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Importance and Challenges of Coordinated Multiparameter Long-term Observing in the Deep Sea

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The world ocean covers over 70% of our planet and comprises over 95% of the living space. It is a fundamental dynamic engine of Earth, controlling energy transport and elemental cycles of the globe. It is also the integrator between what are (on average) the fast processes of the atmosphere and the slower processes of the earth's crust. A key hurdle in coming to grips with understanding this earth-ocean-atmosphere system is the range of spatial and temporal scales at which processes occur, their complex interconnectedness, and in many cases their catastrophic episodicity. Part of this hurdle is our own perspective - through the millennia we have viewed the ocean as a shore or a surface, to travel on or dip blindly into for food.
Spatial Scales: In order to frame earth-ocean processes, it is necessary to capture information from the major regions and transition zones. The underlying bones of the earth, the tectonic structures, define much of the overlying regional distribution and pivot points. By spanning this range of tectonic settings, you also span major zones of the ocean, including a range of photic to aphotic environments, and photosynthetic- to chemosynthetic-energy-based ecosystems. Sources of nutrients range from terrestrial outflow, to coastal upwelling, to cold seeps and hydrothermal vents; transport of resultant primary productivity includes free fall, surface, mid-water and bottom currents, and tidal pumping. Benthic habitats include soft, firm and hard bottom environments in all of the shelf, slope, abyssal plain, and mid-ocean ridge regions. Scales of life range across microbial, meiofaunal, mesofaunal, macrofaunal, and megafaunal.
Temporal Scales: Processes within the earth-ocean system vary on scales of microseconds to millennia. Rapid processes require high-frequency sampling. Assembly of more than one data stream into variable space also requires high resolution time-coordination. The interpretation of longer term processes requires an adequate assessment of the short term processes so that the latter signal can be removed.
Catastrophic episodicity: Many processes are also highly episodic, and these combined with rapid events at long intervals make it difficult to plan sampling expeditions to capture the events. If the rapid processes are heterogeneously distributed through time (episodic), for example earthquakes, then continuous high-frequency time-coordinated sampling is required to capture the event at all. The solution is to have remote sensing capability in place all the time, waiting for the events to occur.
Complex interconnectedness: Perhaps even more powerful than the environmental and temporal scope above however is the requirement for coincident, coordinated sampling of data streams across disciplines. Ideally this allows responsive realtime sampling of events, and analysis of relationships among the disparate data to test relationships and drivers across the earth-ocean system. This also requires extensive documentation of and access to meta-data in order to allow the scientific community the ability to judge the appropriateness of various data combinations for analysis. This not only benefits from, but requires an open data e-science approach, in order to allow for development of research initiatives across disciplinary lines, and across international experience.