

# Accelerating Global Ocean Observing: Monitoring the Coastal Ocean Through Broadly Accessible, Low-Cost Sensor Networks

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## ABSTRACT

The global coastal ocean provides food and other critical resources to human societies. Yet this habitat, for which many depend, has experienced severe degradation from human activities. The rates of human-induced changes along the coast demand significantly improved coverage of ocean observations in order to support science-based decision making and policy formation tailored to specific regions. Our proposal envisions developing a global network of low-cost, easily produced and readily deployed oceanographic sensors for use on a wide variety of platforms in the coastal ocean. A substantially large number of these sensors can thus be installed on existing infrastructure, ships of opportunity, and fishing fleets, or even individually along the coast, particularly in vulnerable and disadvantaged regions. This would vastly increase the spatiotemporal resolution of the current data coverage along the coast, allowing greater equitable access. It would also offer significant opportunities for partnership with communities, NGOs, governments, and other stakeholders, as well as a wide range of commercial and industrial sectors to develop and deploy sensors in scalable networks transmitting data in near-real time. Finally, it presents a vastly lowered bar for participation by citizen scientists and other engaged members of the public to address location-specific coastal problems anywhere in the world.

## Vision and Potential Transformative Impact

Nearly half of the world's population lives near the ocean, where the concentration of life and human activity provides myriad benefits, including food, jobs, access to navigation, and protection from natural hazards. This densely populated area is changing rapidly and in ways that threaten economies and human health with disease, toxic algal blooms, pollution, frequent storms, and climate-induced loss of resources. Managing and mitigating the impacts of these changes hinges on high-resolution, cost-effective measurements; yet, traditional ocean observations are hampered by high costs and limited resolution. A key challenge in sustaining accessible and equitable ocean observation is how to make cost-effective measurements and deliver actionable data at relevant spatiotemporal resolutions necessary for illuminating complex system processes and rapidly evolving changes. Development and deployment of low-cost in-situ ocean sensors are critical to address this observational challenge. Having a suite of sensors that are sufficiently affordable and robust enough to be used by scientists, community members, and stakeholders to measure the coastal ocean will revolutionize both ocean science and resource management. We envision implementing low-cost sensor networks in vulnerable coastal regions across the globe to transform ocean observing, predicting impacts from anthropogenic influences, and sustaining the equitable use of marine resources.

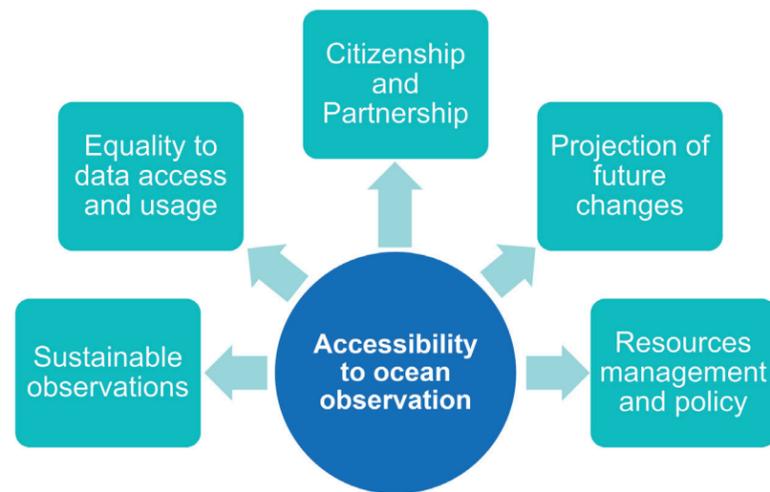


FIGURE 1. Accessibility to ocean observation is a major factor to address many challenges that face the ocean today.

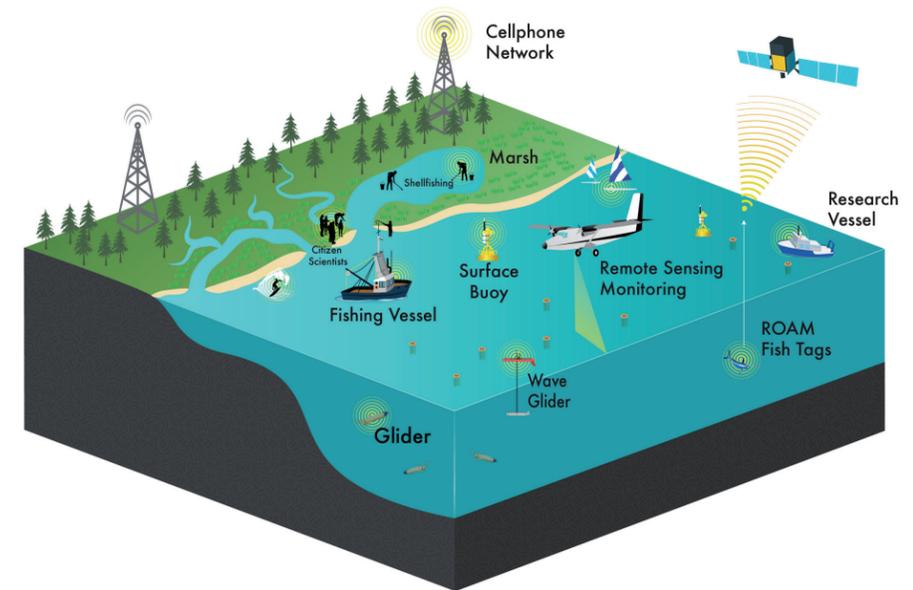


FIGURE 2. Schematic of the conceptual low-cost sensor network in the coastal ocean.

## Realizable, With Connections to Existing U.S. Scientific Infrastructure, Technology Development, and Public-Private Partnerships

Low-cost sensors can be readily adaptable to current ocean observing infrastructure, such as the Ocean Observing Initiatives (OOI), Argo and Biogeochemical Argo, and the Integrated Ocean Observing System (IOOS) networks, thus substantially improving their observing capabilities. Development and deployment of low-cost sensor technologies also requires significant investments in technology development, academia-private and public-private partnerships, and stakeholder engagement. Citizen scientists may be engaged to deploy and maintain a large number of low-cost, simple sensors providing greater resolution and coverage than ever before. There are ample opportunities to engage ocean industries, such as commercial ships of opportunity and commercial fishing fleets to deploy low-cost sensors worldwide. We also have the opportunity of a pervasive and growing global communication infrastructure, such as cell phone communications and Wi-Fi networks, for transferring large amounts of data collected from low-cost sensor networks in near-real time, significantly increasing the accessibility of ocean observing data for use by the public and decision makers.

## Scientific/Technological Sectors Engaged Outside of Traditional Ocean Sciences

Partnerships with other fields engaged in sensor development will enable technologies developed for other applications to be applied to ocean observing. For example, biomedical fields develop miniature sensors that operate within aqueous fluids. Space science requires small, low-power, robust sensors that can operate autonomously to make long-term measurements in harsh conditions. Computer science and engineering will also be critically important for sensor design, incorporating artificial intelligence for data processing and adaptive sampling, and for finding ways to deal with data and computing limitations imposed by transfer of large amounts of data originated from low-cost sensor networks.

## Opportunities for International Participation and Collaboration

The development and deployment of low-cost sensors that are capable of monitoring coastal waters and providing immediate feedback to water quality and properties will entail collaboration with global coastal communities to ensure that the data addresses questions of local or regional concern. Partnerships with remote or disadvantaged coastal communities around the globe, such as Indigenous Arctic populations and coastal communities in developing nations, will be key to success, particularly for those whom climate change will disproportionately impact. Other opportunities include international sailing, commercial shipping, commercial fisheries, offshore energy, the tourism industry, and private and public ocean expeditions.

## Develops Global Capacity and Encourages the Development of the Next Generation of Ocean Scientists, Engineers, and Technologists

Access to low-cost sensors would enable global, high-resolution measurements analogous in its impact to low-cost sensors that underpin weather forecasting in many parts of the world. Providing international communities with the technology needed to measure the ocean waters near them will entrain a new, globally diverse team and engage them in ocean science and marine resource management, while also training the next generation of ocean scientists. Deployment of low-cost sensor networks will also help developing nations train their workforce and narrow their knowledge gap in ocean sciences and resource management while providing opportunities for technology development, employment, and higher education.

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