SeaFlow: high-resolution continuous flow cytometry

Measuring phytoplankton traits along ship tracks at an effective resolution of 1-2 km

SeaFlow in use during a cruise in the California Current region. Surface sea water is run through the instrument continuously from the ship’s flow-through system.

We have collected data on the phytoplankton community structure during 18 cruises, during all four seasons, spanning > 75,000 km, 90,000 samples and 2 billion cells.

Example of the output from SeaFlow. Each point on the scatter plot represents a single particle measured by the instrument.

SeaFlow saves data every 3 minutes, resulting in a spatial resolution of roughly 1-2 km for a research ship underway. We can track how the phytoplankton community shifts by examining how mean values of forward scatter, chlorophyll and phycoerythrin fluorescence vary along a cruise track.

Physical and ecological scales of variation

Can we diagnose the role of physics in setting community structure from the relative scales of variation of physical and biological properties?

We expect that the relationship between $\lambda_P$ and $\lambda_B$ will vary regionally as a function of the physical environment.

Where mixing and dispersal are the dominant control on ecological distributions, we would expect $\lambda_B \approx \lambda_P$.

Where fine scale physical processes drive high frequency variations in the light environment and nutrient supply (e.g. submesoscale), we would expect $\lambda_B < \lambda_P$.

Where biological processes dominate, we could expect $\lambda_B > \lambda_P$ or $\lambda_B = \lambda_P$.

We extend this by examining scales of variation for different biological traits measured by Seaflow, e.g. phycoerythrin fluorescence or forward scatter (a proxy for cell size).

Regional variations in the balance of physical and biological scales

Preliminary results

For each track, we identify continuous sections (no gaps > 10 km) and perform the autocorrelation analysis sequentially over 200 km windows. Scales of variation for biological ($\lambda_B$) and physical ($\lambda_P$) properties, and their relationship to each other vary across the Pacific Basin. We see all three of the potential scenarios described above.

Next steps:

We plan to use these results to examine how the relationship between $\lambda_B$ and $\lambda_P$ relates to physical properties such as EKE and the Rossby radius. We will also explore how the different traits measured by SeaFlow behave. Phycocerythrin appears to behave differently to chlorophyll (results not shown here), these differences reveal how community composition may relate to physical processes.

Decorrelation length scales (bounded by 95% confidence intervals) calculated for chlorophyll (green) and temperature (red) for the cruise tracks indicated in black on the map (left).

Map of the North Pacific, showing the cruise tracks for all of the SeaFlow cruises included in the dataset. The cruises for which we are showing data here are indicated in black, with the rest in dark grey. The background colormap shows estimates of eddy kinetic energy (derived from the ECCO-2 state estimate), and the red contour lines show the Rossby radius of deformation (Chelton et al., 1998).