Mechanisms, Bottlenecks, And Implementation Strategies for Promoting High-Quality Development of the Marine Sports Industry with Digital New Productive Forces

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Abstract: Using literature review and logical analysis methods, based on the theoretical foundation of digital-intelligent productivity and high-quality development of the marine sports industry, this study explores the mechanisms, bottlenecks, and implementation strategies for promoting high-quality development of the marine sports industry driven by digital new-quality productivity. the research suggests that digital new-quality productivity can promote high-quality development of the marine sports industry from four aspects: reconstructing the digital allocation of production factors, optimizing the digital-intelligent system of operational processes, empowering industrial ecosystem integration and innovation, and expanding the technological boundaries of business models. Based on the bottlenecks that exist in the formation process of industrial digital new-quality productivity, such as the shortage of digital marine composite talents, weak digital infrastructure, lack of cross-domain collaborative governance mechanisms, and insufficient adaptation of technology and ecology, this study proposes implementation strategies such as building a talent echelon for digital transformation of marine sports, constructing a diversified scenario infrastructure system for marine sports, achieving cross-domain coordinated governance of marine sports, and promoting the synergy between digital-intelligent and ecological aspects of marine sports.

Keywords: Digital New Productive Forces; Marine Sports; Ecology; High Quality

1. Introduction

In July 2025, General Secretary emphasized at the sixth meeting of the Central Financial and Economic Affairs Commission the need to advance the construction of a unified national market in depth and promote the high-quality development of the marine economy [1]. In September of the same year, while listening to the work report of the Party Committee and Government of the Uygur Autonomous Region, General Secretary stressed the deep integration of scientific and technological innovation with industrial innovation, the development of new productive forces according to local conditions, while strengthening the integration of culture and tourism to promote the development of the cultural tourism industry, and strengthening the protection and restoration of ecosystems to promote a comprehensive green transformation of economic and social development [2]. These important instructions from General Secretary g provide the fundamental guidelines for the high-quality development of the marine sports industry—not only clarifying its positioning of needing to "integrate into the overall marine economy, " but also pointing out the direction of "relying on innovation-driven development, and taking the path of cultural and tourism integration and green development". In the context of the digital era, the development of digital technology helps traditional industries reshape their industrial and value chains, and accelerates the networking, digitization, and intelligent optimization and upgrading of traditional industries [3], which is becoming the continuous kinetic energy and new competitiveness for various industries, including the marine sports industry, to achieve high-quality development.

Currently, digital new productive forces, as the core form of new productive forces, are becoming a key force driving industrial transformation, but in-depth research on them in the field of the marine sports industry is still in the exploratory stage. Some scholars have analyzed the logical role of digital new

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productive forces in upgrading the structure of the sports industry and innovating business formats [4], while other studies have focused on the field of public sports services [5]. However, for marine sports, a subdivided field with both marine and sports attributes, there are still obvious gaps in related research—existing achievements have not yet systematically connected digital new productive forces with the unique developmental needs of the marine sports industry, nor have they clearly answered how the marine sports industry can rely on digital technology to solve its own developmental pain points. In view of this, based on the actual development of the marine sports industry, and on the basis of clarifying the connotation and core characteristics of digital new productive forces and specifying the intrinsic requirements for the high-quality development of the marine sports industry, this paper constructs a logical analysis of the coordinated development of the two, systematically explores the mechanisms by which digital new productive forces promote the high-quality development of the marine sports industry, deeply analyzes the stagnation problems faced in practice, and proposes targeted implementation strategies, in order to provide theoretical reference and practical guidance for the sustainable development of the marine sports industry in the new era.

2. Connotations and Characteristics of Digital New Productive Forces and the High-Quality Development of the Marine Sports Industry

2.1 Connotations and Core Characteristics of Digital New Productive Forces

From the perspective of political economy, different social formations in different historical stages correspond to productive forces with specific "qualitative states, " and the "quality" of this productive force is not only reflected in the technological combination of production factors, but also deeply associated with the relations of production and social structure of that stage [6]. In the era of digital intelligence, digital new productive forces play a key role in promoting high-quality development; the significance of digital new productive forces is crucial, as they inject power through technological innovation, strengthen support through optimized factor allocation, promote low-carbon transformation, advance intelligent governance, and multidimensionally promote high-quality development [7]. From this, it can be seen that digital new productive forces present the following characteristics:

First, the "qualitative transition" driven by technology reshapes the technological system and boundaries of productive forces. Marx pointed out that "the distinction between various economic epochs lies not in what is produced, but in how it is produced and with what instruments of labor" [8]. Digital new productive forces take digital technology and artificial intelligence as core labor instruments, breaking through the technological system dominated by mechanical equipment and energy power in the industrial age, and achieving a "qualitative" change in productive forces. This is not a simple tool upgrade, but reshapes the technological system through a triple path: algorithms transform traditional linear production into a dynamically adjusted mode driven by data to real-time optimization; data breaks down the information barriers of the industrial chain; and intelligent terminals push production scenarios from human-dominated to human-machine collaboration. More importantly, this transformation is deeply coupled with production relations; the rise of platform-based organizations and the popularization of flexible employment are precisely adaptive responses to the transformation of productive forces, which fit the Marxist law of the "contradictory movement" between productive forces and relations of production.

Second, the "collaborative reconstruction" of factor allocation activates the systematic efficacy and value of production factors. According to political economy theory, the efficiency of production factor allocation determines the level of productive forces. Digital new productive forces change the traditional allocation logic of labor, capital, and land, constructing a "data+traditional factors" model, where data, as a key factor, has both non-rivalrous and reusable attributes. This reconstruction is reflected in two dimensions: First, data empowers the precise allocation of traditional factors, such as agriculture utilizing data production factors for more efficient allocation [9], and human resources platforms matching supply and demand [10]; second, digital technology breaks space-time barriers and promotes cross-regional integration of factors, such as industrial Internet platforms building global collaborative networks. This reconstruction not only improves the

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efficiency of single factors but also releases the "1+1>2" aggregate value, the essence of which is the transition of factors from decentralized allocation to systematic integration, fitting the theoretical logic and providing support for high-quality development.

Third, the "low-carbon inclusiveness" of the development model aligns with the value core and orientation of high-quality development. Marxist political economy emphasizes that the development of productive forces must adapt to social laws and the needs of comprehensive human development. Digital new productive forces leverage technological innovation to promote low-carbon transition and promote equity through inclusiveness, forming a "low-carbon+inclusive" model, which aligns with the "people-oriented" and "sustainable" core of high-quality development. From the low-carbon dimension, digital technologies provide pathways for the "dual carbon" goals by optimizing industrial energy consumption, reducing transportation carbon emissions, and decreasing pesticide use; from the inclusive dimension, online education strengthens resource inclusiveness [11], and digital healthcare enhances grassroots service efficiency [12], preventing the widening of the wealth gap and reflecting the requirements of common prosperity.

Fourth, the "intelligent linkage" of governance empowerment boosts the modern transformation of the social governance system. According to the political economy theory that "the economic base determines the superstructure, " the transformation of productive forces will inevitably drive the adjustment of the social governance system. In addition to acting on the economic sphere, digital new productive forces empower governance through data sharing and intelligent algorithms, building a linked pattern from economic production to social governance. In practice, digital technology integrates multiple types of data to create scenarios such as smart government, smart communities, and smart emergency response platforms; its empowerment is not a one-way technological application, but promotes the collaboration of government, enterprises, and the public to form a diverse co-governance system, while the modernization of governance in turn creates a stable environment for the development of productive forces, forming a positive cycle and aligning with the law that "the superstructure reacts upon the economic base".

2.2 Connotations and Characteristics of the High-Quality Development of the Marine Sports Industry

The high-quality development of the marine sports industry is an extension of the requirement to "promote the development of characteristic industries such as marine sports" in the "Outline for Building a Leading Sports Nation, " and it is also the first time that the national sports strategy has endowed it with a "high-quality" positioning. It is not a single-scale expansion, but rather takes "satisfying the people's needs for marine sports" as the core, and has an orientation of "improving quality and efficiency [13], green and low-carbon [14], integration and innovation [15] ", covering a systematic upgrade of "supply, structure, efficiency, and ecology, " and is a development that reflects new development concepts and moves towards a modern sports industry system. Its characteristics are as follows:

First, adhere to the ecological baseline to achieve the symbiosis of the industry and the ocean, promote green events with ecological friendliness, follow the ecological carrying capacity, protect seabed landforms, and ensure that the industry does not cross the ecological red line. This means that the marine sports industry takes ecological protection as its core, abandons short-sighted development models, ensures resource sustainability, and builds a "sports+ecology" competitiveness, aligning with green development concepts and meeting the relevant consumption needs of the public.

Second, break through resource dependence to upgrade supply quality, take innovation as the core, use technology to expand boundaries, and use models to endow educational value, achieving a transformation from resource dependence to innovation value-addition. This means that the marine sports industry has broken the limitation of only developing where there is an ocean, relying on technology to break experience boundaries, using models to add value, improving risk resistance to avoid homogeneity, attracting tourists with high added value, and promoting the industry's transition from scale to quality.

Third, break down industrial barriers to build a "sports+N" collaborative ecology, integrate into the marine economic circle to create diverse business formats, extend the industrial chain,

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and achieve "1+1>2" collaborative benefits. This means that the marine sports industry shifts from isolation to ecological co-prosperity, becoming a bond of the marine economy, amplifying its own influence, driving related income growth, promoting a virtuous cycle, and providing a new engine for the high-quality development of the coastal marine economy.

Fourth, focus on the people's livelihood to allow the fruits of marine sports to be shared by all the people, balance high-end and low-end needs, take multiple measures to lower the threshold, and practice the "people-centered" concept. This means that the marine sports industry breaks the limitations of the high-end niche, returns to the essence of national fitness, promotes public participation through affordable projects, cultivates youth interest, expands the consumer base, improves public literacy, and becomes a benefit for the people, aligning with the goal of nationwide participation in a leading sports nation.

2.3 Connotations and Characteristics of Promoting the High-Quality Development of the Marine Sports Industry with Digital New Productive Forces

The promotion of high-quality development of the marine sports industry by digital new productive forces is mainly reflected in four aspects:

First, promoting the reconstruction and optimization of production factors [16], laying a solid foundation for industrial coupling. Digital technology upgrades the industry's laborers, instruments of labor, and subjects of labor, forming digital new productive forces within the domain, which not only activates new momentum for the blue economy but also points the way to solve problems such as the shortage of digital marine composite talents and weak digital infrastructure, providing theoretical guidance for building a digital transformation talent echelon and constructing a multi-scenario infrastructure system.

Second, highlighting the core of digital technology innovation, fitting the needs of industrial development. As the sublimation of "science and technology are the primary productive forces, " digital new productive forces are highly consistent with the marine sports industry in taking innovation as the primary driving force, where digital-intelligent efficiency improvement and business format innovation both rely on digital technology, which not only helps to break through resource dependence and single value problems, but also provides an innovative orientation for dealing with the risks of insufficient adaptation between technology and ecology and for implementing the synergy between digital intelligence and ecology.

Third, driving the modernization and transformation of the industry to achieve multidimensional value addition. Technologies such as the Internet and big data are integrated into the entire industrial process, deepening "Sports+N" integration, pushing the industry to transform toward coordination and greening, specifically solving the problem of lacking cross-domain collaborative governance mechanisms, creating conditions for realizing cross-domain collaborative governance, and driving the industry's transition from scale expansion to quality improvement, which aligns with the goal of high-quality development.

Fourth, requiring the adjustment of production relations to create a favorable development environment. the development of digital new productive forces requires optimizing governance mechanisms, policy systems, and other relations of production, accelerating the deepening of reforms, clearing institutional obstacles for the industrial digital transformation, mitigating problems such as the dual shortage of hard and soft support and the urgent need to improve the institutional ecology, and guaranteeing the implementation of coupling mechanisms and the advancement of countermeasures to ensure the deep integration of the two.

In summary, digital new productive forces provide ample power for the marine sports industry to move towards an innovative, coordinated, green, open, and shared path of high-quality development from the four aspects of optimizing factors, strengthening innovation, promoting transformation, and adjusting relations.

3. Mechanisms for Promoting the High-Quality Development of the Marine Sports Industry with Digital New Productive Forces

3.1 Reconstructing the Digital Allocation of Production Factors to Activate New Blue Momentum in Marine Sports

Digital technology and productivity factors are

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deeply coupled to generate digital new productive forces; in this process, the laborers, instruments of labor, and subjects of labor in the marine sports industry undergo profound changes under the empowerment of digital technology, accelerating the transformation and upgrading process of the marine sports industry.

First, digital technology reshapes the laborers in the marine sports industry, increasing the labor value of laborers. From the perspective of the marine sports manufacturing industry, by mastering digital technology, laborers become new-type talents with data interpretation and intelligent equipment manipulation capabilities, and by fully exerting the efficiency of high-end manufacturing equipment to optimize R&D and design and improve efficiency, they drive their own value to leap toward innovative R&D [17]. From the perspective of modern service industries, laborers use digital skills to transform from skill instructors to sports experience designers and user relationship operators, and through data analysis and intelligent devices, they provide personalized services, effectively empowering the value creation model to ascend to deep experience and user loyalty.

Second, digital technology innovates the instruments of labor in the marine sports industry, achieving the empowerment of labor instruments. Through intelligence, labor instruments transform from cost-based tools to sources of value creation. While providing services, intelligent equipment and digital platforms continuously accumulate data, providing fundamental power for lowering thresholds, optimizing experiences, and exploring new commercial models, reshaping the industrial value logic. For example, the digital industrial park of Sichuan Angelina Sports uses material robots for automatic replenishment and automatic cutting beds for precise cutting, and feeds back the full-process data to the management system in real time, realizing the digital management from raw material storage to finished product output [18]. This is not only an improvement in efficiency, but also transforms the production process itself into data assets, laying a foundation for subsequent precise decision-making and model innovation.

Finally, digital technology reshapes the value chain of the marine sports industry by expanding data into new subjects of labor. Traditional industries act on physical sea areas, while the practice in Wanning shows that the processing and analysis of user portraits and event data as new subjects have become the core of value creation. By mining data, enterprises precisely target young customer groups and optimize event experiences, thereby transforming information into passenger flow and consumption, ultimately achieving an industrial value increase with a total tourism expenditure of 6.344 billion yuan, a year-on-year increase of 8.35% [19].

3.2 Optimizing the Digital-Intelligent System of Operational Processes to Improve the Efficiency of Marine Sports Management and Services

Entering a new stage of digital-intelligent integration, digital new productive forces reshape the efficiency function of the marine sports industry with their perception, connection, and intelligent decision-making capabilities. By reconstructing business processes such as event organization, venue management, and user services driven by data, they achieve cost reduction, efficiency enhancement, and resource optimization, injecting continuous momentum into the high-quality development of the industry [20].

First, data-driven approaches improve decision-making efficiency in the marine sports industry. Relying on big data and artificial intelligence analysis, operators can transform traditional experience-based decisions into precise judgments and scientific forecasts based on real-time sea conditions, user portraits, and market trends. For example, the internationally renowned sailing event "America's Cup" deploys a large number of sensors to collect data on wind, waves, currents, and boat performance in real time, and combines AI models for tactical simulation and route optimization, upgrading the strategic decision-making of the command center from subjective judgment to data-driven, which significantly improves the precision and winning rate of on-site command.

Second, process reengineering improves process efficiency in the marine sports industry. Digital technology streamlines redundant processes and accelerates service responses by breaking down information silos and automating business links. A typical case is the "zero-waiting" sea condition service realized at the Hangzhou Asian Games sailing event: relying on wind and wave data automatically transmitted every 10 minutes

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by buoys and ground-wave radars, combined with a GPU-accelerated numerical model, the system can generate hour-by-hour forecasts for the next 5 days within 1 hour and update them on a rolling basis, allowing coaches to refresh graphical results in seconds via their mobile phones. This process reengineering significantly compressed pre-match tactical meetings from 45 minutes to 15 minutes; more crucially, in the event of a race delay, the coaching staff could make a decision to continue waiting or immediately launch within 30 seconds based on real-time data.

Finally, intelligent scheduling improves resource efficiency in the marine sports industry. Through the Internet of Things and cloud computing, the dynamic perception and centralized control of decentralized resources such as sea areas, docks, vessels, and equipment are achieved, thus realizing global optimization and on-demand allocation. As verified by the successful practice of the "Smart Fishery Command and Dispatch Center" in Zhangzhou, Fujian, which achieved second-level dispatch through a single map from sea areas to vessels and finally to fishing ports, this model can significantly improve resource utilization rates and emergency response capabilities.

3.3 Empowering Industrial Ecosystem Integration and Innovation to Increase the Multidimensional Value Space of Marine Sports

Digital new productive forces, by deeply embedding new factors such as data and intelligent technology into the laborers, instruments of labor, and subjects of labor in the marine sports industry, have catalyzed a new paradigm for industrial development characterized by smartization, immersion, and integration. This not only reshapes the value creation methods of the industry, but also opens up new paths for value multiplication, pushing the industrial value to expand from a single sports experience to a multidimensional composite space.

First, the digitization of the marine sports industry promotes the transformation of products and services from standardized experiences to personalized customization, achieving deep excavation of consumer value. Leveraging technologies such as VR/AR and smart wearable devices, it combines virtual scenarios with real sports data, breaking space-time restrictions, and can provide real-time physiological monitoring and personalized sports guidance. This enables traditional sightseeing experiences to be upgraded into high value-added immersive training and health management services, significantly enhancing user participation and customer unit value.

Second, the digitization of the marine sports industry promotes a transformation in operations and management from empirical decision-making to data intelligence, realizing an essential improvement in management efficacy. Through the application of the Internet of Things, drones, and big data, it achieves around-the-clock monitoring and intelligent analysis of sea areas, facilities, and foot traffic. This transformation makes safety warnings, resource scheduling, and emergency responses more precise and efficient, fundamentally reducing operational costs and risks, and laying a solid efficiency foundation for the large-scale development of the industry.

Third, the digitization of the marine sports industry promotes the reconstruction of business models from industrial separation to ecological integration, realizing a diversified expansion of value sources. Relying on digital platforms and algorithms, it breaks industrial boundaries and promotes the creative reorganization of marine sports with elements such as tourism, culture, and wellness. the resulting "Marine Sports +" new economic ecosystem, such as smart tourism routes and digital cultural and creative products, extends value creation from single sports services to the entire industrial chain, realizing the value addition and upgrading of the industrial ecosystem.

Finally, the digitization of the marine sports industry promotes the leap of marketing and communication from regional marketing to global interconnection, achieving exponential amplification of brand value. It utilizes 5G live streaming, social media, and algorithmic recommendations to transform top events and distinctive destinations into highly globally attractive digital content. Through panoramic live broadcasting and global content dissemination, regional resources can quickly be elevated to international "digital IPs, " thereby attracting global traffic and cashing in on industrial value in a broader market space.

3.4 Expanding the Technological Boundaries of Business Models to Open Up New

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Development Space for Marine Sports

Marxist political economy points out that a qualitative leap in productive forces will inevitably spawn new social divisions of labor and exchange relations. As the core driving source, digital new productive forces not only shape new business formats, but also open up unprecedented new spaces for value growth in the marine sports industry [21] by reconstructing the interactive relations among supply, demand, and governance.

First, digital new productive forces reconstruct the producer collaboration network of the marine sports industry, opening up new efficiency space from industrial chain integration. Relying on technologies such as industrial Internet platforms and digital twins, the upstream equipment manufacturing, midstream event operations, and downstream tourism services of the marine sports industry can efficiently collaborate within a shared data space [22]. For example, equipment manufacturers can optimize product design based on user sports data fed back by operators, while tourism service providers can accurately allocate resources according to event schedules. This data-based cross-chain collaboration greatly reduces transaction costs and opens up systematic new efficiency space from the deep integration of industrial organizations.

Second, digital new productive forces create and lead new consumer markets for the marine sports industry, opening up new scale space from demand upgrading. Smart and immersive new products and services profoundly change consumer preferences and create entirely new market demands. on the one hand, new products such as smart dive computers and VR surfing simulators shift consumers' interests from traditional sports skills training to the pursuit of high-tech experiences [23]. on the other hand, new business formats such as virtual sailing events and metaverse marine parks break through the carrying capacity and geographical limitations of the physical world, attracting digital-native consumers worldwide, thereby opening up enormous incremental scale space for the industry from the demand side [24].

Finally, digital new productive forces force and empower the innovation of government governance models, opening up stable new development space from adaptive institutional transformation. the emergence of new business formats and models requires governance rules to evolve simultaneously. For example, to guarantee the security and rights of virtual event IPs and user sports data, policies such as the "Guiding Opinions on Promoting the Development of the Data Security Industry" provide a fundamental security guarantee for industrial digitization [25]. At the same time, the government's use of big data platforms to implement precise supervision and scientific planning can more effectively maintain market order and protect the marine environment. This modernization of the governance system provides a stable and reliable institutional environment for the healthy and sustainable development of new spaces in the marine sports industry.

4. Bottlenecks in Promoting the High-Quality Development of the Marine Sports Industry with Digital New Productive Forces

4.1 Shortage of Digital Marine Composite Talents and Structural Imbalance between Supply and Demand

First, there is a severe shortage of digital talent reserves in the marine sports industry. As a field combining typical technology-intensive and resource-intensive characteristics, marine sports urgently requires composite talents who not only understand professional skills such as sailing and diving, but also master data analysis and smart equipment operation and maintenance. However, a cultivation system for such talents has not yet been formed at present, leading to a massive talent gap. Taking the diving industry as an example, the proportion of instructors who can proficiently use smart dive computers for data interpretation and formulate personalized health management plans for clients is less than 10% [26].

Second, there is a severe mismatch between the spatial distribution of talents and industrial layout. Digital marine talents are highly concentrated in developed coastal regions such as the Yangtze River Delta and Pearl River Delta; for instance, Shenzhen and Shanghai gather 70% of the R&D teams of marine technology enterprises nationwide, while emerging marine sports cities like Beihai in Guangxi and Danzhou in Hainan face the dilemma of "having projects but no talents". Among the 12 marine sports enterprises introduced by Zhoushan City in 2024, 60% were forced to relocate their technical departments to Hangzhou due to a lack of local

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digital operation and maintenance talents [27].

Third, there is an absence of integration mechanisms between industry and education for cultivation. Although universities such as Shanghai Ocean University have offered directions related to "marine sports, " fewer than 10 universities in China offer the "smart navigation" direction, and the average course update cycle is 3.5 years, far exceeding the 18-month iteration speed of digital technology, causing graduates to still need 12–18 months of secondary training upon taking their posts [28].

4.2 Weak Digital Infrastructure and Dual Insufficiency of Hard and Soft Support

First, the coverage of dedicated marine digital infrastructure is uneven. the development of marine sports activities heavily relies on dedicated facilities such as nearshore 5G coverage and underwater high-precision positioning and communication networks. Currently, China has only achieved continuous 5G signal coverage in demonstration sea areas of a few developed cities, and most coastal scenic spots and public sea areas have network blind spots, resulting in the inability to implement real-time data return, safety monitoring, and immersive experience projects [29].

Second, the construction of data sharing mechanisms and platforms lags behind. There is a severe "data silo" phenomenon in the field of marine sports, with data on meteorology, hydrology, and events scattered among different entities such as marine bureaus, sports bureaus, and enterprises, resulting in inadequate cross-departmental and cross-system sharing rates. Among them, the obstacles to cross-regional data circulation are particularly prominent; the port and shipping platform interface standards of six coastal provinces and cities are inconsistent, and the "Annual Report on Digital Transportation Development (2025)" issued by the Ministry of Transport explicitly disclosed that the success rate of relevant cross-system data calls is only 55%, directly restricting the joint operation of cross-regional events—for example, the Yangtze River Delta Sailing Rally needs to coordinate port and shipping data from Shanghai, Jiangsu, and Zhejiang to plan the route, and incompatible interfaces extend the route calculation cycle by 3 days, increasing event preparation costs [30]. At the local level, although Liaoning Province has established a marine data sharing platform, the sports-related data integrated accounts for only 15%, which is unable to support the development of intelligent event scheduling systems [31].

Third, there is a severe shortage of inclusive financial supply targeting the marine sports field, highlighting financing constraints for small and medium-sized enterprises. According to survey data from the "Report on the Development of China's Sports Industry (2023), " over 75% of the surveyed sports SMEs list narrow financing channels and high costs as the primary obstacles to their digital transformation. For marine sports enterprises, this predicament is even more severe: their new infrastructure projects possess the dual attributes of heavy assets and high technology, with weak asset mortgage capabilities and high investment risks, which mismatch the credit risk control requirements of commercial banks, thereby widely excluding them from mainstream financial services and greatly inhibiting the digital transformation process of the industry as a whole.

4.3 Lack of Cross-Domain Collaborative Governance Mechanisms and the Urgent Need to Improve Institutional Ecology

First, the barriers to the circulation of marine data elements are strict. the marine sports industry involves multiple management departments such as natural resources, maritime affairs, culture and tourism, and sports; inconsistent data standards and unclear rights and responsibilities among various departments make it difficult to share and integrate marine environment data, ship navigation data, user behavior data, etc., leading to low efficiency in the market-oriented allocation of data elements [32].

Second, regional integrated collaborative governance capabilities are insufficient. In the process of promoting the construction of marine sports industry belts such as the "Bohai Rim" and "Guangdong-Hong Kong-Macao, " local governments have barriers in planning, supervision, and standards, resulting in market segmentation, making it difficult to form a unified industrial ecology and brand synergy, and restricting large-scale development.

Third, the protection of digital rights and supervision lag behind. With the emergence of new business formats such as virtual sailing events and digital event IPs, related rules for digital copyright and virtual asset protection are still blank. Infringements such as pirated

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broadcasts of events and illegal use of user marine sports data occur from time to time, severely dampening the enthusiasm for enterprise innovation, and market order urgently needs to be regulated [33].

4.4 Insufficient Adaptation Between Technology and Ecology, Implying Sustainable Development Risks

First, the ecological interference risks of intelligent equipment are ignored. In the pursuit of extreme experiences, some marine sports activities introducing equipment such as underwater robots and high-performance electric surfboards may cause irreversible noise pollution and physical damage to fragile ecosystems such as coral reefs and marine life habitats, and their long-term ecological impacts have not yet been fully evaluated [34].

Second, the energy consumption of data centers exacerbates environmental protection pressure. the large data centers and edge computing nodes supporting the digital operations of marine sports consume huge amounts of energy, and if deployed in coastal areas, their cooling systems extracting massive amounts of seawater and discharging waste heat may trigger thermal pollution in local sea areas, contradicting the green connotation of marine sports.

Third, digitization exacerbates the issue of equitable access to the ocean. the popularization of digital technology may invisibly raise the threshold for participation, excluding social groups unable to afford smart equipment or digital services, aggravating inequalities in the enjoyment of marine sports resources, and deviating from the sharing tenet of high-quality development [35].

5. Implementation Strategies for Promoting the High-Quality Development of the Marine Sports Industry with Digital New Productive Forces

5.1 Building a Talent Echelon for the Digital Transformation of Marine Sports

First, strengthen the main position of universities and innovate training models for digital talents in marine sports. Universities must face squarely the structural contradiction of the severe shortage of composite talents with marine knowledge, sports skills, and digital literacy that has emerged due to the rapid development of China's marine sports industry. High-level domestic universities have already made cutting-edge layouts in this regard; for example, the new engineering major "Marine Technology and Intelligent Science" established by the Ocean University of China deeply integrates cutting-edge technologies such as artificial intelligence, marine big data, and underwater robots, and its curriculum system and training program provide a referential paradigm for systematically cultivating specialized talents in fields such as marine sports data analysis and intelligent equipment R&D. Relevant institutions should accelerate the layout of cross-disciplines such as "Marine Sports Intelligent Science" and promote deep innovations in curriculum systems and cutting-edge technologies to enhance the efficiency of high-quality talent supply.

Second, deepen the integration of industry and education in marine sports to unblock channels connecting talent supply and demand. Well-known marine sports enterprises are encouraged to build collaborative mechanisms with high-level universities and sports institutions in coastal areas to precisely align with industrial talent needs in areas such as digital skills for diving instructors and smart management of sailing events by co-building practical training bases and co-determining training programs.

Third, adhere to the combination of internal cultivation and external introduction to expand the total volume of digital marine sports talents. Sports regulatory authorities and relevant enterprises need to accelerate the establishment of open, flexible, and efficient talent introduction and cultivation mechanisms; internally, they can enhance the digital literacy of existing employees by establishing corporate universities and organizing special digital skills training; externally, they must innovate talent introduction models, widely attracting scientific and technological talents from fields like marine engineering and information technology to cross over into the marine sports industry by establishing special zones for marine sports digital talents and implementing flexible talent acquisition strategies such as "project-based experts".

5.2 Constructing a Multi-Scenario Infrastructure System for Marine Sports

First, break through technology application bottlenecks in special marine environments and consolidate the foundation of industrial development. Aiming at the inherent difficulties

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restricting the digital development of marine sports, such as strong seawater corrosiveness and unstable signal transmission, it is necessary to concentrate efforts on overcoming key technologies such as underwater high-precision positioning, low-power marine communications, and anti-corrosion of sports equipment materials, with a focus on developing high-end equipment such as smart diving gear integrating environmental monitoring and vital signs perception, and artificial intelligence-based sailing route optimization systems, thereby breaking the "stranglehold" situation of long-term reliance on imports and providing core technological support for the independent and safe development of China's marine sports industry.

Second, cultivate marine sports intelligent equipment industry clusters to elevate the modernization level of the industrial chain. To change the current situation of low concentration and low product added value in the marine sports equipment industry, specialized industrial parks integrating R&D design, smart manufacturing, and market trading should be scientifically deployed in coastal advantage areas; advanced production technologies such as additive manufacturing and flexible electronics should be actively introduced; focused support should be given to the R&D and industrialization of emerging products such as watercraft, competitive unmanned boats, and smart surfboards; and efforts should be made to build a batch of internationally influential independent brands, constructing a safe and controllable modern industrial supply chain.

Third, construct new immersive marine sports experience scenarios to expand new spaces for digital consumption. Aiming at the pain point that traditional marine sports experiences are severely limited by time, space, and weather, cutting-edge technologies such as VR/AR and digital twins should be fully utilized to vigorously develop virtual sailing explorations, immersive diving sightseeing, and other online experience products, while offline building smart water sports centers integrating intelligent training, event viewing, and interactive entertainment; through the online-offline integration model, the industrial radius can be effectively extended to meet the growing personalized and high-quality marine sports consumption needs of the people.

5.3 AchievingCross-Domain Collaborative Governance of Marine Sports

First, innovate marine sports data sharing mechanisms to break down information interaction barriers. To address the "data silo" problem formed by marine-related data being scattered across multiple departments such as sports, maritime affairs, and meteorology, it is urgent to take the lead in formulating unified marine sports data collection and exchange standards, and to use blockchain technology to build a decentralized and trusted data sharing platform; under the premise of ensuring data security and privacy, orderly promote the cross-departmental circulation and integrated application of waterway information, athlete information, and event resource data, providing a unified data base for macro-decision-making and precise services.

Second, establish an integrated marine sports service platform to enhance management and service efficiency. To solve the practical difficulties faced by marine sports participants, such as non-interoperable qualification certifications and imperfect rescue guarantees, it is necessary to create a one-stop digital service platform integrating functions such as identity authentication, activity reporting, insurance purchasing, and emergency rescue, and actively promote the mutual recognition and interoperability of qualifications such as sailing driving and diving instruction among coastal provinces and cities, realizing "one-code access" and effectively enhancing the convenience and safety of management services.

Third, perfect the marine sports risk prevention and control system to build a solid safety baseline for industry development. Facing the inherent high-risk characteristics of marine sports, it is essential to construct a smart risk control system covering the entire pre-, during-, and post-activity process; through means such as accessing real-time marine environmental data, equipping athletes with smart life-saving gear, and deploying autonomous cruising rescue boats, early identification and intelligent early warning of hidden risks can be achieved, and a big data-based credit evaluation model for practitioners can be established to implement hierarchical and classified supervision, comprehensively guaranteeing the safe conduct of marine sports activities.

5.4 Promoting the Synergy between Digital-

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Intelligent and Ecological Aspects of Marine Sports

First, develop green and low-carbon marine sports models in response to ecological protection requirements. To reduce the potential pressure of traditional marine sports on fragile marine ecology, new energy sports equipment such as electric hydrofoils and solar-powered rowing boats should be vigorously promoted and applied; a scientific marine sports carbon footprint accounting methodology should be established; the emission reduction effects of low-carbon sports such as sailing and windsurfing should be quantitatively tracked via digital platforms, and active explorations should be made to include them in the carbon inclusion system, guiding the industry toward an environment-friendly direction.

Second, create eco-friendly marine sports scenarios to promote harmony between humanity and nature. To avoid damage to nearshore ecological environments caused by the overheated development of marine sports tourism, aerial drones and underwater sensor networks can be used for dynamic monitoring of the ecological carrying capacity of key sports sea areas, and ecological research sports projects represented by marine life observation and mangrove exploration can be scientifically developed, transforming the public's passion for sports into practical actions of understanding the ocean and protecting the ecology, achieving unity of sports value and ecological value.

Third, build a smart marine ecological restoration system to innovate industrial responsibility expression. To proactively repair the ecological impacts that marine sports activities may cause, industry associations and enterprises can be encouraged to regularly organize public welfare restoration activities such as coral reef planting and seabed garbage cleanup using smart equipment like underwater robots, and to develop a "sports beach cleanup" mini-program targeting the broad mass of sports enthusiasts, providing corresponding incentives by recording users' behaviors in cleaning marine garbage, and building a new marine protection ecology of "universal participation and digital witnessing".

6. Conclusion

As an emerging field of deep integration between the marine economy and the sports industry, the marine sports industry is not only an important carrier for implementing the requirement of "promoting the quality and efficiency improvement of marine service industries" in the "Outline for Building a Leading Marine Nation, " but also a key track adapting to residents' consumption upgrades and satisfying the people's needs for a better life. It is urgently necessary to reconstruct the talent chain, technology chain, and governance with digital new productive forces. Only by constructing a four-dimensional implementation system of "talent echelon - scenario infrastructure - cross-domain collaboration - ecological symbiosis" can the traditional marine sports resource-dependent development model be broken through, opening up new space for industrial value addition while guarding the blue territory.

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