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Charting Coastal Waters: A Challenge in Prolonged Ocean Health Diagnosis

SPONSOR

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CHALLENGE

A range of users across the globe need cost-effective and scalable systems to better understand the Earth's changing climate, quantify the health of the ocean and better inform agencies developing policies that effectively mitigate the harmful consequences of these changes.

WICKED PROBLEM DESCRIPTION

Tools, techniques and processes exist and under development in research labs that may be scalable to provide the required systems described above. However, the process of evolving oceanographic research technology from the research lab across the so-called "tech canyon of death" into systems that can address current, critical, international needs has always problematic. The fundamental problem is this technology is complex and expensive but the market demand is small. Compounding this technology problem are the cultural, political and economic problems of helping policy makers at the national level accept and use these systems to develop science-based policy mandates.

A Wicked problem based on the specific case study described below might be titled something like *Can state of the art oceanographic research technology be scaled to solve current, critical, complex, international problems?*

POTENTIAL IMPACT

There is a wide range of current global scientific needs for observing systems. Examples where cost effective and scalable observing systems can impact our ability to understand and quantify ocean health include the following.

- Systems that provide relevant data products can be used to develop science-based fishery management policy and mandates. Ideally, these systems will scale to address issues at the national scale, e.g., the UK Marine Management Organisation and the US NOAA fisheries agencies and at a the community scale, e.g., community led, local fishery

management groups that may be responsible for supplying most of their protein required by the local population surrounding their local lake.
- Measurement, reporting and validation (MRV) observing systems are required to quantify the efficacy of marine carbon dioxide removal (mCDR) systems currently being proposed to mitigate the problem of ocean acidification.
- Observing systems that can be used effectively from the Arctic to the Antarctic can be used to quantify the impact of climate change on ocean health. As a specific example, modeling groups working with the UN Intergovernmental Panel on Climate Change (IPCC) are currently improving their predictions of climate change with accurate, defensible data from deep water ocean observing systems.
- Observing systems targeting current marine threats including harmful algal blooms, oxygen dead zones and marine heat waves can be used to understand how, why and where these threats happen and their consequences.

RELEVANT CONTEXT

- The Argo array (https://argo.ucsd.edu/) of profiling floats is currently the only system that has scaled up to meet the definition of a global observing system. For over a decade the Argo system has been providing orders of magnitude more data at a significantly lower cost per data point than other observing technologies. However, the Argo system has been optimized to focus on quantifying ocean heat content in the deep ocean.
- The SOCCOM and Argo-BGC projects (https://soccom.princeton.edu/ and https://www.go-bgc.org/) have extended the capability of the original Argo profiling floats to make a suite of biogeochemical measurements that are being used to begin understanding the health of the ocean. However, this new generation of floats is still optimized for deep water applications. The problems identified earlier will need data from the coastal zones of the world's oceans.
- Working in shallow coastal waters presents a whole new set of problems for scalable observing systems.
- The Argo, SOCCOM and Argo-BGC systems took decades to evolve from the research lab into their current capability.

WICKED CASE STUDY

MBARI researchers have developed a coastal profiling float (CPF) designed to mitigate the challenges of working in coastal environments while making a full suite of biogeochemical measurements (https://www.mbari.org/news/new-coastal-profiling-floats-for-diagnosing-ocean-health/). In addition to the profiling float itself, the CPF system includes tools to manage field deployments and the requisite pipeline for data processing, quality control, analysis and visualization.

Developing answers to questions like the following are examples of Wicked module team tasks using the CPF as a case study.

- Who are the stakeholders at all scales? What are their specific needs?
- What is the range of each stakeholder's available budget?
- What are the barriers for policy makers to use new technology to solve problems they have been addressing for decades?
- Is the CPF system a potential solution for these stakeholders? Is it the best, or at least one of the best, choices?
- Can the cost of the CPF system be reduced? If so, how?
- What improvements to existing CPF system functionality and what new functionality needs to be added in order to address the range of stake holder needs?
- Can the current CPF system be operated by non-expert users? If not, what changes need to be made?
- How can the CPF technology be made generally available? Commercial partners, government agencies, philanthropic organizations, open source or?
- What is a minimum viable product that can be used to demonstrate the utility of a CPF based observing system?
- What is the demonstration project? Pilot project(s), workshops, advertising or?

POTENTIAL BENEFICIARIES

1. Government and non-government policy makers: Improved data supports better policy mandates, resource management and disaster planning.
    a. UK Marine Management Organisation (https://www.gov.uk/government/publications/fisheries-management-plans/fisheries-management-plans#:~:text=The%20UK%20government%20has%20responsibilities,healthy%20and%20productive%20marine%20environment.)
    b. US NOAA Fisheries (https://www.fisheries.noaa.gov/)
    c. United Nations Intergovernmental Panel on Climate Change (IPCC, https://www.ipcc.ch/)
2. Research Scientists and Engineers: Access to cost-effective observing systems aids in understanding ocean health and climate change and facilitates research and interdisciplinary collaborations. Democratizing oceanographic data can entrain a whole new cadre of researchers who haven't had access to the ocean or oceanographic data sets.
    a. UK National Oceanography Centre (https://noc.ac.uk/news/uks-new-fleet-advanced-robotic-floats-deployed-part-global-argo-programme)
    b. US NOAA Future Seas (https://www.integratedecosystemassessment.noaa.gov/regions/california-current/future-seas)
3. Environmental and community led organizations: Reliable data informs advocacy and conservation efforts.

    a. Alaska Marine Conservation Council (https://www.akmarine.org/).
    b. The Nature Conservancy (https://www.nature.org/en-us/what-we-do/our-insights/fisheries/)
    c. Sustain Lake Tanganyika (https://www.sustaintz.org/)
    d. Indigenous fisheries (https://wfc2024.fisheries.org/2023/08/15/indigenous-people-stories-and-local-community-led-fisheries-management/)
4. Commercial Fisheries and Aquaculture Industry: Data aids in sustainable practices and adaptation to environmental changes.
5. General Public: Awareness and education encourage support for ocean conservation efforts

WICKED TEAM RECOMMENDED SKILLSETS

1. Environmental Science and Policy
2. Business (market analysis, risk analysis, non-profit management, etc.)
3. Fishery Management
4. System and Ocean Engineering
5. Data Science (processing, visualization, management, QC, UX/UI design, etc.)
6. Industrial Engineering, Product Design and Design for Manufacturability