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TITLE: Global satellite-observed daily vertical migrations of ocean animals

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ABSTRACT:

Every night across the world's oceans, numerous marine animals arrive at the surface of the ocean to feed on plankton after an upward migration of hundreds of metres. Just before sunrise, this migration is reversed and the animals return to their daytime residence in the dark mesopelagic zone (at a depth of 200-1,000 m). This daily excursion, referred to as diel vertical migration (DVM), is thought of primarily as an adaptation to avoid visual predators in the sunlit surface layer1,2 and was first recorded using ship-net hauls nearly 200 years ago3. Nowadays, DVMs are routinely recorded by ship-mounted acoustic systems (for example, acoustic Doppler current profilers). These data show that night-time arrival and departure times are highly conserved across ocean regions4 and that daytime descent depths increase with water clarity4,5, indicating that animals have faster swimming speeds in clearer waters4. However, after decades of acoustic measurements, vast ocean areas remain unsampled and places for which data are available typically provide information for only a few months, resulting in an incomplete understanding of DVMs. Addressing this issue is important, because DVMs have a crucial role in global ocean biogeochemistry. Night-time feeding at the surface and daytime metabolism of this food at depth provide an efficient pathway for carbon and nutrient export6-8. Here we use observations from a satellite-mounted light-detection-and-ranging (lidar) instrument to describe global distributions of an optical signal from DVM animals that arrive in the surface ocean at night. Our findings reveal that these animals generally constitute a greater fraction of total plankton abundance in the clear subtropical gyres, consistent with the idea that the avoidance of visual predators is an important life strategy in these regions. Total DVM biomass, on the other hand, is higher in more productive regions in which the availability of food is increased. Furthermore, the 10-year satellite record reveals significant temporal trends in DVM biomass and correlated variations in DVM biomass and surface productivity. These results provide a detailed view of DVM activities globally and a path for refining the quantification of their biogeochemical importance.

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