Abstract #11318

Seasonal Dynamics of Organic Carbon in the Deep Eastern North Pacific

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Introduction

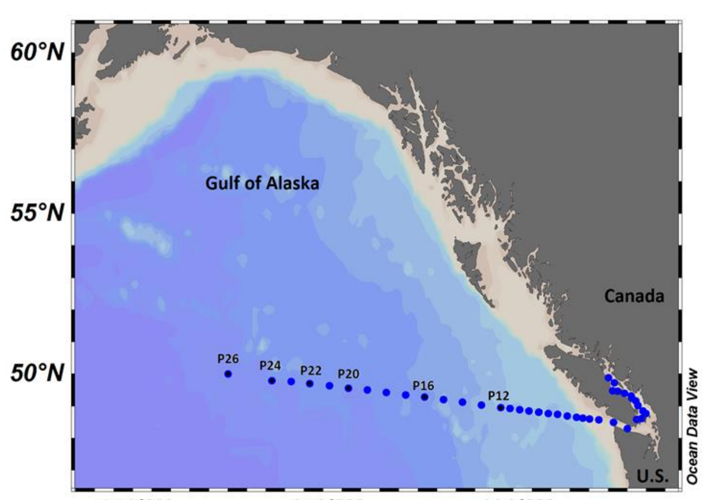
Until this work, we have had no time-series observations of organic carbon in the bathypelagic waters of productive systems. Here we ask these questions: **(1)**: What are the TOC distributions from shelf to basin, and what can they tell us about the system in the North Pacific on seasonal time scales? **(2)**: Do POC export events impact DOC cycling at depth, and is it an important factor for this area? **(3)**: If so, how much modern DOC is introduced into the water column, and what are the impacts on ^{14}C-DOC distributions?

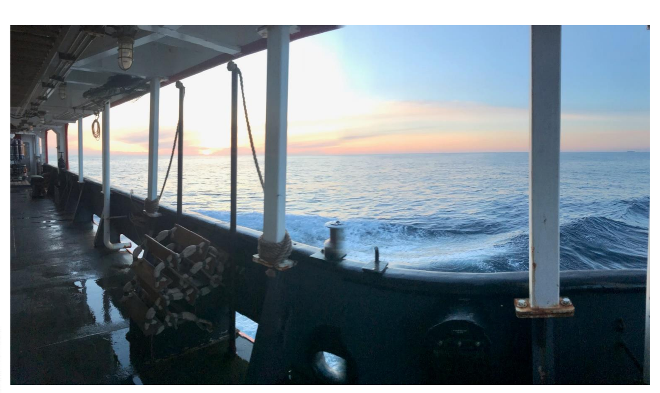
Goals

1. Observe seasonal variability in deep TOC distributions
2. Determine if heterogeneity in TOC at depth is due to particulate matter (POC) or if the signal is in the dissolved state (DOC)
3. Gain insight on inferred variability in modern carbon inventory at depth using a simple radiocarbon model

Study Site

Line P is a time-series in the Eastern North Pacific that is monitored tri-annually by the Canadian Department of Fisheries and Oceans for a variety of oceanic parameters. It operates out of the Juan De Fuca Strait to Ocean Station Papa (OSP - 50°N, 145°W).





We assessed stations in the open ocean, thus experiencing less variability due to coastal influences (e.g., eddies, fluvial inputs, etc); those being P12-P26.

Methods

Sample Collection

Samples of whole water were collected at depths ≥ 300 meters. All samples were acidified to remove inorganic carbon species using 100 µL of 4M HCl per 40 mL of seawater, then analyzed using Shimadzu TOC-L Total Carbon Analyzers.

Investigating 'True' DOC

To investigate the heterogeneity observed in TOC distributions, an extra set of samples, filtered inline at all depths, was collected in June 2018. These were to test for the presence of POC in the samples, to answer Q2 above.

Insight on Modern DOC

A simple model was constructed, assigning a refractory DOC radiocarbon value of -550‰ (adapted from Druffel et al., 2018) and $\Delta^{14}C_{POC}$ of 30‰ (Bertrand et al., 2013). A least-squares regression indicated a 'baseline' concentration of refractory DOC of 38.5 µM, consistent with observations.

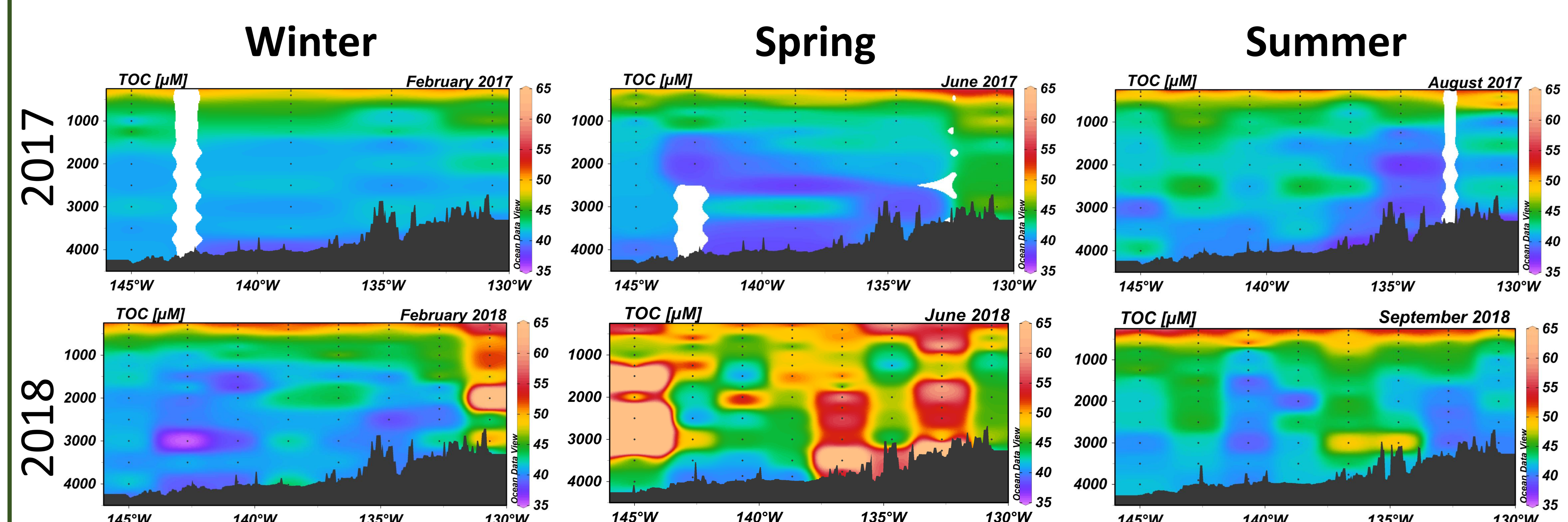
$$\Delta^{14}C_{DOC} = \left(\frac{[DOC]_{obs} - [rDOC]}{[DOC]_{obs}} \times \Delta^{14}C_{POC}\right) + \left(\left(1 - \left(\frac{[DOC]_{obs} - [rDOC]}{[DOC]_{obs}}\right)\right) \times (\Delta^{14}C_{rDOC})\right)$$

1. Seasonal Variability

Seasonal Dynamics

2017: TOC concentrations at depths >1500 m in winter of 2017 were fairly homogeneous, and remained consistent in spring, except at P12 (130.7°W). Summer consisted of slightly higher heterogeneity, with localized elevated TOC concentrations of 45 µM, compared to typical background concentrations of 38-42 µM at depth.

2018: TOC concentrations in winter 2018 were again fairly homogenous, except for elevated concentrations throughout the water column again at P12. A spring bloom occurred in June (from surface Chl observations), resulting in heterogeneity throughout the water column with TOC concentrations up to 153 µM in localized areas. Surface chlorophyll concentrations were elevated (0.75 – 1.25 mg/m^3) from 133 – 143°W. By late summer, much of the TOC was remineralized with only a view areas of elevated carbon concentrations.

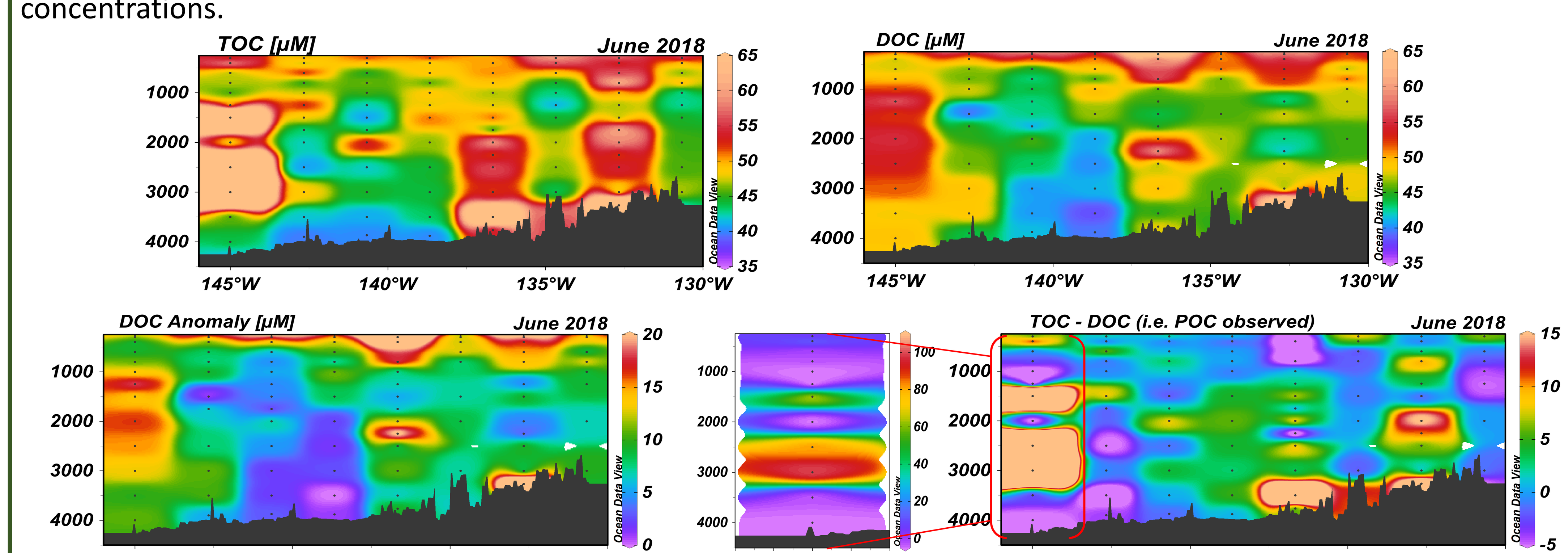


Some Interpretations

TOC distributions in 2018 were more heterogenous than in 2017. During the June 2018 cruise, a salp bloom was present at P26 (145°W). Salps are gelatinous zooplankton that are efficient grazers of phytoplankton and bacteria, which contribute to POC flux via fast-sinking fecal pellets, carcasses, and secretion of DOC at depth (Stone and Steinberg, 2016). There were also elevated numbers of zooplankton such as doliolids and larvaceans in June 2018, indicators of a bloom at the surface along with the observed high surface chlorophyll levels.

2. Investigating "True" DOC

Typically, organic carbon at depth is collected as whole water (TOC) and assumed equivalent to DOC due to presumed low levels of POC. Given the localized heterogeneity observed the TOC distributions in 2017, we aimed to determine whether the TOC signal was in fact a strong indicator for DOC added to the system ("DOC anomaly"; DOC observed – 38.5 µM) or if some of the signal is attributed to POC. An extra set of samples was collected during the June 2018 cruise, which were filtered at all depths (providing DOC concentrations) and compared to whole-water (TOC) concentrations.



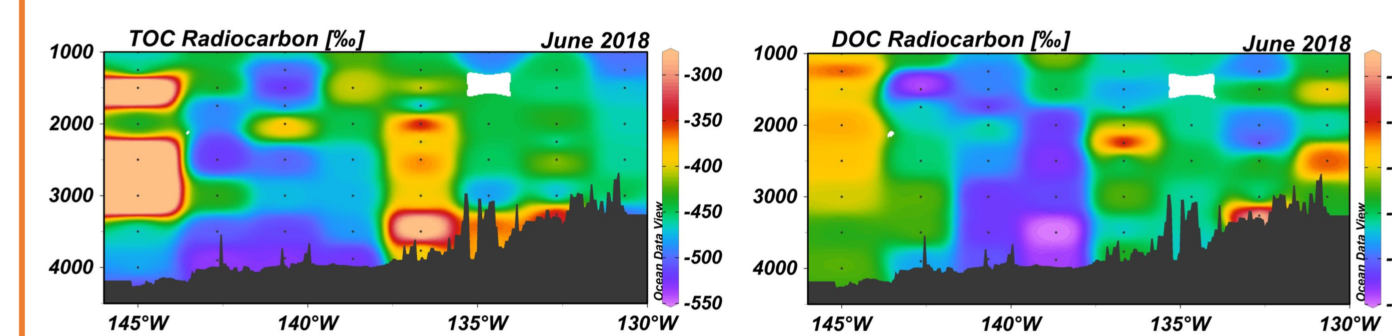
Observations

- In the bathypelagic, there was a substantial difference between whole-water (TOC) and filtered water (DOC), indicating that POC was detected in the water column (up to 5-15 µM, with some reaching much higher). However, some of the elevated signal is due to DOC (DOC anomalies reaching 15-25 µM).

3. Insight on Modern DOC Input

The radiocarbon content of DOC has not been observed at this location, as current data are sparse due to the difficulty and cost of measurements. However, we can infer radiocarbon values along Line P utilizing a simple radiocarbon model (see methods), which considers modern input of carbon through POC flux.

In past work, radiocarbon measurements at depth were on whole-water samples and considered reflective of DOC. Here, we infer radiocarbon distributions of TOC verses DOC in June 2018 below 1000 meters.



- Purple areas indicate areas largely consisting of refractory DOC – considered the 'baseline' concentration of DOC throughout the water column (38.5 µM).
- Given these inferred distributions, the modern radiocarbon values may be overestimated if whole-water (TOC) is measured rather than filtered water. The percentage of modern DOC ranges from 9 – 29% (per station, not bulk budget) using filtered samples (DOC), verses a range of 12-37% for whole water (TOC)

Answers to Questions

(1): What are the TOC distributions from shelf to basin, and what can they tell us about the system in the North Pacific on seasonal time scales?

- **TOC distributions in 2017 showed heterogeneity seasonally in 2017, and with even more variability in 2018.**
- **We observed that high levels of deep carbon can be remineralized on a seasonal time-scale.**

(2): Do POC export events impact DOC cycling at depth, and is it an important factor for this area?

- **We determined not only that POC is detectable in whole-water samples, but that it can leave behind an elevated DOC signal.**

(3): If so, how much modern DOC is introduced into the water column, and what are the impacts on ^{14}C-DOC distributions?

- **Based on our two end-member model, POC flux can provide modern DOC from 9-29% of observed DOC at a single station, providing a modern radiocarbon signature in the deep water column.**

References

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