PICES2025 POC Paper Session
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Yamayuri 3F

Multi-month prediction of summertime hypoxia occurrence in the bottom of Funka Bay, Japan, with a focus on the wintertime surface heat flux

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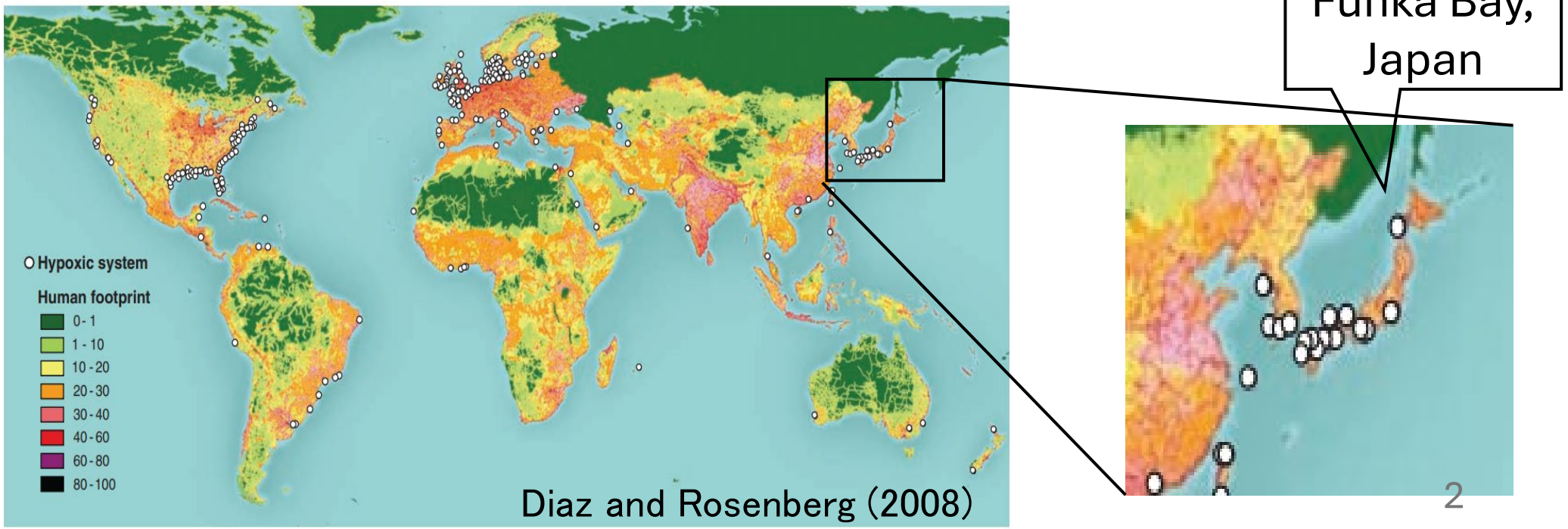
Hypoxia

Water mass with very low dissolved oxygen < 2 ml/L.

It often occurs in enclosed waters around the world.

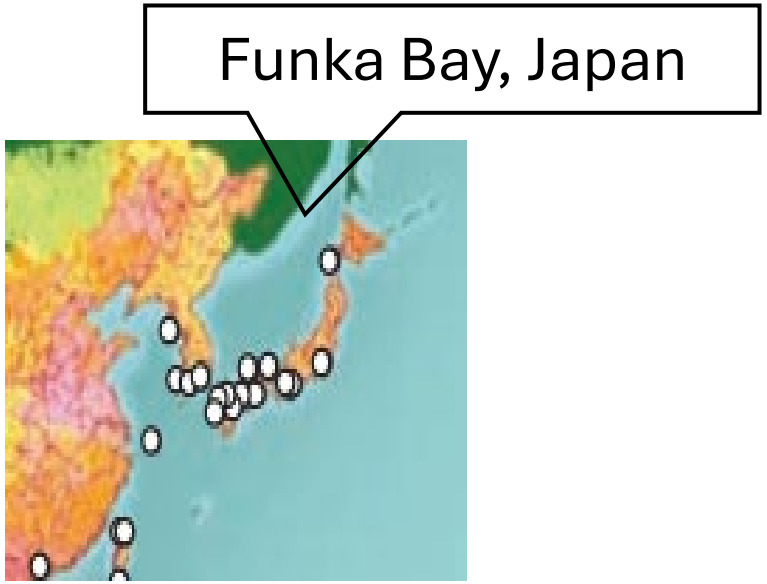
(e.g. Baltic Sea, Chesapeake Bay)

Once happened, it changes spatial distribution of fishes, suppresses their growth with serious case causing mass mortality.



Diaz and Rosenberg (2008)

Funka Bay

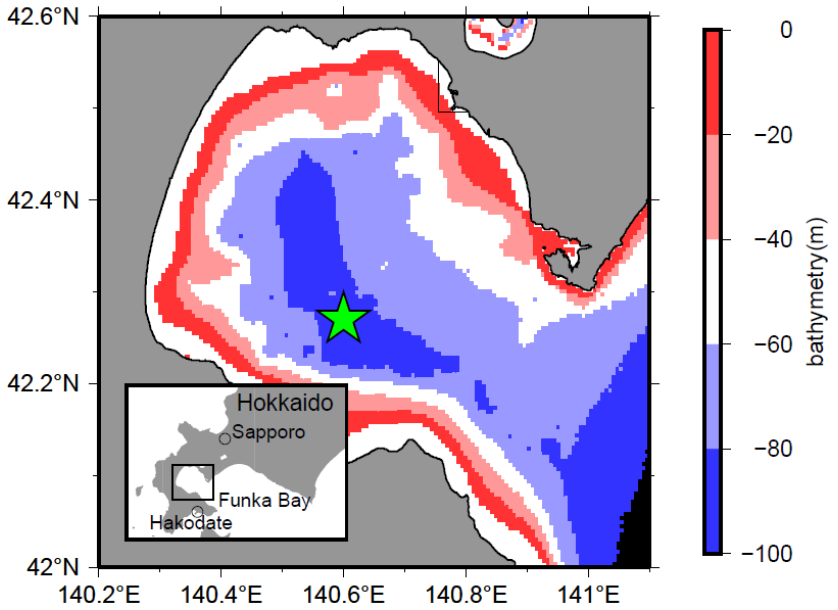


Good fishing ground/aquatic farm with rich fishery resource including scallop, cod, flatfish, shrimp. Annual catch exceeds 100 million US dollars.

Geographical feature

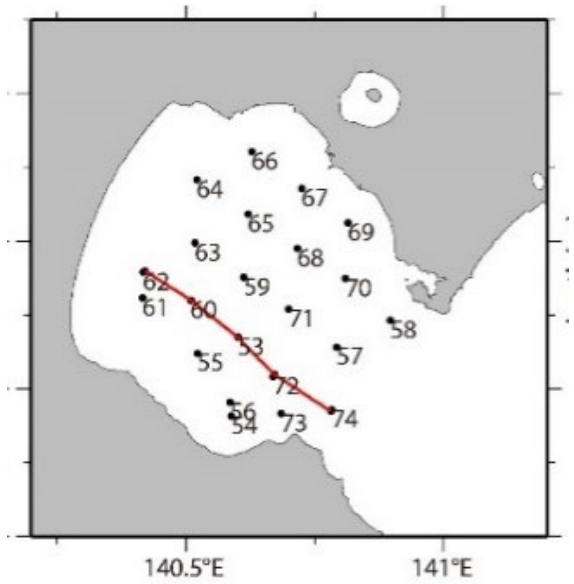
- ✓ A cone-shape
- ✓ surrounded by the land except for SE
- ✓ maximum seafloor depth of 100 m

Hypoxia occurs once every few years.

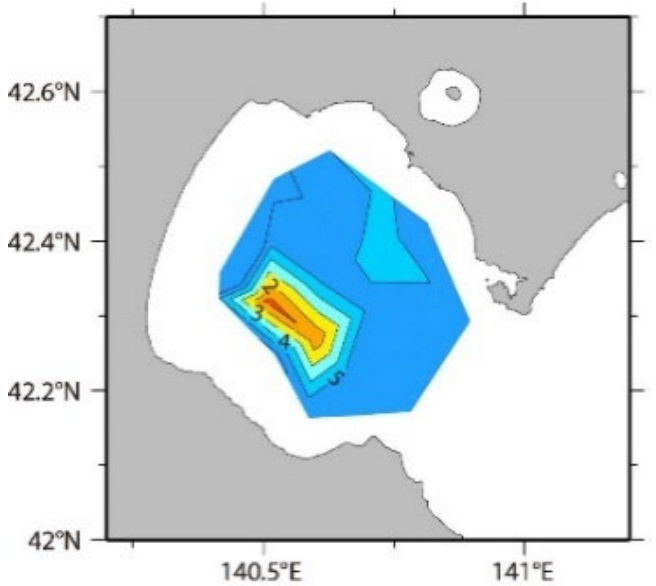


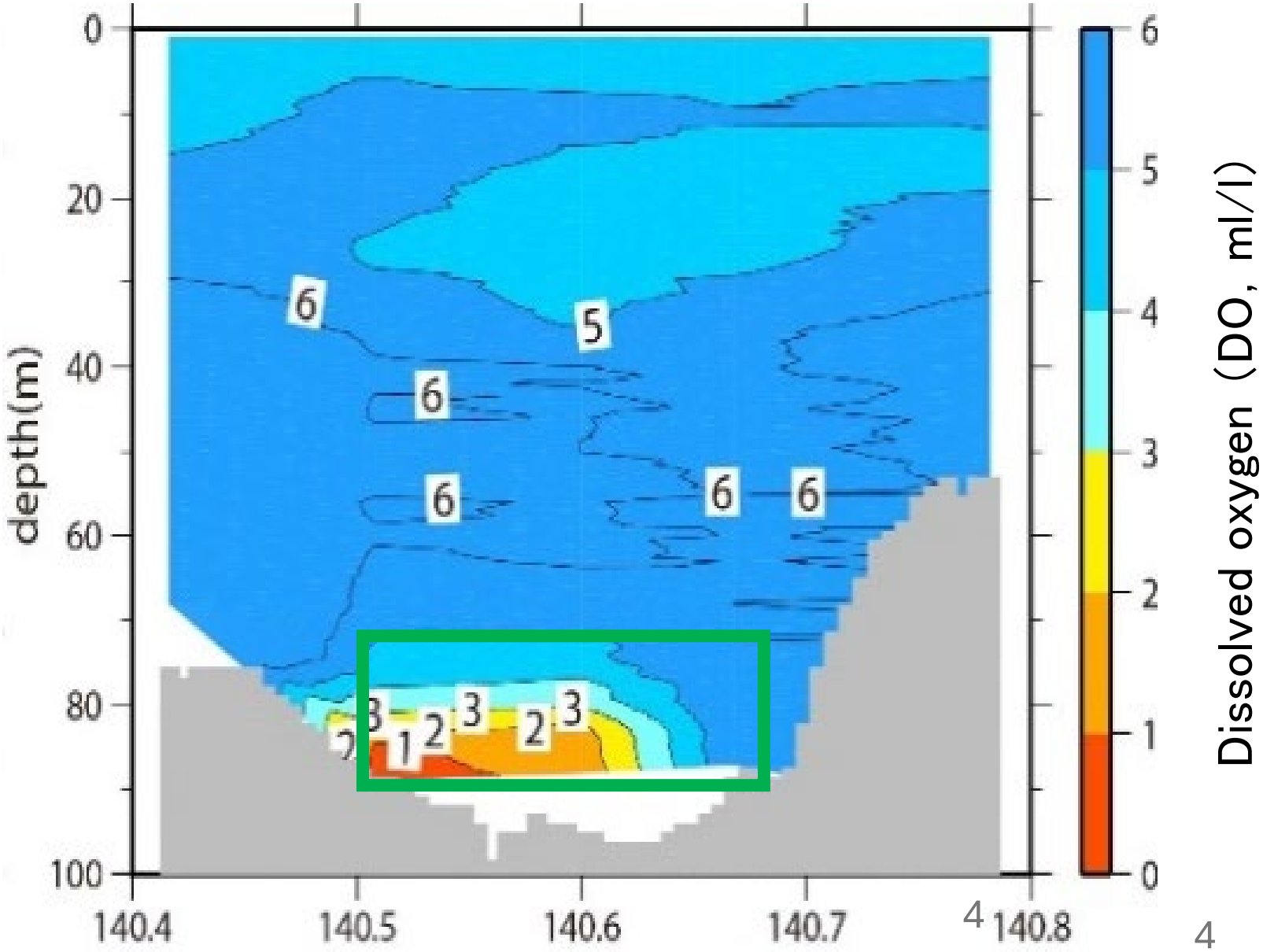
Most serious case is summer 1995 when many benthic species like flatfish died due to lack of oxygen, then floated to the surface.

Recent hypoxia in summer of 2023



DO at the bottom





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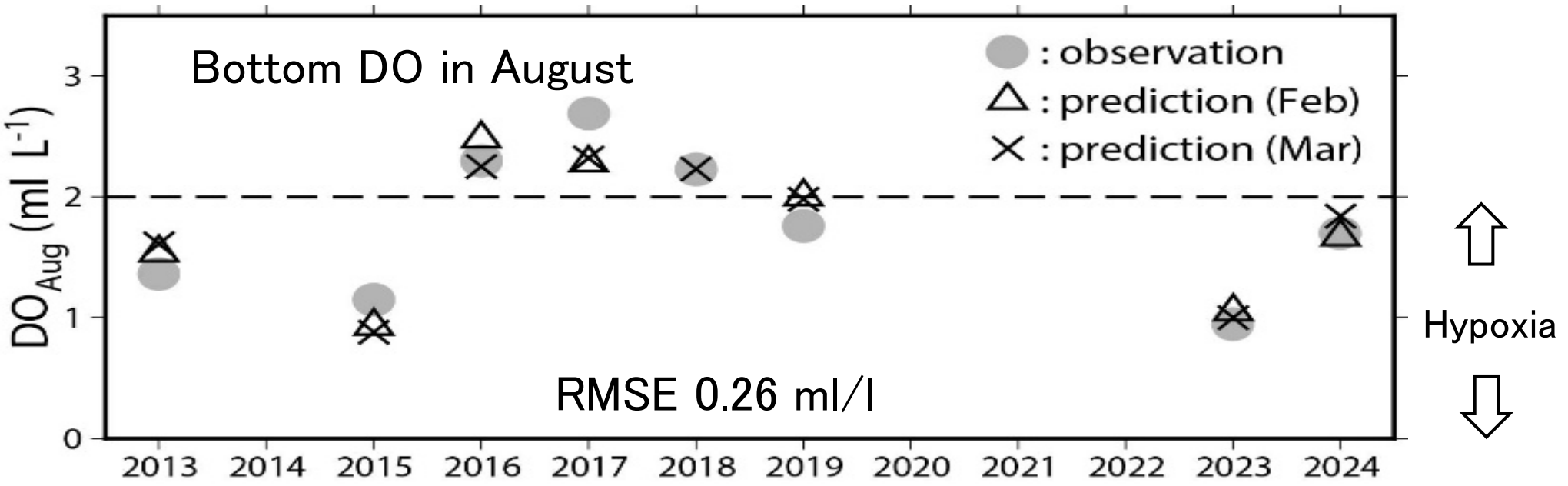
We could have successfully predicted occurrence of summertime bottom hypoxia at 6 month ahead.

e.g. 2023 Feb ⇒ 2023 Aug



Focus : wintertime oxygen recovery process through surface cooling and convection

Use : oceanic and atmospheric data in winter

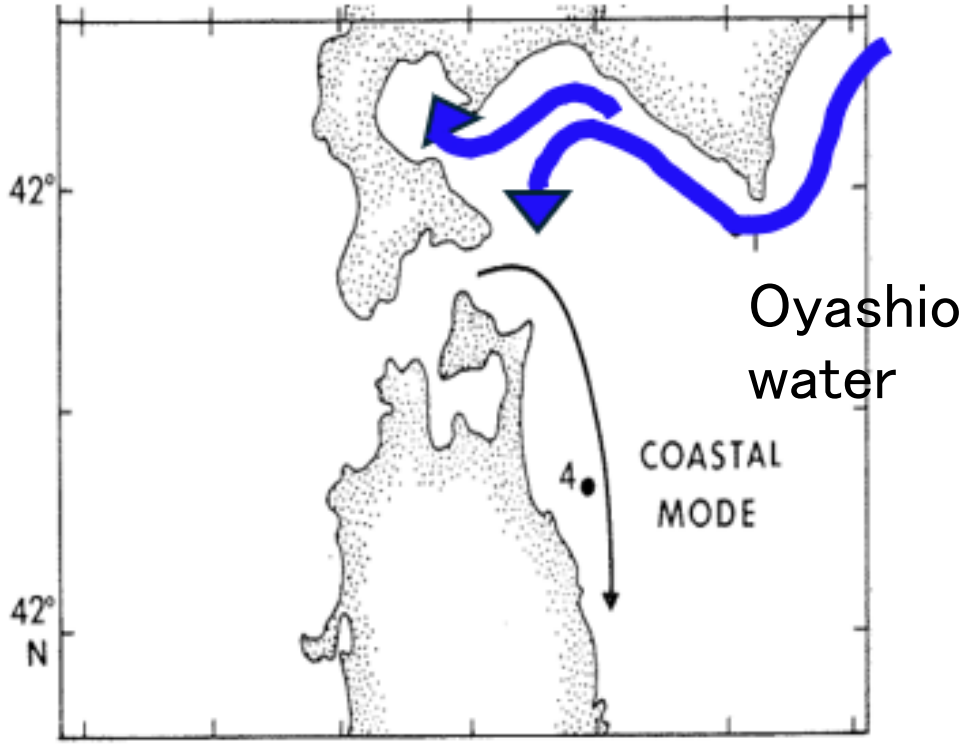
In this presentation, we introduce specific method for predicting summer bottom DO.

Seasonal water inflow

Winter–spring season

Oyashio water inflows

Cold and less saline

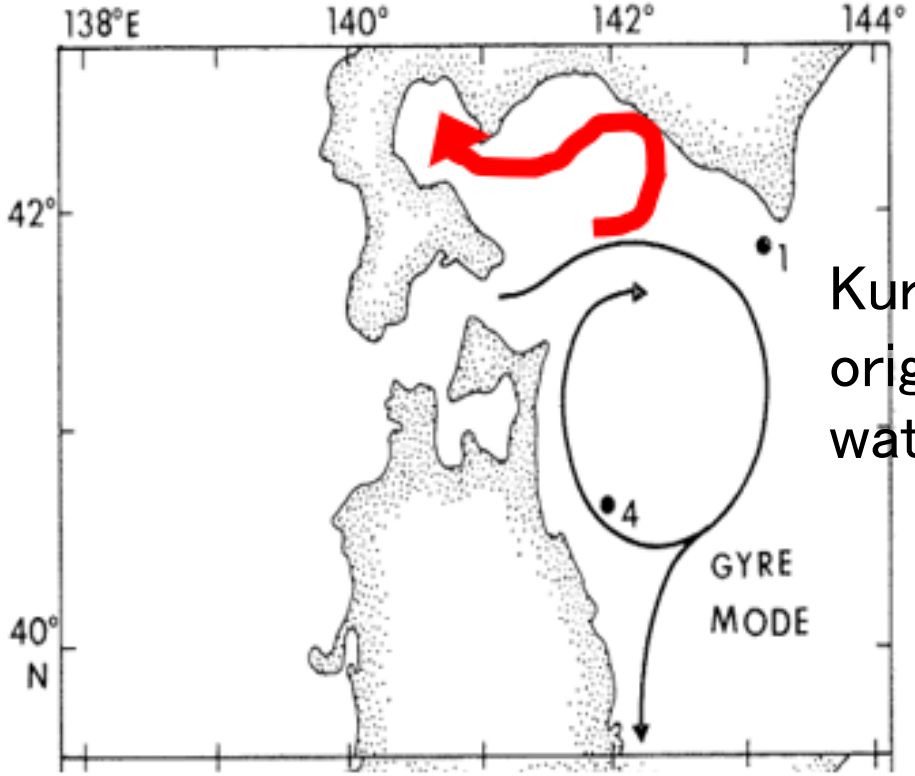


Oyashio water

Summer–autumn season

Kuroshio–originated water intermittently inflows

Warm and saline

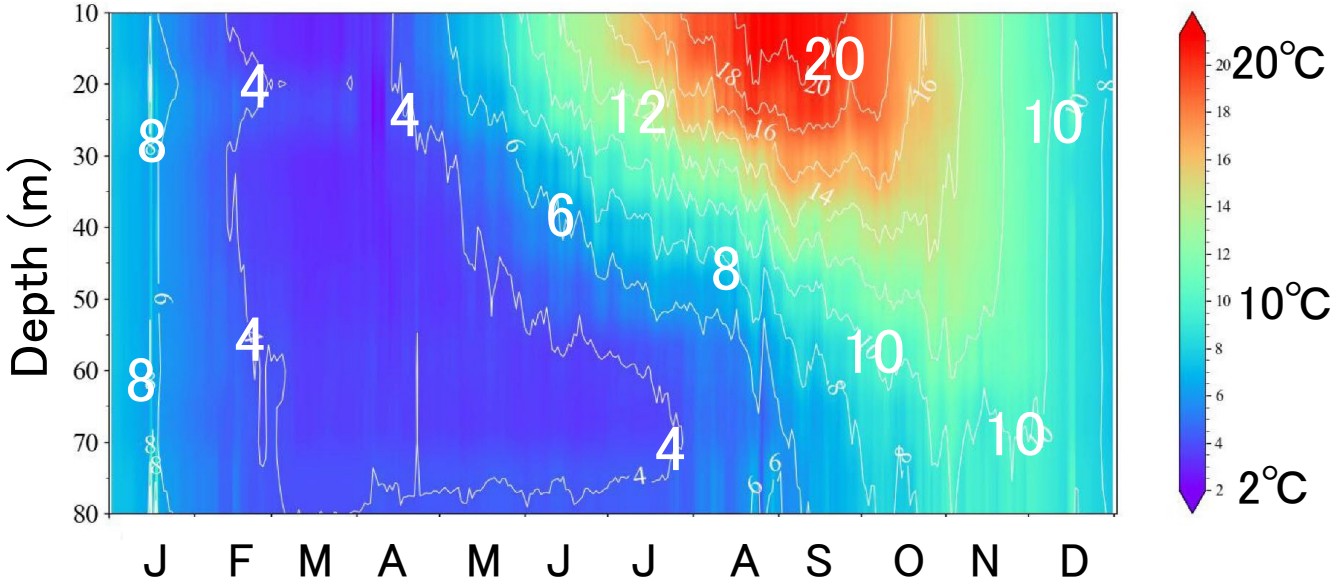


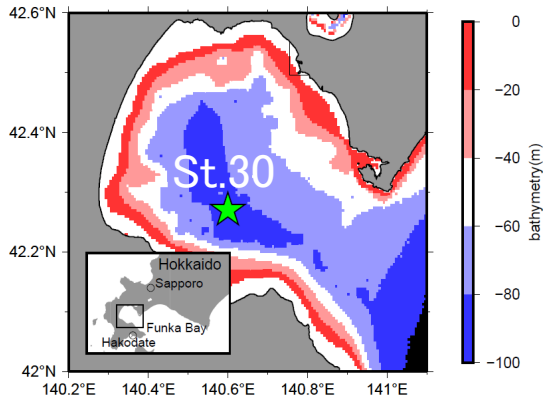
Kuroshio–originated water

Conlon (1982)

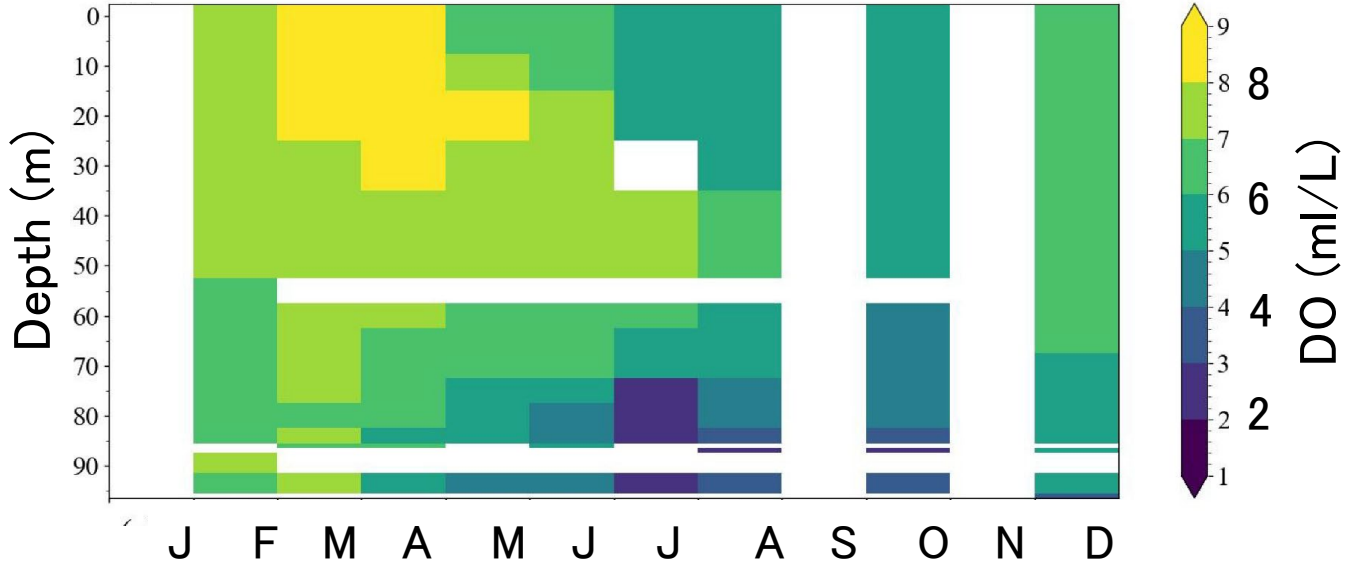
A 7-year mean of oceanic data at St.30 (2012-2019)

Moored water temperature

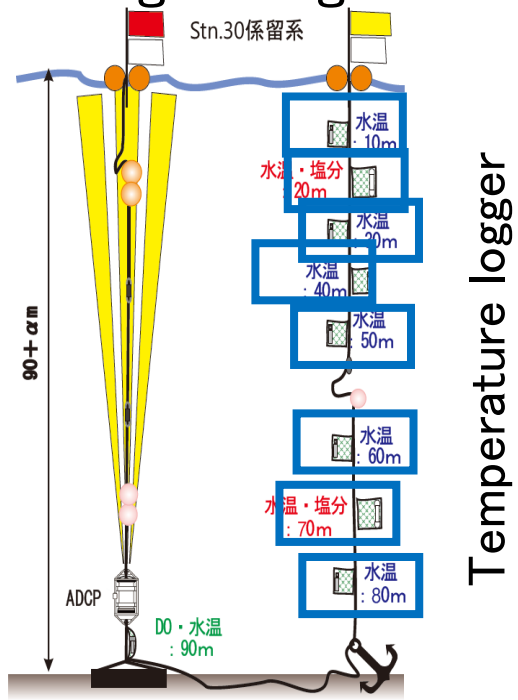




Ship-board CTD's DO profile

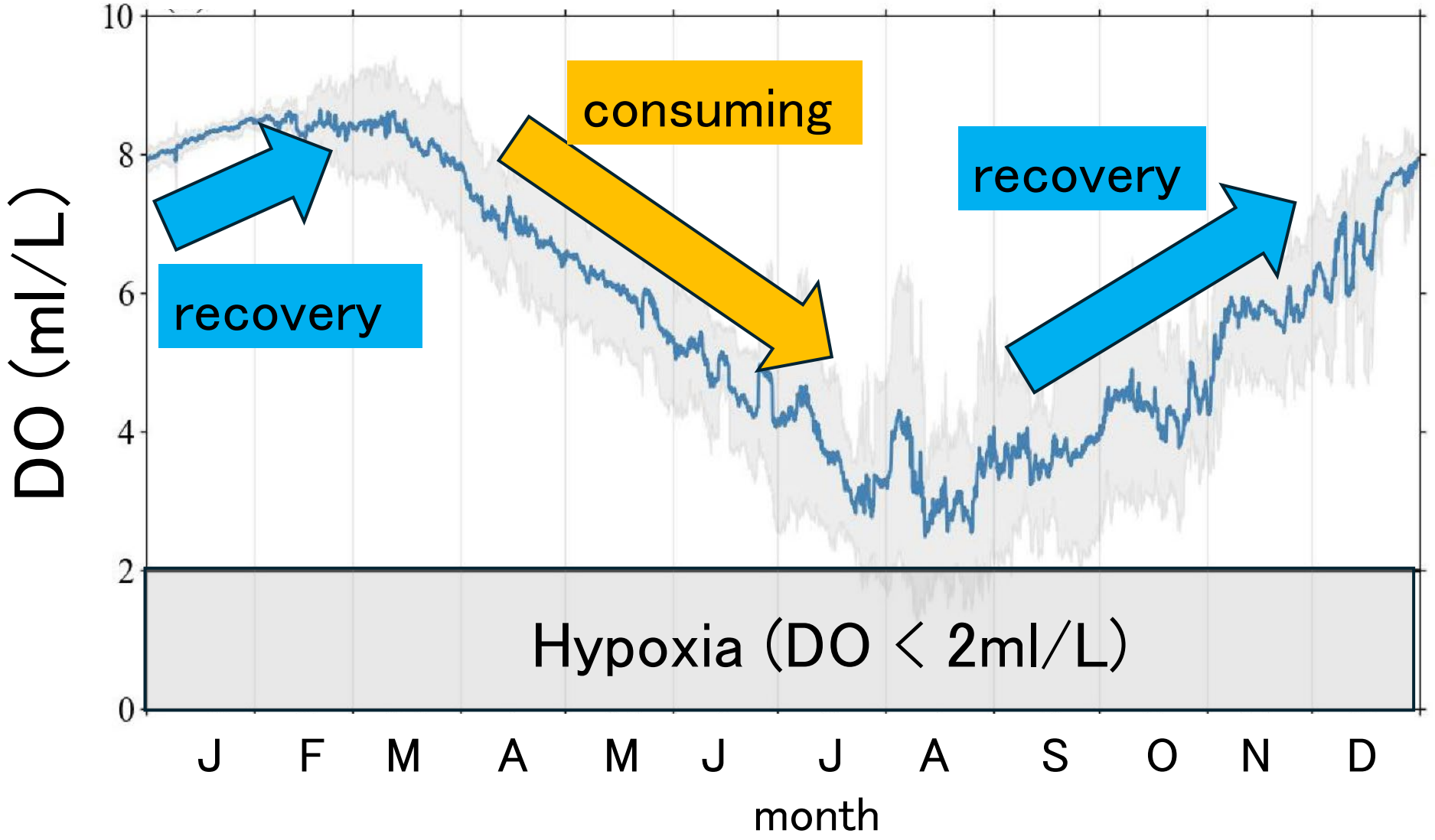


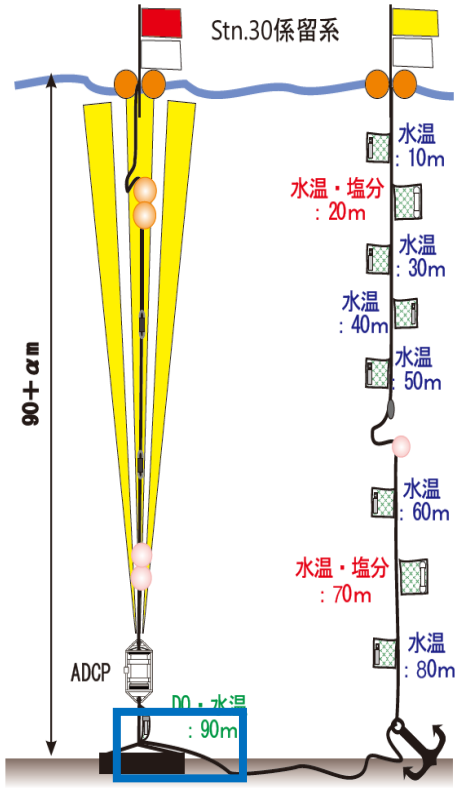
Mooring configuration



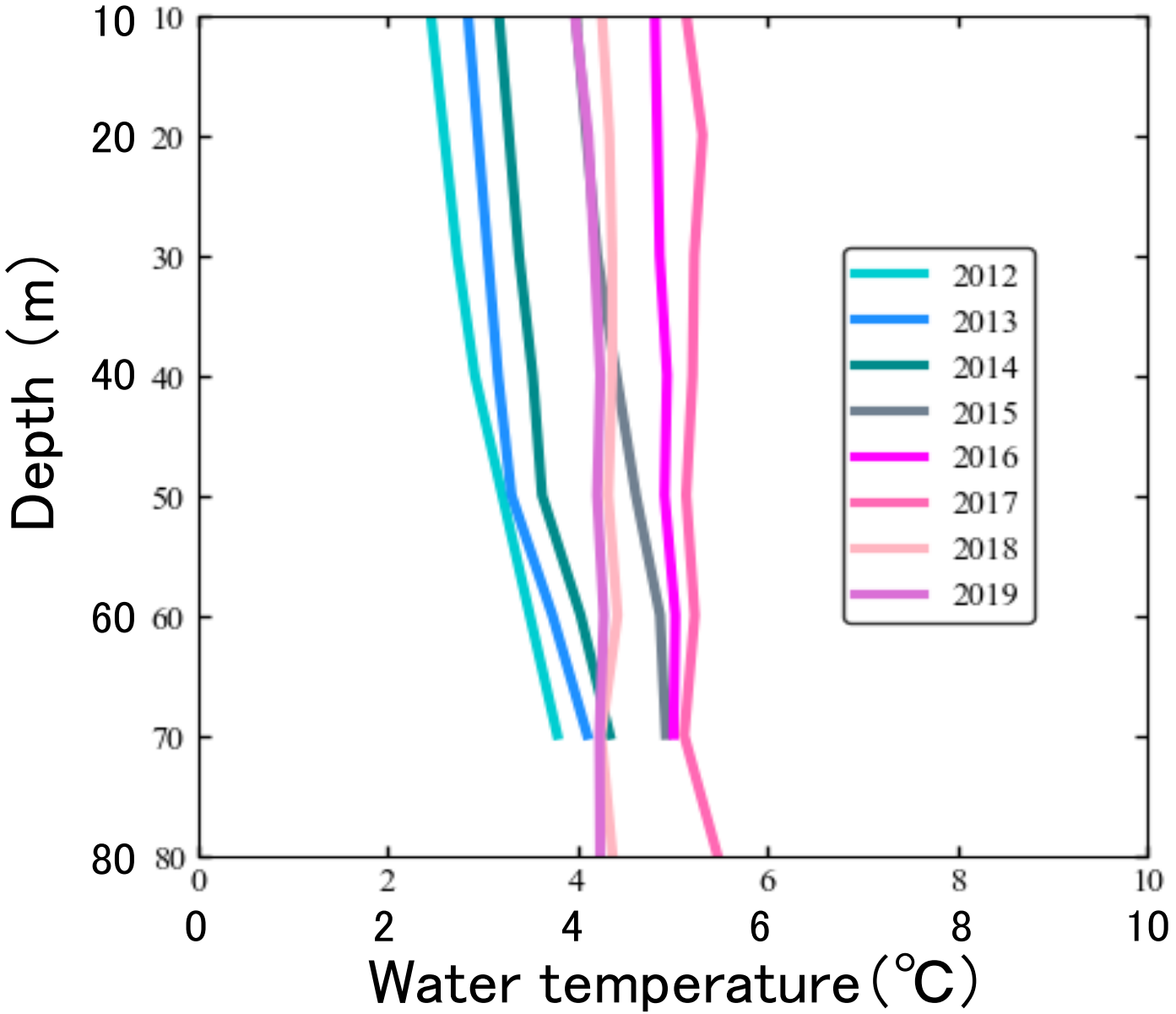
A 7-year mean of oceanic data at St.30 (2012-2019)

Moored bottom DO

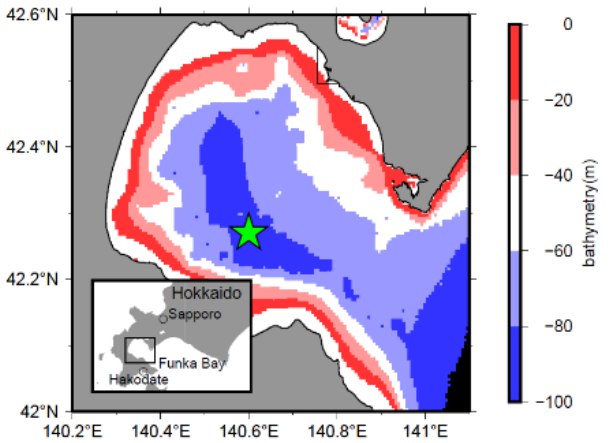




Cold years in early 2010s Warm years in late 2010s

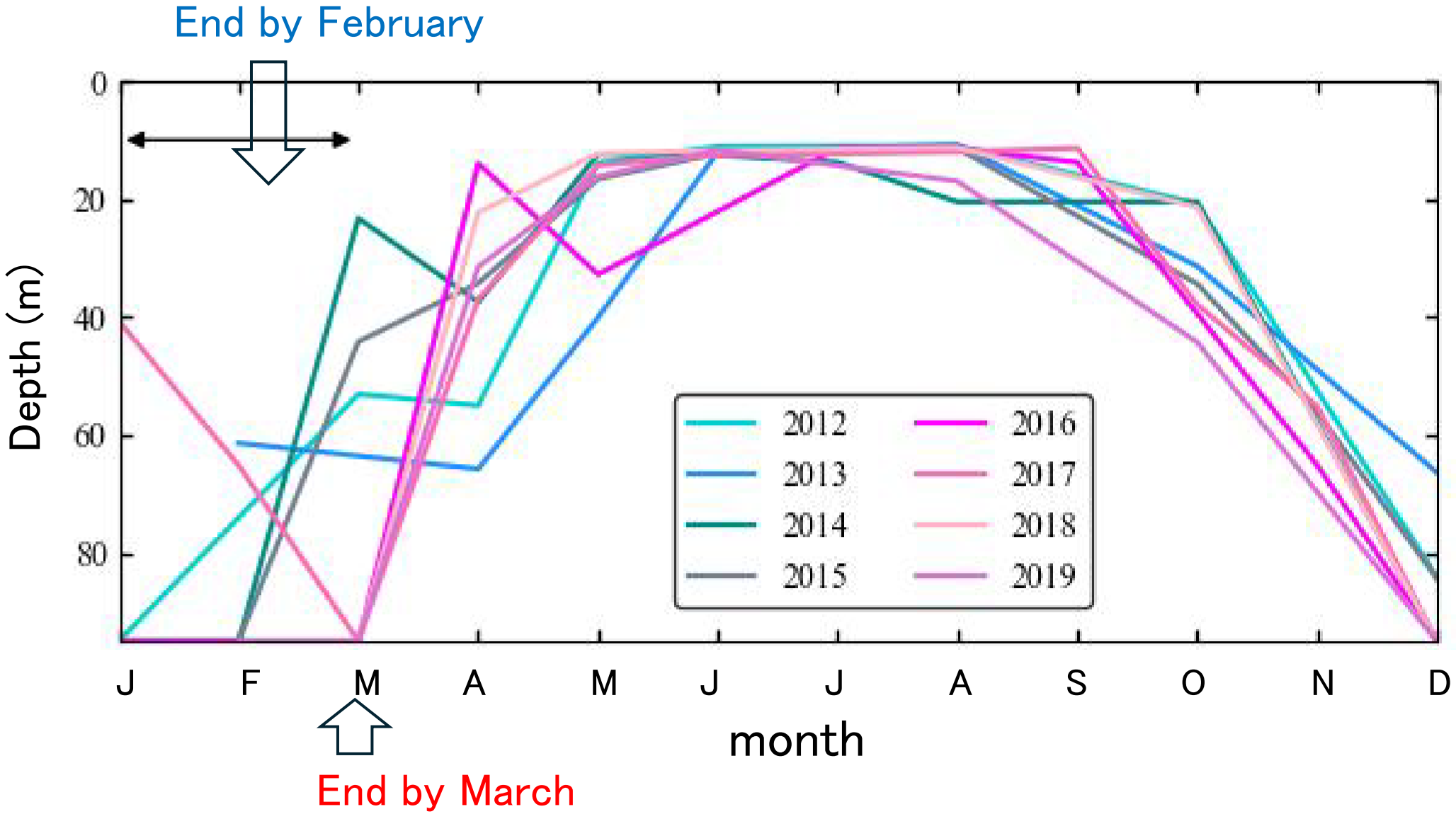


Moored water temperature profiles in February

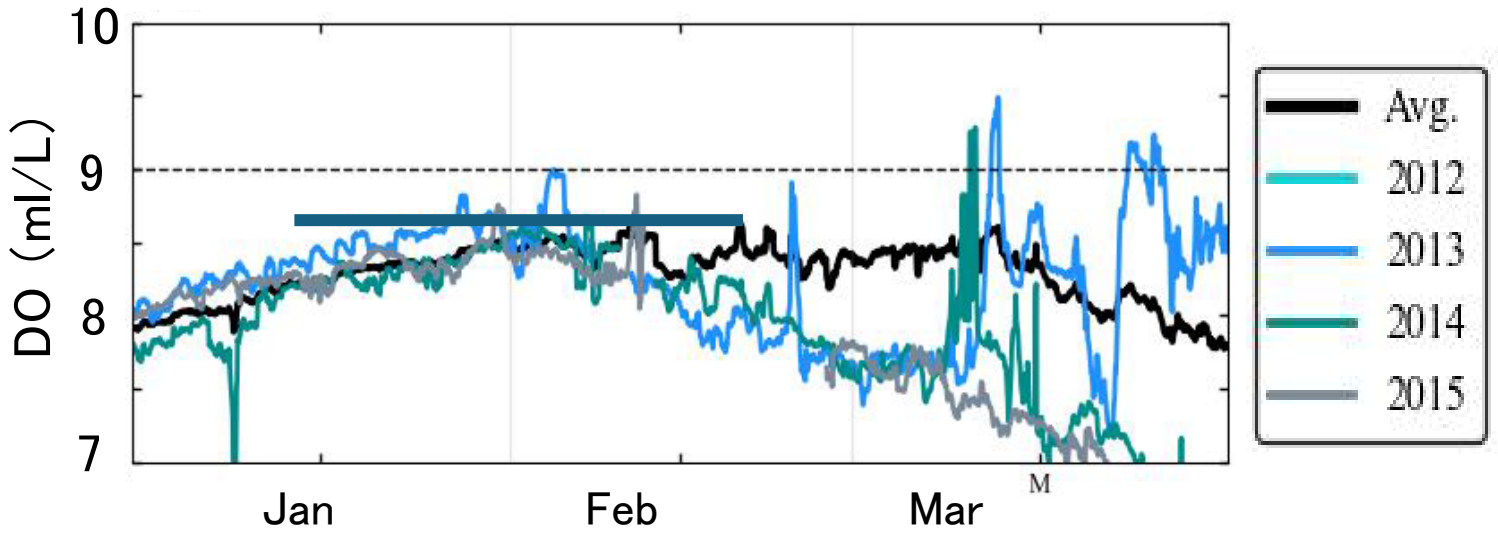


Mixed layer depth (2012–2019)

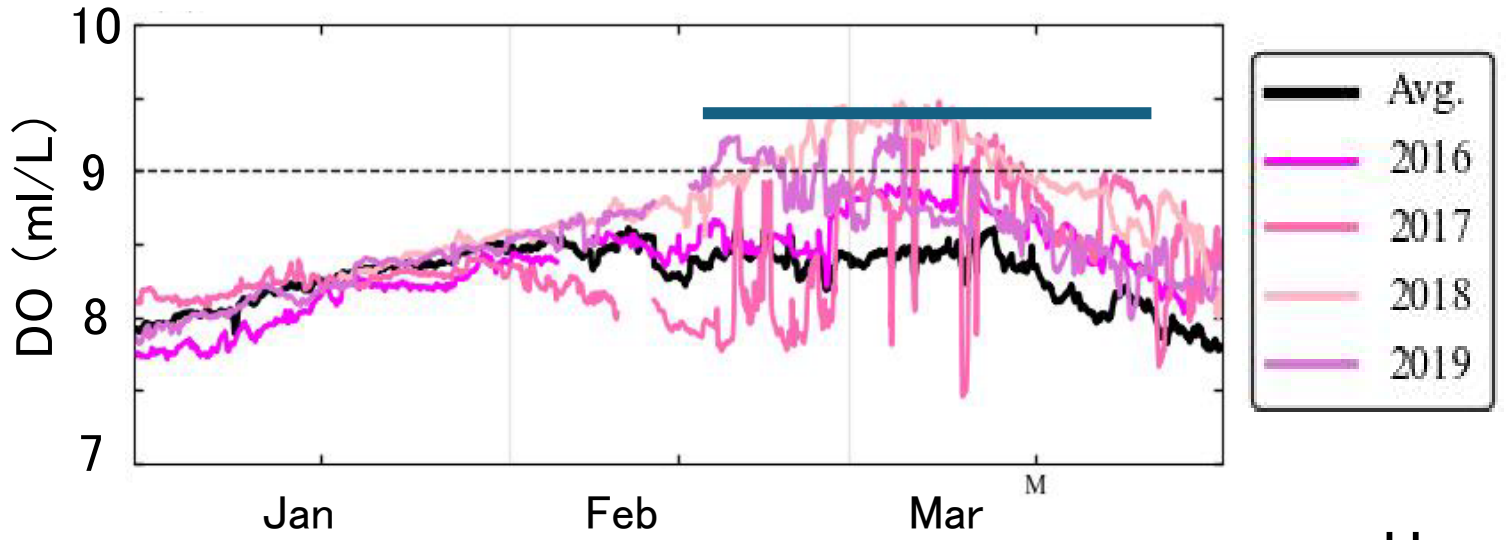
Bottom reaching convection ends earlier in Cold years than Warm years

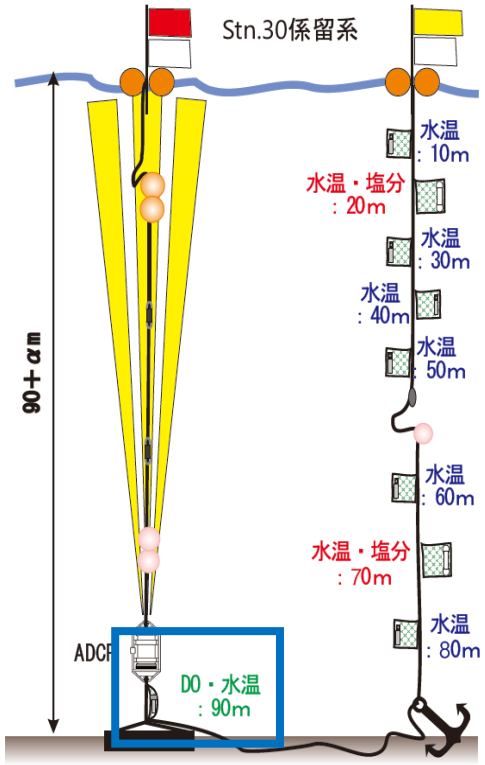


Cold years (Feb's temp 3℃) ⇒ Oyashio inflows and caps the surface



Warm years (Feb's temp 5℃)





Warm years have longer DO recovery period with the higher seasonal DO peak value.

⇒

Hypoxia is unlikely to occur in the following summer

Prediction using multi-regression analysis

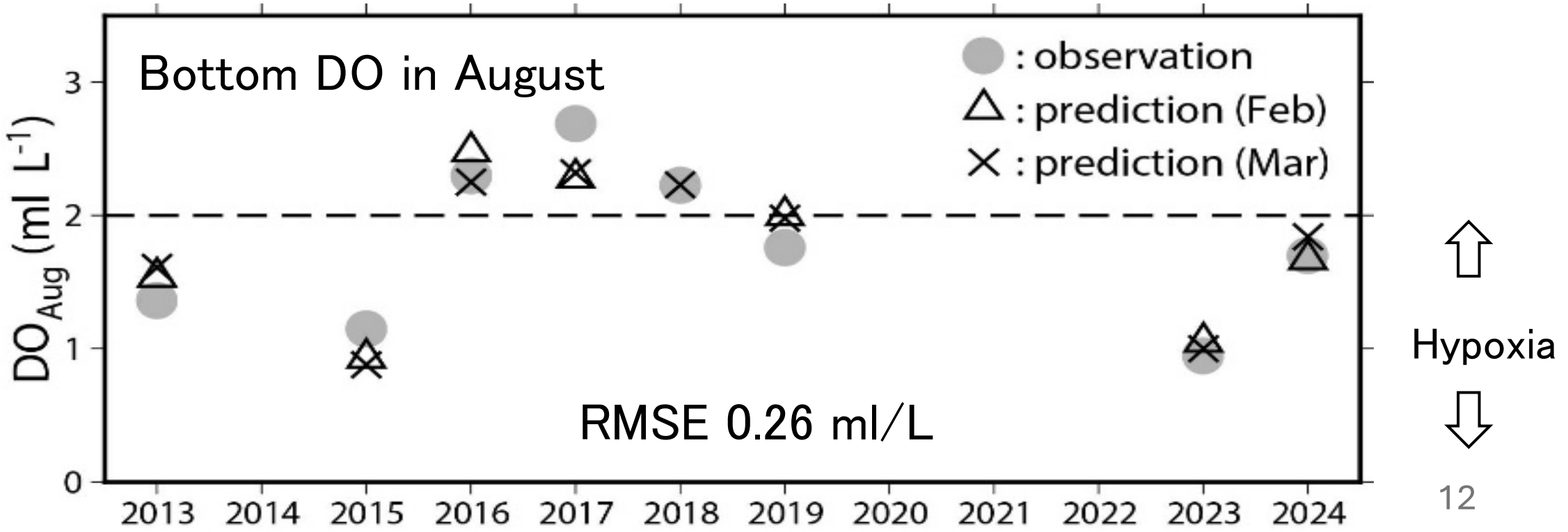
Summertime bottom DO was predicted using previous wintertime atmospheric/oceanic data

$$DO_{Aug} = a(Q_L + Q_S) + b\Delta\rho + c$$

Prediction (summer)

① Surface heat flux ∝convection (winter)

② Water column stability (winter)



Why DO prediction succeeded in Funka Bay?

① natural variability ＞ anthropogenic impact

- Relatively open bay for enclosed bay where water exchange can occur.
- Population and farm in the watershed area are small compared to the bay's area.

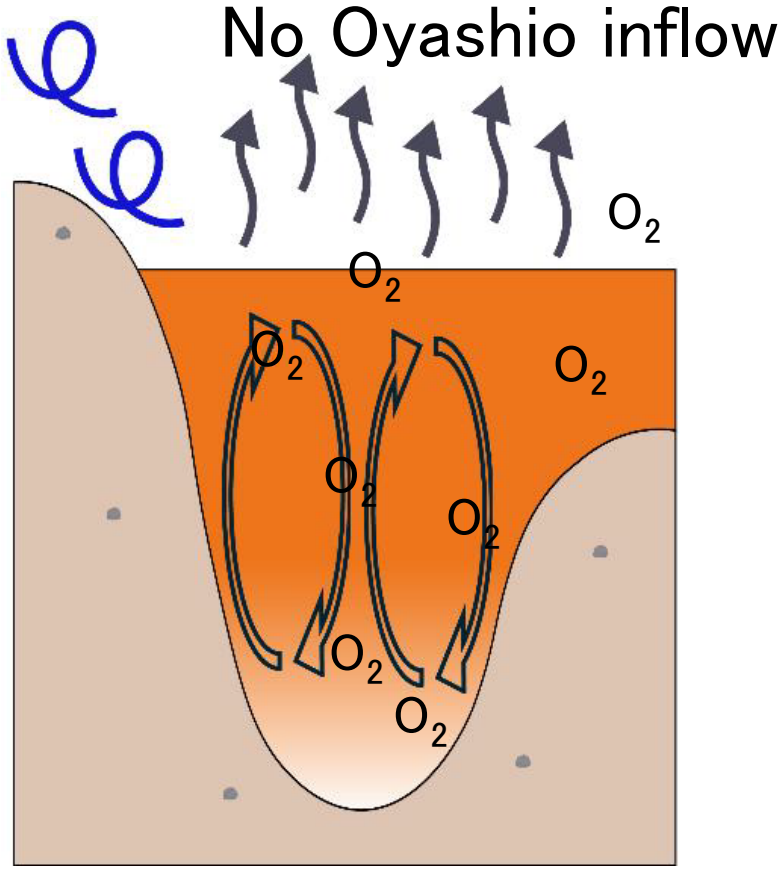
  One order smaller than Baltic Sea
  Two order smaller than Chesapeake Bay, US

② No need to consider short-term weather event

- Thick ocean layer (100 m) prevents direct impact of wind mixing to the bottom.

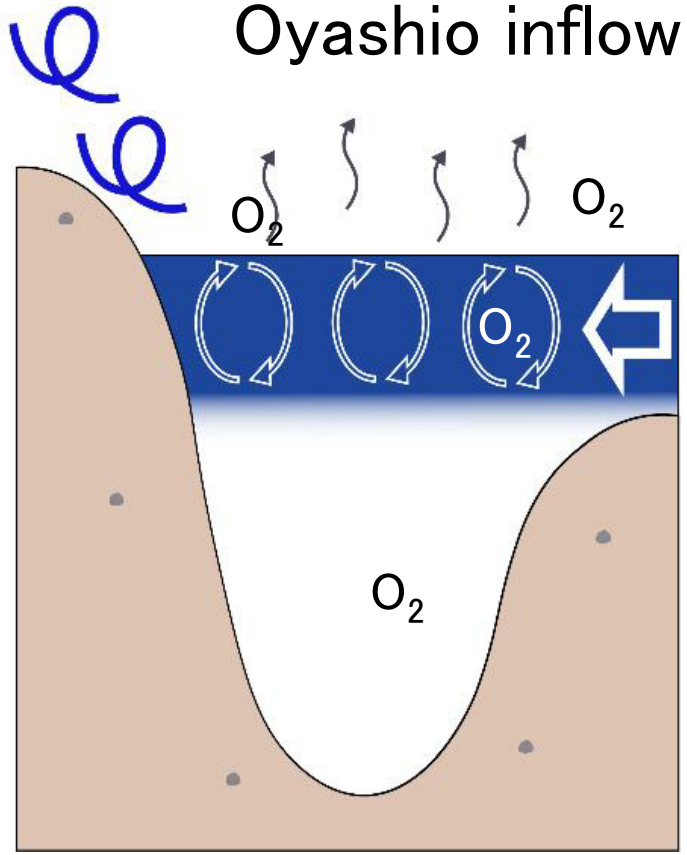
Conclusion

Warm ocean winter



- Active and longer convection
- Winter DO recovery is sufficient
- No hypoxia in the following summer

Cold ocean winter



stratification

- Light Oyashio water caps the surface
- Convection and DO recovery are prevented
- Hypoxia in the following summer

Please see following paper for more detail.

ELSEVIER

Journal of Marine Systems

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