Supplementary Information for

Photoacclimation by phytoplankton determines the distribution of global subsurface chlorophyll maxima in the ocean

Yoshio Masuda[1,7*], Yasuhiro Yamanaka[1,8], Sherwood Lan Smith[2,7], Takafumi Hirata[3,8], Hideyuki Nakano[4], Akira Oka[5], Hiroshi Sumata[6]

[1]Faculty of Environmental Earth Science, Hokkaido University, Sapporo, Japan

[2]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Japan

[3]Arctic Research Center, Hokkaido University, Sapporo, Japan

[4]Meteorological Research Institute, Tsukuba, Japan

[5]Division of Climate System Research, The University of Tokyo, Kashiwa, Japan

[6]Norwegian Polar Institute, Tromsø, Norway

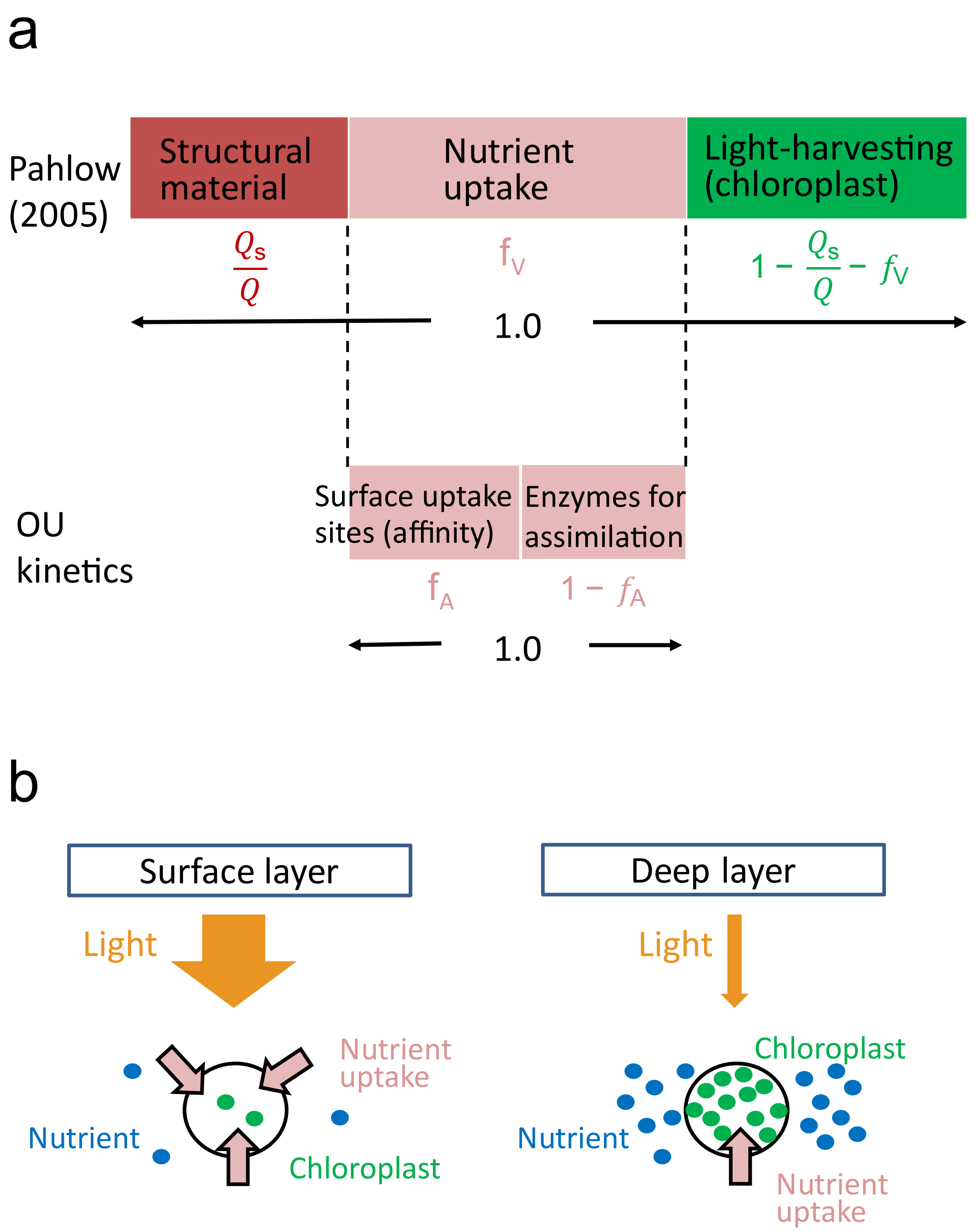
[7]These authors contributed equally: Yoshio Masuda, Sherwood Lan Smith

[8]These authors jointly supervised this work: Yasuhiro Yamanaka, Takafumi Hirata

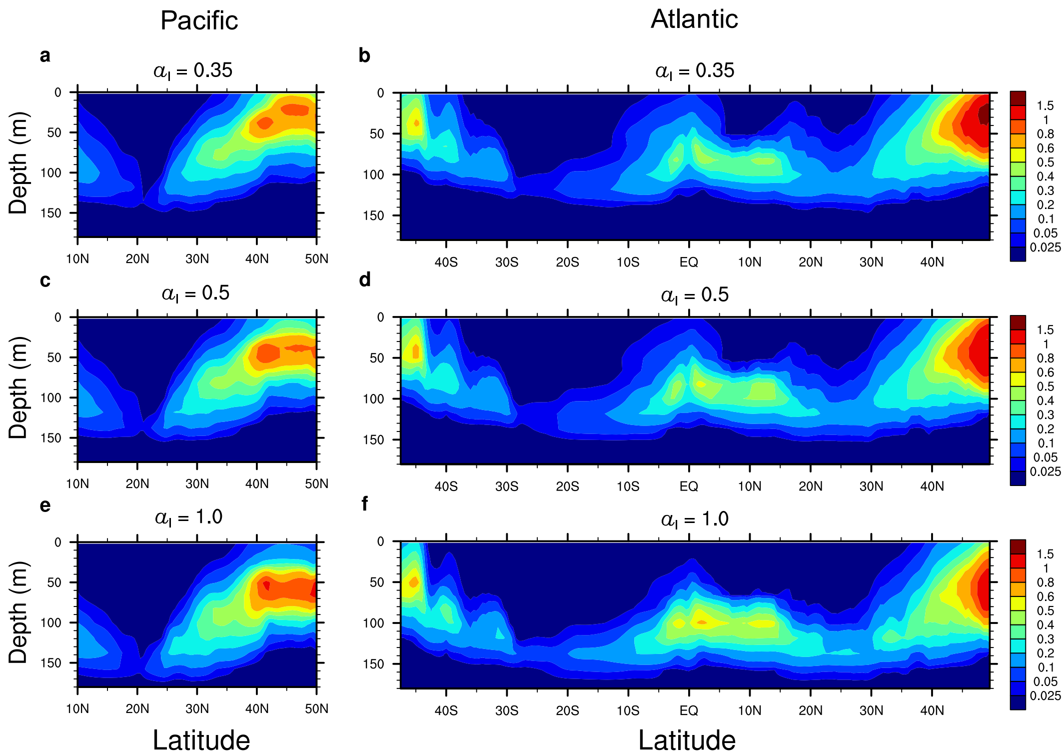
[*]y-masuda@ees.hokudai.ac.jp

Supplementary Table 1. Symbol definitions and values of biological parameters

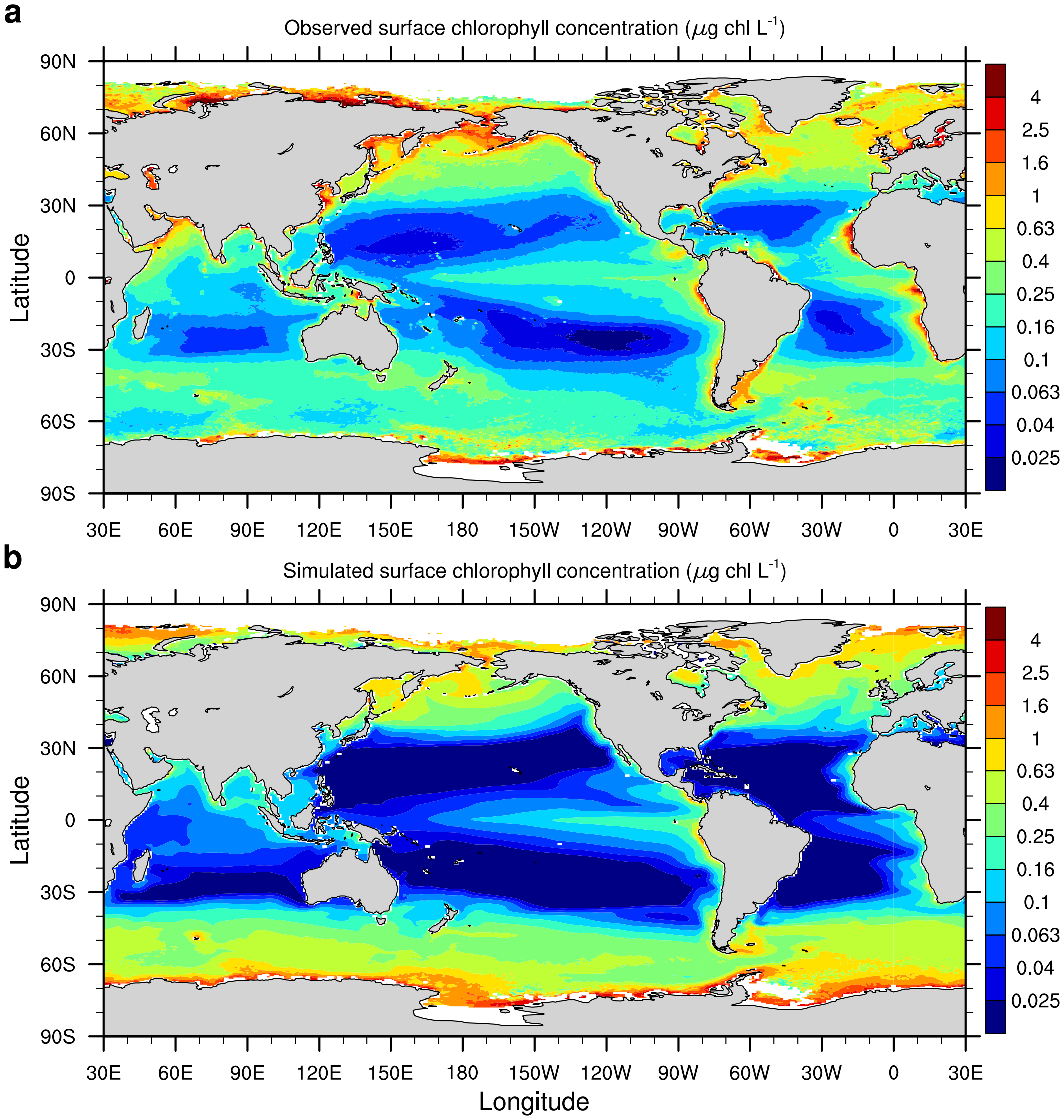
Symbols	Description	Value	Units
	Phytoplankton		
$\hat{A}_0$	maximum value of affinity	0.045	m^3 (mmol C)$^{-1}$ day^{-1}
a_I	chlorophyll-specific initial slope of growth versus irradiance	0.35	m^2 E^{-1} mol C (g chl)$^{-1}$
f_A	fractional resource allocation to affinity	var	non-dim
f_A^o	optimal f_A	var	non-dim
f_V	fractional resource allocation to nutrient uptake	var	non-dim
f_V^o	optimal f_V	var	non-dim
γ_{ex}	coefficient of extracellular excretion	0.135	non-dim
k_{Fe}	half saturation constant for iron	0.11×10^{-6}	mol Fe m^{-3}
M_p	mortality rate coefficient	0.03	m^3 (mmol N)$^{-1}$ day^{-1}
μ	growth rate per unit carbon biomass	var	day^{-1}
$\hat{\mu}^I$	potential carbon fixation rate per unit carbon biomass	var	day^{-1}
$\hat{\mu}_0$	maximum carbon fixation rate	2.86	day^{-1}
$\hat{\mu}_0^{limFe}$	product of $\hat{\mu}_0$ and iron limitation	var	day^{-1}
μ_N	growth rate per unit nitrogen biomass	var	day^{-1}
Q	nitrogen cell quota	var	mol N mol C^{-1}
Q^o	optimal Q	var	mol N mol C^{-1}
Q_s	structural cell quota	0.028	mol N mol C^{-1}
R_M^{chl}	loss rate of chlorophyll	0.1	day^{-1}
Θ^o	optimal celluar chl:phyC	var	g chl (mol C)$^{-1}$
$\hat{\Theta}^o$	optimal chloroplast chl:phyC	var	g chl (mol C)$^{-1}$
$\hat{V}^N$	potential nitrogen uptake rate per unit carbon biomass	var	mol N mol C^{-1} day^{-1}
$\hat{V}_0$	maximum nitrogen uptake rate	4.67	mol N mol C^{-1} day^{-1}
ζ^{chl}	respiratory cost of photosynthesis	0.8	mol C (g chl)$^{-1}$
ζ^N	respiratory cost of assimilating inorganic nitrogen	0.6	mol C mol N^{-1}
	Zooplankton		
a_H	parameter controlling Holling-type grazing	1.7	non-dim
G_{20deg}	maximum grazing rate at 20 ºC	0.8	day^{-1}
k_H	grazing coefficient in Holling-type grazing	0.5	mmolN m^{-3}



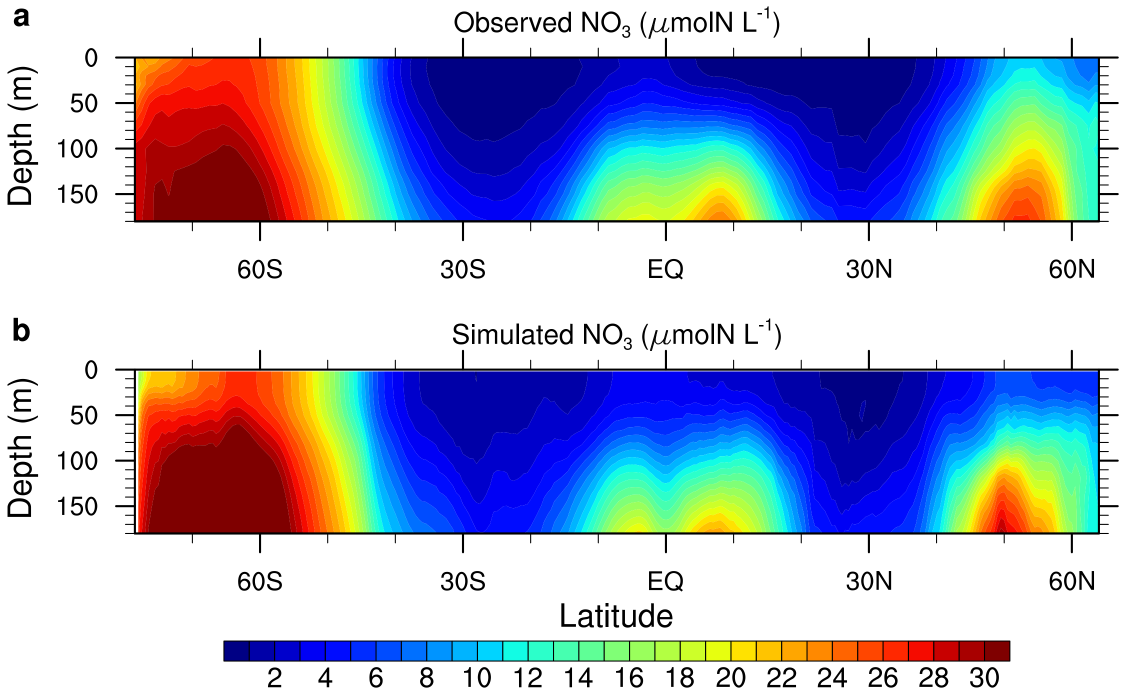
Supplementary Fig. 1. Schematic diagram of resource allocation. a, Resource allocation in the FlexPFT model[1], which combines the models of Pahlow (2005)[2] and Optimal Uptake (OU) kinetics[3]. The variable Q is the nitrogen cell quota, the cellular nitrogen to carbon ratio (mol N mol C^{-1}), and the fixed parameter Q_s is the structural cell quota (mol N mol C^{-1}). The non-dimensional variables f_V, and f_A are the fractional resource allocations to chloroplast and affinity, respectively. Optimal Q, f_V, and f_A, which maximize the phytoplankton growth rate, are uniquely determined depending on light, nutrient, and temperature conditions. **b**, Differences in resource allocation strategy between typical cases in surface and deep layers.



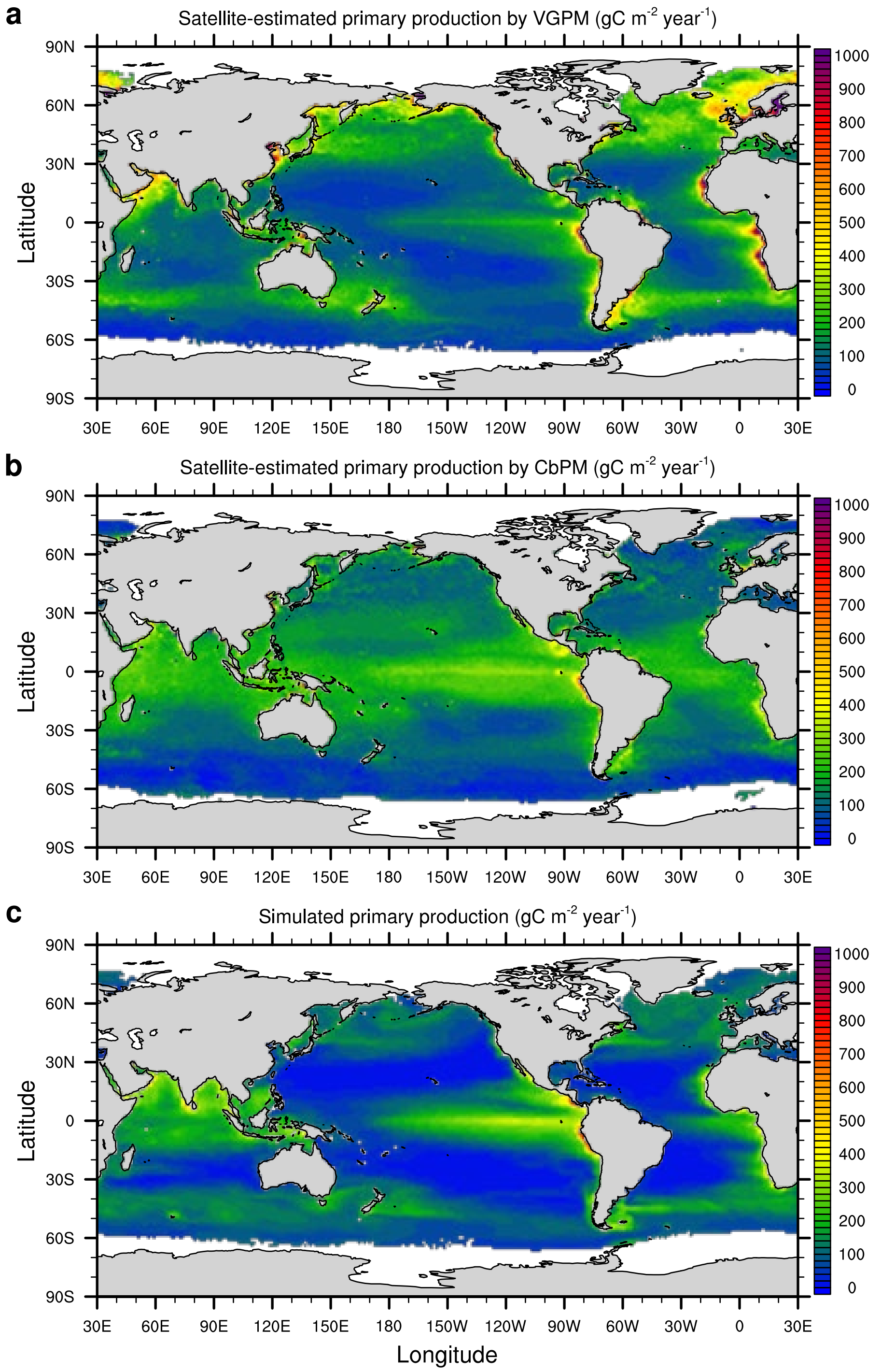
Supplementary Fig. 2. Effects of the chlorophyll-specific initial slope of growth versus irradiance, a_I, on the chlorophyll distributions along the North Pacific (160 ºE) and the Atlantic sectors (AMT 14). a, **b**, Same as Fig. 1c and d in the standard case with a_I of 0.35 m^2 E^{-1} mol C (g chl)$^{-1}$. **c-f**, Same as (**a**) and (**b**), but for the case studies with a_I of 0.5 (**c**), (**d**) and 1.0 (**e**), (**f**) m^2 E^{-1} mol C (g chl)$^{-1}$, respectively.



Supplementary Fig. 3. Surface chlorophyll distributions averaged from 1998 to 2004. a, Satellite observed distribution. **b**, simulated distribution. High latitude satellite data are available only in summer, and therefore simulated monthly data are omitted at any grid point where satellite data are missing. The surface observed chlorophyll data is the products by the Ocean-Colour Climate Change Initiative (https://www.oceancolour.org).



Supplementary Fig. 4. (a) Meridional distributions of the zonal mean of nitrate (NO_3) concentration. a, Annual mean in World Ocean Database 2009[4] **b**, Annual mean in the simulated last year (2004).



Supplementary Fig. 5. Distributions of primary production integrated in depth in 2004. a, **b**, Satellite-estimated distributions by the Vertically Generalized Production Model (VGPM)[5] (**a**) and Carbon-based Production Model (CbPM)[6] (**b**). **c**, Simulated distribution. Satellite-estimated data are omitted at any grid point where data are obtained for less than 6 months. Simulated data are omitted at any grid point where VGPM data are omitted. The satellite-estimated primary production data are obtained in http://sites.science.oregonstate.edu/ocean.productivity/index.php.

Supplementary references

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