

Development of Unmanned Equipment in Marine Rights Protection

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Abstract: Equipment for the protection of marine rights is important for ensuring national marine security. Considering the varying marine security situations and rapid development of intelligent technology, unmanned equipment has demonstrated unique advantages in dealing with complex scenarios of marine rights protection, which makes it a key strategy for improving China's marine security. This study first explored the strategic demands for marine rights protection and then analyzed the current development status and trends of marine rights protection equipment in China; in this paper, we summarize several existing issues that should be addressed promptly. Moreover, we propose important goals, tasks, and techniques for the development of unmanned equipment that can be used for the protection of marine rights in China. To promote marine power, China should perfect its equipment system for marine rights protection using unmanned equipment and make breakthroughs in key technologies by combing unmanned technologies for military and civil use.

Keywords: marine rights and interests; marine rights protection; unmanned equipment; system; key technology

1 Introduction

Maritime rights protection refers to the combined activities that prevent and investigate maritime infringements by foreign ships, declare maritime sovereignty and jurisdictional activities, and protect normal maritime use activities from interference and obstruction by foreign ships to realize maritime rights and law enforcement forces entrusted to a country by the *United Nations Convention on the Law of the Sea* [1]. Maintaining maritime rights and interests is related to supporting national interests. Therefore, all countries, especially those with coastal areas, assign great importance to maritime rights and interests while regarding them as core interests. In the context of the strategic background of building maritime power, there is still considerable work required for several countries in their abilities to safeguard maritime rights compared with some of the global maritime powers.

For a long time, China's maritime rights have faced serious challenges. Japan has repeatedly violated the sovereignty of China's Diaoyu Islands, causing continuous confrontation at sea. Some neighboring countries, including Vietnam and the Philippines, have illegally invaded and occupied several sovereign islands in the South China Sea in attempts to seek "legal" sovereignty through "effective management." These countries sometimes forcibly occupy China's traditional sea areas and have used Western powers to seize the oil and gas resources as well as fishery resources in the sea areas under Chinese jurisdiction, thus infringing on China's maritime rights and interests [2]. As situations involving competition and confrontation have become more apparent, the protection of maritime rights and interests has become the forefront of severe challenges in recent years.

While artificial intelligence (AI) has ushered in substantial technological developments, unmanned systems constitute one of the areas that best reflect the characteristics of intelligence, whose rapid development has become

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a general trend in recent years. Unmanned intelligent equipment, such as unmanned aerial vehicles (UAV), unmanned surface vessels, and unmanned underwater vehicles, can perform diverse tasks. All types of unmanned equipment systems have application advantages that are sometimes unmatched by manned equipment, thereby highlighting the potential for their application to maritime rights enforcement tasks. Owing to China's vast sea area, complex marine geographic environment, and severe need to improve maritime security, new means to enhance maritime rights protection capabilities are urgently needed. With the development of AI and military intelligence technologies, it has become a trend for unmanned equipment to be used on the battlefield, which has received widespread attention, and various types of unmanned systems have been deployed in the sea, land, and air [3–5]. However, the application of unmanned systems is still in its preliminary stages in terms of maritime rights protection. Most of these applications directly use military or civilian unmanned equipment and do not have special design plans to address the specific needs of maritime rights protection and law enforcement. In response to the law enforcement needs, this study presents the development of maritime rights protection equipment and the problems faced by China, realizes the rapid development of such maritime rights protection equipment, and presents a feasible means to enhance the capability of maritime security.

2 Development needs for unmanned marine rights protection equipment systems

2.1 Demand of a wide range of maritime rights protection measures

China has broad jurisdiction and a long front for law enforcement; therefore, the scope of rights protection involves air, water, and underwater regions, and the aquatic environment also requires rights protection and is changeable. Existing equipment capabilities cannot meet the needs of maritime rights protection, and with limited personnel, it is more difficult to achieve no blind spots and full coverage of the jurisdictional sea area. Owing to their unique advantages, unmanned equipment systems can perform all-weather rights-protection tasks under severe weather conditions. This can effectively help with situations such as the large proportion of sea area, complex environment for maritime rights protection tasks, and long operation durations, thus improving the sustainability, reach, and protection capabilities of maritime rights protection.

2.2 Demand of complex marine rights protection objects

In China's jurisdictional seas, the density of law enforcement objects is unevenly distributed. The jurisdictional seas involve complex personnel, large bases, difficulty in obtaining intelligence, and difficult personnel control. With the currently available manned rights protection equipment, it is impossible to handle complex scenarios of maritime rights protection. With the development of marine equipment technology, various new types of marine rights protection targets are increasing, such as unmanned platforms in the air, surface, and underwater spaces, cross-domain unmanned platforms, underwater preset platforms, seabed bass arrays, and cables. Conventional equipment for the protection of marine rights is difficult to effectively use with these new goals, and there is a lack of appropriate disposal methods. Unmanned equipment systems can carry various sensing loads to monitor and detect cruising sea areas and realize autonomous information acquisition, analysis, and judgment by combining AI, big data, and other current technologies. Under autonomous operation conditions of the unmanned system, it is possible to realize verification and trajectory tracking of suspicious targets, which strongly supports the control of complex objects in maritime rights protection.

2.3 Demand of complex maritime rights protection tasks

The different types of maritime rights protection tasks are complex and mainly divided into daily reconnaissance and monitoring of relevant objects and personnel, verification and identification of suspicious targets, and warning and deportation of suspicious ships, aircraft, and persons. UAVs generally enable good maneuverability, strong survivability, low operating cost, low risk of casualties, and wide applications. Through rapid replacement of loads, they can perform many tasks in the sea, such as search and rescue, law enforcement, and marine environmental protection. Unmanned underwater vehicles (UUVs) adapt to complex and changeable underwater environments and can execute underwater reconnaissance, rapid maneuvering, material evidence salvaging, and exploder-clearing activities. The use of increasingly intelligent unmanned equipment to implement maritime rights protection tasks can effectively help manage the increasing number of maritime emergencies, rapidly increase the amount of maritime rights protection equipment, and enrich maritime rights protection methods.

2.4 Need to improve the equipment systems for maritime rights protection

There are various types of coast guard vessels and equipment in China; however, the standard and serialized spectra are insufficient. Moreover, the proportion of ships and aircraft is not balanced; the number of law enforcement aircraft is small, and their equipment systems are not perfect. The newly built ships of the Coast Guard are still divided by tonnage, and the trend of the division of special tasks is not apparent. With the urgent need for diverse maritime rights protection and law enforcement tasks, it is unrealistic and unscientific to use certain types of “all-round ships” to address the various problems. At present, unmanned systems and intelligent technologies are developing rapidly under the joint military and civilian promotion aspects. Unmanned equipment can be used to quickly address the lack of maritime rights protection equipment systems, and mature technologies can be used to build new equipment, with quick results and low cost, which is conducive to rapidly improving the comprehensive level of China’s maritime rights protection equipment systems. The scientific deployment of unmanned equipment for different tasks is expected to significantly enhance law enforcement, as well as the management and disposal capabilities of maritime rights protection forces.

3 Development status and trend of unmanned equipment for maritime rights protection

At present, maritime rights protection is jointly enforced by the navy and Coast Guard, and the principle of “military-to-military and police-to-police” is adhered to [6]. Globally, many countries regard the navy as an important force in maritime rights protection, and the corresponding equipment has a long development history, perfect operational systems, and sufficient high-tech configurations. Because maritime rights protection actions are mainly non-military war actions, the coast guards of various countries have become the main elements of daily maritime rights protection. Therefore, this study mainly analyzed the development of maritime rights protection equipment for the Coast Guard.

3.1 International development status

The maritime rights protection equipment of developed countries is generally composed of various types and sizes of ships, aircraft, and professional ships (such as survey ships), in accordance with the mission requirements of maritime security, defense, and management. The equipment systems are planned reasonably, and the equipment is highly informationized. In recent years, nations have paid more attention to maritime rights and interests, and they have further developed various high-tech equipment. In particular, the United States’, Japanese, and South Korean Coast Guards have gradually deployed various advanced unmanned equipment and applied them to practical actions concerning maritime rights protection. The application of unmanned equipment has enhanced the Coast Guard’s ability to monitor and manage complex situations for a long time. Based on the abilities of manned equipment, a new way to enhance the maritime rights protection force is provided.

3.1.1 The United States

The US Coast Guard considered the deployment of unmanned equipment around the year 2000 and successively tested and used the “Global Hawk” UAV, “Hawkeye” vertical take-off and landing UAV, MQ-9B shore-based UAV, and “Fire Scout” and “Scan Eagle” UAVs. In 2017, the “Scan Eagle” UAV was used to perform a complete patrol mission, and as a trial, major maritime smuggling cases were solved. This plays an important role in large-scale intelligence reconnaissance [7]. The US Coast Guard planned to equip all “Legendary” national security patrol ships with UAVs and proposed the development and application strategies of UAVs covering long-, medium-, and short-range UAVs (Fig. 1).

The US Coast Guard also focuses on maritime unmanned systems, including unmanned surface crafts and underwater vehicles. In 2009, the US Coast Guard used unmanned underwater vehicles to conduct underwater surveys of sunken fishing vessels. In 2017, some maritime unmanned systems were tested in the Arctic region, and the relevant systems focused on improving perceptions of the sea and serving as future force multipliers. In 2020, an unmanned surface craft based on an in-service 7 m interceptor craft was tested, and the SMART autonomous system was integrated to enhance unmanned surface craft clusters and multi-task coordination capabilities. The US Coast Guard’s law enforcement capabilities have been significantly improved through the installation of unmanned equipment.

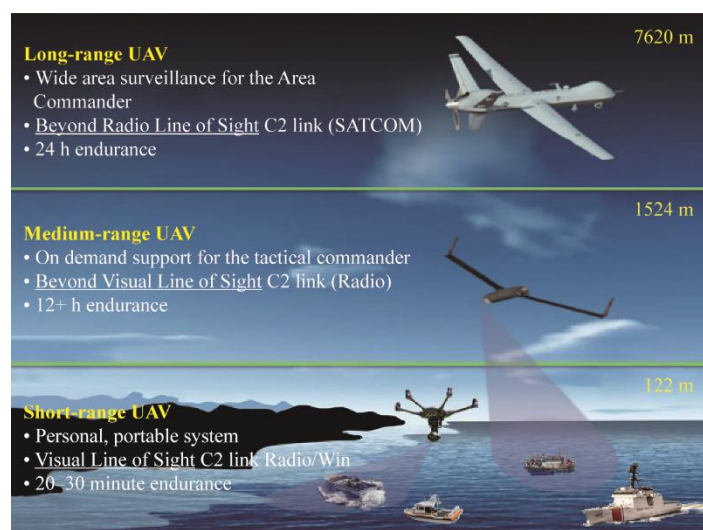


Fig. 1. Development strategy for US Coast Guard UAV.

3.1.2 Japan

The relevant equipment of Japan’s maritime security agency is similar to that of the US Coast Guard. Unmanned equipment is also installed and used in addition to large ships and shipborne helicopters. In 2011, Japan’s maritime security agency purchased the “Explorer” autonomous underwater vehicle for maritime search, rescue, and investigation operations; since 2016, wave gliders have been equipped and used in four regions to efficiently construct an observation network for Japan’s ocean conditions and provide reconnaissance and monitoring data as well as real-time information for maritime operations; in 2018, the wave glider was extended to the ninth region, reflecting its strong application ability for marine monitoring; unmanned surface vehicles (USVs) have been deployed and applied in some maritime countermeasures [6], and unmanned survey vessels equipped with various types of measuring instruments were deployed to collect seabed terrain data (Fig. 2).



Fig. 2. Unmanned survey vessel used by Japan Maritime Security Agency in the East China Sea.

Furthermore, Japan is considering using UAVs to patrol its surrounding waters. In 2020, Japan completed the flight verification of the “maritime guard” UAV and tested its capability for wide-area maritime surveillance and security tasks (such as search, rescue, disaster response, and maritime law enforcement).

3.1.3 South Korea

The South Korean coast guard actively explores the application of unmanned equipment to enhance its maritime strength. In 2017, they completed flight and shipboard landing tests of a TR-60 tilt-rotor UAV (Fig. 3). According to reports [6], in response to the maritime fishery conflict, the South Korean Coast Guard plans to purchase large- and medium-sized UAVs to carry out fishery cruise and surveillance missions. In 2017, the South Korean Coast Guard obtained a “Sea Eye Falcon” underwater robot for seabed investigation and research.



Fig. 3. South Korean TR-60 tilt-rotor UAV.

3.2 Development status in China

As the main force of maritime rights protection in China, the capacity construction of marine police has made rapid progress in recent years, many new ships have been installed, the maximum tonnage of marine police ships is up to 1×10^4 t, and the number of marine police official ships is large; the tonnages of naval vessels have been at the forefront of marine police in various countries, and the technical level of marine police equipment has been significantly improved. Notably, marine police are less equipped with aviation equipment. Although marine police are gradually equipped with multiple types of aircraft, there is a lack of large- and medium-sized aircraft with high performance, long-range, and multi-purpose applications, and the lack of planning of marine police boats and lack of supporting professional ships (such as survey ships) renders the integrity of the equipment system defective [7]. The sizes of helicopters that can be carried by China's coast guard ships are relatively small, and the number of pilots is insufficient. Moreover, marine police often need to conduct tasks under high-sea conditions, so there are potential safety hazards with helicopter take-off and landing at sea [8].

At present, China's marine police have only used small UAVs in maritime cruising, lacking shipborne helicopters or shipborne UAVs with reconnaissance and early warning functions, and the development of the maritime air force is weak [9]; there is also a lack of unmanned equipment, such as USVs and UUVs. From the objective view of a large range of territorial waters and the complex and onerous tasks of rights protection and law enforcement, the search scope and means of verification are limited, which makes it difficult to competently perform various tasks beyond the limits of visual range detection. In addition, the currently used unmanned equipment is still mainly remote-controlled and semi-autonomous. Domestic research on unmanned equipment technologies, such as intelligent autonomous control, reconnaissance and detection, rights protection, and disposal, has not been sufficiently explored and cannot meet the needs of rapid response, flexibility, independence, and long-term self-sustaining tasks.

3.3 Field development trends

3.3.1 Gradual improvement of marine rights protection with unmanned equipment systems

In the future, marine rights protection will face urgent, difficult, and dangerous tasks in complex environments. It is difficult to manage all types of static/dynamic targets from the air, underwater, and the water surface. The response speed of equipment disposal is low, and it is difficult to fully respond to all scenarios. Therefore, the global maritime power should reasonably plan for marine rights protection equipment systems, build professional marine police ships, promote the professional development of law enforcement equipment, consider unmanned equipment as a new quality force in the system, develop and improve marine rights protection using unmanned equipment systems, enrich and improve the entire marine rights protection force using unmanned equipment, and focus on the future to rapidly improve combat effectiveness for marine rights protection.

3.3.2 Focus on developing the adaptability of unmanned marine rights protection equipment

With rapid changes in the international environment and the increasing complexity of manned/unmanned objects for rights protection, global marine powers are focusing on technologies such as long-lasting power at sea, adaptability to complex and harsh environments, early warning and detection of air/underwater small targets, and underwater special operation equipment. Research is underway to comprehensively improve the adaptabilities of unmanned equipment to respond to complex maritime rights protection tasks. Therefore, the targeted development of unmanned equipment that can adapt to harsh oceanic climates and environments has led to rapid approaches for reconnaissance and underwater rights protection operations to realize the warning, drive away, strike, or control of

underwater “low, slow, small” targets, aerial vehicles, and other suspicious underwater and aerial targets over the sea area, thus supporting maritime police forces to carry out three-dimensional rights enforcement tasks.

3.3.3 Improvement in intelligent level of unmanned marine rights protection equipment

Driven by AI, future unmanned marine rights protection equipment will be developed for intelligence. Unmanned equipment such as UAVs, unmanned surface craft, and UUVs can fuse and analyze data obtained by multiple methods, create autonomous decision-making tasks, re-plan and execute tasks, and complete corresponding patrol and surveillance tasks autonomously; other unmanned equipment cooperate to accurately perform different types of rights protection tasks. Promoting the intelligent development of unmanned marine rights protection equipment, as well as mastering autonomous collaborative control, big data analysis, intelligent task planning, cluster intelligence, and other technologies will significantly reduce the number of operators, reduce the possibility of casualties, and improve task execution efficiencies. In the future, unmanned equipment with intelligent features will be applied to maritime rights protection and law enforcement, thus adding strong equipment support for maritime rights protection.

4 Problems faced by the development of China’s unmanned marine rights protection equipment

4.1 Level of equipment systemization and intelligence is not high

Compared with progress in the development and application of unmanned equipment by other global maritime powers, China’s equipment is highly dependent on personnel and lacks intelligence. For emergent, dangerous, and important tasks and complex environments, on-site personnel disposal urgently requires the support of new equipment capabilities. Owing to the vast area of law enforcement, there is a relative shortage of systematic intelligent unmanned equipment, such as long-endurance drones to address severe sea weather [10,11]; unmanned ships with a rapid approach, reconnaissance, and strike capabilities [12]; and UUVs that can perform underwater salvage operations, evidence collection, and reconnaissance missions [13].

4.2 Weak underwater and aerial control and disposal capabilities

The status quo of the composition of China’s coastal police force demonstrates that the water surface control and disposal capabilities of marine power are relatively strong, but the underwater/air control and disposal capabilities are weak. For example, the lack of underwater and aerial control and disposal equipment has made it difficult to meet the needs of three-dimensional rights protection and law enforcement tasks. Further, there is a lack of underwater “low, slow, and small” target disposal equipment that can monitor the entire sea area and aerial vehicle strike equipment that cannot warn, drive away, strike, or control suspicious targets from underwater and the air.

4.3 Global three-dimensional situational awareness is not strong

Situational awareness regarding controlled sea areas requires the real-time acquisition of various dynamic/static target information from the air, water surface, and underwater. The existing equipment can meet the needs of surface situation awareness but lack a special awareness of underwater/air targets. Thus, weak real-time perception capabilities restrict the scope and efficiency of maritime rights enforcement.

4.4 Insufficient disposal methods for maritime rights protection

Current marine rights protection operations are equipped with only water cannons and loud-sound drive-off equipment. The ability to respond quickly to mass incidents at sea is not strong, and the control of underwater, air, and surface dynamic targets is weak. Therefore, there is an urgent need for new, non-lethal, deterrent, new response, and disposal methods.

5 Unmanned equipment development plan for China’s marine rights protection

5.1 Development goals and suggestions

To meet the needs of China’s maritime rights protection, it is necessary to build unmanned equipment systems for maritime rights protection that cover the air, water, and underwater areas. The three-dimensional perception of “air/sea/water” and the ability of law enforcement to protect rights are necessary to achieve no blind spots and full coverage in the jurisdictional sea areas while enhancing the ability of maritime rights protection under complex

conditions and fully guaranteeing maritime security. Considering the next five to ten years as the key development stage, the plan is to conduct targeted construction and application based on early-, mid-, and late-period divisions.

In the early stage, research on the development needs of unmanned maritime rights protection equipment will be carried out, and models of such unmanned maritime rights protection will be proposed. Combined with the development trends of marine intelligent unmanned systems, a preliminary plan for the development of marine unmanned rights protection equipment will be developed. Based on this, a roadmap for the development of unmanned rights protection equipment for the implementation of maritime rights enforcement tasks will be formulated.

In accordance with the advanced planning and development roadmap, combined with the development of dual-use unmanned equipment technology, the development of typical maritime unmanned rights protection equipment, such as unmanned ships, UAVs, and UUVs, will be carried out in the mid-term. In actual maritime rights protection operations, these will be gradually tested, and the maritime unmanned rights protection capabilities will have been formed. In response to the special needs of marine security, we will focus on applications in key areas. In addition, we have researched key technologies and formed comprehensive breakthroughs in such key technologies.

In accordance with the maritime security requirements under the guidance of the maritime power strategy, a series of unmanned maritime rights protection equipment will be developed in the late stage to form a relatively complete unmanned equipment system. By constructing the basic communication network of this unmanned system, the interconnection and cross-domain coordination capabilities will be improved, and the law enforcement capabilities for maritime rights protection will advance globally.

5.2 Development direction and key tasks

The development of unmanned equipment for the protection of marine rights has continuously maintained maritime safety and ensured the implementation of maritime rights protection tasks. The construction of such equipment systems focuses on the intelligent and efficient coordinated operation of unmanned systems, supporting the smooth execution of tasks such as information acquisition, security guards, crime combat, and resource protection.

Owing to complex environmental conditions, full-time monitoring, and unexpected incidents in maritime rights protection tasks, combined with maritime police ships and airpower, a strong rights protection equipment system has not yet been developed. In the new era, China's maritime security situation can be used as a guide to analyze the developmental needs of unmanned marine rights protection equipment, involving the needs of maritime rights protection tasks and the elements of the law enforcement environment. Through an in-depth study of the marine rights protection style after the use of unmanned systems, the mission, use methods, and capability requirements of unmanned equipment are proposed.

Relying on advances in military and civilian technologies, the unmanned equipment of the 14th Five-Year Plan is closely integrated with the needs of marine rights protection, and the equipment development plan and roadmap are proposed. The composition of the unmanned equipment system is proposed based on the developmental needs of the equipment. By studying the types of unmanned equipment, type spectrum series, and mission use methods that require rights protection, the development direction of the equipment and development steps of key technologies are clarified.

According to the development plan and roadmap for marine unmanned rights protection equipment, the development and demonstration of typical equipment, such as UAVs, unmanned ships, and UUVs, will be completed for air, surface, and underwater mission domains, respectively. In the development process, the planning and construction of subsequent serialized unmanned equipment for the protection of marine rights will be considered. Based on the special environment in marine rights protection, we will implement coordinated research on key and difficult technologies while gradually building unmanned equipment systems. By conducting trials and summarizing experiences in a timely manner, maritime rights protection and law enforcement capabilities can be significantly improved.

5.3 Key technologies

The key technologies that unmanned marine rights protection equipment must focus on are the following: basic information network support technology for unmanned marine systems, manned/unmanned coordination technology, cross-domain unmanned coordination technology, load integration technology, and offshore energy supply technology. Through research on basic information network support technology for unmanned maritime systems, a

multi-node, multi-platform unmanned system for maritime rights protection is constructed. By completing breakthroughs in manned/unmanned collaboration and cross-domain unmanned intelligent collaboration technologies, the capabilities of maritime autonomous and integrated collaborative missions will be formed. Research on load integration technology and the development of various types of integrated loads can improve the comprehensive handling capabilities and form a series of deterrent equipment for rights protection.

6 Strategies and recommendations

6.1 Actively use unmanned maritime rights protection equipment to improve marine rights protection

Marine rights protection is currently limited by complex environments, numerous emergencies, wide scope, and long duration; manned equipment cannot fully manage such situations. Therefore, developing unmanned equipment systems, including UAVs, unmanned boats, and underwater unmanned vehicles, should be prioritized, thereby enriching the unmanned equipment used by the maritime police force and considering the advantages of unmanned and intelligent vehicles. By improving the ability to achieve diverse tasks, the enforcement of rights protection will be promoted, and the sustainability and reach of maritime rights protection will be improved. This process also enhances how maritime rights protection is achieved. For example, exploration through drones and strikes with non-lethal weapons can assume the advantages of adaptability to harsh weather conditions at sea. Unmanned ships implement rapid maneuvers to approach reconnaissance and carry non-lethal weapons onboard for strikes and control, which can be adapted to severe sea conditions. Underwater operations carried out using unmanned underwater vehicles can support the adaptability of undercurrents, currents, and muddy underwater environments. The concealed reconnaissance, surprise attack, and other tasks carried out via cross-domain unmanned mobile platforms can use the capabilities of different media, such as water and land, sea and air, water surface, and underwater.

6.2 Targeted key technology research

Based on China's maritime security situation in the new era and by integrating military, police, and civilians as the foundation, all types of maritime powers can be commanded and coordinated to jointly complete maritime security tasks. The top-level plan for the development of China's marine unmanned rights protection equipment will be revised and improved. Manned/unmanned collaborations, cluster collaborations, cross-domain collaborations, and other future maritime unmanned equipment applications will be valued. The reference and application of military and civilian unmanned system technologies will also be emphasized. Combined with the current domestic mature technologies on drones, unmanned surface crafts, and unmanned underwater vehicles, the intelligence and autonomy of the unmanned equipment will be strengthened, and technical integration verification and equipment use will be accelerated. By promoting the coordinated development of both military and civilian use of marine rights protection with unmanned equipment, the introduction of civilian technology and capital will strengthen market competition. This approach can improve design and manufacturing capabilities and assist the construction and development of maritime rights protection systems.

References

- [1] Mao C Y. The concept definition and future prospect of maritime law enforcement [J]. *Journal of Dalian Maritime University (Social Science Edition)*, 2020, 19(1): 11–19. Chinese.
- [2] Wang J T. Conception on development strategy of China maritime police [J]. *Journal of China Maritime Police Academy*, 2015, 14(2): 48–52. Chinese.
- [3] Shi J C. Conception of unmanned system and application in future sea war field [J]. *Ship Electronic Engineering*, 2017, 37(12): 5–8. Chinese.
- [4] Sun Z S, Meng C N, Hou Y. Analysis on the basic elements of unmanned operations of maritime police in the future [J]. *Aerodynamic Missile Journal*, 2019 (6): 47–51. Chinese.
- [5] Li P Z. The development status of the equipment system of coast guard in coastal states and its inspirations [J]. *The Journal of South China Sea Studies*, 2016, 2(2): 76–80. Chinese.
- [6] Ou Y H, Zhang Z J. Research on the new leadership and command system of the armed police force [J]. *National Defense*, 2018, 39(8): 45–51. Chinese.
- [7] Zhu L L. Analysis of requirements and development trend of high-tech equipment in China coast guard [J]. *Journal of China Maritime Police Academy*, 2018, 17(6): 38–44. Chinese.
- [8] He Z W, Xin K. The future development of Chinese coast guard ship equipment from the perspective of equipment system [C].

- Beijing: 2015 Excellent Academic Papers of Chinese Society of Naval Architects and Marine Engineering, 2016. Chinese.
- [9] He L H, Chen F, Qian L L. Application of UAV in public service vessel [J]. *Guangdong Shipbuilding*, 2017, 36(4): 40–43. Chinese.
- [10] Zhang Z R, Qi M X. On countermeasures for development of informatization equipment of China coast guard ships [J]. *Journal of China Maritime Police Academy*, 2020, 19(4): 33–39. Chinese.
- [11] Yang J. Research and implementation of safeguard technologies for maritime rights cruise [D]. Shanghai: Shanghai Ocean University (Master's thesis), 2018. Chinese.
- [12] Sun B, Guo H Y. A study of innovative ways on safeguarding our interests in South China Sea under the new situation based on unmanned surface vehicles [J]. *National Defense Science & Technology*, 2016, 37(1): 43–46. Chinese.
- [13] Wang X Y, Li P Z. Research on tactics of China coast guard to cope with maritime terrorism threats [J]. *Journal of the Armed Police Academy*, 2017, 33(1): 92–96. Chinese.