Subsurface chlorophyll maximum layer acting as a nutrient trap in typical stable water columns

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In a typical stable water column, nitrate exhibits a strong vertical gradient in the euphotic zone, conventionally referring to as the nitracline. Depth, steepness and thickness of the nitracline are important measurable parameters that can be related to the vertical transport of nitrate into the euphotic zone. The subsurface chlorophyll maximum layer (SCML) commonly emerges near the bottom of the euphotic zone, regulating the supply of nitrate to the euphotic zone and hence affecting new primary production. The correlation between the SCML and the nitracline has been widely reported in the literature, but the analytic solution for the relationship between them is not well established. By incorporating a piecewise function for the approximate Gaussian vertical profile of chlorophyll, we derive the analytical solutions from the system of phytoplankton and nutrient: 1) the thickness of SCML is positively related to the nitracline thickness, and a thinner SCML corresponds to a steeper nitracline; 2) the nitracline depth is deeper than the SCML depth, shoaling with an increase in light attenuation coefficient and a decrease in surface light intensity; the light level at the nitracline depth is positively correlated to the maximum rate of new primary production, an indicator of the rate of new primary production; and 3) the nitracline steepness is positively related with vertical nitrate gradient below the nitracline depth, but is negatively related to vertical diffusivity in the stratified deep layer.