Deglacial-Holocene variability of sea ice and surface water temperature in the Bering Sea: Reconstruction based on "IP25" and alkenone data

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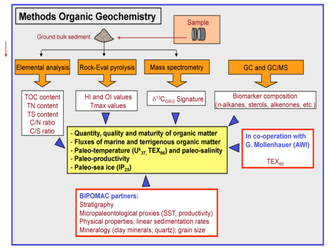
1-Introduction

The objective of the project is a high-resolution reconstruction of the variability in surface water characteristics and terrigenous input in the North Pacific and Bering sea using organic geochemical proxies.

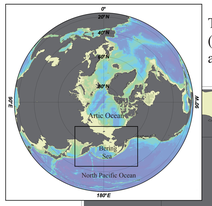
Primary targets of the study are:
-Reconstruction of the sea surface temperature (SST) based on alkenones (UK´37)
-Reconstruction of sea-ice cover based on highly-branched isoprenoids(HBIs, IP25)
-Reconstruction of marine productivity using specific biomarkers (n-alkane, sterols)
-Reconstruction of organic-carbon sources, input of terrigenous OC using n-alkanes and sterols

The same geochemical proxies have been measured in three kastenlot (highlighted in Figure1) in order to understand the climatic changes over the last 50 ka.

2-Methodology



3-Surface sediment data



The core material study within this project was collected during RV Sonne Cruise202 (INOPEX) (5th of July to the 28th of August 2009; Gersonde et al., 2010) in the (sub-) polar North Pacific and Bering Sea.

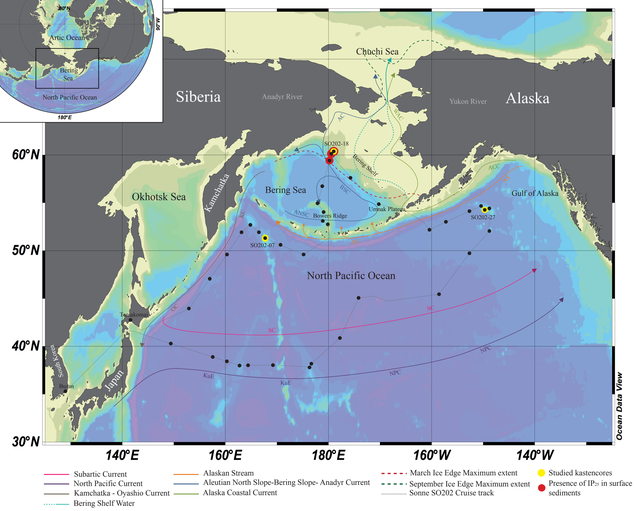


Fig.1: Locations of sampling sites from the cruise RV Sonne cruise SO202 in the North Pacific and Bering Sea. Summertime current and water mass features, typical spring and fall ice extent bounds (Danielson et al. 2011). Sea ice proxies IP25 in surface sediment are highlighted in red.

-IP25-

In order to reconstruct the sea-ice cover, the newly developed so-called „IP25 Index" was used (Belt et al., 2007; Müller et al., 2009). We found this specific biomarker only in the 3 northern most surface sediment samples of the INOPEX cruise, which highlight the presence of sea ice in this area. The absence of the IP25 in the rest of the sediments samples may reflect the modern dominantly open water condition through the year.

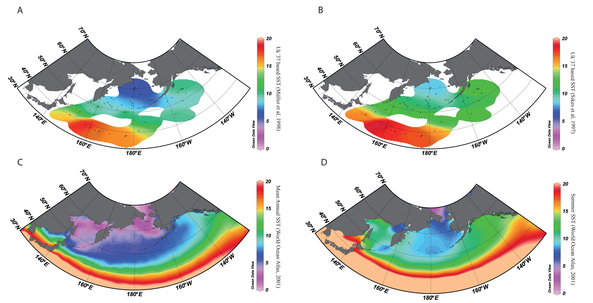


Fig.2: Uk´37 based SST (Müller et al., 1998) (A), UK´37 based SST (Sikes et al., 1997) (B) in surface sediments from the North Pacific and the Bering Sea. Annual SST (C) and Summer SST (D) from Ocean Atlas 2001.

-Sea Surface Temperature-

In order to define the best calibration for this region, Uk´37 was converted to temperature according to two different equations. First the alkenone based Calibration, UK´37= 0.033T + 0.044, obtain by Müller et al. (1998) on surface sediment from the global ocean (60°N-60°S), and suitable for temperatures range between 0 and 27 °C. The second calibration, UK´37= 0.038T - 0,082, was proposed by Sikes et al. (1997) and obtain with alkenone in core top sediment from Southern Ocean. By comparing the alkenone-based SST and the measured temperature (extracted from the World Ocean Atlas 2001), we observe that the estimated Uk'37 –SST show the same latitudinal distribution pattern than the Annual-Mean SST but is a few degrees higher (about 4°C). However, the alkenone-based SST match well with the Summer Mean temperatures, suggesting that the based-alkenone SST mainly reflects surface water temperature in summer.

4- Data from sediment cores: Late Quaternary variability

• Kastenlot SO202-18-6

Sea surface temperature and IP25 measurement

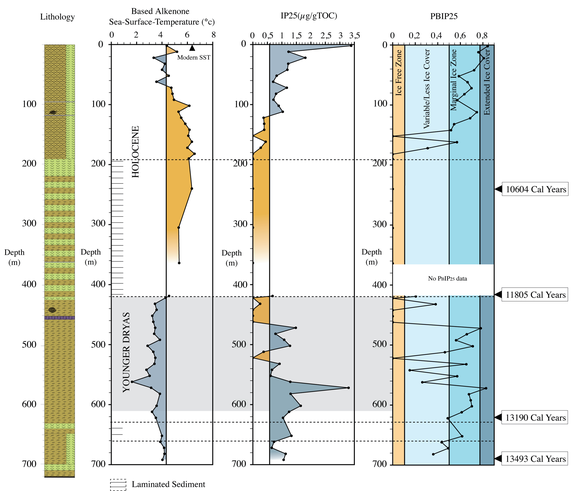


Fig.3: SST, IP25 concentration of kastenlot SO202-18-6 from Bering Sea

Total Organic Carbon and Sterols measurement

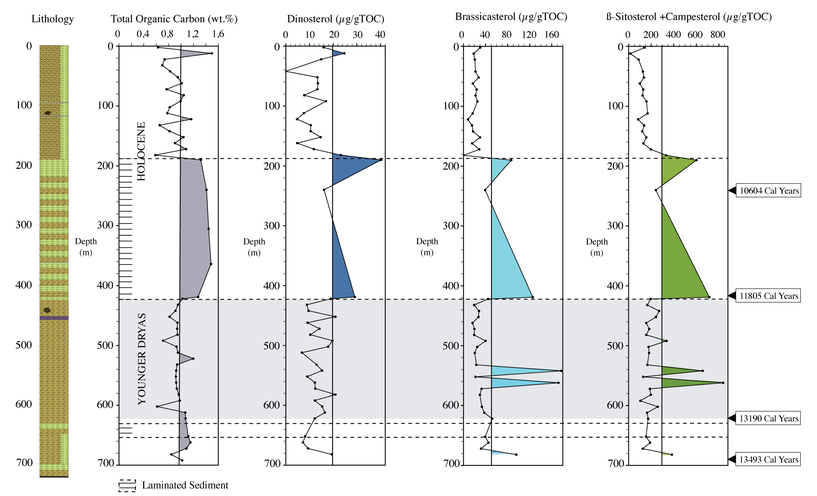


Fig.4: TOC contents and Sterols concentration of kastenlot SO202-18-6 from Bering Sea.

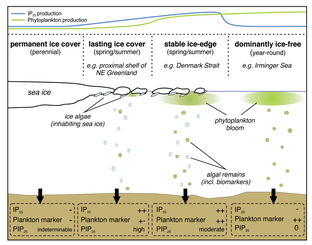


Fig.5: Generalised scheme illustrating sea surface conditions and respective (spring/summer) productivities of ice algae and phytoplankton.Overview sedimentary contents of IP25 and the phytoplancton-derived biomarkers and resulting PIP25 indices for each setting (Müller et al., 2011)

Phytoplankton IP25 index (PIP25)

PIP25 correspond to the coupling between IP25 and phytoplankton biomarkers (Brassicasterol in this study) and proves a valuable approach to reconstruct spring sea ice (Muller et al., 2011).

$$PIP_{25} = IP_{25}/(IP_{25}+(\text{phytoplankton marker}*c))$$

with c=mean IP25 concentration/mean phytoplankton biomarker concentration.

Coincident with the low SST observed during the Younger Dryas, the concentration of IP25 is high, which may suggest an extension of spring sea ice coverage in Bering Sea during this period. Between the early and mid-Holocene, the sediment is strongly laminated. The alkenone-based SST shows an increase in temperature, and the absence of IP25 may be interpreted as open-water conditions.
However, only 4 samples from this interval have been studied so far, i.e., further data are needed before a more detailed interpretation is possible. From the mid-Holocene to the late Holocene, we observe an increase of IP25 as well as the PIP25index, which may suggest an advance of the sea ice margin in Bering Sea.

TOC content in this core varies between 0,33 wt % and 1,085 wt%. Highest TOC values are found in the laminated sediment and refer to an increase of input and/or preservation of the organic carbon. Preliminary age model from Kuehn, Gersonde et al., 2011, unpublished)

• SST, IP25 and PBIP25 in cores SO202-07-6 and SO202-27-6

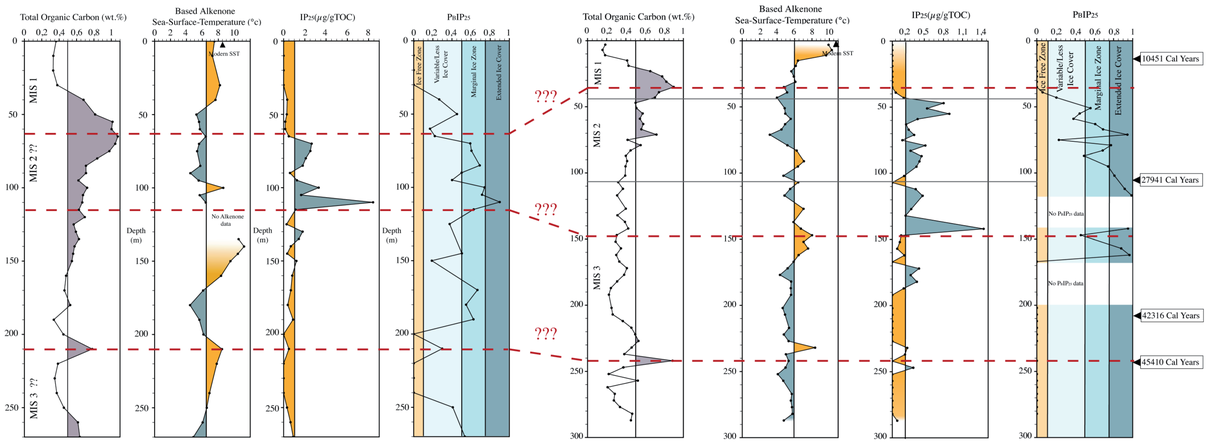


Fig.6: SST, IP25 concentration and PBIP25 indices from kastenlot SO202-07-6 from North West Pacific and from kastencore SO202-27-6 from North-East Pacific

TOC, SST, IP25 and PBIP25 have been measured in the kastenlot SO202-07-6 (from the North-West Pacific) and the kastenlot SO202-27-6 (from North-East Pacific). Based on these preliminary results, a correlation of the cores seems possible.
Furthermore, increased IP25 and PBIP25 values suggest increased sea-ice cover and reduced SSTs during MIS 2 (?) (Preliminary age model from-Abelmann, Maier et al., 2011, unpublished)

References:
-Belt, S.T et al., 2007. Organic Geochemistry
-Cruise Report, 57, Gersonde R. et al., 2010. Sonne Cruise SO202-INOPEX
-Danielson S. et al., 2011. Journal of geophysical research
-Müller P.J et al., 1998. Geochimica et Cosmochimica Acta
-Müller, J. et al., 2009. Nature Geosciences
-Müller, J. et al., 2011. Earth and Planetary Science Letters
-Sikes E.L. et al., 1997. Geochimica et Cosmochimica Acta