The linkage between the Yellow Sea algae bloom burst in 2008 and regional climate change

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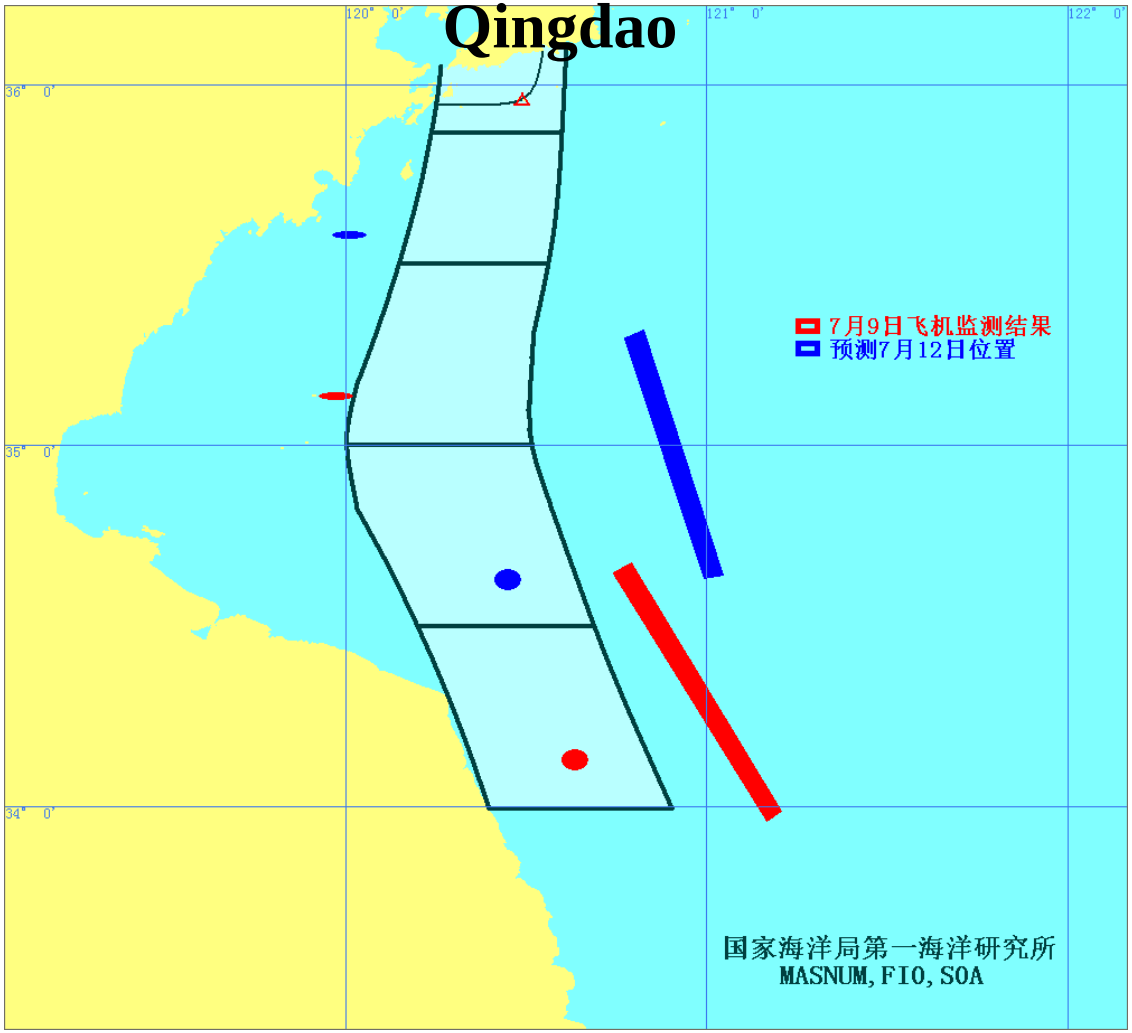
1. Drifting channel

Background

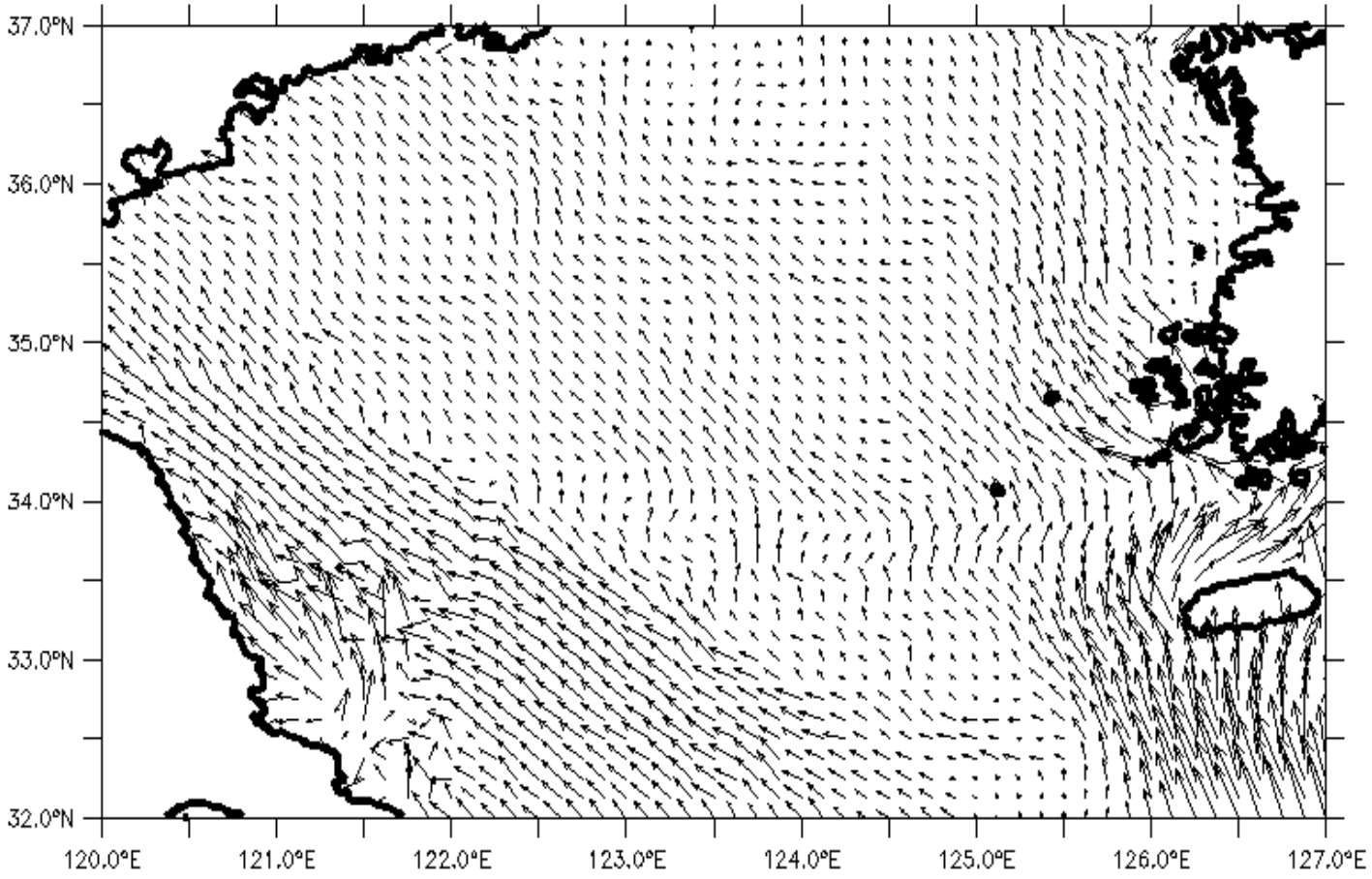
Firstly noticed on May 31, 2008 and arrived Qingdao on June 21. A national scientific committee was formed, and the author served as vice-chair of the committee.

Can algae accumulate in Qingdao is a key question, both for science and local government



Qiao et al，CSB, 2011

The algae float on sea layer, so the sea surface current is the main factor controlling drift channel

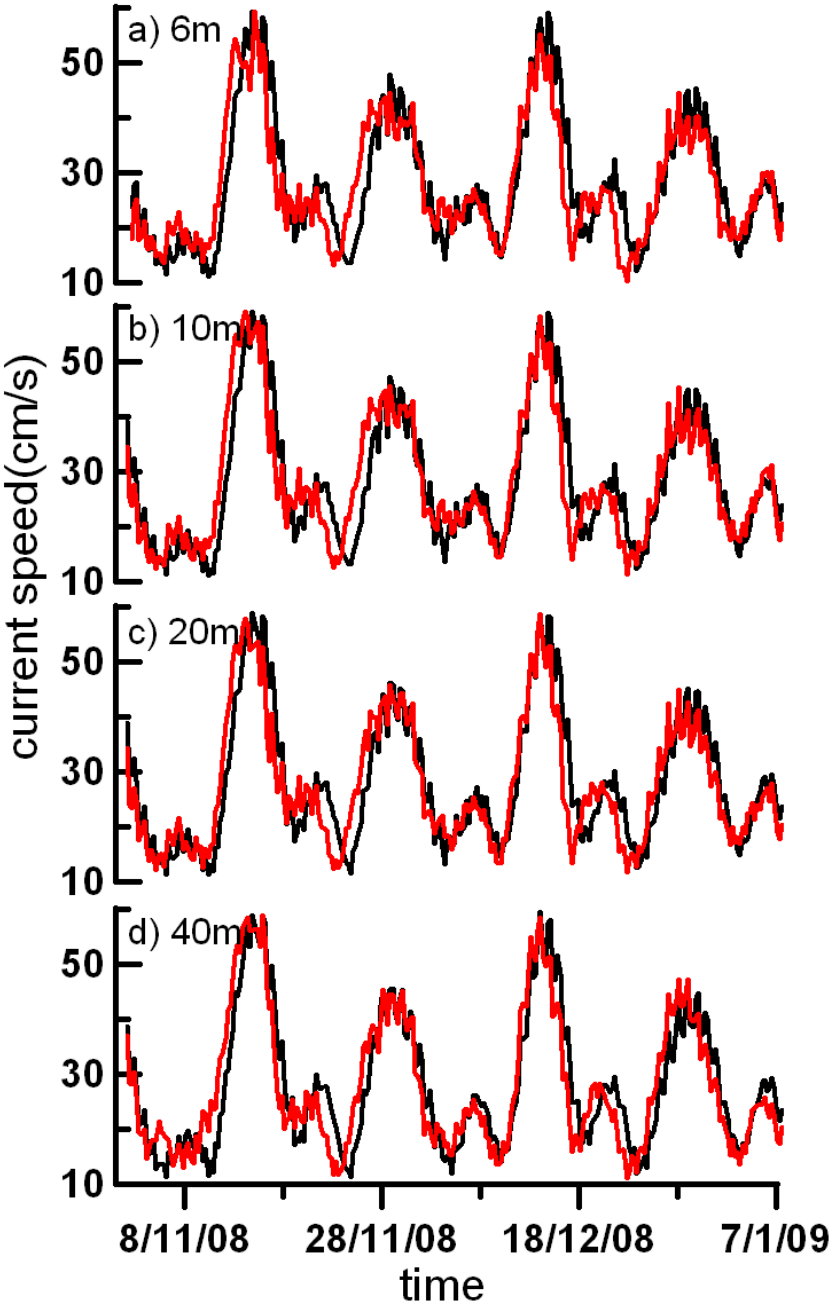


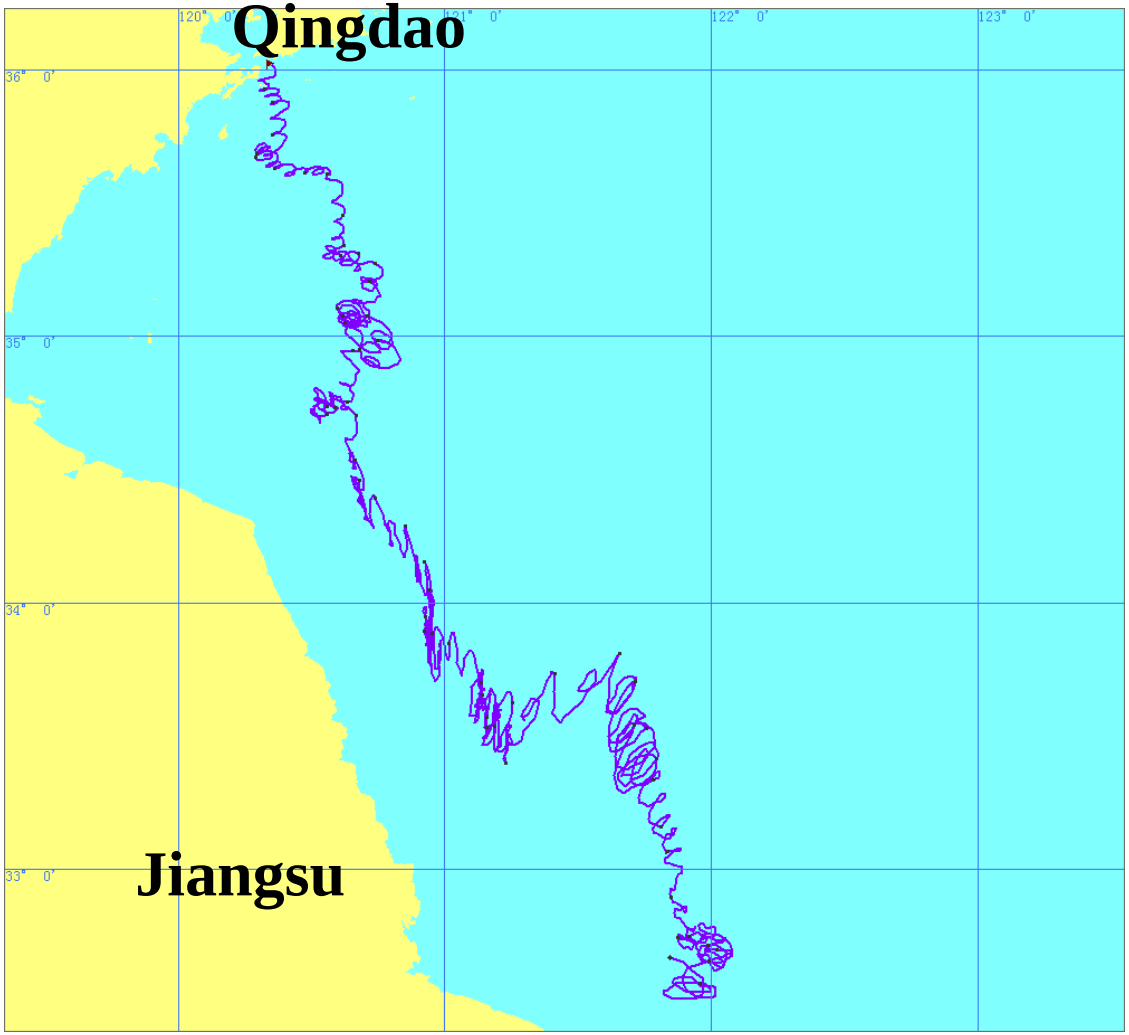
Our model results on June 23, 2008

Model validation

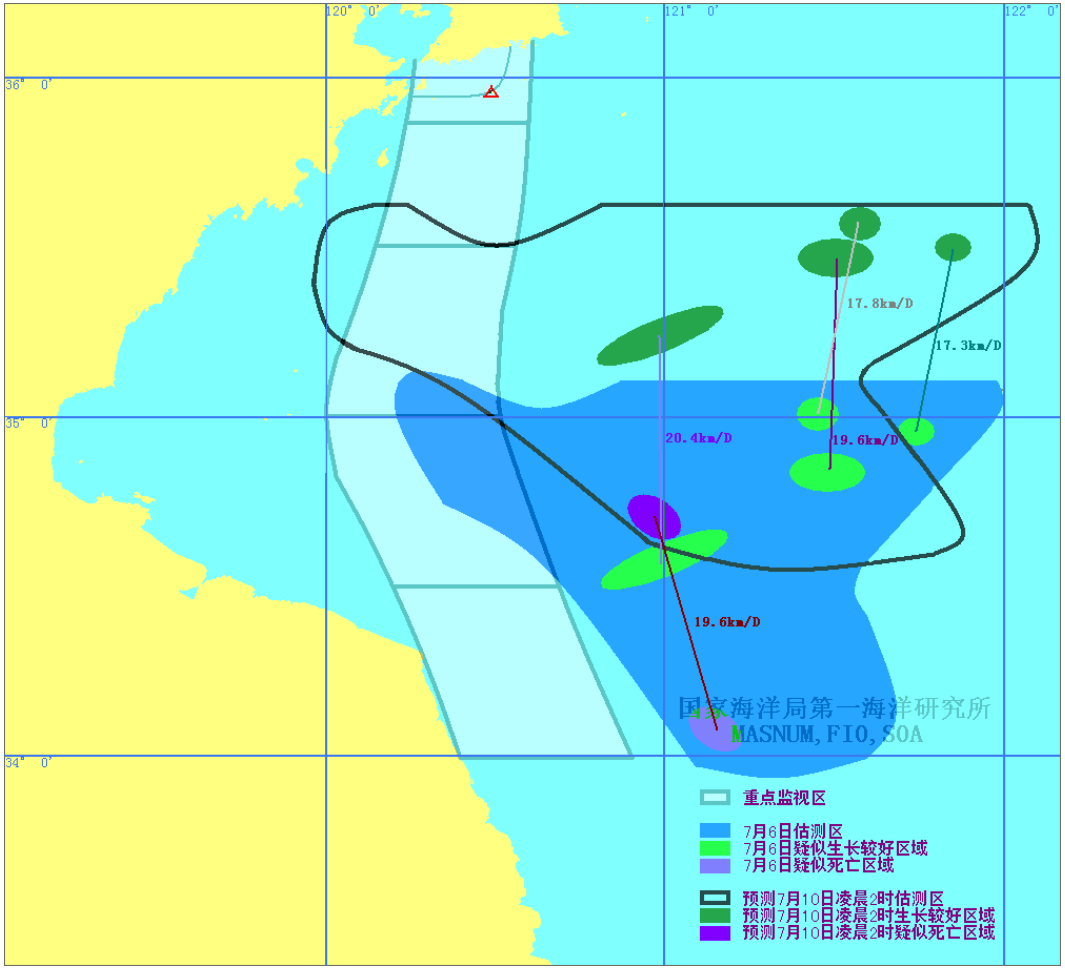
An accurate numerical model is important for the prediction of algae float.

Red line is from model while the black line from ADCP data.



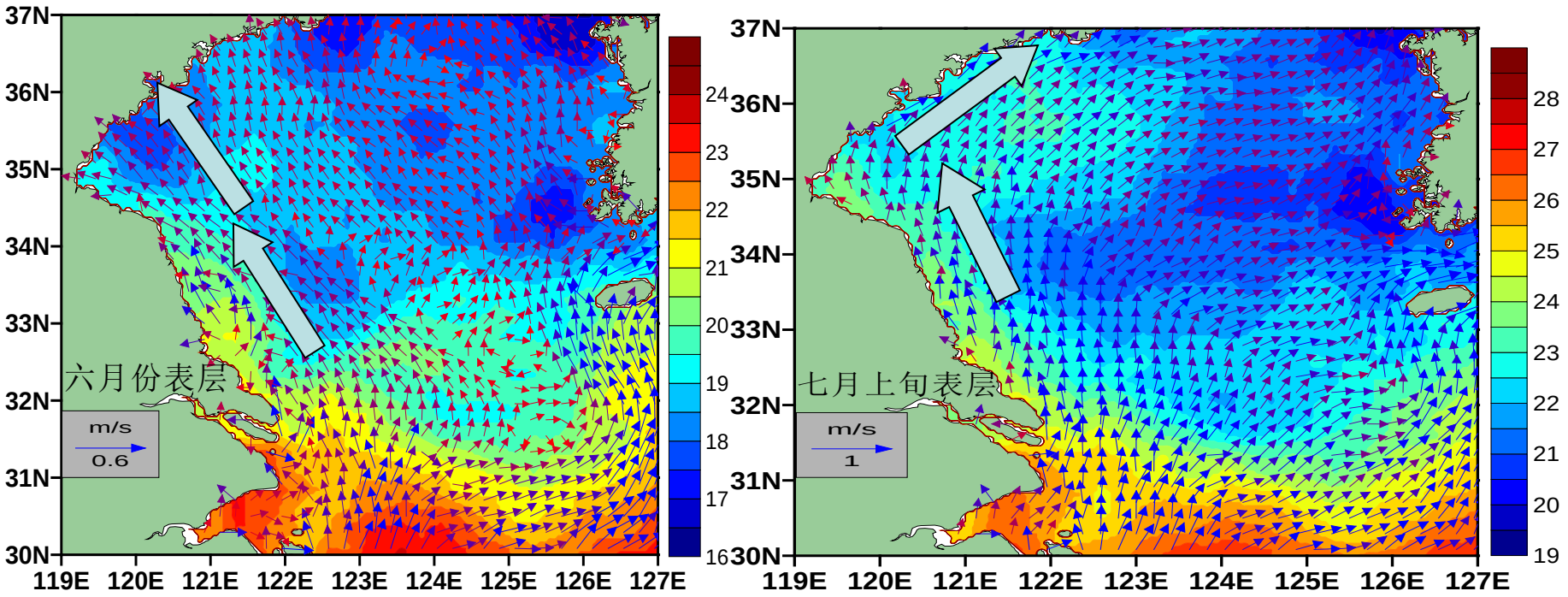


Where did the algae originate? Source identification from model for 2 months (June 22 back to April 23, 2008).



Operational application of drifting channel：On July 6, 2008, all monitoring algae by airplanes of SOA was out of the drifting channel, 3 days forecast results confirm that all these algae will not affect Qingdao.

Why the algae accumulated along the coast of Qingdao in June, 2008? It alleviated much in July, 2008

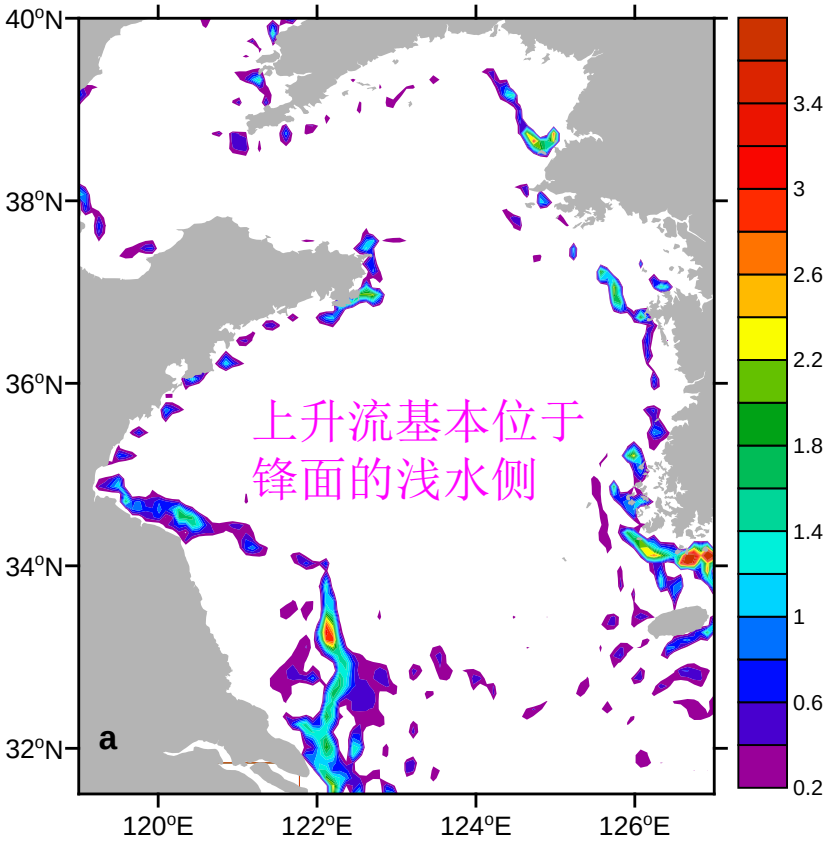


Simulated surface current and SST in June (left) and July 1-10 (right) 2008

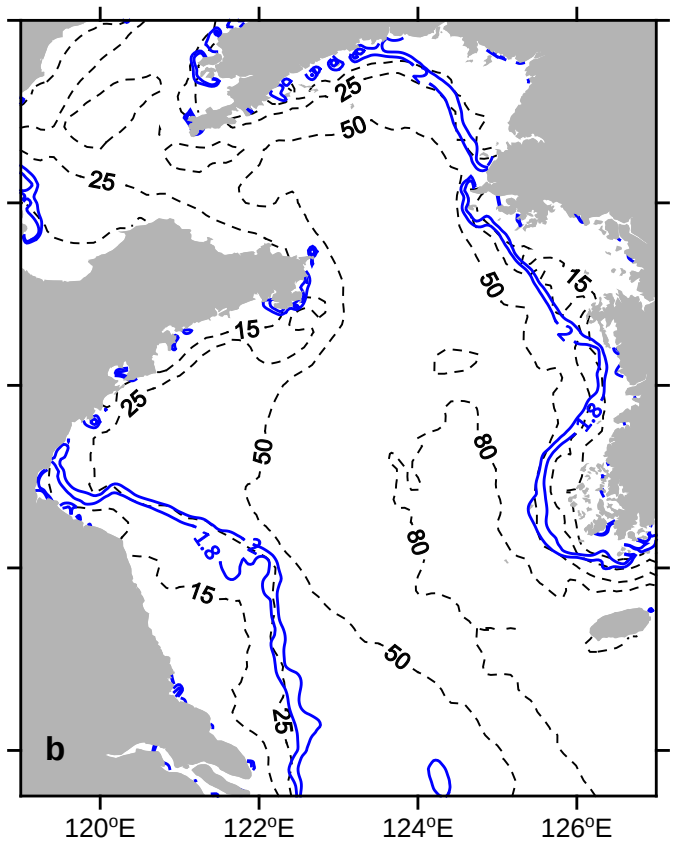
2. Nutrient supply

(Lv et al, 2010, CSR)

Upwelling system

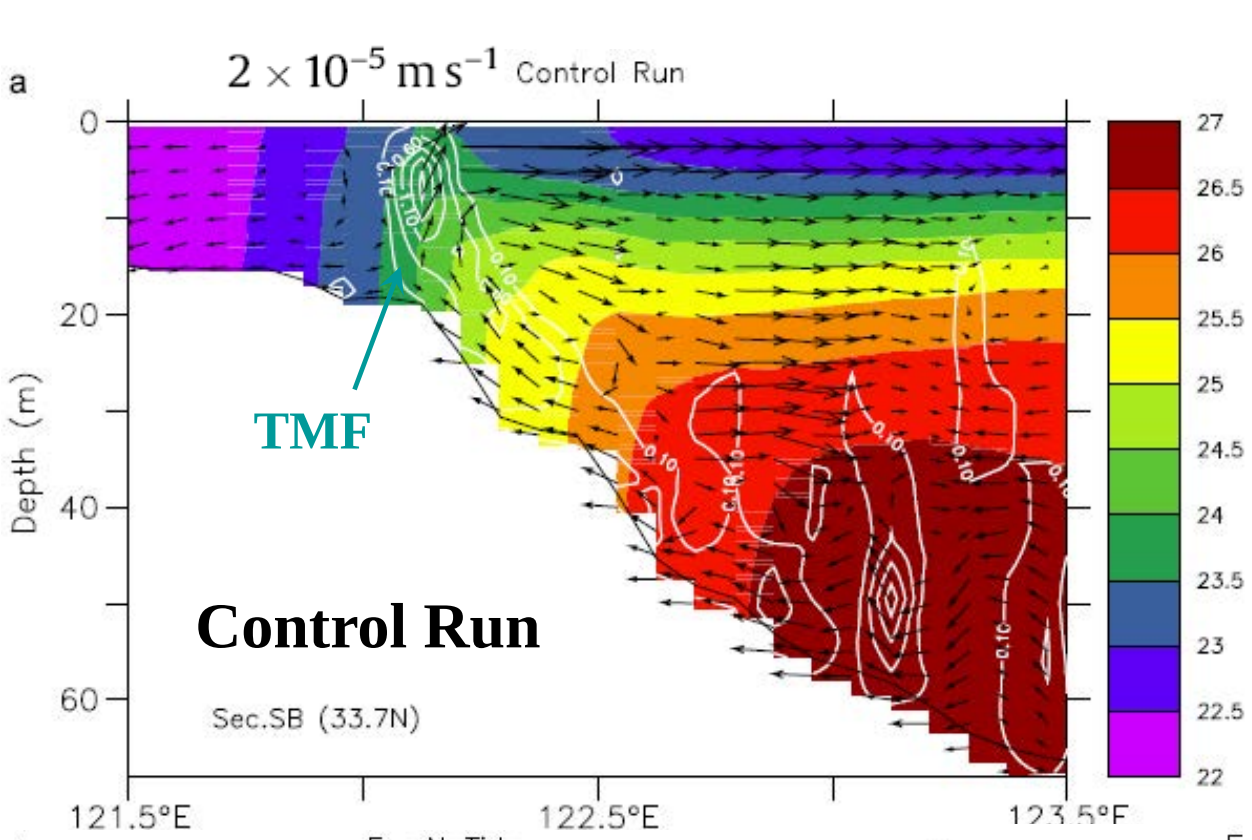


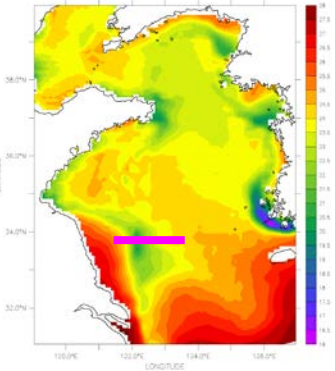
上升流水平分布(10m, 10^{-5} m/s)



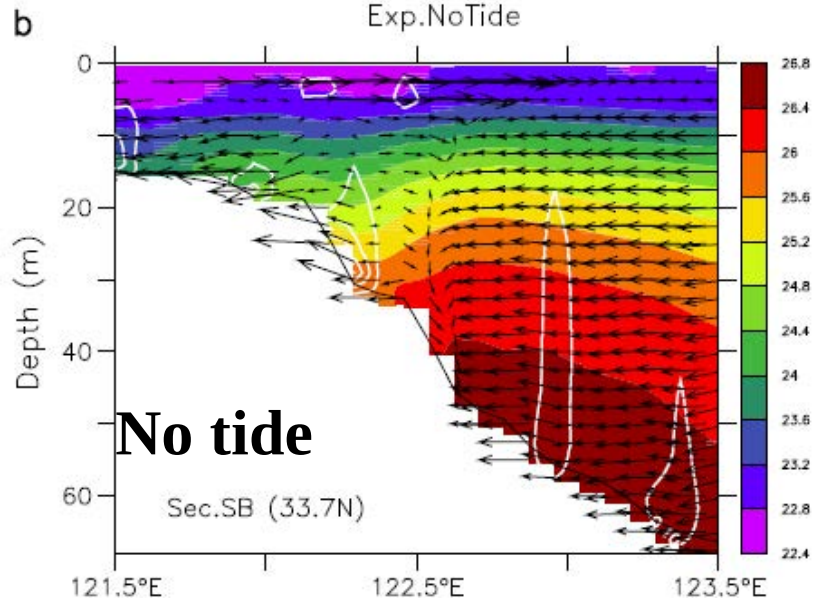
$$SH = \log\left(H \Big/ |u|^3\right)$$

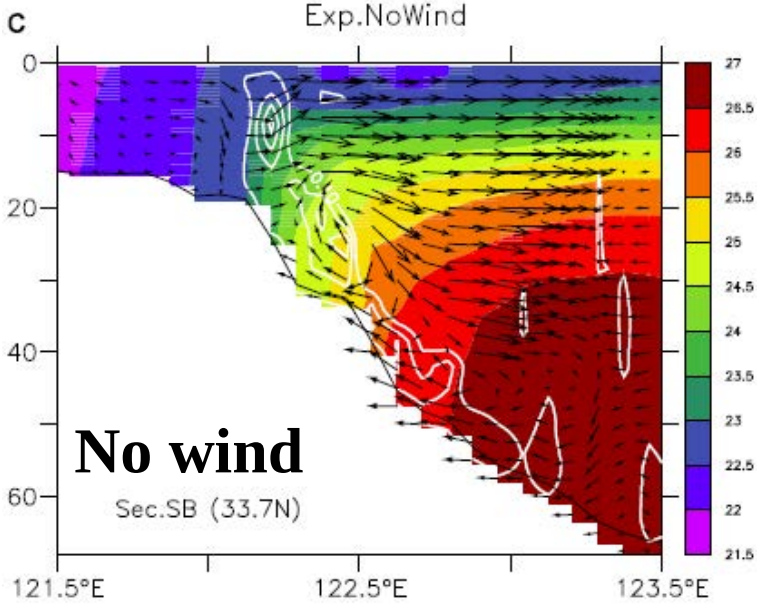
Simulated upwelling along the temperature front in the Yellow Sea.



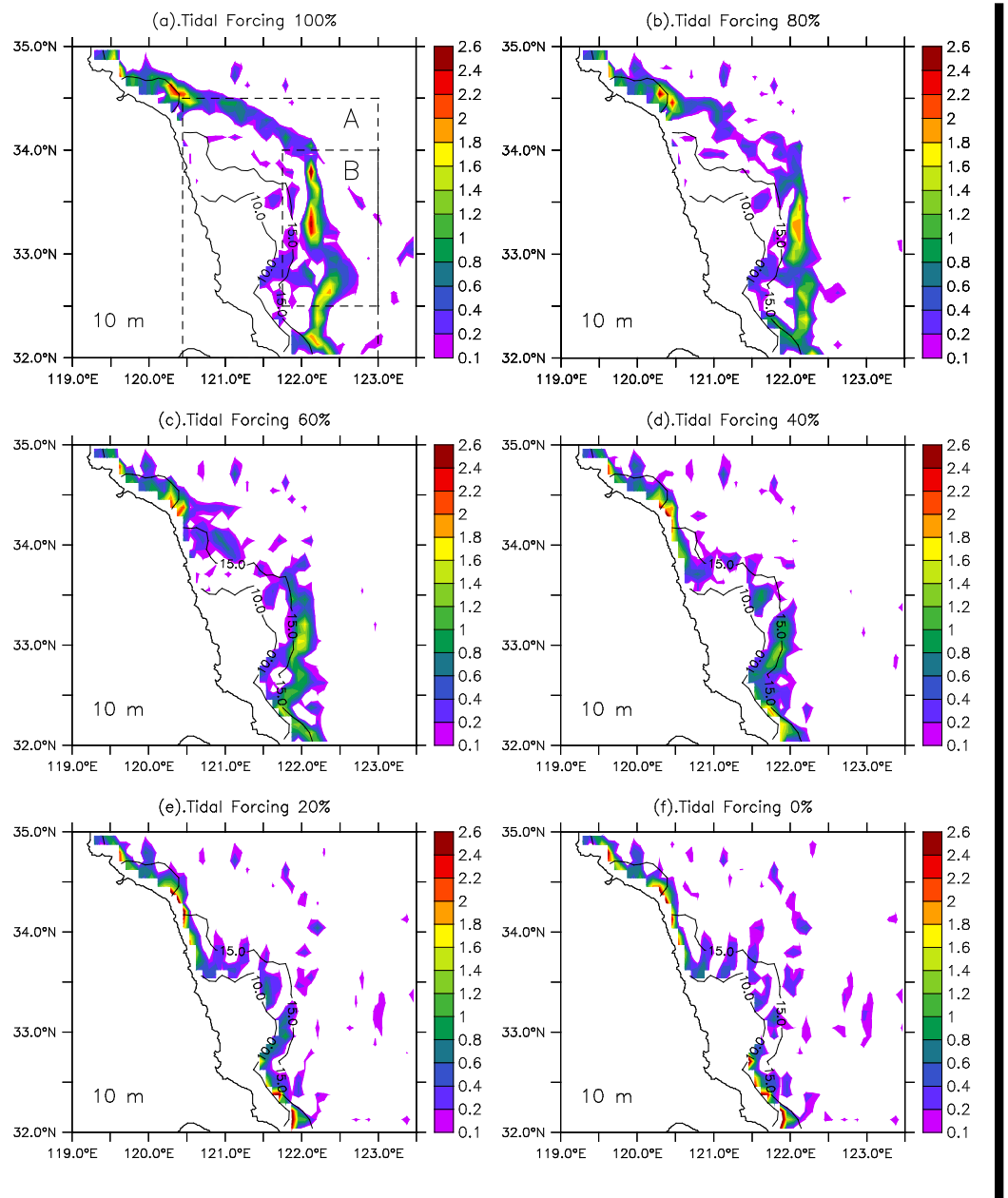


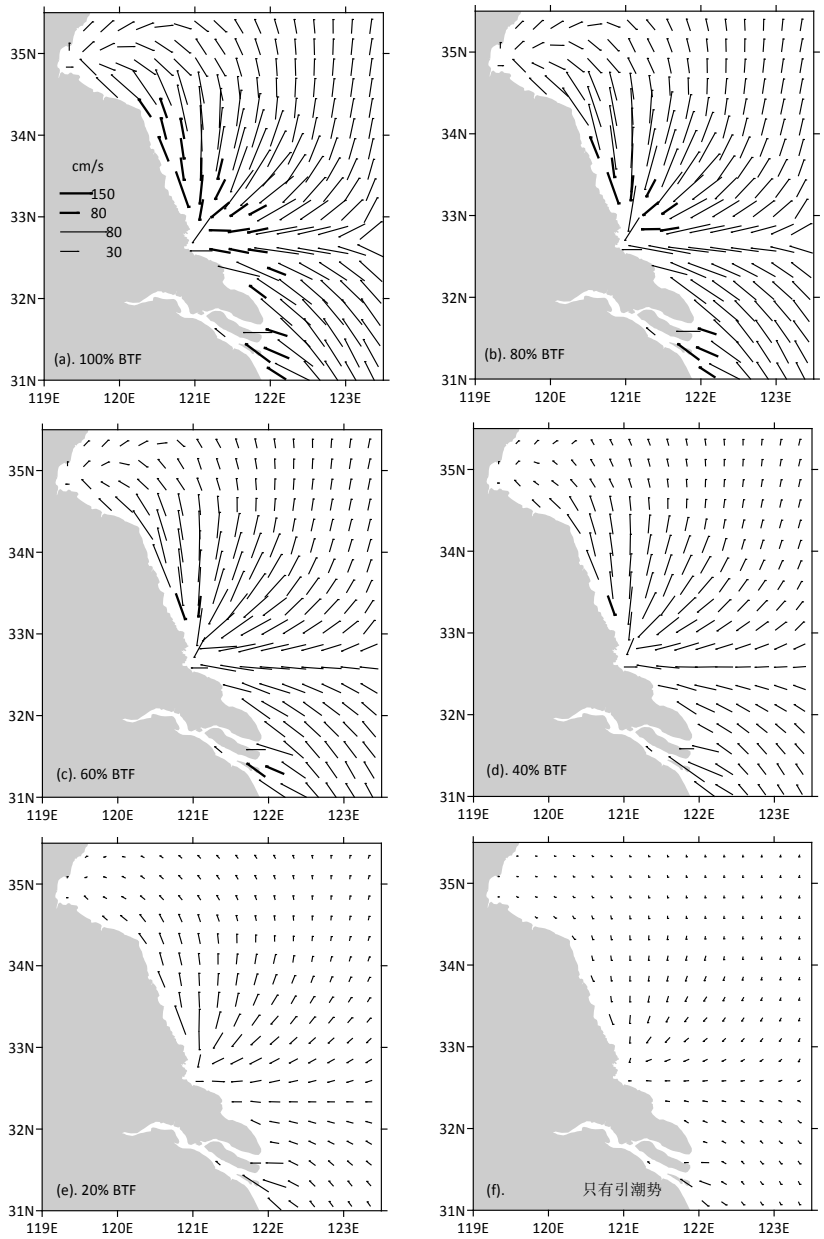
Temperature (shade), current (vector) and upwelling (white contor) along the Transect (Pink line)



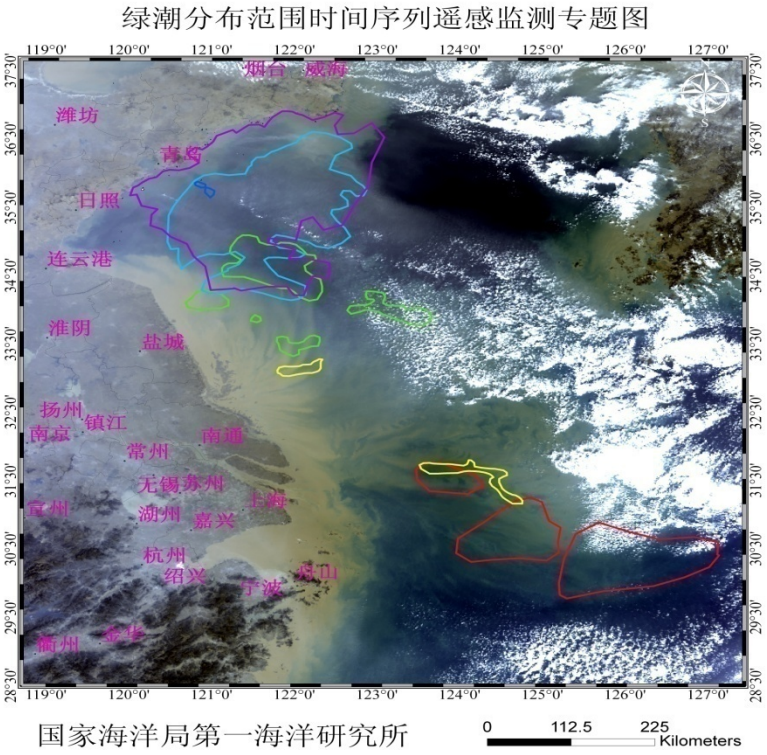


The relationship between upwelling and tide





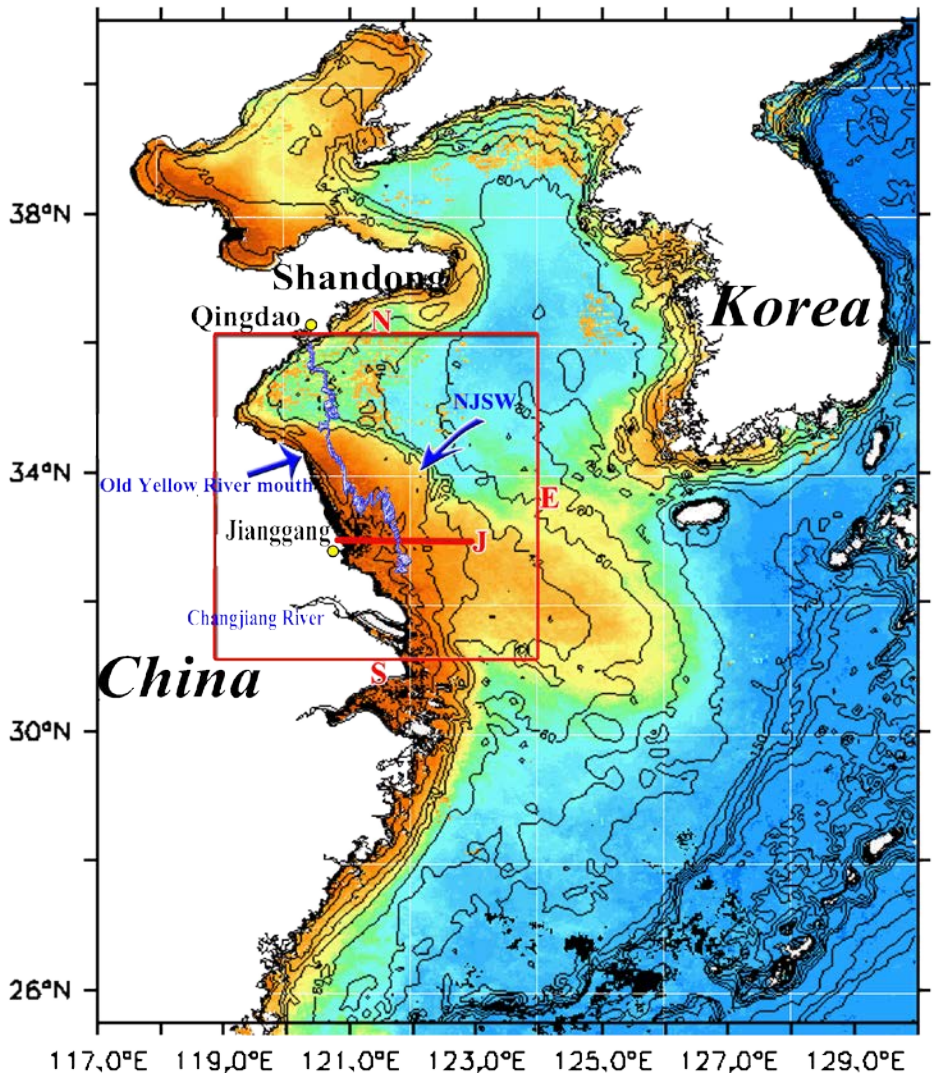
The right panel is simulated upwelling, while the down panel is the merged algae image from satellite. The similar pattern suggests that algae along the upwelling band will bloom due to enough nutrients.

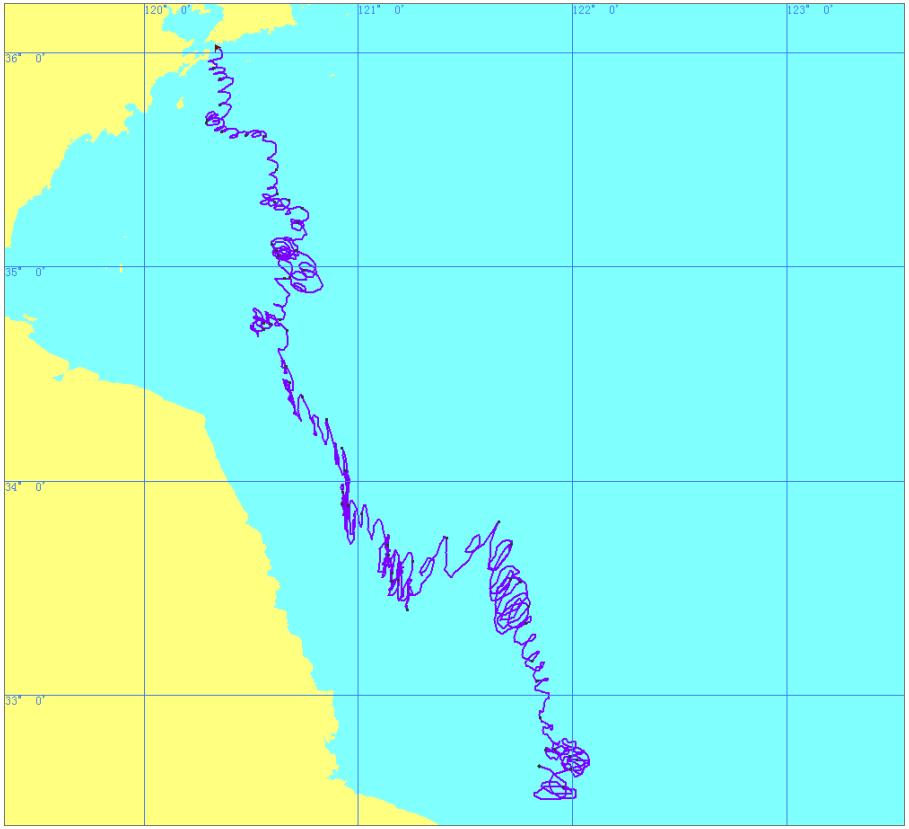


3. Why first burst in 2008

(Wang et al, 2010, ECSS)

- **Coastal farmers told that algae bloom often appear in coastal area, but much less serious than that in 2008. And farms can kill the algae bloom simply through mixing their ponds by sticks.**
- **The author thought that the algae burst of the Yellow Sea in 2008 should be related with low sea surface turbidity.**





The shade in left panel is turbidity from satellite.

- **Previous studies suggest that the algae origin area is with high turbidity, which is controlled by the strong tidal current. However, there should be no much difference for different years, because the tidal current has large variation within one month.**
- **The control effects of surface wave**

Wave

No wave

		MODIS (mg l^{-1})	Exp 1 (mg l^{-1})	Exp 2 (mg l^{-1})
2006	March	50.1	36.2	9.7
	April	50.9	36.4	9.3
2007	March	42.9	48.1	10.2
	April	32.7	35.8	9.4
2008	March	42.0	31.5	9.6
	April	22.9	34.6	9.4
Average	March	45.0	38.6	9.8
	April	35.5	35.6	9.4

Based on our sediment numerical experiments, surface waves play dominant role on the surface turbidity concentration

The area (red square on P18) averaged wind and waves

		Wind speed ($m\ s^{-1}$)	Wave amplitude (m)
2006	March	6.03	0.78
	April	6.06	0.82
2007	March	6.68	0.90
	April	5.88	0.66
2008	March	5.65	0.64
	April	5.50	0.65

The summer Asian monsoon has been weakened which is confirmed by data. Weak monsoon results in smaller surface wave in April, 2008, so turbidity concentration is low in April, 2008, which is the algae burst period.

Summary:

Summer Asian Monsoon weak ⟶
Wind of Yellow Sea weak ⟶
Surface waves weak ⟶
Sea surface turbidity concentration low ⟶
Favorable for the bloom of algae in 2008;

- The favorable physical condition, low turbidity concentration, should be the reason for first burst in 2008.
- In the following years after 2008, algae bloom appeared each year, the detailed mechanism was detected by recent studies, e.g. physical-biological interactions.

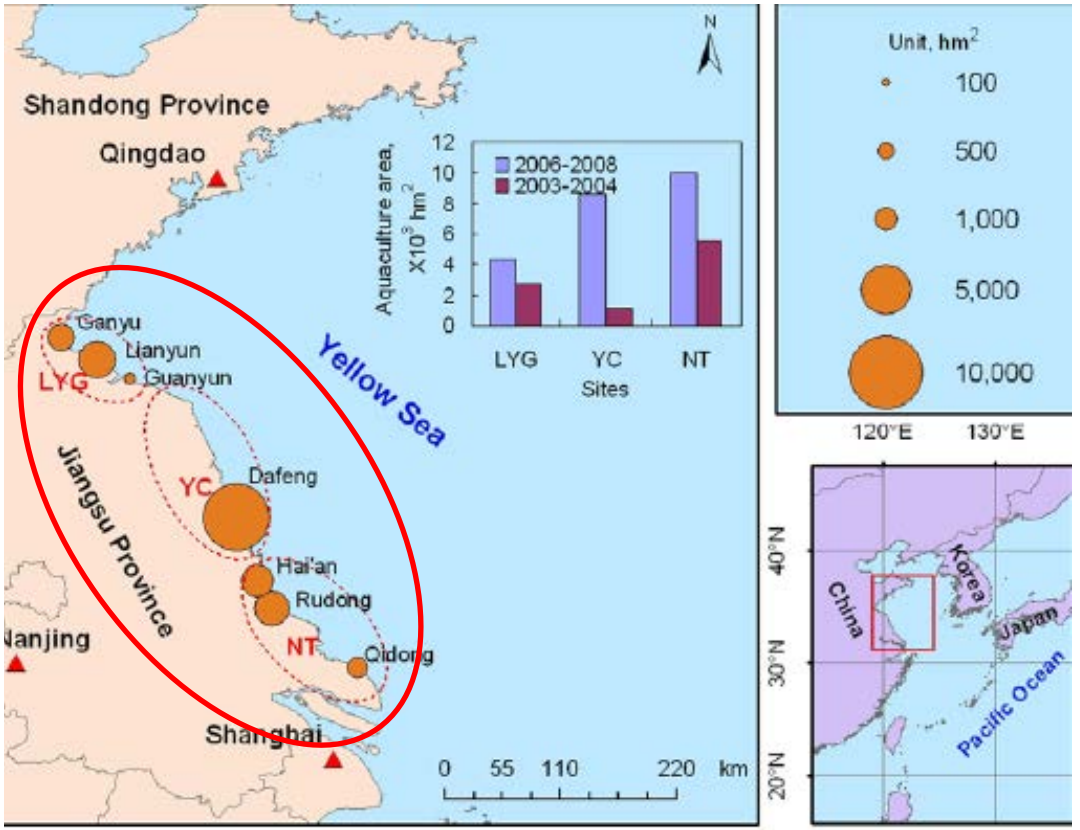
Biological Source

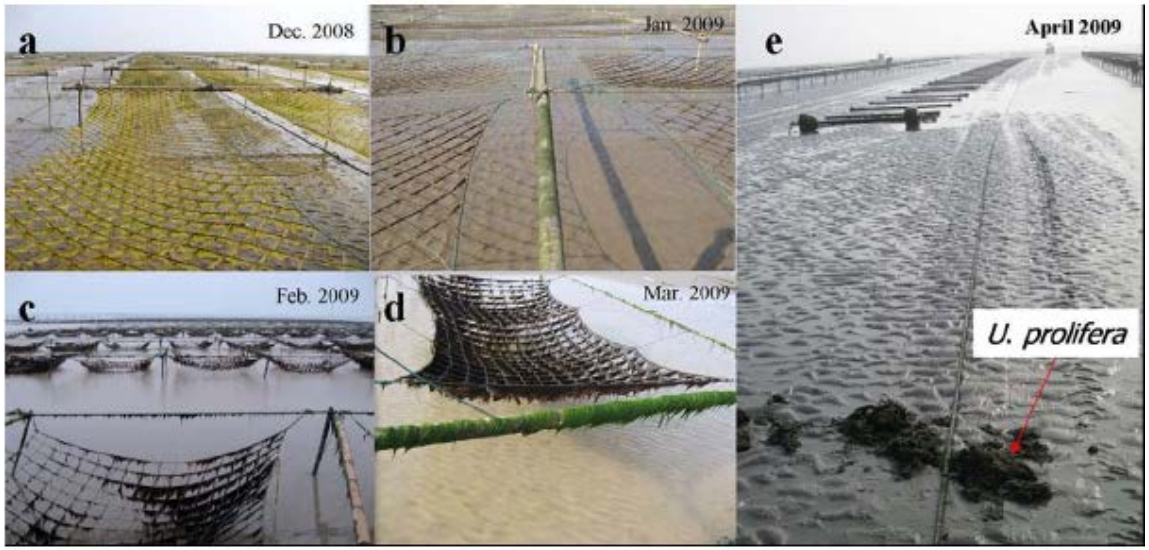
- Seaweed aquaculture:

  Porphyra yezoensis

- confirmed as nursery for macroalgal blooms

e.g. Liu et al 2009, 2010





Thanks

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