Ichthyoplankton succession and assemblage structure in the Bohai Sea during the past 30 years since 1980s

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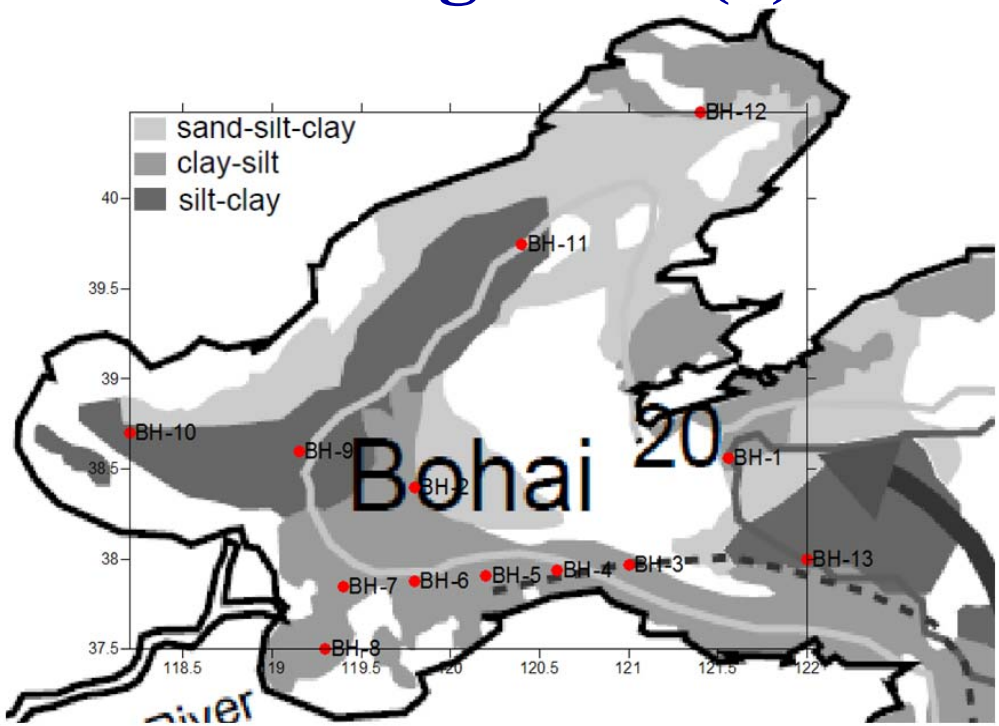
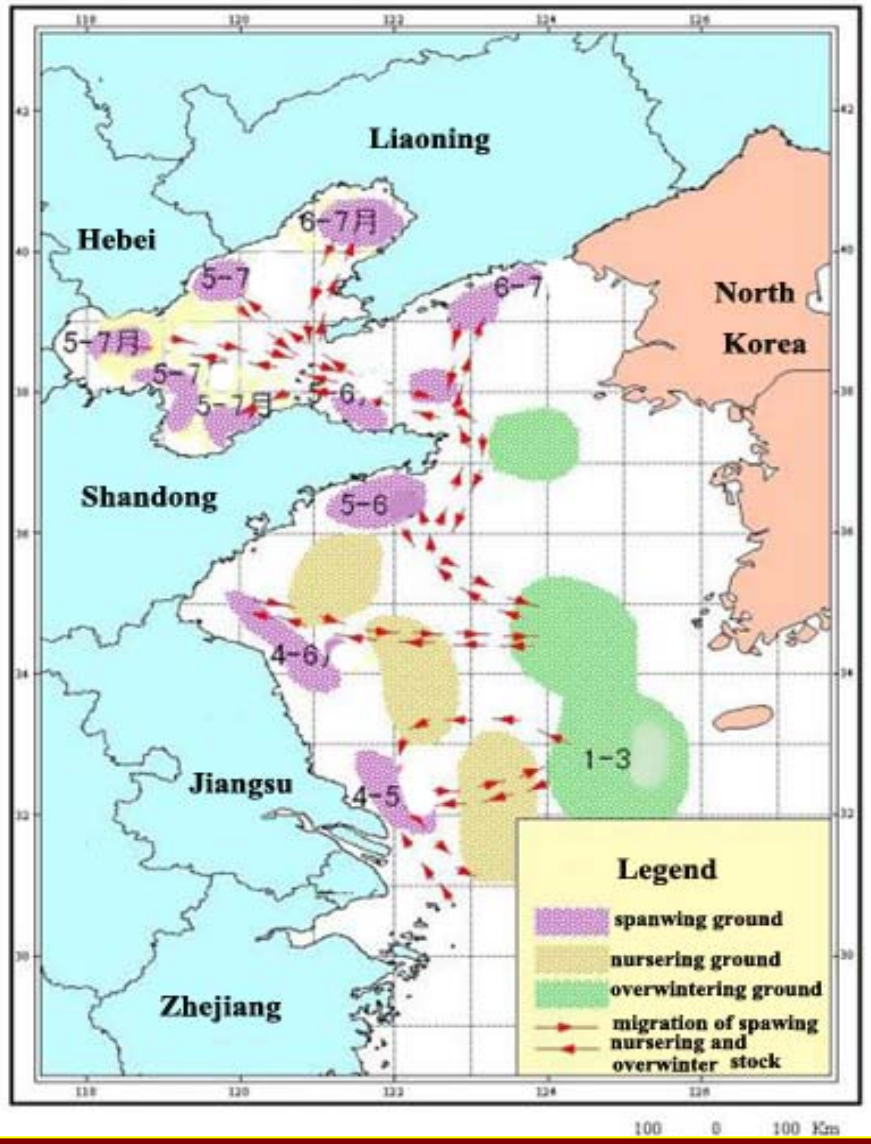
Background(1)



- **Semienclosed marginal sea of the NW, covering an area of about 80000km^2, with an average depth of 18 m.**
- **Surrounded by heavily populated areas in the northern part of China.**
- **Seasonal fluctuations in hydrographic conditions (Tang et al., 2003).**
- **Shallow temperate and strongly fluctuating system.**

- **Total 16 rivers (Yellow river second largest river in China, freshwater discharges, an average run off of 420 * 10^8 m^3 year^{-1}).**
- **Habitat benefits (Spawning and nursing ground) for most major fish stocks in both the Bohai Sea and Yellow Sea.**

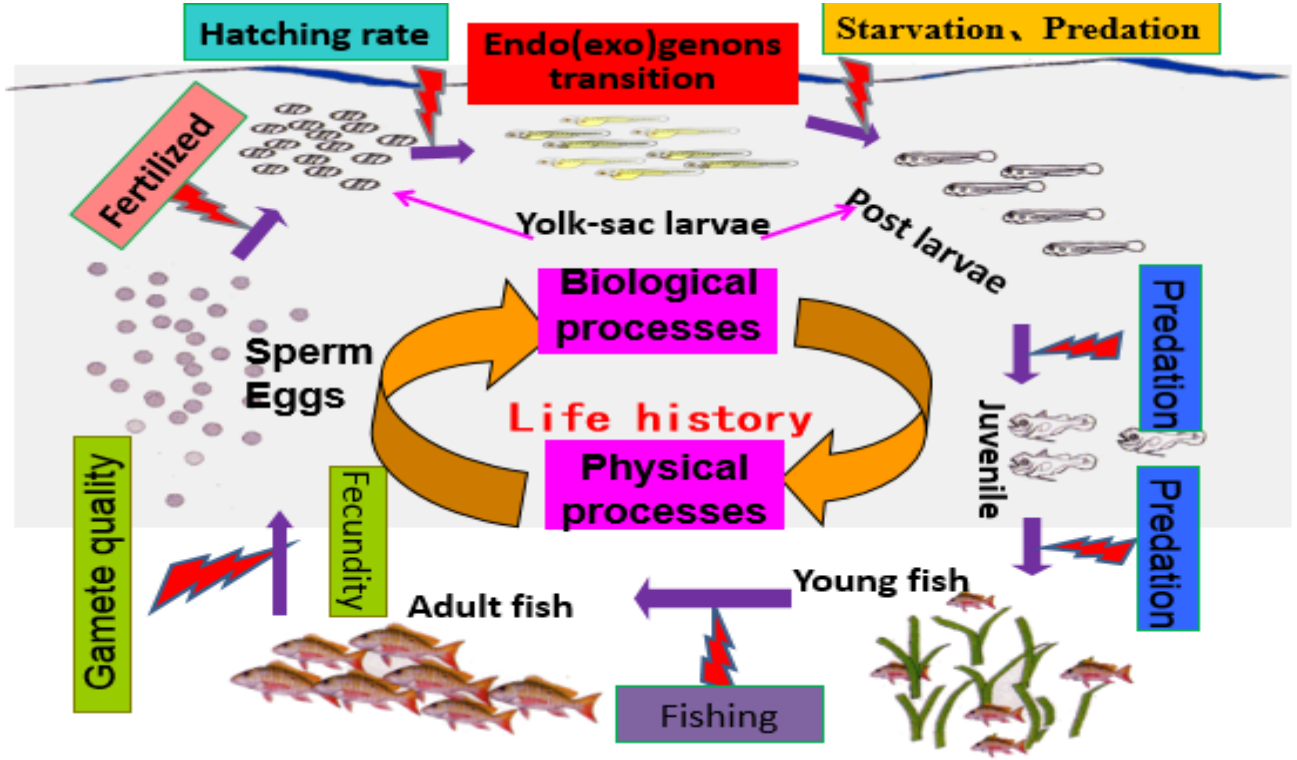


- Major fishery stocks low salinity areas in the estuary or coastal waters (salinity fronts and eddies with favorite water temperatures) during their spawning season(Wei et al., 2002; wan et al., 2014).
- Variation in recruitment strength in Bohai Sea affect the population structure and sustainable production (Deng et al., 2000).

- The “fisheries cradle” of both the Bohai and Yellow Sea(Jin et al., 2015).

Background（2）

Early recruitment— key recruitment process and control factors

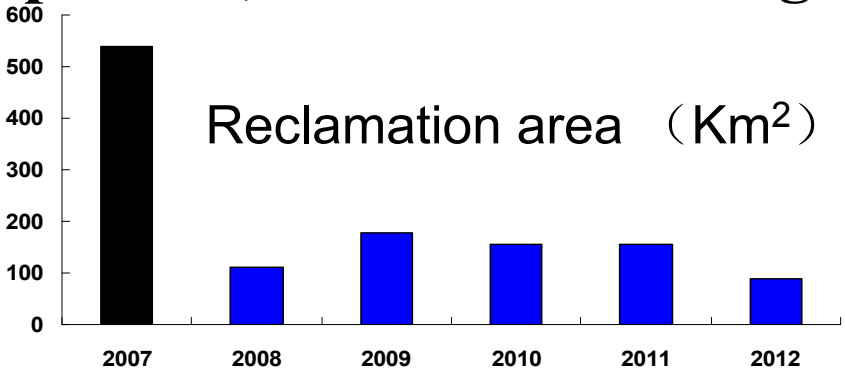


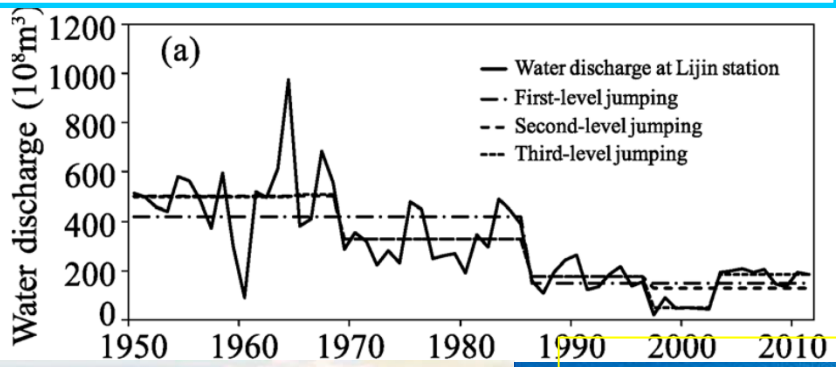
- **Early life stages have narrower tolerance (Pörtner and Peck 2010) to be more sensitive to environmental changes.**
- **“Critical period” eg. the time of first feeding (Hjort, 1914)**

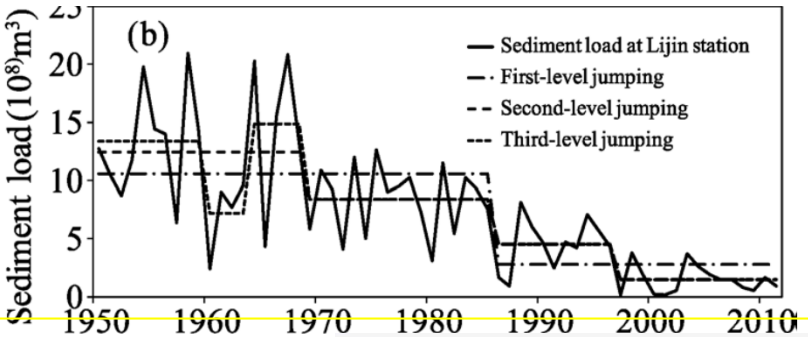
Habitat (spawning ground) loss or fragmentation

- **Multiple sources of exogenous interference factors**
- **Every key link of recruitment process, irreversible changed**

  - Large-scale reclamation
  - Land-sourced pollution
  - Decreasing runoff
  - Large-scale mariculture

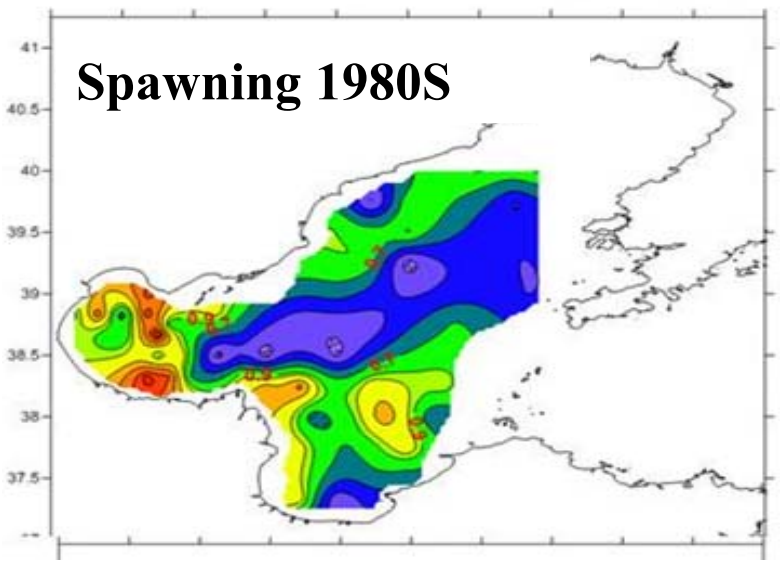


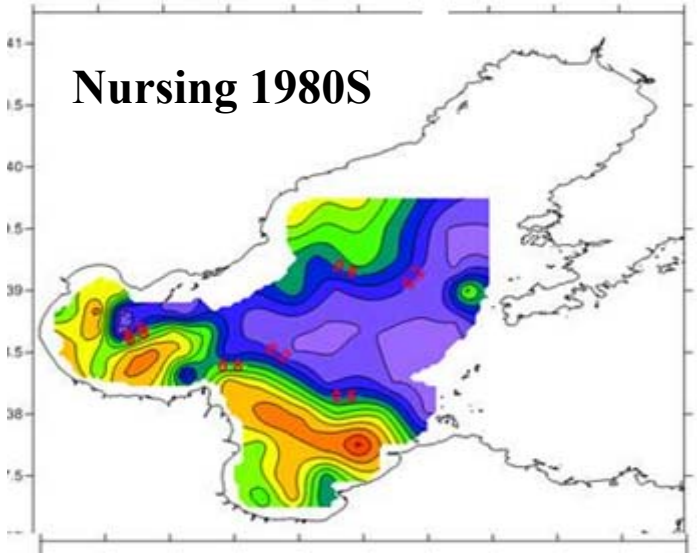


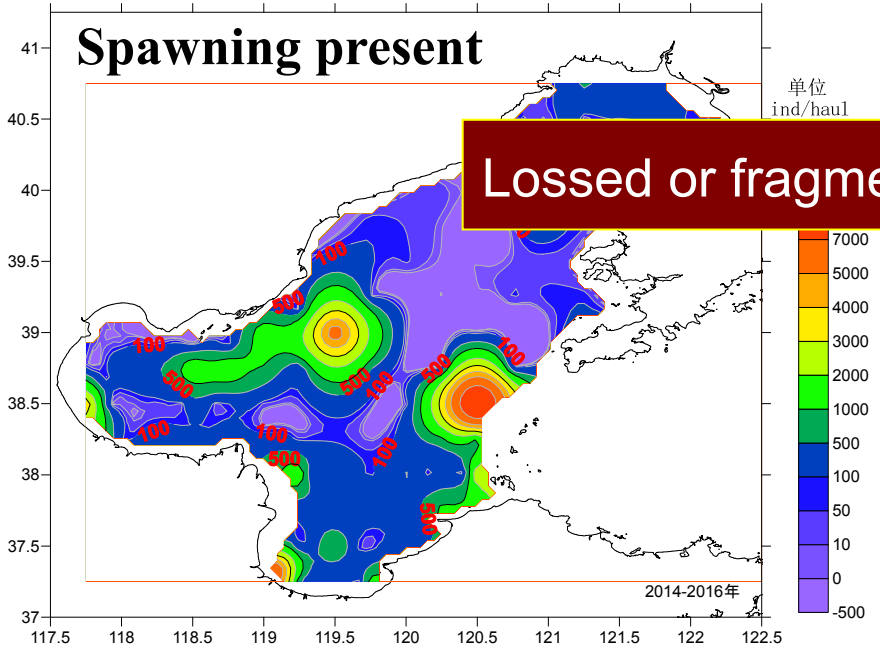


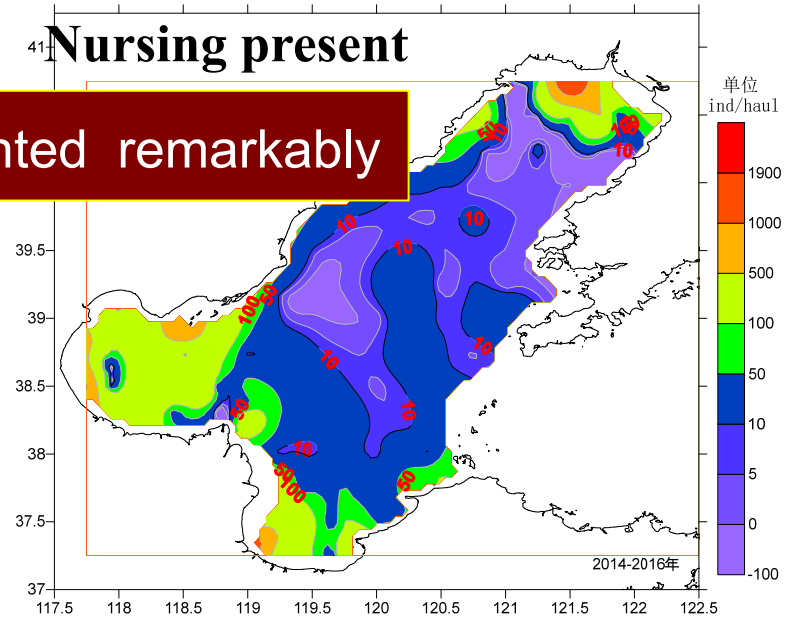
Ren et al., 2015; J. Geogr. Sci. 2015, 25(1): 85-100

Spawning and nursing center past &present





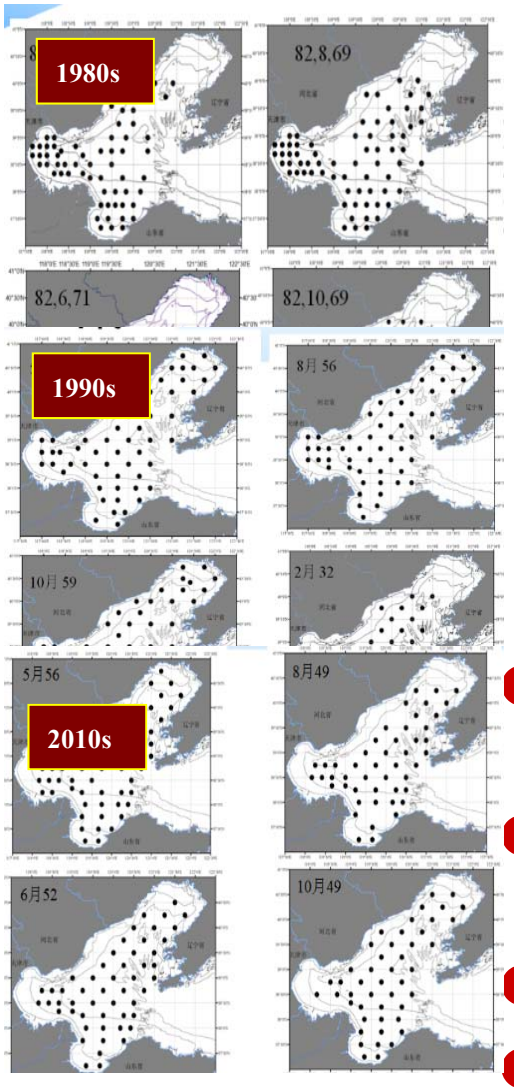


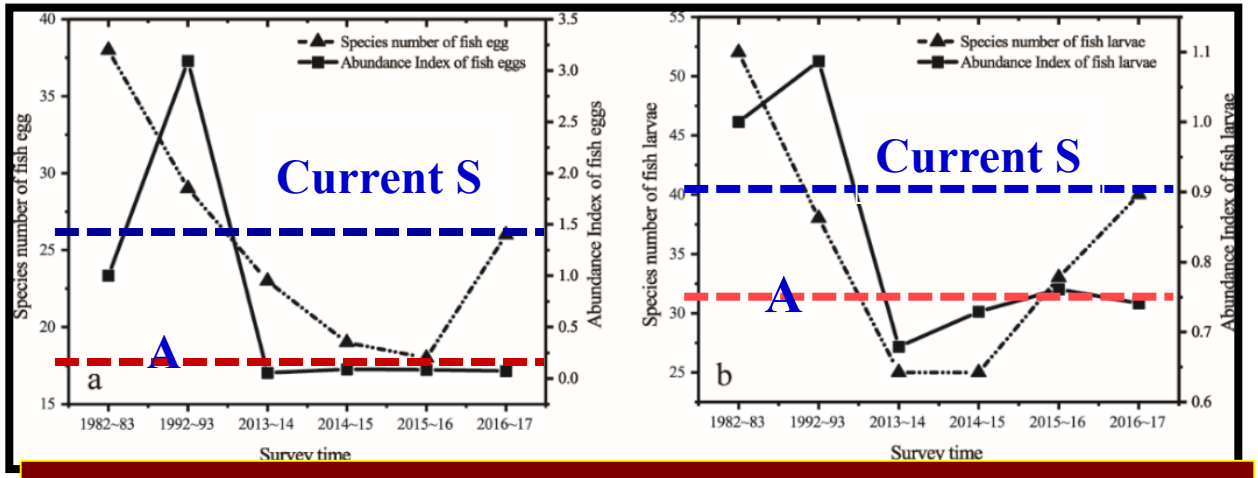


Lossed or fragmented remarkably

Result

2.1 Abundance Index and species number of fish eggs and larvae

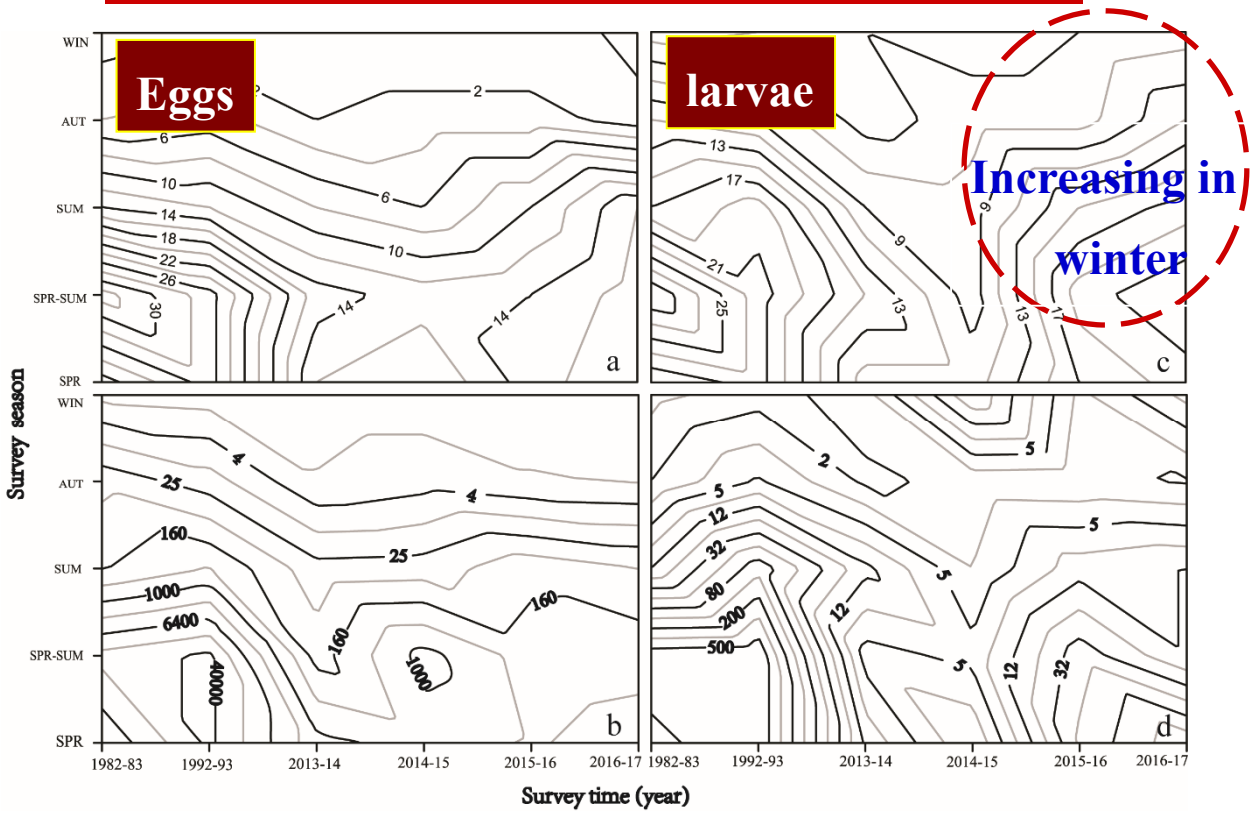




Presents different degrees of decline

- **Species:** declining at the beginning and rising up in late
- **Abundance:** rising first, then declining at the second and rising up in late
- **Eggs**: current, half, one tenth of 1980s
- **Larvae:** current, three fourths of 1980s

2.1 Number of species and ecological density to fish eggs and larvae



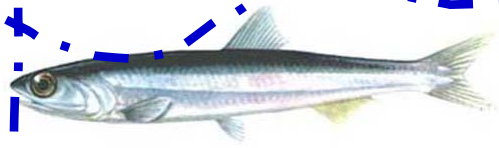
- In recently obvious increasing tendency of fish larvae species in winter.

Profiles along survey season across different survey times

2.2 Dominant species in fish eggs and larvae

- **The dominant species of fish eggs did not change significantly at the same season in each investigation period, however, variation of dominant species in fish larvae was more obvious.**

- **Belanger's croaker and Joyner´s Tongue Sole（Small demersal fishes）； goby**

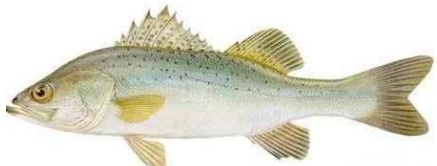


Japanese anchovy *Engraulis japonicus*

Sappa *Sardinella zunasi*

Atherina bleekeri

ATU



spotted sea bass *Lateolabrax maculatus*

Dotted Gizzard Shad *Konosirus punctatus*

Japanese halfbeak *Engraulis japonicus*

Japanese whiting(Sillago japonica)

greenlings ***Hexagrammos otakii***

Gunnel, *Enedrias fangi*

SPRING

SPR-SUM

SUM

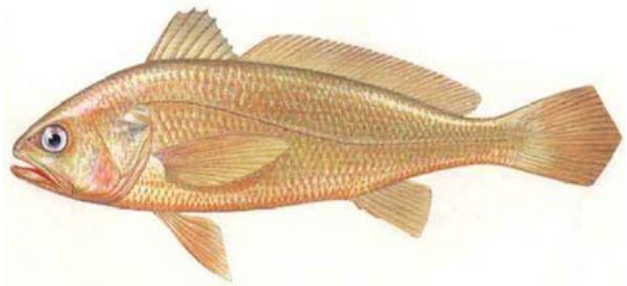
WIN

Small pelagic fishes

Reef associate and demersal fishes

2.2 Dominance continental shelf demersal fish eggs and larvae

- The dominance of the continental shelf demersal fish eggs and larvae with high commercial value decreased sharply.



Small Yellow Croaker *Larimichthys polyactis*

Silver Pomfret *Pampus argenteus*

Largehead Hairtail *Trichiurus lepturus*

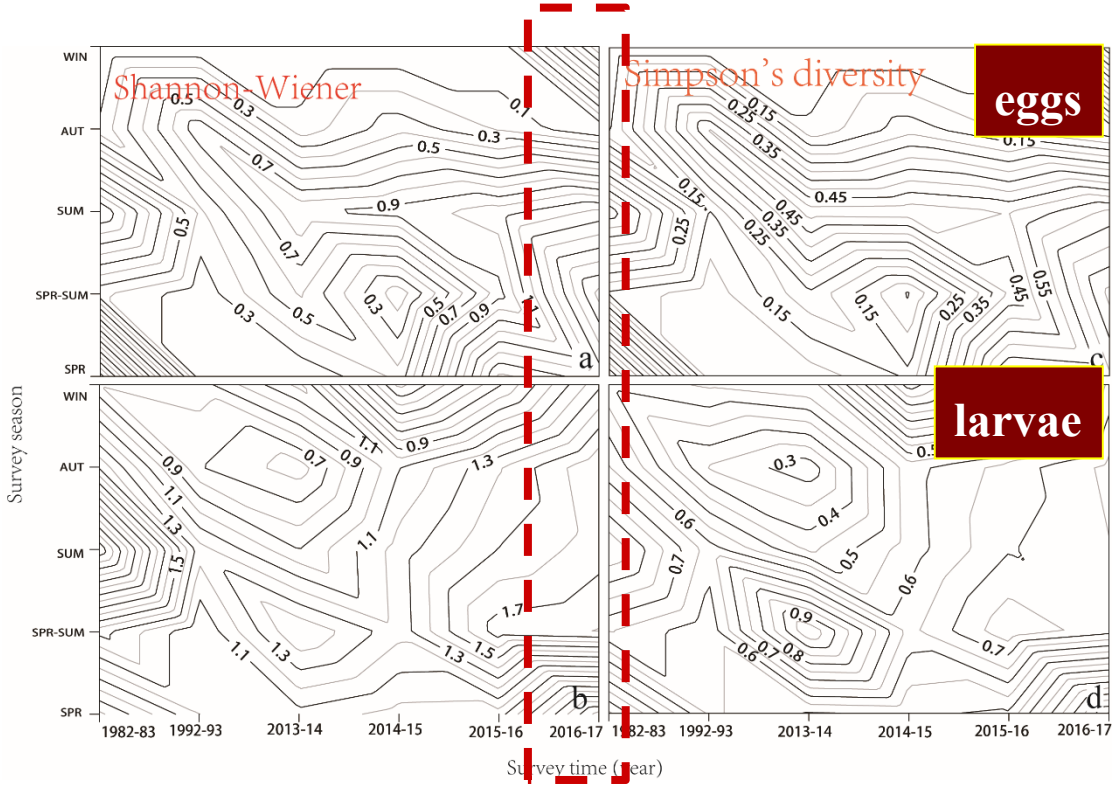
red Sea bream *Pagrosomus major*

Japanese flounder *Paralichthys olicaceus*

Tongue sole *Cynoglossus semilaevis*

◆ Even then some species disappeared in recent surveys(Chinese herring, *Ilisha elongate* (Bennett,1830) (one pelagic fishes)

2.3 Shannon-Wiener （H'）and Simpson's diversity Index （ D_S ） profiles along the survey season across different survey times

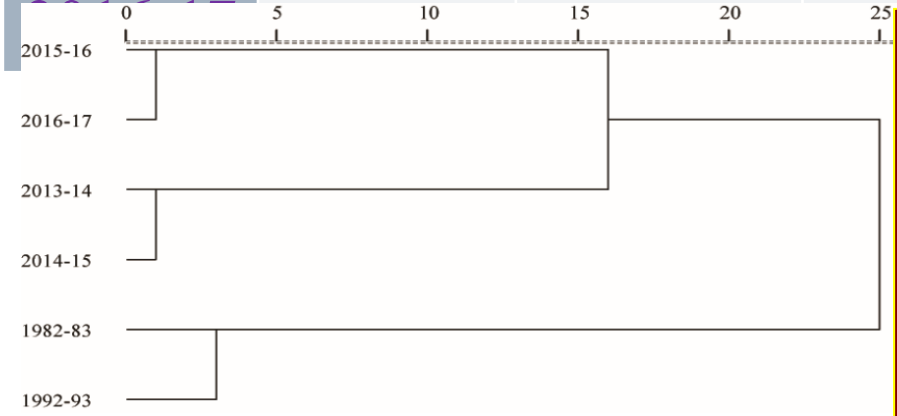


- ***Eggs*:** H' and D' bimodal distribution; higher temperature rising season(Spr-Sum); lower in temperature cooling season, and lowest in the WINTER
- ***Larvae*:** H' and D', "unimodal distribution", highest in summer and lowest in Spring.

- **Heavy exploitation leading to an increase in diversity, which was consisted with Bianchi' （2002）studies on the adult fishery community.**
- **Diversity (richness and evenness), in patterns of dominance.**

2.3 Coefficient of ichthyoplankton communities in the Bohai Sea

Year	1982-83	1992-93	2013-14	2014-15	2015-16	2016-17
1982-83		0.62	0.46	0.48	0.45	0.48
1992-93	0.62		0.57	0.54	0.46	0.49
2013-14	0.46	0.57		0.64	0.47	0.51
2014-15	0.48	0.54	0.64		0.59	0.58
2015-16	0.45	0.46	0.47	0.59		0.63



- The species replacement in the early life stages of fish was obvious.
- The replacement rate was significantly accelerated in recent years.

2.4 Habitat type in parent of the recruitment stock between different survey periods

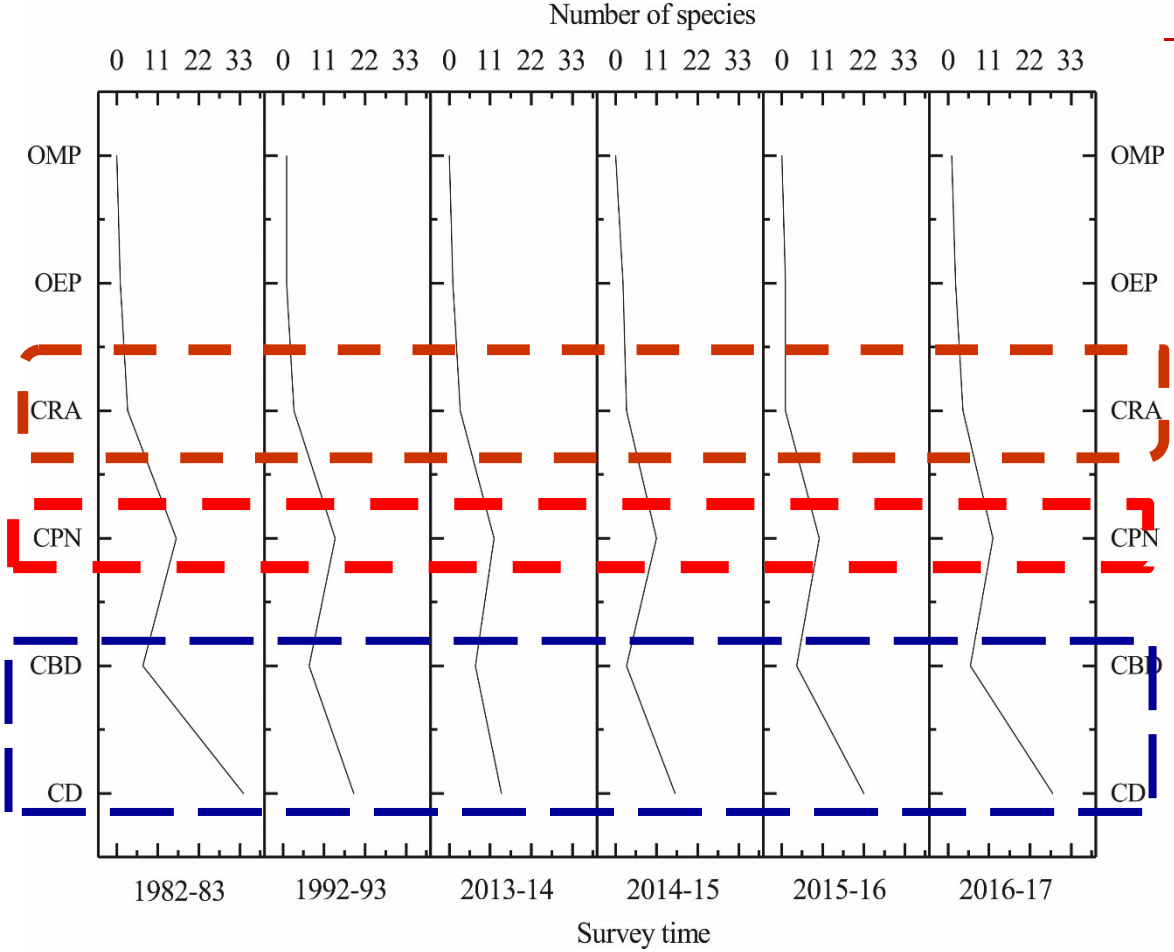
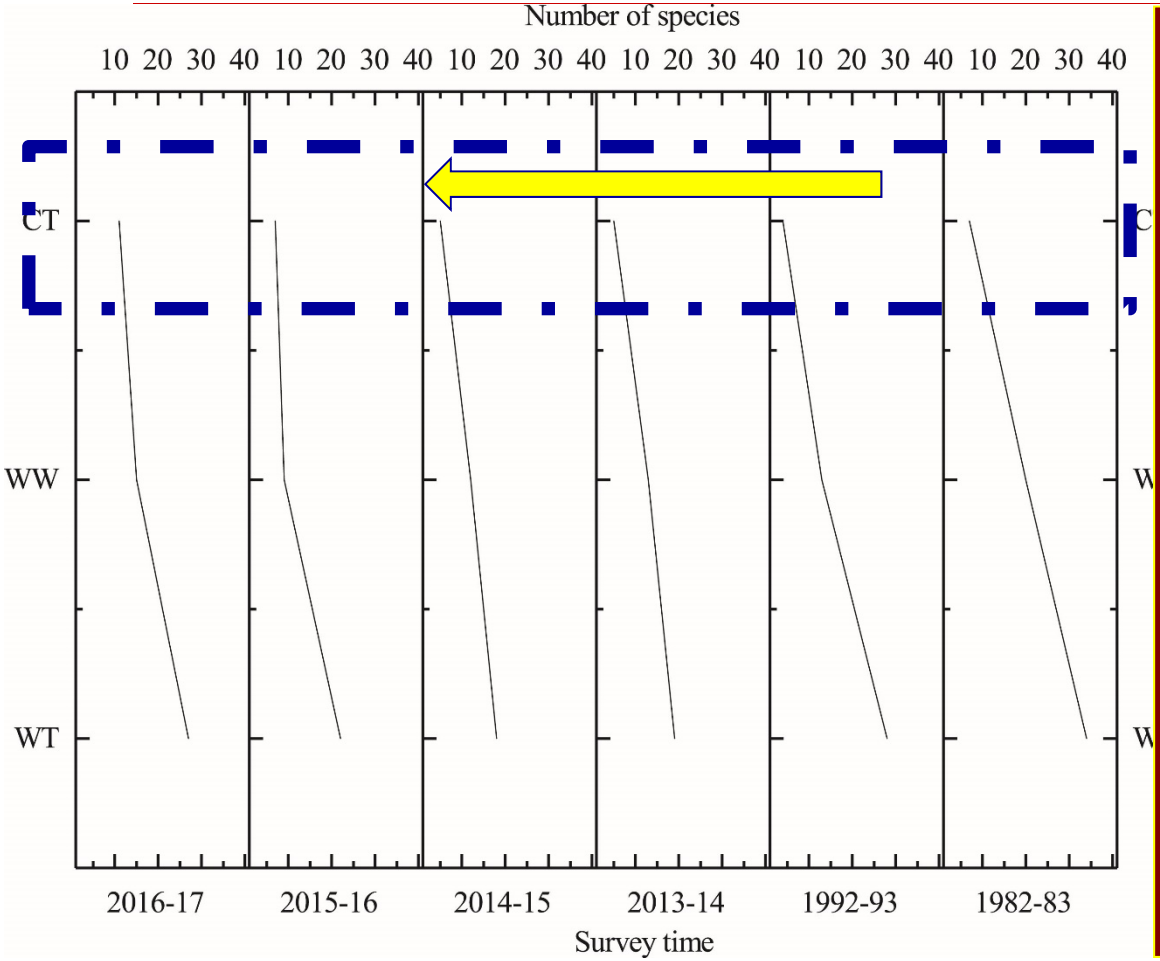


Fig Number of species to different habitat type in parent of the recruitment stock between different survey periods.

- **Annual percentage of pelagic(CPN) increased, combined with demersal (CD and CBD) decreased.**
- **CRA species remained constant, but with percentage raising. Fisheries conservation project carried out in this area.**

2.5 Temperature adaptation type in parent of the recruitment stock

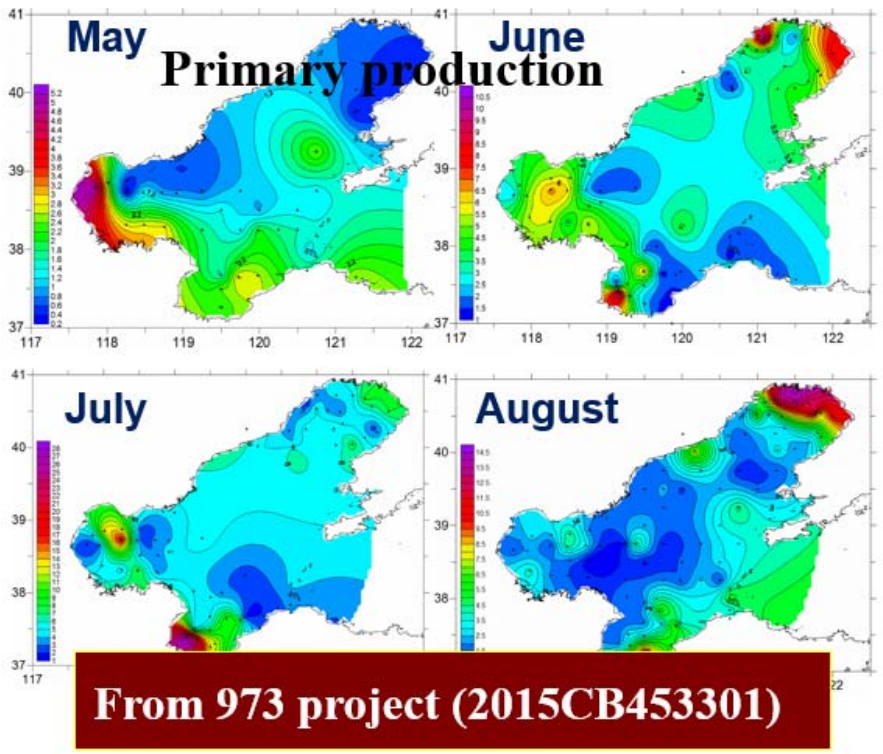


- Species number decreasing first and then increasing.
- The seasonal or annual percentage of each type remained almost stable.
- CT showed an increasing tendency from 11.48%(1982-83) to 20.75%(2015-16).

Disscussion (1)

Main exogenous driving factors analysis

I. Bottom-up control theory



- Globle warming (warming occurred 1982–1998, 0.8 to 2° C per century, twice global mean SST trend (Wu et al., 2016).
- Decreasing run off ½ of 1980s (Ren et al., 2015).Water-sediment regulation since 2002 till now (Sun et al., 2017).

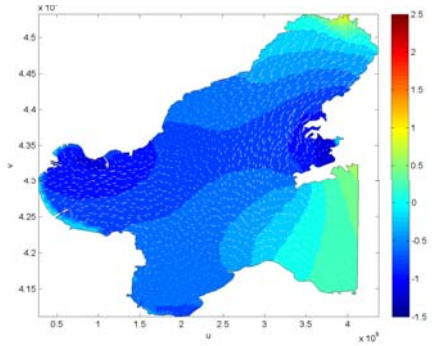
✓ Spring diatom blooms time cycle (Edwards & Richardson, 2004).

- **Dominant species of the phytoplankton has changed from diatoms to diatoms and dinoflagellates recently (Guo et al, 2014).**

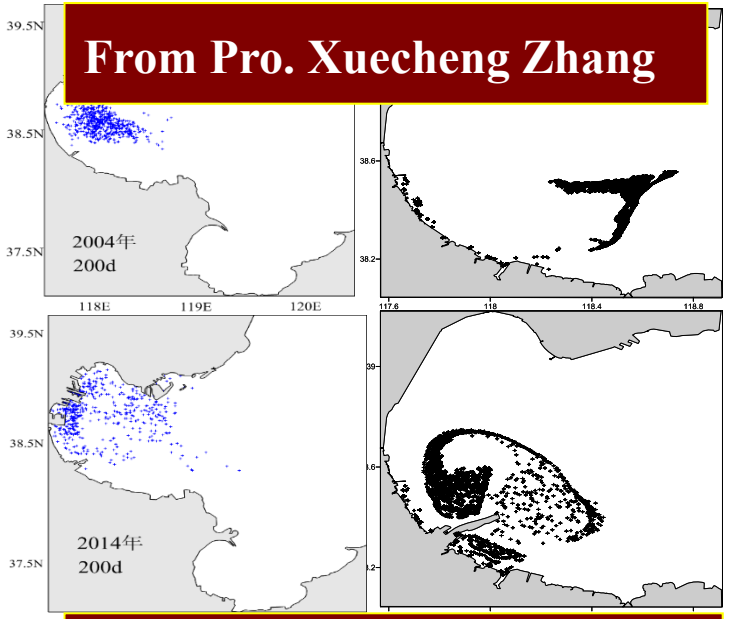
◆ **Mismatch between production of fish larvae and prey organisms.**

Main exogenous driving factor analysis

I. Bottom-up control theory



- Iles and Sinclair's (1982) “member vagrant” hypothesis most important factors affecting recruitment were physical factors promoting retention and life cycles closure by reproduction.
- Large-scale reclamation impacting wetlands, intertidal zones, and the gulf; also changed the hydrodynamic features then causing further loss and fragmentation of essential fish spawning ground (CCICED 2013).Thus the recruitment abundance.

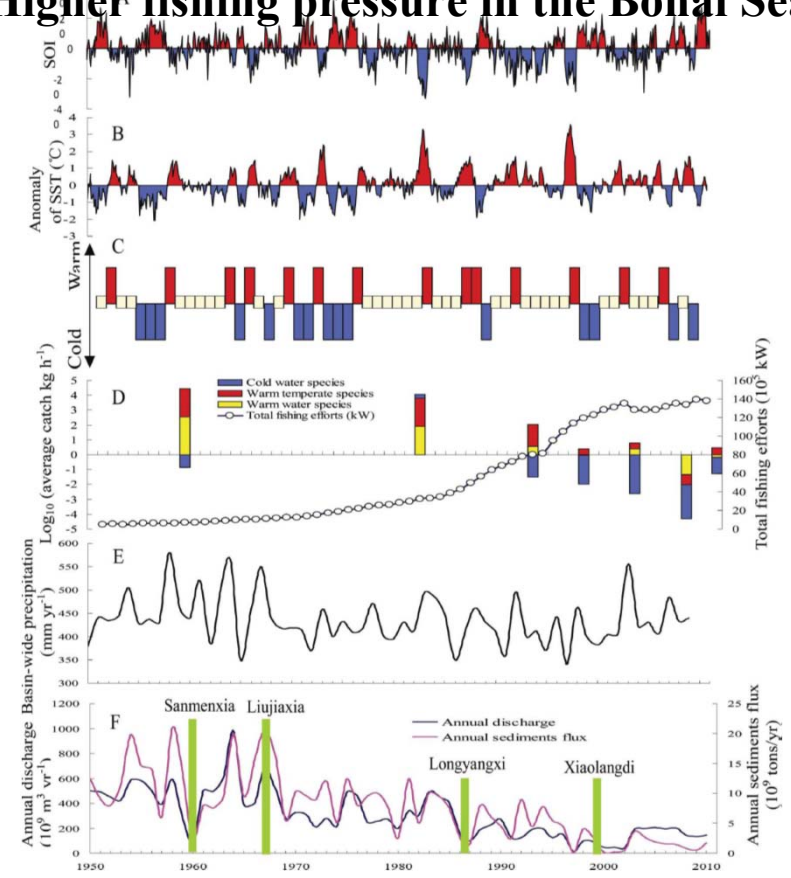


Disscussion (2)

Main exogenous driving factors analysis

II Top and down control theory

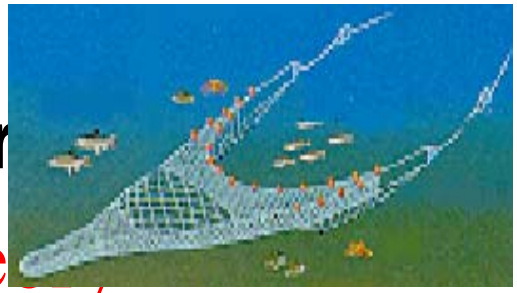
Higher fishing pressure in the Bohai Sea



- Overfishing recognized as one of the most significant anthropogenic activities (Edgar et al. 2005).
- The fishing pressure was 50 times more than that of the 1950s (Shan et al., 2013).
- Abundance, diversity and community structure

Shan et al., 2013; Marine and Coastal Fisheries, 65-78

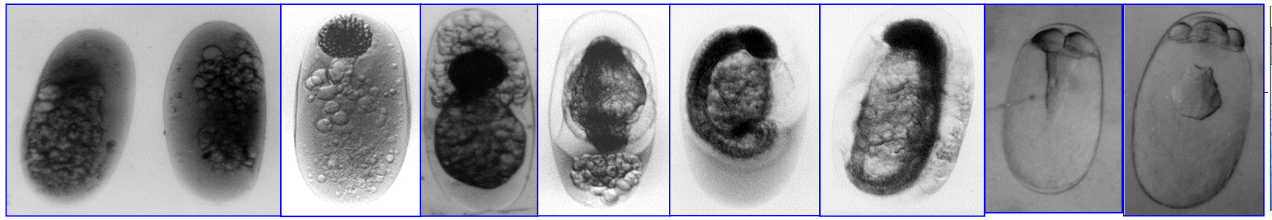
Main exogenous driving factor

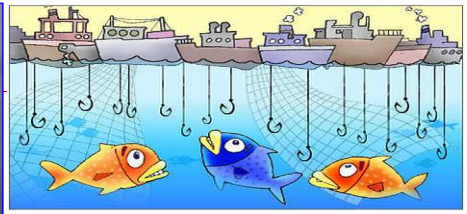


II Top and down control control the

- **Recruitment overfishing has led to insufficient spawning stock**
- Smaller sizes and earlier maturity in fish species (Small Yellow Croaker has decreased from 20 cm in the 1970s to 10 cm in recent years (Jin, 2004; CCICED, 2013)
- Egg quality of the key fishery species decreased (Parents effect). Wan &Bian (2012) has point out that decreased size and significantly increased natural mortality rate of anchovy eggs are long-term adaptive responses, via the reproductive biology of the anchovy population, to the enormous fishing Pressure;)

All these has become the main factors to explain the insufficient recruitment abundance and declining of the whole fishery stocks.

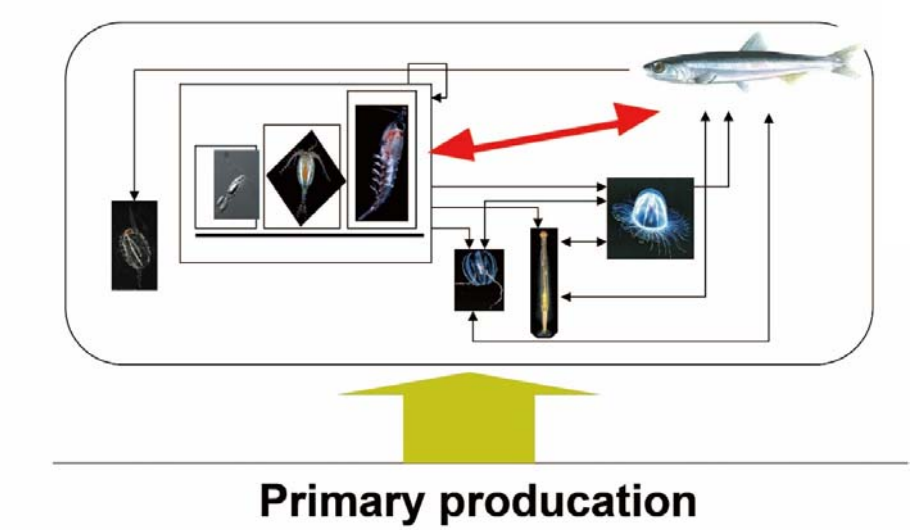




Disscussion (3)

Main exogenous driving factors analysis

III Wasp-waste control theory



- **Zooplankton play a key role in transferring primary production to higher trophic levels in all pelagic ecosystem.**
- **Over a long-term period of Top-down control may lead to an increase of zooplankton biomass(Tang et al, 2013).**
- **Affected both directions (may grazing a large proportion of phytoplankton, providing plenty of food to fish larvae). Produce a constraint effect on the zooplankton biomass. Which induced yearly variation patterns of the different levels of productivity did not show a stable and regular trend (Tang et al, 2002).**
- **Species replacement was obvious and significantly accelerated.**

Conclusions

- It is difficult to use any traditional theory (bottom-up control or top-down control or wasp-waist control) to directly or clearly explain the long-term changes of ichthyoplankton succession and assemblage structure in the Bohai Sea.
- Stressors such as overfishing and environmental changes (climate or anthropogenic activities induced) promote the multidimensional niche disturbance in the fish community and the structural decline in fishery resources, while succession and assemblage structure of the fish eggs and larvae is the embodiment of this development.

Acknowledgements

I deeply appreciate the contribution to this work made in various ways by my colleagues and the older generation who help in sampling collection and sample analysis.

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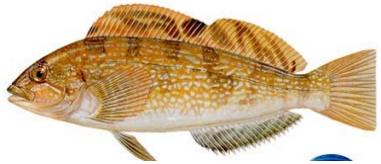
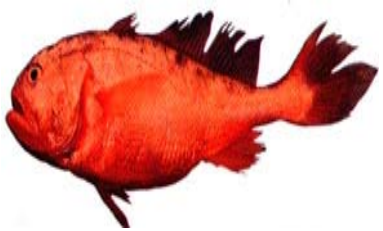



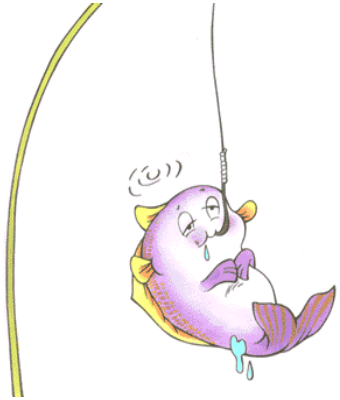


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