Physical factors influencing the recapture rate and yield of the edible jellyfish in the Liaodong Bay, China

Liping Yin
The first institute of oceanography, China
2018. 11. 2

Outline

- Motivation and background
- Methods
  - Hydrodynamic model
  - Jellyfish individual based model
- Results
  - Physical environment in LDB
  - Transport and connectivity
  - Recapture rate
  - Jellyfish weight
- Summary

Motivation and background

Harvesting

Releasing

Young jellyfi

Fishing

Mixed cold jellyfish with cucumber

Motivation and background

- Why is the recapture rate this low and big annual fluctuation? What is the factors that impact the recapture rate? How can we raise the jellyfish yield?
- Why is the mean weight for each jellyfish in each year varying so huge? What are the physical processes that affect the jellyfish productivity?
- When and where to release the young jellyfish?
- When is the optimum harvest date? Where is the favorable fishing ground?

Year	Releasing number/billion	Recapture number/(ten housand)	Recapture rate/%	Yield/thousand tons	Mean weight per jellyfish (kg)
2008	0. 3	305. 7	1. 02	2. 834	0. 91
2009	0. 318	214	0. 67	10. 8	5. 04
2010	0. 365	168	0. 46	3. 19	1. 9

Methods

- **A couple of the hydrodynamic model and the jellyfish individual based model**

- **Hydrodynamic model**
  - A real time and operational application prediction system for China and ambient.

  - Based on the synchronous coupling of two models: the Princeton Ocean Model (POM) for the circulation part and the MASNUM model for the wave number spectral which providing the vertical mixing.
  - 30 sigma layers in the vertical and a horizontal resolution of $1/24° \times 1/24°$
  - Triple nested technical for lateral boundary and MPI technical for fast calculation

Methods

- **Jellyfish individual based model**
  - Movement: Passive movement and diel-vertical migration
    - Lagrange particle-tracking algorithm for passive movement.
      - $\frac{d\vec{x}}{dt} = \vec{u}_c + u'$
      - Random walk
      - $K'(\mathbf{x}_n)\Delta t + R\sqrt{2r^{-1}K(\mathbf{x}_n + K'(\mathbf{x}_n)\Delta t)\Delta t}$ (Visser, 1997) or $R\sqrt{2r^{-1}K\Delta t}$ (naïve walk)
      - Runge-Kutta integration method
    - Vertical swimming for diel-vertical migration.
  - Mortality

1. Young jellyfish at temperature below 12º C or exceed 34º results in either death or severe growth retardation
2. Natural mortality $N_t = N_0 e^{-Mt}$ （Dong， 2013）

Growth

Weight of the jellyfish can be determined by the diameter of umbrella, L:

$$W = 0.5346 \cdot L^{2.355} \qquad (1)$$

/miu is the function of growth rate (GR) of the umbrella diameter (UD):

$$L_2 = \frac{2+\mu t}{2-\mu t} \cdot L_1 \qquad (2)$$

Where t is the growth time, μ is the GR of UD, which is determined by the Growth time, temperature and salinity:

$$\mu = f_t \, f_T \, f_s \qquad (3)$$

f_t, f_T, f_s are the time, temperature, and salinity determined GR, respectively, which can be expressed by the temperature-control function, the cubic polynomial, and the Rayleigh function.

Growth

Temperature- controlled function：

$$f_T = K_a(T)K_b(T),$$ （Thornotn and Lessem，1978）

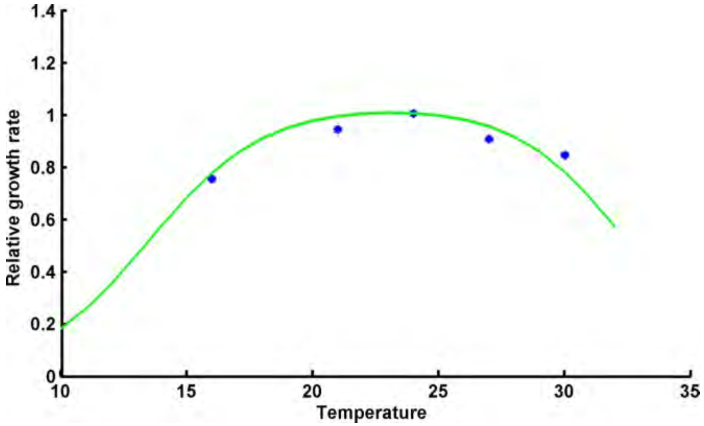
Where,

$$K_a(T)=\frac{K_1 \exp^{\gamma_1(T-T_{\min})}}{1+K_1\left[\exp^{\gamma_1(T-T_{\min})}+1\right]}, \quad K_b(T)=\frac{K_4 \exp^{\gamma_2(T_{\max}-T)}}{1+K_4\left[\exp^{\gamma_2(T_{\max}-T)}+1\right]},$$

$$\gamma_1=\frac{1}{T_{opt\min}-T_{\min}}\ln\left[\frac{K_2(1-K_1)}{K_1(1-K_2)}\right], \quad \gamma_2=\frac{1}{T_{\max}-T_{opt\max}}\ln\left[\frac{K_3(1-K_4)}{K_4(1-K_3)}\right],$$

$K_1=0.19 \quad K_2=0.97 \quad K_3=0.98 \quad K_4=0.65$

f_T



$T_{\min}$ and $T_{\max}$ are the minimum and the maximum optimum temperature for the jellyfish growth. $T_{opt\min}$ and $T_{opt\max}$ are the minimum and the maximum temperature that the jellyfish can growth, which are taker to be 12° C and 34 ° C.

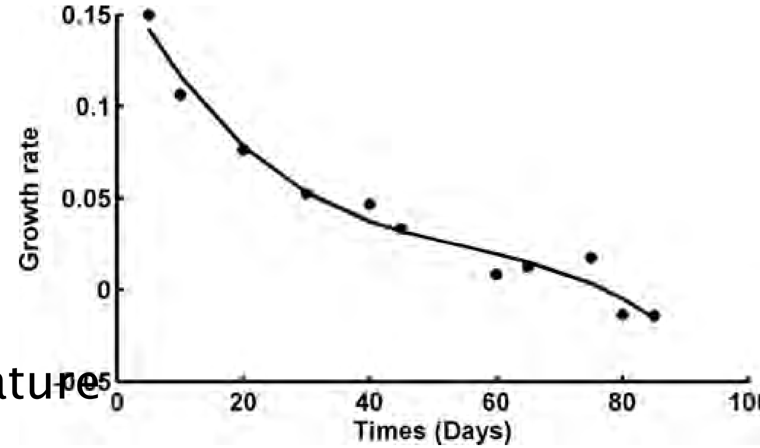
Picture shows the simulated(green line) and the observed calculated (blue dots) growth rate that controlled by the temperature.

,

Time-control:

$$f_t = at^3 + bt^2 + ct + d$$

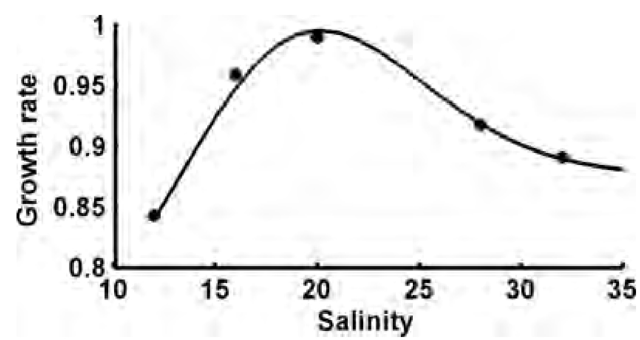
$$a = \text{-6.536e-07}, b = 0.0001208, c = -0.008229, \ d = 0.2233$$



Right: growth rate along with the temperature

Growth rate influenced by the salinity:

$$f_s = 8.62 * \left(\frac{x - 13.31}{301.8} \exp\left(-\left(\frac{x - 13.31}{83.29} \right)^2 \right) + 0.0124 \right)$$



Right： Simulated (black line) and observed (black dots) growth rate variability along with the Salinity, with the growth be normalized.

Design of the experiments

The experiment time is from June to July for years 2008-2010.
Releasing time, location, jellyfish amount are the same as the real situation:

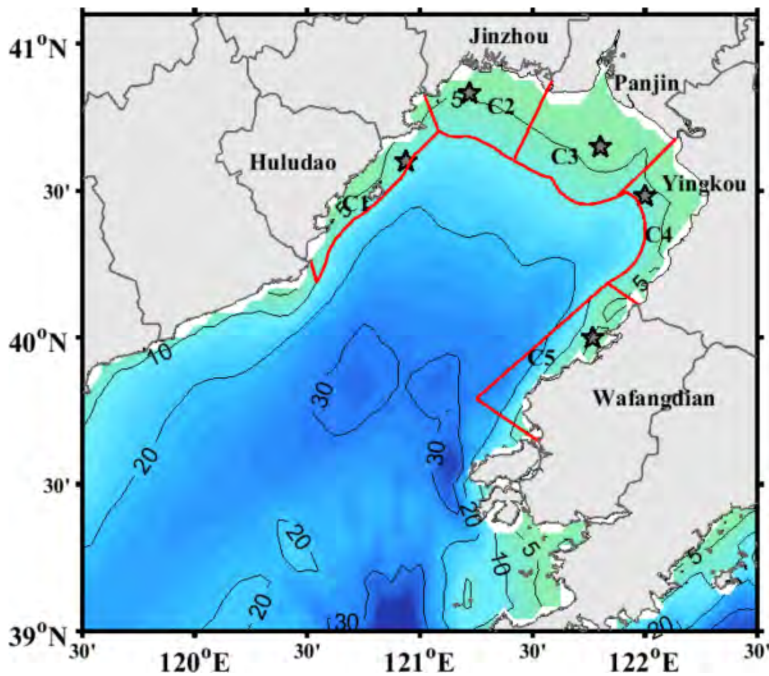
	Releasing date	Fishing date	Jellyfish releasing number (10 thousand)				
			HLD	JZ	PJ	YK	WFD
2008	16-25 Jun	27 Jul	4331	4343	5384	12245	3645
2009	31 May -6 Jun	20 Jul	4797	4568.8	6460.8	12757	3249.2
2010	1-7 Jun	21 Jul	5451.2	4514	5433	17651.5	3470.8

We assume that the amount of the releasing is the same for each day during the releasing season. In the experiment.

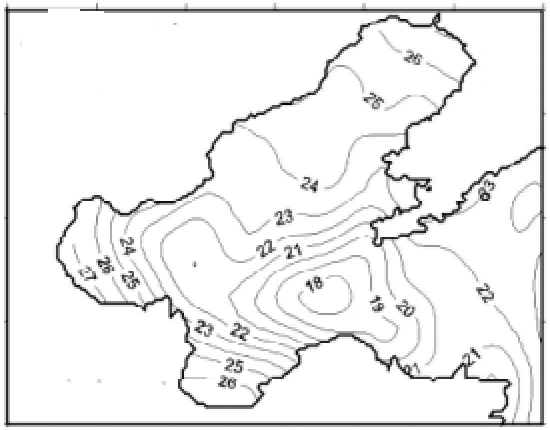
The fishing time is assumed to be 2 days according to the report, in which the jellyfish are reported to be thoroughly recaptured in 2-3 days.

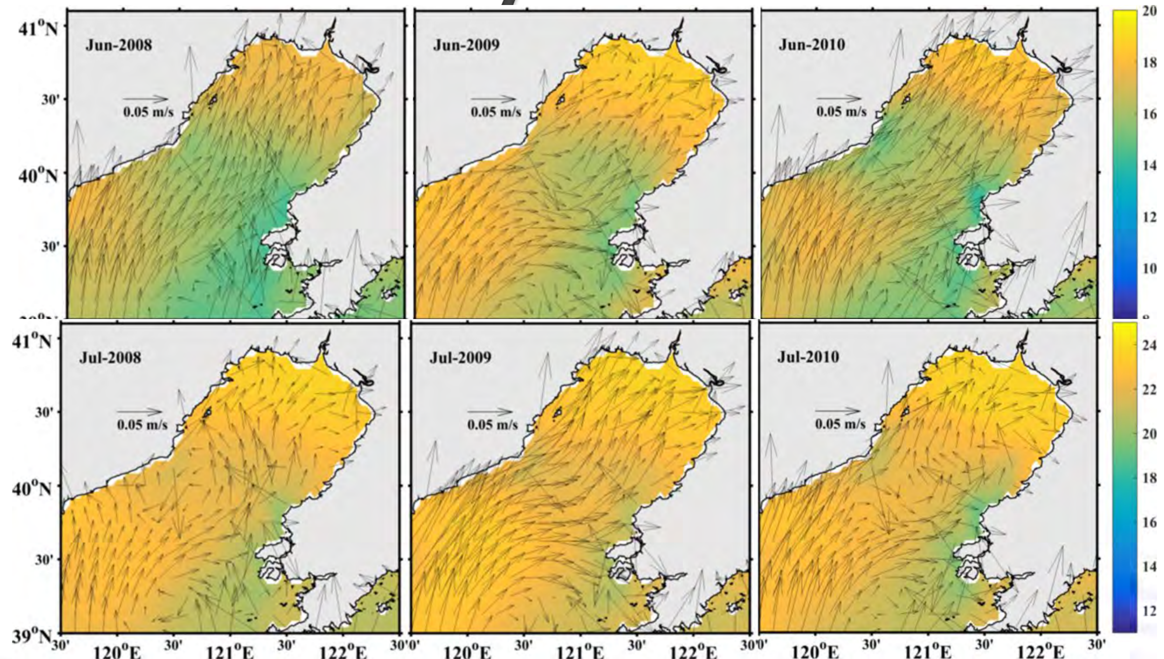
The initial umbrella diameter is set to be 1cm.

Methods- study area

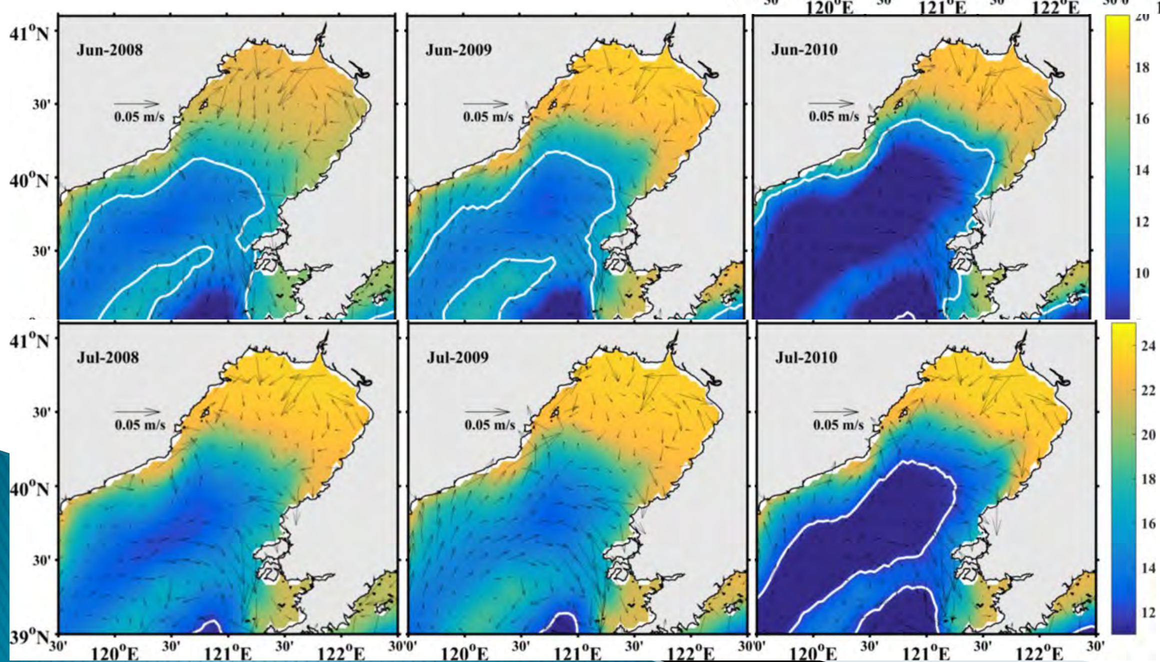


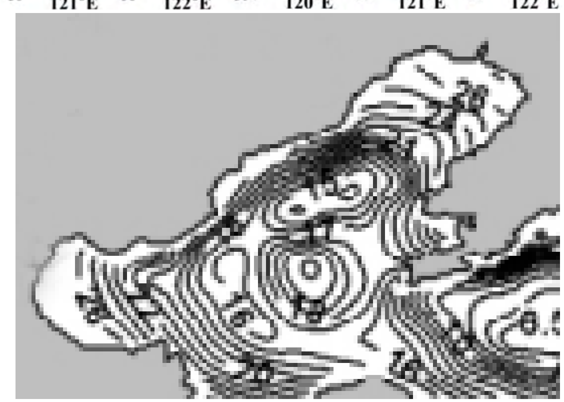
Results–Model reliability





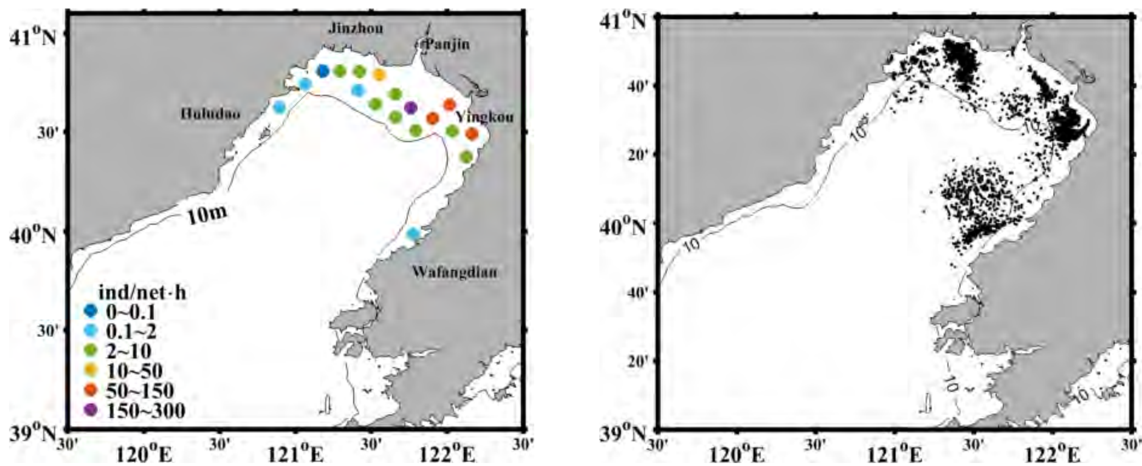
Right: Monthly mean surface circulation and temperature
Upper: Observation in summer in 2006



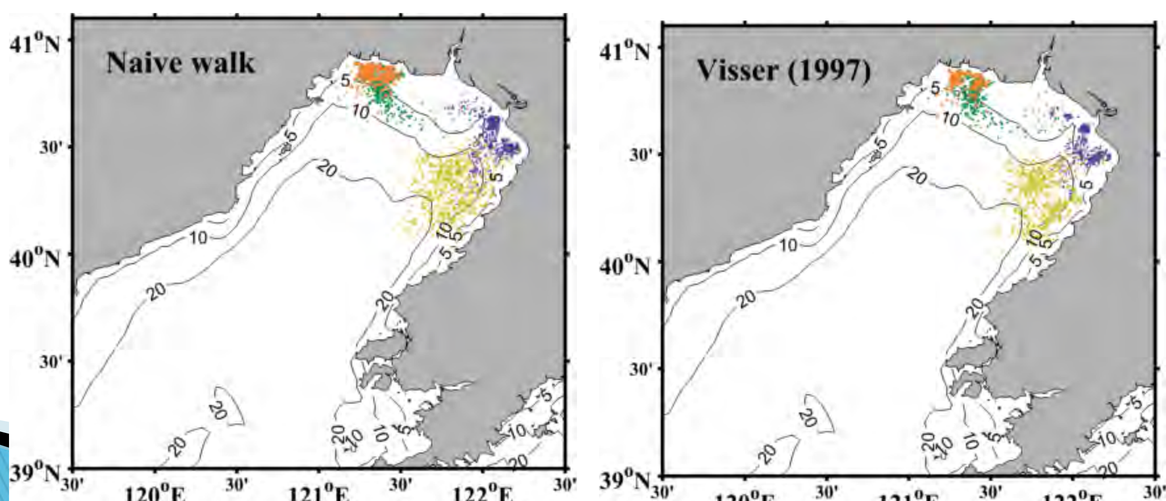


Left: Monthly mean bottom circulation and temperature. White lines are the contour of 12° C.
Upper: Observation in summer in 2006

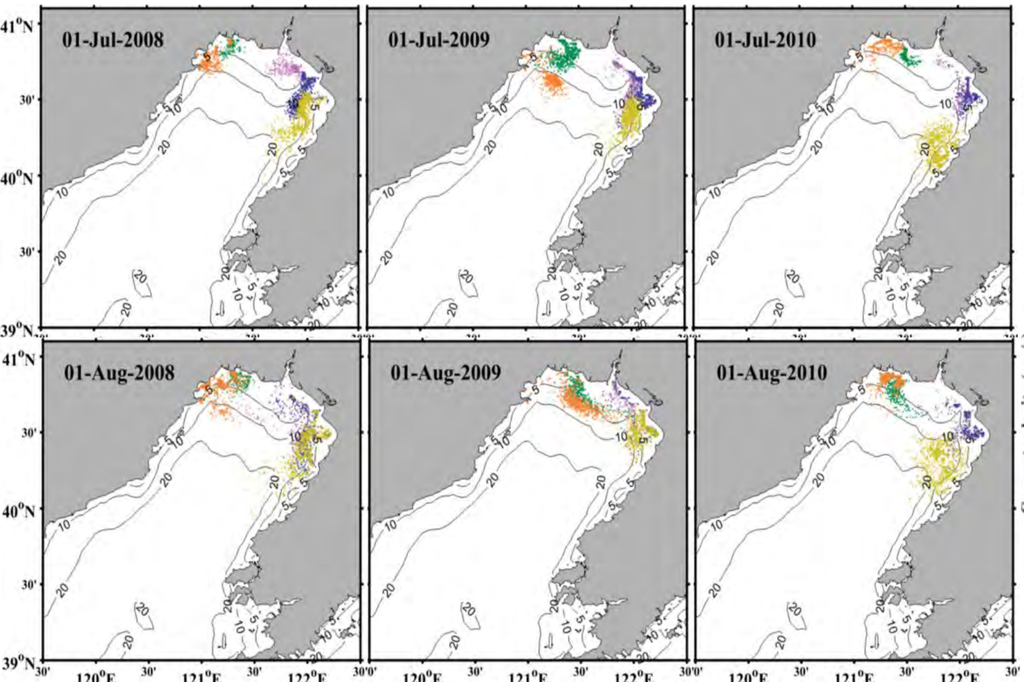
Results－Model reliability



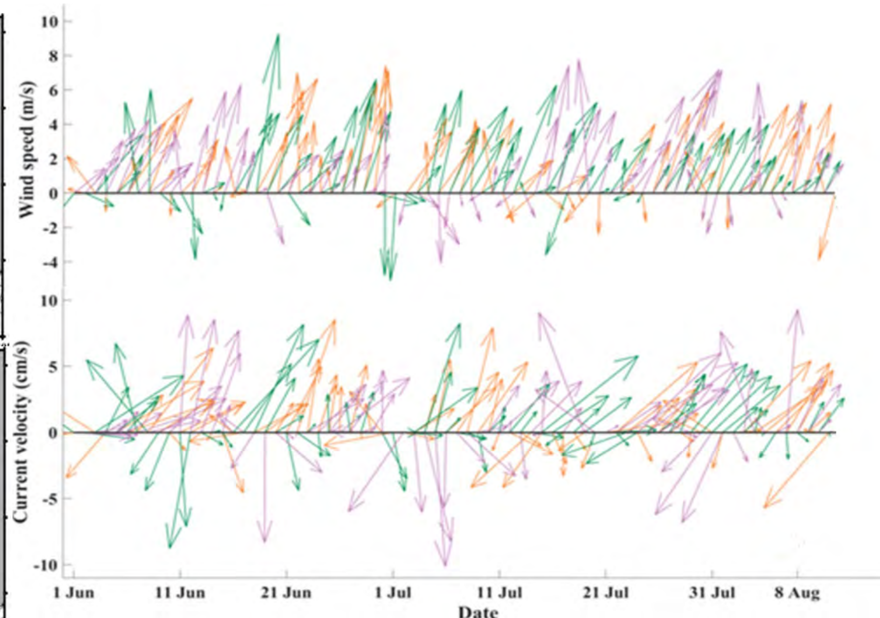
Observed mean distributions of jellyfish over the period 5 to 13 July in 2010 (Redraw from Dong et al., 2013). The simulated jellyfish is released at the sites shown in figure 1 and released the same date as the reality.



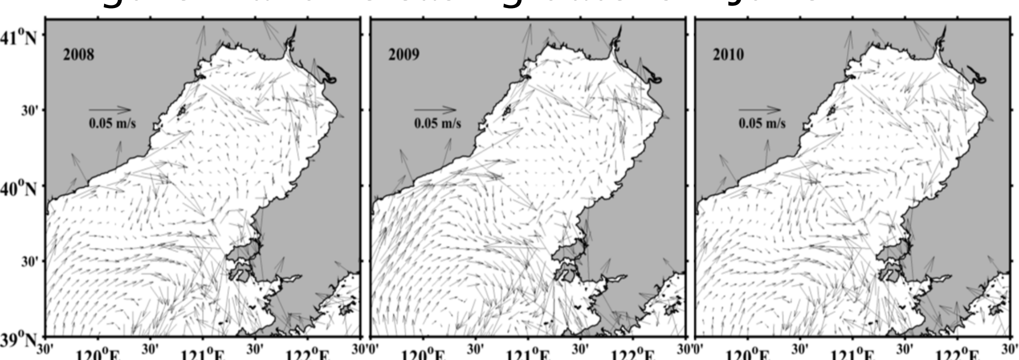
Results– distribution



Daily mean jellyfish distribution on 1 August in 2008–2010 which are released at the sites shown in figure 1 and releasing date is 1 June.

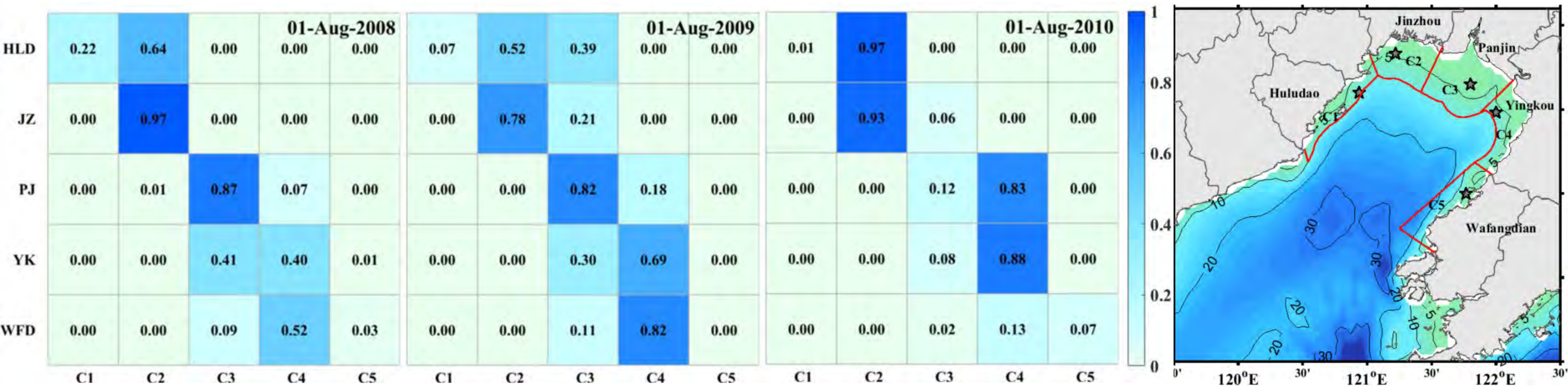


Daily mean wind speed (upper panel) and surface current (lower panel) vectors from June to July in 2008 (Orange), 2009 (Green) and 2010 (Magenta).



Vertical mean current fields for the average of June and July for 2008, 2009 and 2010.

Results- connectivity



Connectivity matrix of particles from the releasing sites to the fishing grounds shown in figure 1 after 1 month and 2 months integration.

Not a perfect releasing area

Year	HLD	JZ	PJ	YK	YFD
2008	0.97	0.86	0.95	0.82	0.64
2009	0.99	0.98	0.99	0.99	0.93
2010	0.99	0.98	0.95	0.96	0.22

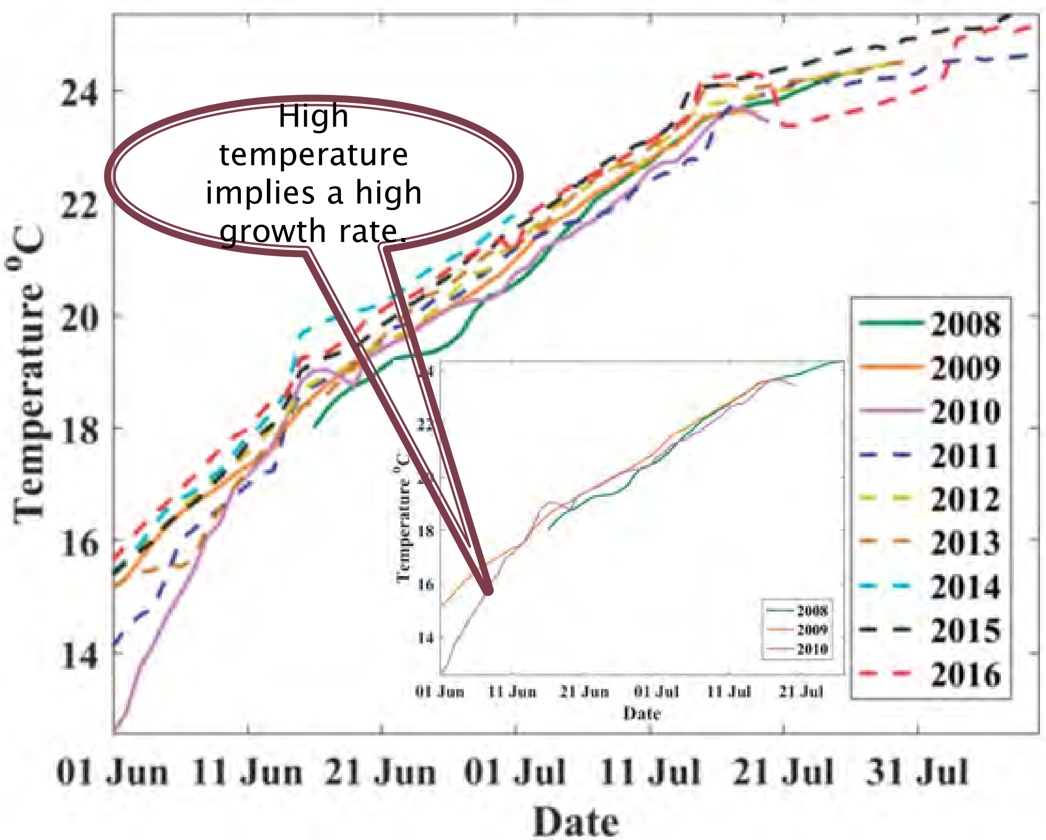
Row summation [illegible] the connectivity matrix in August for 200[illegible]2010

Not good fishing grounds

Year	C1	C2	C3	C4	C5
2008	0.22	1.62	1.36	0.99	0.04
2009	0.07	1.30	1.83	1.70	0.00
2010	0.01	1.89	0.29	1.85	0.07

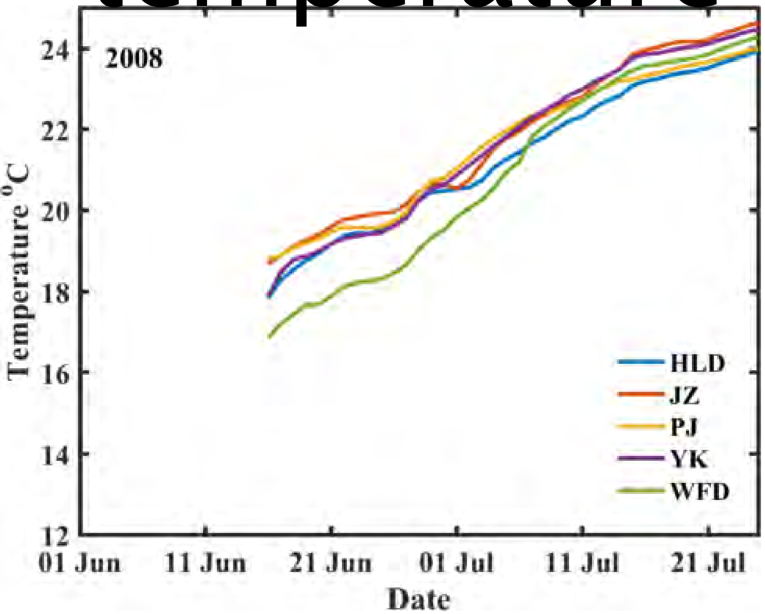
Column summation of the connectivity matrix in August for 2008-2010

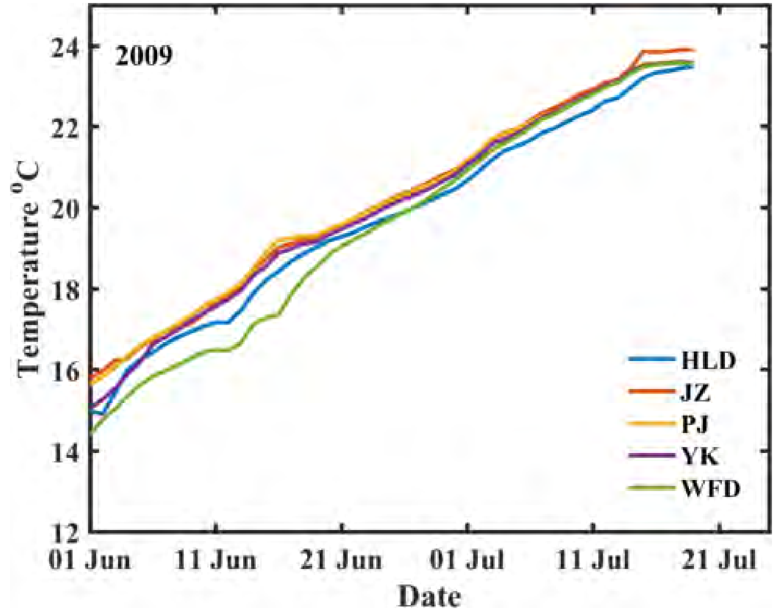
Results–Influence of the temperature

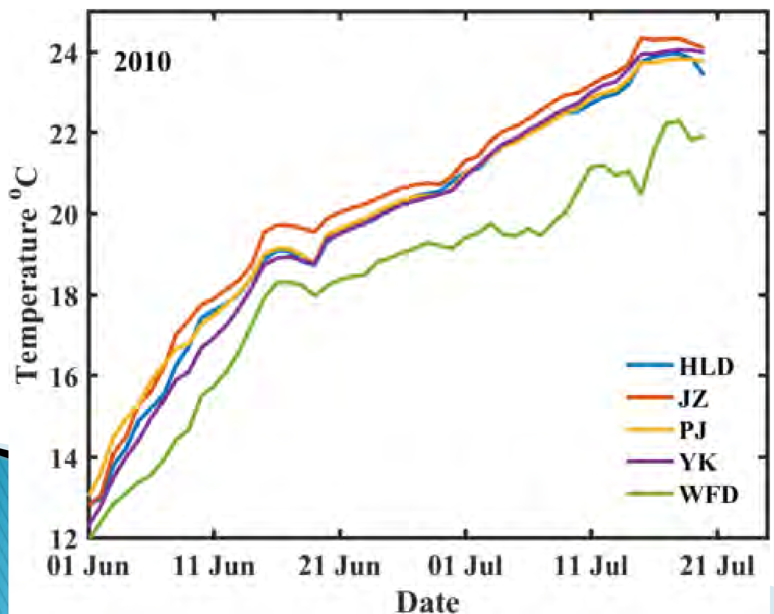


Mean temperature that all the jellyfish encountered during the enhancement season for years 2008 through 2016.

Results–Influence of the temperature

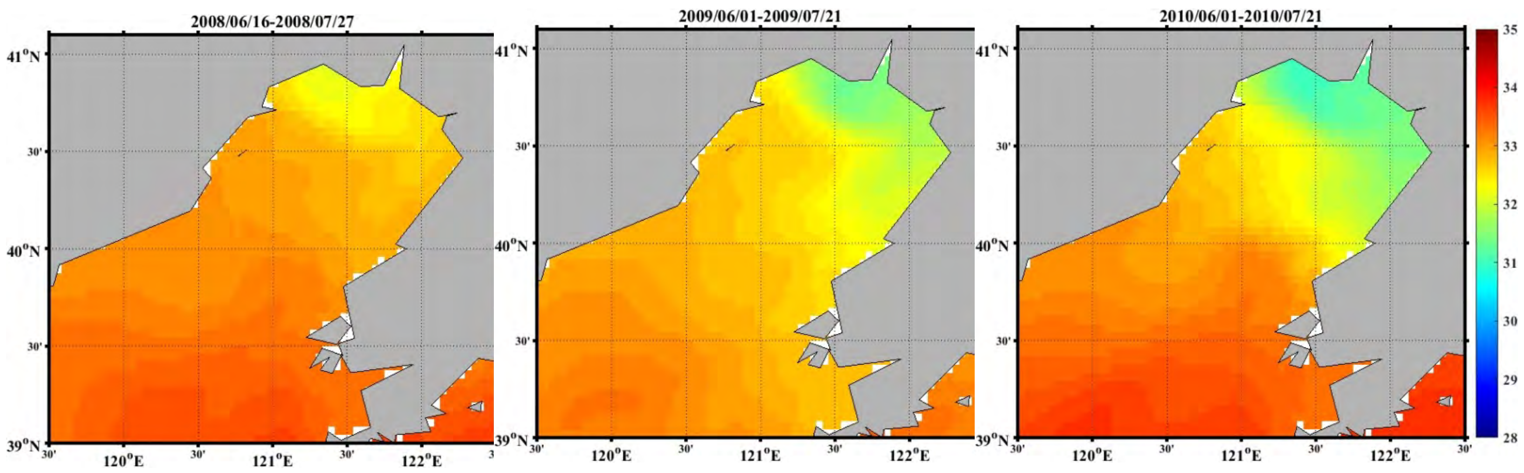




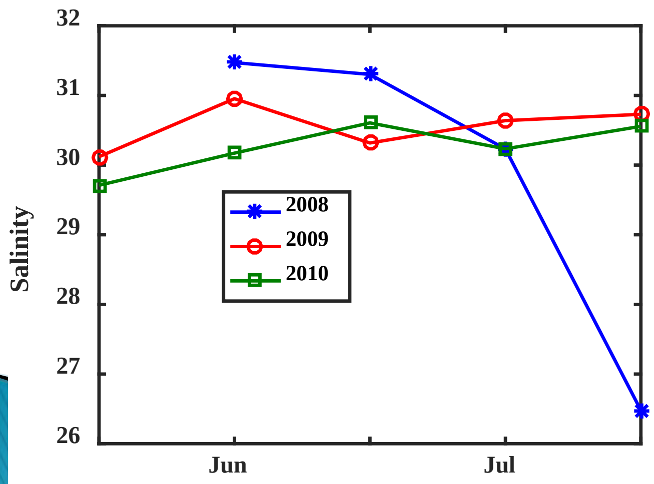


Mean temperature that all the jellyfish released in 5 different sites encountered during the enhancement season for years 2008 through 2010.

Results–Salinity

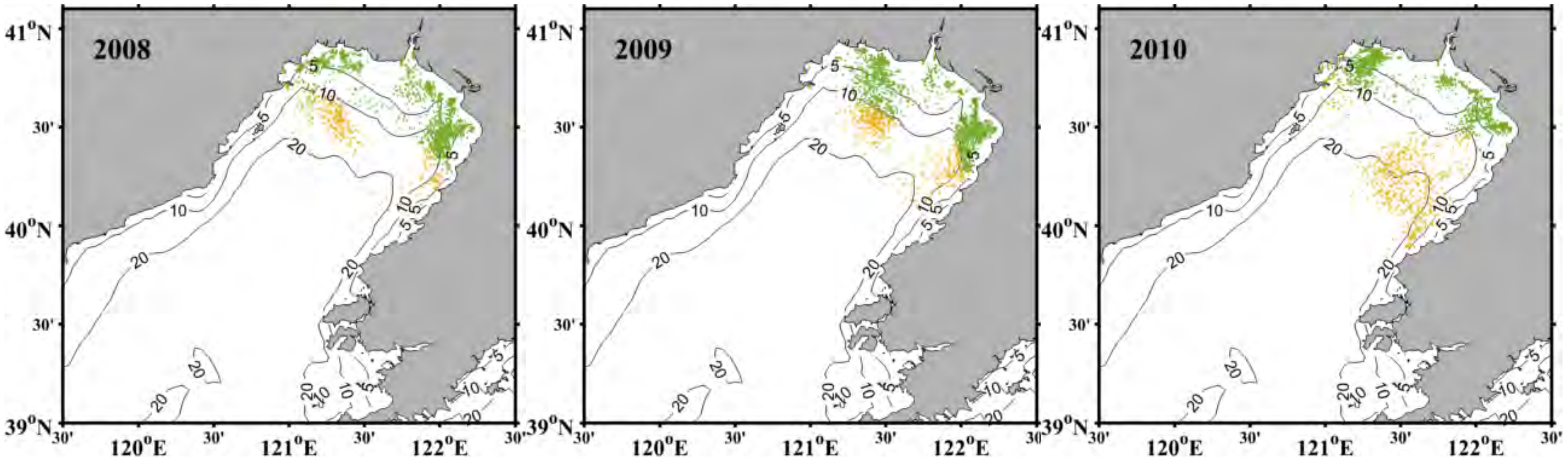


The simulated salinity field in the LDB for years 2008–2010.

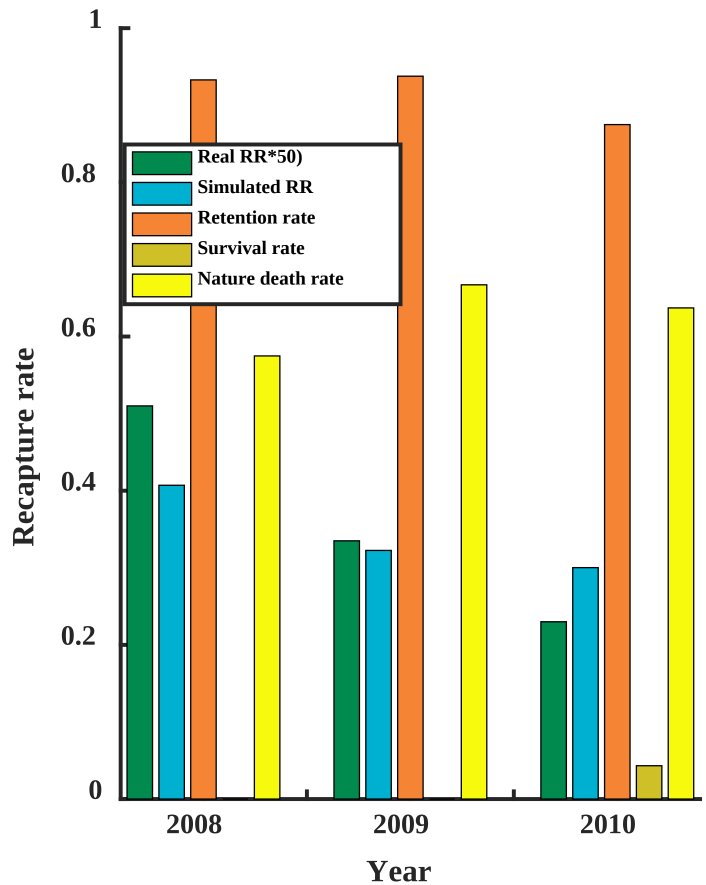


Observed salinity for years 2008–2010.

Results–Influence of the current

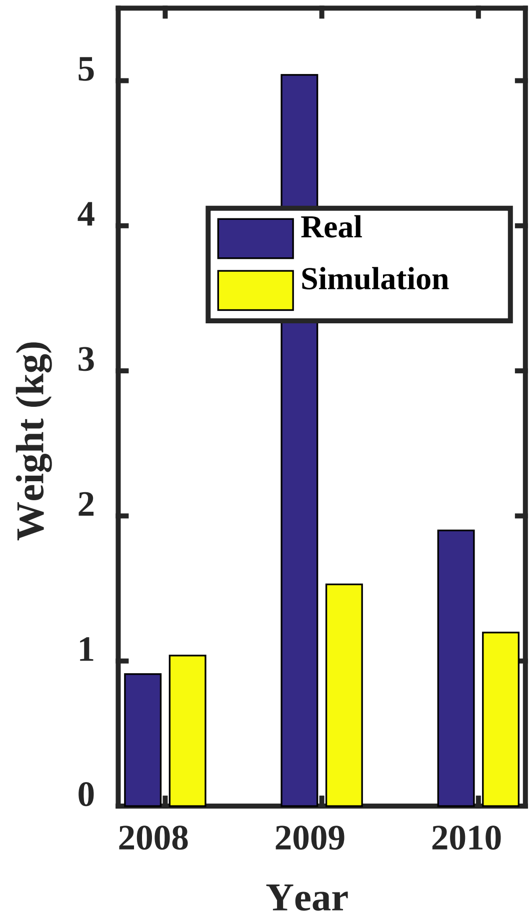


Results-recapture rate



The real recapture rate (green), simulated recapture rate (blue), rate of the jellyfish that enter the grounding area (orange),survival rate (brown), and natural mortality (yellow) during years 2008-2010.

Results-weight per jellyfish



Comparison of the simulated and realistic mean weight of each jellyfish for years 2008-2010

Summary

1、The recapture rate is impacted by: (1）Circulation of the LDB which influence the amount of jellyfish that enter into the fishing ground.（2）Sea temperature on the releasing date. Too cold water will cause hypothermia （3）The natural mortality.

2、The mean weight of the jellyfish is impacted by（1）The growth period. The too long or too short growth time both go against to the jellyfish growth.（2）Temperature. The low temperature will restrict the growth（3）The Salinity. The high salinity will limit the jellyfish growth.

3、The yield is impacted by the mean weight and the recapture rate. Thus the relatively higher yield in 2009 may due to the high temperature, the relatively longer growth time, the proper salinity and the normal recapture rate.