Dynamic evolution analysis of recreational fisheries development in China

Qi Ding1,2 | Xiujuan Shan1,2 | Xianshi Jin1,2 | Harry Gorfine3 | Yali Wang4

Abstract
Understanding the dynamic spatial distribution characteristics and evolving trends in recreational fisheries development is of great importance for formulating policy for responsibly managing recreational fisheries. However, regional economic differences among China’s recreational fisheries have yet to be examined and quantified. In this study, a methodological approach applies a series of techniques, including Kernel density estimates, Gini coefficients and Theil indexes, to provide a comprehensive analysis of the dynamic distribution and evolution of recreational fisheries in China. Results showed that recreational fisheries in China have been developing rapidly since the early 21st Century. The total economic value of recreational fisheries in China increased from 5.4 billion Yuan in 2003 to 90.2 billion Yuan in 2018. However, there is a serious imbalance of development of recreational fisheries between regions. Specifically, the combined economic value of recreational fisheries in the main provinces of Shandong, Hubei and Guangdong accounted for 53.4% of recreational value for the whole country, whereas the combined contribution for the bottom 20 of the 31 provinces in the country together accounted for only 10.1%. Analysis of temporal variation at four points in time by kernel density estimation revealed that the development of recreational fisheries exhibited a polarised tendency both among the provinces within the eastern, central and western regions and among the 31 provinces of China. Based on the results of the Theil index decomposition, the overall differences in China’s recreational fisheries economy mostly came from differences within each region, which accounted for over 90% of the overall difference. This study provided a means to understand and visualise how key dimensions of recreational fisheries development vary within each region and within the 31 provinces of China, and provides a basis for making short-term and long-term policies aimed at promoting coordinated and sustainable development of recreational fisheries in China.

KEYWORDS
Gini coefficient, Kernel density estimate, regional difference, Theil index

1Key Laboratory of Sustainable Development of Marine Fisheries, Ministry of Agriculture and Rural Affairs; Shandong Provincial Key Laboratory of Fishery Resources and Ecological Environment, Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Qingdao, China
2Function Laboratory for Marine Fisheries Science and Food Production Processes, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China
3School of Biosciences, The University of Melbourne, Parkville, Vic., Australia
4Periodical Agency, Shanghai University of Finance and Economics, Shanghai, China

Correspondence
Xiujuan Shan, Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, 106 Nanjing Road, Qingdao, Shandong, China. Email: shanxj@ysfri.ac.cn

Funding information
Major Science and Technology Innovation Projects of Shandong Province, Grant/Award Number: 2018SDKJ0501-1; National Natural Science Foundation of China, Grant/Award Number: 31872692; Special Funds for Taishan Scholars Project of Shandong Province: AoShan Talents Cultivation Program Supported by Qingdao National Laboratory for Marine Science and Technology, Grant/Award Number: 2017ASTCP-ES07; Innovation Team of Fishery Resources and Ecology in the Yellow Sea and Bohai Sea, Grant/Award Number: 2020TD01

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2021 The Authors. Fisheries Management and Ecology published by John Wiley & Sons Ltd.
1 | INTRODUCTION

Recreational fishing is defined as fishing for aquatic animals (mainly fish) that do not constitute the individual’s primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets (FAO, 2012). Recreational fishing occurs around the globe in inland, estuarine and marine waters, spanning developed and increasingly, developing countries, involving high numbers of participants and making a considerable economic contribution to national economies (FAO, 2012; Cooke et al., 2018; Pita et al., 2018). Approximately, one tenth of the population across all countries engages regularly in recreational fishing, providing many social, economic and ecological benefits to society and harvesting millions of fish on a global scale (Aas et al., 2008; Arlinghaus et al., 2015). In China, recreational fishing is an activity with high socioeconomic importance, involving 0.80 million employees and generating 90.23 billion RMB (13.63 billion US$) in 2018 (Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2019). Recreational fishing can involve a variety of gear types (including rod and reel, nets, bow and arrow fishing, spearguns) and occur in both natural and aquaculture waters. In general, the fish caught is eaten by the fisher against payment of a fee, especially in dedicated ponds and marine enclosures. The Chinese Government identified recreational fishing as one of the five major industries among its modern fisheries in 2011 (Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2018).

Recreational fisheries have become the fastest growing fisheries in China. Its development in China can be roughly divided into three stages: a budding stage (from 1980s to 2000s), a rapid development stage (during 2011–2015) and a normative stage (since 2016) (Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2018). Supply-side structural reform and integrated development of the primary, secondary and tertiary industries have become the main tasks at the present stage of fishery development since the 13th Five-year Plan (launched in March 2016). Recreational fishing is an important direction for promoting supply-side structural fisheries reforms, and the Chinese Government has actively encouraged recreational fisheries development and places strong emphasis on its healthy and standardised development.

While not large in terms of tonnage compared with commercial capture fisheries, recreational fisheries have substantial economic impacts through value-added activities (Freire et al., 2020). In addition to contributing to economies and general well-being, recreational fisheries also play an important role in aquatic conservation (FAO, 2018; Browscombe et al., 2019). Its sustainably managed expansion offers an effective way for providing more employment to local fishers seeking to transfer their skills and utilise experience gained from less lucrative commercial fishing, and who remain demographically dependent upon aquatic resources for their livelihoods. In China, surveys of sea anglers in Shandong Province found that the ratio of economic value directly from recreational fishing, that is, value of fish caught, to allied consumption (boat charter; purchase of angling equipment) was 1:53, and per sea angling location promotes potential job transfer opportunities for more than 27 fishers (Yu, 2016). Therefore, recreational fishing in China is an important leisure activity that contributes economic, ecological and social benefits to the Chinese society.

Recreational fisheries in China have been developing rapidly, especially over the past decade, but this rapid overall development has been accompanied by widening discrepancies in its extent among regions (Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2018). Nevertheless, to date, the dynamic evolution (see Nowak (2006)) of recreational fisheries in China remains unknown, hampering progress in promoting a coordinated, evidence-based approach to policies for developing recreational fisheries to reach their potential. To address this lack of quantitative information, this paper provides a comprehensive analysis of the dynamic spatial distribution and evolving trends in recreational fisheries among China’s provinces to enable a broader understanding of recreational fisheries development. It is anticipated that this will provide a scientific reference for promoting coordinated and sustainable development of recreational fisheries throughout China.

2 | MATERIALS AND METHODS

2.1 | Indicators and data sources

Total economic value and per capita economic value of recreational fisheries were selected as indicators to investigate changing trends and regional disparities among China’s provinces. No data are available on the number/weight of fish caught so total economic value is used here to assess the progress of the fishery. According to China’s official statistics, economic value of recreational fisheries refers to the economic value of the fishery-related tourism service industry in this study. A kernel density estimation model was constructed to quantify the dynamic evolution of recreational fisheries development in China. Then, a series of techniques, including the Gini coefficient and Theil index decomposition, were applied to illustrate the relative differences among provinces. All recreational fisheries data were acquired from the China Fishery Statistical Yearbook. Data on human population size were sourced from the China Statistical Yearbook.

To illustrate the provincial differences and regional disparities in recreational fishery development better, China’s 31 provinces (including municipalities and autonomous regions) were divided into three broader regions: eastern, central and western. The eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan provinces. The central region includes Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan provinces. The western region includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang provinces.
2.2 | Kernel density estimate

Kernel density estimation (KDE) is a non-parametric method used in probability theory to estimate a probability density function (Pennino et al., 2017; Wang et al., 2018). In this paper, the KDE model was used to study the temporal trend of the recreational fisheries in China (Edge et al., 2017). In a random sample \(x_1, x_2, ..., x_n\), the KDE is given by

\[
f_h(x) = \frac{1}{nh} \sum_{i=1}^{n} K \left( \frac{x-x_i}{h} \right)
\]

where \(x_1, x_2, ..., x_n\) are independent identically distributed samples extracted from a population with the distribution density function \(f\) to estimate the value of \(f\) at a point; \(h\) (bandwidth) affects the shape and smoothness of the curve; \(K(x-x_i)\) represents the distance from the estimated point to the sample \(x_i\); and the kernel function \(K()\) is a weighting function. This study employs a Gaussian kernel to quantify the evolution of recreational fisheries development in China, given by:

Gaussian: \(\frac{1}{\sqrt{2\pi}} e^{-1/2x^2}\)

Combined with the distribution form of the kernel density function graph, the change in the value of indicators studied (total economic value of recreational fisheries or per capita economic value of recreational fisheries) in different observation stages can be effectively judged, and then the dynamic evolution characteristics can be obtained. If the waveform of the kernel density curve moves to the left (showing a right skewed distribution), the vertical height of the crest increases, the horizontal width decreases, and the number of peaks decreases, then the kernel density tends to decrease its value. This reveals a dynamic convergence characteristic, showing that the decomposition gap of the studied indicator in the region narrows, and vice versa.

As Silverman (1986) pointed out, in the case of large samples, usually the non-parametric estimation is not sensitive to the choice of kernel, but the choice of bandwidth \(h\) has greater influence on the estimator. In this study, a normal kernel with bandwidth chosen by Silverman’s rule (option “nrd0” in the density function in R) was applied to the matrix entries (Edge et al., 2017). “nrd0” is the standard bandwidth selector for symmetric kernels with constant parametric starts.

2.3 | Gini coefficient

The Gini coefficient is an indicator widely used by economists and is derived from the Lorentz curve (Drezner et al., 2009; Liu et al., 2017). The Gini coefficient measures the inequality among values of a frequency distribution. The larger the value, the larger the disparity among regions, and vice versa. The formula is:

\[
\text{Gini} = \frac{1}{n(n-1)} \sum_{i=1}^{n} \sum_{j=1}^{n} |y_i - y_j|
\]

where Gini represents the Gini coefficient. \(n\) represents the total number of study areas (which equals 31 provinces in this paper). \(y_i, y_j\) \((i = 1, 2, ..., n)\) represents the selected indicator (which refers to the total economic value of recreational fisheries or per capita economic value of recreational fisheries) of province \(i\) or province \(j\). \(u = 1/n \sum_{i=1}^{n} y_i\) represents the national average value of selected indicator.

2.4 | The Theil index and its decomposition method

The Theil index measures regional differences (Theil, 1967; Bhattacharyya & Sinha, 2016; Yu & Zhou, 2018), where higher values of the index refer to larger disparities. One advantage of the Theil index is that the total regional disparity can be decomposed into inter-regional disparity and intra-regional disparity; hence, it provides a better representation of imbalance in heterogeneous regional structures. The inter-regional index measures the disparity between different regions, whereas the intra-regional index is a weighted average of provincial disparities within each region. Within this context, the overall regional disparities of the recreational fisheries economy in China can be decomposed into the within eastern region differences, within central region differences, within western region differences, within central region differences, within western region differences and between-regions differences.

Taking the province as a basic spatial unit, the Theil index indicating national overall difference is:

\[
I_{\text{theil}} = I_{\text{inter}} + \sum_{i=1}^{m} \left( \frac{Y_i}{Y^2} \right) I_{\text{inter}_i}
\]

where \(I_{\text{theil}}\) represents the Theil index. \(I_{\text{inter}_i}\) represents disparities among the eastern, central and western regions, \(I_{\text{inter}_i}\) represents the disparities among provinces within the region \(i\) (which refers to eastern, central, or western regions); \(m\) represents the number of regions which equals to 3 in this study, and \(\sum_{i=1}^{m} \left( \frac{Y_i}{Y} \right) I_{\text{inter}_i}\) represents the weighted average value of the internal differences of the three regions.

\[
Y_i = \sum_{j=1}^{3} Y_j \quad j \in i \quad i = 1, 2, 3
\]

\[
X_i = \sum_{j=1}^{3} X_j \quad j \in i \quad i = 1, 2, 3
\]

\[
I_{\text{inter}} = \sum_{i=1}^{m} \left( \frac{Y_i}{Y} \right) \ln \left( \frac{Y_i}{Y_j} \right)
\]

\[
I_{\text{inter}_i} = \sum_{j=1}^{3} \left( \frac{Y_j}{Y_i} \right) \ln \left( \frac{Y_j}{Y_i} \right)
\]

where \(i\) represents the studied region \((i = 1, 2, 3\) for the eastern, central and western regions, respectively); \(j\) represents the provinces in region \(i\); \(Y_i\) is the value of studied indicator (total economic value of recreational fisheries or per capita economic value of recreational fisheries).
in region $i$; $Y$ is the total value of the studied indicator in China. $X_i$ is the total population in $i$ region; and $X$ is the total population of the whole country; $y_j$ is the value of studied indicator in province $j$; $x_j$ is the human population size in province $j$.

3 | RESULTS

3.1 | General developmental trends in economic value

China’s recreational fisheries experienced rapid development between 2003 and 2018 (Figure 1). The total economic value of recreational fisheries in China increased by a factor of 16.7, from 5.4 billion Yuan in 2003 to 90.2 billion Yuan in 2018, an annual growth rate of 20.6%. Accordingly, the per capita economic value of recreational fisheries increased from 4.2 Yuan in 2003 to 64.7 Yuan in 2018.

Although the economic value of recreational fisheries in China grew sharply between 2003 and 2018, differences in regional development were evident (Table 1). Specifically, in 2003, Shandong Province had the highest economic value of 1.3 billion Yuan, whereas in Shanghai municipality, the region with the lowest economic value, it was 1300 times less at 0.001 billion Yuan. In 2018, Shandong Province still had the highest economic value of recreational fisheries (25.0 billion Yuan), but the lowest economic value of recreational fisheries (0.03 billion Yuan or 833 times lower) occurred in Gansu Province. In terms of the proportion of overall economic value among the 31 provinces in 2018, the top three provinces were Shandong, Hubei and Guangdong, respectively, accounting for 53.4%. By contrast, the provinces that comprised the bottom 20 in the ranking had an aggregate proportion of only 10.1% of the overall value (Figure 2).

Recreational fisheries developed rapidly at the provincial level in China between 2003 and 2018. In terms of the economic value of these recreational fisheries, the top ten provinces were Shandong, Hubei, Guangdong, Jiangsu, Liaoning, Sichuan, Anhui, Zhejiang, Jiangxi, Hunan, with annual growth rates of 21.5%, 27.0%, 36.0%, 28.2%, 13.7%, 11.2%, 31.6%, 17.8%, 21.8% and 31.6%, respectively. Furthermore, the per capita economic value of recreational fisheries in six provinces including Shandong, Hubei, Jiangsu, Liaoning, Guangdong, Jilin was higher than that of whole country in 2018, of which the per capita economic value of recreational fisheries in Shandong Province was 3.8 times higher than the national level of 64.7 Yuan (Table 1).

3.2 | Dynamic evolution analysis on the time axis

R software was used to perform KDE for the two indicators between 2003 and 2018 to analyse the dynamic evolution trend. The kernel density distributions from four different years (2003, 2008, 2013 and 2018) (Figures 3 and 4) showed several key features that are explained below.

In terms of the economic value of recreational fisheries (Figure 3) at the national level, the annual KDE distribution curves tended to shift progressively to the right between 2003 and 2018, indicating that the overall economic value of recreational fisheries across China was steadily rising. This shift to the right was most obvious when comparing 2018 with 2013, indicating that the economic value of grew more rapidly between 2013 and 2018. An analysis of the peak showed a change from a narrower spike shape to a broader shape between 2003 and 2018: the heights of the peaks successive showing a progressively downward trend, with the right tail gradually becoming more heavily extended, to exhibit a more polarised distribution as development became more spatially variable among the 31 provinces. There were three peaks, including one central peak and two right lateral peaks in 2018. The peak corresponding to the economic value of recreational fisheries, and these economic values varied widely among the three peaks, indicating that the phenomenon of multi-polarisation occurred in China’s recreational fisheries development. This suggests that the economic value of recreational fisheries is mainly concentrated at low and high levels in China.
At the regional level, the relative position of the curves of economic value moved gradually to the right in the eastern, central and western regions between 2003 and 2018, with a continuous decrease of crest height and an increasing horizontal width. The curves also all showed multimodal distribution. All the above changes in KDE indicated a gradually increasing level of economic value of recreational fisheries in the eastern, central and western regions, but gaps at the national level continued to widen over time and exhibited the phenomenon of polarisation. Based on an analysis of the rightward movement of the locations of the curves, it moved slightly to the right from 2003 to 2008 and continue to moved slightly to the right from 2008 to 2013, but moved substantially to the right from 2013 to 2018, especially for the central region. An analysis of the peak showed that the number of peaks in the year of 2003, 2008, 2013, 2018 were 3, 2, 2 and 3, respectively, for both eastern and western regions and 3, 2, 2 and 2, respectively, for central region (Figure 3).

In terms of the per capita economic value of recreational fisheries (Figure 4), at the national level, based on an analysis of the shape of the curves, the curve also tended to move to the right between 2003 and 2018, and the rightward shift of the locations of the curve was more obvious in 2018 than in 2013. The height of the peak in 2018 was much lower than that in the other three years and showed a broader shape, which indicated the distribution of the per capita economic value of recreational fisheries in the provinces tended to disperse. The curve transformed

| Regions | Provinces | Total economic value in 2018 (million Yuan) | Per capita economic value in 2018 (Yuan) | Annual growth rate of total economic value during 2003–2018 (%) |
|---------|-----------|---------------------------------------------|-----------------------------------------|-------------------------------------------------|
| Eastern | Shandong  | 24,989.0                                    | 248.7                                    | 21.5                                            |
|         | Guangdong | 10,580.3                                    | 93.3                                     | 36.0                                            |
|         | Jiangsu   | 10,431.6                                    | 129.6                                    | 28.2                                            |
|         | Liaoning  | 4513.0                                      | 103.5                                    | 13.7                                            |
|         | Zhejiang  | 2947.1                                      | 51.4                                     | 17.8                                            |
|         | Hebei     | 795.9                                       | 10.5                                     | 14.2                                            |
|         | Fujian    | 785.5                                       | 19.9                                     | 12.6                                            |
|         | Beijing   | 730.8                                       | 33.9                                     | 12.1                                            |
|         | Tianjin   | 381.6                                       | 24.5                                     | 26.7                                            |
|         | Hainan    | 130.6                                       | 14.0                                     | 26.5                                            |
|         | Shanghai  | 118.4                                       | 4.9                                      | 37.1                                            |
| Central | Hubei     | 12,650.6                                    | 213.8                                    | 27.0                                            |
|         | Anhui     | 3489.3                                      | 55.2                                     | 31.6                                            |
|         | Jiangxi   | 2556.1                                      | 55.0                                     | 21.8                                            |
|         | Hunan     | 2345.5                                      | 34.0                                     | 31.6                                            |
|         | Jilin     | 2116.2                                      | 78.3                                     | 38.3                                            |
|         | Henan     | 827.2                                       | 8.6                                      | 27.5                                            |
|         | Heilongjiang | 656.4                               | 17.4                                     | 0.2                                             |
|         | Shanxi    | 56.4                                        | 1.5                                      | 17.5                                            |
| Western | Sichuan   | 4501.9                                      | 54.0                                     | 11.2                                            |
|         | Chongqing | 1459.3                                      | 47.0                                     | 20.2                                            |
|         | Yunnan    | 1188.4                                      | 24.6                                     | 18.9                                            |
|         | Shaanxi   | 678.5                                       | 17.6                                     | 24.2                                            |
|         | Guangxi   | 468.0                                       | 9.5                                      | 26.3                                            |
|         | Inner Mongolia | 310.0                         | 12.2                                     | 31.0                                            |
|         | Guizhou   | 188.3                                       | 5.2                                      | 29.2                                            |
|         | Ningxia   | 167.3                                       | 24.3                                     | 26.2                                            |
|         | Xinjiang  | 134.0                                       | 5.4                                      | 21.8                                            |
|         | Gansu     | 28.1                                        | 1.1                                      | 21.5                                            |
|         | Tibet     | —                                            | —                                        | —                                                |
|         | Qinghai   | —                                            | —                                        | —                                                |

Note: The economic value of recreational fisheries in Tibet and Qinghai is too low and not counted in the fishery statistical yearbook.
in shape from a multimodal distribution pattern in 2003 into a bi-modal distribution pattern in 2018, exhibiting a more polarised tendency.

At the regional level, the relative positions of the curves of per economic value of recreational fisheries shifted towards the right in the eastern, central and western regions between 2003
and 2018, with a continuous decrease in crest height and an increasing horizontal width. The curves all showed a multimodal distribution pattern, similar to the evolution of economic values among the eastern, central and western regions. The relative positions of the curves shifted substantially to the right from 2013 to 2018, especially for the central region. The number of peaks in the years 2003, 2008, 2013 and 2018 was two for both eastern and central regions and 3, 2, 2 and 2, respectively, for western region (Figure 4).

3.3 Regional disparities among provinces in China's recreational fisheries development

The Gini coefficient of economic value showed large fluctuations with its peak value occurring in 2016, but the value of the Gini coefficient in 2018 was slightly smaller than that in 2003 (Figure 5). The Gini coefficient of the per capita economic value declined from 0.68 in 2003 to 0.60 in 2018.

The Theil index of the economic value gradually decreased from 2.25 in 2003 to its lowest value of 1.33 in 2012 and then slightly increased to 1.37 in 2018 (Figure 6). Similarly, the Theil index of the per capita economic value fell from 2.28 in 2003 to its lowest value of 1.19 in 2012 and rose moderately to 1.25 in 2018. According to the results of the Theil index decomposition, the overall difference in both the economic value and the per capita economic value primarily arose from the differences within each region, which accounted for more than 90% of the overall difference.

In terms of intra-regional differences in economic value of recreational fisheries, the within-region difference of the eastern region showed the greatest volatility, with values falling from 0.43 in 2003 to 0.35 in 2018 (Figure 7). The within-region values in the central region declined from 0.90 in 2003 to 0.53 in 2011, and slightly increased to 0.55 in 2018. By contrast, the within-region values of the western region gradually decreased from 0.87 in 2003 to 0.35 in 2018.

In terms of the differences of the per capita economic value within each region (Figure 7), the values within the eastern region
decreased from 0.54 in 2003 to 0.23 in 2018. The values within the central region declined from 1.06 in 2003 to the lowest value of 0.53 in 2011 and then slightly increased to 0.58 in 2018. Similarly, the values within the western region first decreased from 0.63 in 2003 to 0.27 in 2012 and gradually increased to 0.39 in 2018.

4 | DISCUSSION

This study provides a nationwide assessment of evolution of recreational fisheries in China. Participation in recreational fisheries has expanded rapidly in many developing countries in accordance with the expansion of the middle class (Gupta et al., 2015; Freire et al., 2016; FAO, 2017). Recreational fisheries also play an important role in supporting local communities of countries with developing economies (FAO, 2012; Holder et al., 2020). China has shown substantial growth in demand for leisure and recreational activities with its rising levels of income (Yu, 2016; Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2018). The economic value of recreational fisheries in China reached 90.2 billion Yuan in 2018, a rise of over 1500% from that in 2003. Recreational fisheries are the fastest developing sector among all fisheries industries and have become one of the most important economic sectors of fisheries in China. However, the phenomenon of imbalanced development of regional recreational fisheries is of concern and is reflected in the kernel density distributions of both total and per capita economic value of recreational fisheries and variations in the Theil index. The eastern, central and western regions of China all exhibited a polarised tendency in the development of their respective recreational fisheries. The development of regional recreational fisheries is inevitably related to the abundance of fisheries resources across the regions. However, with the continued imbalanced development of regional recreational fisheries between 2013 and 2018, the annual KDE
distribution curves of total fishery production do not show a right skewed distribution and an increasing horizontal width when comparing 2018 with 2013, indicating that gaps at the national level are stable over time (Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2019). Therefore, the abundance of fisheries resources may not be the key factor that causes the increasing regional inequality of recreational fishery development across provinces of China.

Indeed, the varying development status of recreational fisheries among different provinces is inextricably linked with policy support and market development (Liu & Jiang, 2019). The economic value of recreational fisheries in Shandong Province is highest among the 31 provinces in China. The government of Shandong has paid great attention to recreational fisheries development and is quite effective in its stipulation of policies that reinforce its recreational fisheries management. Specifically, the government has formulated a series of normative documents including guidance for the cultivation and development of recreational sea angling in 2013, interim measures for the management of recreational sea angling in 2014, interim measures for the pilot management of recreational sea angling boats in 2017 (Zhao et al., 2015; Shandong Provincial Oceanic & Fishery Department, 2017). In addition, the government of Shandong has issued policies to support better the development of recreational fisheries, such as combining recreational fisheries development with marine ranching, artificial propagation, release and enhancement, and other industrial policies (Zhao et al., 2015). By fully utilising cultural aspects together with the construction of beautiful countryside, recreational fisheries in Hubei Province have gradually integrated into a holistic leisure, vacation, sightseeing and entertainment experience for its citizens and tourists, and now Hubei Province has the second-highest economic value of recreational fisheries in China. Due to factors, including an underdeveloped economy, inadequate infrastructure, vast territory and low population density, recreational fisheries development in the western region of China falls far behind that in the eastern and central regions (Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2018). The development of the recreational fishing sector in the western region of China started relatively later than the eastern and central regions. However, some provinces in the western region, such as Sichuan, are expected to enter a period of rapid development in the future. Sichuan Province has a better development base for recreational fisheries than the other provinces in western region of China. By combining with its local rural tourism resources, the government of Sichuan has strengthened recreational fisheries planning and provided policy support for a potential recreational fishery base, which is anticipated to accelerate the development of its recreational fishing sector (Fishery Bureau of Sichuan Province, 2020; General Office of the People’s Government of Sichuan Province, 2020). To narrow the gap within each region, local municipal governments need to understand the value of returns from investing in developing their recreational fisheries and actively facilitate this through policy support. Meanwhile, provinces with well-developed recreational fisheries, such as Shandong Province in eastern China and Hubei Province in central China, should strengthen cooperation with other neighbouring provinces.

Recreational fisheries in China have generally developed smoothly through the joint efforts of various government and business initiatives, and have become one of the key economic sectors among China’s fisheries (Chai, 2008; Yu, 2016). However, recreational fisheries development among the 31 provinces in China is facing a series of challenges, including uncoordinated development, weak infrastructure facilities, lack of a deep cultural connection and unsound management mechanisms (Yang et al., 2017; Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2018). The supervision and management of recreational fisheries has lagged behind its commercial fisheries development. Recreational fisheries are a relevant and valuable sector of fisheries and need better governance and management (Arlinghaus et al., 2019; Potts et al., 2020).

Individuals and governments around the world value the conservation and sustainable use of recreational fisheries (Hughes, 2015). Many industrialised countries have already developed
comprehensive governance structures for recreational fisheries (e.g. USA, Canada and Australia). These include policies that outline the broad principles, fisheries laws and regulations relating directly to this fishing sector, while also identifying the organisations or structures that fulfil governance and management roles (Potts et al., 2020). Although compared with other industrialised countries, recreational fisheries in China are not considered to be managed effectively. Chinese governmental fishery agencies at both national and provincial levels are currently showing great interest in developing and properly managing recreational fisheries. Specifically, the Ministry of Agriculture and Rural Affairs of China (MARA) issued “guidance on promoting the sustainable and healthy development of recreational fishery” in 2012 and has implemented programmes for monitoring recreational fisheries since 2017. Further, many provinces and cities in China have formulated regulations and standards in recreational fishery-related fields, and some even release the development planning of recreational fisheries (Fisheries Bureau of the Ministry of Agriculture & Rural Affairs, 2018).

Countries that experience sustained economic growth and rising levels of income, such as China, have typically shown substantial growth in demand for leisure and recreational activities, and in demand for the resources and goods needed to satisfy these demands. Overall, recreational fisheries development in China is still at the initial stage, the economic contribution of recreational fisheries to total fisheries value is still relatively small at less than 5%. A great potential is yet to be tapped in terms of both the depth of the industrial chain and industry convergence. Below are some suggestions on facilitating the development of the recreational fishing sector as a sustainable, long-term and valuable contributor to the Chinese economy.

1. **Supportive policies and improved planning.** Generally, historical policy support and market development are the main causes of regional differences in China’s recreational fisheries economy. It is critical to strengthen policy guidance to support and encourage the development of multicultural recreational fisheries. Appropriate allocation of funds should be devoted to investment subsidies and loan interests should be focused on recreational fisheries projects to support their development. Planning is an effective way to avoid scattered construction of infrastructure. Combining the infrastructure construction plan with tourist development will help to establish a comprehensive base for the gradual integration of recreational fisheries with leisure, vacation, sightseeing and entertainment activities.

2. **Strengthening the supervision and management of recreational fisheries.** With the growing economic, socio-cultural and ecological importance of recreational fisheries, there is a need to increase effort to build effective governance arrangements. Monitoring systems should be put in place to evaluate the effects of the regulations on fish stocks targeted by recreational fishers or even their levels of compliance. In addition to management measures and monitoring programmes conducted at the national level, local governments are encouraged to establish coordination mechanisms for recreational fisheries management and also form clear, rational and efficient coordination mechanism and monitoring systems.

3. **Strengthening brand building and improving facilities construction.** Increasing brand publicity using emerging media such as social media and hosting fishery festivals for fishing culture will expand the influence of recreational fisheries. In addition, deep tapping the local cultural resources and increasing the heterogeneity of recreational fisheries products and services will have positive outcomes. In addition, the infrastructure in many fishing ports and fishing villages of China is too poor to provide services. Strengthening the construction of high-quality breeding bases, restaurants and other facilities consistent with local resources will contribute to the sound and fast development of recreational fisheries.

4. **Strengthening the training of professional talents and employees of recreational fisheries.** Many front-line recreational fisheries employees in China come from traditional capture or aquaculture fisheries and lack the professional skills necessary to operate competently and effectively in recreational fisheries operations. In addition, talents among the recreational fisheries industry sector related to management, operation, marketing, scientific research and service are seriously lacking. It is of vital importance to improve the professional qualities of recreational fisheries sector employees and cultivate a host of recreational fisheries leaders and management talents, thereby boosting the rapid and sustainable development of the recreational fisheries.

5 | **CONCLUSION**

The Chinese government has attached great importance to recreational fisheries development, especially in the past ten years. However, limited research has been conducted on the quantification of regional differences in the development of China’s recreational fisheries. Within this context, this study used a series of techniques, including Kernel density estimate, Gini coefficient and Theil index to illustrate the provincial differences and regional disparities in China’s recreational fisheries economy. Results showed that China’s recreational fisheries have experienced a rapid development with an annual economic growth rate of 20.6% between 2003 and 2018, but the gaps among regions had gradually increased and the eastern, central and western regions of China all exhibited a polarised tendency. According to the results of the Theil index decomposition, the overall difference in China’s recreational fisheries economy mostly came from the differences between provinces within each region, which accounted for over 90% of the overall difference. To promote the sustainable development of recreational fisheries in China, it is of great importance to focus government effort in the following areas: supportive policies and improved planning, strengthening the supervision and management of recreational fisheries, strengthening brand building and
improving facilities construction, strengthening the training of professional talents and employees of recreational fisheries.

ACKNOWLEDGMENTS

This work was supported by the Major Science and Technology Innovation Projects of Shandong Province (2018SDKJ0501-1), the National Natural Science Foundation of China (Grant No. 31872692), the Special Funds for Taishan Scholars Project of Shandong Province (2018SDKJ0501-1), the Innovation Team of Shandong Province (2018SDKJ0501-1), the Innovation Team of the National Natural Science Foundation of China (Grant No. U20A2051). We also thank two anonymous reviewers for constructive comments that improved this manuscript.

REFERENCES

Aas, Ø., Arlinghaus, R., Ditton, R.B., Policansky, D. & Schramm, H.L. Jr (2008) Global challenges in recreational fisheries. Oxford: Blackwell Publishing.

Arlinghaus, R., Abbott, J.K., Fenichel, E.P., Carpenter, S.R., Hunt, L.M., Alós, J. et al. (2019) Opinion: Governing the recreational dimension of global fisheries. *Proceedings of the National Academy of Sciences*, 116(12), 5209–5213. https://doi.org/10.1073/pnas.1902796116

Arlinghaus, R., Tillner, R. & Bork, M. (2015) Explaining participation rates in recreational fishing across industrialised countries. *Fisheries Management and Ecology*, 22, 45–55. https://doi.org/10.1111/fme.12075

Bhattacharya, J. & Sinha, A. (2016) Inequality in per capita water availability: a Theil’s second measure approach. *Desalination and Water Treatment*, 57, 136–144. https://doi.org/10.1080/19443994.2015.1006818

Brownscombe, J.W., Hyder, K. & Potts, W. (2019) The future of recreational fisheries: Advances in science, monitoring, management, and practice. *Fisheries Research*, 211, 247–255. https://doi.org/10.1016/j.fishres.2018.10.019

Chai, S. (2008) *Theory and practice: a study on the development of the leisure fishery*. Ph.D Thesis, Ocean University of China.

Cooke, S.J., Twardek, W.M., Lennox, R.J., Zoldero, A.J., Bower, S.D., Gutowsky, L.F.G. et al. (2018) The nexus of fun and nutrition: Recreational fishing is also about food. *Fish and Fisheries*, 19, 201–224. https://doi.org/10.1111/faf.12246

Drezner, T., Drezner, Z. & Guyse, J. (2009) Equitable service by a facility: Minimizing the Gini coefficient. *Computers & Operations Research*, 36, 3240–3246. https://doi.org/10.1016/j.cor.2009.02.019

Edge, M.D., Algee-Hewitt, B.F.B., Pemberton, T.J., Li, J.Z. & Rosenberg, N.A. (2017) Linkage disequilibrium matches forensic genetic records to disjoint genomic marker sets. *Proceedings of the National Academy of Sciences*, 114, 5671–5676. https://doi.org/10.1073/pnas.1619944114

FAO. (2012) *Recreational fisheries*. FAO Technical Guidelines for Responsible Fisheries. No. 13. Rome.

FAO. (2017) *Globefish Highlights – A quarterly update on world seafood market April/2017*. Issue. Rome.

FAO. (2018) *The state of world fisheries and aquaculture 2018 - Meeting the sustainable development goals*. Rome.

Fisheries Bureau of the Ministry of Agriculture and Rural Affairs. (2018) 2018 China recreational fisheries development report. *China Fisheries*, 12, 20–30.

Fisheries Bureau of the Ministry of Agriculture and Rural Affairs. (2019) *China fisheries statistical yearbook 2019*. Beijing: China Agricultural Press.

Fishery Bureau of Sichuan Province. (2020) Notice on the issuance of the 13th Five-Year Plan of fishery development in Sichuan Province. Available from http://www.scsccj.cn/a/xingzhengwenjian/tongzihigonggao/20170509/1163.html [Accessed 20th June 2020].

Freire, K.M., Belhabib, D., Espedido, J.C., Hood, L., Kleisner, K.M., Lam, V.W. et al. (2020) Estimating global catches of marine recreational fisheries. *Frontiers in Marine Science*, 7, 12. https://doi.org/10.3389/fmars.2020.00012

Freire, K.M., Tubino, R.A., Monteiro-Neto, C., Andrade-Tubino, M.F., Belruss, C.G., Tomás, A.R.G. et al. (2016) Brazilian recreational fisheries: Current status, challenges and future direction. *Fisheries Management and Ecology*, 23, 276–290. https://doi.org/10.1111/fme.12171

General Office of the People’s Government of Sichuan Province. (2017). Opinions on accelerating the development of modern fishery industry. Available from: http://www.sc.gov.cn/zwjw/xgk/NewT.asp?i=20171101165234-361111-00-000 [Accessed June 17, 2020].

Gupta, N., Bower, S.D., Raghavan, R., Danylchuk, A.J. & Cooke, S.J. (2015) Status of recreational fisheries in India: Development, Issues, and Opportunities. *Reviews in Fisheries Science & Aquaculture*, 23(3), 291–301. https://doi.org/10.1080/23308249.2015.1052366

Holder, P.E., Jeanson, A.L., Lennox, R.J., Brownscombe, J.W., Arlinghaus, R., Danylchuk, A.J. et al. (2020) Preparing for a changing future in recreational fisheries: 100 research questions for global consideration emerging from a horizon scan. *Reviews in Fish Biology and Fisheries*, 30, 137–151. https://doi.org/10.1007/s11160-020-0959-y

Hughes, R.M. (2015) Recreational fisheries in the USA: economics, management strategies, and ecological threats. *Fisheseries Science*, 81, 1–9. https://doi.org/10.1007/s12562-014-0815-x

Liu, B., Xu, M., Wang, J. & Xie, S. (2017) Regional disparities in China’s marine economy. *Marine Policy*, 82, 1–7. https://doi.org/10.1016/j.marpol.2017.04.015

Liu, G. & Jiang, J. (2019) The influencing factors of the operation effect of leisure fisheries: retrospective and prospect. *Chinese Fisheries Economics*, 37, 26–33.

Nowak, M.A. (2006) *Evolutionary dynamics: Exploring the equations of life*. Cambridge, MA: Belknap Press of Harvard University Press.

Pennino, M.G., Bellido, J.M., Conesa, D., Coll, M. & Tortosa-Ausina, E. (2017) The analysis of convergence in ecological indicators: An application to the Mediterranean fisheries. *Ecological Indicators*, 78, 449–457. https://doi.org/10.1016/j.ecolind.2017.03.041

Pita, P., Hyder, K., Gomes, P., Pita, C., Rangel, M., Veiga, P. et al. (2018) Economic, social and ecological attributes of marine recreational fisheries in Galicia, Spain. *Fisheries Research*, 208, 58–69. https://doi.org/10.1016/j.fishres.2018.07.014

Potts, W.M., Downeybreedt, N., Obregon, P., Hyder, K., Bealey, R. & Sauer, W.H.H. (2020) What constitutes effective governance of recreational fisheries—A global review. *Fish and Fisheries*, 21, 91–103. https://doi.org/10.1111/faf.12417

Shandong Provincial Oceanic and Fishery Department. (2017) Interim measures for the pilot management of recreational sea angling boats. Available from http://www.shandong.gov.cn/art/2017/9/5/art_2259_27061.html [Accessed 1st June 2020].

Silverman, B.W. (1986) *Density estimation for statistics and data analysis*. London: CRC Press.

Theil, H. (1967) *Economics and information theory*. Amsterdam: Horth-Holland.
Yu, K. (2016) Yu Kangzheng: recreational fisheries in China have ushered in a golden period of development. *China Fisheries*, 11, 3–7.

Yu, W. & Zhou, W. (2018) Spatial pattern of urban change in two Chinese megaregions: Contrasting responses to national policy and economic mode. *Science of The Total Environment*, 634, 1362–1371. https://doi.org/10.1016/j.scitotenv.2018.04.039

Zhao, X., Xu, L., Luo, G. & Zhao, J. (2015) The development of recreational fishery in Shandong Province is in the ascendand. *China Fisheries*, 6, 16–19.

How to cite this article: Ding Q, Shan X, Jin X, Gorfine H, Wang Y. Dynamic evolution analysis of recreational fisheries development in China. *Fish Manag Ecol*. 2021;28:305–316. https://doi.org/10.1111/fme.12475