2012 Yeosu Workshop on "Framework for Ocean Observing"

by David Checkley and Candyce Clark

A workshop to discuss the Framework for Ocean Observing (FOO) was held on May 18, 2012, at the 2nd International Symposium on "*Effects of Climate Change on the World's Oceans*" in Yeosu, Korea. Approximately forty symposium participants attended the workshop co-convened by the authors of this article. Albert Fischer (Intergovernmental Oceanographic Commission), Pedro Monteiro (Council for Scientific and Industrial Research, South Africa), and Martin Visbeck (GEOMAR, Germany) served as panelists.

Albert Fischer introduced FOO that had its genesis at the OceanObs'09 conference (Venice, 2009). The conference concluded with a call for a collective vision for the coming decade of ocean observations for societal benefit. Amongst other things, it was proposed to develop a Framework for planning and moving forward with an enhanced global sustained ocean observing system over the next decade, integrating new physical, biogeochemical and biological observations by expanding and building on present efforts. The follow-on FOO (http://www.oceanobs09.net/foo/) consists of recommendations for best practices for observing and a multi-level structure to facilitate global observing (Fig. 1). The Framework and its coordination processes are organized around **"**Essential Ocean Variables" (EOVs, Fig. 2), rather than by specific observing system, platform, program, or region. New EOVs meeting societal requirements will be carried out according to their readiness levels, allowing timely implementation of components that are already mature, while encouraging innovation and formal efforts to improve readiness and build capacity in ocean observations.

Sanae Chiba (JAMSTEC, Japan) described the Global Alliance of Continuous Plankton Recorder Surveys (GACS). The Continuous Plankton Recorder is an excellent example of a biological sampler that has been used for decades worldwide, collecting information about the plankton that has provided insights into its response to climate variability and change. The formation of a global alliance and augmentation to the sampler are also valuable examples of global reach and methods development, whilst maintaining consistency hence comparability.

Each workshop attendee was then asked to recommend one or more EOVs. This led to a rich discussion of diverse aspects of biological sampling. Common measurements that might lead to EOVs included size structure, taxonomic diversity, and biogeographic boundaries.

Size structure was the most commonly mentioned biological feature to be measured. The exact variables (*e.g.*, size -

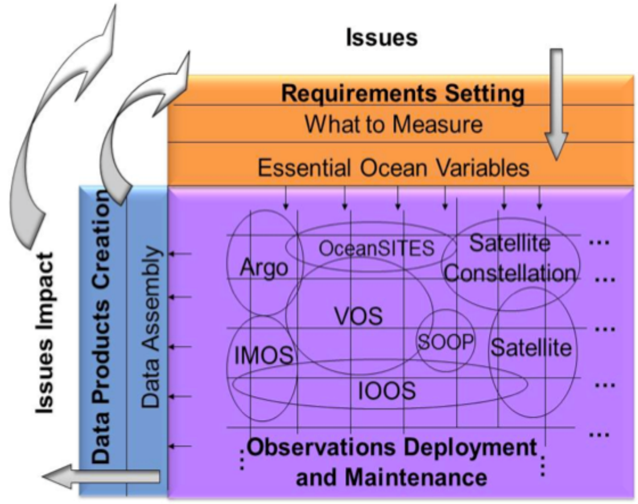

Fig. 1 Structure of the Framework for Ocean Observing. How ocean observing activities fit into the systems model of the Framework. The critical feedback loop between observing system outputs and science-driven requirements is shown. (Observation system examples are illustrative only, not comprehensive.) (Source: Framework for Ocean Observing)

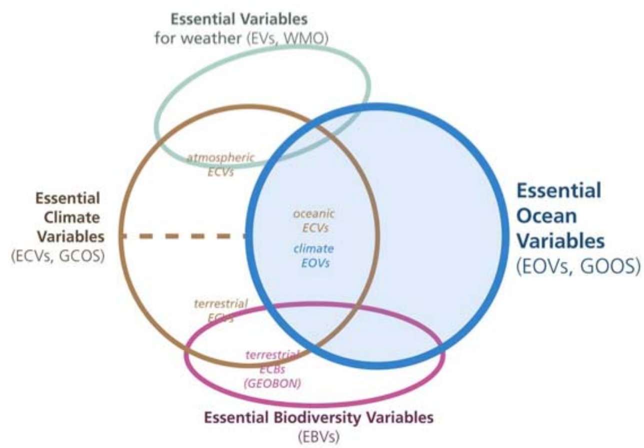

*Fig. 2 Conceptual overlap of Essential Ocean Variables (EOVs) in a Venn diagram. **Essential Variables** defined by the World Meteorological Organization for weather forecasting inspired **Essential Ocean Variables** later defined by the Global Climate Observing System. The concept has been adopted for **Essential Biological Variables** on land by the Group on Earth Observations Biodiversity Observation Network. The Framework for Ocean Observing processes will define ocean observing EOVs. Overlap among these groups is shown, which argues for the need to adopt a consistent approach. (Source: Framework for Ocean Observing)*

spectrum slope) were not discussed. Zooplankton, phyto plankton, and particles were proposed for measurement. While size structure may be a necessary feature to characterize, it is not sufficient (see below in regard to taxonomic diversity). It was also noted that production, not only standing stock (amount), is important.

Taxonomic diversity was the second primary biological feature to be measured. All taxa were noted, from viruses and bacteria to seabirds and whales, including the phytoplankton (*e.g*., coccolithophorids and nitrogen-fixers) and zooplankton (*e.g*., copepods, euphausiids, and gelatinous forms), micronekton, and top predators, and both mero- and holoplankton. Sentinel species might be given priority, as might indicators (*e.g*., the ratio of diatom to non-diatom phytoplankton and plant pigments). Functional relationships, not only abundance, are important to consider. Collected samples might be stored for future genetic analysis. Measurements of biodiversity should be considered.

The third primary biological feature was boundaries. These might be considered in space (*e.g*., biogeography) and time (*e.g*., phenology). Oceanic, in contrast to coastal, areas provide special challenges for observing. The concept of biogeographical provinces, and how these might change, was noted.

A variety of methods issues were raised. The importance of measuring rates, not only amounts, was noted by many attendees. Examples included production (*e.g*., Ar/O_2 for primary production), water-column respiration, extracellular enzyme activity of bacteria, particle sinking rates, carbon export, and sediment oxygen demand. The response time of systems, populations, and individuals was mentioned. The usefulness of the contemporaneous measurement, in both time and space, of different variables was noted. A new water sampler has been incorporated into some of the Continuous Plankton Recorders.

Finally, some general considerations regarding FOO were made. Nothing is 'in or out'. The observing system will remain a mosaic of evolving and increasingly integrated observing entities. It was noted that even the current measurement of ocean temperature is a patchwork. There will be overlap among disciplines, including physics, biology, and biogeochemistry, both in current and future systems that use new technologies. Both the benthos and the pelagos must be considered. Capacity development with a two-way dialogue and benefits for all is necessary, for observing occurs in waters of and between all countries, developing and developed. As stated in the Framework, observations support science and research, policy decisions and the regulatory process and are taxpayer funded, and hence must have public support. Broad-scale and, at times, global observing already exists, with examples including: temperature, sea surface height, wind, phytoplankton, and salinity from *in situ* and satellites; fish catch and abundance from fisheries; plankton from the GACS and fishery oceanography programs such as CalCOFI and those of ICES; oxygen from some Argo floats, all of which also measure temperature and salinity. As Carl Wunsch (Massachusetts Institute of Technology) said at OceanObs'09, "*Sustaining such a system … is truly an intergenerational problem … people who perhaps will be in a position to solve these climate problems decades or longer in the future…are likely to look back at us 50 or 100 years hence and ask what were they thinking, why were not they making these measurements, why didn't they calibrate them?*"


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