Dynamic Ecological Provinces:a biogeochemical and physiological template for the global ocean.

Mark D. Dowell, Janet W. Campbell, and Timothy S. Moore

Ocean Process Analysis Laboratory, University of New Hampshire, Durham, NH 03824, USA, mark.dowell@unh.edu

The concept of oceanic provinces or domains has existed for well over a century. Such systems, whether real or only conceptual, provide a useful framework for understanding the mechanisms controlling biological, physical and chemical processes and their interactions. Criteria have been established for defining provinces based on physical forcings, availability of light and nutrients, complexity of the marine food web, and other factors. In general, such classification systems reflect the heterogeneous nature of the ocean environment, and the effort of scientists to comprehend the whole system by understanding its various homogeneous components. If provinces are defined strictly on the basis of geospatial or temporal criteria (e.g., latitude zones, bathymetry, or season), the resulting maps exhibit discontinuities that are uncharacteristic of the ocean. While this may be useful for many purposes, it is unsatisfactory in that it does not capture the dynamic nature of fluid boundaries in the ocean. Boundaries fixed in time and space do not allow us to observe interannual or longer-term variability (e.g., regime shifts) that may result from climate change.

A satellite-based methodology is presented using multiple satellite-derived variables and a novel mathematical procedure based on fuzzy logic to address temporal and spatial variability of primary productivity in the ocean. We have identified nine ecological provinces or “classes” based on a large primary productivity data set with accompanying in-situ measurements of surface chlorophyll (CHL), sea surface temperature (SST), and photosynthetically available radiation (PAR). Based on the CHL, SST, and PAR statistics derived from the in-situ data, we have mapped the global distribution of these classes using monthly composited satellite observations of these properties. Thus mapped globally, the classes represent spatially coherent and seasonally dynamic provinces within which the environmental controls on primary productivity are homogeneous.

A multi-year time series synthesizing the geographic and seasonal variability of specific variables relevant to primary production modeling as well as the global distribution of net primary production has been produced based on the province distribution. Nutrient depletion temperature maps for the limiting nutrient (e.g. NO_3, PO_4, SiO_2) have been determined and subsequently matched with coincident temperature maps for each month to identify nutrient-deplete and nutrient-replete areas at the global scale. This approach is relevant to existing algorithms for primary productivity (Behrenfeld - PhotoAcc) and pigment packaging (Carder - MODIS chlorophyll). The variability of photosynthetic parameters and light limitation has also been characterized in each province, thus providing input to existing models for estimating primary production. In short the proposed approach provides all of the oceanographic and ecological insight of traditional classification schemes whilst retaining the fluid boundaries and dynamic interaction of the different ocean biomes as perceived in global satellite imagery.