Biological Assessment of Ecologically Important Areas for Fish and Invertebrate Taxonomic Groups of the Yellow Sea Ecoregion

China part

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Ecological sub-regions

Definition and description of sub-regions

Sub-regions were divided by unique bio-geographical features.

Sub-region 1 is defined as spawning and nursery grounds where most fish and invertebrate species spawn and are shallow costal areas (shallower than 30 m) in the Yellow Sea and bays in the Bohai Sea.

Sub-region 2 is defined as wintering grounds where most fish species and invertebrates stay during the winter and are deepwater areas (deeper than 30 m) in the central to south Yellow Sea and the north East China Sea.

Common Criteria for identification of Ecologically Important Areas of the Yellow Sea Ecoregion (YSE)

The common criteria to identify ecologically important areas for fish and invertebrate species in the YSE are given in Table 1.

Table 1. List of proposed common criteria for fish and invertebrates

Adopted Common Criteria	Proposed Indicator Species/Species group	Definition of Indicator Species	Definition of Ecologically Important Areas
Criterion 1: representative species / habitat types	small yellow croaker, Spanish mackerel, Chinese shrimp, Japanese anchovy, largehead hairtail, chub mackerel	Species that used to be dominant with a wide range of distribution.	spawning grounds, nursery grounds, wintering grounds
Criterion 2: Isolated stock or species, endemic and unique species assemblages	Pacific herring, Pacific cod	species that are isolated geographically in the Yellow Sea cold water mass	areas of distribution of each species
Criterion 3: Species richness	not adopted	not adopted	not adopted
Criterion 4: Species of special concern 1 (threatened, depleted stocks and/or protected species)	Pacific cod, pacific herring, Chinese shrimp, red seabream, all species of flatfish	species that experienced significant decrease in stock sizes	current key areas of distribution

Criterion 5-A: Commercially important (Volume)	small yellow croaker, Spanish mackerel, chub mackerel, Japanese anchovy, largehead hairtail, Acetes shrimp, Pacific herring, flatfish species	landings, top 5 species in each decade	key areas of distribution of species selected from the historical market record
Criterion 5-B: Commercially important (Value)	Chinese shrimp, small yellow croaker, Spanish mackerel, Chub mackerel, largehead hairtail, Pacific cod, flatfish species	market value, top 5 species for each decade	key areas of distribution of species selected from historical market records
Criterion 6: Intact habitat/ecological processes	not adopted	not adopted	not adopted
Additional Criterion: Changes in Biological characteristics	small yellow croaker, Chinese shrimp	early maturation, decreased genetic diversity	spawning ground, nursery ground, wintering ground

Proposed Indicator Species under Criterion 1: Representative species/ habitat types

1. Definition of Indicator Species under Criterion 1: Dominant species with a wide range of distribution in the YSE.

2. Proposed Indicator Species

[Small yellow croaker] *Larimichthys polyactis* [小黄鱼, xiaohuangyu]

Reason for Selection:
Small yellow croaker is a warm-temperature bottom fish. It is distributed in the Bohai Sea, Yellow Sea and East China Sea. Three geographical stocks, the northern stock, the Lüsi stock, and the East China Sea stock, are recognized (Liu et al. 1990). Small yellow croakers start their spawning migration from wintering grounds in March and spawn in shallow coastal waters of 10-20 m depth from April to May, mostly along Chinese coastal waters. The fish winters in the central to south Yellow Sea and the north East China Sea.

[Spanish mackerel] *Scomberomorus niphonius* [蓝点马鲛，Landianmajiao]

Reason for Selection:
The Spanish mackerel is widely distributed and highly abundant in the Bohai Sea, Yellow Sea and East China Sea. There are two wintering stocks: the southeastern Yellow Sea stock and the offshore East China Sea stock. The stock in the East China Sea spawns mainly in coastal waters of the southern part of the Shandong peninsula and Fujian province from April to May. The other stock spawns mostly in the Bohai Sea and the north Yellow Sea from May to June (Wei, 1991). After spawning, Spanish mackerel disperse and feed along the coastal waters. The distribution of this stock is strongly influenced by water temperature, and the fish migrates south as temperatures decrease. Until November the main stock is distributed in the central to southern Yellow Sea. The stock begins returning to wintering ground in December.

[Chinese shrimp] *Penaeus chinensis* [中国对虾，Zhongguoduixia]

Reason for Selection:
This highly valued species is mainly distributed in the Bohai Sea and Yellow Sea and is seldom observed in the East China Sea and South China Sea. The shrimp population can be divided into two sub-populations according to their distribution. One is the west coast of the Yellow Sea population, which hatches in the coastal waters of the Bohai Sea and Yellow Sea. The other is the east coast of the Yellow Sea population, which hatches in the coastal waters on the west side of the Korean Peninsula. The major spawning ground of Chinese shrimp is in the three bays (Laizhou Bay, Bohai

Bay and Liaodong Bay) of the Bohai Sea. A spawning ground also exists in the nearshore water of the west coast of the Korea Peninsula.

[Japanese anchovy] *Engraulis japonicus* [日本鳀鱼, Ribentiyu]

Reason for Selection:
The Japanese anchovy is a small pelagic species and is widely distributed in the Bohai Sea, Yellow Sea and East China Sea. It migrates seasonally in response to changes in sea surface temperature. The optimum distribution temperature ranges from 10-13°C and the anchovy is usually not found in water below 7°C (Zhu,1991; Iversen *et al*. 1993). In November and December, the densest area of distribution is at the northern and central parts of the Yellow Sea. During the wintertime the Japanese anchovy migrates into the southeast Yellow Sea and the north East China Sea. Responding to the increase of water temperature and the development of gonads in the spring, the Japanese anchovy migrates to shallow coastal waters for spawning (Li, 1987). The anchovy biomass, estimated using acoustic methods, is about three million tons (Zhu and Iversen, 1990; Iversen *et al*. 1993).

[Largehead hairtail] *Trichiurus haumela* [带鱼， Daiyu]

Reason for Selection:
The Largehead hairtail is a semi-pelagic species, inhabiting the Bohai Sea, Yellow Sea, East China Sea and South China Sea. There are two major stocks of the hairtail: the Bohai Sea and Yellow Sea stock, and the East China Sea stock. In addition, there are also some local stocks in the South China Sea and in the shallow coastal waters of Fujian Province and the Taiwan Strait. The spawning grounds of the Bohai Sea and Yellow Sea stock are located in the coastal waters of the Yellow Sea and three bays (Laizhou Bay, Bohai Bay, and Liaodong Bay) in the Bohai Sea. Wintering grounds are in the central to south Yellow Sea and north East China Sea. It is the most abundant species in the East China Sea among all fish and invertebrates.

[Chub mackerel] *Scomber japonicus* [鲐鱼, Taiyu]

Reason for Selection:
The Chub mackerel is a warm water fish and has two wintering grounds: one southeast of Jejudo and the other from the central to eastern parts of the East China Sea. The two stocks (Chikuni, 1985) start their spawning migration in late March or early April. Spawning mainly occurs in waters south of the Shandong peninsula from May to June. When water temperature decreases, the species migrates southwards along 124°00'-125°00'E for wintering. However, young fish (including 0-group) mostly feed at the coastal waters off Korea from September to November (Wang, 1991).

3. Definition of Ecologically Important Areas for the Proposed Indicator Species:
Spawning, nursery and wintering are important stages of life for fish species and invertebrates in the YSE. Hence, areas used by indicator species during those life stages are defined as ecologically important areas.

Proposed Indicator Species under Criterion 2: Endemism and unique species assemblages

1. Definition of Indicator Species under Criterion 2: Species that are geographically isolated in the Yellow Sea cold water mass.

2. Proposed Indicator Species:

[Pacific cod] *Gadus macrocephalus* [大头鳕, Datouxue]

[Pacific herring] *Clupea pallasi* [鲱鱼，Feiyu]

The Pacific cod and Pacific herring in the Yellow Sea are two typical stocks that are isolated from the north Pacific Ocean. They stay with the cold water mass in the central part of the Yellow Sea all year around. It is possible that some other endemic species with low commercial value also exist in the YSE , but are unknown by scientists.

3. Definition of Ecologically Important Areas for the Proposed Indicator Species: Area of distribution in the central part of Yellow Sea.

Proposed Indicator Species under Criterion 4: Species of Special Concern

1. Definition of Indicator Species under Criterion 4: Species that experienced significant decreases in stock sizes.

2. Proposed Indicator Species:

[Pacific cod] *Gadus macrocephalus* [大头鳕, Datouxue]

[Pacific herring] *Clupea pallasi* [鲱鱼，Feiyu]

[Chinese shrimp] *Penaeus chinensis* [中国对虾，Zhongguoduixia]

[Red seabream] *Pagrus major* [真鲷，Zhendiao]

[Flatfish species] (mainly) *Cleisthenes herzensteini* [高眼鲽，Gaoyandie]

[Red seabream] *Pagrus major* [真鲷，Zhendiao]
Red seabream is mainly distributed in the Yellow Sea and the Bohai Sea. The wild stock of this highly valued species is currently too small to sustain capture due to over fishing. It is now a species of cultural importance in China.

[Flatfish species] (mainly) *Cleisthenes herzensteini* [高眼鲽，Gaoyandie]
Cleisthenes herzensteini is mainly distributed in the Yellow Sea and the Bohai Sea.

Its stock size has decreased to a rather low level.
Pacific cod and Pacific herring are already commercially extinct.

3. Definition of Ecologically Important Areas for the Proposed Indicator Species: Areas of distribution of the selected species in the YSE.

Proposed Indicator Species under Criterion 5A: commercially important (Volume)

1. Definition of Indicator Species under Criterion 5A:
Species or species groups with landings ranking in the top five biggest landings according to northern China's marine catch records (China Fisheries Yearbook, 1950-2000).

2. Proposed Indicator Species:

1950's:

- Largehead hairtail (*Trichiurus lepturus*)
- Small yellow croaker (*Larimichthys polyactis*)
- Acetes shrimp
- Chinese shrimp (*Penaeus chinensis*)
- Large yellow croaker (*Larimichthys crocea*)

1960's:

- Acetes shrimp
- Largehead hairtail (*Trichiurus lepturus*)
- Small yellow croaker (*Larimichthys polyactis*)
- Spanish mackerel (*Scomberomorus niphonius*)
- Chub mackerel (*Scomber japonicus*)

1970's:

- Acetes shrimp
- Pacific herring (*Clupea pallasi*)
- Chub mackerel (*Scomber japonicus*)
- Largehead hairtail (*Trichiurus lepturus*)
- Spanish mackerel (*Scomberomorus niphonius*)

1980's:

- Acetes shrimp
- Largehead hairtail (*Trichiurus lepturus*)
- Spanish mackerel (*Scomberomorus niphonius*)
- Chub mackerel (*Scomber japonicus*)
- Southern rough shrimp (*Trachypenaeus curvirostris*)

1990's:

- Japanese anchovy (*Engraulis japonicus*)
- Acetes shrimp
- Spanish mackerel (*Scomberomorus niphonius*)
- Chub mackerel (*Scomber japonicus*)
- Southern rough shrimp (*Trachypenaeus curvirostris*)

[Acetes shrimp] *Acetes chinensis* [中国毛虾，Zhongguomaoxia]

Acetes chinensis is the most abundant species in its genus, and is only distributed in the South and East China Seas and the Yellow/Bohai Seas. It is the most important species in catch by fixed nets. The stock of *Acetes* is in good condition, with annual landings following an increasing trend.

3. Definition of Ecologically Important Areas for the Proposed Indicator Species:

All species selected have been covered by previous criterion. Thus, their EIAs have already been defined.

Proposed Indicator Species under Criterion 5B: commercially important (value)

1. Definition of Indicator Species under Criterion 5B:
Market values of species or species group that rank in the top five in northern China marine catch (price was based on records of commercial organizations).

2. Proposed Indicator Species:

1950's:

- Chinese shrimp (*Penaeus chinensis*)
- Largehead hairtail (*Trichiurus lepturus*)
- Small yellow croaker (*Larimichthys polyactis*)
- Large yellow croaker (*Larimichthys crocea*)
- Flatfish species (mainly *Cleisthenes herzensteini*)

1960's:

- Chinese shrimp (*Penaeus chinensis*)
- Largehead hairtail (*Trichiurus lepturus*)
- Small yellow croaker (*Larimichthys polyactis*)
- Spanish mackerel (*Scomberomorus niphonius*)
- Flatfish species (mainly *Cleisthenes herzensteini*)

1970's:

- Chinese shrimp (*Penaeus chinensis*)
- Largehead hairtail (*Trichiurus lepturus*)

- Spanish mackerel (*Scomberomorus niphonius*)
- Pacific herring (*Clupea pallasi*)
- Chub mackerel (*Scomber japonicus*)

1980's:

- Chinese shrimp (*Penaeus chinensis*)
- Spanish mackerel (*Scomberomorus niphonius*)
- Largehead hairtail (*Trichiurus lepturus*)
- Southern rough shrimp (*Trachypenaeus curvirostris*)
- Chub mackerel (*Scomber japonicus*),

1990's:

- Spanish mackerel (*Scomberomorus niphonius*)
- Southern rough shrimp (*Trachypenaeus curvirostris*)
- blue crab (*Portunus trituburculatus*)
- Acetes shrimp [*Acetes chinensis*]
- Chub mackerel (*Scomber japonicus*)

3. Definition of Ecologically Important Areas for the Proposed Indicator Species:

All species selected have been covered by previous criterion. Their EIAs have already been defined.

Proposed Indicator Species under Additional Criterion: Changes in Biological characteristics

1. Definition of Indicator Species under Additional Criterion:

Species that have experienced changes in Biological characteristics, such as early maturation and decreased genetic diversity.

2. Proposed Indicator Species:

Small yellow croaker: the main age of maturation has changed from two years in the 1950s to one year (Jin, 1996).

Chinese shrimp: the genetic diversity of the wild stock in coastal waters of the YSE has been reduced compared with wild stocks in other ecoregions (Deng and Jin, 2000).

3. Definition of Ecologically Important Areas for the Proposed Indicator Species:

The spawning, nursery, and wintering are important life stage for fish species and invertebrates in the YSE, and those areas are ecologically important areas.

Table 2. List of Proposed Indicator Species

Number	Proposed Common Criteria / Seleted indicator Species	Criterion 1: representative species / habitat types	Criterion 2: isolated stock or species, endemism and unique species assemblages	Criterion 4: species of special concern 1 (threatened, depleted stocks and/or protected s)	Criterion 5A commercially important (Volume)	Criterion 5B commercially important (Value)	Additional Criterion Changes in Biological characteristics
1	Small yellow croaker	X			X	X	X
2	Pacific herring	X	X	X	X	X	
3	Pacific cod	X	X	X		X	
4	Chinese shrimp			X		X	X
5	Red seabream			X		X	
6	Largehead hairtail	X			X	X	
7	Flatfish species (mainly *Cleisthenes herzensteini*)	X	X	X	X	X	
8	Chub mackerel	X			X	X	
9	Japanese anchovy		X	X	X		
10	Spanish mackerel	X	X		X	X	
11	Acetes shrimp				X	X	
12	Japanese squid (*Loligo japonica*, *L. beka*)	X		X			
13	Japanese flying squid (*Todarodes pacificus*)	X					

Note: X indicates that the species was proposed under the corresponding criterion.

Table 3. List of Maps and Area Names for Fish and Invertebrate Ecologically Important Areas

Map Number	Indicator Species	Area and Location Names of Fish and Invertebrate Ecologically Important Areas									
Map 1	Chinese shrimp (*Penaeus chinensis*)	Liaodong bay	Bohai bay	Laizhou bay	Haiyang dao	Yanwei	Shidao	Rushan	Haizhou bay	The central and south Yellow Sea	
Map 2	Japanese anchovy (*Engraulis japonicus*)	The central Bohai Sea	Laizhou bay	Haiyang dao	Yanwei	Shidao	Rushan	Haizhou bay	The central and southern Yellow Sea	Zhoushan	
Map 3	Spanish mackerel (*Scomberomorus niphonius*)	Liaodong bay	Bohai bay	Laizhou bay	Haiyang dao	Yanwei	Shidao	Rushan	Haizhou bay	Lűsi	Zhoushan
Map 4	Pacific herring (*Clupea pallasi*)	Coastal water off the Liaodong peninsula	Yanwei	Shidao	Rushan	The Central Yellow Sea					
Map 5	Chub mackerel (*Scomber japonicus*)	Haiyang dao	Yanwei	Rushan	Haizhou bay	The central to south Yellow Sea	Zhoushan				
Map 6	Small yellow croaker *(Larimichthys polyactis*)	Liaodong bay	Bohai bay	Laizhou bay	Haiyang dao	Yanwei	Shidao	Rushan	Haizhou bay	The central and south Yellow Sea	Lűsi
Map 7	Flatfish species (mainly *Cleisthenes herzensteini*)	Liaodong bay	Bohai bay	Laizhou bay	Haiyang dao	Shidao	Rushan	Haizhou bay	The central Yellow Sea		
Map 8	Largehead hairtail (*Trichiurus haumela*)	Liaodong bay	Bohai bay	Laizhou bay	Haiyang dao	Yanwei	Rushan	Haizhou bay	The south Yellow Sea and north East China Sea		

Maps and Description of Ecologically Important Areas for Mammal Taxonomic Group

Invertebrate Ecologically Important Area for Chinese shrimp (Map 1)

Area Name: Liaodong bay
Description of Area: Spawning and feeding ground

Area Name: Bohai bay
Description of Area: Spawning ground

Area Name: Laizhou bay
Description of Area: Spawning ground

Area Name: Haiyang dao
Description of Area: Spawning and feeding ground

Area Name: Yanwei
Description of Area: Feeding ground

Area Name: Shidao
Description of Area: Feeding ground

Area Name: Rushan
Description of Area: Spawning and feeding ground

Area Name: Haizhou bay
Description of Area: Spawning and feeding ground

Area Name: Central and southern Yellow Sea
Description of Area: Overwintering ground

Fish Ecologically Important Area for Japanese anchovy (Map 2)

Area Name: The Central Bohai Sea
Description of Area: Spawning and feeding grounds

Area Name: Laizhou bay
Description of Area: Spawning ground and nursery grounds

Area Name: Haiyang dao
Description of Area: Spawning and nursery grounds

Area Name: Yanwei
Description of Area: Spawning and nursery grounds

Area Name: Rushan
Description of Area: Spawning and nursery grounds

Area Name: Haizhou bay
Description of Area: Spawning and nursery grounds

Area Name: The Central and south Yellow Sea
Description of Area: Wintering grounds

Area Name: Zhoushan
Description of Area: Spawning ground and nursery grounds

Fish Ecologically Important Area for Spanish mackerel (Map 3)

Area Name: Liaodong bay
Description of Area: Spawning and feeding grounds

Area Name: Bohai bay
Description of Area: Spawning and feeding grounds

Area Name: Laizhou bay
Description of Area: Spawning and nursery grounds

Area Name: Haiyang dao
Description of Area: Spawning and feeding grounds

Area Name: Yanwei
Description of Area: Spawning grounds

Area Name: Shidao
Description of Area: Feeding grounds

Area Name: Rushan
Description of Area: Spawning grounds

Area Name: Haizhou bay
Description of Area: Spawning and feeding grounds

Area Name: Lűsi
Description of Area: Spawning grounds

Area Name: Zhoushan
Description of Area: Feeding grounds

Fish Ecologically Important Area for Pacific herring (Map 4)

Area Name: Coastal water off the Liaodong peninsula
Description of Area: Spawning and nursery grounds

Area Name: Yanwei
Description of Area: Spawning and nursery grounds

Area Name: Shidao
Description of Area: Spawning and nursery grounds

Area Name: Rushan
Description of Area: Spawning and nursery grounds

Area Name: The Central Yellow Sea
Description of Area: Wintering and feeding grounds

Fish Ecologically Important Area for chub mackerel (Map 5)

Area Name: Haiyang dao
Description of Area: Spawning and nursery grounds

Area Name: Yanwei
Description of Area: Spawning and nursery grounds

Area Name: Rushan
Description of Area: Spawning and nursery grounds

Area Name: Haizhou bay

Description of Area: Spawning and nursery grounds

Area Name: The central and south Yellow Sea
Description of Area: Wintering and feeding grounds

Area Name: Zhoushan
Description of Area: Spawning, nursery and feeding grounds

Fish Ecologically Important Area for small yellow croaker (Map 6)

Area Name: Liaodong bay
Description of Area: Spawning, nursery and feeding grounds

Area Name: Bohai bay
Description of Area: Spawning, nursery and feeding grounds

Area Name: Laizhou bay
Description of Area: Spawning, nursery and feeding grounds

Area Name: Haiyang dao
Description of Area: Spawning, nursery and feeding grounds

Area Name: Yanwei
Description of Area: Feeding grounds

Area Name: Shidao
Description of Area: Wintering and feeding grounds

Area Name: Rushan
Description of Area: Spawning and nursery grounds

Area Name: Haizhou bay
Description of Area: Spawning and nursery grounds

Area Name: The central and south Yellow Sea
Description of Area: Wintering grounds

Area Name: Lűsi
Description of Area: Spawning and nursery grounds

Fish Ecologically Important Area for flatfish species (Map 7)

Area Name: Liaodong bay
Description of Area: Spawning, nursery and feeding grounds

Area Name: Bohai bay
Description of Area: Spawning, nursery and feeding grounds

Area Name: Laizhou bay
Description of Area: Spawning, nursery and nursery grounds

Area Name: Haiyang dao
Description of Area: Spawning, nursery and feeding grounds

Area Name: Rushan
Description of Area: Spawning and nursery grounds

Area Name: Haizhou bay
Description of Area: Spawning and nursery grounds

Area Name: The central Yellow Sea
Description of Area: Overwintering grounds

Fish Ecologically Important Area for largehead hairtail (Map 8)

Area Name: Liaodong bay
Description of Area: Spawning, nursery and feeding grounds

Area Name: Bohai bay
Description of Area: Spawning, nursery and feeding grounds

Area Name: Laizhou bay
Description of Area: Spawning, nursery and nursery grounds

Area Name: Haiyang dao
Description of Area: Spawning, nursery and feeding grounds

Area Name: Yanwei
Description of Area: Spawning, nursery and feeding grounds

Area Name: Rushan
Description of Area: Spawning, nursery and feeding grounds

Area Name: Haizhou bay
Description of Area: Spawning, nursery and feeding grounds

Area Name: The south Yellow Sea and north East China Sea
Description of Area: Wintering grounds

Knowledge Gaps and specific studies needed for fish species and invertebrates

In addition to the knowledge gaps specific to each Indicator Species, at the ecosystem level there are knowledge gaps about species composition, distribution in the intertidal zone, and biodiversity in the whole of the Yellow and Bohai Sea ecosystem.

The intensity of influence from anthropogenic activities and climate change has not been extensively studied.

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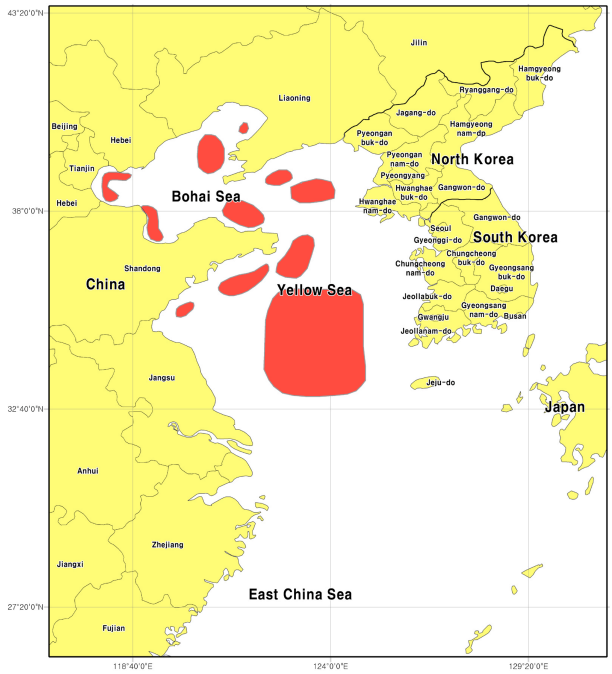
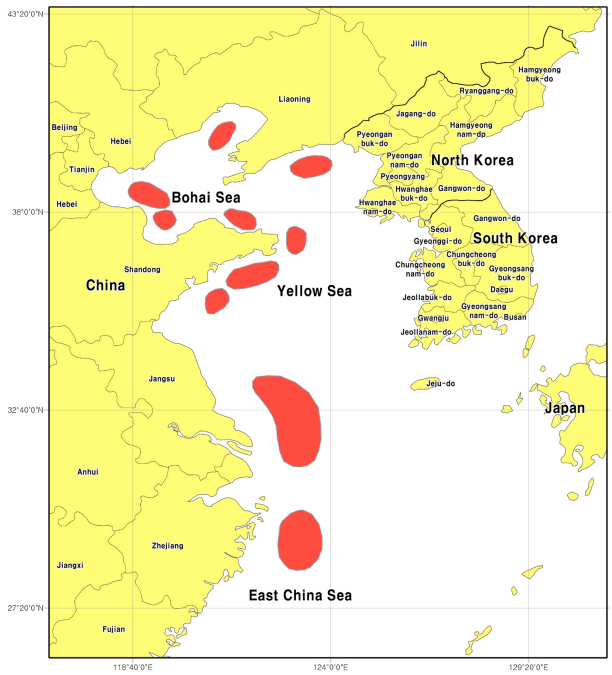


Map 1 Chinese shrimp
(*Penaeus chinensis*)

Map 2 Japanese anchovy
(*Engraulis japonicus*)



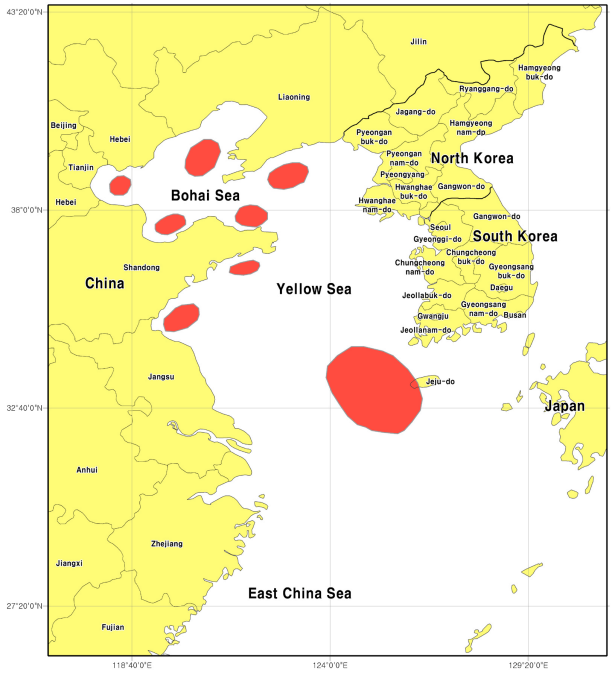
Map 3 Spanish mackerel
(*Scomberomorus niphonius*)

Map 4 Pacific herring
(*Clupea pallasi*)

Map 5 Chub mackerel
(*Scomber japonicus*)

Map 6 Small yellow croaker
(*Larimichthys polyactis*)

Map 7 Flatfish species
(mainly *Cleisthenes herzensteini*)



Map 8 Largehead hairtail
(*Trichiurus haumela*)