

# Assessment

## BOHAI SEA

**Table 1** Scoring table for the Bohai Sea region.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter).		The arrow indicates the likely direction of future changes.							
<b>IMPACT</b> 0	No known impact	<b>IMPACT</b> 2	Moderate impact	↗	Increased impact	→	No changes	↘	Decreased impact
<b>IMPACT</b> 1	Slight impact	<b>IMPACT</b> 3	Severe impact						
Bohai Sea		Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***		
<b>Freshwater shortage</b>		3.0* →	1 →	1 →	1 →	1.5	3		
Modification of stream flow		3							
Pollution of existing supplies		3							
Changes in the water table		3							
<b>Pollution</b>		2.3* ↘	2 →	1 →	2 ↘	1.5	4		
Microbiological pollution		2							
Eutrophication		3							
Chemical		2							
Suspended solids		1							
Solid waste		2							
Thermal		1							
Radionuclide		0							
Spills		3							
<b>Habitat and community modification</b>		2.6* ↘	3 →	1 ↗	3 →	2.5	2		
Loss of ecosystems		2							
Modification of ecosystems		3							
<b>Unsustainable exploitation of fish</b>		2.6* →	3 →	2 →	3 →	2.7	1		
Overexploitation of fish		3							
Excessive by-catch and discards		1							
Destructive fishing practices		2							
Decreased viability of stock		2							
Impact on biological and genetic diversity		3							
<b>Global change</b>		1.0* →	3 ↘	1 →	2 ↘	1.5	5		
Changes in hydrological cycle		1							
Sea level change		1							
Increased UV-B radiation		0							
Changes in ocean CO <sub>2</sub> source/sink function		0							

\* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

\*\* This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

\*\*\* Priority refers to the ranking of GIWA concerns.

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 1.

## IMPACT Freshwater shortage

The naturally uneven distribution of water resources has created severe freshwater shortages in parts of the country (SEPA 2003). In the densely populated southern region of China, a relatively abundant water supply is provided by the Yangtze River and Pearl River basins. However, the areas north of the Yangtze River, particularly the northwest region and the North China Plain, which account for 60% of China's land mass and half of the country's population, only receive 20% of the nation's water resources; and there is severe freshwater shortage. The freshwater shortage in Northern China is further aggravated by serious soil erosion, deforestation, land conversion, excessive water usage for agricultural production and conversion of lakeshore wetlands into rice fields (SEPA 2003).

### Environmental impacts

#### Modification of stream flow

The main river basins or systems that contribute to the source of freshwater supplies in the region include those associated with the Liao River, the Shuangtaizi River, the Hai River, the Luan River and the Yellow River. The Yellow River Basin is the largest among them, and covers an

area of 940 065 km<sup>2</sup> in China (WRI 2003). The annual volumes in the Yellow River were greatly modified over the past decades due to serious water and soil erosion, which has led to frequent basin-wide drought in its upper and middle reaches, and tremendous flood disasters in its lower reaches (WAF 2003). The impact of this issue in the region has been considered to be severe.

### **Pollution of existing supplies**

Fish kills frequently occurred in the major water basins associated with the Liao River, the Hai River, the Luan River and the Yellow River, covering a total area of 1 300 567 km<sup>2</sup>. Pollution of the river basin waters was serious as evidenced by the fact that most of the surface waters that include more than 30% of the surface of these river basins did not meet WHO drinking water standards (see Annex V). The freshwater shortage situation is further worsened by inefficient use of the limited water supply. Studies have indicated that in China, only 20-30% of industrial water is recycled, and water consumption per industrial product is 5 to 10 times higher than that of industrialised countries. Additionally, only 25-30% of irrigation water is effectively used due to poor irrigation facilities (SEPA 2003). It is estimated that 2.5 million tonnes of grain yield are lost each year due to water shortages. The impact of this issue has been considered to be severe.

### **Changes in the water table**

In several urban centres in the region, overextraction of groundwater for industrial and domestic uses has lowered groundwater tables. For example, in Beijing, water tables are dropping 1.5 to 2 m per year. A lower water table could not only aggravate water shortages, but also decrease water quality and increase the risk of earthquakes and landslides. Coastal aquifers are suffering salinisation over a wide area, particularly in the coastal, heavily populated cities along the coast of the Bohai Sea such as Dalian and Tienjin, as well as the adjacent Hebei Province, due to the extensive use of underground water for human consumption, agricultural and industrial activities. This heavy use has caused the water tables in these areas to subside, which has led to increased seawater intrusion. The impact of this issue has been considered to be severe.

### **Socio-economic impacts**

Interruptions in the water supply for a few hours per week have frequent been reported in several of the coastal cities along the Bohai Sea such as Tienjin and Dalian. Water supplies affect societal stability, which is far more significant than economic and human health effects. Business costs increased over 10% as a result of using seawater or other alternatives to offset the freshwater shortage in satisfying business demands. This economic impact is considered less

important than the social impact of the problem but more important than the human health impact. A slight increase in infectious diseases has occurred in the last decade, such as problems with teeth as a result of the need to drink saline water in seawater intruded areas. The impact was considered to be slight. A severe reduction of stream flow in major rivers (e.g. the Liao, Hai and Yellow rivers) has occurred over the past decades. The severe freshwater shortage has led to increased business cost by 10% and frequent interruptions in the water supply of the region.

### **Conclusion and future outlook**

The trend of stream flow reduction in the region is unlikely to improve much in the future. The reduction problem may be alleviated if the planned national project to divert water from the country's south to north is implemented (See Box 2 in the Yellow Sea report). Further deterioration of water quality is unlikely in the future as some mitigation measures (e.g. control the discharge of agricultural run-off, industrial discharges, etc.) to improve water quality of the river basins were and are being undertaken by the Chinese government.

The accelerated urbanisation and shortage of surface water resources in the region are likely to exert continued pressure on the demand of underground water. The situation is unlikely to improve much in the future. Population growth will increase demand for freshwater. Freshwater shortages in the region will continue, which will significantly impact community welfare, much as is the case now. Business dependence on fresh water or its alternatives will increase, but the fresh water supply will not improve very much. This will increase business costs. The water resource status and water quality will improve, reducing the occurrence of diseases.

The Chinese government has recognised the vital need to address water shortage issues in order to maintain the nation's development. In 1988, China promulgated its Law of Water Resources, which provided a legal basis for water resource management. In 1993, further legal support to ensure efficient water use emerged as China adopted water resource licenses. By the end of 1995, nearly 90% of the nation's water utilities were registered and licensed. Since then, China's water supply is estimated to have increased 15 per year. The government is also promoting wastewater recycling by increasing investments in water pollution prevention and treatment facilities. Finally, efforts explore new water resources, such as seawater desalination, are being initiated.

# Pollution

## Environmental impacts

### Microbiological

Incidents of bacterial gastroenteric disorders in the population due to consumption of contaminated seafood or aquatic products caused by microbiological pollution in the coastal and inland waters of the region have been frequently reported over recent decades. However, in recent years, reports of human health problems caused by microbiological pollution have decreased due to measures taken by local governments (e.g. local government of Dalian City) to restrict the marketing of contaminated aquatic products for human consumption. Additionally, more wastewater treatment facilities have established in the large urban centres; these have greatly reduced incidences of microbiological pollution in the waters of the region. The impact of this issue has been considered to be moderate.

### Eutrophication

There were reports of harmful algal blooms (HAB) due to eutrophication. The dinoflagellate *Gymnodinium* sp. dominated these reports in August-September 1989 in the area offshore of Huang Hua. These blooms caused mass mortality of shrimps with heavy economic losses. A mass-scale HAB event occurred again in 1997, covering an area of 3 000 km<sup>2</sup> in Liaodong Bay of the Bohai Sea. High eutrophication caused by an increase of discharges of nutrient-rich sewage, agricultural and industrial wastes has resulted in frequent occurrences (e.g. more than 5-6 times per year) of HAB events along the coastal waters of the Bohai Sea (Cui & Song 1999). Eutrophication in the region has been considered severe. The issue is likely to have transboundary importance as the HAB organisms may be transported across national and international boundaries via ballast water and tank washing.

### Chemical

Large-scale use of pesticides and insecticides in agriculture has resulted in agricultural run-off that is high in chemical pollutants. Increased industrial waste discharges have further added to incidences of chemical pollution in the region. Heavy metal pollution in Jinzhou Bay sediment has significantly changed benthic biodiversity. However, the impact of this issue the region has been considered to be moderate.

### Suspended solids

There are reports of increased suspended solids in the river basins and coastal waters of the region as a result of increased construction of coastal roads and dams, and dredging and mud discharges from salt farms. For instance, the suspended solids contents were greater than 1 000 mg/l during high tides in the upper portion of the Liaodong Bay

in the Bohai Sea. However, the problem of high suspended solids is localised around river mouths and its impact in the region is considered to be slight.

### Solid wastes

On beaches and in the tourist sites of Jinzhou, Xingchen, Qinghuangdao and Dalian along the coastal areas of the Bohai Sea, litter has frequently been reported. The environmental impact of the issue has sometimes been significant enough to deter the public from recreational activities and is considered to be moderate.

### Thermal

There are localised thermal problems caused by power plant discharges and offshore oil production, but there is no evidence that the biodiversity of the region has been altered by thermal pollution. The impact of the issue is considered to be slight.

### Radionuclides

The environmental impact of this GIWA issue is unknown as, at the moment, there is no nuclear power plant in operation in the region.

### Spills

There are four oil fields currently in operation in the region: Shengli, Bohai, Dagang and Liaohe oil fields. Small-scale (a few hundred tonnes) oil spills from these oil fields have frequently been reported (more than two to three spills per year). Oil tar balls have often been found on beaches in the coastal areas of the Bohai Sea. Avian mortality due to oil spills has also been reported often. The impact of oil spills on the region has therefore been considered to be severe.

## Socio-economic impacts

Many rivers and coastal waters in the region are now not suitable for swimming. Commercial and recreational fishing activities have been reduced by 30-50% due to pollution impacts, particularly in freshwater systems. There have been reports of eye infections from swimming, as well as cases of PSP (paralytic shellfish poisoning), and gastroenteric disorders attributable to consuming contaminated aquatic products.

## Conclusion and future outlook

More and more wastewater treatment facilities have been built or are being planned for the region's large urban centres, such as in the cities of Beijing, Tianjin and Dalian. The municipal sewage treatment rate is thus expected to grow from the current 25% to above 40% coverage over the next 5 to 10 years. Long-term improvement in the situation for microbiological pollution, particularly in the population centres in

the region is expected in the future. The problems with eutrophication, and subsequent HABs are likely to decrease when measures taken by the Chinese government to improve the management of fertiliser and detergent uses are realised. More importantly, there are two government-funded ongoing environmental management projects, the “Bohai Sea Environmental Management Project” and the “Bohai Sea Clean Water Project”, which are expected to greatly improve the future environmental conditions in the region.

The problem of chemical pollution is likely to be controlled with the implementation of the ongoing “Bohai Sea Environmental Management Project” and the “Bohai Sea Clean Water Project”. No significant changes in the status of the suspended solid situation are expected in the future. The situation with solid waste will be improved with increased public awareness, the use of degradable wrapping materials and the implementation of GEF projects. More large-scale power plants may be constructed to meet the increased industrial development needs; offshore oil and gas development in the Bohai Sea will also be expanded. These are expected to aggravate the thermal pollution problem of the region in the future. With the expansion of offshore oil and gas development, particularly in the Bohai Sea, incidences of oil spills is expected to increase.

Pollution will be mitigated through the implementation of several environmental management projects currently ongoing in the region. Oil pollution will continue to be a threat to recreational activities as well as ecosystems and habitats. Pollution will continue to affect species of economic value. Associated economic losses may be unavoidable. Pollution through sediment re-suspension will continue to be a problem at levels similar to the present.

## **Habitat and community modification**

Habitat and community modification is a concern of high priority in the region. For example, the the Luan He estuary in the northeastern part of the region comprises a small area of saline meadows that has been modified. It supports a breeding site for Saunders’ gull and passage for some migratory birds such as the Relict gull (*Larus relictus*). Otherwise this section of coast has been largely converted to shrimp ponds and salt pans.

The Dongying-Huang He Nature Reserve houses the second largest oil field in China; the Shengli Oilfield and oil industry is the primary

industry of Dongying City. Other industries include chemical fertiliser manufacturing, textile, paper-making, cement manufacturing, salt chemical industry and food processing (MacKinnon et al. 1996). Threats to the Dongying-Huang He Sanjiaozhou Nature Reserve include hunting (36 000 to 52 000 shorebirds are trapped annually), pollution from nearby oil fields, and reclamation for the rapid commercial and industrial development that is occurring here (MacKinnon et al. 1996). Other threats include extensive marine aquaculture, particularly pond-rearing of shrimp.

## **Environmental impacts**

### **Loss of ecosystems or ecotones**

The types of habitats or ecosystems in the region that have been lost to various extents include:

- Marshlands: Surface area decreased by as much as 30% due to cumulative impacts of coastal and offshore oil fields development, e.g. in the Panjin area.
- Wetlands related to running water: Surface area decreased by more than 30% due to urbanisation and industrialisation.
- Periodic waters: Area of rice fields has increased but other periodic water areas reduced.
- Wetlands of saline habitats: Surface area decreased by more than 30%, due to various types of development activities.
- Running waters (rivers): Surface area decreased by up to 30% due to various types of development activities.
- Standing waters (e.g. lakes): Surface area decreased by more than 30%, mostly due to reclamation.
- Sandy foreshores: More than 30% of the area lost to sand mining and shrimp ponds, etc.
- Estuaries: Water surface area decreased by more than 30% due to reclamation, diking, reduction of stream flow and siltation.
- Rocky foreshores: Area decreased by up to 30% largely due to port development, particularly in East Liaodong Bay, northern Shandong Peninsula and Qinghuangdao.
- Mud bottom: Area decreased by some 50% due to development of shrimp ponds, salt fields and ports in areas such as Huanghua, Liaodong Bay, Bohai Bay and Laizhou Bay.
- Sand and gravel bottom: Area decreased by up to 30% due to sand mining in such areas as Bayuquan and Shuizhong.
- Rocky bottom: Some reduction due to port development (removal of reefs with explosives).

### **Modification of ecosystems or ecotones**

The ecosystems or habitats in the region that have been modified, resulting in various degrees of changes in biodiversity, species composition and community structures include:

- Marshlands: Population structure, species composition and ecosystem functions changed.
- Wetlands related to running water: Population structure, species composition and ecosystem functions changed due to pollution and overexploitation of living resources.
- Periodic waters: Fish species have disappeared due to intensive use of pesticides, reduction of rainfall and stream flow.
- Wetlands of saline habitats: Significant reduction in crab abundance in Liaodong Bay. Most crabs in the market are cultured. Some migratory bird species have disappeared.
- Running waters (rivers): Population structure, species composition and ecosystem functions changed, particularly in Liaohe River, Haihe River and Yellow River.
- Standing waters (e.g. lakes): Population structure, species composition and ecosystem functions changed in Beiyangdian Lake.
- Sandy foreshores: Massive mortality of shellfish found in some areas, e.g. the massive mortality of the clam *Meretrix meretrix* occurred in 1997 in the Golden Beaches, Hebei Province. Population structure, species composition and ecosystem functions changed.
- Estuaries: Some species, e.g. Hairtail herring (*Coilia mystus*), have disappeared. Survey showed that the food chain in estuaries has been shortened.
- Rocky foreshores: Some species have disappeared or population abundance has been reduced, e.g. crabs and shellfishes, due to pollution, overexploitation and changed ecosystem functions.
- Mud bottom: Bottom trawling frequent, leading to reduced population abundance, species disappearance and changed ecosystem functions, e.g. crabs, fishes and shellfishes.
- Sand and gravel bottom: Changed population abundance and species disappearance due to artificial restocking of shellfishes.

### Socio-economic impacts

Aquatic products of high economic value have been significantly decreased, biodiversity has been reduced, landscapes have changed, and the number of endangered species is on the increase. Many of these changes due to habitat loss or modification may be irrevocable or threatening to the preservation of biodiversity. Aquatic resources have been depleted and aquatic product processing business (e.g. for shrimps and shellfishes) affected. These have led to a loss of employment opportunities in over 50% of the concerned processing businesses. Aquatic raw materials that can be used for pharmaceutical industry have decreased by 10-20%.

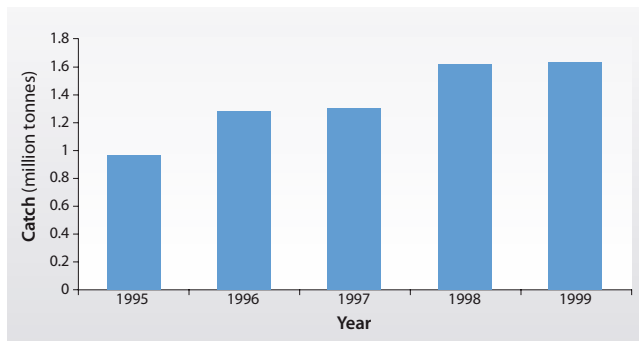
### Conclusion and future outlook

Future prospects for loss of ecosystems in the region are likely to be as follows:

- Marshlands: With increased urbanisation, the loss will continue.
- Wetlands related to running water: With urbanisation process, the loss will continue.
- Periodic waters: No significant changes in the current status expected.
- Wetlands of saline habitats: With urbanisation process, the loss will continue.
- Running waters (rivers): With urbanisation process, the loss will continue.
- Standing waters (e.g. lakes): Lake environments will be improved and reservoirs will increase.
- Sandy foreshores: Slight increase of sand mining is expected, but management will improve (e.g. alternative mining sites will be found). No large-scale mining of sandy foreshores will occur.
- Estuaries: Despite management measures, the losses may continue with continued reduction of stream flow.
- Rocky foreshores: No change in current status. A few experts expected a slight loss to port development.
- Mud bottom: No significant change in current status.
- Sand and gravel bottom: No significant change in current status.
- Rocky bottom: No significant change in current status.

Future prospects for modification of ecosystems in the region are likely to be as follows:

- Marshlands: The situation may be getting worse. Ecosystem restoration is difficult, and very slow if any.
- Wetlands related to running water: Changes in population structure and abundance will continue.
- Periodic waters: No change of current status is expected.
- Wetlands of saline habitats: Loss of some ecosystem functions is expected due to pollution and development activities.
- Running waters (rivers): Restoration of some ecosystem functions is possible with improved management of riverine environment and closure of polluting enterprises.
- Standing waters (e.g. lakes): Partial improvement of lake environments is possible, but effective ways to prevent lakes from being pollutant catchment areas has yet to be found.
- Sandy foreshores: No significant change in the current status.
- Estuaries: Ecosystem integrity will be impaired by coastal and offshore oil and gas development.
- Rocky foreshores: No significant change of current status is expected.
- Mud bottom: No significant change of current status is expected.



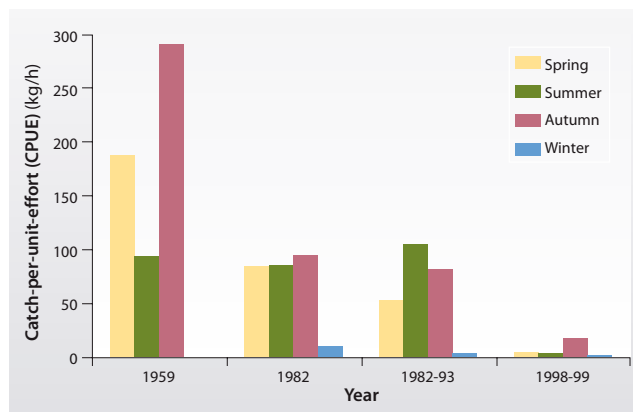
**Figure 5** Total catch in the Bohai Sea, 1995-1999.  
(Source: Dai 2001)

- Sand and gravel bottom: No significant change of current status is expected.
- Rocky bottom: No significant change of current status is expected.

The number of species of high economic value will continue to decrease. Pressure on overexploited species of high economic value will remain. Restoration of damaged habitats takes time. Some damages are irrevocable. As natural aquatic resources are depleted, management and enforcement will focus on reducing harvesting efforts. This may mean that employment opportunities in harvesting natural aquatic resources will be reduced by 50%. Aquatic raw materials for pharmaceutical industry will continue to decrease.

## IMPACT **Unsustainable exploitation of fish and other living resources**

Fisheries resources in the Bohai Sea have been dramatically decreasing since the 1980s. Compared with the fisheries resources in the early 1980s, the biomass of invertebrate animals in the Bohai Sea was reduced by 39% in 1992 and 1993 and the average weight of spawning fish reduced by 70%. The biomass of high value species such as Japanese sea perch (*Lateolabrax japonicus*), Chinese herring (*Ilisha elongate*), Genuine porgy (*Pagrosomus major*), Olive flounder (*Platichthys flesus*), Chinese prawn (*Penaeus chinensis*) and Swimming crab (*Portunus pelagicus*) decreased by 71%, and the total biomass of low value species was 2.4 times that of the early 1980s. A survey in 1998 indicated that the total biomass of fish stocks had been reduced by 89% compared to 1992 (Qiao 2001). The overexploited fisheries in the Bohai Sea are the result of failure to control access to the fisheries resource and failure to control the negative environmental impacts from mariculture. Inevitably, the fall in catch of



**Figure 6** Catch per unit effort in the Bohai Sea.  
(Source: Jin 2003)

high value species has been accompanied by a shift towards catches of low value pelagic species such as anchovies and sardines. The total catch from the Bohai Sea has increased in the 1990s (Figure 5), which is mostly due to the increasing fishing effort in Bohai Sea. In addition to the 75 000 locally registered fishing vessels and 290 000 fishermen from the Bohai Sea region, fishing vessels from other provinces further away (mainly Jiangsu Province, 16 460 tonnes in 1999) also fish in the Bohai Sea (Dai 2001).

The dominant species shifted from the late 1950s to the 1980s in the Bohai Sea; high valued, commercially important species such as Small yellow croaker (*Pseudosciaena polyactis*), Large-head hairtail (*Trichiurus lepturus*), and penaeid shrimps (*Penaeus* spp.) were replaced by low valued, small-sized species such as Japanese anchovy (*Engraulis japonicus*) and the Half-fin anchovy (*Engraulis* sp.). Although the dominant species has varied between years, the small pelagic fish, such as anchovy (*Engraulis* sp.), Half-fin anchovy (*Engraulis* sp.) and Gizzard fish (*Clupanodon punctatus*) have dominated the fishery resources since the beginning of the 1980s. However, in 1998-1999, the catch-per-unit effort (CPUE) of most fish species declined to a very low level (Figure 6). The CPUE of small pelagic fish and economically important invertebrates have sharply decreased, with reduced distribution areas that directly affect the growth of carnivorous fishes, such as Spanish mackerel (*Scomberomorus japonicus*) (Jin 2003).

### Environmental impacts

#### Overexploitation

Yields of highly valuable fish in the region have drastically reduced. For instance, the annual production of Chinese prawn (*Penaeus chinensis*), which used to reach as high as 40 000 tonnes a decade ago, has now decreased to around 500 kg annually. The highest recorded annual

production for the Threadfin fish (*Eleutheronema tetradactylum*) was around 40 000 tonnes two decades ago; it is now just 8 tonnes annually at current production. The catch of Yellow croaker (*Pseudosciaena* sp.) and Hairtail (*Trichiurus haumela*) fish are now so small that no fishing seasons for these fish have been identified. The impact of this issue on the region has been considered to be severe. This issue has transboundary importance in that many fish species in Bohai Sea are migrate to fishing grounds in the territorial waters of China, Korea and Japan.

#### **Excessive by-catch and discards**

There are occasional incidences of capturing protected or endangered species such as Spotted seals (*Phoca largha*) and Lancelets (*Branchiostoma belcheri*) by fishing fleets in the region. No discards are so far known. The impact can be considered to be slight.

#### **Destructive fishing practices**

The destructive fishing practices that are common in the region, as well as in the Yellow Sea region, include the indiscriminate trawling along the coastal waters of the Bohai Sea, fishing with explosives in lakes, and the use of pesticides for fishing. These destructive fishing activities have destroyed several benthic habitats, both spawning and fishing grounds, which in turn have resulted in reductions in both the fisheries resource as well as the recruitment of fish stocks. The impact is considered to be moderate.

#### **Decreased viability of stock through pollution and disease**

Several anadromous species such as the Hairtail herring (*Coilia mystus*) were once commonly caught in large quantities in Liao River estuary. These fish have disappeared over the past two decades, which might be a result of increased pollution. The impact of this issue on the region has been considered to be moderate. No significant changes in the current status are expected in the future.

#### **Impact on biological and genetic diversity**

There is evidence that the unsustainable exploitation of fish and other living resources has changed the biological and genetic diversities of aquatic organisms in the region. For instance, population declines, mass restocking of hatchery-produced post-larvae/fry and other environmental factors may have changed the genetic grouping of the Oriental prawn (*Penaeus orientalis*). The number of genetic polymorphous locations of wild oriental prawn is now just 20 as compared to only 15 in the cultured species. The impact of this issue in the region has been considered to be severe

### **Socio-economic impacts**

Total catches of fish species with high economic value, e.g. Yellow croakers and prawns, has dropped by more than 50% over the past decades. The catch per unit effort (CPUE) for all species has also decreased by more than 50%. The economic impact of this GIWA concern is of primary importance because any decrease in catches means reduced employment opportunities for coastal and riverine communities. Unemployment that results from depleted fisheries resources may be alleviated with alternative working opportunities. There were many cases of diseases such as gastroenteric disorders attributed to the consumption of fish and other aquatic products in the past few decades. Some of these cases have caused epidemics.

### **Conclusion and future outlook**

Measures like strict enforcement of fisheries management laws and restrictions on the number of fishermen allowed to enter the fishing industry to improve fisheries management are being implemented by the Chinese government. Effective controls on overfishing have yet to be undertaken. Overfishing problems are likely to exist but some improvements may be expected in the future. Incidence of by-catch of endangered species as well as the composition and quantity of by-catch is unlikely to increase in the future. Destructive fishing may decrease if appropriate control measures are taken by the government. The future fisheries management in the region is likely to focus on reducing fishing efforts, e.g. restricting the entry of fishing boats and fishermen to reduce fishing capacity to conserve the fisheries resource. The scale of reduction may have to be more than 50% of the current levels in order to achieve effective management of the fisheries resources. As an effective way to solve the overfishing problems has yet to be determined and implemented, overfishing may continue and the CPUE may continue to decrease.

## **Global change**

### **Environmental impacts**

#### **Changes in the hydrological cycle**

The GIWA Experts anticipate that global change has already had some effect on the hydrological cycle. One example is the trend of declining rainfall in the region.

#### **Sea level change**

The GIWA Experts acknowledge that some studies had shown evidence of sea level rise in the region. For instance, the Ramsar Workshop on the vulnerability assessment of the Yellow River Delta, held in Beijing in January 1999, describes the threat of rising sea levels in the region as:

“The estimated relative sea level rise rate in the Yellow River Delta is 8 mm per year and the sea level rise will be 48 cm by the year 2050. This will lead to critical impacts such as the frequency of storm surges and El-Niño events to strengthen hydrodynamics, beach erosion, and landward retreat, wetland loss, saltwater intrusion, and land salinisation.”

### Increased UV-B radiation as a result of ozone depletion and Changes in ocean CO<sub>2</sub> source/sink function

The GIWA experts concluded that no observed evidence of increased UV-B radiation or changes in ocean CO<sub>2</sub> source/sink function could be found in the region.

### Socio-economic impacts

Climate changes may cause changes in the status of various natural resources, which could result in user conflicts and disputes regarding property rights and administrative jurisdiction of those resources, thus affecting social stability. These problems are increasing. Economic restructuring, including improvements in resource management and use may help improve the situation.

### Conclusion and future outlook

No significant changes in the current status of the environmental issues are expected in the future. Use conflicts and disputes over property rights and administrative jurisdiction of resources may be reduced with improved legislation and management actions taken by the government in the future. The many national and international environmental management and protection projects that have been or will be implemented in the region are likely to facilitate a search for sustainable environmental management and economic development in the region to cope with the consequences of global environmental changes.

## Priority of concerns for further analysis

Based on the results of the assessment for the Bohai Sea region the GIWA issues that have been assessed as having severe environmental impacts were selected for further analysis and summarised in Table 2.

The GIWA concerns were ranked in descending order:

1. Unsustainable exploitation of fish and other living resources.
2. Habitat and community modification.
3. Freshwater shortage.
4. Pollution.
5. Global change.

**Table 2** Summary of environmental and socio-economic impacts of the prioritised GIWA concerns and issues in the Bohai Sea region.

Prioritised GIWA concern	Prioritised GIWA issue	Environmental and socio-economic impacts
Freshwater shortage	Modification of stream flow	Severe reduction of stream flow for major rivers (e.g. Liaohe, Haihe and Yellow Rivers) occurred over the past decades. Severe freshwater shortage had led to increased business cost by 10% and frequent interruption of water supply.
	Pollution of existing supplies	More than 30% of the major river basins in the sub-region have been polluted with surface waters below the WHO drinking water standards.
	Change in the water table	Large-scale salinisation (salt water intrusion) of coastal aquifers was observed over the past decades, particularly in some areas of the Chinese side of the sub-region (e.g. Hebei Province, and Dalian and Tianjin cities).
Habitat and community modification	Loss of ecosystems	Up to or more than 30% of the areas of critical habitats such as freshwater marshlands, running water wetlands, rivers, lakes, sandy foreshores, rocky foreshores, and sand & gravel bottoms were lost over the past decades. Some 50% of the areas of mud bottoms were lost during the past decades. Significant loss of freshwater and brackish habitats as well as seasonal drying up of Yellow River and other rivers occurred over the past decades. Significant loss of over 50% employment opportunities in the concerned aquatic product processing industries occurred over the past decades.
	Modification of ecosystems	Population structure, species compositions and ecosystem functions for habitats such as, (a) freshwater marshlands; (b) running water wetlands; (c) periodic waters; (d) saline habitat wetlands; (e) rivers; (f) offshore; and (f) lakes had greatly changed over the past decades. Modifications signified by species disappearance and reduction in population were obviously evidenced for habitats such as the sandy foreshores, estuaries, rocky foreshores, mud bottoms and sand & gravel bottoms were observed. Obvious increases in salinity (averaged 27 ppt in 1960s to around 31 ppt nowadays) in Bohai Sea due to decreased freshwater inputs from Yellow River had modified several coastal ecosystems were observed.
Unsustainable exploitation of fish and other living resources	Overexploitation	Yields of several stocks (e.g. <i>Penaes chinensis</i> , <i>Eleutheronema tetradactylum</i> ) drastically decreased over the past decades. Economic values of the fisheries sectors greatly decreased over the past decades due to decreased catch per unit efforts (CPUEs) and reduction in the total catches of some commercially important fish species.
	Destructive fishing practices	Include indiscriminate trawling along the coastal waters of the Bohai Sea, fishing with explosives in lakes and the use of pesticides.
	Impact on biological and genetic diversity	Genetic diversity of oriental prawn ( <i>Penaes orientalis</i> ) has significantly changed over the past decades.