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EDITED BY
Sebastian Villasante,
University of Santiago de Compostela, Spain

REVIEWED BY
Kui Zhang,
South China Sea Fisheries Research Institute, (CAFS), China
Chongliang Zhang,
Ocean University of China, China

*CORRESPONDENCE
Xiujuan Shan
shanxj@ysfri.ac.cn

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Achieving greater equity in allocation of catch shares: A case study in China

Qi Ding[1,2,3], Xiujuan Shan[1,2,3]*, Xianshi Jin[1,2,3] and Harry Gorfine[4]

[1]Key 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, [2]Function Laboratory for Marine Fisheries Science and Food Production Processes, Pilot National Laboratory for Marine Science and Technology (Qingdao), Qingdao, China, [3]National Observation and Research Station for Fishery Resources in Changdao, Shandong, Yantai, China, [4]School of Biosciences, The University of Melbourne, Parkville, VIC, Australia

The allocation of catch shares among fishing entities is a key element of a total allowable catch control system. Current allocation schemes fall short in their ability in terms of ensuring fairness and feasibility and there is much scope for improvement. In this study, a new allocation method based on applying a relative deprivation coefficient is introduced into the allocation of catch shares, and demonstrated in a case study involving the 11 coastal provinces in China. Advantages of this process of quota allocation in comparison with well-established allocation methods were investigated. Compared with the conventional single-criterion approach and simple multi-criteria-based allocation with equal weights, the new allocation scheme integrating the new weighting method with multi-criteria allocation showed superior performance in rendering the outcomes in catch shares allocation fairer and more reasonable, with a Gini coefficient below 0.2. Quota proportions for the 11 coastal provinces under the newly developed allocation scheme were between maximum and minimum ratios of those under schemes using a single-criterion, which shows strong utility in reducing the rigidity of a single-criterion allocation approach and improving the acceptability of the allocation results. This study offers a viable yet fairer alternative for facilitating sustainable fisheries *via* quota management and provides a reference for fisheries policy makers in equitably allocating catch shares.

KEYWORDS

total allowable catch system, multi-criteria allocation, relative deprivation coefficient, Gini coefficient, quota management

1 Introduction

Food security, social well-being and economic prosperity of coastal communities can be highly dependent on sustainable marine fisheries (McClanahan et al., 2015; Asche et al., 2018; FAO, 2022). Output controls such as Total Allowable Catch (TAC) provide a direct method for curbing fishing mortality to maintain biomass at levels where population recruitment is not impaired (Liu et al., 2016). TACs can take the form of tradeable shares of a variable quota owned by individuals and corporations. However, a problem common to all catch shares programs is how to determine the initial allocation of quota among fishing entities.

Reliance on a legacy of historical catch records is the most frequently used means for initial quota allocation when transitioning to a catch shares system. Lynham (2014) reports that among fisheries in the global database 91% employed this method to proportionately allocate a TAC, with sole reliance on historical records in 54% of the world's main catch share fisheries. However, issuing shares based on a legacy of prior involvement is by no means the only option. Bailey et al. (2013) point out the lack of success in delivering sustainable outcomes with this allocation method because participants who stand to benefit financially are inclined to force delays on implementation until production and catching capacity have risen to ecologically harmful levels.

Establishing a fair and reasonable initial allocation scheme for catch shares is an important precept for ensuring TAC systems are effective (Plummer et al., 2012; Severance, 2014; Bellanger et al., 2016). Applying multiple criteria is likely advantageous compared with using a single criterion when allocating catch shares because it is often more readily accepted by participants and simplifies decisions through its integration of diverse information. A more agile system of weighted metrics reviewed annually avoids the rigidity of predetermined allocation outcomes, which can deliver greater benefits compared with a system reliant on personal catch histories (Seto et al., 2021).

Currently, many Regional Fisheries Management Organizations (RFMOs) have outlined the principles of equity, citizenship, and legitimacy to guide allocation. Specifically, equity relates to access to employment and social welfare, citizenship enshrines the rights of those contributing cooperatively to resource management, and legitimacy recognizes those with a long-standing involvement in the fishery. However, different criteria may incur various allocation outcomes, and different fishing entities prefer to choose and adopt criteria that are most beneficial for them as individuals, often resulting in the various fishing entities being unable to reach consensus on a proposed multi-criteria allocation scheme (Seto et al., 2021). In practice, there has been an absence of these principles from the process for allocating access to fish resources. Clearly, a suitable process for promoting sustainability through the issuance of catch shares, has yet to become established more generally for fisheries. Constructing an improved multi-criteria allocation method to increase its feasibility is necessarily required for effective catch shares programs. However, catch shares allocation schemes have not yet been thoroughly investigated in this regard.

China having the greatest number of fishers and fishing vessels worldwide lands the largest fish catch of any nation (China Daily, 2017; Huang and He, 2019; Zhang et al., 2020). Persistently high fishing pressure has resulted in abrupt declines in stock abundance in China's major fishing grounds. This has disrupted ecological relationships as fishing has progressively targeted species of lower trophic status as higher order species have depleted (Cao et al., 2017; Szuwalski et al., 2017; Su et al., 2020). Marine fisheries management in China has in recent years sought to strengthen its strict input control with the addition of output control (Su et al., 2021; Zhang et al., 2022). To build an output control system, an initial allocation of catch shares among fishing entities is fundamental. This has challenged policy-makers deliberating over the best way to allocate catch quotas among China's coastal fishing provinces to achieve the total allowable catch target.

This study explores options for the allocation of catch shares in China. Instead of conventional allocation approaches such as using catch histories as a basis for allocation, this study builds improved allocation methods to increase both fishing entities' acceptance and equity. Furthermore, to demonstrate the advantages of the new allocation method, a comparative analysis of the allocation schemes proposed in the study is conducted. It is anticipated that the scheme developed in this study will better facilitate sustainable fishing and provide a reference for effective and equitable allocation of catch shares.

2 Materials and methods

A comparative analysis of different allocation schemes was undertaken with data acquired from the China Fishery Statistical Yearbook 2018–2022 (Fisheries Bureau of the Ministry of Agriculture and Rural Affairs, 2018; Fisheries Bureau of the Ministry of Agriculture and Rural Affairs, 2019; Fisheries Bureau of the Ministry of Agriculture and Rural Affairs, 2020; Fisheries Bureau of the Ministry of Agriculture and Rural Affairs, 2021; Fisheries Bureau of the Ministry of Agriculture and Rural Affairs, 2022). Results were generated from applications of three single-criterion allocation approaches and an alternative multi-criteria allocation method in this study, using an identical dataset.

2.1 The allocation of catch shares using the single-criterion approach

Based on existing studies, three criteria including legitimacy, equity, and citizenship are adopted in this study for catch shares allocation. The specific indicators for each of the three criteria are as follows:

2.1.1 An allocation scheme based on legitimacy

The legitimacy principle is built upon the cumulative historical domestic catch from 2017 to 2021 according to the latest available data. The details are as follows:

$$Q_i^1 = \frac{\sum_{t=2017}^{2021} C_{it}}{\sum_{i=1}^{11}\sum_{t=2017}^{2021} C_{it}}$$

where Q_i^1 (i=1, 2, 3, …, 11) is the quota proportion obtained by province i with the legacy approach; C_{it} is the domestic marine catches of province i in year t.

2.1.2 An allocation scheme based on equity

The equity principle is expressed by the accumulated number of professional marine fishers from 2017 to 2021. The quota proportion (Q_i^2) for province i can be obtained by:

$$Q_i^2 = \frac{\sum_{t=2017}^{2021} F_{it}}{\sum_{i=1}^{11}\sum_{t=2017}^{2021} F_{it}}$$

where F_{it} is the number of professional marine fishers of province i in year t.

2.1.3 An allocation scheme based on citizenship

Fisheries resources in many countries such as China are under severe pressure. Reducing fishing capacity to appropriate levels is crucial in achieving sustainable fisheries goal (Yu and Yu, 2008; Zhao and Jia, 2020). This study develops an allocation method that integrates the conventional legacy approach based on individual catch histories with an efficiency index to create incentives to reduce fishing pressure, and uses it as a proxy for citizenship principle for quota allocation. To be specific,

$$Q_i^3 = \frac{\sum_{t=2017}^{2021}(C_{it} * CPUE_{it})}{\sum_{i=1}^{11}\sum_{t=2017}^{2021}(C_{it} * CPUE_{it})}$$

where Q_i^3 is the quota proportion for i province. $CPUE_{it}$ is the catch per unit of effort (t/kW) of province i in year t.

2.2 A composite indictor construction method

A common problem in the multi-criteria-based allocations is how to determine the weight of each index. In this study, a new weighting method utilizing a relative deprivation coefficient is introduced into the allocation of catch shares, reflecting the requirements of perceived fairness among the fishing entities. The main difference between this new allocation method and the existing methods is that existing single or multi-criteria approaches can only support one allocation scheme prone to rigidity. In contrast, under the newly developed allocation scheme, each of the fishing entities can adopt a different weighting scheme according to their preferences about the criteria, which is actually a "one fishing entity, one allocation scheme", which satisfies the requirement for perception of fairness among all fishing entities. Figure 1 provides a flowchart of the allocation procedure used.

2.2.1 Measuring perceived fairness of the allocation based on coefficient of relative deprivation

According to the concept of relative deprivation defined by Runciman (1966) and the computational formula for a relative deprivation coefficient proposed by Yitzhaki (1979); assuming group X=(x_1, x_2, …, x_j), j is the number of samples (here j equals to 11), x_i and x_s are the individual i and s in group X. In terms of individual i, feelings of relative deprivation would arise when x_i<x_s. To be specific,

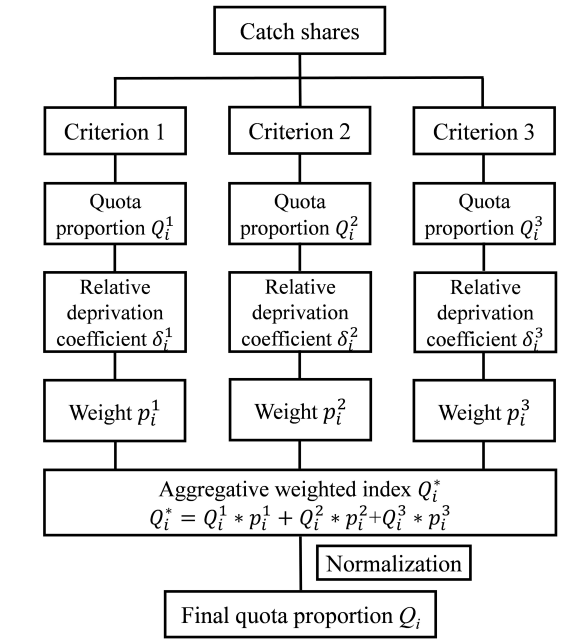

FIGURE 1
Flowchart of the allocation procedure under the multi-criteria comprehensive weighted scheme based on a relative deprivation coefficient.

$$d_{is} = \begin{cases} x_s - x_i \ ,if \ \ x_i < x_s \\ 0 \quad\ \ ,if \ \ x_i \geq x_s \end{cases}$$

The relative deprivation coefficient δ of x_i relative to group X is calculated by the following equation:

$$d(x,\ x_i) = \sum_{s=1}^{j} d_{is}/(j \star x_i)$$

2.2.2 Determining the weights based on coefficient of relative deprivation

Based on the calculation of a relative deprivation coefficient, the sense of deprivation of fishing entity i under a certain criterion is high when the value of the relative deprivation coefficient is large. Therefore, to improve the perception of fairness, a smaller weight should be assigned to this criterion (Wu et al., 2021). In contrast, a larger weight would be given in instances which have a small value of the relative deprivation coefficient. In terms of the multi-criteria allocation scheme based on perceptual fairness, the weights should be inversely associated with the relative deprivation coefficient (Wu et al., 2021). Therefore, the weight function is constructed as follows: (i) p_i^k is the weight of criterion k for i province, and $\sum_{k=1}^{3} p_i^k = 1$; (ii) δ_i^k is the relative deprivation coefficient of criterion k for i province, and the mapping relation of weights function $p_i^k = f(\delta_i^k)$ should satisfy the following equations including $dp/d\delta<0$ and $p_i^k \subset [0, 1]$. In this study, we calculated the weights using the probability functions. To be specific,

$$p = f(\delta) = \frac{1}{1 + e^{\delta}}$$

$$p_i^k = \frac{f(\delta_i^k)}{\sum_{k=1}^{3} f(\delta_i^k)}$$

And then quota proportion $Q_i^{\star}$ for province i can be obtained by:

$$Q_i^{\star} = \sum_{k=1}^{3} Q_i^k p_i^k$$

Lastly normalize $Q_i^{\star}$ to get the final quota proportion Q_i:

$$Q_i = \frac{Q_i^{\star}}{\sum_{i=1}^{11} Q_i^{\star}}$$

2.3 Gini coefficient in catch shares allocation system

As a powerful tool to examine the equality of income distribution in an economic system, the Gini coefficient method has been widely used to quantify the inequality in the allocation of environmental resources (Yuan et al., 2017; Ma et al., 2020; He and Zhang, 2021). The Gini coefficient ranges from 0 to 1. A small Gini coefficient means a higher level of equality, and 0.4 has been regarded as the warning line of impending inequity risk. To apply the Gini coefficient to the allocation of catch shares, we replaced human population and income with the number of professional marine fishers in 2021 and allocated catch shares respectively and calculate the corresponding Gini coefficient. According to Kong et al. (2019), the calculation process of the Gini coefficient is simplified as follows:

$$G = \frac{S_A}{S_A + S_B} = \frac{S_A}{0.5} = 2S_A = 1 - 2S_B$$

$$S_B = \sum_{i=1}^{11} \frac{(X_i - X_{i-1})(Y_i + Y_{i-1})}{2}$$

Where S_A represents the area between the Lorenz curve and the straight "absolute equality line", S_B is the area under the Lorenz curve, S_A+S_B=0.5, X_i represents the cumulative share of fishers up to province i, $X_0 = 0$; Y_i refers to the cumulative proportion of catch quotas up to province i, $Y_0 = 0$; and G is the Gini coefficient for the equality evaluation of allocation results, which can be calculated by:

$$G = 1 - \sum_{i=1}^{11} (X_i - X_{i-1})(Y_i + Y_{i-1})$$

3 Results

3.1 Allocation results using the single-criterion approach

As is shown in Figure 2, the three single-criterion allocations gave rise to diverse results. When a legitimacy criterion was applied, the top three provinces were Zhejiang (27.35%), Shandong (16.77%), and Fujian (16.05%), followed by Guangdong, Hainan, Guangxi, Liaoning, and Jiangsu with catch shares proportions of 12.20%, 10.49%, 5.31%, 4.95%, and 4.51%, respectively. Catch shares proportions were lowest in Hebei, Tianjin and Shanghai, with respective values of 1.98%, 0.27%, and 0.12%.

When an equity criterion was applied, Guangdong, Fujian, Liaoning, Jiangsu, Hebei, and Shanghai had much higher catch shares proportions compared with those obtained from application of the other two single-criterion allocations, with catch shares proportions of 20.84%, 18.29%, 11.08%, 4.95%, 2.73% and 0.33%, respectively. In contrast, when a citizenship criterion was applied, Shandong had much higher catch shares

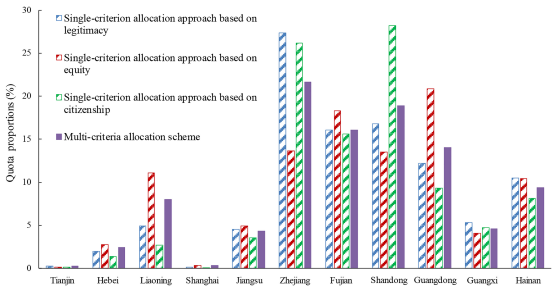

FIGURE 2
Allocation results under the different schemes.

proportions amongst the three single-criterion approaches, with a catch shares proportion of 28.20%.

3.2 Weights of criteria determined by relative deprivation coefficient

This study obtained the weights of selected criteria in the multi-criteria allocation scheme based on the relative deprivation coefficient. The weights of criteria for each province were determined by their different preference for the three selected criteria, which can effectively avoid the drawbacks of a one-size-fits-all approach. Specifically, in terms of Tianjin, applying the criterion of legitimacy was the most advantageous, having the lowest value of relative deprivation coefficient amongst the three criteria. In contrast, the values of relative deprivation coefficient for the three criteria including legitimacy, equity, and citizenship in Hebei were 3.76, 2.50, and 5.61, with corresponding weights of 0.22, 0.74, and 0.04, respectively. However, adopting the criterion of citizenship was the most advantageous to Shandong, and the relative deprivation coefficient was equal to zero. The distribution of weights across criteria reflected the preferences of fishing provinces, which increased both the acceptability and the practical value of the allocation scheme. The relative deprivation coefficients and weights of the three criteria for the 11 fishing provinces are shown in Table 1.

3.3 Allocation results using the multi-criteria approach

Based on the weights of the three criteria listed in Table 1, this study obtained catch shares proportions for the 11 coastal provinces derived using the multi-index based method (Figure 2). The ranking from high to low was Zhejiang, Shandong, Fujian, Guangdong, Hainan, Liaoning, Guangxi, Jiangsu, Hebei, Shanghai, and Tianjin provinces, with corresponding ratios of 21.67%, 18.90%, 16.07%, 14.01%, 9.40%, 8.03%, 4.60%, 4.31%, 2.42%, 0.32% and 0.26%, respectively. Quota proportions for the 11 coastal provinces under the multi-criteria approach lay between the maximum and minimum ratios of those under the schemes using a single-criterion, effectively reducing the rigidity of the single-criterion allocation approach (resulting in very low or very high values of catch shares proportions).

3.4 A comparative analysis of the equality of allocation results

The equality of allocation results generated by different allocation schemes were measured by the Gini coefficient method. Figure 3 presents the Lorenz curves of the catch shares allocation results derived from the three single criterion allocation schemes and one multi-criteria approach.

TABLE 1 Relative deprivation coefficients of the three criteria and corresponding weights under the multi-criteria allocation scheme.

Provinces	Relative deprivation coefficient			Weight		
	Legitimacy	Equity	Citizenship	Legitimacy	Equity	Citizenship
Tianjin	33.06	73.48	56.40	1	0	0
Hebei	3.76	2.50	5.61	0.22	0.74	0.04
Liaoning	1.07	0.18	2.60	0.33	0.58	0.09
Shanghai	73.27	26.23	167.36	0	1	0
Jiangsu	1.24	1.07	1.82	0.36	0.41	0.22
Zhejiang	0	0.08	0.01	0.34	0.32	0.34
Fujian	0.07	0.01	0.13	0.33	0.34	0.32
Shandong	0.06	0.08	0	0.33	0.33	0.34
Guangdong	0.18	0	0.41	0.34	0.37	0.29
Guangxi	0.96	1.42	1.24	0.40	0.28	0.32
Hainan	0.26	0.22	0.52	0.35	0.36	0.30

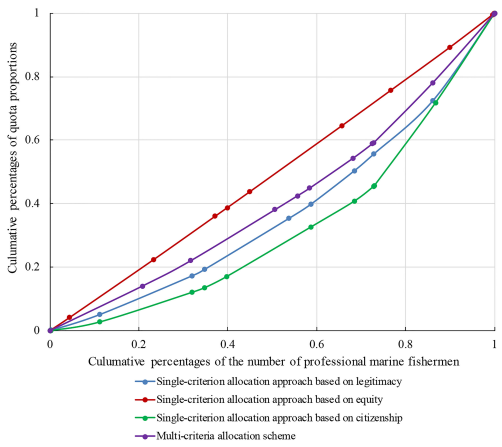

FIGURE 3
The Lorenz curves of allocation results derived from the schemes using single-criterion and multi-criteria allocation approaches.

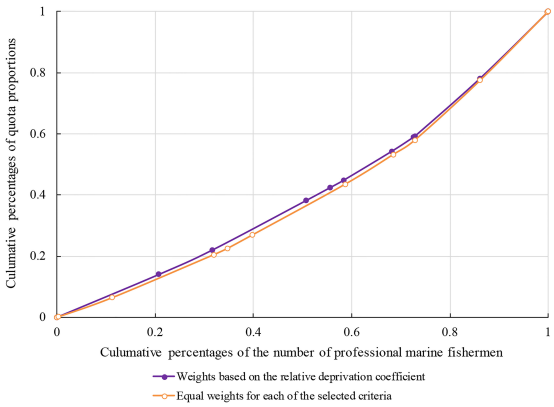

FIGURE 4
The Lorenz curves of allocation results under the multi-criteria-based allocations.

Unsurprisingly, the Gini coefficients of the allocation results derived from the scheme that solely considered the equity criterion had the smallest Gini coefficient among the four schemes, with the curve above those generated by the other three schemes. It's worth noting that the Gini coefficient is below 0.2 under the multi-criteria approach, indicating a high equality distribution interval. In contrast, the Gini coefficients for the schemes that exclusively considered either legitimacy or citizenship were 0.25 and 0.35, respectively.

To illustrate the advantages of the newly developed weighting method in improving the equality of allocation results in the multi-criteria-based allocations, we compared two scenarios under the multi-criteria allocation schemes, as follows: (1) determination of the weight of each index based on the relative deprivation coefficient; and (2) equal weights for each of the selected principles. The scenario analysis resulted in small changes to the Gini coefficients as shown in Figure 4. The Gini coefficient of the scheme based on the relative deprivation coefficient was smaller than that based on the equal weights method.

4 Discussion

Among the many challenges which confront governing the exploitation of a common pool resource, the allocation of access entitlements is fundamental (Ostrom, 1990; Ostrom, 2003). To date, most catch share programs appear to have relied heavily on the principle of historical catch in determining allocations, but also recognize, in different ways, that this single criterion is not the most effective and equitable strategy (Cox, 2009; Bailey et al., 2013). This study initially conducted a comparative analysis of different allocation approaches of catch shares, our analysis suggested that quota proportions for the 11 coastal provinces vary widely under the three single-criterion approaches, which may face challenges in their practical feasibility. When the single criterion approach which analyzed legitimacy, equity, and citizenship criteria separately was applied, provinces that obtained the largest quota proportions among the 11 coastal provinces were Zhejiang, Guangdong, and Shandong, respectively. Different provinces have diametrically opposed preferences depending on the allocation criterion in each instance. In contrast, the newly developed allocation scheme shows strong utility in addressing the problems of rigidity which have existed in single-criterion approaches, thus facilitating a substantial improvement the practicality of ensuring fairness in sustainable resource allocation.

Allocation models with multiple weighted criteria would facilitate the quantitative incorporation of multiple principles that have historically been under-represented and may offer alternative allocation possibilities that could improve the management of fish resources (Bailey et al., 2013). Weight determination is one of the most significant steps in a multi-criteria allocation scheme. Compared with the conventional multi-criteria allocation scheme based on an equal weights method, the improved catch shares allocation scheme incorporated not only a multi-criteria system but also requirements for perceptual fairness among the fishing entities participating in the allocation scheme, thereby increasing the equity and feasibility of multi-criteria-based allocations. Our analysis suggests that the new allocation scheme will ensure a

more equitable distribution of catch shares among China's coastal fishing provinces, with the Gini coefficient below 0.2.

Overfishing has been a problem facing China since the early 1990s (Zheng et al., 2021) and overcapacity is one of the leading causes of this problem (Han, 2018; Liu, 2019). To achieve sustainable development of the marine fishing industry in China, excess fishing capacity must be addressed through a timely reduction in the number of fishing vessels operating in marine waters (Wang, 2019; Zheng et al., 2021). Domestic fishery management in China is stepping into a new era of output control (Su et al., 2021). Establishing a fair and reasonable allocation scheme for catch shares is an important requisite for China's implementation of an output control system. However, current allocation schemes based on catch histories have not provided the right incentive structure to eliminate overcapacity, leaving much scope for improvement. In this study, an improved catch shares allocation scheme has been developed which places consideration on creating incentives to eliminate overcapacity. Provinces with higher CPUE, such as Shandong Province which has the highest among the 11 coastal provinces, would have higher quota proportions.

The newly developed allocation scheme satisfies simultaneously both individual perceptions of fairness and overall equity, thereby contributing to consensus on catch shares allocation among fishing entities. Instead of setting the weights to zero or one under single-criterion approaches, each province determines the values of the weights for different criteria between zero and one according to its preference under the newly developed allocation scheme, thereby increasing both fairness and feasibility of the allocations. In addition, the proposed method in quota allocation has great advantages in terms of future compatibility. Although only three indicators are incorporated into the multi-criteria allocation scheme in this study, more indicators could be added upon the specific needs. This concept paves the way for further research in formulating fairer and more reasonable allocation schemes for catch shares.

Based upon the main findings of this study, the following policy implications are proposed. First, when policy makers in China allocate catch shares among different provinces, they should not only consider historical catch as a legacy criterion, as this explicitly ignores motivators of fisher behavior and fails to elucidate tradeoffs among policy decisions. Allocating catch shares should be a consistent practice which is applied flexibly but equitably with changing circumstances. Although by integrating multiple indicators from different perspectives the multi-criteria decision analysis model can make the outcomes more reasonable, it may become highly contentious during the implementation process on account of the different preferences among the fishing provinces for the allocation criteria. Hence, the proposed allocation scheme integrating the new weighting method with multi-criteria allocation not only renders the outcomes fairer and more reasonable in catch shares allocation but also increases the likelihood of acceptability.

Second, this study focused on the allocation method of catch shares, however, setting scientifically based catch limits is also an indispensable part of TAC systems (Emery et al., 2014). Annual maximum allowable catch in China is approximately 8–9 million tonnes (China National Radio, 2016). However, domestic marine catches in China reached 9.3 million tonnes in 1994, and the actual exploitation of fishing resources has long exceeded the maximum allowable catch (Fisheries Bureau of the Ministry of Agriculture and Rural Affairs, 1995). Further reduction of fishing capacity is needed considering that problems of overcapacity and depleted fisheries stocks continue to pose a serious threat to marine ecosystems in China. Occupational transfer of marine fishers to other industries is a vital measure that can contribute substantially to fishing effort reduction (China Fisheries News, 2017; Zhao and Jia, 2020), thus serious attempts should be made to implement effective transfer programs across the 11 coastal provinces. In particular, policy options including providing greater financial investment in boosting onshore employment opportunities for former fishers augmented by enhancing training programs should be considered. Meanwhile, the government could increase policy support and financial input for the development of marine ranching and recreational angling, which have been playing vital roles in helping to protect fisheries ecosystems, conserve fish stocks and create alternative employment opportunities as local fish farmers throughout China (Yu and Zhang, 2020; Qin et al., 2021; Qiu et al., 2021).

Third, China should strengthen its procedures for the allocation of the total catch and enhance its fisheries monitoring. Unified approaches to policy management and implementation at and below provincial scales, using a suite of control indicators should be instituted from the top to the bottom of the governance hierarchy in an integrated way. The Chinese government needs to reform its fisheries statistical system and develop a strong set of robust monitoring programs that take advantage of emerging technology. Fisheries monitoring is a crucial instrument in fisheries management that records and reports fishery-dependent data to inform decision-makers (Zhu et al., 2021) and China will need this if its approach towards catch share allocation is to lead to long-term ecologically sustainable development outcomes.

5 Conclusions

Developing a reasonable allocation scheme for catch shares amongst fishing entities is an essential part of a volume control policy. This study constructs a multi-criteria comprehensive weighted scheme based on a relative deprivation coefficient, and further compares the allocation outcomes from this new scheme with those obtained using single-criterion approaches to

show the advantage and feasibility of the proposed method in quota allocation. The allocation of catch shares among the 11 coastal provinces in China is illustrated as a case study. The results reveal that quota proportions for the 11 coastal provinces vary widely under the three single-criterion approaches, which may impede their implementation in practice. However, the newly developed allocation scheme shows strong utility in increasing the fairness and feasibility of the allocations. Quota proportions for the 11 coastal provinces under the newly developed allocation scheme were between the maximum and minimum ratios of those under the schemes using a single criterion. This study will help to enrich catch shares allocation methods and provides a new fair and reasonable method for policy makers to assign catch shares.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

QD, conceptualization, methodology, and writing. XS, investigation and validation. XJ, visualization and reviewing. HG, reviewing and editing. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Appendix A

TABLE A.1 The cumulative value of selected indictors for 11 fishing provinces in China during 2017–2021.

Provinces	Domestic marine catches C_{it} (tons)	Number of professional marine fishers F_{it}	Index that is calculated by multiplying the domestic marine catches by the catch per unit effort (C_{it}*$CPUE_{it}$)
Tianjin	135145	5636	86379
Hebei	999844	126012	769370
Liaoning	2502689	511651	1465365
Shanghai	61884	15449	29417
Jiangsu	2281607	228547	1926932
Zhejiang	13828070	628864	14256951
Fujian	8116112	844550	8507994
Shandong	8476230	625029	15361644
Guangdong	6167616	962266	5087997
Guangxi	2684116	189095	2560353
Hainan	5305740	480579	4426723