세계 초일류 이공계 대학

Effects of riverine discharge on planktonic food web in a temperate estuarine bay

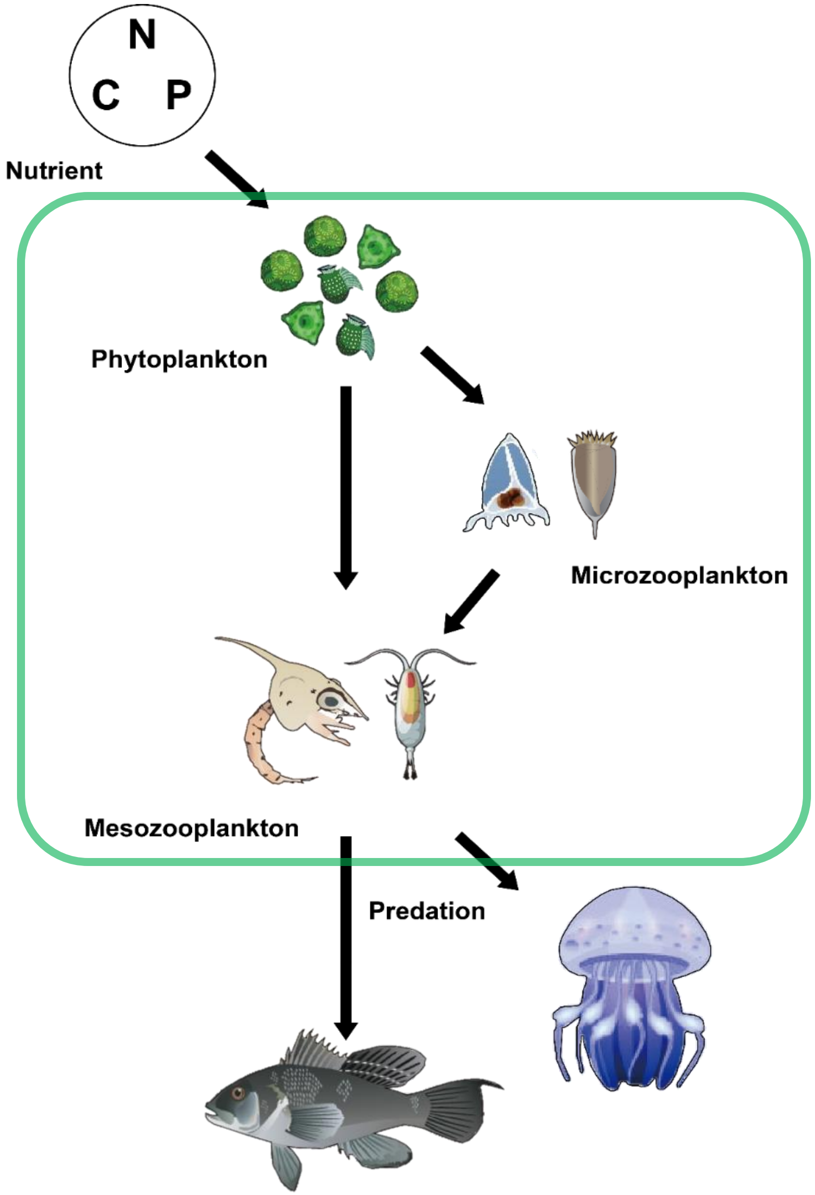
Jaebin Jang

Stable Isotope Ecology Laboratory(SIEL)

School of Earth Sciences and Environmental Engineering (SESE)

Gwangju Institute of Science and Technology (GIST)

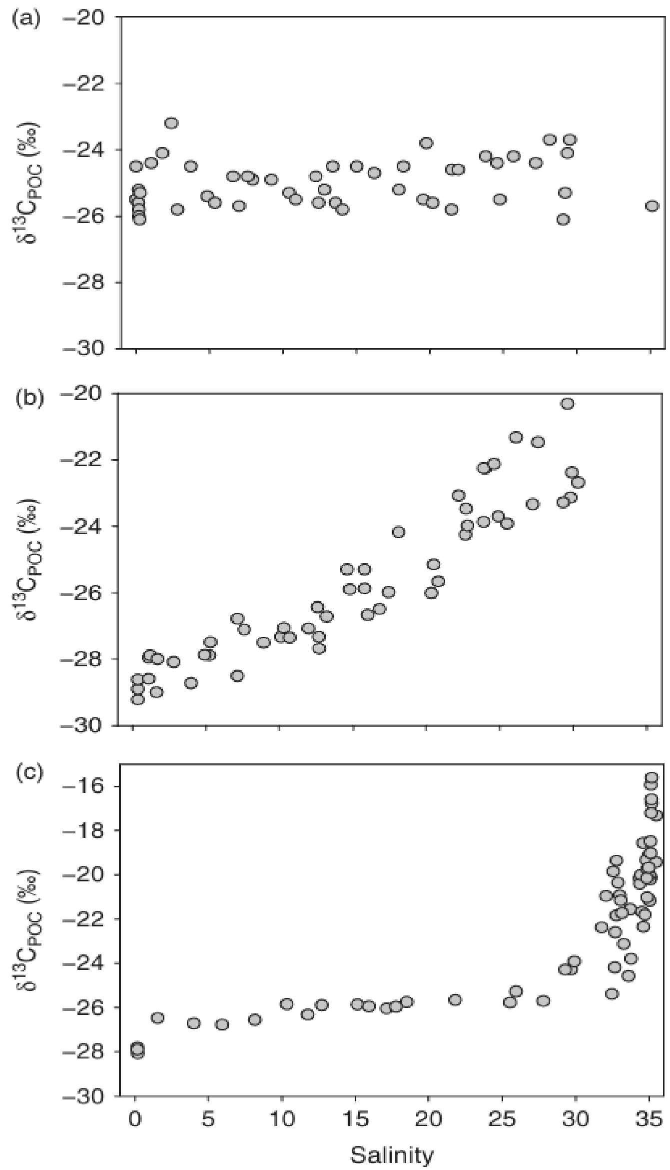
Background



Planktonic food web:

- Transfer of energy and materials from lower to higher trophic levels
- Bridging microbial and classical grazing food webs
- Exhibit distinct seasonal and spatial patterns within estuaries
- Sensitive to urban drivers (e.g., dissolved inorganic nutrients)
  → useful biological indicator

Background



(Bouillon et al., TECS, 2011)

Types of estuaries:

- High turbidity & longer residence time

  e.g.) The Gironde

- Low turbidity & shorter residence time

  e.g.) The Scheldt

- Clear boundaries between habitats

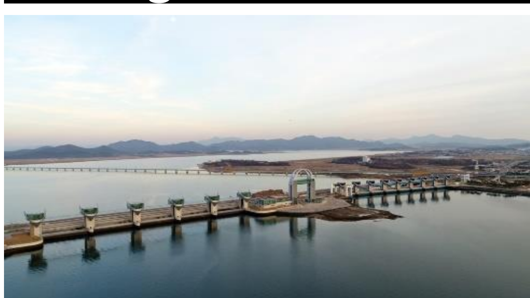
  e.g.) The Kidogoweni

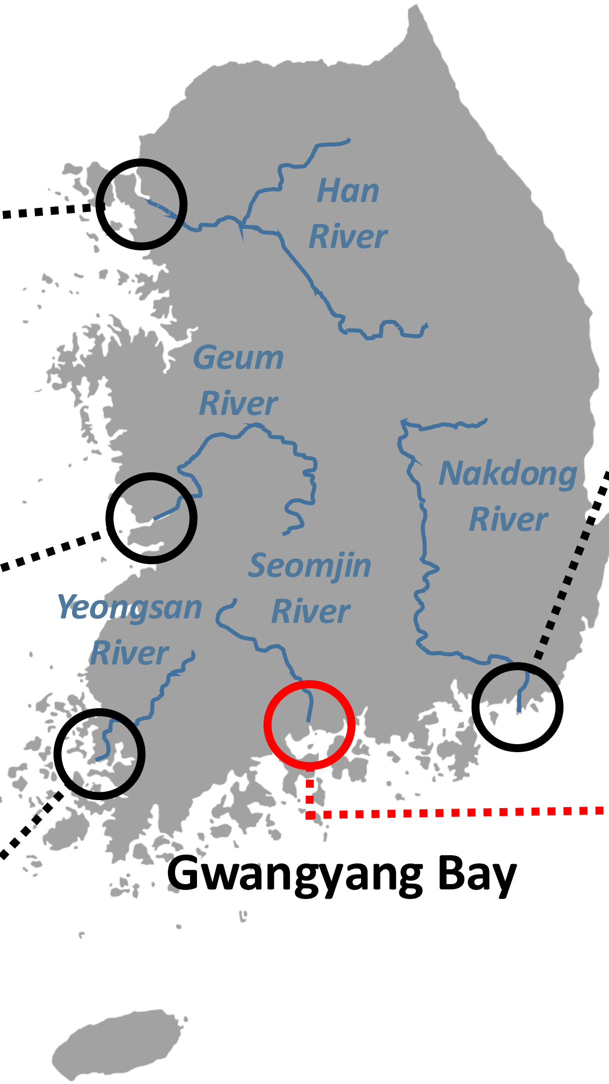
Background

Singok Weir

Geum River Bank

Yeongsan River Bank





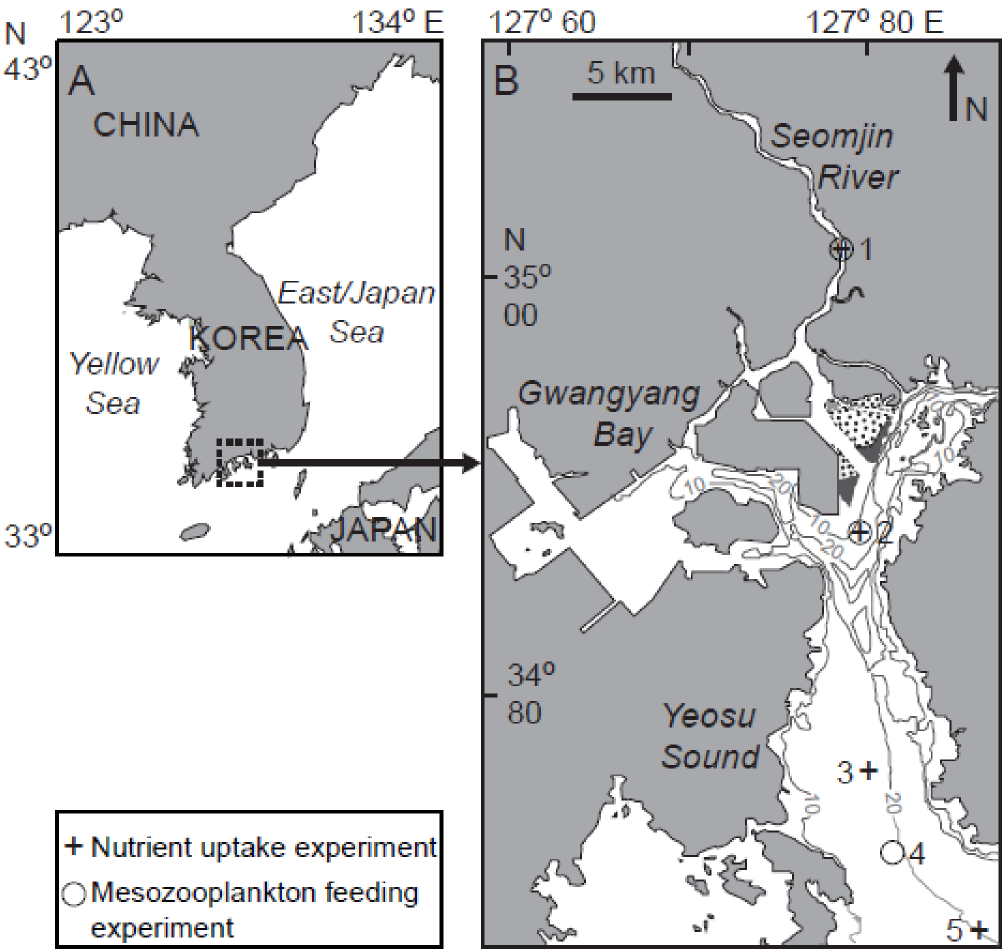
Gwangyang Bay

Nakdong River Bank

No estuary bank

Background

Gwangyang Bay :



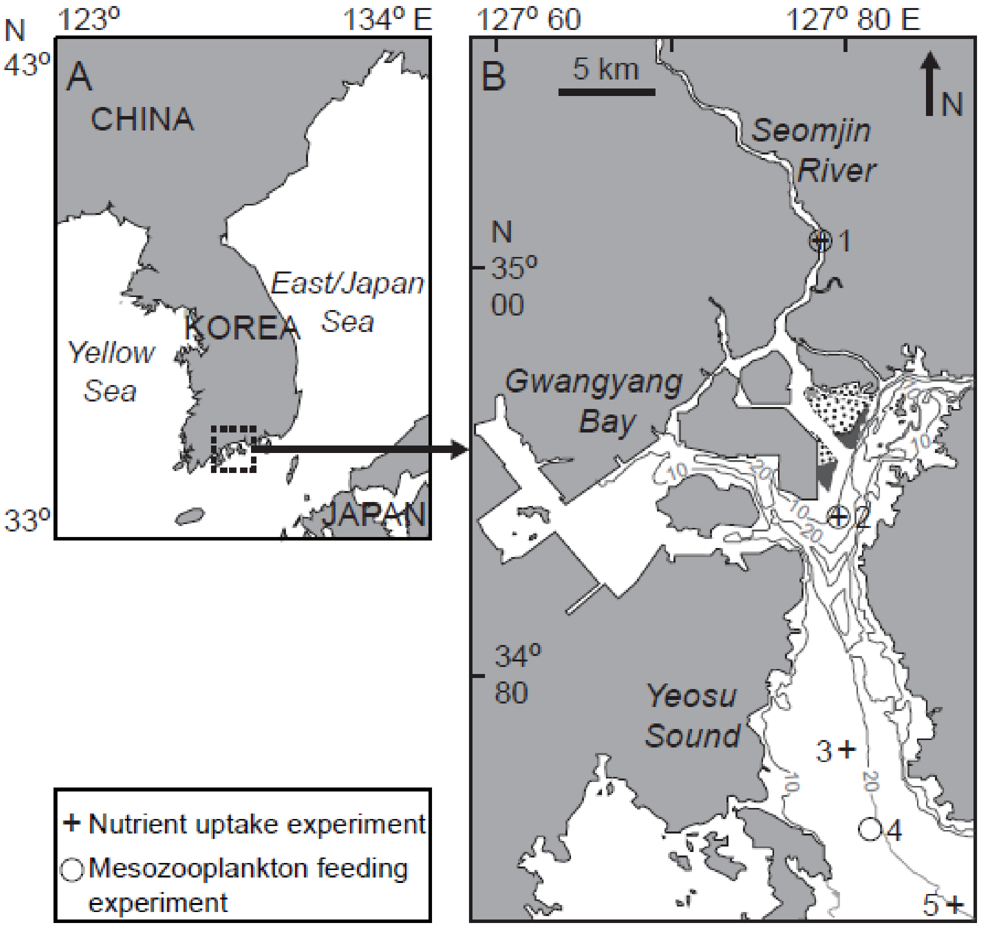
- Riverine discharge from Seomjin River
  ($30–400\ m^3\ s^{-1}$)
- Semi-closed bay
- Low-turbidity (SPM < 20.0 mg L^{-1})
- Short water residence time
  (3.6 – 12.2 d)
- Spatial gradients in urban drivers

Objectives

- Investigate how **riverine discharge** affects the **planktonic food web** in Gwangyang Bay by examining environmental parameters and biological responses across **estuarine gradients**

- Determine the influence of riverine discharge on **phytoplankton community composition**, **primary productivity**, **nitrogen uptake rates**, and **mesozooplankton feeding traits**

Variables & Measurements



- Physics: T, S, Secchi depth
- Nutrients: NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SiO_2
- Phytoplankton: Total & size-fractionated Chl *a* (micro/nano/pico), Composition (HPLC)
- Productivity: PP, $^{15}N{-}NO_3^-/NH_4^+$ uptake, *f*-ratio
- Grazers: Mesozooplankton feeding rates (clearance, ingestion)
- November 2017–September 2018

  August 2020–August 2021

Variables & Measurements

Mesozooplankton feeding rates

In-situ MZ → Bottle incubation experiment → Size-fractionated Chl *a*

Net towing   *Fluorometer*

Bottle incubation

24h

200 μm filtered seawater → **No MZ**

unfiltered seawater → **MZ remain**

Variables & Measurements

Mesozooplankton feeding rates (1972, Frost)

Growth of phytoplankton based on chl *a*

$$F = \frac{k_c - k_t}{dw} \times V \qquad (\mathrm{L \cdot mg^{-1} \cdot d^{-1}})$$

Clearance rate **Dry weight** **Volume of treatment bottle**

$$\mathrm{I = F \times C_{mean}} \qquad (\mathrm{\mu g \cdot mg^{-1} \cdot d^{-1}})$$

Ingestion rate

Mean concentration of chl *a* of phytoplankton during incubation

Statistics & Diagnostics

- Principal Component Analysis (PCA) with environmental factors

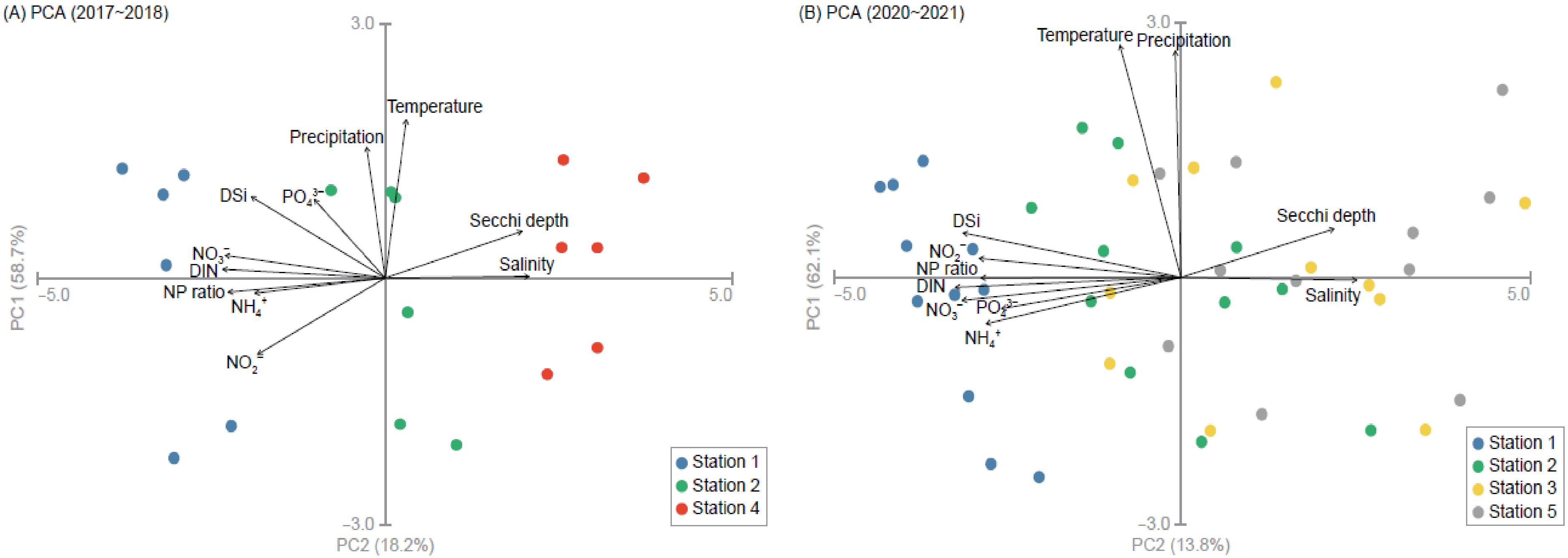
- Generalized additive models(GAMs) for phytoplankton & productivity:

  E[Response variables] $= \beta_0 + s_1(\mathit{PC1})$

- GAMs for mesozooplankton feeding rates:

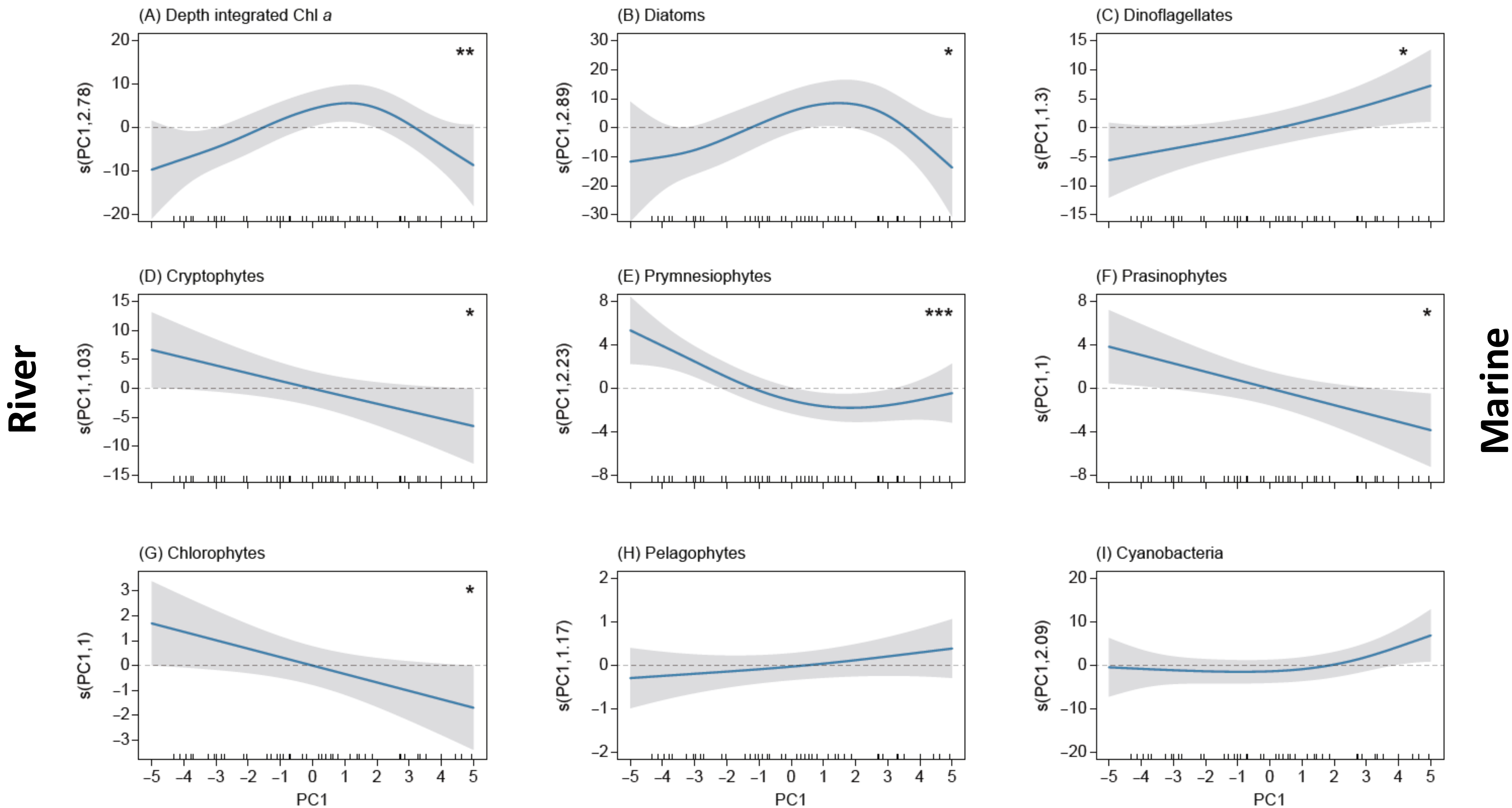
  E[feeding rates] $= \beta_0 + s_1(\mathit{PC1}) + s_2(\text{Chl } a_{\text{micro}}) + s_3(\text{Chl } a_{\text{nano}}) + s_4(\text{Chl } a_{\text{pico}})$

Results



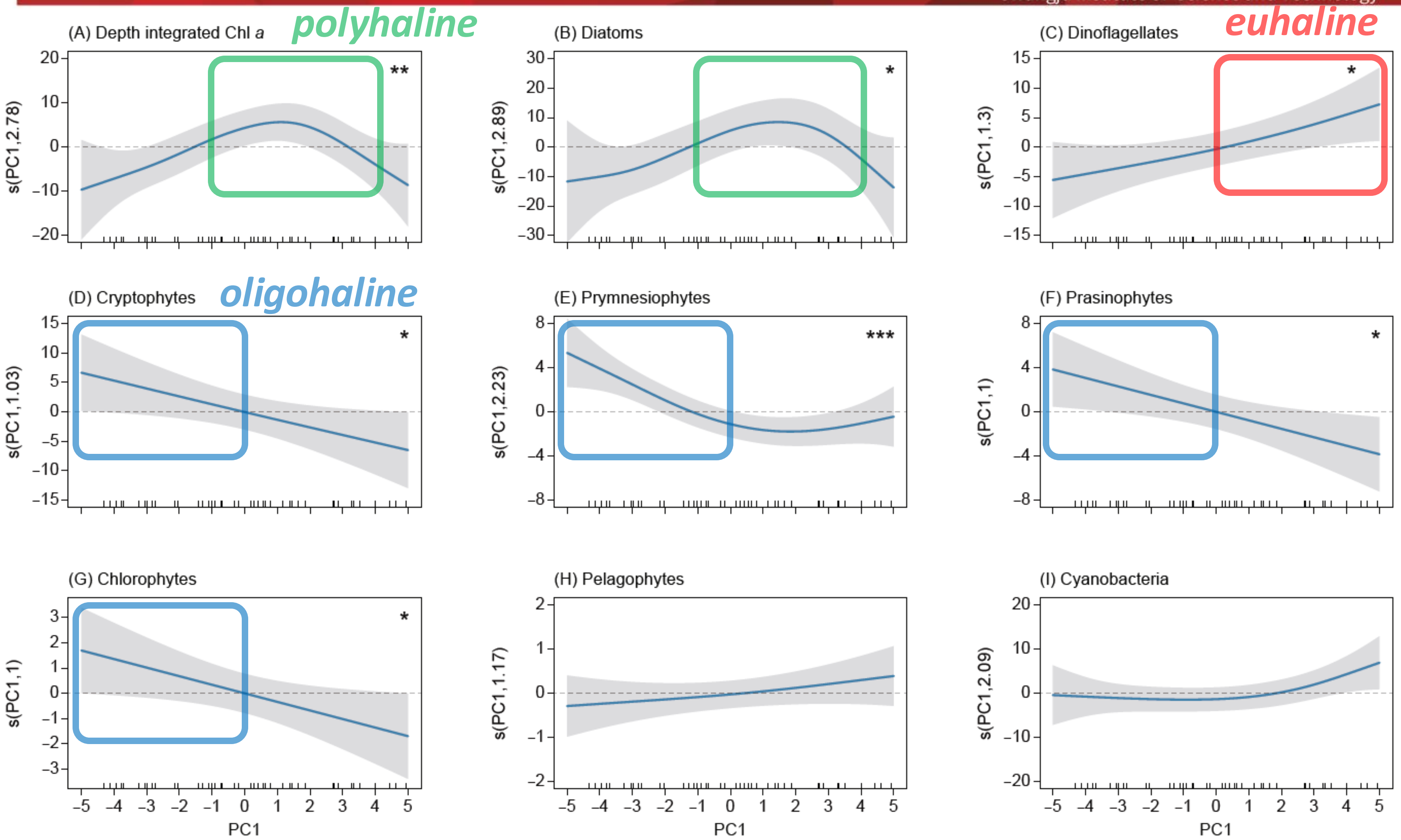
- ***PC1* (state axis): salinity** and **Secchi depth** (+) vs **nutrients** (–), discharge–light–nutrient balance axis explaining ~**60%** of variance across periods
- ***PC2* (season axis):** Captures temperature and precipitation signals
- *PC1* orders the **river→mid-estuary→shelf** gradient and serves as a practical **riverine discharge index** for subsequent GAMs
- *PC1*↑ → marine characteristics↑

Results



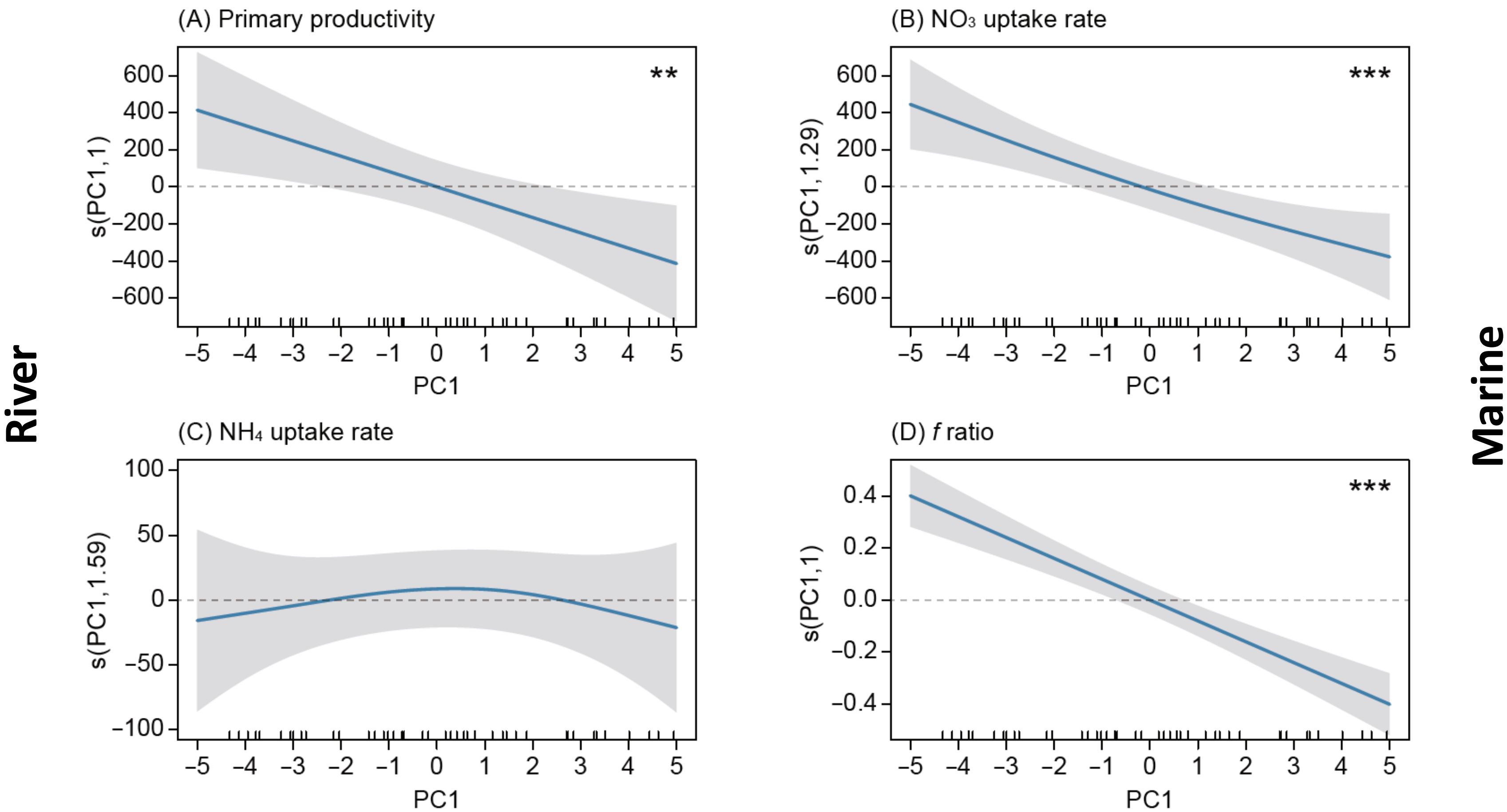
- Riverine discharge alters phytoplankton community composition

Results



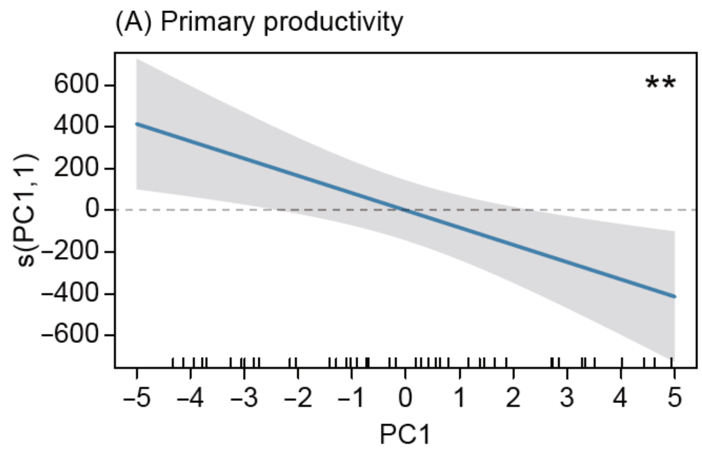
- Promoting **diatom** dominance in the **polyhaline reach**
- Creating marked species succession

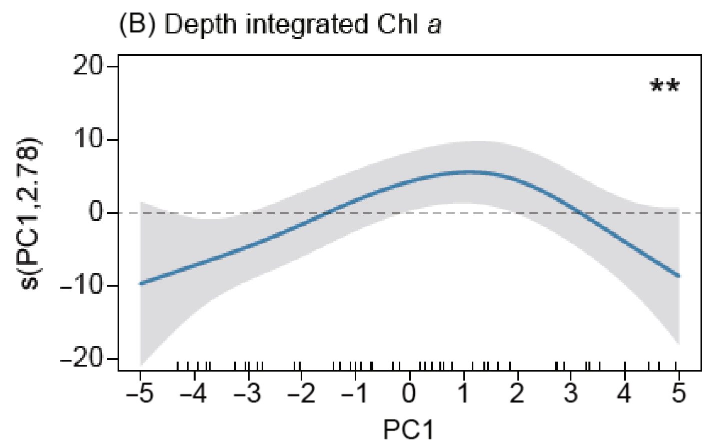
Results



- Riverine discharge enhances **nitrate uptake** in the **oligohaline reach**
- Nitrate uptake-based **primary production (new production)** is pronounced

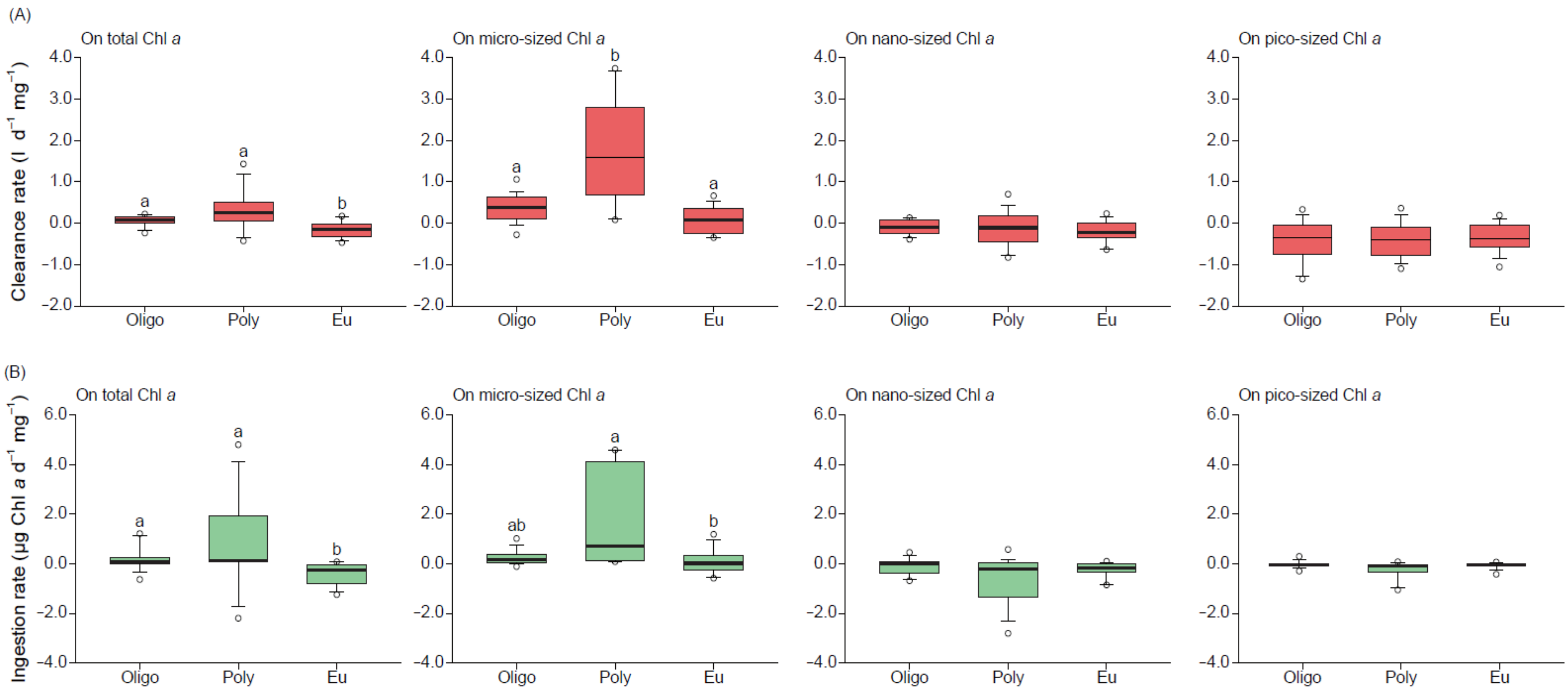
Results





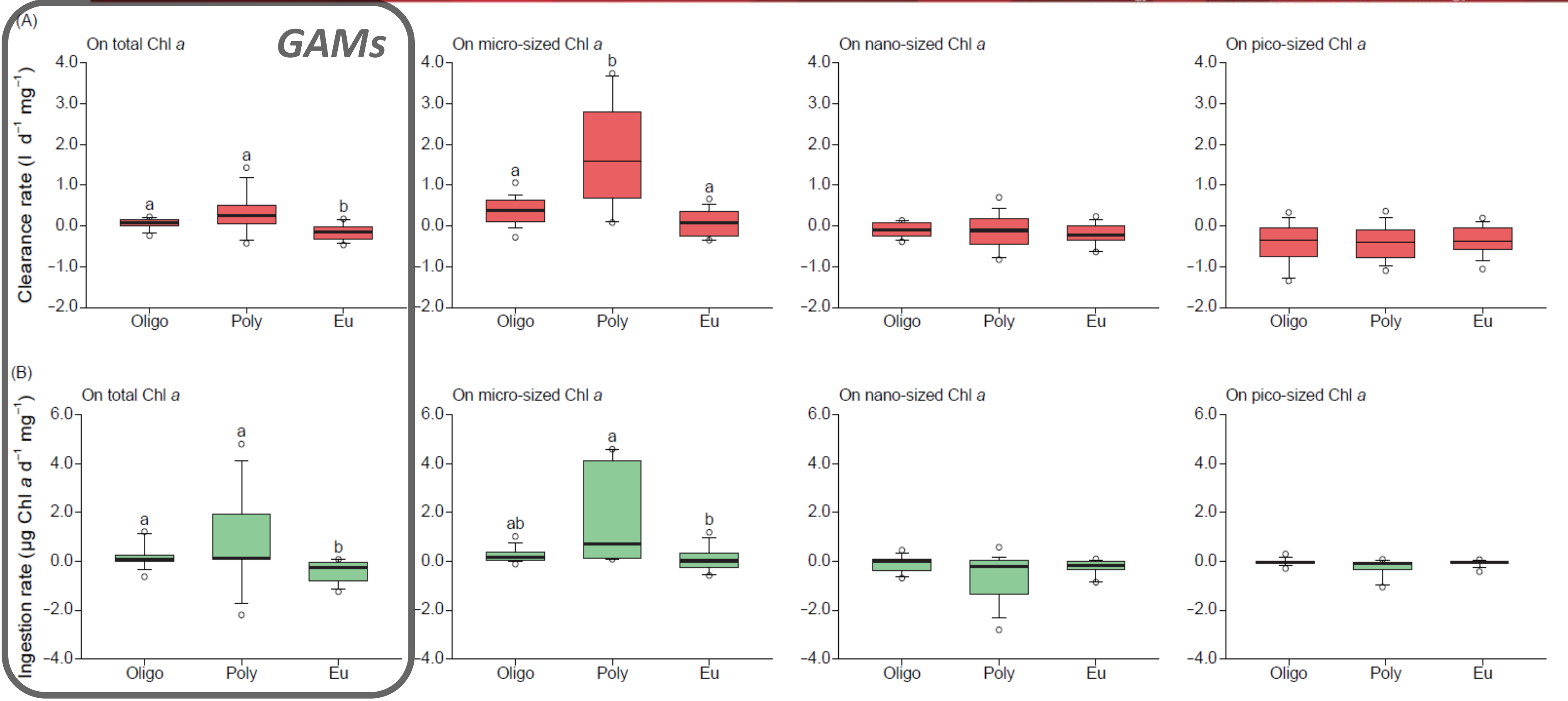
- Upstream: high primary production rates, short residence → low standing stock
- Mid-estuary: longer residence → biomass peak
- **Rate–stock decoupling**

Results



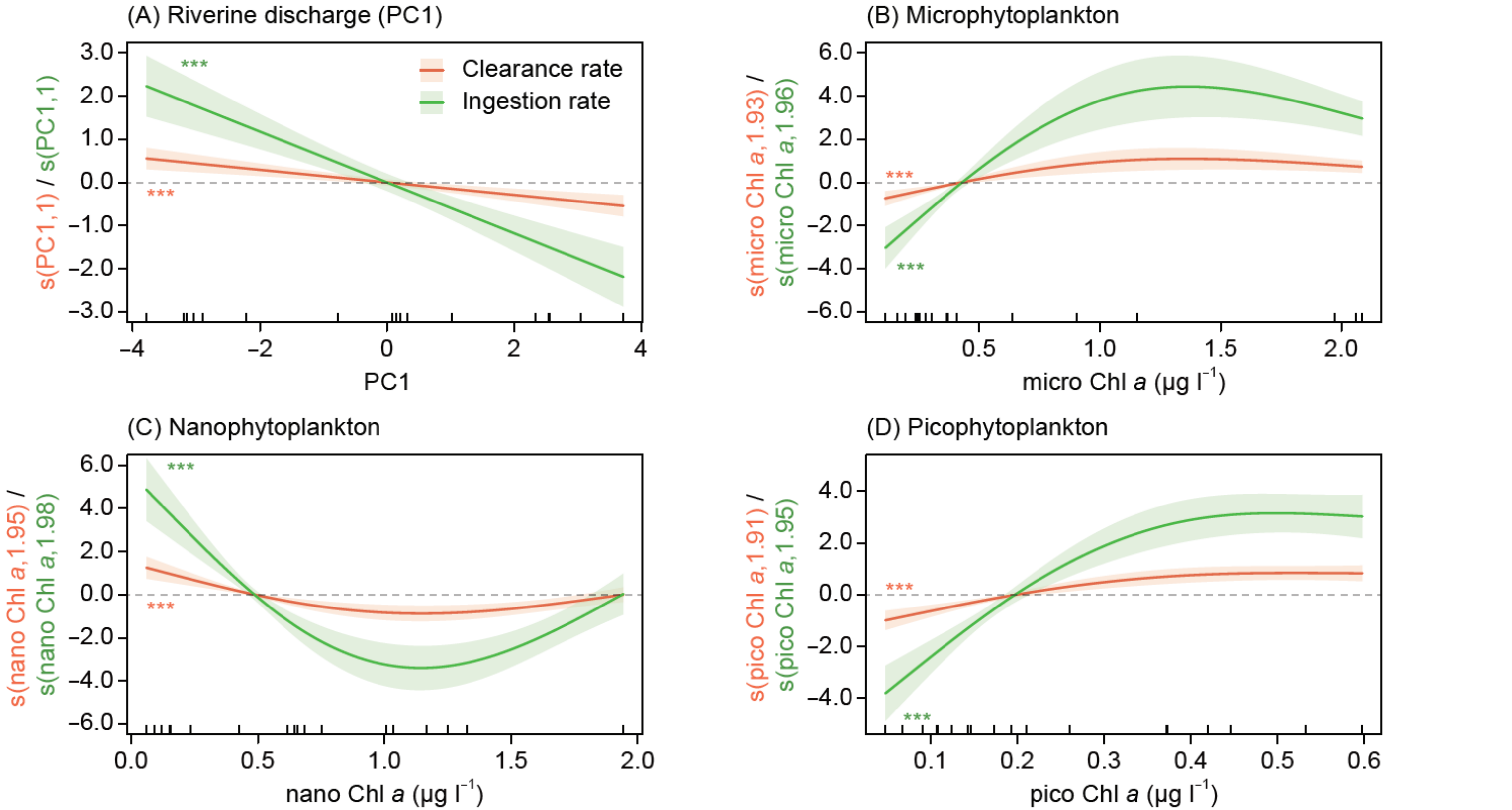
- Feeding rates on micro-sized Chl *a* > on nano and pico-sized Chl *a*
  → *size-selectivity & trophic cascade, low edibility*
- Lower feeding rates on total Chl *a* in euhaline reach (*PC1* ↑)

Results



- Feeding rates on micro-sized Chl *a* > on nano and pico-sized Chl *a*
  → *size-selectivity & trophic cascade*
- Lower feeding rates on total Chl *a* in euhaline reach (*PC1* ↑)

Results

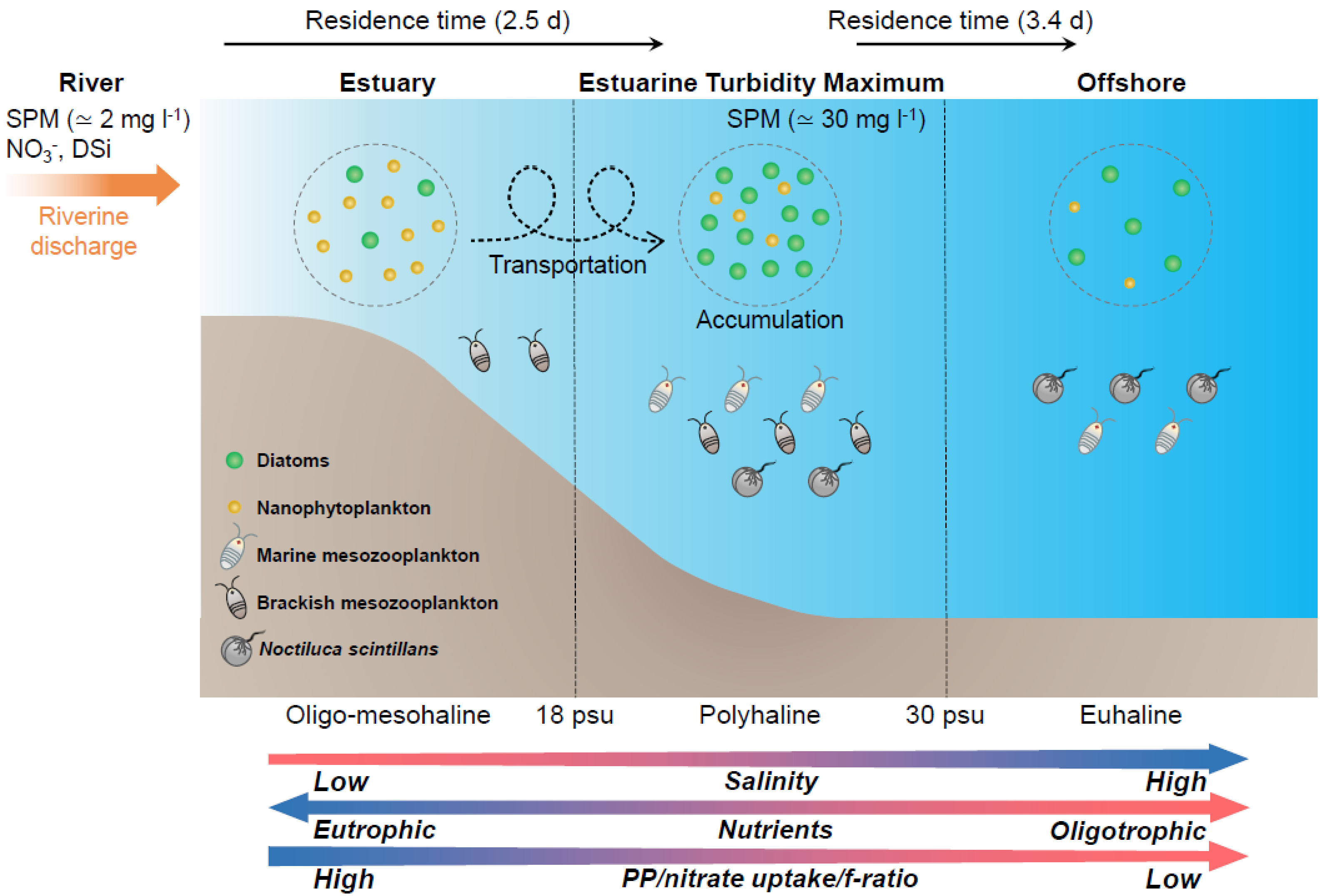


- Partial effect of *PC1* → **negative**
- Partial effect of micro Chl *a* (+) vs nano Chl *a* (–)
- **Food quality** (lack of DIN, DIP), **stronger competition/cascades** (e.g., *Noctiluca scintillans*), **prey toxicity** can suppress feeding rates

Conclusion

- **Riverine discharge** structures the urban gradient along the river–estuary–offshore continuum, and the ***PC1* score** serves as a practical state index
- Riverine discharge promotes **PP** and **nitrate uptake** in the **oligohaline** reach; horizontal transport produces **rate–stock decoupling** and **diatom** dominance in the **polyhaline** reach
- As riverine influence weakens (*PC1* ↑), mesozooplankton feeding rates decline—likely via lower **prey quality**, **stronger competition**, and **episodic toxicity**
- **Size-selective feeding** by mesozooplankton, coupled with elevated **prey availability** in the **polyhaline** zone, generates a trophic-transfer **"hotspot"**
- *PC1*-based indicator of watershed drivers guides adaptive, data-driven management of plankton resources and nearby urban aquatic ecosystems

Conclusion



Residence time (2.5 d)
Residence time (3.4 d)
River
Estuary
Estuarine Turbidity Maximum
Offshore
SPM (≃ 2 mg l-1)
NO3-, DSi
Riverine discharge
SPM (≃ 30 mg l-1)
Transportation
Accumulation
Diatoms
Nanophytoplankton
Marine mesozooplankton
Brackish mesozooplankton
Noctiluca scintillans
Oligo-mesohaline
18 psu
Polyhaline
30 psu
Euhaline
Low
Salinity
High
Eutrophic
Nutrients
Oligotrophic
High
PP/nitrate uptake/f-ratio
Low

Thank you