Primary Productivity in Future Oceans: An analysis of how increased turbulence could affect marine microbes

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Why study the effects of turbulence on marine microbes?

1. Models have predicted that with global climate change there will be increases in atmospheric winds leading to a potential increase in fine-scale turbulence in the photic zone:

2. Potentially affecting many biological processes that occur in the photic zone:

3. RESEARCH QUESTION: Will increased fine-scale turbulence affect phytoplankton growth and marine snow production?

4. POSSIBLE IMPLICATION: Because larger cells will likely be affected by the turbulent eddies and small cells will remain unperturbed, an increase in fine-scale turbulence could lead to changes in the global size distribution of marine microbes.

Methods: Culturing under turbulent conditions

Phytoplankton were cultured with their associated bacteria in turbulent conditions using oscillating grids under constant light, temperature, and nutrient replete conditions (AQUIL medium1). Nitrate was limited to ensure the cells went into stationary growth.

Results

Growth Rates

Phytoplankton cells (*10^5 L^-1)

Bacterial cells (*10^5 L^-1)

Bacterial enzyme activity (amol cell^-1 h^-1)

The phytoplankton and bacterial cell counts and the bacterial enzyme activity increased throughout the culture experiments but the effects due to increased turbulence were not measurable.

Cell Counts and Bacterial Enzyme Activities

Turbulence:

- strong
- weak
- intermediate

Growth phase:

- Beginning
- Exponential
- Stationary

Future directions

Culture experiments under nutrient limitation: A nutrient depleted concentrated boundary layer (solid black line around the cells) develops around large \( r \) and small \( s \) cells in a nutrient limited system. In strong turbulence, the horizontal scales \( (\eta) \) are similar in size to \( r \) but much larger than \( r \). The linear shear (blue lines) associated with the \( \eta \) could deform the concentration boundary layer around \( r \) resulting in more effective diffusion of nutrients into the cell but the concentration boundary layer around \( r \) would be unaffected. In weak turbulent conditions, \( \eta \) is much larger than both \( r \) and \( r \) so the nutrient diffusion around both large and small cells is unaffected.1

Acknowledgements

We thank Leandra Vicci (UNC) who built the oscillating grid tanks. We also thank Zackary Johnson (DUML) for letting us use his flow cytometer and Carol Arnosti (UNC) for help with the enzyme activity measurements. This work is funded by NSF grant OCE-3350888.

Cited references

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