COMMENTARY

A Prosperous Economy Requires Ocean Biodiversity Information, Technology, and Innovation

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The variety of life—or biodiversity—of the United States' coastal areas, ocean, and Great Lakes is a keystone in the production of vital resources and significantly contributes to ocean economic growth. The economic activities in these areas (including tourism and recreation, energy and mining, transportation, medicines and genetic discoveries, fisheries and other foods, as well as various finance and ecosystem management operations) contribute around $400 billion to the nation's annual gross domestic product. Global expansion of the ocean economy is predicted; however, this growth is predicated on ocean ecosystem health and sustainable use. Managing growth and balancing the ecosystem health that sustains those benefits require baseline data obtained through sustained monitoring efforts and reliable forecasting.

Technology Innovation to Monitor Ocean Biodiversity

Forecasting biodiversity trends and patterns, and developing scenarios of sustainable ocean uses require observations and developing a workforce that can adeptly manage ocean information. Today, services for marine biodiversity information are not keeping pace with the data revolution, offering opportunities and areas of potential growth. Sensors, platforms, and information management and delivery are examples. The continued lowering costs of observing technologies would facilitate a global expansion of coverage and increased local applications of the data, including coastal resiliency issues for Small Island Developing States, subsistence fishery communities, and storm warnings and preparedness. Areas for sensor innovation for monitoring biodiversity include optics and imagery, animal biotelemetry and biologging, passive acoustics, active acoustics, environmental DNA and other "omics technologies," and remote sensing from under and above water, and from satellites. Combining several of these approaches provides new ways to monitor how marine life is changing (genes, species, habitats). Multi-sensor approaches will help us predict how organisms modify the environment, how they affect other organisms, and how the environment is driving changes in life and biodiversity.

A practical avenue for technology development is the consideration of biology, ecosystem forecasting, and scenario planning, in a manner analogous to weather forecasting. Combining ecosystem models with Artificial Intelligence (AI) holds the potential to unlock a predictive capacity and transform data analysis for biodiversity information for managers, fishers, and communities. Applications include faster identification of species, behaviors, and species interaction patterns using different technologies simultaneously, like video footage coupled with acoustic recordings. There is a possibility for the prediction of biogeographic (temperature, salinity, and nutrient levels, etc.) seascapes—which are not static. AI also can play a role in the recovery of data collected in the past but never published or shared. Much can be utilized from historical data if they can be discovered and mobilized into decision-making scenarios.

Perhaps among the highest priorities to advance understanding and modeling of marine life is the need for interoperability. Industry, academic research, government agencies, and civil society need to strive for convergence on standard observing methods as well as data formats to generate interoperable data and resources. This efficiency could be achieved from investments in leveraging machines to read, analyze, and synthesize observations. Manufacturers of instruments and practitioners that generate observations could better use common standards so more applications can ingest data more efficiently. The international community is converging on frameworks, such as Essential Ocean Variables and Essential Biodiversity Variables, that can help us all compare variability from place to place. We already do this in medicine, engineering, meteorology, architecture, and in so many other fields—why not coastal and marine ecology? There are now globally agreed data formats, including Darwin Core and vocabularies, which we could adopt as minimum standards to ensure data are widely accessible, interoperable, and reusable for multiple applications. Big data and cloud-based solutions can now process, aggregate, and synthesize data from different methods and data providers. Open-source, modular software code for visualization and scalable analysis tools are now possible and can help more users of information. Resource managers need simple and reliable tools to access all this information from among an ever-expanding universe of websites, data portals, and dashboards.

Financial Drivers

Ocean biodiversity supports our culture and an ocean economy through ecosystem services. There is opportunity for innovation in tools for investment and incentives from private capital, blended finance structures, and offsets. There are tool development opportunities for the evaluation and verification of ecosystem services by using standards to gauge progress and success, with a goal to incentivize investment in ecosystem services with blue bonds, biodiversity credits, parametric insurance, and aquaculture incentives. Offsetting, an approach by which biodiversity in one area is traded for increasing and fostering biodiversity in another area that may be far away, can end up in a disaster. Incentives for mismanagement may result from insufficient monitoring, unreliable or inaccurate baselines, and weak verification processes. Some of these problems have emerged in the carbon credit market, with undesired, negative local impacts. Enhancing these emerging markets will require interoperable biodiversity databases and capable people that understand the links between ecology, the economy, and human health, and who can communicate observing needs and apply the data in management actions.

Conclusion

There are many examples in our daily lives of how we depend on ocean biodiversity. Our collective dependence presents wide ranging opportunities. The current gaps in sensors, platforms, models, and biodiversity information products and services for all sectors represent employment opportunities and economic growth. Industry, government agencies, and academic institutions can better coordinate so that the people needed to translate management requirements into technological innovations, who can design sampling programs and who generate the data required to satisfy societal needs, are trained and available when needed. Developing this human capacity should be a high priority in conversations among sectors. Opportunities exist to satisfy a very large national and international market by addressing technology cost, complexity, time constraints, scalability, data interoperability, and biodiversity information management. Application of our nation's imagination and commitment can solve many of these problems.