised a concern regarding data that has historically been provided by the public sector at no cost. Should such data become only accessible by purchase, researchers and service providers in the public sphere fear that their ability to conduct science and deliver solutions will be dramatically reduced. The United States Group on Earth Observations held a series of dialogues seeking the perspectives of the Earth Observing Enterprise on the use of commercial environmental and geospatial data, which was synthesized into a report - United States Government Commercial Earth Observations Data Purchases: Perspectives from the Earth Observation Enterprise, which had input from several academic and scientific organizations on this topic.

While data are an asset within the private sector to sustain a business, ultimately there are costs to collect or purchase the data that must be paid. However, revenue is not the only motivating factor for industry, and the alignment of incentives was suggested as important to functioning partnerships regarding data. In this context, regulation can be an incentive, and sharing in discovery can also be an incentive. The private sector is driven primarily but not only by revenue, whereas the public sector is driven by missions and societal benefits.

There was recognition by industry of the value of making their data accessible to academia. For example, Planet Labs, a corporation with a mission of public benefit, operates a large constellation of earth observation satellites, and benefits immensely from releasing free or deeply discounted data to the academic community and the scientific community at large. In one instance, Planet Labs worked with scientists in a marine dye experiment for tracking ocean currents, which was a novel way to use the data. These types of the partnership were of benefit to Planet Labs to understand new use cases where their products are relevant and could be developed into a commercial offering.

Other participants echoed this sentiment of finding value in working with academia and the scientific community. This alignment of interest can be in the form of a scientific publication or in highlighting/developing new data uses (markets), but at the same time, there is caution because a business still needs to protect its data from being shared further and potentially detracting from their ability to create additional revenue from this data or that the data will be used by another company to generate revenue without compensation to the company that collected the data.

In the earth observation satellite sector, there are examples where providing free or low-cost data to the science community has benefited the provider and society. In this context, one suggestion is that some form of partnership working group could be useful in looking at how suppliers and science can work together.

Note: in the current corporate governance world Environmental, Social, and Governance (ESG) factors have become a global imperative, placing companies under increasing investor and customer scrutiny. This heightened stakeholder focus means companies are confronted with new expectations. The ESG perspective could also be an incentive to engage in mutually beneficial public-private partnerships.

Licensing

The crafting of data licenses underpins the procurement of commercial data. In the United States, the government (Department of Defense and NASA) has developed End User License Agreements (EULAs) that determine the use and distribution of data. These licenses are tiered and include provisions for sharing data with academic science communities, with no commercial interest, and where publication was a reward for both scientists and private sector participants.

Additional terms have now been crafted to enable data to flow from one organization to others, for consumption in a scientific capacity. Another important consideration is for open products where, through partnership, there has been success in building derivative products that are uncoupled from the underlying data such as the Allen Coral Atlas. The big challenge for this type of open product development is transparency in data processing and version control.

Agreements and licenses for end users are important, but there is not one size that will fit across the private/public sector partnership. For example, real-time or fine-scale data could be available for purchase, however, the delayed or coarse scales data could be open.

NOAA is currently looking at how to better partner and interface with the private sector to the benefit of both. A key aspect of this is to look at buying data holistically, across NOAA and down the value chain, to understand what data and licenses work best for users. There are different aspects to this, with a key concern regarding data quality and standards. Concerns include how the calibration/validation is done for harmonization with other data sets, another is the licensing for public release. NOAA is governed by legislation which means NOAA procured data must be made available, thus it is important to work with private sector partners to achieve agreements that meet both NOAA and private sector needs.

Changing the perception of ocean data

In general, countries consider data needed for weather forecasting, most of which is collected from terrestrial stations or from space, as an essential element of operating a country. Ocean data is not yet considered to be similarly essential. Many nations still do not understand that ocean data is key for managing a country. If this can be more fully recognized this will move ocean data from peripheral to the mainstream. In turn, the private sector will have more assurance that governments are in it for the long run, and this lowers risk, as noted in the first section.

In addition, if we need environmental data for running countries, countries might be prepared to create a policy ensuring that environmental data, including that purchased in real-time from private companies, becomes part of the public record after a few years.
Changing the perception of ocean data will require strengthening government and international commitment to a necessary ocean observing system. Argo was cited as a successful model for global ocean observing

growth, however, there was some discussion as to how successful this has been. Argo delivers vital information for climate monitoring and modeling at a modest cost of $20 million annually, and yet all the countries participating in Argo are struggling for the 1-, 2-, or 3-year budgets to fund this global network. The network is still functioning thanks to the hard work of the network leaders and scientists in advancing the float technology, such that although Argo budgets have decreased the floats now have an increased 10-year lifespan and so the network is maintained. However, coverage is now starting to decrease as this long-term budget decline can no longer be compensated for by technological advances. Argo has been a visionary and revolutionary program, yet despite this network providing critical data streams, real-time, day in and day out, it is embraced as a vital global infrastructure. This needs to change. National commitment to a global observing system would address this gap. In addition, countries that do contribute can also often deploy their assets, such as buoys, according to national priorities, not to create a global coverage that benefits all.

So how do we change this? These are complex issues: there is good work in the GOOS Ocean Observing Co-Design Ocean Decade Programme that looks to strengthen the connection of requirements to user needs, and co-design in general is an important approach: we also need to have an ambitious and transdisciplinary approach: and recruit champions to highlight the need for ocean observing.

In some areas, there is growing recognition of the importance of ocean data or ocean observations for applications. For example, WMO now has recognized the importance of oceans in weather forecasting, and the services that WMO members provide moving forward - to take a quote from OceanObs'19: "If you like your weather forecast then thank an oceanographer." The community could do more to highlight these links in creating a market for ocean observing.

Unrestricted data vs. business reality – a source of conflict?

The new data policy at WMO notes that there should be free and unrestricted sharing of core data. Some participants, in this workshop, suggested the argument could be made that data critical for property and life, weather, and climate should be free and unrestricted.

Although powerful arguments can be made that this should be the case, the realities of business and legal issues are that this has not been how it has played out in other sectors, despite the need to tackle climate change.

Core data that the government needs, is likely always going to be funded by the government, however, it could be obtained through government/intergovernmental entities contracting with commercial entities. In the ocean sector, however, there are likely data that can never be productively or practically delivered by private companies, and this may be a way of constraining the question of commercial data delivery.

Section 3: Hybrid architectures - how are they shaping the landscape

The conversation was focused on the interdependencies between public and private infrastructure, shared management of risk, and the adoption of new business models to grow the marketplace.

Hybrid public/private observation network opportunities

A major opportunity for engaging with the private sector is that the need for and the delivery of services can be expanded, a range of observations filling gaps can be realized and that diversity in a system is often a strength. In addition, companies may take on some of the risk normally borne by governments, for example placing equipment in extreme ocean conditions to take observations.

There is an opportunity to look at what data are operationally needed by users. It is not simply a need for data of the highest quality, there are many levels of operationally useful data. The public sector can partner with the private sector in ensuring that the data quality, data resolution, and methodological approaches are consistent with what users need.

It is important to have dialogues between the public and private sectors and with major private sector users such as insurance, energy, and others that are investing in infrastructure in the ocean. Infrastructure is typically placed in the ocean for 30-40 years and with climate change, it is in the commercial interest of companies to have more and better data, so that they can design, engineer, and construct infrastructure to last. This is an alignment of commercial and public interests, in that these companies are incentivized to take observations and provide this data to improve their decisions.

The public and private sectors need to work together to lift the ocean observing system towards a critical mass that will create a more sustainable market for the private sector partners. Currently, the ocean

observing system is fragmented and a niche market and both the public and private sectors are too weak today to realize the ambition and the data required for the blue economy. Nations could do more to support this transition.

The innovation that industry can bring is important, for example, innovation can play a part in increasing the ability to take measurements of higher resolution and/or lowering the cost of incremental measurements, although these benefits are only realized at scale. Evolving to a hybrid system can bring benefits of scale.

It is obvious that there is not enough public sector funding now to support what is required for the blue economy, monitoring/predicting changing weather, climate, and ocean health. However, in a hybrid system what is a realistic model by which risk and opportunity are shared? One size may not fit all. Considering the different parts of the value chain ranging across technological assets, observing, and data assets, it might help models to emerge if we first assess who owns what asset and so gains the benefit, but also carries the risk. An analogy could be the railway system, where we see different models in different parts of the world. Some of them are entirely publicly owned, there are other models where the private sector owns the entire network, everything from the rail tracks through to the trains, the stations, and everything that goes with it. There are also hybrid models where the public sector owns and carries the risk for the track, whereas the private sector owns and profits from the trains, and some of that profit goes back into the public purse through taxation to help support the basic track. What is important to consider is the partition of the ownership of the assets and who carries the risks of them.

In the meteorological sector, there are examples of where the public sector activities have expanded to the extent that is costly to maintain and so they are looking for the private sector to play an increased role and to help lower costs. One important hybrid model, following the metrological community example, is where the public sector plays a core role and the private sector a complementary role.

Aggregating demand

A hybrid observing system model idea is very exciting for the private sector, but a roadmap from prototyping to large-scale observing systems is part of what is needed. If private enterprise is to take on this risk, then there needs to be a pathway as to how public and private systems can inter-operate, and someone has to pay for the observations in the long term.

Part of the answer to strengthening the system might be in aggregating the demand because a critical mass of opportunity is ultimately important to strengthen growth. This is something that governmental and intergovernmental agencies would need to spearhead. GOOS could play a clear role in doing this both for individual nations and internationally. The path to aggregating demand might be clearer in national waters than in the open ocean, where in the latter case there is not a strong international framework to aggregate this demand. Aggregated demand can also be created when countries sign up to international conventions, for example for biodiversity or climate, where there are associated nationally defined contributions to undertaking observations to evaluate the effectiveness of actions. While many find this approach too discretionary at present, in the future this could create institutionalized frameworks for demand.

Having three clear elements, standardization, aggregation of demand, and high-level coordination, could allow private industry to address some of these needs and develop a hybrid system.

Growing the market

Regulations can help create market pull. In the Norway mariculture sector, the need for data from commercial activities has been mandated by the state. This is a successful model for data sharing and involves management benefits for all by for example mitigating the risk of the initiation of infections and their subsequent spread among commercial operations. After consultation, the Norwegian regulators provided a regulatory environment for the in-situ information required, which is of benefit to the operators and state. This combination led to the installation of a robust observing system, supported, and funded, by the private sector mariculture operators and reporting through government organized frameworks. This is an example that demonstrates how regulatory pull can be a powerful driver for good practice and benefit for all, it is unlikely that this model would have spontaneously developed without this regulation.

Continuing to communicate the value of the public data can also serve to aggregate and increase sustained demand. The United States has made its government collected weather data available publicly without use restrictions. This has fostered the creation of many energy and weather companies to provide value-added weather services. Japan shared its weather data some 25 years ago and the Japanese weather service has established a consortium to aid the private sector by holding seminars to provide information on their products. This could also be a model for the

ocean community. While the recent Ocean Enterprise studies done by the United States, Canada, and the United Kingdom have identified a small set of companies (intermediaries) that are providing services based on public ocean information, these service-based companies identified themselves as being small to medium companies that are in their early phases.

Another opportunity is private sector infrastructure owners. In a changing environment, with climate change, it's not yet clear what the next 30 years or 50 years will look like. So, the traditional and historical models may no longer be valid, and as a result, it's in everyone's interest to have improved resolution and improved density of measurements and observations. With this improved confidence in what this future climate will look like, the world can properly design, engineer, and construct future ocean infrastructure. It is the interest of the private sector to help provide or facilitate the provision of this data.

The area of action for the private sector is likely not primarily in the open ocean and in addressing climate change, it is likely to be much more focused and active in the coastal zone. There are competing desires for access to coastal resources from the private sector, so management of this coastal zone "marketplace" will be important. There are many opportunities for data and service provision in this space, to businesses and regulators. Such approaches to management are already employed on land and they will come to the ocean space.

Developing the landscape for data services

Looking at whether the private sector could step in and create an ocean data marketplace for one particular component of the observing system, three factors were suggested as important: 1) data brokerage, 2) services and 3) relationships. Data could be brokered to a broader community through some sort of public sector developed private-sector marketplace, where the public sector would provide lower resolution broad area data, and the private sector could offer complimentary high resolution, small-area ground truthing data. Then services would be the main value stream for the private sector, providing data management, interpretation, and analysis. Finally, a great deal of work is needed in developing relationships, connecting public and private, and driving new business for the stakeholders of the marketplace.

The provision of services is expected to be a growing demand in the blue economy. Data-derived products that are insightful, and analytical will drive the development of a commercial marketplace for data.

Much of the data collected in ocean observation takes a degree of sophistication and knowledge to create the operational insight that decision makers need. There is still a lot of market development needed about how we develop these insights and derived products that are fit for purpose and suitable for industries like ship routing. For example, products are needed to help understand the impacts of increased storminess in the ocean on supply chains, insurance, risk, etc. The ocean, climate, and weather are changing, and traditional statistical methods will not give the prediction skill required. But there is a lot to do to market and develop these services. The ability to collect the observations and provide services will require investment, but the investments offer the potential to profit from the significant opportunity.

It was noted by several of the participants that there are likely data streams, such as those critical to human safety that may need to remain as public data whether it's provided by publicly funded infrastructure or privately (through contracts to the public entities.) There may also be classes of data that may never be profitably generated and delivered by commercial entities. A continuous and realistic discussion is needed on this spectrum of what data are needed and by whom should they be generated.

The participants suggested developing data "marketplaces." Such data marketplaces or exchanges could create desired data flows. The public sector can play an important role in creating such exchanges and associated standards for data comparability and interoperability.

Accelerating the change to grow the Ocean Observing Market

The final part of the Dialogue was an open discussion with both the Dialogue participants and observers.The discussion focused on ideas for making a step change to the ocean observing market.

The future ocean observing architecture will be a hybrid concept (i.e., made up of public, private, and academic entities) but how can we break out of the existing boundaries and speed up this shift?

Speeding technological advances by combining collaboration, investment models, and standards is one approach. Focusing on agreed areas of 'issue' where public-private collaboration groups/hubs could work to solve technology issues would highlight to all players in the market, be they large, medium, or small, that this is an area where technology is sought and hence demand exits. The provision of solutions can make a step change difference – a good example from Argo is in the float batteries.

In addition to this, the community could focus on selected large collaborative experiments to test new technology in public-private collaboration, which would not only look at technology for instruments but also at the link between technology and improved model performance. There is a growth area in new technology to solve problems, particularly for environmental data where there is an increasing need for data for multiple reasons.

Part of this technology work/solution could be supported with technology funds, for example, in the US there is a Small Business Innovation Research (SBIR) Fund, which provides seed funding and could help with de-risking companies' technology investments. Other schemes look at access or sharing facilities for testing new technology. This type of funding could be a source to help speed up new technology to market. However, this type of investment does not address the initial funding required to bridge the gap between initial product development and its mainstream use (known as the 'valley of death'), which is an issue for new technology ventures. Ensuring that there is known/defined demand (standards and aggregate demand) and thinking about how to scale technology production in the early planning stages, could help address this problem.

It is also important to create structures to facilitate dialogue. The WMO adopted the Geneva Declaration, which notes that all the stakeholders, including public, private, and academic sectors and civil sectors should work together to solve societal issues. From this declaration, the WMO has provided guidelines for countries to support working with the private sector and has also established an open consultative platform. This platform is a dialogue facility to share common goals, inviting the public, private, and academic sectors to participate. Could the ocean community create something similar?

Potential Pathways Forward

This Dialogue builds on the first Dialogue. The next two Dialogues with Industry will refine and develop the issues and ideas across the value chain from ocean observation to service delivery. The results from all Dialogues will be synthesized in a final summary paper for the series and a concise set of practical and implementable recommendations will result from the process. In the following page is an initial take on the key issues and potential pathways forward drawn from the second Dialogue.

- Communicate with government, blue financial investors, and the private sector on the chicken- and egg- status of the blue and new blue economy markets, where the current levels of data are insufficient to de-risk investments, and the ocean observing market is too niche, immature, and fragmented, which is not conducive to the investment needed in technology for new and lower cost solutions/data – government and private sector should jointly seek beneficial solutions.

- Develop coordination structures to facilitate standard setting to support private sector investment and more efficient development.

- Develop coordination structures to work on aggregating demand, this again will lower investment risk and create a more stable marketplace.

- Speeding development of technological advances through combining collaboration, investment models, and standards. Co-identify focus areas based on public needs and market opportunities and work together to speedily solve technology issues. Some potential funding options could support this type of work.

- Strengthen government and international commitment to a vital and necessary ocean observing system, as a part of national infrastructure.

- Develop data marketplaces to foster data exchange and the landscape for data services.

- Work on changing the perception of ocean data as niche, through communication and advocacy, at global and national levels.

Appendix 1: Participants

Sector	Affiliation	Name
Public/Australia	Commonwealth Scientific and Industrial Research Organization (CSIRO)	Andreas Marouchos
Public/Canada	Ocean Tracking Network	Fred Whoriskey
Public/Germany	GEOMAR Helmholtz Centre for Ocean Research Kiel	Martin Visbeck
Public/USA	National Oceanic and Atmospheric Administration (NOAA)/U.S. IOOS	Carl Gouldman
Public/USA	National Oceanic and Atmospheric Administration (NOAA)	Wayne Mackenzie
Intergovernmental	Data Buoy Cooperation Panel and Core Coordination (WMO)	Boris Kelly-Gerreyn
Intergovernmental	World Meteorological Organization	Mathieu Belbeoch
Intergovernmental	World Meteorological Organization	Tatsuya Kimura
Academia	Woods Hole Oceanographic Institute (WHOI)	Carol Ann Clayson
Industry	AiiM Partners	Shally Shanker
Industry	Alseamar	Laurent Béguery
Industry	ESRI	Keith VanGraafeiland
Industry	Fugro	David Millar
Industry	Fugro and Ocean Decade	Terry McConnell
Industry	Planet	Joe Mascaro
Industry	Saildrone	Kim Sparling
Industry	SeaAhead	Mark Huang
Industry	SOFAR	Tosca Lichtenheld
NGO	Centre for Spatial Law and Policy	Kevin Pomfret
NGO	EUROGOOS	Inga Lips
NGO	Global Oceans	Jim Costopulos
NGO	National Oceanography Center UK	Ed Hill
NGO	Ocean Assets Institute	Joan Fulton
NGO	Plymouth Marine Laboratory (UK)	Icarus Allen

Appendix 2: Use Case

Dialogue 2 | Multi-Sectoral Ocean Architecture: Integrating new observing networks and business models

Background and scope

Climate change is reshaping the geostrategic, operational, and tactical landscape. At COP26 a critical link was made between the Ocean and Climate. Marine ecosystems were also recognized as "carbon sinks" which emphasizes the importance of the protection, conservation, and restoration of terrestrial and marine ecosystems in the reduction of greenhouse gas emissions.

Increasing societal demands for ocean data are driving a rapid expansion of the ocean observing enterprise. Currently, the immaturity of ocean observing as a market significantly inhibits, among others, system development and efficiency, market growth, new technologies' speed to market, economies of scale, and cost and range of service delivery. Working with the private sector, GOOS, MTS, and NOAA would like to co-develop practical steps to greater market maturity, which will benefit companies, governments, and ultimately society.

The leadership of the global ocean observing enterprise, working with the Ocean Enterprise business cluster[1], and the non-governmental and academic sectors are poised for significant growth opportunities. The public and private sectors must develop practical steps to greater market maturity. In this, second of four industry dialogues, we look at the opportunities and barriers to entry in the network and data service provision. This sector is poised for significant global growth. While in recent years companies have created new commercial models, barriers to entry remain.

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[1] The Ocean Enterprise business cluster comprises businesses that support ocean measurement, observation and forecasting, often termed or now called the New Blue Economy. These businesses supply technology to generate ocean data or work with ocean information to deliver societal or business benefits. https://ioos.noaa.gov/project/ocean-enterprise-study/

Section I – Building an integrated system with public and commercial networks

Up until recently the global ocean observing networks have been government funded, ocean research or meteorological services, with the understanding that the data they provide is for the public good, and flow into areas like climate research and weather forecasts. Recently, however, there have been disruptive new entrants into this marketplace, businesses offering networks of platforms and downstream data services. These are filling niches in the ocean observing enterprise, be it in terms of ocean information or capacity to undertake and process ocean observations. The Space Sector has adopted the term New Space[2] and the United States government is now adopting a philosophy of the Hybrid Space Architecture (HSA) which is the integration of emergent "new space" smallsat capabilities with traditional US Government large space systems. Similarly, the Ocean community has seen the growth of the Ocean Enterprise deploying commercial ocean observing networks.

How does the existing and predominantly research funded ocean observing system integrate and work with these new network and data service entrants? What are the opportunities, standards, barriers, and norms that we need to look at for greater efficiency and integration? How have other sectors approached this? How can the Ocean sector learn from the Space or Meteorological sectors in developing a 'Hybrid Ocean Architecture' for the global ocean observing system?

Discussion Topics

- What are the barriers for businesses entering and developing commercial observing networks in the ocean observing market? What are the expectations from the existing observing networks towards private sector involvement and what are the expectations of the private sector towards the existing networks.

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[2] New Space: A post-millennial, modern approach focused on lowering the barriers of entry to space through increased risk tolerance and innovations in spacecraft development, launch, contracting, and business practices, largely led by new and agile private sector commercial organizations focused on bringing increased and rapid access and affordability to space. National Academies of Sciences, Engineering, and Medicine. 2022. Leveraging Commercial Space for Earth and Ocean Remote Sensing. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/26380.

- How can current best practices for privately collected ocean observing data fit with new business models and/or be improved to support public needs? How would FAIR data principles, data harmonization, metadata standards, calibration, and validation be handled in an integrated system of public and private networks?

- What are the opportunities for adapting modes of operation from other sectors? Are there exemplar models of mixed public/private data collection networks, say, from the remote sensing community, the ocean observing enterprise can use to accelerate advancement to maturity?

- How can current best practices for publicly collected ocean observing data - including FAIR data, data harmonization, metadata standards, calibration and validation, and accessibility, fit with new business models and/or be improved to support industry?

- How could the Ocean Enterprise best support a thriving 'hybrid' system?

Section II – Understanding a new paradigm of commercial data streams

The purchase of commercial ocean data is rapidly evolving as is the public sector's understanding of how to make these purchases both effectively and efficiently. To deliver informed services and decisions, it will be necessary to draw upon the resources of the public and private sectors.In many instances, it will be necessary to combine data from the public sustained ocean observing networks, data collected by the public or private sector ('citizen science'), and commercial data licensed by the public sector and other third parties. The commercial sector is also interested in developing and licensing derived products and analyses using these data sources. It will be useful to understand licensing and data sharing models that are mutually beneficial to the government (national) sector and commercial sectors. It will also be important to understand the potential impact on academic and international partnerships when a government moves from government-owned data and platforms to commercially-owned data and platforms. There are technical issues such as calibration and validation of data that need to be explored. If commercial data is blended with public data to provide warnings, what are the liability implications? Finally, what are the ethical issues that may arise? As higher and high-resolution data is collected are there privacy concerns that have to be considered? What can we learn about licensing best practices from other more mature sectors such as space and meteorology? How does the public sector minimize the risk of the private sector not being able to sustain the observations if they go out of business?

Discussion Topics

- What licensing and data sharing models support the growth of the ocean data ecosystem while being mutually beneficial to the public and commercial sectors?
  - What types of licenses exist and how do they handle data sharing restrictions?
  - Given the take once/use many current data principles what models for licensing from other sectors or in ocean observing are closest to this principle?
  - Is upholding this take once/use many principles realistic with commercial providers, or should we adopt a different/mixed model?

- How are private companies (end-users) using private sector data/tools infrastructure? Would private sector end-users be willing to provide public access to their data, and if so, under what terms would they be willing to provide these data?

- Considering the sample once/use many times principle, what are data licensing models to enable this principle? Going further, is upholding the sample once/use many times principle realistic in a blended public and private ocean observing space?

- How are private companies using public sector data/tools infrastructure and if so, does it meet your needs?

- If data that was historically collected by a government/national agency is now procured, how does that impact the academic sector, and international partnerships?

- How can and should data licenses, the intentions of the WMO unified data policy and the FAIR data principles are used to drive market development?

- How do government/national agencies safeguard unauthorized sharing of information? If data is collected along a coast as high resolution, what steps should the public entities and businesses be required to take to protect the privacy and data of individuals within the affected communities? Are there any applicable laws or policies that must be followed?

Section III - Hybrid architectures - how are they shaping the landscape

Data sharing and licensing are important elements of growing a hybrid architecture but other elements such as interdependencies between public and private sector infrastructure, new business models, and risk are all factors for consideration. Fundamentally does the same market equation exist in the ocean sector as it has in the other sectors e.g., remote sensing to create the same marketplace for ocean data? Markets for products, services, and data can't be created if demand doesn't exist. "Demand" in this case is a sufficiently large number of customers willing and able to pay for a product or service.

Discussion Topics

- What are the risks for the public sector in moving towards a hybrid architecture? (e.g. data quality assurance, instrument calibration, companies exiting the market) What risks are borne by the private sector in a hybrid architecture?

- How are commercial observing networks linked to and/or reliant on the infrastructure of public observing networks? More broadly, what are the infrastructure and data interdependencies that underpin the operation of public and private sector observing networks?

- Historically, demand for ocean data has been driven by the user-, temporal-, and location-specific requirements—hardly the elements needed to establish a robust data marketplace.Conversely, demand for the enabling technologies to collect ocean data has been more uniformly distributed. To what degree can a commercial marketplace for ocean data emerge in coming years, and what pull exists today that can be leveraged to bolster demand for such a marketplace?

- What new business models have the commercial sector identified as being attractive and/or potentially viable for providing data and data services to governments?

- What are the available funding mechanisms that can enable the maturation of public-private partnerships for ocean observing?

- To what degree a commercial "marketplace" for ocean data can/will sufficiently emerge soon? What is "pull" that exists in the near-term (e.g. technical solutions to enhance data network cybersecurity in undersea cables, port data networks, energy storage technologies for the deep sea) that can will require unique technology solutions and create a market?

- What are the risks for the public sector in moving towards a hybrid architecture? (e.g. calibration, companies going out of business.)

Q&A session

Focusing on market demand for data and data products. Demand for ocean data has historically been driven by the user-, temporal-, and location-specific requirements—and these elements are insufficient to establish a robust data marketplace. But the economic and technological landscape, along with our environment and climate, is changing.Looking ahead, to what degree can a robust commercial marketplace for ocean data emerge in coming years, and what pull exists today that can be leveraged to bolster demand for such a data marketplace?

What are the discrete recommendations that accelerate the growth of the ocean observing enterprise as a hybrid system—that allows scalability and takes the enterprise to the next level?

Appendix 3: Planning Team

Sector	Affiliation	Name
Public - Australia	Bureau of Meteorology	Boris Kelly-Gerreyn
Public - United States	NOAA	Brittany Croll
Public - United States	NOAA	Kelly Spalding
Public – United States	NOAA	Liz Tirpak
Intergovernmental	GOOS	Emma Heslop
Intergovernmental	GOOS	Laura Stukonyte
Industry	Kongsberg Maritime	Peer Fietzek
Industry/NGO	L3 Harris/MTS	Donna Kocak
Industry	South Seas Science Consulting	Sebastien Boulay
NGO	IMOS	Michael Heupel
NGO	MTS – India	R. Venkatasen
NGO	MTS	Chris Ostrander
NGO	MTS	Monica Ostrander
NGO	MTS	Zdenka Willis
NGO	Society for Underwater Technology (SUT)	Ralph Rayner

The Global Ocean Observing System

marine technology SOCIETY

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

DIALOGUES WITH INDUSTRY

Report out from Dialogue 2

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