Time-Series Observation for biogeochemistry at the Western North Pacific TS stations KNOT, K2 and S1

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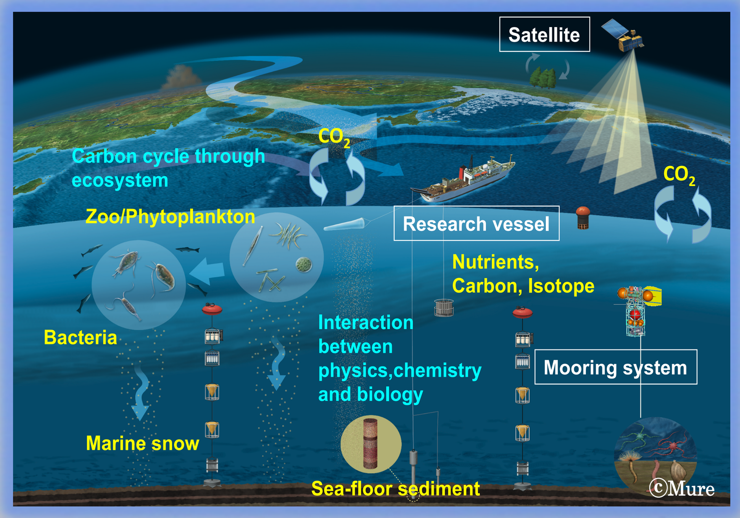
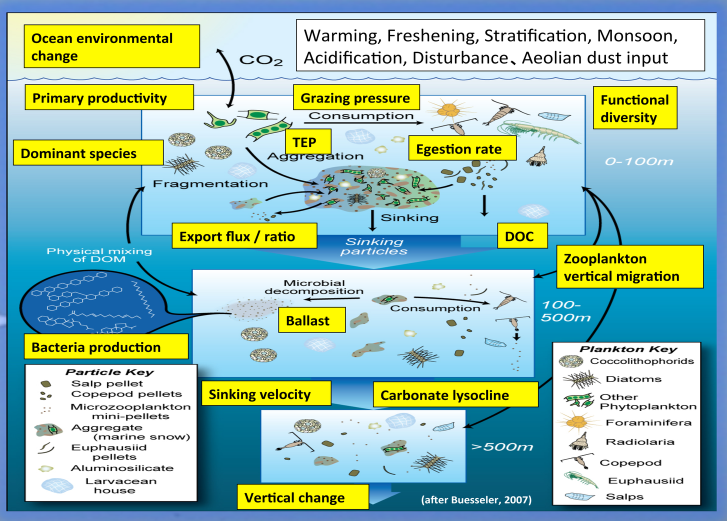
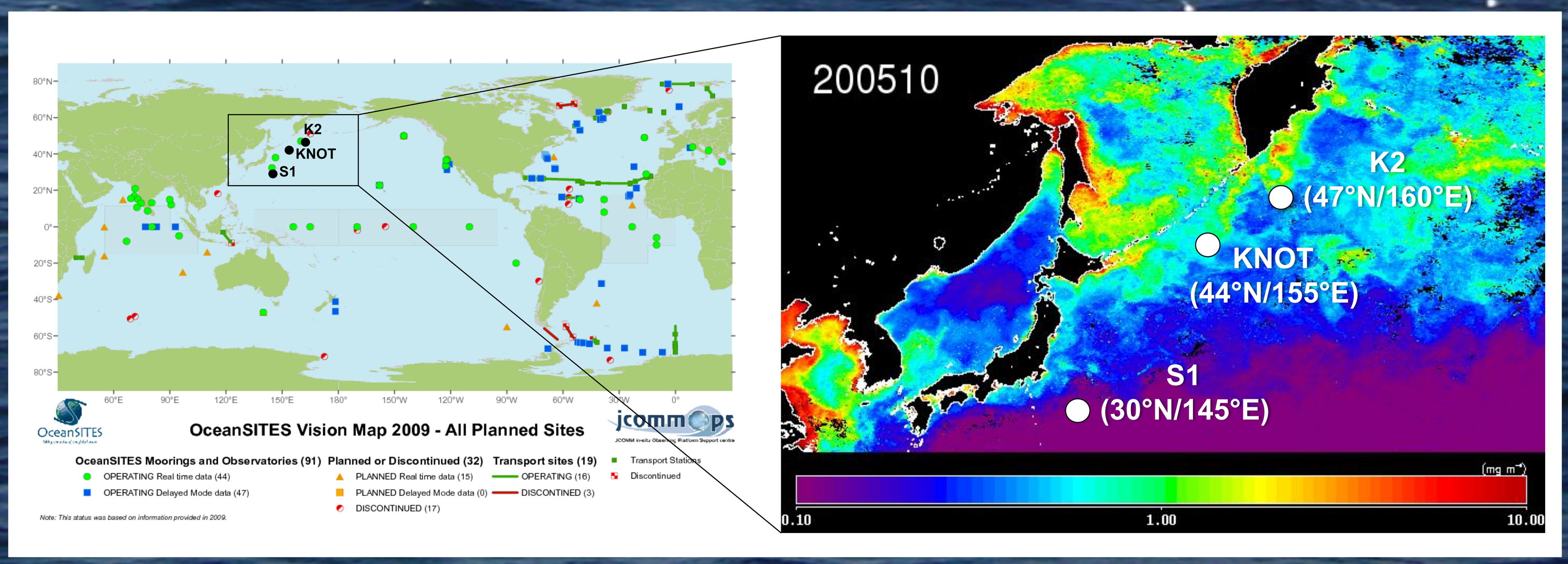






KNOT (44°N / 155°E)

TS station KNOT was established in 1997 for JGOFS North Pacific Process Study and multidisciplinary biogeochemical observation was conducted by all Japan biogeochemistry team (many Japanese universities and governmental / semi-governmental laboratories). As a result, unique characteristics of the Western Pacific Subarctic Gyre (WPSAG) were verified (*e. g.* the WPSAG has large seasonal biogeochemical variability and has very efficient biological pump for uptake and vertical transport of atmospheric CO_2: Deep-Sea Research II, 49, 2001). Although multidisciplinary observation by all Japan BGC team was over in 2001, JAMSTEC has continued re-visiting KNOT and measuring nutrients and carbonate chemistry.

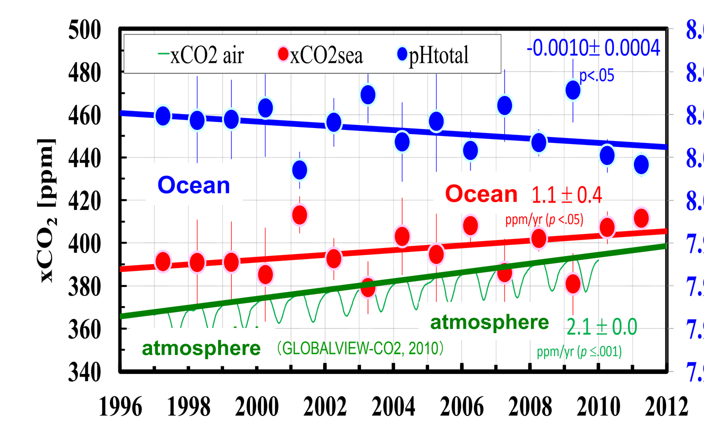
K2 (47°N / 160°E)

KNOT became representative WPSAG time-series station. However KNOT was located at the southern end of the WPSAG and it was found that subtropical water sometimes invaded KNOT. Thus its oceanography does not always represent that of the WPSAG. In order to study biogeochemistry more precisely and monitor decadal change in biogeochemistry at more stable TS station in the WPSAG, new TS station K2 was established in 2001. Since then, biogeochemical TS observation has been conducted at station K2 by not only onboard observation / experiment, but also mooring system with sediment trap, optical sensor and water sampling system. Based on this TS observation with mooring system, it has been verified that biogenic materials including atmospheric CO_2 is quickly transported to the ocean interior (Buesseler et al. 2007,Honda et al. ,2006, 2009, Honda and Watanabe. 2007, Kawakami and Honda, 2006).

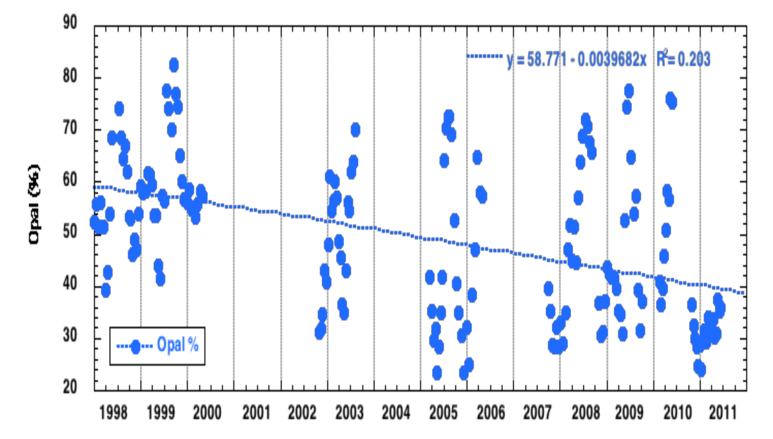
Decadal observation of carbonate chemistry and sinking particle

Based on decadal TS observation of carbonate chemistry at KNOT and K2, it was verified that surface $pCO_{2(sea)}$ in winter has been increasing and, however, its rate was slower than that in atmosphere (Wakita et al., 2010). It is indicative of that the WPSAG would become a sink of atmospheric CO_2 all year round. Decrease of pH has been also observed and, therefore, acidification will affect ecosystem and biogeochemical cycle in the WPSAG.

In addition, approximate decadal TS observation of sinking particles revealed that biogenic opal plays a role of "ballast" in transporting CO_2 to the ocean interior (Honda and Watanabe, 2010). However concentration of biogenic opal in sinking particles tends to decrease.



$xCO_{2(sea)}$, $xCO_{2(air)}$ and pH in winter surface water at North Pacific TS stations (KNOT and K2)



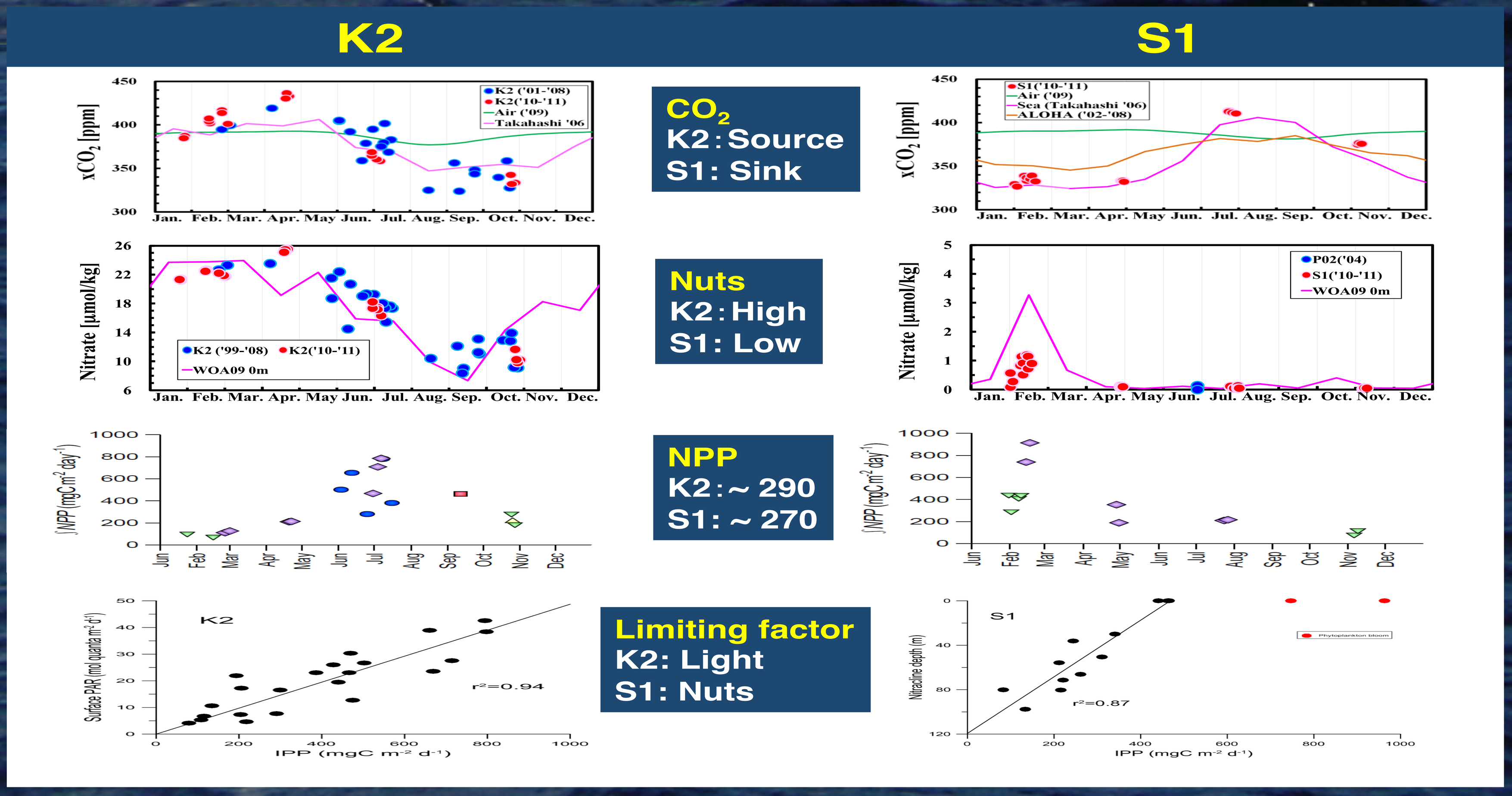
Biogenic opal concentration of sinking particle in North Pacific sediment trap (50N, K1, K2)

S1 (30°N / 145°E)

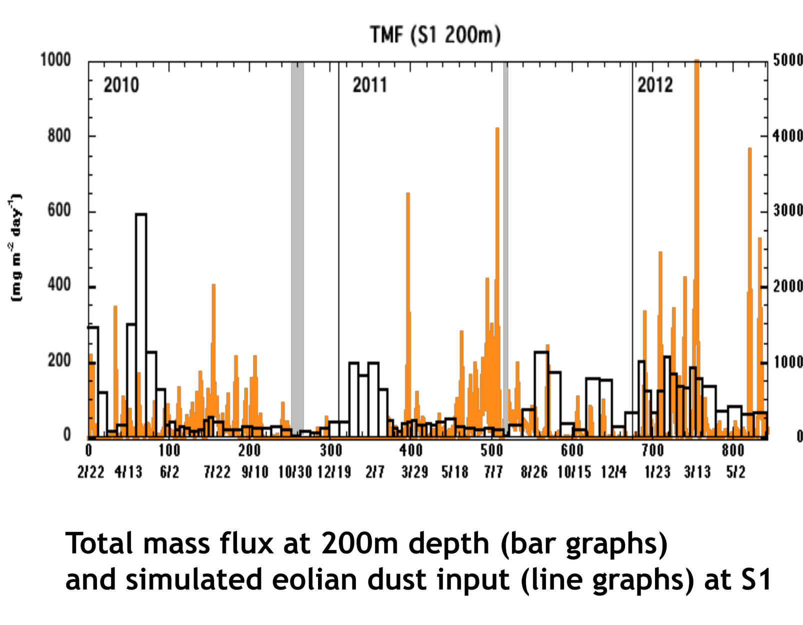
Recently It has been reported that the environmental changes in the ocean such as warming and acidification is ongoing. It is predicted that the oceanic environmental change leads the change in oceanic ecosystem and, sequentially, the change in marine biogeochemical cycle via end-to-end food web. It is possible that, consequentially, the ocean's role in controlling the atmospheric CO_2 will change and its change will affect the global climate significantly. We have conducted the research of interactions between climate variability and changing marine ecosystem dynamics and biogeochemical cycles. In addition to station K2, we established TS station in the western North Pacific subtropical gyre, S1 in 2010. These stations have contrasting oceanic properties and it is suspected that respective oceanography in respective gyre respond differently to the atmospheric / oceanic events such as Asian monsoon, ENSO and the Arctic oscillation. Since 2010, shipboard observation / experiments have been conducted at K2 and S1 to study responses of ecosystem dynamics and biogeochemical cycles to atmospheric and oceanic events in two contrasting oceanographic conditions. Intra-seasonal short-term variability has been studied by visiting the stations with aid of various moored instruments and satellite.

Preliminary results of comparative observation

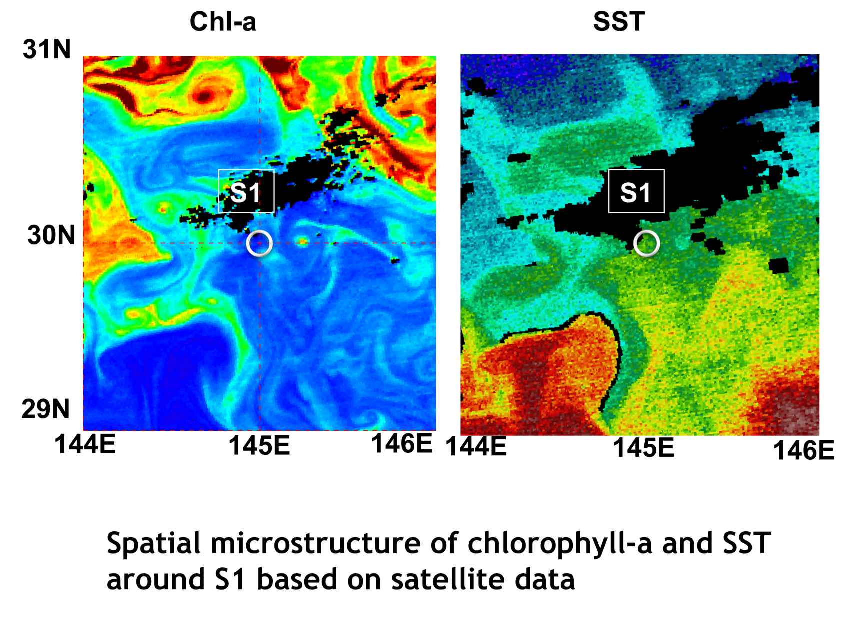
As a result of a few years' time-series observation at K2 and S1, various oceanographic properties have been reconfirmed or newly discovered.
pCO_2 in the sea is higher than that in air in winter and vice versa in summer at station K2. This seasonal variability is attributed to strong surface mixing in winter and high biological activity from late spring to summer. K2 is a weak source of CO_2. On the other hand, S1 is annual sink of atmospheric CO_2. Its seasonal variability is mainly attributed to variability of water temperature.
Nitrate and nutrient at station K2 show the annual maximum in late winter and minimum in autumn. Nutrient is never depleted. Nutrient level at station S1 is low in even in winter and usually a little or depleted in other season.
Primary productivity at station K2 is low in winter and high in late spring or early summer while primary productivity at station S1 is high in February. It is noteworthy that annual mean of primary productivity at station S1 is never little and comparable to that at station K2.
Based on observation, limiting factors of primary productivity at stations K2 and S1 are intensity of Photosynthesis Available Radiation (PAR) and nutrients, respectively. This result throws some lights on what will happen in the ocean and on the earth when climate and oceanographic change occur in future.



Mechanism of nutrients supply at S1 is important issue to be clarified. It has been reported that eolian dusts supply major- and micro-nutrient to the ocean and enhance ocean productivity. We are analyzing the relation between biological pump and eolian dust carefully. In addition, we are also focusing on meso-scale cyclonic eddy. Meso-scale eddy causes upwelling resulting nutrients supply from subsurface layer.



Total mass flux at 200m depth (bar graphs) and simulated eolian dust input (line graphs) at S1



Spatial microstructure of chlorophyll-a and SST around S1 based on satellite data

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Related URL

KNOT / K2 database
<http://www.godac.jamstec.go.jp/k2/>
K2 / S1 project
<http://www.jamstec.go.jp/rigc/e/ebcrp/mbcrt/index.html>