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## Chinese aquaculture in light of green growth



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### ABSTRACT

Over China's long history of aquaculture development, great achievements have been made by enhancing aquaculture as the major contributor to aquatic products supply, while lessons have also been learnt that aquaculture has been developing at the cost of environment. Priority is now given to the aquaculture development in the light of green growth, which attaches importance to both environment protection and high productivity. To sustain Chinese aquaculture in a green-growth manner, policies changes have been made, a comprehensive legal framework has been developed, and an organized institutional framework has been set up. The extension of science and technology also serves as the back-up for green growth in Chinese aquaculture. Chinese aquaculture is still confronted with various challenges, while green growth will be the key to a more responsible and prosperous aquaculture industry in China.

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### 1. Introduction

In China, the initial years after the Open and Reform of the late 1970s were dominated by a supply-driven paradigm focused on output volume in fisheries (Note: fisheries cover both aquaculture and capture in this paper). To meet the increasing demands from both domestic and international markets for aquatic products, more and more priorities are given to the development of aquaculture, which is now playing a more and more important role in the output contribution. Besides, increased awareness of the need to enhance fisheries resources conservation in the 1980s has led to the development of an "aquaculture-oriented" fisheries policy, boosting China as the only country whose aquaculture output outruns capture and which now produces almost 70% of the world aquaculture output. The contributions and achievements from aquaculture are undeniable. However, the rapid expansion of aquaculture has brought about such growing pains as pollution, food safety, disease outbreaks, etc. The government has responded by shifting policy focus, setting up regulations and introducing technological innovations to strengthen sustainability and responsibility in aquaculture. The history for the aquaculture development is the history for exploration, while years of exploration comes with the enlightenment that green growth is the key to a responsible and prosperous Chinese aquaculture.

### 2. Method

With a retrospective investigation into the development of Chinese aquaculture, the paper explores how it is driven to the track of green growth, the sustained growth which, as OECD documents (OECD, 2012) defines, means enhancing growth on the one hand while reducing environmental footprints of economic activities on the other hand. The 3rd session begins with an introduction of Chinese aquaculture history with both highlights and pains over half a century. It is followed by a detailed introduction of various measures to sustain Chinese aquaculture in a green-growth manner, thus a review of policy changes and an illustration of legal and institutional framework will give a picture about what Chinese aquaculture is undertaking towards green growth. The paper will end with an outlook into the future of Chinese aquaculture.

### 3. Chinese aquaculture and green growth

As a legend country in aquaculture, China has a long history for aquaculture which has witnessed both highlights and pains. With raised consciousness of environment protection, green growth is currently one of the keys to the Chinese aquaculture development and sustainability. Various measures have been taken to maintain green growth in aquaculture. Policies have been changed with more focus on environmental protection. Comprehensive legal and institutional frameworks are further enhanced to serve as back-ups. Much priority is also given to the extension of science and technology to aquaculture.

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### 3.1. Chinese aquaculture history

The development of Chinese aquaculture is the history of explorations, discoveries, and sometimes, pains.

Before 1950s, with abundant wild fish stocks in waters, fishers were actively involved in capture fishing. Later, with depleting fishing resources, fishers resorted to the culture-based fisheries in lakes or reservoirs. Culture-based fisheries fall into the realm of aquaculture (FAO, 1994). However, different from the conventional aquaculture, culture-based fisheries are sustained by regular stocking, and take place in such existing water bodies as lakes, reservoirs and dams, causing little competition with other uses; besides, culture-based fisheries do not involve external inputs, like feed, bringing less disturbance to the environment (De Silva, 2003). With the increasing demand for fish at the markets, other more efficient aquaculture methods were explored. Between mid-1960s and mid-1980s, pond aquaculture was popular, and brought good profits to the fish farmers. With more competitive markets and little potential for the expansion for aquaculture farms, intensive aquaculture was viewed as another efficient way to enhance output, such as cage aquaculture and pen aquaculture. With raised consciousness of environment protection, currently much importance is attached to the green growth in aquaculture. An ecological and healthful aquaculture is encouraged. Integrated aquaculture is a good case in point for ecological and healthful aquaculture. It can take various forms, involving integration of different species and integration of different systems (Dong, 2011). Integrated multitrophic aquaculture is a typical form of integration of different species, with by-products from one species recycled as inputs like feed or fertilizer to another species, bringing a balanced system where environment sustainability, economic stability and better management practice are all achieved. There are also vigorous patterns for integration of systems, promoting aquaculture efficiency and environment protection by successful nutrient and energy transfer among different systems, for example, shrimp–fish–shellfish–algae integration in group ponds with a water recirculating system, and mulberry–fish integration where fish, mulberry tree, and silkworm play as both of a donor and consumer in the system. China is a good practitioner for above-mentioned integrated aquaculture. An ecological approach to aquaculture highlights the harmonious integration of different species in the system(s) where energy use is most optimized, while a healthful approach to aquaculture is a further step forward by combining technological, engineering and management measures to attain aquaculture with high-productivity, environment-friendliness and quality-products. With contributions from science and technology, sustainability, environmental protection as well as enhancement and recovery of the aquatic ecosystem are all attainable, as are high quality aquatic products. To facilitate ecological and healthful aquaculture, much research has been done to assess how aquaculture affects bodies of water, how to control water quality, quality feed, disease, and how to get biodiversity maintenance.

However, in the history of aquaculture development, various lessons have been learnt. Culture-based aquaculture in lakes, gave rise to biodiversity risks owing to its dependence on the introduction of exotic species. Pond aquaculture brought about the environment degradation, disease outbreak, and space competition with other industries. Besides the problems encountered by pond aquaculture, cage, and pen aquaculture also suffered from such problems as escapees and feed of poor quality. To pursue higher profits, fish farmers were always ready to shift from aquaculture of low-trophic-level species (e.g., traditional aquaculture species like *Asian carps*) to high-trophic-level species which will rely on inputs of fish or other feed rather than ambient primary production, imposing burdens and dangers to the environment and ecosystem balance and health. More worse, to pursue high produc-

tivity, fish farmers used to prevent fish diseases by an extensive use of medication, which in turn caused environmental deterioration and finally did harm to aquaculture sustainability. Shrimp aquaculture corruption in 1993 is a case in point: the lack of aquaculture species variety, together with high density aquaculture pattern, contributed to the disease outbreak; extensive use of medication not only corrupted the shrimp aquaculture, but also polluted the environment. Chinese aquaculture suffers from the environmental deterioration, while it also contributes to the environmental deterioration. Luckily, with enhanced consciousness of environmental protection, green growth is now receiving more and more attention from both the government and the industry to sustain aquaculture and protect environment.

### 3.2. Chinese aquaculture policies

#### 3.2.1. Policy changes

The focus for Chinese aquaculture used to be on the expansion of farming areas and increasing output. Today the focus has shifted to environment protection, the structural adjustment of farmed species and the quality enhancement. There is a strong research emphasis on the culture of aquatic species with high quality, good nutritional and high economic value. In addition, scientific research has been directed at technological innovation to increase efficiency through intensification and integration. Great importance is also attached to environmental issues associated with aquaculture. In the light of the concept of green growth, Chinese aquaculture is striving its way to grow as well as green. Lessons have been learnt worldwide that aquaculture should not be developed at the cost of environment. Environment issues are attracting greater attention in China, and high priority is given to environmental concerns in the policy-making process. Meanwhile, much research has been done regarding how to conduct aquaculture in a more environment-friendly and green manner.

#### 3.2.2. Policies in the light of green growth

China is the country with a long history of aquaculture. As early as in 1950s the successful aquaculture practice was interpreted by Chinese experts into eight words: water, seedling, feed, density, integration, rotation (stocking & harvesting), prevention, and governance. Eight words are believed to attend to every detail in aquaculture, ranging from the field practice to government management. In 2003, “Regulations on Quality and Safety in Aquaculture” was released to regulate the use of water, medicine, and feed with a view to develop aquaculture in an environment-friendly and green-growth manner. In 2009 “Suggestions on Green Aquaculture and Enhancement of Quality and Safety” delivered by the government elaborates on enhancement of aquaculture license issuance, infrastructure construction, monitor system for quality and safety of aquatic products, supervision of aquaculture law enforcement, and construction of demonstration farms for green aquaculture. Policies mentioned above, coupled with other specific legal regulations, are put in place to green and grow Chinese aquaculture.

“Regulations on Quality and Safety in Aquaculture” released in 2003 gives a definition for green growth of aquaculture that it is to enhance the productivity and quality in an environment-friendly manner. Its theme matches the concept of “Green growth” by OECD (2013), which means fostering economic growth and development while ensuring that the natural assets continue to provide the resources and environmental services on which our well-being relies. It is agreed that investment and innovation are key to sustained growth and new economic opportunities (OECD, 2012) while addressing environmental externalities of production.

**Table 1**  
Chinese legal framework for the key fisheries laws and regulations.

General areas	Specific regulations
Basic legislation	The Fisheries Law (1986, amended in 2000 and 2004) Regulation for the implementation of the fisheries Law (1987)
Accessibility legislation	Aquaculture licenses (2002) The Land Administration Law (1986, amended in 1988, 1998 and 2004) The Water Law (1988, as amended in 2002) The sea area use management law (2002)
Environment influence assessment	The environmental protection law (1989) The law on the prevention and control of water pollution (1984) The marine environment protection law (1982) The environmental impact assessment law (2002)
Water and wastewater	The rules for implementation of the law on the prevention and control of water pollution (2000) The Regulations on the prevention of pollution damage to the marine environment by land-sourced pollutants (1990) The Regulations on the administration of environmental protection in the exploration and development of off-shore petroleum (1983) Regulations on the prevention of vessel-induced sea pollution (1983) Regulations on control over dumping of wastes in sea waters (1985) Regulations on the environment protection from shipbreaking (1988) Regulations on the prevention of the marine environmental pollution by coast construction projects (1990) Water quality standards for fisheries (1989)
Fish movement	The entry and exit of animal and plant quarantine law (1991) The law on the protection of wildlife (1988) The regulations for the protection of aquatic wildlife (1993)
Disease control	The law on animal diseases (1997)
Drugs	The regulations on the environmental management of first import of chemicals and the import and export of toxic chemicals (1994) The regulations on the management of pesticides (1997) The regulations on the control over the safety of dangerous chemicals (2002) The regulations for the administration of veterinary medicines (1988, amended in 2004)
Feed	The regulations for the administration of feed and feed additives (1999) The procedures for administration of registration of imported feed and feed additives (2000)
Food safety	The Food Hygiene Law (1995) The Standardization Law (1988) The regulations on the implementation of the standardization law (1990)
Aquaculture investment	The catalogue for the guidance of foreign investment industries and its appendix (2002)
Genetically modified organisms	The safety administration regulation on genetic engineering (1993) The safety administration implementation regulation on agricultural biological genetic engineering (1996)

As reported by [China Fisheries Yearbook 2013 \(2014\)](#), lately concrete measures have been taken to develop Chinese aquaculture in a green-growth manner.

Farm infrastructure construction is greatly enhanced with government financial back-ups. Confronted with the pressure of output enhancement and shrink of aquaculture farms, intensive and integrated aquaculture are trends for Chinese aquaculture, and the facilities of traditional farms have to be improved to uphold them. For example, the water recirculating system was updated to enhance the farming conditions and facilitate the aquaculture renovation on many traditional culture farms in China.

Demonstration farms are set up, where standard production procedure is encouraged, various data are efficiently recorded, quality control system is facilitated, label system is adopted, certification of green products is encouraged. The theme for demonstration farms is being “ecological, healthful, circulatory, and intensive”. Data from Ministry of Agriculture indicate that there have been more than 6000 demonstration farms set up since 2006. Those demonstration farms are targeted for different purposes, for example, for species-specific aquaculture, water-body-specific aquaculture (e.g., pond, reservoir, intertidal zone, etc), mode-specific aquaculture (e.g., cage, net-pen), integrated aquaculture (e.g., fish-turtle, fish-rice field integration, etc) and so on. Management measures are followed-up at demonstration farms and standardized to be feasible for “duplication” ([Rong et al., 2013](#)). Technological back-ups are provided to ensure that aquaculture is conducted in the ecological and healthful manner. Supervision is also conducted over the use of medication, feed quality, water control, etc. Profiles are recorded for different production stages, medication, feed, product labels, etc.

Service back-ups for aquaculture farming are also enhanced. Quality seedlings, formula feed, and aquatic vaccine play a very important role in aquaculture, and they are provided by govern-

mental agencies or extensions. Extension of science and technology to the field provides a back-up as well. It is acknowledged that investment in science and technology in aquaculture will pay off sooner or later.

Cooperatives are set up to provide a platform where those concerned in the different chains in aquaculture or those involving in the same aquaculture can exchange information. Cooperatives will promote the self-service, production standardization, food quality, brand construction, etc. Besides, self-discipline is also encouraged in the cooperatives. Different aquaculture cooperatives are set up throughout the country in the light of “Law of the People’s Republic of China on the Specialized Cooperative of Farmers” which was enforced in 2007.

Enhancement of law enforcement and supervision plays an important role in facilitating a responsible aquaculture industry. Aquaculture farm planning and aquaculture license issuance guarantee an organized industry, which fits well into the country’s development blue print and does not need to develop at the cost of environment. Fisheries sectors at different levels as well as in different domains coordinate well with each other for a more efficient technological extension, quality control and monitor, environment monitor, etc.

### 3.3. Legal framework for Chinese aquaculture

In China, legal frameworks for aquaculture and capture industries are, to some degree, integrated. A close examination into the fisheries legal framework will reveal China’s efforts in “greening” aquaculture.

The fisheries industry in China is largely regulated by the Fisheries Law which entered into force in 1986, and which was updated in 2000 and 2004. This law provides the legal framework for the aquaculture and capture industries, and for enhancement and con-

servation of fisheries resources. In addition, other specific laws, rules, regulations, international treaties, and administrative acts have been put in place to regulate Chinese fisheries. This framework attaches great importance to the green growth of Chinese aquaculture by regulating various practices in aquaculture and highlighting such issues as licensing, environment protection, products quality, etc. A comprehensive legal system and effective enforcement is seen as the back-up for sustainable aquaculture development in the light of green growth. A Chinese legal framework for the aquaculture laws and regulations is listed in Table 1. However, the aquaculture laws and regulations enacted by local authorities and tailored for local features are not incorporated into this framework although they are also playing a key role in local aquaculture management.

#### 3.4. Institutional framework for Chinese fisheries

Chinese fisheries industry operates in a hierarchical jurisdictional context involving the participation of fisheries administration departments at national, provincial, autonomous regional, and municipal levels. In provinces and autonomous regions, counties and cities also play a role.

The Bureau of Fisheries, under the guidance of the Ministry of Agriculture, is the most authoritative fisheries administrator who has a decisive role in making national fisheries development strategies and formulating policies to facilitate development. Fisheries administrative bodies in the local regions are responsible for monitoring and enforcing the national fisheries regulations as well as establishing local regulations to address regionalized problems. The Fisheries Law Enforcement Command of China, whose mission is to coordinate fisheries law enforcement, falls under the leadership of the Bureau. Responsibilities for regional fisheries law enforcement go to regional fisheries management bureaus. By the end of 2013, there had been 2949 fisheries law enforcement agencies with 35,139 enforcement staff throughout the country. An organized fisheries institutional network consisting of different fisheries agencies at different levels throughout the country is attained for a better fisheries governance. Besides government administrative bodies, other important organizations and institutes are also playing a role in fisheries management enhancement. Some act as extensions of government agencies, providing various services to the aquaculture farmers, like the Chinese Academy of Fishery Science, the National Centre for Fisheries Technology Extension, the

China Fisheries Society, etc. Some are non-governmental organizations, acting as the coordinator between farmers and government agencies, enhancing self-education and self-discipline within the farmers for a responsible aquaculture industry. The institutional framework for Chinese fisheries is comprehensive and diversified, providing an organized administrative body for aquaculture development.

#### 4. Outlook

In 2011, Chinese Ministry of Agriculture released the 12th Five-year (2011–2015) Plan for fisheries development. Aquaculture development with priorities given both to environment-friendliness and high productivity is highlighted in the Plan. To enhance green growth and to make sure that aquaculture is not developing at the cost of environment, the Plan gives a framework for the concrete measures. Measures can be summarized as the extension of science and technology, innovations in applying ecological and healthful aquaculture, visionary policies made by the government, legislated aquaculture industry, and aquaculture farmers' raised consciousness of green-growth aquaculture. It is noted in the Plan that aquaculture will still act as the major contributor for aquatic products supply in China. To sustain in a green growth manner will be the only key to a responsible and prosperous Chinese aquaculture in the future.

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