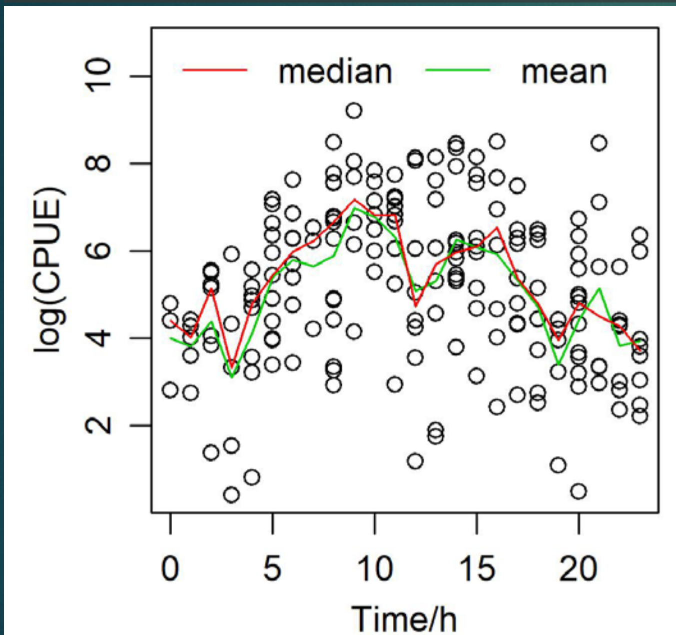
黄海水产研究所
Yellow Sea Fisheries Research Institute

Improving estimations of fish species abundance and distribution via accounting for the effects of diel vertical movements

Lisha Guan, Xiujuan Shan, Xianshi Jin
Email：guanls@ysfri.ac.cn

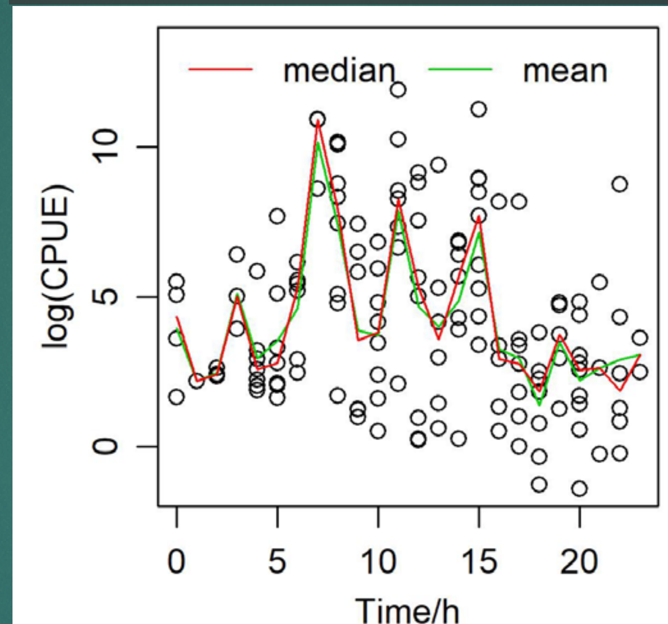
Introduction

Small yellow croaker (*Pseudosciaena polyactis*)



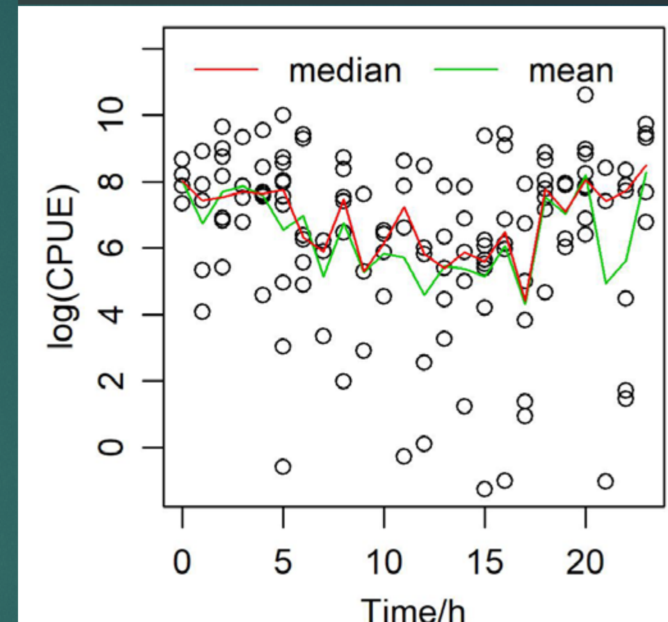
https://image.baidu.com/

Anchovy (*Engraulis japonicus*)



https://image.baidu.com/

Brown shrimp (*Crangon affinis*)



https://image.baidu.com/

Introduction

Many fishes exhibit **diel vertical movements (DVM)** (e.g., Piet & Guruge 1997; Stockwell *et al*. 2010; Weng *et al*. 2013; Currey *et al*. 2015).

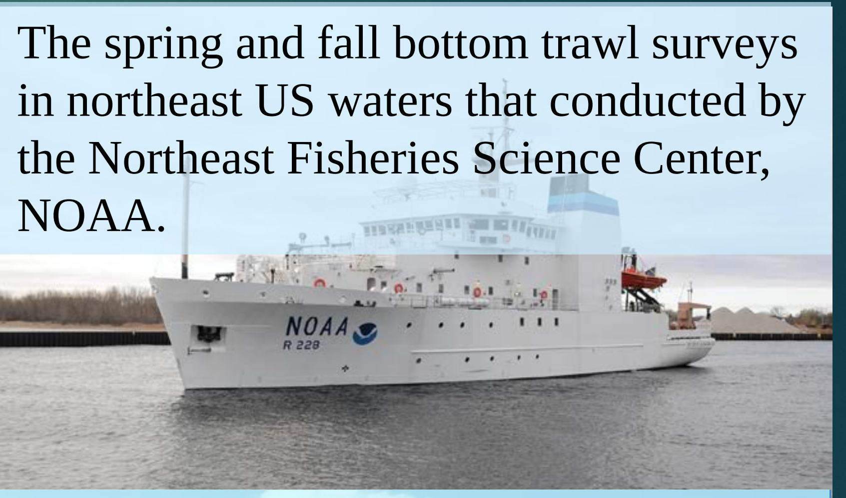
Fisheries surveys:

- Target at a specific water column;
- Be conducted over day and night;

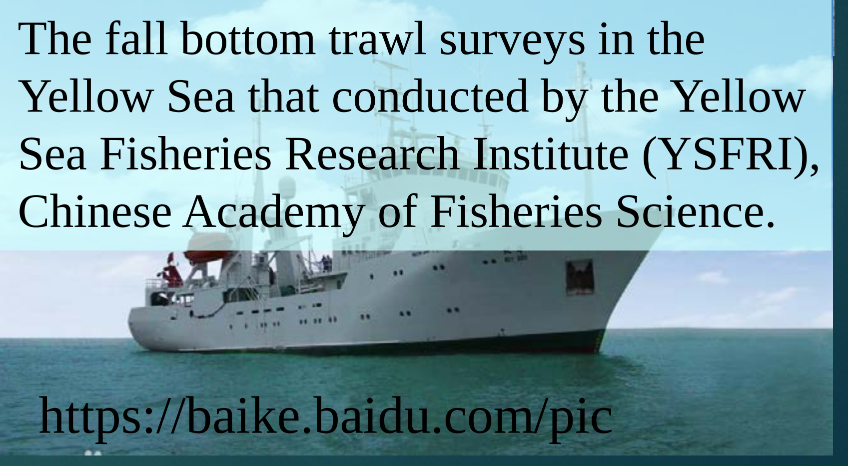
DVM of fishes

↓

Diurnal variation in catchability



The spring and fall bottom trawl surveys in northeast US waters that conducted by the Northeast Fisheries Science Center, NOAA.



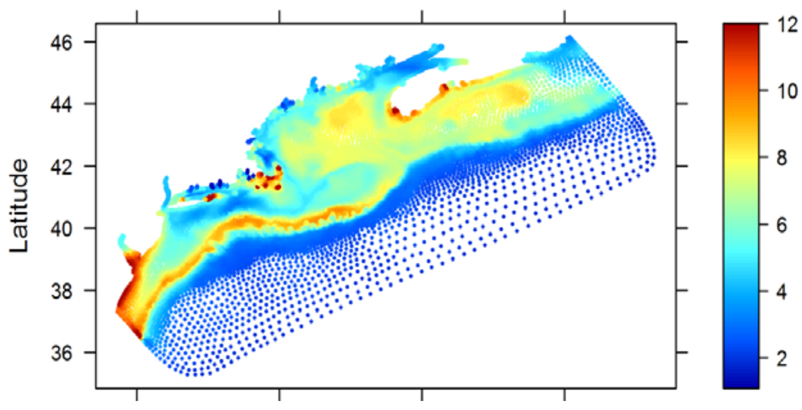
The fall bottom trawl surveys in the Yellow Sea that conducted by the Yellow Sea Fisheries Research Institute (YSFRI), Chinese Academy of Fisheries Science.

https://baike.baidu.com/pic

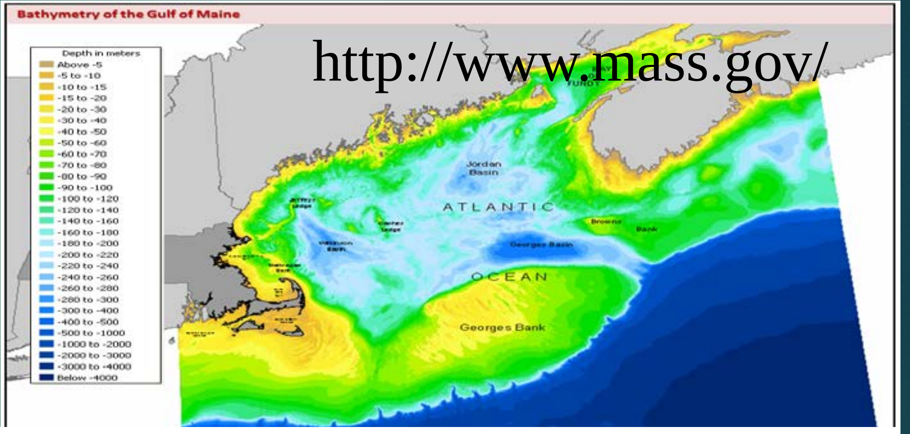
Introduction

黄海水产研究所
Yellow Sea Fisheries Research Institute

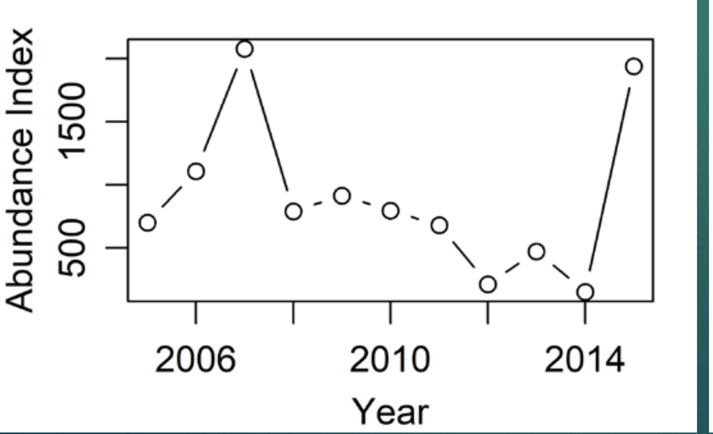
The effect of DVM on catchability is often ignored in the standardization of CPUE (catch-per-unit-effort) for estimating fish species abundance and distribution.

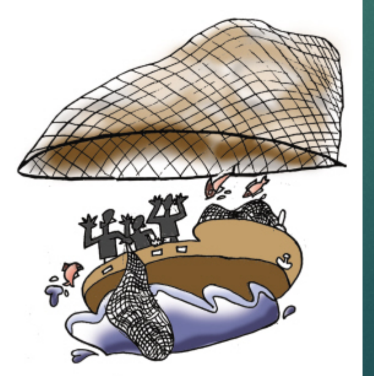


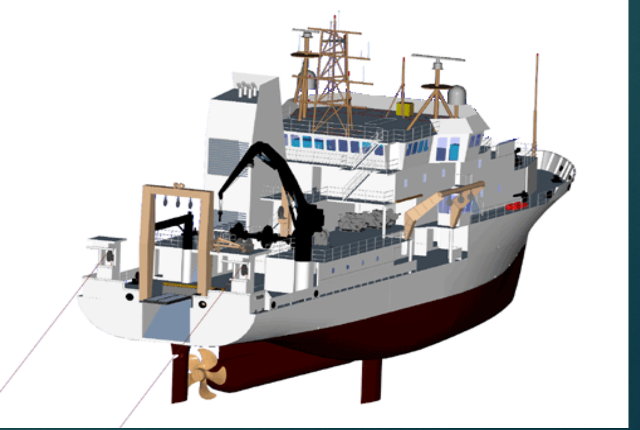
Heterogeneity in temperature



Heterogeneity in depth







Introduction

Objective:

To develop a general statistical model for quantifying the effect of DVM on the catchability of a fishery-independent survey, thereby improving estimations of fish species abundance and distribution.

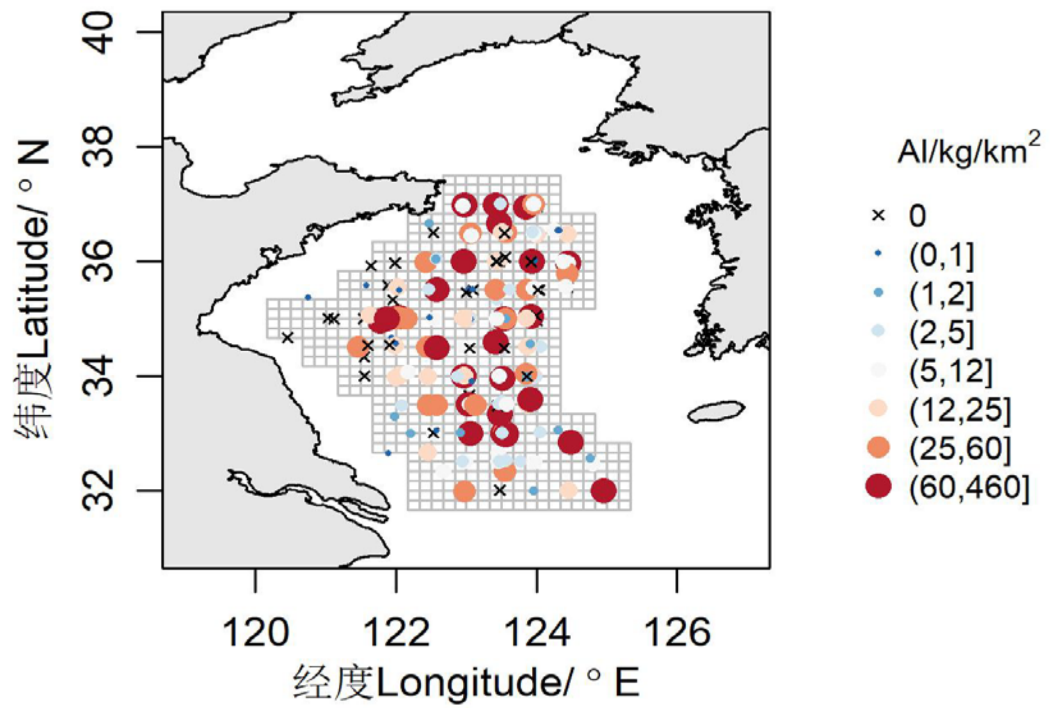
Hypothesis:

The effects of time periods of a day on CPUE reflect the influence of DVM on the catchability of a fishery-independent survey that being conducted over day and night.

Data & Methods

- A demersal feeding on both pelagic and demersal species (e.g. anchovy, Pacific krill and brown shrimp), with proved DVM.
- Important in ecology and economics;
- Exploited by China, South Korea and Japan.

Data: catches (kg) of **small yellow croaker** and related spatial and time information from the Yellow Sea Fisheries Research Institute (YSFRI) fall bottom trawl survey in the **Yellow Sea** (2006-2009, 2011)



Statistical Models

Spatio-temporal delta-generalized linear mixed model

Encounter probability/catch rates

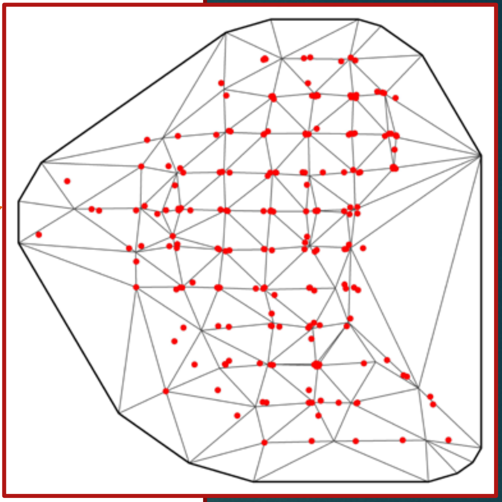
$$
\begin{aligned}
&f(\\
&d_{T(i)} + \\
&\omega_{J(i)} + \varepsilon_{J(i),T(i)} + \\
&\mu_{h(i)} + \\
&\beta_1 D_{J(i)} + \beta_2 BT_{J(i)} + \\
&\ldots \\
&)
\end{aligned}
$$

Year

Unmeasured habitat variables

Time period of a day

Each observed habitat variable



Statistical Models

1st stage: **Encounter probability p_i for sample i at patch s_i :**

$$p_i = \log it^{-1}(d^{p}_{T(i)} + \omega^{p}_{J(i)} + \varepsilon^{p}_{J(i),T(i)})$$

2nd stage: **Positive catch rate for sample i at location s_i :**

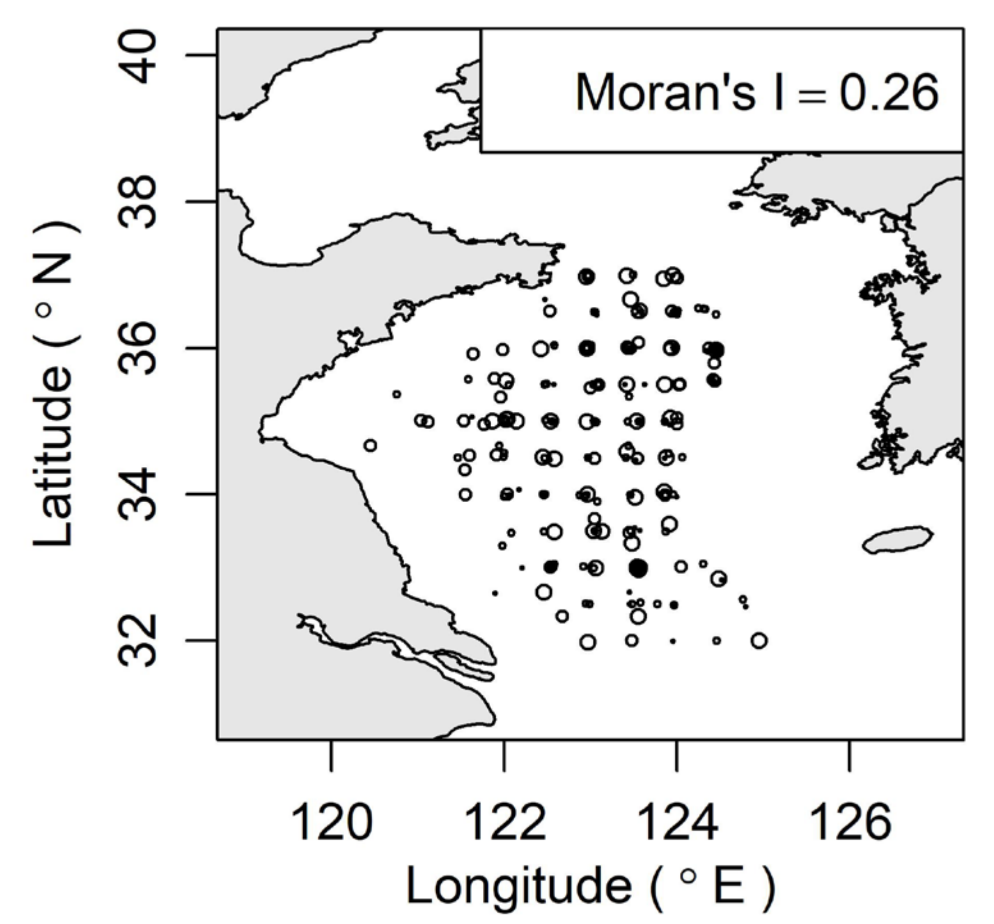
$$AI_i = \lambda_i / w_i = \exp(d^{\lambda}_{T(i)} + \omega^{\lambda}_{J(i)} + \varepsilon^{\lambda}_{J(i),T(i)} + \mu^{(\lambda)}_{h(i)})$$

Average density at patch s_i at year t:

$$d_{s,t} = p_{s,t} * \lambda_{s,t}$$

Results -- Model Validation

No spatial correlation in the residuals



Deviance explained by the model

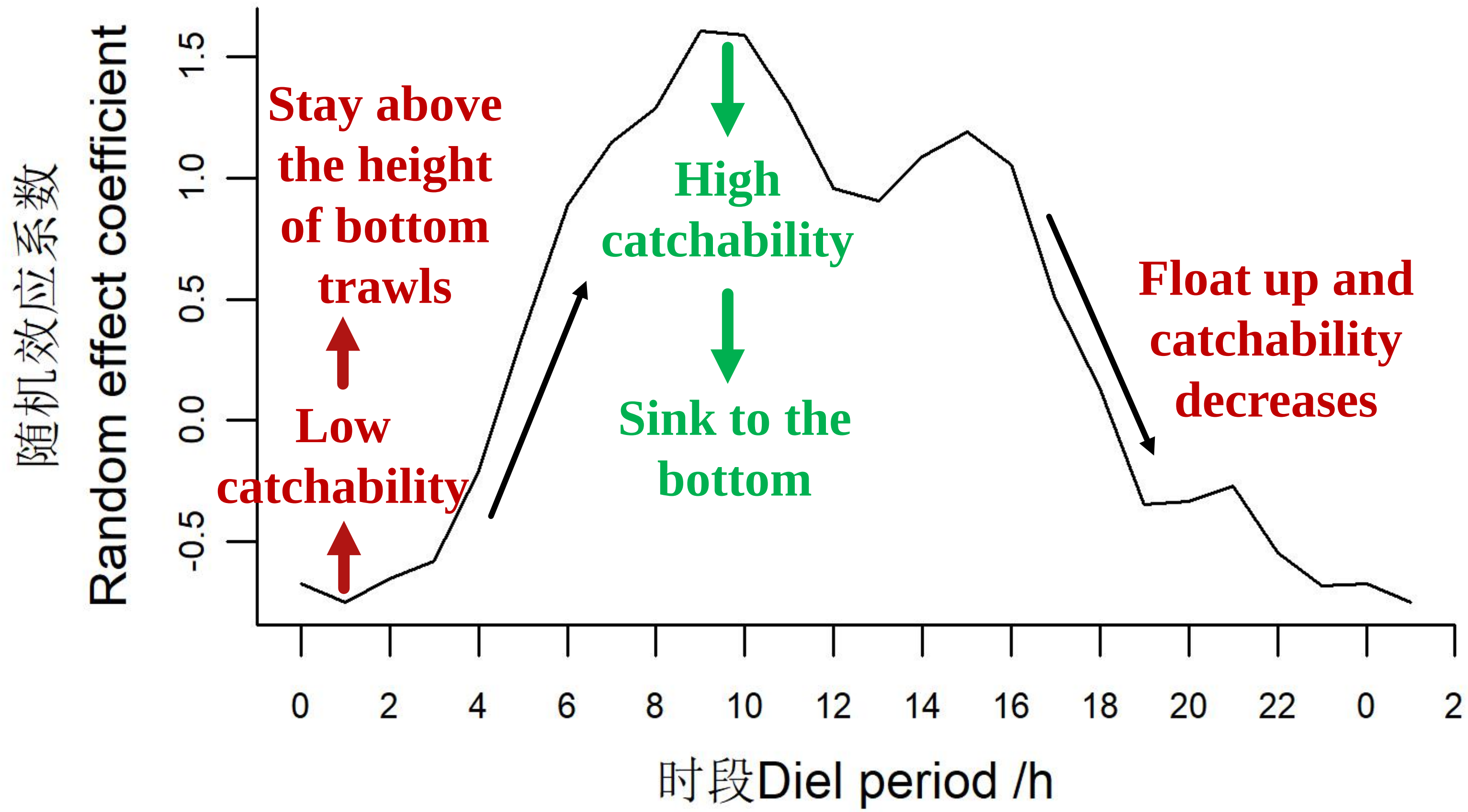
$$= \frac{\sum(\widehat{AI}_i - \overline{AI}_i)^2}{\sum(AI_i - \overline{AI}_i)^2}$$

= 37.2%

, of which 24.6% was explained by the effect of time period.

Results

The effect of DVM on catchability



DVM of small yellow croaker and its effect on catchability

2 Start to sink down

3 Prey on brown shrimp at the bottom

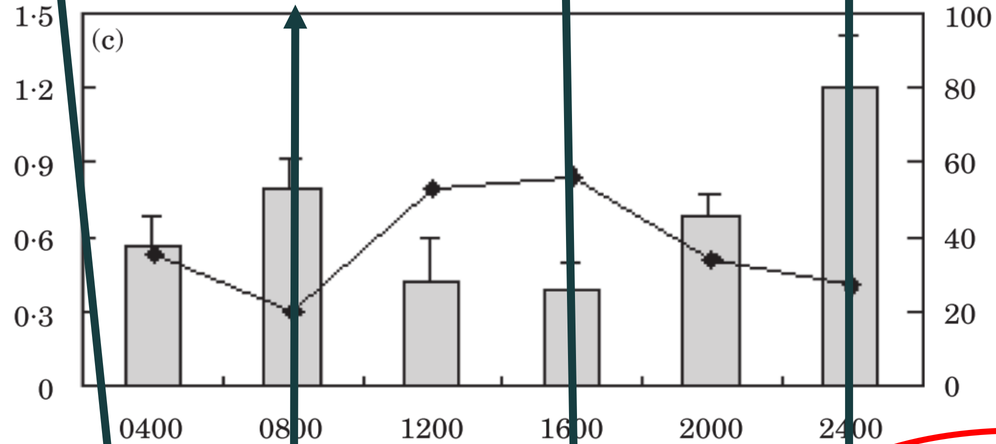
4 Start to float up

1 Prey on anchovy and Pacific krill

(▭) stomach fullness

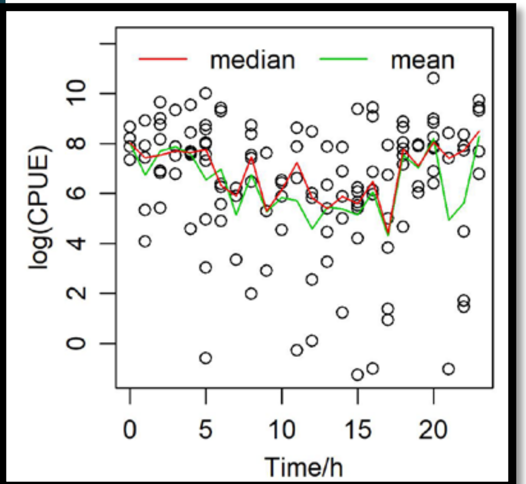
(◆) percent of empty stomachs

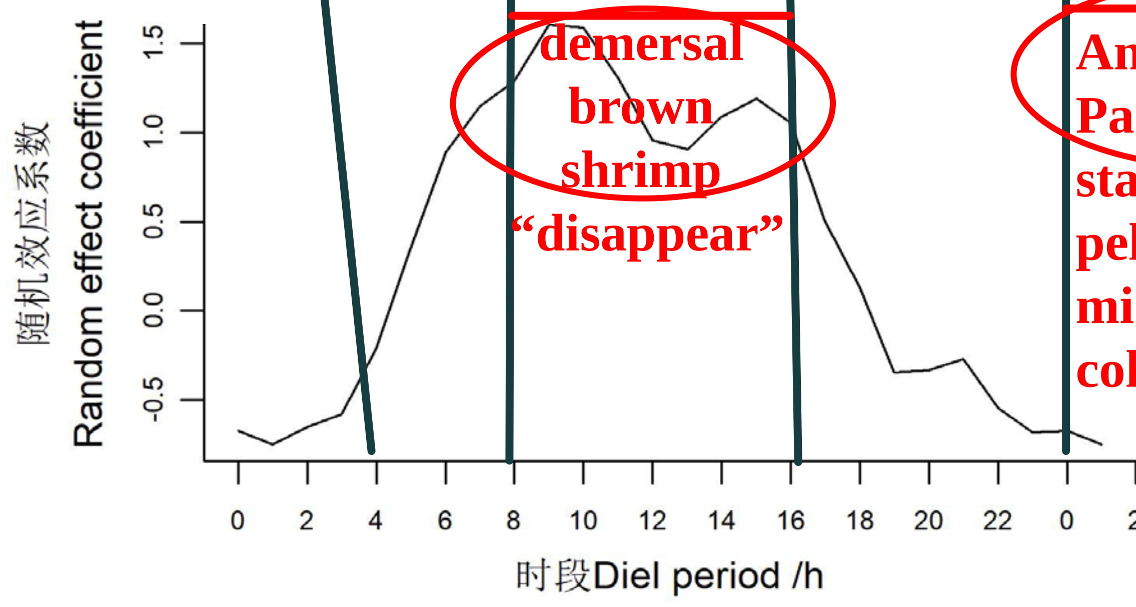
(Xue et al. 2005)



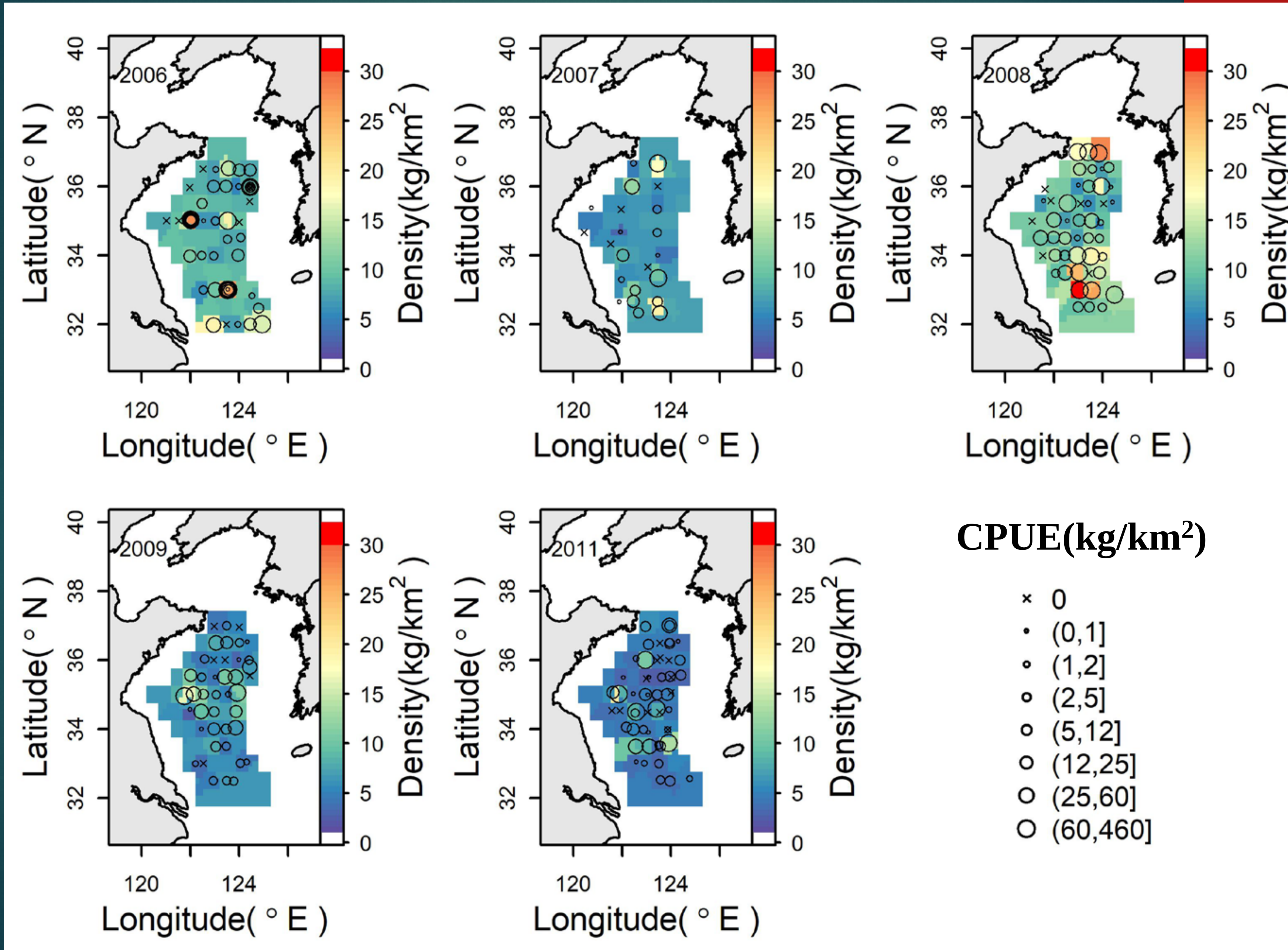
demersal brown shrimp "disappear"

Anchovy and Pacific krill stay in the pelagic or midwater column in Fall

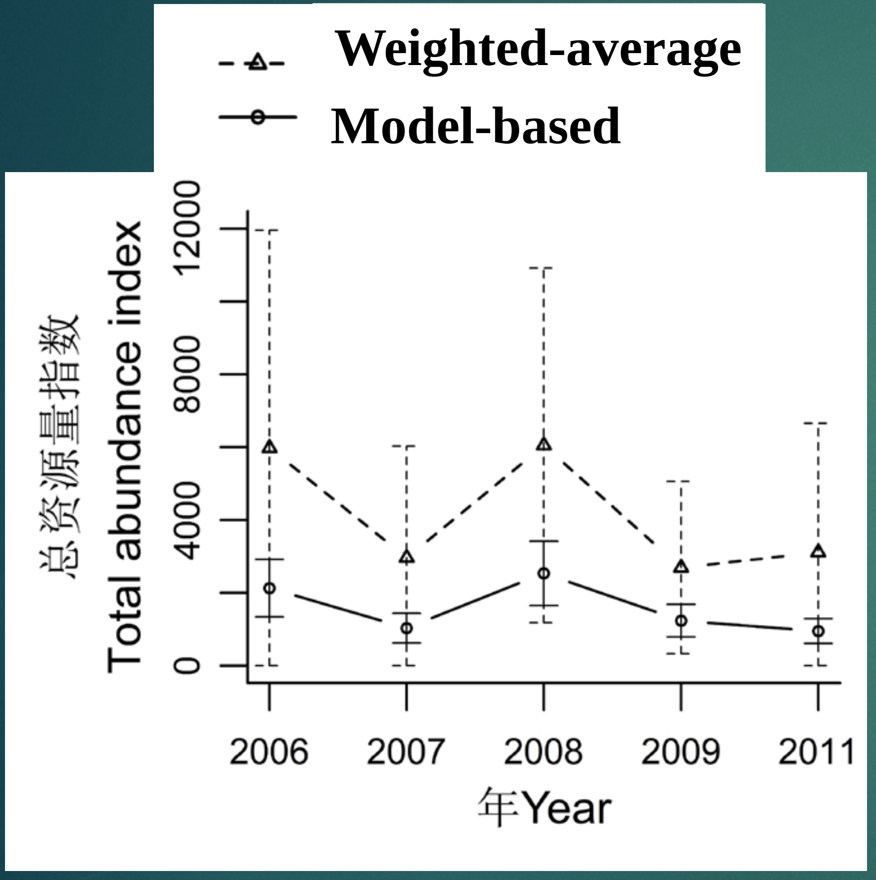




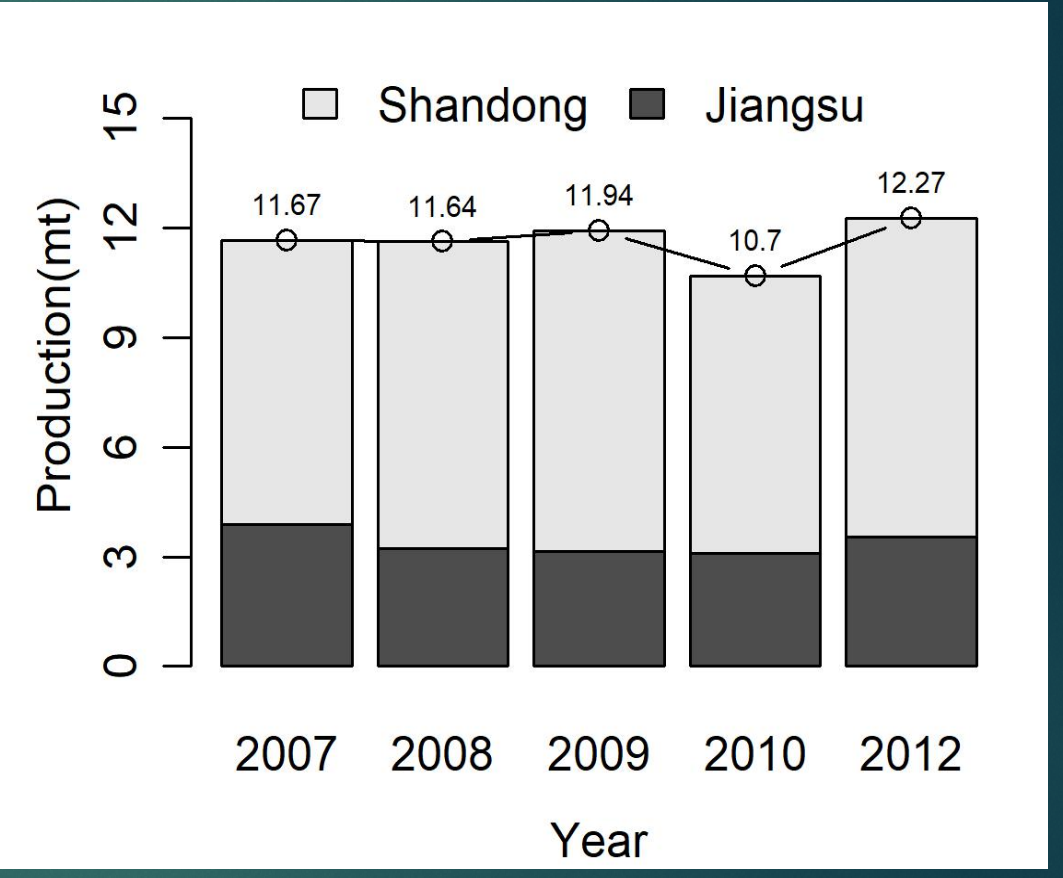
Results


2006
2007
2008
2009
2011
Latitude(° N)
Longitude(° E)
Density(kg/km2)
40
38
36
34
32
120
124
0
5
10
15
20
25
30
CPUE(kg/km²)
0
(0,1]
(1,2]
(2,5]
(5,12]
(12,25]
(25,60]
(60,460]

Results



Weighted-average
Model-based
总资源量指数
Total abundance index
0
4000
8000
12000
2006
2007
2008
2009
2011
年Year



Shandong
Jiangsu
Production(mt)
0
3
6
9
12
15
11.67
11.64
11.94
10.7
12.27
2007
2008
2009
2010
2012
Year

Conclusions

- ✓ For fish species with DVM, the effects of diel vertical movements should be considered in the calibration of abundance indices for improving the precision of abundance and distribution estimations.

- ✓ Spatio-temporal models may be used to study the DVM behaviors of fish species that are not large enough for carrying animal-attached transmitters or not easy to identify by acoustic telemetry system.

Acknowledgement

- All my colleagues from the Fisheries Resource & Ecosystem Department, Yellow Sea Fisheries Research Institute for collecting the bottom trawl survey data.

- PICES for supporting my travel to Vladivostok.

Thanks!

Question?