Vertical migration by bulk phytoplankton sustains biodiversity and nutrient input to the surface ocean

*S. Lan Smith[1], Kai W. Wirtz[2]

1. Marine Ecosystem Dynamics Research Group, Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology, 2. HZG, Geesthacht, Germany

Phytoplankton subsumes the great variety of unicellular photoautotrophs that perform roughly half of Earth’ s primary production. They achieve this despite their challenging oceanic habitat, with opposing vertical gradients of nutrients (which often limit their growth near the surface) and light (which becomes limiting with increasing depth). Most phytoplankton species are commonly assumed to be incapable of moving actively between the zones of light and nutrient availability, which are separated vertically by from 30-120 m. Here we propose that a considerable fraction of phytoplankton vertically traverse these gradients over time scales from hours to weeks, employing variations of a common migration strategy to acquire multiple resources. We present a mechanistic Lagrangian model resolving phytoplankton growth linked to optimal migration behaviour and demonstrate unprecedented agreement of its calculated vertical CHL-a distributions with 773 profiles observed at five prominent marine time-series stations. Our simulations reveal that vertically cycling phytoplankton can pump up enough nutrients to sustain as much as half of oceanic Net Primary Production (NPP). Active locomotion is therefore a plausible mechanism enabling relatively high NPP in the oligotrophic surface ocean. Our simulations also predict similar fitness for a variety of very different migration strategies, which helps to explain the puzzling diversity of phytoplankton observed in the ocean.

Keywords: trade-offs, ecosystem modeling, biogeochemistry