Impacts of atmospheric deposition on phytoplankton community structure in the Yellow Sea

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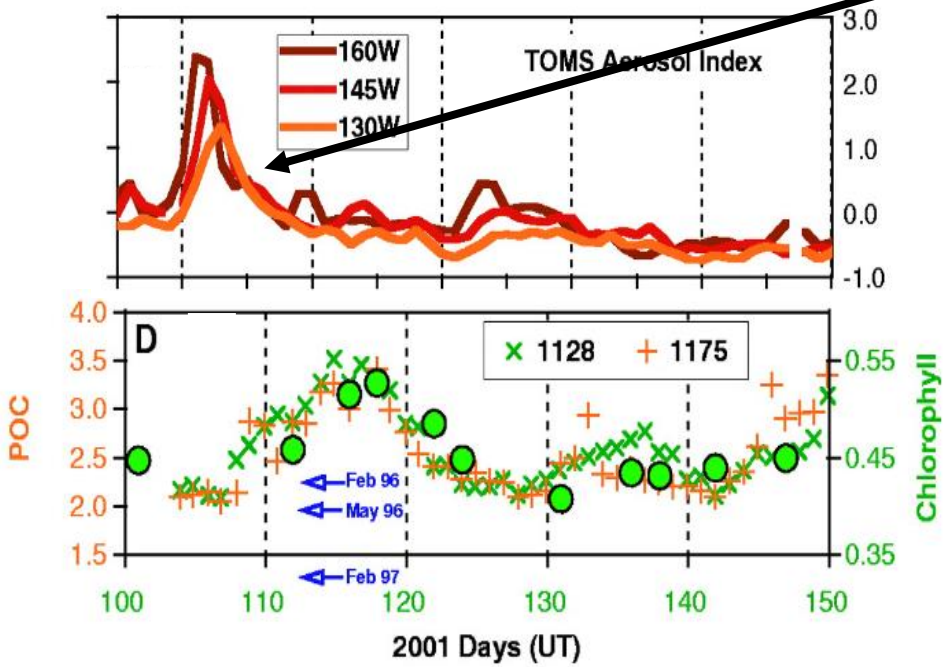
Influence on Chl *a*

Dust storm event

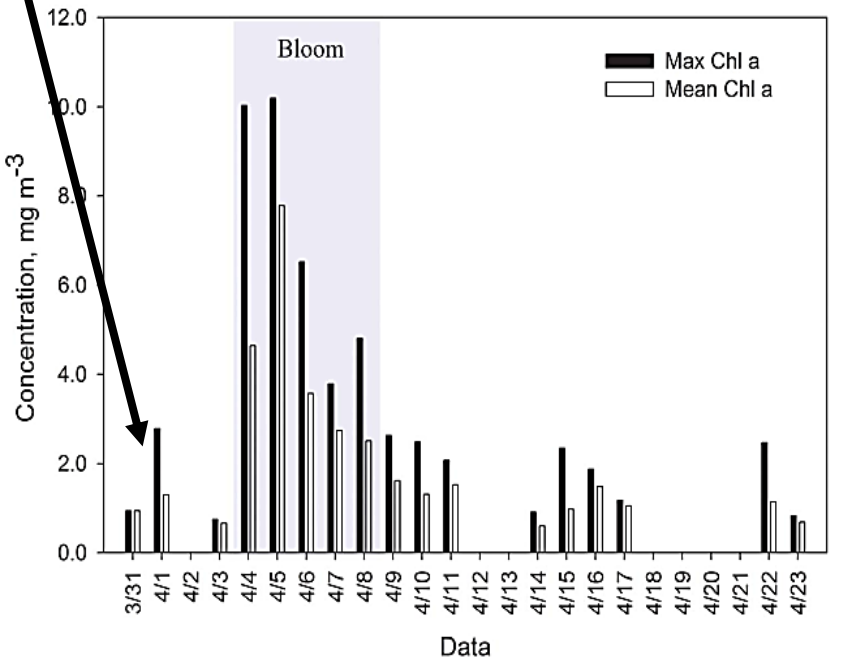
Subarctic Pacific



Changes in TOMS aerosol index, POC and Chl *a*.

Bishop et al., *Science*, 2002

Middle Yellow Sea

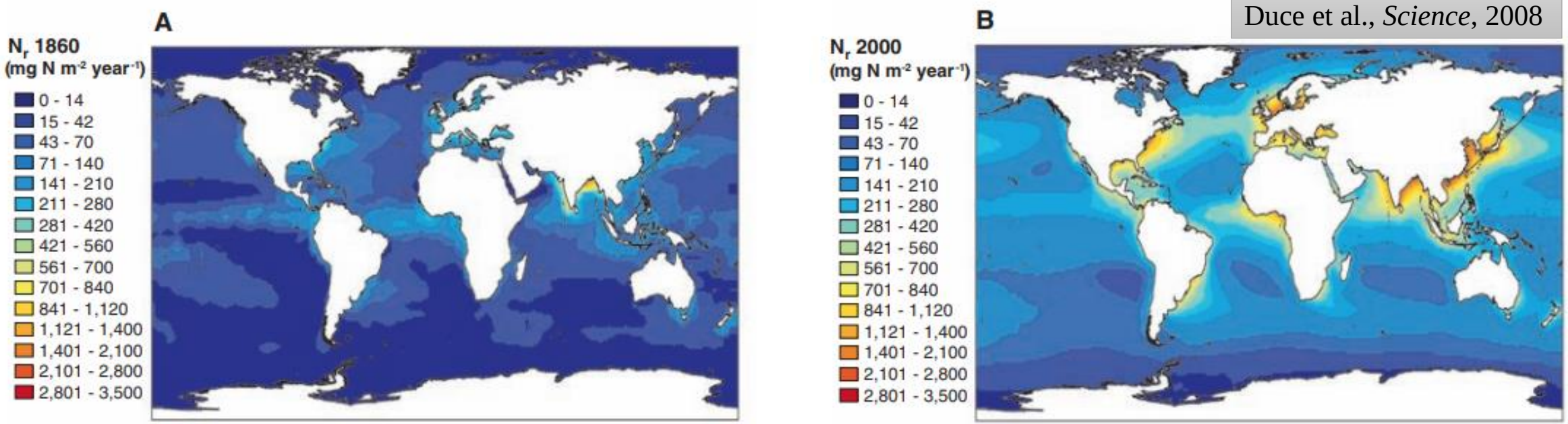


Changes in Chl *a*.

Shi et al., *JGR*, 2012

Atmospheric deposition significantly affect the marine primary production.

Atmospheric deposition



Duce et al., *Science*, 2008

Fig. 1 Total atmospheric reactive nitrogen (Nr) deposition in 1860 and 2000.

- Total atmospheric reactive nitrogen (Nr) deposition in 2000 was 2 times higher than 1860.
- Atmospheric deposition is an important source of **nutrients** for surface and upper ocean.

Atmospheric deposition in East Sea

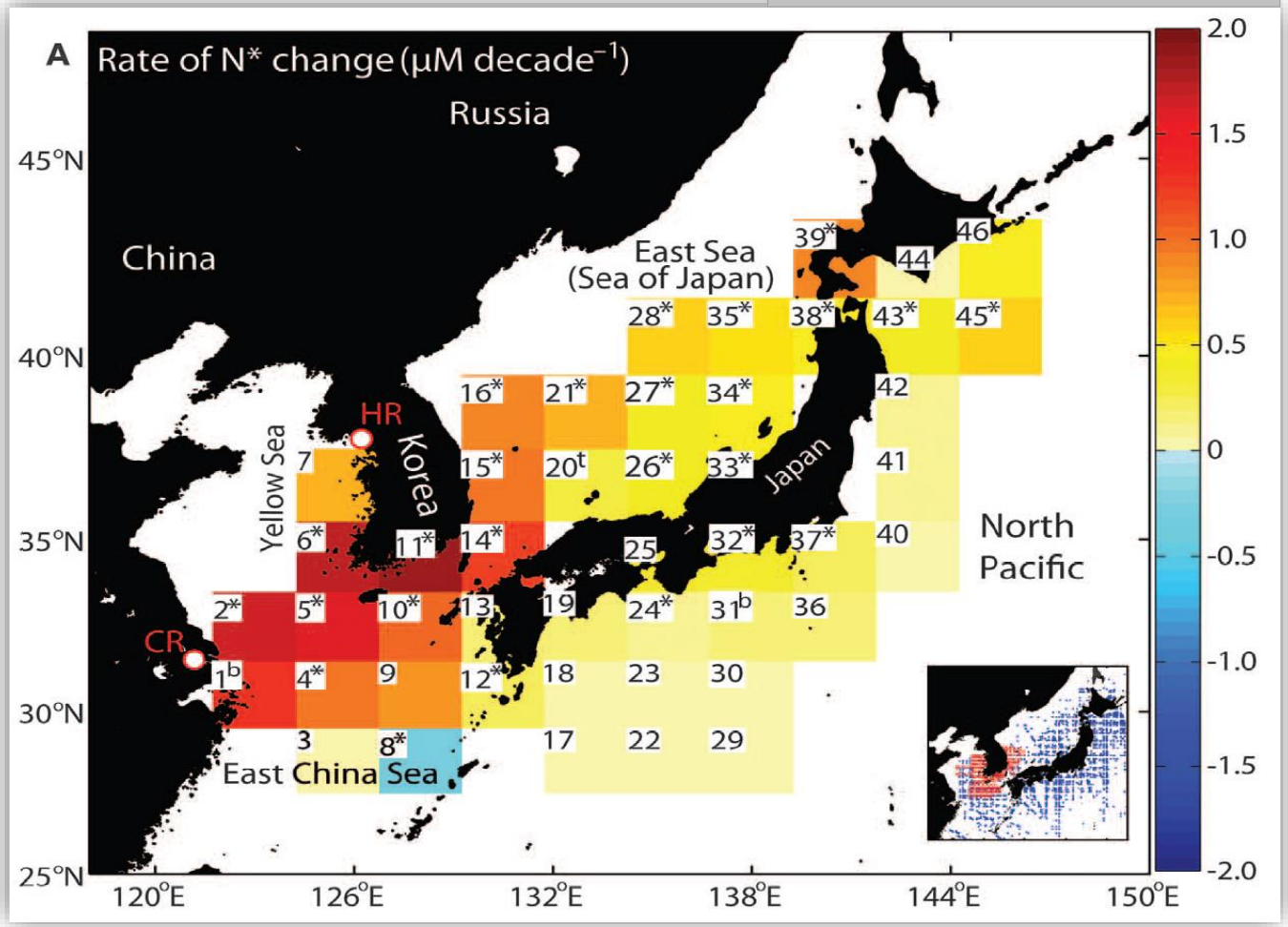
- The concentration of **nitrogen** (N) in east Asia has increased significantly in recent years.
- The **ecological effects** caused by atmospheric deposition need to be further evaluated and confirmed.

Estimated budget for DIN and phosphorus

Species	DIN	Phosphorus
Riverine input	42	25
Atmospheric deposition	58	75

Zhang et al., *JGR*, 1999

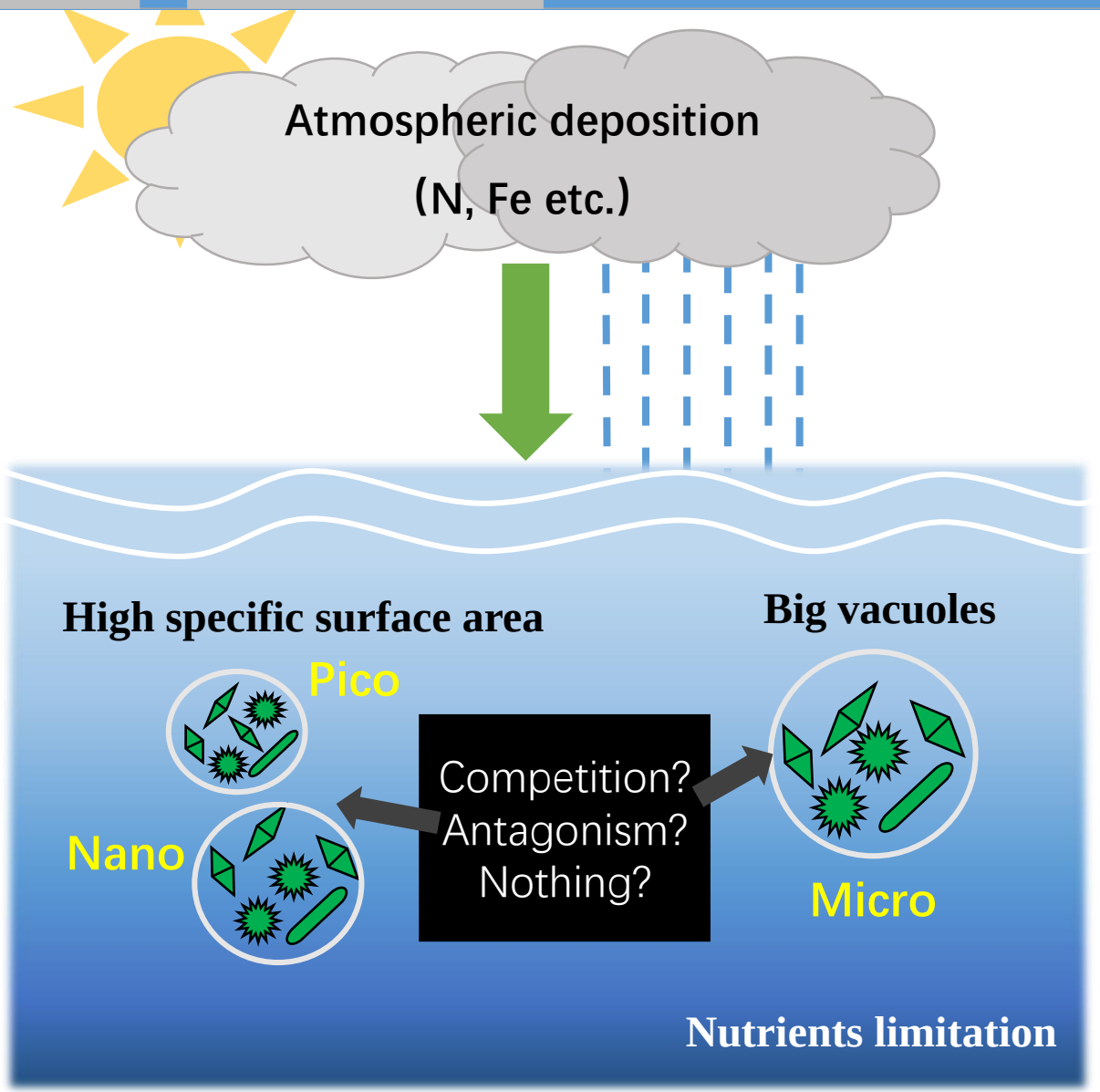
Kim et al., *Science*, 2011



Changes in N* rate. (N* =N-16P)

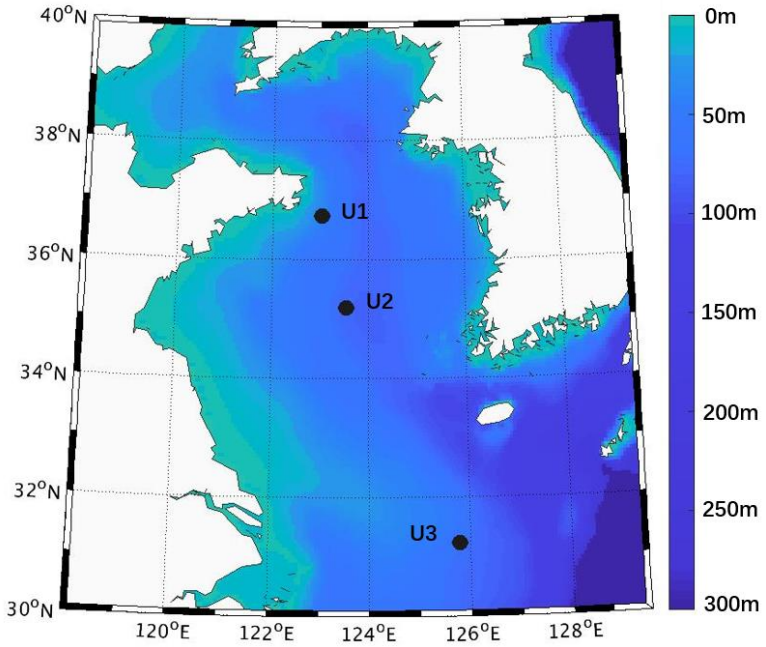
Objective

- Illustrate the impacts of **aerosol particles** on the shift of phytoplankton size structure.
- Explore the role of **micro-sized** phytoplankton in affecting the shift of phytoplankton size structure.

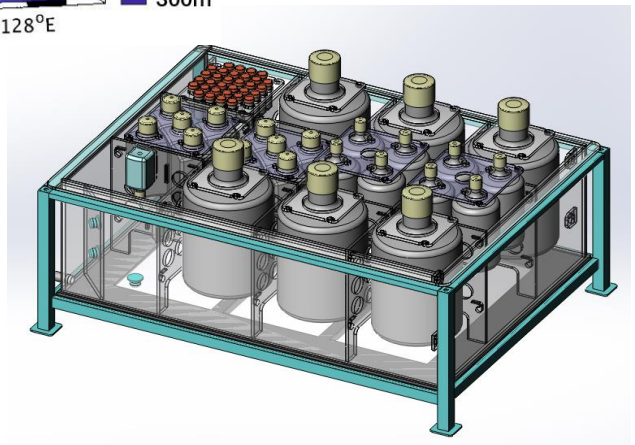


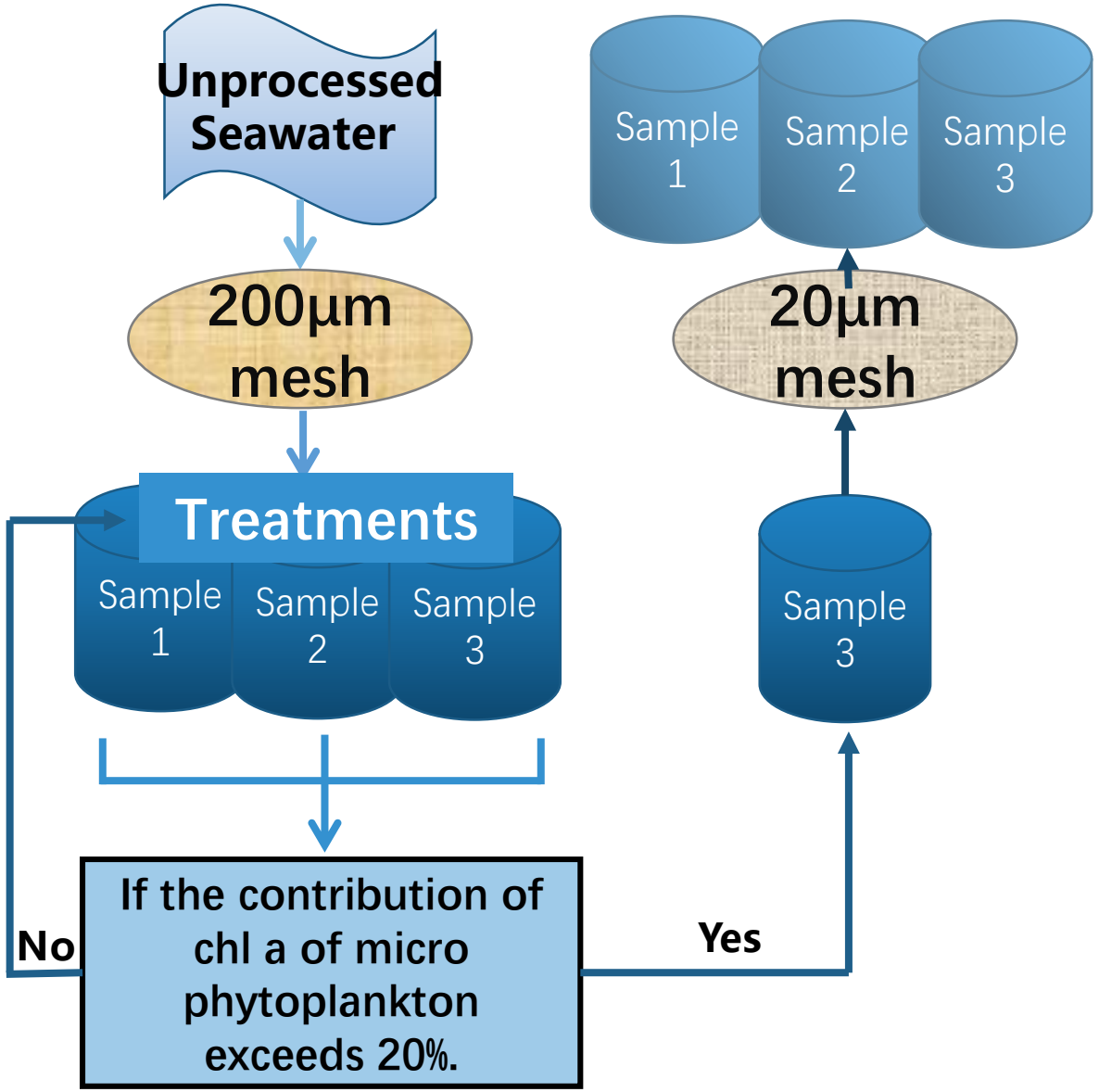
Factor that infiuences phytoplankton size structure.

On-board incubation experiments



Surface and subsurface layers.





Fili treatment procedure.

Aerosol sampling

Air quality conditions during aerosol sampling

Date	AQI	$PM_{2.5}$	PM_{10}	Humidity (%)	Visibility (Km)
2019.6.30	72	43	94	75	9.67

Laoshan compus.

- The aerosol samples used in this study was collected in the **Laoshan compus of Ocean University of China** (36°9′39″ N, 120°29′29″ E).

Treatments

Adding scheme

Sites	Additions*	Amended concentrations** (µmol L^{-1})
U1	Control	None
	Aerosol (N)	2
	N	2
	N+P	2 +0.2
U2	Control	None
	Aerosol (N)	1.7
	N	2
	N+P	2 +0.2
U3	Control	None
	Aerosol (N)	1
	N	1
	N+P	1+0.2

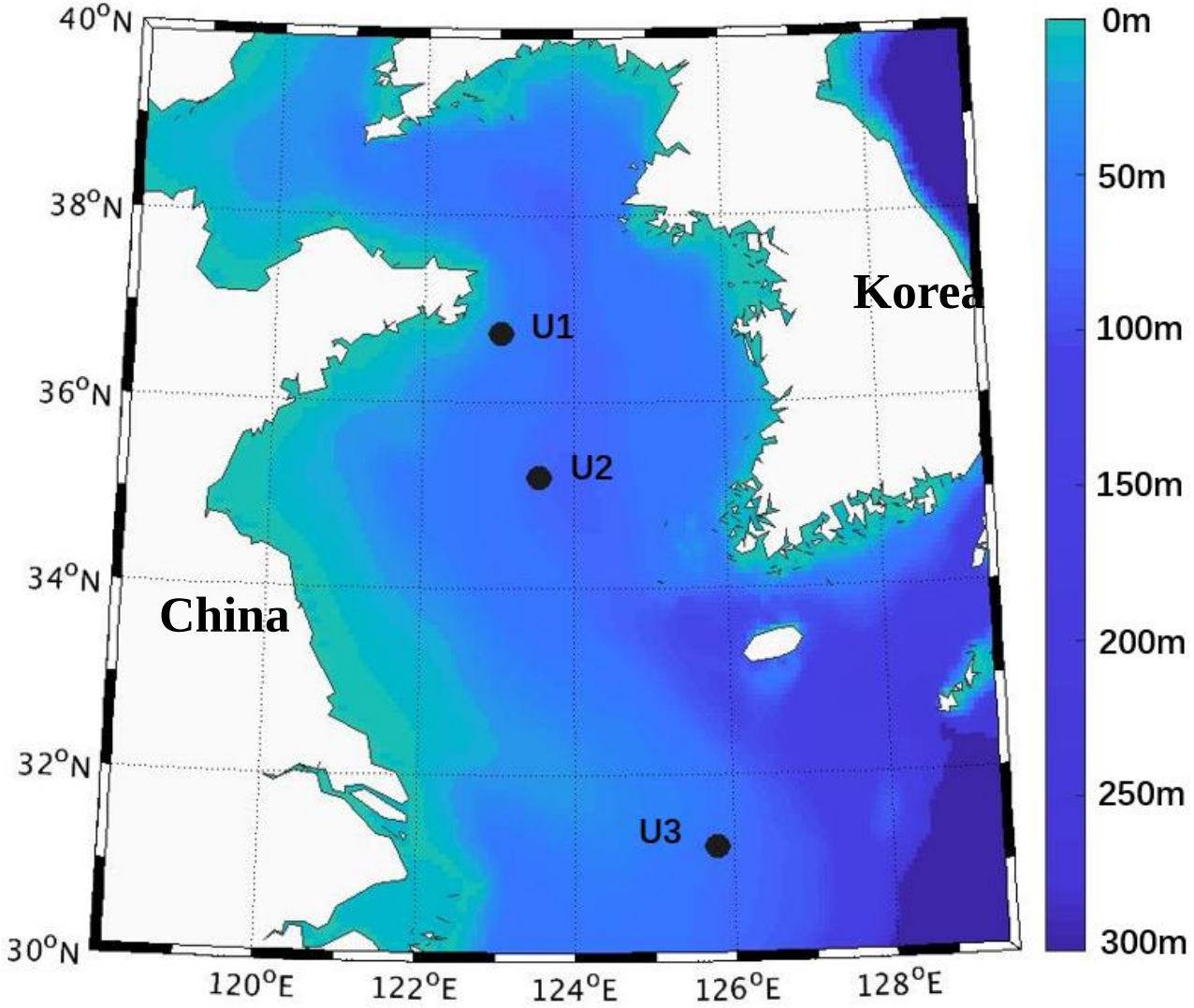
Chl a- Trilogy fluorometer (Turner Designs)- Characterize biomass and size structure.

Nutrients- QuAAtro continuous-flow analyser (SEAL Analytical)- Nitrate + Nitrite (N+N), Phosphate and Silicate.

APA (Alkaline phosphatase activity) - Trilogy fluorometer (Turner Designs) - Assess the consumption velocity of DOP (dissolved organic phosphorus).

Phytoplankton Community – Analysis using high-throughput sequencing.

Incubation stations

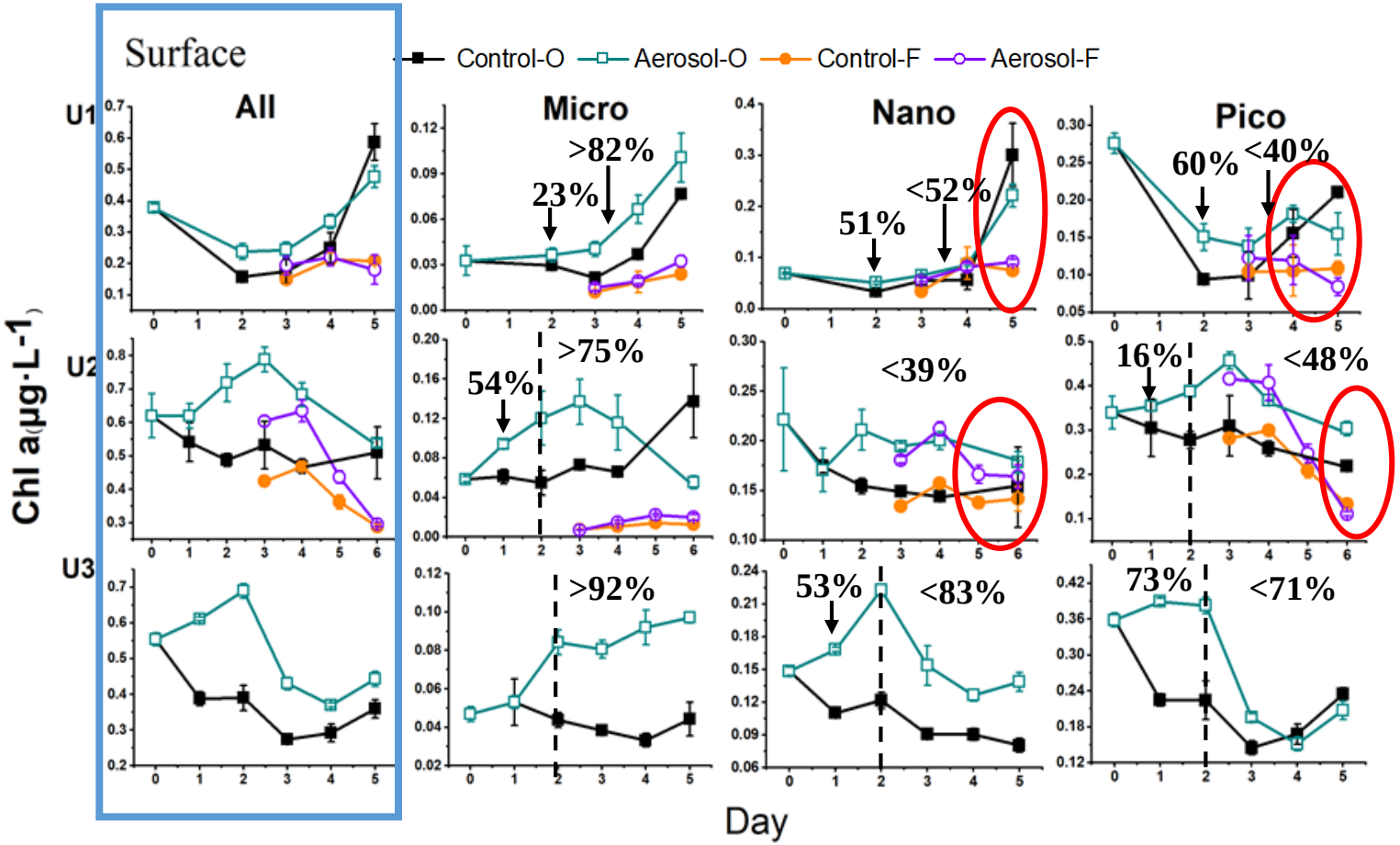


Maps of incubation stations.

Background conditions.

Site	U1		U2		U3	
Incubation time (2019)	8.16-8.21		8.22-8.28		9.3-9.8	
Water layer	Surface	Sub	Surface	Sub	Surface	Sub
Water depth (m)	3	19	3	29	3	34
Temperature (℃)	24.2	18.0	27.7	20.3	28.6	26.7
Salinity	31.5	31.8	30.2	32.6	31.4	32.8
NO_3^- + NO_2^-(μmol L^{-1})	0.19	1.70	0.10	0.11	0.08	2.59
PO_4^{3-} (μmol L^{-1})	0.01	0.17	0.01	0.01	0.00	0.11
SiO_4^{3-} (μmol L^{-1})	2.85	4.78	1.71	0.98	1.34	4.90
N:P (μmol:μmol)	15:1	10:1	12:1	11:1	20:1	24:1
Chl a (μg L^{-1})	0.38	1.19	0.62	0.58	0.55	0.95
Micro Chl a (%)	9	26	9	15	8	7
Nano Chl a (%)	18	22	36	38	27	30
Pico Chl a (%)	73	53	55	47	65	62

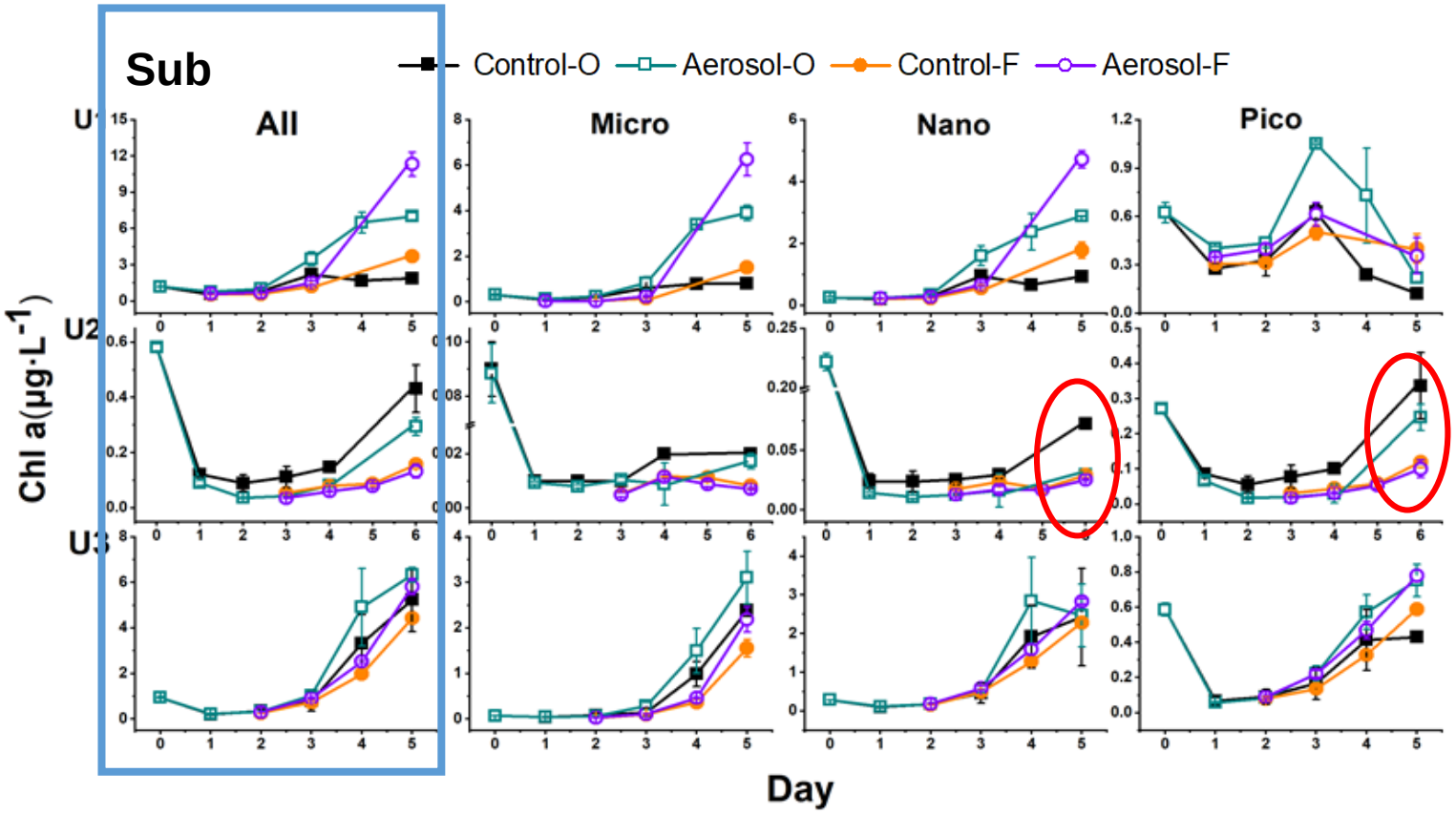
Impact of aerosol on Chl *a*



Changes in Chl *a* concentration in control and aerosol treatments of the surface water. -O and -F means system and subsystem.

- Compared with the control, the **total Chl *a*** concentration in aerosol treatments increase significantly.
- **Micro-sized cells** were more advantageous in aerosol treatments
- In the subsystem, the Chl *a* concentration of **nano- and pico-sized** was lower than these in the system.

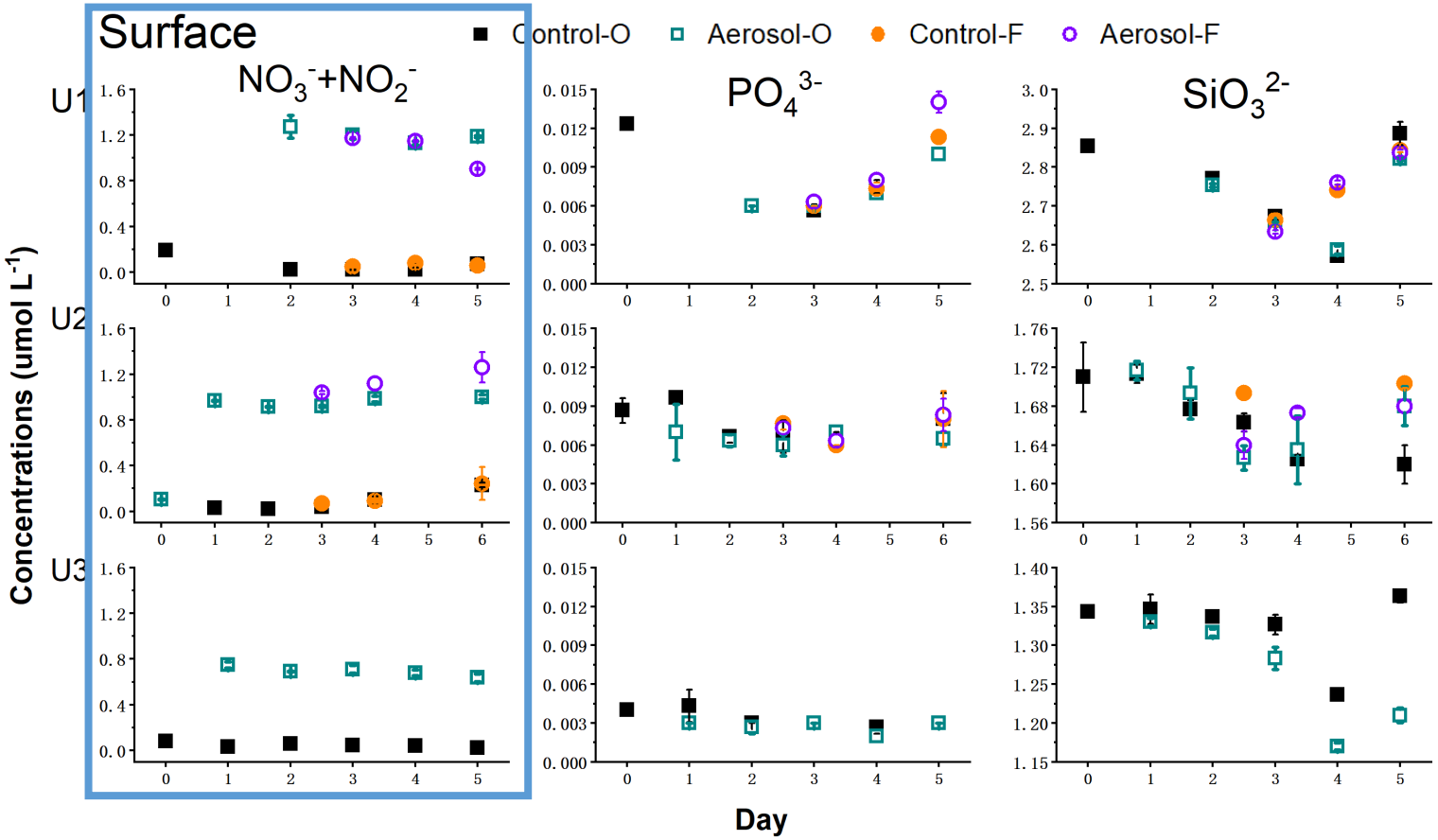
Impact of aerosol on Chl *a*



- Complexity on **total Chl *a*** concentration in aerosol treatments.
- We found a similar phenomenon in **site U2** with all **surface** sites.

Changes in Chl *a* concentration in control and aerosol treatments of the DCM. -O and -F means system and subsystem.

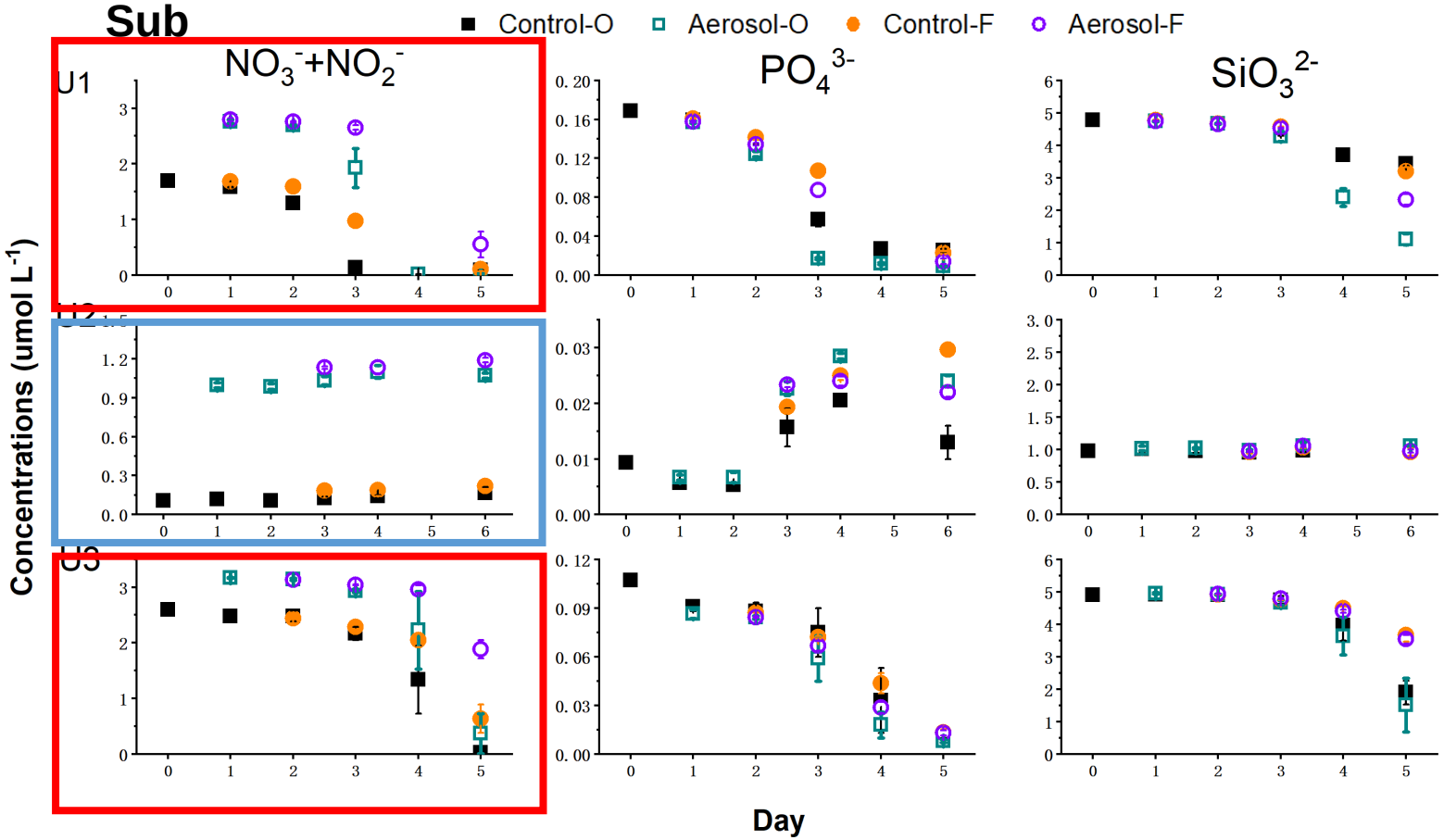
Impact of aerosol on nutrients



Changes in N + N, PO_4^{3-} and SiO_4^{3-} concentration in the control and aerosol treatments in surface water during the incubations. -O and -F means system and subsystem.

- The concentration of N+N in aerosol treatments was significantly higher than control.
- There are no obvious differences between the system and subsystem.

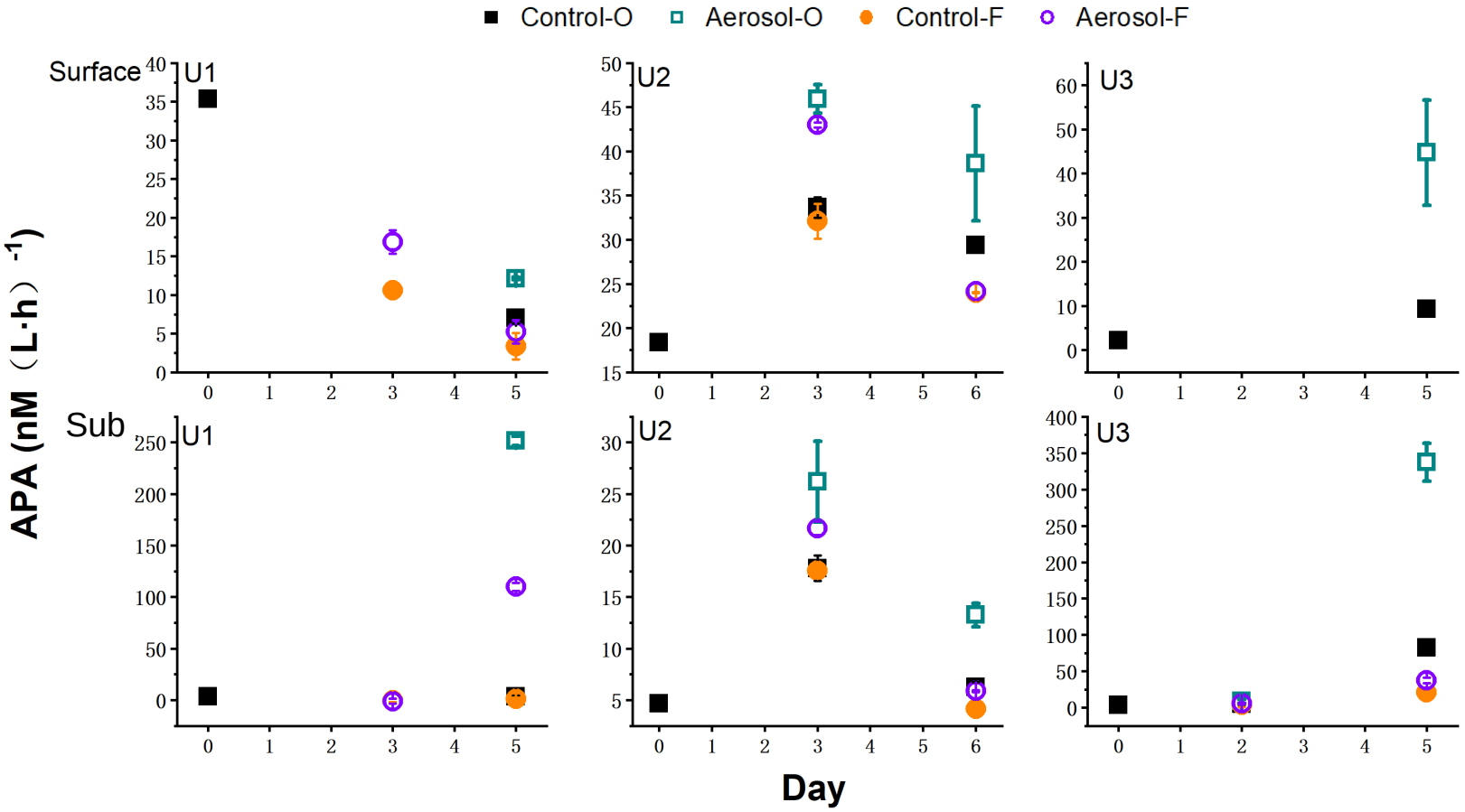
Impact of aerosol on nutrients



Changes in the N + N, $PO_4^{3-}$and SiO_4^{3-} concentration in the control and aerosol treatments in subsurface layer during the incubations. -O and -F means system and subsystem.

- The result in U2 **was similar with surface**.
- At sites U1 and U3, the concentration of N+N and PO_4^{3-} were gradually decreased.
- P was the reason that the Chl *a* concentration of **nano- and pico-sized** in subsystem was lower than system.

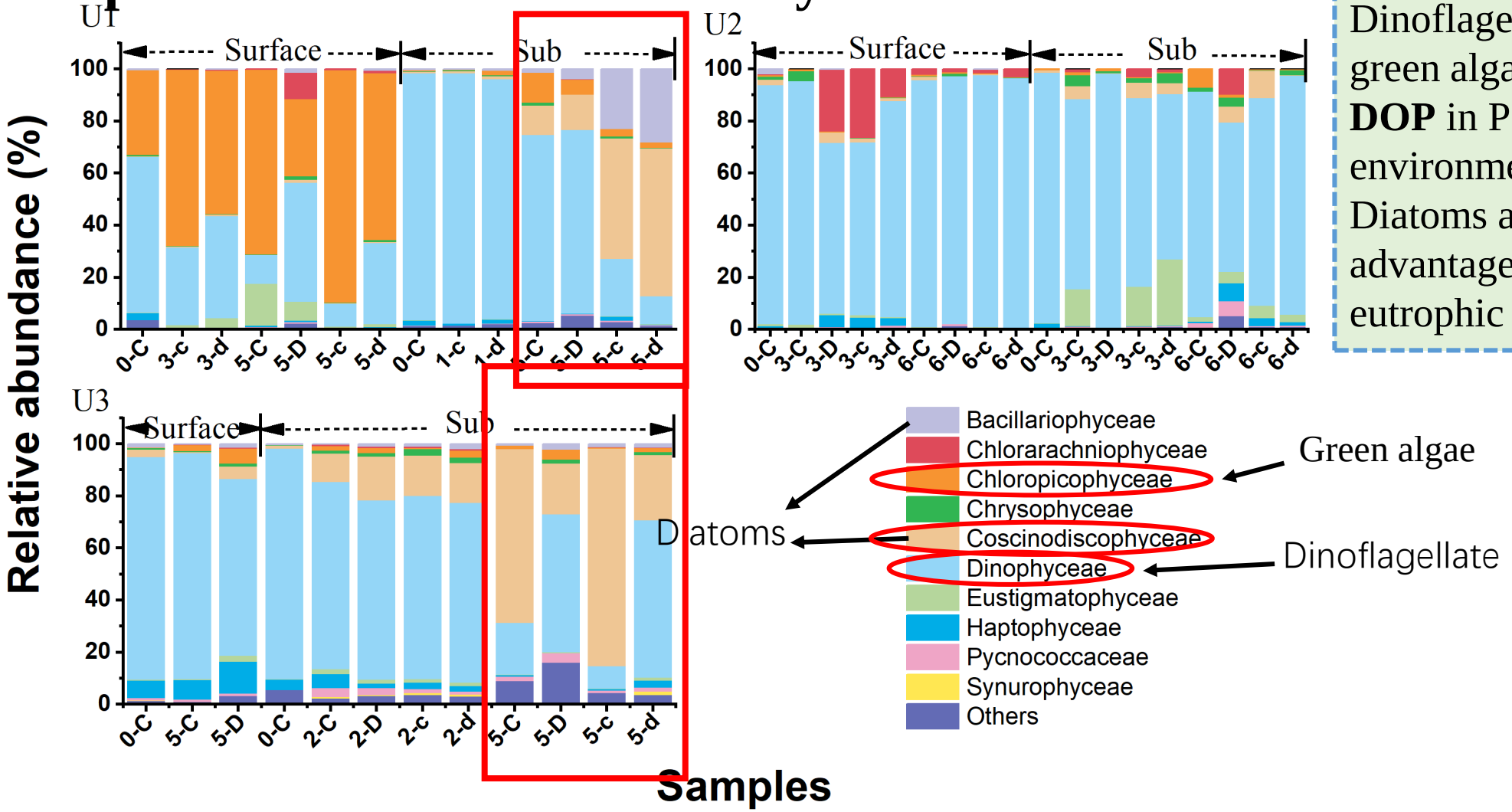
Impact of aerosol on alkaline phosphatase activity



- The **APA value** of aerosol treatments was significantly higher than that of the control.
- The **APA value** of the subsystem was lower than the system.
- Micro-sized cells can accelerate the **turnover rate** of bioavailable P

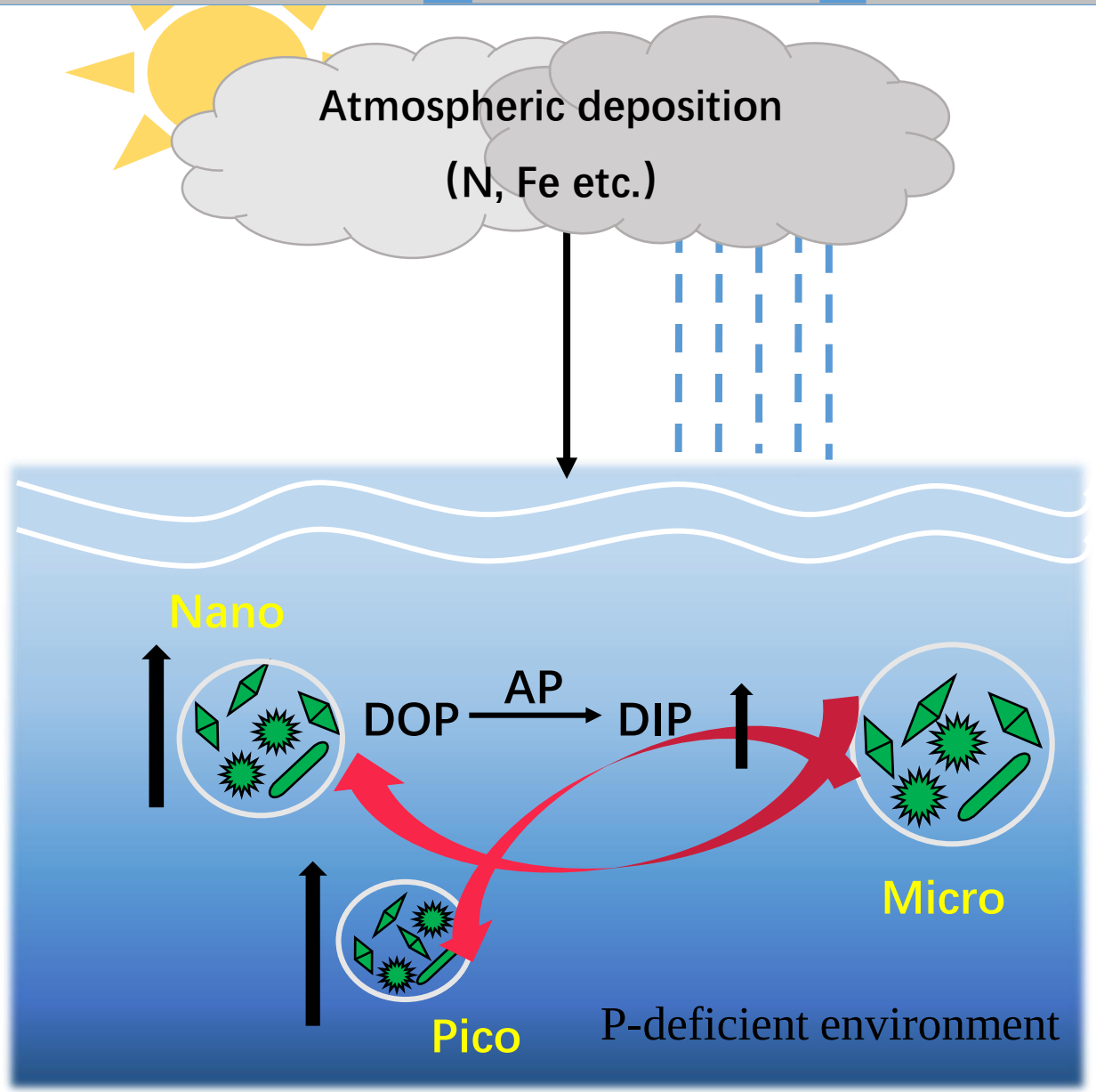
Changes in APA in the control and aerosol treatments in subsurface layer during the incubations. -O and -F means system and subsystem.

Impact of aerosol on community



Dinoflagellate and green algae can use **DOP** in P-deficient environment.
Diatoms are more advantageous under eutrophic conditions.

Relative abundances of dominant phytoplankton classes in the control and aerosol treatmentss during the incubation experiments. Where -C, -D, -c, and -d refer to the control, and aerosol treatments in system, the control and aerosol treatments in subsystem. e.g. 0-C means control on day 0 in system.



- Atmospheric deposition can change the **phytoplankton size structure** by providing N directly and P indirectly.

- **Micro-sized cells** can promote the growth of nano- and pico-sized cells in P-deficient environment.


Thank you for your attention!