3RD
YSLME
SCIENCE
CONFERENCE
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Overview on Scientific Issues for advancing Ecosystem-Based Management of YSLME

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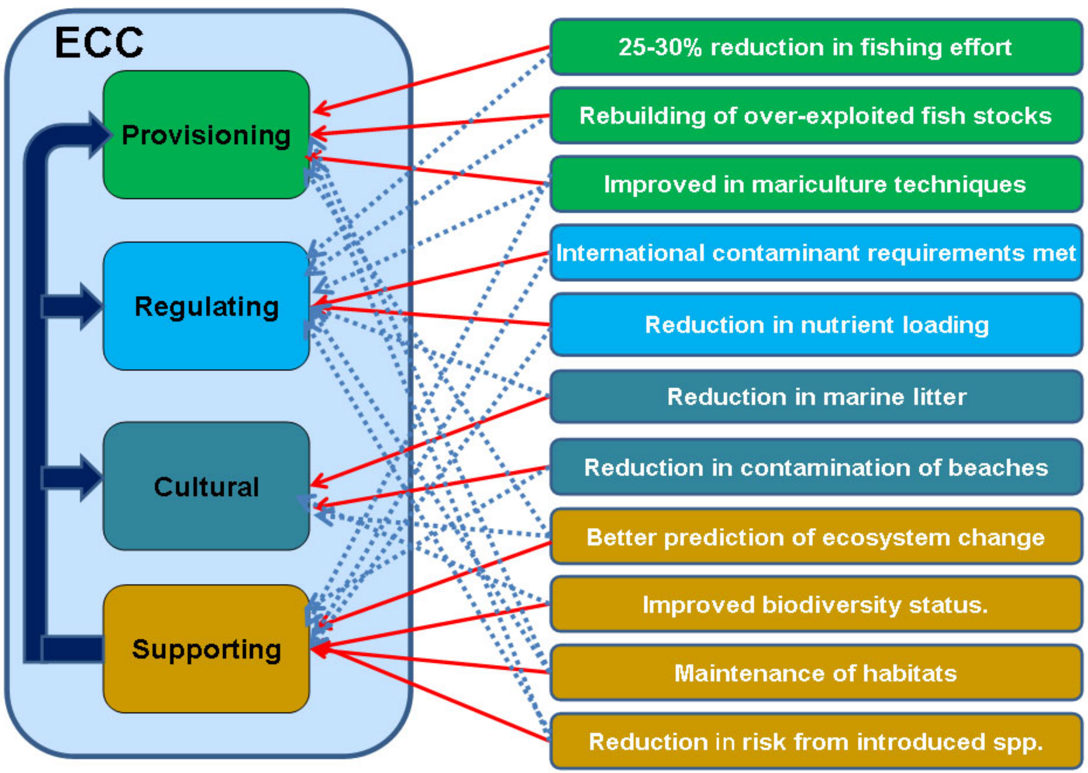
gef UNDP UNOPS YSLME UNDP/GEF Yellow Sea Large Marine Ecosystem

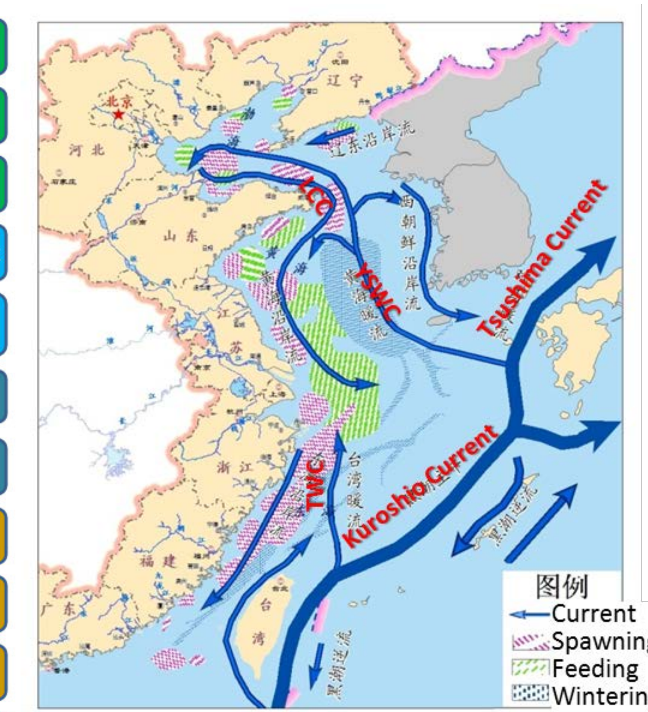
Main Contents

- I. EBM for sustainable YSLME
- II. Main scientific issues on YSLME trends and threats
- III. Conclusions and Perspectives

1.1 Targets of YSLME SAP in 2009

- **Sustainable ECC: A living sea, which is vital, productive and healthy**





(*Source: Jilan Su，2001*)

- # Ecosystem services of YSLME
  - **Trend:** Great loss of ecosystem services value (-37%) of the coastal wetlands (tidal flats) from 1980s to 2010s
  - **Most important component**: the regulating services, such as carbon sequestration and waste treatment (Immaterial value)
  - **Main cause**: huge historical loss of tidal flats directly linked to coastal reclamation

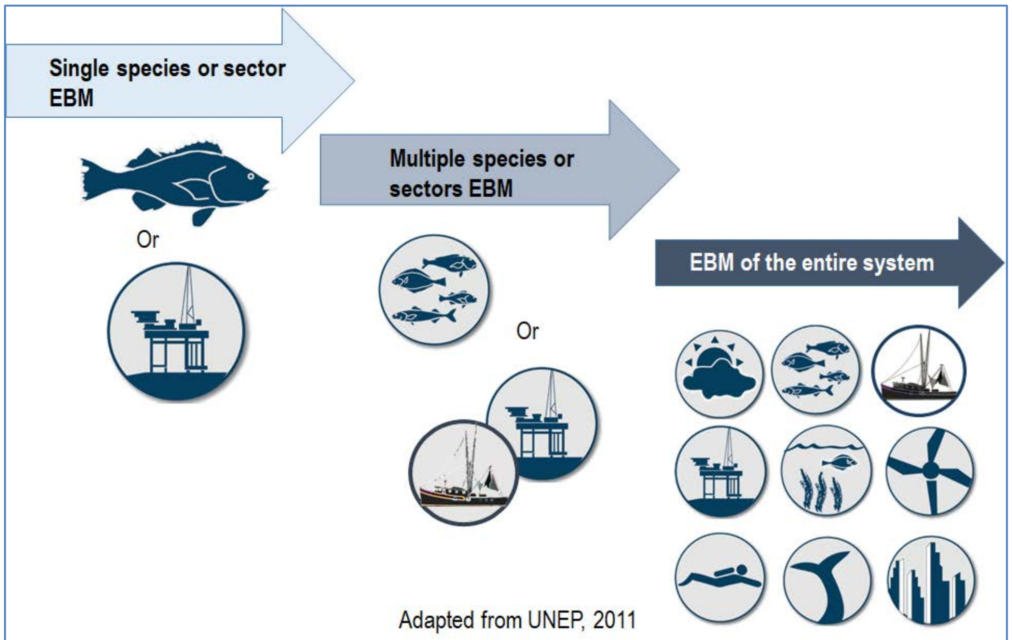
(ESV; 10^6 USD yr^{-1})

Region	Total ecosystem services			Provisioning		Regulating		Supporting		Cultural	
	1980s	2010s		1980s	2010s	1980s	2010s	1980s	2010s	1980s	2010s
China	12416	7543	(▼39)	3104	1886	7419	4507	395	240	1498	910
South Korea	5156	3298	(▼36)	1475	943	2697	1725	652	417	332	212
North Korea	3798	2713	(▼29)	1086	776	1987	1419	480	343	245	175
Total	21370	13554	(▼37)	5665	3605	12103	7651	1527	1000	2075	1297

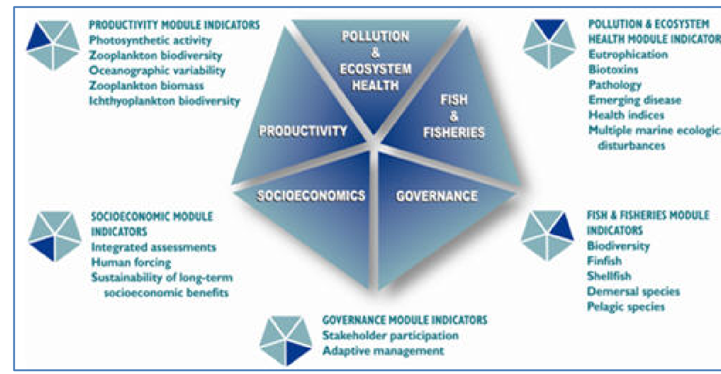
（*Source: Jongseo Yim et.al, 2018*）

1.2 EBM: strategy for sustainable ECC

- **EBM: integrates all components of an ecosystem, including humans, into the decision-making process**



Continuum of transitioning from traditional single-species management to multisector comprehensive EBM

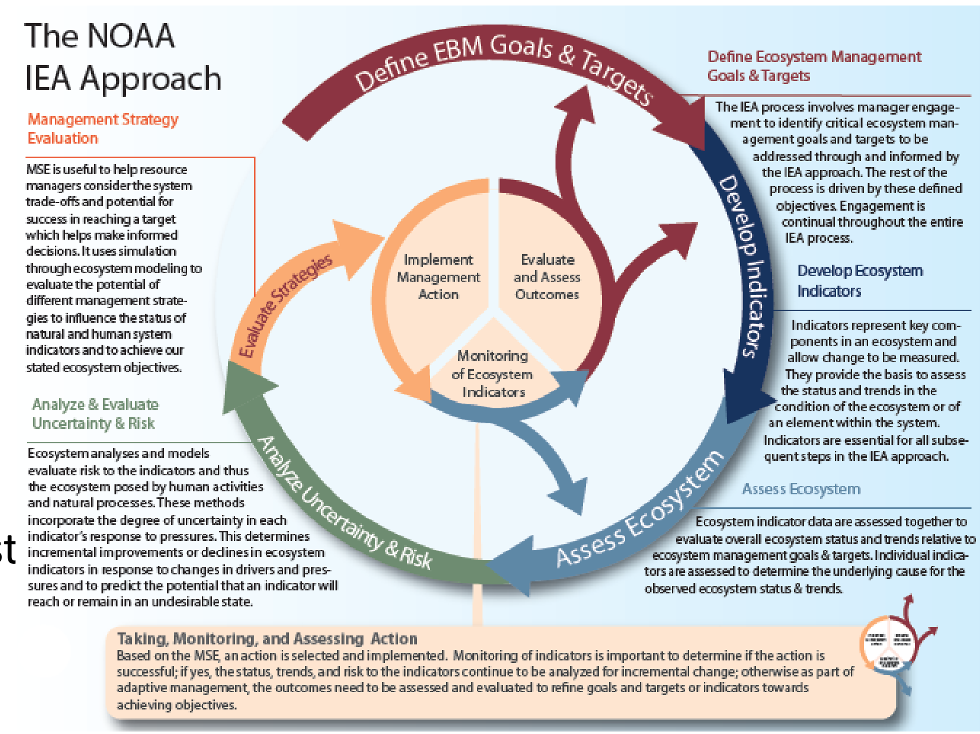


5 modules of spatial and temporal indicators of ecosystem (i) productivity, (ii) fish and fisheries, (iii) pollution and ecosystem health, (iv) socioeconomics and (v) governance

http://www.noaa.gov/iea

• Scientific research needs for advancing EBM of YSLME

- ➢ Building consensus and more complete understanding of the ecosystem
- ➢ Building a network of interdisciplinary scientists
- ➢ Explicitly considering all components of the ecosystem including humans
- ➢ Identifying trade-offs to make decisions that result in the most desired outcome
- ➢ Supporting transition to ecosystem-based management



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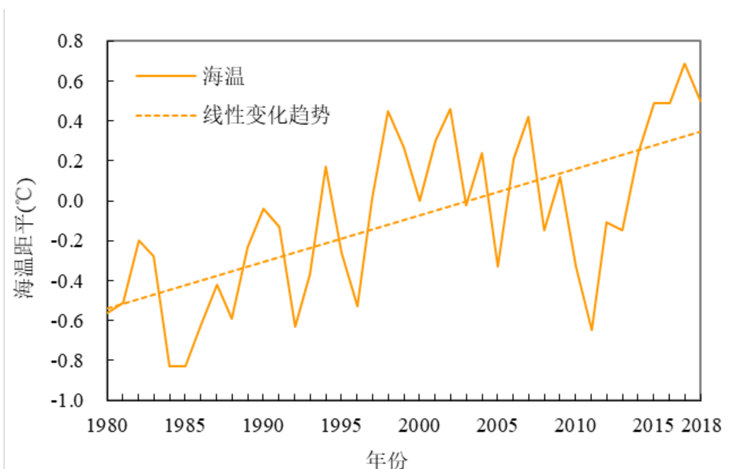
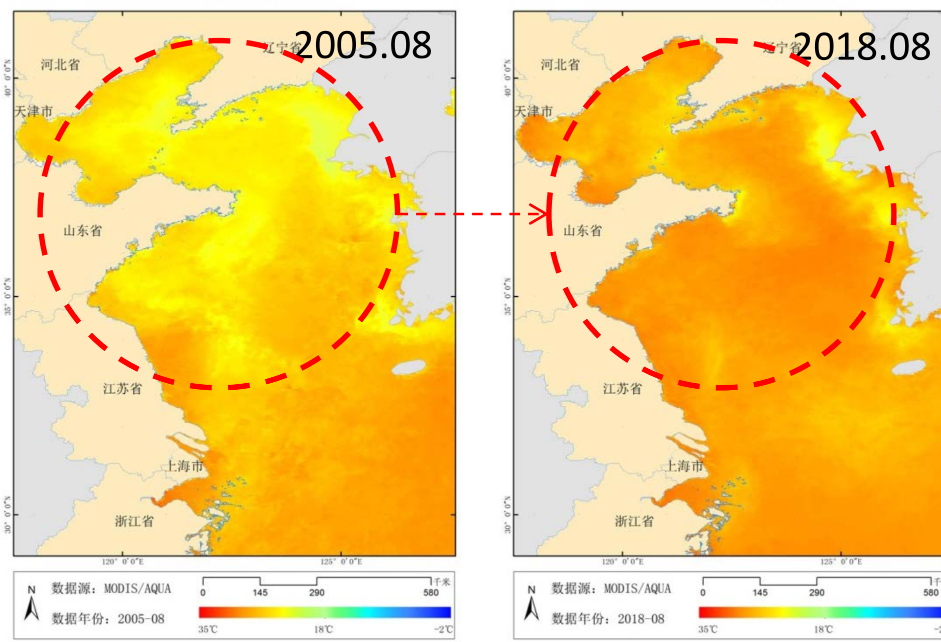
2.1 Climate change implications in YSLME

- **2.1.1 Rising sea surface temperature (SST)**
  - From 1980 to 2018, the SST of China's coastal waters increased by 0.23°C per ten years
  - Rising SST in Bohai Sea and Yellow Sea are most significant



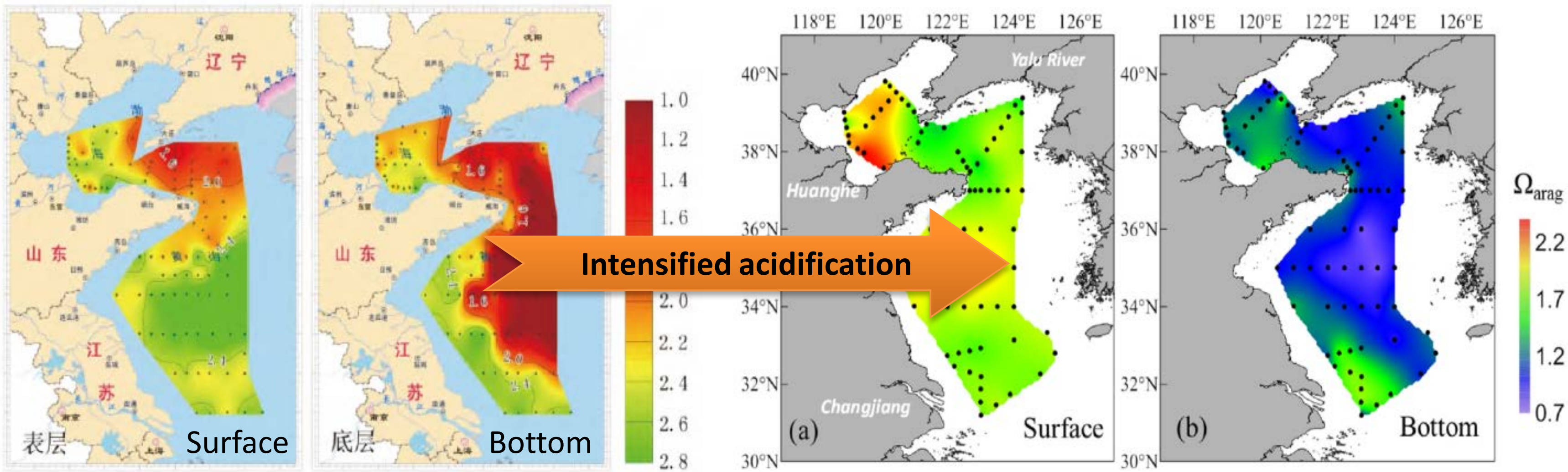
SST anomaly time-series of China's coastal waters

(*Source: China Sea Level Bulletin 2018*)



2.1.2 Intensified marine acidification

- Intensified acidification esp. for the bottom water of YS



Distribution of Calcium Carbonate Saturation
Aug. 2012

Prediction of distribution of Calcium Carbonate Saturation
Aug. 2100

Marine acidification will affect biocalcification rate, primary productivity, nitrogen fixation and reproduction, esp. for the shell formation process of calcareous organisms

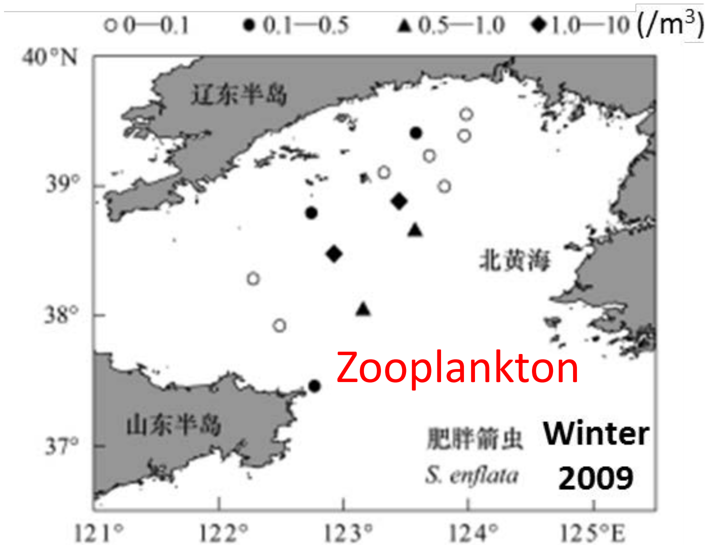
(*Source: X. Xu, H. Zhao, W. Zhai et al, 2018*)

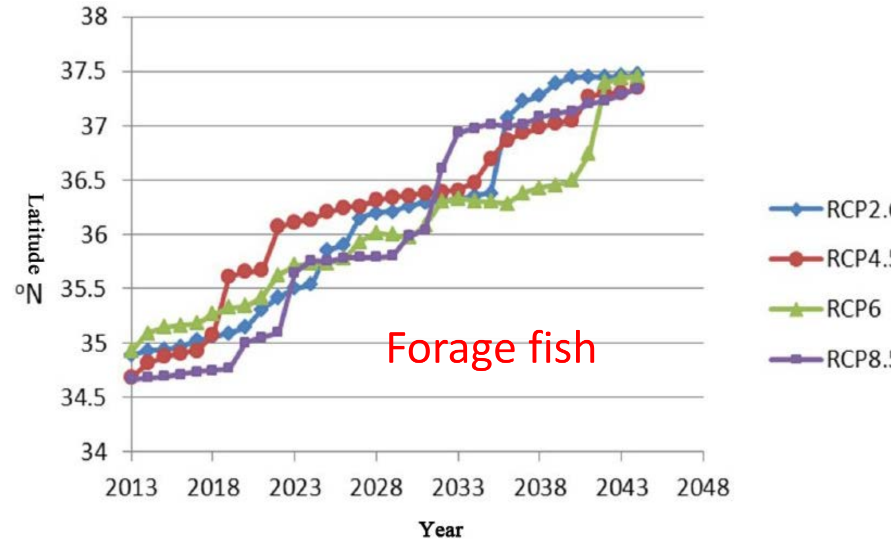
2.1.3 sea level rise and environmental impacts

- **Rate of sea level rise**
  - In 2018, the sea level of YS was 28 mm higher than annual average.
  - It was predicted that the sea level of YS will rise for 70□ 165 mm in the following 30 years
- **Environmental impacts**
  - **Coastline erosion** rate up to 35 m/yr
  - **Saline intrusion** distance up to 20-30 km

Region	Coastline erosion	Saline intrusion
Dalian	0.8 m/yr	0.3 km
Weihai	0.7 m/yr	2.03 km
Nantong	**35 m/yr**	**21.30 km**

2.1.4 Northward distribution of warm water species





Abundance of *S. enflata* in northern YS

S. enflata as warm water species have never been found in northern YS before 1959 in winter, which were found widely distributed in this region since 2009.

(*Source: J.F. Fan et al. 2010*)

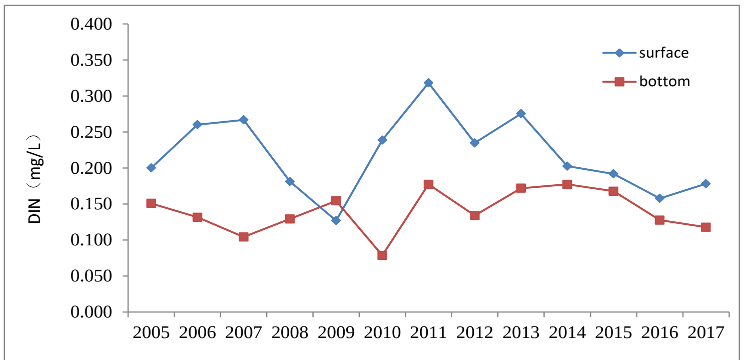
Distribution of anchovy stock under climate change

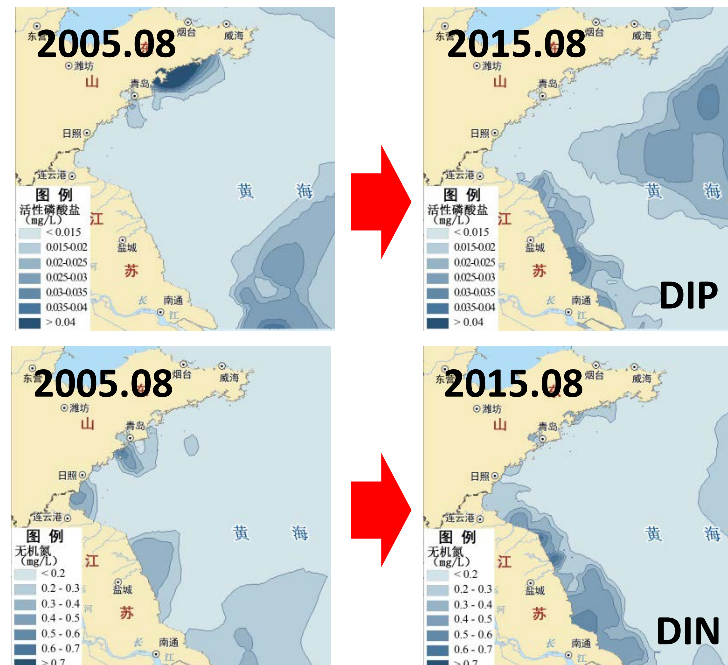
These 4 scenarios representing the low, relative low, modest and the highest emission scenarios. The wintering anchovy stock shows the obvious northward trend, reaching as much as to 2.5-2.7 degree in the next 30 years.

- **Time-series monitoring and scientific research are expected!**

2.2 Significant shifts of nutrient distribution and sources

- **2.2.1 Nutrient contents and distribution shifts**
  - P-limited eutrophication: N:P ratio = (18-22):1
  - Varied distribution pattern in the bottom water of south YS





(*Source: NMEMC*)

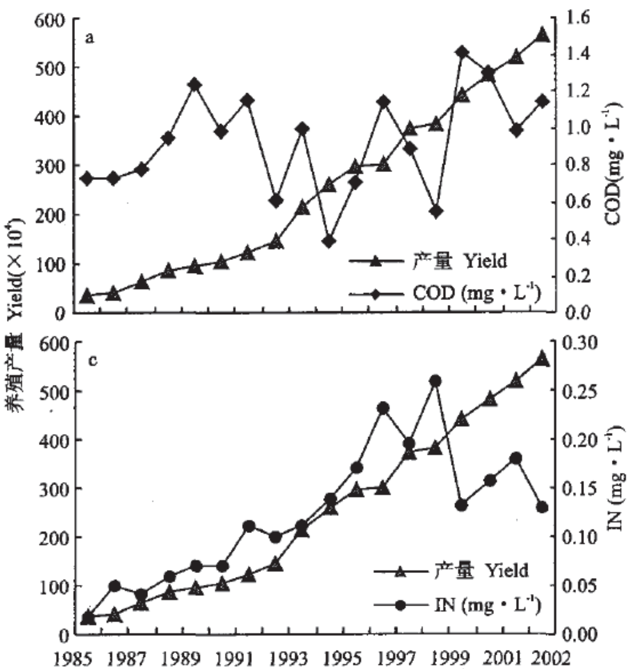
2.2.2 Transboundary input of nutrients by Green Tide

- **Amounts of transboundary nutrient inputs**
  - In 2012, total amount of 4 million tons of *Enteromorpha Prolifera* containing **22500 tons of nitrogen and 400 tons of phosphorus** were transported from Changjiang Estuary to south YS.
- **Effects on the nitrogen contents in seawater**
  - The macro algae completely decomposed within 80 days, leading to the contents of organic nitrogen increased from **25%** to **>90%** of the total nitrogen in bottom seawater of south YS.

Nutrient inputs for YS (1000 t/yr)			literature
Source	N	P	
Transboundary inputs by Green Tide	22.5	0.40	*L. Xing et al, 2013*
Inputs from Direct Discharge Outlets	9.96	0.25	*China Marine Ecological Environment Bulletin, 2017-2018*
Inputs from Yellow River	21.1	1.81	

2.2.3 Increased input of nutrients from mariculture

- **Increased contribution** of nutrients by increased yields
- **Main components:** particulate nutrients (mostly organics)



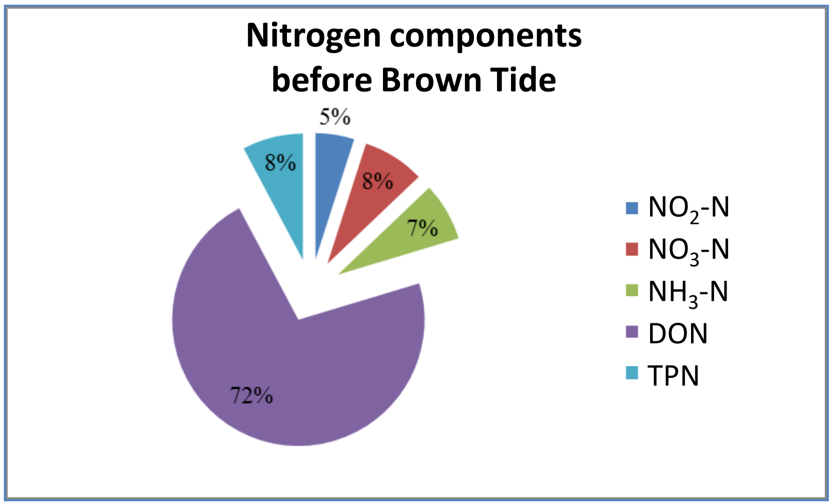
(*Source: Y. Cui, et al, 2005*)

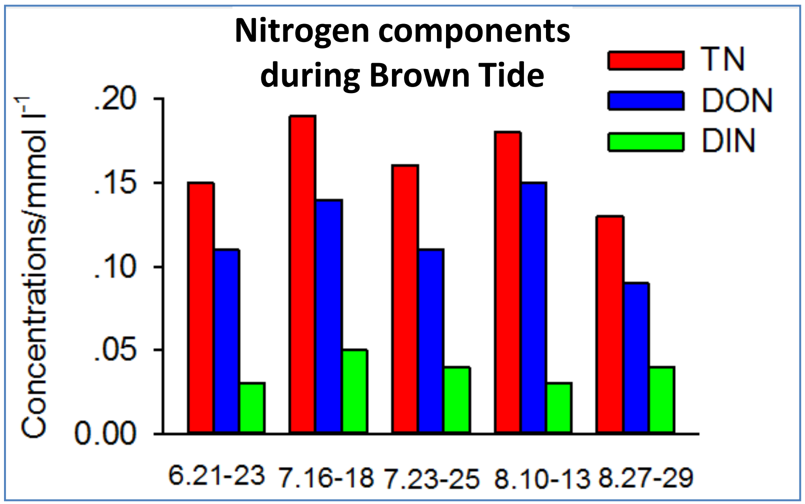
Distribution of mariculture areas by RS

Nutrient inputs (t/yr)		Mari-culture	Land-based inputs
Particulate	TPN	2517	2991
	TPP	1304	712
Dissolved	DIN	1516	5025
	DIP	91	902
	DON	219	937
	DOP	18	679
	TDN	1735	5962
	TDP	109	1581
Total	TN	4252	8953
	TP	1413	2293

(*Source: X. Yuan et al, 2015*)

- **Monitoring and research gaps for organic nutrients**
  - Organic nitrogen: key factor inducing the outbreak of pico-plankton blooms (*Aureococcus anophagefferens*) in YS and BS since 2009.
  - Organic nutrients are neither included in the *National Seawater Quality Criteria of China*, nor included in annually monitoring projects. Related researches were also rare.

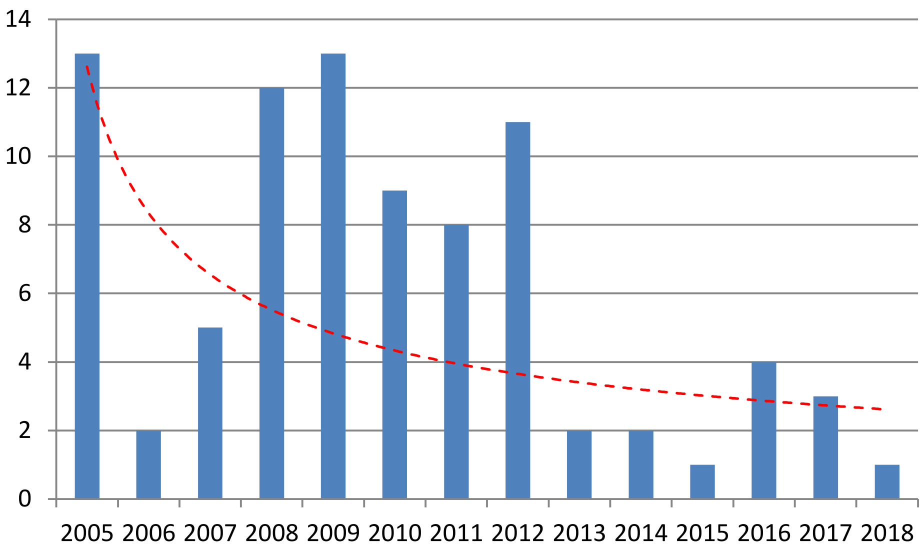


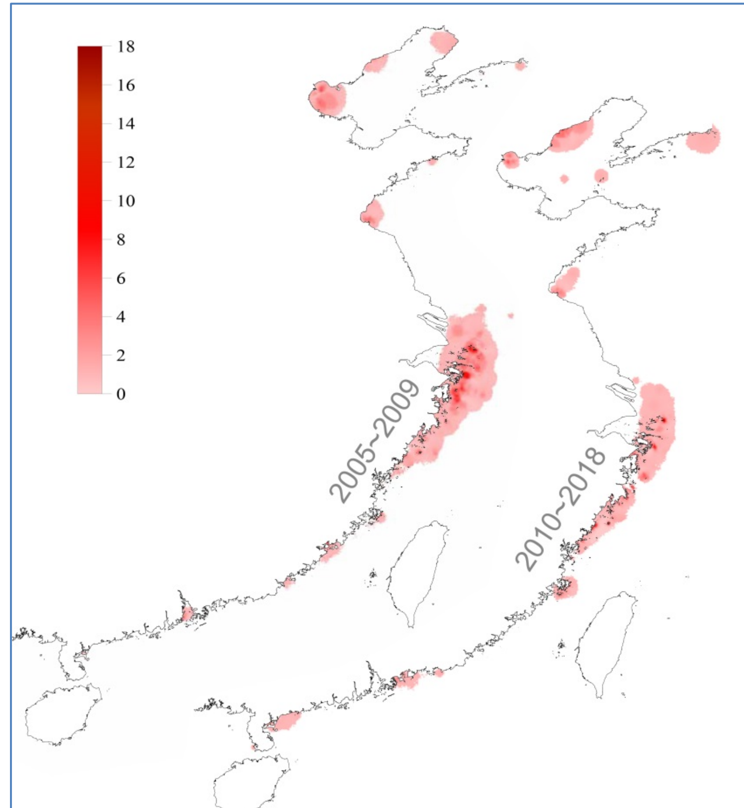


(*Source: S. Lv et al, 2013*)

2.3 Multiple threats of plankton blooms to YSLME

- **2.3.1 Decline of Red Tide events, with increased proportion of toxic species**
  - Decline of Red Tide events, mainly found in estuaries and bays.

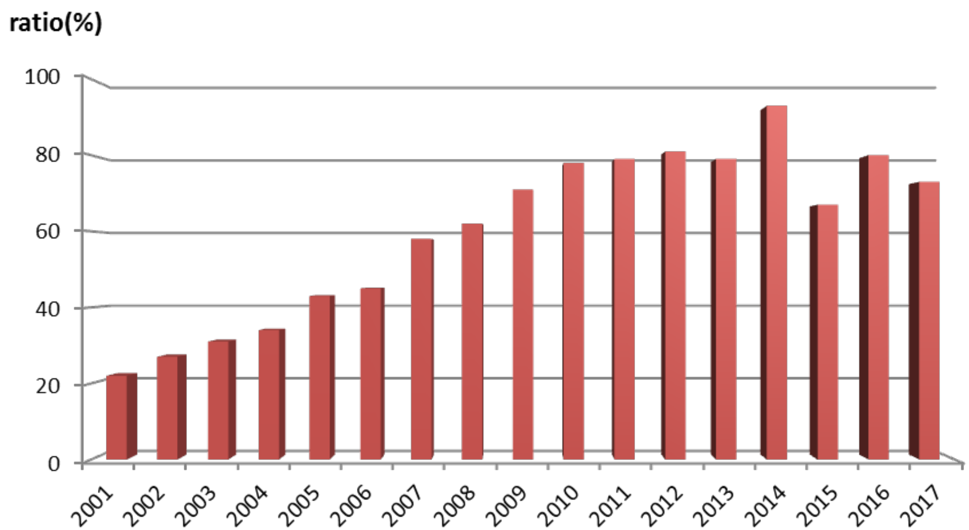




Distribution of HAB events (2005-2018)

- # 2.3.1 Decline of Red Tide events, with increased proportion of toxic species

  - Increased proportion of HABs caused by toxic species



Proportion of HABs caused by *Dinoflagellate* and *Flagellates Pigmentosa* in China’s coastal area□ 2001-2017□

表 1　黄海近岸海域麻痹性贝类毒素调查结果统计

Tab.1　Statistics of the investigation results of PSP in the coastal waters of the Yellow Sea

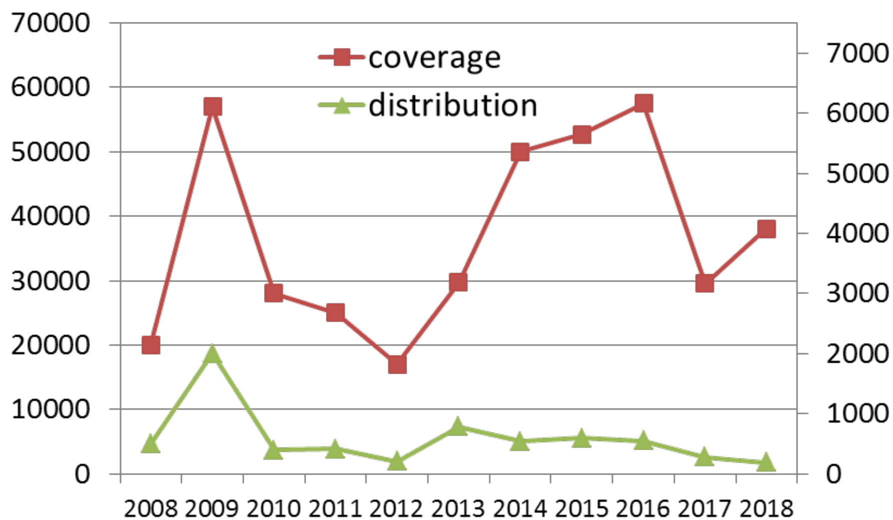
海域	年份	样本数(个)	检出率(%)	超标率(%)	最高含量 (μg/kg)	参考文献
青岛	1994—1996	805	0	0	0	李伟才等, 2000
烟台	1995—1997	429	0.2	0	0	李伟才等, 2000
大连、青岛、[illegible]等	1996	10	0	0	100	林燕棠等, 2001
	1999	16	8	0	460	林燕棠等, 2001
连云港	1996—1997	23	4.3	0	70	Zhou *et al*, 1999
黄海近岸	1997	18	5.5	5.5	1152	关春江等, 1999
烟台	1997	21	9.5	4.7	1330	Zhou *et al*, 1999
黄渤	2003—2005	97	6.1	2.1	801	孔凡洲等, 2007
大连黄海	2003—2004	14	57.1	7.1	3314	江天久等, 2007
连云港	2004	8	100	100	220000	林祥田等, 2005
大连黄海	2007—2008	72	70.8	26.3	65140	夏远征等, 2010
大连大窑湾*	2007—2008	24	100	33.3	5628	韩华等, 2012
大连大窑湾	2007—2008	24	75	25	1847	韩华等, 2012
北黄海**	2007—2008	4	100	100	8430	Li *et al*, 2012a
大连	2007—2008	54		48.1	2041	宋普江等, 2011
大连	2007—2008	21	90.5	47.6	4291	杜克梅等, 2013a
江苏	2007—2008	21	0	0	0	杜克梅等, 2013a
山东蓬莱	2007—2008	19	5.3	0	277	杜克梅等, 2013a
北黄海*	2006—2008	120	45.8	4.2	1138	梁玉波, 2012
北黄海	2006—2008	120	35.8	3.3	1139	梁玉波, 2012
南黄海*	2006—2008	122	26.2	4.9	1567	梁玉波, 2012
南黄海	2006—2008	122	0.8	0.8	341	梁玉波, 2012
北黄海*	2013—2015	273	74	21.2	98996	本文
南黄海*	2013—2015	100	64	17	453154	本文
平均值			38.2	18.8	36300	

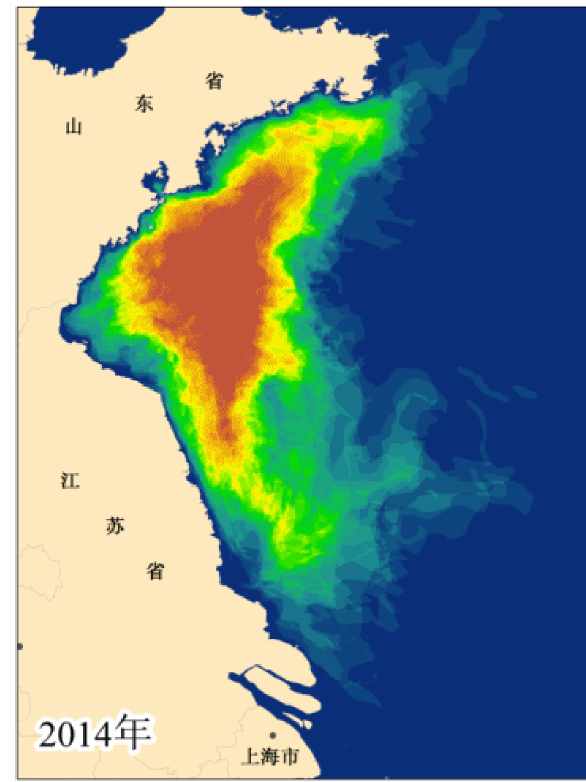
注: *为液相色谱法, **为液相色谱-质谱法, 其他为小鼠生物法

Reported algae toxins in YS region (1994-2005)

2.3.2 Macroalgae bloom with widening spatio-temporal scope

- **Green Tide bloomed continuously since 2008**
  - Species: *Enteromorpha Prolifera*
  - Time: April to August
  - Spatial distribution□ Mainly in coastal area
  - Transportation□ south → north





- **Golden Tide (*Sargassum*) bloom lasted all year long**
  - Time: Oct. 2016 to Nov. 2018
  - Spatial distribution□ From offshore to coastal area
  - Transportation□ north → south

April to June 2017, co-occurrence of green tide, golden tide, and red tides

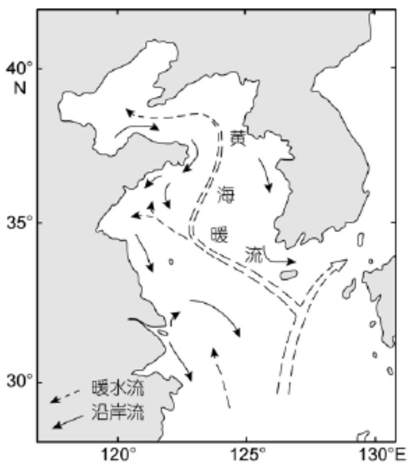
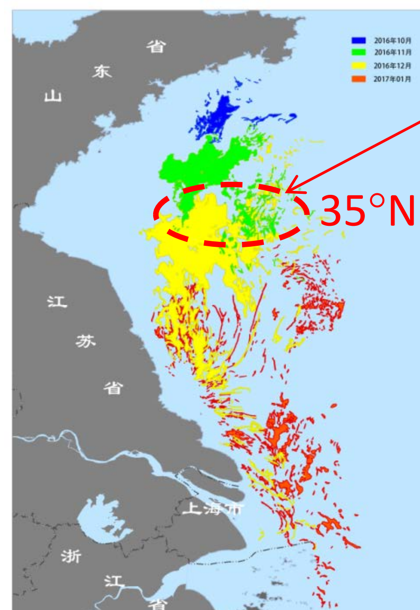
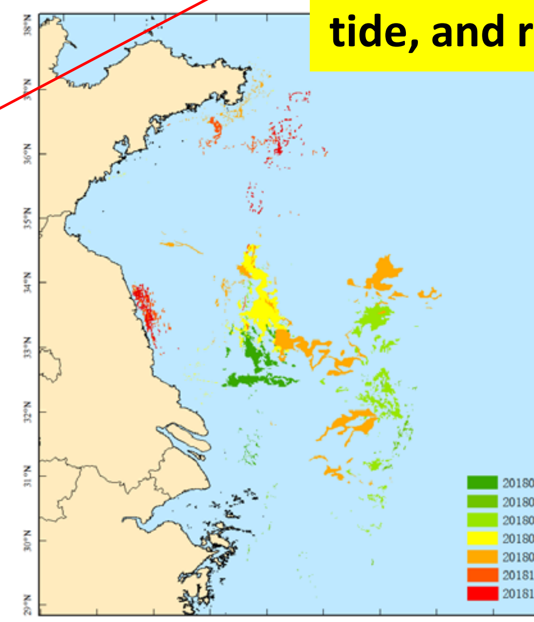


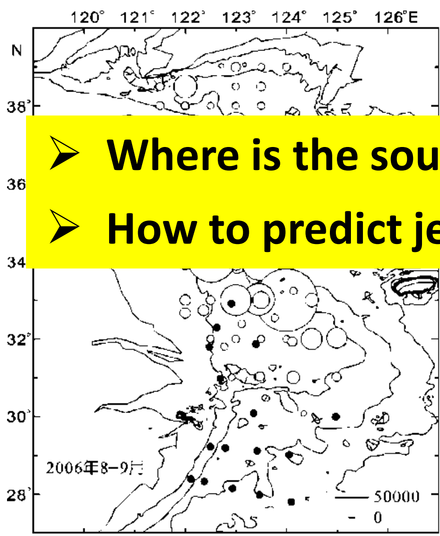
图 3 黄、东海冬季海流分布(彭承基, 1986)
Fig.3 The ocean current in the winter at the Yellow and East China Seas



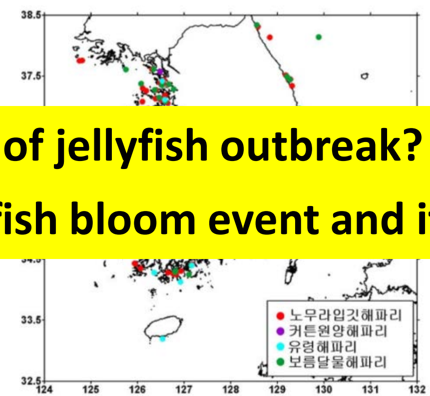


2.3.3 Jellyfish bloom from episodically to continuously

- **Jellyfish bloomed continuously from 2003 to 2009**
  - Dominant species: *N. nomurai* and *A. aurita*. *N. nomurai*
  - Time: episodically in 1920, 1950 and 1995 (Kawahara et al., 2006), and continuously in 2003-2009 (Yoon et al., 2014)
  - Spatial distribution: appearance all over the YS region

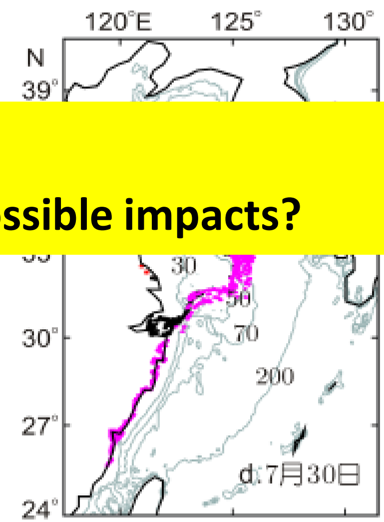


Distributions(kg/km^2) of *N. nomurai* in the Yellow Sea and East China Sea



Jellyfish appearance in Korean waters in August of 2007

(*Source: NIFS, 2017*)

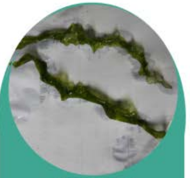


(*Source: X. Luo, 2012*)

- ➢ **Where is the source of jellyfish outbreak?**
- ➢ **How to predict jellyfish bloom event and its possible impacts?**

High risks of plankton bloom to seawater utilization engineering May to Sept.

Macroalgae bloom



缘管浒苔（*Enteromorpha linza*）

俗名：绿菜，长石莼

形态特征：高10-30cm，最高可达90cm。不分枝，披针形、线形或倒卵形，形状变化很大，并常呈螺旋状扭曲，边缘具波皱，基部逐渐变细，形成明显的柄部。

生态习性：生长在海湾内潮间带的岩石上或石沼中。

缘管浒苔风险月份			
5月	6月	7月	8月

孔石莼（*Ulva pertusa*）

俗名：海菠菜

形态特征：株高10～40cm。卵形、椭圆形、圆形和披针形，叶片上有形状和大小不一的孔，叶边缘略有皱褶或呈波状，叶基部有盘状固着器，但无柄。

生态习性：生长在海湾内中、低潮带的岩石上。

孔石莼风险月份				
5月	6月	7月	8月	9月

点叶藻（*Punctaria latifolia*）

俗名：小海带

形态特征：长10~16cm，宽3~7cm。藻体呈披针形，顶端稍钝圆，基部为楔形或心脏形。柄短，固定器圆盘状。叶面上散布着暗褐色斑点。

生态习性：一般生长于低潮线附近岩石上或石沼内。

点叶藻风险月份	
4月	5月

萱藻（*Scytosiphon lomentaria*）

俗名：海麻线、骆驼毛、海通草

形态特征：高20~50cm，长可达1m以上。萱藻藻体黄褐色至褐色，单条丛生，直立，管状，幼时中实，不久变为中空。

生态习性：生长于中低潮带岩石或水潭里，系泛温性海藻。

萱藻风险月份		
4月	5月	6月

海蒿子（*Sargassum pallidum*）

俗名：小海带

形态特征：藻体一般高30~60cm，最高可达1m。藻体多年生,可区分为固着器、主干、分枝和藻叶几部分。有气囊，气囊生在末枝上，幼时为纺锤形或倒卵形，顶端有针状突起

生态习性：生长在低潮带石沼中或潮下带2~3米水深处的岩石上。

海蒿子风险月份
9月

Jellyfish bloom

海月水母（*Aurelia aurita*）

俗称：四眼海蜇

形态特征：直径约10~30cm。呈盘状，白色透明。胃部下有4个明显的马蹄状生殖腺。

危害特征：能够大量繁殖，并在短期内爆发。

打捞方法：利用海蜇网在取水口处进行围网打捞。

海月水母风险月份			
5月	6月	7月	8月

沙海蜇（*Nemopilema nomurai*）

俗名：沙蜇

形态特征：成体伞径25~60cm，最大近1m。外伞表面光滑，中胶层厚而硬。

危害特征：沙蜇体质厚而硬，应急打捞不易破碎。

打捞方法：利用海蜇网在取水口处进行围网打捞。

沙海蜇风险月份			
5月	6月	7月	8月

白色霞水母（*Cyanea nozakii*）

俗名：白蜇

形态特征：成体伞径20-30cm，大型个体超过50cm。伞呈半球形，外伞表面光滑，中胶层厚而硬，尤以中央更厚。

危害特征：由于生物量较低危害较小，但应注意其毒性。

打捞方法：利用海蜇网在取水口处进行围网打捞。

白色霞水母风险月份			
5月	6月	7月	8月

海蜇（*Rhopilema esculentum*）

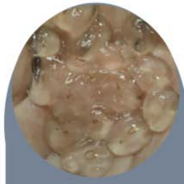
俗名：绵蜇

形态特征：成体伞径一般在25-100cm。成体伞呈半球形，外伞表面光滑，中胶层厚而硬，尤以中央更厚。

危害特征：能够大量繁殖，并在短期内爆发。

打捞方法：红沿河周边海域暴发的可能性较低。

海蜇风险月份		
6月	7月	8月



球型侧腕水母（*Pleurobrachia globosa*）

俗称：水豆子

形态特征：水母个体高约7~12mm，宽约5~10mm，具有很强的发光能力。

危害特征：能够大量繁殖，并在短期内爆发；但易破碎，风险性低。

打捞方法：利用毛虾网在取水口处进行围网打捞。

球型侧腕水母风险月份		
5月	6月	9月

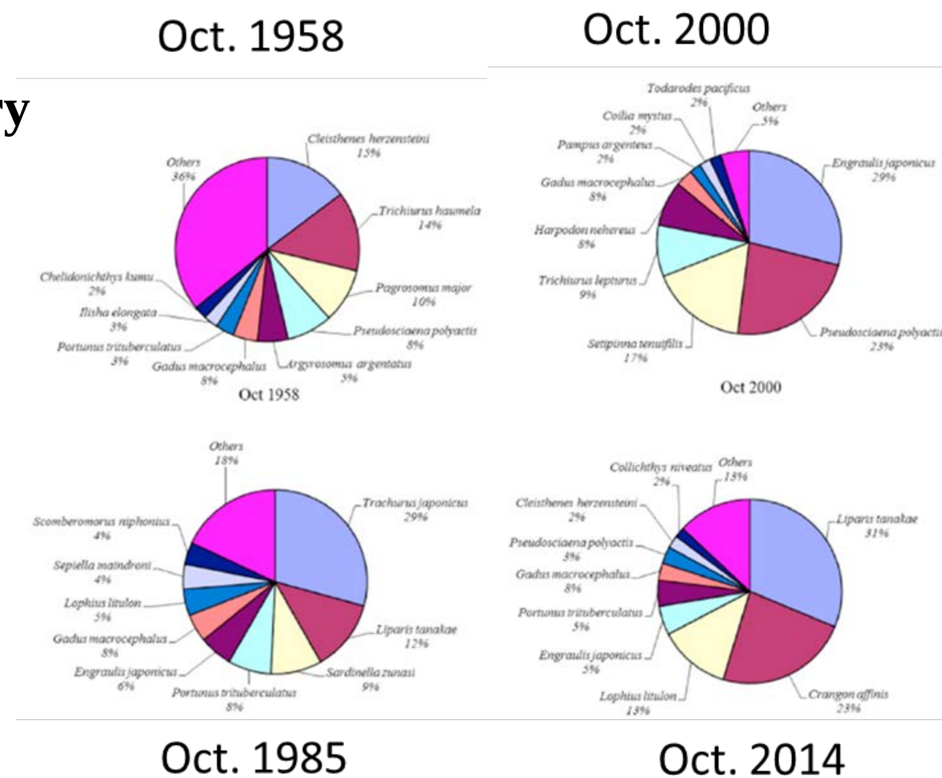
2.4 Multiple pressures on sustainable fishery

- **2.4.1 Changes in fishery species composition and trophic level**

Two different species shift of fishery species composition in the YS

– 1) from demersal, high-valued species to pelagic, low-valued species during 1958 - 2000

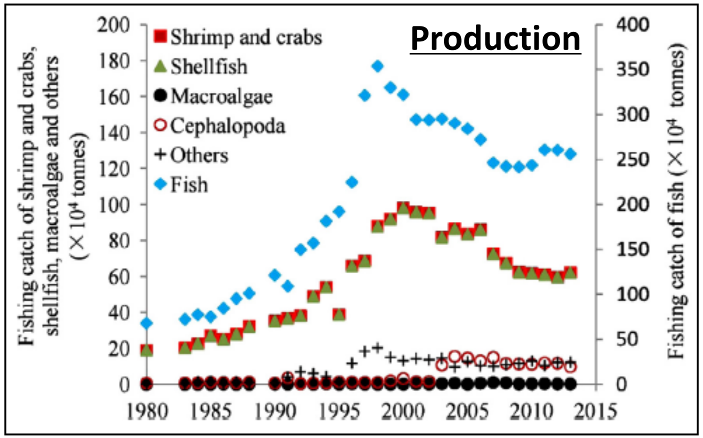
– 2) from pelagic, low-valued species to demersal, low-valued species since 2000

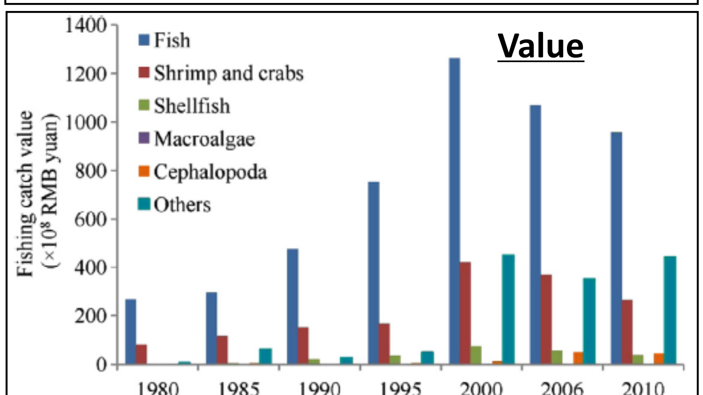


(Source: Q. Wu, 2019)

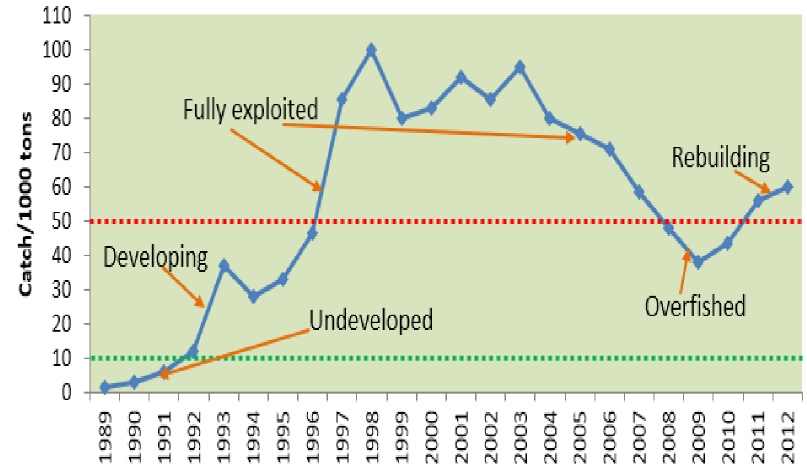
2.4.2 Impacts of overfishing down the food chain

- Declined fishing catch production, with declined catch value





- Production of low-valued fish also downscaled greatly

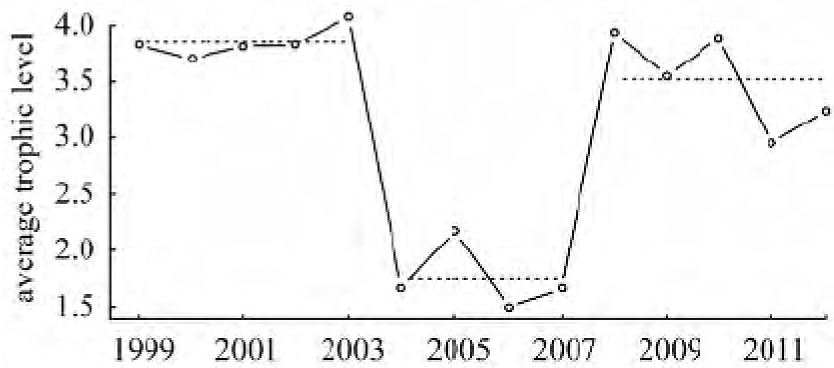


Production of Anchovy in YS Based on catch data
(*Source: Steven Martell et al, 2013*)

(*Source: Q. Wang et al, 2016*)

2.4.3 Impacts of plankton bloom on fishery trophic level

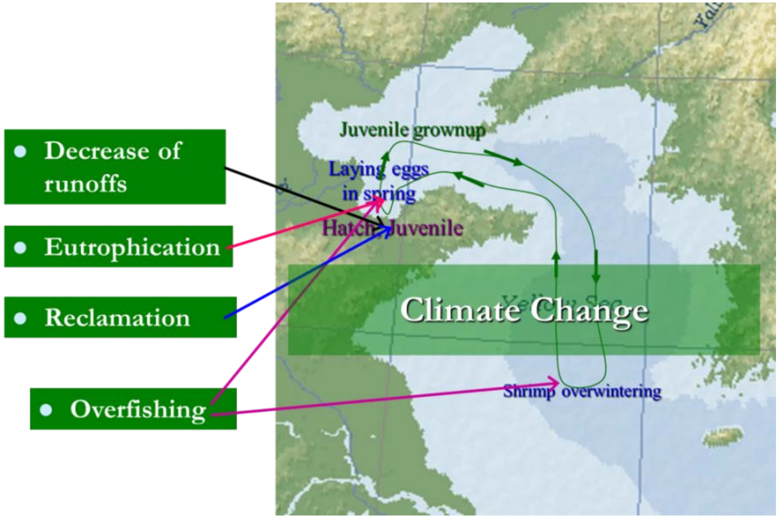
- **Declined trophic level of fishery species**: the living space of other species being squeezed out by jellyfish blooms
- **Heightened volatility** of fishery resource composition after jellyfish bloom
- Severe impacts on the **habitat environment** esp. for demersal and benthic species

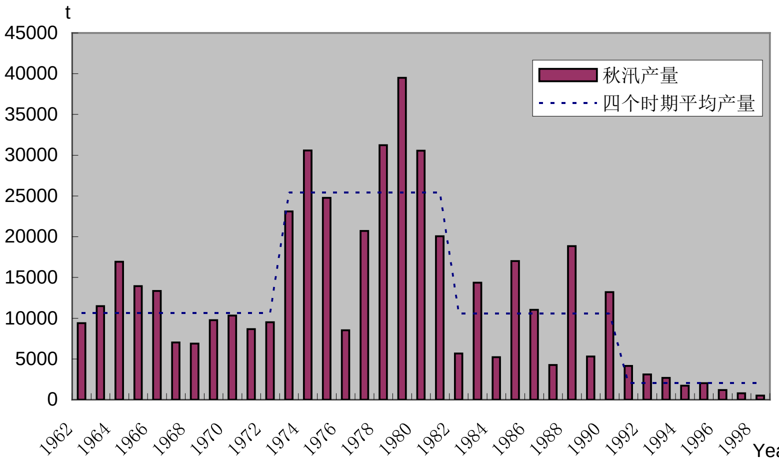


Time-series of average trophic levels of main fishery species in southern YS

(*Source: Y. Liu et al, 2015*)

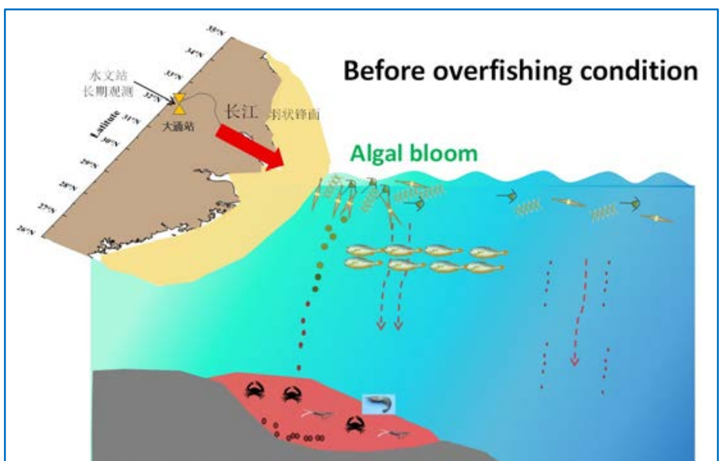
Production of prawn could not recover after 1990s because of multiple pressures

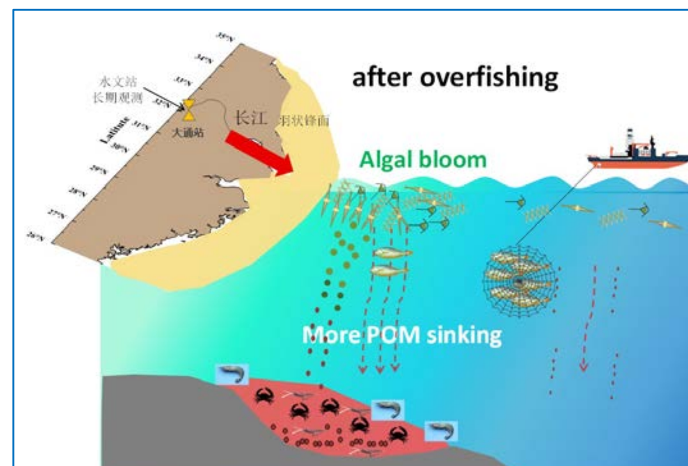




Time-series production of BS prawn

(*Source: J. Su et al, 2008*)





2.5 Degradation of wetlands for keystone species

- Coastal wetlands in the Yellow Sea are critical to the survival of many **migratory waterbird species**
- The nearshore waters in Yellow Sea are also critical habitats for the **marine mammals** (e.g. spotted seal, finless porpoise, whales)

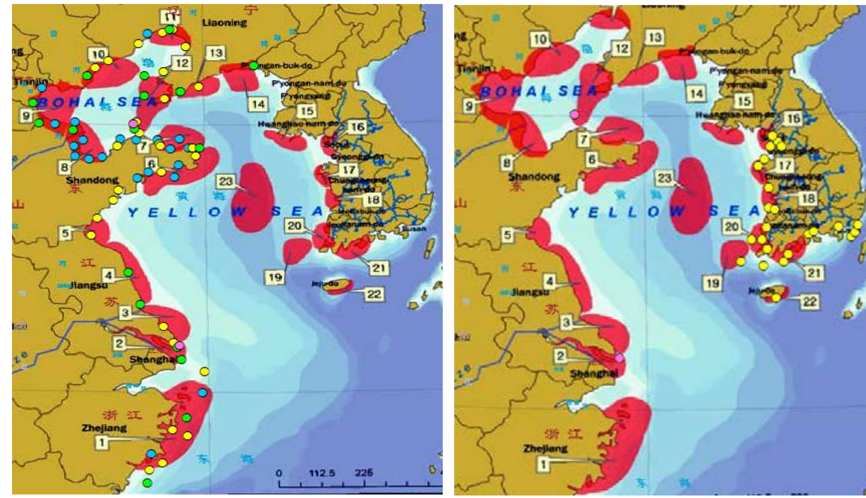
23 potential priority areas in the Yellow Sea Eco-region for keystone species and their habitats

- Marine mammals
- Migratory waterbirds
- Valuable fishes
- Mollusk
- Vegetation
- Algae…

(*Source: WWF, 2003*)

2.5.1 Defective MPA network

- Existing MPAs of China and Korea could not cover all the priority areas, esp. **nearshore waters**
- Some of the keystone species were not included as **protecting objects** of MPAs
- Lack of **ecosystem-based regional MPA network** weakened the protection efforts and results.



Spatial protection gaps in the Yellow Sea Eco-region
(*Source: WWF, 2003*)

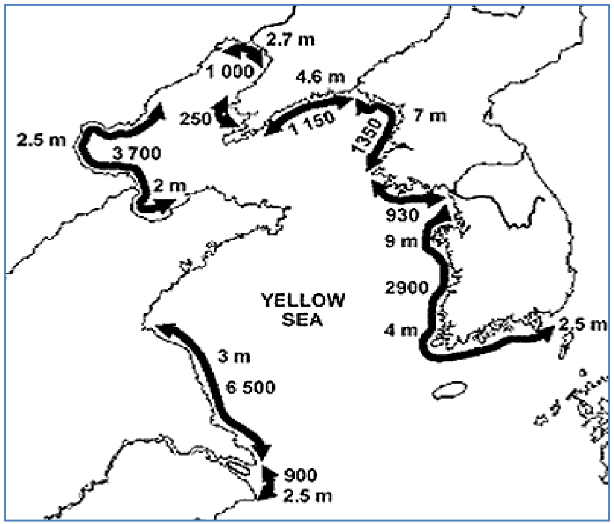
Summary of the status protection for the habitats of four shorebird categories

	Anatidae	Laridae	Waders	Stork and Crane
Protected	6	5	4	17
Unprotected	24	25	28	0

(*Source: Y. Liu et al, 2019*）

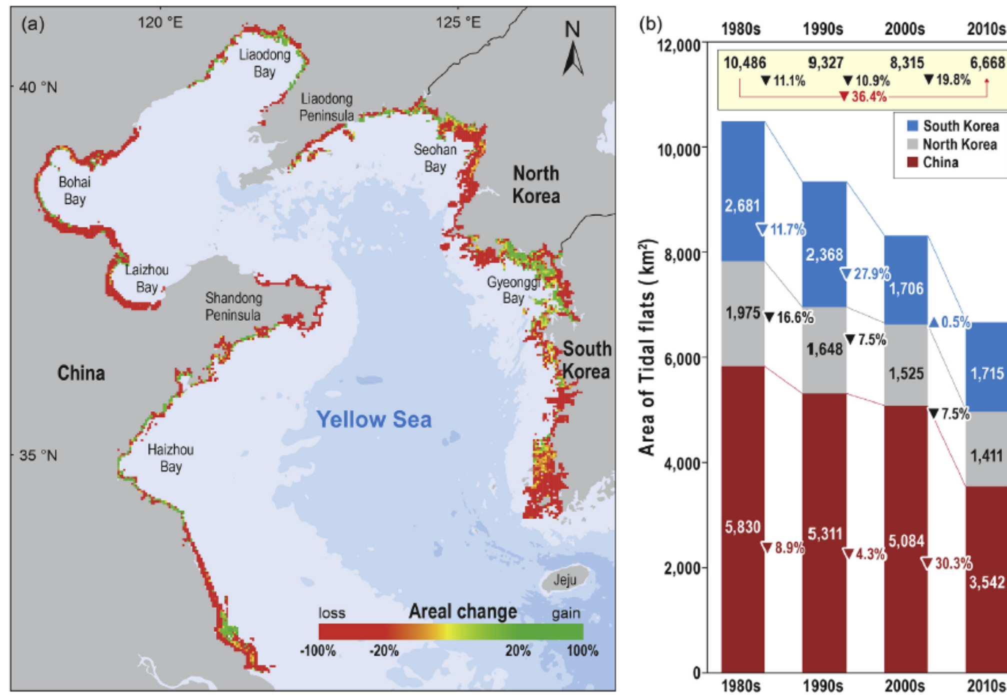
2.5.2 Loss of habitats by historical reclamation

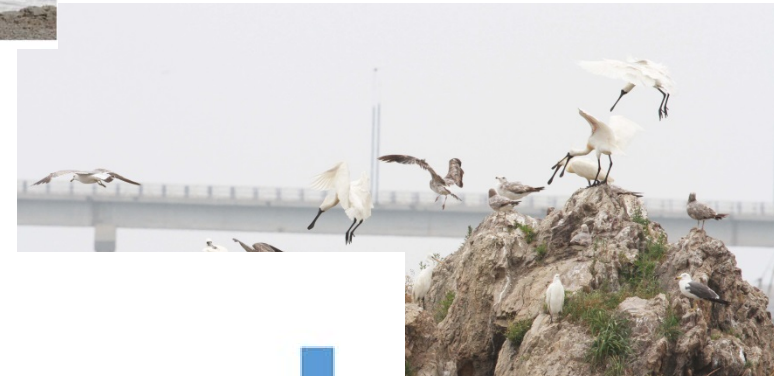
- Compared with 1980s, the Yellow Sea **lost 9700 km²** of the sea area, with **40%** of total natural tidal flats lost.

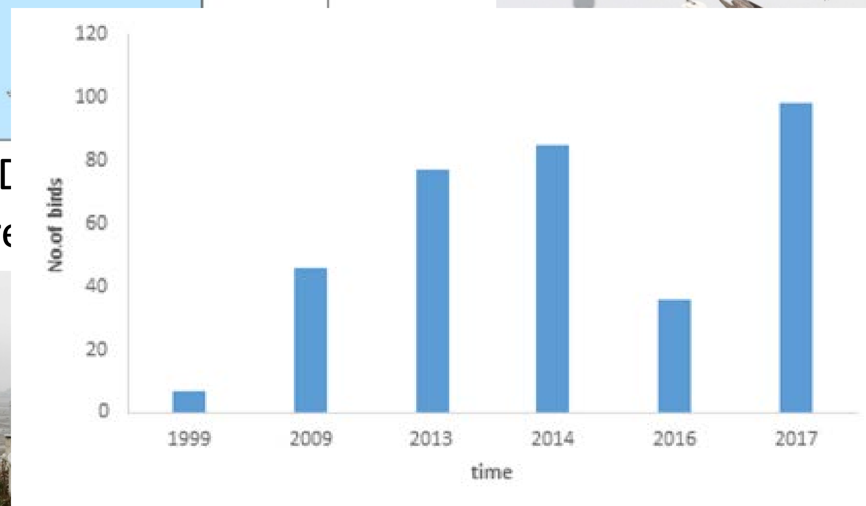


Tidal Mudflats on the Periphery of the Yellow Sea

(*Source: Jongseo Yim et al, 2018*)

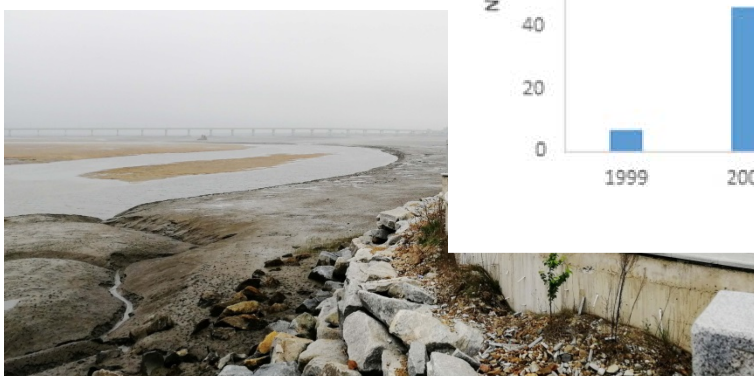






The location and range of D
Spoonbill Municipal Nature

bill and Chinese Egret
he estuary

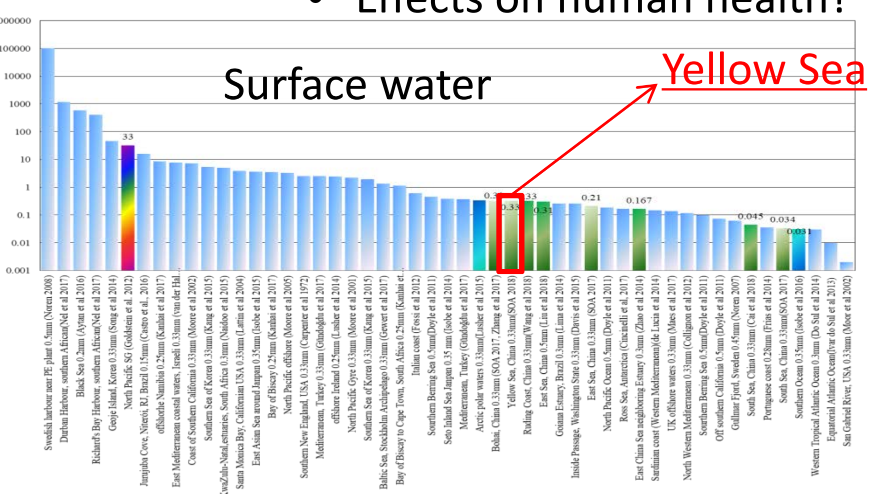


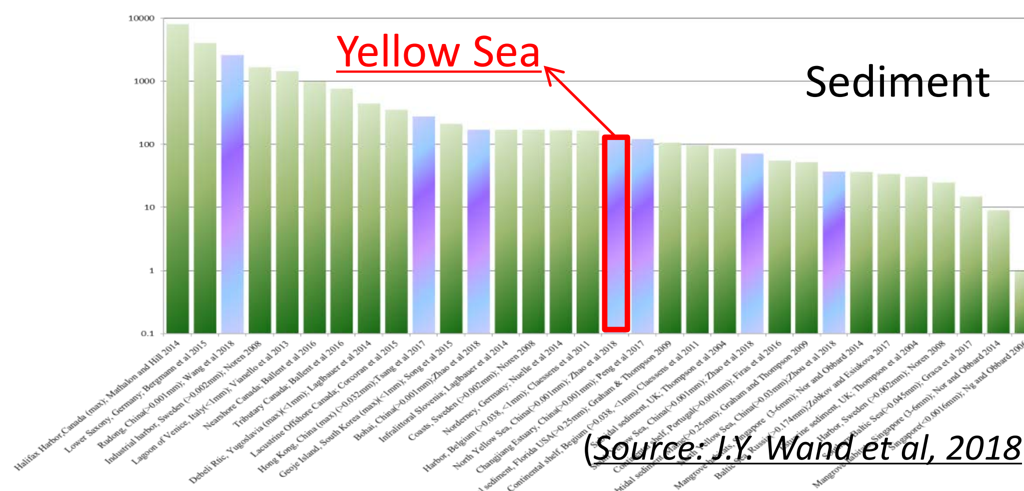
Reclamation and infrastructure around Zhuanghe estuary

Fishing business for leisure around Zhuanghe estuary

2.6 Emerging environmental issues and ecological risks

- **2.6.1 Marine microplastics**
  - Contents of MPs in the surface water and sediment of YS were relatively low, compared with other sea areas world wide
    - Source, transportation and distribution mechanism?
    - Total amount, density and composition?
    - Impacts on marine ecosystem?
    - Effects on human health?

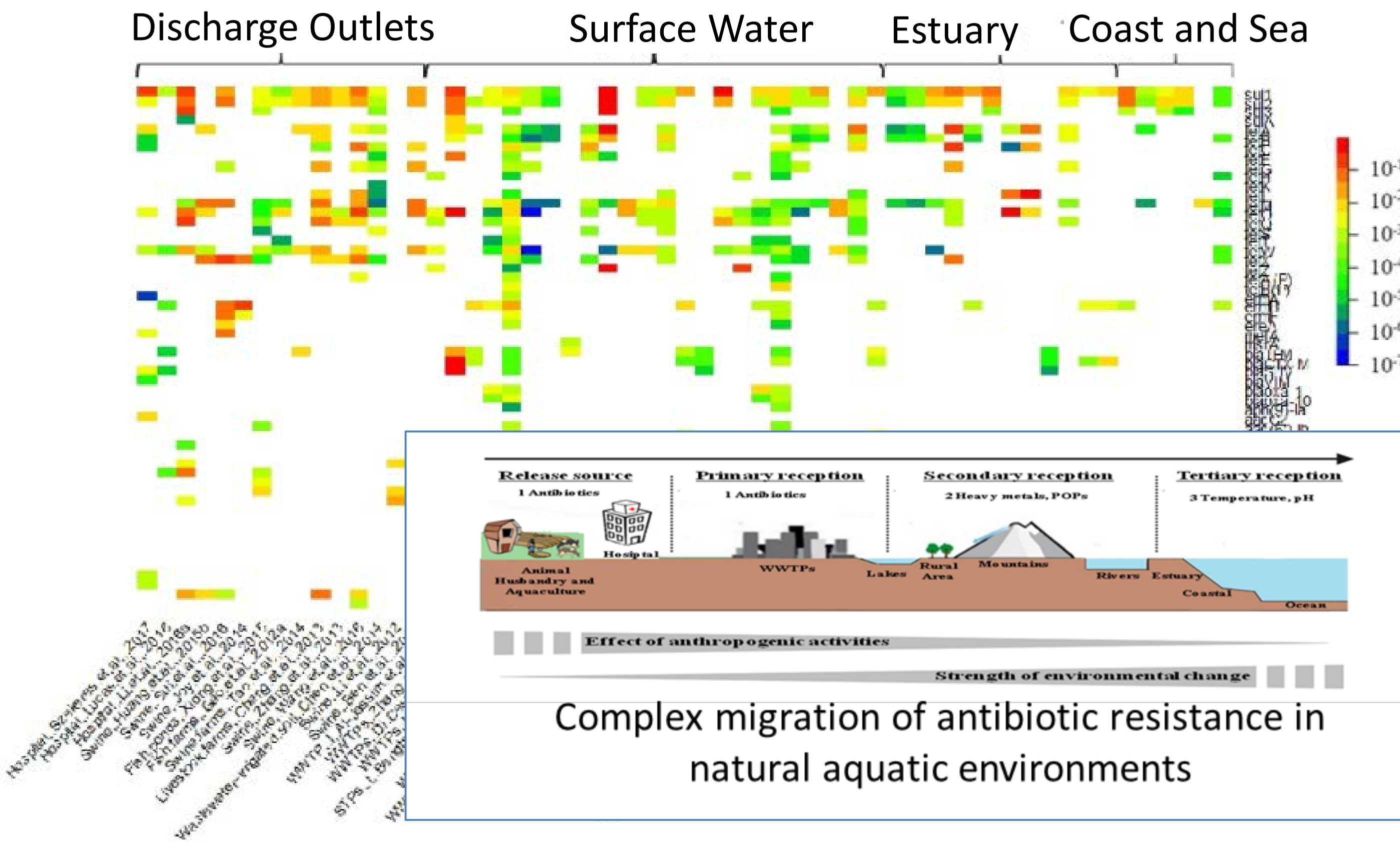




(*Source: J.Y. Wand et al, 2018*)

2.6.2 Antibiotics Resistance Genes (ARGs)

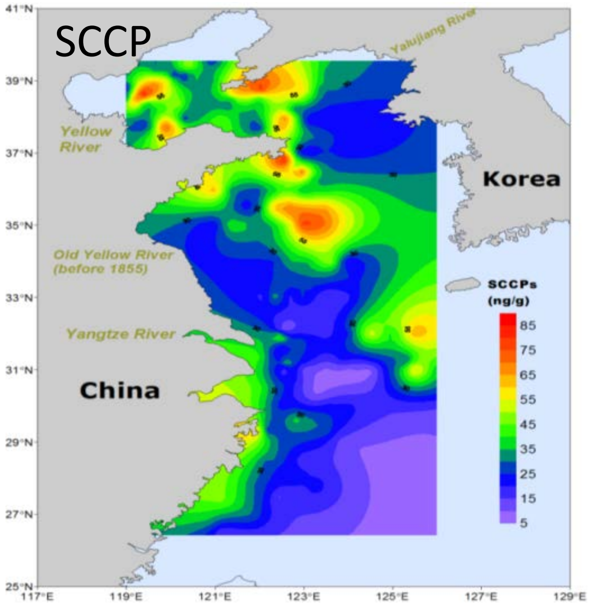
- High-risk of ARGs transported from ridge to reef



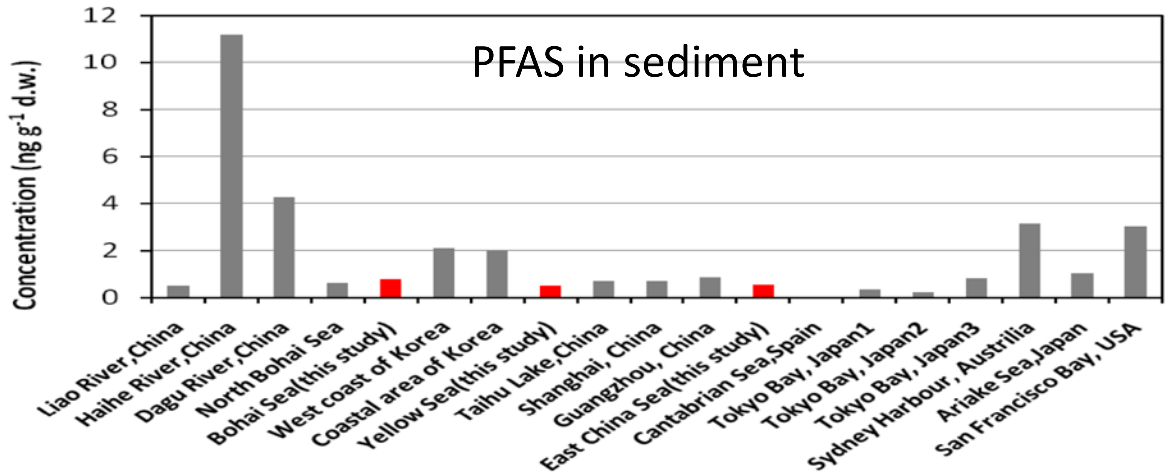
Complex migration of antibiotic resistance in natural aquatic environments

(*Source: H. Gao et al, 2018*)

2.6.3 Combined pollution from accumulating POPs



(*Source: L.X. Zeng et al, 2013*)

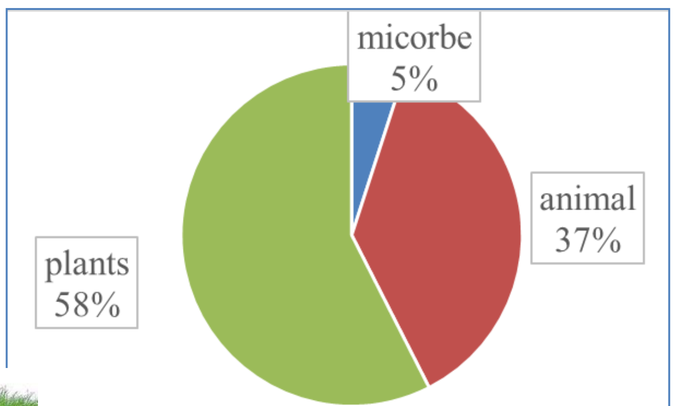


(*Source: Y. Wang et al, 2014*)

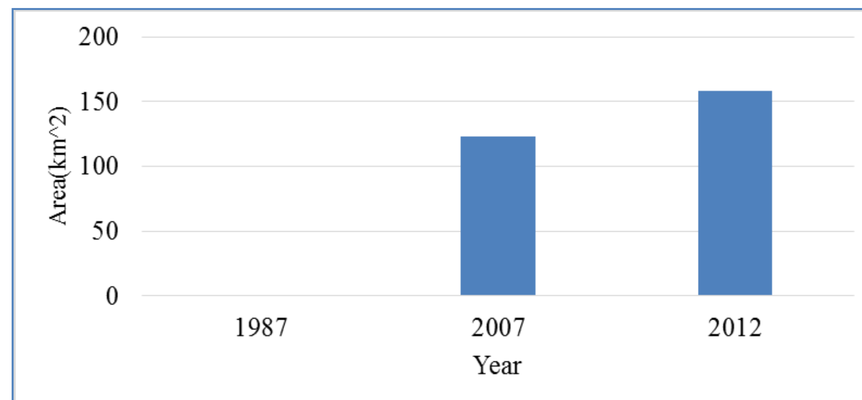
POPs	**PCBs、DDT…**
Emerging POPs	**PFOS, PFAS…**
Potential POPs	**SCCPs, HBCD, TBBPA, TBTs…**

2.6.4 Invasive species

- Research indicated the number of marine invasive species in YSLME was 120, in which, 6 species were microbes, 45 species were animals and 69 species were plants
- *S.alterniflora* spread extensively in the coast of China, especially in Jiangsu coastal wetland, resulting in significant impact on wetland ecosystem health and safety. In 2012, the expansion of *S.alterniflora* was still increasing, with an area of 153.8 km2.



Invasive species in YSLME



The area of *S.alterniflora* in Yancheng, Jiangsu

(*Source: G.X. Liao et al, 2019*)

Main Contents

- I. EBM for sustainable YSLME
- II. Main scientific issues on YSLME trends and threats
- III. Conclusions and Perspectives

3.1 New trends or threats to sustainable YSLME

Type of issue	TDA of YSLME phase I	New trends or threats
Pollution	Nitrogen enrichment, mainly caused by land-based inputs	Organic nitrogen enrichment, mainly caused by transboundary Green Tide
	Heavy metal, POPs, Marine litter	ARGs, Micro-plastics, emerging POPs
Ecosystem	Increased frequency of HABs	Decreased frequency of HABs, with increased proportion of toxic species; Widespread macroalgae and jellyfish blooms
fishery	Changes in fishery species composition and trophic level	Declined fishing catch production, with declined catch value, even for low-value species
	Unsustainable mariculture practices	Increased input of nutrients from mariculture
Biodiversity	Loss of benthic habitats, decline of endemic species	Loss of wetlands, degradation of habitats for prior species, defective MPA network
Climate change implications		**Increased risks related to climate change, such as acidification, coastline erosion and saline intrusion etc.**

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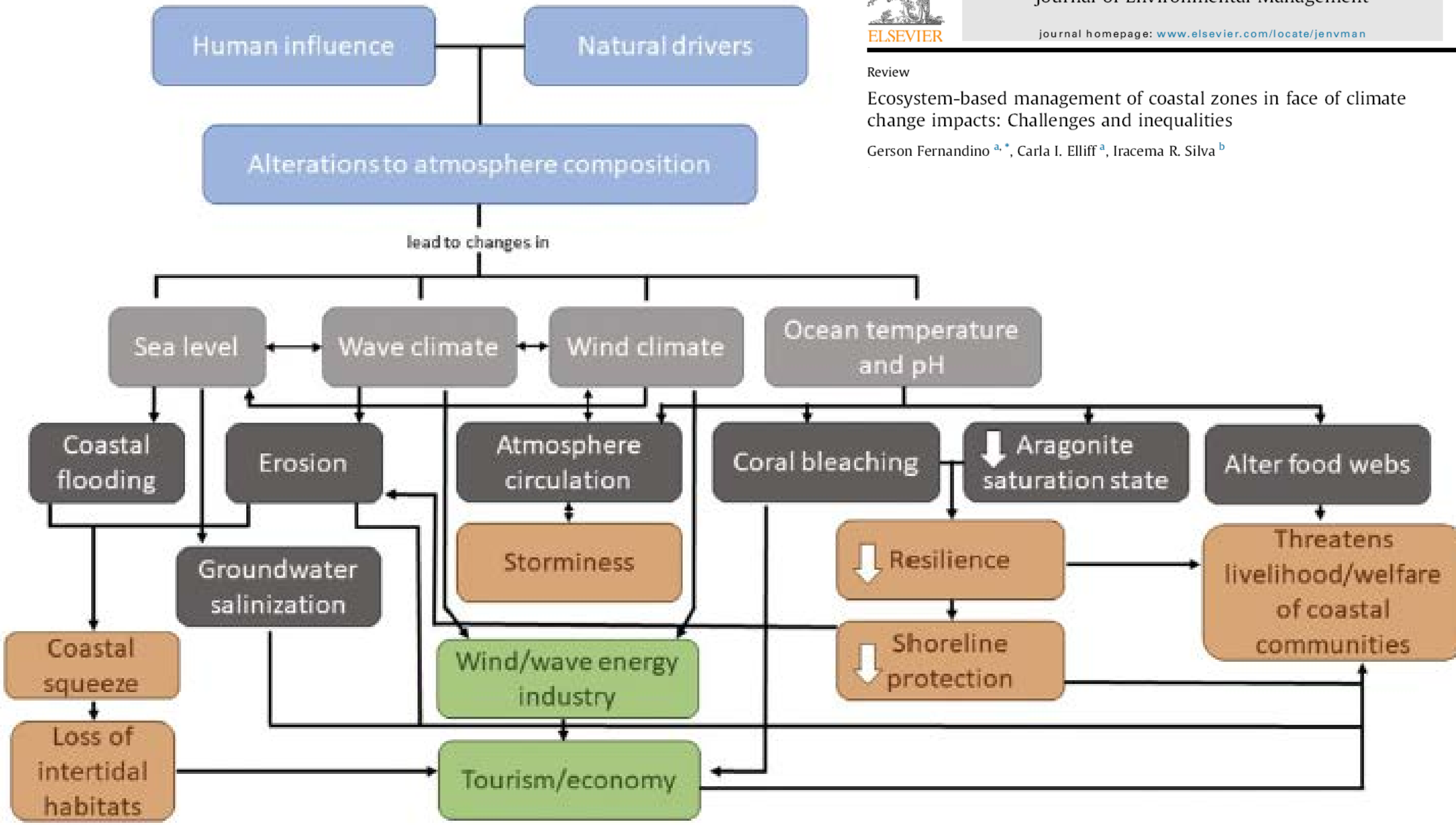
Review

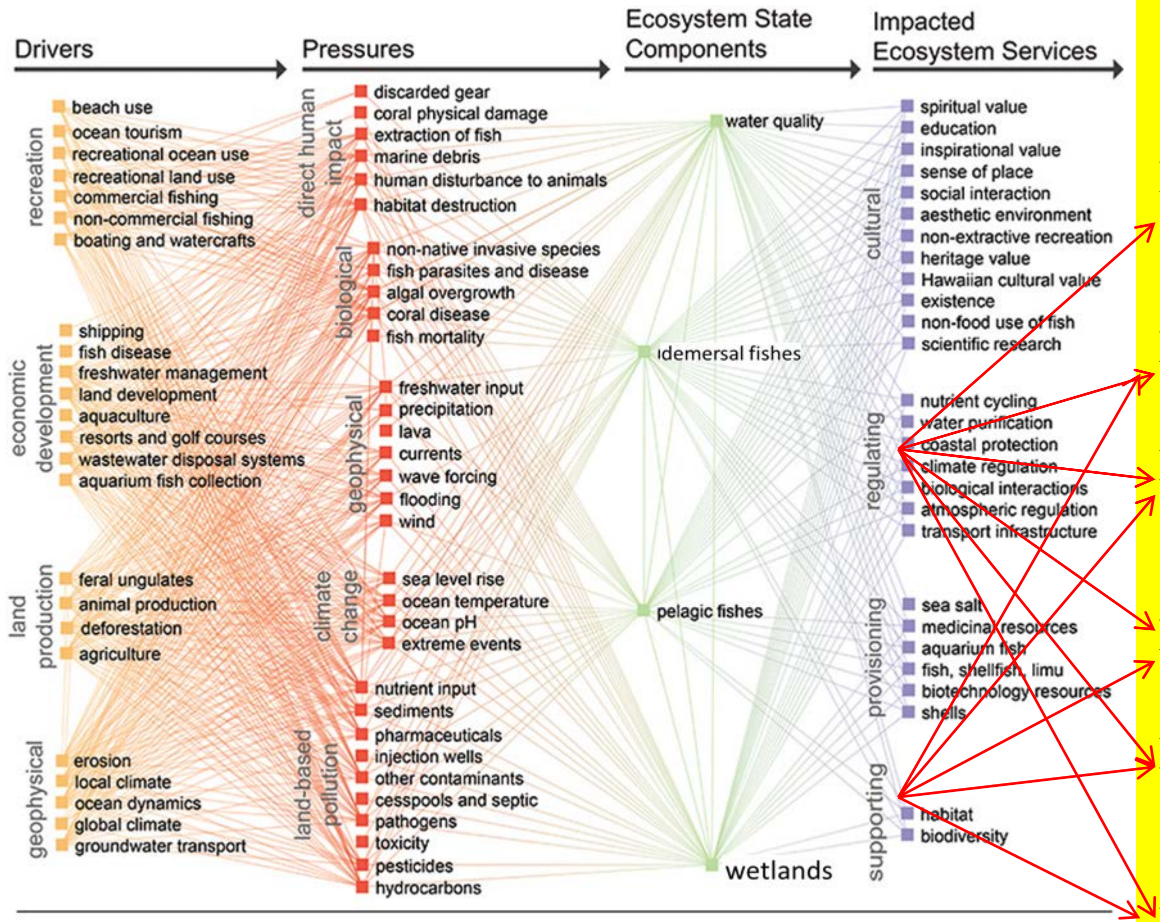
Ecosystem-based management of coastal zones in face of climate change impacts: Challenges and inequalities

Gerson Fernandino [a, *], Carla I. Elliff [a], Iracema R. Silva [b]



Comprehensive impacts of Climate Change and Human Influence

3.2 Perspectives for scientific research interests



(*Revised from Ingram et al, 2018*)

Proposed scientific research interests

- **Source, fate and impacts of organic nutrients, MPs, ARGs and other pollutants**
- **Prediction of trends and risks of multiple plankton blooms**
- **Restoration of spawning, nursing, feeding grounds and other habitats for keystone species**
- **Evaluation and protection of immaterial values of YSLME**
- **Understanding of comprehensive impacts of climate change and anthropogenic influences**
- **Adaptive management strategy**

Thanks for listening