Exploring the use of automated long-term dissolved oxygen records to estimate pelagic primary production in the Arctic

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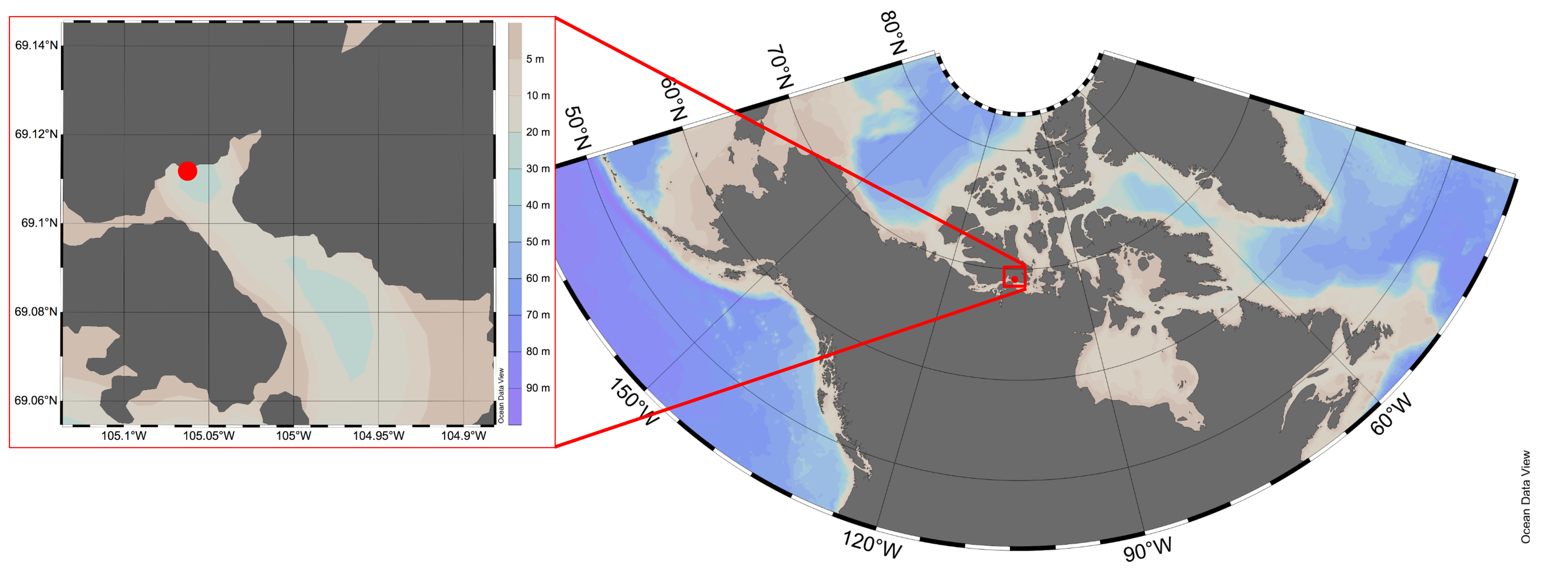
Introduction

Due to perennial sea-ice cover, polar regions remain a challenging frontier for oceanographic research and, therefore, most studies have been limited to the summer months, when ice coverage is reduced or absent.

This limitation has restricted our understanding of environmental and biological dynamics over long time scales, critical under current climatic changes in the Arctic[3].

This study is an initial effort to estimate long-term pelagic primary production by comparing cabled observations with experimentally measured rates in the Arctic, essential for testing the validity of automated long-term data collection in a marine setting.

Study location



Seawater sample collection:

- Location: Cambridge Bay, Nunavut, in the Canadian Arctic Archipelago
- When: June 16th to July 15th daily, and every other day from the 17th to the 3rd of August, during the summer of 2016.
- Where: Surface water (5 m) within ~10 m distance of the Ocean Networks Canada (ONC) Underwater ocean observatory situated at ~8 m depth.

Methods

- Carbon uptake rates (ρC) were measured by enriching seawater samples with ^{13}C-bicarbonate. Incubations were conducted *in situ* at 5 m for 24 hours.
- Oceanographic variables have been recorded by the ONC observatory since 2012, including water temperature, salinity, oxygen, chlorophyll *a* fluorescence, ice thickness and photosynthetically active radiation (PAR).
- Other measurements*: biogenic silica ($bSiO_2$), chlorophyll *a* (Chl *a*), dissolved nutrients: nitrate (NO_3^-), phosphate (PO_4^{3-}) and silicic acid ($Si(OH)_4$), phytoplankton taxonomy.

ONC underwater observatory (Image courtesy of Akash Sastri)

**not shown in this presentation*

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References

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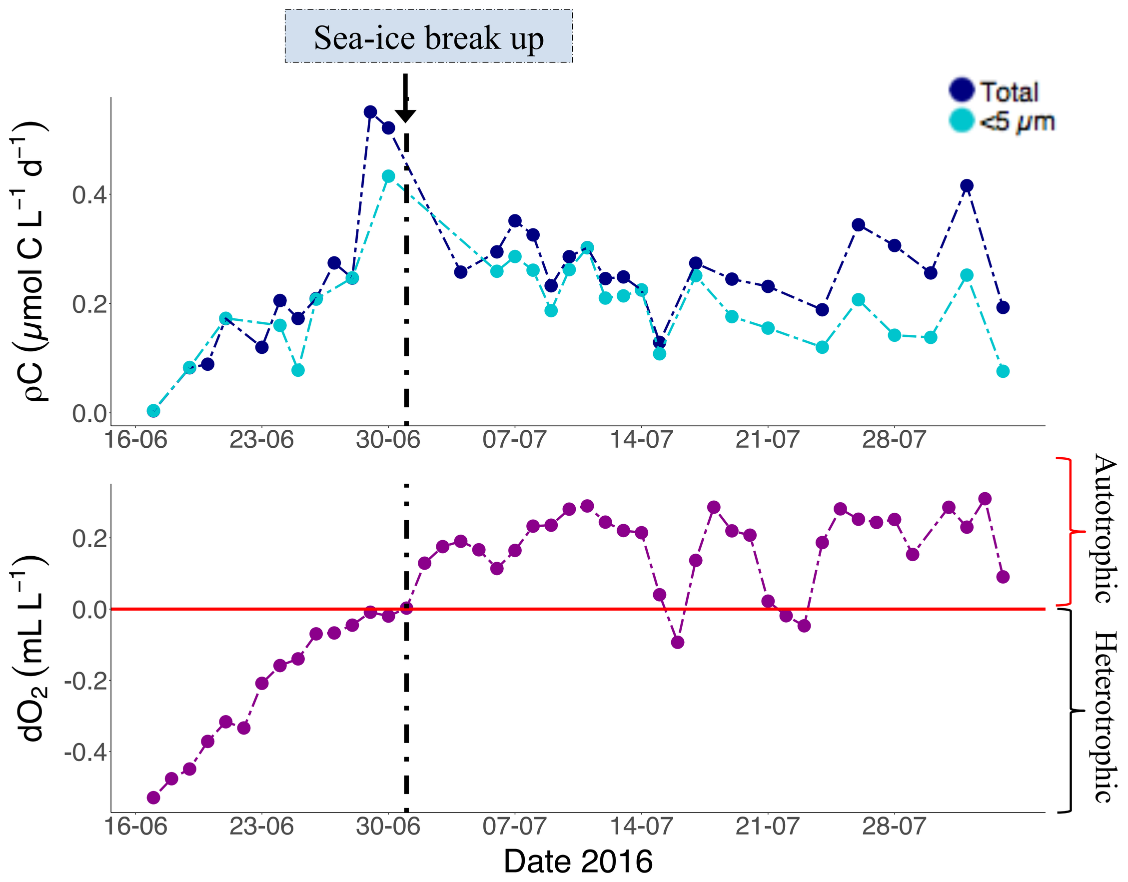
Measurements of Primary Production and Oxygen



Primary production

- Low ρC in comparison to other Arctic regions[2]
- Primary peak: Sea-ice break up (29/06-01/07)
- Secondary peak: Later in the summer (24/07-01/08)

- Cells < 5 μm were responsible for the majority of ρC throughout the study period
- After 15/07, cells >5 μm contributed more to ρC than earlier in the growing season

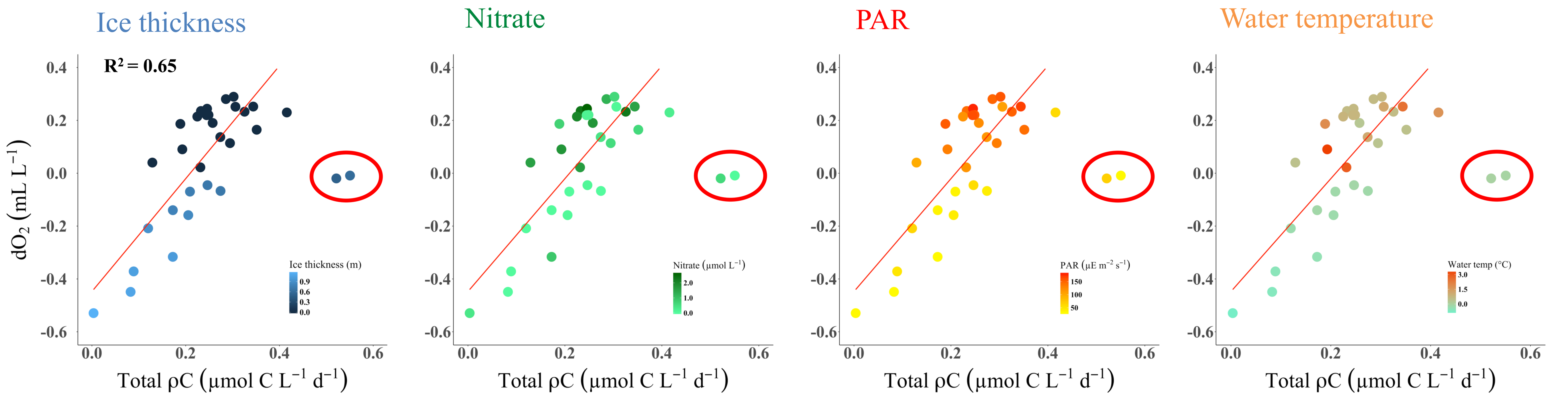
Residual oxygen (dO_2):
Positive dO_2 values after the sea-ice break up indicate net autotrophic conditions.

dO_2 (mL L^{-1}) = $O_{2,in\ situ} - O_{2,eq}$

$O_{2,eq}$ = calculated oxygen given salinity and temperature assuming equilibrium with the atmosphere[1].

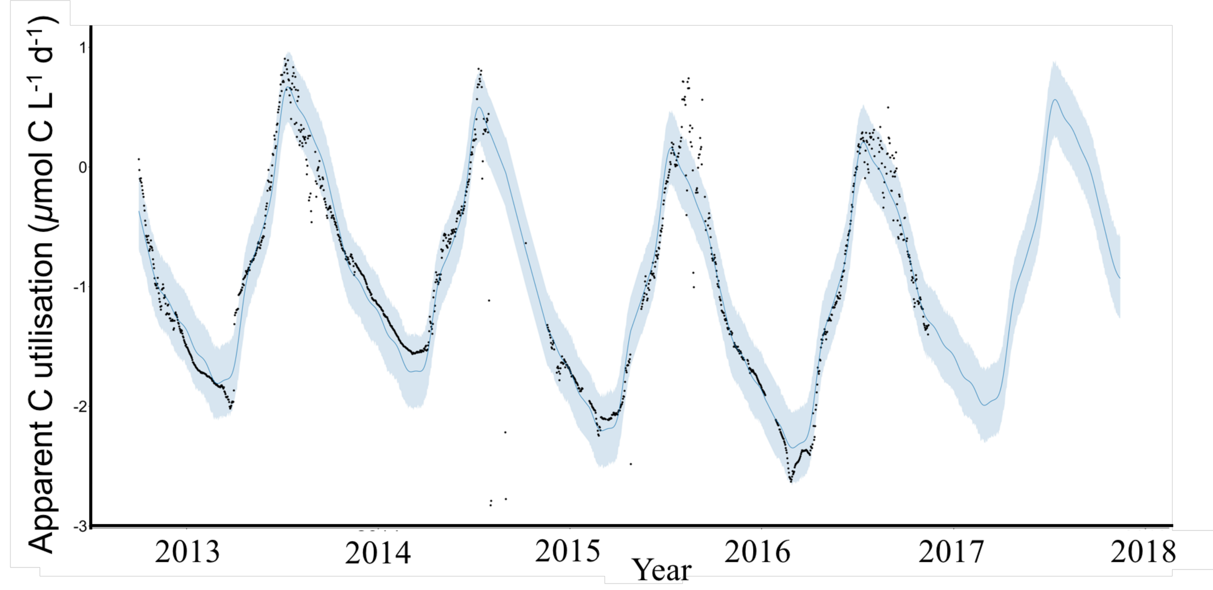
Relationship between Primary Production and Oxygen

The calculated dO_2 and measured ρC have a **strong relationship ($R^2 = 0.65$, $p = <0.05$)** when in 'steady state' (excluding the sea-ice break up days).

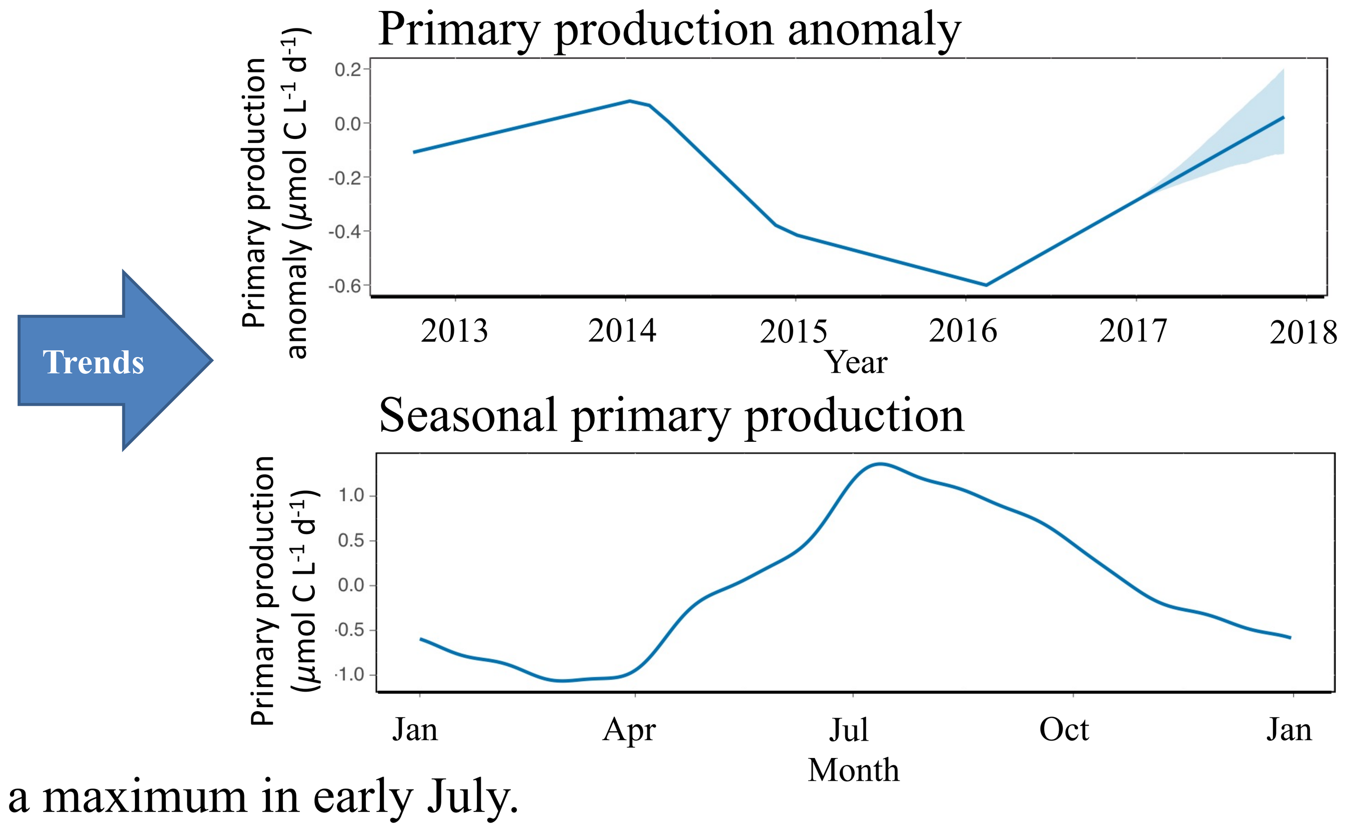


Increase in primary production can be associated to changes in the environmental variables, such as ice thickness, nitrate concentrations, irradiance (PAR) levels and water temperature.

Estimates of Interannual Primary Production from Oxygen



Points are the calculated (apparent) carbon utilisation values based on dO_2. The blue line is the modelled apparent carbon utilisation based on an additive model with an 80% uncertainty (blue shaded area) that forecasts into 2018[5].



- Primary production rates begin to increase in April, reaching a maximum in early July.
- This method estimates a decrease in production of ~0.6 μmol C L^{-1} d^{-1} from 2014-2016.

Summary and future applications

- We found a strong linear relationship between dO_2 and ρC.
- High primary production values during sea-ice break were excluded from the dO_2 and ρC relationship as outliers which causes an underestimation of production events in dynamic periods.
- Increases in primary production rates are associated to changes in abiotic variables.
- This approach provides a means of estimating interannual variation of primary production over longer time series.