TABLE OF CONTENT

INTRODUCTION *2*

AQUACULTURE AND SUSTAINABILITY IN CHINA: AN OVERVIEW *3*

Aquaculture in China **3**
China's Aquaculture Feed supply **11**
Ecological sustainability **13**

NATIONAL POLICIES *21*

Authorities **26**

RESEARCH INSTITUTIONS *29*

NON GOVERNMENTAL ORGANIZATIONS *31*

Position of NGOs in China **31**

CONCLUSIONS *34*

BIBLIOGRAPHY *36*

USED USEFUL WEBSITES *37*

SUPPLEMENTS AND APPENDICES *38*

Contacts in China **38**
Appendix A **41**
Appendix B **42**
Appendix C **44**

Introduction

China is an important country in various respects. In economic respect, regarding international relations, in environmental respect, China is of indubitable importance. Today, marine biodiversity and fish stocks all around the world are considered to be under threat. How does China's fishery and aquaculture look like and how does China face the degrading marine biodiversity and the declining fish stocks? And furthermore, what can various actors, such as Chinese as well as Dutch government, NGOs, business etc. do? That were the initial questions for beginning this project. A choice is made for a focus on sustainability in Chinese aquaculture, and its real and potential threats to marine biodiversity and ecological environment.

In the project, attention is paid to various aspects of the aquaculture industry in China. It gives a general overview of aquaculture production, but also of the feed supply for aquaculture in China. The ecological and environmental sustainability of aquaculture in China is discussed. However sustainability can be understood in many ways, included in this discussion is threat to marine biodiversity, but not energy use. No quantitative analysis have been done.

Besides an overview of sustainability in Chinese aquaculture, also Chinese authorities and national policies are discussed. Furthermore, the role of research institutions is described. For understanding the potential role of (environmental) NGOs in protecting and maintaining the environment and marine biodiversity in China, their position as in China is discussed.

Many may think that China, as a country in transition and development, is careless about the environment, sustainability or biodiversity. As this report focuses on aquaculture, it shows that the aquaculture is also in rapid development. The way in which this development is made possible, is as well in transition. Although the aquaculture industry still faces many problems, which are not all unique for China, it is heading in the right direction under government guidance and scientific support. And surely, there can be contributed to its sustainable development by foreign government institutions, NGOs and business.

This report is written under the authority of the Dutch Ministry of Agriculture, Nature and Food Quality (Ministerie van Landbouw, Natuur en Voedselkwaliteit) and it is the result of a six-month internship project, of which two months in the Netherlands and four months in China.

Notice: Some statistical information in this report is derived from China (Statistical) Yearbooks. This information is possibly not reliable. Furthermore China is not easy accessible for gathering information and as a result, information in this report may be incomplete.

Aquaculture and sustainability in China: an overview

This part gives an overview of sustainability in aquaculture in China. The first chapter describes the aquaculture and characteristics in China in general. Besides general information such as the economic importance of aquaculture and regional variation is given, attention is paid to origin of brood stock, the structure of the industry, innovation and development, food safety and certification of Chinese aquaculture. The second chapter describes China's aquaculture feed supply, and what this means for the ecological sustainability of aquaculture in China. The third chapter discusses the ecological sustainability of aquaculture in China, paying attention to different issues, such as water quality and escapes of non-native species. Energy use is not included.

Aquaculture in China

Aquaculture in China has a history of more than 2500 years. Since the 1980's the aquaculture industry has been growing very rapidly in China. China has the biggest aquaculture production in the world and accounted for 67% of global animal aquaculture in 2006 (FAO,2008). It is the only country in the world where aquaculture production exceeds wild catch production. Total aquatic production including aquaculture and wild catch accounted for 34.13 million ton (MT) in 2008 made up of 13.4 MT from marine culture and 20.73 MT from freshwater culture. In 1978, total aquaculture production was 1.2 MT (China Statistical Yearbook 2009). Marine and inland catch fishery account for 26% and 5% of total fishery production respectively.

Geographic characteristics

China is a very big country with a land area of 9.6 million square kilometer. There are 22 provinces, 4 municipalities, 5 autonomous regions and 2 special administrative regions (SAR of Macao and Hong Kong). These SAR are not included in this report. The territory stretches over several time zones from west to east and stretches over different climate zones from north to south. This means there is a wide variety in natural circumstances within China. As a result, China's aquaculture is very diversified. China's sea area counts 4.73 million square kilometer and the coastline has a total length of 32 000 kilometer including islands. The marine area that is cultivable is 2.6 million hectares in total, while 1.3 million hectares is used already for seawater culture, comprised of sea, tidal flats, but also land based culture. Guangdong, Liaoning and Shandong are the provinces with the biggest cultivable marine areas of shallow sea, tidal flats and harbors. Shandong, Fujian, Guangdong and Liaoning are the biggest seawater aquaculture production provinces with 3.614 MT; 2.778 MT; 2.23 MT and 2.021 MT production in 2008 (China Statistical Yearbook 2009).
China has a cultivated freshwater area of 4.7 million hectares made up by pools, lakes, reservoirs, brooks and more. The biggest freshwater aquaculture producers are Guangdong, Hubei and Jiangsu wit a production of 2.911 MT; 2.831 MT and 2.676 MT respectively in 2008 (CSY 2009).

Variation

As already mentioned, China's aquaculture is very diversified. China has freshwater as well as marine aquaculture, traditional as well as modernized aquaculture, extensive and intensive, family run as well as large scale integrated production, for domestic as well as export market, cheap but also exclusive products. Moreover, aquatic plants (algae), fish, crustaceans, shellfish, and other creatures are cultured in a wide variety. Different culture methods and technologies are in use.

Marine culture

Aquaculture in seawater is called marine culture or mariculture. Before the 1980's, main marine cultured species in were shellfish and seaweed. Abalone and

Figure 1: Fishery production 2008 in million ton. Source: China Statistical Yearbook 2009

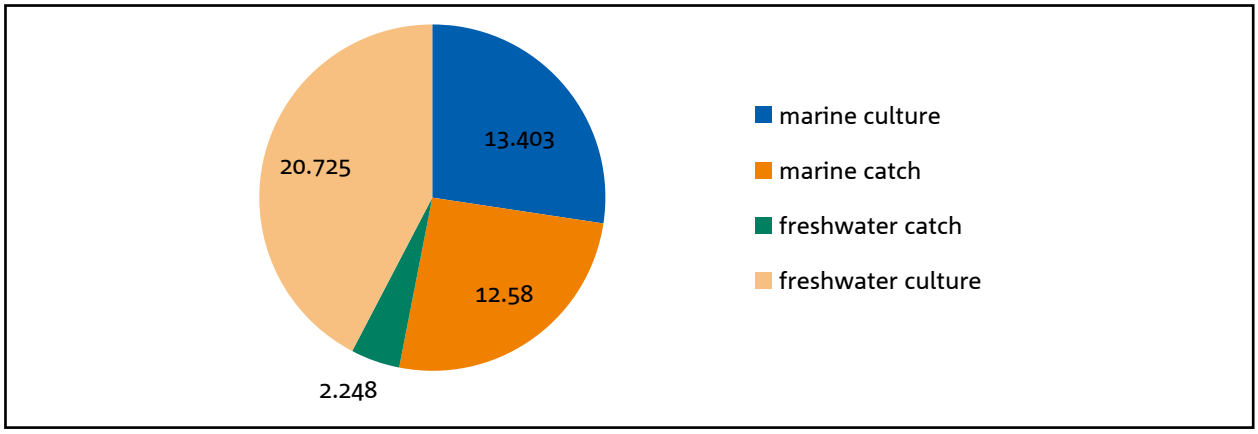

Table 1: Main marine cultured species

Fish:	Shellfish:	Algae:	Crustaceans:	Others
perch	oyster	kelp Laminaria japonica	shrimp	sea cucumber
grouper	abalone	wakame Undaria pinnatifida	swimming crab	sea urchin
red drum	snails	purple laver Porphyra	mud crab	pearl
cobia	blood clam	red alga Gracilaria verrucosa	jellyfish	
pilot fish	mussel	Eucheuma Sp		
porgy	pen shell	agar Gelidium amansii		
large yellow croaker	scallop	Sargassum fusiforme		
puffer fish	cockle	Enteromorpha prolifera		
turbot	razor clam			
japanese flounder				
japanese seabass				
gilthead seabream				
black seabream				
milkfish				
pomfret				
black rockfish				
bastard halibut				
Rainbow trout				

scallop culture developed in the 1980's. Marine fish culture began developing in the 1990's. Today, shellfish account for the biggest production in marine aquaculture, being approximately 75% of total marine culture in weight. Important marine culture species are large yellow croaker, shrimp, scallop, abalone, crab, red drum, perch, Japanese flounder and puffer fish. Aquatic plants are also important mariculture products. With the increase of Chinese people's income, the demand for high value species expands. The depletion of wild fish stocks also stimulates the farming of some species, such as big yellow croaker. The cultured species form a substitute for the wild caught fish. See table 1 for more marine cultured species.

At present, saltwater culture is seen as having a large potential for development. 40 million hecares of alkaline wasteland is available for saltwater culture, 2 million hectare of beaches, 22700 million m^3 underground brackish water resource, 12100 million m^3 half salt water, abandoned shrimp ponds and an inexhaustible resource of seawater (Li Sifa, tilapia forum). At the same time, marine culture inshore has not much space left for expansion, because the available space at the coast is also being used for other purposes, such as maritime activities and tourism. Mariculture area has grown considerably since mid 1980's and mariculture activities have expanded in all coastal areas, mainly in Liaoning and Shandong in the north and Guangdong and Fujian in the south.
In north-east coastal China (Bohai and Yellow Sea region) at the coast of Liaoning, Hebei and Shandong provinces, mainly shellfish species, sea cucumber, algae and shrimps are cultured in marine water, while marine fish culture is done predominantly in the southeast coastal region of China. Grouper, cobia, porgy are cultured in south china, mostly in Fujian and Guangdong. Large yellow croaker is cultured mainly in Fujian. However, in south-east China the culture of shrimp and shellfish is also large. Shrimp culture is also important in Hainan province.

Map 1: China and main cultured species per region.

Bohai Sea and Yellow Sea: seaweed; shellfish; sea cucumber, shrimp, crab; puffer fish; flatfish; jellyfish

East China Sea region: shellfish; shrimp; large yellow croaker; shrimp; crab; seaweeds; pearl; flatfish; finfish; eel; catfish

South China region: porgy; grouper; cobia; eel; tilapia; shrimp; pearl; shellfish; sea bass

Marine culture is now done in various ways. The culture methods used in coastal areas in open seawater are floating raft culture and (net) cage culture. Floating rafts are used for culturing shellfish, such as abalone and scallop. Net cage culture is a new technology for the culture of fish inshore, for example large yellow croaker and sea bass. The net cage culture for offshore culturing

is in a developing stage. In total, one million marine cages are in use of which 3000 offshore (Chen et al, 2008). Most of the marine cages are in Fujian (over 600 000), Guangdong (over 300 000), Zhejiang (75 000) and Shandong (20 000) provinces (Chen et al). Such offshore cages are located between the 20m and 40m isobaths, which means that the cages are not located in water that is more deep than 40m. Furthermore, tidal flat culture is being used for example for scallop, mussel, abalone and sea cucumber. In Dalian region, by some companies small abalone and sea cucumber are released on the seabed were sea grass is available. The animals live and feed in a natural way, and are harvested by scuba divers. Thereby, the natural seabed is maintained.

Picture 1: Floating raft culture for shellfish in Dalian region

Marine aquaculture can also be land based, meaning culture in ponds or in the Recirculated Aquaculture System (RAS). Ponds are used for example for sea cucumber in Dalian region, Liaoning Province, or for shrimp and crab. The RAS is used for example for culturing flatfish, such as turbot and tongue fish. However, the RAS is not (yet) a widely used culture technology in China.

Picture 2: net cage grouper culture Guangdong province

Freshwater culture

In freshwater production, fish accounts for the biggest production with almost 89% of total freshwater production (CFY 2008). Freshwater culture in China is done all over the country. Freshwater culture is done in ponds, lakes, reservoirs, rice paddy fields, rivers and brooks. Intensified freshwater is done in rail enclosures, in net cages, green house culture and industrialized.

Various carp species are very important in freshwater culture. Carp culture provides cheap fish for the domestic market. Other main freshwater culture species include tilapia, Wuchang bream, bluntsnout bream, shrimp, eel, catfish, sturgeon and crab.

Picture 3: Catfish culture

Picture 4: Eel culture

Carp species are cultured in inland regions all over China. Eel is predominantly farmed in Fujian and Guangdong province. Tilapia is farmed mostly in Guangdong, Guangxi and Hainan province. In the Yangtze river basin, some major species include catfish, river crab and eel. China is the world's largest producer of tilapia, shrimp and prawn. Pond culture accounts for the biggest production in freshwater aquaculture, namely 68% in culture production output in weight. Most pond culture is to be found along the Yangtze River and Pearl river basins, in Guangdong, Jiangsu, Hubei, Hunan, Anhui, Jiangxi and Shandong. Total area of freshwater culture ponds is 1.27 million hectare (CFY 2008).

Picture 5: tilapia pond culture in Guanxi

Picture 6: shrimp and crab culture in shallow water in Jiangsu province

In both marine culture and freshwater culture, there are species farmed that are not native species in China. Various species have been introduced to China for commercial cultivation. For example tilapia, different kinds of sea cucumber, or American sturgeon species and white shrimp.
Tilapia accounts for 6% of freshwater culture production in weight and reached 1.13 MT in 2007. Shrimp culture has grown considerably in the last decade from less than 0.1 MT in 1996 to more than 1.2 MT in 2006. Penaeus vannamei is the dominant cultured species which accounts for nearly 85% of shrimp culture production, which is introduced from America in 1988 (EU report). Salmon is also a cultured species in China, but is not cultured on large scale.

Table 2: main freshwater culture species

Fish	Other
Carp: silver; bighead; black;	Giant river prawn
Tilapia	Soft shelled turtle
Sturgeon	Chinese river crab
Eel: Japanese; European	Crawfish
River nail	Frog
Mandarin fish	Shrimp
Loach	
Snakehead	
Rainbow trout	
Catfish	
Paddlefish	
Mullet	

Brood stock

It is clear that a wide variety of aquatic organisms is cultured in China. The culture of certain species depends on wild brood stock or fry while other species can be hatched and bred artificially. Various carp species have been researched for artificial hatching and improving breeding strains. Flatfish and large yellow croaker can be hatched artificially too. However, new brood stock often derives from the wild, for maintaining optimum genetic composition of farmed fish. Eel and grouper is dependent on the catch of wild fry for culturing. This poses a threat to wild stocks. In general, wild caught fry and brood stock is preferred by Chinese farmers, even when a specific species can be artificially hatched and bred (HK porcupine). Wild fry is often thought to be of better quality. Most seeds for freshwater fish are derived from wild parents in artificial hatching (FAO, Hu technical paper)
Brood stock is sometimes imported. This is the case for white leg shrimp (Penaeus vannamei), some Nile tilapia, channel catfish and more. Brood stock of some flatfish species, such as turbot, also is 'refreshed' with imported brood stock. Fry can also be imported, glass eel (Anguilla anguilla) is imported from England, France and Spain.

Economic importance

Aquaculture is an important sector for employment and provides jobs to nearly 5 million people of a total of 7.5 million people that work in fishery sectors. Another 5.6 million people work part time in fishery or related sectors (CAY 2008). Aquaculture provides a replacing employment opportunity for fishermen that cannot continue fishing. China has a fleet size reduction program to tackle overfishing and reduces the number of fishers. Aquaculture is stimulated by the government to provide food for the Chinese people and for alleviating poverty in rural areas. Aquaculture also provides raw material for processing and products for export.
In 2007, marine aquaculture production had a value of 105.74 billion RMB. Freshwater aquaculture accordingly had a value of 216.86 billion RMB and aquatic fry culture 25.13 billion RMB (CFY 2008).
China is the leading exporter of fish products from fishery and fish processing industry. There is also an increase in fish imports, in part of raw material for processing designated for re-export. The main export countries for Chinese fishery products are Japan, US, European Union, Russia. Aquaculture products exported to the Netherlands include tilapia, shrimps, crawfish. There is also processing of imported wild catch fish in China that is re-exported to the Netherlands. For trade statistics, please refer to World Trade Atlas or the GAIN Fishery Products Annual.

Structure

The structure of the aquaculture industry is as varied as the species cultured. There are family run farms producing for the local market, companies that produce for a bigger domestic market and also large scale enterprises and smaller farms producing for export markets. In general in

the Bohai sea and Yellow Sea region of Liaoning, Hebei, Shandong province and Tianjin city, the most aquaculture companies are large integrated corporations, which were cooperatives before 1978. In the southeast coast region of Zhejiang, Fujian, Guangdong, Guangxi and Hainan province, the aquaculture is in the most part controlled by individuals and private companies. In the inland Yangtze river basin region including Jiangsu, Anhui, Jiangxi, Hubei, Hunan, Chongqing and Sichuan province the most farms are family run (Deng, 2009). Most freshwater farms are small scale and producing for the local market. However, tilapia, shrimp and catfish are important export species and farms may be large scale.
As the above is a rough description, it does not mean that there are no small scale farms in Shandong or Liaoning province, or that there are now large integrated companies in the south of China. For example in Dalian region, the abalone aquaculture companies are mainly small, and the farmers have close contacts with their mostly regular domestic customers in other provinces of China.

Integration
Processing companies that use aquatic raw material from aquaculture and are supplying the export market tend to contract their suppliers of raw material. This is for better traceability of the raw material and control of the use of chemicals and drugs by the aquaculture farms. It is also possible that the processors provide the seed and feed to the farms and have a part in the farming management. This is a recent development in the sector, spurred by the more strict control for food safety and by concerns over food safety. Some big companies are even horizontally integrated for ensuring that the raw materials meet the standards that are set for exporting. The companies coordinate the hatchery, the farms, feed plant and the processing plant in one. In this way, the complete supply chain is controlled and food quality and safety is ensured as to meet the export market requirements (Deng, 2009). Some feed producing companies even set up their own fields for own cultivation of raw material for feed, as far as plants are concerned.

For more detailed information about shrimp and tilapia culture in South China, see EU report

Local, domestic or export: difference in development
The use of advanced technology greatly varies around China amongst different farmers. There are technologically advanced farms as well as farms that are backward in technology. Reason for this can be the value of the farmed product, for example flatfish and abalone are high value products, so it is more viable to have higher production costs for the use of more advanced technologies, construction, brood stock or feed input. Low value species may be cultured in a quite backward situation. Aquaculture production for export to US or EU generally is quite advanced. This is partly spurred by the strict requirements of the importing countries. Exporting producers have to comply with several standards that are set by receiving countries, such as HACCP and ISO9001, before they are able to sell their products on these foreign markets. Meanwhile, on US and EU markets, their products can be sold for a higher price than at the domestic market, so it is possible to make investments in technologies.
There is also a big difference in the educational levels of farmers. Exporting companies can invest in the employment of university degree specialists to work in their laboratories and to compose their feeds. Also producers of high end products can have quite good education and a degree in aquaculture. This is different for local producers and those producing lower value products for the domestic market. A considerable part of fish farmers in China is not well-trained (Zhou et al).
For more information on main aquaculture producers in China, please see 'Aquaculture in China', NBSO Dalian 2009.

Innovation and development
The development of aquaculture and the huge increase of production in the last decades is in part due to research and application of new technologies. The yield of fish pond culture for example was 724 kg per hectare in 1979 and has increased to an average 7 399 kg per hectare in 2007. Research is done at universities and research institutes for improving aquaculture production (see also Research Institutions chapter). This improvement is focused both on production increase and efficiency and market development as well as safe and sustainable development. This sustainable development is regarded important for the aquaculture itself. However, to a certain extent this has implications for the environment, so the attention for sustainability also benefits the natural environment. Main disciplines include breed improvement, disease control, aquaculture construction engineering, ecological aquaculture models, hatchery technology, food safety control, feed and water quality improvement.
Different research institutions have developed aquaculture technologies for specific regions. In this way, there is made efficient use of the local resources and local conditions. Developments include for example net cage and pen technique that made possible the culture in open water, such as lakes and shallow sea. Deep sea cage culture is now being developed. Submersible marine cages for fish culture are already in use, but not on a large scale.
Recycling processes are in development for aquatic production. Biochemical products from wastes from fish processing industry, for example Chitin from prawn crust and crab scale is used in the pharmaceutical industry and Chitosan is used for water treatment, cosmetics, food, agrochemicals.. Also fish processing waste can be used for fish meal production in China or for manufacturing gelatine. Another recycling process that is being researched is the use of nutrient rich water from closed aquaculture models for the cultivation of algae and production of biofuel.

Improved strains

Breeding strains are being improved to enhance productivity. Selective breeding is done to create fish with higher disease resistance and more efficient growth. For example, a new tilapia is developed by the Shanghai Fishery Research Institute by Li Sifa. This new tilapia Jili (吉鲕) has high salt tolerance and is developed because freshwater farming sites are scarce. At the same time, tilapia can be raised with lower animal protein input than the carnivorous marine fish that currently dominate in marine culture, while supply of feed resources fall short. The taste is comparable with the taste of seawater species, and therefore it is expected that this 'saltwater tilapia' has good market prospects (Li Sifa, presentation tilapia forum). Other improved strains include several carps, Jifu tilapia and shrimps.

Polyculture

Polyculture is a traditional way of fish farming in China and a method more than 2000 years old. Polyculture stands for the breeding of more than one species in the same environment. For example seaweed, mollusks and fish can be cultured in the same pond. Advantages of polyculture include the use of one water resource for culturing multiple crops; a complementation of feed habits and for example, the one species feeds on the 'waste' of the other species (Wang, 2009). Aquatic plants provide feed for animals, animals provide nutrients through excrement to algae and plankton, and are themselves sometimes feed for cultured animals of higher trophic levels. Plankton in turn provides feed for animals. This makes water purification possible and the water quality can be more balanced. Furthermore, there is less need of artificial feed input. However, polyculture also has disadvantages. It may be difficult to choose the right species to farm together and how to choose added feed. Breeding densities of different species and the carrying capacity are not well known. Another difficulty may be the use of medicines, as different species react differently on the same medicine and dosage (Wang, 2009).

One traditional polyculture method is the farming of fish, shrimps or crabs in paddy fields. Mulberry trees on fish pond dikes and a simultaneous cultivation of pig or duck is also a traditional model. Other ways of polyculture include sea cucumber together with jellyfish in ponds; kelp together with finfish in pens; laver with crab and shrimp in shallow sea pens; kelp and shellfish in floating raft culture etc.[1]

Mixed or alternate culture of shell and algae contributes to adjust the ecological conditions (Chen et al). Aquatic plants are used in aquaculture for water quality improvement, for example in shrimp ponds. The plants remove nutrients from the pond water and in this way, a better ecological balance is achieved. At the same time, plants can provide feed for the farmed animals. Polyculture can have microbiological benefits to all of the crops farmed. Also there are more marketable crops farmed at the same time, using each others waste, which is very efficient.

Polyculture is seen as a traditional farming method while the development mode of modern Chinese aquaculture currently aims intensified monoculture. However, polyculture models are explored for modern aquaculture because of the benefits for water quality, disease prevention and efficiency.

Polyculture with tilapia and shrimp

The farming of tilapia is sometimes done in combination with silver carp. The silver carp helps in purifying the water in which the tilapia is farmed.

Tilapia can help in disease control in shrimp ponds by improving the water quality. This is because the simultaneous farming of tilapia and shrimp cause a balance in nutrients in the pond water. The polyculture of shrimp in combination with tilapia is already done in Indonesia in a closed system with separate basins for shrimp, tilapia and Gracilaria seaweed, in which the water is pumped from the one basin to the other. The tilapia has a beneficial influence on disease prevention for shrimp. Other kinds of fish can be farmed together with shrimp as well. Especially suitable fish for this kind of polyculture are omnivorous fish that are able to eat toxic algae, and partly carnivorous fish to eat the diseased shrimps that would otherwise be eaten by other healthy shrimps and would get affected by disease too. In tilapia ponds, trials are done with various aquatic plants for ecological water management methods (EUCTP report).

Chinese herbs and probiotics

Chinese herbs are used and researched for use in mariculture of fish. These herbs can also be good for the growth and appetite of the fish, improving water quality prevention of diseases. For example for flatfish in industrial aquaculture. Tea seed meal is used and sold to kill snails, in ponds or coastal cropland and it is beneficial for shrimp, eel, crab and it improves the water quality (GAIN 2008). At the moment, the use of Chinese herbs is in a stage of research and not widespread in practice. Beneficial bacteria, so called Effective Micro-organisms (EM) and other probiotics are popular in shrimp culture. These bacteria are used for maintaining water quality and this in turn is beneficent to growth, survival, feed intake and disease management (EUCTP report). EM can be mixed with the feed before feeding to prevent disease. Probiotics are more popular than Chinese herbs and used mainly in shrimp pond culture.

Food Safety and Quality

At the moment, food safety and quality receives considerable attention from governments, consumers and aquaculture producers in China. In the past, big food safety related incidents occurred. For example, the melamine scandal in 2008 caused health problems and even deaths. This has sparked consumer consciousness as well as government stringency on food safety. Also in fishery products there have been found harmful chemicals and

[1] *See for example: http://www.fao.org/docrep/field/003/ab724e/AB724E08.htm for more info on kelp polyculture*

other problems, leading to bans on foreign export markets. The presence of harmful chemicals in aquaculture products can be caused by various factors. Uncontrolled medicine use caused residue on aquatic products. Some aquaculture farmers and companies disobeyed the related regulations and standards, causing disqualifications in aquatic products.

The natural water environment can be a problem, as a considerable part of China's inland waters is contaminated by industrial pollution. Marine waters are polluted by land-based sources, but also for example marine based oil spills. If fish is farmed in contaminated water, the end product probably is also contaminated. Pollution is a cause for eutrophication, meaning that there is an excess of nutrients such as nitrogen in the water. This potentially leads to algal bloom and red tides (Yu). If the algae that bloom are of a toxic kind, the toxic algae can be eaten by shellfish. These shellfish in turn contain toxins and if consumed by humans, these can cause serious sickness. Furthermore, the chemical residues in aquatic products do not exclusively come from the farming itself. For example, problems occur in another stage of production, such as the processing, or shipment. Disinfectants can have been added before shipment (Zhou,2007).

The use of chemicals and medicines in aquaculture is often driven by the pursuit of higher yields. Medicines are used to prevent disease that would otherwise lead to loss in farmed stock. Farmers tend to raise fish in high density stocking rates, while specific fish species easily get sick when stocked in high density. Furthermore, the quality of China's inland and marine waters is for a considerable part deteriorated. If fish is farmed in water of bad quality, it is more susceptible to disease. As a result, farmers tend to use antibiotics. For example, malachite green was used in eel farming for lowering the death rate from 4 of 10 to 1 of 10 eels (USA today, 2007). Some shrimp farmers make use of pesticides to fight algae that cause disease and death in shrimps. A chemical that is in use for pond water management in shrimp culture is formaldehyde. A part of farmers are not aware of the risks of the chemical they use, or do not even know what is in the products they apply. Producers want to lower their costs. The cost of feed is the main concern for producers. Melamine was added to animal feeds to lower the production costs and sales price.

There is currently an EU ban on import of shellfish from China, because of food safety problems in the past. While shellfish producers are eager to export their products to the EU, they are together with researchers and governments very aware of food safety. Furthermore, food safety problems led to several bans by the US on various aquatic products from China. Rejections were caused by additives, drugs, but also pathogens and filth. Chloramphenicol was found in exported products in 2003, Nitrofurans in 2004, Fluoroquinolones in 2005 and 2007, Malachite Green in 2006 and Gentian Violet in 2007. Endosulfan has been found in eel exports to Japan, causing Japan to restrict eel imports from China and focussing on domestic production of eel in Japan.

It is hard to say to what extent (forbidden) medicines are used, but food quality and safety problems in aquatic products are not uncommon (Zhou, 2007). A contributing factor to this problem is a widespread lack of knowledge amongst Chinese farmers, about the use of feed or medicines in aquaculture (Zhou, 2007). Although use of specific hormones is forbidden by government regulations, there are farmers that make use of hormones (EUCTP report). By some tilapia farmers, hormones are used for changing the sex of tilapia. In tilapia farming, male tilapia are preferred, because male tilapia do not 'waste' feed and energy for producing unneeded reproduction organs and provide higher meat production. Today, some forbidden substances are still used in aquaculture in China. According to the China Fisheries Yearbook, there are still problems with forbidden chemicals. Standards for the quality of aquaculture products are still imperfect, management tools of fishery departments are inadequate and coordination between related departments is not effective (CFY 2008; Zhou, 2007). Furthermore, test methods can be inefficient and need modification. Zhou writes that the research on substitute fish drug is retarded and the fine breeds are not widely used. Furthermore, technology of fish feed development is backward.

However, the situation is improving. There is more control over the production, the use of medicines is more strict and there is more inspection of processing factories. Also, farmers that produce for exporting processors gain better knowledge. Local governments play an important role in food safety, inspection and setting up testing centers. Inspection is done by the CIQ (see chapter 'authorities'). The quality of export aquaculture products has been promoted. The government has set standards for aquaculture production, food safety and residues[2]. A list has been publicized of medicines and chemicals that are now forbidden to use in animals farming and aquaculture. This list includes for example Chloramphenicol, Nitrofuran, Malachite Green, see also Appendix A.

The contracting of different producers in the supply chain for complete supply chain management is mainly done by the processing companies that will eventually export the products. In this way they are sure that the products that are provided are from good quality and will meet the standards for export and food safety/ quality. Large aquaculture companies are encouraged to contract fresh fish and shrimp producers, to integrate the production under their management system. On large-scale aquaculture companies, on-farm high level trainings can be provided and supervision and testing for product quality is more consistent. As described above under 'structure', by some companies there is vertical integration of the supply chain to make traceability easier and to ensure food safety. Small scale producers often have good relationships with their suppliers and customers, which can contribute to ensuring food

[2] *Appendix 10 of the EUCTP report Sustainable Aquaculture in South China lists the water discharge standards and allowed contents.*

safety. See 'authorities' for more detailed description of inspection.
The use of medicines and other chemicals pose threats to the sustainability of aquaculture. The use of chemicals may have negative effects on the natural environment and for people's health. The use of antibiotics for example is risky, as it potentially causes insensitivity in bacteria that cause disease. Furthermore, food safety problems are not good for the name of Chinese aquaculture products in domestic markets nor export markets.

Certification

Chinese certification

In China there are different certifications for food and agricultural products: 'organic food' (有机食品), 'green food' (绿色食品) and 'harmless' food (无公害食品). The 'harmless food' certification is most widespread in aquaculture, but 'green food' is also widely seen. 'organic food' certification is also done for aquaculture, but less than the other two. 'Harmless food' can be characterized as causing no harm to people and 'green food' as posing no harm to both people and nature. The standards of green food and harmless food are created according to the economic development and market demand of China itself. Both have minimum standards for environmental quality of the production base, feed and medicines, but the main objective is to ensure food quality and safety. Factors such as water use and biodiversity protection are not included.

Picture 7: certification symbols for harmless agriculture, green food and organic food

In case of 'harmless food', certification authorities handle the agricultural product certification and are approved by the Certification and Accreditation Administration of the PRC (CNCA). Companies have to apply for a certification and are certified according to their production mode after inspection. Certification is authorized by the Center For Agriculture Food Quality & Safety of MOA. For 'green food' , certification is carried out by China Green Food Certification Center and its provincial branches. After certification, the companies will be monitored and the certification will be adjusted if there are findings that require adjustments.

International certification

Next to the domestic certification standards, HACCP and ISO are also in use in China. HACCP and ISO9000 have standards for quality management systems and are required for export to the EU or the US. As a result, ISO9000 and HACCP certification is found at most if not all fish processing companies that produce to export. Major feed companies and aquaculture farms are also certified. The ISO14000 standards that focus on environmental management are also in use in China, but not a lot in aquaculture. ISO22000-2005 food safety management is also in use in aquatic production.
NGOs that are active in setting up certification for aquaculture in China include the following: Aquaculture Certification Council (ACC), Global Aquaculture Alliance (GAA) and GlobalGAP. These review the sustainability of aquaculture practices and provide a certification and marketing logo. Basic goals of NGOs are protecting the environment, protecting consumers, protecting workers and protecting society and farm neighbours. This means reducing effluent impacts, protecting wildlife, reduction of hormones, antibiotics and contaminants, fair wages and a safe environment for workers, follow local laws and reduction of environmental externalities.
The certification of farms and plant by NGOs as ACC and GlobalGAP is in a starting up stadium. The ACC had recently certified 16 processing plants and 14 farming sites with the standards that are developed by GAA, the Best Aquaculture Practices (BAP). ACC currently certifies shrimp hatcheries and farms, and tilapia and channel catfish farms and processing plants. GlobalGAP had no aquatic production certified yet. There are however other kinds of products certified by GlobalGAP in China, such as fruits. China developed in cooperation with GlobalGAP also its own ChinaGAP with a national standard. At the time of writing, there was not ChinaGAP certification for aquaculture yet. The certification of aquaculture by NGOs is done mainly in South China. It is more important there, because of the big export market in South China.
A part of fish processing companies and their plants are certified by the Marine Stewardship Council (MSC). This is done for wild catch fish that is being processed and then exported. A lot of processing companies are MSC certified in Dalian.

Summary

China's aquaculture industry is big and diverse. In this way, no generalized conclusions can be made about 'the' aquaculture in China. On the one hand, characteristics can be found that can be considered as sustainable, while at the other hand, also unsustainable practices exist. Aquaculture is economically very important and production has grown and will continue to grow considerably. Furthermore, various technological developments can be witnessed that contribute to the sustainable development of aquaculture production, such as the use of probiotics and modern polyculture. Disease outbreak is a problem for various kinds of aquaculture in China. Food safety problems are still present, but efforts are made for relieving food safety problems and risks by integration and management of the supply chain. Certification for aquaculture is available in several forms, mostly stressing food safety. However, NGO certification for sustainable aquaculture is in a developing stage.

China's Aquaculture Feed supply

Feed

Feed is an important factor in assessing sustainability in aquaculture in multiple ways. First, raw material originates from animal or vegetable sources. For example, fishmeal is an ingredient widely used in aquatic feed. This causes a higher demand for fishmeal, potentially putting pressure on wild fish stocks. However, feed is not necessarily put in, when for example the feed already is in the cultivating environment by growth of algae, plankton or other organisms. Second, feed quality is important for healthy cultivation of animals. Trash fish is still in use in Chinese aquaculture, as it is cheap and easy to obtain in local markets, but it is also a source of disease (Chen et al). Compound feed can alternatively enhance the disease resistance of the cultured animals. Third, the feed efficiency determines how much feed is needed for the cultivation of a certain amount of product. For example, modern compound feeds can achieve a feed conversion ratio (FCR) of 1 (depending on fish species). This means that for the production of 1 kilogram of fish, 1 kilogram of feed is needed for the cultivation. Using trash fish on the other hand, the FCR is approximately 6 to 8, meaning that it is less efficient than compound feed (Chen et al). Fourth, feed input potentially causes waste, contaminating the water in which the fish is cultivated. Uneaten feed forms excess nutrient input, such as nitrogen, which impacts the water quality and can give rise to the growth of unwanted algae for example. Uneaten feed and aquatic animal excrement can build up as sediment on the bottom. In this respect, use of raw fish as feed is bad for water quality, and even worse if the fish is cut into pieces before feeding. Furthermore, feed influences the make-up of the animal excrement, and in turn on the amount of nutrients in the water. Finally, medicines and chemicals can be added to the feed, having unsecure effect on the environment.

Trash fish

In China, marine fish are commonly cultured and fed with small fish that are unsuitable for human consumption (Feng et al). China is the biggest consumer of trash fish as input for aquaculture in the world (4 MT in 2000) (NACA website). Increasing pressure for trash fish catch fishery contributes to overexploitation of commercial fish stocks in the East China Sea, with a resulting negative impact on marine capture fisheries (APFIC 2005). According to surveys by FAO at ports in China, large quantities of trash fish and low value fish are taken by trawl and sail stow net gears. Trash fish can account for half of the catch, and between 32% and 50% of that are juveniles of commercially important species. There are concerns about impacts of increasing fishing efforts for trash fish and low value fish on the ecosystem and biodiversity (APFIC 2005). As stated above, trash fish as feed input for aquaculture has low feed efficiency, is a source of disease and causes water quality decrease by excess nutrient input.

Modern compound feed

The growth in the aquaculture sector sparked the booming of the aquaculture feed production sector. Aquafeed production in China grew from 1.8 MT in 1994 to 4.9 MT in 2000 and 14.2 MT in 2008 (IFFO, 2009). In 2008, China consumed 17,3 million ton aquafeed (IFFO, 2009). This is 8% of total feed consumption in weight. Although domestic produced feeds are often cheaper than foreign feeds, foreign feeds can be preferred for their quality.

In compound feeds, protein and energy sources such as fishmeal, soy and corn are mixed with vitamins and minerals, and can be bound with for example algae starch and put in pellet form. Aquatic plants are also used in compound aquafeed. For example for shellfish, feed consists mainly of these plants. Other additives can be feeding attractants, appetite stimulants and growth enhancers. These additives can be probiotics. Local fish farmers and feed producers can be assisted by expert feed composers to compose the feed according to specific needs of the farmer and the cultivated animals. The feed composition for example helps in disease management. Although automatic feeding systems are in use in China, the application is not widespread and feeding relies mostly on judgment by view of the feeder (Chen et al). In this way, potentially to much feed is put in, leading to excess of nutrients.

It is better to use less feed for the water quality in the aquaculture system, in RAS, pond, as well as net cages. The fish cannot take up more proteins in a certain time than they naturally can, so using more feed would be wasting feed. Small Chinese factories offer a high protein percentage in the fishmeal, but because the quality is low, the absorption rates for these products are low. This means that the fish will excrete the proteins that it can not absorb. This causes pollution of the water. Nitrogen derived from proteins in the feed that end up in the water can cause ammonia contamination.

Picture 8: pellet feed for marine fish,' green and environmentally friendly'

Raw material costs for fish feed are rising. For exporting companies, and companies that produce expensive products, raw materials are often sourced from imported goods. Some producers are concerned with domestic supplies of raw material, related to the quality and

contents of (toxic) chemicals. In the EU Report, it is supposed that there is high chance that the soy used is from the US and thus probably is genetically modified soy (GMO).
The percentage of fishmeal used in fish feed depends on the fishmeal market situation. In fish farming, the cost of feed often makes up the highest cost in total production costs. For example in tilapia farming, the feed can make up 70% of total cost. If fishmeal is very expensive, farmers can choose for less fishmeal use to save costs. High fishmeal prices speeded up the change in formulation of feed and nutrient formulation technique improvement with lower demand for fishmeal, for example by constituting fishmeal protein partly with soy. Peanut, rapeseed, wheat and rice bran, cotton seed, corn, krill, crab, shrimp and squid meal can be used in fish feed. There is a wide range of products on the market as raw material for aquafeed to substitute fishmeal, for example silkworm meal, feather meal and land animal meal. As a result, fishmeal use in aquafeed can be decreased.
On the other hand, if fishmeal prices decrease, generally fishmeal is preferred in aquafeed production. Some feed producers do not lower the fishmeal content of feed, because they think feed quality would be reduced this way. Fishmeal content is in some cases raised for higher productivity as it can lead to higher feed efficiency. In this way, higher fishmeal content, means a lower feed conversion rate and consequently should lead to less feed input.
Fishmeal use in feed for carp species can range from 1% (specifically grass carp) to 20% (specifically crucian carp). The percentage of fishmeal in shrimp feed ranges from 25% to 40%. Fishmeal use for other species as follows: turtle feed 70-75%; eel 50-70%; marine fish 25-35%; tilapia 2-15% (IFFO). The use of fishmeal in feed is also influenced by formula and feed technology improvement. Feeds substitute the use of wastes and other material. The use of formulated compound feeds has improved pond water quality and raised yields of fish that is healthy. Domestic production of feed in China is done for example by integrated companies that have aquaculture, processing but also research for composition of feed. There are state owned plants that produce for research trials. Feed can be accompanied with labels such as 'healthy aquaculture', 'green environmental protection feed', 'green feed', showing a concern about water quality and 'healthy' aquaculture. Some big aquaculture feed companies in China are: Tongwei, Hengxing Evergreen, New Hope Group, East Hope Group.

Other nutrition sources

Other kinds of feed in Chinese aquaculture include naturally available nutrients in the environment, for example for algae culture where no artificial feeding is done. Rich algal growth is used as part of feed in shrimp ponds, amongst others, in south China (EUCTP report). Artemia brine shrimp eggs are harvested in the Bohai sea or artificially cultivated for feeding fish fry.
Animal and human excrement can be used in fish farming as well as crop residues from land based farming. Feed can also be composed of available residue material from land cultivation that is being recycled. This is mixed on site by the fish farmer and tailored to the specific requirements of the time and place.

Fishmeal

China is the single largest user of world fishmeal stocks. Total fishmeal consumption was 1.48 MT in 2008 (IFFO, 2009). The world annual production is relatively stable at 6 million tons (FAO, 2008). It is used in feed for ruminants, pork and poultry, as well as in fish feed. Fishmeal is an essential ingredient in most fish feed. The amount of fish oil used in fish feed China is relatively small compared to fishmeal. The yearly supply of fishmeal in China, from import as well as domestic production, is not stable and varies year by year. Most of fishmeal supply comes from imports. The supply of fishmeal is unlikely to grow.
In 2008 fish feed production for marine species was around 500 thousand ton and accounts for 100-150 thousand ton of fishmeal use. Freshwater feed production uses 150 thousand ton. Shrimp feed production is around 800-900 thousand ton annually and consumed 200-250 thousand ton fishmeal, however, this number has not been stable, as disease in the shrimp industry caused a decline in feed demand. Eel and turtle used 190 thousand ton fishmeal (IFFO).

Domestic production

The domestic annual fishmeal production accounts for approximately 250.000 tons (Fishery Advance), mainly produced in Liaoning, Shandong and Zhejiang provinces. There are large-scale producers of high-value fishmeal with high protein content, but domestic fishmeal production is mainly done by small-scale low-value producers using backward processing technologies.
The raw material for Chinese produced fishmeal includes both whole fish and residue and waste material from food industries, such as fishbone and other offal. As a result, there is a big difference in fishmeal quality. Various fish species are used for the production of fishmeal in China, for example anchovy, carp or cod. Fish that is aimed caught for fishmeal production is a variety of low value species, with no other market value than as raw material for fishmeal production. Furthermore, bycatch fish is used. The fishmeal produced from waste material and fishbone has a lower protein content and higher ash content. Also, Chinese fishmeal can be produced from material that has been allowed to degrade before being processed to fishmeal. As a result, the Total Volatile Basic Nitrogen (TVBN) level is higher than fishmeal produced from fresh raw material. Some fish feed producers regard the domestically produced fishmeal as of low quality. Indeed, quality is measured by the protein content and TVBN. The protein content of offal produced fishmeal is around 55%, while herring fishmeal protein content reaches over 70%. Different categories of fishmeal (waste material/bycatch/aimed fish) can be mixed together. Some think that Chinese fishmeal contains additives such

as preservatives, land animals and bad chemicals. The Chinese products are thought to be low quality products.

Fishmeal imports

In 2008, China imported 1.35 MT of fishmeal (China Fishmeal Fish oil Association CFFA). The import of fishmeal is not very stable as in 2007, the fishmeal import by China was 0.97 MT, while in 2005 1.58 MT. In 2009, the estimated total fishmeal supply was 1.45 MT of which an estimated 1.2 MT is imported. Fishmeal imports are mainly from Peru (0.6 MT) and Chile (0.2MT), and the remainder from USA, Russia, Argentina and a little from Norway. Imported fishmeal is regarded as high quality fishmeal, especially from Peru and Chile. At the time of writing, fishmeal was nit imported from the EU because of import restrictions on EU fishmeal.
Main fishmeal ports: Guangzhou; Zhanjiang; Huangpu; Shanghai; Tianjin; Dalian; Qingdao; Fuzhou; Xiamen; Fangcheng.

Subconclusion

Feed is of significant importance for China's aquaculture and there is good potential for further development of modern feeds and alternatives for fishmeal in aquafeed to enhance the sustainability of aquaculture. The use of trash fish in aquaculture should be restricted, as it is both posing a threat to commercial fish stocks and to water quality of the aquaculture sites. Therefore, it is a priority to develop quality formulated compound feeds. Aquafeed is now partly produced domestically, but the demand for aquafeed is higher than domestic supply. As the aquaculture sector is growing, there is a good potential for scientific aquafeed production in China. China is heading in the direction of scientifically composed feeds, that pose no harm to the culture environment as far as compound feed is concerned. As culture of omnivorous and carnivorous marine and high quality fish is in development, there is a growing demand for feed with animal content. There is potential for feeds with lowered fishmeal content and high qualitative results, and substitutes for fishmeal protein. Research is very important in aquafeed formulation and for ensuring credibility for producers.
On the other side, in China farmers tend to be good at recycling wastes, which at first glance seems a good attitude. However, if put in culture environments as feed, wastes can have a detrimental effect on water quality, the environment and on the farmed animals. In a way, use of trash fish in aquaculture can be regarded as more efficient than making no use at all of trash fish and discarding it into the sea after catch. However, as the seas around China are getting empty, it seems better if catch of trash fish is prevented and the catch would not be stimulated by the demand for trash fish in aquaculture.

Ecological sustainability

This chapter discusses the ecological sustainability of aquaculture in China. The issues included in this discussion are habitat modification, origin of seed and brood stock, feed and efficiency, water use and contamination, disease and medicine use, introduction of non-native species and escape of farmed fish into wild. Information is derived from site visits to aquaculture farms and from various literature. Despite energy use is an important issue in measuring sustainability, it is not included in this discussion. At the time of this project, research on the impact of aquaculture on marine biodiversity in China had not yet been completed.

Habitat modification

Natural coastal habitats can be modified by the construction of aquaculture farms in coastal areas. For example wetlands or mangrove forests are converted to farms for shrimp, crab or fish. By such conversion, ecosystem services of nursery habitat for wild stocks, coastal protection, flood control, sediment trapping and water treatment are lost. In the 1950's, China had a mangrove area of 60 000 hectares, but this has declined to 22 000 hectares. This is due to urban development, farmland conversion, but also conversion to aquaculture ponds. There is not a good estimation on what the impact is of the habitat modification on wild stocks in China.
It has been estimated that the conversion of mangrove forests to fish or shrimp ponds can cause a loss of 400g of wild catch resources for 1kg of farmed shrimp (Naylor et al, 2000).
According to some Chinese researchers, the breeding grounds and nurseries of certain kinds of fish of which the stocks are depleted in the Yellow Sea and Bohai sea, are not in the coastal areas were the fish farms are. They say that the ecology in the sea is only influenced locally, at the site of the fish farm. At these sites, the ecosystem can be heavily burdened, as the Chinese coast at some places is crowded with farmers. There is no space left for further expansion of aquaculture in coastal areas after the rapid development (Chen et al). The farming density is too high at some places, while farmers also may not be aware of the harms to the local ecosystem (interview Dalian University).

Feed and ecological sustainability

Small pelagic fishes are caught on large scale for the production of fishmeal, to be used in animal feed, including aquatic feed. Half of the fishmeal supply in China is used in aquafeed. The feed efficiency of modern feeds can be high, dependent on the species. The effect and efficiency in aquaculture of compound feed and trash fish is discussed in chapter Feed.
In China, fishmeal is also produced from trash fish and waste from fish processing industry. In the Yellow Sea, one million ton of anchovy is caught in the Yellow Sea every year for fishmeal production, while the Yellow Sea is already overexploited. In general, the depletion of wild pelagic fish is thought to reduce the available food supply for wild fish higher in the food web, including species of economic value for people. The depletion of pelagic fish stocks is associated with decline of certain stocks of other wild fish, such as cod and with change in distribution

of seal and seabird colonies (Naylor et al). The role of fishmeal oriented catch in the distortion of the marine food web in China's seas is not fully clear, but the catch of fish for fishmeal in the Yellow Sea is believed to be far from sustainable. Moreover, the Chinese demand on global fishmeal supplies is considerable, being between one fourth to one third of total global supplies. As a result, demand of fishmeal in China impacts the fisheries and fish stocks elsewhere in the world. For example Peru is an important supplier of fishmeal to China.
On the other side, China produces approximately two thirds of global animal aquaculture production. In this way, 32.7 million ton of aquatic animal was farmed in 2008, by using approximately 750 thousand ton of fishmeal in aquafeed. This can partly be explained by the use of trash fish, because a considerable part of marine fish culture is not dependent on compound feed, but on trash fish as feed input. As discussed in Chapter Feed, the use of trash fish has a negative impact on the ecological sustainability of fish farming because the amount of uneaten feed and excrement is relatively high in cage culture were small fish is used as feed. The main impact of the feeding of trash fish is on the sea bottom. Under and around fish cages, sedimentation of faeces and uneaten feed can occur, in some places leading to a sedimentation of more than one meter (Chen et al). This sedimentation has a negative effect on the biochemistry of bottom ecology. High sediment oxygen demand, anoxic sediments, production of toxic gases and a decrease in benthic diversity have been observed. Anoxic sediment can release ammonia, hydrogen sulphide and methane, potentially killing animals (Feng et al).

Non-native species and escapes
Introduction of non-native species is an issue that is acknowledged by the government but there is no clear estimation or research on the impact of escaped fish from aquaculture on the wild stocks. According to MOA, there are strict rules for alien species that are introduced in aquaculture. The alien species are allowed to be farmed only in closed cages and there are special rules that stipulate that precaution measurers against escapes should be taken.
To what extent the regulations on prevention of escape by alien species work in practice is not clear. It is known that escapes happen frequently, but there is no good evaluation of the escape of farmed animals. What is clear on the contrary, is that a lot of alien species already have been introduced into the wild. Moreover, these species have already had their negative impact. A lot of these species have been introduced for aquaculture production, including algae. These species can have disastrous effects on the local ecosystem and biodiversity, by competing with native species, causing diseases, replacing their genetic make-up and potentially damaging their immune systems. For example tilapia has been introduced and became widespread in river habitats in southern Yunnan province, with a negative influence on biodiversity. Laminaria japonica, a kelp species, has been introduced in the open marine environment and is now an important economic product. Also crawfish is an introduced species which is now farmed in open systems and became a wild species in China.
Movement of stocks can increase the risk of spreading pathogens. Spread of disease caused by movement of species for aquaculture production does not only influence the natural environment and biodiversity, but can also have negative impact on aquaculture production itself. For example in shrimp farming, white spot disease has caused big crop losses, also in China. Wild brood stock from Latin America of L. vannamei shrimp was imported but introduces the Taura Syndrome Virus with it in 1999, causing high mortality (EUCTP, 2009). However, the entry quarantine of live aquatic animals became more strict recently for example with issuance of the Law on Entry and Exit Animal and Plant Quarantine in 1992.
People are not concerned about dangers of introducing new species for farming. Especially small farmer have small knowledge of the environmental impacts. There is not a lot awareness about intruder species. There is not a good evaluation of the fish that escape from cages and end up in the wild. It is however known that it happens frequently that fish escape from the culture site. It is not clear what their impact is on the natural ecosystems and biodiversity. This problem is regarded with serious attention. It is hard to differentiate the cultured species from the wild species. The immune system can be damaged of the species which is a problem.

Origin of brood stock and fry
Considerable part of Chinese aquaculture depends on the catch of wild brood stock. Also, some species are cultured from wild caught fry. Hatcheries rely on caught brood stock for more than 80% of farmed fresh water fish species. Origin of brood stock is potentially problematic to the industry. The cultivation of certain species has led to excessive fishing of juveniles of that species, such as grouper, yellowtail and eel. Furthermore, eel culture for example relies for a considerable part on imported glass eel, and indirectly impacts eel stocks in Europe. Also for other species, brood stock has to be imported, as production in China is not (yet) possible. However, research institutions currently do research on artificial breeding of various culture species. In the past, the production of brood stock without proper guidance resulted in the spread of disease amongst aquaculture farms.

Water contamination
Effluent discharge from aquaculture can contribute to nutrient pollution of water bodies near aquaculture sites. Nutrients such as nitrogen and phosphorus can cause eutrophication if the contents are excessive. According to Feng et al, high levels of organic matter are discharged into coastal waters. When the content of nutrients is too high, bacterial growth is stimulated, the oxygen demand is raised, pH value is lowered and less dissolved oxygen is available for aquatic animals. High oxygen deficits

and microbial loading have resulted in high mariculture losses in places were unsustainable practices have been followed (Feng et al). If the carrying capacity of a certain water body is exceeded by nitrogen wastes, this leads to deterioration in water quality that is toxic to fish and shrimp. Decrease in dissolved oxygen can extend to 1 km away from the fish farm where trash is used and culture conditions poor (Feng et al). More research on the impact of this oxygen decrease on wild fish stocks and marine biodiversity is needed.
Furthermore, if aquaculture constructions such as net cages or rafts are placed in high densities, the constructions cause a reduction in water speed and flow. Thereby, dispersion of wastes and nutrients is limited. As a result, hydrologic regimes are changed (Feng et al).
With defect management of discharge of waste water from aquaculture production sites, viruses can spread to wild stocks, causing decline in wild stocks. An article in the Fisheries Advance reports for example about the difficulty to find a spot in China that is not infected with shrimp diseases. Water from shrimp pond that is discharged into water bodies is not by all farmers disinfected and may contain pathogens, that spread into the environment when the water is discharged. As China has shrimp farming everywhere along its coast, there is no place to find that is free from shrimp and shrimp disease. It is therefore not only hard to breed SPF (pathogen free) shrimp and shrimp fry, but the spread of disease also poses a threat to a commercial catch fishery species.

Water quality
As described above, aquaculture can have a negative impact on the quality of surrounding water. At the same time, water quality is also very important for aquaculture itself, as already described in earlier sections. Especially for open systems, such as net cages in shallow sea or lakes, water quality influences the farmed organisms directly. Large parts of China's inland as well as coastal waters is polluted by industrial pollution and agricultural and domestic wastes, and does not meet national standards. In inland waters, the water quality can be considered very serious while at the coast, the water quality at some places can be quite good. This depends on the management of the marine environment in a specific area. For example the water quality around Dalian is considered quite good, while in other regions there have occurred problems with eutrophication and red tides resulting from a polluted sea. Such red tides affect aquaculture production and profitability and contribute to great economic losses (report FON, Feng et al).

Medicine and chemical use
Medicine use is already discussed in Chapter 1. Nutrient pollution and poor water quality are likely to promote disease outbreaks in high stocking density. As a result, farmers tend to use chemicals and medicines for disease prevention, such as antibiotics. Forbidden and harmful chemicals are still widely in use in aquaculture. Some of these are harmful for humans. Use of antibiotics can cause the development of medicine resistant pathogens. The use of medicines and harmful chemicals in aquaculture is still under ineffective control.

Case Studies
In this project, three places have been visited, being Dalian, Qingdao and Nanning. The visited production sites have been assessed to give insight in the environmental sustainability of aquaculture in China. However, these three case studies should not be taken as representative examples for the whole aquaculture industry in China. Furthermore, aquaculture farms were not easily accessible for this project, because a majority of fish farmers did not want to have foreign visitors, potentially due to shame for their backward situation. Therefore it is assumed that the sites that were indeed accessible, also had a relatively good performance with regard to technological advance and ecological sustainability.

Abalone farm in Dalian
The farm is located at a place with not too many other aquaculture farms. The site was chosen partly because of the clean environment. The person guiding us, had an university degree in aquaculture and believed the farming activities had not a considerable impact on the natural environment. However, the water was never tested before use neither before discharge to the sea and was discharged directly. It was not clear if the abalone species was a native species, or introduced. They kept their own brood stock for hatching for every new breeding cycle, so no wild stock was caught for the hatching.
As the small abalone were kept indoors in a closed system with constantly circulated sea water, the chance of escape was minimal. The bigger abalone were kept in cylindrical nets in open water. There was not a big modification of the natural site. Abalone being a shellfish, can be seen in some cases as having beneficial effect on the environment. This is because it eats mainly algae and filters the water from nutrients. However, if kept in a high density, the impact of abalone culture can also be negative. If in a net cage, some of the abalone die, their bodies degrade and at the same time release nutrients to add sediment to the sea bottom. Furthermore, abalone still release faeces. However, the water current was quite strong, so a local excess of nutrients could be flushed away.
The feed used, consisted for great part of dried seaweed and was custom made for the specific area. The formula was made by and expert feed composer and the feed made by a small local plant in a mixing machine. The algae was harvested from the wild in the same region, and then dried, powdered and mixed with vitamins, minerals and a small amount of fishmeal. The conversion rate was unknown. The amount of feed needed for abalone is very small, so there was not a lot of feed used. As a result, feed use for abalone farming was not believed to impact the natural environment. The feed did contain some fishmeal, as this was especially important

Picture 9: Abalone culture

for the growth of young abalone. The used fishmeal was imported fishmeal from Peru or Chile, as this was of higher quality than domestic Chinese fishmeal. No chemicals or medicines were used, neither in the feed nor separately. If there would be a disease, there was nothing to do about it.

Flatfish farm in Qingdao

The flatfish farm near Qingdao used the Recirculated Aquaculture System (RAS), which is a closed system, with no direct impact on the marine environment, as far as effluent water is concerned. The water used, was salty groundwater pumped up near the seaside. What is the effect of this groundwater pumping is unclear. The water was constantly circulated and recycled, by filtering and disinfecting it, so almost no adding of new groundwater was needed and there was almost no

Picture 10: RAS for flatfish

Picture 11: turbot in RAS

wastewater discharge. The use of RAS was stimulated by the local government by offering a subsidy to farmers for its implementation, as government policy for aquaculture was to move aquaculture partly away from the coast.

The farm was at the same time a hatchery for flatfish and they kept their own brood stock. The variety of tongue fish was a native species in China, but turbot is introduced to China in the early 1990's from Europe. Also a sole species was cultured. Turbot breeding research was done at the YSFRI by professor Lei, who also assisted this farm in setting up the breeding activities. There was no risk of escaping fish at this farm, but an amount of small fish was sold to other farmers. Their customers possibly cultivated the flatfish in wetlands and tidal flats, but for this project such a site was not visited and the eventual chance of escape is not clear.

The feed used for fry was artemia (rotifers). Artemia is widely used in hatcheries in Shandong province and artemia production is a prominent industry. For the bigger fish they imported feed from Japan. This feed had an estimated conversion rate of 1.3 and a fishmeal content of 60%, which is quite high compared to modern high quality salmon feed (apprx 35%). Other materials in the feed were legally allowed growth stimulants,

attracting feed agents and vitamins. Only small amount of medicines was used if needed, and only legally permitted medicines. The owner said the farm met all the EU standards for exporting.
The fish feed factory visited in Qingdao is government owned and focused on research for green and environmentally friendly feed. The manager is very aware of feed use and ecological issues, and the goal is to produce high quality feed. Again, the fishmeal content was very high. Lowering the fishmeal content of the feed was not a part of the research or feed production. Fishmeal is thought to be very important for the taste of the farmed fish, and less fishmeal would mean less taste. Moreover, with a high fishmeal content, only a small amount of feed would be sufficient for the farming. The conversion rate at optimum was 1.1 and quite efficient. Use of too much feed is not good for the water quality, and furthermore it would be a waste as the fish would not be able to take up more protein in a certain amount of time.

Tilapia farm in Nanning
The tilapia company visited in Nanning was part of a company group. It has several bases around the province for catfish, tilapia and shrimp. The base visited was not located at a big water body, such as at the coast or at a lake, but made use of groundwater for its ponds. According to the manager, the groundwater was very clean. How this affected the groundwater table, was not clear, but the manager was aware that the water should be used economically and could not be refreshed by pumping groundwater indefinitely. The tilapia and shrimp are cultivated in ponds of varying size. Some were 15*60 meter and had a depth of approximately 2 meter. The water quality was enhanced by the use of beneficial bacteria. The water quality looked quite good, but some waste matter drifted in one pond. Water aerators where in use to reduce the need for replenishing water. Wastewater was discharged after simple filtering to a channel that led further to another channel for the irrigation of crop land. Before water discharge it is ensured that the water meets the quality requirements for discharge, mostly by taking care that the pond water would not get contaminated, for example by using the

right amount of feed. The farm was inspected once a year and was ISO9001, HACCP and 'harmless' (wugonghai) certified.
Escape of fish was not ruled out. Furthermore, on other production bases of the company group, open systems of net cages in reservoirs were used for tilapia farming and catfish farming. In such open systems, there is a bigger chance of escape, disease transmission to wild fish and water contamination of natural water bodies by excess feed and faeces.
As an integrated production base, the hatching, feed production and processing was done at the same base. For the whole production chain technology, highly educated people are hired. Fry from the own hatchery was used. Tilapia is not a native species in China, and the farmed species is genetically very different from its wild ancestors, done by selective breeding and breeding research with the aim to enhance productivity. Tilapia hatching is done a lot in China and new brood stock is being produced domestically and imported. Research on breeding strain enhancement is done and the government designates tilapia hatcheries for the distribution of good quality fry to tilapia farmers.
Raw material for feed include imported fishmeal and bean dreg. The fishmeal content was 5 to 10%. Additives for enhanced disease resistance and Chinese herbs were added. The conversion rate was not clear and unknown by the person spoken to. On average, feed conversion for tilapia is round 1.5 (EU Report). The water quality in the ponds was good, and the fish had strong disease resistance, so medicine use was not needed.
As the visit was together with a relatively big group of people, there was not a lot of space to go into detail. This makes it difficult to make detailed conclusions about the performance of this farm. However, environmental sustainability was not a very prominent value on the farm. Producing clean and safe products is more important for the producer.
At the visited forum in Nanning, a topic of discussion was the outbreak of disease in tilapia farms. As tilapia has strong disease resistance, it was mentioned that the breeding was done in an unsustainable way, and the resistance was bred out. Another reason mentioned was that a number of farmers kept the tilapia in too high

stocking densities, causing stress and susceptibility to disease.
Most of the tilapia farmers produced for the export market, and therefore they have to meet the legal requirements for exporting. These requirements in most cases also mean higher production costs. As a result, the tilapia they produce is too expensive to compete on the local and domestic market. The industry is thus dependent on the demand from the international market, and if this demand declines, the tilapia producers cannot sell all of their tilapia.

Discussion: threats and chances of Chinese aquaculture methods

From the case studies can be seen that the visited sites as described have performance for ecological sustainability that is not too bad. Especially the flatfish farm with RAS can be considered quite sustainable when natural environment is considered. However, on the visited sites there are some issues that can be considered unsustainable. Aquaculture in general in China still shows environmental problems. This depends on the method of culturing and the cultured species and more.
One of the problems is the reliance on wild brood stock and fry. Brood stock for the culture of some species relies on wild catch, while the wild stocks are overexploited. Investments are made for the development of artificial breeding technologies for certain cultured species, but wild brood stock can be preferred by farmers. For certain species, there have been set up nature reserves for the conservation of wild stocks with the aim to conserve genetic diversity for aquaculture. However, wild stocks of species such as grouper and yellowtail are under threat in part caused by the catch for culture (Liu, 2006). For such species, artificial breeding and hatching still has to be developed by scientific research and wild stocks should be conserved to prevent loss of biodiversity that could be caused by aquaculture production. It is acknowledged by research groups that there is a lack of improved culture breeds for sustainable culture.
Another problem is the introduction of non-native species that are not only introduced in aquaculture, but also into natural ecosystems. The management framework to prevent non-native species from escape into the wild, is still incomplete and many intruder species have caused harms to natural ecosystems and biodiversity in China[3]. Besides, exotic species can be very popular in China and therefore spread quickly amongst farmers, making the risk of introducing non-native species to natural ecosystems even bigger. If non-native species would be allowed to be farmed only in closed systems, such as the RAS, the risk would be reduced. However, it is allowed to farm these species in open systems, such as net cages, from which escape is not ruled out.
Closed systems such as RAS do not contaminate natural water bodies with excess nitrogen or pathogens while open systems in lakes or shallow sea such as net cages and pens do contaminate the natural water body, leading to water quality deterioration. This in turn induces disease outbreak, while in the RAS, water is continuously filtered for water quality maintenance. Farming in high stocking rates with use of unprocessed fish as feed and a lot of waste sedimentation and medicine use is being done in open water, but at an unknown scale. There exist entire villages of aquaculture, build on floating rafts above fish cages, where water quality is deteriorated by the high stocking density, human excrement and use of chopped fish as feed input and to prevent disease outbreak, medicines are used a lot by farmers who may not be aware of the (environmental or health) risks. High stocking densities should be prevented in open culture systems and systems were there is no sufficient water quality management, for preventing disease outbreak and excess medicine use. FTECs already contribute to this by giving trainings to farmers.
The use of freshwater for some aquaculture models, such as in the pond of visited tilapia farm, can burden scarce freshwater resources. It is not clear what the effect is on the groundwater table if large part of pond culture in a certain region distracts groundwater. More research should be done on what is the impact of groundwater distraction on the groundwater table.
At the same time, polyculture can contribute to the water quality and ecological balance in aquaculture. This is still in use, but is regarded as traditional and there is a move from traditional culture to intensified monoculture. It would be useful to research polyculture models and the specific stocking densities and feed use, because polyculture has a lot of advantages and there is huge potential for its application in China. The culture of aquatic plants in open water can contribute to restoring the ecological balance in areas were dense aquaculture deteriorated the water quality (Feng et al) while at the same time producing another crops. Seaweeds can absorb large quantities of nitrogen, phosphorus and carbon dioxide and produce large quantities of oxygen. Seaweeds help to reduce eutrophication (Feng et al). In this regard, there is large potential for the culture of (edible) seaweeds. The EU Report reports the use of silver carp and aquatic plants in a tilapia farm and a shrimp farm in south China for pond water quality management.
Forbidden and harmful medicines are still used. Uncontrolled and illegal use of medicine and medicine residue are still a problem. Residue of antibiotics, nitrofuran and malachite green are still found in aquaculture production (CFY 2008). Furthermore, illegal hormone for sex-change in tilapia is still in use. Again, the environmental impact is greater when chemicals are used in open systems than in closed systems, as chemical directly end up in natural ecosystems. Besides, if water is discharged from ponds after chemicals have been put in, chemicals in the end also end up in the environment. Management and treatment of effluent water is not efficient (Zhou, 2007; EUCTP, 2009). Aquaculture farms should make sure the discharged water meets certain requirements for the content of toxin and nutrients,

[3] *See for example: http://www.fao.org/fishery/introsp/search/en, http://www.fao.org/fi/website/FISearchAction.do*

but the discharge water is not frequently tested for its contents and not by every farm disinfected. Moreover, the standards seem to be insufficient, as requirements regarding diseases seem not to be in place. There are regulations on the quarantine of imported brood stock, to prevent further import of unwanted disease.
Fishmeal is an important raw material for fish feed in aquaculture, and the demand for fishmeal for aquafeed is growing, as the use of compound feed is promoted and the industry is stimulated to grow. At the same time, reduction of fishmeal in aquafeed is not a hot topic. This means a growing burden on pelagic fish stocks, not only in China, but for a considerable part in South America. However, substitution of fishmeal by soymeal or other protein sources is also being done and the government has pilot projects for aquafeed with reduced fishmeal content (CFY 2008). Still, feeds with relatively high fishmeal content have a higher feeding efficiency and quality than vegetable protein based feeds, and thus less feed is needed if the feed contains relatively high fishmeal content. More research for improved formula is needed to make lower input of fishmeal possible. The quality of feed in which fishmeal is (partly) substituted with other protein sources should be proofed with scientific research.
The use of trash fish poses a big threat to biodiversity in China's seas, but also to aquaculture industry itself, as discussed above. Therefore, the use of modern aquafeeds is preferable.
Aquaculture in China takes in a lot of space, which is equally true for land-based agriculture. To some extent, this is harmful to natural ecosystems and habitats, especially regarding net cage culture inshore and pond culture in coastal areas that otherwise would be natural wetlands. This is because inshore net cage culture is done in too high densities and by too many farmers with resulting negative environmental effects and an upset ecological balance and because the conversion of wetlands cause a loss of important ecosystem services and biodiversity. The Chinese government pays attention to these problems. There is international cooperation for the conservation of wetlands, including mangrove forests. Also, the government launches projects for regeneration of wetlands. Furthermore, the government aims at moving aquaculture partly away from inshore sea partly offshore and partly land-based.
The EU-China Trade Project (EUCTP) report Sustainable Aquaculture in South China, that is a report about the tilapia and shrimp culture in Hainan and Guangdong province, is in its conclusion positive about the environmental sustainability of exporting shrimp and tilapia farms in south China. The research project performed for the report included more site visits. It concludes that site selection by the visited farms was appropriate and that there was no evidence of negative impact on the surrounding area. The farms minimised their water exchange, had simple treatment of discharge water and because the management at the farms was good there was low incidence of disease (EU report). Furthermore, only artificially farmed brood stock was used for hatching and all feed used was modern compound feed. There were effective traceability systems used. Testing of water quality discharge was unclear according to the report. Also, there was high chance that the soy used in the feeds was derived from GMO crops (EUCTP report).
At government level, aquaculture mainly has an economic role, and a role of feeding China. High productivity is pursued, and large-scale industrialized and integrated production is a development goal. At the same time, the government pursues a healthy development in a scientific way. Investments are made for research to enhance safe and healthy aquaculture. The most important value for producers and consumers is food safety and health for the consumer. Environmental and ecological sustainability seems not very important in the industry. However, safe and healthy production is made possible by a clean environment with good water quality, limited medicine use etcetera. As a result, production of safe products is indirectly of limited impact to the environment.
By government regulation, open system aquaculture can only be done in areas with a good water quality. Companies promote their clean farming environment. There is standardization and certification for good practices in place, Chinese as well as international certification is in use, also by NGOs. Unfortunately, international standards seem to be used only at export oriented companies. This is certainly true for GlobalGAP and ACC. The Chinese government pays attention to the standardization of the aquaculture industry, and is aware of the weaknesses of the management system (CFY 2008). In this regard, the central government shows its aim to make aquaculture an industry that produces food of good quality, that is healthy, and that has limited impact on the direct environment. Standards for discharge water quality for example should reduce the environmental impact of aquaculture. However, control and monitoring on the compliance with these standards is incomplete and authorities lack capacity. In general, the monitoring over aquaculture industry is done mainly at exporting companies, while locally producing companies may never be monitored by inspection authorities.

Subconclusion

Aquaculture in China has both sustainable and unsustainable sides. Considerable part of aquaculture depends on the catch of wild fry and brood stock, posing a threat to wild fish stocks and biodiversity. Scientific development of hatchery technology is needed for sustainable aquaculture. The management for prevention of escapes of farmed animals, including non-native species should be improved to protect the surrounding ecosystems and biodiversity. High stocking rates and culture densities pose a threat to the sustainability of aquaculture itself and to the environment. A positive note is that government policy aims at relieving the stress on the coastal environment by moving aquaculture away from the coastline (see chapter National policy),

by implementing closed intensive culture models, such as RAS, and supporting deep sea culture. Positive is the mixed culture (polyculture) for maintaining water quality, disease prevention, and even bioremediation and ecological balance. However, more research is needed on polyculture. The government pays attention to sustainable development of aquaculture. To support this, there is standardization and certification. However, monitoring of these standards can be improved, and the standards are not yet complete.

Food safety problems still exist. More control on medicine use and effluent water is needed by inspection and training. Trainings are already given to a part of farmers, but assumedly there is not enough capacity for training nor inspecting all farmers. Also, there is need of legal substituting medicines that have now negative impacts. Furthermore, there is need for culture breeds with high disease resistance. Sustainability of feed in aquaculture can be improved by restricting the use of trash fish, making fishmeal production within China more efficient and improving feed composition formula with lower fishmeal contents and substitutes for fishmeal protein.

National Policies

Introduction

While aquaculture production developed very rapidly, poor management resulted in disease outbreaks and high mortality. Aquaculture technologies were poorly spread and transferred and infrastructure and facilities were poor. In the last two decades, the management for aquaculture has been strengthened with several regulations, standards, aquaculture related committees, inspection agencies and technological extension centers. This chapter gives an overview of policies, government plans and relevant authorities regarding fisheries. It must be noted that this overview is not complete and does not give a total scan of all regulations. Technological extension centers are discussed in the next chapter about research institutions.

Laws

National laws are very general in nature and complemented by regulations. Regulations can be issued nationally and apply nationally, but can also be local. Provincial and local level fishery departments are in the position to stipulate more detailed regulations and requirements for aquaculture, for example requirements for shrimp pond construction to prevent contamination of surrounding water. Local regulations only apply to the territory of the concerned administration where the regulation has been stipulated. These local regulations should not contravene the national laws, regulations or the constitution. Furthermore, provisions are issued by central as well as local governments to guide fisheries when the situation asks for additional guidance and to solve problems or promote aquaculture development in a certain place or time. Therefore, there is wide variety in management of aquaculture development from place to place.

National laws that are important for aquaculture and the aquatic environment include the following.

Fishery Law, promulgated in 1986 and amended in 2004, stipulates the rational use of fishery resources, protection of the fishery environment and fishery development and management and more. This law makes reference to aquaculture sustainability.

The 2004 amended Fishery Law should contribute to the sustainable development of the fishery industry, which is currently suffering from the depletion of resources and water pollution. Fishing quotas and a fishing permit system are introduced for the management of fishery resources. The law also needed improvement because of the many aquatic farming areas which have been seriously encroached upon and contaminated. According to the law, the State will make plans for controlling the waters and beaches used for aquatic farming purposes (Globefish 2004).

Water areas and aquaculture lands in China are either state-owned or collective. Producers can hire land or contract the government or village leadership for land/water area use. An application for area use must be authorized by the local governments above county level to ensure the protection of the environment. Permits should help in rationally limiting the farming densities, as well as the use of harmful bait or feed. The law also states that China will encourage and support the rearing and spread of high quality aquatic species and breeds. Imports and exports of aquatic fry should be quarantined to curb the spread of diseases and a safety assessment should be undertaken in line with regulations of the State Council in regard to imported, genetically modified aquatic breeds and fries (Globefish 2004, p9).

Real Right Law of the PRC (2007) states that the right to use water areas or tidal flats for breeding or fishery shall be under the protection of law. This is to safeguard the interests of fish producers and lay a foundation for legal production. Aquaculture farmers have to obtain a license for their aquaculture practices at the seaside or offshore. This makes the management and monitoring of aquaculture more easy and there is more control over farming in the coastal area.

Hatcheries have to get a license for the production of aquatic fingerling. The largest hatcheries are evaluated on site by national level inspectors and the rest of hatcheries by the provincial level inspectors.

Entry and Exit Animal and Plant Quarantine Law of China, 1992. Implementing an entry quarantine procedure has to counter problems of disease importing with imported brood stock. Regulations on Inspection and Quarantine of Entry and Exit Aquatic Products were issued in 2002.

Environmental Impact Assessment Law Construction of new projects has to be approved of before the construction starts. And Environmental Impact Assessment EIA has to be conducted for estimation of the potential impact on the environment.

Environmental Impact Assessment (EIA) should be made by the relevant local administration, before construction of culture sites and licensing. For most industry, it is the Environmental Protection Bureau of the local locality, but for aquaculture, the Ocean and Fishery Bureau is the responsible agency to do the assessment. The application of EIA to mariculture is not so common according to Feng et al. Together with licensing, in some cases training should be attended at a FTEC.

According to the **Law of Water Pollution Prevention and Control (1984, revised 1996)**, the aquaculture farm shall protect the environment and prevent water pollution. The **Marine Environment Protection Law (1982, amended 2000)** concerns the marine environment in more detail and applies to supervision of the marine environment and controlling marine water pollution.

Law of Quality Safety for Agricultural Products (2006) is to fill in the vacuum in the legal system for quality safety of agricultural products. A quality control system is being set up at national, regional and county levels for agricultural products. The system of quality and safety standards and the certification system have been improved (QS paper). See also 'Inspection'
Water Law, 1988; Environmental Protection Law (1989); Law on Sea Island Protection; Sea Area Use Management Law (2002)

Fishery policy of the PRC

Aquaculture has been promoted since the 1980's as an important sector for employment and food production for a growing population and relieve the stress on exploitation of wild stocks by compensating for the declining wild catch. Reducing fish catches to sustainable levels is one of the goals of the Fishery Bureau and the 'Regulation on Breeding and Protection of Aquatic Resources' was issued. Currently, there is a 'negative growth' policy on wild catch fisheries. The strategy for achieving this goal includes implementation of closed seasons and catch limits for wild catch fishery and cutting the number of fishing boats and fishermen. In the Yellow sea for example, every year there is a closed season of three months (June, July, August) for fishing activities. The stocks of commercially important fish, such as small yellow croaker, are replenished by putting artificially bred fry into the sea. Artificial stones are put on the bottom of the sea to create a living place for sea animals. Furthermore, the fish processing industry has to be developed as an alternative employment source. Thus, labor force is moved from catch fisheries to aquaculture and the fish processing industry.
The coast can be used for aquaculture, but also for may other purposes, such as tourism and recreation. Coastal construction of for example resorts, ports also take place at the coast. The government makes a functional zoning plan for different functions, also maritime activities. This means that aquaculture is not possible everywhere along the coast, and in many cases, aquaculture cannot expand any further. In Qingdao region and other regions, aquaculture is encouraged to shift from the coastal area to inland areas, or to offshore.
During the 10th Five Year Plan (2001-2005), Chinese aquaculture was to be developed with the objective of increasing benefit, increasing the income of marine farmers and promoting its competitiveness (Zhou). Besides, importance was attached by the Chinese government to 'healthy aquaculture'. Healthy aquaculture was further included in the following 11th Five Year Plan. The development of mariculture has been considered as especially important. Government policy has promoted the development of the culture of high value species to expand the export production and thereby attract foreign money. In regions were aquaculture was not developed, the government has been giving support for aquaculture development to help rural people improve their living standard. In the policy of tax and fee collection, the Regulation on the Implementation of Enterprise Income Tax Law of P.R.C. specifies that fishery companies are exempted from collection of income tax or have to pay less tax. Agricultural production, including aquaculture, is not taxed according to national policy. Only the big enterprises are taxed.
The MOA issued various Action Plans for fisheries, such as the Action program for Aquatic Plants and Animal Resources Protection in China (2006), discussed under the caption 'Marine biodiversity'. The Action Plan on Transformation of the Growth Mode of Aquaculture Industry (2006) promotes the transition from a growth mode of 'high productivity' to a mode of 'quantity and quality' and 'profit and ecology'. The Action Plan on Healthy Aquaculture will be discussed later on. The government also guides the development of cooperative organizations to make the sector stronger in the modern market. One example is the China Fishmeal and Fish oil Association (CFFA). According to MOA fishery law enforcement has been strengthened, including the enforcement of aquaculture law, by focussing on farming licenses, hatchery license and drug use.
Standards have been set for the environment for the production site, feed, medicines and drug residues, fry, production techniques, aquaculture management and aquaculture product quality. Furthermore, infrastructure and facility related standards are made. These set requirements for the base of the farm, the road, the pond, wetland, electricity facility, 'greening', storage of medicines and feed, and laboratory for water quality and disease testing. There are also standards for the processing, testing, classification, packaging and shipment of products.
The farming of new and high quality breeds is encouraged. Aquatic seed resource banks, breeding stations for pure breeds of selected species and testing centers should be set up. Administrative Rules on Aquatic Seed" have been issued in 1992 and the "Administrative Rules on High Quality Original Aquatic Seed" in 1999. Feed quality standards have been set since 1997 for some species, for example carps, tilapia and eel. A legal framework for the feed industry is in place since 1999 with the issuance of 'Regulation on feed and feed additives'. New feeds and additives should be approved of by certain procedures, imported goods have to be registered, labelling etc is stipulated in this regulation. Growing concern over water quality deterioration that was caused by aquaculture and in turn affects aquaculture, was followed by the adoption of regulations of aquaculture water quality and water discharge. The water in which the aquaculture activity takes place shall meet the National Water Quality Standard for Fisheries. Before water is discharged from ponds, it should meet the standard requirements for pond water discharge. There is a special standard for discharge water that is to be used as irrigation water. Water inlet should be placed as far away as possible from the water outlet and effluent water should be treated before discharge. Regulations that support fishery water quality include the Provision on

Investigation Procedure for Pollution Accidents in Fishery Areas, Regulation on Prevention of Damage to the Marine Environment by Land-based Pollution and Regulations on the Management of the Prevention and Control of Marine Environmental Pollution Damage by Marine Construction Projects.
More info on regulations and standards can be found on government websites, FAO website and in the EU report.

Qingdao City policy for fisheries and marine biodiversity

Aquaculture in Qingdao region is being improved with high efficiency, few disease incidence, increase in production and competitiveness.
Food quality and safety management is comprehensive. There is a check of the products on illegal medicine and also on the water environment of the aquaculture site. Farmers should abide by the national regulations. Farmers receive training only for improving their practices. There are no special requirements on the techniques used, as long as they abide by national regulations, for example for water discharge. RAS is encouraged with for example subsidy and the use of medicine and feed is constrained. Also, there are requirements for the bottom of fishponds. Farmers are being inspected for the monitoring of them abiding the regulations. Aquaculture cannot be set up on the seaside, because of the development of the tourism industry. Farmers are encouraged to set up inland farming and will receive compensation if they have to leave from their farm at the seaside because of development plans. Regarding the wild catch, fishermen with small boats are encouraged to change their boat to a bigger boat to create more profit. With a bigger boat the fisherman can also go more far offshore to catch other kinds of fish. There are no seaports near aquaculture. The city government has to issue a license for long distance fishing. Qingdao has only one ship that fishes on long distance.

Quality Safety and Inspection

Disease prevention in aquaculture, administration of drugs and inspection of drug use and drug residue in aquaculture are task of the Fishery Bureau. The last mentioned task looks the same as the task of the AQSIQ. Sometimes it is not clear which bureau is responsible for the same task. In practice, there are inspection bureaus for testing on aquatic farms that are administered by the Fishery Bureau, and separate inspection bureaus that inspect the end products, that are administered by the AQSIQ.
Regulations for Administration of Aquaculture Quality Safety was issued in 2003 by MOA and stipulates daily recording of production, scientific medicine use, water environment monitoring, product labeling, raw material monitoring. It is accompanied by Provisions on the Management on Quality Safety for Aquaculture Products. MOA published in 1999 the List and Usage of Pharmaceuticals that can be Used for Aquaculture and the List of Pharmaceuticals that cannot be Used for Aquaculture. Production, sale and usage of the drugs on this list was further forbidden. Tracing systems and a file system for medication were set up in aquaculture production. MOA started specialized examinations and inspections on major banned drugs in the pursuit to regulate drug markets, punish illegal drug use and improve the control over the fish drug market.
The producers that supply raw material to processors for export must have a record keeping system that is certified by CIQ. Aquatic farms that produce to export are usually inspected once a year. However, some farms that supply raw material to processing plants for export products may not be inspected at all. In such cases, only the processing plant is inspected by the inspection authority. The responsible party that exports aquatic products, which is in most if not all cases the processor, should have a system that is HACCP certified, and abide by the relevant national standard.
Traceability systems for aquatic products are in a stage of development. Furthermore, the systems are different for the domestic market producers and export market producers. For only a few domestic producers it has been set up, and only for the biggest companies. For export producers the system is developed for the major species. There is a number on every sub product from which pond it is, which feed is used and what factory it is from, and what treatment it has had, what chemicals are used. The Administrative Rules on Aquatic Product Processing was issued by MOA in 1999.
Inspection for food safety is strict for exporting producers. It is not very strict for domestic producers. Farmers that produce for the local market are not inspected.

11th Five Year Plan

Aims in the 11th Five Year Plan (2006-2010) (FYP) include implementing the national policy of saving resources and protecting the environment, building a sustainable national economic system and a resource efficient and environmental friendly society with low discharge.
In November 2006, MOA issued the development plan for the fishery industry, which is part of the 11th FYP. In the 11th FYP for fisheries not only production goals are set in numbers, but also goals regarding to the way of development of fisheries. According to this plan, the fishery industry must modernize by means of sustainable development. Efficient use of resources is encouraged and innovation is to promote sustainable development. Science and education are stressed. Furthermore, the rehabilitation of marine fishery resources and aquatic ecology should be facilitated, circulated water use enlarged and the exploitation of international resources (international waters and fish stocks) should be developed.
The main goals in the 11th FYP include:

- Accelerate the transfer of science and technology into commercial production
- Developing quality strain seed and breeding technology and cultivate 10 new good species for aquaculture

- Technological improvement for conservation of aquatic species and aquatic ecology, selective capture, pollution prevention, recovery of the environment.
- Develop aquatic product processing and increase the processing of aquatic products
- Improve the technology for disease prevention for cultured species and establish a well-functioning food safety control system. Six new kinds of compound feeds and four new kinds of vaccines should be developed. (Deng 2009)

The budgets of central and provincial governments have been increased to support the fishery sector, to improve ponds for breeding and to implement policies to support the development of aquaculture by for example subsidies. Subsidies are provided for example for the use of new techniques. Thus, offshore cage culture and the land-based RAS are be subsidized in certain areas. Subsidies are not uniform in all of China, but dependent on the county or city level government. Offshore cage farming is to become a major sector in the aquaculture industry (projected output 500 000 ton in 2010). Mariculture development and sea ranching are part of the policy to establish sustainable fisheries (Chen et al). National policy is also to promote large-scale industrial integrated aquaculture 'cities'.
The government attaches great importance to the application of science and technology. Technology development is organized all over China with research plans, and the achievements are spread by education to improve aquaculture. Research results are spread by sending experts to producers for assistance and by organizing trainings for farmers. Cooperation of scientists and technicians with fishermen and farmers has been encouraged under government preferential policies. On TV there is training and also promotion of producers of clean aquaculture to make the regulations regarding aquaculture and pollution known.
At administrative level, a system of scientific decision making was to be developed. Research priorities for the fishery sector are determined by the MOA. Research is done at universities and research institutes, but also at aquaculture farms, hatcheries and feed factories that can be government owned or private owned.
Trainings are organized by the government for producers that want to export and that have to comply with certain foreign standards, such as EU standards, before being able and licensed to export.
A system for the prevention of animal epidemics is being established, including systems for disease monitoring, prevention and control, quarantine, supervision of veterinary medicine quality and for technical support. MOA issued the Regulations on Administration of Veterinary Drugs.

Healthy Aquaculture in China

Healthy aquaculture plans were one of the priorities in the 10th and 11th Five Yearplan and the 'Action plan for the Extension of Healthy Aquaculture' has been implemented. Regulation on Healthy and Safe Aquaculture Production was issued in 1999.
´Healthy aquaculture´ is mainly defined as aquaculture with efficient disease control and products without harm to human health. In healthy aquaculture policy, attention is paid to food safety and product quality. Before, it was focused mainly on shrimp culture, but now applies to most of the aquaculture sector. In some cases it can have a focus on the environment of the culture site. People's health and safety are the most important values, and thus there is attention for clean production environment. Water quality is regarded as important for aquaculture and theoretically, aquaculture is only approved by the government in clean water. According to MOA, the healthy aquaculture concept is also linked to biodiversity. The Action plan includes promoting healthy aquaculture technologies; raising the management level of aquaculture production; pushing forward mudflat planning; identification and issuance of ownership rights of aquaculture waters; strictly controlling drug residues and establishing product quality traceability system.
The concept of healthy aquaculture is communicated to producers and at the same time technological guidance is provided. The action plan suggests the set-up of certain numbers of model marine aquaculture farms that comply with the national standards, model tidal flat aquaculture counties, disease prevention model farms and industrialized recycling marine aquaculture pilot sites. Incentives for the construction of these aquaculture bases are made by AQSIQ and MOA.
Demonstration bases for healthy aquaculture or healthy hatcheries are set up. Ecological aquaculture models should be explored and healthy and ecological aquaculture demonstration areas should be established. Furthermore, goal is to extend ecological breeding techniques and reduce pollution originating from aquaculture. The government supports the establishment of ecological aquaculture models. Development of internal water circulation, copying nature and plant cultivation are encouraged for integration in aquaculture. For example, aquaculture pond models that make use of man-made wetlands for water treatment are built with government support. Also mangrove swamp is regenerated and used for shrimp farm effluent (EU report). Aquaculture farmers are stimulated to reduce water use, because provincial governments have authority to set water use and discharge fees. For example groundwater pumping can be taxed, but the taxing is not yet implemented in every province. The license system and water use compensation system is not complete yet.

International relations

The national policy of opening-up should be maintained with a strategy of mutual beneficial and win-win cooperation, including economic cooperation and technological cooperation. Aims in this opening-up include promotion of the domestic development and

reform and protecting national economic security. A shift from quantitative growth to qualitative growth is proposed for foreign trade modes, including introducing advanced foreign technologies. According to MOA priorities for cooperation include the following: mutual trust; introduction of foreign capital, professional technologies, breeds varieties, management concepts, talent exchanges and joint study; trade and international standards; provide agricultural technical assistance to other countries; study foreign agriculture (MOA website). This shows that MOA is willing to cooperate internationally on trade issues as well as knowledge exchange and resourcing. Cooperation on biodiversity issues and fishmeal etc is the responsibility of the national government.

See Appendix B for further information on international cooperation of China and EU.

China is member in several international organizations, including the following: Food and Agriculture Organization (FAO); UN Conference on Trade and Development; Asian Development Bank; International Development Association; International Fund for Agricultural Development (IFAD); International Hydrographic Organization; International Maritime Organization; International Monetary Fund; International Organization for Standardization (ISO); Shanghai Cooperation Organization; World Health Organization (WHO); World Trade Organization (WTO); World Organization for Animal Health (OIE); Consultative Group on International Agricultural Research (CGIAR). China is a dialogue partner of the Association of South East Asian Nations (ASEAN), but not a member.

China is a party to international environment-related conventions including the following: Antarctic Environment Protocol; Antarctic Treaty; Convention on Biological Diversity (CBD); Kyoto Protocol; Convention on International Trade in Endangered Species (CITES); Conference on the Law of the Sea (UNCLOS);

China has a big interest in trading its aquatic products and exporting it to foreign countries. At the moment of writing, shellfish from China was banned by EU for import. China seeks to cancel this ban. The regulations regarding food quality are in China regarded as too strict, but it is acknowledged that it is necessary to abide by the regulations in order to be able to export aquatic products. The Dalian Fishery Bureau showed serious willingness to cooperate with the Netherlands for knowledge exchange. Knowledge about logistics is very welcome. Also there is interest for Dutch seawater utilization. Furthermore, desalination technology is needed in Dalian because there are a lot of islands surrounded by seawater. The Dalian Fishery Bureau also had several aquaculture projects for which it sought foreign investors. Such projects include sustainable aquaculture model construction.

There is not a lot of international cooperation of other countries with China on marine biodiversity related issues. Norway has had a longstanding MoU from 1984 until 2004 on marine biodiversity research in the Yellow Sea. Norway donated a research ship to China. Another MoU of Norway with China is on environmental cooperation, including climate change and biodiversity, but not in first place focused on marine biodiversity. Denmark has started a pilot project to promote Danish aquaculture technologies in China, contributing to sustainable development of aquaculture. The Danish Embassy showed interest in cooperation with the Netherlands on fishmeal trade with China and on sustainable development of aquaculture. The US had a research project on fish feed based on soybean instead of fishmeal. The goal was to promote such feed to promote the US soy and to cause Chinese fish farmers to use less fishmeal based feeds.

Hardships in cooperation

China is not as accessible on government level as other countries. China has a hierarchic society, and so is its government. The different competences of different departments are hard to know clearly as an outsider. Moreover, the various departments are not aware of the other's activities. There is no cooperation between the different departments nor coordination. It is therefore hard to find the right dialogue or cooperation partner. It also seems hard to have two different departments from Chinese government in one dialogue.

Marine biodiversity

Biodiversity in all Chinese seas is degrading. The Bohai sea is seriously empty, even if the fishers want to fish a lot, they will not find fish. Now there are only small fish left of the commercially important fish. The small yellow croaker, big yellow croaker, angler, lionfish (狮子鱼) are in a serious condition. The fish stocks are not for every species decreasing.

The species that can be found in the seas have been recorded for a long time. For example, according to files on the species, some decades ago 5000-6000 different types of shellfish were found in the Chinese seas. In a recent research program lasting 3-4 years only 500 species of shellfish were found. There are multiple factors causing the biodiversity loss. There is a lot of industrialization at the coastline and these cause for example pollution by industrial waste water discharge. Furthermore, there are a lot of projects and construction at the seaside,

such as real estate and development projects. These cause decrease of the wild resources. Together with the abovementioned causes, overfishing and climate change are factors causing loss of biodiversity. For example different kinds of seaweed are disappearing in specific areas because of the higher temperatures. These seaweeds cannot recover anymore, as the climate change is hard to reverse.
Seaweeds are good to purify the seawater from excess nutrients (OUC). This is needed while the marine environment is affected by eutrophication, red tides etcetera. In Japan, giant jellyfish from the Bohai sea come into the fishing nets of Japanese fishermen. These giant jellyfish are very large because of over nutrition in the Bohai sea, where an excess of nutrients causes algae to bloom, that in turn forms an abundance of food for jellyfish.
The government has issued the Regulation Concerning Protection of Wild Aquatic Animals. MOA has carried out the Action program for Aquatic Plants and Animal Resources Protection in China. More than 200 million RMB has been invested for the release of fry certain aquatic species. Aquatic genetic resources protection zones on national and provincial level have been selected for protection and a list for protected aquatic animals and plants resources has been publicized. This list includes the Chinese sturgeon. Nature reserves are created for brood stock and reproduction and marine nature reserves have been established for protection of important ecosystems and aquatic species. There should be no companies in the vicinity that can harm or pollute the protected areas. In environmental protection investment, a compensation fund for damage to aquatic biological resources has been listed of 792 million RMB as part of a compensation program of resources and ecology.
Conservation of marine biodiversity also is done by constituting artificial reefs, putting stones on the sea bottom and by the fishery restrictions. In this way, it seems as if biodiversity is understood as having enough fish in the sea. So far, the release of fry does not have the effect hoped for as the fish stocks have not increased. Furthermore, the release of artificially hatched fry can have a negative effect on ecology and biodiversity, because the genes of released fish are different from the wild fish, have lower disease resistance, and if they reproduce with the wild stocks, the genetic make-up of wild stocks will be influenced (Liu, 2006; Interview YSFRI). Also, the release of fish can affect the food chain balance, while the food chain is already greatly distorted (Interview YSFRI).
There are rules for the introduction of alien species in aquaculture. Alien species can only be kept in closed cages and it is required to take precautionary measures to prevent escapes. New varieties of aquatic organisms for aquaculture have to be registered. Such regulation applies to introduced foreign species as well as species from local breeding improvement. Release of fry into the wild for stock enhancement is only done for native species.
The Chinese MOA is aware of biodiversity and environmental problems, but the priority is production of food. In practice, MOA does not put a lot of effort in biodiversity. Laws on paper may state biodiversity protection, but in practice there is not a lot done regarding biodiversity. Policy focus is on protection of resources for an economic goal, not in first place to protect biodiversity.

Authorities

In this subchapter, the most important authorities such as ministries, regarding aquaculture, marine biodiversity and international cooperation are described briefly.

MOA

The Ministry of Agriculture (MOA) is responsible for agriculture including fisheries. The Bureau of Fisheries is part of MOA and has a division for aquaculture. MOA is responsible for the protection of ecological environment of fishery waters, fisheries and aquatic wild animals and plants. In some cases, MOA is responsible for the management of nature reserves. This depends on the kind of a specific nature reserve.
The Bureau of Fisheries makes development plans for the fishery sector, including aquaculture, and is responsible for its administration. On city and county level, the Bureau of Fisheries is represented by Ocean and Fishery Bureaus. These bureaus represent the State Oceanic Administration as well.
International cooperation regarding agriculture related issues, are centrally managed by MOA. However, it is possible to have cooperation with a local level fishery bureau, but this cooperation should be approved of by the central Ministry in the first place.
MOA has several branch administrations for specific subjects, such as the China National Feed Management Office which is responsible for the management and guidance of the Chinese feed industry. Another is the National Committee on High Quality Original Seed.
The National Fishery Technological Extension Center (NFTEC) is also under MOA's administration. NFTEC will be further discussed in the chapter 'Research Institutions'.
Government organised social organisations include the China Feed Industry Association (CFIA) and the China Society of Fisheries.

AQSIQ

The General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) is an administration directly under the State Council. The AQSIQ is in charge of national quality and food safety; entry-exit commodity inspection; entry-exit health, animal and plant quarantine; import and export food safety; certification and accreditation and standardization. For aquaculture this means in practice that the AQSIQ is in charge of inspections on aquaculture products and factories. China Inspection and Quarantine (CIQ) which is under the AQSIQ, supervises every point in the production. A farm theoretically has to be approved by the CIQ before it can supply to a processing plant.

MEP

The Ministry of Environmental Protection forms the central administration of protection of nature and ecology, safeguard a healthy environment and control environmental pollution. In relation to marine biodiversity and aquaculture, the MEP is relevant because the MEP has the task to conduct environmental impact assessments (EIA) and prevent environmental pollution. Furthermore, the MEP makes the state of environmental pollution public by making pollution reports. In practice, the MEP focuses on pollution issues. Standards for environmental quality and pollutant discharge standards are formulated by MEP.

In the MEP's tasks, planning of ecological conservation in river basins is included, as well as the supervision of marine environmental protection work, but this may not be put in practice. Whatever its name may suggest, MEP is not in all cases the responsible authority for the protection of nature, for example nature reserves. Dependent on the sort of nature reserve, it is managed by MOA, SOA, or Ministry of Forestry for example.

State Oceanic Administration

The State Oceanic Administration (SOA) is an administrative agency under the Ministry of Land and Resources. This agency supervises and manages sea area use and marine environmental protection. Besides, it is in charge of organizing marine scientific research. The SOA develops functional zoning scheme for the sea area under China's national jurisdiction and issues permits for sea area use. Another task is the control of marine pollution by a control system. SOA makes surveys of the status of China's marine area with regards to pollution. On lower levels, it is the task of the Ocean and Fishery bureaus to monitor sea water quality, as these bureaus represent both the MOA Fishery Bureau and the State Oceanic Administration. Provincial Ocean and Fishery Bureaus publish annual marine environment quality reports on their web-sites. The SOA is the agency that is in practice responsible for the management of marine protected areas and monitoring of marine biodiversity protection. The Forestry Administration, which is also under the Ministry of Land and Resources, administers the management and regeneration of mangroves. This Ministry controls land use by the management of EIAs for significant changes in land use.

The "China Marine Surveillance" force is managed by the SOA. This force carries out routine coastal surveillance. It investigates and prosecutes illegal activities on sea areas. SOA also manages other public marine service systems, such as hazard forecasting and warning systems. Furthermore, regarding international seas and international marine conventions and treaties, SOA is in charge. For example, it manages polar and ocean expedition.

Other authorities

Ministry of Science and Technology (MOST): This Ministry guides science and technology for the improvement of peoples' livelihoods. This ministry in most cases also manages international technological exchange and exchange of scientists. Large part of research institutions is under the administration of this ministry.

National Development and Reform Commission (NDRC) makes plans for the economic and social development of China. One of its tasks is the promotion of sustainable development. The NDRC is a potential partner for dialogues or projects in China. For example, the USDA signed a MoU with the NDRC after being rejected by MOA.

China Council on International Cooperation for Environment and Development (CCICED) is a group of approximately 40 experts and advises the government. It made several proposals to the Chinese government and has environmental cooperation internationally.

Certification and Accreditation Administration of PRC (CNCA) is responsible for the certification of a wide range of products, including 'harmless food'.

Ministry of Commerce MOFCOM: This ministry is responsible for foreign economic cooperation and foreign investment.

The authorities tend not to work together, even if they have an overlap in responsibilities for a certain issue. One of the challenges in Chinese government is the coordination of different government agencies that are involved in certain activities. AQSIQ and the CIQ focus on product quality, while the fishery bureau focuses on the production and environment of production. Food safety issues are related to the production and food safety problems can often be traced back to the production and/or it's the environment.

It is therefore also hard, if not to say, impossible to get more than one ministry in the same dialogue or MoU. The distribution of tasks and responsibilities can be quite unclear. Sometimes more institutions work on the same issue, but do not work together. Some say that different authorities are competing. There is rivalry between local, provincial and central governments. China recognizes the problems in the dispersed competences and responsibilities of the authorities.

Subconclusion

As one can see from this chapter, China has several laws and regulations for the management of aquaculture in China. The Chinese government attaches importance to the management of aquaculture and this can contribute to the sustainable development of aquaculture. Healthy aquaculture development is even stressed in a special 'development plan'. In the 5th FYP, saving resources and the protection of the environment are included. Stronger control on the aquaculture production is focused on food safety. Many of regulations concerning water pollution control, fisheries including aquaculture and the (marine) environment, are implemented only recently, showing the recently growing awareness of Chinese government. Simultaneously, laws as the Marine Environment

Protection Law (1982) are implemented for a longer time, but are not effective.
The organization of aquaculture management by the government and the standards for aquatic production could still be improved for enhancing sustainable aquaculture. National standards for aquaculture discharge and aquaculture medicine guidelines are considered for improvement. In some areas, some government tasks regarding aquaculture are not yet well divided. Coordination between various government agencies could be improved to enhance aquatic environmental protection.

Research institutions

Research institutions have a very important place in the development of China's fishery in general, and in aquaculture specifically. Research institutions develop technologies and knowledge to be applied in the aquaculture industry. The priorities of research are laid down by the government and there is a National Research Program. Research on fishery related issues is managed by the Bureau of Fisheries under MOA. Whilst the central government has a goal to stimulate the aquaculture production as stipulated in the 11th Five Year Plan, research is focused on optimizing aquaculture production. The research is mainly basic and applied research. Research regarding fishery production currently includes:

- Breeding strain improvement; develop new commercial aquaculture varieties
- Introduction of foreign species for aquaculture
- Brood stock production improvements and hatchery technology
- Control of food safety and safety assessments; toxin safety limits in seafood
- Feed productivity increase
- Prevention and control of aquatic diseases, medicines
- Ecological Aquaculture, including polyculture
- Pond water quality
- Intensive aquaculture technology
- Mass plankton culture
- Efficient and healthy marine pond culture
- Aquaculture technology improvement, engineering of aquaculture construction
- Ecological effects of pond culture
- Contamination effects on environment
- Additives
- Use of fish byproducts
- Purification of shellfish
- Tracking and tracing systems for aquaculture products
- Drug residues
- Fishery engineering, fishing gear, such as trawling gear.

In the past, research on for example breeding strain improvement, has facilitated large increases in production in Chinese aquaculture.
There have been set up several research programs and research groups in China. For example the National High Technology Research & Development Program of China, the HEAD program for health improvement, ecosystem conservation, bioremediation etcetera, or the Center for Information Technology & Management in Agriculture and Fishery (CITA). The National Natural Science Foundation (NSFC), which is a member of NACA, coordinates and provides funding to research programs. Furthermore, it cooperates with state administrations in formulating research related policies and plans. Governments on various levels can seek for advice at research institutions for example for policy making, but also for making assessments of the impact of the construction of a nuclear powers station next to the sea on the marine environment. Scientific research and research results are important for Chinese legislation. Development of aquaculture, as well as other industries, should follow a scientific way. Law makers are more easily convinced with scientific research.
The research institutions that perform research on fishery sciences, including aquaculture, provide trainings for aquatic farmers. Enterprises may look for scientific support from and cooperation with research institutions for enhancing their production methods. For example, the new tilapia strain of Jili is cultivated by an enterprise with support from the professor that developed the strain. Commercial companies also do research themselves, for example on feeds or medicines to use in aquaculture. Research bases that specialize in marine biodiversity understandably are located at China's coastal regions, and not in Beijing where the head office of the institution may be.

Fishery Technical Extension Center

The National Fishery Technical Extension Center (NFTEC) is an institution directly under the Ministry of Agriculture, established in 1990. It leads the promotion of fishery technology and the demonstration and spreading of national research findings and technologies. The NFTEC imports, tries and demonstrates foreign technologies. Issues as disease outbreaks, quarantine, quality and safety tests, raw material use, medicine use and more are monitored and guided by the NFTEC. Also technical work regarding seedlings and brood stock of improved breeds is done by this institution. The NFTEC has a task to educate the public and provide trainings for the promotion of fishery technologies. Spread over China, there are more than 18 thousand lower level branches of the NFTEC, that are managed by the local governments. The technical extension stations are a part of the government policy for 'healthy aquaculture'.
The task of the separate extension stations is to spread knowledge about aquaculture, for example farming technologies and feed use. One of the goals in the spread of knowledge is to make the industry more sustainable. Fishery Technical Extension Centers (FTEC) at provincial, municipal, county and township levels give support to industry. Breakthroughs and innovations are observed and achievements promoted. The research results of research institutions and universities are put in practise by the technical extension stations and popularized. An FTEC can focus on different issues in aquaculture. For example on stocking rates, or the farm management to

prevent disease, which in turn can lead to lower use of medicines. The stations give trainings to local farmers. However, these trainings are not necessarily accessible for all aquaculture people and may in certain areas be accessible only for exporting companies or companies that plan to export.

Universities and institutions

The universities that do fishery related work, are for example the China Agriculture University (CAU), China Ocean University (COU), Dalian Fishery University, Shanghai Fishery University and more. The China Academy of Agricultural Sciences (CAAS) and the Chinese Academy of Sciences (CAS) are also important universities, but do not have a focus on fisheries. CAAS focuses on land based agriculture and the CAS a very wide scope of research, including environmental sciences. Universities are under administration of the Ministry of Education or under provincial governments. The fishery research institutes that are spread around China, are administered by the Chinese Academy of Fishery Sciences (CAFS), which in turn is under direct administration of MOA. National research institutions are funded by the central government.

Universities have education programs for aquaculture study. Master degrees and doctoral degrees in aquaculture and related studies are also offered by some universities. Around 10 technical professional train technical workers for the fishery industry.

Local institutions are funded by provincial or municipal government. They seek to solve the technological problems in local aquaculture and respond to the needs of the local aquaculture industry for enhancing the development of the local aquaculture. The research they do is mainly practical applicable in the industry. Biodiversity is also being researched, for example the OUC does research in cooperation with the Yellow Sea Fisheries Research Institute on biodiversity.

CAU China Agriculture University

The focus of the CAU is on agriculture related topics, including fishery and environment. The university has several branches in the country. CAU has specialists on aquaculture and ecology of fishery in Yantai, not in Beijing. CAU has an extensive network with the government, industry organization, national and international universities and research institutions, media, SME etc.. CAU has for example cooperation with China Peoples Congress (CPC) Environment and Resource Committee, the NDRC, MEP, WWF and CITA. Research centers of the MOA include Feed Industry and Agricultural Product Quality Control Monitoring.

China Academy of Fishery Sciences

As described above, the China Academy of Fishery Sciences is administered directly under MOA, funded by the central government, and has its branches spread over China. CAFS organizes integrated fish farming courses since 1980.

It initiated and hosts the Forum on Fishery Science and Technology, which is a serial platform for fishery science and technology exchange in China. CAFS also hosts other science related forums. The CAFS signed cooperative agreements with numerous parties, such as the World Fish Center, SeaGrant NOAA USA and Fishery Research Agency Japan.

All the abovementioned research topics are carried out by the branches of CAFS. Examples of the research institutions under CAFS are Yellow Sea Fisheries Research Institute and South Sea Fisheries Research Institute. Branches also fulfil a part of food safety inspection tasks. The Committee of Conservation and Utilization of Fishery resources (CUF) does investigation and stock assessment. It provides management advices and measures for rational utilization, conservation and enhancement of fishing resources and establishing a fishery management system. It manages the protection of fry resources and endangered species in coastal seas and inland waters by establishing a system of domestication, breeding and rescue for aquatic rare species.

For more information on the abovementioned research institutions, please refer to their websites (Contacts list).

Non Governmental Organizations

Introduction

Since 1978, Chinese society and economy opened up as state control became less rigid. Non Governmental Organizations (NGOs) were tolerated and stimulated to operate in fields like social welfare provision and environment. NGOs have had relative autonomy and served interests of society, instead of mainly serving the state's interests. However, the government and Chinese Communist Party still control social and political life in China to considerable extent. A lot of factors prevent NGOs to fulfil their public interest functions effectively.

Position of NGOs in China

NGOs have not the same position in China as they do in Western societies. In China, NGOs tend to have closer relationships with the government than in the West. Most Chinese NGO leaders do not see their goal in confronting the Chinese government or to protect the society from the state, but rather seek to achieve their goals by collaboration with the government.

Before the Tiananmen incident in 1989, NGOs were not regulated by the government. From 1989, the government adopted regulations for registration and management for social organizations, referring to NGOs, to control them. From then on, government policies regarding NGOs have been ambiguous.

The Chinese state is aware of the significance of NGOs and their importance in providing social services. The government has been willing to tolerate NGOs working areas like environmental protection and social welfare provision, for which the government lacked funds or capacity to manage. The government in some cases even transferred some of its task to organizations outside the state system and set up social organizations itself. At the same time, the government has been and is still afraid that the increasing influence of social groups will cause social and political instability in China. This is why the government tries to control NGOs.

New registration and management regulations made it more difficult to establish grassroots organizations and improved state and party control over NGOs. The result was that the NGOs that were able to register, were founded by government departments themselves or by individuals that had a link to the government.

All NGOs are required to register with the Ministry of Civil Affairs which has a NGO Administrative Bureau, or one of its regional/local branches. All organisations must be sponsored by a government or party department in a relevant field, which is called the 'professional leading unit'. NGOs' application for sponsoring can be rejected by a department.

Regulations make it possible for only one NGO with a specific goal, for example 'protection of the environment', to be registered in a specific administration area. Moreover, NGOs are not allowed to operate outside the region where they are registered. Registration agencies are responsible for investigating NGOs once a year and are responsible for supervision if NGOs do not comply with the regulations. In this way, the Ministry of Civil Affairs and departments have political and legal power over NGOs that should not be underestimated. The departments where an NGO is registered have authority to demand organizational changes or even nullify the registration of an NGO, and they can use this authority to put pressure on an NGO.

Nowadays, there are so-called government organized NGOs (GONGOs), registered NGOs, unregistered NGOs and international NGOs in China. Participation of GONGOs in development projects in China made it easier to obtain funding and technical assistance from international sources. GONGOs were also founded for providing welfare services. GONGOs often have good management and access to funding due to the relationships with government or the Chinese Communist Party (CCP).

Registered NGOs tend to be established by rather influential individuals as they often have some link to the government or governmental backing before they are able to register at the Ministry. Because of the difficulties in registering, some NGOs found another path and found a company, which they then registered at the Bureau of Industry and Commerce as an enterprise. This also provided higher autonomy. For example, Global Village of Beijing was registered in 1996 as a business enterprise. NGOs have also associated themselves with universities, commercial enterprises or other institutions as secondary or subsidiary organizations. Universities are very popular for registration of NGOs and environmental student associations.

There are many NGOs that do not register and set up informal groups that circumvent the rules. Non-registered NGOs have no legal existence and thus cannot act as independent legal entities, cannot offer employees basic social services and therefore it is hard to attract qualified staff. Attracting funding is also hard as non-registered NGOs cannot open their own bank account.

Constraints in registration for NGOs can lead to frustration. Substantial funding is also a problem.

Fund raising is done by collecting TV program fees and volunteers raising for example. NGOs experience a lack of respect from authorities and a lack of influence. NGOs in developed countries are mostly more professional and influential, can involve in key government legislation and are able to sue government departments.

Scarce funding causes that it is hard for independent NGOs to attract high quality employees. Chinese NGOs have lack of management skills, technical information and clear goals. Street collections are prohibited and media

control makes it impossible for NGOs to start public fund raising campaigns. Therefore, attracting funds is mainly done through personal connections. There is a great dependence of Chinese NGOs on funding from abroad, for example from foreign governments or foundations. International NGOs are also subject to limitations in their work. There are no laws covering the activities of international NGOs (Edele, 2005). Chinese authorities are insecure about how to handle international NGOs. In part the activities of international NGOs are subject to the administration regulations that apply to Chinese NGOs. They have to be sponsored by a government or party department in a relevant field. This causes difficulty as departments possibly are not willing to sponsor international NGOs. While they have no legal existence in China, many foreign NGOs seek cooperation with Chinese counterparts.
'Some international NGOs have been able to negotiate special conditions for their activities in so-called "memoranda of understanding". These documents are usually negotiated between international NGOs and local authorities, and they specify the area in which international NGOs are allowed to operate' (Edele, 2005). The same as a number of Chinese established NGOs, a lot of international NGOs registered as foreign enterprises and opened a representative office in China. The registration requirements for an enterprise are more transparent and it saves time and money. Rather than involving directly in activities in China, there are a lot of international NGOs supporting Chinese NGOs with funding and by consulting them.

Decision making

Some NGOs advise the government, but they do not play a significant role in decision making in China. One way of participating in policy making is through personal relations. NGOs can invite community representatives to send proposals to or speak out their minds in the National People's Congress (NPC) or the Chinese People's Political Consultative Conference (CPPCC), which are the legal official and public participation institutes. Liang Congjie, the leader of Friends of Nature (FON) is also member of the CPPCC and is able to make use of his position in this way directly. Another possible way of influencing decision making is to lobby at so called think tanks, that in turn are asked by the government for advise on policies. These think tanks consist partly of researchers, because research and scientific proofs are regarded as very important by policy makers.

Environmental NGOs

Until 1994, there were no environmental NGOs in China. Environmental activism has been flourishing since the 1990, when the people became more aware of the degrading environment and the government put environmental protection high on the political agenda, for example with the China Agenda 21 in 1992. The government acknowledges that it has limitations in handling the huge environmental problems and needs help from social society. Therefore China's environmental authorities have a relatively positive attitude towards environmental NGOs.
Focus of Chinese environmental NGOs in general is to educate and to guide the public, for example by TV serials; promote public involvement; lobby at government on issues of environmental protection policy; monitor what is happening in the field of environmental protection; help enterprises develop greater concern for environmental issues. Furthermore, Chinese environmental NGOs in general tend to focus on pollution, not on biodiversity. However, there are already projects related to aquatic environments and marine biodiversity, which often focus on training officials and capacity building to enhance effective management of important ecosystems. These projects are organized by cooperations of NGOs, funding organizations, central and local governments and sometimes researchers.
Chinese environmental NGOs are for example Friends of Nature , Global Village of Beijing and China Mangrove Conservation Network. The first two focus primarily on pollution issues and make for example reports on the pollution situation in China and the marine environment. Global Village of Beijing is involved in EU China Biodiversity Program in the China Biodiversity Partnership Framework CBPF.
In 2006, according to the deputy head of the Ministry of Environmental Protection 'new circumstances have given NGOs more opportunities to advise the government on environmental affairs, protect environmental rights and interests of the public, mobilize the public to participate in environmental protection and promote international exchanges and cooperation in this field.' (MEP website, September 2009)
There are some NGOs that have a focus on marine environment and biodiversity, international as well as Chinese. For example the international Pacific Environment, which provides funds and capacity building support to other NGOs, including Chinese. Pacific Environment works together with the China Mangrove Conservation Network.

For contact information and websites, please refer to the Contacts chapter

Public awareness

Public awareness in China regarding fisheries and marine biodiversity should not be considered big. While the awareness about the environment is growing, concern about biodiversity is very limited. The environmental awareness amongst government, business and general public is mainly about pollution. However, awareness on the marine environment is growing, be it in a beginners stadium. Concern about fish stocks, the marine environment, and biodiversity comes in the first place from researchers, followed by the government recently (personal communication). Fishermen can be very well aware, as their income depends on marine life and fishermen may receive some government organized

trainings from research institutes (interview YSFRI). Awareness of the general public can be considered very small, some may even say absent.
Main concern of consumers is food safety and quality, and this awareness is concerned quite big. In the past there have been some major food safety incidents, for example the melamine scandal in 2008. These have led to awareness of food safety. Food safety incidents have had a big impact on the market situation of various products, also aquaculture products. Such awareness is has grown since 2002 and is mainly from the more wealthy public. The awareness of Chinese people for healthy consumption keeps rising (Wang Yutang). The concern for food safety and quality is also the main concern for producers. Feed producers, processors and farmers make advertisements with 'healthy' and 'high quality'. Producers are however also paying attention to the environment. A Chinese feed producer for example states that its mission is to offer 'green environmentally friendly nutritious and healthy' food. Ecological production seems to be or become a hot item in the market. A Chinese hatchery in South China makes use of 'ecologic hatching, biological preparations and Chinese medicine, and does not use any forbidden medicine' and states to be more natural.
This business awareness may be nourished by government campaigns for 'healthy and ecological aquaculture', stronger control on food safety and trainings from an FTEC. However, foreign import regulations on aquatic products also contribute to this awareness. In South China, most aquaculture companies have awareness about the environment, health and the ecosystem. A lot of aquaculture companies want to export to for example EU. Before such export is possible, the companies have to comply with a set of regulations, which they in turn regard as important. At the same time, business awareness may be limited to the exporting companies, those companies that plan to export and companies that supply products to exporting companies. However, there is not a clear view on this for all of China. Furthermore, awareness on environmental protection by fish farmers can be primarily understood as the prevention of water pollution (EU report).

Subconclusion

(Environmental) NGOs in China have a unsecure position. Nevertheless, some contribute to improving management of the marine environment. There are no apparent activities by NGOs that focus on aquaculture, nor marine biodiversity, with the exception of WWF and Wetlands International. However, there are some projects on marine aquatic biodiversity. NGOs could be helped or encouraged to create more awareness about the marine environment and biodiversity amongst the general public. The public awareness is very limited and could be spurred. However, China may not be ready for this, and it should be considered that China may not be such a society in which awareness changes the situation. It may be more efficient to encourage NGOs to lobby with central/local governments for better management of aquatic biodiversity and the prevention and reduction of aquatic pollution. Please see Appendix C for more info on NGOs' activities.

Conclusions

Aquaculture in China faces various problems regarding sustainability. Reliance on wild brood stock, lack of high value breeds, habitat conversion, overburdened ecosystems and high stocking densities, reliance on caught fish for feed, food safety, escapes and lack of training and inspection capacity are amongst the main problems.
Aquaculture is of significant economic importance and will grow in the near future as a supply of food, jobs and foreign exchange. Demand for fish feed and raw material is growing. The growing aquaculture sector gives rise to chances as well as threats. China is working on sustainable development by government policy, FTECs, certification and by companies themselves, but there is a lot of work to do. There is pressure on natural ecosystems and fishmeal resources. There are chances for research and technology and for business to make China's aquaculture more sustainable. There is a notable difference in the development levels and use of modern science and technology of different aquatic farmers. Exporting producers and high-end producers use the most advanced technologies.
Government focus regarding fisheries is on research for sustainable development, aquaculture development and high seas fisheries. The government promotes high productivity in a scientific way with attention to the environment and standardization.
There is a lot of research done for improvement of the aquaculture industry in China, with a focus on healthy production, including increase in production, quality and sustainability. Furthermore, the research achievements of Chinese research institutions are put in practice by FTECs. However, there is insufficient capacity for training all aquaculture farmers in China, and so the pursued scientific development is not accessible for all of the aquaculture sector.
There is a development of aquaculture from high quantity low-value fish to better quality products. This implicates a growing demand for better quality technology and raw material, that as a result these two have potential for production and development in China, such as modern breeding engineering and formulated feeds.
Policies, laws and regulations are in place, but there is not enough capacity for monitoring and control of the entire aquaculture industry to make regulation regarding biodiversity, fishery and environment reality.
The Chinese inspection system is still imperfect and although the government has the ambition to improve this, in practice there are not enough resources. The lags in the safety inspection give chance to incidence of food safety problems of export products to EU and US. Food safety problems in aquaculture call for better feed formulation, alternative medicines and disease resistant species, as well as better management in aquaculture sites.
A threat of aquaculture for sustainability and aquatic biodiversity is the dependence on wild brood stock and fry. Simultaneously, there is a chance for the development of scientific artificial hatching for such species. Furthermore, there is demand for genetically improved breeds. Another threat is the introduction of non-native species, even more because of the lacking control on this. The regulatory framework for management in practice should be improved, including escape prevention management. Aquaculture is also a threat to marine biodiversity by way of reliance on wild catch fish for feed input. In a way, use of trash fish in aquaculture can be regarded as more efficient than making no use at all of trash fish and discarding it into the sea after catch. However, as the around China are getting empty, it seems better if catch of trash fish is prevented. More quantitative research is needed on the impact of aquaculture on biodiversity and fish stocks.
The effect of standardization and certification is limited in large part to big and exporting companies, for which inspection is much more strict, and exporting companies are the only producers that would consider certification by international NGOs, as there is no social carrying capacity for the success of such certification on the domestic market. Chinese certification is more widespread, but certified producers have been reported to break the regulations of certification. China needs more capacity for training fish farmers and more capacity for inspections for food safety.
Awareness about (marine) biodiversity is only present at universities and in a beginning stage at the central government. The public awareness considering fish is mainly food safety and quality. It is regarded as useful to raise the awareness of the government, local as well as central, about marine biodiversity, by way of dialogues and trainings for officials. In the end, raised government awareness will lead to policy in advantage of marine biodiversity. Various organizations organize such trainings and related projects. Although NGOs in China do not have the same standing as in the West, they have potential influence to contribute to sustainable development of aquaculture.
Overall, although aquaculture in China is not in all aspects sustainable and the impact of aquaculture on marine biodiversity is not fully clear, China's aquaculture is stimulated to develop towards a sustainable industry.

Suggestions for further research

More quantitative research is needed on the impact of aquaculture on biodiversity and fish stocks due to use of wild stocks for feed input. In this research, no measurements of water, fishmeal, fish feed or energy inputs have been done or compared with aquatic

end product amounts. This would further elucidate sustainability of aquaculture in China.
More research is needed on the impact on aquatic biodiversity due to habitat conversion for the purpose of aquaculture. At the moment of writing, no such research had been completed for China yet. Furthermore, there is no complete estimation of the introduces species and their impact on the local ecosystems.
While the demand for aquafeed is rising, there is a growing demand on fishmeal and soy. It may be useful to explore raw materials that could substitute fishmeal. A study including risk assessment could be made on the use of land-based animal residues from meat industry in aquafeed. In China, ruminant meal, bone meal and feather meal are already available on the market for use in aquafeed. It is cheaper and in plenty supply compared to fishmeal.
Energy use was not a topic of research for this report. Nevertheless, energy use by the aquaculture industry, including the CO_2 emissions and fuel use in the transport of exported products should be assessed. This is important for making a measurement of the total 'ecological footprint' of aquaculture products from China.

Suggestions for Dutch Business

There are various chances for Dutch business for further development regarding Chinese aquaculture and for supporting sustainable development of Chinese aquaculture. There is potential for further research on applications in aquaculture in China.

- Development of offshore aquaculture in all Chinese marine regions: chances for offshore culture equipment and technologies, such as net cages, submersible cages, automatic feeding systems, monitoring equipment etc. Aquaculture is being developed for increasing export production. Offshore cage culture of high value species has potential for high investment in modern technologies. There is a need for equipment that can stand deep sea flow and winds for culture offshore within the 40m isobaths.
- Development of algae culture for biofuel from waste water from aquaculture.
- Also development of land-based culture gives potential for aquaculture technologies. Closed intensive land-based culture systems currently enjoy preferential policy and implementation receives subsidies in some regions.
- There is a potential growth in demand for modern aquafeed with a scientific composition. Currently, there is a shortage in domestic production, while part of aquaculture still relies on trash fish and marine fish culture is growing. A possible strategy is to contract the mixing companies in China or set up a factory in China itself.
- Trainings to producers can contribute to sustainable aquaculture. For several products, it may be relevant to offer a training simultaneously with the product itself. For example, when a number of fish fry is sold to a fish farmer, the hatching company may provide training and instructions to the farmer for stocking density, feeding and more to make sure that the product (fry) will show optimum results. In this way, the farmer is trained and the hatchery is sure that his company will not be blamed for bad results that could be caused by lack of knowledge of the farming customer.
- Artificial hatching and breeding of improved strains have potential to grow in China. More research is needed to develop scientific hatchery for a number of culture species in China. This would relieve the pressure on wild stocks of such species by reducing the reliance on these wild stocks.
- Currently, Chinese research is searching for substituting medicines that are legal and do not pose a threat to food safety and quality. Also other products for maintaining water quality and fish health are being developed. There is potential for further research and knowledge exchange, and for production of allowed medicines. While diseases still are a problem in aquaculture, research on disease prevention would contribute to the sustainable development of aquaculture in China.
- Consultancy bureaus for food safety could be set up. Currently, China has a lack of capacity for testing food safety. Consultancy bureaus with testing laboratories could do the testing. An example of such a bureau is AmeriSci, that helps tilapia producers meet the strict export requirements.
- Take mixed culture models of plants, shellfish and fish as an example for own implementation.
- There are many chances for investment in Chinese aquaculture projects that are organized by local Fishery Bureaus. These projects vary per locality, so it is advised to contact an NBSO for communication with the specific local Fishery Bureau.

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All China Environment Federation http://www.acef.com.cn

CAPPMA www.cappma.org ; www.fish.gov.cn

Certification and Accreditation Administration of China (CNCA) http://www.cnca.gov.cn/cnca/zwxx/xwdt/zxtz/36643.shtml http://food.cnca.cn/cnca/spncp/sy/index.shtml

http://foodcert.cnca.cn/foodcertWeb/web/certSearch.jsp to search certified producers, by certificate number etc.
China (marine) Biodiversity Conservation Action Plan http://english.agri.gov.cn/ga/amoa/organs

China Biodiversity Conservation Foundation www.cbcf.org.cn

China Feed Industry magazine http://www.chinafeedindustry.com/chinafeedindustry/features/
Chinese Environmental NGOs online www.greengo.cn

EU China Biodiversity Program www.ecbp.cn/web/index.aspx

EU-China Trade Project www.euchinawto.org

Feed in China and related issues www.efeedlink.com

Fish Base www.fishbase.org

Fisheries Advance magazine www.fishfirst.cn

Fishery Bureau of PRC http://www.cnfm.gov.cn/

Fishery Trade Net http://www.fish.gov.cn/index.asp (Chinese only)

IFFO International fish meal and fish oil organization www.iffo.net

Law Info China, with law texts in Chinese as well as English www.chinalawinfo.com

Ministry of Agriculture of China http://www.agri.gov.cn/

Ministry of Environmental Protection http://www.mep.gov.cn/

National Development and Reform Commission of China http://en.ndrc.gov.cn/

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Appendix A

List of prohibited chemicals and drugs for animals that provide food to humans:

食品动物禁用的兽药及其它化合物清单

序号	兽药及其它化合物名称	禁止用途	禁用动物
1	β－兴奋剂类：克仑特罗 Clenbuterol、沙丁胺醇 Salbutamol、西马特罗 Cimaterol 及其盐、酯及制剂	所有用途	所有食品动物
2	性激素类：己烯雌酚 Diethylstilbestrol 及其盐、酯及制剂	所有用途	所有食品动物
3	具有雌激素样作用的物质：玉米赤霉醇 Zeranol、去甲雄三烯醇酮 Trenbolone、醋酸甲孕酮 Mengestrol，Acetate 及制剂	所有用途	所有食品动物
4	氯霉素 Chloramphenicol、及其盐、酯（包括：琥珀氯霉素 Chloramphenicol Succinate）及制剂	所有用途	所有食品动物
5	氨苯砜 Dapsone 及制剂	所有用途	所有食品动物
6	硝基呋喃类：呋喃唑酮 Furazolidone、呋喃它酮 Furaltadone、呋喃苯烯酸钠 Nifurstyrenate sodium 及制剂	所有用途	所有食品动物
7	硝基化合物：硝基酚钠 Sodium nitrophenolate、硝呋烯腙 Nitrovin 及制剂	所有用途	所有食品动物
8	催眠、镇静类：安眠酮 Methaqualone 及制剂	所有用途	所有食品动物
9	林丹（丙体六六六）Lindane	杀虫剂	水生食品动物
10	毒杀芬（氯化烯）Camahechlor	杀虫剂、清塘剂	水生食品动物
11	呋喃丹（克百威）Carbofuran	杀虫剂	水生食品动物
12	杀虫脒（克死螨）Chlordimeform	杀虫剂	水生食品动物
13	双甲脒 Amitraz	杀虫剂	水生食品动物
14	酒石酸锑钾 Antimonypotassiumtartrate	杀虫剂	水生食品动物
15	锥虫胂胺 Tryparsamide	杀虫剂	水生食品动物
16	孔雀石绿 Malachitegreen	抗菌、杀虫剂	水生食品动物
17	五氯酚酸钠 Pentachlorophenolsodium	杀螺剂	水生食品动物
18	各种汞制剂包括：氯化亚汞（甘汞）Calomel，硝酸亚汞 Mercurous nitrate、醋酸汞 Mercurous acetate、吡啶基醋酸汞 Pyridyl mercurous acetate	杀虫剂	动物
19	性激素类：甲基睾丸酮 Methyltestosterone、丙酸睾酮 Testosterone Propionate、苯丙酸诺龙 Nandrolone Phenylpropionate、苯甲酸雌二醇 Estradiol Benzoate 及其盐、酯及制剂	促生长	所有食品动物
20	催眠、镇静类：氯丙嗪 Chlorpromazine、地西泮（安定） Diazepam 及其盐、酯及制剂	促生长	所有食品动物
21	硝基咪唑类：甲硝唑 Metronidazole、地美硝唑 Dimetronidazole 及其盐、酯及制剂	促生长	所有食品动物

注：食品动物是指各种供人食用或其产品供人食用的动物
http://www.chinagmp.cn/PolicyList.asp?ID=092270905131126

Appendix B

EU-China relations

The relations between China and the EU are laid down in the 1985 EU-China Trade and Cooperation Agreement. EU and China agreed on a strategic partnership in 2003. China and EU should work together in their international activities. The EU as well as China should both open their markets and safeguard a fair trade field.

EU wants to intensify the cooperation on behalf of sustainable development. For the EU, China has a central role in worldwide sustainable development. China and EU should support close international relations regarding the environment and climate change. They should both take care for a sustainable energy supply. EU and China should cooperate on enhancing China's management capacity and technical expertise for improving energy efficiency and renewable energy use.

Both sides should work together to fight climate change and to improve the environment. In the Top Conference EU-China in 2005, a partnership was established that is a good base for cooperation on environmental issues and climate change. EU should share its regulation and management expertise with China. Furthermore, EU should work together with China to fight pollution, conserve biodiversity, make more efficient use of natural resources such as water and energy, and enhance environmental law enforcement transparency. Both sides should work together to fight deforestation and illegal logging and work together for sustainable management of wild fish stocks and responsible marine management. International agreements on biodiversity or sea treaties are not mentioned explicitly.

Cooperation on science and technology is a priority for the Chinese government. China is an important country participating in the 6th Framework Program for research in EU research projects. In this way, China has access to 600 million Euro research funds. The joint statement on the forum for science and technology in May 2005 forms the framework for more cooperation, based on mutual interest and participation.

Since 2007, the EU and China have a Partnership and Cooperation Agreement. There are more than 20 sectorial dialogues and agreements on various issues, for example environmental protection or trade. These dialogues are between different DG of the EU and different ministries of the PRC, for example a dialogue on agricultural policy between EU DG Agri and the PRC MOA. There are various MoUs, for example on food safety between the EU and AQSIQ. The EU also provides funds for work of NGOs. There is a lot of contact between EU and China on food safety.

In recent years, the EU has intensified its environmental policy cooperaton with China and wants to encourage China to implement environmental policies. The so-called EU-China Development and Cooperation has been further enhanced on environmental issues by the creation of a policy dialogue between the DG for Environment and the MEP of China and by the formation of an EU environment counsellors group in Beijing. In the policy dialogue on environment, priorities include water pollution, air quality and biodiversity.

There are several multiannual programmes for development and cooperation, such as the EU-China Trade Project (EUCTP), the EU-China Biodiversity Program (ECBP), River Basin Management Program (RBMP), Natural Forest Management Project (NFMP) and the Energy/Environment Program (EEP). In addition, there is cooperation with various Chinese ministries and administrations that are responsible for example for climate change and water resources. Climate change cooperation has the highest priority. One of the aims in environmental cooperation is enhancing the take-up of environmental technologies in China.

EU China Biodiversity Project

http://www.ecbp.cn/en/about.jsp

The EU China Biodiversity Project (ECBP) is a component of the China Biodiversity Project Framework (CBPF). The ECBP funds so-called 'field projects' (currently 18), testing innovative mechanisms for biodiversity management, policy implementation, and establishment of partnerships between international, national and local governmental institutions and NGOs. An important activity is developing the capacity of MEP and the Secretariat of the China Steering Committee and to implement the Convention on Biological Diversity.

The ECBP aims at making China able to manage its ecosystems in a sustainable way. This has to be achieved by strengthening the national policy for biodiversity conservations as well as the institutional framework. Biodiversity should be integrated into relevant policies and legislations, such as the EIA. In the EUBP, demonstrations have to show how to effectively implement biodiversity protection. Public knowledge should be enriched and education campaigns are held. Furthermore, the project is aimed at raising the awareness about biodiversity of decision makers and the general public. The ECBP establishes partnership field projects in central, south and western China to increase the capacity for biodiversity conservation at provincial and local level. The field projects support and initiate appropriate changes to laws, policies and plans and emphasize environmental awareness.

The ECBP is funded by the European Union, and implemented by the UNDP in partnership with the MEP, local governments and NGOs.

Now, China is drafting the China National Biodiversity Strategy and Action Plan and China has drafted 2010 biodiversity targets and indicators. Ecological guidelines

were revised and approved. Inter-agency coordinating bodies for biodiversity have been set up under several field projects and initial projects have been undertaken to incorporate biodiversity considerations into governmental work plans and performance appraisal systems for government agencies. Local awareness about local biodiversity has been increased by awareness activities. The ECBP is a joint initiative between the EU, MOFCOM, UNDP and the MEP. Funds account for 51 million Euro in total. It is a five-year project (2005-2010) aimed ad conserving specific ecosystems in China by the strengthening of the biodiversity management.

EU-China Trade Project

China is the EU's second largest trading partner, while the EU is China's largest trading partner. The EU-China Trade Project (EUCTP) was initiated in 2004 by the EC and the Ministry of Commerce of the PRC. This project is aimed at enhancing mutual understanding and help China's integration into the world trading system for mutual benefit in trading, while promoting closer trade relations with the EU. In this project, the EU assists China in its institutional, policy and regulatory process for implementing its WTO commitments and strengthening China's trade-related capacity. Thereby it helps further trade liberalisation and promotes economic development. The funding for this trade-related assistance project accounts for 20.6 million Euros over five years.
The EUCTP organises various activities, such as conferences, workshops, seminars and training programmes. It also includes training programmes to Europe and internship placements. The EUCTP held a workshop on environmental sustainability in aquaculture in June 2009, where EU knowledge and practices in aquaculture where exchanged. Participants included amongst others the Fishery Bureau of MOA, AQSIQ, National Fishery Technical Extension Centre, Chinese Academy of Fishery Science and Global GAP. Also, an EU organised research project on sustainability in Chinese tilapia and shrimp aquaculture in south China was performed in 2008.

Appendix C

((non) governmental) Organizations and their activities related to aquaculture and marine biodiversity.

WWF China 世界自然基金会

The World Wide Fund for Nature (WWF) is directly involved in the implementation of projects in China. This in contrast to some international NGOs that only provide funding. WWF was the first international conservation organization that was invited by the Chinese government to carry out activities in China in 1980. It started with giant panda protection projects. In 1996, WWF opened its own office in Beijing. It has also six field offices. WWF is sponsored by the State Forest Administration. Working directly with the Chinese government offers a possibility to rapidly and widely spread new approaches in fields where cooperation is successful (Edele, 2005).
WWF has a team of scientists and experts to conduct biodiversity surveys and analyze information gaps. Detailed action plans have been worked out with WWF Japan, WWF China and the Korean Ocean Research and Development Institute for example for conserving coastal wetlands. Plans are being carried out with governments in related areas amongst nature reserves, local communities, fishermen, schools and related enterprises. The plans emphasize the protection and sustainable use of the biodiversity in the region.
WWF works together with several Chinese government departments, for example with MEP, SOA and MOA, but also provincial government departments. It has signed a Memorandum of Understanding (MOU) with the MOA Fisheries Bureau on the sustainable use of resources in the Yangtze river in 2007 and signed and MOU with the SOA in 2008 on promoting the sustainable management and conservation of China's coastal areas and seas. Other partners include Chinese banks and enterprises, Chinese and international organizations and research institutes. Projects for freshwater and marine ecosystems of WWF China include the development sustainable water resource management in the Yangtze river; wetland conservation and protection and the development of effective management plans; river basin management; mangrove coastal management plans in the southern Chinese coastal region.
WWF was a key initiator and supporter of the Yangtze Forum. The aquatic biodiversity in the Yangtze river is weakened by land conversion and pollution. Provincial officials and key ministers from China's water, environment, forest and agriculture sectors gathered for the first time in 2005 to set up a common strategy and action plan for the protection of the entire Yangtze river basin.
WWF wants to promote sustainable management and utilization of wetland resources and the restoration and protection of wetland habitats. WWF sees a solution in the use of efficient technologies for plumbing and irrigation, reuse of wastewater and appropriate pricing of water and thereby reducing the growth in water demand. WWF China helped to get together several ministries and government departments for an action plan for preservation of wetland in the National Wetland and Conservation Action Plans. WWF seeks to mobilize university students for the protection of wetlands with a Wetland Ambassadors campaign since 2001. WWF also helps communities to set up management and supervision teams to supervise the restoration of reclaimed farmland to the former wetland state. WWF reintroduced the Pere David Deer in Dafeng. In Hong Kong, WWF manages the Mai Po Nature Reserve, protecting several species and providing training for staff from mainland China.
The Yellow Sea region has been selected by WWF to focus on as an ecoregion that represents different collections of biodiversity and ecological processes in the Asia Pacific within WWF Global 200. The Yellow Sea region is relatively large and is not limited to Chinese territory only, but also borders the Korean Peninsula. In July 2002, WWF Japan and China, Wetlands International China Programme and others launched a joined project for the conservation in the Yellow Sea, covering also the Bohai sea. A biodiversity vision of the Yellow Sea ecoregion is to be developed for determining priority areas for conservation intervention. Next to that, environmental education in elementary and secondary schools is to be developed for the raising of public awareness about Yellow Sea conservation issues. WWF helps in implementing educational activities and material at schools and communities in the program areas in the different countries.

Wetlands International

Wetlands International-China was established in September 1996. Wetlands International (WI) has scientific research on bird migration, which is the main target of the NGO in China. The NGO has only limited funds. There has been a project on mangrove reserves in south China (Zhanjiang), but this is not in hands of Wetlands Int. Wetlands Int. does not have any specific programmes on aquaculture. There is a program being planned to enhance sustainable aquaculture in South China.
WI has worked on the replanting of mangrove for the restoration of mangrove forests in order to protect the coastal region from erosion and to prevent natural disasters. WI supported Hainan province to develop Dongzhaigang nature reserve management plan which also incorporates aquaculture aspects. This is a Ramsar mangrove site. It is however not involve in the implementation so it is not sure how the plan is carried out and strictly followed or not. Zhang Xiaohong of WI said that activities could have been implemented

dependent on the financial support. She explained that the economic development of local communities was limited and their income decreased after the establishment of the reserve, mainly because restrictions on land use and harvesting and fishery activities. This was cause for conflict. Therefore it is needed to provide the local communities with incentives to preserve the area and the resources by developing economic benefits from the mangrove forests and involve the local community in management decisions. There have been planned various actions for achieving this, which are the following: planting work for improving the ecological environment leading to an increase the production of fish, crab, oyster and shrimp; technical assistance to rural households to improve the farming techniques, promote sustainability in aquaculture, provide judicial assistance and education on environmental protection and sanitation; encourage local people to participate in ecotourism services to bring direct benefit to the communities and reducing pressure on the wetlands; cage culture trials for marine resources in an extensive use zone for increasing the income of the local communities and reduce pressure on the core zone of the reserve; development of small-scale cash crops, for example species of medicinal value to provide economic incentive for the local communities.

Global Environment Insitute

www.geichina.org

The Global Environment Institute (GEI) is a Chinese NGO established in Beijing in 2004. The vision of GEI is that environmental protection cannot be seen as separate from economic development. GEI aims to design and implement market mechanisms for solving environmental problems and achieve economically, ecologically and socially sustainable development. China is in economic development and conventional methods of environmental protection often fail because they are in conflict with economic activities. The Chinese development was predominantly focussed on economic growth, emphasising GDP increase and overlooking environmental problems. GEI was founded to find new solutions that work with the market to provide sustainable livelihoods and healthy ecosystems. GEI seeks to build local and international collaboration between government agencies, research institutions, private enterprises and NGOs. Furthermore it aims at self-sustaining and ecologically sound rural development by linking the local communities with partners in for example biodiversity conservation and renewable energy. It seeks to spur the economic development of communities living near buffer zones of nature resources. Another goal is mitigating global warming and increasing energy conservation by for example commercializing environmental technology. Besides that, GEI seeks to improve leaders' capacity to design, implement and enforce development policies that are socially and environmentally sound.

For achieving its goals, GEI has a function as 'think-tank' promoting the establishment and enforcement of environmental policies in its Environmental Governance Program. It has assisted in making training programmes for high-level officials to be used by the Party School of the Central Committee of the CPC for cultivating environmental values amongst government leaders. GEI uses Conservation Incentive Agreements to encourage local governments to adopt an environmentally responsible approach to economic development. Regarding forests, GEI has projects to strengthen the ties between the Chinese government, enterprises and overseas governments, as well as between NGOs and government units, thereby promoting unified action. In its Partnership Program, GEI assists international NGOs with environmental protection projects in China.

IUCN China

IUCN China has involvement in China since the 1980s, through IUCN Headquarters and IUCN Commissions. In recent years, IUCN has been involved in various conservation work in China. This work includes environmental law, environmental economics, species management and protected area management. IUCN has 8 members in Mainland China. China is a State member of IUCN since 1996, represented by the Ministry of Foreign Affairs. The IUCN and State Environmental Protection Administration (SEPA, now MEP) signed a MOU in 2000, for carrying out a cooperation program from 2001-2004. IUCN also signed a MOU with the State Forestry Administration in 2004. Furthermore, IUCN has been a member of the China Council for International Cooperation on Environment and Development (CCICED). IUCN supports its members and partners in China by providing information, strengthening capacity and demonstrating innovative approaches on the ground. It facilitates international exchange by bringing international technical expertise to China and Chinese expertise abroad (http://www.iucn.org/). In the past, IUCN also had marine biodiversity related activities in China, but does not have it currently.

Friends of Nature

The first environmental NGO which was registered in China was 'Academy for Green Culture'. The name has been changed in 'Friends of Nature' 自然之友 and Liang Congjie is the president. He is a member of the Chinese Peoples Political Consultative Conference simultaneously. FON is registered at the Ministry of Civil Affairs of China. In this way, he has a strategic position. FON makes annual reports on oceanic pollution of Chinese seas.

Global Village of Beijing

'Global Village of Beijing' 地球村 (GVB) was founded in 1996. GVB has a mission to enhance the public awareness and promote public involvement in environmental protection in China with mass media, various social activities, TV series. GVB helps farmers raising eco-vegetables, using solar energy, sustainable development of wetlands, species diversion. Global Village of Beijing is involved in EU China Biodiversity Program in the China

Biodiversity Partnership Framework CBPF.
On the moment GVB has no program on marine biodiversity or aquaculture. It made a report on pollution of the Yellow Sea.

All-China Environment Federation

The All-China Environmental Federation (ACEF) is a government organized NGO and was established by the State Environmental Protection Agency (SEPA) (now Ministry of Environmental Protection) in 2005. ACEF has three approaches to environmental work: public environmental education, assisting and supervising the government in achieving environmental objectives and safeguarding the environmental rights of disadvantaged groups. This is a very well-connected organization in China's environmental movement. Legal service by the ACEF for legal assistance has helped the government to solve environmental pollution cases. This organization is regarded important as a major organizer of environmental events. Website: http://www.acef.com.cn

Pacific Environment

Pacific Environment is an international NGO, that basically works together with and supports local NGOs in achieving goals of marine conservation, supporting local efforts for protecting mangrove system. It does so for example by offering capacity building support to Chinese NGOs and bringing NGOs together for cooperation. It works together with the Global Greengrants Fund to provide funds to over 50 NGOs around China. Pacific Environment works together with China Mangrove Conservation Network. It aims at supporting grassroots activism and empowering communities along the Pacific Rim.

China Mangrove Conservation Network 中国红树林保育联盟

The China Mangrove Conservation Network (CMCN), located in Xiamen, promotes mangrove conservation and has cooperation with several NGOs. Its main project is the China Mangroves Protection Project. Its work consists of scientific research, plantation, environmental education and more. Please visit the website for more information: www.china-mangrove.org .

NACA

Network of Aquaculture Centers in Asia-Pacific (NACA) is not an NGO but an intergovernmental organization, that promotes sustainable aquaculture. It provides development assistance in partnership with governments. NACA is aimed at supporting institutional strengthening, technological exchange, development of policies for sustainalble aquaculture and aquatic resource management. Partners of NACA include FAO, UNDP, Asian Development Bank, EU, DANIDA and WWF. The YSFRI, National Natural Science Foundation and the Freshwater Fisheries Research Institute are participating members of NACA in China.
The Center of Integrated Fish Farming (Wuxi) is established by the Chinese government, and supported by UNDP and FAO. Please visit the website iffc.fish.cn for more information.

UNDP

United Nations Development Program in China
UNDP (also not an NGO) started its work in China in 1979 after signing a basic agreement with the Chinese government. Its projects range form agriculture, industry, public health, poverty alleviation, energy, and more. Chinese citizens have been trained and key ministries of the Chinese government have a strengthened capacity. Millennium Development Goals are important priorities for UNDP. UNDP has close relationships with Chinese government departments. Relationships with the Chinese government are essential for achieving its goals. UNDP focuses on supporting China in achieving its Five Year Plan goals in the 11th FYP, and to improve China's compliance with multilateral agreements, amongst which also the UN Convention on Biological Diversity.
UNDP has a project in China on marine biodiversity conservation, focusing on South China's coastal environment. In this project, important partners include the State Oceanic Administration (SOA), Global Environment Facility (GEF), local governments of the provinces Hainan, Fujian, Guangdong, Zhejiang and Guangxi AR. The project has to strengthen capacities for conservation and management of four existing MPAs, test and demonstrate instruments for handling the causes of threats to marine biodiversity, and implement tools for conservation and sustainable use in 6 sites for promoting broader adoption at China's South Sea coastal area. MPA staff received training in workshops in China Education and Training Center for Marine Biodiverstiy and Ecosystem Management. Strategic partnerships have been established with bilateral donors, NGOs, village communities and the private sector. UNEP, another UN institution, is also active in biodiversity management in China.
The majority of UNDP projects in China are directly executed by Chinese institutions, including government ministries as well as NGOs and private sector parties. UNDP works towards advocacy, policy advice, dialogue and facilitation, as well as brokerage for innovative solutions. (http://www.undp.org.cn)

Others

The list above is not the complete picture of NGOs that are related to marine biodiversity or aquaculture, active in China. There are some other NGOs that might be interesting to mention. However, information about these NGOs is scarce. They include :

- Ocean Protection Commune 大海环保公社 www.dahai.ngo.cn
- Fujian Greenhome Environment Friendly Center 福建省绿家园环境友好中心
- Institute of Public and Environmental Affairs www.ipe.org.cn; http://en.ipe.org.cn with a map of polluting enterprises and polluted spots in China, also for water pollution 中国水污染地图 .
- China Biodiversity Conservation Foundation www.cbcf.org.cn