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The FUTURE of PICES: Science for Sustainability in 2030

Physical drivers of *Noctiluca scintillans* (Dinophyceae) blooms outbreak in the northern Taiwan Strait: A numerical study

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2024.10.23

Outline

01 Background

02 Methods

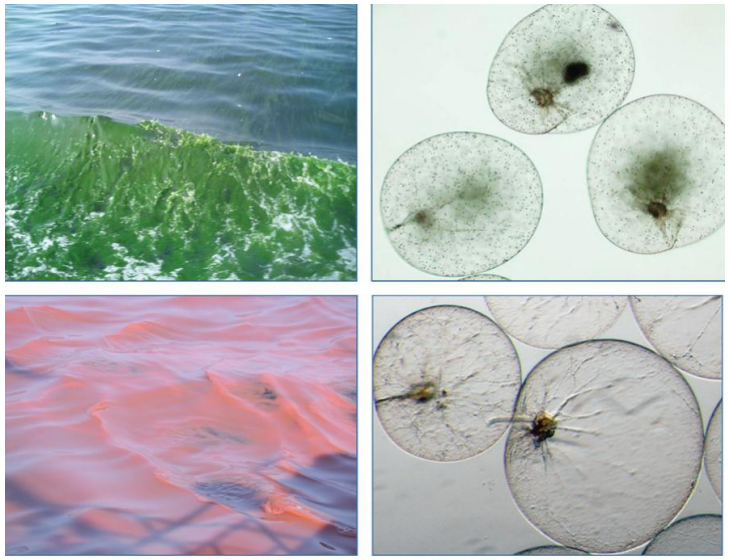
03 Results

04 Perspective

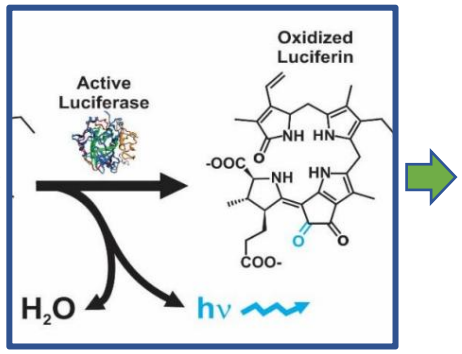
1. Background

25—30 °C

10—25 °C



Chemical reaction



Green and red *Noctiluca scintillans* (RNS)

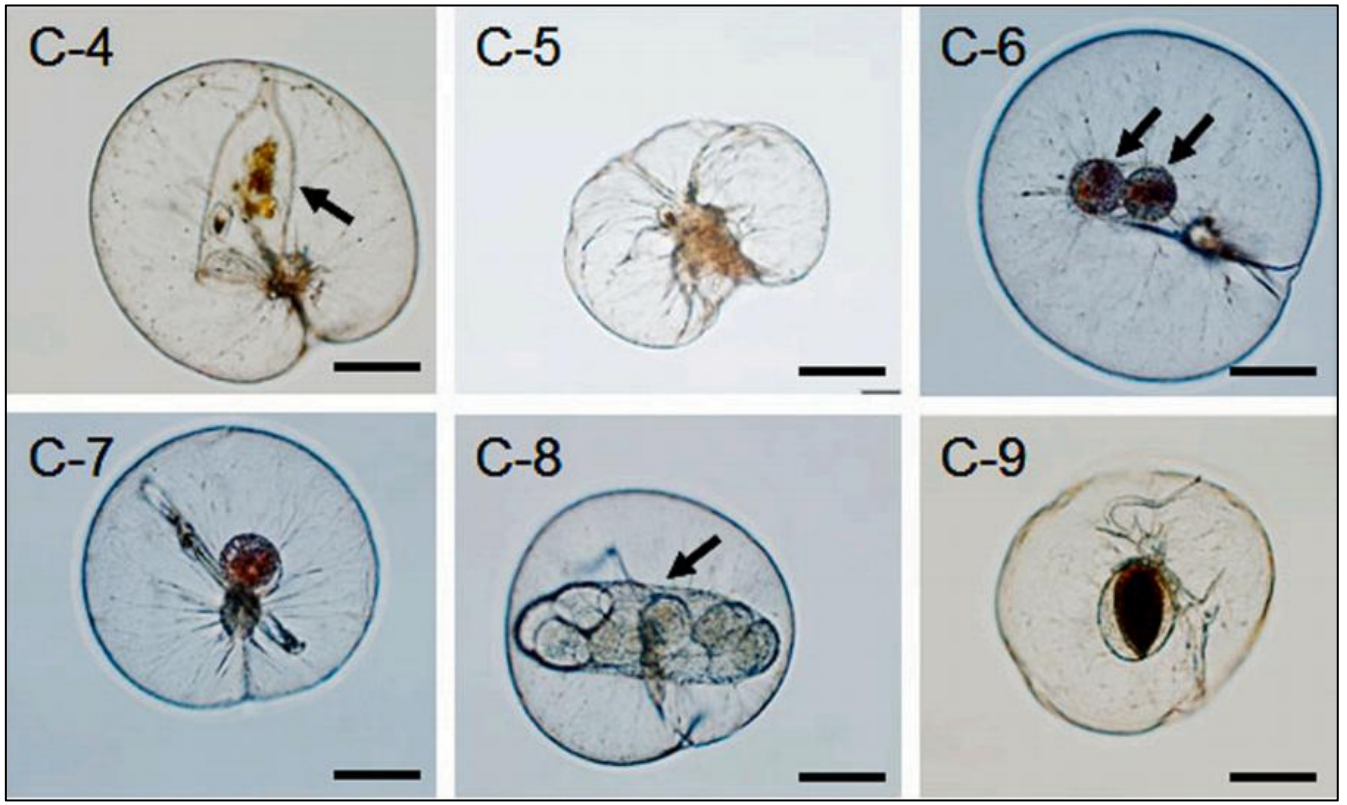
Harrison et al. 2011 Distribution of red *Noctiluca scintillans*

'Blue tear'

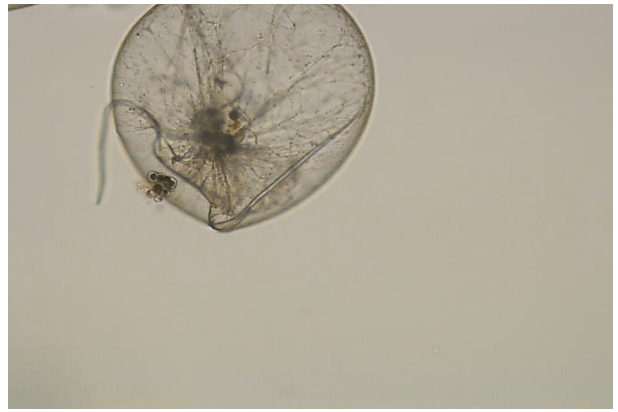
1. Background

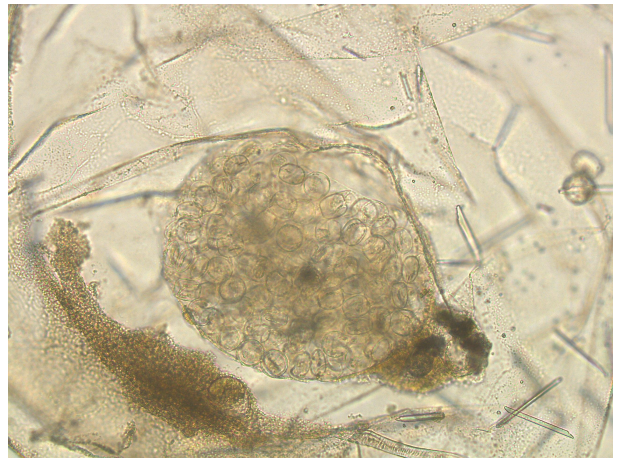
➢ *Noctiluca scintillans* is a passive feeder

Dinoflagellates



Ciliates





Eggs

Diatoms

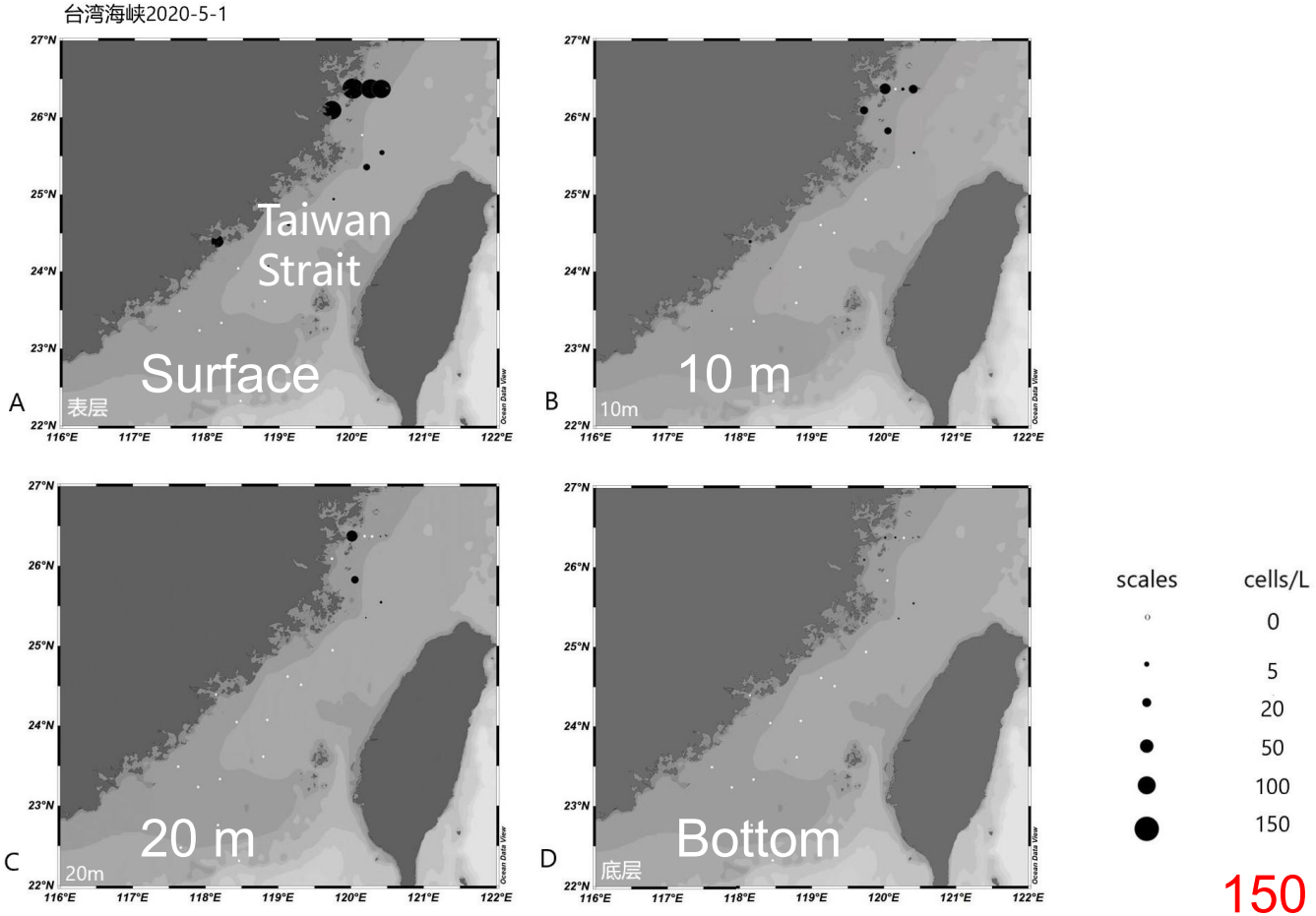
Diverse food of *Noctiluca scintillans*

An outbreak of *Noctiluca* requires sufficient food

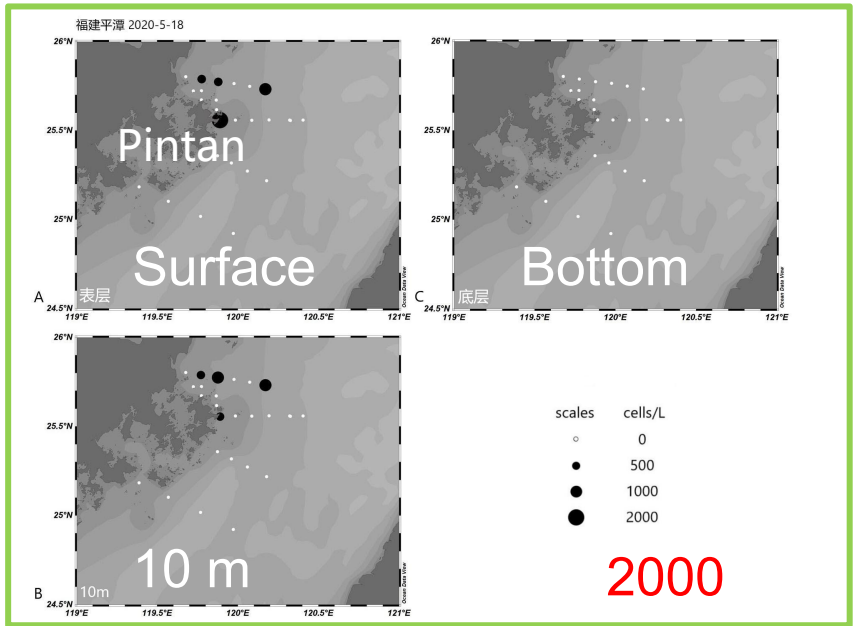
Nishitani et al. 2020

1. Background

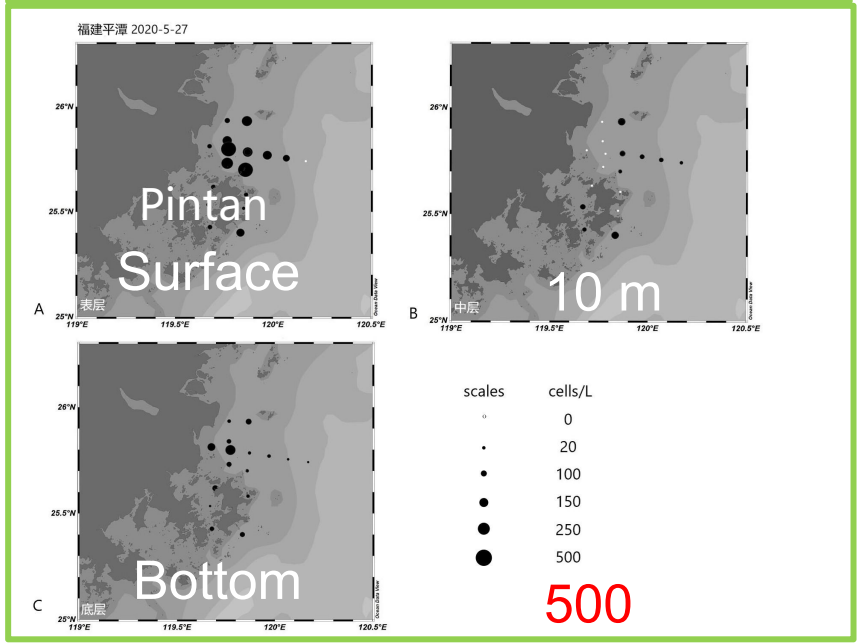
Noctiluca in May 1-5, 2020



Noctiluca was mainly distributed in the surface of northern Taiwan Strait



May 18, 2020

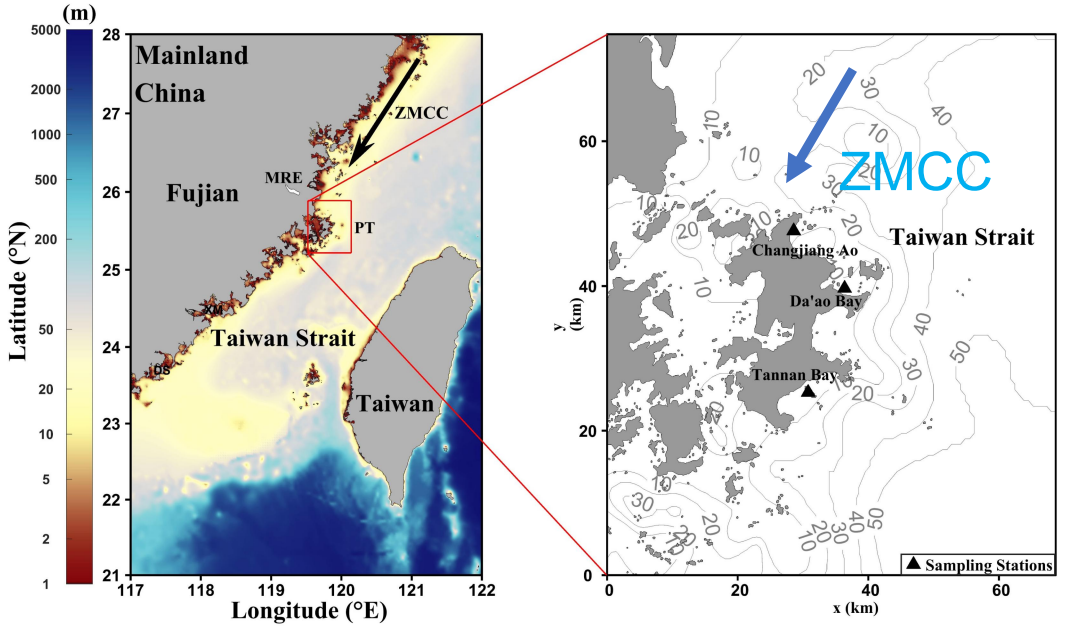


May 27, 2020

1. Background

➢ *Noctiluca scintillans* broke out in Pingtan from April to June

Festival of ‘Blue tear’



Why Pintan?

- ZheMin Coastal Current (ZMCC)
- Downstream of Minjiang River

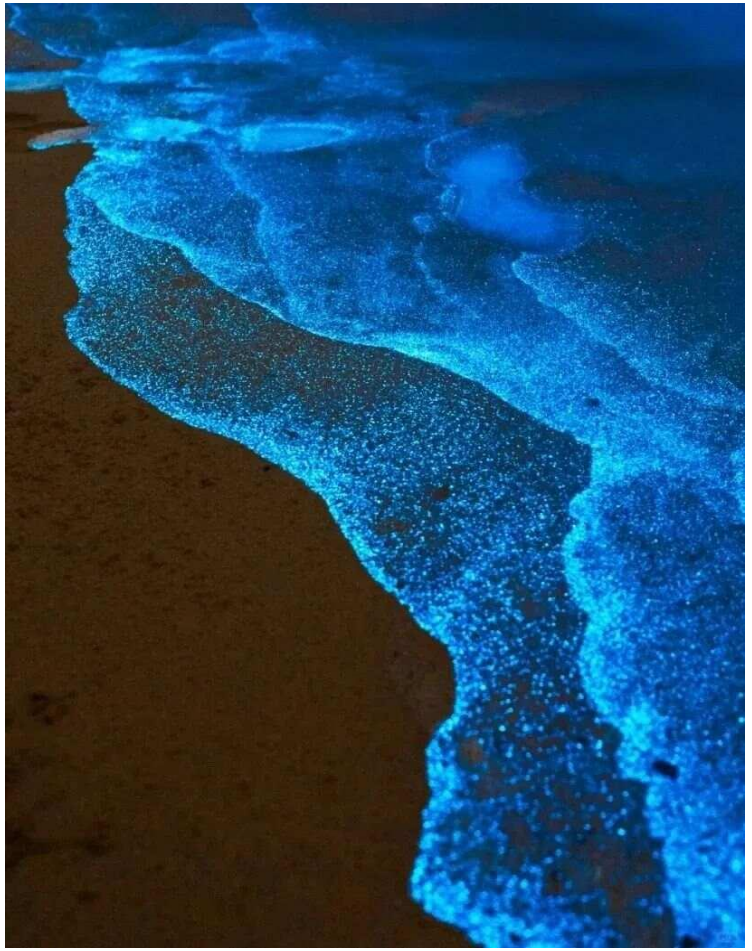
Location of Pintan

20-25 °C are the optimum condition for *Noctiluca*

1. Background

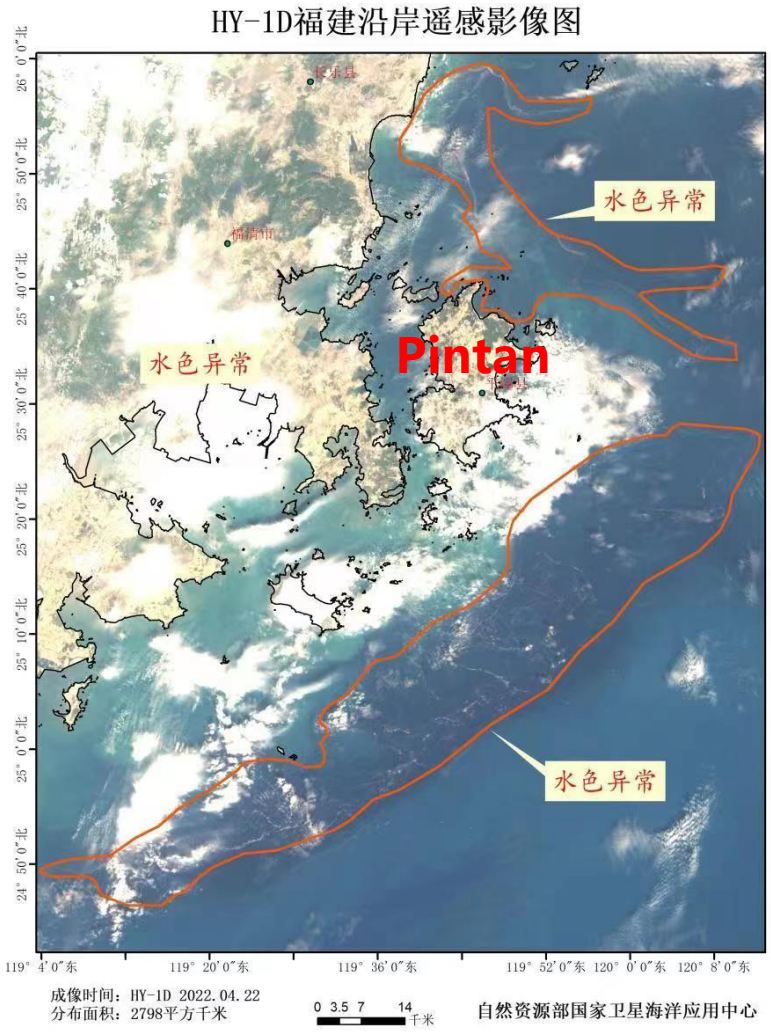
Tourism is the biggest economy in Pintan (July-Oct ⟶ Apr-Oct)

Pintan has beautiful beach, but nothing else



Blue tear in Pintan

1. Background



A massive bloom of *Noctiluca* (2800 km^2) in April 22, 2022

1. Background

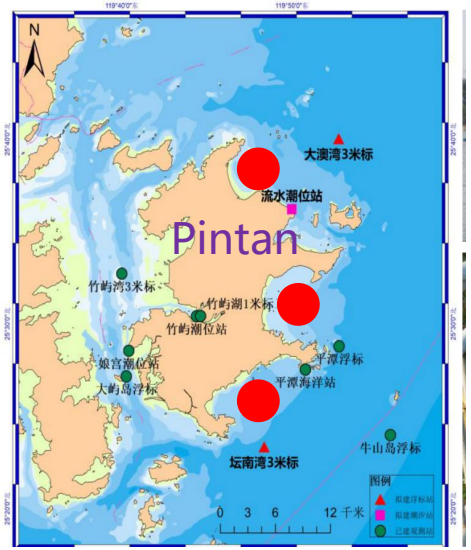
Questions:

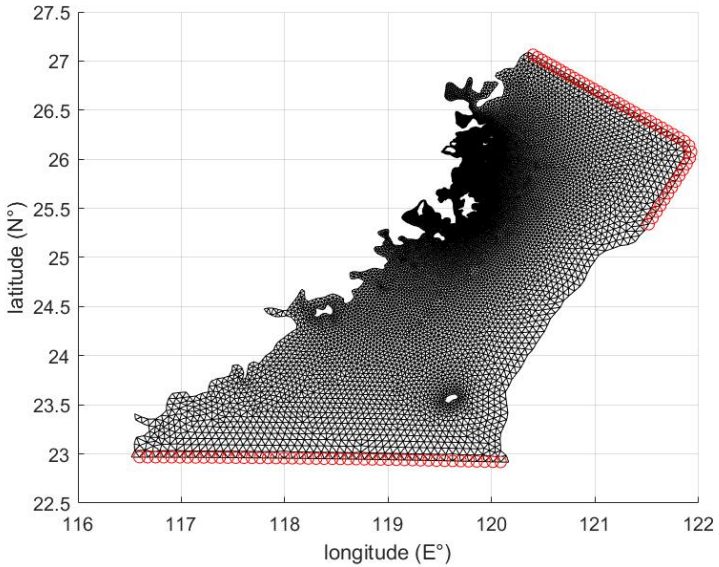
What is underlying mechanism of Noctiluca bloom in Pintan?

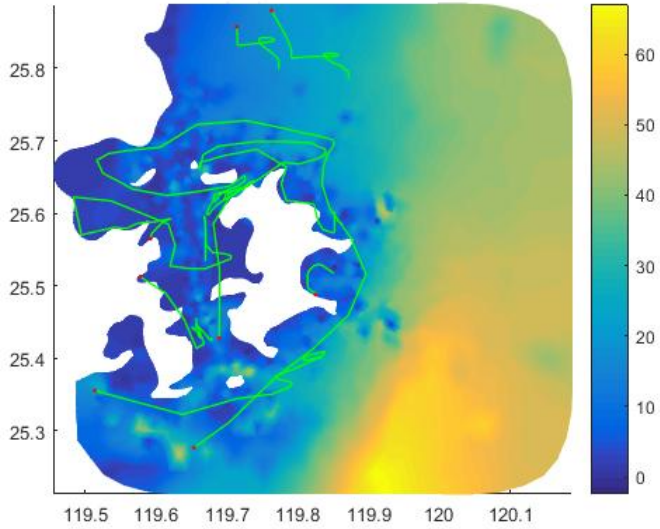
Is it possible to predict the bloom outbreak?

2. Methods

Sampling in Pingtan from April to May 2022







Light microscopy

Standard counting

Finite Volume Coastal Ocean Model (FVCOM)

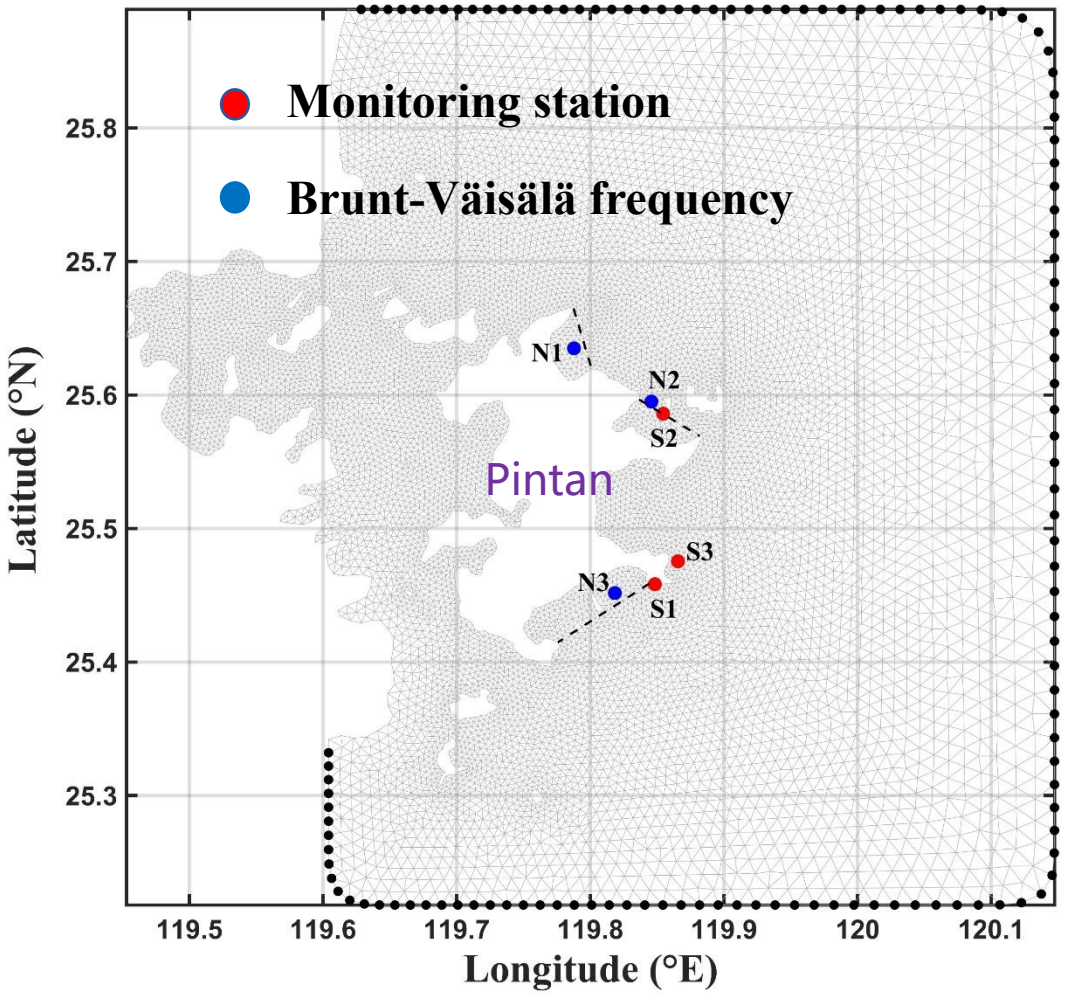
Fine resolution

Lagrangian particle tracking

Cell simulation

2. Methods

➢ FVCOM simulate sea water movement near Pingtan



Unstructured grid diagram of the model area (200-2200 m)

Model settings

Model setup	Variables	Sources	
Open Boundary	Tides	TPXO_7.2	
	x-velocity & y-velocity	HYCOM	1/12
	Temperature & salinity	HYCOM	1/12
Initial field	Coasts & Depth	Electronic marine charts	
	Temperature & salinity	HYCOM	1/12
Surface forcing	Wind	NCEP CFSv2	coupled forecast system model
	Heat flux	NCEP CFSv2	

S1: tidal level observation

S2, S3: surface temperature observation

Modeling time: March 15, 2022 to June 1, 2022

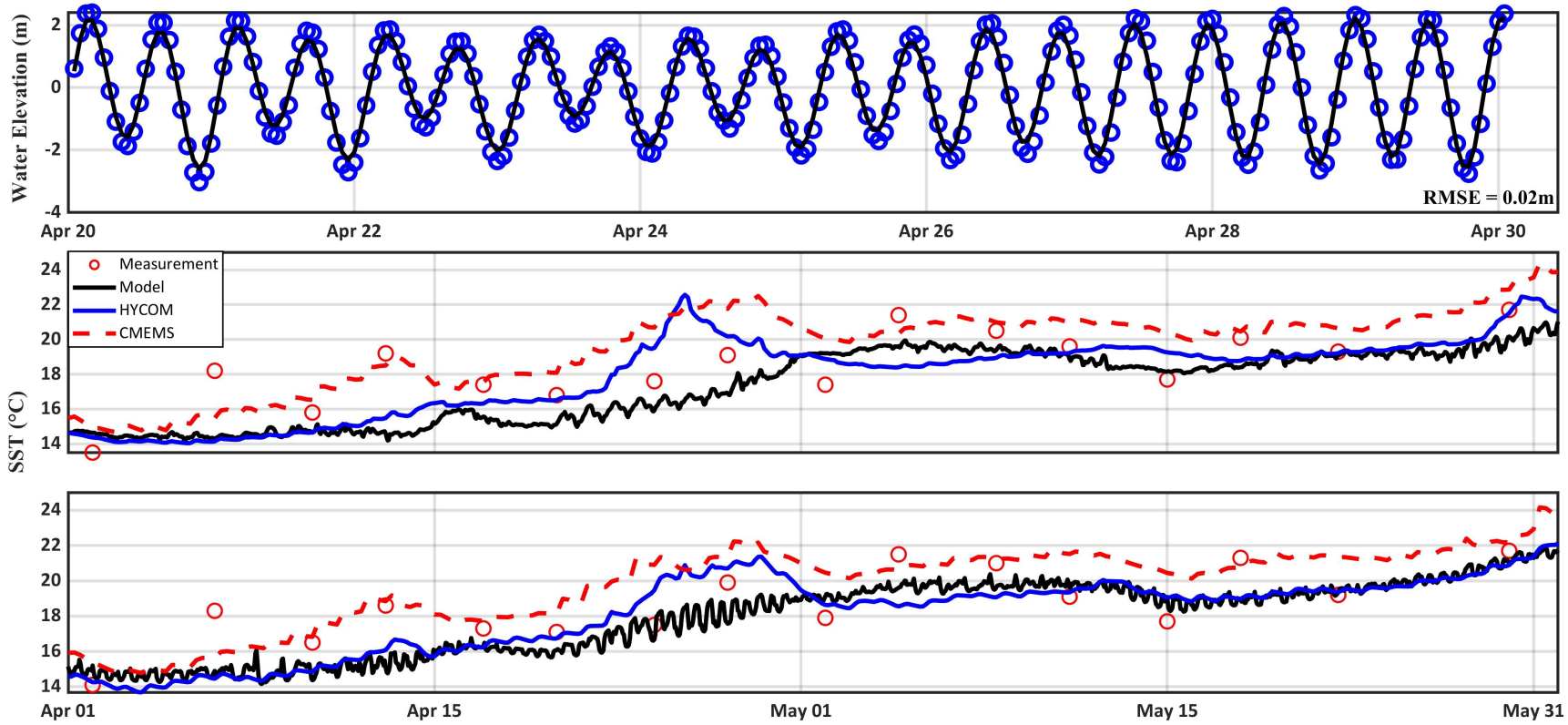
2. Methods

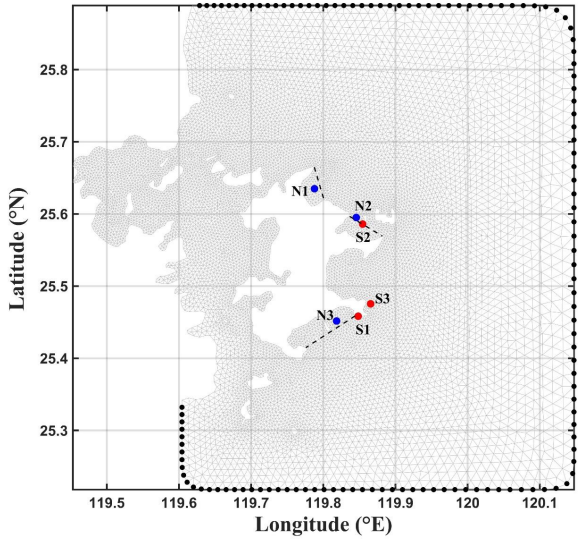
➢ Model result validation

S1

S2

S3





Circles: measured data;

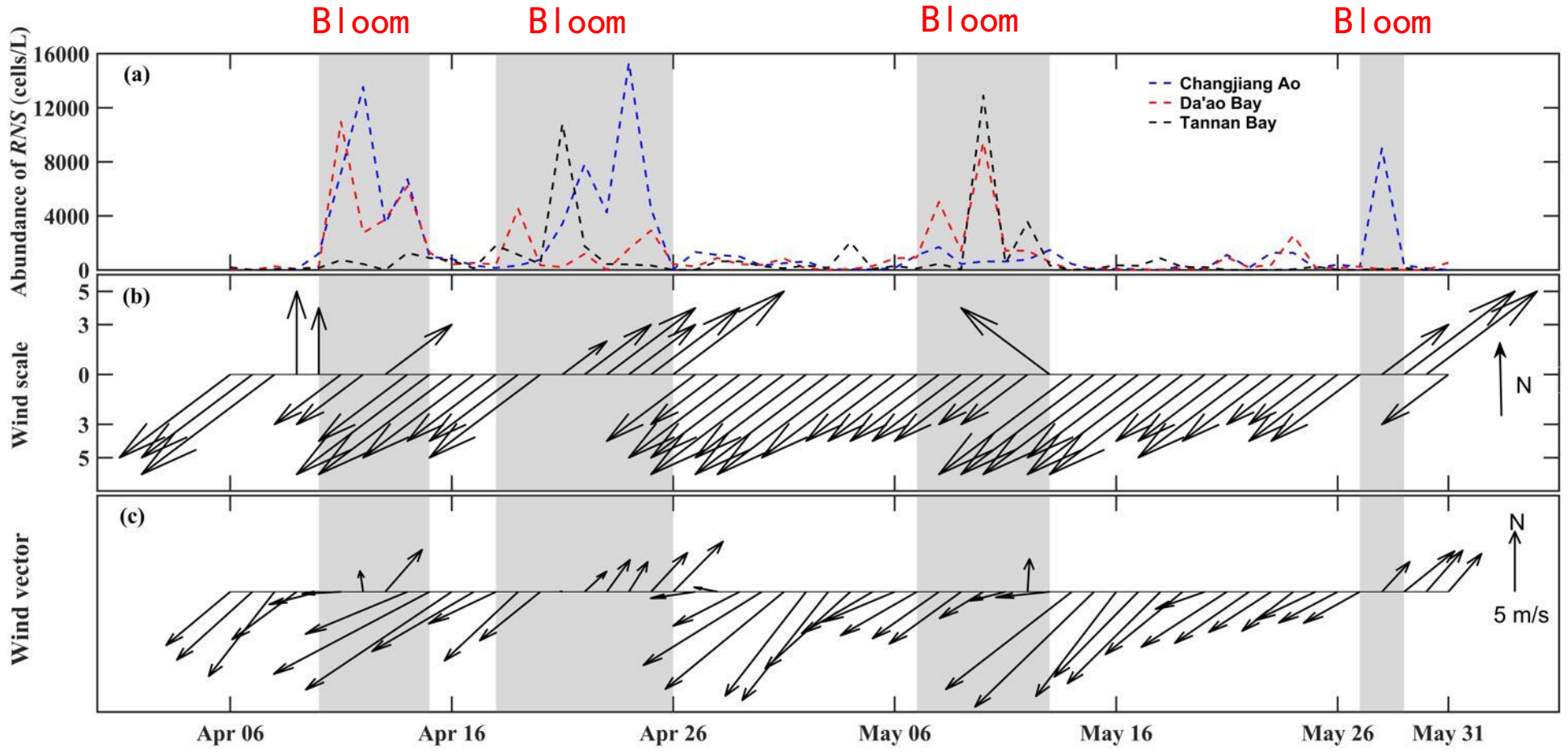
Solid lines: model data.

Comparison between model output data and measured data.

Simulating tidal levels is in line with the measured data, and the SST output of the model basically match other data.

3. Results

➢ Comparison of temporal changes in wind vector and *Noctiluca* density



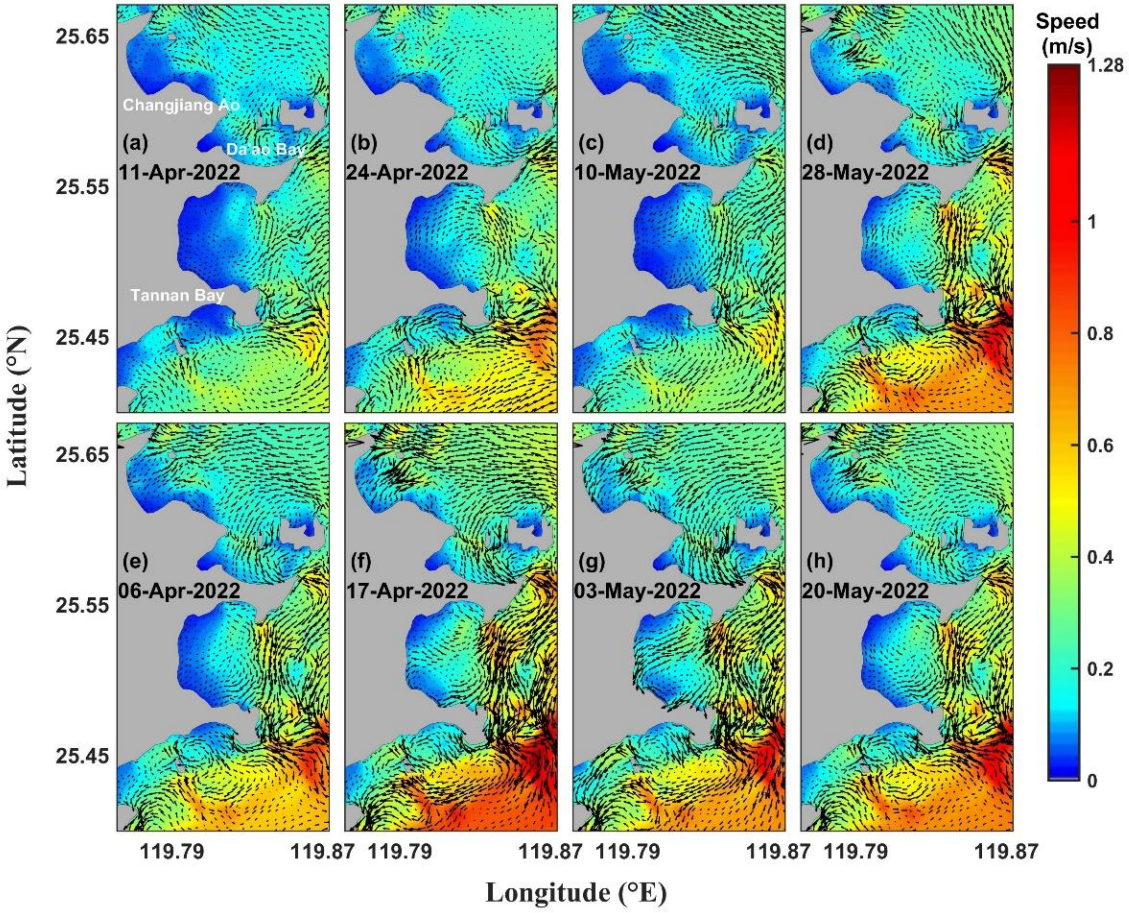
Observed wind

Wind from CFSv2

Noctiluca bloomed when the northeaster weakened and the southwester strengthened.

3. Results

Surface water stability



Blue: low flow velocity

Red: high flow velocity

Bloom

Low flow occupied three bays during bloom.

Non-bloom

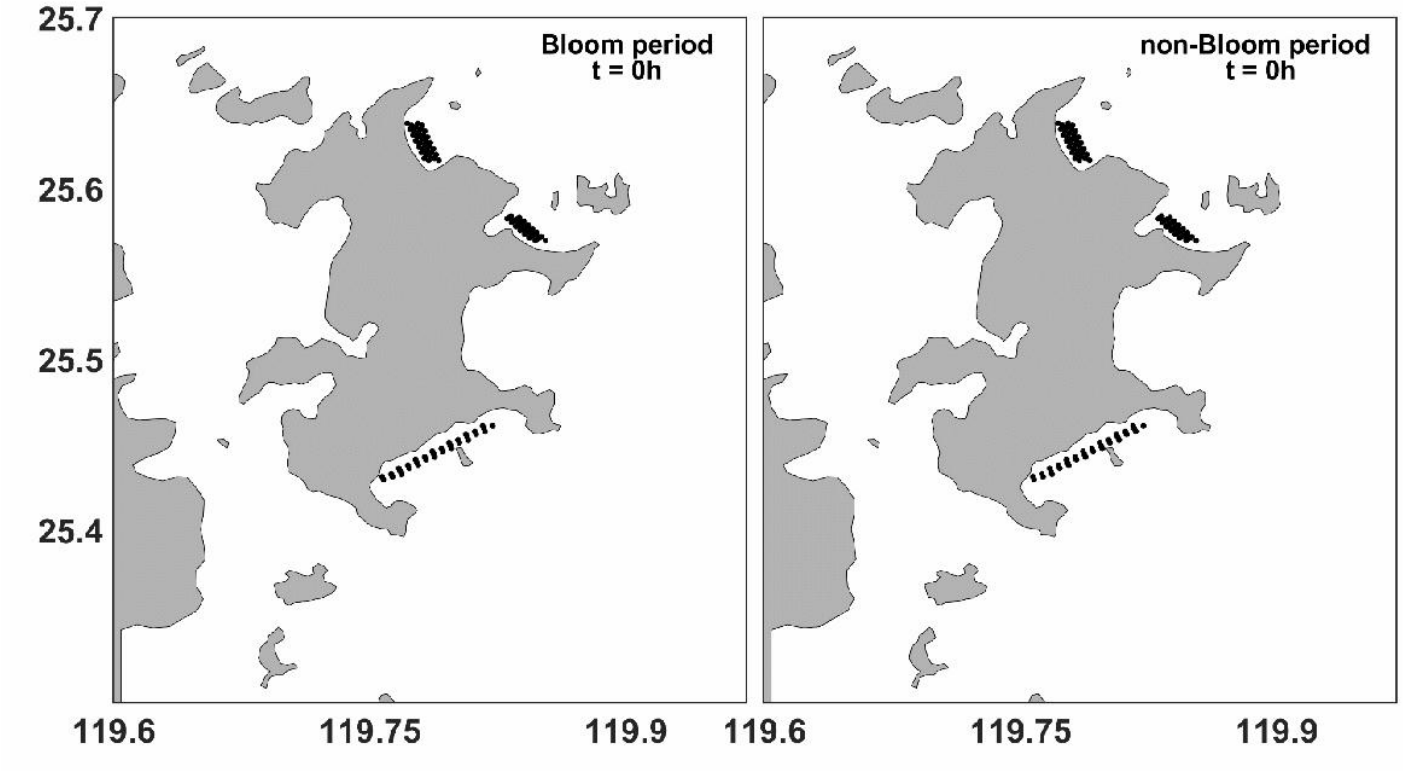
High flow occupied three bays during the non-bloom.

Sea surface velocity during bloom and non-bloom

3. Results

➢ **Lagrangian particle tracking**

Cells remained mostly in the bay within 48 hours during the bloom.



Bloom Non-bloom

Particle drift within 48 hours

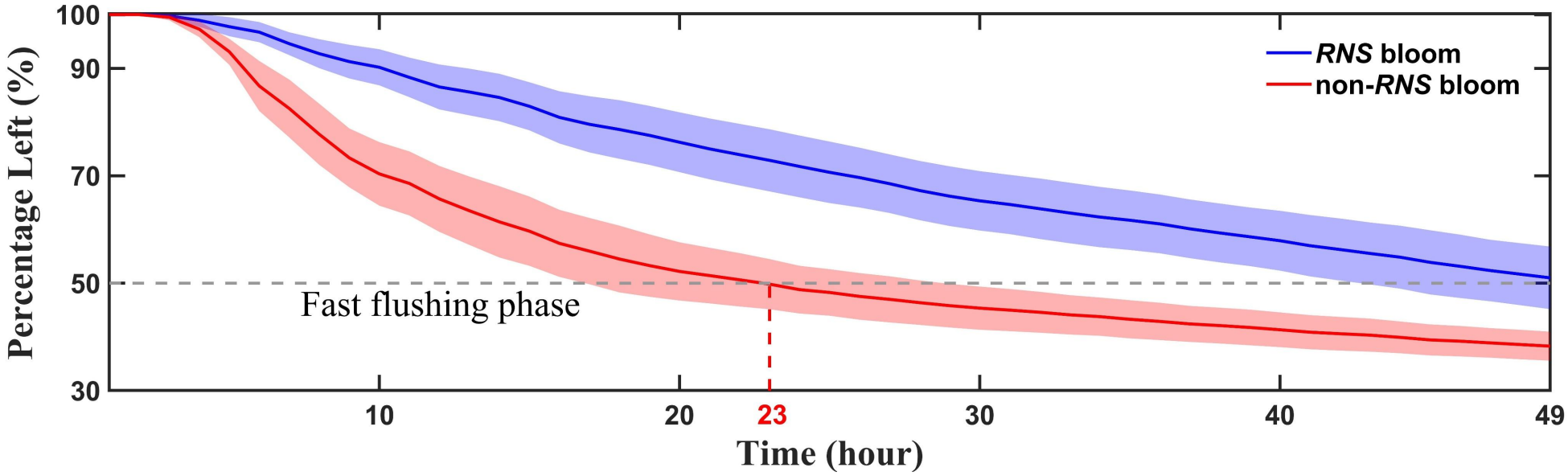
◆Release particle tracing and observe its movement on the sea surface.

◆The trajectory and diffusion range of particles reflect the transport capacity of seawater.

3. Results

Lagrangian particle tracking

- Residence time: a method of measuring the retention capacity of seawater.
- Fast-flushing phase: The time needed for the portion of remaining particles from 100% to 50%

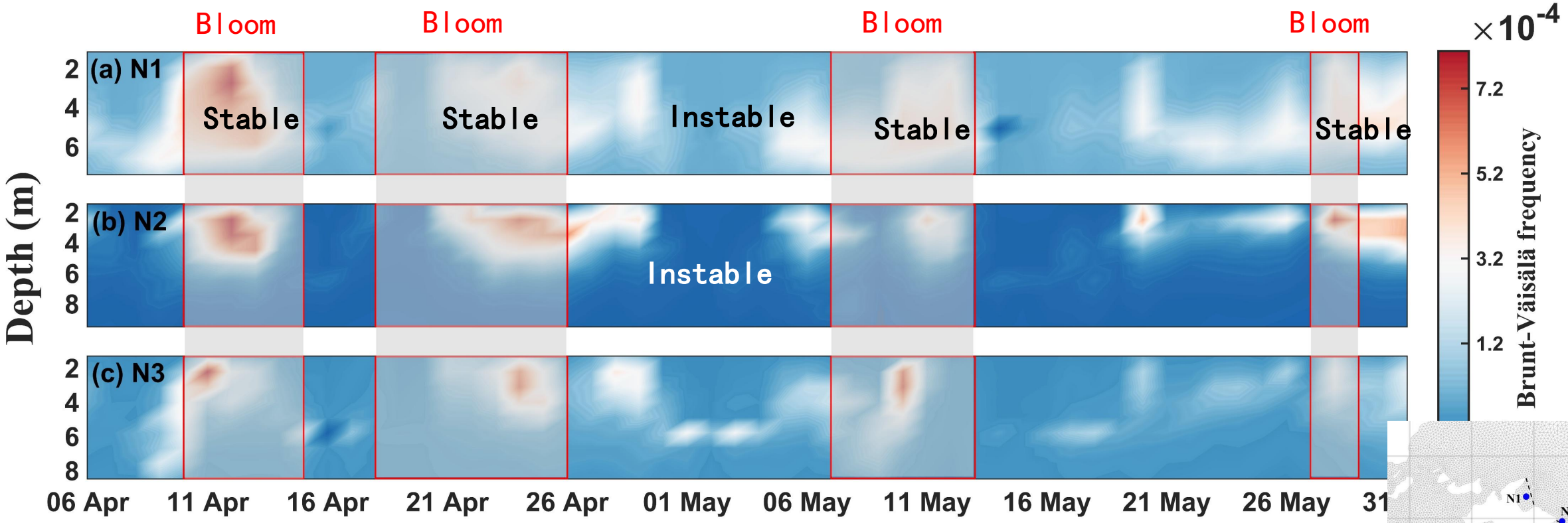


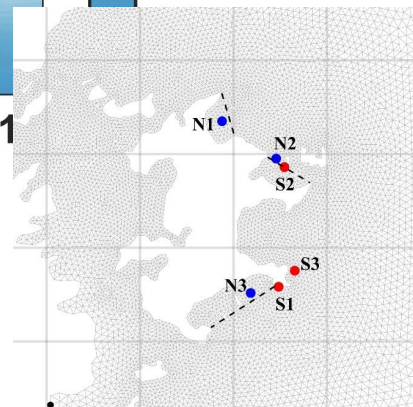
Residence time of seawater is much longer during blooms

3. Results

Water column stability

➢ **Buoyancy frequency (Brunt-Väisälä frequency) to measure stratification.**

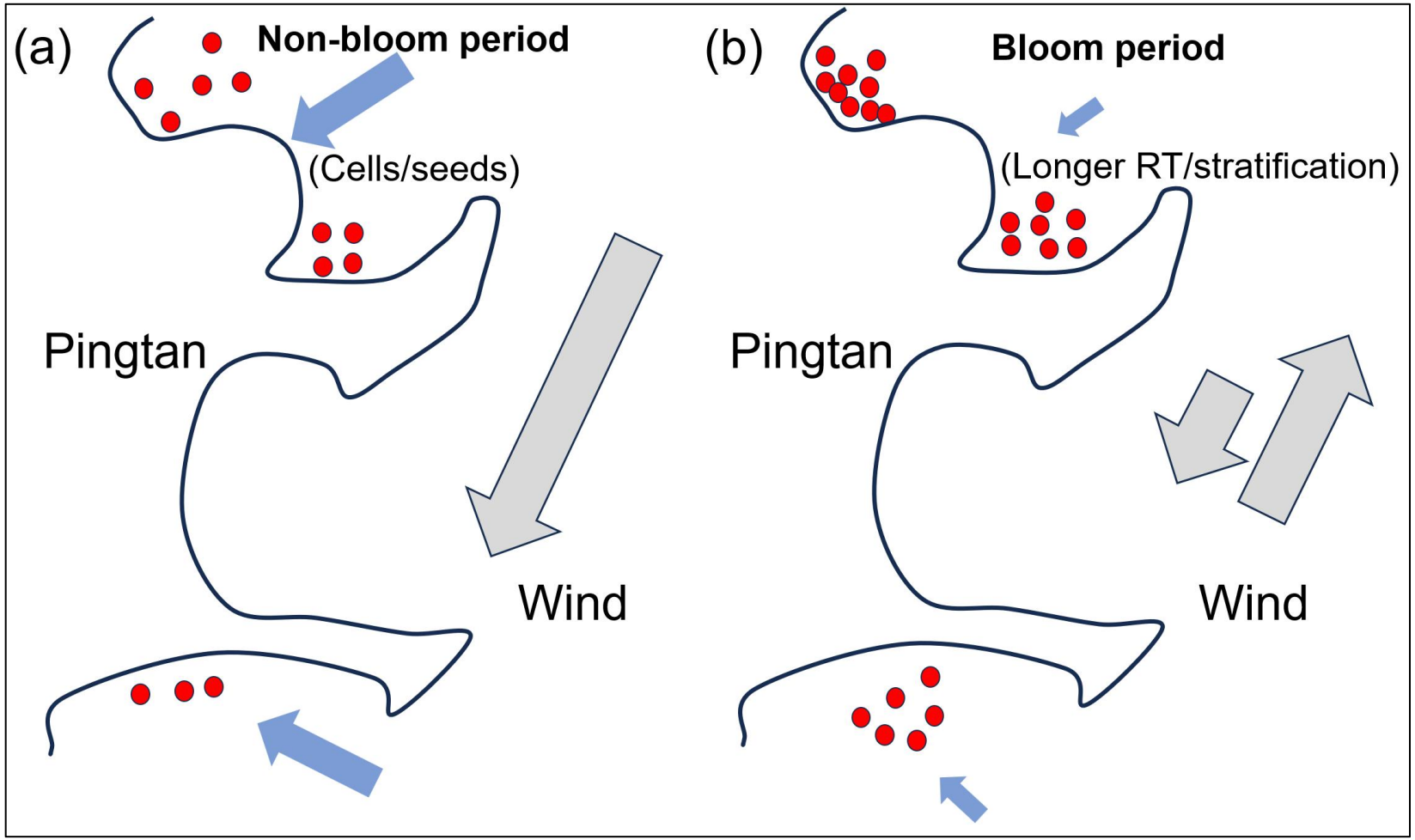




Strong stratification co-occurred with four massive blooms

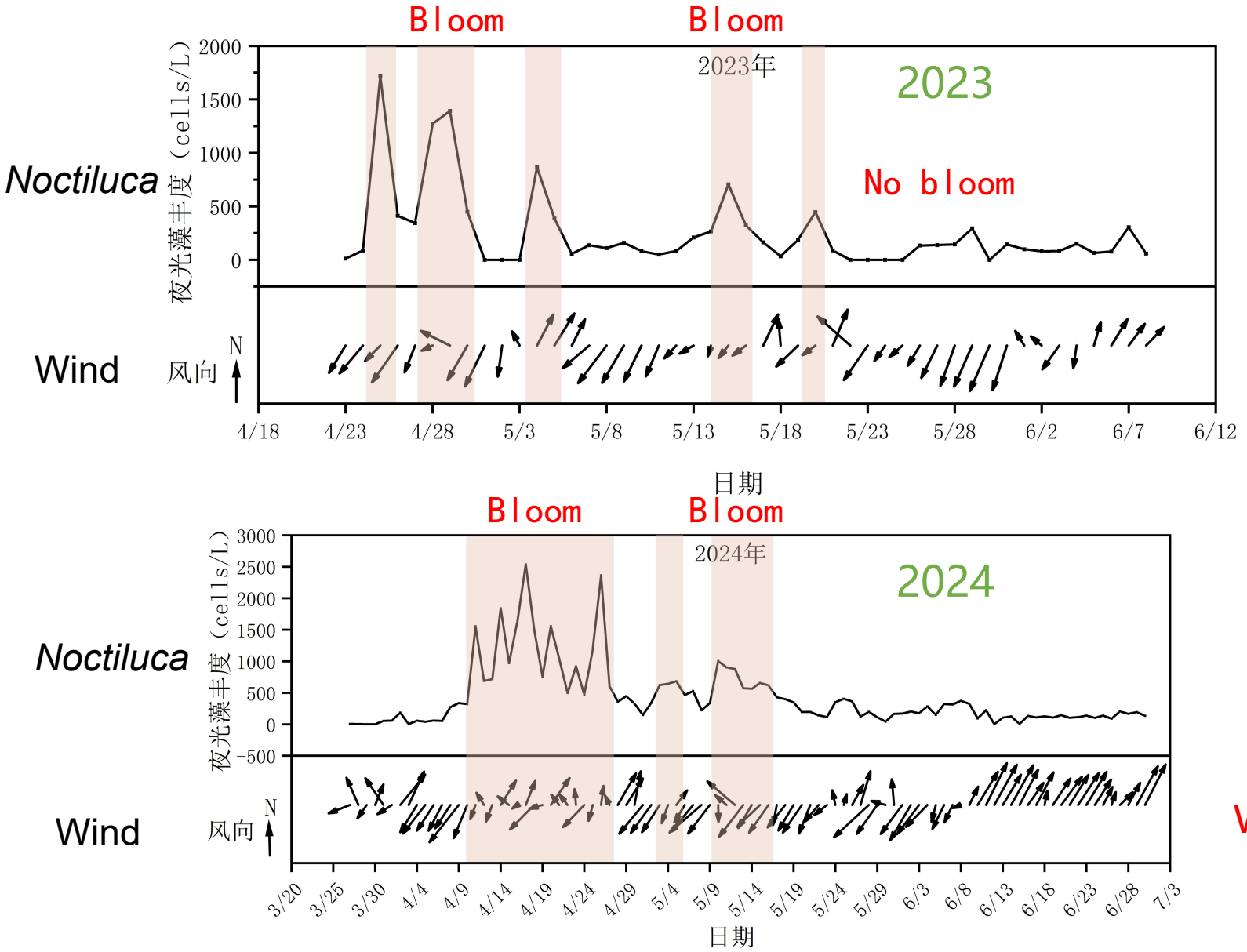
3. Results

- *Noctiluca* bloom when the northeaster weakens or turns to the southwester.
- The horizontal and vertical stability of seawater favors the bloom as well as the retention time.



Schematic diagram of *Noctiluca* bloom outbreak

3. Results



Northeaster<3 wind scale,

or southwester

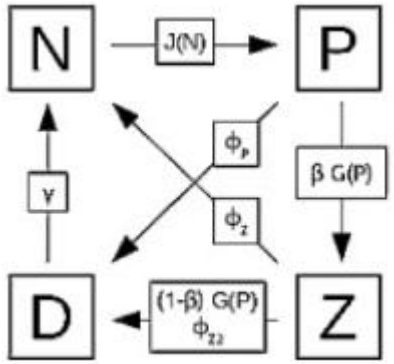
Wind helps to predict *Noctiluca* bloom

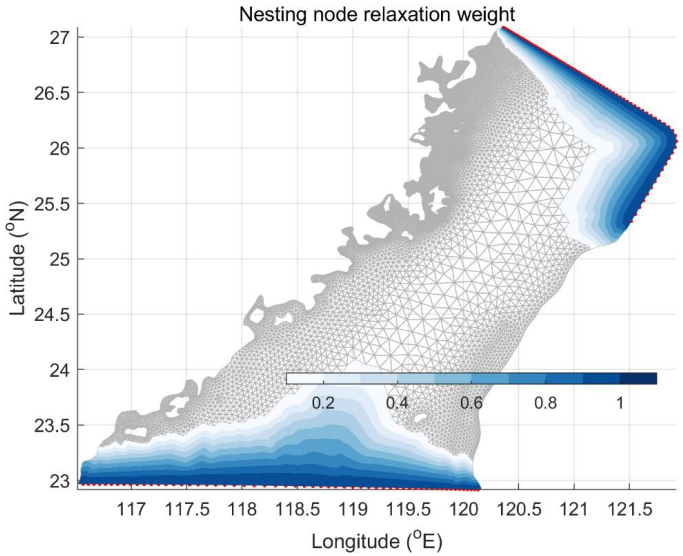
4. Perspective

➢ FVCOM-Ecology coupled model

Nutrient-Phytoplankton-Zooplankton Model

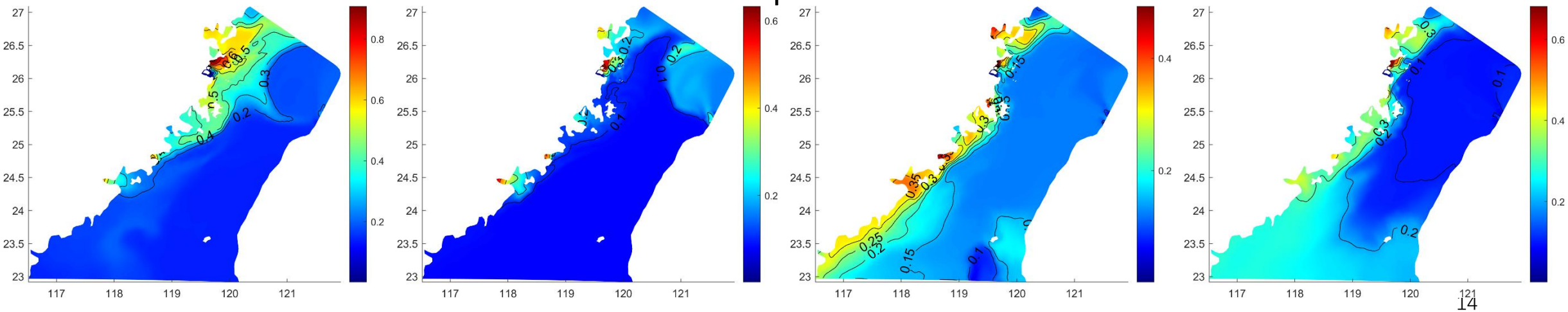
Model setup	Variation	Source
Open Boundary	Tides	TPXO_yellosea
	Temperature & salinity	HYCOM
	Coasts & Depth	Fujian hydrological station
	River discharged	Fujian hydrological station
	x-velocity & y-velocity	HYCOM
Surface forcing	Wind	NCEP CFSv2
	Heat flux	NCEP CFSv2





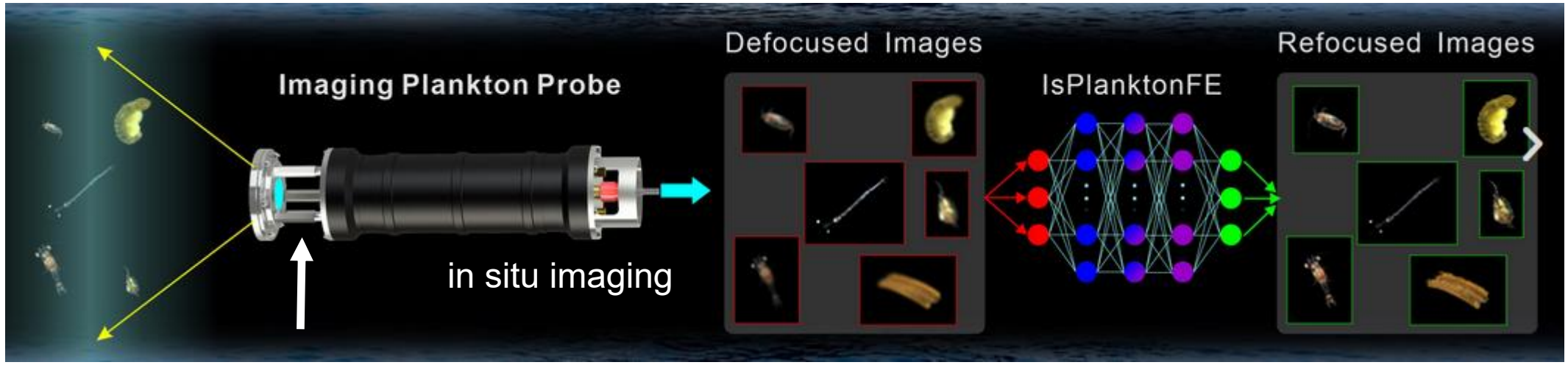
2021.7 2021.10 2022.01 2022.04

Zooplankton

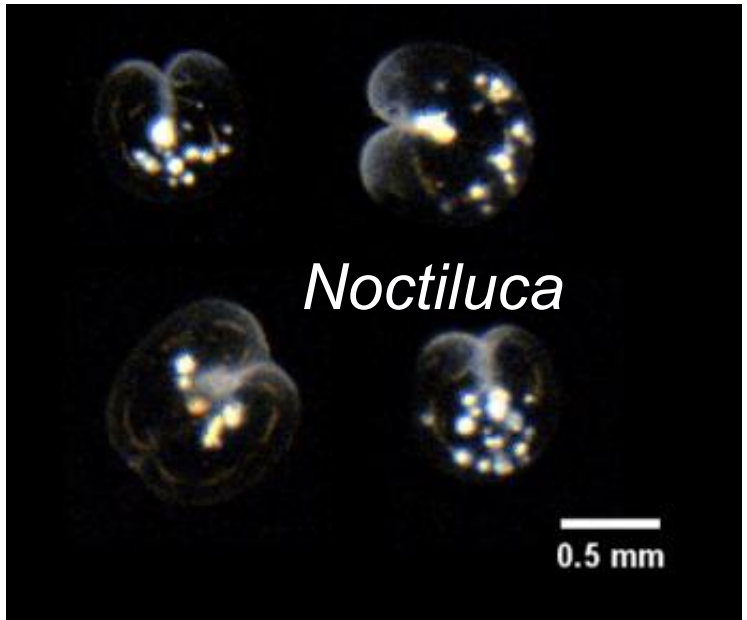


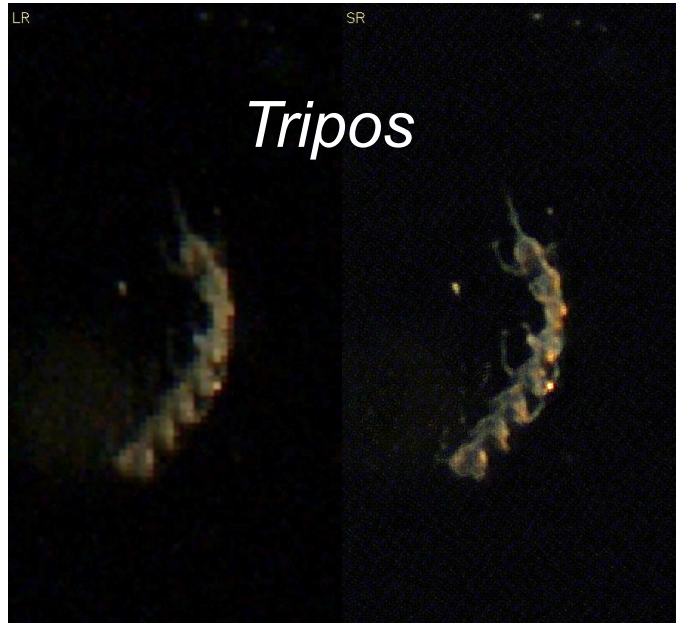
4. Perspective

Real time monitoring



Depth of field　　Input images　　Deep Network　　Output images





4. Perspective

Depolyment

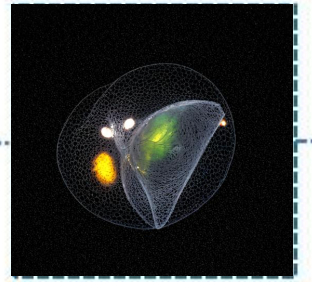
部署

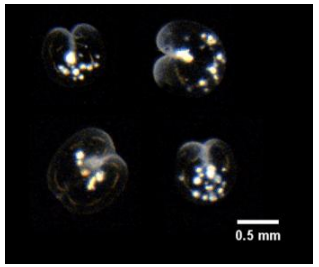
Platform

浮标

Data collection

数据采集

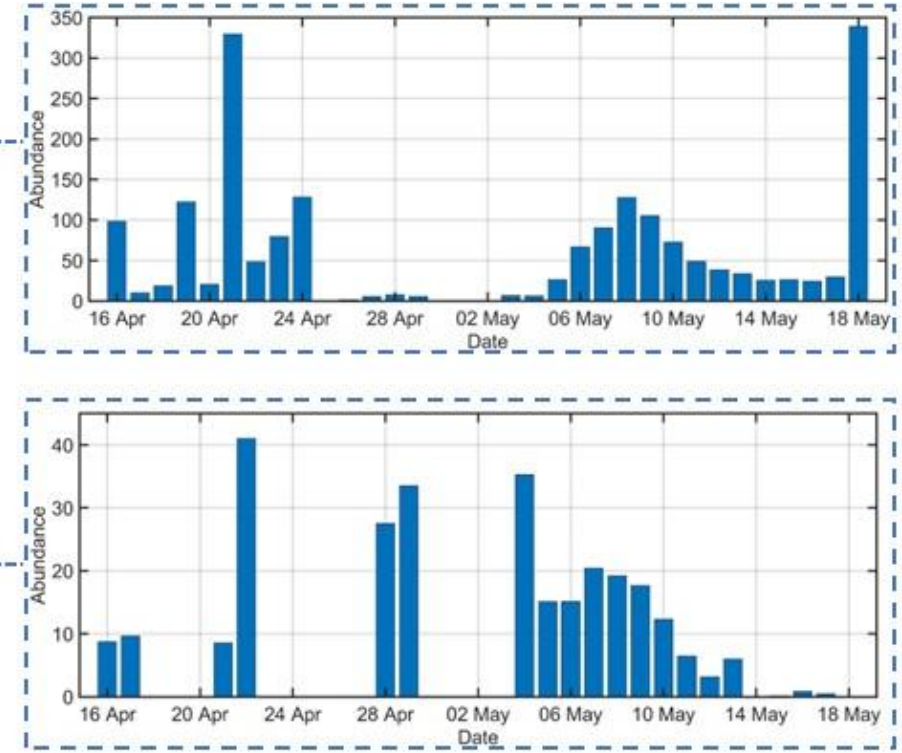




AI

人工智能算法

Temporal distribution of *Noctiluca*



Real time monitoring helps to predict potential blooms

Jianping Li, et al, “Development of a Buoy-borne Underwater Imaging System for *in situ* Mesoplankton Monitoring of Coastal Waters”, IEEE Journal of Oceanic Engineering , 2022, 47(1): p. 88-110.

Thank you for your attention

谢谢

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Zhan P

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