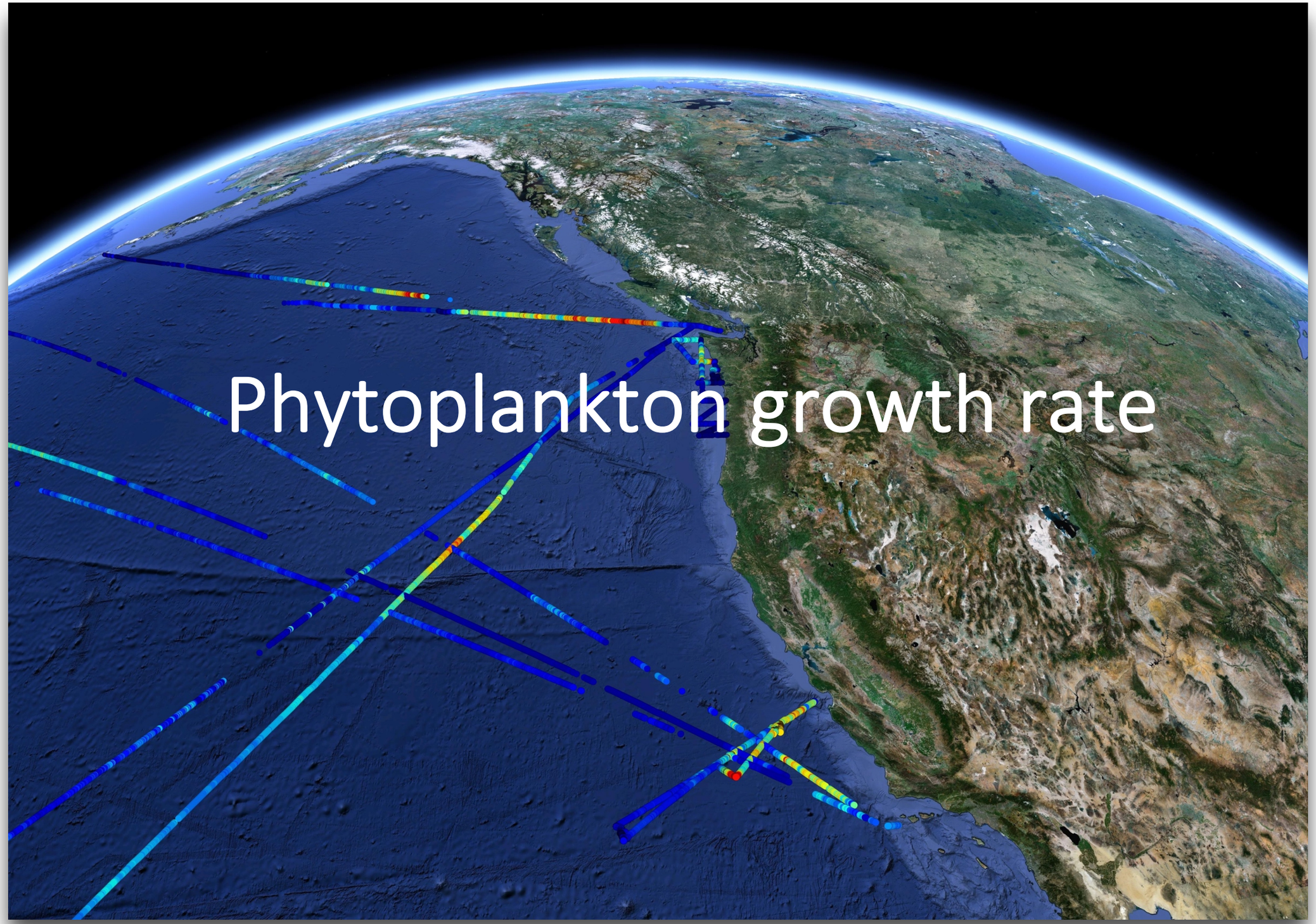
COLLEGE OF THE ENVIRONMENT
UNIVERSITY of WASHINGTON

SIMONS FOUNDATION

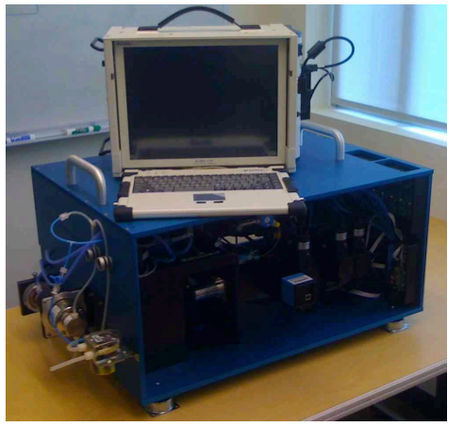


Phytoplankton growth rate

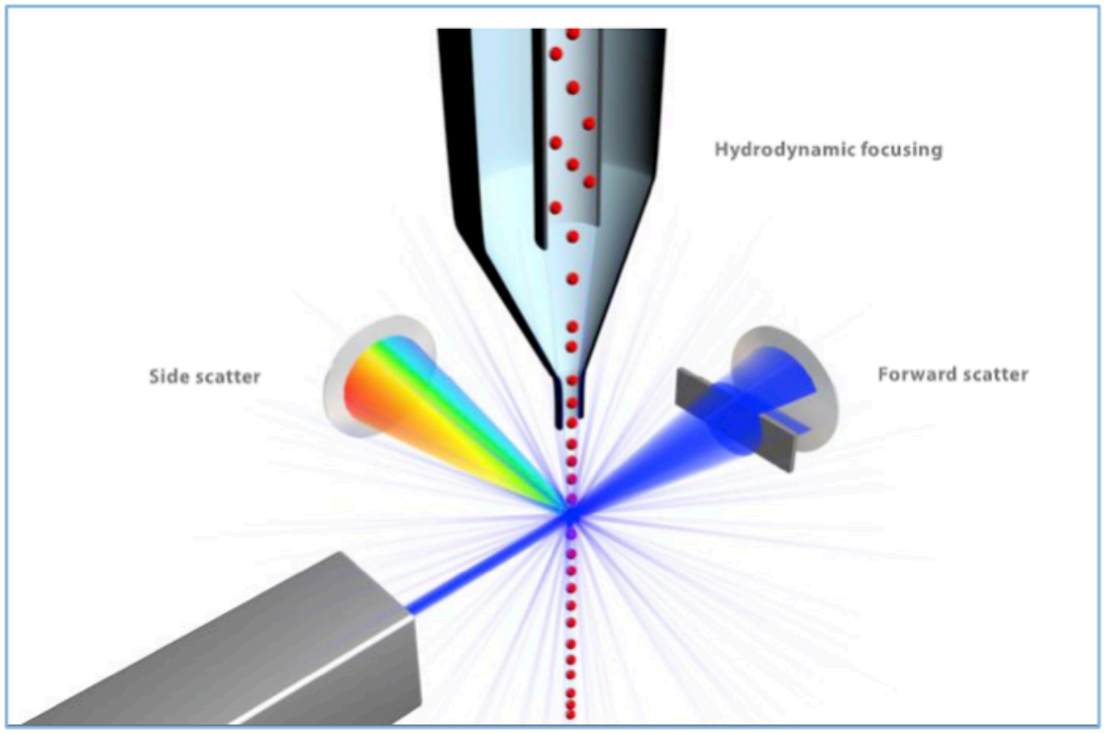
François Ribalet
ribalet@uw.edu

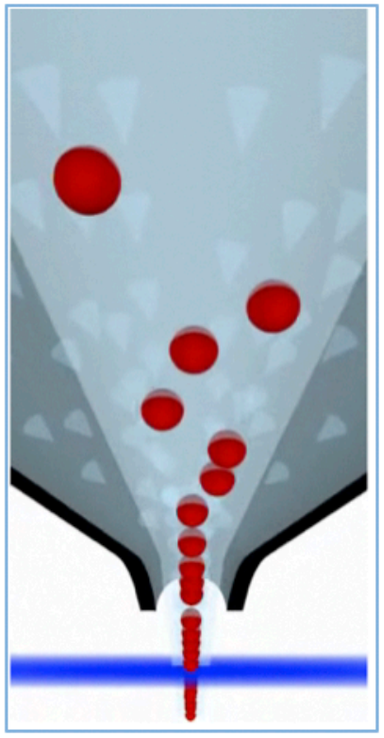
SeaFlow UW
A census for the very small.

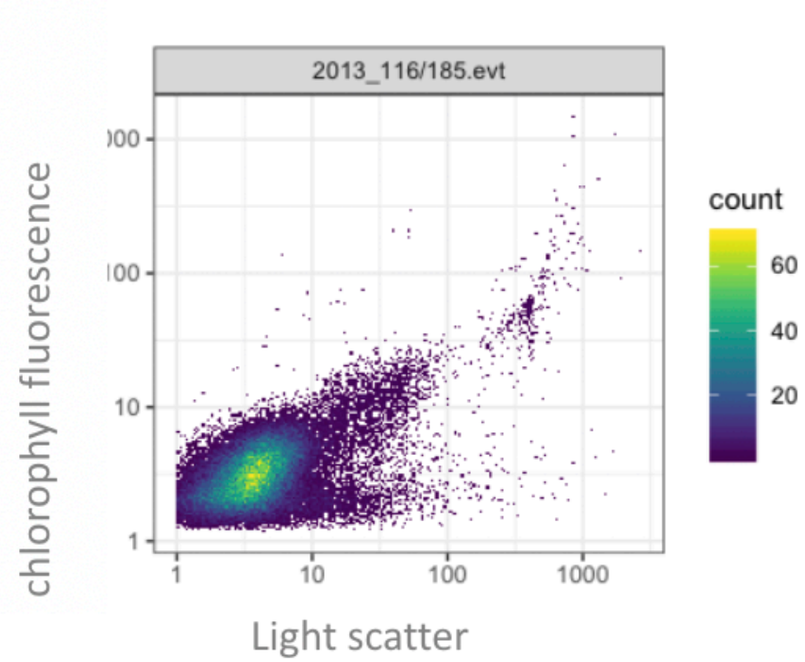
SeaFlow UW
A census for the very small.



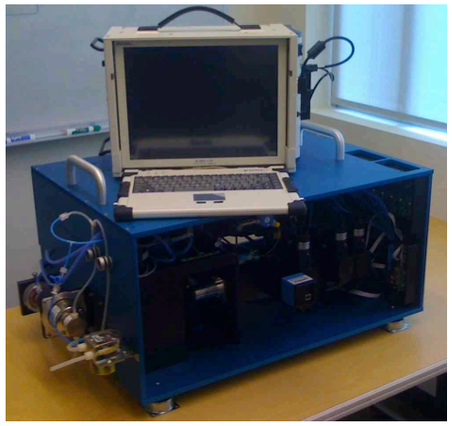
SeaFlow, a continuous flow cytometer





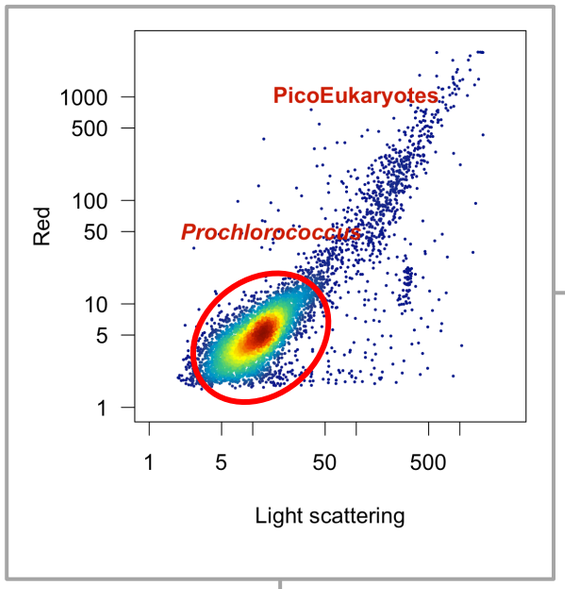


- High speed, single-cell analysis
- Multiparametric (light scattering, pigment fluorescence)

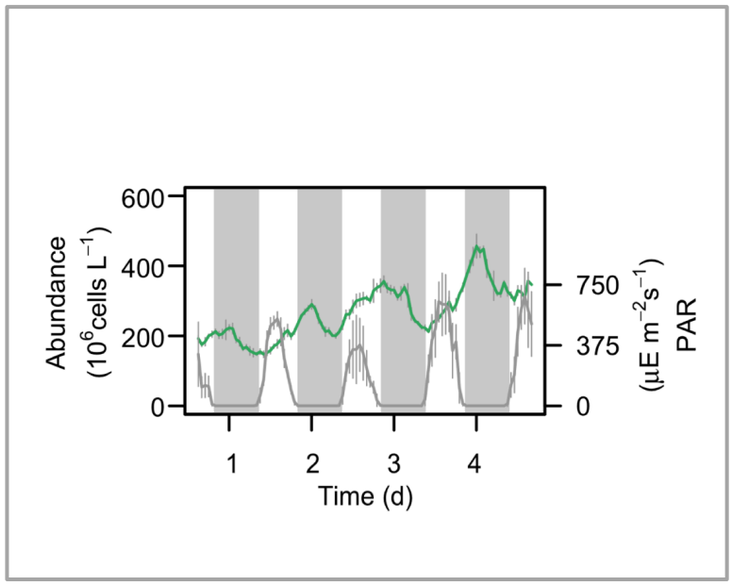


Cell abundance and size distribution measured by SeaFlow

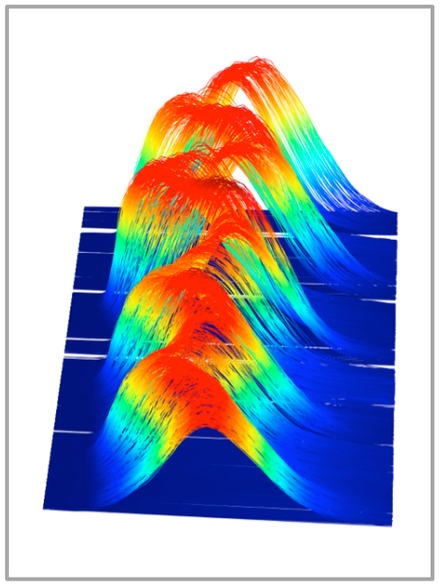
Community structure



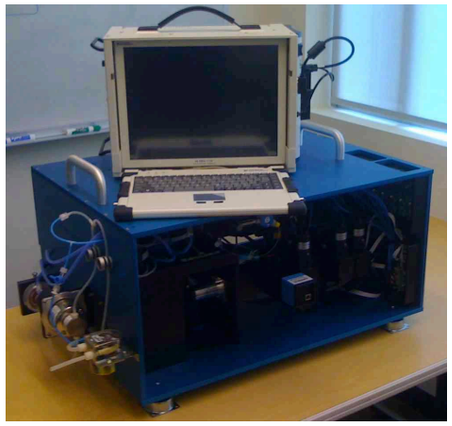
Cell abundance



Size distribution

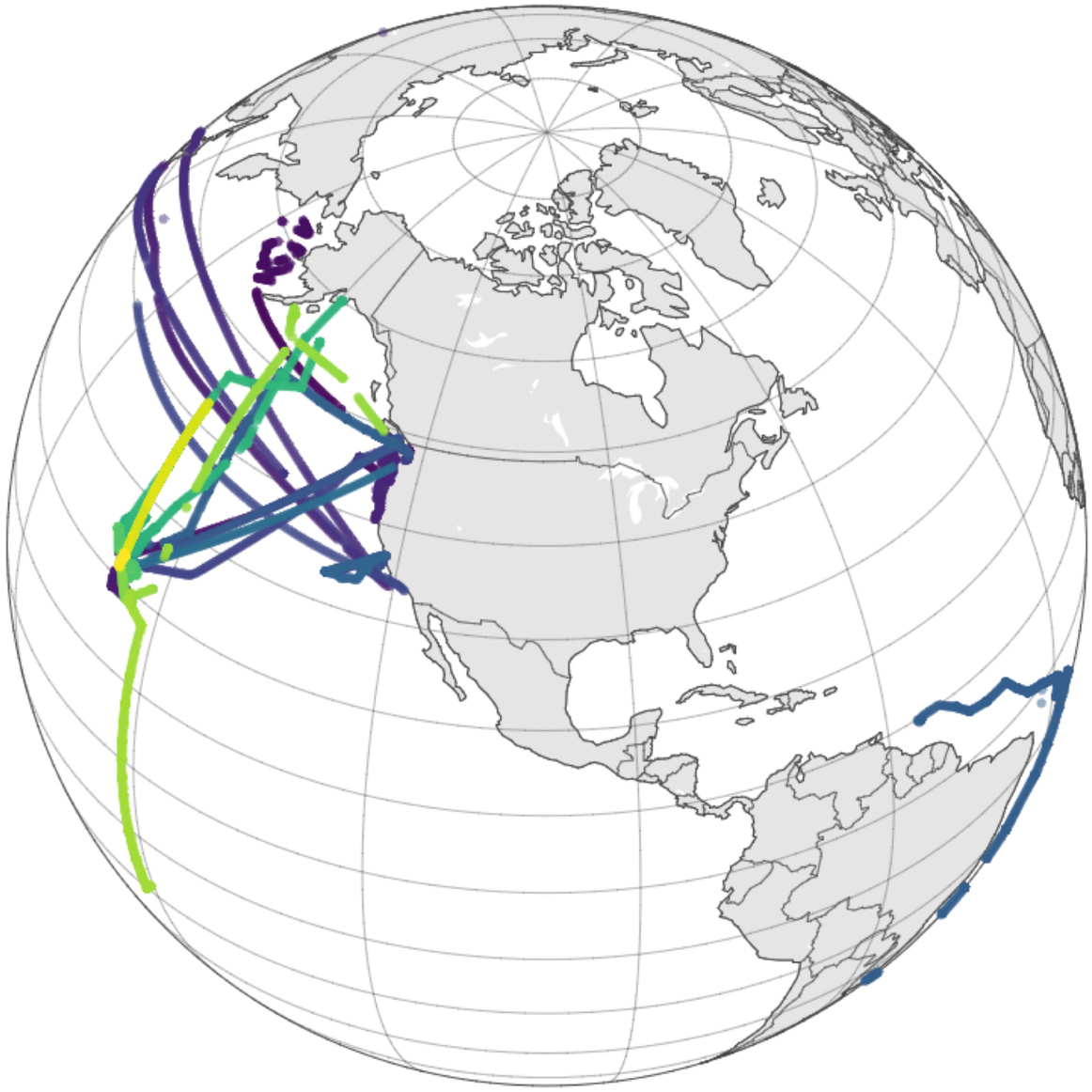


* Light scattering converted to cell volume



SeaFlow, a continuous flow cytometer

- 65 cruises
- 10,000 hours of continuous observations
- 60,000 km coverage in the North Pacific
- 400 x 10^9 particles



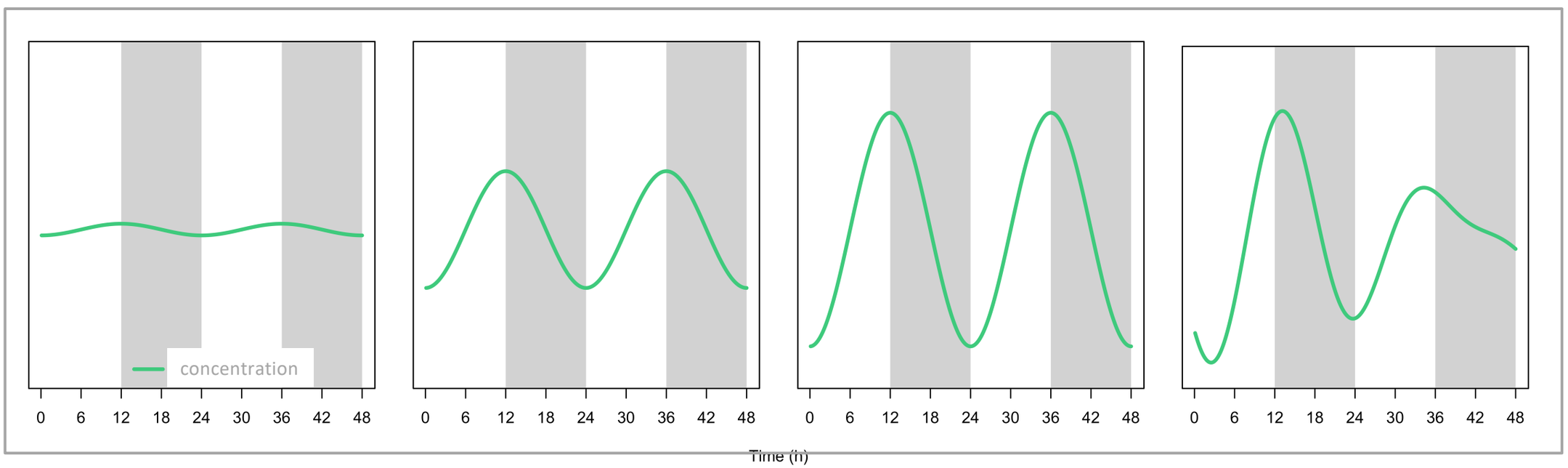
Data available at Zenodo

doi.org/10.5281/zenodo.3240587

Interpretation of cell abundance

$$\frac{dC}{dt} = (\mu - m + \text{transport}) \times C$$

Cell abundance measured at time *t*

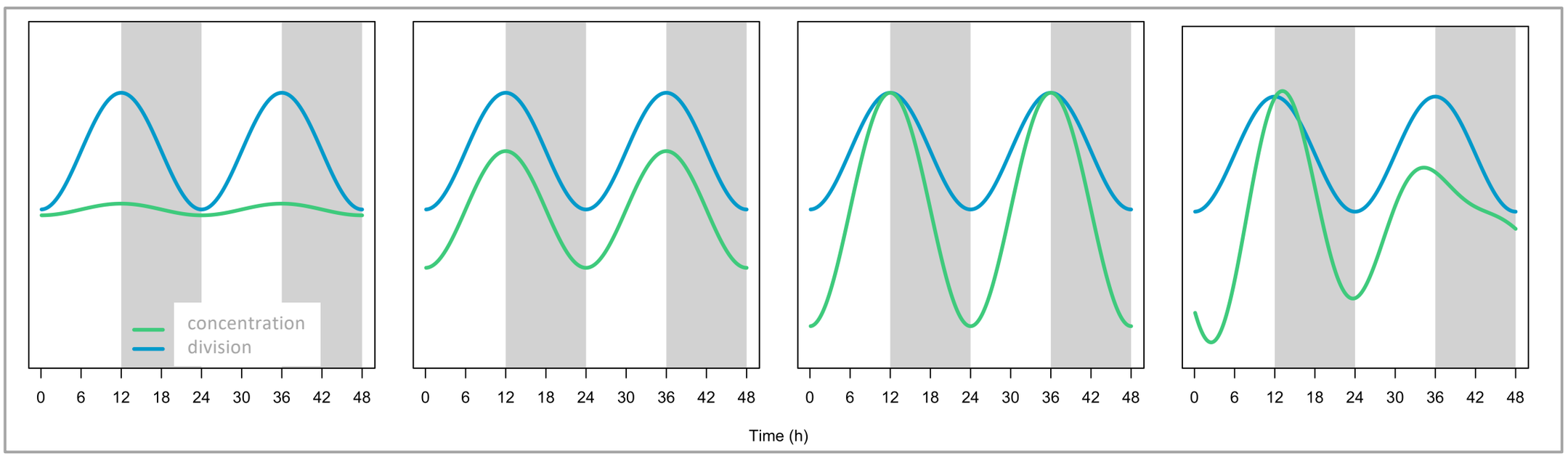


Amplitude and periodicity matter

Interpretation of cell abundance

$$\frac{dC}{dt} = (\boxed{\mu} - m + \text{transport}) \times C$$

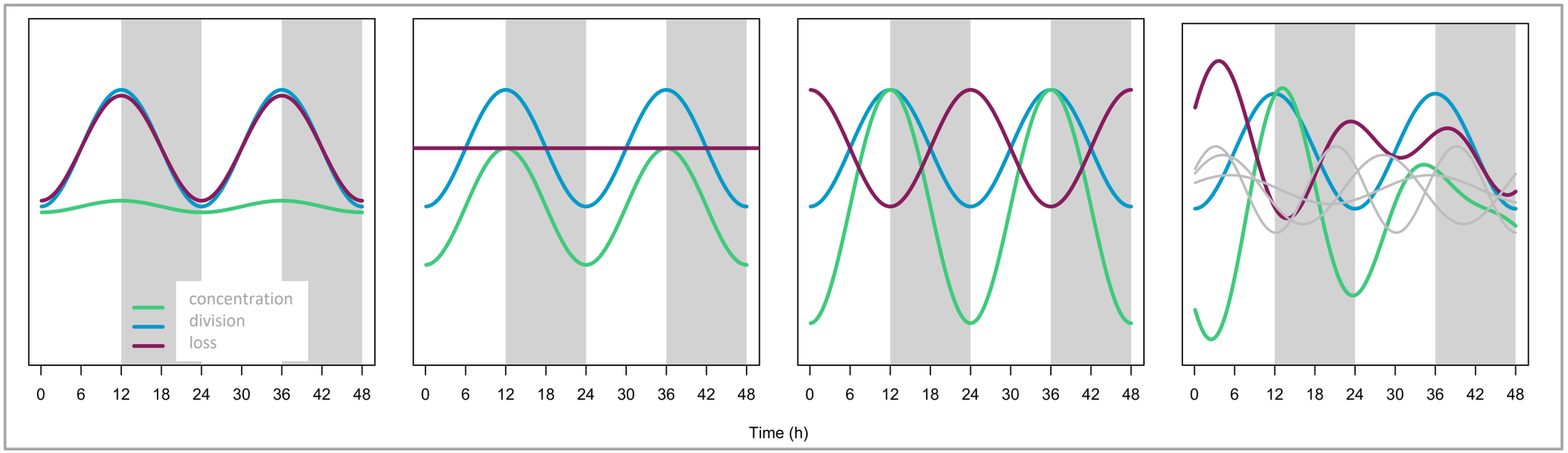
Cell division rate



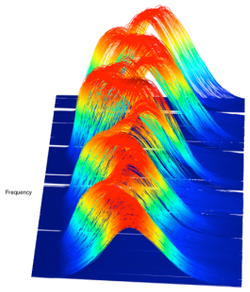
Interpretation of cell abundance

$$\frac{dC}{dt} = (\mu - \boxed{m + \text{transport}}) \times C$$

Net loss rate = biotic + abiotic factors



***Division rates** are key*
to our understanding of phytoplankton dynamics

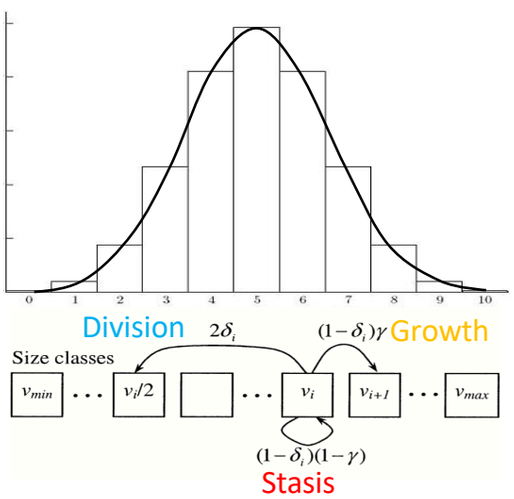


μ Size-structured matrix population model (Caswell 2000, Sosik et al. 2003)

I. INPUT

- Observed size distribution

Independent of cell abundance



- irradiance

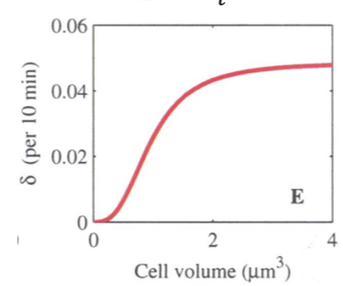
Assumptions

Respiration, grazing & viral lysis do not affect the shape of the size distribution

II. OPTIMIZATION

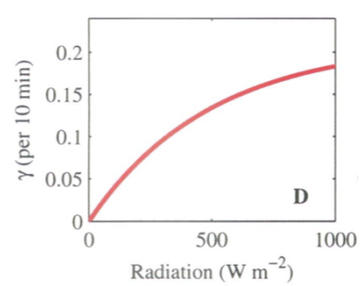
- Division depends on cell volume

$$\partial(t) = \frac{av_i}{1+av_i}\partial\max$$

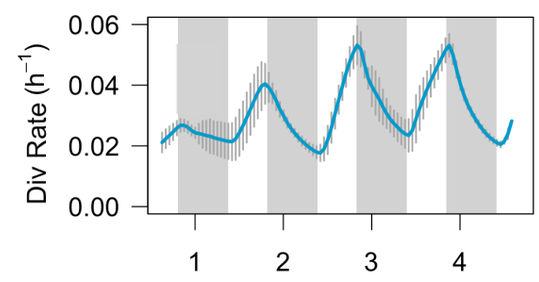


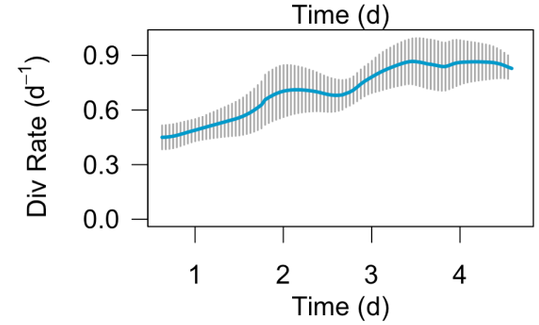
- Growth depends on irradiance

$$\gamma(t) = \left\{1 - exp\left[\frac{E(t)}{E^*}\right]\gamma\max\right\}$$



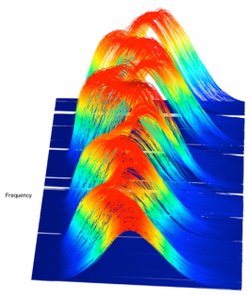
III. OUTPUT





IV. NET LOSS RATE

$$m + \text{transport} = \left(\mu - \frac{dC}{dt}\right)$$

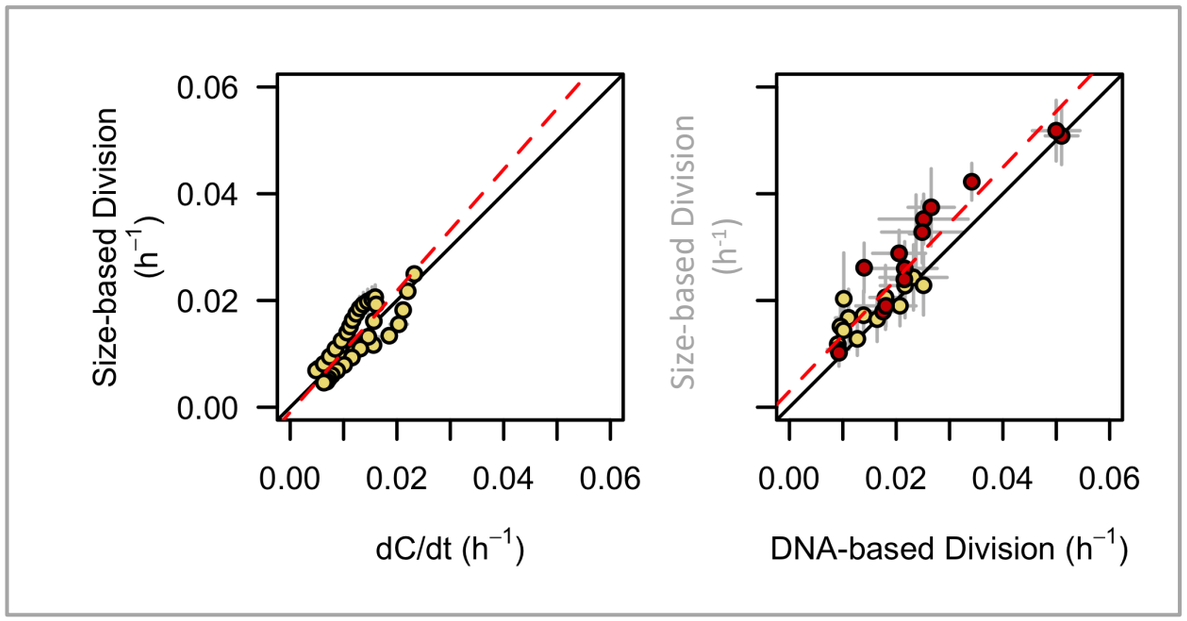


Model validation

$$\frac{dC}{dt} = (\mu - m + \text{transport}) \times C$$

Prochlorococcus

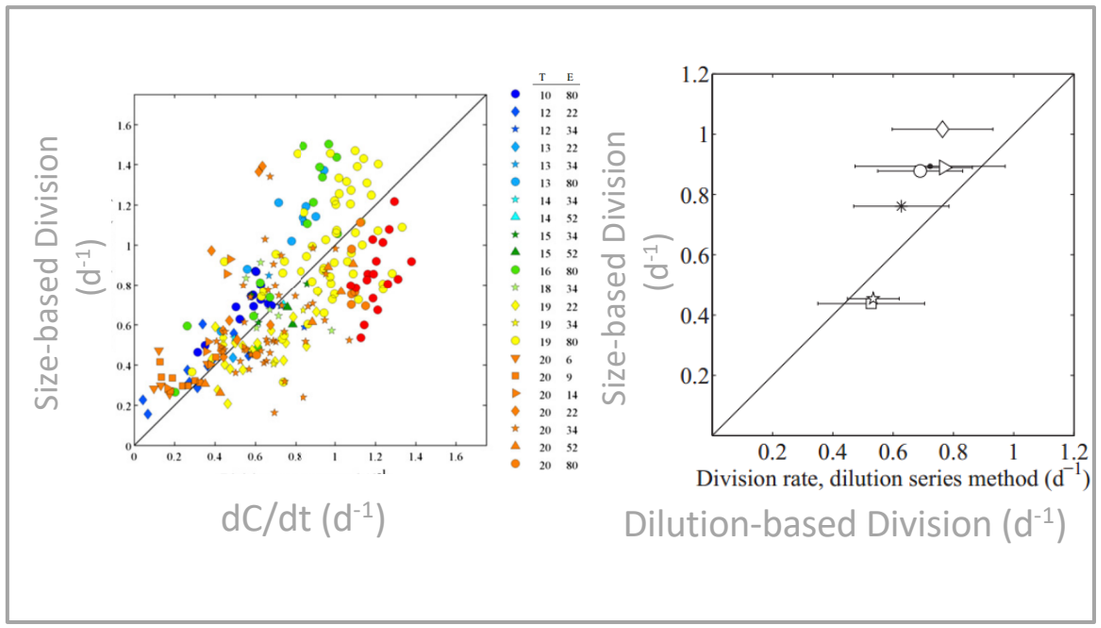
Batch culture experiment | In-situ experiments



(Ribalet et al. 2015)

Synechococcus

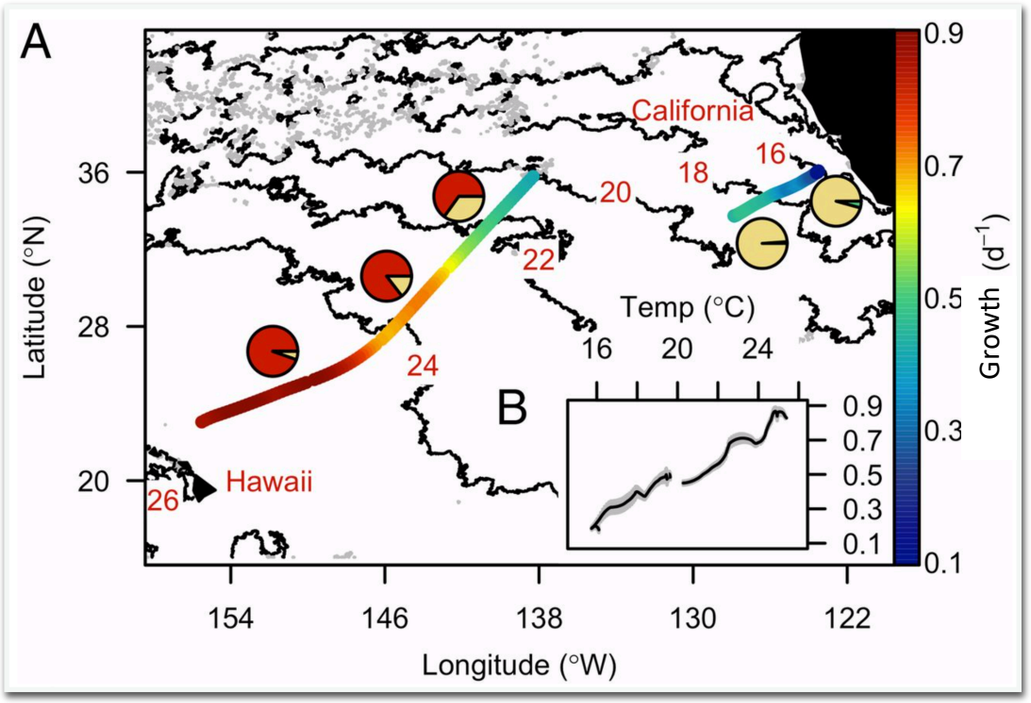
Batch culture experiment | In-situ experiments



(Hunter-Cevera et al. 2014)

Light-driven synchrony of *Prochlorococcus* **growth** and **mortality** in the subtropical Pacific gyre

I. Daily rates



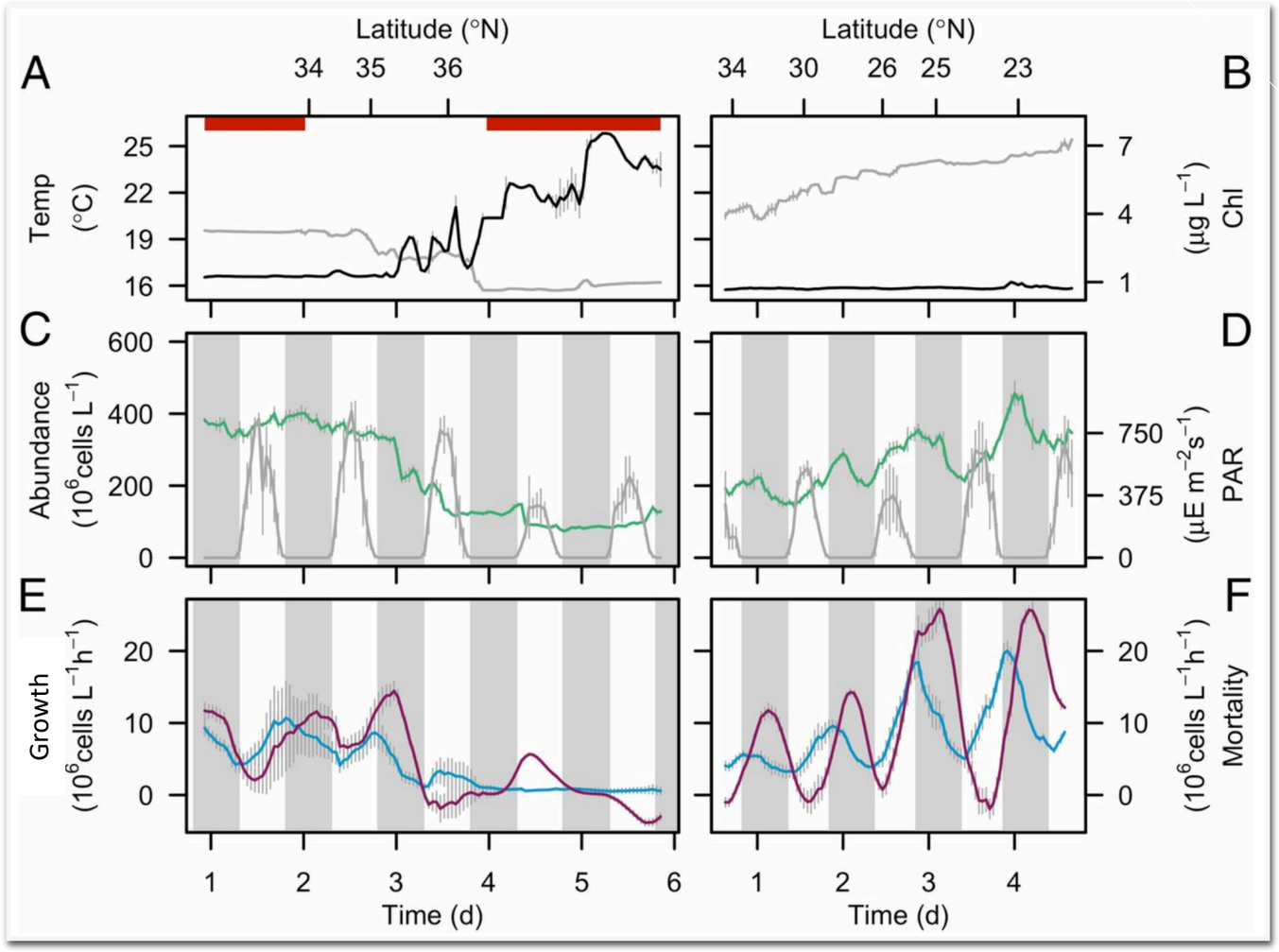
Ribalet *et al.* 2015

https://doi.org/10.1073/pnas.1424279112

II. Hourly rates

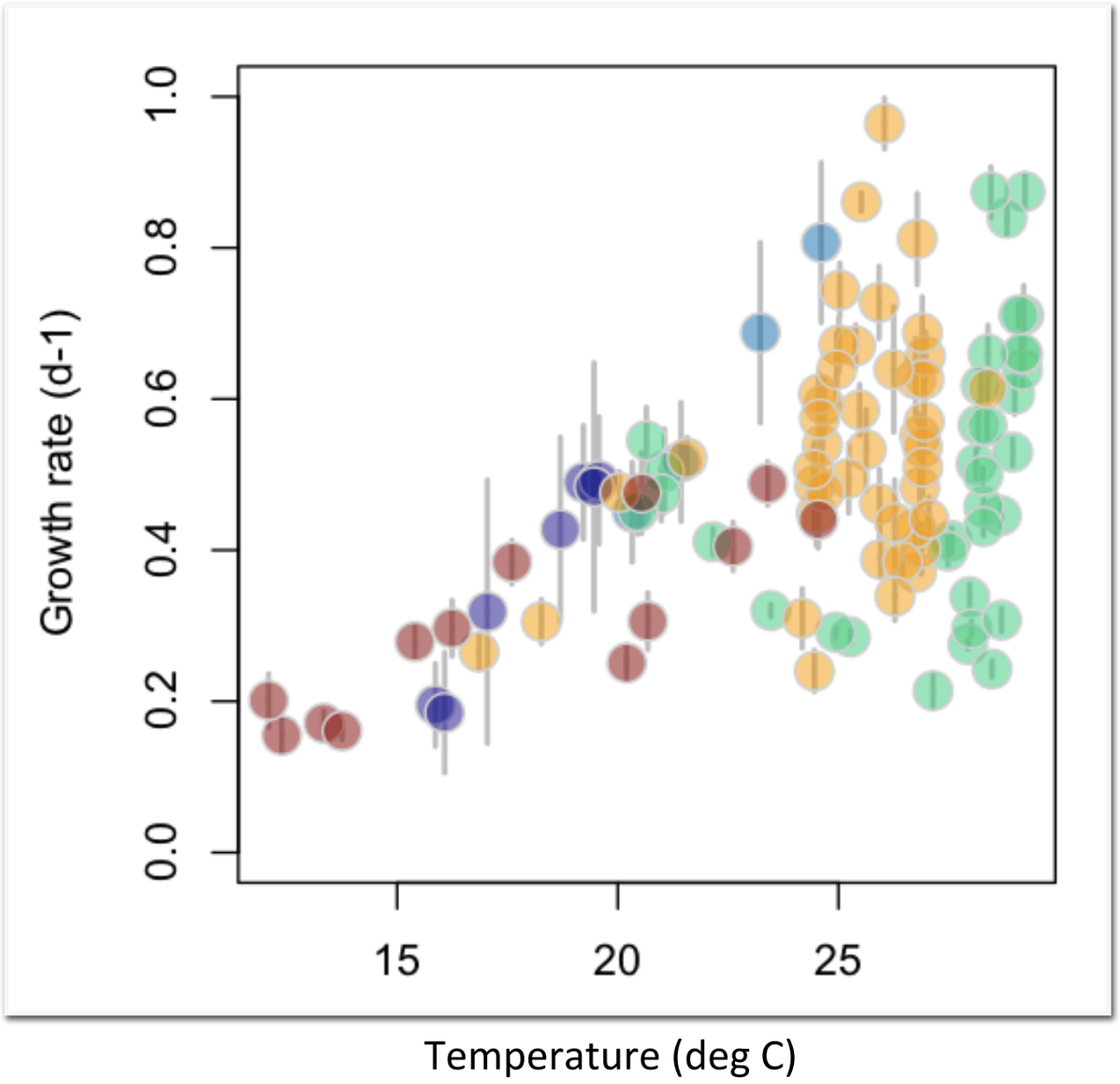
Growth

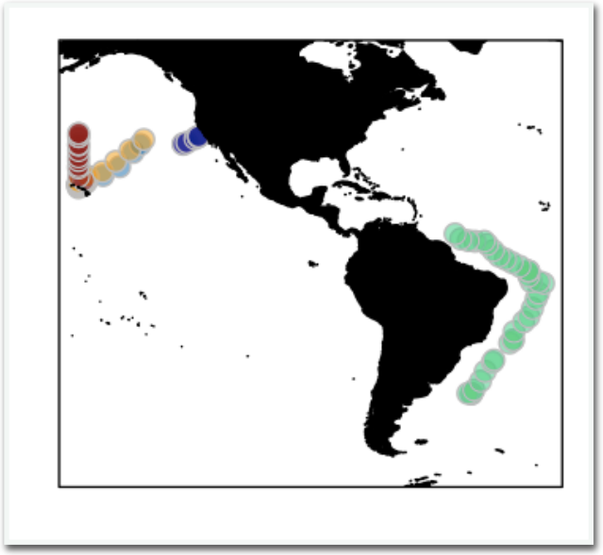
Mortality



I. Daily rates of *Prochlorococcus* **cell growth** in surface waters

- 105 daily rates of cell growth in surface waters, paired with SST, PAR and nutrient concentrations (35 cruises).





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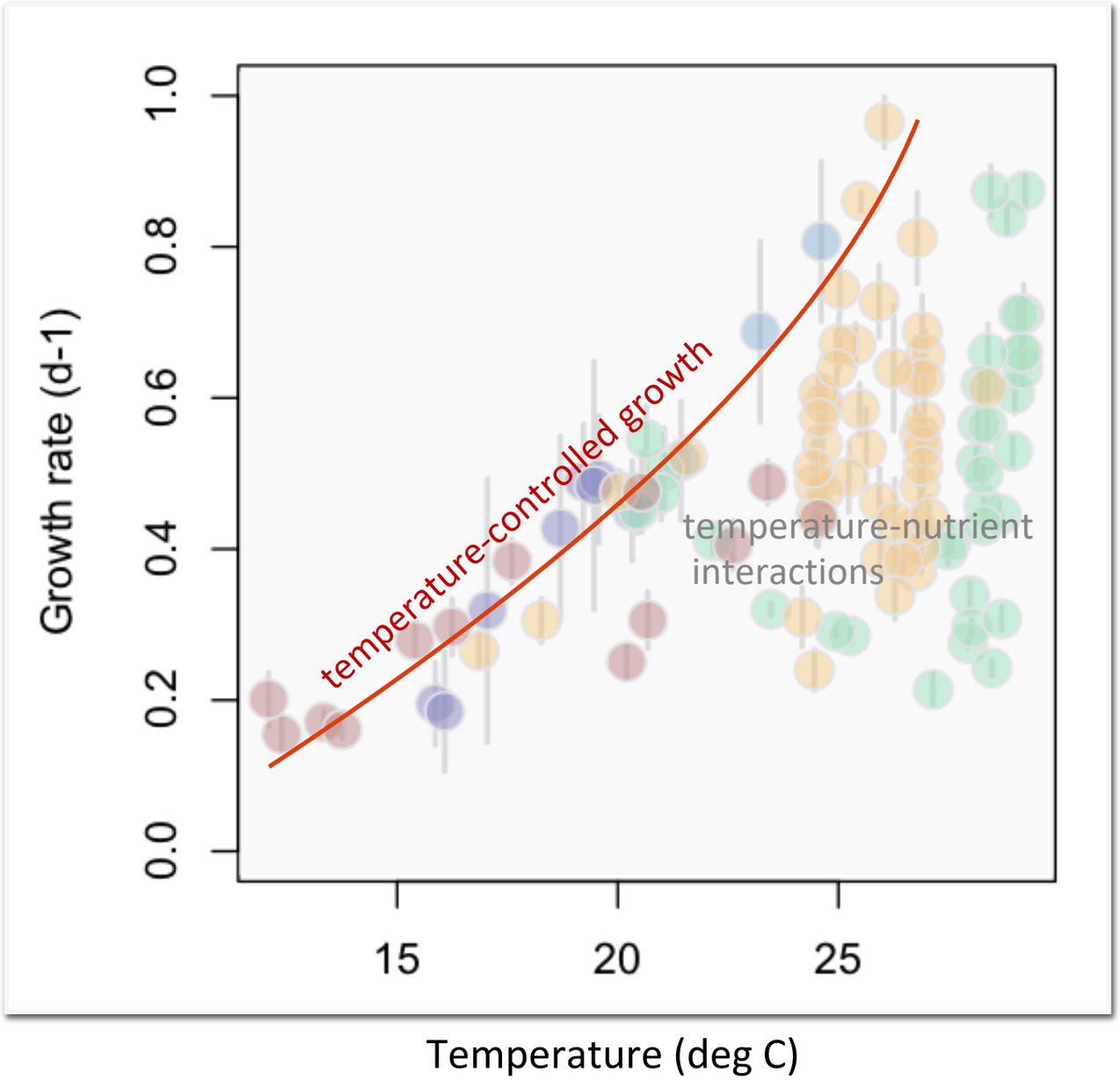
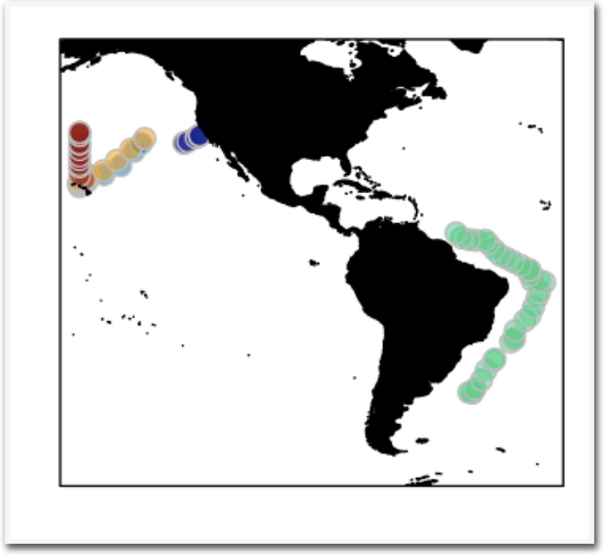


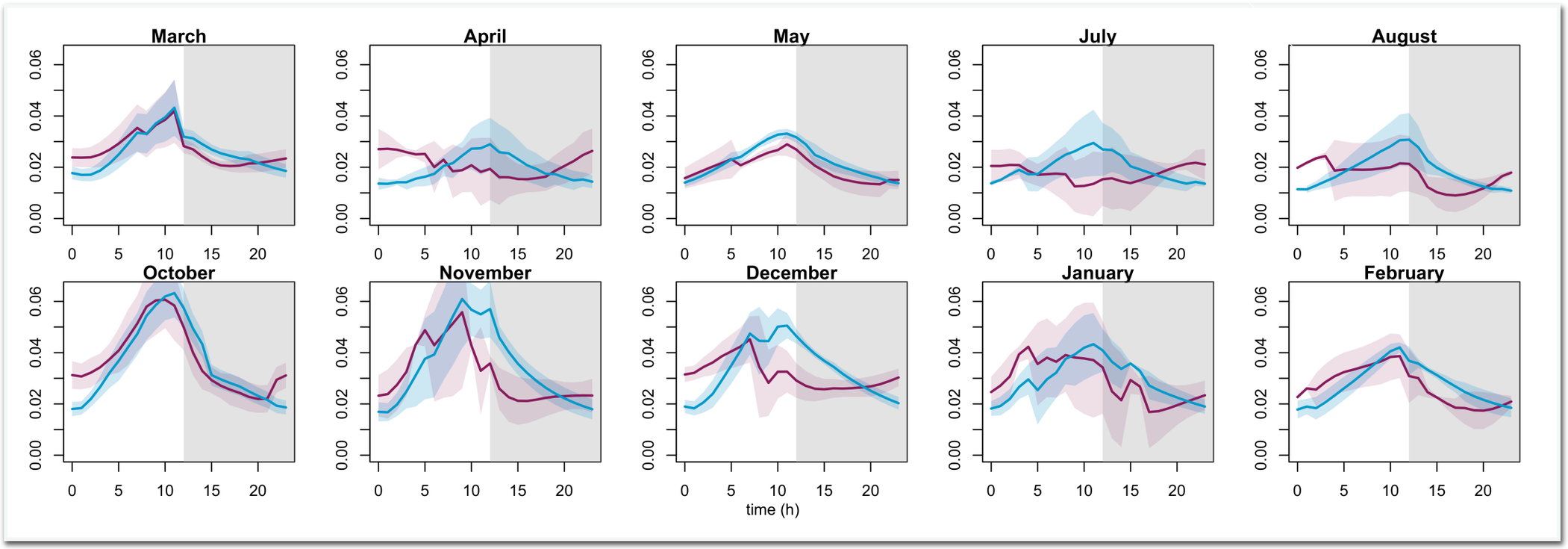


Thermal acclimation and nutrient availability control *Prochlorococcus* growth rates in surface waters

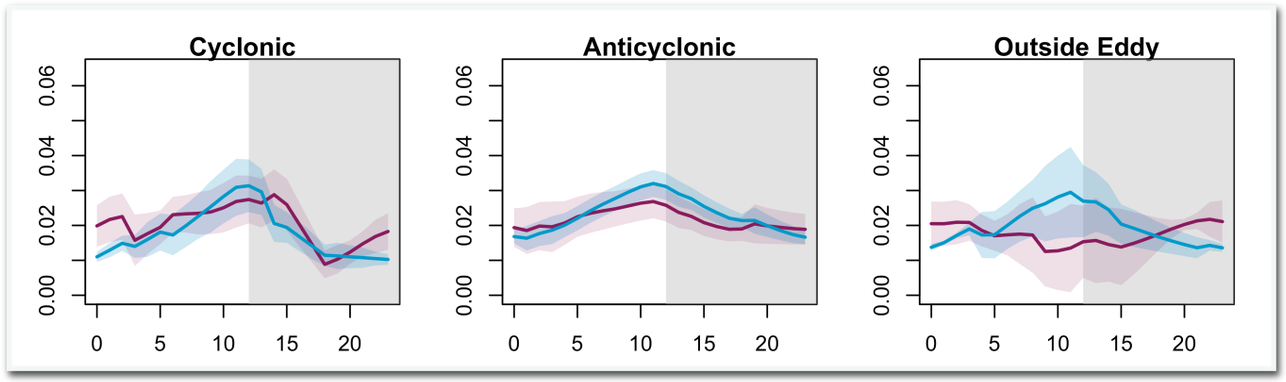
II. Diel coupling of *Prochlorococcus* **growth** and **mortality** in the subtropical gyre

Hourly Growth rates
Hourly Mortality rates

Seasonality



Mesoscale



Preliminary data suggest that the diel coupling of growth and mortality varies over the **season** and with the **flow regime**

Hackathon ideas

- Effect of **size / time resolution** on growth rate estimates
- Add **Respiration** to the model
- **Allelometric** carbon fixation rates
- Size distribution composed of **multiple species**