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Planktonic Trait Scaling

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Trait distributions of plankton communities exhibit scale-invariance in many ways. The size distribution of marine microbial organisms follows a power law with exponent around -2 over almost 3 orders of magnitude. Furthermore, size distributions of many different unicellular aquatic species grown in the lab are self-similar upon re-scaling with the species' mean sizes. And scaling is not limited to size. The distributions of cellular chlorophyll content of phytoplankton populations grown in the lab under different light intensities show an interesting change in scaling when transitioning from a nutrient-rich to a nutrient-depleted phase. In the nutrient-rich phase the chlorophyll distributions are self-similar across different light intensities. In the nutrient-depleted phase they exhibit multi-fractal moment scaling.

We present a new class of models incorporating generic processes of cellular trait accumulation and cell division. All of the observations mentioned above are naturally explained under the assumption that these systems are close to the scale-free critical point of this class, which marks a second order phase transition from a phase dominated by trait accumulation (e.g. cellular growth) to a phase dominated by cell division. This criticality hypothesis entails further robust scaling predictions amenable to experimental testing.