

Game Theory Analysis of Marine Rights Protection

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Abstract: This study discusses marine rights protection from the perspective of game theory. It introduces the role of marine rights protection in handling marine disputes, and the nature, direction, and elements of the game in China's marine rights protection. Currently, to minimize marine disputes through the game theory and pursue joint governance accord with China's national interest, this study categorizes marine rights protection into three basic game processes: entry into disputed sea areas, cross-border operation by fishing boats, and non-cooperative fishing. It then conducts corresponding game analysis to determine the critical directions for building the marine right protection force of China. It concludes that improving technological means for marine rights protection can effectively change the game's revenue and achieve a beneficial game equilibrium. Mainly, the development of technologies for high-tech interference, underwater protection, marine wide-area surveillance, and remote sea fishery development can assist China in gaining an advantageous position in repeated game processes.

Keywords: marine rights protection; game theory; marine rights protection technology; United Nations Convention on the Law of the Sea

1 Introduction

The ocean is the foundation upon which human society depends. The level of marine resource development and its health directly affects the sustenance of human society. The *United Nations Convention on the Law of the Sea* [1] (UNCLOS, 1982) provides for the contiguous zone of 24 nautical miles and an exclusive economic zone of 200 nautical miles from the baselines of coastal states and confers them with rights, jurisdictions, and obligations in the exclusive economic zone. Thus, the ocean is referred to as the "blue land." China has risen in geopolitics, has closely integrated economically with the global industrial chain, and has a new understanding of the national security and long-term development of maritime rights and interests, thus becoming more proactive.

Nevertheless, some countries, with the "zero-sum game" view on China's rapid development, have generated strategic anxiety, evoking frequent maritime disputes with China. Recently, the typical events are the 2012's "Diaoyu Dao purchase incident," "South China Sea Arbitration Case," launched by the Philippines in 2013, and the China-Vietnam conflict incident of "NanHai 981" oil drilling platform in 2014. These incidents have led to the rapid escalation of maritime disputes, and the struggle for maritime rights is exceptionally complex and acute. Similar rights struggle is based on the confrontation of the law enforcement forces of the participants; the scope of the rights-fighting game involves politics, economy, trade, military, diplomacy, etc. The risk of crisis may get out of control if not handled properly.

Presently, maritime rights protection and struggles are highly political and sensitive. Maritime rights protection is an act of infringement that occurs within the jurisdiction of the rights and interests and is administered according

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to a statutory authority [2]. Article 73 of UNCLOS provides that the coastal state may exercise its sovereign rights in various ways in its exclusive economic zone, as well as the primary means and convention of the existing maritime rights protection. There is a premise on the enforcement of rights under UNCLOS: the sovereign nature of the law enforcement sea area is not disputed. Because dealing with maritime sovereignty disputes is usually more complex and challenging, it is reasonable for China to take a certain degree of fuzzy sovereignty attributes in the interrelated maritime disputes, which needs to be flexible in the jurisdiction, adjustable according to the changes in the surrounding political and economic environment.

Intending to restrain and control maritime disputes and maritime rights protection, China and ASEAN, based on the *Declaration on the Conduct (DOC, 2002)* of Parties in the South China Sea, reached a framework document of the South China Sea Code of Conduct (COC, 2017). To hasten the establishment of the South China Sea crisis control and coastal state cooperation mechanism, it eliminated extraterritorial interference, which resulted in positive outcomes. However, it should be expected that after the COC is determined, a fierce game will exist for a long time around the allocation of fishing rights and quotas, marine resources exploration and development, etc. China should prepare its marine development capabilities, rights protection technology, and strategy to safeguard its maritime rights and interests adequately.

Many types of research have been conducted in China on the study of marine rights. Regarding China's recent maritime disputes and rights protection, Wang Hongxia, et al. give the history and status quo of the infringement of rights and interests in the East and South China Seas [3]. Li Zhiwen has analyzed the current maritime disputes and the dilemma of the rights and protection in the South China Sea [4]. Regarding the construction of the legal system for the protection of rights, Fan Jinlin, et al. point out that the existing marine legal system in China still lacks unified planning, causing marine law to reflect the marginality and the attributes [5]. Regarding the implementation of rights protection, Ding Xiaojun and others believe that the rights of the disputed maritime areas should adhere to the principles of "the supremacy of national sovereignty interests," "peaceful use of resources," and "cooperation in solving maritime problems." Zhang Yong [6] summarized five types of means of marine rights protection: means of declaration, legal means, law enforcement forces, means of marine development, and multi-party cooperation. Regarding foreign military surveys and illegal surveying and mapping, Wu Qiang et al. suggested strengthening prevention, ship, and on-site law enforcement, as well as domestic laws under the jurisdiction of accountability [7].

Because of historical and geographical factors, China and many neighboring coastal countries have very complex maritime disputes, with diverse forms of maritime rights struggle, and confusing concepts. Concurrently, China's marine rights protection mission, supported by the national soft and hard strength, serves the development and utilization of marine resources and the Maritime Silk Road, with features of long-term, sensitive and sudden. Questions on how to grasp the equilibrium state of the rights protection, handle the struggle for marine rights protection well, and form the valid law enforcement norms of maritime rights protection, which is an urgent problem in the current construction of marine rights protection forces, remain. Therefore, this paper analyzes the nature and characteristics of China's maritime rights protection, distinguishes between the national rights struggle under maritime disputes, the law enforcement under specific agreements, studies "disputed sea area entry," "fishing vessel cross-border rights protection," and "non-cooperative fishery game model," and analyzes the capability needs for maritime rights protection. On this basis, the supporting role and value of rights protection technology are discussed.

2 The game problem of marine rights protection

2.1 The role of marine rights in the handling of maritime disputes

The preferred means of resolving maritime disputes is the delimitation negotiations between the parties, such as the China–Vietnam Beibu Gulf demarcation agreement. The second way is to shelve disputes and make transactional arrangements for maritime and fisheries, such as the China–South Korea disputes over the East China Sea demarcation, which is some form of joint governance. These two methods, through the formation of binding agreements, are to establish a specific cooperation mechanism; the type of maritime rights protection is mainly embodied in the game between the maritime law enforcement forces and infringing individuals (such as cross-border fishing vessels).

The third way is the struggle for maritime rights, that is, to realize the declaration and control of the disputed sea area by rights protection, such as the Diaoyu Island dispute. In order to achieve the purpose of sovereign

declaration, the law enforcement forces of the two sides realize certain confrontational equilibrium by means of normal cruise operations.. The fourth solution is the military conflict or war, with maritime control through territorial or island occupation (Table 1).

Table 1. The resolutions for maritime disputes.

Solutions	Sea areas	Game forms	Math models
Delimitation negotiation	Disputed sea	Non-cooperation game	Complete information dynamic bargaining, subgame perfect equilibrium (SPE)
Joint governance	Disputed sea	Cooperation game	Rule of income corresponds to contribution (Shapley Index [12])
Struggle for maritime rights	Disputed sea	Non-cooperation game	Repeated games of long-term participants
Wars	All sea	Non-cooperation game	Ability, cost, and affordability model

2.2 The nature and direction of China's marine rights protection game

In the macro perspective, marine rights protection is the game of the country's concept and policy of marine development, to avoid escalation of maritime conflicts or state confrontations under short-term interests. The Chinese government put forward [8] that "China will fully participate in the formulation and implementation of marine governance mechanisms and related rules within the framework of the United Nations, and implement the sustainable development goals for oceans" and "achieve the orderly development and utilization of marine resources." Generally, the nature of China's marine rights protection is not adversarial to achieve the orderly development and utilization of marine resources, including rational distribution. China's maritime rights struggle aims to maintain regional peace and to participate fully in the formulation and implementation of maritime governance mechanisms and related rules within the framework of the United Nations (showing in Table 2) [9].

It is essential to recognize that today's global environment and ocean conditions are very different from those of the 1980s and that the ocean health faces pressing threats. Plastic pollution in the sea has increased tenfold in the past four decades. The deoxygenated dead zones are growing in extent and number, and ocean acidification, rising sea-levels, and other effects of climate change are taking a massive toll [10]. Food and Agriculture Organization of the United Nations [11] estimated that the percentage of stocks fished at biologically unsustainable levels (overfished, depleted and recovering stocks) has grown from 31.4% in 2013 to 33.1% in 2015, thereby continuing the trend of deterioration of stocks. Recently, the international community has come to a consensus and has gradually formed binding rules for the prevention and control of marine pollution, biodiversity conservation, and the suppression of excessive, illegal, unreported, and unregulated fishing practices, which is both a challenge and an opportunity for China's marine rights protection. This paper discusses the means to grasp the direction and progress of the struggle, under the premise of maintaining maritime cooperation, and to promote the game of maritime rights protection to micro-level, thus comprehensively and evenly safeguard China's maritime rights and interests.

Table 2. China's signing status of the convention and the related agreements (partially, data to 6/27/2019).

the Convention and of the related Agreements	Signature	Ratification /accession	Totals*	The signing status of neighboring coastal countries
<i>United Nations Convention on the Law of the Sea</i>	12/10/1982	6/7/1996	168	Japan, South Korea, Six countries in the South China Sea
Agreement relating to the implementation of Part XI of the <i>Convention</i>	7/29/1994	6/7/1996	150	Japan, South Korea, Six countries in the South China Sea
Agreement for the implementation of the provisions of the <i>Convention</i> relating to the conservation and management of straddling fish stocks and highly migratory fish stocks	11/6/1996	No ratification	90	Japan, South Korea, Philippines, Vietnam, Thailand, and Indonesia

2.3 The elements of the game model for marine rights protection

It is in China's national interest for marine rights protection to develop from struggle to joint governance. Generally, the game model of marine rights protection is complex, and the range and intensity change significantly with the capacity balance among the game players and the change of international situation.

Taking the South China Sea dispute as an example, the basic elements of the game model are game participants (China, the other six countries in the South China Sea, the United States and the geo-related countries of the South China Sea, other countries), torts, countermeasures to defend rights, game gains, etc. Infringements can be broken down into intrusive marine legislation, oil and gas exploration/exploitation in disputed sea areas, maritime and fishery disputes, illegal detection, mapping, and uninhabited island/reef activities, etc. Military cruises under “free navigation” and the illegal island reef occupation are paramilitary acts and not included in the scope of maritime rights protection. The countermeasures of protection of rights can be broken down into domestic sea-related legislation, leaders' and government declarations, ship/aircraft cruises, maritime and fisheries enforcement, fishing protection, UNCLOS provisions of “close pursuit, boarding, inspection, seizure and expulsion” of the infringement vessels, the establishment of marine ecological protection areas, and maritime confrontation and conflict. The game revenue includes national sovereignty and reputation, direct marine economic interests, political, economic, and trade relations among the game participants, and the investment of rights protection.

Currently, the overall situation of China’s marine rights protection is manageable. In the South China Sea and the East China Sea, China is in a definite equilibrium with the United States, Japan, and other countries. The six countries of the South China Sea have vital economic and trade interests with China, and tend to maintain a particular stage of game equilibrium.

2.4 The game model of maritime rights protection

The game process of maritime rights protection can be classified at different levels. Considering the constraint of the specific stage and form of struggle, the simplified game models are used to study the rights protection process, like the typical cases in South China Sea rights protection game, including “the entry model of the disputed sea area,” “the cross-border model of fishing vessels in the cooperative mode,” and “the fishery rights protection model in the non-cooperative mode.”

2.4.1 The entry model for the disputed sea area

In the second half of the 20th century, China was very cautious about the development activities of the disputed sea areas, which resulted in the development and infringement of the neighboring countries at the lowest cost. Now in some sea areas, China should restore the legitimate and reasonable rights, and consider the game problem of the area entry. The game tree of the disputed sea area entry model is shown in Fig. 1, in which assumed numerical values are used for the model equilibrium state analysis. Here (-100,500) indicates that when the rights defender chooses to enter the sea zone, and the infringer chooses to conflict, the rights defender’s income is -100, and the infringer’s income is 500.

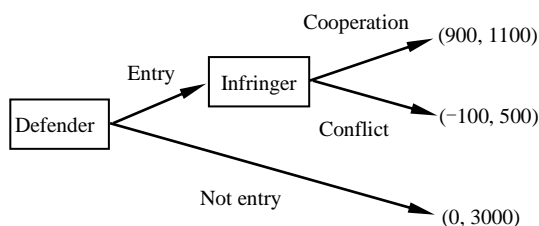


Fig. 1. The game tree of the disputed sea entry model.

In the entry game of disputed sea area, there are two Nash equilibriums: (1) the rights defender enters the sea area for development, the infringer threatens conflict, the defender chooses not to enter the sea area; (2) defenders enter the sea area, the infringer chooses to accommodate, and the two sides gradually form a certain cooperation mechanism. One of the typical cases is the conflict between China and Vietnam over the “981” drilling platform in the South China Sea, in which Vietnam threatens to block China’s entry through conflict. Notably, the marine rights protection is a repetitive game process; conflict and interference, to block entry, are used by the infringer first, and then by the defender to prevent entry (infringement) in a more extended period and larger disputed sea area. Hence to enter the disputed sea area for development, the defender should prepare for a protective defense to ensure the profits in the conflicts while raising the cost of the infringer, eventually to form the Nash equilibrium of cooperative development.

2.4.2 The game of fishing boats crossing border

Under the fisheries agreement reached by the countries concerned, the rights game involves cross-border fishing vessels. Because of the ability limitation to defend rights, cross-border fishing behavior will be punished in a certain probability. Table 3 gives the game matrix (p is the penalty probability; q is the cross-border probability).

Table 3 The game matrix of fishing boats crossing border.

	Punishment by rights enforcement party	No punishment by rights enforcement party	Crossing border probability
Cross-border fishing	$(a, 2)$	$(5, -1)$	q
No-crossing border fishing	$(1, 0)$	$(1, 0)$	$1-q$
Penalty probability	p	$1-p$	

For a fishing vessel, the higher the probability and severity of the punishment, the lower its willingness for cross-border fishing. In the cooperative game, the degree of penalty is subject to certain constraints (provisions of the agreement), such as the value of -1 in the table. Thus, improving the probability of discovery and punishment becomes the main direction of the rights-defend activist.

Assume that the gains are equal for fishing vessels crossing or not crossing the border, i.e., $-p + 5(1 - p) = p + 1 - p$ then $p=2/3$. It shows that if the probability of being punished by law enforcement is $2/3$, and the fishing vessel has no risk preference, the probability of the fishing vessel crossing the border is 0.5 . In this model, the probability of fishing vessels without risk preference can be expressed as:

$$q = \begin{cases} -\frac{3}{2}p + \frac{3}{2}, & 1/3 \leq p \leq 1 \\ 1, & 0 \leq p < 1/3 \end{cases} \quad (1)$$

If there exist N fishing vessels in a given sea area, the probability of no cross-border infringement occurring is $(1-q)^N = (\frac{3}{2}p - \frac{1}{2})^N$. Assuming the existence of 10 potential cross-border fishing vessels in the area and the probability of punishment is 0.9, the calculated probability of no occurring of cross-border fishing is only 0.2. Conversely, under the 0.9 penalty probability, there will still be a 0.8 probability of cross-border fishing, showing that the task of monitoring is very heavy.

2.4.3 Non-cooperative fishery game model

The fishery resources in the South China Sea are distributed in the land shelf and island-reef areas, with a specific catch cycle. The construction of marine pastures may expand the traditional fishing area. The fishery game practices of the two sides are set to drive the other's fishing vessels away, without external influence (e.g., claims of sovereignty by both parties). Assuming that the disputed sea area is S , the fishermen are risk-averse and operate only in their respective ranges of fishing. Moreover, assuming that the catch income per unit area is equal, and differences exist in the technical level and cost of fishery between the two-game sides.

Considering the catch income and the cost of defending rights, the unit (area) composite income p is a decreasing function of the fishing cruise area s (shown in solid line in Fig. 2), whose attributes are determined by geographical distance and the ability of far-sea fisheries. To get the best decision point (the best yield), a set of equal income curves will be plotted. As the total yield C changes, the equal income curve will be tangent to the unit yield curve, and the tangent point is the best decision (point A in Fig. 2). When fishing efficiency improves, the return per unit area will also increase, the decline in the return function will slow down, and the best decision point (the largest total benefit) will move forward to a larger fishing area (see Fig. 3, point B).

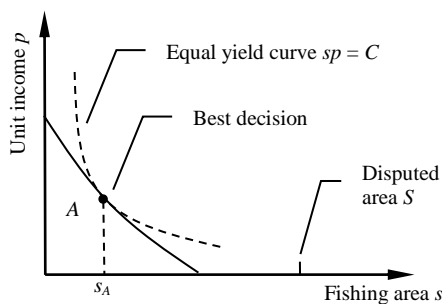


Fig. 2. The total yield curve of the non-cooperation fishery game.

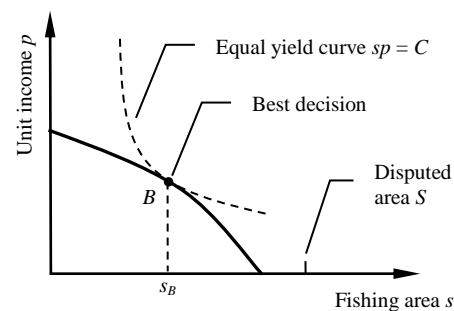


Fig. 3. The total yield curve for the higher-efficiency side.

In the law enforcement process, the fishing area s ($0 \leq s \leq S$) is the decision variable. One side may choose to cruise in the disputed sea area close to the other side or close to its side. If there is an overlap between the fishing areas of the two sides, the conflicts will be initiated, and additional losses will be taken to both sides. Fig. 4 gives the combined yield curves of both sides on the same graph, with s_A being the fishing area of the best decision point for side A and s_B being the fishing location of the best decision point of side B. When $s_A > s_B$, the two sides will have a fishing conflict and will suffer losses L_1 and L_2 respectively, the equilibrium point will locate between s_1 and s_2 . If the equilibrium point is found, the Nash equilibrium will be reached quickly, and the efficiency of rights protection can be improved. In practice, the two sides will observe and evaluate the equilibrium point position based on experience.

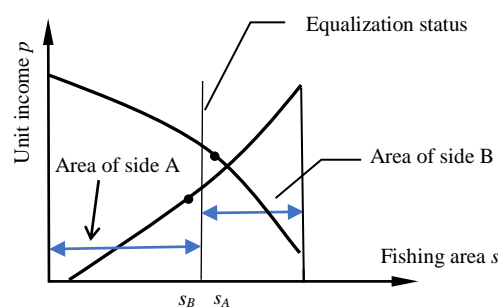


Fig. 4. Nash Equalization for Fishery rights protection.

From Fig. 4, the equilibrium point of fishing protection is based on the far-sea fishery capacity of both sides. Thus the party with less far-sea fishery capacity will face an adverse equilibrium state, which corresponds to China's fishery situation in the South China Sea. Presently, the offshore areas are overfished in the South China Sea; fishery resources are depleted and in dire need of conservation, contrary to the under-fishing area in the Nansha, zhongsha islands, and open ocean area [13,14]. Compared to Vietnam and the Philippines, China has significant deficiencies in far-sea fisheries, including technology and scale. Therefore, improving the comprehensive income will be a crucial measure in this game problem, which shows the income curve extension to the far-sea (larger area) in Fig. 2 to 4.

The rapid development of the far-sea fishery is suggested for China's current far-sea rights protection capacity. Practical measures include encouraging the establishment of large-scale open-ocean fishing companies, absorbing offshore fishers, developing far-sea fishery equipment, and improving the fishing efficiency, establishing supporting industries such as far-sea catches processing and services, developing far-sea pastures and expanding the far-sea fishery industry.

3 Ways to enhance the ability of the maritime rights protection game

According to the non-cooperative fishery game model, the basis of marine rights protection lies in the ability and level of marine industry development. Fishing in the far-sea, especially for migratory high-value fish species (e.g., tuna), requires fishing equipment like sonar and high-end fishing machines. Low emphasis on fishery science and technology in the past cost China its domestic advanced fishing sonar market, and the market occupied by Norway's Simrad, Japan's Furuno, and other companies. Therefore, it is vital to develop marine industry science and technology and strengthen the equipment and capacity for marine rights protection.

Protective measures are necessary for sea area entry conflict, including the underwater space defense, in which Vietnam's divers have carried out threats in the South China Sea drilling rig conflict. It is necessary to develop detection and emergency response capabilities for underwater targets, to safeguard and enhance China's revenues in the conflict state. For example, the Hainan Province planned to establish ten far-sea pastures near the Zhongsha and Nansha islands. In the protective facilities construction, warning buoys and underwater cage monitoring systems are needed to avoid collisions and damage to the professional divers.

To prevent infringers from conducting oil and gas exploration, offshore mapping, and other activities in disputed waters, it is necessary to develop high-tech conflict interference means, such as remote intelligent acoustic suppression, false echoes deception, unmanned underwater submarine (UUV) close jammer, to reduce the revenue of the intruder in the conflict, thereby preventing intrusion. According to cross-border fishing, it is necessary to develop a low-cost and high-efficient surveillance system, including the surface surveillance and

evidence collection system based on ship networking, aerial drone cruise systems, etc., which increase the punishment probability for cross-border fishing vessels.

Developing marine science and technology, improving the ability of maritime rights protection, can effectively change the game income, and then affect the game decision-making to achieve the game balance beneficial to China. Meanwhile, the advanced techniques can effectively improve the efficiency and level of law enforcement of rights, reduce the conflict cost, and significantly increase the acceptance of international public opinion, especially in open oceans. The far-sea rights protection needs: (1) offshore fuel leakage and pollutant diffusion is closely related to marine meteorology and ocean current activities; hence a far-sea environment monitoring and numerical forecasting system should be established soon. (2) As an essential part of maritime rights protection, marine biodiversity, and ecological environment protection have been focused upon in recent years. At present, 18% of the jurisdictional sea area and 1% of the international waters have been protected areas in the world [11]. China needs to strengthen marine ecology research, to regulate the fishing in the high seas, for protection of the diversity of ecological species and improving national reputation.

4 Policies and suggestions

(1) The key to safeguarding marine rights is the ability and level of marine development. It is necessary to speed up the marine industry technology, achieve the balance between marine environmental protection and orderly development of resources, and establish the basis for the next stage of marine cooperation game.

(2) Given the capacity-building requirements of maritime rights protection, the development of new technology, equipment for use in conflict interference and defense protection, changes the game benefits of both sides and achieves a Nash equilibrium conducive to it.

(3) The maritime rights game is comprehensive and complex, requiring industry, natural resources, science and technology, information media, diplomacy, and maritime police to strengthen policy coordination, form a linkage mechanism, and comprehensively respond to emergencies.

(4) To understand maritime cooperation and protection of rights, to work in the areas of marine environmental management, ecological resource protection and orderly exploitation of marine resources, to establish an autonomous and controllable far-sea observation system, and form a marine hydrological and dynamic environment, real-time monitoring capabilities are enhanced for large-scale whales and marine vessels. In marine disaster management and emergency disposal, the establishment of a rapid intervention system, the development of reliable remote maritime precision positioning and long-distance control capabilities, the construction of marine information technology, promote the maritime rights game to the high-quality direction.

(5) It is suggested to optimize and integrate the existing national rights protection forces, and to develop the diversity of rights protection technology means, for improving the efficiency of marine rights protection. A professional research institution is favorable for the countermeasure of rights protection, working with the rank and file personnel to solve the outstanding contradictions in daily rights protection, and making strategic prediction and deployment of emergencies.

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