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A statistical analysis of China's fisheries in the 12th five-year period

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ABSTRACT

This paper reviews the status and development of China's fisheries in the 12th five-year period using data from FAO, China Fishery Statistics Yearbooks, China Statistical Yearbooks and other sources. The main observations are as follows: in the 12th five-year period, China's aquatic products accounted for more than 35% of global aquatic production; China's aquaculture products accounted for more than 60% of global aquaculture production; in freshwater aquaculture, pond aquaculture accounted for about 70% of the national freshwater aquaculture production, and fish products were proportionally higher than others; in mariculture, bottom sowing and raft culturing products accounted for more than 50% of total marine aquaculture production and shellfish production was proportionally higher than others. There has been only a slow rise in capture production of wild fish over the same period. The freshwater catches from four provinces including Jiangsu accounted for half of the country's total freshwater catches, in which fish catches accounted for more than 70%. Marine capture production from four provinces including Zhejiang accounted for about 80% of the country's marine catches, in which fish catches accounted for more than 70%. There was an overall growth in production of processed aquatic products, particularly frozen aquatic products, surimi-based products and dry-cured products which together accounted for more than 80% processed seafood products. The average annual net income of fishermen per capita witnessed a growth of 11.71%, outpacing the GDP growth over the same period. With the rapid development of China's fisheries, there are also challenges such as overcapacity, low aquaculture product quality, resource overexploitation, as well as environmental problems. A change in approach, transformation and structure adjustment are suggested to reshape China's fisheries development model and to achieve the goal of sustainable development.

Fisheries are also known as "capture and aquaculture industries", which is an ancient business in China. According to historical records, fisheries can be dated back to as early as 11th century B. C., and had already achieved a considerable scale in the Warring States Period (475 B. C. - 221 B. C.). The world's oldest known work on fish culture - *Fan Li's Experience on Fish Farming*—was written in 460 B. C., over more than 2400 years ago. After the founding of new China, fisheries entered a new stage of development, especially after the adoption of the Reform and Opening-up Policy in 1978, when fisheries policies were adjusted in accordance with the country's condition and changes in fishery resources, and aquaculture-oriented approach were favoured, which has led to increasing enthusiasm and creativity among fishermen. The analysis of (Yue & Wang, 2012) shows that China's aquatic production between 1949 and 2010 has grown exponentially. Since 1996, aquatic production increased by 10 million tons every 6—7 years (Cheng, Jiang, & Zhao, 2016); analyzes the changing structure of Chinese fishermen's income from 2008 to 2013 using a grey correlation degree model, which reveals fishermen household income ranks first relative to general family income. China's fisheries have been developed from a relatively unsophisticated, low productivity and individual practice to an industry with advanced equipment, optimized structure, better competitive edge and high productivity.

The five-year plan, is an important fundamental work since the founding of the People's Republic of China. The 12th five-year plan was the 12th plan for the development of national economic and social development of the People's Republic of China from 2011 to 2015. The 12th five-year period has been important for China's modernization and was complex since the domestic and

international economic and political situation was complicated and changeable with risks and challenges for economic development. Currently China's economy has entered a new normal state with the economy growing at a medium-high speed instead of super-high. The development model has changed from extensive growth of scale and speed to intensive growth of quality and efficiency, the improvement of industrial structures from mid-low to mid-high end growth powered by innovation with resource allocation decided by market demands with economic well-being shared across the population rather than being skewed towards one group (Zhang, 2015). As part of China's economy and agriculture, fisheries are vulnerable to external environmental changes, which may have a high impact on the quality and efficiency of fisheries development. Thus, the discussion and analysis of China's fisheries status and development in the 12th five-year period is essential to understand its status and trends in world fisheries, and to give clear guidance for future development.

The present study discusses China's fisheries development and its status in the world by conducting statistical analysis with data from FAO and the China Fishery Statistics Yearbooks, and tries to give guidance for the future development of China's fisheries against the background of the existing modern economy.

1. Materials and methods

1.1. Data sources

In order to improve comparability of data from different sources, China's fisheries data and world fisheries data are taken from the FAO statistical database for comparison, while data about China's fisheries industry are taken from the China Fishery Statistics Yearbooks over the past few years (Fisheries Administration Bureau, 2016).

1.2. Data retrieval

1.2.1. FAO database
Data on China's fisheries and fisheries production of major countries and world regions are retrieved from the FAO database, categorized and analyzed by statistical standards according to Yearbook main groups by species of fish, crustaceans and molluscs, etc.

1.2.2. Yearbook data
Data of fisheries production, such as aquatic production and output of processed aquatic products etc. are retrieved from the China Fishery Statistics Yearbooks, including fishermen populations, practitioners, aquaculture areas, fishing vessels and so on.

1.3. Statistical contents of yearbook data

1.3.1. Production factors and production outputs
Data of fisheries production characteristics and production outputs from January 1 to December 31 annually are acquired by surveys conducted by the Chinese Ministry of Agriculture, with respondents from fisheries companies, organizations and units from all provinces, autonomous regions and municipalities (excluding Hong Kong SAR, Macao SAR and Taiwan), excluding research institutes. Outputs of aquatic products are weighed at time of capture (raw weight), with the exception of three alum jellyfish and algae that are measured by dry weight, while the output of algae is included in aquatic products.

1.3.2. Statistical principle of fishermen's income and fisheries output value

(1) Fishermen's income. Data of fishermen's income are from the Ministry of Agriculture (MOA) using a multi-stage sampling system. 221 sample counties and 10,000 sample households are taken from 30 provinces, autonomous, regions and municipalities (excluding Tibet Autonomous Region, Hong Kong SAR, Macao SAR and Taiwan). The family income and expenditure from November 1 of the previous year to October 31 of the inquiry year are recorded, completed on-line, aggregated, and evaluated to get an overall provincial average. Taking the fishermen population in each province as the weight, and the weighted average as the per capita value of a specific indicator. The formula is as follows:

$$\overline{y} = \sum \overline{y}_t W_t$$

Where, $\overline{y}_t$ represents the per capita net income for fishermen in the province (autonomous region or municipality), W_t is the weighting factor of fishermen population's in province t, $\overline{y}$ is the calculated net income per capita of national fishermen's families.

The overall provincial average net income per capita is average net income divided by population. Calculation of net income is as follows:

Net income = total income - household operational expenses - depreciation of fixed assets for production - taxes and fees.

According to sources of income, total income includes four items, namely household operational income, wage income, net property income and transfer income.

Household operational income refers to income of a family unit for operational production and management; wage income refers to the total remuneration and welfare in a fishermen's family obtained by various ways; net property income refers to the revenue of fishermen household or family members obtained from the investment of financial assets and natural resources in other organizations, households or individuals after deducting associated cost; transfer income refers to all kinds of transfer payments from the States, institutions, social organizations and recurring income transfers between households. Household operational expenses refers to the consumption of goods and services in family production activities; taxes and fees refers to levy collected in cash and in kind for the production activities in a fishermen's family.

(2) Value of fisheries output. Data of fisheries output value is calculated by the Chinese National Bureau of Statistics using the fishery production statistics from MOA and the method of Products Act according to Harvest Principle. It is calculated as follows:

$$Z = \sum C_t P_t$$

Where: C_t is the production of the variety t, P_t as the sale price for the variety t, and Z the national fisheries output value.

1.4. Data analysis

Because of time limits, data analysis of China's fisheries development in the 12th five-year period is conducted with the indicator of average growth rates in order to understand the fisheries production factors and production outcomes. The average growth rate formula is as follows:

$$\overline{\gamma} = \left[\left(\frac{2015 data}{2010 data} \right)^{\frac{1}{5}} - 1 \right] \times 100\%$$

In order to facilitate the analysis of China's aquatic production in proportion to the world's total output, a conventional exponential statistical model is applied. The formula is as follows:

$$y = a \times \ln(x) + b$$

Where y represents the proportion of China's aquatic products relative to the world's total production; a and b are parameters to be estimated, and x denotes the year.

Degree of intensification is an important indicator for the development of aquaculture, in which the proportion of intensive aquaculture production in proportion to the aquaculture production is an important indicator (Dong, 2015). Degree of intensification is calculated as follows:

$$I_t = \frac{\gamma_t}{\lambda_t} \times 100\%$$

Where I_t represents the degree of intensification of aquaculture in year t, γ_t refers to the production of cage aquaculture, fencing aquaculture and industrial aquaculture in year t. λ_t refers to the total aquaculture production in year t.

2. Comparative analysis of aquatic production between China and major fishing countries

2.1. Status of China's aquatic production in the world

The aquatic production (excluding the production of aquatic plants) in China and other major countries and regions between 1980 and 2014 were obtained from the FAO database. China's aquatic production in proportion to the world's total output is shown in Fig. 1. The aquatic production in world's major countries and regions is shown in Table 1.

In the 1980's, China's aquatic production only accounted for 6.19% of the world's total output. After 10 years' development (1990), this proportion increased to 13.44% and was followed by a rapid growth in the following years. By 1995, it was over 20.00%—24.35%. In 2003 the China's aquatic production was more than 30% of world production for the first time and was still in a state of slow growth. By the end of 2010, the last year of 11th five-year period, this proportion reached 35.21%, and the year 2014 witnessed the highest point of 37.42%.
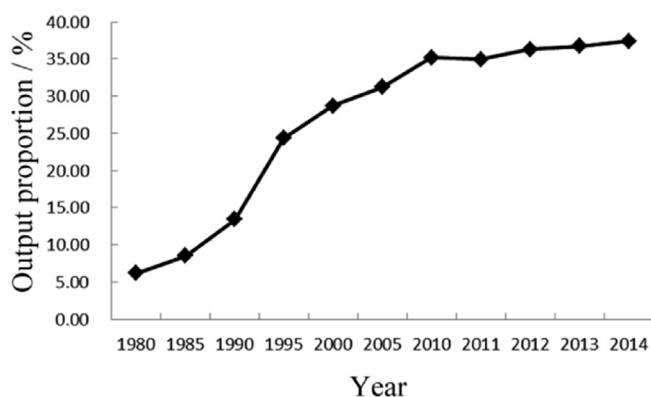

Fig. 1. China aquatic production in proportion to the world's total output.

2.2. Aquatic production in major fishery countries

The author retrieved the data of aquatic production in the world's major fishery countries or regions from the FAO database, and used the data of the top 10 producing countries or regions, including China, India, Indonesia, Vietnam, the United States, Japan, Peru, Russia, Myanmar and Norway for analysis. The aquatic production in the top 10 countries or regions in proportion to the world's total output has increased from 40.51% in 1980 to 69.16% in 2014, an increase of 28.65%. A general understanding of the development trends of global fisheries can be obtained by analyzing the fishery statistics from these 10 countries.

In the 1980s, Japan was the country with world's highest aquatic production, which, however, declined gradually due to changes in development policies. In 1989, China surpassed Japan as the country with world's highest aquatic production output. Since the 1990s, there has been a clear differentiation in the development of aquatic production between China and Japan. While the aquatic production in China increased rapidly, Japan's aquatic production was in a sharp decline and in 2014 dropped to 4.318 million t and was 41.31% of the production in 1980. Over the same time China's aquatic products increased from 4.455 million t to 62.756 million t, an increase of 58.120 million t and 1304.50% by percentage. The increase was mainly due to the rapid development of aquaculture, which increased from 1.679 million t to 45.470 million t, an increase of 43.791 million t, accounting for 75.35% of the increased Chinese aquatic production. According to FAO statistics, in 2014 the aquaculture products of the world's top 10 countries accounted for about 88.89% of global aquaculture production and China alone contributed 61.63%, as shown in Table 2. Due to the rapid development of China's aquaculture industry, the famous American scholar Brown spoke highly of the contribution of aquaculture to food safety: one of the two contributions China offers to the world - family planning and aquaculture (Tang, Ding, & Liu, 2014).

3. Structure of China's fisheries production in the 12th five-year period

3.1. Continuing increase in aquaculture production

In the 12th five-year period aquaculture production in China increased substantially and exceeded 40.000 million t, and was 49.379 million t in 2015, an increase of 11.091 million t compared to the end of the 11th five-year period and was 83.60% of the total aquatic production. During the 12th five-year period aquaculture production increased by 28.97% with an average annual growth of 5.22%, and accounted for 73.70% of total output, which is an increase since 2010 of 2.40%.

3.1.1. Structure analysis of freshwater aquaculture production

(1) The largest proportion of freshwater production, 70%, was from pond aquaculture. At the end of the 12th five-year period freshwater aquaculture production in China was 30.623 million t, an increase of 7.157 million t compared to 2010, the end of the 11th five-year period, and accounted for 64.54% of the increase in aquaculture production. Reservoir aquaculture production accounted for more than 12% and lake aquaculture accounted for 6% (Table 3).

(2) Fish production accounted for the biggest percentage of freshwater aquaculture and can be categorized into 5 types, fish, crustaceans, shellfish, algae and others (Table 4). In 2010 fish aquaculture had an annual production of 20.642 million t (87.97% of total freshwater production) and increased to 27.150 million t in 2015. Crustaceans were the second most

Table 1
Aquatic production in world's major fishery countries and regions. Unit: 10^4t.

Country/region	1980	1990	2000	2010	2011	2012	2013	2014
China	445.54	1313.68	3617.07	5214.90	5438.99	5727.57	5982.47	6257.55
India	244.53	379.97	560.90	847.51	798.42	908.16	919.59	959.98
Indonesia	182.73	302.24	490.36	767.83	836.64	878.66	1001.16	1069.06
Vietnam	55.87	93.92	212.81	508.50	535.99	579.02	601.03	631.63
US	370.75	587.12	517.45	488.42	551.07	551.18	556.33	540.18
Japan	1045.17	1036.89	583.55	478.52	433.33	428.40	426.45	431.80
Peru	270.96	687.41	1066.39	439.06	834.14	492.14	598.00	368.86
Russia	0.00	760.41	404.77	419.03	438.37	447.63	450.33	438.68
Myanmar	58.00	74.38	119.21	391.39	414.98	446.44	471.60	504.54
Norway	240.90	175.35	319.07	369.97	342.62	347.14	332.72	363.41
Total output	7193.83	9774.09	12594.69	14810.28	15549.18	15777.66	16292.99	16722.90
Proportion (%)	40.51	55.36	62.66	67.02	68.33	68.49	69.60	69.16

Notes: excluding output of aquatic plants.
Data source: www.fao.org/fishery/collection/global-production/en.

Table 2
Aquaculture production in the world's major fishery countries or regions in 2014. Unit: 10^4t.

Country/region	Fish	Molluscs	Crustaceans	Others	Total	Percentage (%)
China	2721.94	1341.87	399.35	83.95	4547.11	61.63
India	448.11	1.42	38.57		488.10	6.62
Indonesia	363.99	4.44	61.39	0.01	429.83	5.83
Vietnam	268.70	19.89	50.62	0.49	339.70	4.60
Bangladesh	182.68		13.02		195.70	2.65
Norway	133.05	0.20			133.25	1.81
Chile	96.81	24.64			121.45	1.65
Egypt	112.99		0.72		113.71	1.54
Myanmar	90.37		4.28	1.56	96.21	1.30
Thailand	42.06	20.96	30.04	0.41	93.47	1.27
Global	4986.19	1497.87	804.96	89.36	7378.37	

Notes: excluding output of aquatic plants.
Data source: www.fao.org/fishery/collection/global-production/en.

Table 3
Production of freshwater aquaculture by water types and methods. Unit: 10^4t.

Year	2015	2014	2013	2012	2011	2010
Freshwater aquaculture output	3062.27	2935.76	2802.43	2644.54	2471.93	2346.53
Where: pond	2195.69	2090.26	1988.75	1866.42	1743.50	1647.72
Output proportion (%)	71.70	71.20	70.97	70.58	70.53	70.22
Area (10^4hm^2)	270.12	266.19	262.32	256.69	244.99	237.70
Unit output (t/hm^2)	8.13	7.85	7.58	7.27	7.12	6.93
Lake	164.78	164.63	163.43	161.50	154.15	153.66
Output proportion (%)	5.38	5.61	5.83	6.11	6.24	6.55
Area (10^4hm^2)	102.24	101.53	102.27	102.48	102.30	100.71
Unit output (t/hm^2)	1.61	1.62	1.60	1.58	1.51	1.53
Reservoir	388.40	377.09	353.66	333.77	309.30	284.44
Output proportion (%)	12.68	12.84	12.62	12.62	12.51	12.12
Area (10^4hm^2)	201.24	199.48	195.80	191.15	185.19	179.56
Unit output (t/hm^2)	1.93	1.89	1.81	1.75	1.67	1.58
Rivers and ditches	88.87	86.42	85.63	84.31	80.23	74.27
Others	68.71	71.68	65.93	65.40	64.76	62.17
Rice puddles	155.82	145.67	145.05	133.14	119.99	124.27
Method: fence	48.17	48.74	49.53	49.58	45.96	52.30
Cage	137.91	139.17	138.83	127.32	110.82	113.09
Industrial	20.34	19.74	20.81	20.39	16.44	16.72
Intensification degree (%)	6.74	7.07	7.46	7.46	7.01	7.76

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (2011–2016) [M]. Beijing: China Agriculture Press, 2011–2016.

produced freshwater aquaculture organism and increased from 2.138 million t in 2010 to 2.691 million t in 2015, although the proportional contribution dropped from 9.11% to 8.79% (Table 4).

3.1.2. Structure analysis of marine aquaculture production

(1) High yielding from bottom sowing and raft culture (Table 5).
At the end of the 12th five-year period, marine aquaculture

production in China was 18.756 million t, an increase of 3.933 million t or 35.46% compared to 2010, the end of 11th five-year period. Bottom sowing produced the largest yield, accounting for about 28.13% of marine aquaculture production, followed by raft culture with 27.68%. Pond culture ranked third and production accounted for 12.55%.

(2) The largest marine aquaculture production was from shell-fishes (Table 6). The annual production in 2010 was 11.082 million t, which corresponded to 74.76% of the total mari-culture output, and it increased to 13.584 million t in 2015.

Table 4
Production of freshwater aquaculture by types. Unit: 10^4t.

Type	2015	2014	2013	2012	2011	2010
Fish	2715.01	2602.97	2481.73	2334.11	2185.41	2064.18
Crustaceans	269.06	255.97	242.94	234.30	216.44	213.80
Shellfish	26.22	25.12	25.58	25.88	25.22	25.10
Algae	0.89	0.86	0.82	0.80	0.73	0.97
Others	51.09	50.85	51.37	49.45	44.14	42.49

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (2011–2016) [M]. Beijing: China Agriculture Press, 2011–2016.

Table 6
Mariculture Production by species. Unit: 10^4t.

Species	2015	2014	2013	2012	2011	2010
Fish	130.76	118.97	112.36	102.84	96.42	80.82
Crustaceans	143.49	143.38	134.02	124.96	112.72	106.11
Shellfish	1358.38	1316.55	1272.80	1208.44	1154.36	1108.23
Algae	208.92	200.46	185.68	176.47	160.18	154.13
Others	34.08	33.30	34.38	31.11	27.65	33.01

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (year 2011–2016) [M]. Beijing: China Agriculture Press, 2011–2016.

Algae production was ranked second in total mariculture output and increased from 1.541 million t (10.40%) in 2010 to 2.089 million t (11.14%) in 2015.

3.2. Slow increase in capture production

In the 12th five-year period, capture production in China grew slowly. In 2015, the annual catch reached 15.426 million t, an increase of 1.100 million t compared with that in the end of 11th five-year period, accounting for 8.29% of the total increase of aquatic production. The average annual increase was 22.000 million t, with the average annual growth rate of 1.49%.

3.2.1. Structure analysis of freshwater capture production

From 2010 to 2015, there has been little change in China's freshwater capture fisheries. The annual catch peaked in 2013 with 2.307 million t, and 2011 the lowest of 2.232 million t, a deviation of 75,200 t, as shown in Fig. 2.

(1) Significant differences by production in provinces. According to the analysis of freshwater capture data in different provinces in the 12th five-year period, catches in 4 provinces including Jiangsu, Anhui, Jiangxi and Hubei were comparatively higher than others, accounting for more than half of the total freshwater catches, followed by catches from Shandong, Hunan, Guangdong, Guangxi, Hebei, Zhejiang, Fujian, Heilongjiang. The catches in the above 12 provinces accounted for about 80% of the total freshwater capture production (taking catches in 2015 for example, as shown in Table 7). Categorized by waters, the middle and lower Yangtze River, the lower Yellow River, Huaihe River, Pearl River, Heilongjiang River were the main areas for freshwater capture.

(2) Stable Structure of species variety. As can be seen from the analysis of freshwater catch data between 2010 and 2015,

Fig. 2. Trend in freshwater capture production.

Table 7
Freshwater catches in major fishing provinces in China in 2015. Unit: 10^4t.

Province	Catch	Percentage (%)
Hebei	10.27	4.51
Heilongjiang	5.72	2.51
Jiangsu	32.54	14.29
Anhui	31.64	13.89
Fujian	8.76	3.85
Jiangxi	26.40	11.59
Shandong	10.26	4.50
Hubei	19.10	8.39
Hunan	10.89	4.78
Guangdong	12.43	5.46
Guangxi	13.84	6.08
Zhejiang	8.84	3.88
12 provinces in total	190.69	83.72
Total	227.77	

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. The 2016 China Fishery Statistics Yearbook [M]. Beijing: China Agriculture Press, 2016.

Table 5
Mariculture production by culturing types. Unit:10^4t.

	2015	2014	2013	2012	2011	2010
Mariculture production	1875.63	1812.65	1739.25	1643.81	1551.33	1482.30
Where: pond	235.33	229.58	228.12	212.70	195.76	197.83
Output proportion (%)	12.55	12.67	13.12	12.94	12.62	13.35
Area (10^4hm^2)	45.50	45.69	46.36	43.76	40.54	41.38
Unit output (t/hm^2)	41.22	39.67	37.51	37.56	38.27	35.82
Common cage	46.66	43.74	40.00	39.35	34.84	32.49
Offshore cage	10.57	8.87	7.39	7.10	5.62	5.55
Raft	519.11	496.93	477.31	453.73	414.99	403.34
Hanging cage	134.31	120.53	115.29	96.67	83.29	86.81
Bottom sowing	527.58	510.05	494.99	440.90	430.99	401.94
Industrial culture	19.07	17.03	17.74	15.89	13.13	11.46
Degree of intensification (%)	4.07	3.84	3.74	3.79	3.45	3.34

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (2011–2016) [M]. Beijing: China Agriculture Press, 2011–2016.

there was little change in the structure of organism variety. Fish accounted for 70%–74%, crustaceans 14%–15%, shellfish 11%–14%, and others about 2% of catch (Table 8).

3.2.2. Structural analysis of marine capture fisheries production

From 2010 to 2015, there was not much change in China's marine capture fisheries, which generally had a linear growth. The annual production in 2015 reached peaked at 13.148 million t compared to 12.036 million t in 2010. The average annual growth was 0.222 million t, and the average annual growth rate was 1.78% (Fig. 3).

(1) Significant differences in catches by province. According to the statistical analysis of marine capture data by province in the 12th five-year period, marine capture in 4 provinces including Zhejiang, Shandong, Fujian, Guangdong and Hainan accounted for up to about 10% respectively. The catch in Zhejiang Province was the highest, accounting for 25.61% of the total catch and collectively the 4 provinces accounted for about 80% of the total catch (taking catches in 2015 for example, as shown in Fig. 4).

(2) Stable structure of marine biology variety. Analysis of marine capture data from 2010 to 2015, revealed the relative contribution of the main variety captured in China changed little. Fish accounted for 68%–69%, crustaceans 16%–18%, while others accounted for about 13% (Table 9).

3.3. Increase in processed aquatic products

The 12th five-year period witnessed a linear growth trend in the amount of processed aquatic products. In 2010, the processed aquatic production was 16.333 million t, and increased to 20.923 million t in 2015, an increase of 4.590 million t, with an average annual growth rate of 5.08%.

3.3.1. Seafood processing as the mainstream

During the 12th five-year period, there were increases in both freshwater and seawater processed products. Freshwater products increased by 0.916 million t, with an average annual growth rate of 5.78%, and marine products increased by 3.674 million t, with an average annual growth rate of 4.93%. Marine products accounted for more than 80% of the main processed products (Table 10).

3.3.2. Frozen aquatic products as the main type in processing

The main processed aquatic products include frozen aquatic products, surimi products and dry-cured products, processed algae, canned products, fish meal, fish oil products and other aquatic products (Table 11). Frozen aquatic products accounted for 60% of the total processed aquatic products, followed by surimi and dry cured products (15%).

Fig. 3. Growth trend of marine Catches.

Fig. 4. Structure of marine catches in 2015 by province.

4. Discussion and conclusion

4.1. Expanding scale of fisheries economics, steady growth in the supply of aquatic products

In the 12th five-year period, China's fisheries have made remarkable achievements. The total output of aquatic products accounted for 38% of the global production, aquaculture production accounted for about 62% of global aquaculture production. From 2010 to 2015, there was continued growth in aquatic production in China, which broadened the available food protein supply and also contributed to food security in China. At the end of 11th five-year period, China's output of aquatic products was 53.730 million t, and had increased to 66.997 million t at the end of 12th five-year period, an increase of 13.267 million t, with an average annual increase of 2.653 million t and an average annual growth rate of 4.51%.

According to the data from China's National Bureau of Statistics, at current prices, the value of fisheries production was 1.092 trillion *Yuan* and by the end of 12th five-year period had an added value of 658.7 billion *Yuan* (Table 12). Fisheries production value in proportion to the total value of forestry, animal husbandry and fisheries rose from 9.26% in 2010 to 10.21% in 2015, and the added value in the fishing industry increased from 9.6% in 2010 to 10.5% in 2015.

As can be seen from Table 9, with the acceleration of industrialization and urbanization, offshore fishery resources have been greatly overexploited, and there has been negative growth in

Table 8
Freshwater catches by organisms. Unit: 10⁴t.

Organisms	2015	2014	2013	2012	2011	2010
Fish	168.297	167.345	166.123	163.602	158.247	161.468
Crustaceans	31.099	32.770	34.061	34.391	32.398	34.332
Shellfish	25.408	26.330	27.227	28.078	28.658	28.698
Algae	0.037	0.026	0.027	0.004	0.004	0.003
Others	2.926	3.070	3.305	3.714	3.920	4.437

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (2011–2016) [M]. Beijing: China Agriculture Press, 2011–2016.
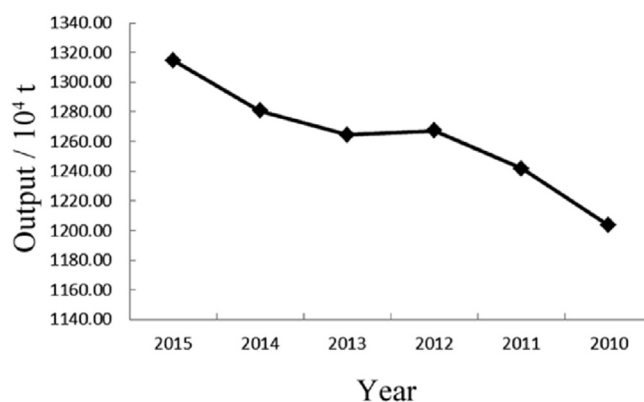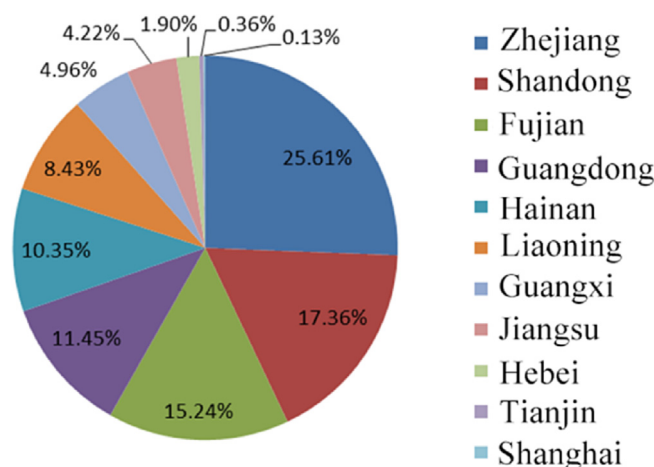
Table 9
Marine catches by organisms and vessel features. Unit: 10^4t.

Organisms	2015	2014	2013	2012	2011	2010
Total catch	1314.78	1280.84	1264.38	1267.19	1241.94	1203.59
Fish	905.37	880.79	871.76	875.85	863.99	825.51
Crustaceans	242.79	239.57	228.55	220.74	209.13	204.33
Shellfish	55.60	55.16	54.76	56.34	58.41	62.21
Algae	2.58	2.43	2.80	2.57	2.74	2.46
Cephalopods	69.98	67.67	66.43	69.89	69.53	65.83
Others	38.45	35.22	40.08	41.80	38.15	43.25
Number of vessels	187223	191944	196803	194240	201694	204456
Vessel power (kW)	14419960	14087583	13614004	13270770	13255855	13040623
Power per unit (kW/vessel)	77.02	73.39	69.18	68.32	65.72	63.78
Unit power output (t/kW)	0.91	0.91	0.93	0.95	0.94	0.92

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (2011−2016) [M]. Beijing: China Agriculture Press, 2011−2016.

Table 10
Production of processed freshwater and marine products. Unit: 10^4t.

	2015	2014	2013	2012	2011	2010
Processed aquatic products	2092.31	2053.16	1954.02	1907.39	1782.78	1633.25
Processed freshwater products	373.90	374.52	362.98	343.99	305.14	282.28
Processed marine products	1718.41	1678.63	1591.03	1563.40	1477.64	1350.97

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (2011−2016) [M]. Beijing: China Agriculture Press, 2011−2016.

Table 11
Production of aquatic processing products. Unit: 10^4t.

Types	2015	2014	2013	2012	2011	2010
Frozen aquatic products	1376.49	1317.15	1229.98	1174.97	1103.72	1004.89
Surimi products and dry-cured products	309.24	306.88	290.64	273.44	259.79	242.70
Processed algae	98.20	108.71	98.99	101.39	96.96	94.59
Canned products	41.31	39.99	37.49	35.54	26.56	24.31
Fish meal	71.12	75.99	99.55	195.26	182.15	149.29
Fish oil products	7.31	10.13	7.70	6.02	4.80	3.88
Other aquatic products	108.29	194.02	189.68	120.78	108.80	113.59

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (2011−2016) [M]. Beijing: China Agriculture Press, 2011−2016.

Table 12
Fisheries production value and added value. Unit: 10^8 Yuan.

	2015	2014	2013	2012	2011	2010
Fisheries production value	10923.0	10309.0	9634.6	8706.0	7568.0	6422.4
Percentage in forestry, animal husbandry and fisheries (%)	10.21	10.10	9.93	9.70	9.30	9.26
Added value in fisheries	6587.0	6257.3	5842.5	5266.9	4590.0	3903.8
Percentage in forestry, animal husbandry and fisheries (%)	10.5	10.4	10.3	10.1	9.7	9.6

Notes: The absolute numbers in this table are calculated at current prices. The value of fish fry is excluded from the fisheries production value and added value.
Data Source: The National Bureau of Statistics of People's Republic of China. China Statistics Yearbook (2011−2016) [M]. Beijing: China statistics press, 2011−2016.

marine catches. While traditional fishing grounds are shrinking, fishing capacity remains at high level, far exceeding the renewable capacity of fishery resources. The status of fishery resources in major waters, such as offshore, inland rivers, lakes and reservoirs, has not been improving and the environment is under high pressure.

Aquaculture is one of the earliest industries in China but has been suffered from severe competition, because of low market entry barriers—usually operated in a family-based workshop–and high dependence on the distribution channels. Traditional aquaculture enterprises are unable to meet the consumer demand for aquatic products and they have benefited from industrial expansion and demand-pull and this has resulted in rapid development. Pond aquaculture is the main form of aquaculture in China. Most of the ponds are old and built with poor construction standards, and do not meet the requirements of culturing sanitation. The rapid development of the aquaculture sector has intensified the conflicts between industry and resources, and between industry and the environment, and currently there is an urgent need to improve product quality and production efficiency. The production factor-driven approach of aquaculture has now reached its production capacity and is unable to sustain further development.

4.2. Higher degree of aquaculture intensification, increasingly prominent ecological and environmental problems

The degree of intensification reflects the development level of fisheries aquaculture in any country or region. Time series analysis of key characteristics of the sector helps to further understand and learn the way to regulate and control the development of aquaculture in a country or a region. According to the author's calculation and estimation, the degree of intensification China's mariculture industry during the 12th five-year period was generally in an upward trend, rising from 3.34% in 2010 to 4.07% in 2015, an

Table 13
Chinese people's possession and consumption of major animal proteins per capita. Unit: kg/person.

	2015	2014	2013	2012	2011	2010
Possession of aquatic products per capita	48.8	47.4	43.7	43.7	41.7	40.2
Possession of pork, beef and mutton per capita	50.0	49.8	48.6	47.4	45.4	45.8
Consumption of aquatic products per capita	11.2	10.8	10.4			
Consumption of pork, beef and mutton per capita	26.2	25.6	25.6			

Notes: Possession and consumption per capita are calculated by the annual average population in mainland China. The annual average population equals to the number of population at the end of last year plus the number of population this year then divided by two.
Data Source: Household Survey Office of the China National Bureau of Statistics. China's Housing Survey Yearbook (2014—2016) [M]. Beijing: China Statistics Press, 2014—2016.

Table 14
Fishermen's net income per capita. Unit: *Yuan*.

	2015	2014	2013	2012	2011	2010
Fishermen's net income per capita	15595	14426	13039	11256	10012	8963
Annual growth rate (%)	8.10	10.63	15.84	12.43	11.70	

Data Source: Fisheries Administrative Bureau, Ministry of Agriculture. China Fishery Statistics Yearbook (2011—2016) [M]. Beijing: China Agriculture Press, 2011—2016.

increase of 0.73%. In other words, the mariculture industry in China in recent years is characterized by intensification and modernization and problems of discoordination, misbalance and unsustainability between traditional development approaches and the environment have become increasingly prominent. In general the exploration and exploitation of resources exceeds the capacity of the ecological systems and the environment. The protection of water-related resources has given way to economic development in a specific time and area because of the versatility of water. The extensive use of water in hydropower, shipping and aquaculture leads to irreparable adverse effects on the environment and its ecology. Therefore, it is urgent to change the current model of aquaculture development, as well as to develop a clear understanding of the relationship between management, production and protection of ecological resources.

4.3. Increase in aquatic products per capita and consumption

The rapid development of China's fisheries industry has been driven by the increasing demand for aquatic products. The Chinese per capita consumption of aquatic products increased from 40.06 kg in 2010 to 48.80 kg in 2015 and this rise has effectively improved the diet structure and widened the sources of animal protein. The survey by China's National Bureau of Statistics in 2013 of household incomes and expenditure in urban and rural areas revealed that the consumption of aquatic products ranked third in the consumption of animal protein in China, after pork meat and dairy, reaching 11.2 kg (Table 13). The increase in Chinese per capita consumption of aquatic products is closely related to the rising income of residents (Li & Tan, 2012).

4.4. A significant increase in fishermen's net income per capita

In the 12th five-year period, fishermen's net income per capita in 2015 was 15,595 *Yuan*, an increase of 6632 *Yuan* compared with 8963 *Yuan* in 2010, with an average annual increase of 1326.4 *Yuan* and an average annual growth rate of 11.71%, far higher than the GDP growth over the same period (Table 14). The increase in the net income of fishermen sets the basis for the development goal of a moderately prosperous society.

According to the composition of fishermen's household income, family operating income was the main source of household income, accounting for about 90%, followed by wage income of about 5%,

transfer income 4% and the lowest proportion was the net property income of 1%, as shown in Fig. 5.

4.5. Optimized structure of fisheries economics, expanding proportion of production in secondary and tertiary industries

Analysis of the data in the China Fishery Statistics Yearbooks (2011—2016), reveals that the structure of China's fisheries has been gradually optimized, with an expanding proportion of production in secondary and tertiary industries, which has been increased from 47.78% in 2010 to 48.55% in 2015. The prosperity in secondary and tertiary industries has been promoted by the development of modern fisheries and has led to the development of the aquatic processing industry and also the recreational fishing industry. In some areas the development of aquaculture industries has promoted the integration of primary, secondary and tertiary industries due to the cluster effect, which affects the development of the whole industry and consumer choices. Technology innovation is at the core of industry clusters and forges the integration of primary, secondary and tertiary industries. Local governments play a key role in supporting the development of local aquaculture
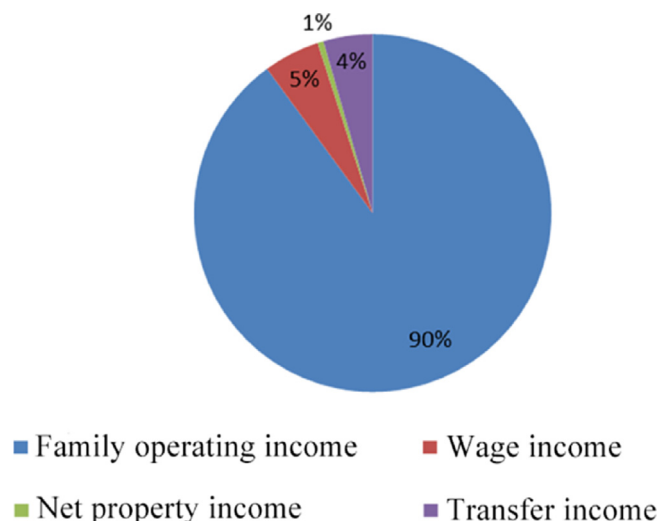

Fig. 5. Composition of fishermen's household income.

industry through planning, establishment of a unified processing place of origin, setting up relevant associations to facilitate sector management and to exchange successful experiences. The combination of "the visible hand of the government" and "the invisible hand of the market" may lead to the upgrading of the fisheries industry.

In summary, China's fisheries economics and the dimension of the industry are not what they used to be. Traditional development models that rely on production factor investment and access to appropriate production environments are bottlenecks contributing to unsustainability of fisheries development. Transformation and upgrading are the inevitable approaches to achieve sustainable development of fisheries. In order to effectively reverse the situation and explore a new fisheries development model, changing approaches, structure adjustment and promotion of transformation are the way to achieve sustainable and healthy development of fisheries in China.

References

Cheng, Y., Jiang, Q. J., & Zhao, W. W. (2016). Analysis on the structure changes and pulling power of Chinese fishermen's income from 2008 to 2013. *Journal of Shanghai Ocean University, 25*(1), 8.

Dong, S. L. (2015). A Study on the development of ecological intensification of China's aquaculture industry. *Chinese Fisheries Economics, 33*(5), 6.

Fisheries Administration Bureau, M. o. A.. (2016). *China fishery statistics Yearbooks (2011-2016).* Beijing: China Agriculture Press.

Li, H. X., & Tan, C. L. (2012). Empirical analysis of influential factors in aquatic products consumption per capita. *Heilongjiang Agricultural Sciences, 4*, 4.

Tang, Q. S., Ding, X. M., & Liu, S. L. (2014). Strategy and responsibility of green and sustainable development of China' s aquaculture industry. *Chinese Fisheries Economics, 1*, 9.

Yue, D. D., & Wang, L. M. (2012). A study on the growth characteristics of China's aquatic products. *Jiangsu Agricultural Sciences, 40*(6), 3.

Zhang, Z. B. (2015). Trend characteristics and policy adoption of China's economy of new normal. *Journal of China National School of Administration, 1*, 6.