Infochemical mediation of the degradation of sinking particulate organic matter.

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- Bethanie Edwards.
- Van Mooy Lab: Jamie Collins, Helen Fredricks, Justin Ossolinski.

• Colleagues: Kay Bidle (Rutgers), Matt Johnson (WHOI), Tracy Mincer (WHOI), Assaf Vardi (WIS).

• Funding: Gordon and Betty Moore Foundation (current project support), NSF (cruises and Graduate Research Fellowship), and ONR (early method development.

Outline

Context for the study of infochemicals in sinking particles.

Background on diatom-derived polyunsaturated aldehydes (PUAs).

• PUA mediation of the bacterial degradation of sinking particulate organic matter.

• Speculation on evolutionary underpinnings and biogeochemical significance of PUA signaling in sinking particles.

Molecular characterization of POC: biomarkers vs. major biochemicals

• Characterizing the chemical composition of organic matter in sinking particles has played a significant role in the study of particulate organic carbon (POC) export since before VERTEX.

•Biomarkers Approach:

- Molecules derived from a specific planktonic source.
- Not a large fraction of POC.
- Proxies for the <u>sources</u> of exported POC.
- Major Biochemicals Approach:
 - Common molecules that tend to be ubiquitously distributed.
 - In sum, a large fraction of POC.
 - Proxies for the <u>lability</u> and <u>fate</u> of exported POC.

• "Passive" viewpoints of organic molecules: information for oceanographers or source of food for microbes.

Molecular characterization of POC: infochemicals.

- Infochemicals are "active" organic molecules:
 - Sources of information for microbes (and oceanographers).
 - Molecules whose primary role is signaling, not nutrition.
- Infochemical approach.
 - Molecules derived from poorly-understood microbial sources.
 - Tiny fraction of POC.
 - Mediate organismal interactions that shape complex systems.
- Infochemical analysis is complementary to:
 - Process studies on microbial/zooplankton dynamics.
 - Emergent 'omics'-based studies of sinking particles.

• Many infochemical classes fall within the analytical window of lipidomics methods we are developing and applying.

Infochemicals: two examples.

• Testosterone.



• (E,Z)-2,6-nonadienal.

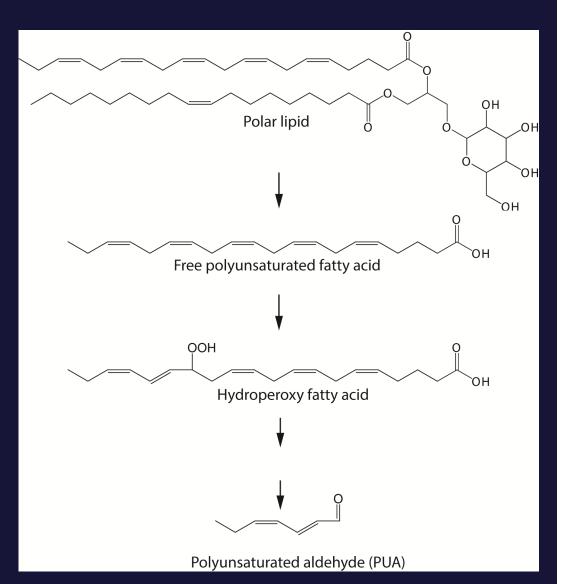


PUA biosynthesis in diatoms.

• PUAs have been Identified in lots (but not all) of diatom species (Wichard, 2005, J. Chem. Ecol.).

 PUAs produced on effectively instantaneous timescales in response to wounding by copepod grazers (e.g. Miralto et al., 1999, Nature).

• Also produced by when diatoms experience nutrient-stress.

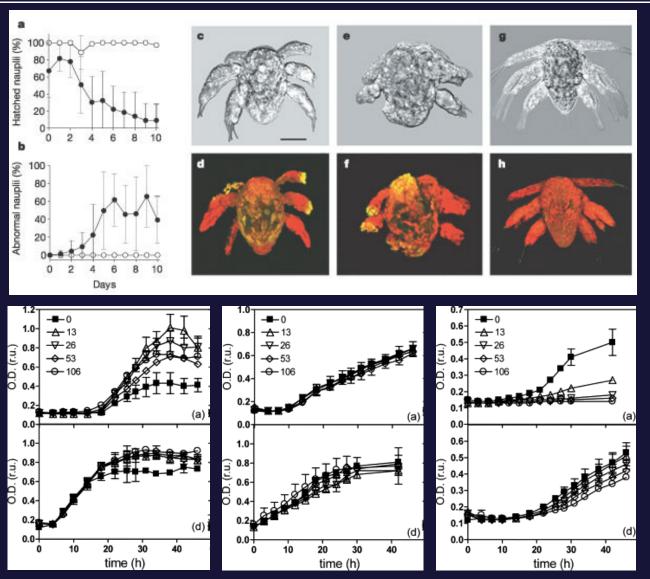


Effects of diatom-derived PUAs on other plankton.

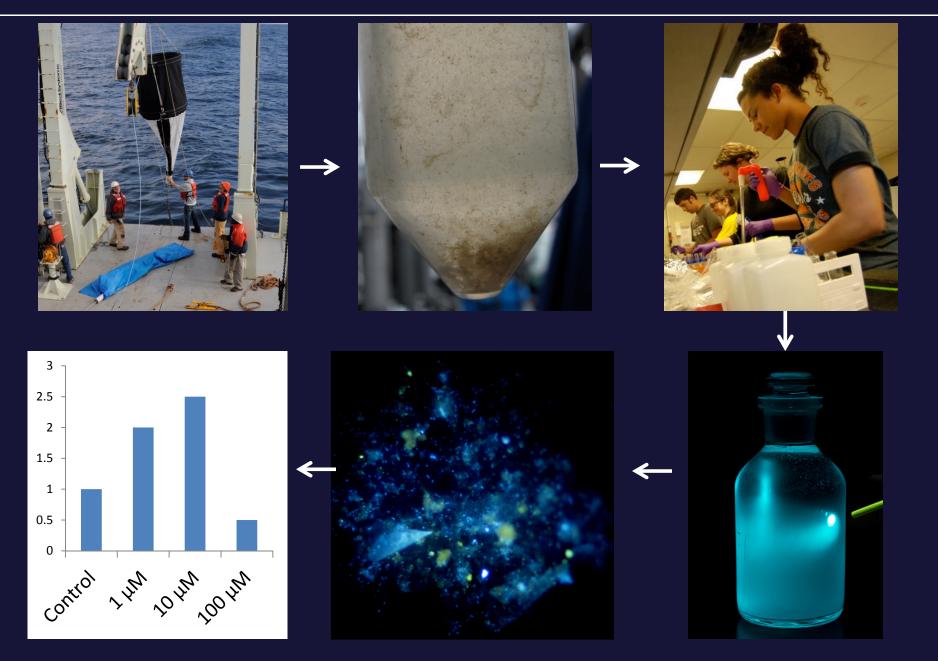
• PUAs are teratogens in cultured copepods (e.g. lanora et al., 2004, *Nature*).

• PUAs can affect growth rates of cultured marine bacteria, but they are not food (Ribalet et al., 2008, Aquat. Toxicology).

• Also can effect other phytoplankton (e.g. Ribalet et al., 2007, Aquat. Toxicology).



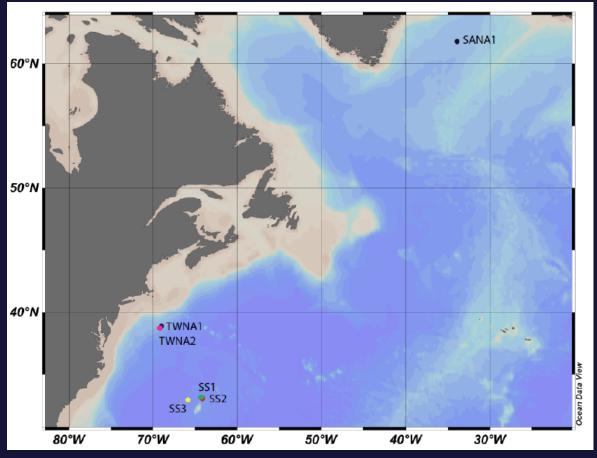
Experiments: effects of PUAs on bacteria in sinking particles.



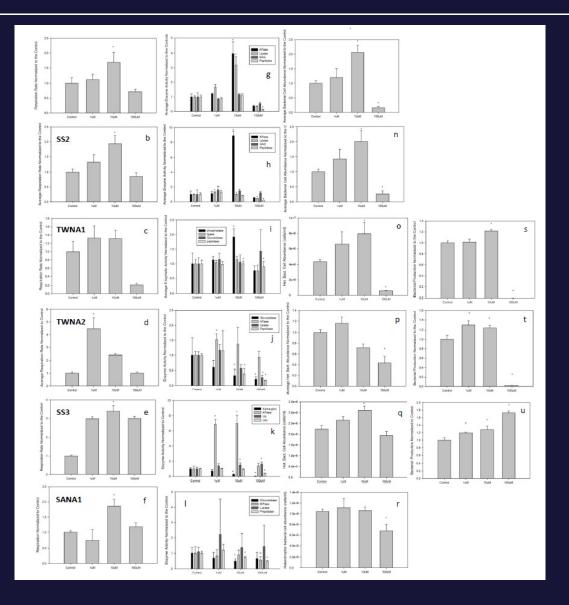
• PUA amendment experiments conducted at six stations across the North Atlantic.

• Measurements:

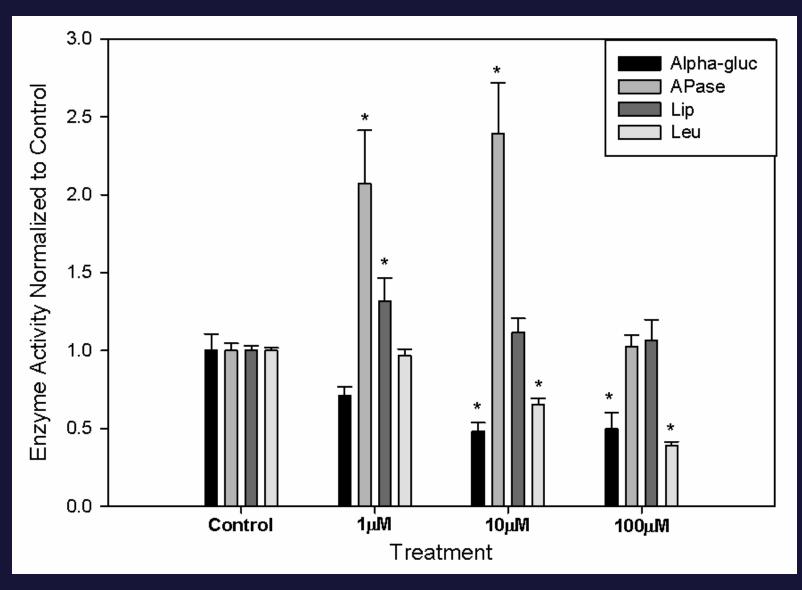
- Hydrolytic enzyme activity
- Respiration
- Bacterial production
- Bacterial cell numbers
- Bacterial community composition (ARISA)
- PUA concentrations



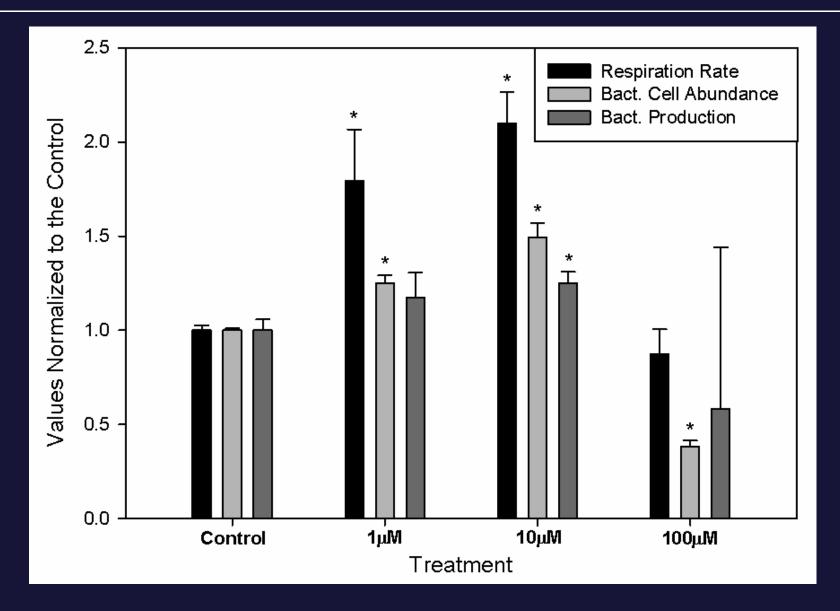
Edwards, et al.



Edwards, et al.

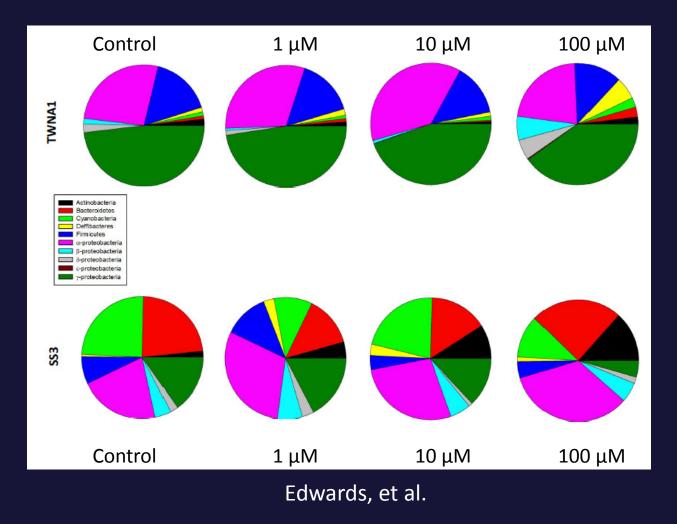


Edwards, et al.

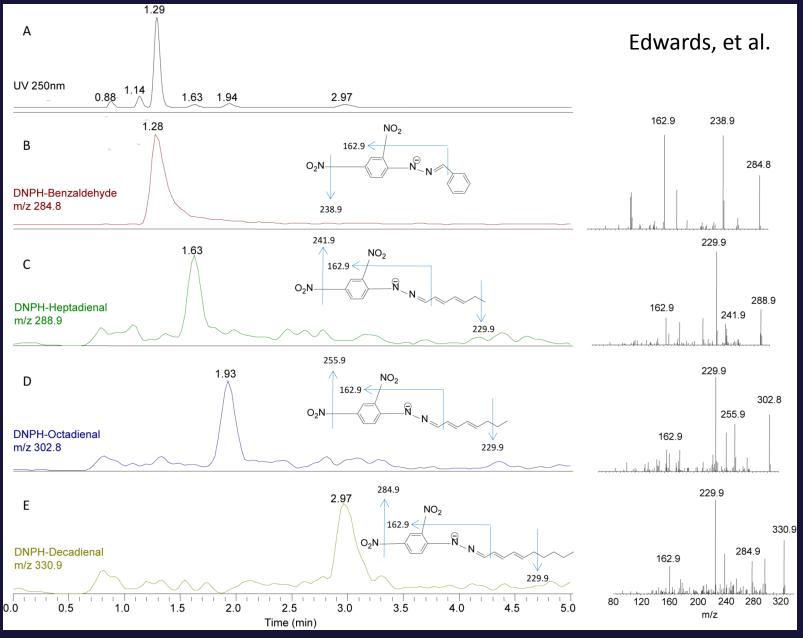


Edwards, et al.

 Automated ribosomal intergenic spacer analysis (ARISA) shows that PUA amendments led to shifts in the distribution of major bacterial phyla.



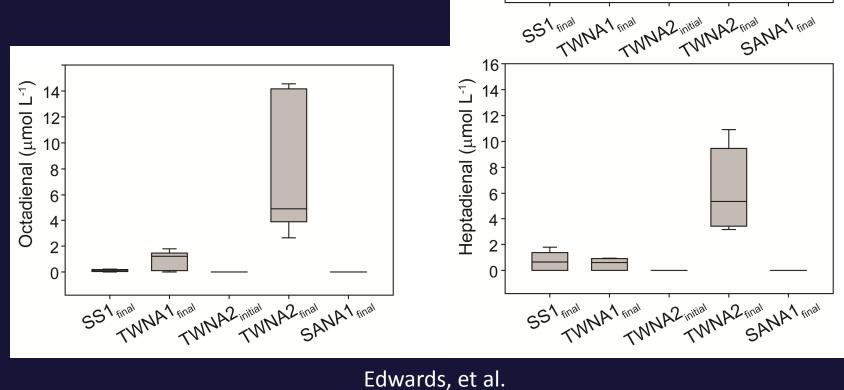
Analysis of PUAs in sinking particles.



Analysis of PUAs in sinking particles.

 Concentrations calculated using parallel [POC] data and POC/volume factor for diatom-derived marine snow (Brezinski et al., 1997, Limnol. Oceanogr.).

 PUAs are likely to be present in the lowmicromolar concentration range \rightarrow enhanced microbial activity and metabolism.



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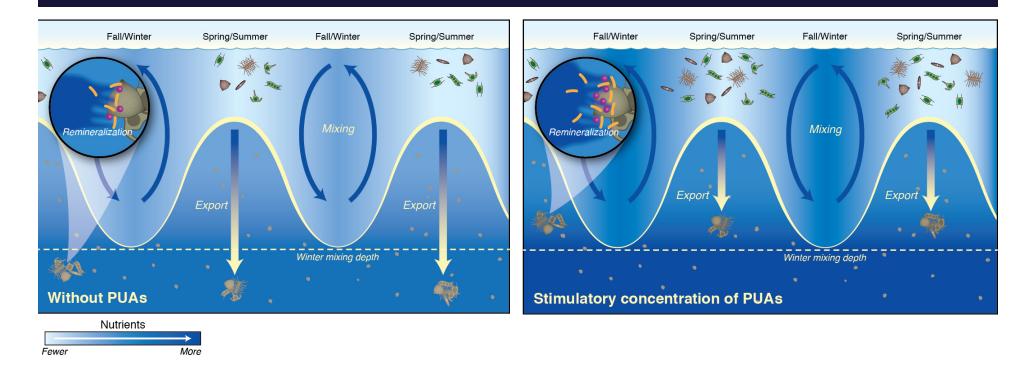
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Conclusions and open questions.

1) Amendments of PUAs in the low-micromolar range led to stimulation of microbial processes that could lead to enhanced dissolution, disaggregation, and remineralization of sinking particles.

Model: evolutionary underpinnings & biogeochemical impact.



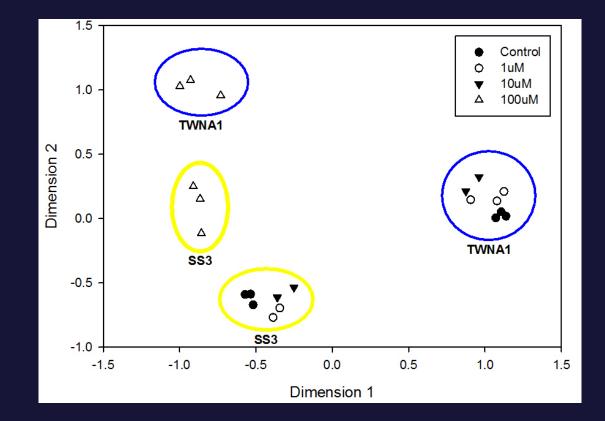
- There are many, many open questions:
 - What's in it for bacteria? What is the ultimate fate of PUAs?
 - How/why do PUAs continue to be produced on sinking particles?
 - How can we quantitatively tie PUA effects to POC flux attenuation in the ocean?
 - What about other infochemicals (e.g. other oxylipins)?
 - What about other export of other elements? See Bethanie's poster.

Thank you for your attention!

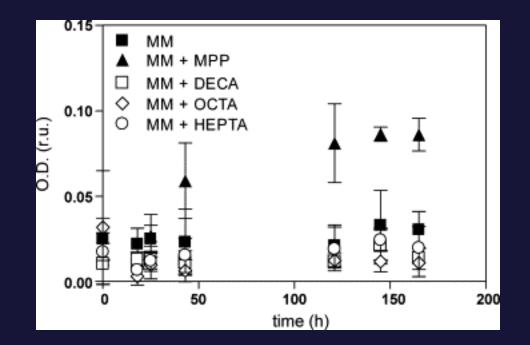








PUA don't seem to be food.



Ribalet et al., 2008. Aquat. Toxicol.