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Assessment on the impacts of major threats to marine biodiversity in coastal area of Yantai and Dalian, China

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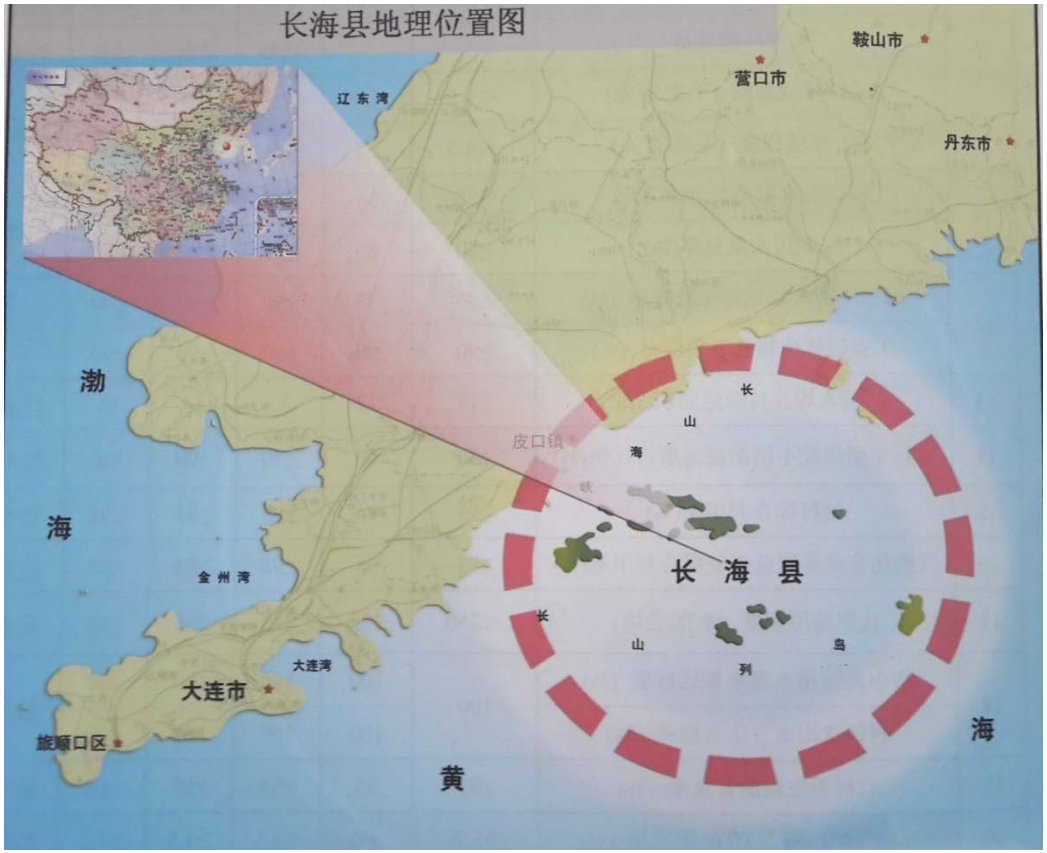
Contents

Introduction (Changhai County)

Located in the northern Yellow Sea offshore of the Liaodong Peninsula, Changhai County is consisted of >100 islands and reefs, with land area of 157 km^2, and governing 4 villages and 3 towns

- Sub-humid warm temperate continental monsoon climate separated four seasons and warm to cool temperatures, moderate rainfall, long frost-free period, strong wind and frequent foggy days
- Regular semi-diurnal tide
- 26126 households, 73000 people by the end of 2013



Introduction (Changhai County)

Changhai County is rich in natural resources as well as marine aquaculture products

Economicly important species: shrimp, globefish, flounder, sea cucumber, abalone, scallop, and ark clam, and others including conch, ark shell, oyster, sea urchin, shark, rock greenling, eel, algae, nori, and asparagus plants, of which the fan shell, butter clam and hard-shelled mussel are exclusively abundant in Changhai

Introduction (Changhai County)

- Mainstay industries include marine fishery, marine aquaculture, and processing and presentation of sea products, and tourism, of which the scale of marine aquaculture took up 70% of the total volume in Dalian City, thus made it one of the most important marine aquaculture ground in China

Introduction (Changhai County)

- Tourism industry in Changhai, now as one of the famous island tourism destinations in northern China, has seen great increase in the last decade
- The number of tourists reached 1.34 million, and the revenue exceeded RMB 1.12 billion in 2013

Introduction (Changhai County)

Local government attaches importance to marine resource protection. There are two marine protected areas and sewage treatment plants in Changhai county.

Introduction (Changdao County)

Located on the north east of Shandong Province between the Shandong Peninsula and Liaodong Peninsula, Changdao County is comprised of 32 islands across the Bohai Strait, with land area of 56 km^2 and sea area 8,700 km^2, and total coastline of 146.6 km

- Consists 2 towns and 8 villages, with population of 43,000 in 2013
- East-Asia warm temperate monsoon climate, with maritime climate in summer and continental climate in winter
- Regular semi-diurnal tide, with tide ebbs and flows twice a day of nearly the same height

Introduction (Changdao County)

Changdao archipelago is surrounded by open waters where many migratory fish species passing through, and thus make it one of the most important passing fishing ground in northern China. Marine fishery, marine aquaculture, and processing and presentation of sea products are three mainstay industries in Changdao County, where scallop, sea cucumber, abalone, shrimp, and many fish species, like blue mackerel, ribbonfish, small yellow croaker, flounder, and flatfish are produced in a great amount.

Other aquatic resources are also abundant in this area, like certain shrimps including sand pink shrimp and mantis shrimp, and cephalopods as baby squid (*Loligo japonica*) which is the primary prey for spotted seals (*Phoca largha*).

Introduction (Changdao County)

Located between Yellow Sea and Bohai Sea and comprised of 32 islands, Changdao County is a natural marine garden where islands, land and sea water are gathered together to develop a special natural and cultural scenic site, which has been listed as one of the National Park of China in 1988. Changdao County is an attracting place for tourists for its appealing climate, comfortable sunshine, sand, sea water, and seafood, as well as multiple national protected areas for seal, seagull, migration birds, and forests. The number of tourists reached 2.62 million and tourism value arrived at 2.71 billion RMB in 2013.

Introduction (Changdao County)

Changdao county attaches great importance to environmental protection.

Garbage is transported to Yantai City for processing after compression. There are underground sewage treatment plants in scenic spots.

Major threats and their changes

1. **Eutrophication**
2. **Non-indigenous species**
3. **Habitat alteration**

Data source

Changhai County, Dalian City

Liaoning Statistical Yearbook series (2004-2013)
Dalian Statistical Yearbook series (2004-2013)
Changhai Statistical Yearbook series (2004-2013)
Bulletin of Marine Environmental Quality of Dalian (2004-2013)
Report of Marine Environmental Quality of Changhai (2004-2013)
Annual Report of Environment Monitoring of Changhai (2004-2013)
Statistical Communique of Changhai on the Economic and Social Development (2004-2013)
Phytoplankton in nature reserve for precious sea food in Hedatuozi, Changhai County (1994)
Quantitative distribution and seasonal change of phytoplankton in Changhai waters (1995)
Report on the integrated investigation of nature reserve for precious marine species in Changhai, Dalian (1998)
Assessment of Changhai County Island sustainable development (2011)
The variation in species composition, and density of phytoplankton in the ranched northwest coast in Changhai County, Liaoning Province, China (2012)

Changdao County, Yantai City

Shandaong Statistical Yearbook series (2003-2013)
Statistical Yearbook of Yantai series (2003-2013)
Changdao Statistical Yearbook series (2003-2013)
Bulletin of Marine Environmental Quality of Yantai (2003-2013)
Statistical Communique of Changdao on the Economic and Social Development (2003-2013)
Report on the investigation of Changdao Spotted Seal National Nature Reserve (2004)
Evaluation on ecosystem service value of coastal zone for three island towns in northern Miaodao Archipelago (2009)
The ecological study of macrobenthos in the waters around Changdao islands (2014)
Biodiversity of macrofauna in the southern waters of Miaodao Archipelago, China (2015)
Statistical data from the official webpage of Changdao County: http://www.changdao.gov.cn

Major threats and their changes

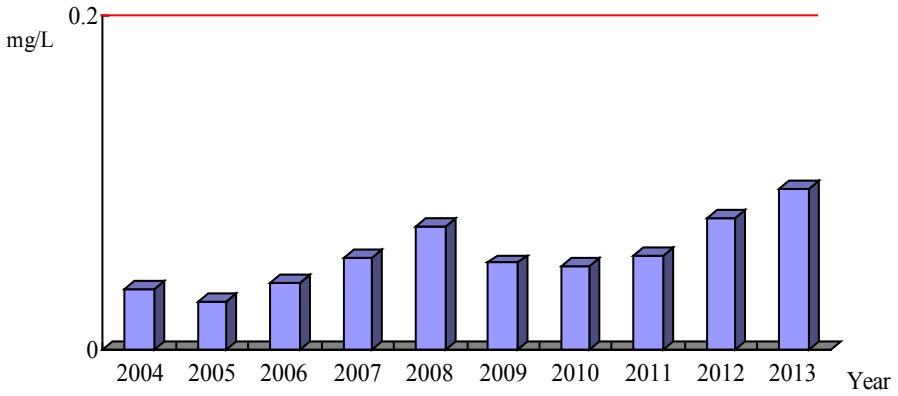
1 Eutrophication

Changhai County

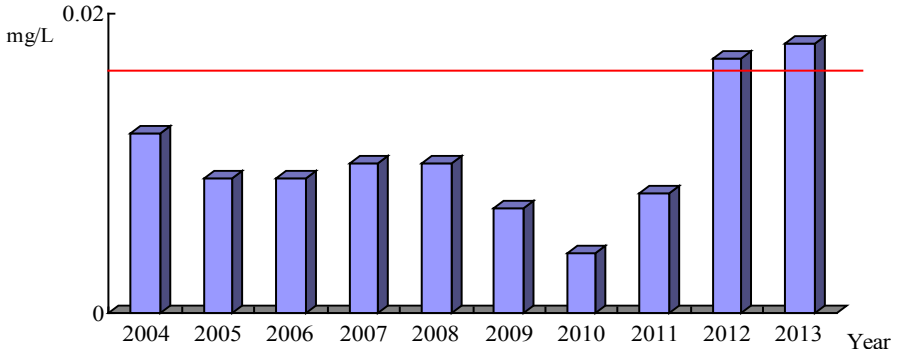
Direct indicators: DIN, AP

Indirect indicators: Population, Usage of fertilization, Waste water discharge

Indicators on impact: SS, COD, DO, Oil



DIN concentration in Changhai waters



AP concentration in Changhai waters

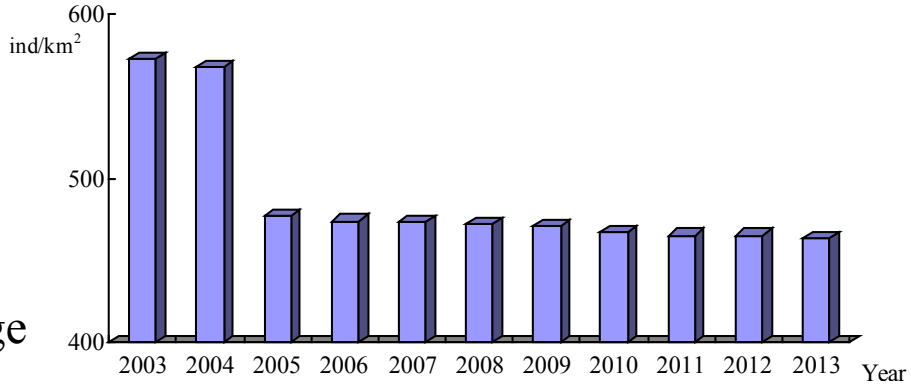
Major threats and their changes

1 Eutrophication

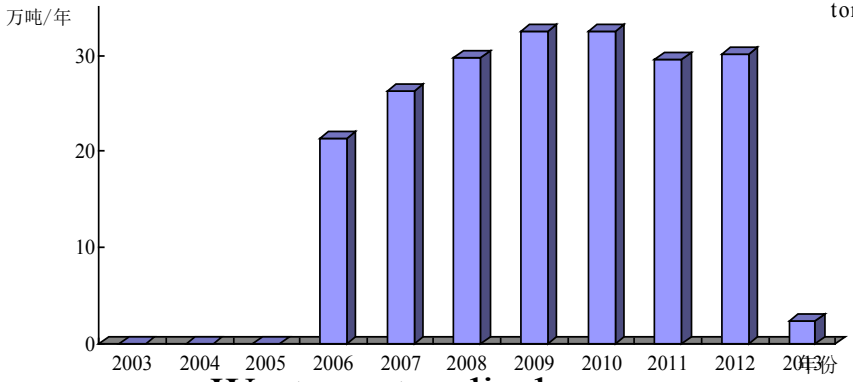
Changhai County

Indirect indicators: Waste water discharge

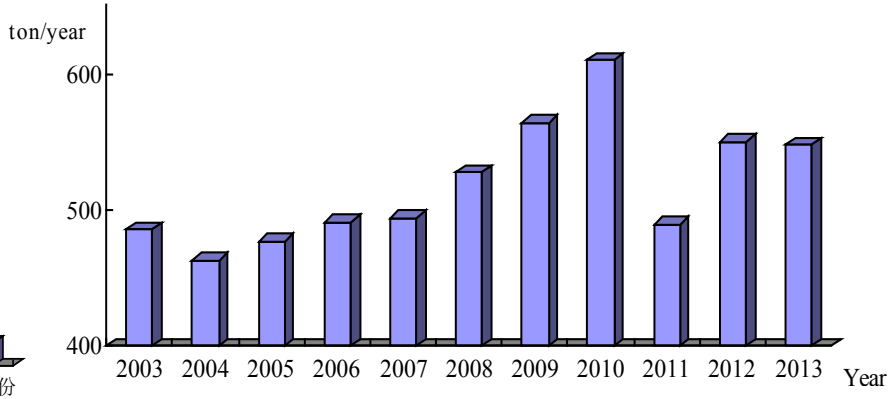
Population, Usage of fertilization



Population in Changhai county



Waste water discharge



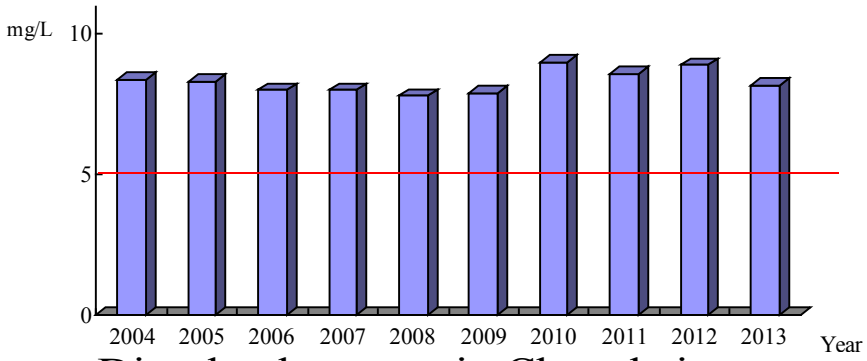
Fertilization usage in Changhai county

Major threats and their changes

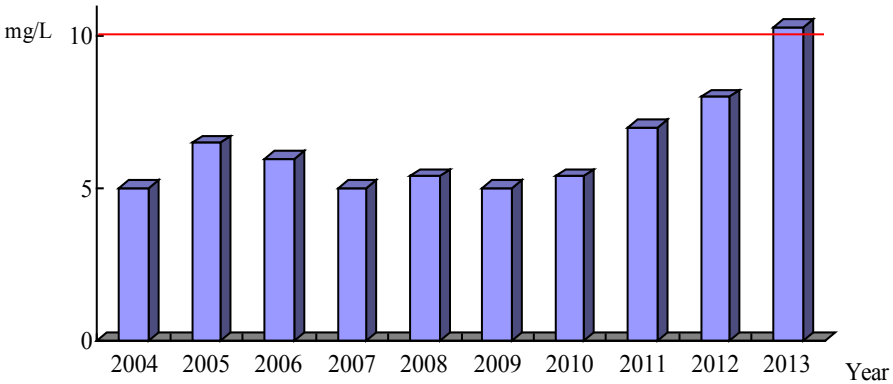
1 Eutrophication

Changhai County

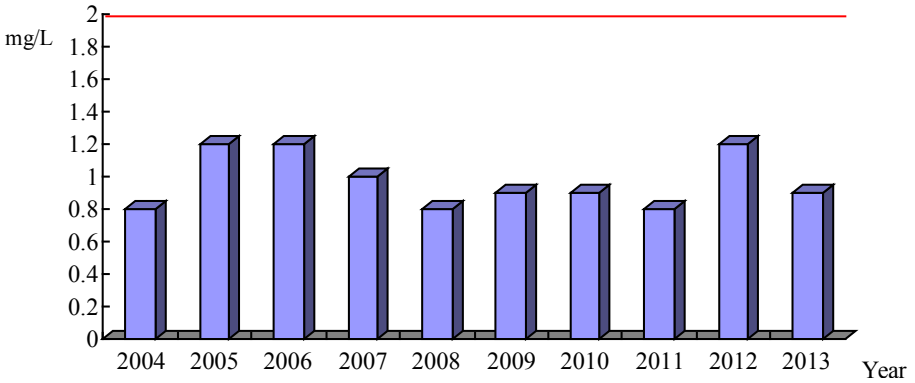
Indicators on impact: SS, COD, DO



Dissolved oxygen in Changhai waters



Suspended solids in Changhai waters



COD in Changhai waters

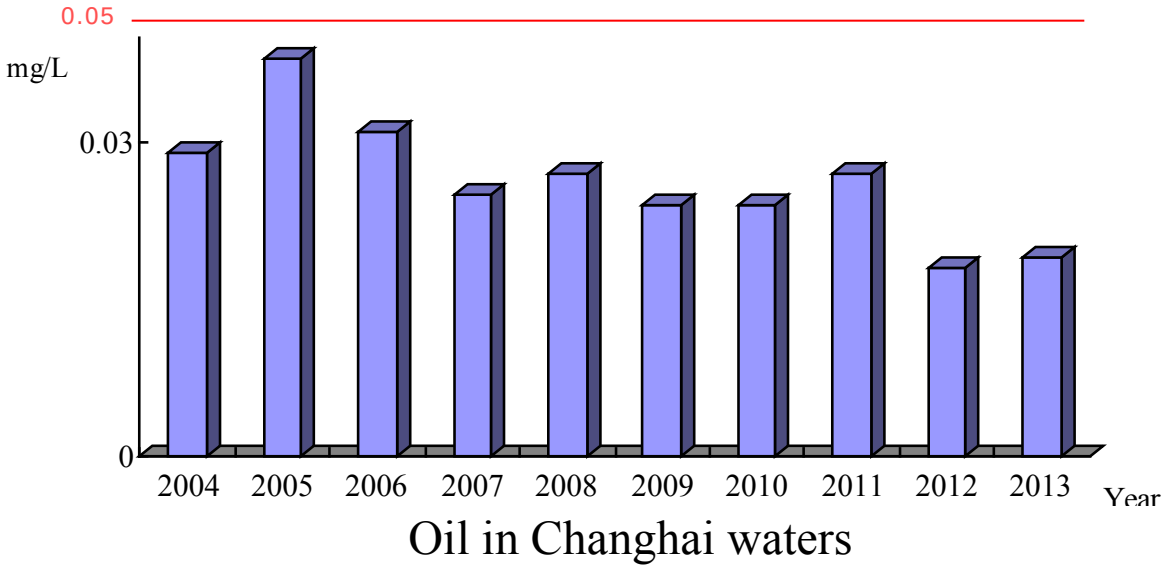
Major threats and their changes

1 Eutrophication

Changhai County

Indicators on impact:

Oil



Oil in Changhai waters

Major threats and their changes

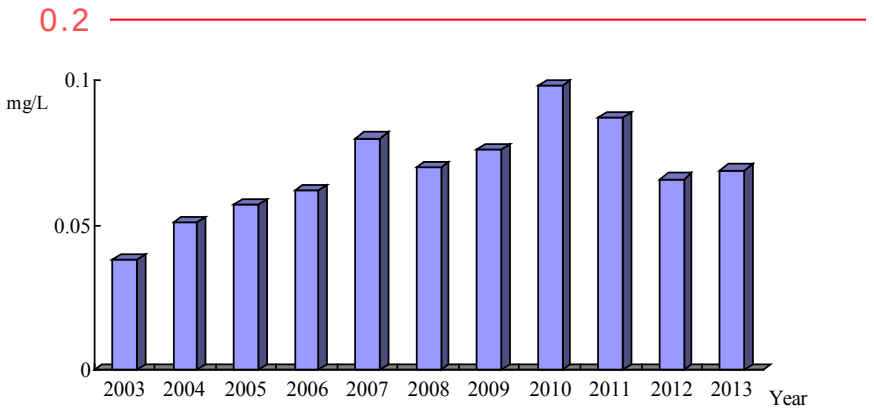
1 Eutrophication

Changdao County

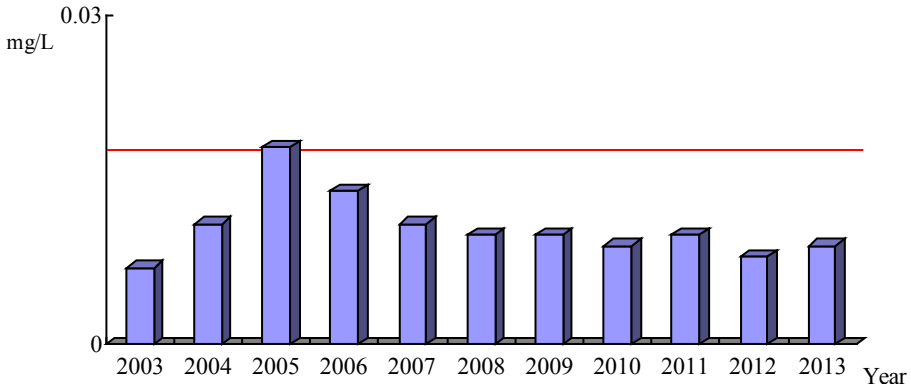
Direct indicators: DIN, AP

Indirect indicators: Population

Indicators on impact: SS, COD, DO, Oil



DIN concentration in Changdao waters



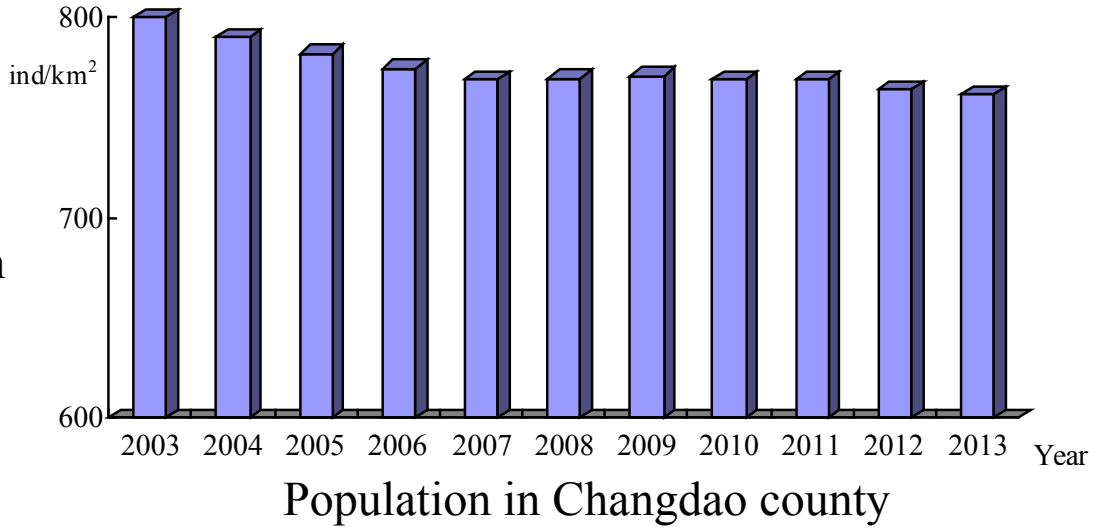
AP concentration in Changdao waters

Major threats and their changes

1 Eutrophication

Changdao County

Indirect indicators: Population



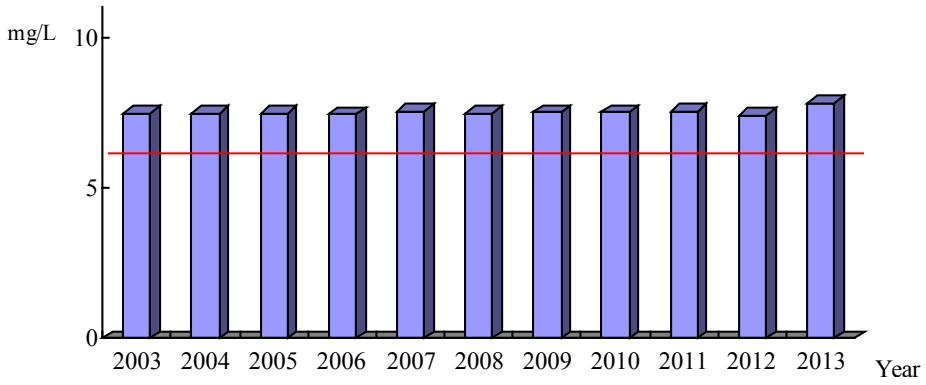
Population in Changdao county

Major threats and their changes

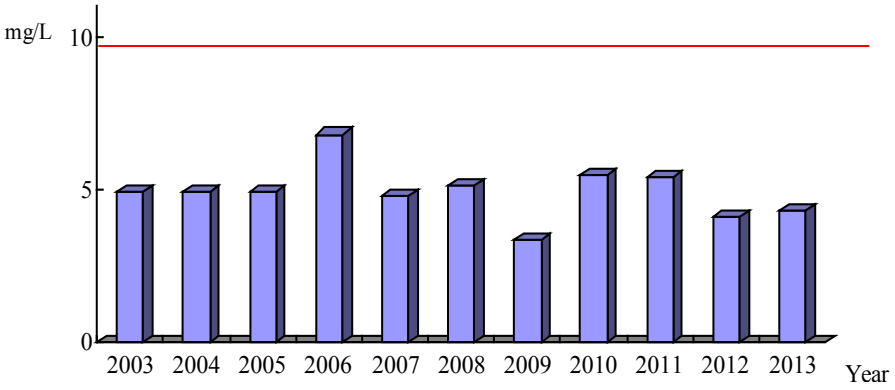
1 Eutrophication

Changdao County

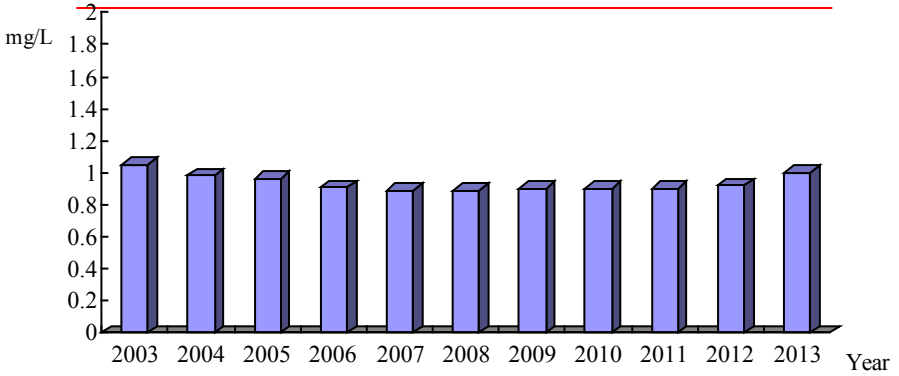
Indicators on impact: SS, COD, DO



Dissolved oxygen in Changdao waters



Suspended solids in Changdao waters



COD in Changdao waters

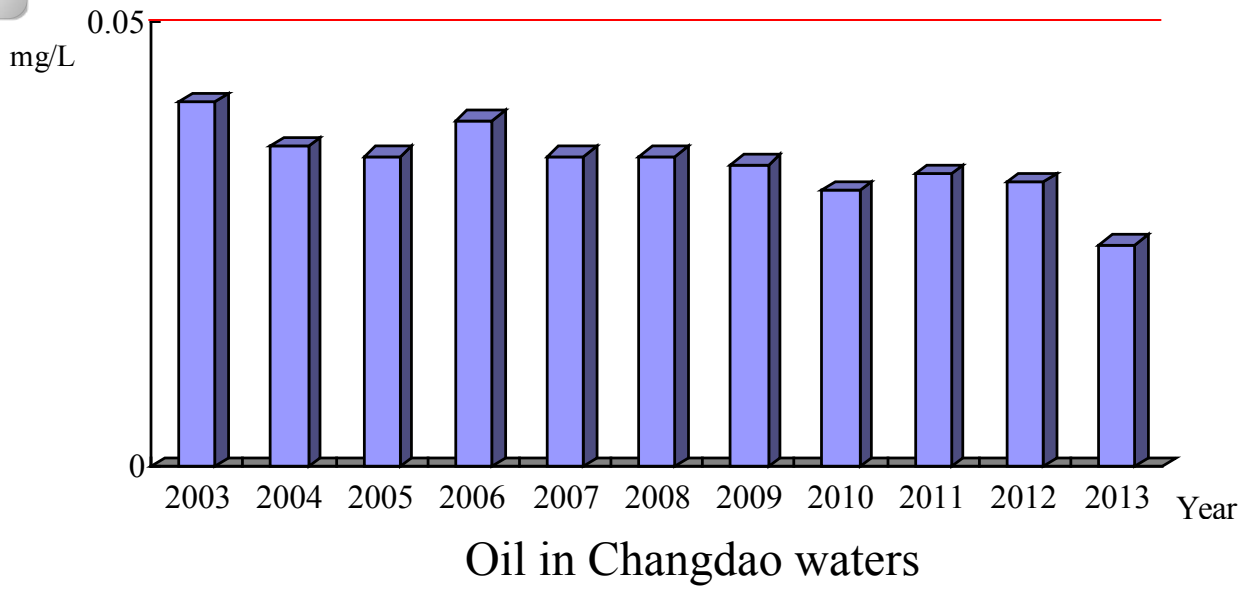
Major threats and their changes

1 Eutrophication

Changdao County

Indicators on impact:

Oil



Oil in Changdao waters

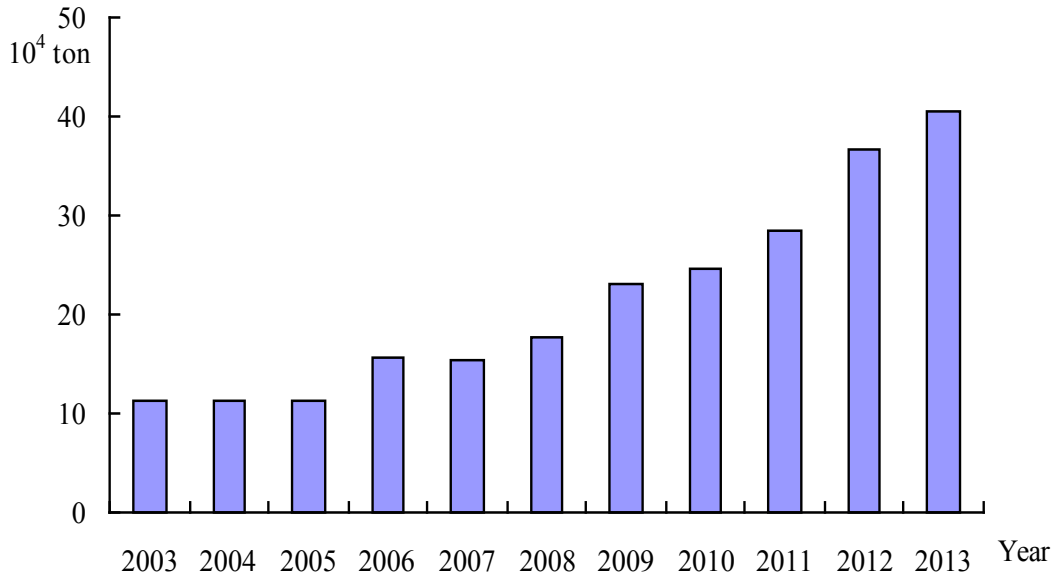
Major threats and their changes

2 Non-indigenous species

Changhai County

Indirect indicators:

Aquaculture of NIS,
Port cargo throughput,
Maritime passenger transport



Aquaculture production of NIS in Changhai County

The non-indigenous Bay scallop and Yesso scallop have outweighed the local Farrer's scallop (*Chlamys farreri*), and become the primary shellfish species in Changhai and Changdao county.

Major threats and their changes

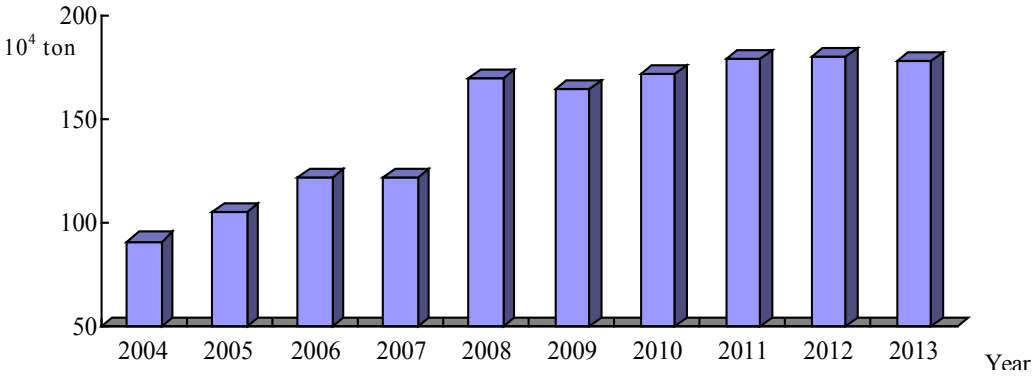
2 Non-indigenous species

Changhai County

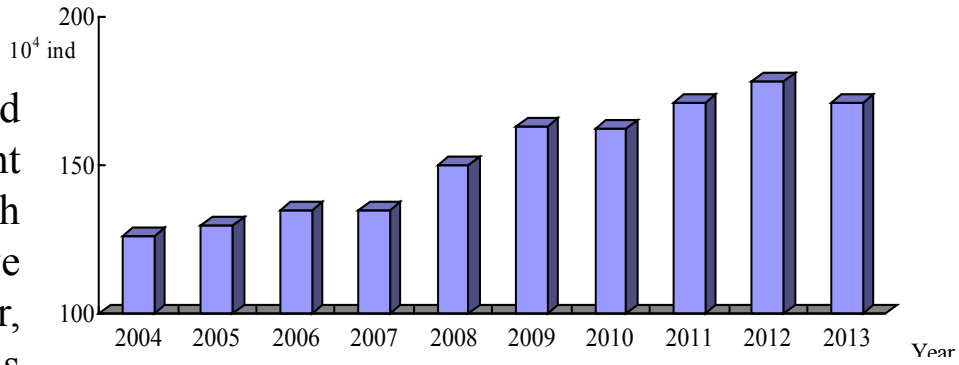
Indirect indicators:

Port cargo throughput,

Maritime passenger transport



Port cargo throughput in Changhai County



Maritime passenger transportin Changhai County

While the development of cargo and passenger transport would definitely brought about more foreign passengers and ships which might serve as appropriate media for invasive species unintentionally through ballast water, fouling organisms, and adhering individuals with people or their belongings.

Major threats and their changes

Changdao Spotted Seal Nature Reserve

The spotted seals (*Phoca largha*) in China waters only occur in the Yellow and Bohai Sea, and the breeding ground in the ice areas in Liaodong Bay of Bohai Sea is the most southern one among their eight breading grounds in the world.

The Changdao Provincial Spotted Seal Nature Reserve was established in June 2001.

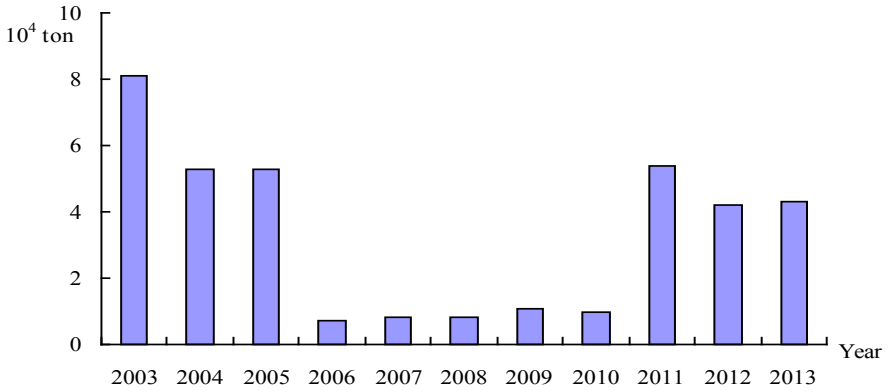
Major threats and their changes

2 Non-indigenous species

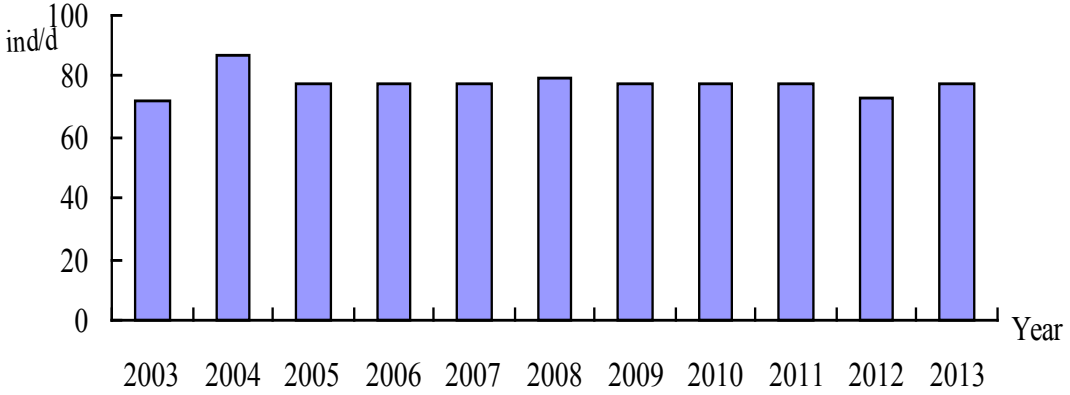
Changdao County

Indirect indicators:

Number of protected animals,
Aquaculture of NIS,
Port cargo throughput,
Maritime passenger transport



Production of NIS aquaculture in Changdao County



Number of spotted seals observed in Changdao County

Major threats and their changes

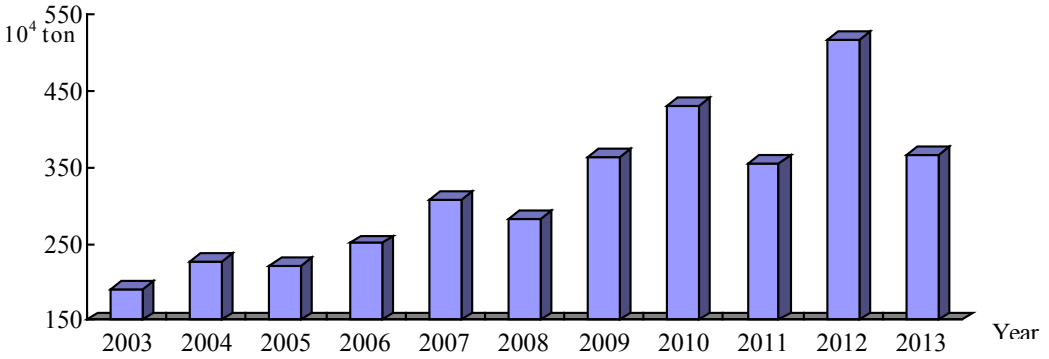
2 Non-indigenous species

Changdao County

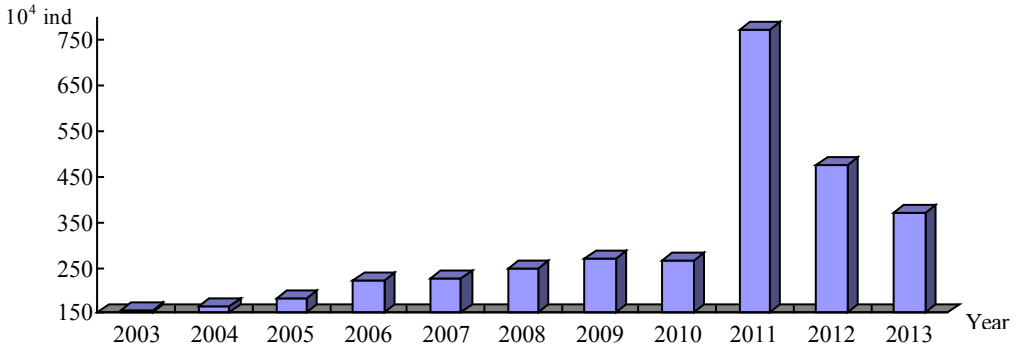
Indirect indicators:

Port cargo throughput,

Maritime passenger transport



Port cargo throughput in Changdao County



Maritime passenger transport in Changdao County

Major threats and their changes

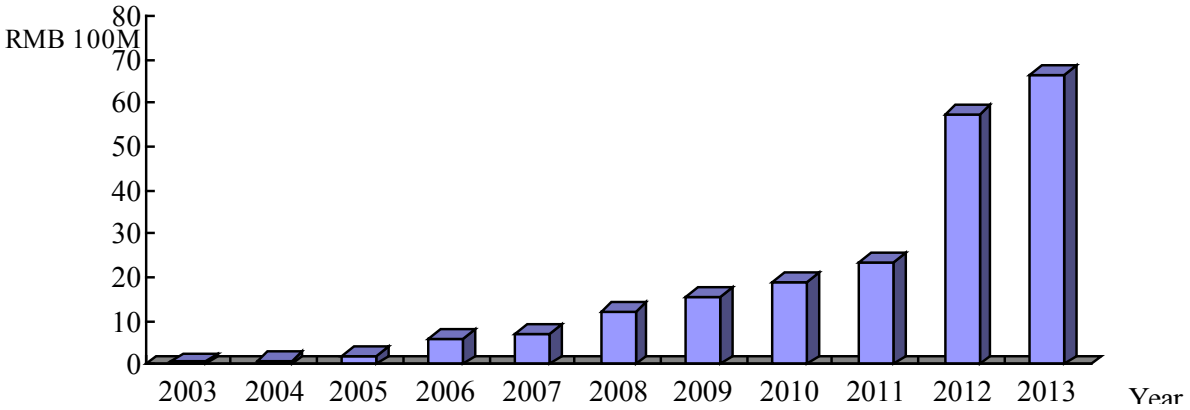
3

Habitat alteration

Changhai County

Indicators on impact:

Fixed asset investment



Amount of fixed asset investment in Changhai County

While no direct or indirect indicators for habitat alteration was identified in this study, fixed asset investment was taken as a potential indicator on impact in Changhai County.

The fixed asset investment is a measure of capital spending, i.e. any investment within the measurement period in physical assets, such as real estate infrastructure, machinery, etc. The growing investment on fixed assets has led to the over-exploration of land in many placed, accelerated the habitat alteration, and brought potential risks to local ecological environment.

Major threats and their changes

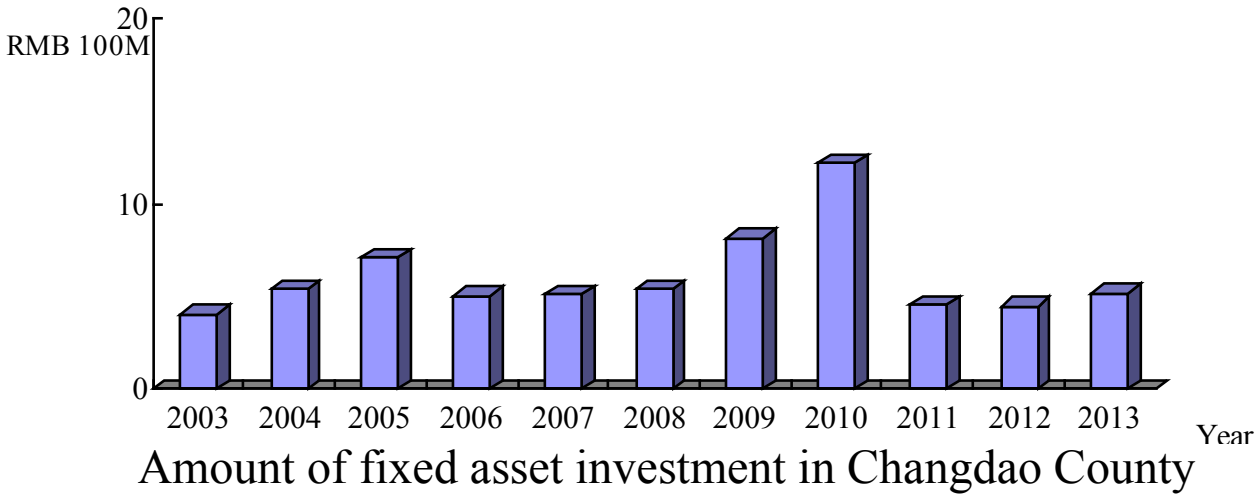
3

Habitat alteration

Changdao County

Indirect indicators:

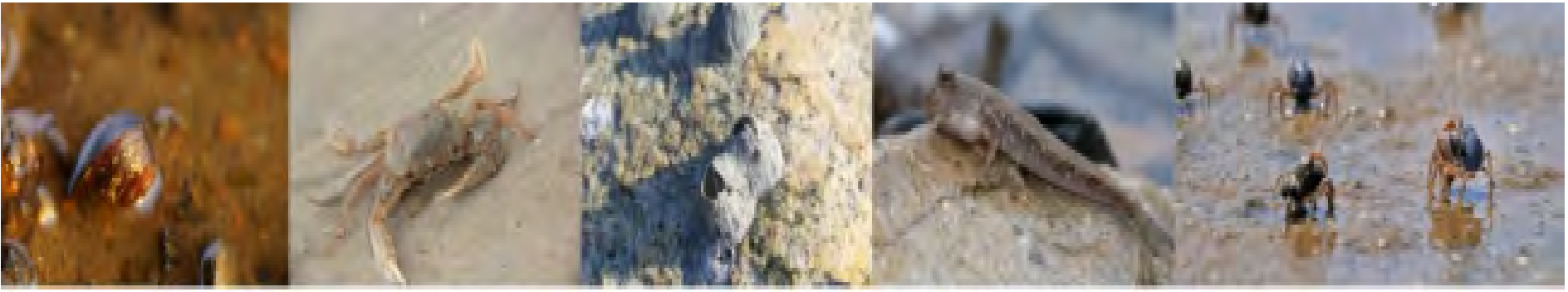
Fixed asset investment



Amount of fixed asset investment in Changdao County

Assessment on marine biodiversity

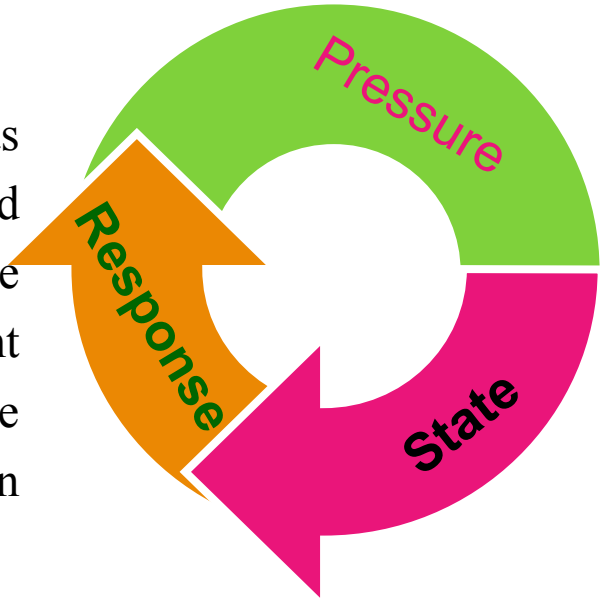
1. PSR Model
2. Changhai County
3. Changdao County



Assessment on marine biodiversity

1 PSR Model

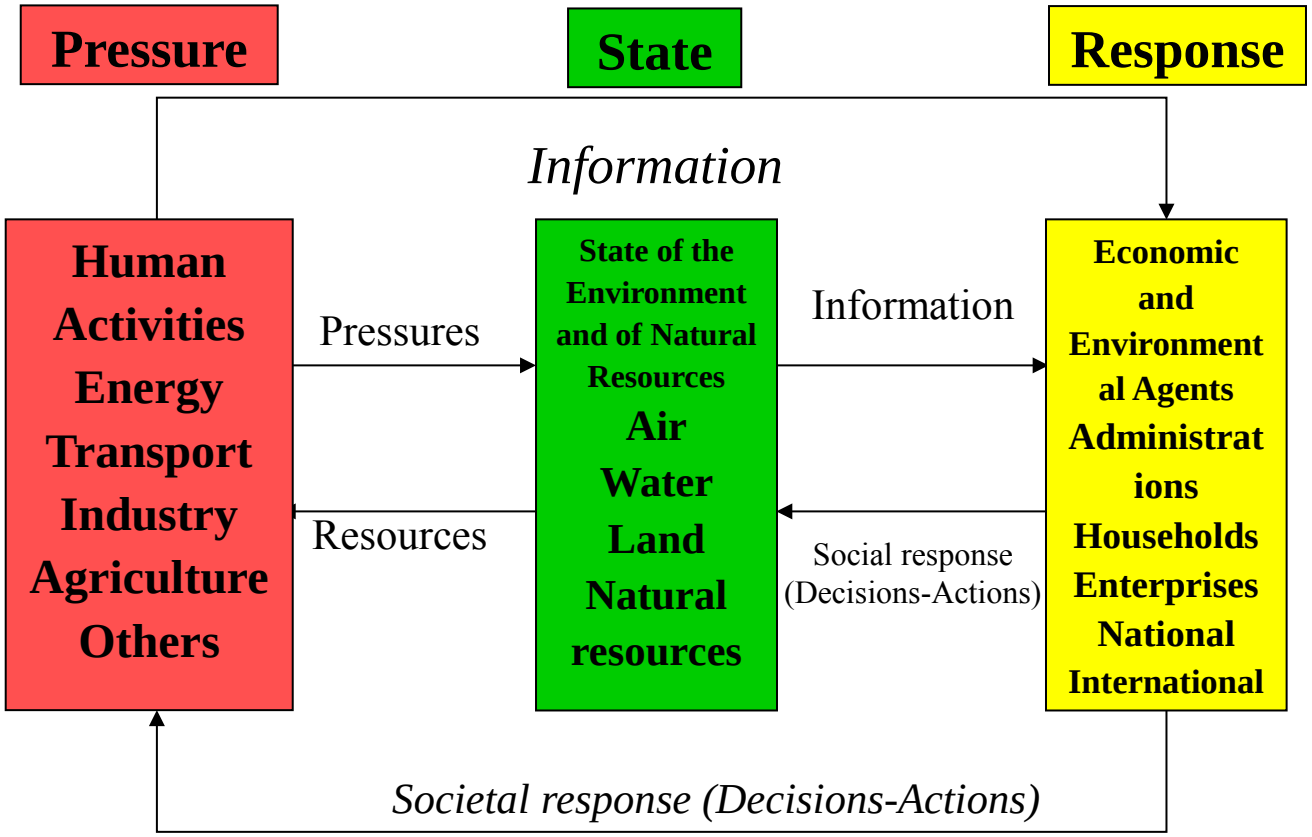
Pressure-State-Response (PSR) framework



The Pressure-State-Response (PSR) framework was initially proposed by two Canadian statisticians, Tony Friend and David Rapport, in 1979. In the 1980s and 1990s, the Organization for Economic Co-operation and Development (OECD) and the United Nations Environment Programe (UNEP) began applying the framework to its work on environmental reporting.

The PSR model is based on the concept of causality: human activities exert pressures on the environment and change its quality and quantity of natural resources (state). Society responds to these changes through environmental, general economic and sectorial policies (responses).

Assessment on marine biodiversity



Assessment on marine biodiversity

1 PSR Model

Pressure-State-Response (PSR) Model

↓

PSR indicators framework

↓

Standardization and calculation

↓

Weight assignment

↓

Assessment

Assessment on marine biodiversity

1 PSR Model

Standardization: deviation standardization of selected indicators was implemented to exclude the effects of different units, and the formulation was as follows,

$$Ii=1-|X-Xmax/Xmin-Xmax|$$

where the standardized value *Ii* ranges 0-1, x is the measured value for each indicator, and *Xmax* and *Xmin* stands for the best and worst value, respectively.

The **Marine Biodiversity Index** (MBDI) was calculated as,

$$MBDI = \sum W_i I_i$$

where *Wi* stands for the normalized weight and *Ii* is the standardized value of indicator *i*, respectively.

Assessment on marine biodiversity

1 PSR Model

Since the assessment framework comprised different indicators with comprehensive social, economic, and environmental parameters, while most of them were not covered by the existing standards, thus a set of normalized baseline was established. The establishment of baseline for each indicators was based on the following guidelines, (1) the physiochemical parameters included in **the Sea water quality standard of China** (GB3097-1997) were set according to the Class I level sea water; (2) the physiochemical parameters not included in that standard were set according to **the related standards, the annual offshore marine environment monitoring dataset, or the corresponding statistical references**; (3) the socio-economic parameters were set based on the **investigations of national environmental protection key cities by the Ministry of Environmental Protection of China during 2005-2007.**

Assessment on marine biodiversity

1 PSR Model

Weight: the Analytical Hierarchy Process approach was applied to evaluate the relative importance of indicators. Several experts were invited to score the relative importance of every two indicator comparisons, and then the resulting weights were calculated based on the AHP approach using Matlab R2014b. The standards for relative importance scoring followed as, 1 (i.e. equally important); 3 (i.e. slightly more important); 5 (i.e. obviously more important); 7 (i.e. significantly more important); 9 (i.e. extremely more important); and 2, 4, 6, and 8 for those in the medium range.

The principle basis is the relevant importance of each assessing indicators, and the judgment matrix is as follows,

$$B = \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_1} & \cdots & \frac{w_2}{w_n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix}$$

Assessment on marine biodiversity

1 PSR Model

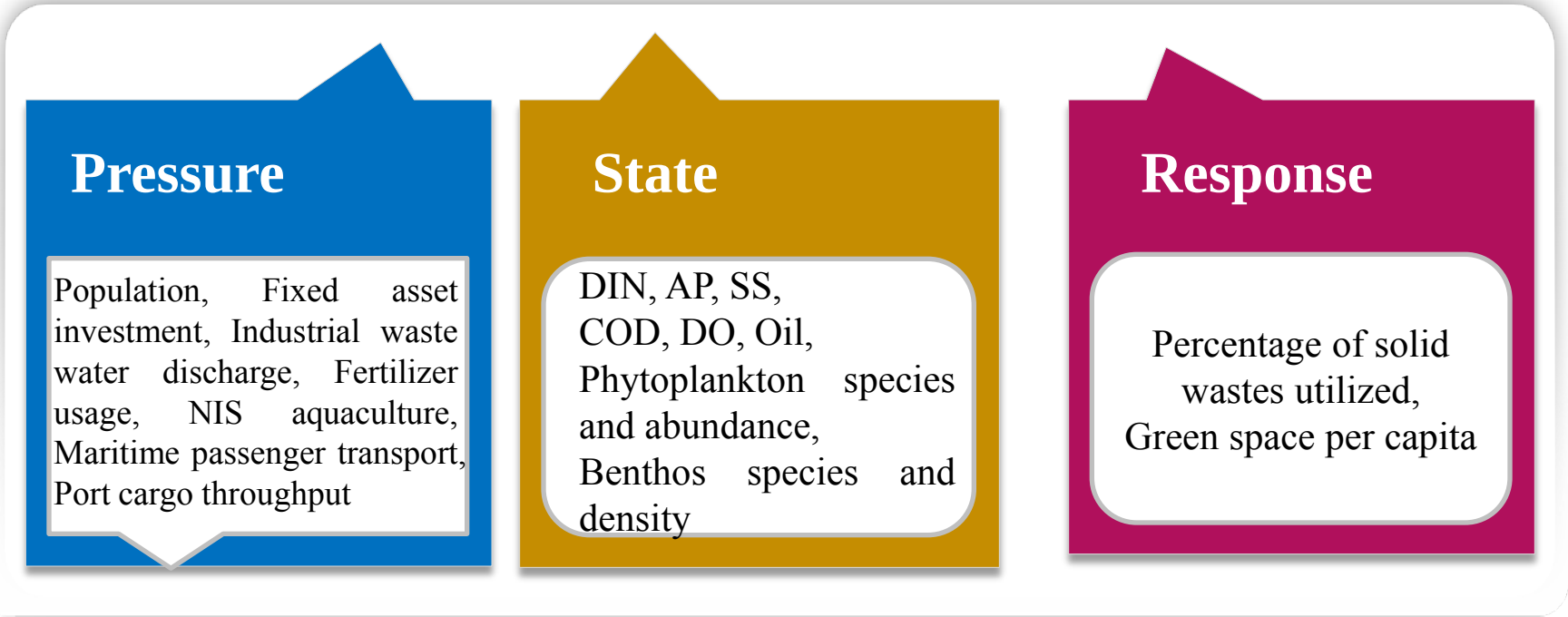
Grade for marine biodiversity assessment in this study

Grade	MBDI	Definition
Excellent	0.8≤MBDI≤1.0	Marine biodiversity is slightly disturbed, with high species richness, with plentiful domestic and exclusive species, with diverse ecosystem types, with stable structure and function, with high ability to recover, with favorable habitat for diverse species
Good	0.6≤MBDI<0.8	Marine biodiversity is somehow disturbed, with relatively high species richness, with many domestic and exclusive species, with different ecosystem types, with high diversity in some areas and well functioned, with certain ability to recover, with available habitat for diverse species
Medium	0.4≤MBDI<0.6	Marine biodiversity is moderately disturbed, with medium species richness, ecological environment being affected, with basic ability to maintain its function, habitable for different species
Poor	0.2≤MBDI<0.4	Marine biodiversity is largely disturbed, with low species richness, with few domestic and exclusive species, with serious environmental problems, with degenerated ecosystem structure and function, habitat unsustainable
Bad	0.0≤MBDI<0.2	Marine biodiversity is heavily disturbed, with low species richness, with few ecosystem types, with fragile structure and function, ecological environment severely destroyed and unable to recover, not habitable

Assessment on marine biodiversity

2 Changhai County

Framework of marine biodiversity indicators



Assessment on marine biodiversity

2 Changhai County

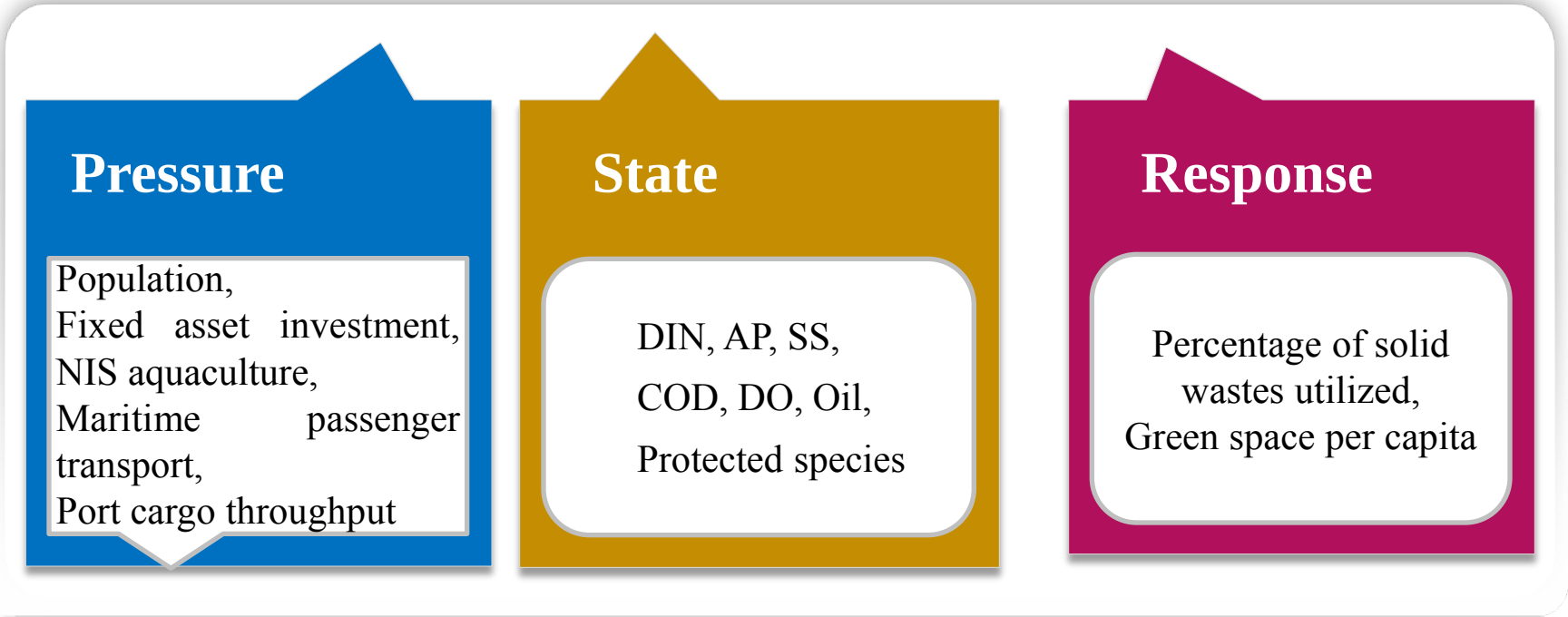
Marine biodiversity assessment

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Pressure	0.326	0.304	0.257	0.253	0.165	0.133	0.119	0.106	0.060	0.084
State	0.327	0.332	0.342	0.342	0.348	0.334	0.290	0.332	0.322	0.311
Response	0.030	0.042	0.058	0.092	0.108	0.110	0.116	0.111	0.117	0.116
Total	0.683	0.678	0.657	0.688	0.620	0.577	0.525	0.549	0.500	0.511
Grade	Good	Good	Good	Good	Good	Medium	Medium	Medium	Medium	Medium

Assessment on marine biodiversity

3 Changdao County

Framework of marine biodiversity indicators



Assessment on marine biodiversity

3 Changdao County

Marine biodiversity assessment

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Pressure	0.234	0.251	0.244	0.292	0.275	0.279	0.240	0.210	0.133	0.147	0.198
State	0.337	0.368	0.361	0.369	0.361	0.359	0.358	0.362	0.361	0.347	0.347
Response	0.083	0.088	0.095	0.104	0.119	0.110	0.118	0.131	0.115	0.106	0.102
Total	0.654	0.706	0.700	0.766	0.755	0.748	0.716	0.703	0.610	0.600	0.647
Grade	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

Conclusion

1 Changhai County

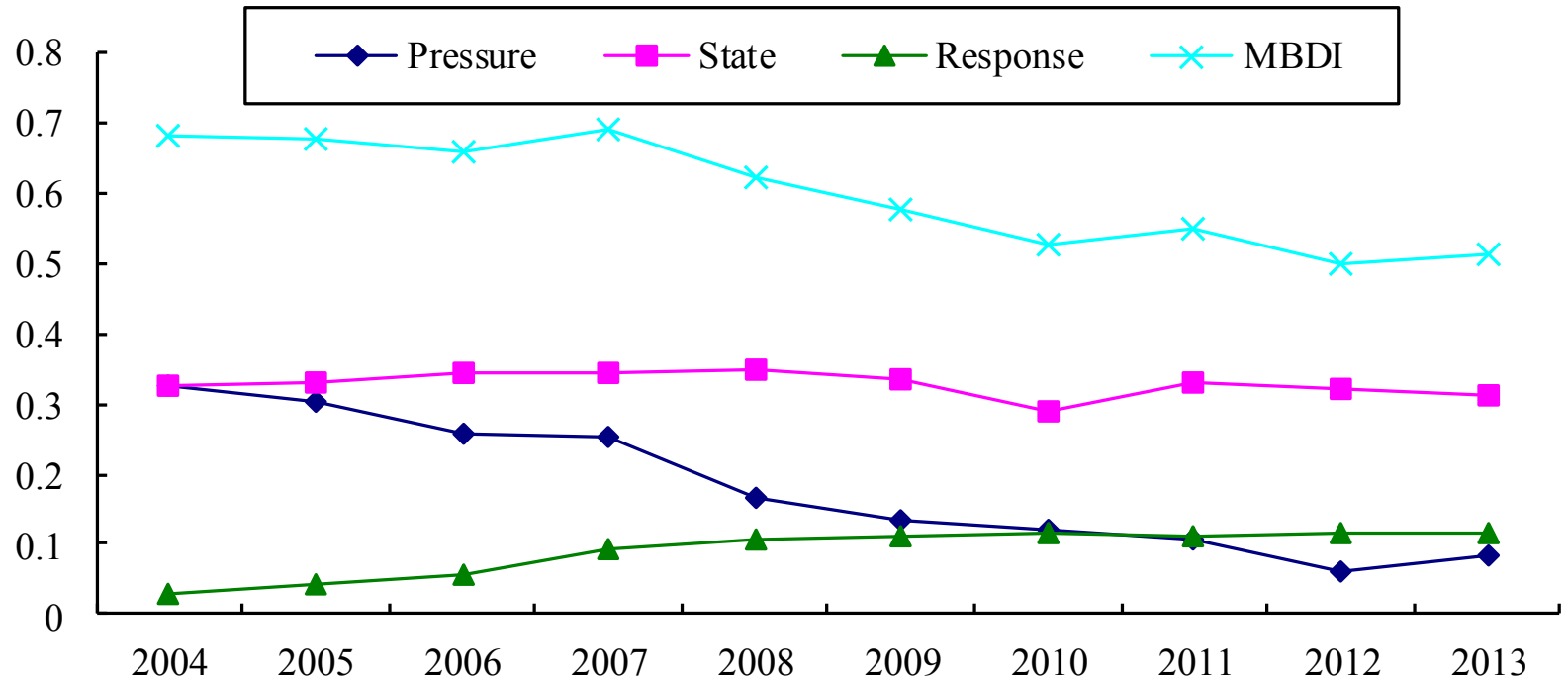
The status of marine biodiversity in Changhai remained moderate to good during the investigated period. The MBDI values kept at a higher level and graded into the Good level in 2004-2008, and then decreased obviously and leveled down to the Medium level in 2009-2013. The overall status of marine biodiversity showed an decline trend during 2004-2013.

Major causes: discharge of industrial waste water, fixed asset investment, aquaculture of NIS, maritime passenger transport, and Port cargo throughput all showed obvious increasing tendency. The expansion of pollution, NIS introduction, and economic activities could definitely cause negative impacts on local ecological environment and marine biodiversity.

Assessment on marine biodiversity

1 Changhai County

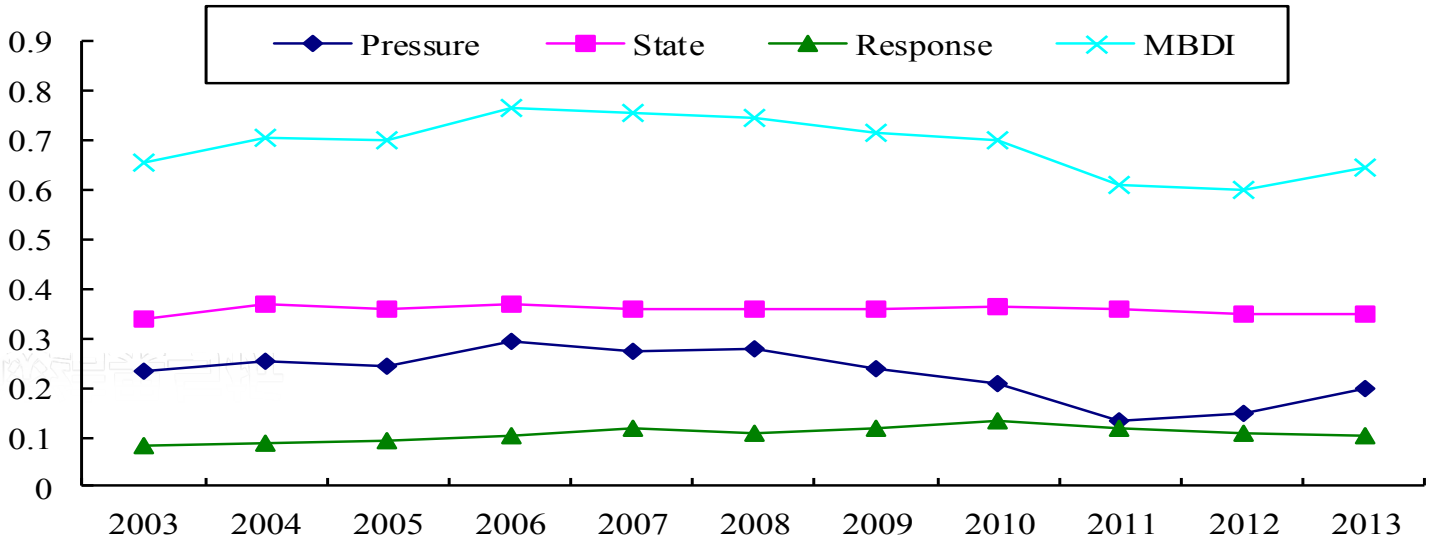
Indices of Pressure, State, Response, and marine biodiversity



Conclusion

2 Changdao County

In summary, the status of marine biodiversity in Changdao was good. The MBDI values remained above 0.6 and graded into the Good level during the whole studied period, suggesting a relatively stable state of marine biodiversity with few fluctuations.



Thank you !