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The implications of military unmanned maritime vehicles on the international maritime security order: from challenge to re-balance

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In recent years, the continuous application and expansion of unmanned intelligent technology in military maritime equipment have spurred the rapid development of military unmanned maritime vehicles, represented by Unmanned Surface Vehicles and Unmanned Underwater Vehicles. Their accelerating deployment across various maritime domains is profoundly reshaping patterns of maritime military competition and the maritime security order, making them an urgent topic for discussion concerning international maritime peace and development. Furthermore, with their unique advantages such as low cost, potential for mass deployment, high concealment, long endurance, and the avoidance of personnel casualties, unmanned maritime vehicles are redefining maritime situational awareness capabilities for nations, especially small and medium-sized states, to an unprecedented degree. Their large-scale application not only poses severe challenges to traditional maritime rules based on the United Nations Convention on the Law of the Sea but also creates uncertainty for the maintenance of the existing maritime security order. Military unmanned maritime vehicles will drive nations toward a re-balance of power. This paper aims to analyze the historical progression and practical application of military unmanned maritime vehicles. It will systematically discuss how they can constructively perform this re-balance function across dimensions such as peacetime, crises, and wartime, and re-examine their potential contributions to the international maritime security order.

KEYWORDS

major power competition, maritime security order, military use, re-balance of power, unmanned maritime vehicles

1 Introduction

Military Unmanned Maritime Vehicles (MUMVs), as a broad general term, encompass all unmanned seaborne craft used for military purposes, primarily including unmanned surface vehicles (USVs) and unmanned underwater vehicles (UUVs) for military purposes (Bahadir, 2023). These platforms are typically powered and can operate on the surface or underwater autonomously or semi-autonomously according to diverse military mission requirements. The military utility of unmanned maritime vehicles is hard to overlook; whether serving as more effective delivery platforms or as "robots that auto-reload," MUMVs can effectively help nations gain maritime advantages while reducing potential personnel casualties (Daum, 2018). Some U.S. scholars even assert that the unmanned fleet carries the future of national technological and military power (Grome, 2018a).

In the foreseeable future, MUMVs will not only change the fundamental modes of maritime armed conflict but will also play equally important roles during peacetime as efficient means of reconnaissance and deterrence, thereby profoundly impacting the maritime security landscape and the distribution of maritime power (Martin, 2013). Most current research focuses on introducing the technological evolution or developmental status of unmanned maritime vehicles, or discussing the prospects for regulating them and their military use through legal frameworks (Martin, 2013; Quintana, 2008). Some authors concentrate on classification systems for the military application of unmanned craft, integrating the application of international rules with levels of automation (Ljulj et al., 2024). The widespread use of unmanned maritime vehicles with low human intervention in armed conflict will constitute a severe challenge to International Humanitarian Law (Grome, 2018b). The issue of regulating the peacetime military use of unmanned maritime vehicles has not yet been adequately resolved within the rule system centered on United Nations Convention on the Law of the Sea (UNCLOS) (McLaughlin, 2011). Concerns have been raised about naval unmanned vessels collecting marine data without the permission of relevant states. However, there is scant research exploring the impact of MUMVs on the maritime security order. Against the backdrop of navies universally beginning to develop and deploy unmanned maritime vehicles, allowing "gray zones" to emerge is tantamount to forsaking preemptive prevention of maritime disputes and risks of international conflict, which is clearly not the best option (Nasu and Letts, 2020).

In light of this, this paper aims to discuss the potential impact of military unmanned maritime vehicles on the international maritime security order, particularly the challenges and the prospects for re-balance the power of various stakeholders. The study involved primarily employs qualitative policy and literature analysis, incorporating a technology-institution interaction analysis perspective to achieve the research objective of comprehensively demonstrating the impact of MUMVs on the international maritime security order. The first part elaborates on the developmental trajectory of MUMVs and the changes and challenges brought about by their practical application. The second part analyzes the potential dynamic changes in the balance of power among stakeholders resulting from the development of MUMVs during both peacetime and wartime. The third part explores pathways through which the development and use of MUMVs can contribute to the international maritime security order.

2 Development and applications of military unmanned maritime vehicles

The historical development of military unmanned maritime vehicles can be largely traced back to the end of the 19th century. Evolving from radio remote control and ultra-shortwave communication technologies to GPS, inertial navigation, and sonar technologies, and further to today's unmanned intelligent technologies, the historical progression of military unmanned maritime vehicles can be broadly divided into three stages: early military exploration, initial technological breakthroughs, and diversified development, which leads to the comprehensive competition among major powers.

2.1 Early exploration stage

In September 1898, Nikola Tesla, a Serbian-American, remotely controlled a vessel named "Teleautomaton" using radio signals, achieving the first-ever use of wireless remote-control technology in human history. Although it did not attract significant military attention at the time, it demonstrated the feasibility of the command-remote control-execution process (Yan et al., 2010). During World War II, radio technology was still relatively rudimentary and susceptible to enemy jamming or interception. Germany employed wire-guided remote-control technology to deploy "FL-Boote" unmanned boats for suicide attacks against Allied ships, setting a precedent for unmanned surface vehicles directly participating in combat. By the late 1940s, unmanned undersea vehicles began to emerge in the military field. The United States Navy took the lead in successfully developing the "CURV" remotely operated underwater vehicle, primarily used for searching and recovering crashed aircraft from the sea (Roberts and Sutton, 2006). In the early Cold War period, as the two superpowers, the United States and the Soviet Union, utilized unmanned surface vehicles for military training, controlling them via cable or from a mother ship for target practice. Examples include the US Firefish target boat and the Soviet Project 1784 target boat.

2.2 Technological breakthrough stage

In the 1980s, computer and sensor technologies led to leapfrog development for unmanned undersea vehicles. Entering the early 21st century, especially after the "9/11" attacks, with the continuous expansion of civilian information technologies, GPS positioning, inertial navigation, and sonar technologies, unmanned platforms gradually shifted from relying on remote control toward initial autonomous operation (Manley, 2016). Unmanned maritime vehicles began to demonstrate their potential in civilian fields such as marine mapping, deep-sea exploration, and environmental monitoring. In July 2008, the "Tian Xiang 1" unmanned marine meteorological survey ship, jointly developed by the China Meteorological Administration Atmospheric Observation Technology Center and the Aerospace Science and Industry Corporation, served during the Qingdao Olympic Sailing Competition. Beyond civilian applications, unmanned maritime vehicles also achieved significant development in military domains such as anti-ship/anti-terrorism operations, mine countermeasures (mine clearance and laying), and maritime surveillance. During this phase, Western nations began various verification designs and developed a range of unmanned maritime vehicles. In 2003, the United States deployed the "Spartan Scout" unmanned surface vessel on the USS Gettysburg cruiser, participating in Operation Enduring Freedom and Operation Iraqi Freedom in the Gulf region, primarily responsible for battlefield reconnaissance and target acquisition missions. In 2006, Israel deployed the "Protector" unmanned surface vessel in waters near Gaza, mainly tasked with maritime surveillance, maritime blockade missions, and assisting the Israeli Navy in operations codenamed "Operation Summer Rains" and "Operation Autumn Clouds." Beyond periods of high-intensity conflict, unmanned surface vessels also became an integral part of the Israeli Navy for daily patrols and combat readiness duties (Kozera, 2018).

2.3 Strategic competition stage and challenges

The current stage represents a critical period where unmanned intelligent technology evolved from low to high level and from simple to complex, enabling military unmanned maritime vehicles to possess a certain degree of autonomous navigation capability under preset path conditions (Yan et al., 2010). Their types, functions, and sizes achieved more profound development compared to the past. It can be said that military unmanned maritime vehicles proliferated during this stage (Martin, 2013). Since 2010, the US military successfully demonstrated cross-domain information exchange technology between unmanned platforms, and major breakthroughs were made in the development of large or extra-large UUVs. Reportedly, as early as September 2015, the US Washington Free Beacon first publicly reported that Russia was building a nuclear-powered UUV, which the US Department of Defense designated with the code name "Kanyon".

New-domain and new-quality combat capabilities developed toward larger scale, greater intelligence, and swarming, further driving the profound transformation of military unmanned maritime vehicles from mechanization and informatization to intelligentization (Serhii, 2025). According to recent statements from the Security Service of Ukraine (SBU), Ukrainian forces have, for the "first time," successfully damaged a Russian Navy submarine using an unmanned underwater vehicle (UUV). The target was identified as a Project 636.3 Varshavyanka-class submarine (known by the NATO reporting name Kilo-class). The SBU claimed the attack resulted in an onboard explosion and fire, rendering the vessel inoperable. This incident marks the second offensive action by Ukraine against a Kilo-class submarine of Russia's Black Sea Fleet. The first attack occurred in September 2023, when a submarine of the same class, moored at the Sevastopol naval base, was reportedly damaged by a combined-arms strike involving cruise missiles and uncrewed surface vessels (USVs), commonly referred to as maritime kamikaze drones (Xinhua News Agency, 2025).

Undoubtedly, the Russia-Ukraine conflict that began in February 2022 became the first case in history that truly provided a comprehensive battlefield test for military unmanned maritime vehicles (Wang and Ke, 2022). Governments and military branches worldwide recognized the inevitability of future unmanned intelligent technology empowering military unmanned maritime vehicles and consequently released clearer strategic planning documents. For instance, in March 2023, the US Coast Guard released its Unmanned Systems Strategic Plan, aiming to enhance the development and application of unmanned systems. In May of the same year, the US Navy conducted the "Unmanned Systems Integrated Battle Problem" exercise. In June, the Russian government approved the 2030 Strategy for the Development of Unmanned Aircraft Systems, outlining five main development directions.

Consequently, this stage further propelled military unmanned maritime vehicles beyond possessing merely single unmanned intelligent functions; they are now transitioning toward becoming all-spectrum (surface, underwater, cross-medium), miniaturized or large-scale, swarm-capable, and highly autonomous systems, quietly altering the future form of naval warfare and influencing the international maritime order (Kunertova, 2024). The significant development of military unmanned maritime vehicles empowered by different technologies will bring diverse and complex risks and challenges (Bae and Hong, 2023). Military unmanned maritime vehicles primarily rely on remote control, making them susceptible to external detection, jamming, or disruption, and vulnerable to being hijacked or captured resulting in loss of control. Secondly, with the proliferation of information and sensor technologies, the sources of risk for military unmanned maritime vehicles are diverse.

Coupled with the need for improvement in key technologies such as global supply chains, data links, and cybersecurity, perceptual confusion, misinformation, missing information, and chaotic data transmission are likely to occur in complex maritime environments. This could lead to decision-making errors and incorrect commands (Liu and Feng, 2025). Simultaneously, AI's coverage of maritime situational awareness cannot achieve complete predictability and accuracy. Combined with their inherent weakness in autonomous navigation planning capability, this could lead to incidents such as mistaken attacks and bombings, and collisions between unmanned and manned vessels. Finally, in this phase of high integration of new-domain and new-quality capabilities, military unmanned maritime vehicles will raise concerns worldwide, particularly as they may spur major maritime powers to initiate a new arms race. This could lead to large-scale swarms of military maritime vehicles conducting indiscriminate attacks against non-military targets at sea, posing a series of challenges to international maritime law, ethical constraints, and risk management (Bahadir, 2023).

3 Military unmanned maritime vehicles and maritime power re-balance

Empowered by unmanned intelligent technologies and with the year-on-year decrease in the development costs of unmanned platforms, military unmanned maritime vehicles will see large-scale, batch utilization in the future (Ljulj et al., 2024). It can significantly impact the traditional maritime force organizational structure centered around large manned platforms, particularly evident in both peacetime environments and during crisis intervention or wartime. The path through which military unmanned maritime vehicles achieve breakthroughs in military re-balance is not singular or linear, but rather an all-encompassing, systemic transformation, covering all links of the Observe–Orient–Decide–Act (OODA) loop. Particularly across multiple dimensions such as information, speed, cost, risk, and rules, they are redefining the new paradigm of future maritime military competition.

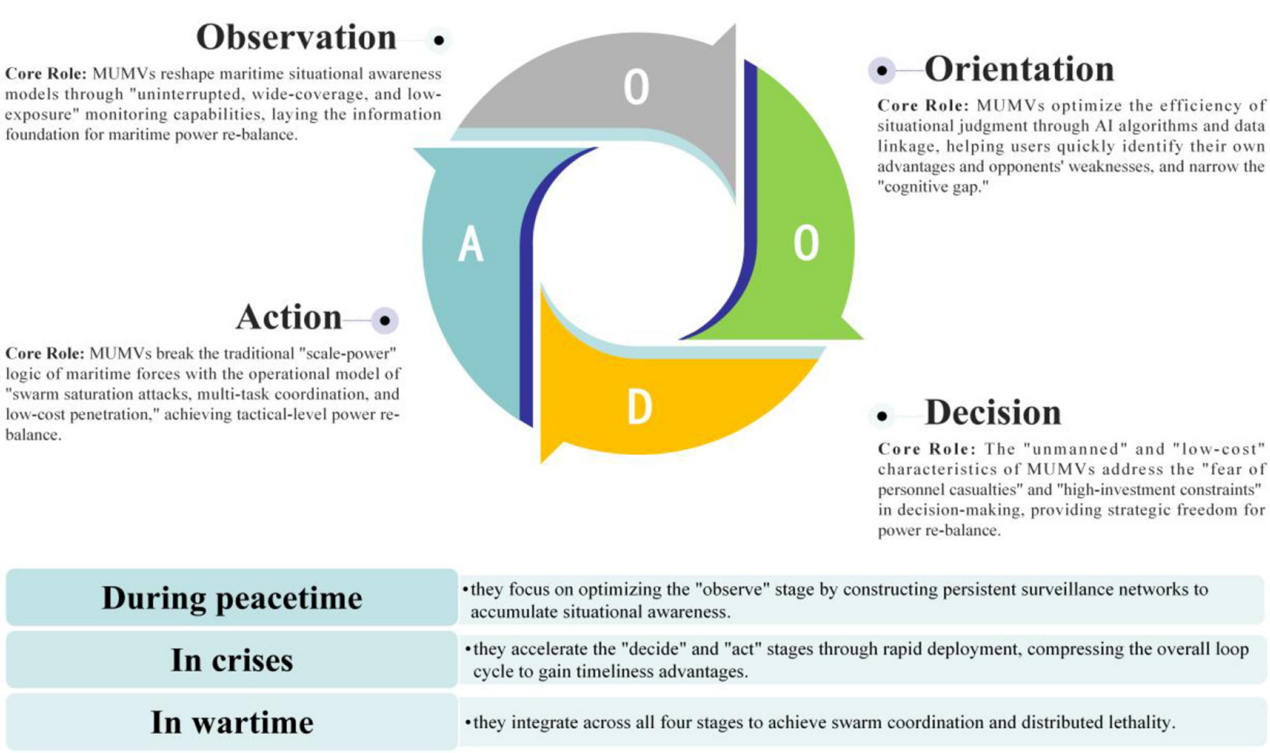

FIGURE 1
Action mechanism of military unmanned aerial vehicle in OODA cycle system. Source: The author draws by himself according to the open source information.

To clarify the theoretical foundation guiding this analysis, two core concepts are defined upfront: the Observe–Orient–Decide–Act (OODA) loop and "power re - balance" (Figure 1). The OODA loop, proposed by military strategist John Boyd, refers to the iterative combat decision - making cycle encompassing four sequential stages: observing the operational environment, orienting oneself based on the collected information, deciding on a course of action, and acting to implement the decision. For MUMVs, their technical advantages (e.g., long endurance, high autonomy, swarm deployability) enable the compression or optimization of key links in this loop, thereby helping users seize the battlefield initiative. "Power re-balance" in the maritime context specifically denotes the tactical - level restructuring of asymmetric capabilities, rather than a fundamental reversal of the global maritime power structure. It emphasizes that MUMVs empower states (especially small and medium - sized ones) to narrow the gap in specific operational capabilities, without altering the core strategic advantages held by major maritime powers in areas such as global command and control systems. These two concepts form the analytical framework for exploring MUMVs' impact on maritime power dynamics. In terms of the OODA loop, MUMVs exert differentiated effects across peacetime, crisis, and wartime scenarios.

3.1 Re-balance by reshaping maritime awareness capabilities

During peacetime, military unmanned maritime vehicles possess multiple attributes as weaponry, detection devices, and disguised civilian platforms, blurring the line between military and civilian use (Veal et al., 2019). The flexibility in their classification under international law indirectly creates a vast "gray zone" for extensive practical application by various nations. Through persistent, low-intensity, and widespread use, they are restructuring the strategic advantage in maritime situational awareness.

Firstly, the application of military unmanned maritime vehicles promotes information re-balance, dispelling the fog of maritime situational awareness. The widespread use of military unmanned maritime vehicles in peacetime is fundamentally altering how nations' militaries achieve maritime situational awareness, significantly accelerating the pace of building situational awareness platforms, and expanding the geographical scope of such efforts [Dimitrakieva and Kostadinov (n.d.)]. The core impact lies in transforming maritime environment sensing, battlefield picture construction, and strategic prepositioning from intermittent, sampling-based activities into sustained, all-domain, and precise routine activities (Forti et al., 2022).

Military unmanned surface vessels and undersea vehicles, with their characteristics of long endurance, high stealth, and deployability in swarms, are constructing an unprecedented "oceanic transparency" monitoring network (Palbar Misas et al., 2024). For instance, by prepositioning USVs and UUVs in swarms and grids during peacetime—potentially disguised as containerized, disassemblable civilian vessels-around global key straits, chokepoints, or rival maritime areas, they can autonomously form a wide-area, persistent, concealed Ocean Internet of Things supported by emerging technologies like artificial intelligence and edge algorithms. This network continuously collects data on adversaries' military meteorology and hydrology, vessel routine patrols, maritime weapon tests, and joint exercises at different ocean depths, relaying the information back to friendly intelligence centers via communication nodes such as high/medium/low-orbit satellites, USVs, and UUVs.

It can be said that whether for major maritime powers or small and medium-sized states, this approach can substantially challenge the deterrence and stealth traditionally provided by large vessels and nuclear/conventional submarines of established maritime powers, enabling a capability leap from strategic passivity to area denial (Jacq et al., 2019).

Secondly, the application of military unmanned maritime vehicles promotes re-balance in maritime battlefield development, leading to a significant acceleration thereof. Traditional oceanographic surveys rely on research vessels and a small number of manned ships, which are costly, time-consuming, and offer limited coverage. In contrast, UUVs and USVs can conduct grid-based inspections over long durations, across vast areas, and autonomously, continuously acquiring key hydrological data such as water temperature, salinity, depth, seabed topography, and magnetic fields. This high-precision, real-time marine environmental information forms the foundation for building high-fidelity digital maritime battlefields and optimizing sonar detection and submarine stealth strategies, directly determining who holds the underwater advantage in wartime.

Concurrently, a key focus of peacetime maritime battlefield development is acquiring strategic intelligence on other nations' vessel daily activity patterns, base comings and goings, and new equipment tests. Unmanned maritime vehicles, leveraging their advantages of low detectability, long endurance, and low political sensitivity, can conduct persistent, surveillance in forward waters or key channels, seamlessly integrating information from satellites, manned platforms, and various unmanned systems to form a continuously updated map of maritime dynamic order (Giurgiu et al., 2023). This behavioral baseline accumulated during peacetime enables the rapid identification of any anomalous deployments or suspicious activities, greatly enhancing strategic early-warning capability. Military unmanned maritime vehicles are elevating peacetime maritime battlefield development from a supplementary, preparatory activity to a persistent strategic competitive action that directly shapes military advantage. The core lies in using unmanned and intelligent means to achieve one-sided transparency in the maritime battlefield even during peacetime, laying a decisive foundation for any potential conflict (Boretti, 2024).

Thirdly, the application of military unmanned maritime vehicles achieves a re-balance of military development costs, lowering the economic investment threshold for achieving combat power and deterrence, and altering the status quo in force development comparisons. Currently, with the continuous improvement of emerging technologies and even modular design, and the ongoing optimization of global supply and industrial chains, the costs associated with the research, development, manufacturing, production and operation of military unmanned maritime vehicles are continuously decreasing, relative to the tens of billions or even hundreds of billions of dollars required to build large traditional manned combat vessels (Ljulj et al., 2024). This makes it possible for most countries worldwide to deploy military unmanned maritime vehicles diversely, at scale, and systematically. For example, in July 2025, the New Zealand and Fijian navies collaborated to deploy Bluebottle USVs. Other examples include Sweden's Double Eagle UUV and Turkey's Marlin USV. The unit cost of a Ukrainian developed suicide unmanned speedboat is approximately USD 250,000, while the unit price of the US Sea Dart unmanned submarine is only USD 150,000, representing a significant cost advantage compared to the USD 13 billion unit cost of a US Ford-class nuclear-powered aircraft carrier (Xinhua News Agency, 2024).

Some small and medium-sized states have also made significant progress in military unmanned maritime vehicles. In October 2023, the Turkish Navy, during a joint operational experiment, utilized coordinated USVs and UAVs to sink a maritime target. In September 2025, the Philippines expressed strong interest in introducing Ukrainian-developed USVs, hoping to deploy them in the South China Sea to create geopolitical friction. It must be said that states with limited resources and technical capabilities can increase their investment in deploying military unmanned maritime vehicles through avenues such as R&D cooperation with other countries, purchases, and leases, continuously breaking the underlying logic that powerful maritime strength requires exorbitant costs, and providing an effective path for re-balance against the asymmetric strength exerted by major maritime powers (Banas et al., 2020). Nevertheless, it must be acknowledged that a global or large-scale maritime awareness network and its operation still require substantial satellite infrastructure and artificial intelligence processing capabilities. These resources are often held by major powers, which may lead to new imbalances and the disadvantaged position of small and medium-sized states.

3.2 Re-balance to maintain integrated maritime deterrence

During crisis period, the naval forces of the involved states gradually move forward, assuming a confrontational posture. The core essence of re-balance in this stage is the urgent need to rapidly create a favorable maritime situation and clearly demonstrate one's own maritime intentions to the adversary, thereby effectively managing crisis escalation and avoiding the direct outbreak of war (Bergeron, 2020). Furthermore, the wartime period refers to the phase where both sides are already in direct combat confrontation. Military USVs and UUVs can be directly integrated into joint operational systems, employing multi-service, cross-domain coordination, and distributed lethality to thoroughly dismantle the adversary's combat capabilities.

Firstly, military unmanned maritime vehicles are promoting a re-balance in the timeliness of naval decision-making and tactical execution, compressing the situational decision cycle, and assisting users in seizing the initiative during a crisis (Ljulj et al., 2024). Military unmanned maritime vehicles come in various models and can be rapidly strategically deployed to the adversary's forward crisis waters within a short time via land, air, or sea transport, or even airdrop or mothership deployment. These deployable and easily assemblable surface and undersea vehicles can achieve "lightning" situational deployment, moving ahead of the adversary's forces. Simultaneously, leveraging their forward deployment, they can quickly utilize the various functions of USVs and UUVs, significantly shortening the user's own OODA loop cycle. This creates a greater time and information disparity compared to the adversary. Finally, the acquired situational information can be released in real-time or communicated to the adversary, generating immediate deterrence in political, diplomatic, and public perception spheres, further seizing the digital control of the battlefield situation.

Secondly, military unmanned maritime vehicles significantly achieve a re-balance of naval risks, including reducing personnel casualties and alleviating the political and public opinion constraints on the party taking proactive actions. The inherent "unmanned" nature of military unmanned maritime vehicles makes them ideal platforms for operating in high-intensity crisis or wartime environments. In such environments, USVs and UUVs can conduct close-in reconnaissance, electronic warfare, channel blockade, limited armed strikes, and even support main warships in primary attacks within the adversary's forward areas. Furthermore, using autonomous or remotely controlled military unmanned maritime vehicles offers greater personnel safety compared to military personnel directly executing these actions. Consequently, the issue of personnel casualties no longer constitutes a major constraint in the user nation's political and public discourse, substantially freeing national leaders to have greater strategic freedom of action. This may enable the adoption of more assertive approaches, further authorizing military unmanned maritime vehicles to conduct higher-risk, higher-value operations to probe the adversary's political bottom line and psychological defenses (Boretti, 2024). Meanwhile, if the adversary reacts excessively, attacking these low-cost unmanned platforms could potentially backfire, indirectly delaying and limiting the adversary's maritime options for action.

Finally, military unmanned maritime vehicles are altering the balance of naval power and its deterrent effect, reconstructing an asymmetrical, saturated, and integrated deterrent posture (Kunertova, 2024). For example, military unmanned maritime vehicles, through their networked, swarm, and autonomous systems, demonstrate high levels of coordination, saturation attack capability, and multi-layered defense capability. They can pose severe challenges to the traditional large naval surface vessels, such as aircraft carrier battle groups, amphibious assault ships, and large hospital ships, upon which adversaries have long relied and showcased. Additionally, the defense systems of current traditional weapon platforms struggle to intercept these low-cost surface and undersea vehicles. The low-cost, high-volume munitions launched by these unmanned platforms, or their suicide attack postures, significantly degrade the survivability of traditional weapon platforms. Therefore, when high-intensity crises or even wars occur, these "wolf-pack" or "swarm" military unmanned maritime vehicles allow the user to reconstruct an asymmetrical, integrated deterrent posture vis-à-vis the adversary, making the adversary perceive the high cost of armed intervention in the conflict (Banas et al., 2020).

4 Enhancing contributions of military unmanned maritime vehicles to the maritime security order

With the rapid development and wide application of unmanned maritime vehicle technology, their role in maritime security governance is becoming increasingly prominent, while also bringing a series of new challenges. Although the application of military unmanned maritime vehicles is altering the balance of maritime power, this does not necessarily signify a disaster. Through sound legal institutions, emphasis on technological accessibility for smaller states, and preventing acquisition by non-state entities, the development of military unmanned maritime vehicles could even have a positive impact on the international maritime security order. By establishing reasonable international rules and cooperation mechanisms, military unmanned maritime vehicles are expected to become an important force in safeguarding maritime security.

4.1 Adjusting the international legal framework

Legal regulation of research, development, and deployment is the foundation for ensuring that military unmanned maritime vehicles promote the international maritime security order. Currently, although the UNCLOS is regarded as the key framework for modern law of the sea, it almost entirely failed to anticipate the development of unmanned maritime vehicles, resulting in gaps concerning their legal status, jurisdiction, and behavioral norms (Chang et al., 2020). The legal status of military unmanned vessels—namely, whether they qualify as "ships" or "warships"—is legally intertwined with the navigation rules applicable to them, as well as the scope of exemptions, rights, and obligations they are entitled to under international law. For instance, whether an unmanned undersea vehicle can be considered a ship and subject to the regime of innocent passage remains unsettled in international law. This requires clarifying the legal attributes of unmanned maritime vehicles through legal interpretation or amendment, and incorporating them into the international legal regulatory system (Schmitt and Goddard, 2016).

A preliminary observation is that different types of military unmanned maritime vehicles cannot easily be subsumed under a single international legal status. Consequently, the applicable international navigation regimes and the scope of jurisdictional immunities they enjoy also vary significantly. Although the design and application of MUMVs do not entirely fall within the scope of UNCLOS, and they enjoy extensive immunities under this convention in most cases—sometimes even beyond the realm of peacetime law - it may still contribute partially to resolving the legal status of military unmanned vessels and help establish a fundamental legal framework for them.

Concurrently, the international community should establish technical standards and norms to ensure that the design, manufacture, and use of unmanned maritime vehicles comply with international safety and ethical requirements. For example, the International Maritime Organization (IMO) could develop intelligent classification standards for unmanned ships, regulating their levels of autonomy and safety performance (Chae, 2024; Milger, 2024). As previously mentioned, these rules cannot be directly applied to military unmanned vessels, and the ambitions and recent efforts of the IMO have primarily focused on the legal regulation of Maritime Autonomous Surface Ships (MASS). Nevertheless, this remains crucial for achieving clarity and regulation of the legal status of military unmanned vessels. These rules will serve as an important reference for nations in determining whether to formulate regulations for military unmanned vessels individually or jointly, and will function similarly to "soft law." In this case, domestic legislation needs to advance accordingly. National legislative practices not only provide a legal basis for managing unmanned maritime vehicles but also offer references for the formulation of international rules (Nainggolan, 2018). For instance, China, in its Coast Guard Law and Maritime Traffic Safety Law, appears to have included unmanned undersea vehicles of all types within the category of "ships," and requires foreign unmanned maritime vehicles to report to the maritime administrative authority when entering its territorial sea (Wang and Ke, 2022). Building upon these efforts, nations may, driven by practical needs in maritime activities or other considerations, find common ground to initiate joint international law-making work, particularly to meet the demand for secure maritime interactions among major powers.

Furthermore, it is necessary to focus on regulating the activities of unmanned maritime vehicles within maritime areas under coastal state jurisdiction. It is argued that military survey activities in the exclusive economic zone may harm the security interests of the coastal state, and their limits need to be defined by law, while some countries, such as the United States, deny that low-intensity military activities, such as military surveys conducted in EEZs, constitute a threat to peace or fall within the scope of the coastal state's jurisdiction over its EEZ (Pedrozo, 2014). In this light, the navigation scope, payload functions, and combat uses of unmanned maritime vehicles should be restricted by international law to prevent their use for undermining maritime peace and security. For example, the principles of peaceful uses of the seas and duty to have due regard to the rights and duties of the coastal State from UNCLOS can serve as a significant starting point for the debate of the non-public military survey activities conducted by unmanned maritime vehicles. The granting and boundaries of immunity are also a very important subject for discussion (Kraska, 2024; Felencia et al., 2022).

4.2 Balancing accessibility beyond major maritime powers

The development of military unmanned maritime vehicle technology provides new opportunities for smaller states to enhance their maritime security capabilities. Traditionally, maritime security governance has been dominated by major powers, with smaller states, limited by technological and economic strength, struggling to participate effectively. However, unmanned maritime vehicles, with their characteristics of low cost and high efficiency, are changing this landscape. Low cost and high efficiency enable smaller states to acquire advanced maritime monitoring and defense capabilities at an affordable price. For example, the cost of an unmanned surface vessel is typically only in the range of hundreds of thousands of US dollars, far less than the billions for traditional large armed platforms, yet their effectiveness in intelligence collection, anti-submarine warfare, mine countermeasures, and collision avoidance should not be underestimated. This cost advantage allows small and medium-sized states to enhance their monitoring and control capabilities over their jurisdictional waters by introducing or independently developing unmanned maritime vehicles, thereby more effectively combating maritime threats such as smuggling, piracy, and illegal fishing (Bae and Hong, 2023).

Technological cooperation and capacity-building are key to enhancing technological accessibility for smaller states. The international community should encourage technologically advanced states to help small and medium-sized states master the use and management of unmanned maritime vehicles through means such as joint research and development, technology transfer, capacity training, and procurement leases. For instance, the US-Ukraine cooperation in developing an unmanned vehicle capable of both aerial flight and surface navigation demonstrates the potential of technological cooperation in enhancing maritime security capabilities (Kunertova, 2024). Such cooperation not only helps smaller states build autonomous maritime security systems but also promotes the overall enhancement of regional maritime security.

Additionally, the modular and multi-functional design of unmanned maritime vehicles further enhances their applicability in small and medium-sized states, allowing them to flexibly configure the functions of unmanned maritime vehicles according to their own security needs, achieving personalized development of maritime security capabilities (McLaughlin, 2011). Nevertheless, vigilance should be exercised over the widespread use of highly offensive unmanned vessels in military activities, particularly the high risk that armed conflict may pose to the peaceful order of the oceans. Therefore, the leading powers in this field should be responsible for the export of key technologies and manufacturing capabilities.

4.3 Guarding against acquisition by non-state entities

While the proliferation of military unmanned maritime vehicle technology helps smaller states enhance their maritime security capabilities, it also carries the risk of acquisition and misuse of this technology by non-state entities, including terrorist organizations, pirate groups, and private military companies—their acquisition of unmanned maritime vehicle technology could pose a serious threat to international maritime security. The potential risks of technological proliferation are mainly reflected in the possibility of non-state entities using unmanned maritime vehicles for illegal activities (McLaughlin and Klein, 2021). For example, the low detectability and high mobility of unmanned surface vessels make them ideal tools for terrorists to launch attacks. The recent incidents involving UUVs in territorial waters indicates that non-state entities already possess the capability to use unmanned maritime vehicles for intelligence gathering and attacks. Furthermore, the swarm combat capability of unmanned maritime vehicles might be used by non-state entities for saturation attacks, causing severe damage to merchant ships and port facilities.

Control measures are crucial to preventing non-state entities from acquiring unmanned maritime vehicle technology. First, the international community should establish export control and technology confidentiality mechanisms, implementing strict export management on the core technologies and components of unmanned maritime vehicles. For example, multilateral export control agreements can restrict the transfer of sensitive technologies to prevent them from falling into the hands of non-state entities. Second, domestic legislation should clarify the registration and supervision system for unmanned maritime vehicles, ensuring their traceability throughout production, sale, and use (Pandey, 2023). For instance, China's requirement in the Maritime Traffic Safety Law for foreign unmanned maritime vehicles to report upon entering the territorial sea could be extended to monitor the activities of non-state entities.

Finally, international cooperation and information sharing are effective ways to guard against threats from non-state entities. States should enhance their monitoring and response capabilities against the use of unmanned maritime vehicles by non-state entities through intelligence exchange, joint law enforcement, and combined exercises. For example, establishing a surveillance network for unmanned maritime vehicles in sensitive sea areas to promptly detect and intercept suspicious activities. It should be acknowledged that, much like the current state of most arms export controls, it is unlikely to completely prevent relevant entities from accessing technology or acquiring dual-use products. However, the collective efforts of the international community and the criminalization of such practices remain essential, particularly for curbing large-scale improper acquisition. Furthermore, the focus of regulation should be specifically on restricting the leakage of unmanned vessel products and technologies with high autonomy and high lethality capabilities.

As an emerging maritime technology, military unmanned maritime vehicles have a dual impact on promoting the international maritime security order: on one hand, they provide smaller states with new means to enhance their maritime security capabilities, promoting the multipolarization of maritime security; on the other hand, their technological proliferation could be exploited by non-state entities, increasing maritime security risks (Boretti, 2024). By perfecting the legal framework, emphasizing technological accessibility for smaller states, and preventing acquisition by non-state entities, their positive role can be maximized while mitigating potential risks. In the future, the international community should continue to deepen the legal regulation of unmanned maritime vehicles and promote the formulation of unified international rules. Simultaneously, technological cooperation and capacity building should take into account the needs of smaller states, ensuring the fairness and inclusiveness of maritime security governance. Finally, preventing non-state entities from acquiring unmanned maritime vehicle technology must become a priority in global maritime security governance, safeguarding the peace and security of the oceans through domestic legislation and international cooperation.

5 Conclusion

The technological development and application of military unmanned maritime vehicles are profoundly reshaping the maritime power landscape and the international maritime security order. Their historical evolution, progressing from early remote-controlled exploration through technological breakthroughs and diversified development, has now entered a stage of strategic competition among major powers. Driven by intelligent technology, unmanned maritime vehicles have achieved a leap from remote control to high autonomy, with their forms and functions becoming increasingly diverse, encompassing types ranging from large unmanned undersea vehicles to swarm unmanned surface vessels.

At the operational level, unmanned maritime vehicles are systematically challenging traditional naval forces through a "re-balance" across four dimensions: information, speed, cost, and risk. In peacetime, they reconfigure maritime situational awareness models through persistent, covert, and wide-area surveillance, significantly accelerate naval battlefield development, and their low-cost nature lowers the threshold for small and medium-sized states to acquire maritime capabilities. During crises or wartime, unmanned maritime vehicles enable rapid deployment, compress the Observe-Orient-Decide-Act loop, and seize battlefield initiative. Their "unmanned" characteristic reduces the risk of personnel casualties and political baggage, potentially enabling states to take more assertive actions. Their advantages in swarming and low cost can further construct asymmetric saturation attack capabilities, posing a severe threat to traditional large vessels and thereby altering the deterrence balance.

However, the rapid development of unmanned maritime vehicles also brings multiple risks, including susceptibility to interference or hijacking, perceptual and decision-making errors in complex environments, and the potential to trigger a new arms race alongside legal and ethical challenges. Therefore, to guide their contribution positively to international maritime security, it is essential to adjust the legal framework by clarifying their legal status and activity norms under international law such as the UN Convention on the Law of the Sea. Concurrently, technological accessibility for smaller states should be enhanced through cooperation, assisting them in safeguarding their maritime rights and interests, while strictly preventing the proliferation of technology to non-state entities such as terrorist organizations. Military unmanned maritime vehicles are a double-edged sword. In the future, the international community must strengthen legal regulations, promote inclusive technological cooperation, and strictly prevent technological proliferation to effectively harness this emerging technology, mitigate its risks, and ensure it ultimately serves the goal of maintaining maritime peace and security.

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