LIMNOLOGY and OCEANOGRAPHY

ASLO

Limnol. Oceanogr. 9999, 2021, 1–16

doi: 10.1002/lno.11985

Scallop shells as geochemical archives of phytoplankton-related ecological processes in a temperate coastal ecosystem

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Abstract

Phytoplankton dynamics in coastal ecosystems is increasingly altered by land-based human activities. Yet, this global vision conceals major disparities, among sites and through time. As conventional monitoring time series are quite sparse and relatively short, biological records of environmental variability appear as relevant tools to gain insights into phytoplankton dynamics over larger temporal and spatial scales. Here, we present results of an interdisciplinary project dealing with chemical information archived in shells of *Pecten maximus* (Bivalvia; Pectinidae), known to form daily growth striae on its shell surface. Several individuals were collected in the Bay of Brest (France) in 2011 and 2012, and analyzed for the molybdenum and lithium concentrations in their soft tissues and the element-to-calcium ratios (Mo : Ca and Li : Ca) in their calcitic striae. All shells revealed high synchrony and reproducibility in their Mo : Ca and Li : Ca profiles, characterized with a major peak at the end of May and in mid-June 2011, respectively. Detailed analysis of physical, chemical, and biological variables measured in seawater during an extensive 9-month environmental survey enabled a meticulous description of phytoplankton dynamics in 2011 and its impact on shell geochemistry. Main findings strongly suggest that (1) the timing of Mo : Ca peaks reflects the occurrence of silicon limitation and diatom aggregation periods, (2) the height of these peaks relates to the amplitude of the first spring diatom bloom, and (3) Li : Ca serves as a proxy for the temporal dynamics of diatom biovolume and of biogenic silica recycling at the sediment–water interface.

Phytoplankton is the cornerstone of the oceans, forming the pedestal of almost all marine food webs. Although making up only 0.2% of the total photosynthetic biomass on Earth, these tiny organisms are responsible for approx. 46% of the annual global net primary production (Field et al. 1998). Among phytoplankton, diatoms are by far the main contributors to global net primary production (approx. 50%), together with coccolithophores and chlorophytes (approx. 20% each), and finally cyanobacteria (approx. 10%; Rousseaux and Gregg 2014). Up to 25% of this production occurs on continental margins (Boyce et al. 2010) that yet occupy a mere 7% of the ocean surface. These shallow-water ecosystems are strongly affected by land-based human activities. For instance, enhanced nitrogen and phosphorus loadings can change the natural ratios between nutrients, leading to quantitative and qualitative alterations in phytoplankton communities. A decrease in the Si/N ratio (due to enhanced nitrogen supply) can result in shifts in phytoplankton communities initially dominated by silicified species (diatoms) toward nonsilicified species (e.g., dinoflagellates) that are sometimes toxic (Cloern 2001).

Given its crucial role in the functioning of oceanic and coastal ecosystems, and more broadly in the global biogeochemical carbon cycle and regulation of the climate of the Earth, it is paramount to characterize the spatial and temporal variabilities of phytoplankton dynamics. This is commonly achieved using remote sensing since the first satellite sensors

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