Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36586

Exploring Mixotrophic Metabolism in Marine Protists Using Compound-Specific Isotope Analyses

MARC-ANDRE CORMIER[1], JEAN BAPTISTE BERARD[2], MOHAMMAD ALI SALIK[1] AND GAEL BOUGARAN[2]

[1]University of Glasgow
[2]IFREMER

Mixotrophy plays a central yet historically underappreciated role in marine food webs and biogeochemical cycles. It remains difficult to quantify because robust tools for resolving the relative contributions of autotrophic and heterotrophic metabolism in plankton are lacking. By blurring conventional trophic categories, mixotrophic organisms challenge functional classifications and may confer adaptive advantages under variable environmental conditions. Current approaches—typically based on bulk physiological rates or grazing experiments—provide only partial constraints on trophic behaviour. This hinders the integration of mixotrophy into biogeochemical models, underscoring the need for tracers capable of resolving metabolism at the cellular level.

Stable isotope ratios of carbon ($\delta^{13}C$) and hydrogen ($\delta^{2}H$) in biomolecules offer a promising avenue in this context. Widely used in environmental and palaeoenvironmental studies, these isotopic systems are increasingly recognised to reflect intracellular metabolic processes in addition to external environmental conditions (e.g. Holloway-Phillips et al., 2026). While this dual control complicates environmental reconstructions, it also enables their use as tracers of trophic metabolism. In particular, the combined application of $\delta^{13}C$ and $\delta^{2}H$ may help partition carbon sources and identify metabolic pathways associated with mixotrophic functioning.

Previous work has shown that lipid $\delta^{2}H$ values in bacteria (Zhang et al., 2009) and plants and algae (e.g. Cormier et al., 2022) vary systematically with trophic mode. Here we present experimental results from protists testing whether compound-specific $\delta^{13}C$ and $\delta^{2}H$ signatures (including fatty acids, phytols, and sterols) capture shifts in central metabolic pathways. Two complementary systems are examined: continuous cultures of *Chlorella* under osmoheterotrophic conditions, and batch cultures of mixoplankton feeding on prey.

These isotope measurements were obtained using gas chromatography–isotope ratio mass spectrometry, alongside RNA-seq, pigment analyses, and physiological observations. Our results show that both $\delta^{13}C$ and $\delta^{2}H$ values respond sensitively to the extent of heterotrophic metabolism across diverse protist lineages. If these relationships can be robustly constrained and calibrated, compound-specific carbon and hydrogen isotope analysis could provide a powerful framework for tracing carbon acquisition strategies and quantifying mixotrophy across aquatic systems.

References:

Zhang, X. et al. (2009). *PNAS.* doi:10.1073/pnas.0903030106

Cormier, M.-A. et al. (2022). *New Phytologist*. doi:10.1111/nph.18023

Holloway-Phillips, M. et al. (2026). *New Phytologist*. doi:10.1111/nph.70845