Relationships between the surface concentration of Particulate Organic Nitrogen (PON) and the Inherent Optical Properties (IOPs) of seawater

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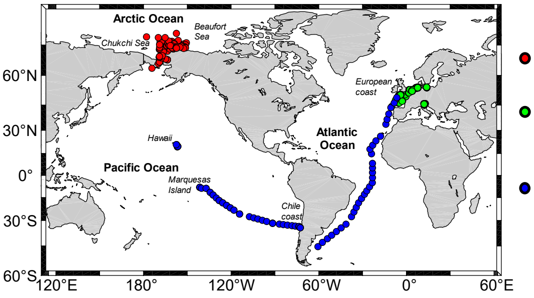
Context and objective

✓ Field observations on the dynamics of particulate organic nitrogen (PON) in the ocean over large time and space scales are relatively limited, which constrains our comprehension on nitrogen cycling and its link with the oceanic carbon cycle.

✓ Satellite observations of Ocean Color Radiometry (OCR) may represent a good opportunity for the estimation of surface PON over the global ocean. For that purpose, relationships between the optical properties of seawater and PON first need to be analyzed and characterized. In the present study, field measurements are used to examine relationships between the concentration of PON and inherent optical properties (IOPs) of seawater including the spectral particulate backscattering, $b_{bp}(\lambda)$, particulate absorption, $a_p(\lambda)$, non-algal particulate absorption, $a_{nap}(\lambda)$, and phytoplankton absorption, $a_{ph}(\lambda)$, coefficients.

A large set of *in-situ* PON and POC and optical measurements has been gathered from different field experiments performed in contrasted oceanic and coastal areas from 1997 to 2017



Arctic Ocean
→ Oligotrophic to turbid waters

European coastal waters
→ affected by phytoplankton bloom, river plumes, sediment re-suspension, and land-ocean exchange

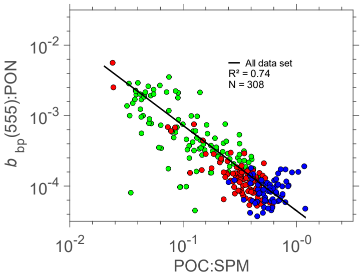
North/South Pacific and Atlantic Ocean
→ Open pelagic waters

In-situ PON and POC and optical measurements

Mass concentrations of
- ✓ PON (Particulate Organic Nitrogen)
- ✓ POC (Particulate Organic Carbon)
- ✓ SPM (Suspended Particulate Matter)

Inherent optical properties = Proxy of particulate matter
- ✓ Spectral particulate backscattering $b_{bp}(\lambda)$
- ✓ Particulate absorption $a_p(\lambda)$
- ✓ Phytoplankton absorption $a_{ph}(\lambda)$
- ✓ Non-algal particulate absorption $a_{nap}(\lambda)$

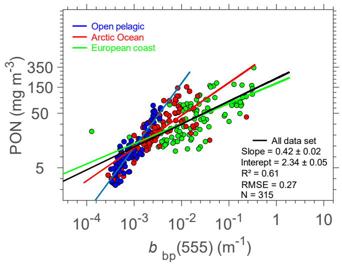
The PON *vs.* b_{bp} relationships are characterized by a high variability which is largely related to changes in the organic *vs.* inorganic composition of the bulk particulate matter



✓ SPM = Organic + Mineral particles

✓ The POC:SPM ratio is a proxy of the proportion of the organic fraction in SPM

✓ The PON-specific b_{bp} tends to decrease with increasing contribution of organic particles to SPM

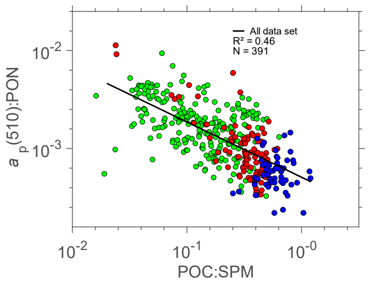


The best relationship for using b_{bp} as an optical proxy of PON is observed for open pelagic waters which exhibit relatively limited variability in POC:SPM (blue dots)

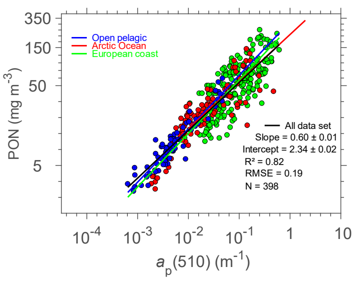
$$log_{10}(PON) = 1.18 \times log_{10}\, b_{bp}(555) + 4.61$$

→ **Difficult to use b_{bp} as a valid optical proxy of PON over large range of oceanic and coastal environments**

The PON *vs.* a_p and a_{ph} relationships are more robust compared to the PON *vs.* b_{bp} relationship over a broad range of oceanic and coastal marine environments



✓ The variations in relative proportion of organic and mineral particles have smaller effect on the PON-specific a_p coefficients than the PON-specific b_{bp}



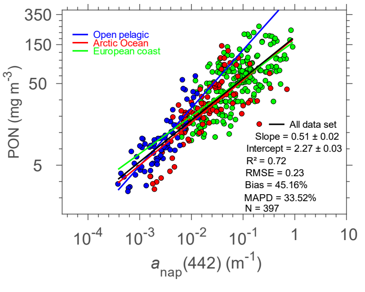
The **slopes** of the PON *vs.* a_p relationships are **relatively similar** whatever the data sets, in contrast to what has been observed when b_{bp} is used instead of a_p

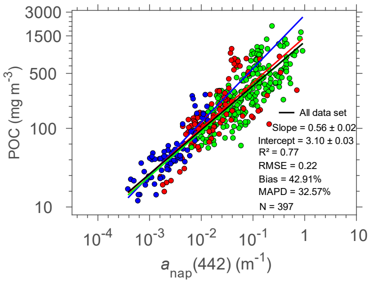
$$log_{10}(PON) = 0.60 \times log_{10}\, a_p(510) + 2.34$$

Similar results are observed for the PON *vs.* $a_{ph}(510)$ relationships (Figures not shown)

$$log_{10}(PON) = 0.60 \times log_{10}\, a_{ph}(510) + 2.49$$

The variation of PON could be more related to living organic matter (and to a lesser extent detritus) than the optical proxy of POC





The POC *vs.* a_{nap} relationship is statistically better than PON *vs.* a_{nap}
→ The a_{nap} variability is slightly more driven by the bulk particulate POC than PON

__Hypotheses__ : This can be explained by
- an **introduction of non-algal POC particles** by rivers and streams
- an important **microbial loop** generating a large amount of carbon-enriched dead organic matter (Ferrari et al., 2002)
- a **preferential remineralization** of nitrogen-rich proteins in contrast to a slower degradation of carbohydrates (Gordon, 1971; Duhammel et al., 2007)

In a forthcoming study, these new relationships also **open a promising avenue to assess PON from ocean color remote sensing** using existing inverse methods

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