“Understanding Changes in Transitional Areas of the Pacific” 24-26, 2018, in La Paz

# Biological responses of small yellow croaker (*Larimichthys polyactis*) to multiple stressors: a case study in the Yellow Sea, China

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PICES

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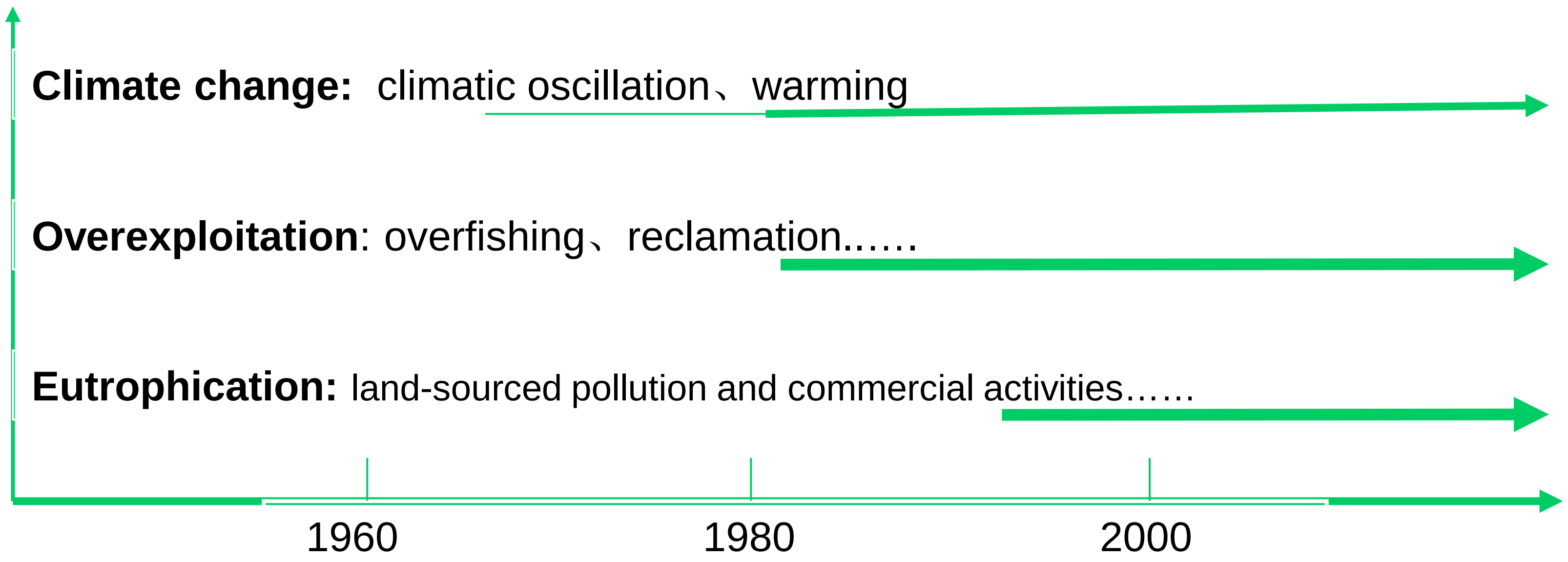
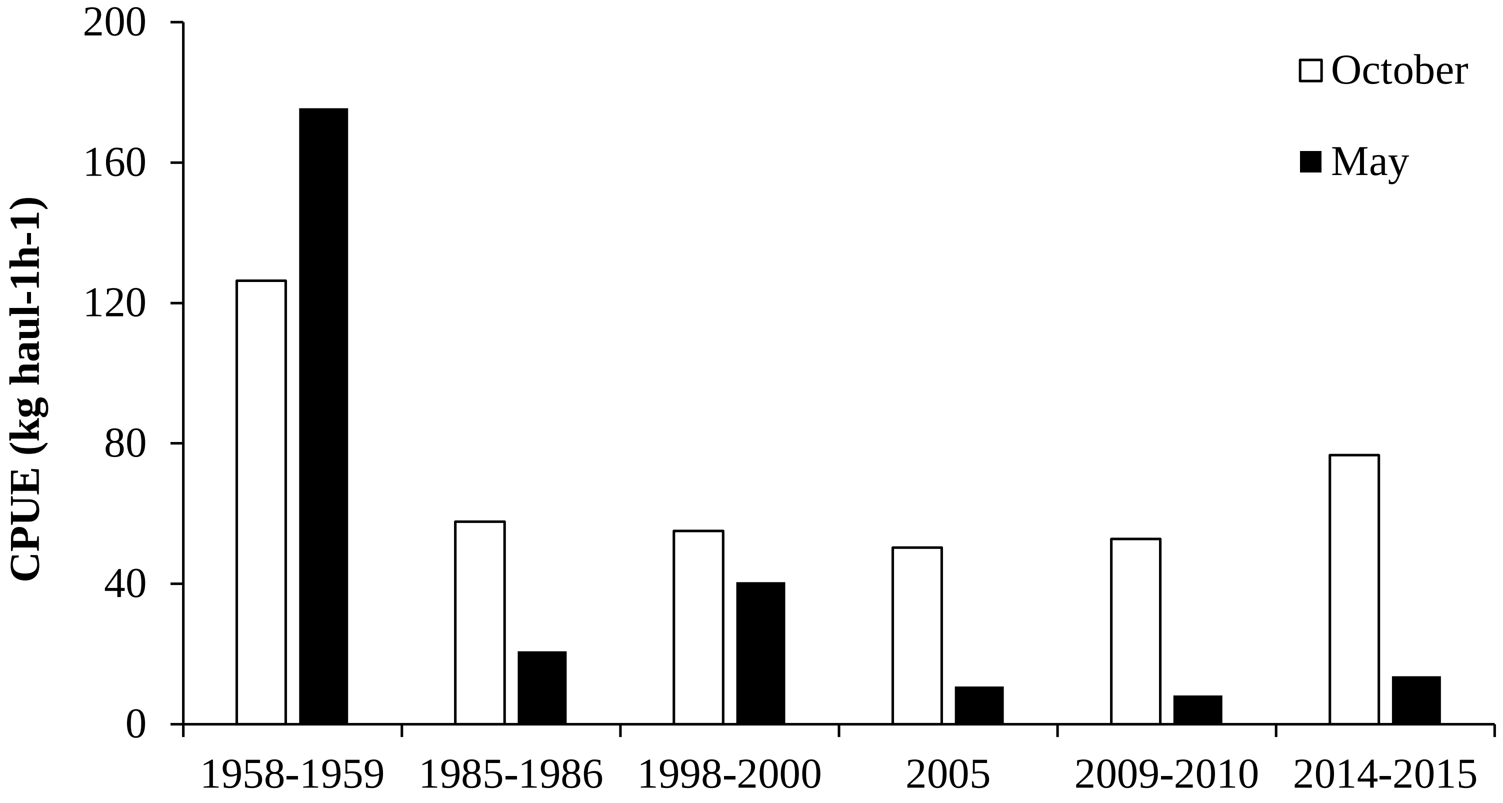
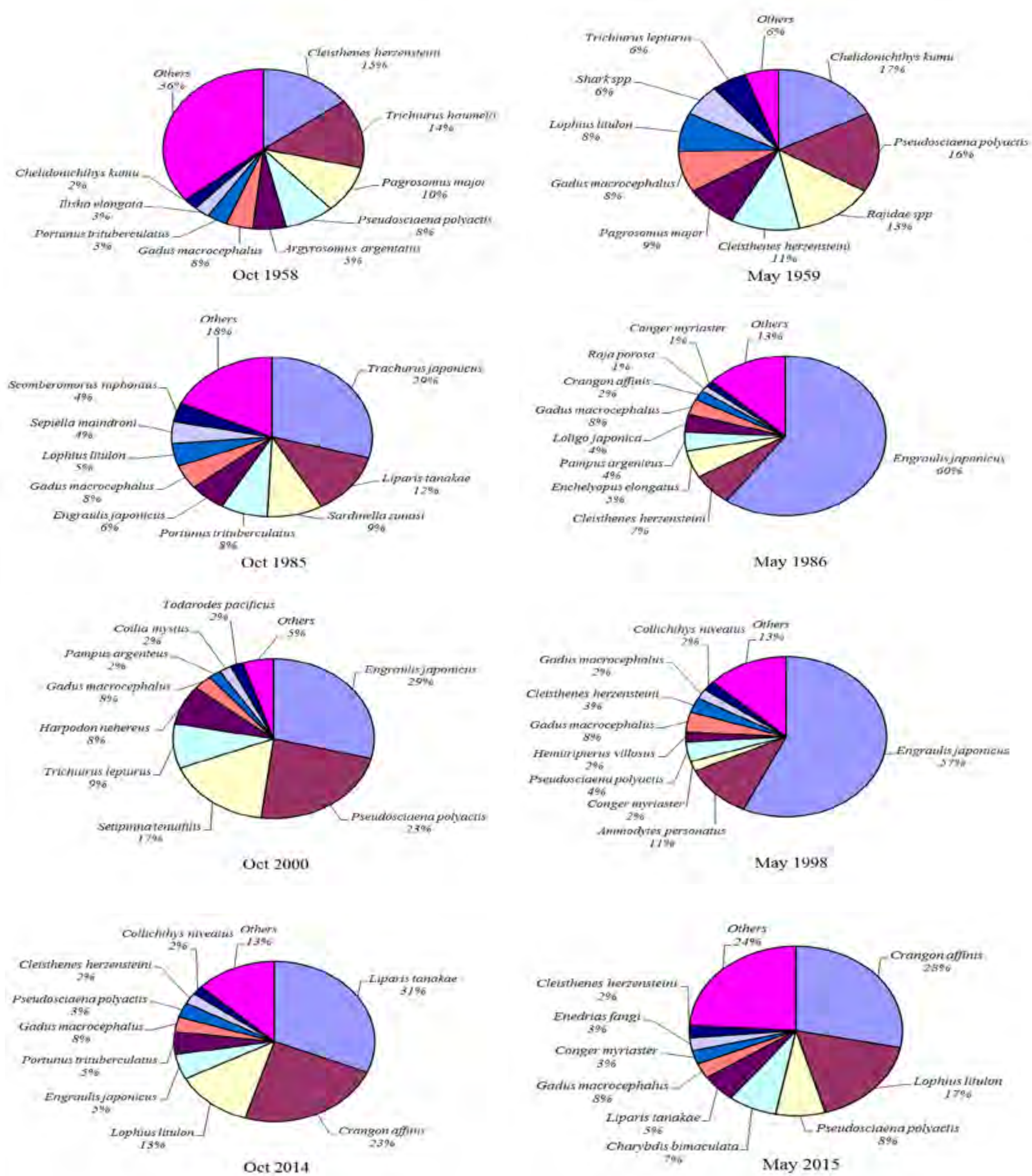
# Multiple stressors in China coastal waters



# Changes of CPUE in the Yellow Sea

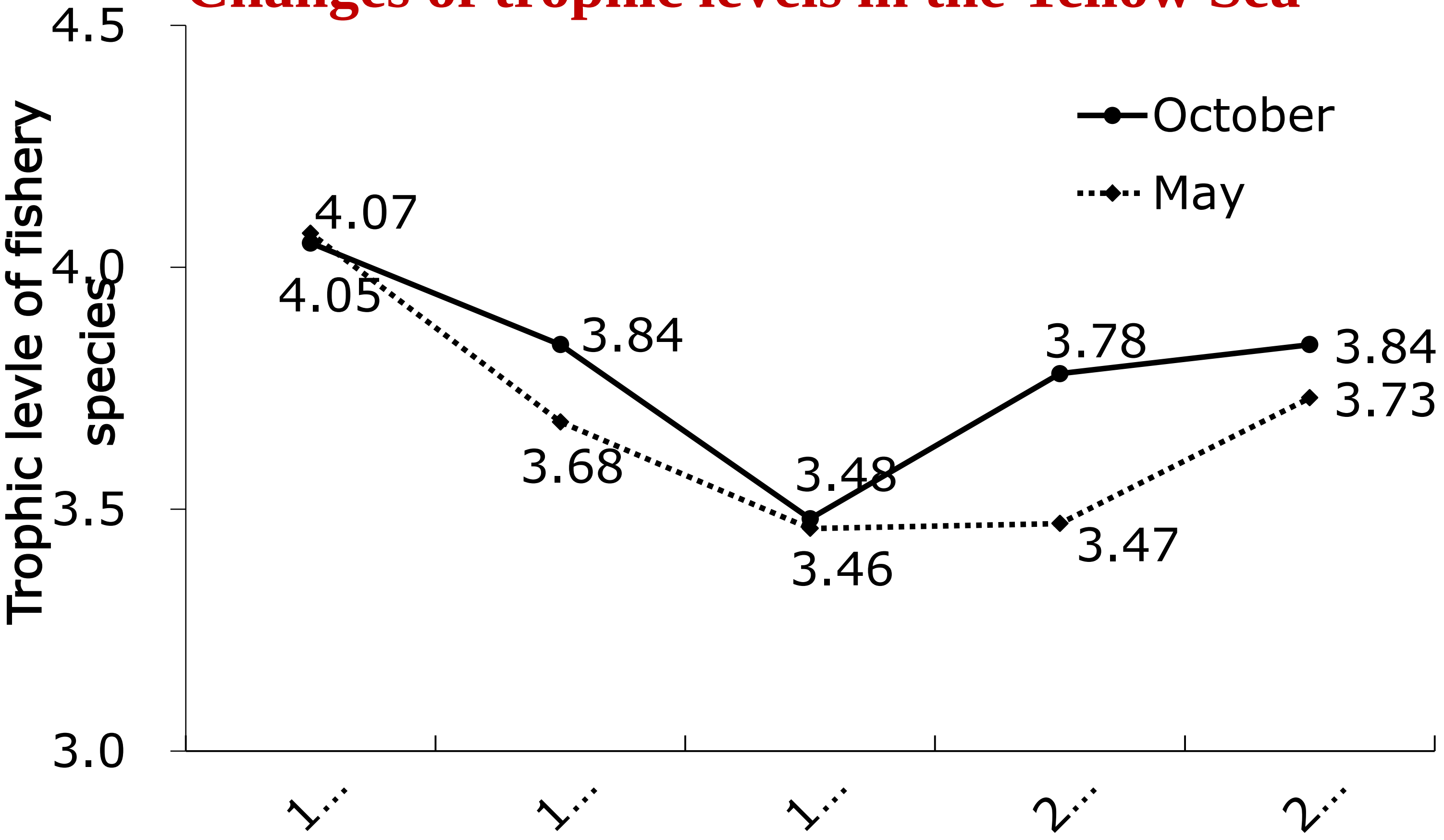



The CPUE data was collected by Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science, based on scientific surveys. Only in 1950s the surveys used fishing vessels, and in other years, the surveys were based on research vessels.



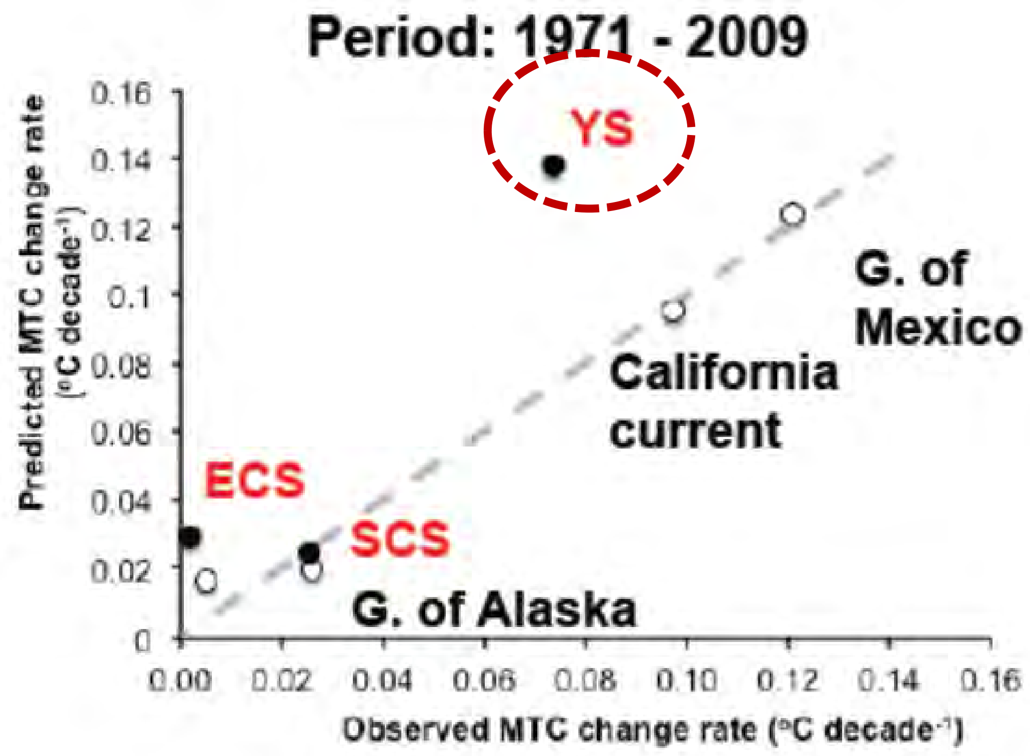

# Changes of species composition in the Yellow Sea

# Changes of trophic levels in the Yellow Sea

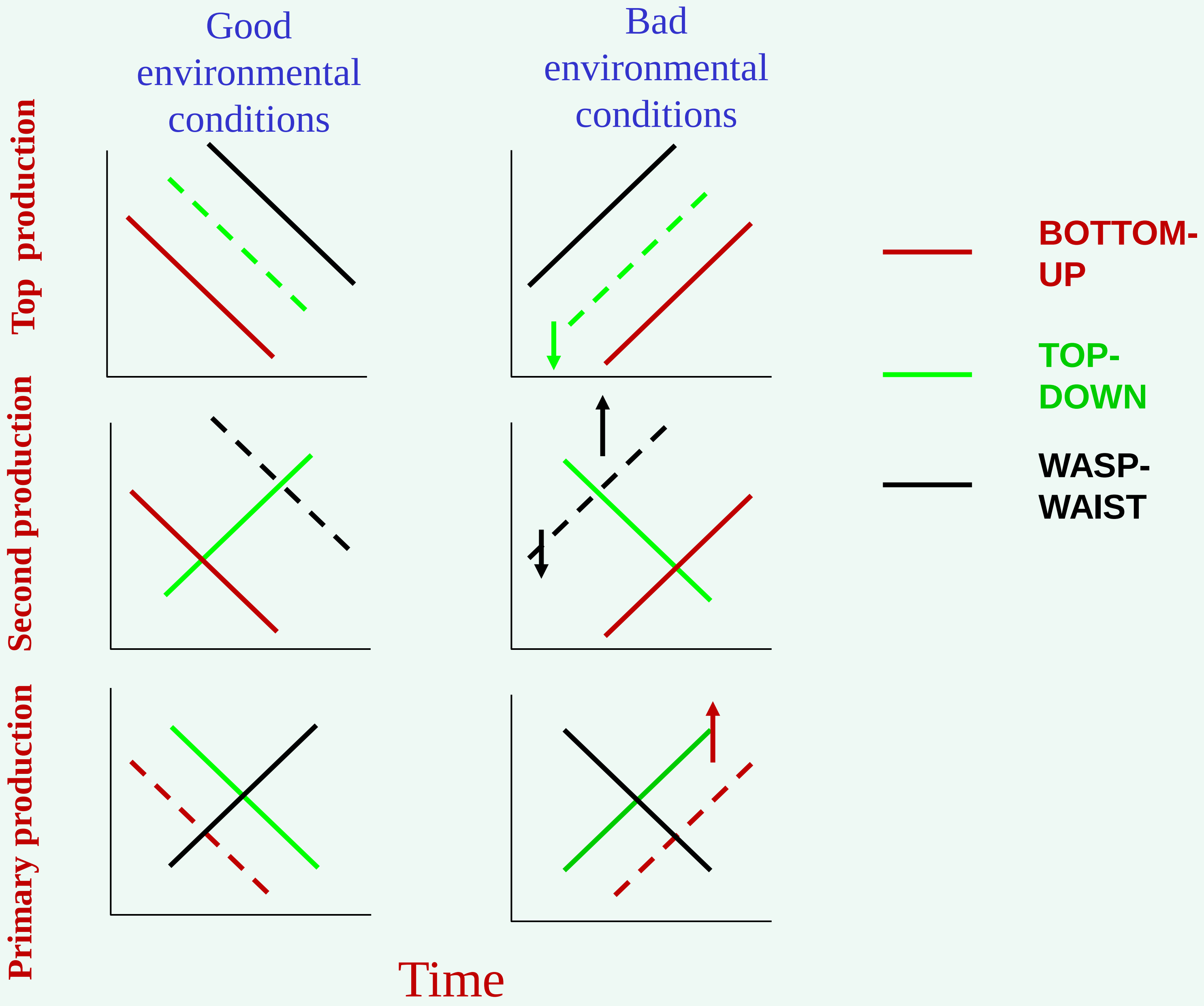



The trophic levels from 1985-2000 cited from Zhang & Tang (2004). The other data was as above mentioned.

**In China seas, MTC increases at the fastest rate in the Yellow Sea (0.08 $_o$C per decade);**




Cheung et al, 2012

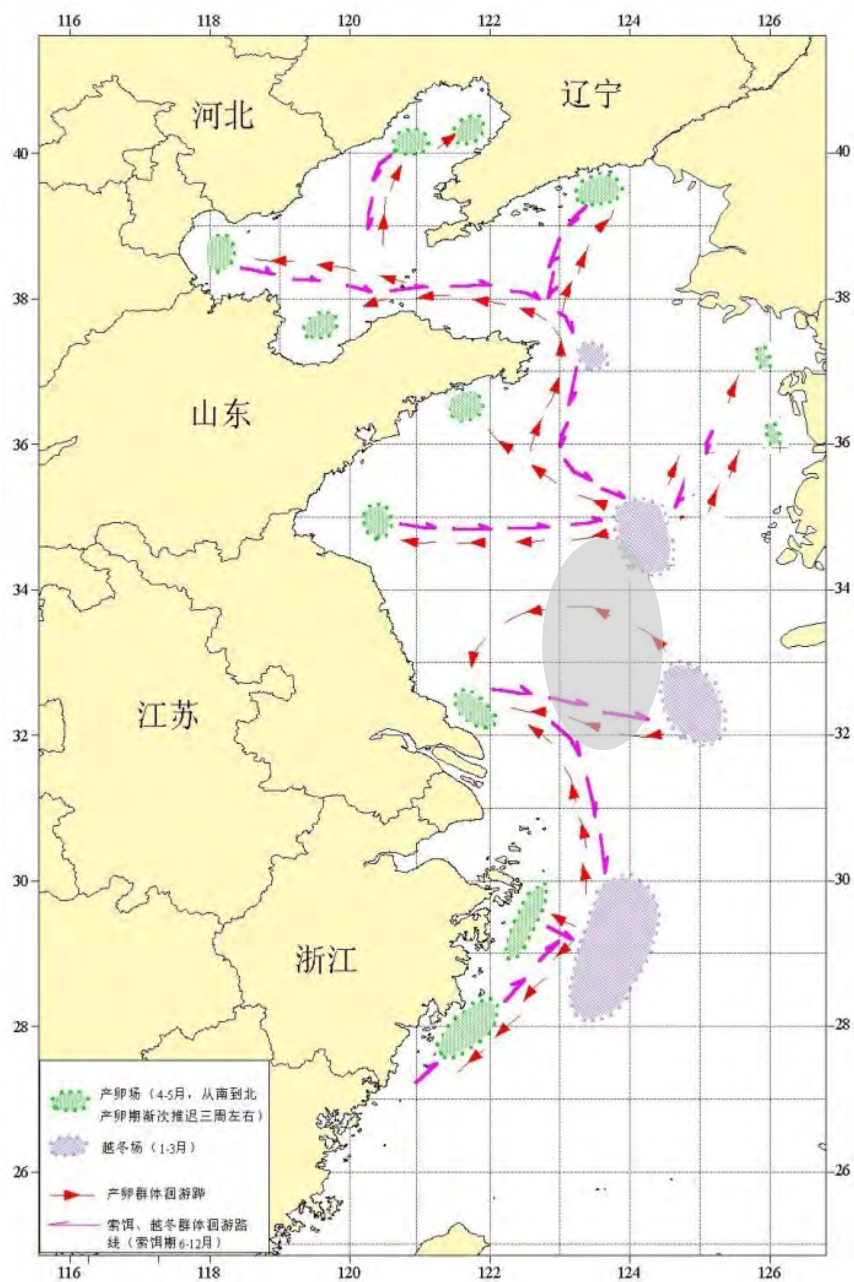



**Control mechanism of marine organisms in coastal waters**

-- 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 variations of the different levels.

-- Different control mechanisms may apply in different periods due to varying conditions. Although each control mechanism has its opportunity to control the ecosystem over a given period, it cannot become the exclusive control mechanism in the long-term.

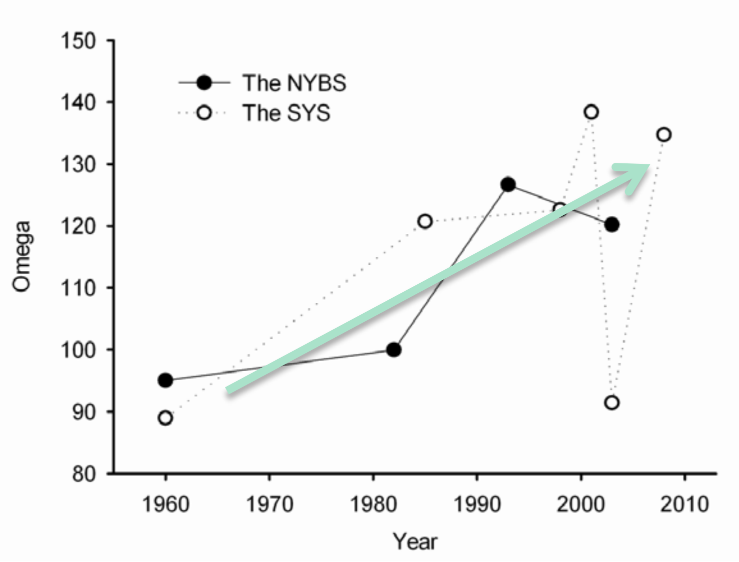
-- Therefore, an acceptable explanation is that the apparently dynamic characteristics of the different levels of productivity may be a consequence of multi-factorial controls. The multi-control mechanism may contribute to ecosystem complexity and uncertainty in terms of different levels of productivity in a coastal ecosystem.

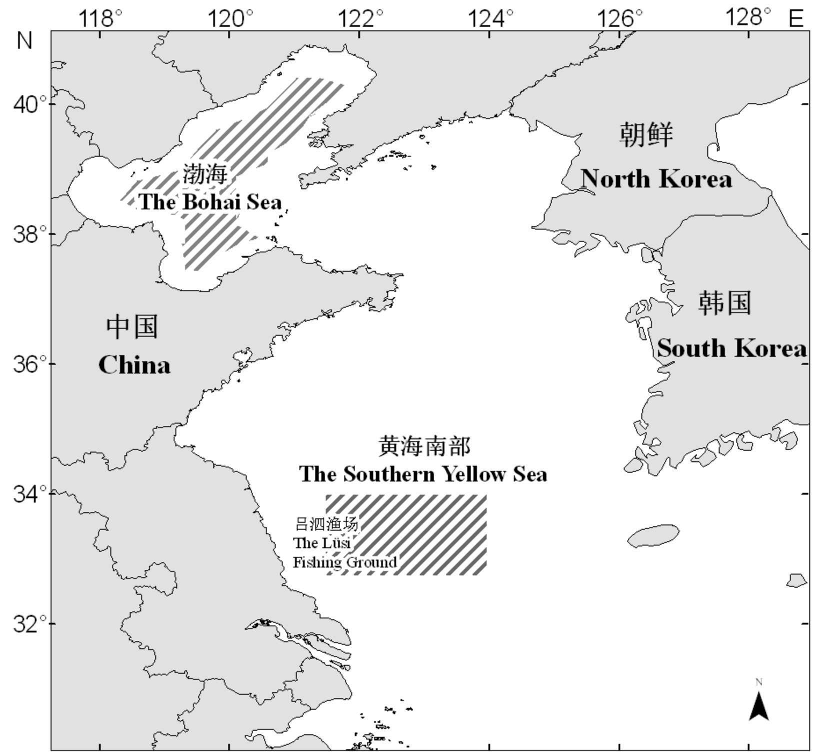



# Small yellow croaker

# Growth rate of fish larvae [1]

$$\omega = K \cdot L_\infty$$



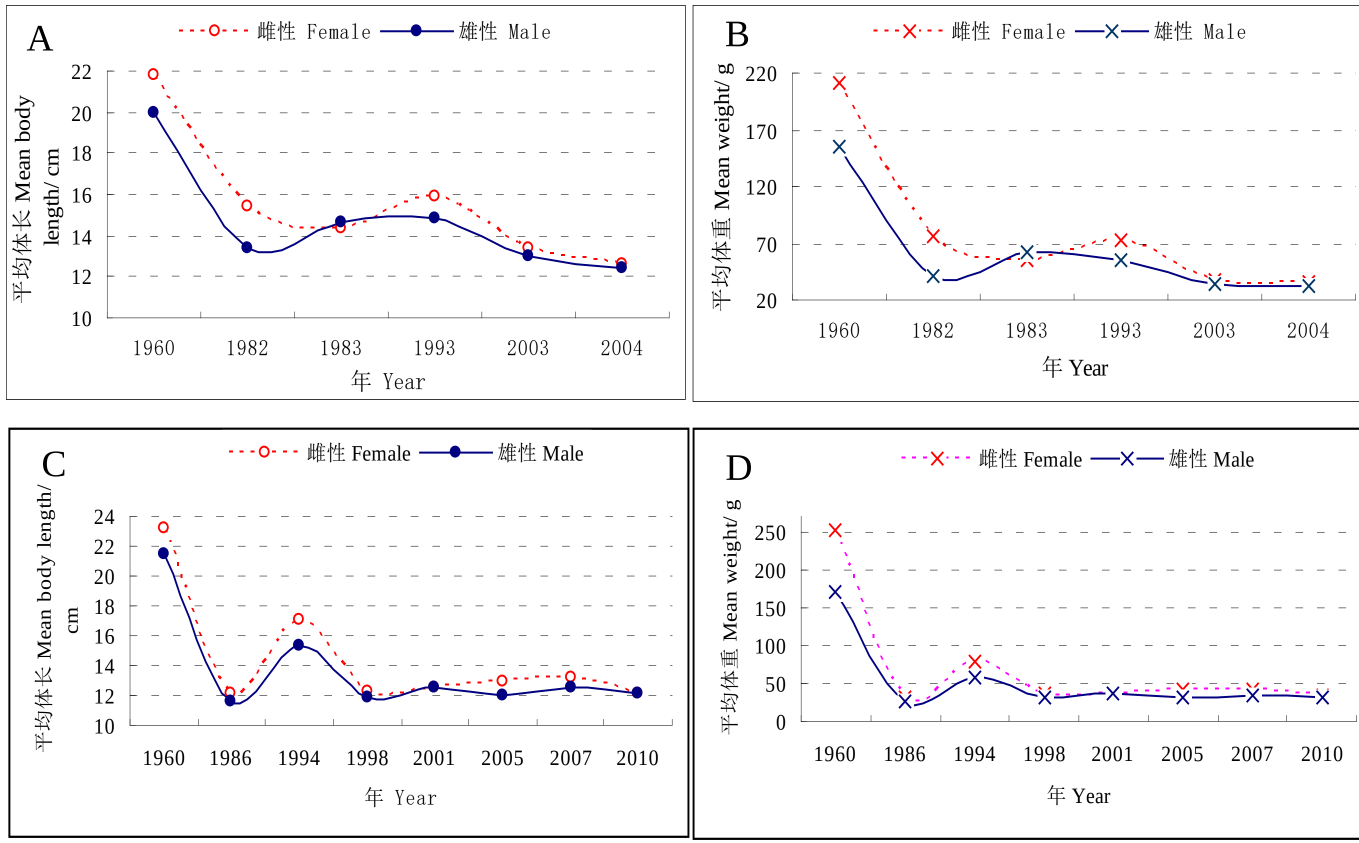




Gallucci, V. F., Quinn, T. J. Reparameterizing, fitting, and testing a simple growth model [J]. Trans. Am. Fish. Soc., 1979, 108(1): 14-25.

Li et al, 2011

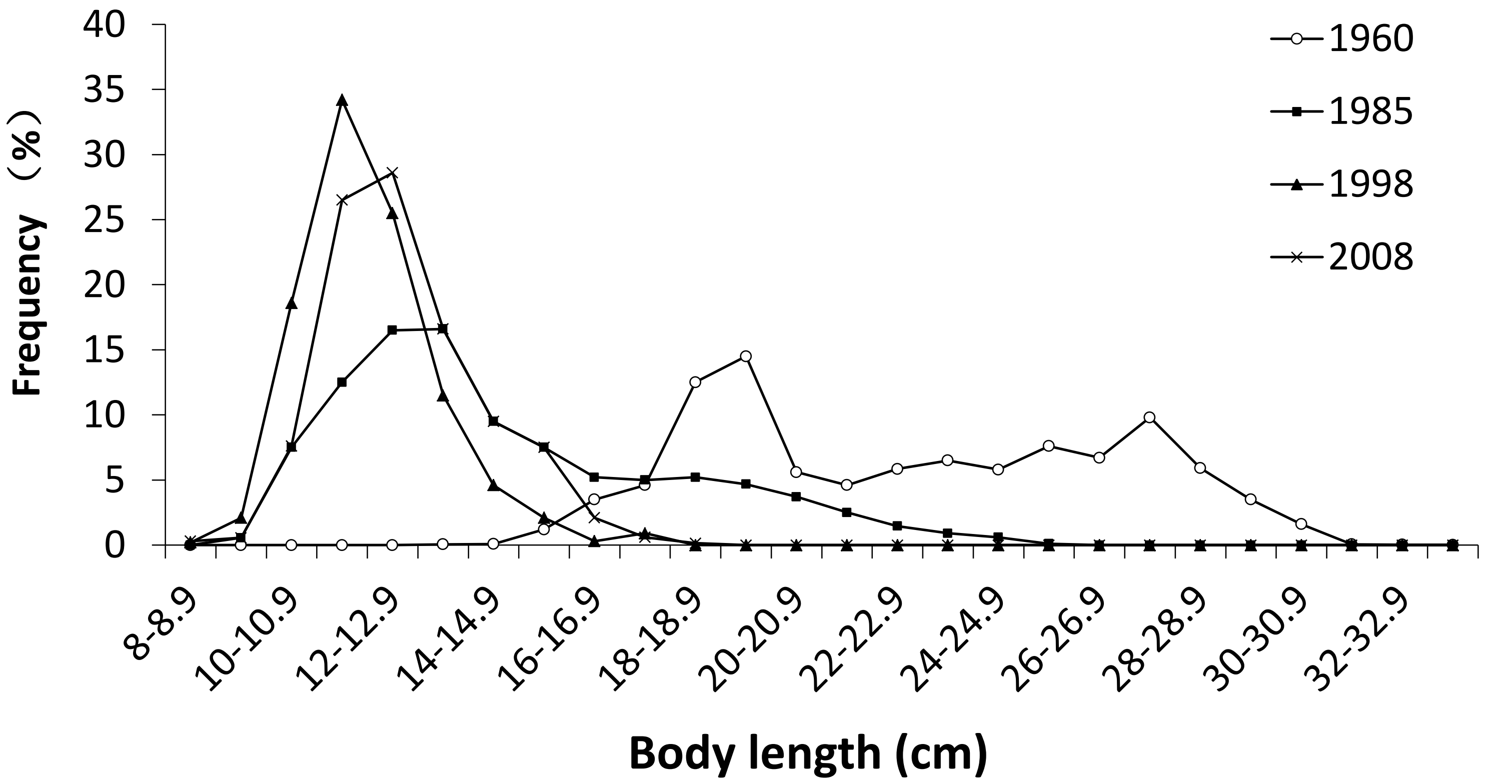
# Variations in average body length and body weight

●**Three phases:**
(1) 1960s-1980s: sharp decrease;
(2) early-1990s: slight increase;
(3) late 1990s: decrease again, even less than that in 1980s.




Variations in average body length (A, C) and average body weight (B, D)
A、B: Northern Yellow Sea-Bohai Sea stock; C、D: Southern Yellow Sea Stock

Li et al, 2011



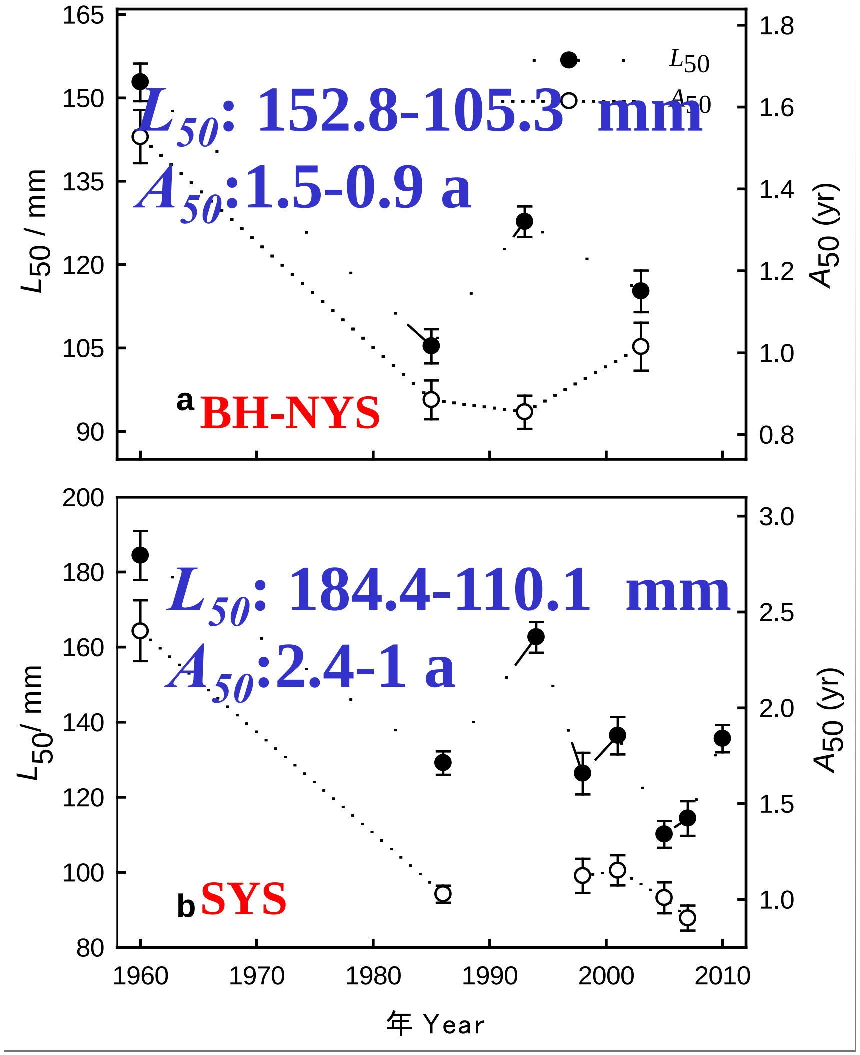

Body length distribution of the small yellow croaker spawning stock in the Yellow Sea from 1960 to 2008

Shan et al, 2016

## Age structure of small yellow croaker in the Yellow Sea

| Year | Age structure (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Beyond 10 | Average age (yr) |
| 1960 | 0.9 | 16.4 | 33.6 | 23.2 | 6.2 | 2.6 | 3.8 | 3.8 | 2.0 | 7.5 | 4.49 |
| 1985 | 28.8 | 55.5 | 8.7 | 3.3 | 2.6 | 0.9 | 0.2 | | | | 1.99 |
| 1998 | 97.6 | 2.36 | 0.04 | | | | | | | | 1.02 |
| 2008 | 93.4 | 5.7 | 0.9 | | | | | | | | 1.08 |

Shan et al, 2016




**Body length and age at median sexual maturity of small yellow croaker decreased;**

Body length and age at median sexual maturity ($L_{50}$ and $A_{50}$) were estimated by *ASR* transformative logistic model and inverse von Bertalanffy growth function

Li et al, 2011

## Biological parameters of small yellow croaker in the Yellow Sea from 1960 to 2008

| | Year | | | |
|---|---|---|---|---|
| Biological parameters | 1960 | 1985 | 1998 | 2008 |
| Growth coefficient k | 0.26 | 0.4 | 0.48 | 0.56 |
| Zero-length age $t_0$ | -0.58 | -0.37 | -0.3 | -0.25 |
| Asymptotic length $L_\infty$/cm | 34.21 | 30.17 | 25.54 | 27.00 |
| Age at inflexion of body weight growth $t_r$ | 3.78 | 2.44 | 1.99 | 1.61 |
| Total mortality coefficient Z | 0.51 | 1.80 | 2.84 | 2.40 |
| Natural mortality coefficient M | 0.24 | 0.33 | 0.39 | 0.77 |
| Fishing mortality coefficient F | 0.27 | 1.47 | 2.45 | 1.63 |
| Goodness of fit $R_n$ | | 0.30 | 0.26 | 0.27 |

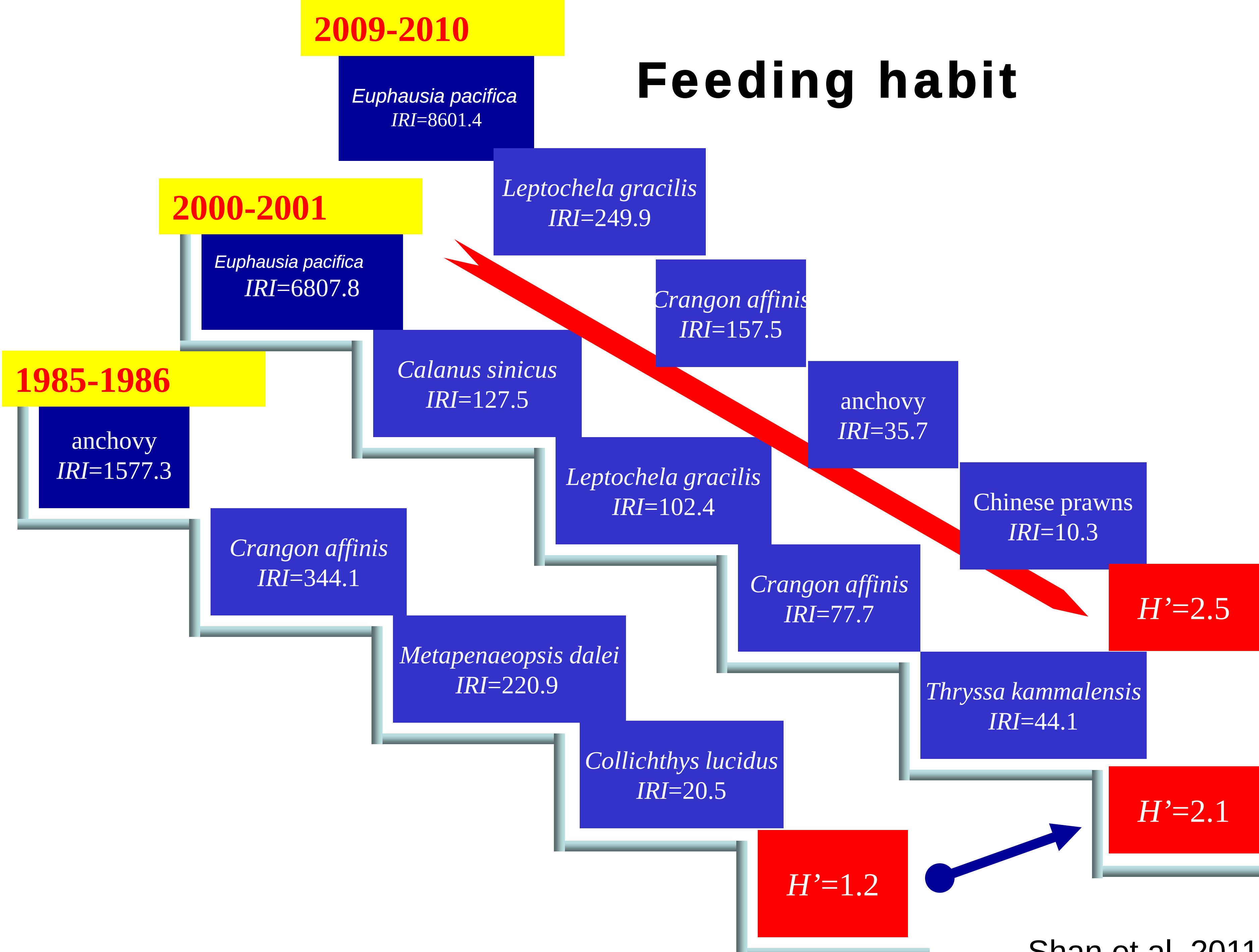
Shan et al, 2016

# Correlations between the decadal changes in the biological parameters of small yellow croaker and influencing factors

| Biological parameters | Sea surface temperature (SST) ℃ | Feeding grade | Fishing vessel power/ MW |
|---|---|---|---|
| Growth coefficient k | **0.6491** | **0.6923** | **0.7273** |
| Zero-length age $t_0$ | **0.6249** | **0.7352** | **0.7596** |
| Asymptotic length/cm $L_\infty$ | **0.7549** | **0.6536** | **0.7361** |
| Age at inflection of body weight growth $t_r$ | **0.6073** | **0.7427** | **0.7689** |
| Total mortality coefficient Z | **0.6404** | **0.6346** | **0.7273** |
| Fishing mortality coefficient F | **0.6403** | **0.7092** | **0.6756** |
| Natural mortality coefficient M | **0.5606** | **0.6645** | **0.6716** |
| Mean value | **0.6396±0.0193** | **0.6903±0.0135** | **0.7238±0.0356** |

Shan et al, 2016

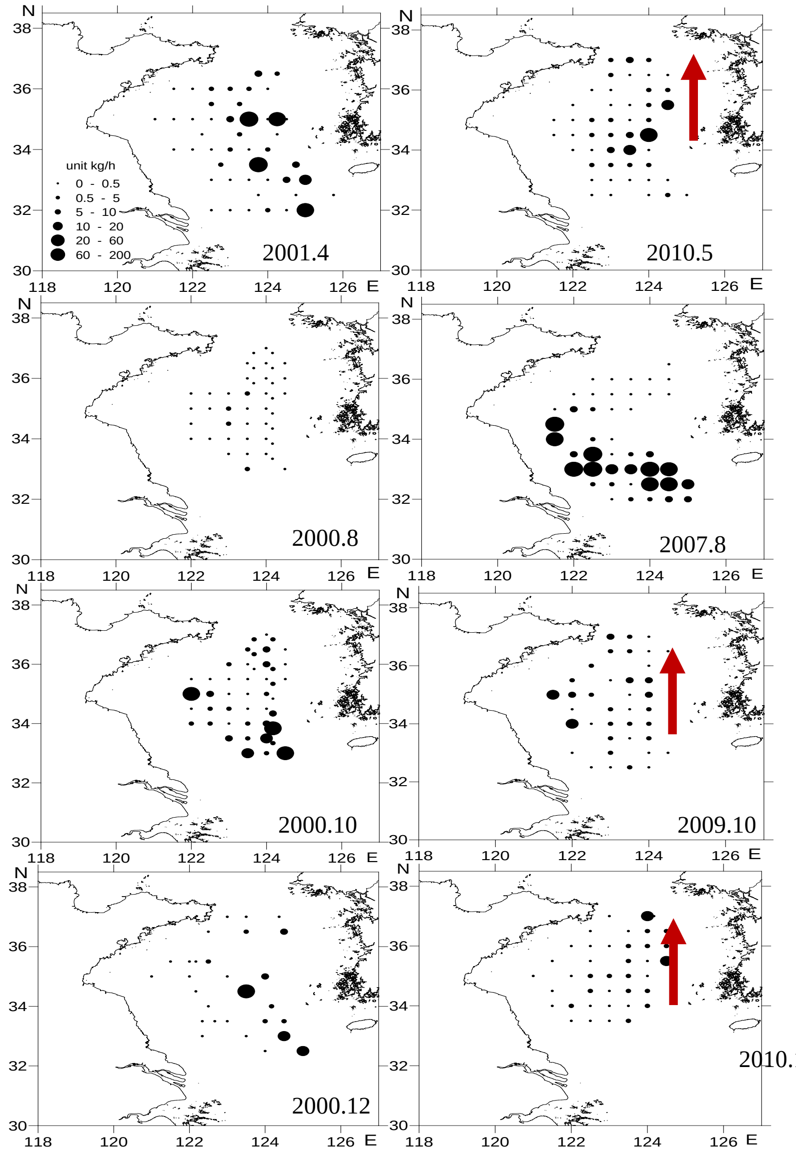
# Feeding habit




Shan et al, 2011

# Distribution

**Corresponding months, small yellow croaker in YS migrated northward.**




Spring

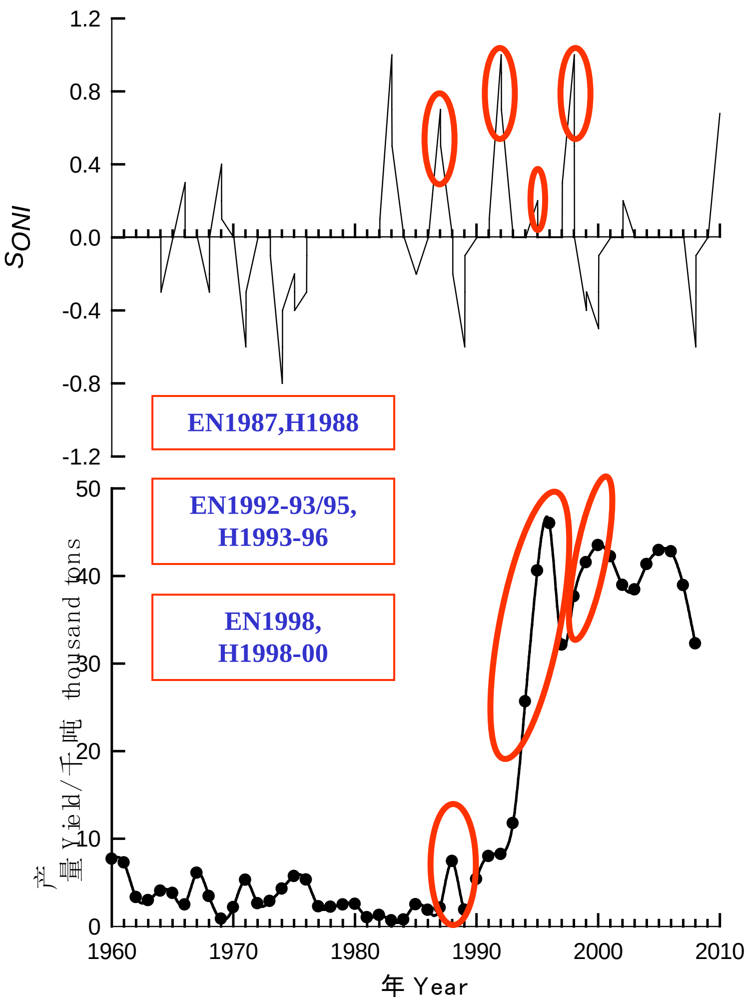
Summer

Autumn

Winter

Shan, et al, 2011

# Changes of catch and ENSO



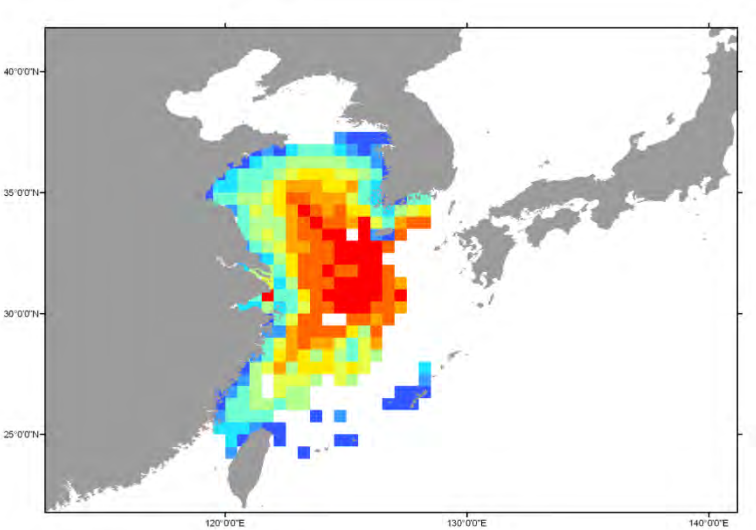

ONI and small yellow croaker production from Jiangsu Province

The yield increased in those years and **in 1-2 years after an El Niños event.**

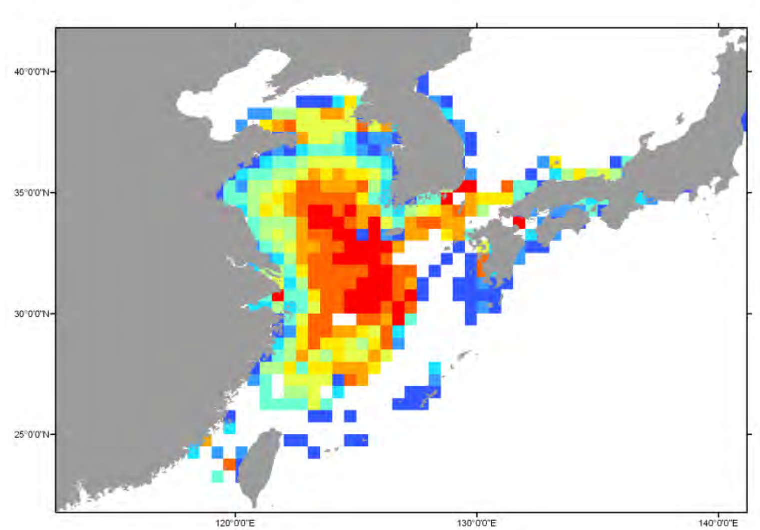
Li, et al, 2012

# Small yellow croaker

**Original (static) distribution**




**Distribution after 50 years**
**(Climate projection from NOAA/GFDL CM)**




**Relative abundance**

**Low**

**High**

Cheung et al, 2008

# Summary

- **The average length of fish in 2008 was reduced by ~85% than those occurring in 1985;**
- **~93% of the total catch was dominated by one-year-old individuals;**
- **Growth parameters also varied significantly over the years, i.e. *k* (growth coefficient) and $t_0$ (zero-length age) gradually increased from 0.26 and -0.58 yr in 1960 to 0.56 and -0.25 yr in 2008;**
- **$L_\infty$ (body length) sharply decreased from 34.21 cm in 1960 to 24.06 cm in 2008, and $t_r$ decreased from 3.78 yr in 1960 to 1.61 yr in 2008.**
- **There was a great increase both in natural mortality coefficient and fishing mortality coefficient;**
- **Changes in the biological characteristics of small yellow croaker were induced by different stressors ranked as: fishing vessel power> feeding grade> sea surface temperature.**


Thank you !