Citizen Science and New Technologies to Navigate Ocean Data Challenges and Opportunities

The protection of marine environment and ensuring the ocean's sustainability are global issues. Nowhere are they more important than in the South China Sea, a body of water offering abundant and complex marine ecosystems. Marine citizen science, along with the promise of data sharing and the adoption of the newest technologies, provide pathways to addressing the ocean conservation process, supporting collective and cooperative action and informing policy and public understanding of key environmental issues.

"The winds, the sea, and the moving tides are what they are. If there is wonder and beauty and majesty in them, science will discover these qualities." – Rachel Carson

Abstract

Oceans and coasts around the world are in peril, which demands a full range of available data resources and marine technologies to bring about positive changes.

The protection of marine environment and ensuring the ocean's sustainability are global issues. Nowhere are they more important than in the South China Sea, a body of water offering abundant and complex marine ecosystems. Marine citizen science, along with the promise of data sharing and the adoption of the newest technologies, provide pathways to addressing the ocean conservation process, supporting collective and cooperative action and informing policy and public understanding of key environmental issues.

Over the past few decades, there has been a "tsunami" of state-of-the art ocean observation systems, from Remote Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs) and towed sleds, Wave Gliders, Sail drones, and large

image collections. These new tools, including marine image informatics, has created a growing demand for non-professionals or citizen (community) scientists to screen these image aggregations for designated regions.

With over 40 million observations of some 115,000 marine species from 1,600 datasets provided by nearly 500 institutions in 56 countries, the Ocean Biogeographic Information System (OBIS) houses the largest single data repository for biological data for the world's oceans. Given that national boundaries have little meaning with respect to environmental problems, this paper offers an examination of the participatory framework for achieving cooperation and ensuring ecological security in the troubled South China Sea.

A focused ocean stewardship initiative among scientists, communities and the general public offers ways in which to address climate change and ameliorate coral reef destruction, biodiversity loss, pollution (especially plastics) and fisheries depletion. It is clear that large amounts of ecological data are required, and that public participation can help analyze, collect, and categorize scientific data to assist in marine conservation and science cooperation. However, it is not enough that scientists have access to remote sensing platforms. The question is how should marine scientists generate knowledge from all the data swimming around? More importantly, are they capable of sharing the scientific knowledge with competing nation-states operating over the same body of water? With emerging new data, there is an urgency for transparent and open access to science information and to placing this uploaded data into a larger accessible digital ecosystem. The expansion of cabled observatories now brings data ashore

through the Internet. An open access of information-sharing in the South China Sea can benefit all claimant nations in the form of ocean governance and fisheries sustainability. The promise of open-access awareness offers an opportunity to establish a regional marine science outreach for a possible Big Data South China Sea science community.

Introduction

Ocean knowledge and technology are more developed today than ever before. Despite significant oceanographic advances, and a continuous flow of ocean data, marine research has failed to ameliorate the competing South China Sea claims nor navigate the sustainable stewardship of ocean resources. In this sea of opportunities, uncertainties and threats, environmental degradation remains at the center of scientific conversation as marine scientists and citizen scientists sound the alarm about how to address issues of acidification, biodiversity loss, climate change, destruction of coral reefs, fishery collapses and pollution - especially plastics. What's certain is that these ecological challenges reveal how claimant nations – The People's Republic of China (PRC), Vietnam, the Philippines, Malaysia, Brunei, and the Republic of China (ROC) and Taiwan – have a legal and ethical responsibility to ensure that none of their activities harm or create additional long-term damage to one of the most biologically diverse marine ecosystems.

The ocean, a natural laboratory, invites communities, governments, institutions, and scientists, to understand the web of interconnections that links all of us. Fortunately, the emergence of marine citizen or community science stands at the intersection

between ocean science and ocean literacy. Their contributions ensure that nations are poised to capitalize on the UN Decade of Ocean Science for Sustainable Development to create an open global data network, especially in the South China Sea. While newest ocean technologies offer vast stores of ocean data, the conundrum is renewing science cooperation for sharing the data.[1]

Marine science has entered the digital age. Expansions in the scope and scale of ocean observations and ‘smart sensors’, now leads to a continuous flood of data. There is much activity within the oceanographic community to develop many types of underwater sensor networks: mobile, fixed, autonomous and cabled.[2]

As a result, this provides opportunities to transform the way the ocean is studied and understood through more complex and interdisciplinary analyses and in coastal community engagement in the management and monitoring of marine resources. The improvement of global understanding of our oceans and their value will rely on innovation that removes barriers of access for the marine data needed among users. This access to marine data and cooperation is seen in the Census of Marine Life, a ten-year (2000-2010) scientific research and outreach program with over 2,700 scientists from 500 institutions and more than 80 countries.[3]

These collective science actions are essential since the focus of policy and research is directed towards understanding the critical changes that are occurring in the ocean systems. In conversations with fishermen, marine scientists, oceanographers and student volunteers (citizen community scientists), there is a growing bandwidth of

ocean data to draw upon. “Yet, it is generally recognized that scientists engaged in international projects historically face numerous scientific, political, and cultural challenges”.[4]

During this pandemic, where science is at the epicenter in the urgent search for a vaccine, there exist impediments for international cooperation. Even so, the 10-member Association of Southeast Asian Nations (ASEAN) has not been able to chart a course to promote sustainable ocean governance. And yet, sustainability and resilience become more important with the pandemic, and its consequences make unprepared communities more vulnerable.

Mark Spalding, president of the Ocean Foundation, asserts that the 625 million people of the 10 ASEAN nations depend upon a healthy global ocean. Meanwhile, coral reefs are dying as a result of an ecological catastrophe unfolding in the region’s once fertile fishing grounds. As reclamation destroys more marine habitats, agricultural and industrial runoff poison coastal waters, and overfishing depletes fish stocks, it is no wonder that marine biologists are expanding their discourse and attempting to engage more citizens about the importance of using a rules-based ecological approach to protect the environment. Through studying the sustainability of the biological seascape, marine biologists are engaged in rallying for public access to ocean data that can be shared to respond to the damage done to the ‘Global Commons’.[5]

Enter Big Data and marine citizen science

Although nation states take different approaches toward ocean data collection, in

general it is agreed that with data, there can never be enough shared. Dr. Peter Neill, director of the World Ocean Observatory in an e-mail revealed that the South China Sea is a case in point. He asks about what we do with all the data and (available technologies) and how is it applied: first to our general compendium of knowledge; second, to our specific scientific interest; third, to others who may use the data differently; and fourth, in what form are the conclusions assembled and communicated beyond the narrow scientific audience to the public? He adds, “that scientists and their sponsoring institutions are not well prepared to address the latter questions”.[6] Neill believes that all too often, science remains in the computers, labs, and ambition of the scientists, and the public is denied access to the ocean data to better understand what must be protected, and understood as a tool for education and the building of political will.

Citizen science, or participatory research, enlists the public in collecting large quantities of data across an array of habitats and locations, and through new technology, in the same way that smartphones and free downloadable science apps, transform the collection of science data.[7] Scientific and technological decision-making should rest on participation by and collaboration among scientists, citizens and civil society.[8] However, as marine citizen science grows, questions remain about how to ensure quality data through interactive technological techniques (Bonney, 2009).

Citizen science marine data models and technology tools

Because of the increasing imperatives to predict changes, to monitor and to protect coastal communities, marine scientists are reaching out and training public volunteers

or citizen scientists in the collection and analysis of marine data that succeeds in broadening the public engagement. With photographic documentation and marine identification tools increasing, there has been a spate of web and smartphone applications thus expanding photographic comparisons of species and trends.

Also, electronic monitoring aboard commercial fishing vessels does lead to higher accuracy in logbook data to address illegal and unreported fishing activities in the South China Sea. Cameras combined with machine learning can spot illegal behavior and they should be compulsory as a condition to access in exclusive economic zones. According to Pew, studies have shown that inaccuracies in reporting are rife throughout commercial fisheries. The installation of next generation monitoring systems does improve the quality of captured data that in real time can be stored in the cloud.[9]

Naturally, the challenges are to ensure the quality of the analysis and documentation efforts. According to data researchers, “citizen scientists have historically been undervalued as data collectors, however, rising interest and increased attention to data quality have shown that properly managed public programs can collect robust and trustworthy data”.[10]

There are more free science apps for the public to adopt in their supporting role to disseminate science data related to oceans and coasts. Vietnam has encouraged remote sensing and citizen science to fill in the gaps of conventional environmental monitoring methods. In the past, Vietnam’s scientists examined national water

monitoring infrastructures but did not take into account the information received from free satellite images and crowd-based data collection.

Now there is a host of free science apps and organizations for volunteers to tap into, like the Citizen Weather Observer Program, the Global Coral Reef Network, the Nature Mapping Foundation, and the Marine Debris Tracker. Available to the public, these digital tools effectively enhance scientific literacy, deepen connections to nature and place and foster new knowledge networks (Brossard et al., 2005). The links between citizen science and the power of ocean data revolution are clear.

According to researchers, Cathy Conrad and Krista G. Hilchey, “there is a wealth of community-based management initiatives around the globe.” In their academic paper, they reinforce that it is not just the traditional role as “scientists using citizen science as data collectors, but rather citizens as scientists”.[12]

The need for marine technologies and the pooling of data sets helps influence policy development. “It is widely acknowledged that more effective environmental monitoring is required to support management in the face of rapid global change”.[13]

Although the pandemic is one of the world’s greatest challenges, Earth Challenge 2020 was initiated to gain the global support for public volunteers or citizen scientists to become the world’s largest coordinated citizen science campaign for data collection, and a platform for global citizen science data. Through the mobile app, it empowers people around the world to monitor threats to environmental health in their own

communities. This new open data platform is making it easier for researchers around the world to find and access high-quality information for international policy assessments like the U.N. Sustainable Development Goals (SDGs).

In Australia, a coalition of students, environmental groups, universities and scientists are gathering critical new data about microplastics in the ocean and their waterways. The data collected by a network of citizen scientists and researchers enables AUSMAP to create vivid maps of microplastic hotspots in the country. According to research scientist, Dr. Michelle Blewitt, “our work enables communities and government to implement behavior change, regulate industry and develop better waste management”.[14]

While civil society activities related to South China Sea dispute management are politically limited and not openly public, Vietnamese-based environmental organizations like the Center for Development of Community Initiative and Environment, Mekong Environment Forum, Mekong Delta Youth, MCD-Marinelife Conservation And Community Development and others, with missions to solve environmental issues in the South China Sea, have been working professionally to educate all of society, especially young people, fisheries, businessmen, and others. In that sense, environmental advocacy translates into successful diplomatic efforts and succeeds in the democratization of science.

New marine technologies connect data but not always nations

While the ocean technology advances have multiplied over the past decade, including

the scale and number of cabled observatories, acoustic modems, and processing and visualization capabilities, the cooperation among nations to foster an open access digital ecosystem requires more development. Unfortunately, vast stores of ocean data remain restricted in the databases of governments, researchers and industry.[15]

For example, China's State Oceanic Administration (SOA), a founding member of the North Pacific Marine Science Organization, known as PICES, is an intergovernmental scientific organization promoting and coordinating marine research in the northern North Pacific and adjacent seas. It was established in 1992 with the United States, Canada, Japan, Republic of Korea and Russia. Their goal is to advance and to collect scientific knowledge about the ocean environment, global weather, climate change, and marine ecosystems.

According to Dr. Sara Tjossem, a senior lecturer in International and Public Affairs at Columbia University, PICES from the outset "struggled with how best to exchange data, but not become a redundant data repository." In Tjossem's research, she calls out for all "data to be quickly accessible to reflect real world events and readily exchanged physical data proved easier to share while chemical and biological data were more challenging." In the end, the organization like many others attempting science cooperation, found the line blurred between fisheries management and science research.[16]

The access to ocean data has been propelled by undersea fiber-optic cables. These conduits of global information flows are responsible for over 95 percent of

international data and continue to add more bandwidth, thereby creating opportunities to expand ocean sensing. At the National Oceanic and Atmospheric Administration (NOAA), their basic tenet of environmental data management calls for full and open access.

As the nation's archive for ocean data and information, the National Centers for Environmental Information (NCEI) are committed to full and open data access in support of both a community of data producers and consumers.

In fact, NOAA's ocean data archive in collaboration with numerous international and national organizations is to increase the accessibility of data worldwide. This includes the Global Earth Observation System of Systems (GEOSS), the Global Ocean Observing System (GOOS), the Committee on Earth Observing Satellites (CEOS), the International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC).

It was encouraging to receive an e-mail from IOC of UNESCO announcing the soon-to-be released publication of a 2020 Ocean Science Report, which contains analysis of national ocean science capacities. "However, when IOC conducts such analyses, we always base them on information provided by our counterparts in the country of interest, if you are interested in such type of work, we can link you with our contacts in the Peoples' Republic of China," claims Dr. Vladimir Ryabinin, executive secretary of IOC UNESCO.[17]

The IOC enables its 150 member states to cooperate through access to ocean health, data and information, tsunami warnings, ocean observatories, capacity building and transfer of marine technology. Even with this program's history and coupled with available improving navigation systems for next-generation Internet-capable microsats, the ocean remains a difficult environment for high-bandwidth communication systems.

While there are advances in various platforms of Unmanned Surface Vehicles and Buoys for real time monitoring of aquaculture environments, the technology still does not fully replace the requirement for in-the-field data monitoring and data collection, according to research completed in Sensors, an international peer-reviewed open-access journal.[18]

Conclusion

It is promising that an increasing number of marine scientists recognize that the South China Sea is a natural laboratory for science collaboration. The mantra is global and simple: There should be no national borders in science. The focus is to rise above the politics and seek solutions on the larger and important question central to humanity's long-term wellbeing.

While it may be too much to hope that South China Sea nationalism will disappear because of advances in technology or community-wide science participation to ease cross-border environmental issues, the creation of a South China Sea open-access domain awareness model may inspire public good from governments, NGOs, and fishers. All of this will require proofs of concept. But there is much to gain and too

much to lose if we do not try.

According to Dr. Sophie Boisseau du Rocher, a senior researcher and associate at the Paris-based Centre Asie IFRI, “Scientific programs obviously serve the interests of both China and the Southeast Asian countries: areas of cooperation are numerous and the easiest ground to establish regional cooperation regimes. In this sense, collective scientific work or the adoption of functional standards could contribute toward defusing threatening attitudes”.[19]

Placing science in the forefront of foreign policy builds common ground and achieves technological breakthroughs to help navigate through our shared “Global Commons.” The oceans require the engagement of marine citizen scientists with their various forms of participatory monitoring; coupled with the adoption of new technologies. The reefs are much more than cathedrals in the ocean; they represent life since they provide food, storm protection, and cultural identity to coastal communities. The challenge for all is to find solutions to protect coral reefs, the rain forests of the sea before it is too late. Ocean data cooperation in the South China Sea is more than possible and vital for sustainable development since it has already shown how it generates new knowledge to preserve biodiversity and protect ecosystems.

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Notes

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