Research on Development Status, Issues and Policy for Ecological Fishery of Large-scale Waters in China

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Abstract. China is rich in fishery resources of large-scale water such as lakes, reservoirs, and river ditch, and large-scale fisheries play an important role in freshwater fisheries. Its area and output account for 46% and 15.42% of the national freshwater fisheries respectively. Both theory and practice show that large-scale fisheries have obviously multiple ecological, economic and social functions. In China, large-scale fisheries can be divided into five types that are industry convergence development, water ranch, environmental cage, reservoir water quality protection, repair ecology in lake. However, in recent years, the back-out of “seine, block, cage” with environmental storm has caused serious negative impacts. Compared with 2016, in 2018, the area of all kinds of large-scale ecological fisheries in the country has decreased by 11%-34%, and it faces social cognition bias, partial or individual short-term economic behavior, insufficient integration and other issues. Focusing on problems and combining the development goals of the new era of fisheries, drawing on typical successful experiences, four countermeasures including adhering to ecological priorities, increasing publicity, innovating institutional mechanisms, optimizing support policies, and building internal motivation are proposed to promote sustainable development of large-scale ecological fisheries.

1. Introduction

The concept of large-scale fisheries was first put forward in 1979 [1]. In its broad sense, it refers to the development of culture and proliferation with inland lakes, reservoirs and river ditches. In a narrow sense, it refers to, on this basis, limiting the waters to 5000 mu and above [2]. Accordingly, the concept and connotation of ecological fishery of large-scale waters can be summarized as the culture and proliferation fishery in rivers and lakes (5000 mu and above) with “ecology” as the key feature based on the eco-environment protection. It is measured by whether there are “seine, block & cage” or whether to feed fry, but by whether the fisheries promote the water improvement even without negative impacts. That is to say, it shall be measured by the internal standard of “ecological environment” instead of the external standard of and “whether to feed fry and whether there are ‘seine, block & cage’”. Because it shows from theory and practice that, “creating invaluable assets with lucid waters and lush mountains” can be realized even in ecological “cage-culture” fishery of large-scale waters by means of evaluation on culture capacity, scientific input, reasonable operation and control, ecological technology, three-dimensional polyculture and so on. Although, General Secretary Xi Jinping pointed out in September 2018 in the research meeting on large-scale fisheries that, the
“ecological protection and eco-tourism development have brought out the best in each other” in Chagan Lake in Jilin Province, there have been many practical issues in the development of regional ecological fishery of large-scale waters, such as the environmental protection storm, the “one-size-fits-all” approach, and short-term economic behavior in some individual regions or entities. In this paper, firstly, the significance, resource base, scale and typical model of developing ecological fishery of large-scale waters are analyzed; secondly, combined with the actual case study, the issues and causes of ecological fishery of large-scale waters are analyzed; finally, based on the typical experiences, the policy suggestions for promoting developing the ecological fishery of large-scale waters are put forward, so as to provide reference for decision-making.

2. Development Status of Ecological Fishery of Large-scale Waters

2.1. The Obvious Versatility of Ecological Fishery of Large-scale Waters

2.1.1. Ecological effect. Fish is a significant component of aquatic organisms and ecological environment of waters. “Fish glide in the limpid deep” is an important symbol of useful resources and beautiful waters. Both theory and practice have proved that herbivorous or filtering-feeding fish, algae and shellfish have the functions of water purification, algae inhibition and carbon sequestration [3]. It was found from comparative experiments that, about per kilogram of filtering-feeding fresh fish could consume 25g nitrogen and 2 g phosphorus, thus eutrophication could be effectively inhibited [4]. “Ecology” is the prominent feature of ecological fishery of large-scale waters. Restoration of ecological environment in waters and resource protection could be effectively promoted through scientific and reasonable regulation [5], which is also an efficient path to meet the residents’ demand for beautiful waters and recreation lifestyle in the new era.

2.1.2. Economic effect. Large-scale fisheries are an important part of fisheries and agriculture. Most of Fishery resources of large-scale water are distributed in poverty areas [6]. In the overall context of revitalizing the countryside and building a moderately prosperous society in all respects, developing the ecological fishery of large-scale waters is a crucial means to practice the “Two Mountains” Theory in the regions, which is also an effective means to reasonably protect the advantages of “Green Hills and Clear Waters” in the region and transform them into “Mountains of Gold and Silver” to drive the sustainable development of industry, increase the income of farmers, and boost poverty alleviation and targeted poverty alleviation. The last is social effect. As an industry integrating ecology and economy, ecological fishery of large-scale waters has created a considerable number of jobs, such as local patrol guards, operations operation and scientific fishermen, and absorbed the labor force in the region for employment [7]. Also, with better quality products, ecological fishery of large-scale waters is an important supply source of high-quality proteins.

2.2. Resource Endowment of Ecological Fishery of Large-scale Waters

Reservoirs and lakes are the main parts of large-scale fisheries in China in terms of water area and output volume. However, their water ditches are relatively small. Large-scale fisheries in China are rich in resources, which are widely distributed and relatively concentrated in the central and eastern plains, the Northeast Plain and Qinghai-Tibet Plateau areas (see Table 1). At present, there are about 1500 large-scale natural waters with an area of 5000 mu and above that are suitable for fishing in China, including 1047 reservoirs and 421 lakes, which accounts for 9.32% of the current total freshwater aquaculture area in China.
Table 1. Major resources of large-scale waters in China.

| Type                        | Famous large-scale waters                                                                                   |
|-----------------------------|-------------------------------------------------------------------------------------------------------------|
| Freshwater lakes            | Xingkai Lake, Chagan Lake, Poyang Lake, Dongting Lake, Taihu Lake, Hulun Lake, Hongze Lake, Nansi Lake, Bosten Lake, Chaohu Lake, Gaoyou Lake, Eling Lake, Zaling Lake, Sayram Lake, Baiyangdian Lake, Honghu Lake, Longgan Lake, Liangzi Lake, Dianchi Lake, Wuliangshuai Lake, Luoma Lake, Erhai Lake, Junshan lake, Fuxian Lake, Shiji Lake, Wabu Lake, Nanyi Lake, Dongping Lake, Gehu Lake, Yangcheng Lake, Chenghai Lake, Dianshan Lake, Yangzonghai Lake, Xingyun Lake, Qilu Lake, Yilong Lake, Dongqian Lake, Changbaishan Tiantchi Lake, Cibi Lake, Jianhu Lake, Tangjiashan Barrier Lake, Xiaonan Lake and Xinxu Lake |
| Saline lakes                | Qinghai Lake, Nam-co, SilingCo, Zhari Namco, Tangra Yumco, Yamzho Yumco Lake, Bangong Co, Hala Lake, Lake Ayakum, Ebinur Lake, Daihai Lake and Yuncheng Salt Lake |
| National key scenic spots   | Jingpo Lake, Wudalianchi Lake, Taihu Lake, West Lake of Hangzhou, Donghu Lake of Wuhan, Heavenly Lake of Tianshan, Songhua Lake, Jingyuetan, Slender West Lake, Dongting Lake, Red Maple Lake, Dianchi Lake, Jinhu Lake, Crescent Spring, Qinghai Lake, Chaohu Lake, Fairy Lake, Huizhou West Lake, Qionghai Lake, Lushui Reservoir, Bosten Lake, Feiyun Lake, Huguangyan, Bailong Lake, Sayram Lake, Huating Lake, Zhelin Lake, Lugu Lake and Dongjiang Lake |
| List of Wetlands of International Importance | East Dongting Lake, Poyang Lake, Dalai Lake, South Dongting Lake, West Dongting Lake, Xingkai Lake, Bitahai Lake, Napahai Lake, Lashihai Lake, Eling Lake, Zaling Lake and Lake Manasarovar |
| National nature reserves   | Chagan Lake, Hengshui Lake, Xingkai Lake, Wudalianchi Lake, Shengjin Lake, Poyang Lake, East Dongting Lake, Erhai Lake, SilingCo, Dunhuang West Lake, Gahai Lake of Gansu Province, Qinghai Lake, Caohai Lake, Dalinor Lake, Kanas Lake, Hongze Lake and Haba Lake |
| Famous large-scale reservoirs | Three Gorges Reservoir, Danjiangkou Reservoir, Longtan Reservoir, Longyangxia Reservoir, Dongjiang Reservoir, Nierji Reservoir, Zhelin Reservoir, Baishan Reservoir, Liujiaxia Reservoir, Ertan Reservoir, Baise Reservoir, Pubugou Reservoir, Shuibuya Reservoir, Miyun Reservoir, Wuqi Reservoir, Panjiakou Reservoir, Chencun Reservoir, Xianghongdian Reservoir, Shuiqiu Reservoir, Wujiangdu Reservoir, Ankang Reservoir, Hongsan Reservoir, Hualiatiing Reservoir, Meishan Reservoir, Mianhuatan Reservoir, Dahuofang Reservoir, Guanying Reservoir, Hunanzhe Reservoir, Zhangle Reservoir, Fengshubu Reservoir, Jiemen Reservoir, Erlongshan Reservoir, Jiangya Reservoir, Lijiaxia Reservoir, Nanwan Reservoir, Fushui Reservoir, Gangnan Reservoir, Yuqiao Reservoir, Zaoji Reservoir, Wangkuaui Reservoir, Xiashan Reservoir, Chaershan Reservoir, Luhun Reservoir, Bailianhe Reservoir, Nanshai Reservoir, Yakeke Reservoir, Huangbizhuang Reservoir, Guxian Reservoir, Huanglongtan Reservoir, Chengbihe Reservoir, Hedi Reservoir, Gaozhou Reservoir, Yuecheng Reservoir, Xidayang Reservoir, Suyahu Reservoir and Shizitan Reservoir |

Note: Due to the typical multi-attribute of individual waters, considering its special status, it will be repeated in the list.

2.3. Scale of Ecological Fishery of Large-scale Waters

Large-scale fishery is one of the production modes of major fish and fishery product in China. Since the reform and opening up, the state has encouraged the development of culture and proliferation fisheries by developing and utilizing all sorts of beaches, reservoirs, river ditches, lakes and waste ditches, so as to increase the supply of fish and fishery products and solve the shortage economy issue. On the whole, the area and output of large-scale fisheries in China are on the increase (see Table 2). The area and output of large-scale fisheries accounted for 74.23% and 35.69% of the total freshwater aquaculture area and output in China respectively in 1978, which were 46% and 15.42% respectively in 2018. In recent years, due to the impact of environmental protection supervision and the back-out of
inland “seine, block & cage”, the aquaculture area and output of large-scale fisheries in China, such as lakes, reservoirs and river ditches, have declined in different degree. The data of China Fisheries Yearbook shows that, in 2018, the culture and enhancement areas of lakes, reservoirs and river ditches in China were 746200 hectares, 1441700 hectares and 179400 hectares respectively, and the corresponding output of fish and fishery products was 978000 tons, 2949200 tons and 637900 tons, decreased by 11% - 34% compared with 2016 (Figure 1).

Table 2. Area and output of large-scale fisheries (lakes, reservoirs and river ditches).

| Year | Area/hectare | Output/ton |
|------|--------------|------------|
|      | Lakes        | Reservoirs | River ditches | Other |
| 1978 | 531100       | 1208427    | 244927        | 477007 |
| 1988 | 636593       | 1441513    | 337640        | 2321567 |
| 1998 | 881081       | 1596400    | 377111        | 2226033 |
| 2008 | 961335       | 1549612    | 202183        | 2257893 |
| 2016 | 914714       | 1644140    | 220014        | 2568572 |
| 2017 | 886492       | 1516407    | 213735        | 2748324 |
| 2018 | 746155       | 1441670    | 179414        | 2779216 |

Ratio of increase and decrease in 2018 compared with 2016 /%:
-18.43 -12.31 -18.45 8.20 -33.81 -11.42 -20.93 8.06

Note: the data are from China Fisheries Yearbook (the corresponding years).

2.4. Typical Development Model
In the early years of the new nation, large-scale fisheries mostly adopted the way of centralized operation in collective fishing grounds, which made enormous contribution to the increase of supply of fish and fishery products in the shortage stage. Since the family-contract responsibility system of fisheries, the large-scale fishery has been reformed and an effective distribution mechanism has been
established, forming a diversified operating entity and a rich operation model. According to the actual research conducted by Liu Qigen et al. [8] and Li Wanbao [6], the current operation model of large-scale fisheries in China can be roughly divided into the types of integration development of three industries, water-area pasture, environmentally friendly cage, protection of water quality of reservoir and ecological restoration of lakes. Table 3 shows the typical cases of each model. Considering that for the purpose of environmental protection, the types of protection of water quality and ecological restoration place emphasis on aquatic ecology and resource protection and restoration means, this paper focuses on the case analysis of the types of integration development of three industries, water-area pasture and environmentally friendly cage, so as to find out and solve the issues that the ecological fishery of large-scale waters faces during the development.

| Model | Typical case  | Basic situation | Experience and practice | Result |
|-------|---------------|----------------|-------------------------|--------|
| Integration development of primary, secondary and tertiary industries | Chagan Lake | Located in the northwest of Jilin Province, it covers a water area of 675000 mu, which can reach 450000 mu. It has an annual output of 6000 tons of fresh fish, with bighead carp as its main product, grass carp, crucian carp, Elopichthys bambusa, Anabarilius macrolepis and Protosalanx hyalocranius as the supplement. | a. The property right belongs to the county-level government, the operation right belongs to the local fishery supervision and administration department, and three fishing grounds are under operation; b. Implement green organic certification; c. Adhere to the principle of “fish culturing with waters and water conserving with fish”, ecological and healthy breeding, and fry feeding in proportion; d. Close the lakes for water source conservation and catch fish and fishery products in rotation; e. Insist on intensive processing, and combine online services and offline services for the expansion of brands; f. Excavate the historical folk culture and festival activities, to build a characteristic ecological and cultural tourism zone. | Ecological protection and eco-tourism development bring out the best in each other; depth integration shall be made among proliferation, fishing, processing and tourism; receive 1.5 million tourists annually, and the comprehensive tourism income is nearly 1 billion yuan; the per capita net income of fishery staff achieves 30000 yuan/year through the development of regional economy; the fishery brand of Chagan Lake is well-known throughout the country. |
| Water-area pasture | Three Georges fisheries | Located in the Three Gorges Reservoir area, it covers a water area of 700000 mu, with an annual output of 600 tons of fresh fish, with silver carp and bighead carp as its main products. | a. Obtain the operation right through the one-time contract from the county-level government and adopt the centralized and unified operation by state-owned companies; b. The company purchase the right to fish in waters at one time with 50000 yuan/household, so as to properly solve the resettlement issue for “fishermen losing their right to fish in waters”; c. The output of each mu of waters shall be not more than 15 kilograms of fresh fish, and the products are popular in the market, and the price is three times of the similar products; dual-transform of the fishermen has been realized effectively; the water quality and aquatic organisms have been improved; more than 300 local jobs have been created; good relations have been maintained with surrounding communities. | |
Environmentally friendly cage  
Xinjiang Tianyun  
Located in Yili of Xinjiang, it has 70000 m² green ecological culture cage, which can breed 800000 rainbow trout fries annually, with an adult fish production capacity of 6000 tons, and 2600 m² automatic adult fish slaughtering, preservation and freezing processing workshop.

Protection of water quality of reservoir  
Miyun Reservoir, Shanxi Reservoir & Guanting Reservoir  
The drinking water source, nature reserves or water quality, etc. need to be improved. Scientifically input proper filtering-feeding and herbivorous fishes; no baiting, no dosing and no fertilizer input shall be allowed; absorb and discharge the excess nitrogen and phosphorus, and purify water with fish. The contents of nitrogen and phosphorus in water body have been decreased, while the plankton has been increased, eutrophication has been effectively controlled, and water quality level has been further improved.

Ecological restoration of lakes  
Taihu Lake, Dianchi Lake, Baiyangdian Lake and West Lake of Hangzhou  
There are issues of water quality deterioration and eutrophication in nature reserves, urban areas or other areas. Make reasonable assessment; no baiting, no dosing and no fertilizer input shall be allowed; input silver carp, bighead carp and indigenous fishes to inhibit algae and recover resources. Blue-green algae and algal bloom have been effectively controlled, and aquatic biological resources have been restored and enriched.

3. Issues in the Development of Ecological Fishery of Large-scale Waters
With significant ecological, economic and social effects, ecological fishery of large-scale waters is not only an important driver for high-quality development of fishery, but also an effective means for the
supply side structure of fishery, which is conducive to resolving the main contradiction between the inadequate development of fishery and the residents' demand for beautiful waters and high-quality fish and fishery products in the new era. However, at present, the development of ecological fishery of large-scale waters in China is facing internal and external issues. The external issues include environmental protection storm, cognitive bias, etc., while the internal issues embody a concentrated reflection of the short-term economic behavior in some individual regions or operating entities, and insufficient depth of industry integration.

3.1. Extrusion of Environmental Protection Storm on the Development Space of Large-scale Waters
The environmental protection supervision, as the supervision and inspection and negative incentive mechanism of green development, guarantees that the government and operating entities correct their deviant behaviors and adhere to the principle of ecological priority. However, serious unscientific and practical issues occur in the implementation of supervision. As far as large-scale fisheries are concerned, they are mainly embodied in “one-size-fits-all” approach, back-out of “seine, block & cage” and the application of “fish escaping prevention” and “sewage interception” facilities, but not taking the improvement of water quality and aquatic organisms before and after production activities as the criterion. All of these are lack of reasonable evaluation and scientific basis, which violate the versatility of ecological fishery of large-scale waters and have directly caused at least two secondary environmental issues.

3.1.1. The operation scale of large-scale waters has been directly reduced. Affected by the environmental production supervision by “one-size-fits-all” approach, some large-scale fisheries with obvious ecological, economic and social effects have been demolished. In 2018, the surface and production of large-scale fisheries in China (reservoirs, lakes and river ditches) decreased by 9.53% and 14.23% respectively. The measures of back-out of seines and nets have been implemented in Jiangsu, Jiangxi, Guangxi, Hainan, Guangdong, Fujian, Hubei and other provinces. The area of large-scale fisheries in Hunan Province, an important province of large-scale fisheries in China, has decreased by more than 60%. It was found from the business research of the operating entities such as Hunan Dahu Aquaculture and Chongqing Three Gorges Fishery that, the environmental protection storm has directly reduced the water area in varying degrees. Two water areas of the Three Gorges Fishery, with a total area of 11000 mu, were forced to withdraw, which accounted for 15% of the total water area of the company, directly reducing its industrial scale.

3.1.2. The normal production and operation of operating entity of large-scale waters have been affected. Cumbersome environmental protection supervision has led to the operating entities of ecological fishery of large-scale waters to invest more human, financial and material resources to deal with it, and dispersed the development of normal business. The environmental protection storm did not cause water surface area reduction and other substantive issues for Xinjiang Tianyun Company, which largely accounted for the company's real-time monitoring and sharing of water quality, as well as complete relevant materials. However, in a period of time, it has greatly dispersed the power of the company, disturbed the route of “listing” of the company, and increased the operating cost of the operating entities of ecological fishery of large-scale waters.

3.2. Cognitive Bias from the Public Against the Ecological Fishery of Large-scale Waters
The public, even the environmental protection department and researchers, hold serious wrong bias against fisheries and “cage, seine & block”. They believe that, as long as there are “cage, seine & block” and baiting, even quantitative fry feeding and “no baiting, no dosing and no fertilizer input”, the water body will be polluted. However, such cognitive bias completely ignores the better ecological and economic efficiency based on scientific assessment, rational fry feeding, ecological regulation, technological innovation and other ecological priority factors.
3.2.1. Bias against the ecological function of fisheries. Chagan Lake, Three Gorges Fisheries and other operating entities have achieved the effects of integration development of three industries, driving regional economic development, increasing fishermen's income, and effective ecological protection through the selection of fish species (silver carp and bighead carp) according to local conditions, scientific assessment of capacity, and control of fish fry input and output (with an annual output of 5-15 kg/mu of fresh fish), and the implementation of “no baiting, no fertilizer input and no fry feeding” measure, ecological and healthy breeding method, “catching in rotation” and reasonable polyculture (appropriate amount of crucian carp, grass carp, etc.).

3.2.2. Bias against “seine, block & cage”. Due to the lack of social cognition of the development of ecological fishery of large-scale waters, the atmosphere needs to be greatly improved, and the propaganda dynamics and cognition need to be expanded. However, these are still heavy tasks for ecological fishery of large-scale waters. The practice of ecological fishery of large-scale waters of Xinjiang Tianyun’s ecological cage has proved that, even if the cage type and fry feeding modes are adopted, the coordinated development of ecology and economy can be achieved through systematic thinking and measures and significant external effects can be achieved (e.g. targeted poverty alleviation of more than 600 households and creating more than 300 jobs, etc.). In addition, according to the practices of Liujiaxia Reservoir in Gansu Province, Longyangxia Reservoir in Qinghai Province, the Thousand-island Lake in Zhejiang Province, Hunan Dahu Aquaculture, Bailong Lake in Sichuan Province and Liangzi Lake in Hubei Province, rather than bringing burden to the environment, the ecological “seine, block & cage” can realize multiple effects. However, all of these are affected by the “one-size-fits-all” approach of environmental protection supervision in different degree.

3.3. Individual Behavior due to Partial Pursuit of Short-term Economic Efficiency
Many ecological fishery areas of large-scale waters and operating entities have realized the coordinated and sustainable development of ecology and economy by means of scientific assessment, reasonable input, real-time monitoring and regulation, etc. Needless to say, there are some short-term behaviors of neglecting ecology occurred in the ecological fishery of large-scale waters due to the simple pursuit of output, which has caused a serious negative impact on the development of large-scale waters ecological fishery.

3.1.1. The ecological environment burden of local waters has been increased, eutrophication has been caused, and the basic resources for the development of ecological fishery of large-scale waters have been directly reduced. For example, high-density purse seine aquaculture, high-intensity baiting, fertilizer input, dosing and insufficient regulation are one of the important reasons for the blue-green algae outbreak in Taihu Lake region, which has aroused widespread concern of the society. In 2018, 45000 mu of water purse seine were basically dismantled in Suzhou Taihu Lake Administrative Region, which was completely removed in June 2019 [9].

3.1.2. The dissatisfaction of local government, non-governmental organizations, communities, residents and other stakeholders has been caused, and the bias of the public against large-scale fisheries has been increased. Because of the negative typicality of the development of ecological fishery of large-scale waters, the negative impact of “point to area” has been formed. This has seriously reduced the public's overall trust in the ecological fishery of large-scale waters, and damaged its good development atmosphere. For example, after the adoption of state-owned fishing ground (before 1999) in Datong Lake, Hunan Province (124000 mu water area), the division contract (2000-2008) and private joint-stock (2009-2018) systems were implemented. However, due to the lack of supervision and the limitation of individual rationality, the operating entities put in a large number of bait and fertilizer, collected and caught aquatic animals such as benthic shellfish, and implemented predatory operation (intensive and semi-intensive culture in 2011).
Therefore, the fisheries in Datong Lake region showed unlimited expansion of investment and production capacity as a whole. As a result, its aquatic resources have been gradually dried up, biodiversity has been seriously weakened and water quality has been rapidly deteriorated. By 2015, the water quality of Datong Lake has dropped to Class V, with total phosphorus exceeding 0.4 times and total nitrogen exceeding 4.28 times. The reason for that is that, under the non-effective external constraints (illegal supervision and punishment), the contractors made short-sighted behavior of neglecting the ecological carrying capacity due to their pursuit of individual economic efficiency. Its basic logic can be interpreted as “the individual rationality but not the collective irrationality” or the “tragedy of the commons”. In recent years, the ecological and environmental issues of Datong Lake have been listed in the key supervision cases by the central environmental protection inspectors. In 2018, the local government took back the right to contracted management of Datong Lake and banned all fishery production activities for centralized pollution control and ecological restoration, so as to solve the issue of ecological environment deterioration. Therefore, regardless of whether from the perspective of ecological environment or social atmosphere, the short-term economic behavior of individual operating entities or local areas of ecological fishery of large-scale waters is not feasible and sustainable.

3.4. Low Degree of Industry Integration
The industry integration of ecological fishery of large-scale waters includes high cost of production and marketing integration and simple industry integration.

3.4.1. High cost of production and marketing integration. Relative to ordinary fish and fishery products, ecological fishery product of large-scale waters is of higher quality, its main products are green or organic foods, and the production cost is higher. Due to the general issue of spatial mismatch of place of production and market, and the existing fish and fishery products’ preservation, processing, cold chain and logistic and transport technology for fresh and living goods to be improved [10], the transportation cost of fish and fishery products is relatively high at present. This has obviously limited the profitability of operating entities of large-scale fisheries. After market research, it was found that, for example, for rainbow trout, silver carp, bighead carp and sturgeon in Shanghai and other coastal cities as the main markets, the circulation cost to transport them from Xinjiang to sales market (mainly including fuel consumption, expenses of labor, ice or water charge, oxygen cost and loss) accounts for about 50% of the total. This has seriously reduced the profit margin of operating entities of ecological fishery of large-scale waters. In addition, due to the non-closed loop characteristics of purchasing and marketing of fish and fishery products, the current reform of “fee and tax reduction” (mainly the “change of sales tax into VAT”) has resulted in the increase of tax by about 4 percentage points, rather than reducing the tax burden of fish and fishery products establishments.

3.4.2. Insufficient and single industry integration. A nationwide market research shows that, in addition to Chagan Lake in Jilin Province and Thousand-island Lake in Zhejiang Province that have formed the integration of primary, secondary and tertiary industries in ecological fishery of large-scale waters with good effect, over 90% of operating entities of ecological fishery of large-scale waters focus on the primary industry (culture and proliferation). Even if individual enterprises are engaged in processing, circulation and other businesses, most of them are only a simple extension of the industry chain (e.g. the ecological culture of rainbow trout and later division, freezing, branding, sales, food experience shop of Xinjiang Tianyun). They are engaged less in business of high value-added catering, experience, recreation, sightseeing, recreation and cultural mining, etc. Compared with the vigorous development of tourism and even recreational fisheries in China, the integration of three industries of large water ecological fishery develops slowly and lacks of deep integration. The data show that, from 2008 to 2018, the average annual growth of tourism and recreational fisheries in China reached 22% and 19% respectively. However, since the establishment of large-scale fisheries in the 1980s, there has been less typical integration of three industries of recreational fisheries. According to the market
research, it is estimated that the average annual growth will be about 10% in recent 10 years.

4. Policy Suggestions
Ecological fishery of large-scale waters has obviously positive externality. Also, its development is facing internal and external issues. In the new era, the multi-functional effect of ecological fishery of large-scale waters shall be brought into full play, and the concept of “creating invaluable assets with lucid waters and lush mountains” shall be put into practice. These are of great significance in boosting the high-quality development of fisheries, industrial and targeted poverty alleviation, the rural revitalization strategy, etc. In view of the issues that the ecological fishery of large-scale waters is facing during its development, four policy suggestions have been put forward based on the experience of typical cases.

4.1. Adherence to the Principle of Ecological Priority and Reducing the Negative Impact of Environmental Protection storm
Stakeholders of ecological fishery of large-scale waters, especially the competent departments and operating entities, shall adhere to the principle of ecological priority, promote the ecological fishery of large-scale waters to follow the green and healthy development direction in improving its ability to withstand the environmental protection storm.

4.1.1. the development area of ecological fishery of large-scale waters shall be scientifically and reasonably demarcated with multiple departments. Combined with the regional spatial and territorial planning and the development of large-scale fishery, the responsibility cooperation among fisheries, environmental protection, resources and other departments shall be promoted, the types and capacity of large-scale culture and proliferation shall be scientifically evaluated, the measures and classification shall be made according to local conditions, focus shall be put on the ecological connotation, instead of focus on whether they are located in the nature reserves, marine sanctuary or whether they are they are blocked or viewing them as the core standards for environmental protection supervision and disposal, and the arbitrariness of neglecting “water purification with fisheries, algae inhibition and carbon sequestration” shall be reduced.

4.1.2. Operating entities shall strictly follow the standards and norms for ecological fisheries. In the process of fry culture, they shall select varieties according to local conditions, and more aquatic varieties such as filtering-feeding and herbivorous fishes and shellfish shall be selected. In the process of culture and proliferation, they shall scientifically evaluate the increasing culture and enhancement capacity, strictly control the fry feeding quality, give priority to the mode of “ecological and healthy breeding” method, and strictly prohibit excessive fry feeding, feedstuff feeding and use of illegal drugs. In the process of fishing, they shall take the ways of catching and stocking in rotation, catching big fishes and releasing small ones and protecting the aquatic wild animals, so as to realize the sustainable utilization of fishery resources of large-scale water. In the process of processing and marketing, they shall actively comprehensively utilize the by-products of fish and fishery production, and lay emphasis on creating and obtaining “ecological” premium. In addition, operating entities shall pay attention to ecological protection and pollution control, improve the precise and intelligent management level, install water quality monitoring equipment, and enhance data sharing, analysis and application with fishery, environmental protection, water resource, wetland and other relevant departments.

4.1.3. Operating entities shall strengthen its technological support role in ecological fishery of large-scale waters. They shall increase the research on green, ecological key and basic technologies, including the evaluation method of ecological carrying capacity, ecological protection technology of waters, key pollution control technology, intelligent and precise management and control system, processing, logistics cost reduction technology, etc., so as to provide major impetus and guarantee for the development of large-scale fisheries.
4.2. Strengthening the Propaganda Dynamics and Enhancing the Public’s Cognition of Science

4.2.1. Operating entities shall strengthen the scientific propaganda of ecological fishery of large-scale waters. They shall strengthen the basic research and scientific propaganda of ecological fishery of large-scale waters, including basic concept and connotation, production mode and effect, standard and application, summary and promotion of experience, etc. They shall focus on clarifying the following basic concepts to the society; in addition to the limitation of physical area, the core meaning of ecological fishery of large-scale waters is “ecology”. Regardless of using the mode of “cage, seine & block” and fry feeding, or the mode of natural waters and ecological and healthy breeding, as long as the water quality and ecological environment have been improved or not deteriorated in a considerable time, it shall be categorized as ecological fishery. That is to say, it shall be measured by the internal standard of “ecology” instead of the external standard of “whether there are ‘seine, block & cage’” and “whether to feed fry”; expand the propaganda and cognition of scientific concept and connotation, so as to reduce the “bias” of some groups against ecological fishery of large-scale waters.

4.2.2. Operating entities shall summarize and publicize the influential typical cases with ecological effect. They shall summarize the experiences and practices of Chagan Lake, Thousand-island Lake and Xinjiang Tianyun, etc. in establishing economic and ecological models, and deeply analyze the economic, ecological and social effects of ecological fishery of large-scale waters based on the data of successful cases; make full use of modern propaganda media to strengthen the propaganda dynamics of popularization of science of ecological fishery of large-scale waters, and expand and enhance the objective cognition of public and even the environmental protection departments toward the fishery of large-scale waters and reduce and avoid the rough and simple practices of back-out of “seine, block & cage” and “sewage interception and fish escaping prevention facilities” and the application of “one-size-fits-all” approach in the name of environmental protection.

4.3. Innovating Systems and Mechanisms to Promote the Collective Action of Maintaining the Development of Ecological Fishery of Large-scale Waters

Ecology is the key of ecological fishery of large-scale waters. To realize the interests of ecological fishery of large-scale waters (Operating Group), a common action to maintain the “ecological” reputation of large-scale fisheries need to be reached. According to Olson's classification, it is a compatible interest group, and the key for it is to build a “cake making” system and mechanism, which can be started from the differentiated incentive mechanism and the number of groups.

4.3.1. Selective incentives shall be given to the production activities conducted by the operating entities of ecological fishery of large-scale waters. Supervision and inspection shall be strengthened on the waters and products of ecological fishery of large-scale waters, a comprehensive index system shall be built, a regular evaluation and appraisal mechanism shall be implemented, and selective incentives shall be given to different types of production activities. On the one hand, positive incentives shall be given to the entities that conduct production activities strictly according to the ecological fishery standard by means of giving reasonable rewards and subsidies, that is, to reward the “cake making” entities to attract and promote the increase of number of such entities. On the other hand, negative incentives shall be given to the entities who break the rules by means of giving appropriate punishment, such as circulating a notice of criticism, imposing a fine and investigating and affixing their legal liabilities, etc., that is, to reduce behavior which is impacting negatively by increasing the opportunity cost of violation. After market research, it was found that, although the number of single entities pursuing short-term economic efficiency is decreased, the negative impact is still serious. It is necessary and important to avoid the free-riding behavior of such entities, namely getting premium through labelling themselves with “ecology oriented” while ignoring ecological production. In addition, it shall be advocated that the operating entities set up the development fund of ecological fishery of large-scale waters through voluntary contribution according to the share of operating revenue, and form the mechanism of “reward the superior, punish the inferior, and first come,
first compensated”, thus having a constraint on violations and give incentives to activities following the “ecological” principle, so as to make the individual behavior consistent with the collective interests.

4.3.2. Encourage shall be given to the development of “controllable, manageable and standardized” large-scale operating entities. Such entities can reduce the number of “cake making” individuals and facilitate collective actions following the “ecological” principle of large-scale fisheries. Also, specific to the larger scale and important characteristics of large-scale waters, compared with the “small, scattered and disordered” peasant household culture entities, the large-scale corporate entities have the advantages of easy operation and control, strong capital strength and high technology. They focus more on brand, quality, responsibility and green environmental protection, conducive to the formation of scaled, industrialized and intensive production mode, and more to the ecological protection and pollution control. For example, Chagan Lake, Thousand-island Lake, Hunan Dahu Lake, Chongqing Three Gorges Fishery and Xinjiang Tianyun are all typical large-scale operating entities with one common ground: corporate operation and standardized management. They set up professional Legal Services Department, Finance and Accounting Department, HR Department and so on in their internal organizations. This has improved the probability of proper positioning and operation efficiency of operating entities of large-scale fisheries, which is an important condition for the realization of the good pattern of ecology and economy. In addition, a reasonable interest allocation mechanism shall be established. On the basis of the collected contract fees or value-added tax of resources, a development fund for peasant households (fishermen) shall be established for support of dual-transform of the fishermen, ecological compensation and ecological restoration, protection, etc. [11].

4.4. Optimizing the Supportive Policies and Creating the Internal Impetus to Promote the Integration Development of Primary, Secondary and Tertiary Industries
Specific to the high cost and single value chain in the integration development of three industries in ecological fishery of large-scale waters, the extension and promotion of the value chain of ecological fishery of large-scale waters shall be promoted through optimization of the external environment and deep internal integration.

4.4.1. In terms of optimization of the external environment, a supportive policy package shall be built and improved for the integration development of three industries in ecological fishery of large-scale waters. Firstly, the construction of fish and fishery product logistics system shall be increased and the circulation cost shall be reduced. The construction of green circulation channel of fish and fishery products shall be strengthened, the cold chain preservation technology of fish and fishery products shall be improved, and the loss and cost of long-distance transportation shall be reduced. Secondly, an advanced demonstration base shall be established and promoted. The pilot of the advanced mode of the integration development of the three industries in ecological fishery of large-scale waters shall be carried out, and the typical experience summary and demonstration and popularization (such as Chagan Lake, Thousand-island Lake, etc.) shall be actively promoted. Thirdly, fiscal, taxation and financial supportive policies shall be established. The production activities of ecological fishery of large-scale waters (culture and proliferation, fishing, processing, recreation, etc.) shall be included in the supportive policy system of large-scale agriculture. Priorities shall be given to the credit, loan and funding of large-scale fisheries-related projects with the integration of three industries. The reform of input tax and value-added tax deduction policy for fish and fishery product processing shall be experimented and promoted.

4.4.2. In terms of deep internal integration of primary, secondary and tertiary industries, ecological fishery of large-scale waters shall build and expand its value chain. Firstly, the mode of innovation and integration shall be adopted. Ecological fishery of large-scale waters shall focus on “fishing”, break the boundary of primary industry, explore and introduce the culture, tourism, recreation, fishing,
sightseeing, healthful aquaculture and other commercial activities or contents around the regional landscape and characteristics, change the vertical mode of simple and comprehensive industry chain of “culturing + processing + sales”, and promote the ecological fishery of large-scale waters to the deep integration and development of “focusing on experience and entertainment in primary industry, simplicity and high quality in secondary industry, and recreation and culture in tertiary industry”. For example, around the winter fishing project, Chagan Lake in Jilin Province has formed an internationally well-known mode of integration development of primary, secondary and tertiary industries in ecological fishery of large-scale waters through culture, experience, catering, specialty, accommodation, etc. Secondly, attentions shall be paid to branding and marketing. The brand of “high quality, safety and health” shall be created focusing on the green production and “ecological” products by E-Commerce, We-Media and other modern marketing management means, so as to expand the brand awareness and influence of ecological fishery of large-scale waters, and obtain the appropriate market price. For example, the Thousand-island Lake in Zhejiang Province (the big fish head) and Xinjiang Tianyun (rainbow trout) have won the recognition of consumers and good market efficiency by branding based on product quality, ensuring the smooth circulation of the value chain.

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