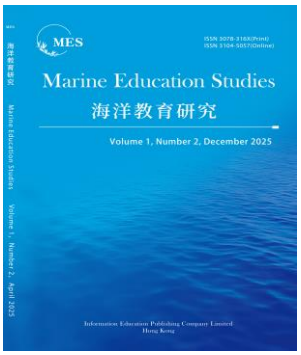

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The Evolution and Implications of Global Marine Education ——A Longitudinal Examination from a Global Historical Perspective

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Abstract: Marine education serves as the cornerstone of maritime power. This article delineates the evolution of global marine education, categorizing it into four developmental stages marked by significant historical transitions: the colonial expansion of the 19th century, the awakening of ecological consciousness after World War II, and the United Nations' Ocean Decade initiative in the 21st century. It reveals the interplay between educational forms, maritime power games, ecological crises, and technological innovations. Furthermore, the article focuses on the modernization of marine education in China, detailing its progression since the 19th century into four distinct phases: the passive enlightenment period, the planned system period, the open transition period, and the strategic leadership period, while also addressing the challenges encountered in its localization practices. Lastly, it critically engages with the developmental experiences of global marine education, elucidating their implications for China's marine education and tentatively proposing innovative pathways that integrate an international perspective with Chinese characteristics.

Keywords: marine education; maritime power; marine literacy; maritime strategy

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题目：全球海洋教育的演进逻辑与时代意蕴——基于全球史观的纵向剖析

摘要：海洋教育是海洋强国建设的基石。本文梳理全球海洋教育的演进历程，划分出以 19 世纪殖民扩张、二战后生态意识觉醒及 21 世纪联合国“海洋十年”倡议为标志的四大发展阶段，揭示教育形态与海权博弈、生态危机及技术创新的互动关系。进而聚焦中国海洋教育现代化进程，详述其自 19 世纪以来经历的被动启蒙期、计划体制期、开放转型期与战略引领期四个阶段，并剖析本土化实践中的挑战。最后，批判性借鉴全球海洋教育的发展经验，阐释其对我国海洋教育的启示，初步提出兼具国际视野与中国特色的创新路径。

关键词：海洋教育；海洋强国；海洋素养；海洋战略

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1. Introduction

Marine education is the cornerstone of a nation’s oceanic endeavors and serves as the vital link in fostering a maritime community with a shared future between humanity and the ocean. With the acceleration of globalization and the intensification of the climate crisis, marine education has taken on the crucial responsibility of breaking ecological predicaments, guiding humanity to reconstruct its understanding and practices regarding the ocean through the lens of a “shared community of destiny”. Global marine education has undergone a lengthy evolution, manifesting diverse developmental characteristics and trends across different historical periods. Revealing its developmental patterns and underlying logic can offer valuable insights for the advancement of marine education in various countries. Currently, as China is actively promoting the establishment of a strong maritime power, investigating the evolution and development of global marine education holds significant theoretical and practical implications for modernizing China’s marine education, enhancing the national marine literacy, and bolstering the nation’s maritime competitiveness.

Specifically, this study focuses on the following three issues: First, what changes in the content and practical pathways of global marine education have emerged during different historical stages, and how are these phenomena related to social, political, economic, and environmental factors of each period? Second, what distinctive characteristics can be identified in the localization practices of marine education in China since the 19th century, what challenges have emerged, and how can it leverage the experiences of global marine education to address these issues? Third, how can an innovative pathway for marine education be developed that incorporates both an

international perspective and Chinese characteristics to meet the developmental demands of the new era?

To thoroughly investigate the aforementioned issues, this study employs a comprehensive range of methodologies, including literature review, historical research, comparative analysis, and case study. First, the literature review serves as the foundational method for this research. A substantial amount of relevant academic literature and policy documents pertaining to marine education, both domestically and internationally, have been collected, allowing for a systematic examination of the concepts, content, competencies, and practical pathways of marine education. Additionally, the study maps the evolution of global marine education in phases. The data primarily derives from academic databases and websites of governmental departments or organizations. Secondly, utilizing historical research, this study traces the development of global marine education and China's marine education chronologically, analyzing the characteristics and advancements at each stage while exploring the intrinsic relationships between marine education, maritime power games, technological innovations, and ecological crises. Historical materials are sourced from scholarly monographs on historical research, relevant news reports, and official websites.

Additionally, comparative analysis is another significant methodology employed in this research. By comparing the development patterns and practical experiences of marine education across different countries and regions, the study aims to discern both the commonalities and distinctions in their progress, thereby identifying the gaps between China's marine education and international standards. Ultimately, representative countries or regions will be selected for an in-depth examination of their marine education practices, allowing us to distill valuable insights and lessons that can inform the localization of marine education in China.

2. Literature Review

2.1 The Study of the Concept of Marine Education

The combination of the terms "marine" and "education" was first utilized in the context of higher education focused on marine science (Zhu,2020). For instance, in 1987, Shandong Ocean University hosted a seminar on the marine science curriculum framework for universities in the Asia-Pacific region, where models of university-level marine science education were discussed (Li,1988). The broad conceptualization of marine education was initially proposed by the American scholar Richard M. Schlenker. He defined marine education as a comprehensive educational

practice aimed at equipping the public with knowledge related to marine science, marine economy, marine pollution, coastal and marine societies, maritime history, marine transportation, marine music, marine arts, and other marine-related issues (Schlenker R M,1977). In China, one of the earliest uses of the term "marine education" was by Hu Zhigang, who, in his 1998 publication Marine Education for the Future, asserted that geographical teaching should prioritize safeguarding national maritime rights and enhance marine education for the youth. Although this perspective expanded the subjects of education beyond university students, its educational content remained narrowly focused on patriotic education aimed at defending the nation's maritime boundaries (Hu,1998).

As research has advanced, the concept of marine education has expanded beyond maritime and fisheries education, broadening its scope from specifically higher marine science (technology) education to encompass education for preschoolers, children, and the general public. According to Huang Jiangang, marine education involves cultivating marine awareness, knowledge, and competencies among citizens. Shen Tian'en emphasizes that marine education is an educational activity that explores the intricate interactions between people, events, times, places, and objects related to the ocean, and is closely related to indigenous education and environmental education, encompassing both natural and cultural elements (Huang,2007). Ma Yong distinguishes between broad and narrow definitions of marine education; the broad definition includes a variety of educational experiences related to the ocean, while the narrow definition specifically refers to marine education within the context of schools (Ma,2012). Liu Xunhua further categorizes marine education into broad, intermediate, and narrow definitions based on the audience and practical context. The broad definition refers to general marine education aimed at the entire populace, the intermediate definition pertains to marine education activities conducted in various schools at all levels, while the narrow definition targets specialized marine education for professionals in marine-related fields (Liu,2024).

In summary, marine education represents a crucial dimension in the evolution of human civilization. The development of the connotations and denotations of marine education reflects the deepening process of humanity's understanding of the ocean. Scholars have transcended singular definitions, shifting toward a conceptual framework that encompasses dimensions such as cognition, practice, and ethics.

2.2 The Study of Marine Education Content and Literacy

The evolution of the concept of marine education drives a structural leap in the knowledge system. There exists a bidirectional interplay between marine education content and marine literacy, with the former providing foundational support for the

latter, while the latter dynamically informs and enriches the former. Thus, they are examined in conjunction.

Marine education in the United States commenced early, and the concept of marine literacy also originated from this context. In 2005, the National Marine Educators Association in the U.S. released a definition and framework for marine literacy. The documents Ocean Literacy: The Essential Principles of Ocean Sciences K-12 and Ocean Literacy Scope and Sequence for Grades K-12 became the foundational framework for marine literacy education. The former delineates seven principles of ocean literacy, such as "The Earth has one large ocean with many features" and "The ocean and life in the ocean shape the features of Earth" (Liu & Lyu,2025). However, this framework for ocean literacy primarily considers the natural attributes of the ocean, neglecting its social and cultural dimensions.

In the 1970s, influenced by the U.S. Sea Grant Program, Japan began to establish relevant institutions for ocean education, emphasizing a national approach to marine education. In higher education, the content of marine education centers around "understanding the ocean", "protecting the ocean", and "utilizing the ocean". In vocational education, knowledge related to the development and conservation of marine and coastal resources is integrated. In primary and secondary education, students are gradually guided to accept marine phenomena and contemplate profound issues related to the coexistence of humanity and the ocean (Song & Jiang,2011).

The year 1998 was designated by the United Nations as the International Year of the Ocean. In response, China actively engaged with the international initiative and, in May of that year, released a document entitled The Development of China's Marine Programs, which stated that "China has initially formed a system for marine specialized education, vocational training, and public marine knowledge education."(Central People's Government of the People's Republic of China,2005) However, at that time, the focus of marine education largely overlooked young people, with the content skewed towards specialized marine knowledge and technology.

Scholars have offered varied insights on the content of marine education and marine literacy. Wu Qinglin categorizes marine consciousness education into several areas: awareness of maritime territory, maritime sovereignty, maritime resources, maritime power, maritime security, maritime passage, and marine ecology (Wu,2010). Li Mingqiu emphasizes that "marine consciousness education" should encompass aspects such as maritime territorial sovereignty, maritime strategy, security of maritime passages, marine resources, and marine ecology (Li,2014). Ma Yong views marine education as a form of marine literacy education, dividing it into school-based marine literacy education and public marine education, aiming for the ultimate goal of

achieving harmony between humanity and the ocean through the cultivation of five fundamental literacies (Ma,2021). Li Lianying and colleagues delineate the core elements of marine literacy into marine cognitive literacy, marine emotional literacy, marine moral literacy, marine willpower qualities, and marine behavioral literacy (Li,2024).

2.3 The Study of Practical Pathways for Marine Education

The essence of marine education determines its practical pathways, which can be broadly categorized into the establishment of international cooperation platforms, legal and policy safeguards, construction of school curriculum systems, and participation of social collaboration networks.

Firstly, the establishment of international cooperation platforms. The European Union has shown a remarkable tendency to form partnerships in ocean governance. In 2007, the EU released Integrated Maritime Policy of the European Union (IMP), which outlined the EU's future visions for the utilization and protection of marine resources, supported the creation of a European marine science partnership, and promoted coordinated dialogue among the scientific community, industries, and policymakers (European Union,2007). International organizations also play a vital role in collaborative marine education practices. For instance, the Intergovernmental Oceanographic Commission (IOC) and the Scientific Committee on Oceanic Research (SCOR) are major international organizations that contribute to advancing oceanographic research (Su,2005). The "Blue Schools" initiative also serves as a quintessential example of international cooperation, enabling students to enhance their marine literacy through immersive experiential activities (Madi et al.,2023). Portugal's "Blue Schools" program is the world's first education scheme providing effective certification for marine literacy endeavors in schools, creating a ripple effect across Europe and the Atlantic (GenOcean Decade,2017).

Secondly, legal and policy safeguards. In 1972, the U.S. Congress enacted the Coastal Zone Management Act, leading to the establishment of coastal management agencies at both federal and local levels, thereby advancing comprehensive coastal management. The United Nations Convention on the Law of the Sea (UNCLOS), which came into effect in 1994, grants coastal nations jurisdiction over their exclusive economic zones, expanding their maritime territories and rights.

Thirdly, the construction of school curriculum systems. In Brazil, marine education at the primary and secondary school levels primarily involves interdisciplinary integration, merging into geography and natural science curricula to enhance students' understanding of both natural and historical oceans (Ma, Ning,2022). Hu Suqing asserts that ideological and political theory courses serve as a

main channel for imparting marine awareness education to university students (Hu,2017). Yao Jie suggests that geography courses can act as a foundational platform for marine awareness education, cultivating students' sense of national identity (Yao,2024). Li Dexian and Zeng Youlai regard campus culture, classroom instruction, and practical activities as effective strategies for marine literacy education in primary and secondary schools (Li, Zeng,2025).

Fourthly, the participation of social collaboration networks. In South Korea, a yearly "Maritime Territory Trek" event is held for university students, fostering awareness of maritime sovereignty through visits to marine cities and islands. Additionally, a "Marine Youth Corps" has been established for middle school students to implement targeted marine education initiatives.

Furthermore, research has devised marine-themed games aimed at imparting knowledge of marine environments to players of all ages (Arboleya,Miralles,2022).

3. The Paradigm Shift and Evolutionary Logic of Global Marine Education

The development of global marine education can be divided into four stages: the pre-modern phase, modernization construction phase, the Cold War transition phase, and the post-modern development phase.

3.1 Pre-Modern Phase (Before the Late 18th Century): Colonial Expansion and the Systematization of Nautical Technology

The pre-modern phase of global marine education is characterized by the colonial expansion of European nations and the nascent development of maritime disciplines, with marine research predominantly reliant on the experiential explorations of navigators.

3.1.1 The Plunder of Wealth During the Age of Exploration

The technical explorations of the Age of Discovery were epitomized by Portugal and Spain. Both countries, located on the Iberian Peninsula and adjacent to the Atlantic Ocean, faced resource scarcity that rendered agriculture impractical. The Pyrenees Mountains further obstructed their connections with mainland Europe, while ongoing incursions by Moorish forces from North Africa compelled them to seek living space at sea.

With the expansion of the merchant class and commerce, by the first half of the 14th century, Portugal established a national lifestyle characterized by long-distance maritime and land trade, forging economic connections with Mediterranean ports in Spain and England as well as ports in the East (Gu,2017: 44). Prince Henry the Navigator (1394–1460), the third son of King John I, emerged as a foundational

figure in Portuguese navigation and overseas ventures. He acquired knowledge of trade routes, scientific principles, cartography, and navigation from the Arabs. Laurence Bergreen notes that Henry recruited numerous navigators and shipbuilders to the Sagres Maritime School, where they collaboratively designed a new type of small, easily maneuverable vessel (Lawrence,2019:23). Although historians debate the extent of his impact, the maritime endeavors championed by Henry undeniably elevated Portugal to the center of nautical and geographical knowledge during that era. He facilitated the expansion of Portuguese navigators by funding the establishment of maritime-related courses at universities, creating trading posts along the west coast of Africa, developing the Lagos maritime center, and establishing trading stations on Cape Arguin. The fleets he funded not only returned to Portugal laden with gold, furs, ivory, and slaves but also brought back precise nautical charts (Gu,2017:58-72). Subsequently, Portugal developed new maritime routes that extended south along the west coast of Africa, leading to India, the southern African coast, and other eastern destinations.

In 1480, after achieving preliminary internal unification, the Kingdom of Spain gradually emerged as another maritime power, following Portugal. In 1492, Spain reached an agreement with Columbus known as the Santa Fe Capitulations, designating the East as their destination. In October of that year, Columbus reached an island named San Salvador in the present-day Bahamas, where he discovered crops, tobacco, and gold, while simultaneously developing a new route for voyages between Europe and the Caribbean region by leveraging trade winds and the warm currents of the North Atlantic. This became a crucial reference in later maritime textbooks. However, Columbus's second and third voyages did not yield the anticipated wealth for the Spanish monarchy, leading the Spanish government to revoke his monopoly on the newly discovered lands. As a result, explorers flocked to the Americas, including geographer Amerigo Vespucci and navigator Diego de Lepe, gradually clarifying the outlines of the northern and northeastern Americas in the eyes of the Spanish. Consequently, European nations joined the ranks of those seeking to plunder wealth from the New World.

3.1.2 The Emergence of Disciplines During the Era of Colonial Expansion

Colonial expansion brought material prosperity to the Iberian powers—Portugal and Spain—subsequently inspiring imitation and surpassing efforts from other European nations such as the Netherlands and England. This ongoing momentum further propelled the movement of peoples throughout history and indirectly fostered the emergence of marine-related disciplines.

To the west and north, the Netherlands borders the North Sea and is known as the

"Low Countries" due to its low-lying geography. Long facing maritime challenges, the Netherlands explored the possibilities of navigation and trade. In 1602, the Dutch East India Company was established, which effectively consolidated multiple enterprises under one umbrella, granting the Netherlands a significant advantage in the competition for maritime trade in Asia. By the mid-17th century, Dutch navigation and world trade were at their zenith. Fishing emerged as the cornerstone of the Dutch economy, with herring fishing and processing forming the backbone of its vital industrial chain, which in turn stimulated the development of ancillary industries such as salt purification and shipbuilding. At the naval shipyard in Zaandam, workers mastered a range of skilled crafts, and by this time, Dutch shipyards had fully employed mechanical manufacturing processes, enabling the construction of a ship in just one day. In the 1750s, over 40,000 people from the Netherlands traveled abroad every decade aboard ships of the Dutch East India Company. Between 1595 and 1795, nearly a million individuals sailed from the Netherlands to Asia. Thus, the trade in the East Indies was viewed as a cradle for the development of seafarers. Alongside population movements, there was a diffusion of technology. The compass, paper, and gunpowder technologies from our country found their way into the West, greatly facilitating navigation, information transmission, and security in Dutch maritime trade (Timothy,2023:17-21).

The key to Britain surpassing the Netherlands in maritime supremacy lay in its advantages in navigation technology and naval power. In 1755, British naval surveyors replicated the captured French "74-gun" ship to produce their own 74-gun vessels, such as the "Dublin" and the "Bellona", continuously enlarging the ship design in subsequent iterations (Wu,2023). The invention of the marine chronometer also heralded a new breakthrough for British navigation. In 1759, clockmaker John Harrison created the H-4 marine chronometer, which, after 64 days of operation, lost only five seconds, achieving an accuracy in tracking longitude of up to ten miles. Moreover, Britain placed considerable emphasis on cultivating naval strength. In the 18th century, the Royal Navy School was established in Portsmouth, which was renamed the Portsmouth Royal Naval Academy in 1806; after two years of education at this institution, one could become a cadet officer (Crowley,1992).

3.2 Modernization Construction Phase (Early 19th Century to Pre-World War II): Geopolitical Competition and the Institutionalization of Marine Disciplines.

During modernization construction phase, European industrial technology transitioned from the steam age to the electric age. The purpose of marine education during this period was to meet the demands of industrial development and ongoing colonial expansion. Meanwhile, marine education gradually evolved into a systematic

framework of specialized disciplines, transforming marine research from empirical exploration into organized fields of study.

3.2.1 Industrial Revolution and Institutionalization of Marine Disciplines

Driven by the Industrial Revolution, the institutionalization of marine disciplines is primarily reflected in the following two aspects:

First, there was the scientific advancement of marine research and the establishment of research institutions. From 1872 to 1876, Britain transformed a naval ship into the world's first oceanographic research vessel, the HMS Challenger, which undertook a four-year global ocean survey. During this expedition, the research vessel discovered stones at a depth of 2,000 meters in the Pacific, later identified as polymetallic nodules (Wang,2013:191,193,200). Additionally, samples of marine organisms were collected, confirming the existence of life in the deep sea. Beyond the development of exploratory voyages, specialized oceanographic institutions emerged in succession. In 1902, the International Council for the Exploration of the Sea was established, laying the groundwork for modern fisheries management in Europe. In 1903, the Scripps Institution of Oceanography was founded in the United States to conduct research on marine organisms. The German North Atlantic Plankton Investigation Team, the Stazione Zoologica Anton Dohrn in Italy, and the Oceanographic Institute of Monaco in France further advanced the classification and morphological studies of marine plankton.

Second, there was the establishment of disciplinary systems and disciplinary standards. During the Meiji Restoration, Japan began to set up specialized marine education. At that time, marine education in Japan primarily aimed to cultivate practical talents such as sailors and shipbuilders to meet the needs of the country's fishing and transportation industries. In the early 19th century, the British publication The Naval Chronicle was issued, serving not only the maritime community but also the general public (Ding,Xiang,2024). In 1921, the International Hydrographic Organization was established, an intergovernmental organization dedicated to promoting the unification of maritime data and advancing scientific and effective marine mapping methods.

3.2.2 National competition and the militarization of marine education

From the early 19th century until the onset of World War II, the institutional development of marine disciplines served as a tangible manifestation of colonial hegemony and resource plunder. During this period, marine education was not only focused on resource exploitation but was also intricately woven into national military strategies.

During the Meiji Restoration, Japan established several renowned military

academies to impart militaristic education. In 1869, the Imperial Japanese Naval Academy was founded. This institution would later be regarded, alongside the United States Naval Academy and the Britannia Royal Naval College, as one of the "three foremost naval academies in the world". Its initial educational and training methods were largely modeled after British practices, yet were executed with even greater rigor. Cadets were required to engage in 16 hours of study and training each day, with discipline enforced through physical punishment, and were indoctrinated with the ideology of unwavering loyalty to the Emperor. In 1888, the Japanese Naval University was established, admitting only graduates from the Imperial Japanese Naval Academy, with the aim of cultivating high-ranking naval officers. Figures such as Isoroku Yamamoto, Shiro Takasu, and Seiichi Ito were closely associated with this institution. In the late 1920s, Japan also implemented the "Naval Aviation Cadet Program", selecting youth aged 15 to 17 to enter the navy for flight training, thereby cultivating a cadre of highly skilled aviators prior to the war. Before embarking on their arduous training, these young men were required to bow in the direction of the Imperial Palace and pledge their loyalty to the Emperor (Ian Toll,2020:130).

In 1845, driven by operational necessities, U.S. Navy Secretary George Bancroft established the United States Naval Academy at Annapolis. In the early years of its curriculum, cadets spent three out of five years at sea. From 1889 to 1916, U.S. naval expenditures surged from 64 million to 153 million, while naval personnel increased from 16,000 to 60,000.

In summary, during modernization construction phase, the global leadership in marine education transitioned from Europe to the Americas. Although this period saw marine education becoming institutionalized, it remained fundamentally a tool for showcasing national military strength.

3.3 The Cold War Transition Phase (Post-World War II to the End of the 20th Century): The Bipolar Structure and Sustainable Development.

During the Cold War, marine education catered to the hegemonic rivalries of superpowers; however, this phase witnessed a transformation from a singular focus on military technical training to a comprehensive disciplinary system, driving innovation in modern marine sciences and promoting a transition towards sustainable development in global marine education.

3.3.1 The Instrumentalization of Marine Education Amid U.S.-Soviet Rivalry.

The essence of the instrumentalization of marine education amid U.S.-Soviet rivalry is the transformation of knowledge into power, with marine education relegated to a "civilizing weapon" in the great power competition. After World War II, developed countries regarded marine development as a fundamental national policy.

In 1966, President of the United States Lyndon B. Johnson signed the Sea Grant Act, officially implementing the National Sea Grant College Program, which operated under a model of "research-education-popularization". From 1965 to 1969, the enrollment in U.S. marine science programs rose to 9,500, and the number of individuals earning degrees in marine-related fields increased to 2,000 (Xu,2015:182). This program gradually established a national network of marine sciences composed of universities and research institutions across the United States. In 1986, President Reagan emphasized the need for the United States to maintain and enhance its leadership in marine science and technology. During the Cold War, the U.S. also initiated the Youth Leadership Program, which focused on shaping the ideological consciousness of potential leaders to counter communism and promote Western democratic ideals (Liang,2025:38-47).

In the mid-1960s, under the leadership of Leonid Brezhnev, the Soviet Union implemented a global naval strategy known as "Blue-Water Offensive", which focused on the expansion of submarines and large vessels to accelerate the growth of its blue-water navy. Consequently, the mission of the Soviet naval aviation forces shifted from a defensive to an offensive stance. Thus, the training of the Soviet Navy placed considerable emphasis on the Marine Corps' amphibious landing drills in diverse environments. Additionally, Soviet naval academies strengthened the training of naval personnel. The Nakhimov Naval School served as a junior naval institution, enrolling students aged 15 to 16, who would either advance to senior naval colleges or directly enter naval service upon graduation. Senior naval schools were responsible for training the primary officers for vessels, with the Frunze Higher Naval School being a notable representative. Furthermore, the Soviet Union established various organizations for training naval personnel, such as advanced naval school research programs, higher naval political schools, and naval academies (Jiang,1981:28,42-47).

3.3.2 The Shift towards Sustainable Development under Global Governance

When the oceans become a testing ground for human geopolitical ambitions, and marine education is distorted into a tool of power struggles, humanity must take responsibility for and reflect upon the consequences of the contemporary maritime crisis. The end of the Cold War also marked the beginning of a global transformation toward governance centered on sustainable development.

In 1992, the United Nations Conference on Environment and Development was held in Rio de Janeiro, during which the Agenda 21 was adopted. This document emphasized "the protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources" (United Nations,1992). In the same year, the

seventh meeting of the Intergovernmental Negotiating Committee, initiated by the United Nations Environment Programme, resulted in the adoption of the Convention on Biological Diversity. In 1995, this convention introduced the "Jakarta Mandate", aimed at establishing a global network for marine conservation. The Convention on Biological Diversity is the only international convention within the current framework of international law that provides a legal definition for marine protected areas. The majority of nations initiated their marine education initiatives following the enforcement of the United Nations Convention on the Law of the Sea in 1994. This document was adopted at the final session of the Third United Nations Convention on the Law of the Sea, held in Montego Bay, Jamaica, in 1982, with the aim of maintaining and enhancing international security. Although it did not explicitly include a provision for marine education, the topic is encompassed within regulations concerning technical cooperation and marine scientific research. For instance, Article 202 mentions that States shall, directly or through competent international organizations, promote programmes of scientific, educational, technical and other assistance to developing States for the protection and preservation of the marine environment and the prevention, reduction and control of marine pollution (United Nations,1982). Furthermore, by the end of the 20th century, the United States, Japan, Canada, the European Union, and others established marine environmental monitoring networks (Liu,2019).

3.4 Post-modern Development Phase (Early 21st Century to Present): Community Building and Cross-Border Collaboration.

In the post-modern development phase, global marine education intertwined with issues such as technological transformation, ecological crises, and the acceleration of globalization. It transcends the traditional realm of environmental education, evolving into a practice that seeks to explore the essence of "harmonious coexistence between humanity and nature".

3.4.1 From Marine Awareness to Marine Literacy

With the intensification of global marine crises such as white pollution and ocean acidification, marine education is undergoing a paradigm shift from knowledge transmission to the cultivation of marine literacy.

At the turn of the 20th and 21st centuries, Brazil's Interministerial Commission on Marine Resources launched the "Promotion of Maritime Mentality" initiative, aimed at enhancing citizens' marine literacy (Hu,2017). In 2007, New Zealand amended the New Zealand Curriculum to incorporate environmental education. To advance marine education, New Zealand also developed teaching resources titled Protecting Our Marine World for students in Grades 1 to 8, integrating marine

education with the cultivation of scientific literacy (Ma,Lin,2021). In 2013, the European Union approved the "Horizon 2020" program, which supported several marine education-related initiatives, including the ResponSEAble project. These initiatives not only disseminated marine knowledge to the public but also developed various educational tools for marine literacy (Ma,Fu,2019). On September 25, 2015, at the seventieth session of the United Nations General Assembly, the resolution Transforming Our World: The 2030 Agenda for Sustainable Development was adopted, calling upon nations to take proactive measures for the sustainable development goals over the following 15 years. Among these, Goal 14 states that humanity should "conserve and sustainably use the oceans, seas and marine resources for sustainable development" (United Nations,2015). It is essential not only to comprehend the oceans but also to engage in their protection. In 2020, the Decade of Ocean Science for Sustainable Development (2021-2030): Implementation Plan was proclaimed at the 75th session of the United Nations General Assembly, representing the largest global initiative in the marine sector. This initiative emphasizes marine technological innovation while encouraging the integration of scientific findings into global ocean governance. Additionally, released by the U.S. Commission on Ocean Policy on September 20, 2004, An Ocean Blueprint for the 21st Century actively advocates for lifelong marine education (Liu,Lyu,2025).

3.4.2 From a Singular Discipline to Interdisciplinary Collaboration

Driven by ecological crises, technological revolutions, and global governance, marine education has evolved from a singular focus on marine science to a multi-sectoral approach centered on problem-solving.

In August 2012, the U.S. Integrated Ocean Observing System issued the Quality Assurance of Real-Time Oceanographic Data Project. Within this framework, marine science and data technology are thoroughly integrated, with GIS systems like Google Maps widely used for the automated acquisition and dissemination of ocean information (Wang,2014). In the United Kingdom, marine education in universities is characterized by collaboration between higher education institutions and research organizations. For instance, the National Oceanography Centre provides high-quality resources and learning opportunities for both the University of Liverpool and the University of Southampton. Postgraduate students at the University of Liverpool have the opportunity to engage in research projects at the National Oceanography Centre, while several marine and earth science degree programs at the University of Southampton are taught by scientists from this organization (Ma,Fu,2019). In Japan, institutions such as Yokohama National University, Kobe University of Mercantile Marine, and Osaka Prefectural University promote marine education to the public

through experiential activities and course offerings. This public-facing marine education not only relies on collaboration among Japanese universities but also enjoys strong support from the business community (Ma,Hu,2022). Furthermore, informational portals serve as effective platforms for marine education. Examples include the Marine Training platform (www.marinetraining.eu) supported by the European Marine Biological Resource Centre (EMBRC-ERIC), the PERSEUS@School Network created by the Hellenic Centre for Marine Research, and South Korea's marine education portal (www.ilovesea.or.kr).

In summary, the evolution of global marine education, from the resource plundering during the era of colonial expansion to ecological governance in the age of globalization, reflects the ongoing reconstruction of humanity's relationship with the oceans. Marine education remains inextricably linked to the political and economic structures of nations; it is only through the pursuit of a balance among technology, humanities, and ecology that humanity can truly transition towards a shared destiny with the ocean.

4. The Exploration of Modernization and Indigenous Practices in Marine Education in China Since the 19th Century

Compared to the international development of marine education, China's journey began relatively late, with the Opium War of 1840 marking its inception. This evolution can be broadly categorized into four phases: passive enlightenment period, planned economy period, opening and transformation period, and strategic leadership period.

4.1 Passive Enlightenment Period (1840—1949): The Emergence of Modern Education Amid Colonial Oppression

China's marine education was passively initiated amid colonial oppression. During the passive enlightenment period, it developed in a convoluted manner through the dual pursuits of national salvation and modernization, primarily characterized by the technological integration of new-style school and the initial establishment of marine institutions.

4.1.1 The Technological Integration of New-Style School

During the period of the Self-Strengthening Movement, China's naval schools were modeled after Western institutions, assimilating Western technologies and offering specialized training for talents, with stringent requirements dictated by military needs.

In 1866, Zuo Zongtang petitioned to establish a shipyard in Mawei, Fuzhou.

Subsequently, Shen Baozhen served as the Minister of Naval Administration, formally founding China's first modern naval and ship engineering school—the Fuzhou Shipping School. This institution comprised two divisions: the Front School, which focused on manufacturing and conducted classes in French, taught by French foreign experts covering shipbuilding and related subjects; and the Rear School, dedicated to navigation and instructed in English, offering studies in navigation, astronomy, and geography. The curriculum encompassed not only traditional cultural courses such as classics, history and policy discourse but also foreign languages, higher mathematics, and scientific knowledge. Under a strict assessment system, the Fuzhou Shipping School produced a cadre of outstanding talents for the late Qing Dynasty, including Yan Fu, Deng Shichang, and Liu Buchan.

The defeat in the First Sino-Japanese War prompted the establishment of the Beiyang Western Studies College (the precursor to Beiyang University), China's first modern university, overseen by Sheng Xuanhuai as its inaugural director. This institution similarly hired foreign instructors and emphasized English and foundational courses. Sheng Xuanhuai outlined the curriculum as follows: "In the first year: Geometry, Trigonometry, Physics, Drawing, Histories of Various Nations, English Composition, and English Translation; in the second year: Navigation and Land Surveying, Mechanics, Differential Calculus, Physics, Chemistry, Drawing and Machine Drawing, English Composition, and English Translation; in the third year: Fundamentals of Astronomical Engineering, Chemistry, Botany, Drawing and Machine Drawing, English Composition, and English Translation; in the fourth year: Epigraphy, Geoscience, Zoology, International Law, Economics, English Composition, and English Translation (Sheng,2024:185-186)".

4.1.2 The Initial Establishment of Marine Institutions

Marine education during the Republic of China period can be traced back to institutions such as National Qingdao University, Xiamen University, and Fudan University, all of which were founded by individuals with backgrounds in Western studies.

In 1930, National Qingdao University (later renamed National Shandong University) was established, with Yang Zhensheng serving as its first president. He meticulously studied Qingdao's geographic environment, natural resources, and historical documents, positioning marine science as a hallmark of the university. He actively advocated for the establishment of programs in marine biology and oceanography. In 1931, Yang Zhensheng also invited scholars from France and Switzerland to visit the biology department to conduct research on marine biology.

Tang Shifeng is regarded as a foundational figure in modern marine science

research in China. In 1934 and 1935, he participated in the South China Sea Biological Survey and the Bohai Sea Oceanographic Survey, respectively. In 1936, he completed an observational report on the hatchery of ribbonfish in Laizhou Bay, Bohai Sea, in Yantai. After returning to China with qualifications from the UK, he became the head of the Marine Department and the director of the Marine Research Institute at Xiamen University. From 1941 to 1946, Tang served as the head of the marine division at the Institute of Geographic Sciences and Natural Resources Research, CAS, collaborating with Fujian Province to establish the Fujian Marine Survey Team. During the Anti-Japanese War, this team was the only marine survey group in the country that continued to operate (Chen,Wang,2004). In 1946, under Tang Shifeng's leadership, Xiamen University established China's first Department of Oceanography and invited scholars such as Zheng Zhong (a researcher from the Plymouth Marine Laboratory) to join the faculty.

In the autumn of 1946, Xue Fen founded the Marine Science Division at Fudan University. In 1948, he planned to return to the University of Liverpool to study the latest marine technologies and methods but tragically passed away during the journey.

4.2 Planned Economy Period (1949—1978): Pragmatic Education with an Industrial Orientation

Under the "Leaning to One Side" policy, China's educational system comprehensively adopted Soviet practices, which in marine education was manifested through departmental adjustments and the dispatch of students abroad, effectively transplanting the Soviet model for talent cultivation. During the Planned Economy Period, China's marine education was characterized by an industrial development orientation, emphasizing practicality, and advancing towards systematic construction propelled by the demands of a planned economy and national defense.

4.2.1 Student Dispatch Program under the Soviet Alliance Framework

In the early years following the founding of the People's Republic of China, the nation was characterized by reconstruction and revitalization. Under the dual influence of national strategic needs and ideological alignment, the Soviet Union emerged as a model for China. In 1951, among the 380 students dispatched abroad, 375 were sent to the Soviet Union. Notable scholars such as Academicians of the Chinese Academy of Sciences Dou Guoren and Chen Hanyu pursued their studies at the Leningrad Institute of Water Transport. Another prominent figure, Academician of the Chinese Academy of Engineering Liang Yingchen, studied at the Odessa Maritime Engineering Academy, while Zhang Bingyan, Weng Shilie, and Xu Binghan attended the Leningrad Shipbuilding Institute. During their time in the Soviet Union, some Chinese students interned at institutions such as the Novosibirsk Institute of Marine

Power, Institute of Oceanology and Institute of Marine Hydrophytic, USSR Academy of Sciences, and USSR Hydrometeorological Service. Upon their return, these Soviet-trained scholars played irreplaceable roles across various sectors in New China, including national defense and military affairs. As illustrated in Table 1, individuals like Zhang Xusan, Fang Qiang, and Xu Shiping infused new vigor into China's maritime endeavors (Zhou,2012).

Table 1 Overview of Naval Personnel Studying in the Soviet Union

Name	Year of Study in the Soviet Union	Graduating Institution	Position
Zhang Xusan	1951—1954	Soviet Naval Higher Specialized School	Deputy Commander of the Navy, Vice Admiral (1988)
Fang Qiang	1955—1957	Soviet Navy Command Academy	Deputy Commander of the Navy, Vice Admiral (1955)
Xu Shiping	1951—1953	Soviet Naval Higher Specialized School	Vice Dean of the Naval Command Academy, Vice Admiral (1988)
Cai Wenyi	1955—1959	Soviet Naval Engineering Academy	Director of the Naval Automated Combat Command Research Institute
Zhou Leting	1953—1957	Voroshigov Naval Academy	Deputy Director of Military Training Department, Naval Headquarters
Liu Daosheng	1953—1957	Voroshigov Naval Academy	Deputy Political Commissar of the Navy
Pei Duan	1957—1961	Leningrad Higher Naval Engineering School	Director of the Naval Military Academic Research Institute
Zou Boxian	1955—1959	Soviet Naval Engineering Academy	The General Staff Headquarters of the People's Liberation Army
Wang Dongshan	1955—1959	Soviet Naval Engineering Academy	Vice Dean of the Naval Engineering Institute
Jiang Huatang	1955—1959	SovietNaval Engineering Academy	Dean of the Naval Engineering Institute

(Source: Zhou Shangwen, Li Peng & Hao Yuqing, ed.(2012), Documentary Records and

Reflections on the "Study-in-Soviet-Union Wave" in Early New China, Shanghai: East China Normal University Press,p.239.)

4.2.2 Establishment of Institutions and Research Organizations in Maritime Regions

In terms of departmental reorganization, in 1952, the new Chinese government, utilizing the Soviet model, advocated a policy focused on "cultivating talent for industrial development and training faculty, fostering specialized colleges, and reorganizing and enhancing comprehensive universities". This marked the official commencement of the university system reform known as "departmental reorganization", establishing a university framework predominantly centered around specialized college (Hu,2024). The National Higher Education Restructuring Plan issued by the Ministry of Education in 1952 indicated that Shandong University was formed by merging departments from the former Shandong University College of Arts, College of Sciences, and Qilu University College of Arts, along with the Shandong University Marine Research Institute, the Aquaculture Department of College of Agriculture, Shandong University, and the physics and chemistry sections of Xiamen University's marine department (He,1998:151). In 1953, the Ministry of Education continued to reorganize departments in accordance with Soviet practices, resulting in the merger of the Northeast Navigation College, Shanghai Nautical College, and Fujian Navigation College to establish Dalian Marine Shipping College, with the names of the original three schools being discontinued (He,1998:214). Additionally, the establishment of institutions such as Shanghai Fisheries College, Zhoushan Fisheries College, and Shanghai Maritime Institute received substantial support from Soviet experts (Ning,Guo,2019). In 1955, the government proposed that Xiamen University, taking into account its geographical and historical context, should focus on "serving the overseas Chinese in Southeast Asia and the maritime realm as future development directions," emphasizing that various departments and research groups within Xiamen University should strengthen their research on issues related to Nanyang, Taiwan, and maritime matters, as well as local characteristics (He,1998:545).

In addition to the establishment of maritime higher education institutions, marine research organizations also began to emerge. In 1950, the first specialized marine research institution in New China was founded—the Marine Biology Laboratory of the Institute of Hydrobiology, Chinese Academy of Sciences. In 1959, the Qingdao Marine Biology Laboratory was transformed into the Institute of Oceanology, Chinese Academy of Sciences, and in the same year, the South China Sea Institute of

Oceanology was established. In 1964, the State Oceanic Administration was founded (Chen,Lei,2019).

4.3 Opening and Transformation Period (1978–2012): Expansion of Marine Disciplines Aligned with Global Standards

During the opening and transformation period, China's marine endeavors received robust support from national policies, leading to a continual elevation of their strategic significance. In alignment with the tide of reform and opening-up, China integrated the development of marine education with global standards.

4.3.1 Establishment of the Academic Community

From 1978 to 2012, China actively engaged in collaboration with other countries in the marine domain, encompassing joint expeditions, the establishment of cooperative centers, and the signing of partnership agreements.

In June 1980, a joint investigation of the East China Sea's submarine sedimentation processes was conducted by China and the United States. This expeditionary fleet comprised the American research vessel "Oceanographer" and three Chinese research vessels. In 1994, China and South Korea signed the Memorandum of Understanding on Marine Science and Technology Cooperation between the State Oceanic Administration of the People's Republic of China and the Ministry of Science and ICT of the Republic of Korea, leading to the establishment of the China-Korea Joint Ocean Research Center the following year. In 1996, China became a member of the International Arctic Science Committee. In 2003, China and Russia signed the Agreement on Cooperative Research in the Marine Sector Between China and Russia. That year, China participated in the international Integrated Ocean Drilling Program, employing a nuclear-powered icebreaker to penetrate 410 meters of sediment in the Arctic Ocean, uncovering evidence of subtropical biota that existed in the Arctic 55 million years ago (Ma,Hu,2022). In August 2005, the first Sino-American joint deep-sea scientific expedition was launched, allowing Chinese experts to study the usage of the American manned submersible Alvin. This experience accelerated the development of China's own manned submersible, which culminated in the production of the "Jiaolong" in 2009. In 2006, the First Institute of Oceanography collaborated with the Russian Pacific Oceanological Institute to define research topics, including climate change. Following four rounds of evaluations between 2008 and 2010, the joint scientific research project received approval from both countries. In 2007, China and Japan signed the Joint Statement on Further Strengthening Environmental Protection Cooperation, advancing prevention and control efforts in the Yellow Sea, Bohai Sea, and Yangtze River basin.

4.3.2 Structural Upgrading of Disciplines

The structural upgrading of marine education is primarily manifested in the expansion of its disciplinary framework and the enhancement of educational training models.

In terms of disciplinary expansion, marine science has progressed from a singular focus on natural sciences to a spectrum of specialized fields. For instance, in 1943, Shanghai Jiao Tong University established the Department of Shipbuilding Engineering. In 1997, the International Shipping Department was founded, alongside the establishment of the School of Naval Architecture and Ocean Engineering. By 2003, the School of Naval Architecture and Ocean Engineering merged with the School of Civil Engineering and Mechanics to form the School of Ocean and Civil Engineering (Shanghai Jiao Tong University,2023).

In terms of educational training models, maritime universities have established and refined a comprehensive system for cultivating undergraduate, master's, and doctoral scholars. For example, Ocean University of China has developed a cross-disciplinary talent cultivation system in ecology that encompasses undergraduate, master's, doctoral, and postdoctoral programs within marine biology. In November 1981, the Department of Marine Biology at Ocean University of China was one of the first institutions to confer master's degrees. By 1984, the marine biology discipline was granted the authority to award doctoral degrees, and in 1988, a postdoctoral research station in marine science (marine biology) was established. In 2011, the Department of Environmental Ecology received the authorization to grant PhD degrees in ecology as a primary discipline, and in 2012, a postdoctoral research station in ecology was additionally set up. Furthermore, the College of Marine Life at Ocean University of China has leveraged resources from the "National Experimental Teaching Center for Marine Life Sciences" and the "National Talent Development Base for Life Sciences and Biotechnology" to enhance the training of professionals in ecology (Ocean University of China,2020).

4.4 Strategic Leadership Period (2012 to Present): The Ecological Civilization Transformation of a Maritime Power

In 2012, the 18th National Congress of the Communist Party proposed the strategic vision of "building a maritime power," marking China's transition towards a nation that embodies both land and sea sovereignty, and ushering in a phase of strategic leadership in marine education development.

4.4.1 Coordination and Leadership of National and Local Government

Since the introduction of the maritime power strategy in 2012, China has progressively rolled out related policy documents. In 2013, during the eighth

collective study session of the 18th Central Politburo, Xi Jinping underscored the significant importance of building a maritime power for promoting sustainable economic development, safeguarding national sovereignty, and achieving the goals of a moderately prosperous society in all respects. In 2017, the 19th National Congress of the Communist Party outlined the strategic objective of "coordinating land and sea development, and accelerating the construction of a maritime power." In 2022, the 20th National Congress called for "developing the marine economy, protecting the marine ecological environment, and hastening the establishment of a maritime power." Furthermore, General Secretary Xi Jinping proposed significant initiatives such as building a maritime community of shared future and collaborating on the 21st-century Maritime Silk Road. He advocated for the creation of a peaceful, secure, and win-win marine order, encouraging the integration of marine cultures, and collectively enhancing maritime well-being.

In addition to policy guidance, international cooperation in marine scientific research during this period has also deepened substantially. For instance, China established the National Committee for the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) and initiated international big science research plans such as "Digital Deep-sea Typical Habitats (DEPTH)," "Ocean Negative Carbon Emissions (ONCE)," "Ocean to climate Seamless Forecasting system (OSF)," exploring pathways for harmonious coexistence between humanity and the ocean. China has fostered blue partnerships through platforms like the Sino-Africa Forum on Marine Science and Technology and China-Island Countries High-Level Forum on Ocean Cooperation, promoting a shared community for marine conservation. In February 2025, supported by the "Global Trench Exploration and Diving programme (Global TREnD)" the Institute of Deep-Sea Science and Engineering of the Chinese Academy of Sciences and the National Institute of Water and Atmospheric Research of New Zealand (NIWA) undertook a joint three-month scientific expedition to explore the Puysegur Trench.

4.4.2 Establishing a framework for marine awareness and literacy

The policies implemented by the central and local governments in China encompass the cultivation of marine awareness.

The Outline of the 14th Five-Year Plan (2021—2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China, issued in 2021, emphasizes the need to "actively expand the development space of the marine economy," enhance the quality and stability of ecosystems, and protect and restore coastal areas, aiming to rehabilitate 400 kilometers of coastline and 20,000 hectares of coastal wetlands. Coastal zones are equally focused on the advancement of marine

awareness. In 2022, the Shandong Provincial Party Committee and Provincial Government issued the Action Plan for Building a Strong Maritime Province, which underscores the importance of "promoting marine cultural revitalization initiatives." This document encourages the exploration of traditional marine cultural values, such as coastal defense culture and Xianhai culture, and advocates for comprehensive marine awareness education through marine venues and virtual reality technologies. Moreover, coastal zones have undertaken localized explorations of marine education content. For example, The Putuo District of Zhoushan City in Zhejiang Province has established a modern marine education curriculum with varying levels designed for elementary, middle, and high school students, comprising five modules: marine resources and conservation, marine nature and science, marine economy and society, marine history and culture, and marine military (Xu,2016).

Research institutions have also deepened their exploration of marine awareness and literacy. In 2016, Peking University Institute of Ocean Research published a"National Marine Awareness Development Index" which selected four indicators—marine political awareness, marine economic awareness, marine natural awareness, and marine cultural awareness—to measure national marine consciousness from the perspectives of knowledge, attitude, and behavior.

Marine awareness and marine literacy are intrinsically linked, with the former serving as the outward manifestation and the latter representing the deeper understanding. Marine literacy aims to engage the entire society in devising and implementing solutions to contemporary marine challenges. (Schio,Reis,2024). With the advancement of the "maritime power" strategy, our nation's marine education has transcended the stage of fostering ocean awareness and has entered an era focused on the cultivation of ocean literacy. During the third China Marine Education Forum in December 2021, scholars discussed the concept of "Chinese Marine Literacy," and constructed a marine literacy system, meeting the developmental needs of the Chinese citizens, through four dimensions: social participation, humanistic sentiment, scientific exploration, and ecological sharing.

5.The implications of global marine education experience for China's marine education

5.1 Upholding the Principle of Land-Sea Coordination in Territorial Spatial Governance

The practices of global marine education demonstrate that land-sea coordination is not only an integration of geographical space but also a manifestation of the

modernization of national governance. By leveraging knowledge production, institutional design, and technological application, the ocean is moved from the periphery to the center.

Currently, there remains a tendency in China's marine education to prioritize land over sea. According to the Zhejiang Province Territorial Spatial Plan (2021—2035), the marine ecological protection red line—comprising undeveloped and unutilized uninhabited islands of special protective value—encompasses an area of 14,600 square kilometers (21.87 million acres). Zhejiang Province needs to coordinate the development and protection of land and sea through measures such as reasonably arranging marine functional zoning, enhancing the level of integrated resource utilization, and fully activating and utilizing existing resources of land reclamation around towns (Zhejiang Provincial Department of Natural Resources, 2024).

The collaborative model among multiple departments in the United States, Japan, the United Kingdom, and other European nations which focuses on problem-solving, suggests that China's maritime governance should pay greater attention to the symbiotic logic of spatial governance. Moreover, it also suggests that our country should cultivate a comprehensive understanding of ecosystems among the general public through education, incorporate mandatory provisions for "land-sea coordinated governance" into legislation, and encourage the collaboration between land-use planning departments and educational institutions to develop local curricula.

5.2 The synergistic mechanism of marine soft and hard power

The enhancement of marine education fundamentally involves the collaboration of "hard power" and "soft power." In the pre-modern phase of marine education, the rudimentary hardware foundations, such as shipbuilding techniques, facilitated the accumulation of navigational knowledge and early ocean exploration. During the phases of modernization and the Cold War transition, global breakthroughs in marine technology and the rise of marine research fleets spurred the systematic development of marine education. Concurrently, the establishment of marine institutions supplying specialized talent for technological research and development. In the post-modern development stage, Global marine education requires not only hard power to support oceanic scientific research but also the cultivation of interdisciplinary talents to harmonize diverse interests.

Currently, China faces a dual challenge of lacking hard power while experiencing a lag in soft power. Although we have developed equipment like the "Haiyan" underwater glider, and the domestic production rate of deep-sea detection equipment continues to rise, there remains a gap compared to the hardware levels of developed nations. Furthermore, China's marine education needs to update its

software in accordance with contemporary developments. For instance, drawing inspiration from South Korea's metaverse experience, virtual reality technology can be employed to simulate marine ecosystems, thereby creating immersive oceanic classroom education for primary and secondary schools.

5.3 A Comprehensive Marine Literacy Cultivation System for the Entire Life Cycle

International marine education centers around three primary pathways: higher education, primary and secondary education, and social education, forming a multi-layered and multidimensional marine education framework that is increasingly diversified in the postmodern developmental stage. Although some researchers have begun to enhance the marine education system—such as by designing professional development training programs (PD) for teachers focused on marine literacy (Freitas,2024)—overall, the current system neglects the integration of marine education within early childhood education, teacher training, and lifelong learning.

The cultivation of marine literacy across the entire life cycle is a contemporary imperative for the resurgence of marine civilization. While there are currently marine-themed picture books suitable for young children available on the market, specialized marine curricula are largely absent from early childhood education, making it challenging to foster foundational awareness and emotional affinity for the ocean from a young age. Similarly, marine education is similarly lacking in teacher training programs, with studies revealing that the marine consciousness among university students major in teacher education remains quite superficial (Liu,2022). Furthermore, marine education is often relegated to a marginal role within the lifelong education of the elderly population. The cultural heritage associated with marine livelihoods is at risk of failing to pass down across generations, particularly among former fishermen in coastal areas. Therefore, it is essential for China's marine education system to horizontally extend into teacher education, vertically descend into early childhood education, and ascend into lifelong education, thereby establishing a comprehensive marine literacy cultivation system. This can be achieved through intergenerational collaboration in coastal community governance, a gradual infusion of marine awareness into inland regions, and an optimization of the teacher education curriculum framework, ensuring the effective nurturing of marine literacy.

5.4 A Collaborative Marine Education Ecosystem Among Government, Schools, Society, and Enterprises

The cultivation of marine literacy necessitates the cooperation of government, educational institutions, society, and enterprises. Marine education serves as a catalyst for awakening public awareness of the ocean. A review of the global history of marine

education reveals that initiatives such as Portugal's "Blue Schools" program, Brazil's "Promotion of Maritime Mentality" initiative, and the European Union's "Horizon 2020" program have all relied on national policy support for their implementation. Effective and sustainable marine education requires a primary focus on school-based instruction, complemented by social education. For instance, researchers conducted long-term educational interventions in a public school in Rio de Janeiro that involved students from three classes (Luca,2025).

In China, collaborative practices are already emerging in coastal regions. For example, Ocean University of China, the Qingdao Marine Food Nutrition and Health Innovation Research Institute, and Fengshi (Qingdao) Marine Technology Co., Ltd. have jointly established the "Marine Functional Food Innovation Joint Research Center," bridging laboratory research with market-level innovation. In 2011, the first marine education popular science base was established in Qingdao at Yiyang Road Primary School, hiring professors from Ocean University of China to impart marine knowledge to students (Ye,2013:187). However, both the level of participation among collaborative entities and the depth of content require significant enhancement. Thus, China should construct and deepen a marine education ecosystem that integrates government, schools, society, and enterprises.

6. Conclusion and Discussion

This article delves deeply into the theme of "The Evolution and Insights of Global Ocean Education." Through a historical examination of global ocean education, it categorizes its development into the pre-modern stage, the stage of modernization, the Cold War transformation phase, and the post-modern development stage, thereby revealing the interactive coupling relationship between the paradigms of ocean education and the evolution of oceanic civilization. Furthermore, it scrutinizes the characteristics and challenges of China's modernization journey in ocean education, transitioning from passive enlightenment to strategic leadership. Building upon this foundation, it critically draws from the developmental experience of global ocean education. This study not only incorporates international advanced concepts at a theoretical level to deepen the understanding of the developmental laws of ocean education but also provides practical references for the reform of ocean education, enabling it to better serve China's national maritime strategy.

The research reveals that the evolution of ocean education paradigms is consistently embedded within the tensions of geopolitical competition and the cognitive revolutions of humanity. Ocean education serves not only as a vehicle for

the dissemination of knowledge but also as a battleground for discourse regarding maritime power competition, ecological governance, and the reconfiguration of international order. Currently, China's ocean education faces structural challenges such as a vague overarching framework, an outdated evaluation system, and a fragmented collaborative network, necessitating urgent breakthroughs through pathways including the design of maritime strategic systems, the development of school curricula, the integration of cross-departmental resources, and the collaborative participation in an ocean community with a shared future.

Future research should delve deeper into the construction and application of evaluation indicators for ocean literacy, the optimization of integrated land-sea educational policies, the establishment of an ocean education community under the Belt and Road Initiative, and the empowerment of ocean education through digital technology. Furthermore, the advancement of ocean education faces numerous challenges. In terms of institutional development, there is a need to further refine the management system of ocean education, enhance collaborative cooperation among various stakeholders, and establish a diversified mechanism for investment and management in ocean education. Mechanistically, it is necessary to integrate the characteristics of the information age to establish and refine the evaluation and incentive mechanism for ocean education, thereby contributing to its sustainable development. Through ongoing practical efforts, we can empower the modernization of ocean education and develop a paradigm that embodies both strategic depth and cultural consciousness for Chinese ocean education.

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