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Seasonal cycle of phytoplankton community structure and photophysiological state in the western subarctic gyre of the North Pacific

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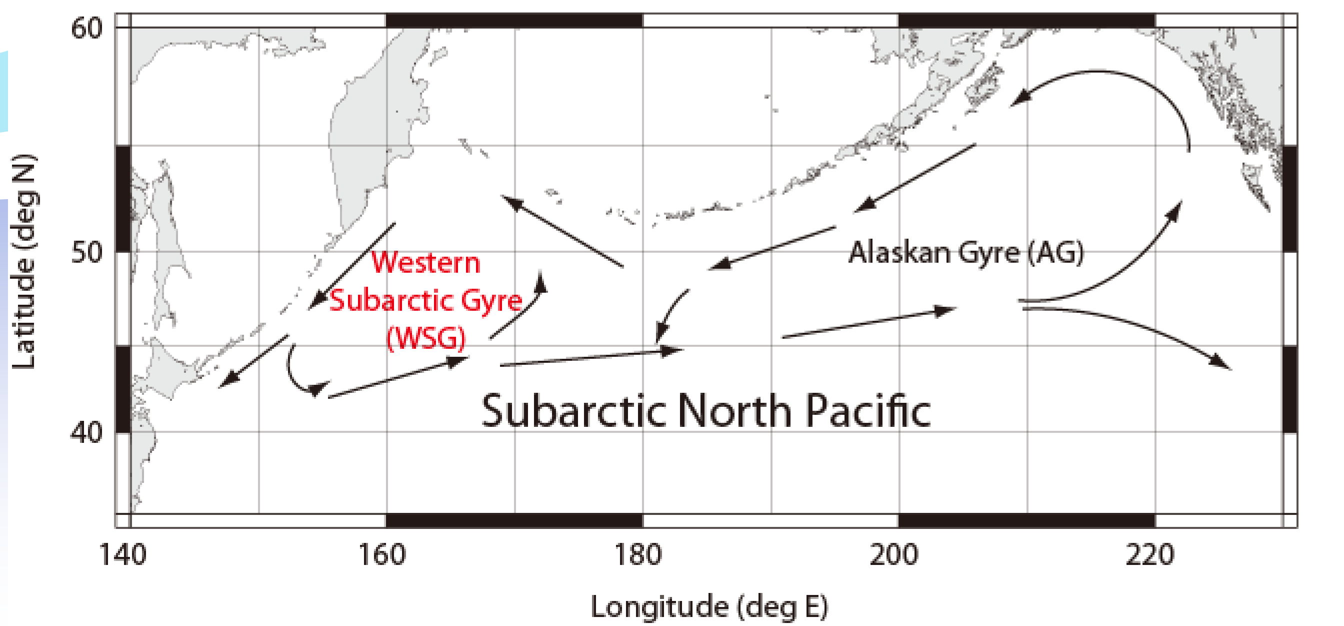
Introduction (1/2)



Subarctic North Pacific: High Nutrient–Low Chlorophyll (HNLC) region

Alaskan Gyre:

Chl *a* concentration is nearly constant throughout the year (Welschmeyer et al. 1993, Wong et al. 1995).

Western Subarctic Gyre:

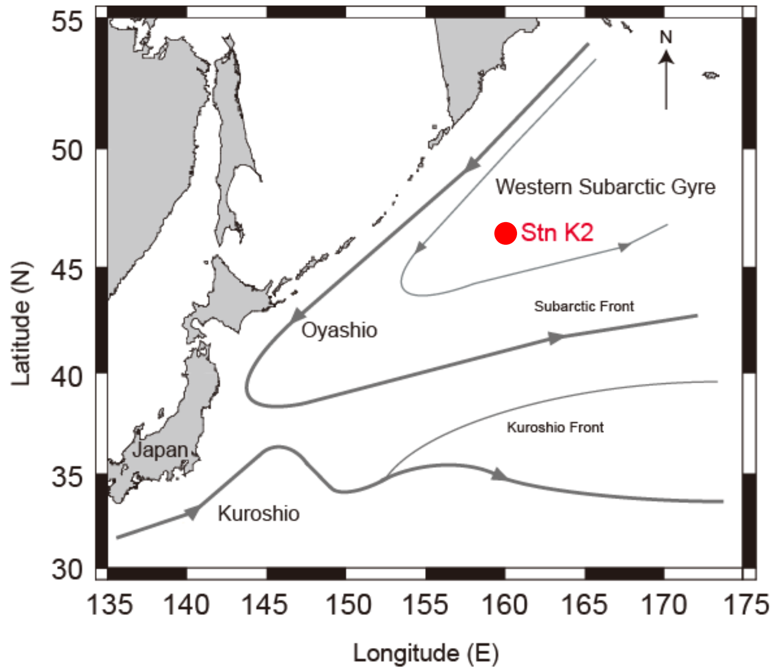
High Chl *a* concentrations (phytoplankton blooms) have been observed from late spring to early summer (Obayashi et al. 2001, Imai et al., 2002).

Introduction (2/2)

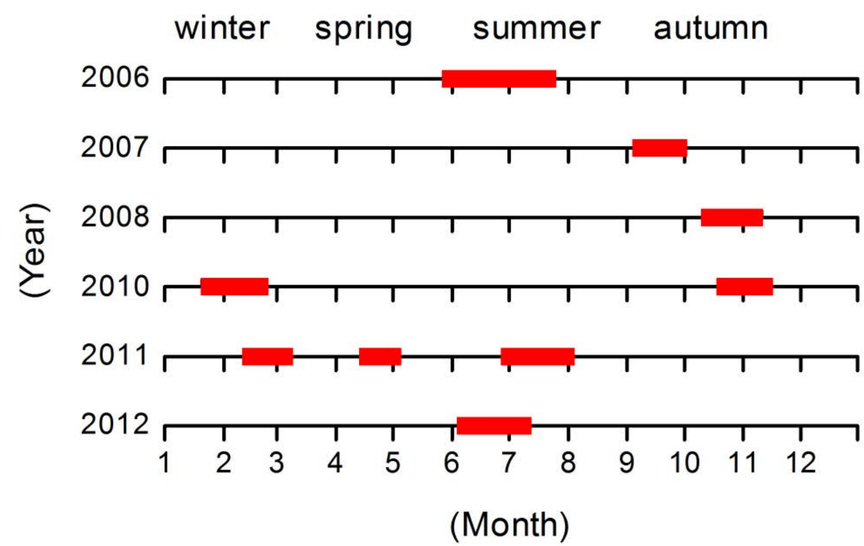
- In the WSG, Honda et al. (2006) used sediment traps and found that sinking particles increased with an increase of surface Chl *a* in spring and summer.
- The seasonal variability of phytoplankton community likely affects the biogeochemical cycles in the WSG.
- However, the phytoplankton composition and its controlling environmental factors are not well understood.

In this study, we examined the seasonal variations in phytoplankton composition and physiological state in the WSG as well as environmental factors.

Observations



Time-series station **K2** (47ºN, 160ºE) in WSG

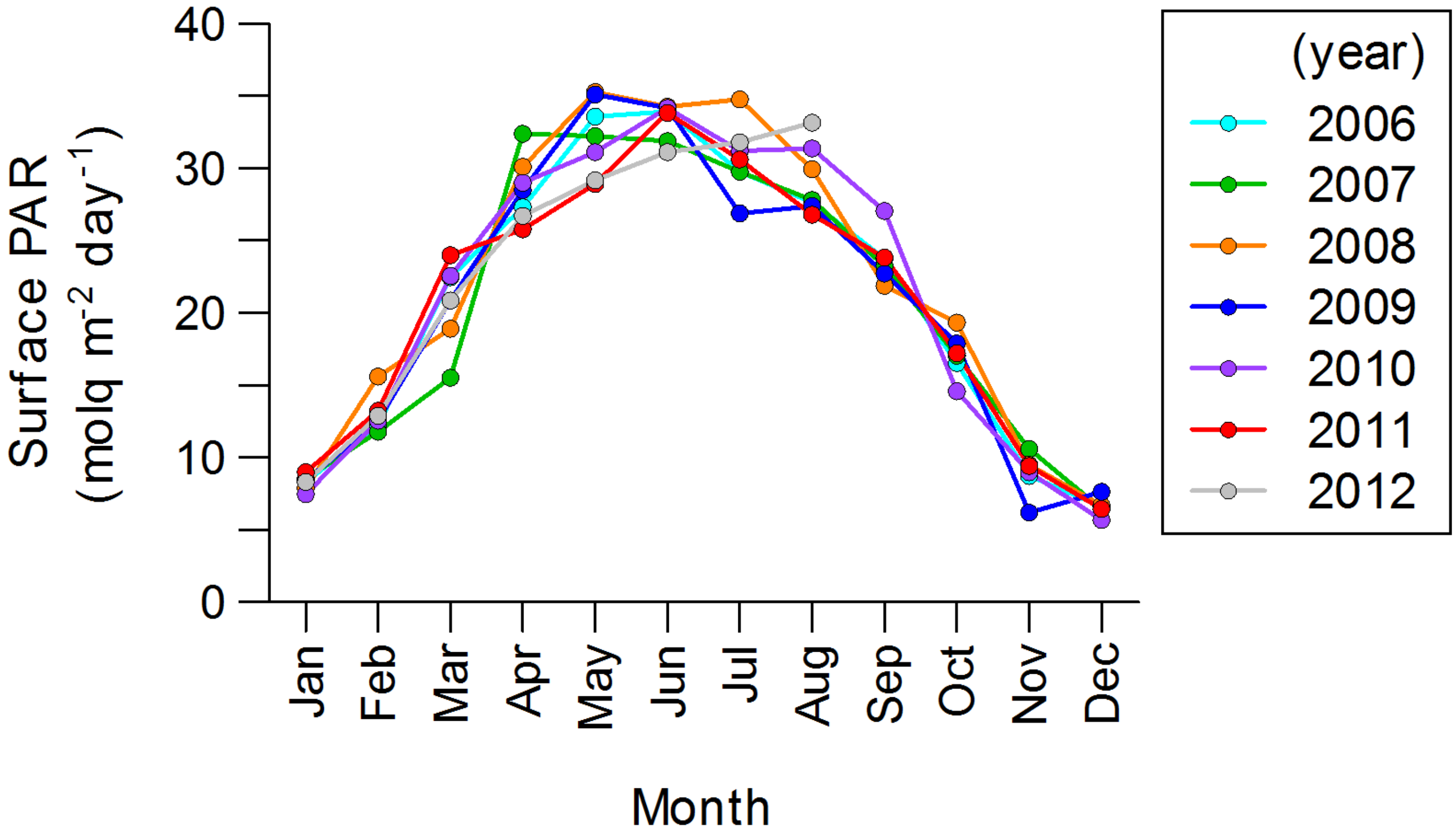


9 cruises of R/V “MIRAI” in the western North Pacific from 2006 to 2012

Measurements:

- Pigment concentrations [HPLC]
- Taxonomic composition [CHEMTAX program (Mackey et al.1997)]
- Physiological state [Fast repetition rate fluorometer (FRRF)]
- Environmental factors [Temperature, Salinity, Irradiance, Nutrients (N, P, Si), etc.]

Monthly mean of sea-surface daily PAR around stn K2

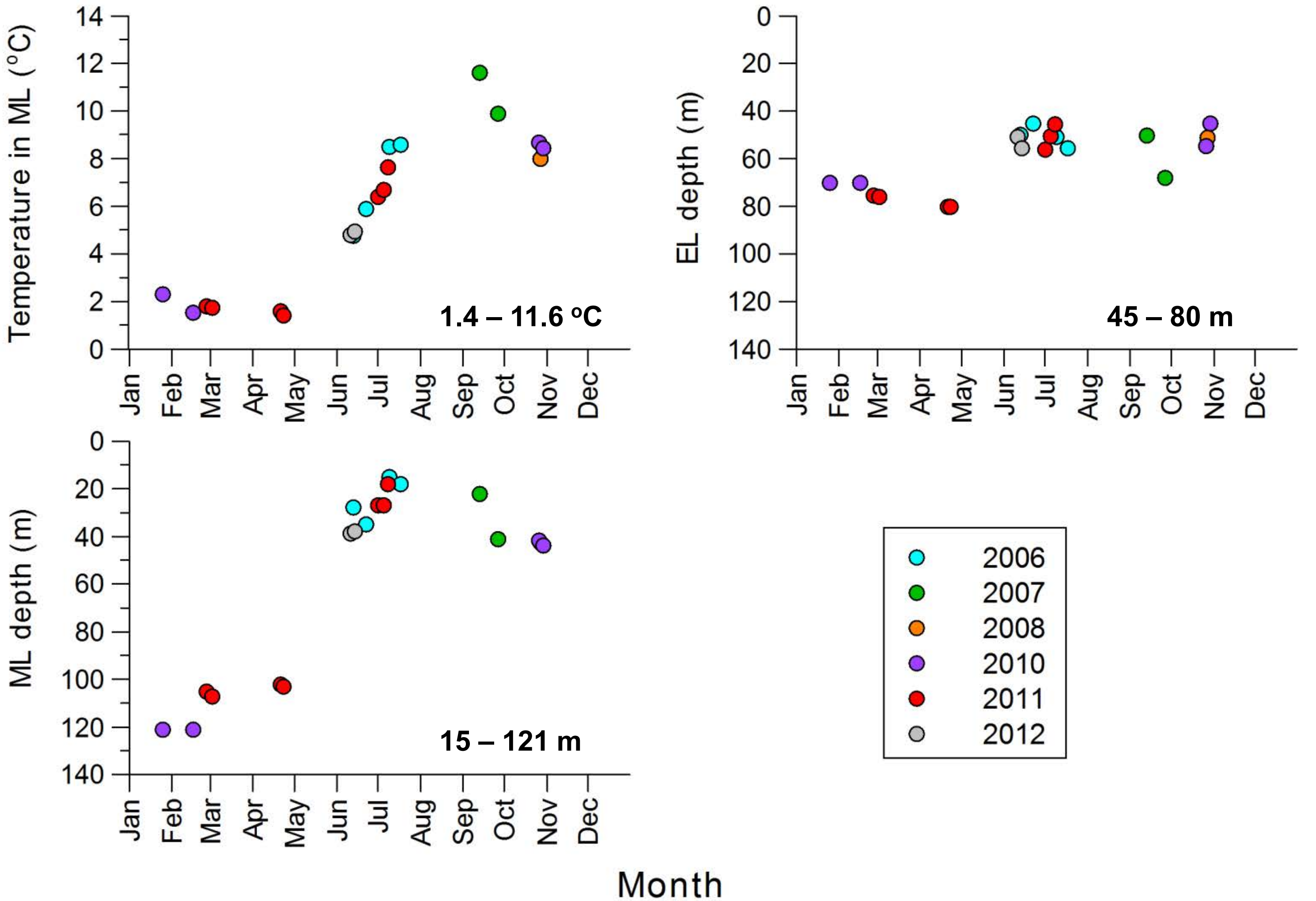


Nov-Jan : 5–10 mol quanta m^{-2} day^{-1}

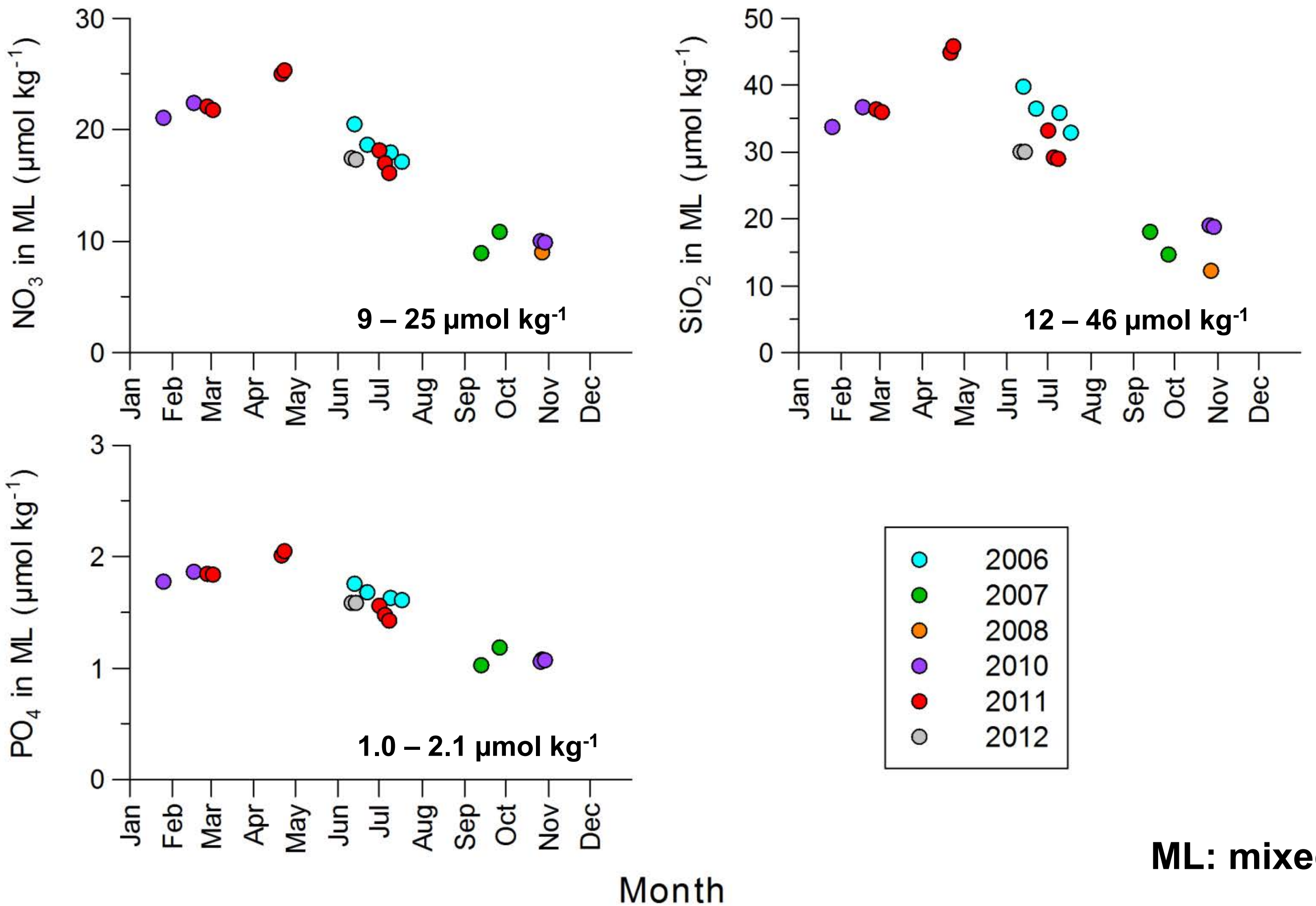
Apr-Aug : >25 mol quanta m^{-2} day^{-1}

(from NASA MODIS satellite images)

Temperature, Mixed layer (ML) & Euphotic layer (EL) depths



Nitrate, Phosphate, Silicate



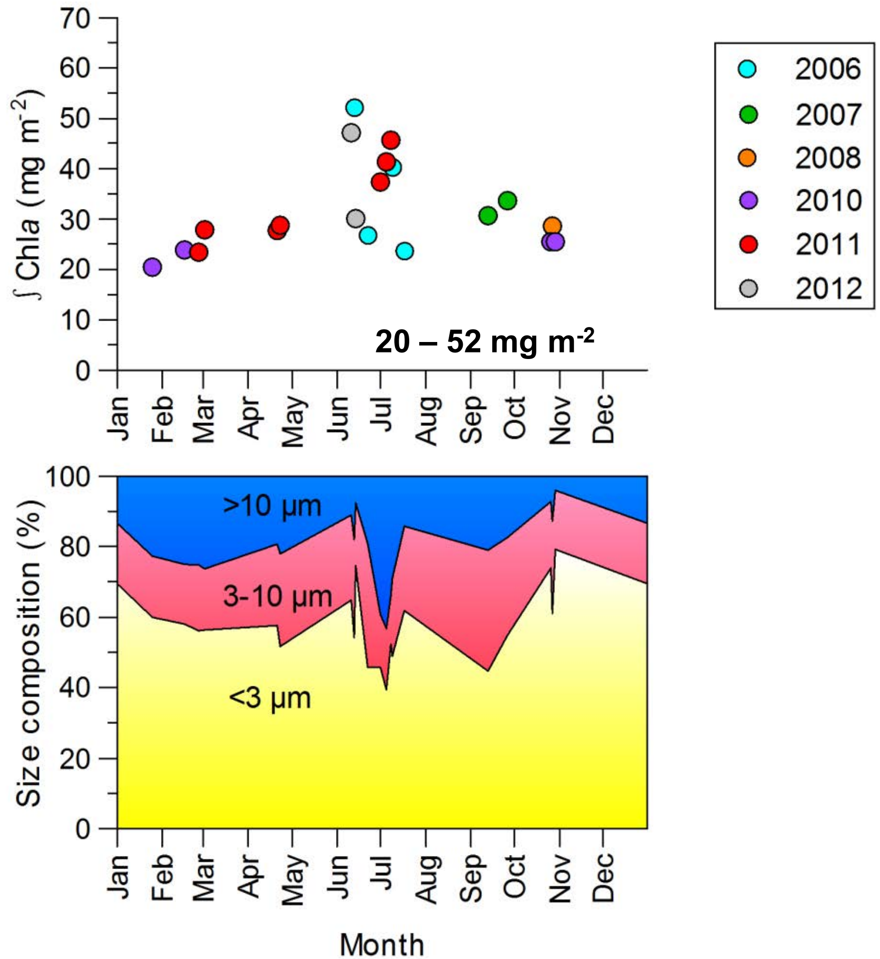
ML: mixed layer

Macronutrients in the ML were not depleted throughout the year.

Chl *a* standing stock & Size composition

Depth-integrated Chl *a*

within the euphotic layer



Relative contribution (%)

of each size fraction to

∫Chla

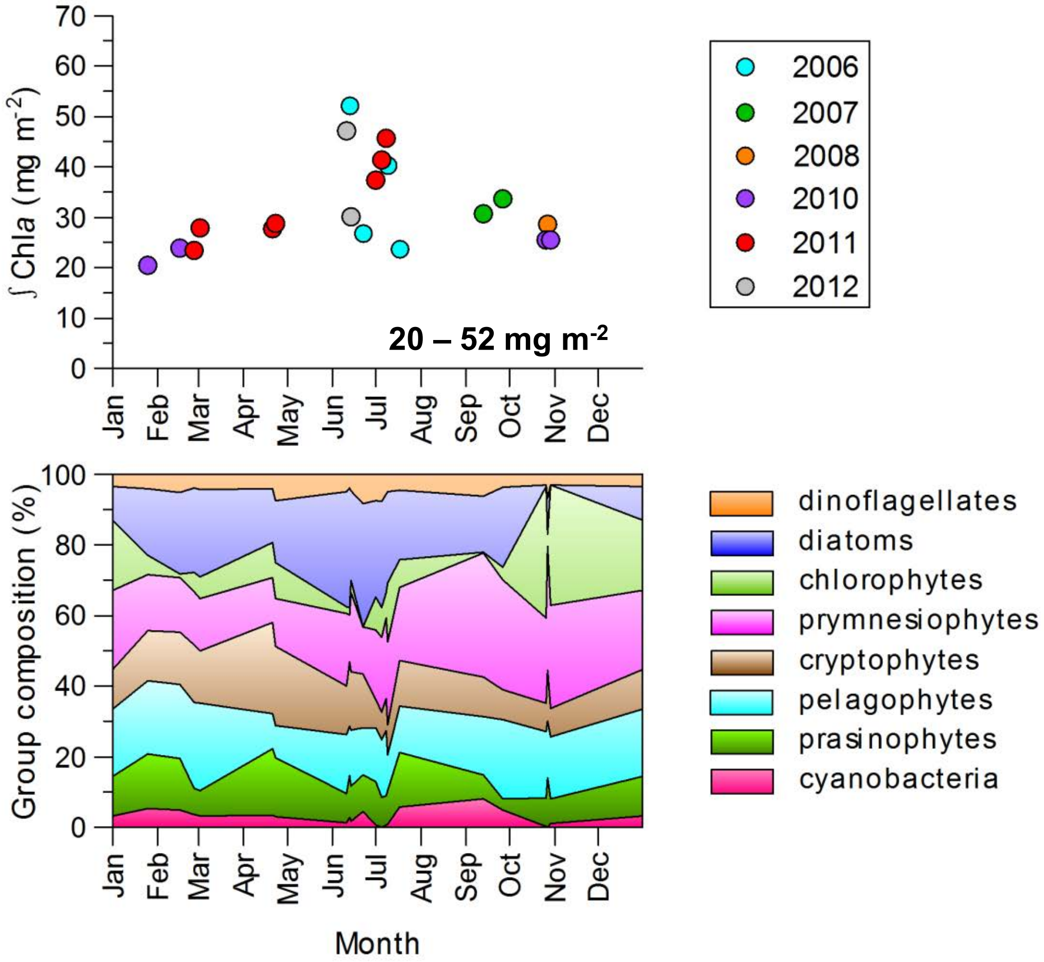
Size composition

<3 µm: 39–79 %, 3–10 µm: 14 –35 %, >10 µm: 4 –43 %

Chl *a* standing stock & Group composition (by CHEMTAX)

Depth-integrated Chl *a* within the euphotic layer

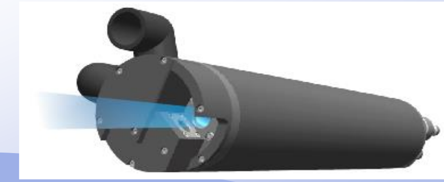
Relative contribution (%) of each phytoplankton group to ∫Chla



Dominant groups

- Prebloom (Jan-Apr) : diatoms, pelagophytes, cryptophytes
- Bloom (Jun-Jul) : diatoms, prymnesiophytes
- Postbloom (Sep-Oct) : prymnesiophytes, chlorophytes

Fast repetition rate fluorometer (FRRF)



The FRRF measures *in vivo* fluorescence related to photosynthesis and can assess the physiological state (e.g., F_v/F_m) of the phytoplankton (Kolber et al. 1998).

F_v/F_m : potential photochemical efficiency (indicator of nutrient stress)

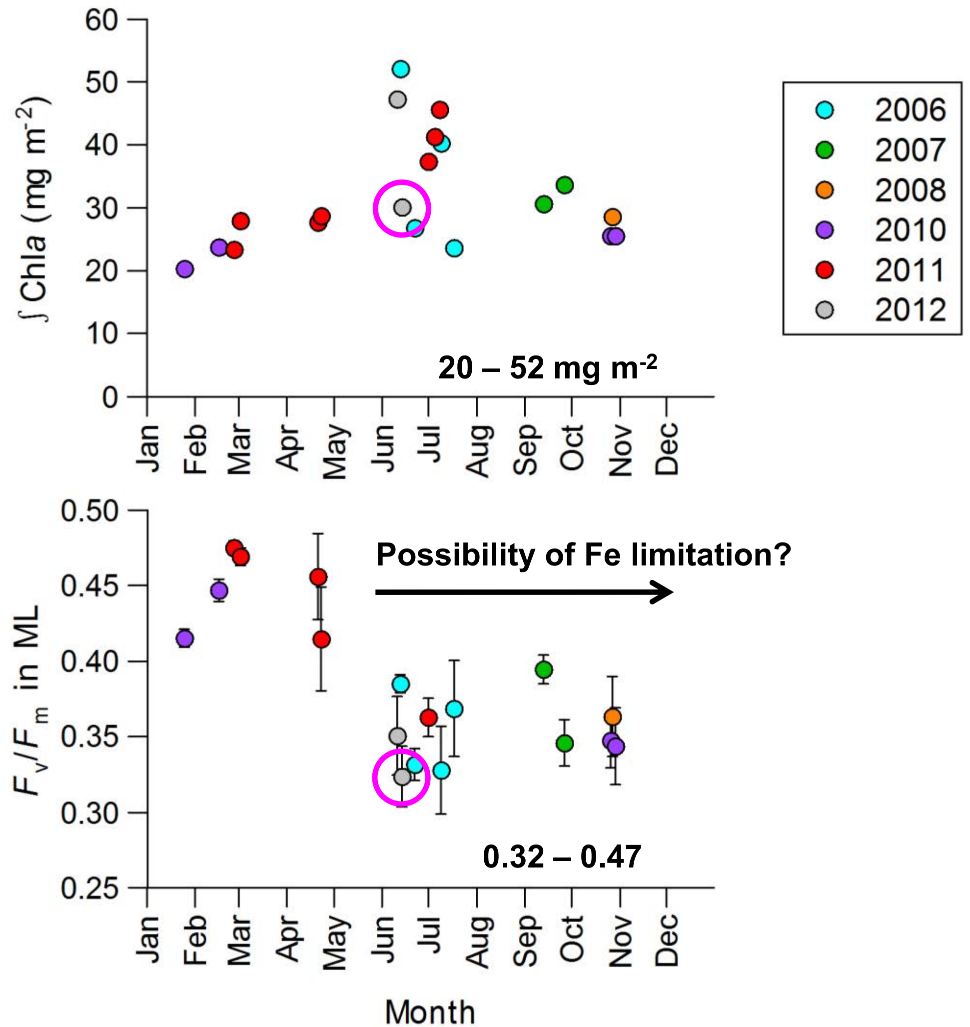
Nutrient-limited		Nutrient-replete
LOW	$\boldsymbol{F_v / F_m}$	**HIGH**

Chl *a* standing stock & F_v/F_m [nighttime] (by FRRF)

Depth-integrated Chl *a* within the euphotic layer

F_v / F_m :

Photochemical efficiency (indicator of nutrient stress)



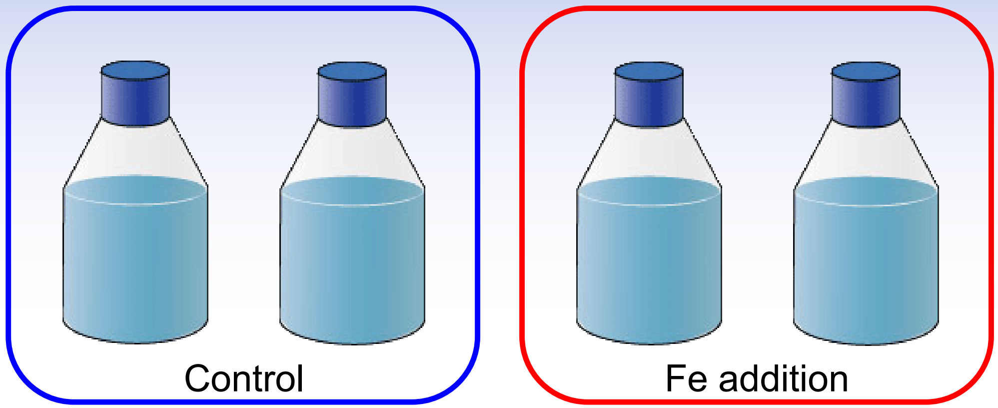
ML: mixed layer

The decrease in F_v/F_m suggests that the phytoplankton growth was limited by nutrients other than macronutrients.

Iron enrichment experiments (Methods)

14 June 2012 (bloom period), 5 m depth

acid-cleaned Niskin-X bottle



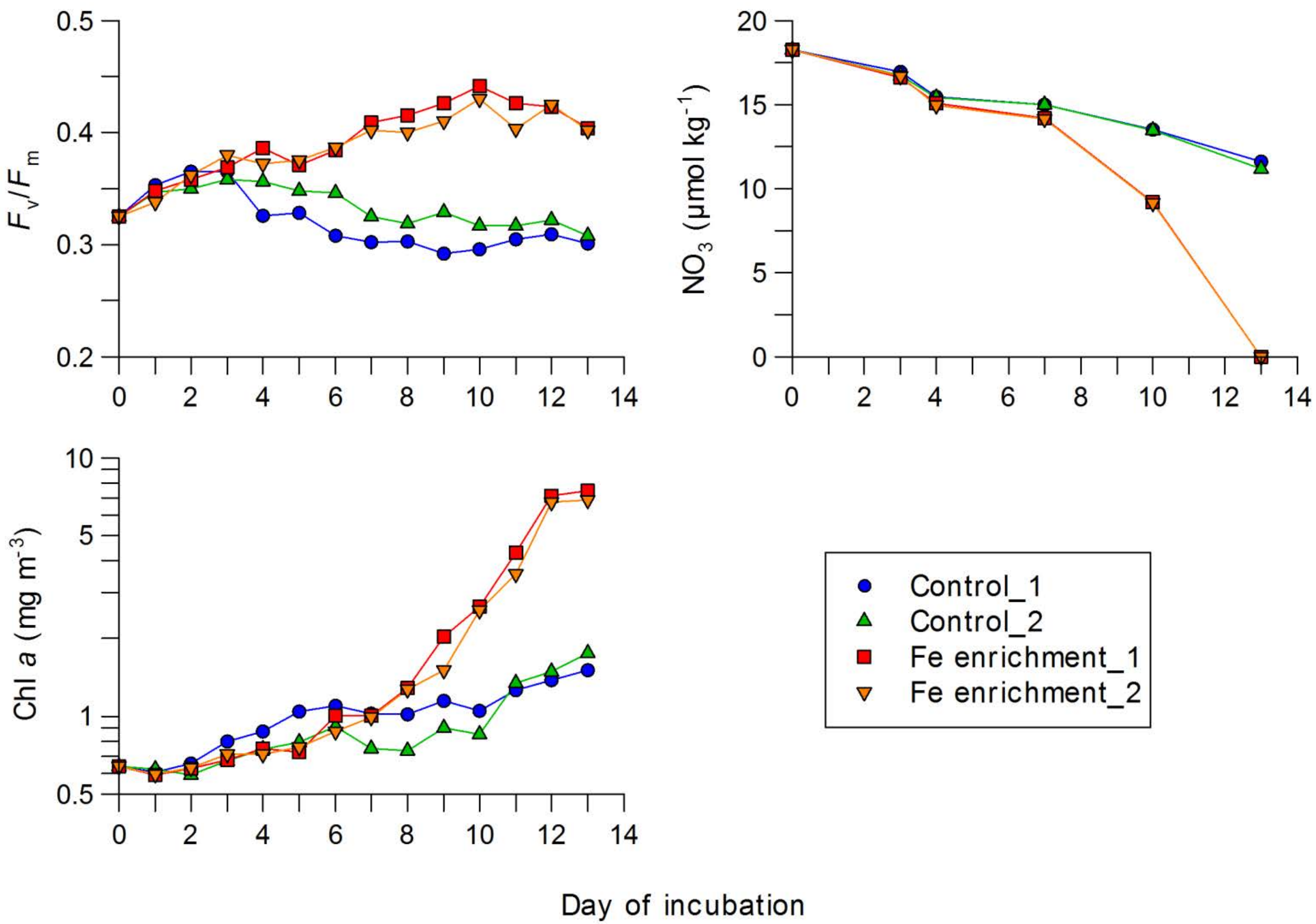
An acidified ferric chloride ($FeCl_3$) solution was spiked to the two bottles to add Fe concentration of 2 nmol L^{-1} (referred to Kudo et al. 2006).

acid-cleaned 1L polycarbonate bottles

Onboard incubator

- Light condition : 150 μmol quanta m^{-2} s^{-1} (14h:10h light/dark cycle)
- Temperature : 5 ^{o}C
- Period : two weeks

Iron enrichment experiments (Results)



The phytoplankton growth had already been limited by iron during the bloom period.

Summary

- ∫ Chl *a* varied seasonally from 20 to 52 mg m^{-2} and increased frequently to > 40 mg m^{-2} in June and July.

- Diatoms (20–35%) and prymnesiophytes (13–23%) comprised major portions of the ∫ Chl *a* during the bloom period. Diatoms decreased to < 23% during the postbloom period, and prymnesiophytes became the most abundant group (24–35%).

- Mean F_v/F_m in the mixed layer were relatively high (0.41–0.47) in winter and early spring, decreased to 0.32–0.39 with bloom development, and remained at low levels in summer and autumn, but macronutrients were not depleted at any time.

- Fe-enrichment experiments stimulated increases of Chl *a* concentrations (from 0.6 to 7.2 mg m^{-3}) and F_v/F_m (from 0.33 to 0.44).

⇩

Seasonal variability of the phytoplankton community in the WSG is controlled mainly by Fe, with light and temperature limitation occurring in winter and early spring.

Fe availability may plays an important role in regulating the magnitude and duration of phytoplankton blooms.

Thank you for your attention !

We thank

- captain and crew of R/V Mirai
- staff of Marine Works Japan for analysis
- J. Onodera, M. Kitamura and A. Tsuda for remarks

R/V “MIRAI” (JAMSTEC)