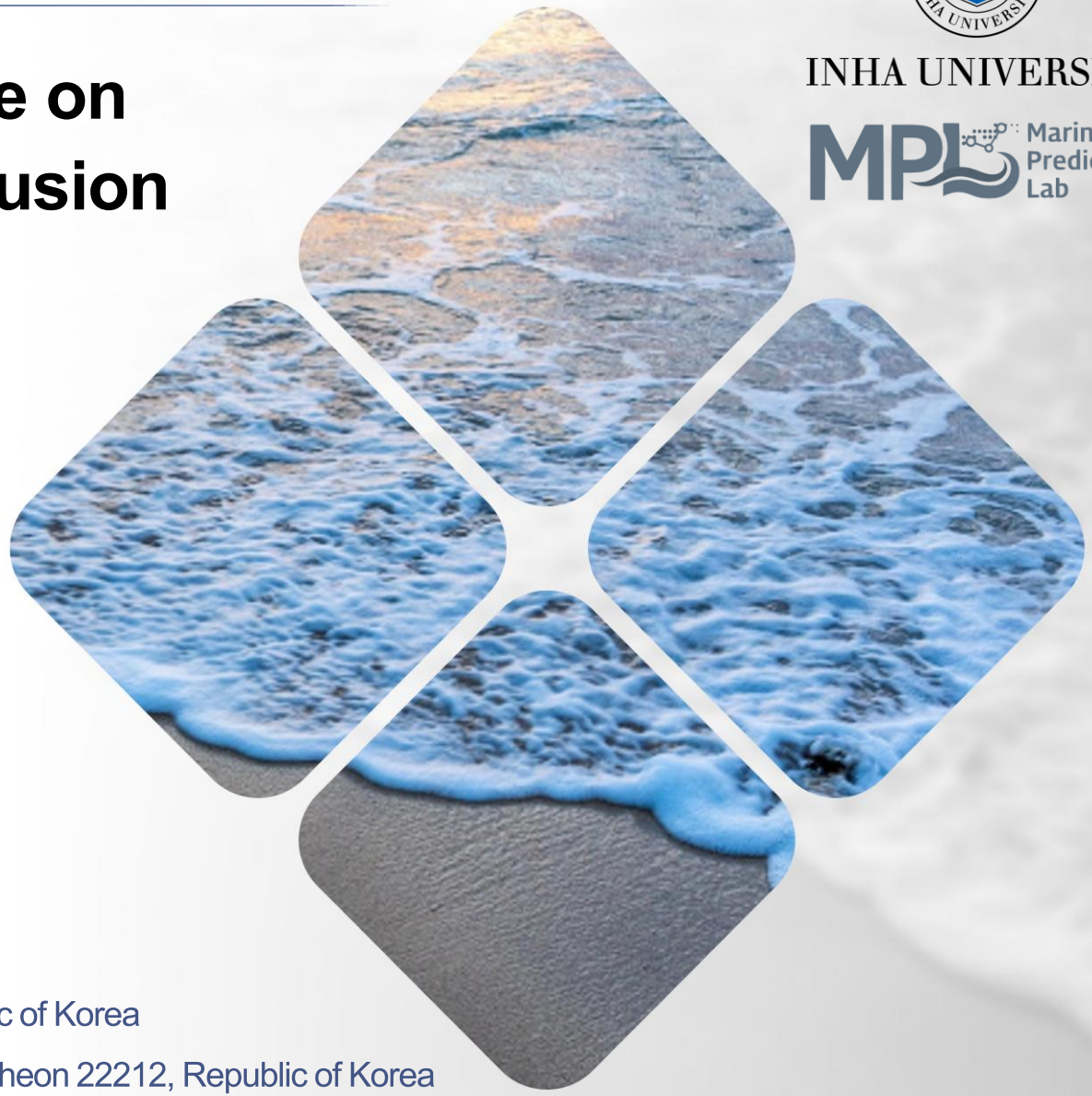
Impacts of Freshwater Discharge on Summer Bottom Cold Water Intrusion in the Southeastern Yellow Sea



INHA UNIVERSITY

MPL Marine Prediction Lab

2026. 08. 05.

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2. Methodology

3. Results

4. Discussion

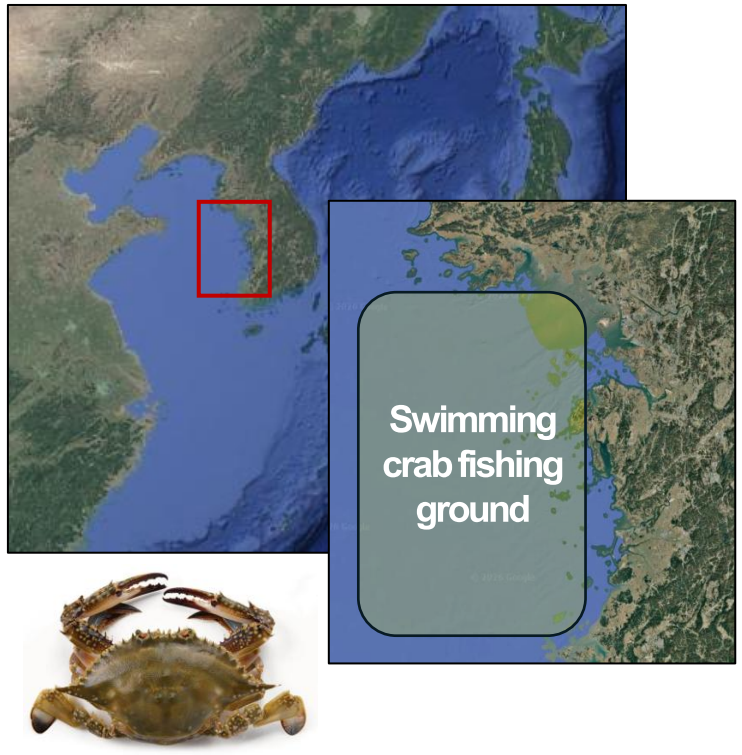
5. Conclusions

1. Introduction

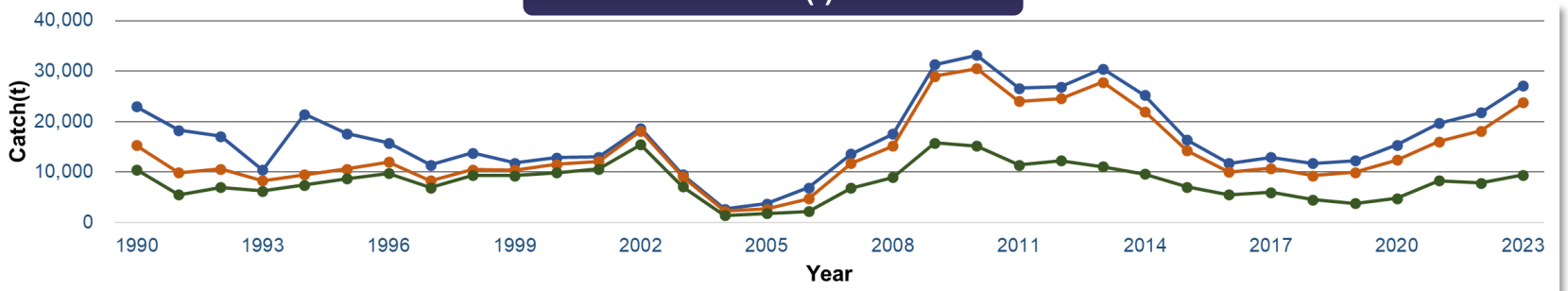
01

Variability in swimming crab catch off the west coast of Korea

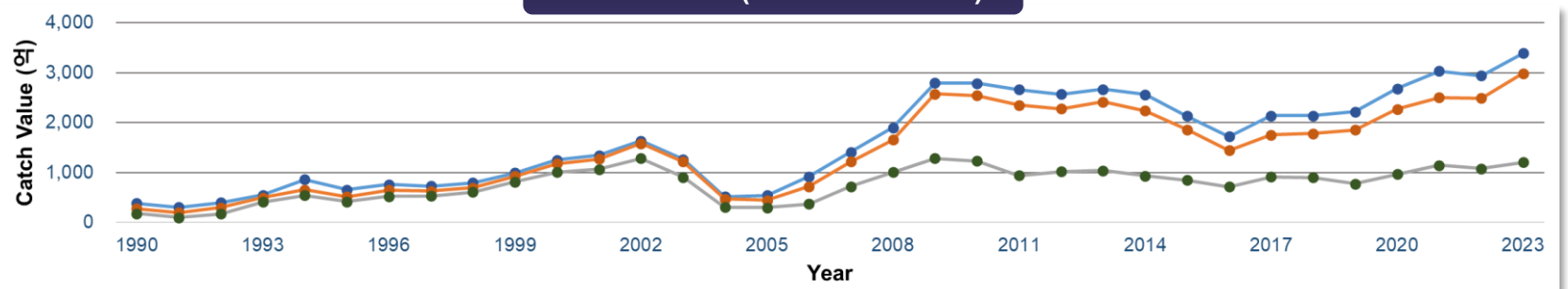
Swimming crab fishing ground



Catch (t)



Catch value (100 Million won)



National Total Yellow Sea Gyeonggi and Incheon

(Source: National Institute of Fisheries Science)

- Swimming crab is heavily caught along the west coast of Korea – a widely consumed, representative fishery species in Korea.
- However, its interannual catch variability is very high.

- **Swimming crab catch: bottom cold water intrusion**

Swimming crab catch forecast report

Ministry of Oceans and Fisheries, National Institute of Fisheries Science — Press Release — 80th Anniversary of Liberation, Shining Discovery & New Path

Release Date: Immediate Release | Distribution: August 19, 2025 (Tue)

This Autumn's Blue Crab Catch in the Yellow Sea Expected to Increase by 4 ~ 40% Compared to Last Year

- Spring catch plummeted, but autumn catch expected to increase due to favorable conditions of fishing groull density and water temperature -

The National Institute of Fisheries Science (NIFS, President Choi Yong-seok), under the Ministry of Oceans and Fisheries, predicted that this year's autumn* blue crab catch** in the Yellow Sea would increase by approximately 104~140% compared to last autumn (7,885 tons). (This is 71~95% of the recent 5-year average of 11,539 tons)

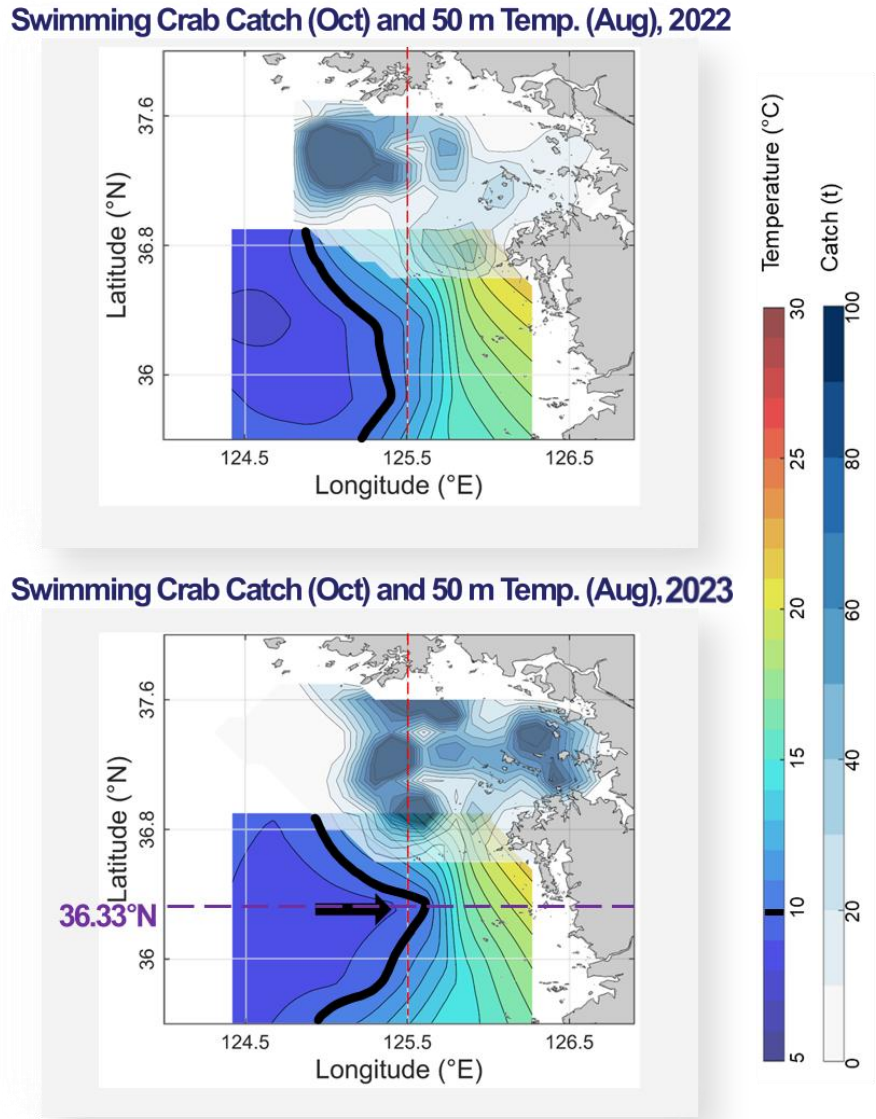
* Spring season: April 1st ~ June 20th, Autumn season: August 21st ~ November 30th

** Yellow Sea Autumn Blue Crab Catch (Tons): ('15) 8,615 → ('18) 6,165 → ('21) 11,697 → ('23) 17,126 → ('24) 7,885

It is expected that in this autumn season, the cold water mass in the lower layers of the Yellow Sea, which affects the concentration and dispersion of blue crab fishing grounds, will expand further towards the coast and south compared to last year. This is expected to lead to a concentration of blue crab fishing grounds, increased fishing efficiency, and ultimately an increase in the blue crab catch.

(Source: National Institute of Fisheries Science)

- NIFS report: Coastal concentration of Swimming Crab fishing grounds due to bottom cold water intrusion in 2023.



(Source: National Institute of Fisheries Science)

- **Swimming crab catch: freshwater discharge**

Swimming crab catch forecast report

Ministry of Oceans and Fisheries, National Institute of Fisheries Science — Press Release — 80th Anniversary of Liberation

Release Date: Immediate Release | Distribution: August 19, 2025 (Tue)

This Autumn's Blue Crab Catch in the Yellow Sea Expected to Increase by 4 ~ 40% Compared to Last Year

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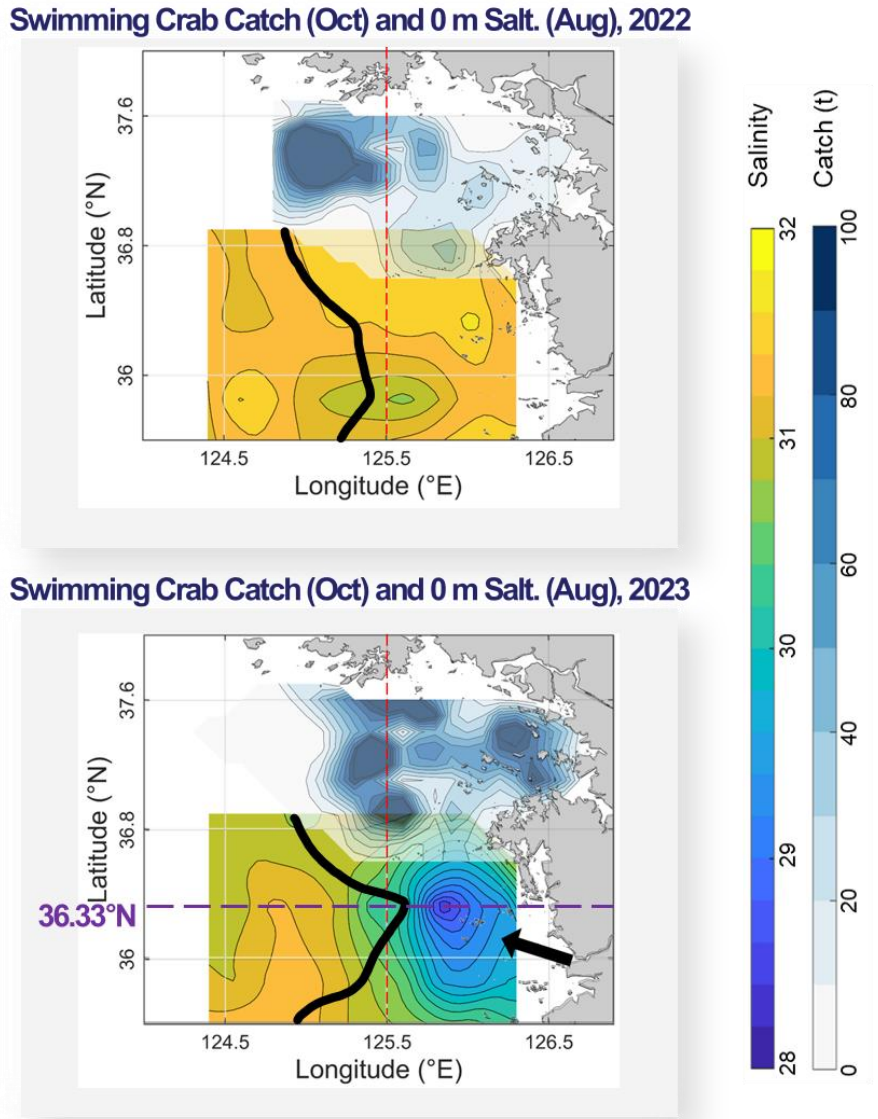
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(Source: National Institute of Fisheries Science)

- Question: Could the coastal intrusion of bottom cold water in 2023 be related to freshwater discharge?



(Source: National Institute of Fisheries Science)

2. Methodology

02

- **Study area**

Tidal Environment

Tidal range exceeding 9 m at maximum (Hwang et al., 2014)

Strong tidal mixing occurs (Lü et al., 2010)

East Asian Monsoon and YSCWM

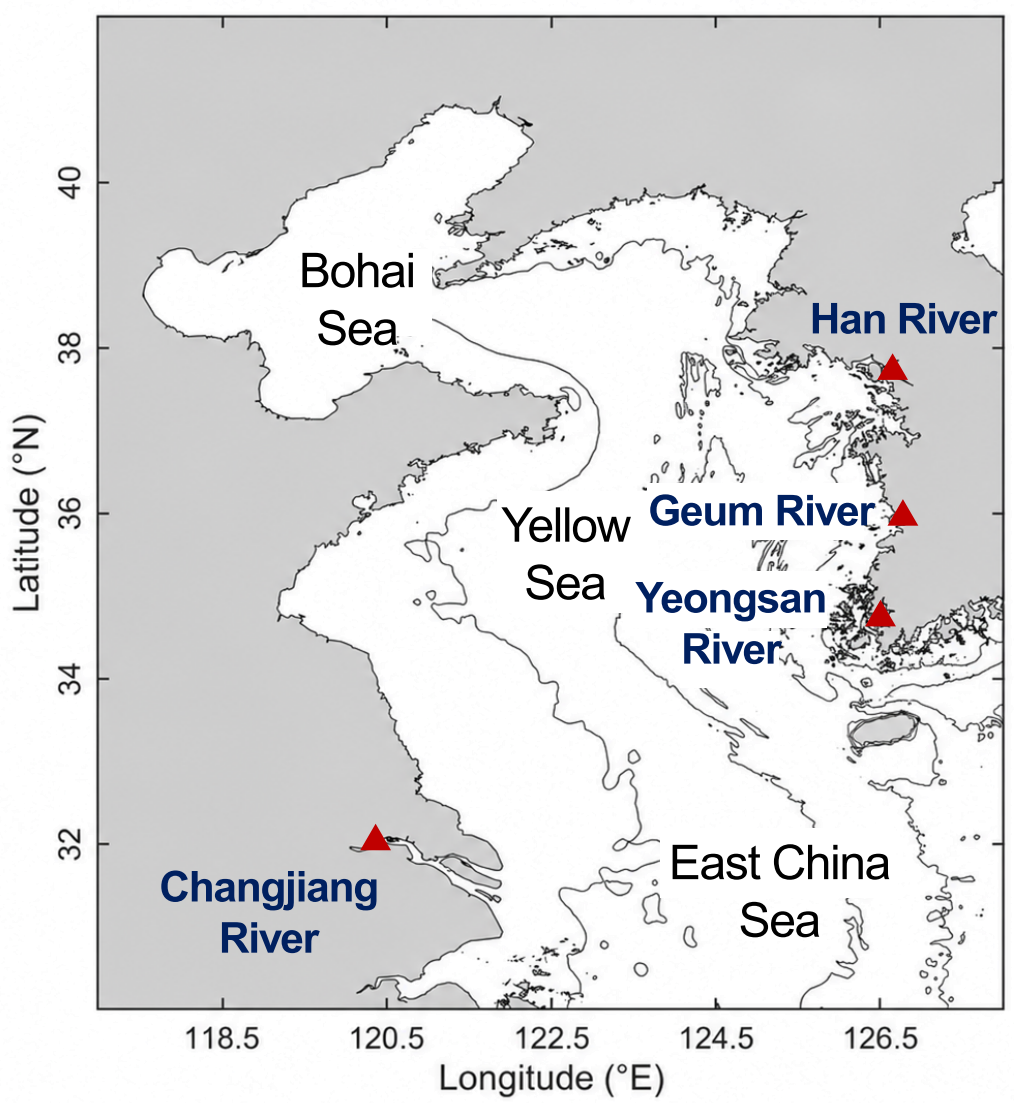
Weak southerly winds and strong solar radiation in summer from a strong seasonal thermocline (Kim et al., 2024)

The YSCWM is distributed below the thermocline (Park et al., 2011)

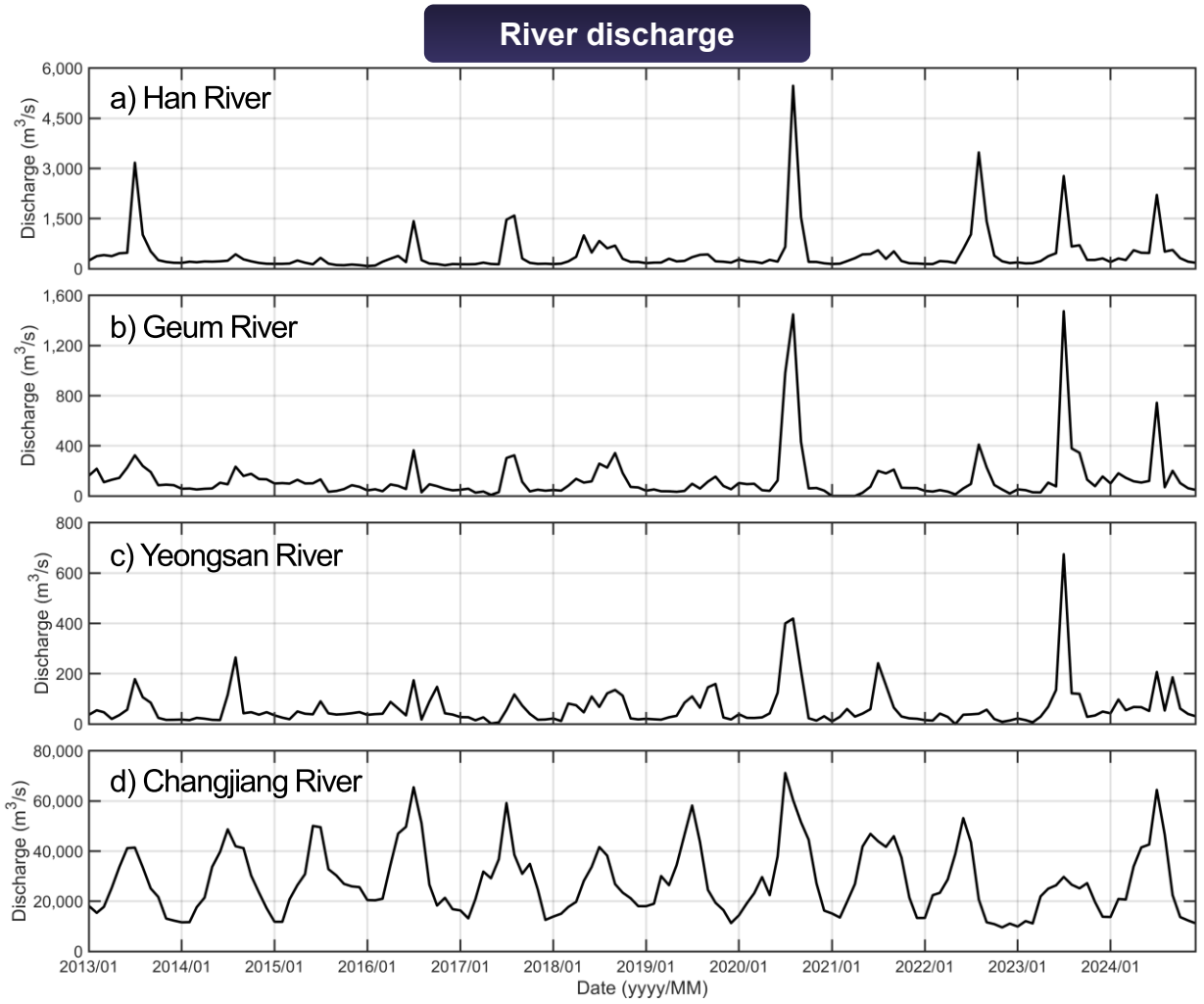
Effects of Freshwater Discharge

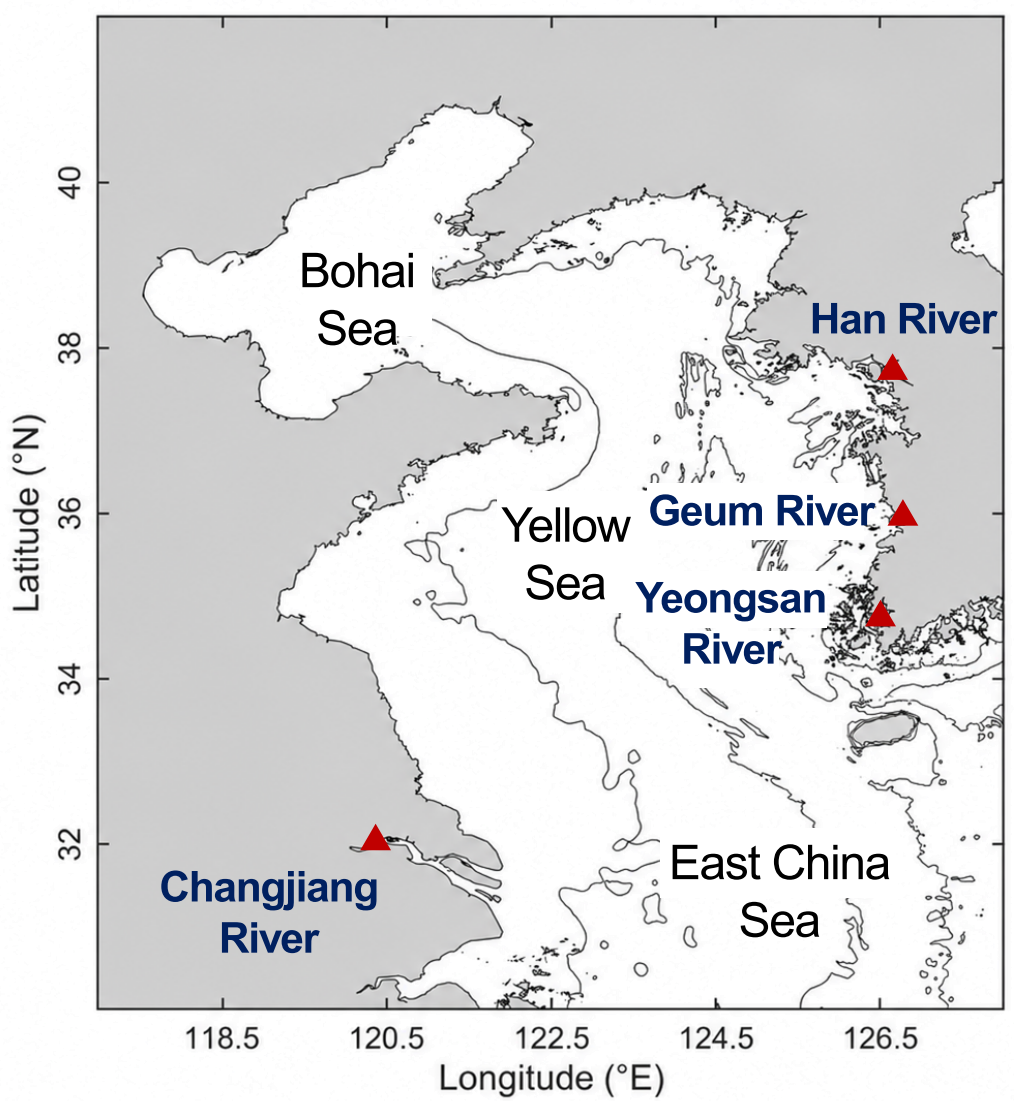
The Han River reduces salinity within tens of kilometers of the estuary (Yoon and Woo, 2015)

In summer, the Changjiang River diluted water plume extends through the ECS into the Yellow Sea (Chang and Isobe, 2003)



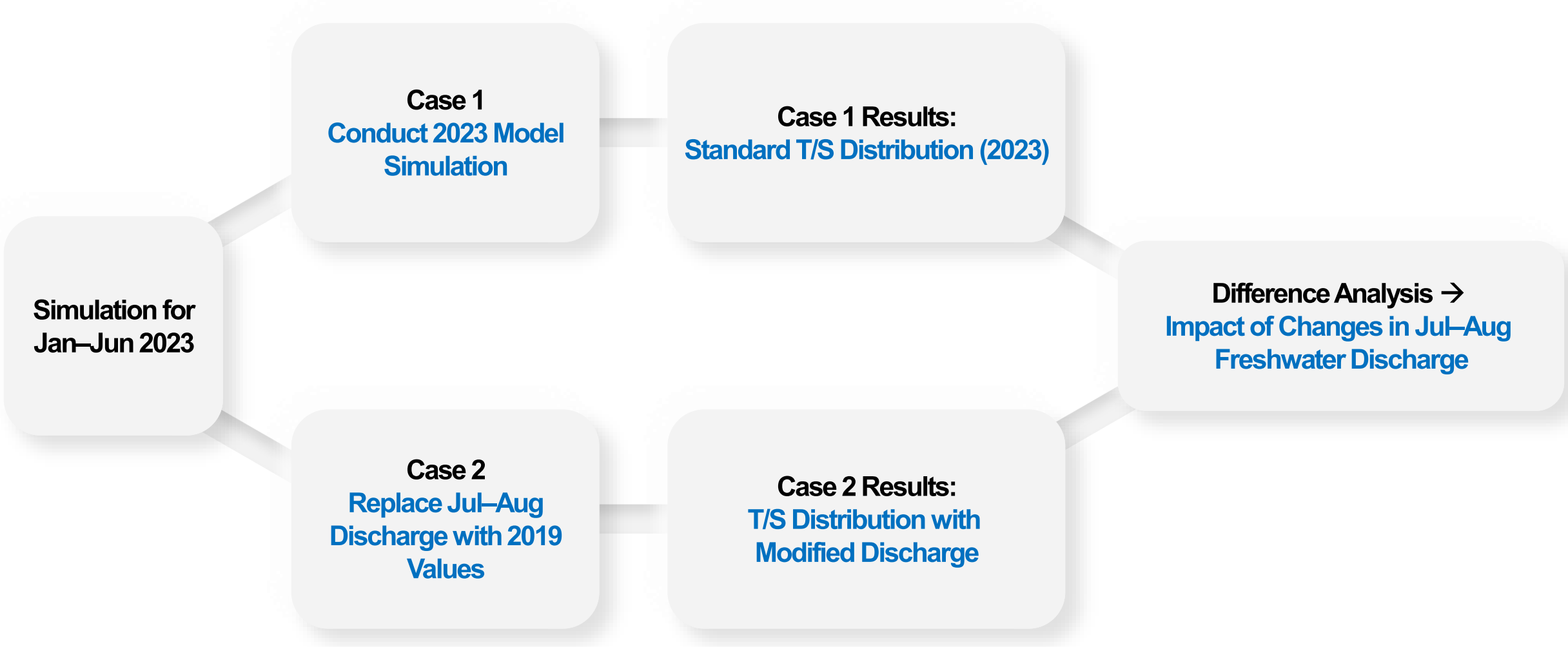
- **River discharge**



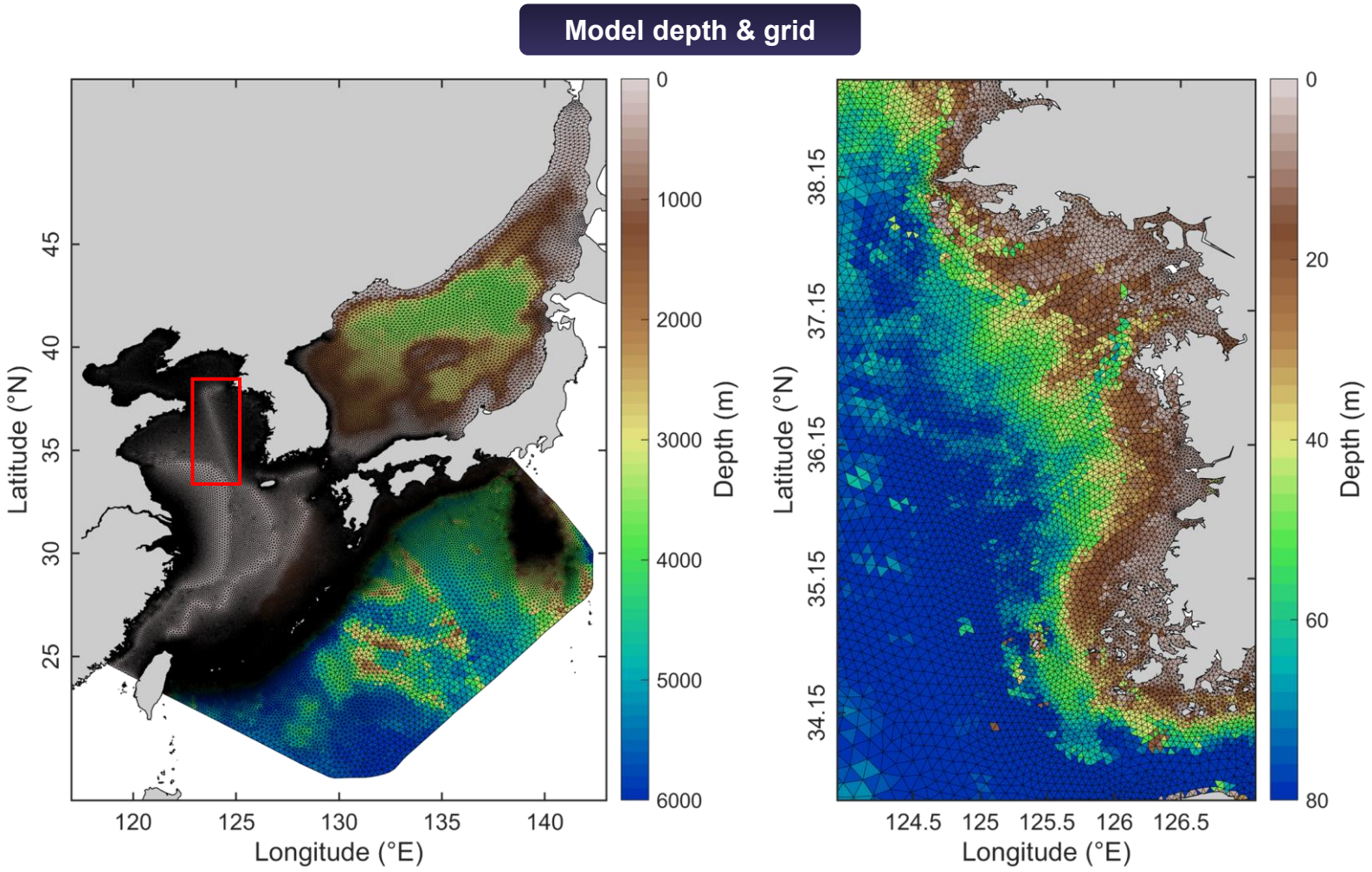


- **Scenario**

Schematic Diagram of Model Scenarios



Model setup



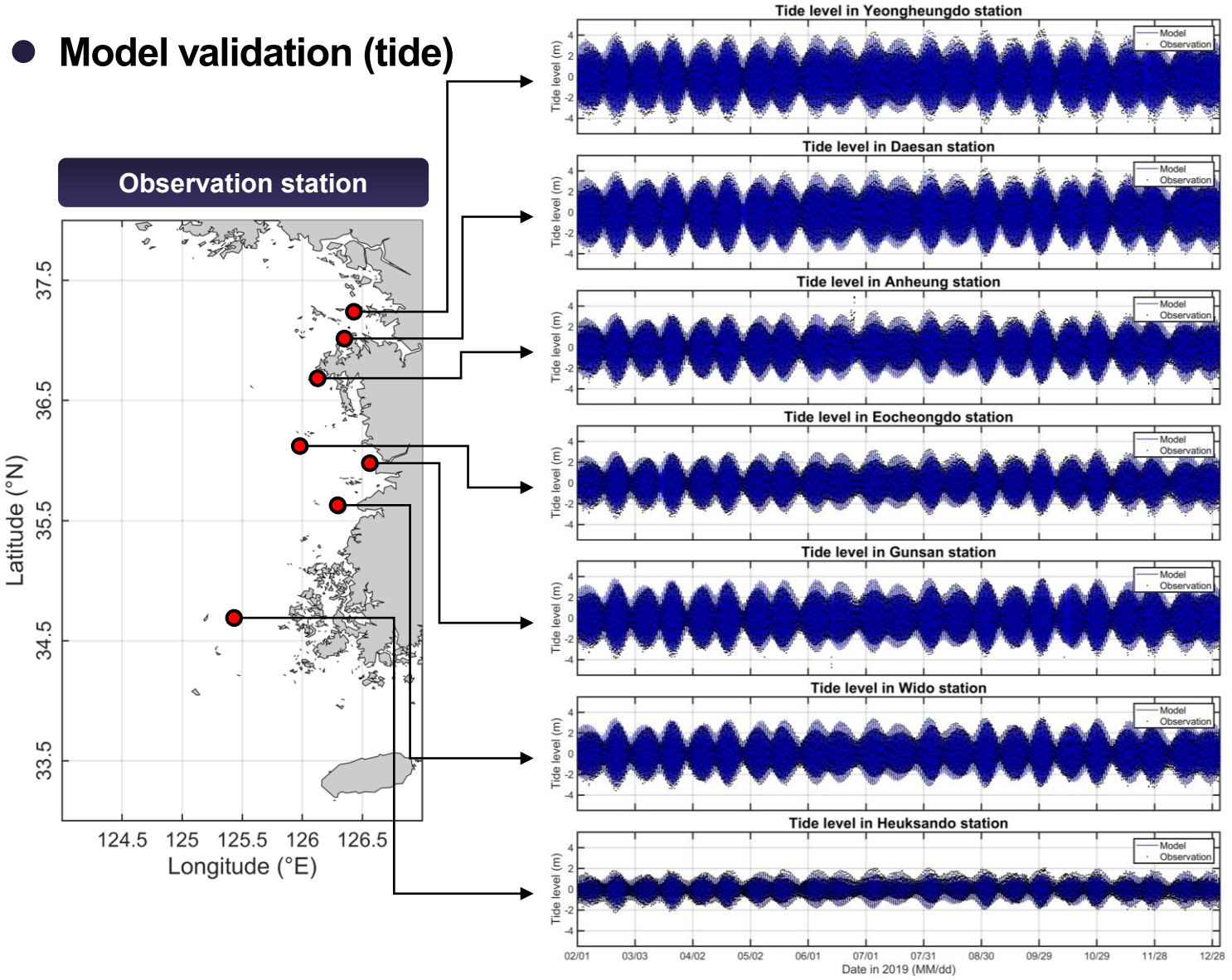
Model setup	
Model	FVCOM (Finite Volume Community Ocean Model)
Number of node	102,238
Number of element	197,684
Minimum depth	0.0 m
Maximum depth	7316.7 m
Minimum resolution	1.05 km
Maximum resolution	33.00 km
Number of vertical layer	40

Data source	
Initial field	HYCOM GLBy0.08
Open boundary	HYCOM GLBy0.08
Tide	TPXO9-atlas
River discharge	WAMIS, KRC, CWRC
Surface forcing	ECMWF-ERA5
SST data assimilation	OSTIA
SSH data assimilation	HYCOM GLBy0.08
Bathymetry	GEBCO-2024

3. Validation

03

- **Model validation (tide)**



M_n: n– th modeled data
O_n: n– th observed data
$\bar{M}, \bar{O}$: time averaged values

$$ME = \sum \frac{(M_n - O_n)}{N}$$

$$MAE = \sum \frac{|M_n - O_n|}{N}$$

$$IOA = 1 - \frac{\sum (M_n - O_n)^2}{\sum (|M_n - \bar{O}| + |O_n - \bar{O}|)^2}$$

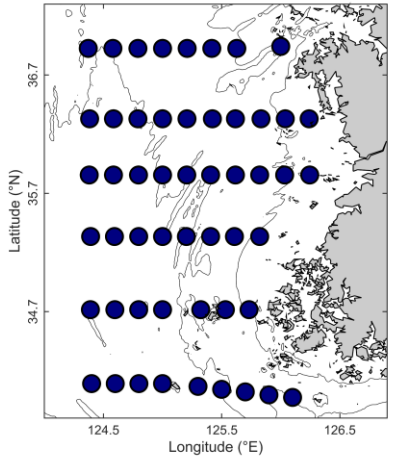
Model validation

Station name	ME (m)	MAE (m)	IOA
Yeongheungdo	−0.00	0.71	**0.96**
Daesan	0.00	0.35	**0.99**
Anheung	−0.00	0.22	**0.99**
Eocheongdo	−0.00	0.20	**0.99**
Gunsan	−0.00	0.25	**0.99**
Wido	0.01	0.23	**0.99**
Heuksando	0.00	0.28	**0.96**

- **Model validation (temperature)**

(Source: National Institute of Fisheries Science)

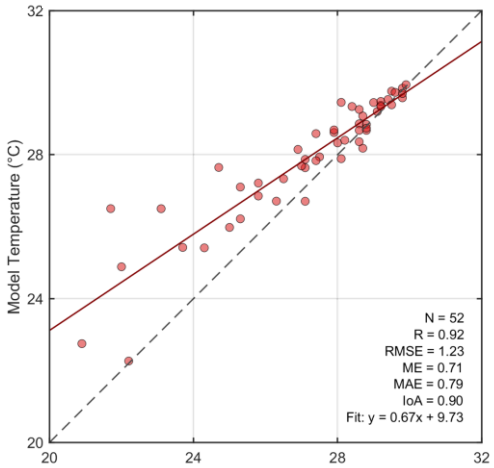
Observation data

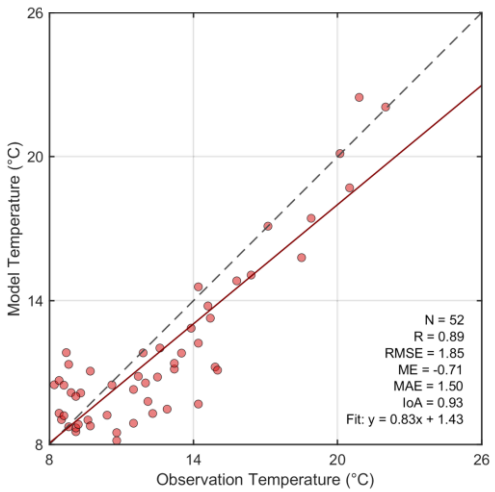


Surface temperature

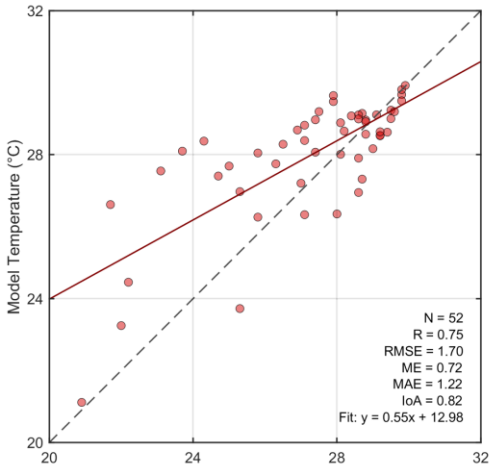
Bottom temperature

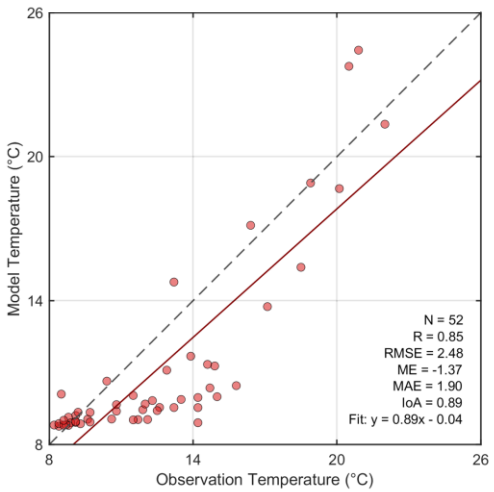
FVCOM



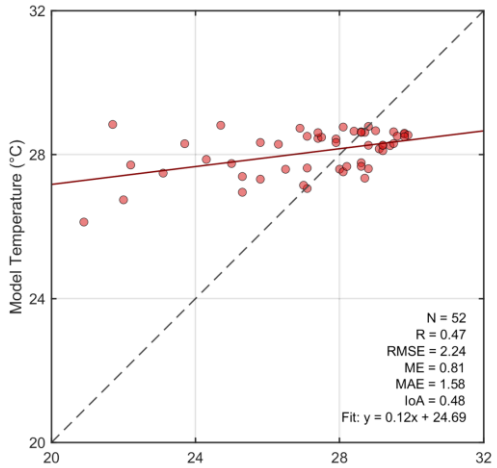


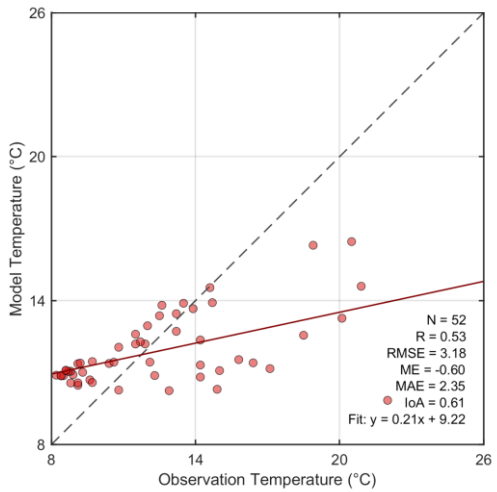
HYCOM





GLORYS12v1





Surface temperature

	FVCOM	HYCOM	GLORYS
RMSE	**1.23**	1.70	2.24
MAE	**0.79**	1.22	1.58
IoA	**0.90**	0.82	0.48

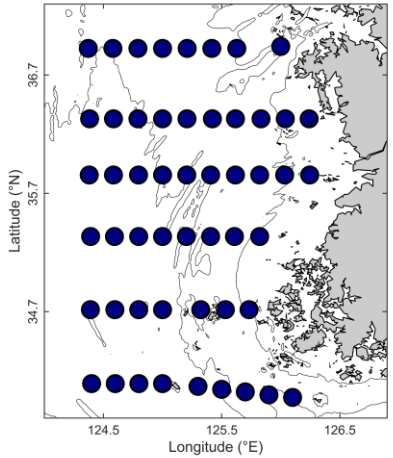
Bottom temperature

	FVCOM	HYCOM	GLORYS
RMSE	**1.85**	2.48	3.18
MAE	**1.50**	1.90	2.35
IoA	**0.93**	0.89	0.61

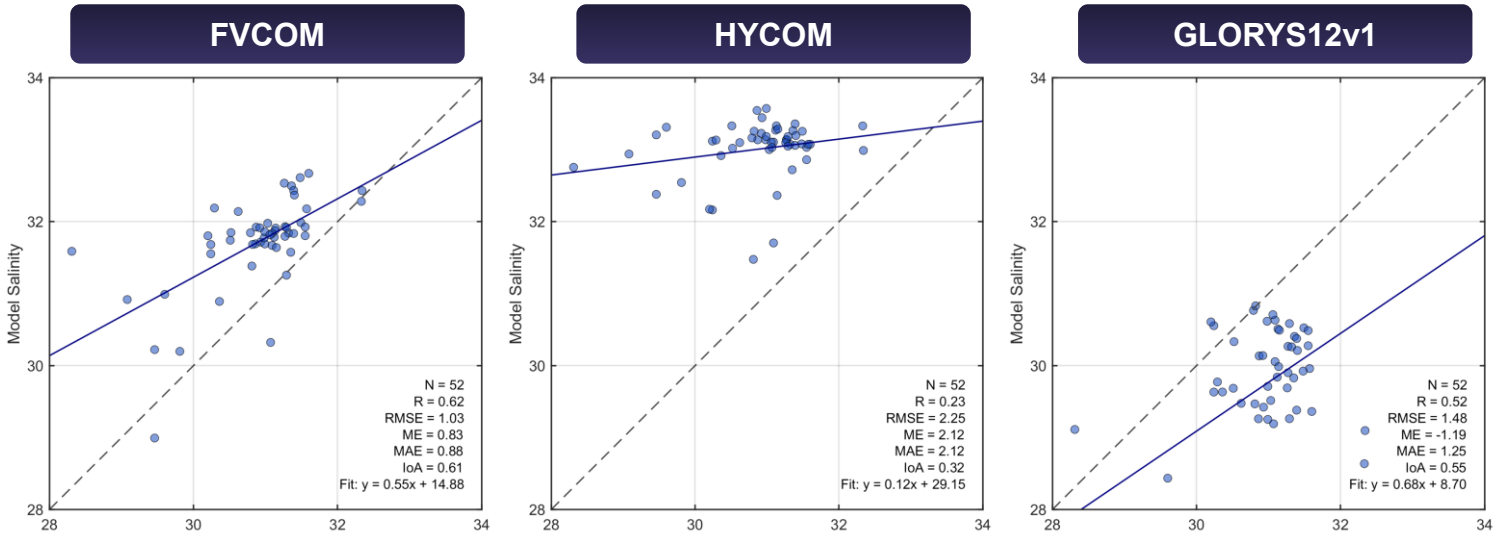
- **Model validation (salinity)**

(Source: National Institute of Fisheries Science)

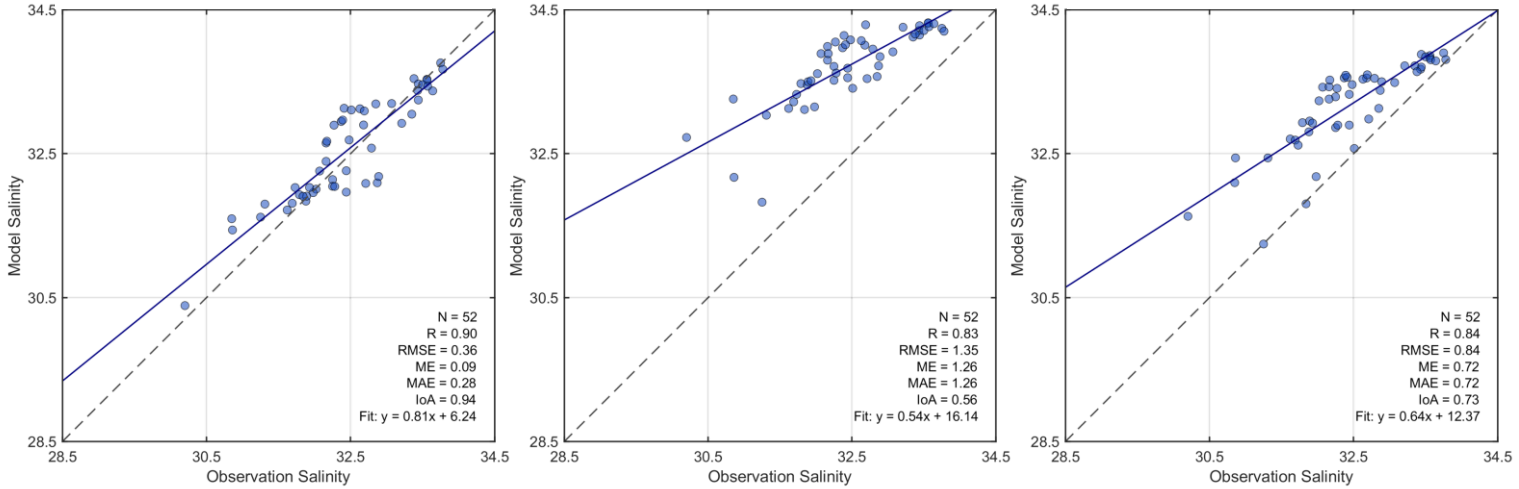
Observation data



Surface salinity



Bottom salinity



Surface salinity

	FVCOM	HYCOM	GLORYS
RMSE	**1.03**	2.25	1.48
MAE	**0.88**	2.12	1.25
IoA	**0.61**	0.32	0.55

Bottom salinity

	FVCOM	HYCOM	GLORYS
RMSE	**0.36**	1.35	0.84
MAE	**0.28**	1.26	0.72
IoA	**0.94**	0.56	0.73

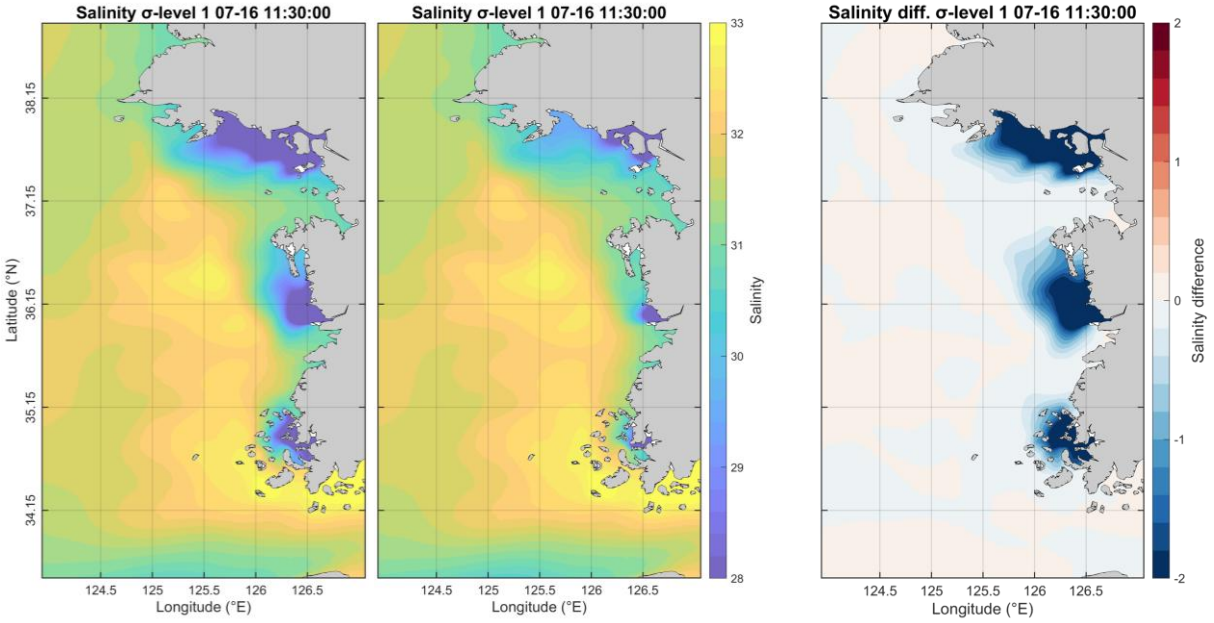
4. Results

04

- **Surface salinity under high/low discharge scenarios**

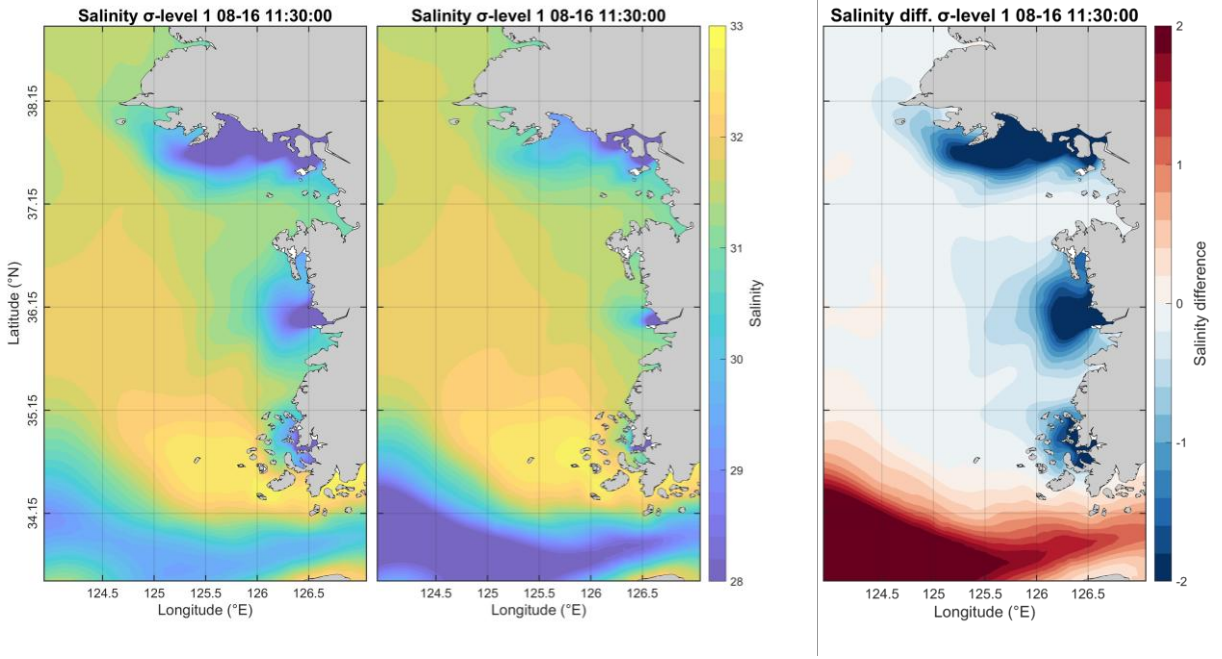
Mean surface salinity in July

High (2023) | Low (2019) | Difference (High − Low)



Mean surface salinity in August

High (2023) | Low (2019) | Difference (High − Low)

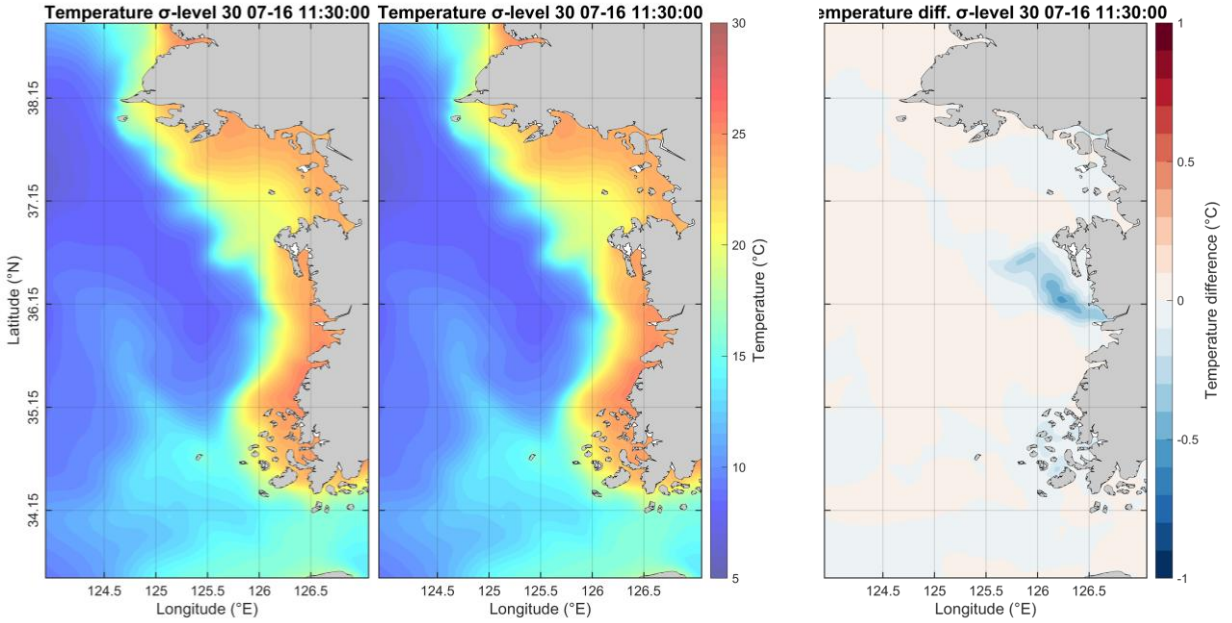


- The Han River lowers salinity by more than 1 as far as 150 km from its outlet, and the Geum River as far as 80 km.
- Clear surface salinity differences appeared in July and August, persisting through August.

- **Bottom temperature under high/low discharge scenarios**

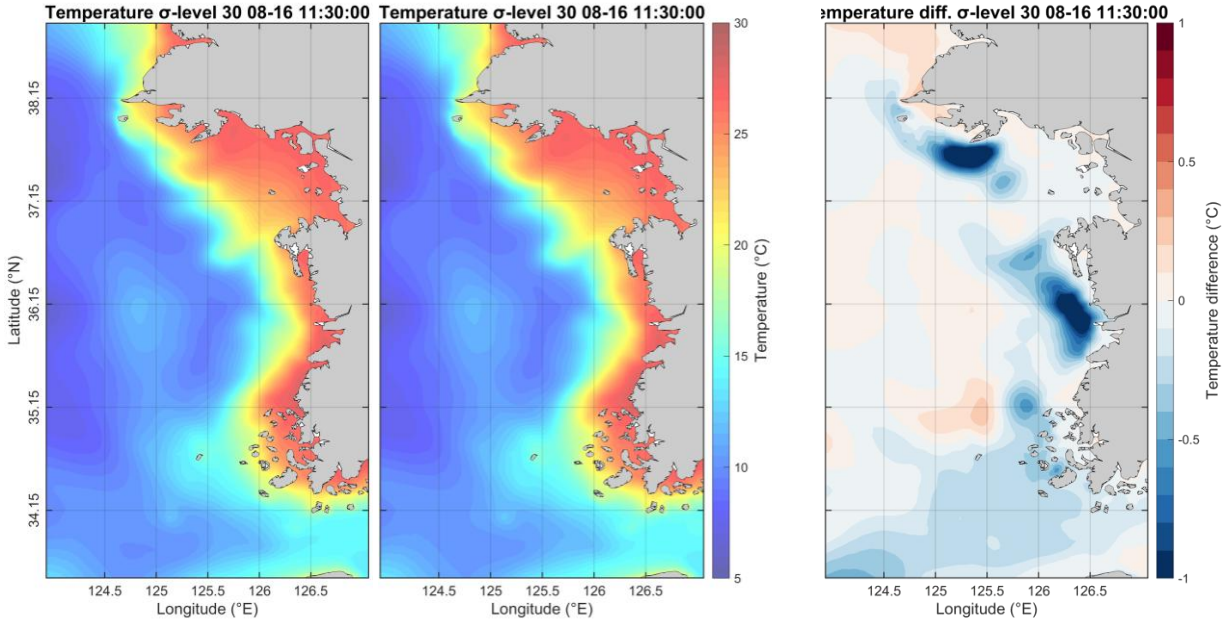
Mean bottom temperature in July

High (2023) | Low (2019) | Difference (High − Low)



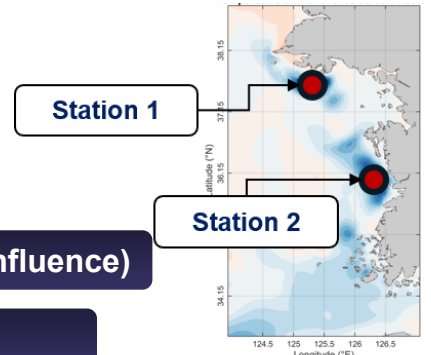
Mean bottom temperature in August

High (2023) | Low (2019) | Difference (High − Low)



- In July, no significant difference in bottom water temperature was observed.
- In August, as the effect of salinity differences accumulated, a clear difference in bottom water temperature was confirmed.

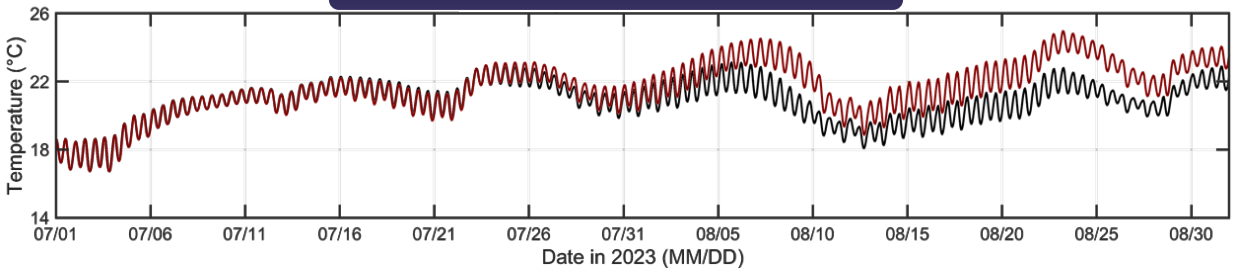
- **Time series analysis**



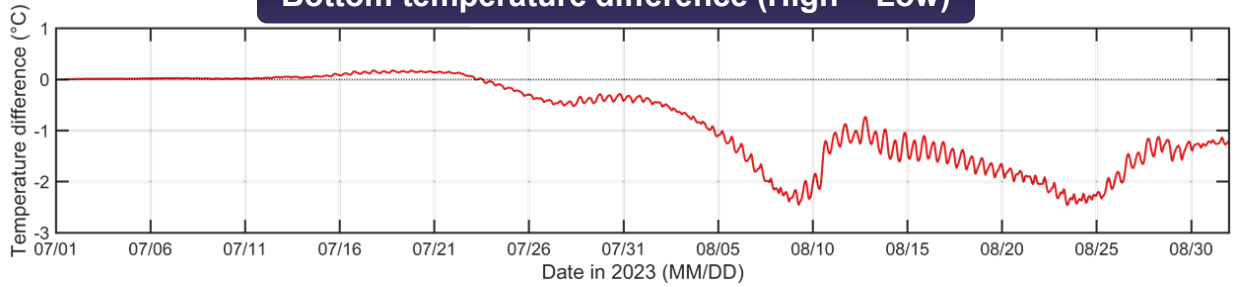
High (2023)
Low (2019)

Station 1 (Extent of Han River influence)

Bottom temperature

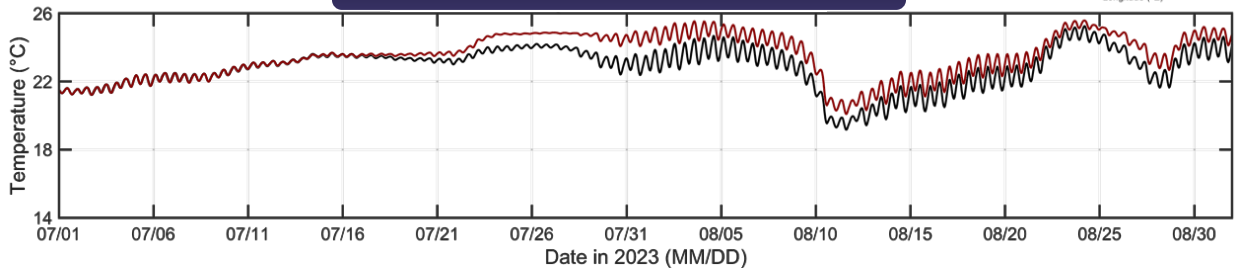


Bottom temperature difference (High − Low)

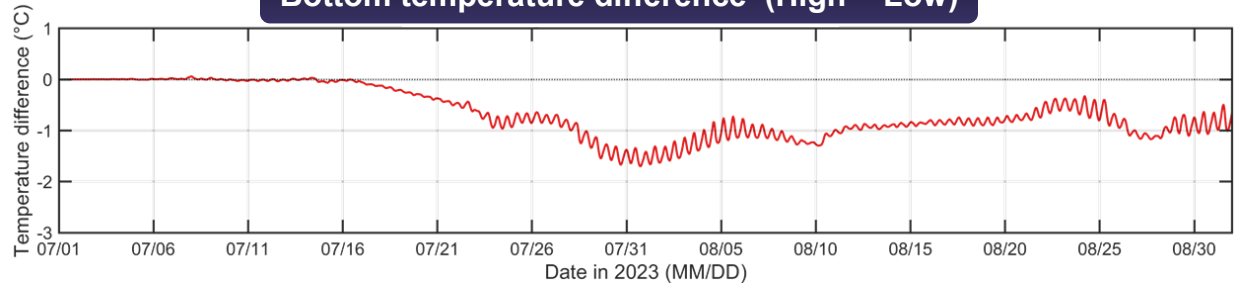


Station 2 (Extent of Geum River influence)

Bottom temperature

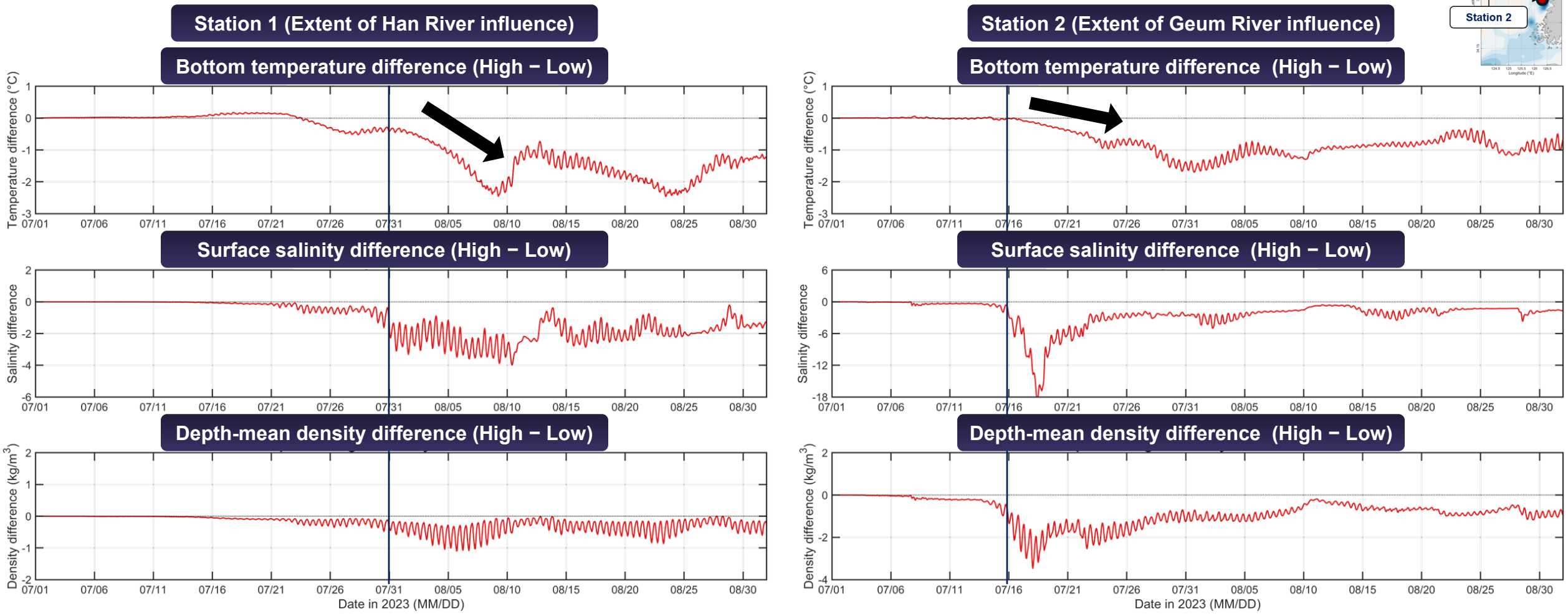


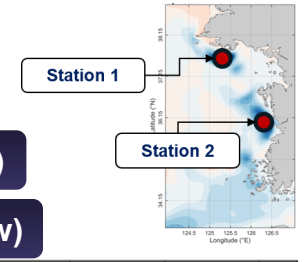
Bottom temperature difference (High − Low)



- Station 1: Bottom temperature dropped sharply starting July 31, reaching a maximum difference of 2.4°C.
- Station 2: The difference began to appear starting July 16, reaching a maximum difference of 1.6°C.

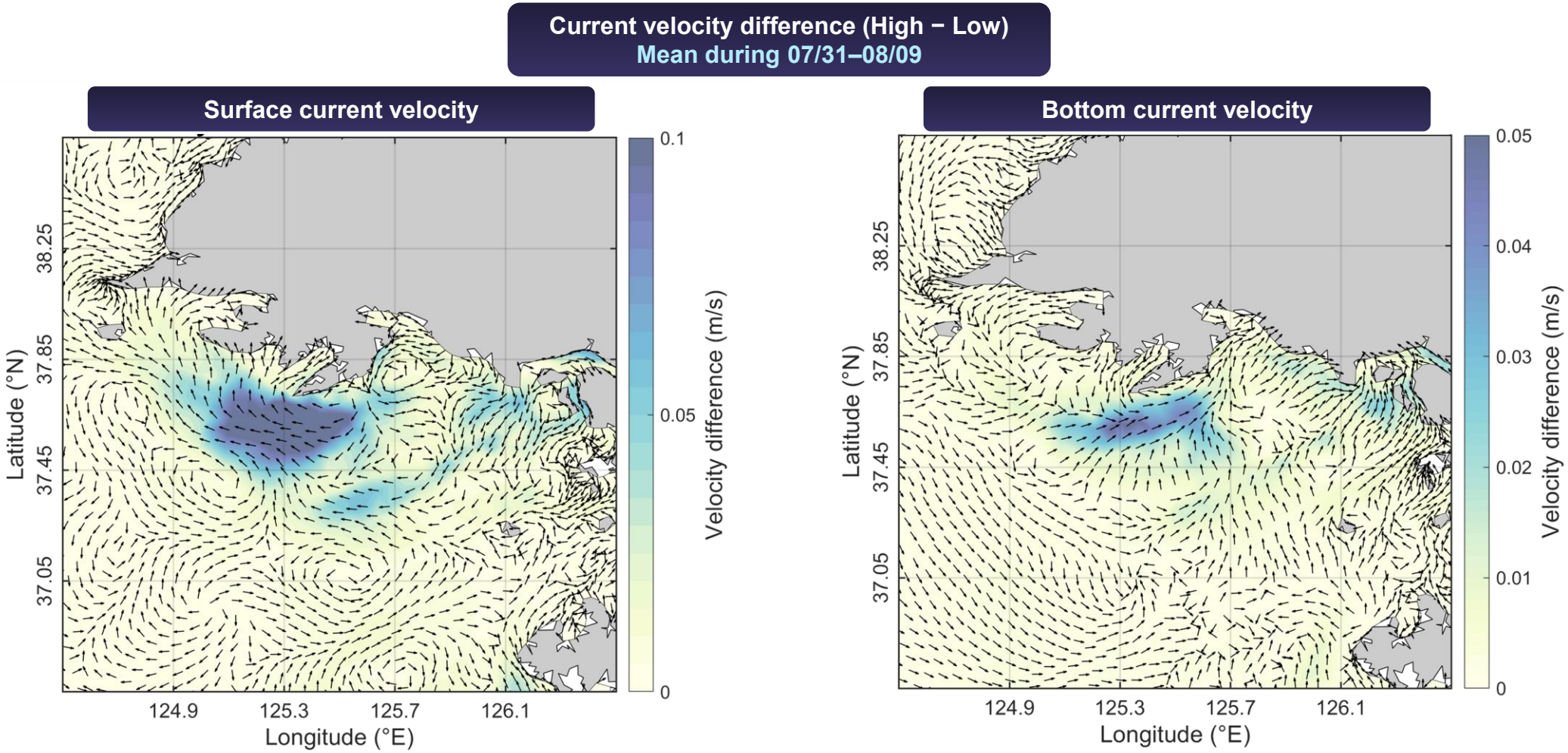
- **Time series analysis**





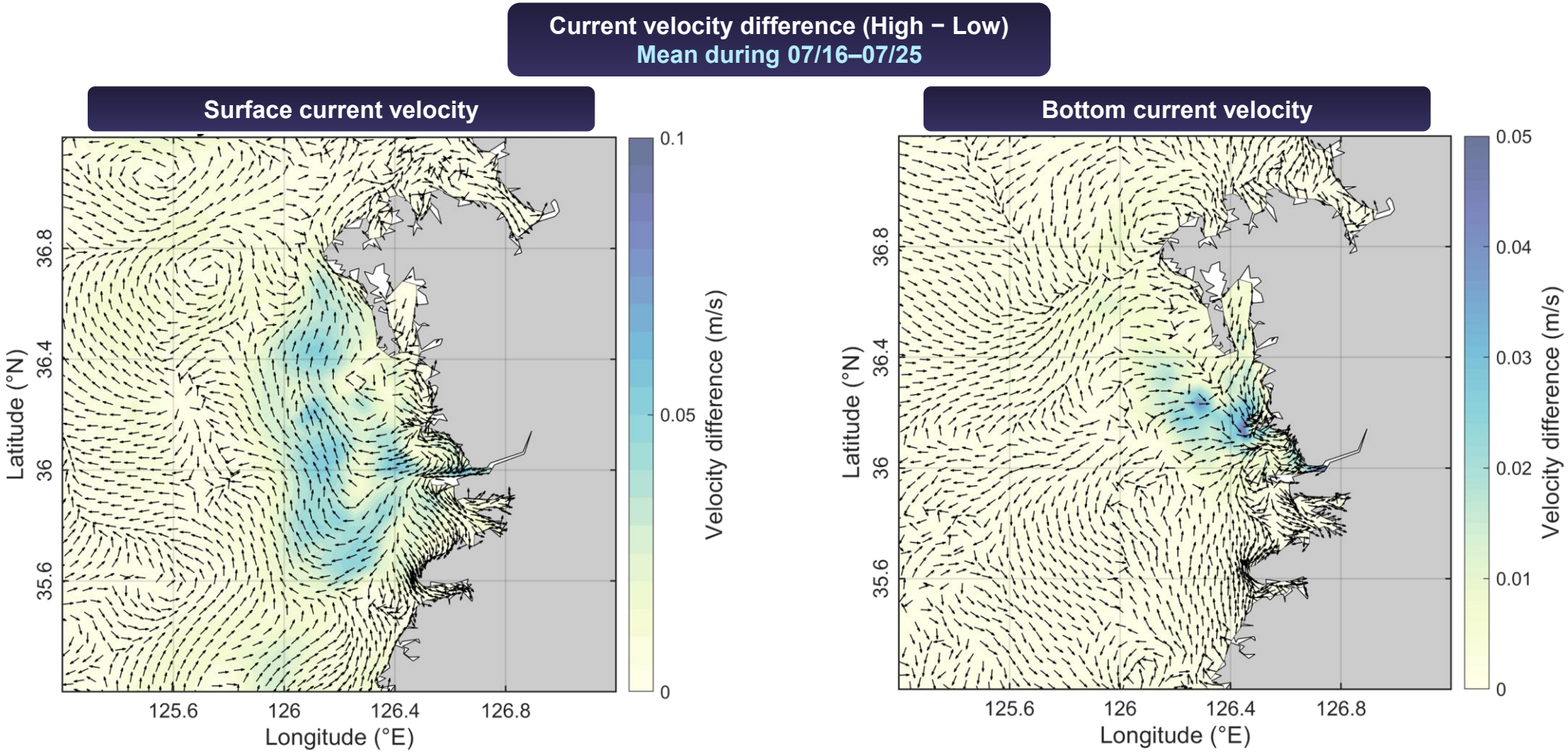
- Bottom temperature began to decrease from the point when surface salinity started decreasing due to freshwater influence.

- **Current velocity difference (Extent of Han River influence)**



- Freshwater discharge differences drive surface outflow in the high-discharge case, compensated by bottom onshore inflow.

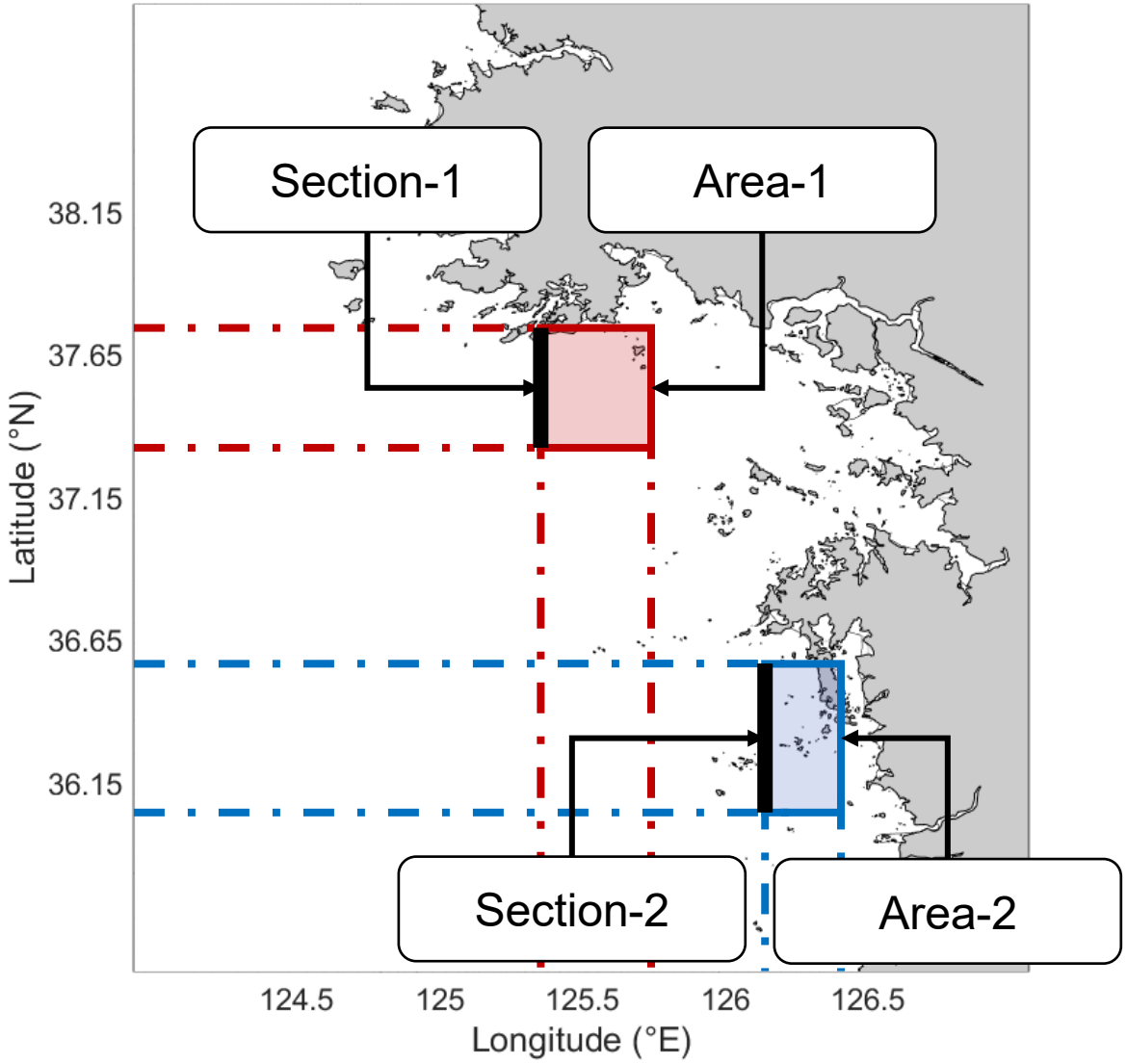
- **Current velocity difference (Extent of Geum River influence)**



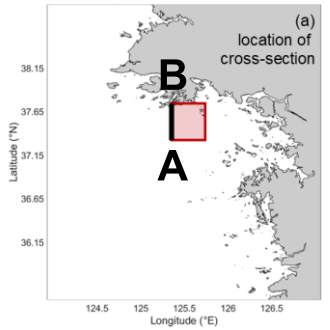
- Freshwater discharge differences drive surface outflow in the high-discharge case, compensated by bottom onshore inflow.

- **Flux calculation**

- **Volume flux (m³/s):** $\iint v_n \, dxdz$
- **Relative heat flux (W):** $\iint \rho C_p \left(T - T_{ref}\right) v_n dxdz$
- **Calculate Cross-sectional Flux for Han River Area**
  - Calculate volume flux through Section-1
  - Substitute mean temperature of Area-1 into T_{ref}
- **Calculate Cross-sectional Flux for Geum River Area**
  - Calculate volume flux through Section-2
  - Substitute mean temperature of Area-2 into T_{ref}



- **Flux difference (Extent of Han River influence)**



Onshore Offshore

Mean flux during 07/31–08/09

Warming Cooling

High (2023)

Low (2019)

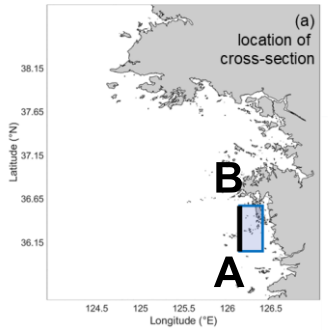
Mean volume flux

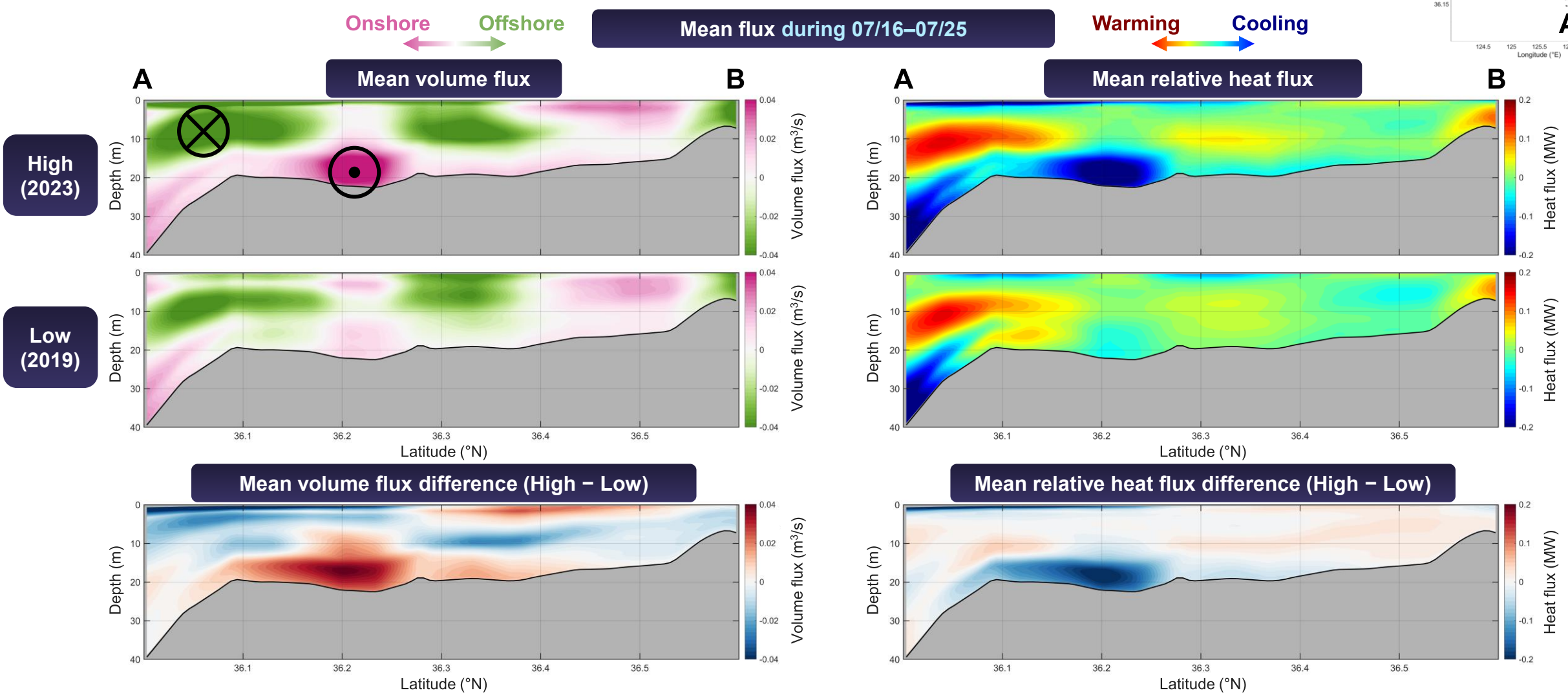
Mean relative heat flux

Mean volume flux difference (High − Low)

Mean relative heat flux difference (High − Low)

- **Flux difference (Extent of Geum River influence)**



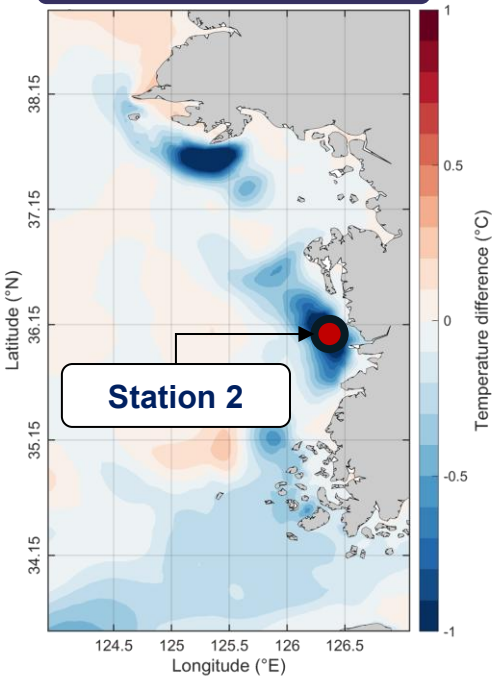


5. Discussion

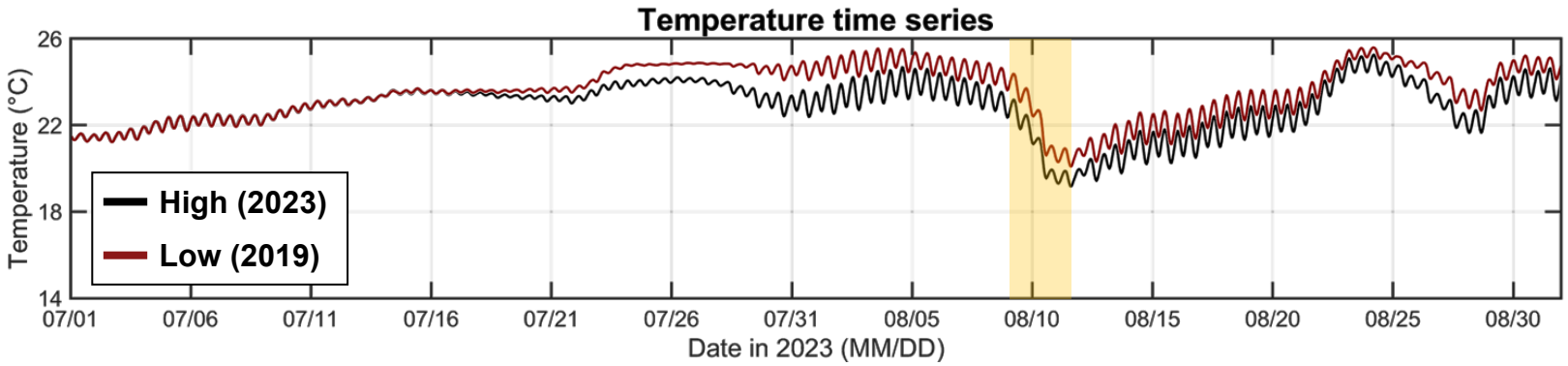
05

- **Effect of wind**

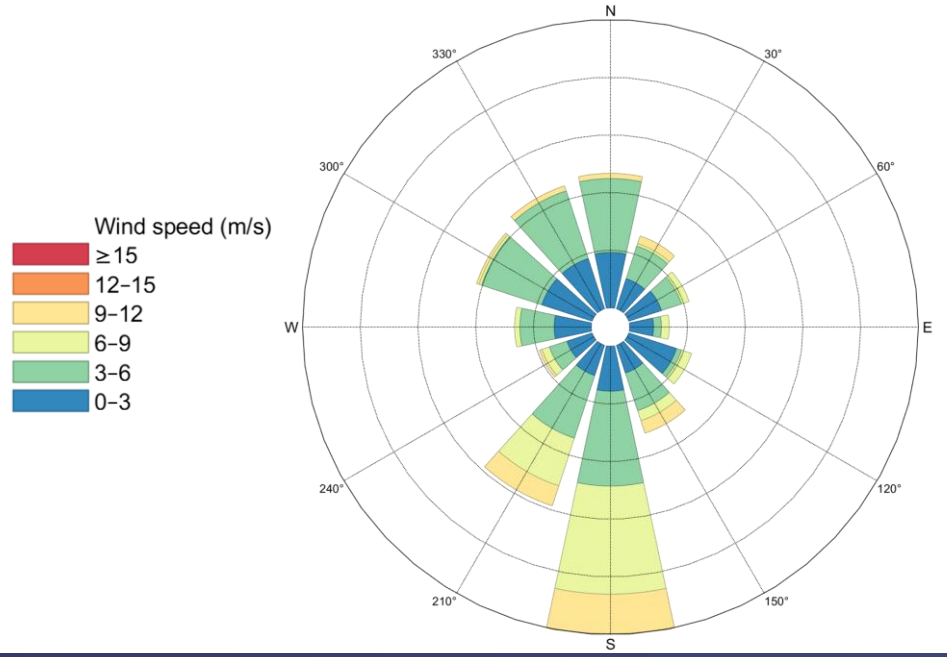
Station location



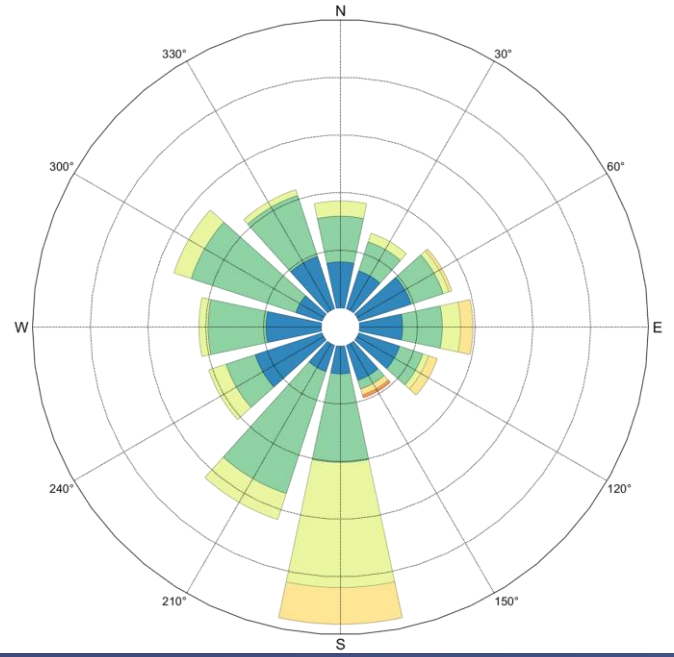
Bottom temperature at Station 2



Case 1: Wind from July to August 2023



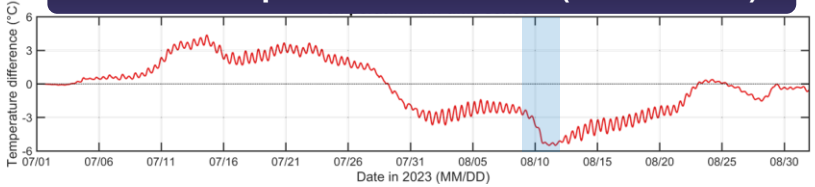
Case 2: Wind from July to August 2019



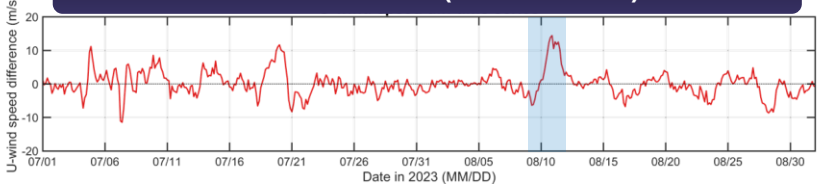
- **Effect of wind**

Station 2 (Extent of Geum River influence)

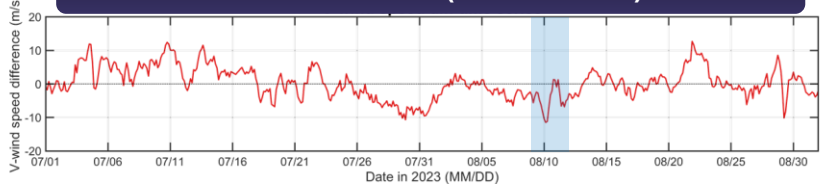
Bottom temperature difference (2023 − 2019)



U10 difference (2023 − 2019)

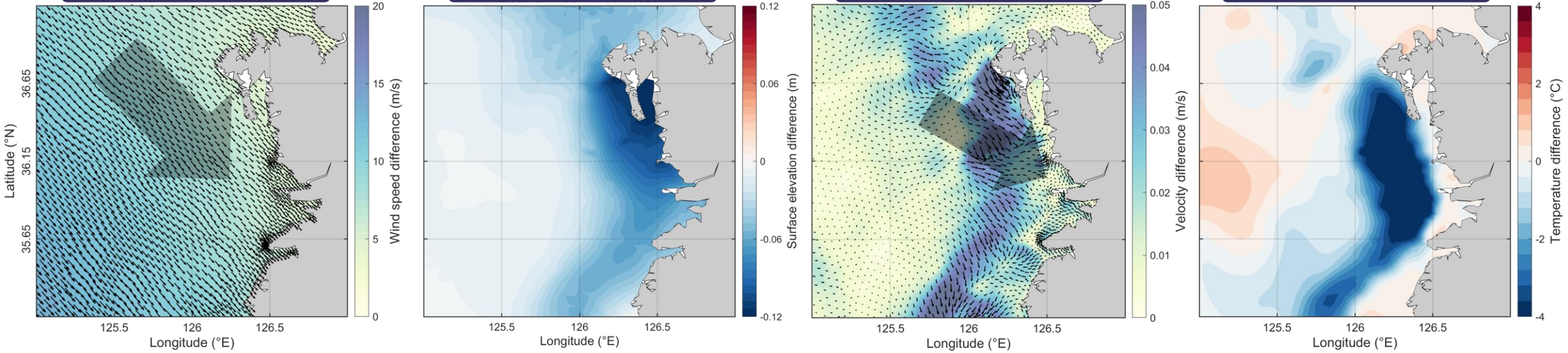


V10 difference (2023 − 2019)



08/09–08/12 mean difference (2023 − 2019)

Wind → **Sea surface elevation** → **Bottom current** → **Bottom temperature**



- The coastal intrusion of bottom cold water in 2023 is inferred to have been intensified by increased northwesterly winds.

6. Conclusion

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Summary

- Freshwater discharge from the west coast of Korea lowered surface salinity, and bottom temperature decreased, confirming a link between freshwater discharge and bottom cold water intrusion.
- This freshwater-driven density gradient generated a compensating circulation – surface offshore outflow paired with bottom onshore inflow – that transported cold water toward the coast.
- Intensified northwesterly winds in 2023 further strengthened this coastal intrusion of bottom cold water.
- Freshwater discharge from rivers acts as a trigger for bottom cold water intrusion, and may serve as a new key factor for improving the accuracy of coastal fishery prediction models.

Thank you