

# CO-DESIGNING THE FUTURE OF OCEAN TECHNOLOGY & DATA

LESSONS FROM GLOBAL WORKSHOPS



Ocean Motion  
Technologies



THE OCEAN  
FOUNDATION

# ABOUT US



Ocean Motion Technologies, Inc. builds AI-controlled wave energy devices paired with the Big Blue Cloud™ platform to deliver reliable power and end-to-end data for the ocean. Together, we enable persistent monitoring and actionable analytics for ocean observation, aquaculture operations, and maritime domain awareness.

 [oceanmotion.tech](https://oceanmotion.tech)

 [x.com/oceanmotiotech](https://x.com/oceanmotiotech)

 [linkedin.com/company/oceanmotion](https://linkedin.com/company/oceanmotion)



As the only community foundation for the ocean, The Ocean Foundation's mission is to improve global ocean health, environmental and community resilience, and the blue economy. We create partnerships to connect all peoples in the communities in which we work to the informational, technical, and financial resources they need to achieve their ocean stewardship goals. Our focus is the ocean. And our community is every one of us who depends upon her. We work to ensure all countries and communities can monitor and respond to changing ocean conditions and support local scientific leaders everywhere.

 [oceanfdn.org](https://oceanfdn.org)

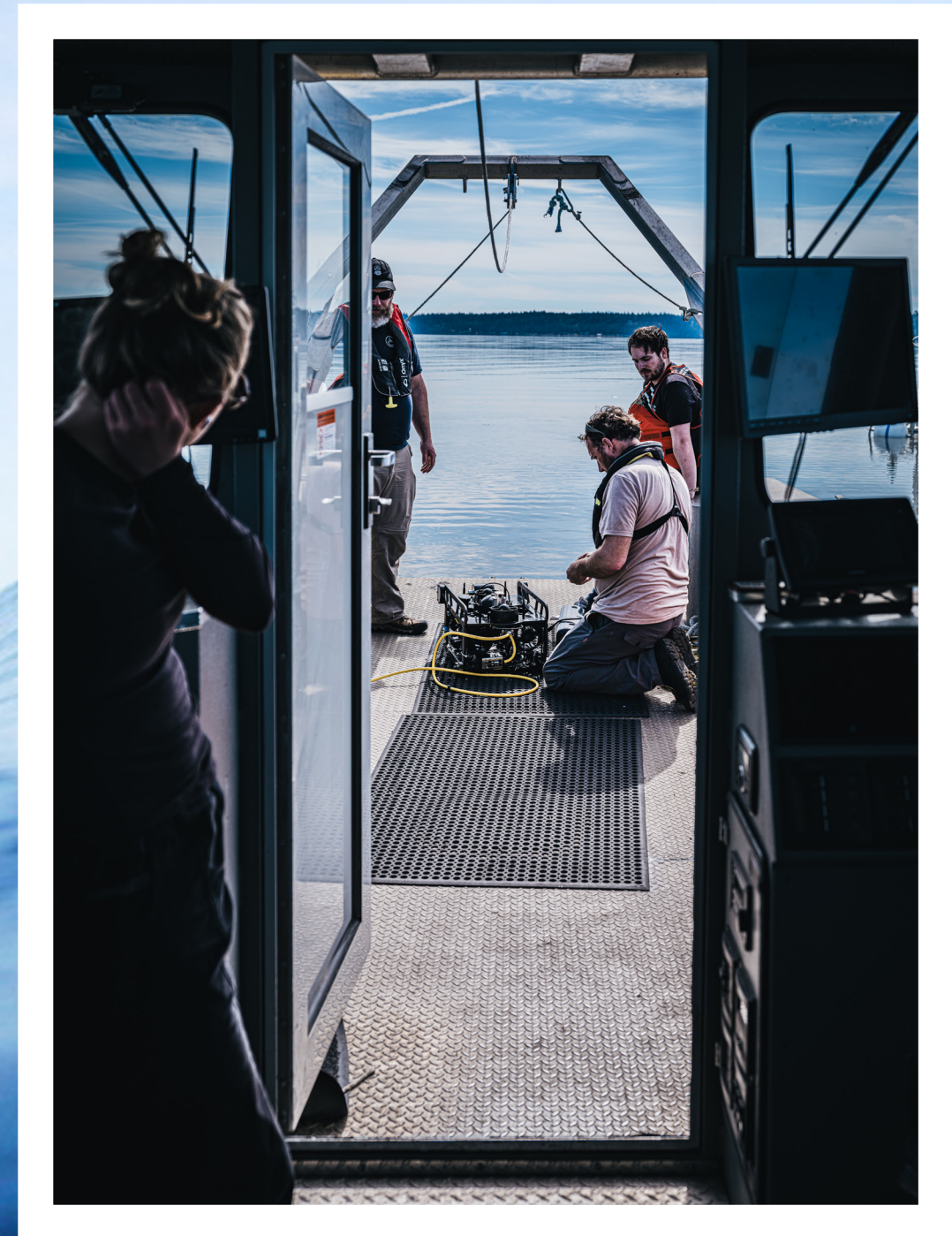
 [instagram.com/theoceanfoundation](https://instagram.com/theoceanfoundation)

 [linkedin.com/company/the-ocean-foundation](https://linkedin.com/company/the-ocean-foundation)

 [youtube.com/user/oceanfoundation](https://youtube.com/user/oceanfoundation)

## Cite this report as:

Ocean Motion Technologies, Inc. and The Ocean Foundation (2025). *Co-Designing the Future of Ocean Data: Lessons from Global Workshops*. San Diego, CA, USA.  
In-text citation: OMT & TOF 2025.



# INTRODUCTION



# TABLE OF CONTENTS

INTRODUCTION	<a href="#">05</a>
EXECUTIVE SUMMARY	<a href="#">08</a>
GLOBAL COMMUNITY INPUT	<a href="#">10</a>
KEY FINDINGS	<a href="#">13</a>
EXCITEMENT FOR NEW TECHNOLOGY	<a href="#">22</a>
WORKSHOP BENEFITS	<a href="#">26</a>
CONCLUSION	<a href="#">28</a>
ACKNOWLEDGEMENTS	<a href="#">30</a>
BIBLIOGRAPHY	<a href="#">31</a>

The ocean covers over 70% of our planet [\[1\]](#), drives global processes, and sustains economies and livelihoods -- yet we have only begun to tap its wealth of information and energy. Today, the field of ocean monitoring is at a tipping point. Breakthroughs in ocean sensing, energy, and “big blue data” are opening new possibilities for understanding and managing marine environments. The emergence of big data in the blue economy, akin to an Internet of Things for the ocean, is enabling high-frequency, widespread data collection from networks of buoys, drones, subsea vehicles, machine learning & numerical models, and satellites [\[2,3\]](#). Together, these innovations herald a future in which we can monitor ocean conditions in real-time, from coastal zones to the open seas, generating insights to inform decision-making, sustainable blue economy growth, marine conservation, and enhance safety during severe weather and other emergencies [\[4\]](#).

The opportunities of this new era are immense [\[5\]](#). By leveraging big blue data, we can obtain more accurate and detailed information about ocean health, fisheries, weather, and environmental impacts than ever before. Richer data streams can improve maritime safety, help coastal communities adapt to change, and even support monitoring of emerging ocean-based carbon removal efforts. Lowering the cost of ocean monitoring and making it more autonomous could significantly reduce the risks and expenses associated with traditional ship-based surveys or sporadic satellite snapshots. In short, a data-rich ocean future holds promise for better science and better decisions, from local resource management up to global policy. However, it is clear that the future will

require surmounting serious challenges. Today’s ocean data infrastructure is still fragmented and inaccessible. There are significant gaps in the current ocean observing system, with many remote or deep regions poorly monitored and critical data often siloed or inaccessible. Technical barriers remain formidable: sensors and platforms must withstand harsh conditions, and long-term power supply at sea is a notorious hurdle in the absence of a plug-in grid. Even as new ocean-powered devices begin to fill this gap, other constraints persist: the high cost of equipment, limited bandwidth for data transmission, and immature data integration tools all pose ongoing difficulties [\[6,7\]](#). Moreover, a capacity gap exists in terms of skilled personnel and user-friendly analytics – a deficit of access to practical training for technicians, data scientists, and accessible software means much ocean data that is collected still goes underutilized [\[4,8,9\]](#). In sum, while the era of big blue data is on the horizon, the community faces a convergence of technological, financial, and organizational challenges that must be addressed to unlock the ocean’s full potential.

To overcome challenges, there is a need for inclusive global dialogue. These hurdles are not felt by one nation or sector alone but are shared across countries and oceans, often most acutely by those with the least resources. Many scientists, policymakers, and community stakeholders, especially in the Global South and remote island regions, find themselves constrained by unequal access to ocean data and tools. Insufficient observational coverage and difficulties in data sharing mean critical knowledge gaps for entire coastlines. High costs and



import barriers can make obtaining modern sensors or maintaining equipment nearly impossible for research teams with fewer resources. Limited funding for operations (not just initial purchases) often leaves promising projects stranded. Likewise, analyzing ocean data can prove daunting without computational infrastructure or training. The result is a patchwork of capabilities, where only a few countries and large institutions enjoy robust ocean data streams, while others struggle with sporadic, low-resolution information. This varied capacity hampers our collective ability to understand changes in an interconnected ocean and respond effectively.

It was against this backdrop that The Ocean Foundation (TOF) and Ocean Motion Technologies, Inc. (OMT) recognized a critical need for an inclusive global dialogue. Technological innovation alone is not enough; to truly shape a scalable and impactful ocean data ecosystem, we must engage the diverse voices of those who collect, share, and use ocean information. Researchers in academia, nongovernmental organizations, and governmental offices each encounter different hurdles in accessing and applying ocean data [8, 9, 10]. By bringing these important end users together, we can illuminate on-the-ground realities. An open dialogue invites shared learning and helps avoid one-size-fits-all solutions. It ensures that emerging technologies are guided by user needs and regional contexts, rather than being developed in isolation. In short, broad collaboration is the only way to ensure that the benefits of big blue data reach all communities and that no region is left behind in the new ocean data revolution [11].

To catalyze this conversation, OMT, in partnership with TOF, convened a series of international workshops in 2024/2025 focused on the future of ocean monitoring technology and data. OMT, a pioneer in wave energy-powered data systems and cloud-based ocean data platforms, and TOF, a leader in advancing ocean health and capacity-building, deliberately co-designed these

workshops to gather input from across the world. By engaging a diverse range of participants with varied skillsets across multiple sectors, the workshops created an environment for honest discussion. As an outcome, these sessions began to reveal a collective vision for moving forward.

From the outset, the workshop series was framed with clear objectives, aimed at turning dialogue into actionable guidance for the field. First, the workshops sought to understand real-world use cases and requirements. Second, they aimed at mapping the barriers that different stakeholders face at each stage of the ocean data value chain. By explicitly cataloguing these pain points, the community can better target solutions. Third, the series endeavored to build consensus on priorities and opportunities. This included highlighting “quick wins” as well as longer-term strategic needs, and identifying areas ripe for collaboration. Fourth, the workshops focused on identifying opportunities for innovation and investment. Through brainstorming and case study discussions, participants pointed to promising developments that could be scaled up with the proper support. The intent was to shine light on where funders, technology developers, or public-private partnerships might most effectively accelerate progress. Finally, and most critically, the workshops set out to gather actionable input to guide future collaboration. The conversations generated a wealth of ideas and recommendations. By capturing this input, the co-hosts have assembled a rich knowledge base to inform strategic planning and ensure that upcoming projects align with the genuine needs of the ocean-monitoring community.

The challenges facing ocean observation today are complex, but they are surmountable through simultaneous innovation and collaboration. While this paper identifies barriers, needs, and opportunities, it is not just a report of workshops but as a blueprint for action crafted by many hands. It is a testament to what can be achieved when a cutting-edge tech company teams up with a mission-driven foundation to listen to the world’s ocean stakeholders. With confidence, clarity, and a spirit of openness, we look toward a future in which ocean science and monitoring infrastructure truly serve all of humanity. The journey to an ocean of information, a “big blue data” revolution, has begun, and it will thrive on the continued leadership, investment, and collaboration of those committed to a healthier, more understood, and more resilient ocean for generations to come.

The lessons learned from these global workshops are fundamental to realizing the **U.S. Department of Energy Water Power Technologies Office’s** vision of a thriving blue economy powered by sustainable ocean technologies. The DOE’s “**Powering the Blue Economy**” Initiative [12] recognizes that unlocking the ocean’s vast energy and data potential requires not just technological innovation, but also access to these transformative tools across all maritime communities. Our workshop findings reveal that the current fragmentation in ocean monitoring capabilities – where only well-resourced institutions enjoy robust data streams while others struggle with sporadic, low-resolution information – directly undermines the holistic growth that defines a regenerative blue economy. By addressing the barriers to technology access, data integration, and capacity building identified by participants from 17 countries, we can ensure that the blue economy’s benefits reach coastal communities, small island developing states, as well as emerging maritime sectors worldwide. The collaborative, user-driven innovation approaches highlighted in this paper provide a roadmap for developing ocean energy and monitoring technologies that truly serve global needs, enabling the comprehensive ocean observation networks essential for sustainable marine resource management, maritime safety, and environmental resilience. In essence, the blue economy can only reach its full potential when ocean technologies are accessible, affordable, and co-designed with the communities who depend on healthy seas for their livelihoods and security.

# EXECUTIVE SUMMARY

Ocean technologies and innovations have the potential to significantly transform our understanding and management of marine environments. The growing focus on “big blue data” is characterized by integrated and real-time data collection from extensive networks of buoys, autonomous underwater vehicles, drones, satellites, and other advanced sensors. This approach offers unprecedented opportunities for marine research, environmental response, resource management, and ocean conservation. However, despite technological progress, global ocean data infrastructure remains fragmented; significant challenges remain in disparities in technology access, resource allocation, and expertise across various regions, particularly in developing nations and remote coastal and island communities.

Recognizing these challenges, a series of international workshops was conducted between 2024 and 2025 to identify critical needs, barriers, and opportunities related to ocean monitoring technologies. These workshops convened stakeholders with diverse backgrounds to promote engaging dialogue, identify real-world barriers, and foster collaborative solutions.

## Participants identified key obstacles across the ocean data lifecycle, including:

- Limited financial resources to support the acquisition, deployment, and sustained operation of ocean technologies, as well as funding for personnel time to operate and maintain these instruments.
- Technical challenges related to maintaining robust, complex sensors in harsh marine environments.
- Digital tool proliferation and the fragmentation of technologies utilized by researchers, communities, and policy-makers to store, share, and analyze information.
- Complex data management issues, such as data processing, accessibility, interoperability, and secure sharing.
- Significant gaps in the necessary technical expertise and training for effective deployment, operation, and analysis of ocean monitoring equipment.
- Regulatory and logistical challenges associated with international collaboration and the import/export of specialized ocean technologies.

## To address these barriers, stakeholders emphasized several actionable recommendations and opportunities:

- Developing and deploying affordable, modular, and resilient monitoring technologies to improve global accessibility, especially in resource-limited regions.
- Enhancing data infrastructure by creating intuitive, secure, and interoperable platforms capable of integrating diverse datasets.
- Utilizing cloud technologies, where results can be both analyzed by researchers and shared with key stakeholders.
- Expanding capacity-building and training programs to foster regional expertise and improve the utilization of ocean technologies.
- Establishing flexible funding mechanisms that accommodate the practical realities of operating and maintaining ocean monitoring systems in diverse geographic contexts.
- Co-designing of instruments and data platforms between industry and geographically diverse end-users.
- Promoting inclusive, user-driven innovation processes that ensure emerging technologies are tailored to the specific needs of end-users and local communities.

## Workshop participants expressed significant enthusiasm for specific innovations, including:

- Enhanced ocean connectivity through satellite-based communications.
- Renewable energy technologies enabling persistent autonomous, long-term ocean monitoring.
- Advanced real-time analytics to expedite decision-making processes and enhance marine management strategies.

The workshops effectively facilitated global stakeholder engagement, promoting open dialogue and collaboration, expanding networks, and stimulating enthusiasm for adopting innovative ocean technologies. This collaborative approach provided a foundation for ongoing partnerships, reinforcing the importance of inclusive dialogue in advancing ocean science.

This paper serves as both a comprehensive summary of current barriers and a strategic blueprint for collective action, emphasizing collaborative approaches to ocean data and monitoring technology. Realizing the full potential of big blue data and related technologies requires sustained innovation, strategic investment, and international cooperation. The diverse perspectives and recommendations captured in these workshops underscore a shared commitment to creating a robust, accessible, and impactful ocean monitoring infrastructure capable of supporting sustainable marine management, environmental resilience, and global conservation efforts.

# GLOBAL COMMUNITY INPUT

## WORKSHOP OVERVIEW

To better understand the global scientific community's perspectives and needs with ocean technology, Ocean Motion Technologies, Inc. (OMT) and The Ocean Foundation (TOF) conducted virtual workshops from November 2024 to May 2025. Each of the five 90-minute sessions was designed to be highly interactive, with structured dialogue, anonymous reflection, and open discussion tailored to every attendee. Considerable effort was made to ensure balanced representation, attentive facilitation, and meaningful follow-up with each participant, making the group size intentionally focused to allow for depth, detail, and genuine exchange. Participants within each session were from similar geographic regions: the Caribbean, North America, Pacific, Africa & Europe, and Latin America. Each workshop integrated avenues for anonymous reflection, open discussion, a short presentation and demonstration of OMT's technical solutions, structured question-and-answer sessions, and post-workshop surveys for end-users. Due to the facilitated discussion that encouraged participants to fully delve into key issues of particular interest, not all workshops administered the list of structured questions in its entirety; however, the post-workshop survey ensured that all intended topics were covered. At the beginning of each workshop, OMT emphasized that the demonstrations were not promotional in nature, but rather intended to showcase examples of current industry approaches in the maritime domain and to spark dialogue, reflection, and discussion on ocean monitoring technology.

Workshops were designed to ensure that all participants could comfortably participate in their preferred communication style and language. Answers to any question could be shared verbally or in writing during, as well as after, the workshop.

To ensure the workshop reached a global audience, facilitators translated all materials and used Zoom's AI captions upon participants' request, allowing all parties to communicate fluidly. Participants were compensated for their time and expertise via an honorarium, distributed upon completion of each workshop.

To ensure the workshops served as the beginning of an ongoing dialogue rather than stand-alone events, OMT actively followed up with participants through email, one-on-one conversations, and additional check-ins. To date, OMT has convened five dedicated follow-up calls, underscoring participants' strong interest in maintaining continued engagement with ocean observing technology developers and further advancing the discussions initiated during the workshops.



## WORKSHOP STRUCTURE

### 01 Introductions

Round robin style introductions highlighting individual roles and research interests.

### 02 Polling

Real-time anonymous polling formatted for word cloud, ranking, and open-ended questions via MentiMeter.

1. What are you most interested in monitoring with ocean technology?
2. Rank the following limiting factors for your organization's ability to acquire and use ocean monitoring technology: Staff capacity, Lack of project relevance, Specialized training, Require additional funding" to make the question complete.
3. What are your current needs and challenges with ocean monitoring technology?

### 03 Tech Presentation

Ocean Motion Technologies, Inc.'s Blue Node Network presentation, demo, and discussion.

### 04 Structured Q&A

Structured question and answer session to allow participants to reflect on the current state of ocean monitoring technology.

1. What is impacting your ability to acquire, deploy, and/or operate ocean monitoring technology the most?
2. What are your current logistical and financial limitations in analyzing data?
3. How can companies such as OMT better facilitate collaborations with your organization?

### 05 Closing

Wrap-up, honorarium update, and anonymous post-workshop survey via Qualtrics.

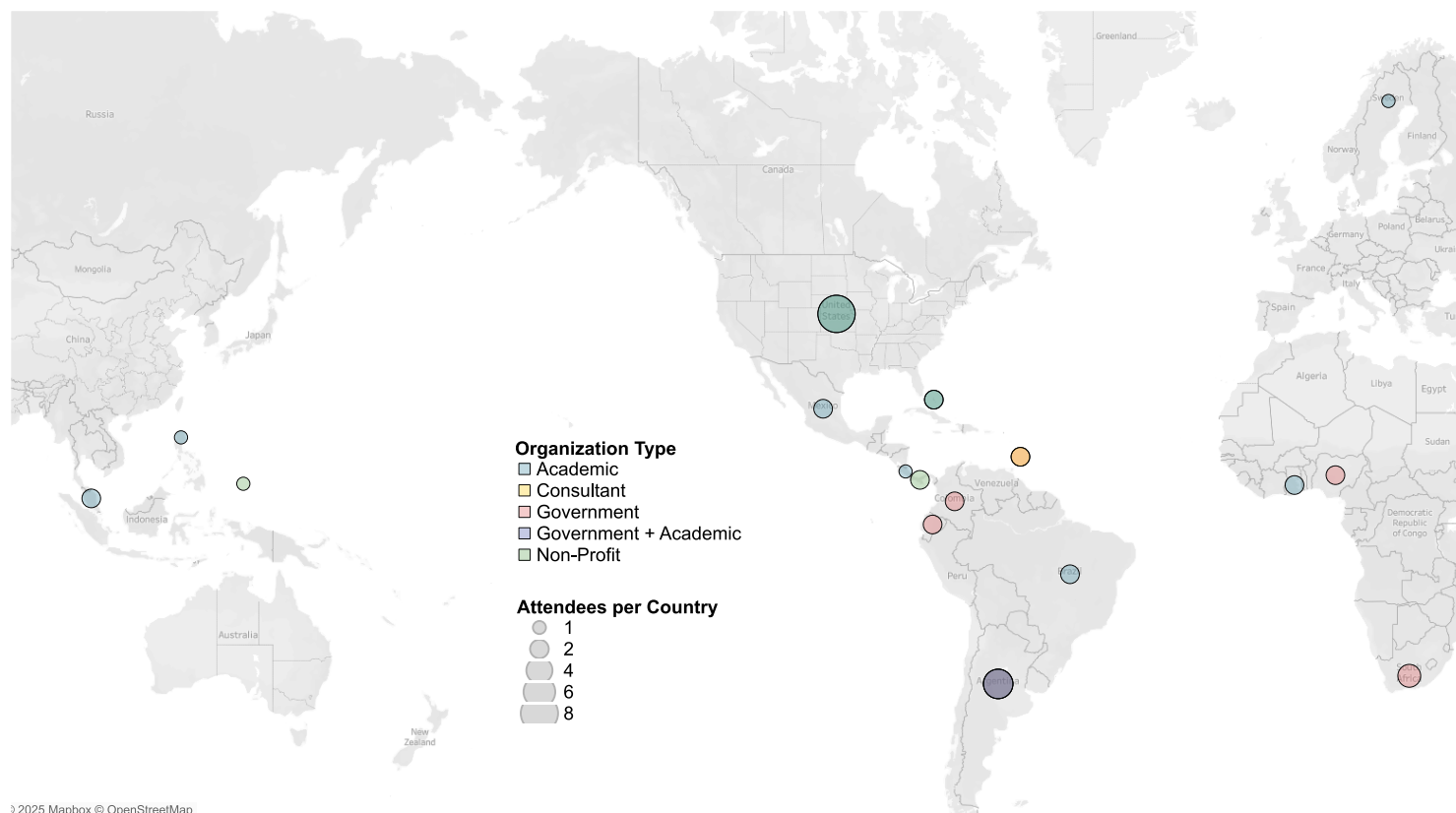
1. What area would your organization need the most support to successfully use ocean monitoring technology?
2. Please rank your level of agreement with the following statements: I have gained a deeper understanding of OMT's Blue Node, "Hardware as a service" package, and Big Blue Cloud, a cloud-based data science platform.
3. How could companies like Ocean Motion Technologies, Inc. support your work in the future?
4. What were you excited to learn after hearing more about some of the possibilities around cutting-edge ocean monitoring technology?
5. What type of ocean technology would you like to see progress in over the next 5-10 years?

## ATTENDEES

To engage a global audience, we invited over 70 individuals from 36 countries to participate in the workshops, resulting in a total of 40 participants from 17 countries (Figure 1). When inviting participants, facilitators aimed to invite individuals from diverse geographic regions, organizations with varying resource levels, differing areas of focus and expertise, and institution types (academic, government, non-profit, and consulting). Some geographical regions were not represented, including Eastern and Central Asia, the Middle East; other locations had limited representation, such as Europe and Canada. Attendance for each session ranged from 4 to 16 individuals.

In the post-workshop survey, participants representing the Africa, Latin America, and Pacific regions self-reported their organization's access to general resources (human, financial, and technical), ranging from low access to moderate access and sufficient access. Notably, less than 10% of respondents overall reported that their organization had sufficient access to resources, indicating a high need for funding and capacity building throughout these regions. This indicates the workshops engaged participants that have likely experienced a range of challenges in conducting ocean observations, enabling them to provide insight into actions and areas of support that would bolster the next generation of ocean technology.

Figure 1: Map of workshop attendees based on country and affiliation type.

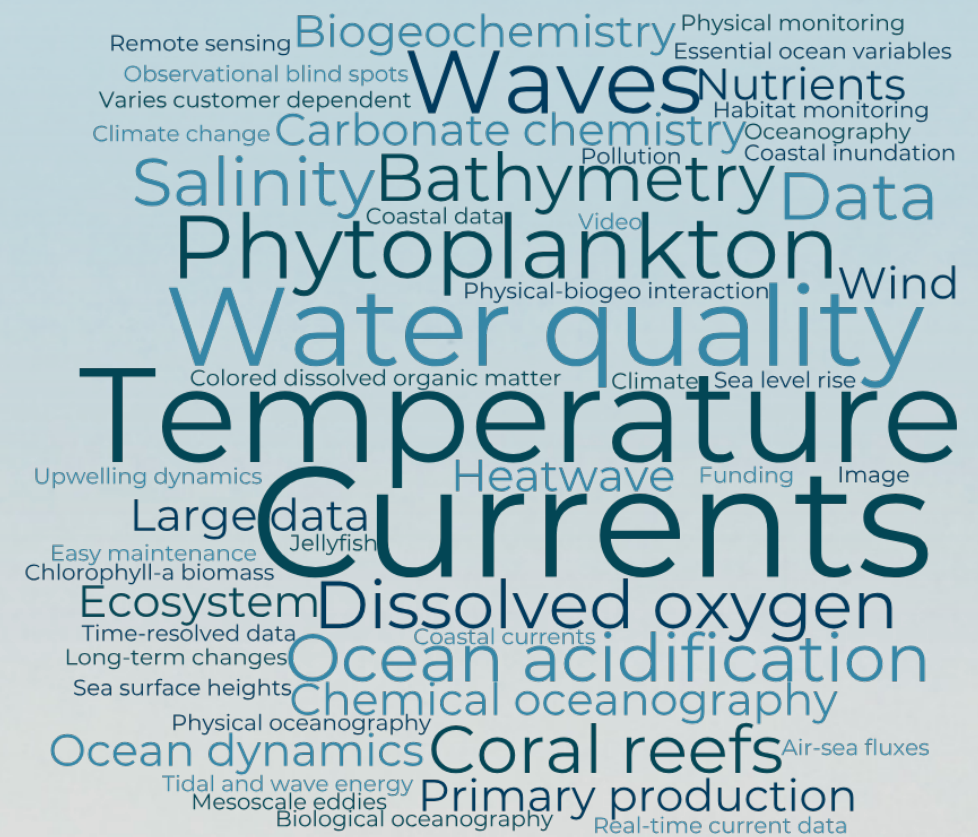


© 2025 Mapbox © OpenStreetMap

# KEY FINDINGS

The global ocean observing community engages with a wide spectrum of biological, physical, and chemical oceanographic questions. This diversity is reflected in the range of parameters researchers seek to measure (Figure 2), signaling to hardware developers & providers that while opportunities for specialization are substantial, individual user bases for niche tools may be relatively limited. One approach is to integrate measurement capabilities for multiple Essential Ocean Variables (EOVs) [13] into a single solution, offering users a more comprehensive instrument package. Such integration reduces the number of systems researchers must learn and maintain, though it also carries the risk that failure of a single component could compromise the entire dataset. Across all discussions, participants underscored the importance of reliable in-situ data collected directly through hardware, particularly for work in dynamic coastal environments where applied research questions demand more than remote sensing and numerical model simulation alone.

Figure 2: Responses to “What workshop participants are most interested in monitoring using ocean technology?” The most common responses include currents, temperature, and water quality.

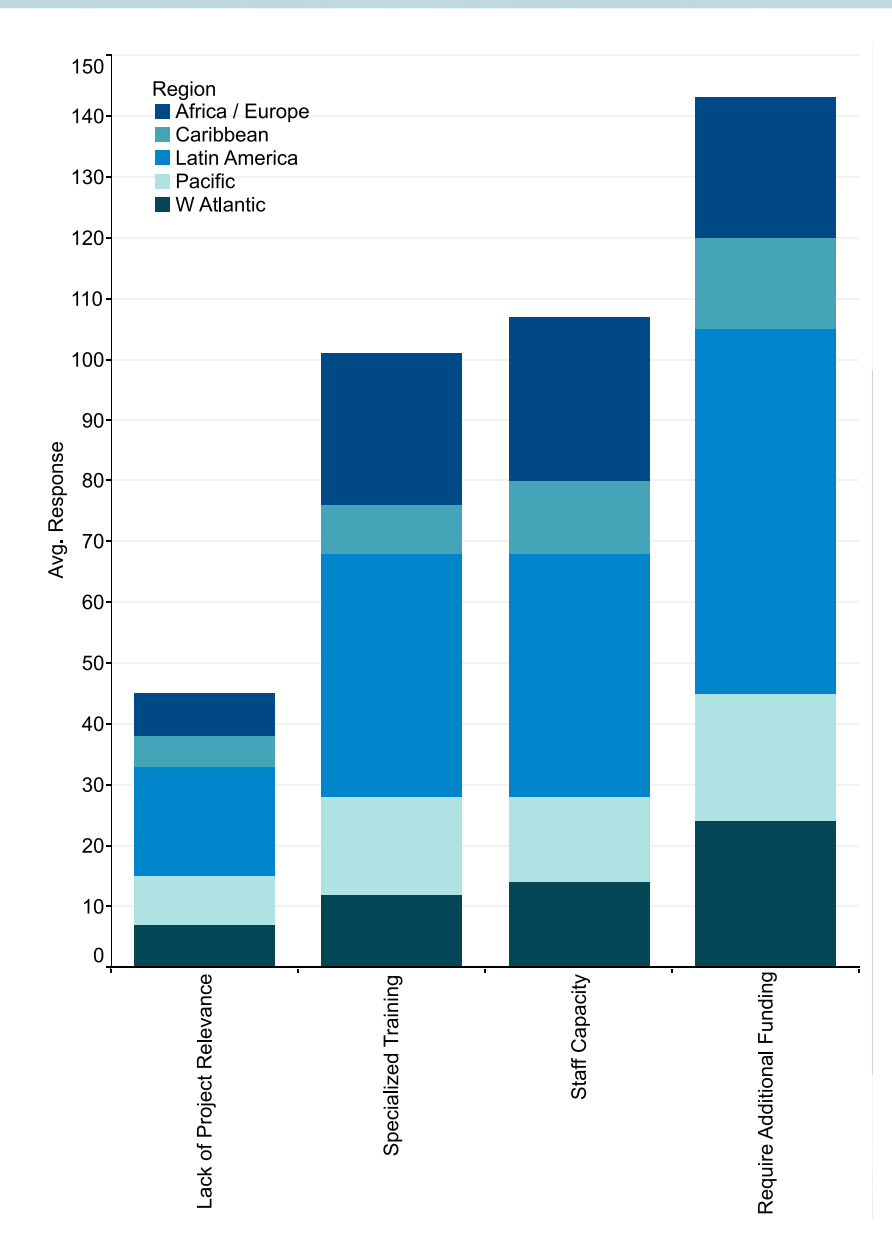


Despite the diversity of regions represented, participants consistently identified a common set of challenges in collecting ocean data. Chief among these was limited funding, which was widely regarded as the most significant barrier to acquiring and using ocean technology (Figure 3). Financial constraints create a cascade of obstacles: not only do they restrict organizations' ability to make initial equipment purchases, but they also undermine essential maintenance, resulting in downtime, reduced data quality, or even permanent equipment loss. In addition, recurring operational costs (such as vessel fuel, transport rentals, and consumables) often fall outside available budgets for long-term monitoring efforts. This mismatch diminishes the impact of projects that may receive large initial investments but lack the sustained resources needed to maintain sustained, high-quality data collection.

Equally important, limited funding also impacts human capital by reducing investment in training, specialized positions, and the staff time needed to support ocean observing. Participants emphasized that insufficient staff capacity and a lack of specialized training remain significant challenges across regions. While online

courses and in-person workshops play a valuable role in building foundational knowledge or supporting skill development, participants noted that applied, hands-on training is essential for effectively utilizing ocean technologies in the field. One participant observed that introductory trainings on new technologies not only help potential users gain confidence but also broaden exposure to innovations that might otherwise remain underutilized. Such training opportunities can also demonstrate how instruments perform in diverse field conditions (for instance, when sensors designed in North America or Europe are deployed in tropical latitudes), providing critical context for their use. Equally, hands-on sessions allow users to practice maintenance procedures that may be too detailed to capture effectively in manuals or online videos. Several participants further highlighted that a lack of exposure to emerging technologies, platforms, and sensors is itself a barrier, limiting uptake and slowing the diffusion of innovations that could strengthen local ocean observing capacity.

Opportunities to secure funding vary greatly in countries where governments do not strongly support scientific research. In some cases, oceanographers are based in nations with relatively high GDPs that disqualify them from development-based funding opportunities, yet these same countries often lack the infrastructure and sustained investment needed to support ocean science. This dynamic is particularly evident in certain remote island nations, where limited local resources leave researchers with few options despite their exclusion from official development assistance programs. Some participants reported that they must look to different sectors, such as private industry and abroad, to build funding relationships. As such, it requires more time invested in identifying and vetting potential partners and funding opportunities relative to conducting research. Partners can also be motivated to support narrow, purpose-focused research goals that may not align with the interests of the engaged research team nor provide the full benefits of more spatially and temporally broad ocean observing that meets the local community's needs.



**Figure 3: Limiting Factors**

The dataset presented was generated from the original workshop survey results, where participants ranked various limiting factors affecting their organizations' ability to acquire and utilize ocean monitoring technology. Initially collected in a wide format, where each column represented a specific limiting factor. This process enhances comparability across regions and factors, providing clearer insights into the relative significance of each limiting factor as perceived by global stakeholders.

## RECOMMENDATIONS FOR FUNDERS

- Allow flexibility in aligning timeframes and project goals so researchers can pool small grants and invest in higher-impact projects.
- Ensure timelines allow for sufficient time to maintain equipment
- Provide grant opportunities that fund equipment operations and deployment in addition to procurement, as well as the required staff time and resources (e.g., software) to analyze and publish data.

## RECOMMENDATIONS FOR GOVERNMENTS

- Value and invest in ocean sciences as marine research can support and guide community food access, safety, health, and sustainability.
- Consider reduced duties for scientific equipment or establish national data repositories.

## BARRIERS TO OBTAINING TECHNOLOGY

This funding gap creates a significant barrier to acquiring ocean technology, thus limiting spatial coverage of observations, reducing the number of parameters an organization can measure, and preventing implementation of new technology that realizes improvements over older options. While suppliers may readily have instruments available for purchase in well-resourced countries, organizations in countries without large technology markets frequently need to import instruments. Even suppliers with a global footprint may only have offices in major hubs that do not fully create global service (e.g., an Australian office may not service all Pacific Islands Nations and Territories). Additionally, an instrument may become even more expensive due to an unfavorable international currency exchange, tariffs, and other customs/import duties further limiting purchasing power. One participant even noted that they have observed an increase in prices when technology is absorbed into security operations, perhaps due to relatively higher budgets from governments. Given these factors, suppliers that offer lower-cost models while also meeting basic needs could access markets that otherwise do not have accessible sources of ocean technology.

International relations can further hinder easy access to ocean technology. Specialized equipment and sensors produced in a small number of locations necessitate cross-border transit with a layer of governmental scrutiny and costs. Firstly, manufacturers may restrict exports to specific countries to avoid the administrative costs of addressing regulatory hurdles. Furthermore, when researchers order scientific equipment from another country, it can be mistakenly characterized as medical equipment (particularly gloves, pipettes, and syringes), resulting in higher duties than if it received the proper Harmonized System classifications. Tariffs imposed and frequently adjusted by countries can also add a layer of uncertainty to budgets.



## RECOMMENDATIONS FOR TECHNOLOGY DEVELOPERS TO INCREASE EQUIPMENT ACCESS:

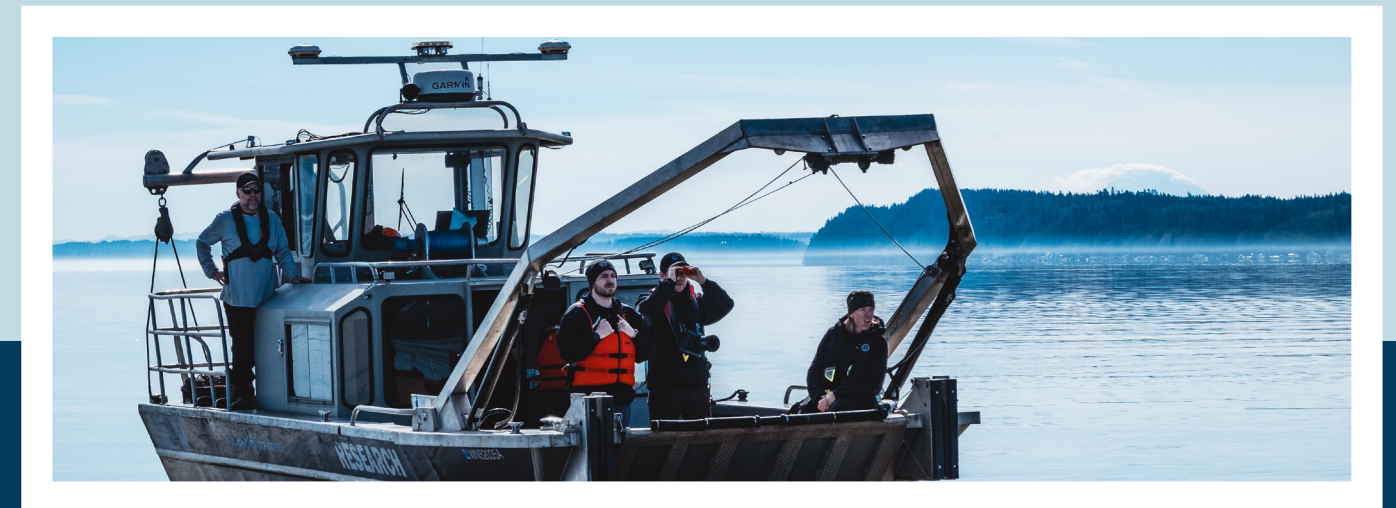
- Produce low-cost options to increase accessibility for more researchers.
- Create higher modularity in design to build more comprehensive measurement options over time.
- Establish features to reduce risk of loss and bolster confidence in purchasing higher-cost equipment.
- Support user-friendly maintenance and accessible spare parts to reduce the need for servicing abroad.
- Include servicing plans or vouchers with international shipment to support maintenance returns.
- Limit instrument size and weight to facilitate easier and safer deployments from smaller vessels.
- Ensure spare parts are easily accessible across all geographical regions.
- Test novel instruments in a variety of locations and nearshore conditions to ensure functionality around the globe, including warm tropical latitudes.
- Integrate low-cost internet, coupled with high-bandwidth capabilities, into instrumentation in remote ocean regions.
- Prioritize improving stable and sufficient energy options for hardware operation.

## BARRIERS TO DEPLOYING TECHNOLOGY

Once technology is in hand, additional barriers can hinder effective deployment. Firstly, initial unpacking and setup of equipment and sensors may not be intuitive. For example, items produced in small batches from specialized suppliers sometimes have exposed components, particular handling techniques, or specific housings for key pieces of equipment that perform specialized measurements. Robust manuals that explain what may be considered basic handling practices are important to provide confidence to users who may be more familiar with fully encased, mass-produced commercial products and to reduce the risk of inadvertent damage from normal handling. Indeed, manuals should delve sufficiently into routine use without assuming the user has extensive experience with complex instrumentation. Furthermore, not all prospective users may specialize in hardware and software. Users may be well-versed with other marine scientific practices – such as technical laboratory approaches, biological observations, etc. – but are incorporating unfamiliar instrumentation & sensor technology into their workflows, necessitating new skills. Additionally, labelled images in manuals can provide important context, mitigating confusion with any specialized terminology and addressing regional linguistic differences.

Modular design can also improve ease of use. Accessing internal components for setup or repair is less daunting when they are organized into distinct sections, rather than entangled with complex tubing or wiring. Although such designs may result in a bulkier housing, the benefits—particularly the ability for users to carry out repairs themselves and replace broken parts more easily—often outweigh the drawback of increased size.

When routine manufacturer calibration, maintenance or more involved repair is required, shipment back to the country of origin can lead to substantial pauses in data collection. One participant shared that she had waited



## RECOMMENDATIONS FOR TECHNOLOGY DEVELOPERS TO BROADEN EFFECTIVE USE OF THEIR TOOLS AND SERVICES:

- Collaboratively co-design instrumentation and platforms with end-users across diverse geographical regions, climates, and resource levels.
- Integrate targeted training to build technical expertise across the globe.
- Develop comprehensive user manuals that do not assume a certain level of experience or knowledge.
- Create payment plans and collaborate with institutions to navigate their diverse purchasing systems.

a year for her instrument to return, only to have it remain functional for just six months before it had to be sent back again, and by the time it was returned functioning, the project was over. Furthermore, shipping costs, in addition to service fees, can make the continued operation of technology financially untenable. Suppliers that sell servicing plans or vouchers with international shipment included can thus help make it easier to return instruments, as researchers have upfront information instead of needing to conduct research into the return process when a problem arises and pre-paying for return costs could be billed to grants or other sources of funding that may no longer be available when the issue occurs.

Researchers also face practical challenges when deploying instruments in the field, where safety is not always assured. Smaller vessels often lack A-frames and other essential gear required for deploying and recovering heavy equipment. Such vessels also often lack protection from harsh ocean conditions for researchers, sensitive equipment, and computers/programming devices. Additionally, the ocean data collected may not yet be integrated into forecasting models, which could enhance warnings for adverse weather or high seas that may affect deployments. Together, these factors limit the types of instruments that can be deployed safely, making lighter, more resilient systems capable of withstanding longer deployments particularly attractive.

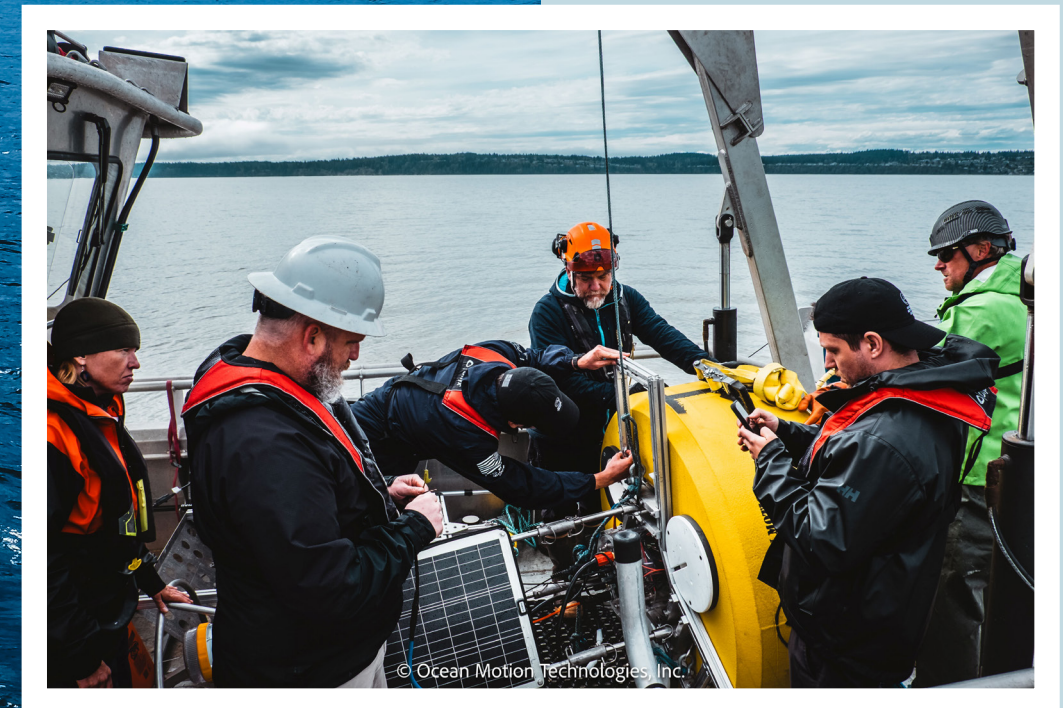
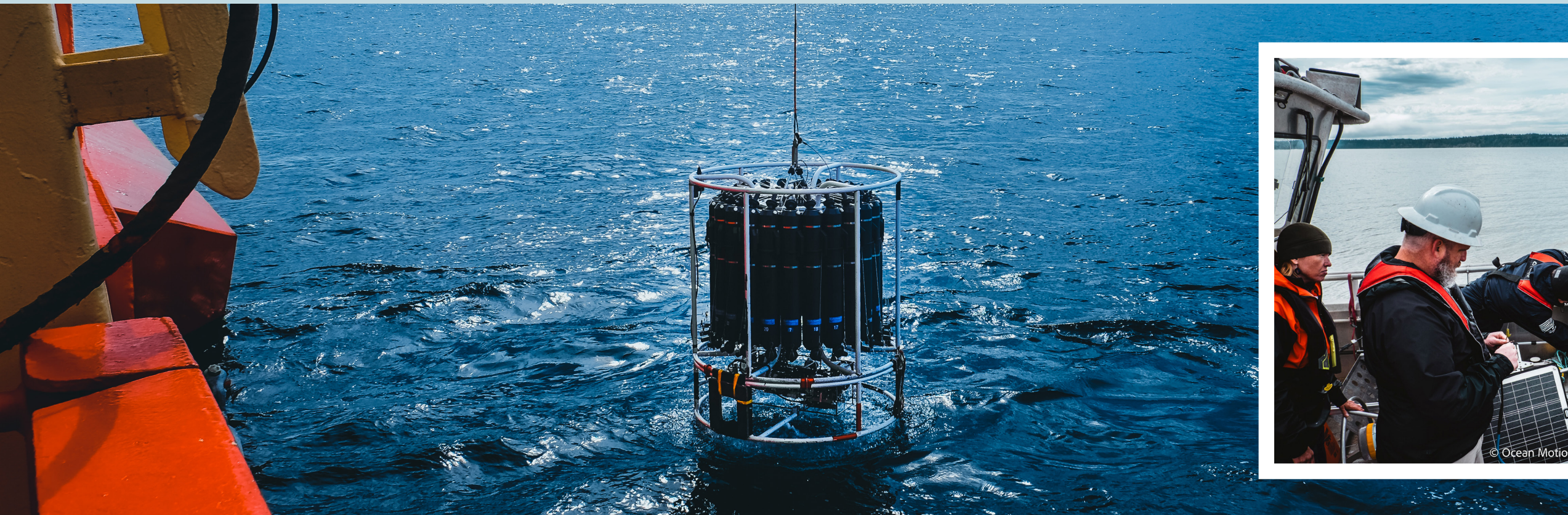
Additionally, participants provided examples of how equipment loss can originate. Storms and other conditions can break moorings, while marine animals may bite and damage instruments or lines. Human-induced loss may stem from negligence, accidental or intentional capture during fishing activities, curiosity-induced handling, or other marine traffic. Yet, intentional vandalism is also a risk, as other ocean users may believe collected data could be used to monitor them or develop policies that restrict their activities, or they may feel the equipment physically impedes their use of the area. These losses can happen at any time, even shortly after procuring an expensive piece of equipment. Such a risk can incentivize investment in multiple less-costly sensors and autonomously deployed and recovered equipment in addition to hands-on sampling excursions.

While the risk of deploying and recovering ocean technology can pose a burden, so can the difficulty of finding partners. Partnership and coordination can be especially challenging for regional projects covering large areas or involving multiple countries. One participant shared that the necessary cross-country and cross-agency coordination can stall large projects due to different priorities and resources. Effective partnerships can be essential to helping organizations overcome deployment barriers, including sharing technical expertise and providing necessary resources, such as a well-equipped vessel. Funders that support such work may consider introducing their grantees that manage similar work, establishing regional centers of excellence, or hosting online discussion spaces to promote knowledge-sharing and collaboration.

An organization's operational demands and competing priorities can delay equipment deployment. Delays can be due to urgent tasks such as addressing a regional flood, oil spill, or navigating understaffing, particularly in regions where ocean professionals do not have the luxury of specialization and must, by necessity, manage a large remit. These urgent taskings have increased in frequency due to the increase in strong storms caused by long-term environmental change. Significant project delays can impact staff readiness and may require refresher training to ensure safe and effective deployment of new equipment. This highlights the need for institutional support and effective time management to ensure deployment is aligned and coordinated with training.

Lastly, participants shared that funding is often allocated for equipment procurement, but not for long-term equipment operations and deployment. These financial limitations impact an organization's ability to train staff for deployment and use of equipment, access to vessels, and equipment maintenance and sensor repair. Functional equipment may be relegated to storage if deployment is particularly burdensome or staff trained in its use transitions to another organization.

In summary, deploying ocean technology is a complex process that faces many challenges, such as logistics (boats, fuel, weather conditions), technical support (manuals, repair, and training), coordination (partners and scheduling), and funding (vessel time, training, maintenance).



# BARRIERS TO ANALYZING DATA

Collecting ocean data is only the first step. Researchers must store, share, transform, and merge data, analyze it, generate analyses and visualizations, and publish results to different stakeholders in order to communicate findings. Transforming raw measurements into reliable information for scientific publications and public use remains a significant hurdle for many organizations. A major barrier is the lack of standardized data parsers and quality assurance/quality control (QA/QC) processes to clean and validate data. Effective QA/QC requires substantial time and expertise, often involving specialized programming skills. Adding to this challenge, data formats vary widely across instruments, requiring staff to manage and process multiple, device-specific outputs. Often, in-situ data is combined with satellite remote sensing data, which itself is in a different format. The processes of contemporary research highlight the urgent need for platforms and tools that can streamline and automate the entire data lifecycle: from data collection, storage, sharing, integration and transformation, analysis, and dissemination.

Typically, processing large datasets generated by ocean observing technologies demands advanced analytical software and computing power. Often, widely used tools (such as MATLAB, ArcGIS, and other specialized programs) are costly, highly technical, and require ongoing subscription fees for updates, expenses that can quickly become unsustainable for smaller institutions – particularly once project funding ends. While open-source alternatives (such as Python, R, QGIS, etc.) offer powerful options, they require skilled personnel to use effectively, which many organizations currently lack. Moreover, many of these tools provide a solution for one stage of the entire pipeline, for example, only in data integration or processing.

The gap in data science expertise is one of the most pressing challenges in ocean research. Many institutions lack staff with the necessary skills to process, model, and interpret large, complex datasets. One participant

noted that they attempted to rely on IT personnel to bridge this gap, but the absence of domain-specific ocean science knowledge often introduced additional difficulties. Early-career researchers increasingly turn to self-teaching in programming and statistics, which can be slow and uneven. As a result, data analysis frequently becomes time-consuming and can limit the scope of projects and funding opportunities that institutions are able to pursue. Moreover, as the availability of public ocean datasets expands and big-data approaches become central to marine science, the demand for robust data science skills will only grow – further widening the gap between available capacity and scientific potential. Some participants reported experiencing uncertainty during the data validation and quality control stage, particularly in determining the accuracy of new sensors and utilizing citizen science sources. The lack of clear, universally accepted standard processes hinders progress, which is exacerbated when researchers are uncertain about the calibration of equipment or the quality of data. It is crucial to build trust and develop QA/QC frameworks to support the effective use of low-cost, community-deployed equipment.

Ultimately, institutions often struggle with insufficient time and resources to analyze data. Often, funders do not allocate sufficient funds to cover staff time and necessary software costs for data analysis, which can hinder effective and efficient data analysis. Furthermore, due to understaffing, many teams must focus on immediate duties, such as report writing, which results in analysis being deprioritized. To ensure the collected data can be used for important regional decisions (such as weather prediction, conservation, or maritime safety) and maximize their dollar impact, funders should also support staff time and software required to process the raw data.



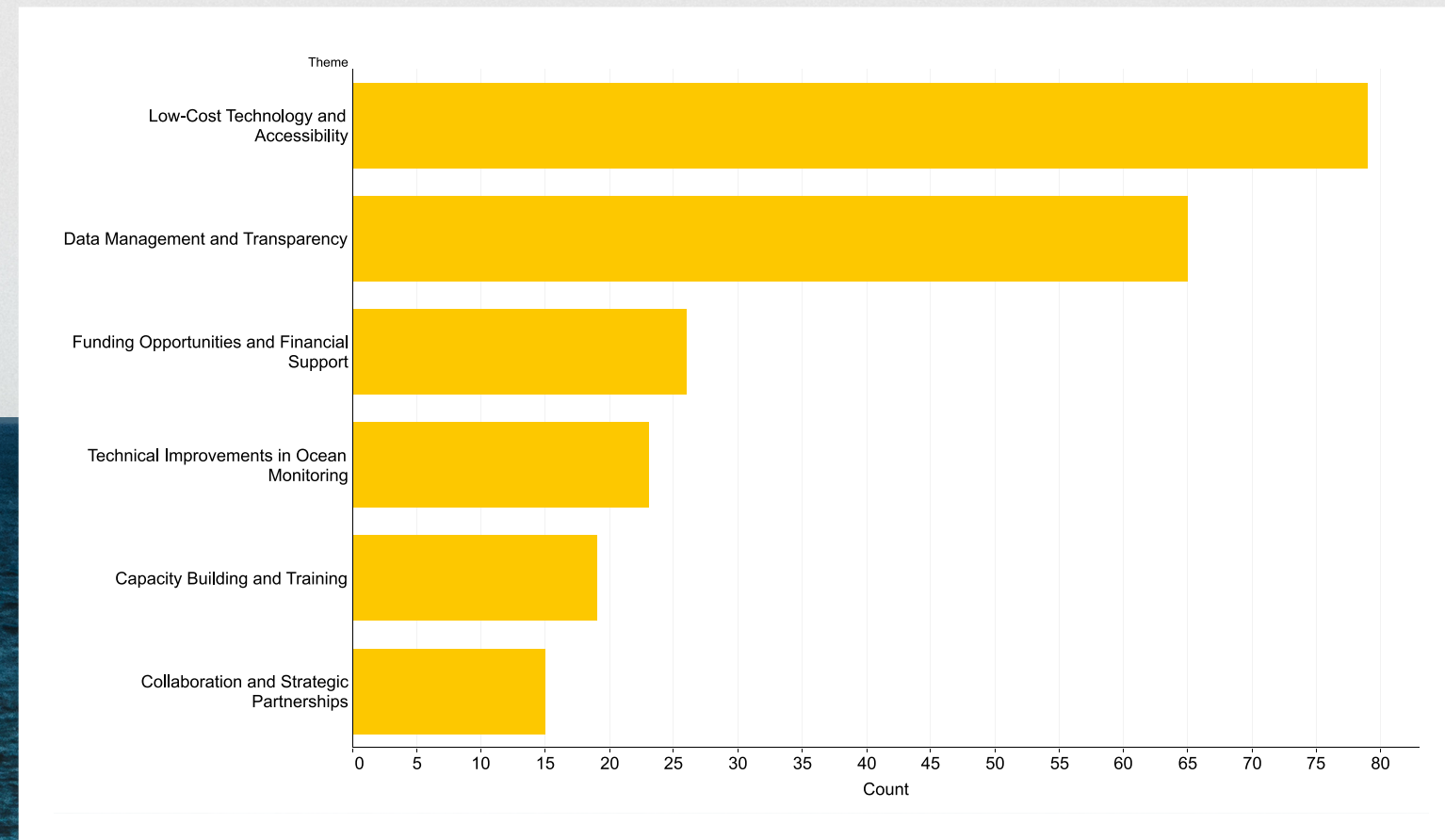
## RECOMMENDATIONS FOR TECHNOLOGY DEVELOPERS TO IMPROVE DATA SERVICES:

- Develop QA/QC frameworks to support the effective use of low-cost, community-deployed equipment.
- Create more cost-effective levels of the 'Data as a Service' option.
- Develop user-friendly data platforms that prioritize analyzing and publishing data.
- Enable cross-platform data linking to enhance collaboration opportunities and the use of various processing tools.
- Provide comprehensive packages to measure multiple Essential Ocean Variables.
- Increase the geographical reach of data collected via in-situ

# EXCITEMENT FOR NEW TECHNOLOGY

Despite the current challenges that end-users experience with ocean technology, participants consistently expressed strong enthusiasm for emerging innovations. There are significant opportunities for blue technology to directly support end-users' needs and invest in a more global market that is frequently forgotten. Participants repeatedly highlighted the need for developing accessible, low-cost technology and deliberate growth around data management and transparency (Figure 4). This feedback is an opportunity for the ocean technology community to overcome these challenges through exciting innovations and intentional collaboration.

**Figure 4: Future of Ocean Tech:** This quantitative summary dataset was generated by analyzing text-based responses from workshop participants related to ocean technology improvements, future needs, and support strategies. Responses were systematically categorized into key thematic areas based on frequently mentioned topics. The identified themes included: Low-Cost Technology and Accessibility, Data Management and Transparency, Funding Opportunities and Financial Support, Technical Improvements in Ocean Monitoring, Capacity Building and Training, and Collaboration and Strategic Partnerships. Each response was examined for relevant keywords associated with these themes. The resulting frequencies highlight priority areas and provide a clear, quantitative overview of participants' perspectives on ocean technology needs and opportunities.



## HARDWARE DEVELOPMENT

Intentionally designed future technologies hold the potential to greatly enhance data collection while overcoming many of the obstacles identified worldwide. A recurring theme across all workshops was the call for the ocean technology industry to actively co-design instrumentation with end-users. Where co-design does occur, it is often limited to the geographic region of product development, leaving the distinct needs of under-resourced regions overlooked. Yet, participants emphasized that these needs can differ substantially from those in well-resourced areas. The consistency of this feedback across regions underscores a clear opportunity: to develop technologies that intentionally serve a truly global community of users.

A key area of interest among participants is improving connectivity at sea, an advancement that has seen significant growth recently due to satellite internet services. Low-cost internet, coupled with high-bandwidth capabilities in remote ocean regions, would enable real-time data monitoring and even remote control of instruments, both of which are currently prohibitively expensive for many institutions. Sufficient connectivity would also enable remote training and support, allowing experts to provide offshore troubleshooting assistance. Furthermore, real-time visual monitoring can enable peace of mind for costly deployed instruments, as researchers can better assess operating status and even monitor for vandalism.

Participants highlighted the need for advancements in technology and tools to improve access to stable, sufficient energy, which would enable meaningful extensions of deployments and increased data collection. These improvements most benefit hardware that is already designed for minimal interventions via onboard calibration tools, antibiofouling applications, and reagentless measurements. Such examples include autonomous underwater vehicles (AUVs) and gliders, the use of which can reduce other challenges, such as safety at sea, and limit the need for costly maintenance cruises [14]. Recharging and data offloading at sea, such as docking at a wave-powered buoy station, thus solves a key limitation of these tools. Gliders could also be powered by changes in buoyancy, while surface and subsurface buoys may be recharged with systems that utilize ocean waves, currents, and temperature variability. If it is feasible to regularly access these autonomous systems or they must be maintained for other reasons, swapping out rechargeable batteries in the field and returning the instrument to service can be an option that reduces data gaps. These options create the potential to have a persistent presence in the areas of interest, which will only be extended as options for ocean power generation increase and a network of in-water hardware support hubs and data nodes develops.

**“I want to see cheaper platforms with higher modularity. Take off sensors as needed, but robust.”**

- Participant reflection on the future development of ocean technology

## DATA PRODUCTS NEEDS

To complement the development of next-generation hardware and power options, data platforms must also evolve. As more options become available and principles such as FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective benefit, Authority to control, Responsibility, and Ethics) are collectively adopted, researchers must discern where best to store and disseminate their data. Participants noted the value in being able to cross-link data across platforms to better reach collaborators, participate in multiple data-collection campaigns, and take advantage of processing tools. However, changes in datasets, such as processing and post-processing, necessitate version management through these data services to avoid confusion and reproducibility issues. Such problems may be addressed by assigning a Digital Object Identifier (DOI) and version control to maintain a log and rapidly identify the most up-to-date data.

For data platform developers, building trust with users will prove to be a key metric for growing their collections of data. In part, this comes through the mechanisms that are established for protecting data ownership and sovereignty. Participants emphasized the importance of continuing to have primary ownership of their data and control over how it is used. For example, options for clearly stating allowable usage (e.g., “Public Domain” or Creative Commons licenses), rights to grant and revoke access to data, and proper data attribution are critical to data sovereignty. This is especially important for researchers at state-operated institutions that may experience more limitations on their ability to share data with foreign colleagues.

Data platforms can also be a key tool to expand the capacity of under-resourced researchers. Cloud-based platforms, in particular, can be useful because they can meet the needs for storage and accessibility simultaneously. When time-limited projects are concluding or there is only sufficient funding for field research but not the costs of analyzing and publishing data, analytics features that are built into data platforms potentially extend project outcomes. This can start with recommendations for data structure prior to uploading and submitting data to a platform, which also assists in combining related datasets to enable comprehensive analyses. To complement the data itself, metadata entry tools should not only be available but straightforward to use, improving the likelihood that researchers will enter all relevant factors. On the other side, robust search tools for metadata tags increase the probability that relevant datasets can be found and their impact extended.

Additionally, participants shared how they saw real-time analysis of incoming data as critical. Real-time analysis on a sensor enables alerts for unusual phenomena that could spur additional sampling efforts. Alternatively, this can signal sensor malfunctioning, allowing the data to be flagged to prevent erroneous analyses later on. Taken together, meaningfully implemented data platforms are a critical component of research and must be integrated into a broader ecosystem alongside in-the-water technology. Beyond what was raised in the workshops, there is also a pressing field-wide need for simpler, centralized tools to manage data. Currently, many instruments rely on proprietary applications, unique file formats, and complex processing pipelines, making it difficult for researchers to integrate datasets efficiently. Many workshop participants stressed the importance of data platforms that are user-friendly and feature an intuitive central interface, with processing tools and standardized file management; such platforms would greatly reduce barriers and accelerate the uptake of new technologies.

Participants in the workshops highlighted industry opportunities to support ocean data progress and reduce persistent challenges for observing organizations. In particular, subscription-based models such as Data as a Service (DaaS) and Hardware as a Service (HaaS) were frequently discussed. There was a desire to export a range of technical tasks to service providers via these subscription models so researchers could focus on project objectives. These service models allow organizations to access data streams or deploy instruments without bearing the full cost of purchasing, maintaining, and servicing equipment outright. By lowering upfront capital costs, they reduce barriers to entry for research teams, while also minimizing the training and time burden required for instrument repair and upkeep, enabling scientists to focus on their core expertise. At the same time, participants noted that these services can currently be prohibitively expensive for some end-users, particularly in resource-limited settings, underscoring the need for flexible pricing structures and tailored offerings. Despite these limitations, DaaS and HaaS have the potential to incentivize service providers to deploy more infrastructure, including in remote areas, thereby expanding global coverage and ultimately lowering barriers for less-resourced organizations to access high-value ocean observing capabilities.



**“Many times, we get researchers on cruises where they come and don’t share their data. There’s a level of mistrust because of that.”**

- Participant reflection on the future development of ocean technology



# WORKSHOP BENEFITS

The workshops offered facilitators and participants a unique opportunity to surface the real-world challenges faced by marine scientists and practitioners working with ocean technology. Just as importantly, they created a rare forum for researchers to engage directly with organizations committed to building solutions that meet global needs. Strengthening regional networks and promoting knowledge exchange was an explicit goal of the series, and participants consistently emphasized the value of this aspect. Many noted that they were able to form new connections while also rekindling collaborations with former colleagues across countries and sectors. Structured introductions at the beginning of each session encouraged attendees to identify common research interests, while time set aside at the end allowed for the exchange of contact information and informal networking – laying the groundwork for future collaborations.

The workshops also enabled rich peer-to-peer learning. By listening to one another’s case studies, experiences, and innovative approaches, participants were exposed to ideas and solutions they might not have otherwise encountered within their local or disciplinary silos. Several attendees highlighted that this exchange broadened their perspective on both the challenges and opportunities emerging from other regions, reinforcing the value of convening diverse voices in a shared space.

Participants reported increased awareness of emerging technological approaches through the facilitated discussions and demonstrations. Seeing examples of how advanced tools can streamline data management, enable broader access, and support field operations generated strong interest and enthusiasm. These sessions underscored the potential for thoughtfully designed solutions to reduce barriers, expand research capabilities, and encourage cross-sector collaboration.

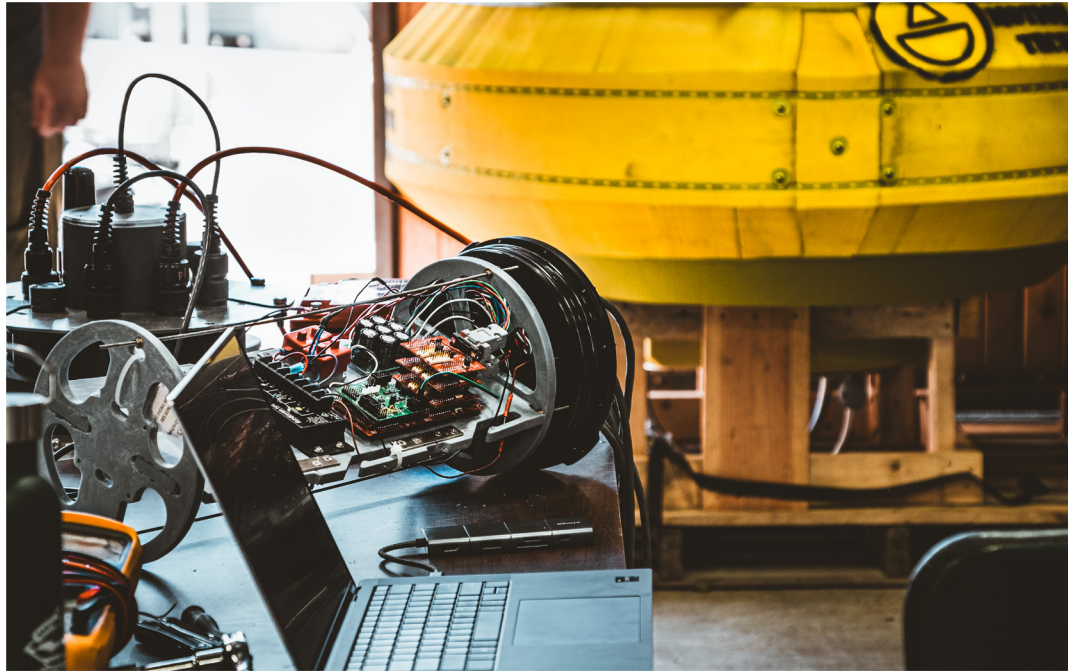
The workshops also showcased the importance of transnational work. Case studies – such as recent advances in global weather prediction powered by high-performance computing [15] – illustrated how international partnerships and innovative tools can drive breakthroughs with wide-

reaching impact. Similar cross-pollination of ideas occurred throughout the series, with follow-up calls and one-on-one conversations extending the dialogue beyond the formal sessions. In some cases, participants raised novel applications – such as parametric insurance for fisheries – that demonstrate the creative directions that can emerge when space is made for open, inclusive discussion.

Taken together, these workshops did more than document barriers; they expanded networks, raised awareness of emerging solutions, and fostered a collaborative environment where technology developers and end-users could engage as partners. Perhaps most importantly, they set the stage for sustained engagement: through post-workshop communications and targeted follow-ups, participants signaled strong interest in continuing the dialogue. Co-organized by Ocean Motion Technologies, Inc. and The Ocean Foundation, the series highlighted the critical role of conveners who can bridge the gap between innovation and user needs – ensuring that global perspectives directly inform the development of tools and strategies that will shape the future of ocean science and stewardship.

**“Ocean monitoring technology is advancing rapidly, enabling real-time data, AI-driven analysis, and sustainable marine management. The workshop has been a great platform for collaboration and exploring innovative solutions for ocean conservation.”**

- Participant reflection



The message from participants is clear: innovation must be paired with the human dimension. Affordable, adaptable, and easy-to-use tools can transform institutions worldwide's ability to contribute to ocean science and decision-making. Equally, partnerships that bridge industry, academia, governments, and communities are essential for ensuring that technology development aligns with real-world needs.

This paper should be viewed not as the end of a process, but as the beginning of a sustained effort to make big blue data a reality for all. The recommendations offered here provide a blueprint for action – whether by technology developers building the next generation of tools, engineers designing the latest instruments, funders seeking to maximize the impact of their support, or governments aiming to strengthen national and regional capacity. Above all, they reflect the voices of a global community united by a shared recognition that better ocean observing is not optional: it is foundational for food security, environmental resilience, maritime safety, and conservation.

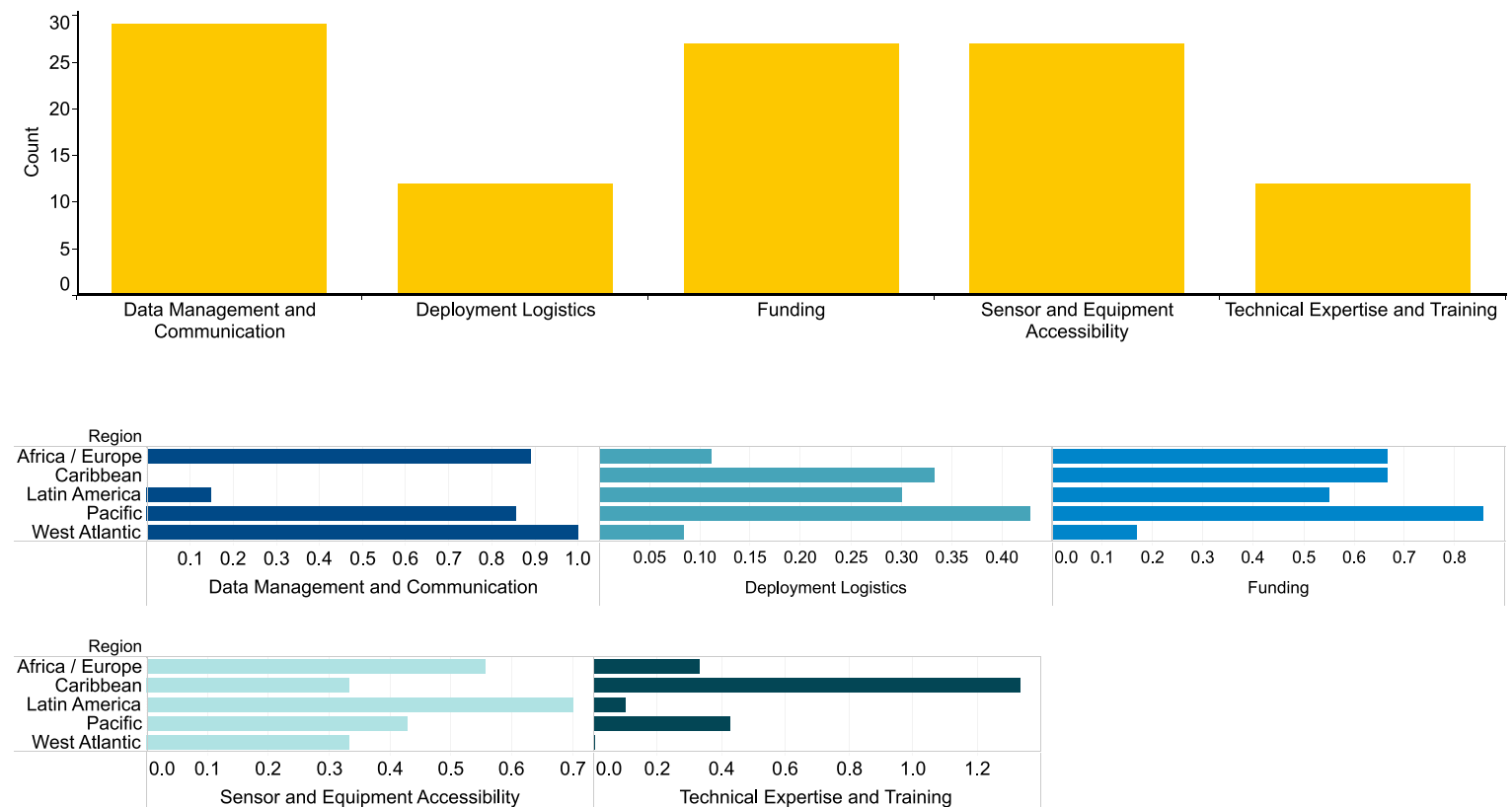
Ocean Motion Technologies, Inc. and The Ocean Foundation are grateful to all who contributed to this effort and remain committed to fostering the networks, dialogues, and innovations needed to ensure that ocean monitoring infrastructure truly serves humanity. With continued collaboration, we can move toward a future where the ocean is observed comprehensively, data and analyses are accessible and actionable, and technology empowers communities everywhere to steward the seas on which we all depend.

# CONCLUSION

The workshops described in this paper underscored both the urgency and the promise of advancing ocean monitoring in an era of rapid technological change. Participants from across the world, disciplines, and institutions shared remarkably consistent challenges: limited funding, technical hurdles, uneven access to expertise, and barriers to data analysis that continue to constrain global capacity to observe and understand the ocean. At the same time, the workshops revealed a strong current of optimism about emerging solutions, from modular hardware and ocean energy systems to user-friendly data platforms and service models that lower barriers to entry.

By convening these dialogues, Ocean Motion Technologies, Inc. and The Ocean Foundation sought not only to document challenges but also to chart a pathway forward. The insights gathered here point to a future in which ocean technologies are intentionally co-designed with diverse end-users, where data infrastructure is accessible, interoperable, and trusted, and where capacity building and funding mechanisms are structured to sustain long-term monitoring (Figure 5). Achieving this future will require continued investment, international collaboration, and the active participation of communities that have historically been under-resourced or excluded.

**Figure 5: Current Areas that Needs Additional Support:** This figure summarizes the key areas in which organizations require additional support, based on workshop participants' responses. Text-based responses were analyzed and categorized into five recurring themes: Funding, Technical Expertise and Training, Sensor and Equipment Accessibility, Deployment Logistics, and Data Management and Communication. The upper section presents the total frequency of these support areas across all respondents. The lower section provides a regional breakdown, normalized by the total number of respondents per region, ensuring a fair comparative view of the specific support needs across different geographic regions.



- Funding: The teams at Ocean Motion Technologies, Inc. and The Ocean Foundation would like to take this opportunity to thank the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Water Power Technologies Office, and the Small Business Innovation Research Program for making this project possible. DOE Award Number: DE-SC0022787.
- Anonymous participants: We would also like to acknowledge all participants in the five regional workshops held between 2024 and 2025. Their willingness to share candid experiences, challenges, and aspirations made this paper possible. From fisheries managers and oceanographers to data scientists, policy advisors, and community practitioners, their collective insights reflect the breadth of expertise and perspectives that define the global ocean community. By contributing openly and thoughtfully, participants ensured that the findings of this paper are grounded in real-world needs and represent the voices of those working at the frontlines of ocean observation and management.
- The Ocean Foundation and Ocean Motion Technologies, Inc. would also like to acknowledge Meagan Gary, Dr. B. Jack Pan, Dr. Kaitlyn Lowder, and Alex Orona, for their authorship and contributions as well as Mark J. Spalding J.D. for his editorial review of this paper.
- The authors also recognize Juliana Corrales' expertise and diligence in developing the graphic design of this white paper.

## ACKNOWLEDGEMENTS

## BIBLIOGRAPHY

- [1] Visbeck, M., 2018. Ocean science research is key for a sustainable future. *Nature communications*, 9(1), p.690.
- [2] Greb, S., Dekker, A.G., Binding, C., Bernard, S., Brockmann, C., DiGiacomo, P., Griffith, D., Groom, S., Hestir, E., Hunter, P. and Kutser, T., 2018. Earth observations in support of global water quality monitoring. International Ocean-Colour Coordinating Group.
- [3] National Research Council, Division on Earth, Ocean Studies Board, Committee on an Ocean Infrastructure Strategy for US Ocean Research in 2030, 2011. Critical infrastructure for ocean research and societal needs in 2030. National Academies Press.
- [4] National Science and Technology Council (NSTC), 2018. Science and Technology for America's Oceans: A Decadal Vision. A Report by the Subcommittee on Ocean Science and Technology Committee on Environment of the National Science & Technology Council.
- [5] PNNL & World Ocean Initiative, 2020. Accelerating Energy Innovation for the Blue Economy. The Economist Group Limited.
- [6] Waterston, J., Rhea, J., Peterson, S., Bolick, L., Ayers, J. and Ellen, J., 2019, June. Ocean of things: Affordable maritime sensors with scalable analysis. In *OCEANS 2019-Marseille* (pp. 1-6). IEEE.
- [7] Speich, S., Lee, T., Muller-Karger, F., Lorenzoni, L., Pascual, A., Jin, D., Delory, E., Reverdin, G., Siddorn, J., Lewis, M.R. & Marba, N., 2019. Oceanobs' 19: An Ocean of Opportunity. *Frontiers in Marine Science*.
- [8] Gouldman, C., Rayner, R. & Bosley, K., 2016. The Ocean Enterprise: a study of US business activity in ocean measurement, observation and forecasting. NOAA/IOOS.
- [9] The Ocean Foundation & TMA BlueTech, 2021. The Blue Wave: Investing in BlueTech Clusters to Maintain Leadership and Promote Economic Growth and Job Creation. The Ocean Foundation.
- [10] Spinrad, R.W., 2021. The new blue economy. In *Preparing a Workforce for the New Blue Economy* (pp. 87-111). Elsevier.
- [11] Intergovernmental Oceanographic Commission (IOC) of UNESCO, 2019. The Science We Need for the Ocean We Want: The United Nations Decade of Ocean Science for Sustainable Development (2021-2030). IOC Brochure 2018-7 (IOC/BRO/2018/7 Rev), p.24 (English).
- [12] LiVecchi, A., Copping, A., Jenne, D., Gorton, A., Preus, R., Gill, G., Robichaud, R., Green, R., Geerlofs, S., Gore, S., Hume, D., McShane, W., Schmaus, C. & Spence, H., 2019. Powering the Blue Economy: Exploring Opportunities for Marine Renewable Energy in Maritime Markets. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Washington, D.C.
- [13] Muller-Karger, F.E., Miloslavich, P., Bax, N.J., Simmons, S., Costello, M.J., Sousa Pinto, I., Canonico, G., Turner, W., Gill, M., Montes, E. and Best, B.D., 2018. Advancing marine biological observations and data requirements of the complementary essential ocean variables (EOVs) and essential biodiversity variables (EBVs) frameworks. *Frontiers in Marine Science*, 5, p.211.
- [14] Počuča, M., 2006. Methodology of day-to-day ship costs assessment. *Promet-Traffic&Transportation*, 18(5), pp.337-345.
- [15] Kurth, T., Subramanian, S., Harrington, P., Pathak, J., Mardani, M., Hall, D., Miele, A., Kashinath, K. and Anandkumar, A., 2023, June. Fourcastnet: Accelerating global high-resolution weather forecasting using adaptive fourier neural operators. In *Proceedings of the platform for advanced scientific computing conference* (pp. 1-11).