Scaling up productivity estimates using autonomous platforms

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WHOI

Profiling floats, Underwater gliders, moorings
CTD, Oxygen, Chlorophyll fluor, Backscatter, PAR, NO$_3$

NOAA PMEL Ocean Climate Station

Teledyne Webb Research Slocum

Kongsberg Seaglider

Seabird BGC Navis
Potential of autonomous platforms

• Provide vertical structure through the water column
• Measure additional variables that constrain PP rates ($O_2$, nitrate, etc.)
• Sampling Coverage
  • High spatiotemporal resolution and long endurance
  • under ice, under cloud cover

Challenges for autonomous platforms

• Limited validation against incubation and in situ tracer methods
• Sensor data QC – biogeochemical sensors still a work in progress
• Methods still evolving w/ little standardization
Terminology of ocean productivity

- **GPP** = Gross Primary Production
- **NPP** = Net Primary Production
- **NCP** = Net Community Production
- **CR** = Community Respiration
- **RA** = Autotrophic Respiration
- **RH** = Heterotrophic Respiration

**NCP** can be + or − (net autotrophic or heterotrophic)

GPP = GPP – CR = NPP – RH

Organic carbon available for export

Net biological CO₂ uptake
NCP from mass balance

Net Community Production can be estimated from mass balance of Oxygen, Nitrate, carbon

\[
\frac{dO_2}{dt} = F_{phys} + F_{as} + J_{bio}
\]

- \(O_2\) sensors most robust, but require accurate air-sea flux est. Air calibration systems
- Must integrate over time – weekly to monthly resolution at best
- Annual NCP is desirable – requires full annual coverage
- Lateral advective fluxes largely ignored (Lagrangian platform would be best)

[Feen and Nicholson, 2017]
[Bushinsky et al. 2016]
NCP at Station Papa

- Autotrophic in summer, Heterotrophic in winter
  - Mass balance O₂, NO₃, DIC

No PP measured at the same time

[Fassbender et al. 2016] – PMEL Mooring

[Plant et. al. 2016] – BioArgo floats
PP from irradiance and chlorophyll

- Combine multispectral downwelling irradiance with chlorophyll fluorescence to estimate PP
- Could be calibrated against NPP or GPP

Depth resolved estimate of PP
High spatial resolution
Optical methods – compare to Remote sensing

Chl Fluor sensor → chl a
Corrections for chl quenching
Param of PP = f(E,chl,T)

[Hemsley et al. 2015, GRL]
Diel O₂ from gliders

- Daytime photosynthesis and nighttime respiration produce diel changes in O₂ (Odum 1956)
- Idealized curve fit to observations
- GPP and CR estimated for each day
  - Minor corrections for gas exchange and physics

Only requires O₂ sensor
GPP and CR can be estimated
Estimate directly in O₂ units

Sensitive to physical variability
Assume constant CR(t)
Volumetric (no depth resolution)
Requires high temporal resolution

[Nicholson et al. 2015]
GPP in the NE Pacific from Seaglider as part of Lagrangian NASA EXPORTS study