

# Marine Science and Technology Innovation for the Polar Silk Road

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**Abstract:** The co-construction of the “Polar Silk Road” is an important way for China to participate in Arctic protection, exploitation, and governance, and scientific and technological innovations are important supports for promoting the co-construction. China has a certain foundation in scientific expedition, scientific research infrastructure construction, equipment research, and manufacturing for the Arctic. However, there remain problems such as weak overall planning mechanisms, inadequate investment, and lagging platform construction. Based on the white paper titled *China’s Arctic Policy* and the relevant principles for the “Polar Silk Road”, China should vigorously promote scientific innovation and humanistic research related to the knowledge, protection, exploitation, and management of oceans in the Arctic. Furthermore, larger breakthroughs in marine observation, sea ice research, biological and ecological systems, pollution control, response to climate change, shipping technology, and oil and gas development technology should be encouraged. To promote scientific and technological innovation for the “Polar Silk Road”, China should strengthen bilateral and multilateral cooperation, launch international scientific programs, establish public platforms, and strengthen talent exchange and training.

**Keywords:** Polar Silk Road; marine science and technology; ocean; the Belt and Road

## 1 Introduction

The Polar Silk Road refers to the sea passage that crosses the Arctic Circle and connects the three economic centers of North America, East Asia, and Western Europe. On July 3, 2017, President Xi Jinping and Russian President Vladimir Putin proposed cooperating in the Arctic waterway to jointly create the Polar Silk Road. On January 26, 2018, the Chinese government published the first Arctic policy document, the white paper on *China’s Arctic policy*, which proposed that China is willing to build the Polar Silk Road with all parties relying on the development and utilization of the Arctic waterway. The Polar Silk Road includes the Northeast channel and Northwest channel; the Northeast channel is jointly built by China and Russia. The Polar Silk Road runs through the Arctic Ocean, covering almost all the Arctic sea areas and coastal zones. The sea areas along the Polar Silk Road are areas that humans have rarely been involved historically. Human understanding of the Arctic remains limited, and the ability to cope with the harsh natural conditions of the Arctic Ocean is still relatively weak. Relying on the Polar Silk Road, actively conducting scientific research, and technological development cooperation related to the Arctic Ocean is not only an important part of the Polar Silk Road, but also an important means for China to actively participate in Arctic cognition, development, protection, and governance.

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## 2 Strategic requirement

### 2.1 Strategic demand for enhancing the security of maritime shipping

More than 90% of China's cargo trade is transported by sea, which can be called the "lifeline" of China's economy. The construction of the Polar Silk Road provides a new way for China to optimize the pattern of maritime transportation and enhance shipping safety. The Polar Silk Road has formed a good supplement to China's traditional maritime trade routes, which can significantly reduce the voyage between China and European countries (especially northern Europe) [1,2], associated fuel cost [3], and navigation time. However, the Polar Silk Road sea area is covered by ice and ice floes year round, and it is easy to form highly variable and unpredictable ice floes in the open sea area in summer and autumn. This puts forward high requirements for shipbuilding technology, marine equipment manufacturing technology, navigation technology, and meteorological, hydrological, and ice forecast technology. To give full play to the shipping function of the Polar Silk Road and reduce the shipping risk, it is urgent to promote the relevant technological innovation.

### 2.2 Strategic demand for optimizing the spatial structure of oil and gas supply

China is a country with a high dependence on oil imports, which reached 72.3% in 2017. The Arctic, which is rich in marine oil and gas resources [4], may become an important oil and gas exploration area and a new important source of oil and gas supply in China [5]. However, the features of the Arctic seabed geomorphology are complex, the sea and land traffic conditions are very poor, and the ecological environment is fragile. Once oil spills and other disasters occur, it is difficult to handle expediently, which may cause serious ecological disasters [6]. Therefore, it is necessary to develop oil and gas exploration, production, and environmental protection technologies suitable for the Arctic sea area, which can reduce development costs and increase development security.

### 2.3 Strategic demand for developing emerging Arctic marine industries

In addition to shipping and oil and gas, Arctic marine fishing and marine tourism are expected to develop into important industries. Sea ice melting expands the boundary of commercial fishing northwards [7], which also improves the economic feasibility of Arctic marine tourism and is expected to generate new industry. However, the distribution of Arctic marine fishery resources and the extent of their change related to climate change have not been fully assessed, and there are insufficient polar fishing boats and cruise ships with certain ice breaking capacity and strong endurance, communication, and safety support capacity to meet the needs of fishing operations and tourism, as well as supporting marine equipment. Therefore, strengthening scientific and technological innovation in related fields is the premise and support for the development of new Arctic marine industries.

### 2.4 Strategic demand for better engagement in Arctic governance

Changes in the Arctic are profoundly affecting the global geopolitical patterns. Changes in the geopolitical economy will inevitably lead to changes in geopolitical patterns. Human understanding of the Arctic region remains inadequate, and the ability to enter, recognize, and develop the Arctic is limited. Considering the complex and changeable meteorological, hydrological, and ice conditions in the region, all development and protection activities cannot be separated from marine science and technology support. Actively participating in Arctic scientific and technological innovation and striving to play an important role in Arctic cognition, Arctic navigation, environmental protection, resource development, and other technological innovation fields should become an important means for China to participate in Arctic governance.

## 3 Basic status

### 3.1 Development status

Since the beginning of Arctic scientific research in 1999, China's Arctic marine science and technology innovation has entered a new stage of sustainable development. After twenty years of development, substantial progress has been made in Arctic marine scientific research, equipment capacity building, scientific research results, technological research and development breakthroughs, and cooperation carrier construction. This has laid a good foundation for innovation activities of marine science and technology cooperation along the Polar Silk Road.

The first part of the foundation is normalization of Arctic scientific investigations. China became a member of the International Arctic Science Committee in 1996. Since 1999, China has carried out nine Arctic Ocean scientific investigations with the Xue Long scientific research ship. It has observed the vast majority of the Arctic sea area,

as well as the hydrological and ice conditions of the Northeast and Northwest channels, and has generated a preliminary understanding of the Arctic ice conditions, hydrology, geology, and biological resources. The training has produced a team of Arctic scientists, technical service teams, and navigation support teams, and comprehensively formed Arctic observation and scientific research capabilities.

Second, infrastructure construction has been continuously promoted. China's scientific research infrastructure in the Arctic mainly includes research vessels, bases, and observation stations. After more than 20 years of development, China has formed the Arctic scientific research infrastructure pattern of "two ships, two stations". "Two ships" are polar exploration ships "Xue Long" and "Xue Long 2". "Xue Long" has carried out 22 Antarctic surveys and 9 Arctic surveys. "Two stations" are the Arctic Yellow River Station and China Iceland Arctic scientific research station. The Arctic Yellow River Station was built in 2004 in the new Olson area of the Spitsbergen islands in Norway. China Iceland Arctic scientific research station was completed in 2018, located in kelhe village, Northern Iceland; it is upgraded from China ice joint Aurora observatory.

Third, the level of scientific research in the Arctic has steadily improved. A complete database of the zooplankton community during the rapid disappearance of sea ice and an automatic meteorological observation station for sea ice drift in Arctic scientific research was established. It was found that the increase in the deep heat sink in the North Atlantic and the Southern Ocean was an important reason for the deceleration of global warming at the beginning of this century, and the main reason for the accelerated rise in global sea level in the most recent twenty years was the increase in Greenland ice sheet melting. Important achievements have been made in water mass and circulation changes, shelf basin water exchange, sub-ice shelf ocean processes, greenhouse gas budget, ocean acidification, biogeochemistry, marine biodiversity and ecosystem evolution, ice sea coupling modeling, and data assimilation.

Fourth, new breakthroughs have been made in polar technological innovation. The research on the new territory of polar strategy has been performed in depth, and a number of major technologies and equipment have been developed to provide on-site support and other support capabilities for China's polar research, fill in gaps in China's major polar scientific research equipment field, and demonstrate the strength of China's equipment and manufacturing. The world's first polar research icebreaker with two-way ice breaking technology (Xue Long 2), the world's first polar heavy-duty deck transport ship, the world's first polar condensate tanker, and China's first deep-water semisubmersible drilling platform (Viking Dragon) suitable for Arctic sea operations have been developed.

### 3.2 Problems

While affirming the achievements, we should also consider the gaps and shortcomings. There is still a large gap between the polar science and technology development level in China and the polar powers. Polar research mainly focuses on tracking and lacks original innovation. The overall level of polar science and technology development in China cannot meet the needs of national economic and social development, and the capacity of independent innovation and achievement transformation of polar science and technology cannot meet the strategic needs of enhancing polar capacity expansion.

First, there is a large gap between China's basic Arctic Ocean research and that of the polar science and technology powers. Bibliometric analysis shows a large gap between China and the Arctic Ocean science and technology powers represented by the United States. The number of SCI papers published by China not only trails the United States, but also lags behind Canada, Japan, Germany, and the Nordic countries.

Second, the investment in Arctic marine science and technology is insufficient. China has not yet established a systematic channel for funding polar scientific research. Funding for Arctic scientific research projects is scattered among various projects set up by relevant departments. The system and continuity of project funding are not strong. The Natural Science Foundation of China (NSFC) has been the main sponsor of related scientific research since 1995. "The comprehensive investigation and assessment of the Arctic and Antarctic environment" project carried out by the State Oceanic Administration is mainly aimed at operational investigation and assessment (since 2011). Since 2016, National Key R&D Program of China has significantly increased funding for Arctic research. However, due to weak infrastructure and many historical disadvantages, China's investment in Arctic-related scientific and technological innovation remains insufficient.

Third, the national Arctic science and technology innovation coordination mechanism is weak. Under the influence of science and technology management departments and resource "fragmentation," China has failed to reach a consensus to form a national Arctic science and technology strategy. The Arctic-related scientific research is mainly promoted by the Chinese Arctic and Antarctic Administration; thus, it is difficult to form a

comprehensive polar research plan including multiple scientific research institutions affiliated with various ministries and systems in China. Due to the characteristics of “big synthesis” of Arctic-related scientific research, there are some unsystematic characteristics in project establishment, infrastructure utilization, and fund allocation among various systems and disciplines, which make it difficult to form joint forces. Integrating the relevant domestic scientific and technological forces to the maximum extent and forming an overall joint force is an important problem that we urgently need to study and solve under the guidance of the National Arctic policy.

In summary, the basic Arctic research capacity, scientific and technological investment, national strategy, overall planning mechanism, and other issues have impeded cooperation of marine science and technology based on the Polar Silk Road. With the development of the Polar Silk Road, the above problems are likely to be exacerbated. It is necessary to analyze the causes of the problems carefully and solve them pertinently.

## 4 Overall concept

### 4.1 Guiding ideology

The ideology follows the basic concepts and principles of the Belt and Road initiative, focusing on the four major themes of the *China's Arctic Policy* white paper about understanding the Arctic, protecting the Arctic, using the Arctic, and participating in Arctic governance, while relying on important pivotal countries along the Polar Silk Road, vigorously promoting Arctic Ocean observation (probing) and basic research, marine ecology environmental protection technology development, Arctic Ocean development engineering technology development, and Arctic maritime humanities and social science research cooperation. The ideology promotes actively participating in and leading the preparation of international scientific organizations related to the Arctic Ocean, combining the scientific and technological development needs of Arctic countries and major Arctic science and technology countries with those of China, through strengthening intergovernmental cooperation, jointly building scientific research platforms, jointly initiating the promotion of the Arctic Great Science Program, co-organizing academic forums, and strengthening staff exchanges and training, to promote comprehensive improvement of China's capability and level of marine scientific and technological innovation along the Polar Silk Road. This will enable China to play a greater role in the cognition, protection, development, and governance of the Arctic Ocean.

### 4.2 Main principles

Understanding the Arctic Ocean forms the core task of the marine science and technology innovation on the Polar Silk Road. China's Arctic scientific research started late, its scientific research foundation is relatively weak, its technical level is not high, and its lack of cognition has become the largest shortcoming of China's participation in Arctic Ocean affairs. We should increase investment, perform in-depth research on basic scientific issues such as Arctic Ocean hydrology, ice situation, meteorology, geology, Arctic and global change, and foster China's Arctic Ocean cognitive ability to join the international advanced ranks as soon as possible.

The protection of the Arctic Ocean is taken as the fundamental tenet of marine scientific and technological innovation on the Polar Silk Road. Protecting the unique natural environment and ecosystem of the Arctic Ocean, and respecting the diverse social, cultural, and historical traditions, should be an important action for China to practice the community concept tied to a shared ocean future. Only in this way can China's ideas and actions to promote marine science and technology innovation along the Polar Silk Road be recognized and supported by Arctic countries.

The exploitation of the Arctic Ocean forms the long-term goal of cooperation in marine science and technology on the Polar Silk Road. Arctic shipping, oil and gas development, and other economic activities have significant economic development potential, but also face large natural, market, and social risks. The sustainable development goals should be followed and the focus of Arctic Ocean development should be placed on the exploration of environmentally friendly technology and business models.

Participation in Arctic governance of the Arctic Ocean is an important practice of maritime scientific and technological cooperation along the Polar Silk Road. We should both earnestly fulfill the observer responsibilities of the Arctic Council and play an active role within the existing framework of international law and also participate as a major country in formulating rules for the Arctic shipping, pollution prevention and control, fishery resource development and protection, emergency rescue and other aspects, while promoting the construction of relevant mechanisms and platforms, contributing as an important provider of relevant public services, and playing a key role in the deepening process of Arctic governance.

### 4.3 Development goals

Relying on the joint construction of the Polar Silk Road, we will promote long-term stable scientific and technological cooperation between China and the Arctic countries, and gradually strengthen exchanges and cooperation with major international Arctic scientific and technological powers. To solve the bottleneck problems of insufficient observation capabilities and weak observation pivots in China, it is essential to establish an ice observation system on the Polar Silk Road, promote the full-scale development of Arctic Ocean research and sea ice research, realize comprehensive sea-ice-gas observation and high-precision model construction, and improve the accuracy of meteorological and hydrological forecast. Substantial progress in the study of Arctic marine biodiversity and ecosystem evolution will be made based on a comprehensive observation system. The level of awareness of Arctic Ocean acidification, microplastic pollution, and other major environmental issues will be significantly improved, and the application of marine environmental pollution assessment and treatment technologies will be developed. It is essential to understand the relationship between Arctic and global climate change and its impact on the Arctic, and take it into the overall consideration of Arctic Ocean governance. It is critical to ascertain the distribution and reserves of the Arctic Ocean channel resources, oil and gas resources, fishery resources, metal mineral resources, and other important resources. The equipment manufacturing technology, shipbuilding technology, oil and gas exploration and mining technology, fishery exploration and capture technology related to Arctic development must meet the requirements of industrial development, and the universal technology of the Arctic Ocean should reach the world's leading level. The Arctic sea-related humanities and social sciences research will be fully launched, and it will achieve fruitful results and play an important role in China's participation in the Arctic governance.

## 5 Key tasks

### 5.1 Conduct marine observation and basic research on the Polar Silk Road to better understand the Arctic

Conducting Arctic oceanographic research will require strengthening the construction of basic platforms for China's Arctic research stations, ships, and aircraft, as well as enhancing the ability to acquire Arctic data. We should strengthen cooperation with Arctic countries, promote the construction of Arctic observation network on sea (ice), land and space, and realize long-term unattended automatic observation of basic environmental parameters. We should focus on the development of observational networking technology in the Arctic Pacific sector to support the research and prediction of the Pacific inflow and its impact on the Arctic Ocean environment and ecosystem. We should strengthen the means of ecological exploration in the central Arctic Ocean region to support the assessment and prediction of ecological changes there.

To conduct Arctic sea ice research we should strengthen cooperation with Russia, Germany, and other Arctic scientific research institutions, and build an observation network integrating sky, space, water, and underwater. We should focus on the central Arctic Ocean region, conduct integrated atmosphere, sea ice, and ocean observation, and understand the influence of the interactions among them. We should focus on ice observation and process research, participate in the international Arctic buoy program, collect sea ice data, and study the Arctic Ocean processes, interactions, and feedbacks that affect the dynamics and thermodynamics of sea ice cover.

To enhance the capability of cooperative observation by Arctic satellites we should vigorously develop satellite remote sensing and data processing technologies, and develop and form a series of polar key element remote sensing products with independent intellectual property rights and international influence. We should improve the ability of obtaining space-based data for Arctic observation in China as an important technical support for China's cooperation with Arctic countries and near Arctic countries. A "space-sky-earth" integrated observation system should be constructed. Finally, we should strengthen observation and basic scientific research on Arctic sea ice, Arctic Ocean primary productivity, and the Greenland ice sheet.

### 5.2 Conduct research on marine ecological environment protection and climate change response to better protect the Arctic

Carrying out the research on Arctic marine biodiversity and ecosystem evolution starts with strengthening international cooperation, building a research platform and observation network for marine ecosystems, and conducting multi-level and multi-field continuous observation of bioecology and biodiversity. We should analyze the biodiversity, unique life characteristics, Arctic habitat adaptation and evolution mechanisms, understand the impact of climate change and human activities on the Arctic vulnerable marine ecosystem, and reveal the response of the Arctic marine ecosystem and biogeochemical process to sea ice recession.

To perform typical Arctic biological research we should strengthen the understanding of the distribution and scale of marine life species in the Arctic. We should strengthen the monitoring of typical biological habitats to understand the distribution and quantity of polar bears, seals, and representative seabirds. We should assess the feeding ecology of Arctic species, fill the seasonal data gaps, and determine the basic life history information, age, and growth rate of key links in the food chain. We should strengthen the protection of typical Arctic creatures and their habitats and promote the establishment of Arctic marine nature reserves.

We plan to assess Arctic marine environmental pollution and develop governance technologies. Through the joint establishment of an international scientific plan, joint construction of scientific investigation stations, and ocean observation stations, we will strengthen the background investigation of the Arctic marine environment, establish a marine environment database, develop technical methods such as environmental multi-media pollutant monitoring and emerging pollutant screening, and carry out typical pollutant observation (including persistent organic pollutants, mercury, microplastics, and radioactive substances) in the polar region. We should study the spatial-temporal distribution, migration, and transformation characteristics of typical pollutants in the Arctic atmosphere and ocean; we should study the impact of global change on the re-release of pollutants in the Arctic Ocean, the accumulation of pollutants in the Arctic marine ecosystem, and their toxicological effects. We should study the response and feedback of Arctic carbon and nitrogen cycle to global change, especially the impact of Arctic Ocean carbon storage changes on ocean acidification and its biogeochemical mechanism. We should assess the impact of human activities such as shipping, oil and gas development, fishing, and fisheries on the Arctic marine environment, and develop pollutant removal technology.

We intent to perform research on the impacts of global climate change on the Arctic Ocean. Based on the observation data of Arctic atmosphere, frozen soil, and glaciers from different countries, combined with the observation data of ocean and sea ice, we will conduct research on the impact of global climate change on the Arctic Ocean. We should study the changes in polar sea ice, water masses, and circulation, and clarify their relationship with global turnover circulation changes and climate warming. We should fully understand the Arctic land–sea–ice–air energy and material exchange process, develop an Arctic regional-coupled numerical model, and improve weather forecasting accuracy. We should study the effects of polar ice caps and glacial dynamics on sea level. Furthermore, we should analyze the impact of global climate change on the Arctic Ocean and its ecological change process, and predict Arctic marine ecological environment and biodiversity trends in the context of global warming.

### **5.3 Perform marine engineering technology R&D to make better use of the Arctic Ocean**

We will develop Arctic observation (detection) equipment manufacturing technology. According to the needs of Arctic observation network construction and Arctic oil and gas and fishery resources exploration for relevant equipment, we will accelerate the development of applicable observation (exploration) technical equipment in high-latitude sea areas. According to the characteristics of Arctic meteorology and hydrology, we will develop specialized polar environmental parameters measuring instruments and equipment with independent intellectual property rights, such as methods for measuring temperature and humidity pressure, wind and wave current, temperature, salt and dense sound, and sea ice, and gradually develop the lineage equipment to meet observation needs. We should research and develop long-range, anti-harsh environment and automatic observation and delivery equipment suitable for high-latitude sea areas, and build an observation (detection) platform that meets the requirements of scientific research and resource development. With polar satellite as the core, we should develop the communication technology and networking technology required for polar observation.

Developing high performance ship technology in the Arctic is a focus of research and development. Focusing on the construction of Polar Silk Road service, we must understand the characteristics of ice floes, low temperature, and fog and storms in the Arctic. To ensure the safety of hull structure, ship stability, normal operation of engine room equipment, personnel, and cargo, we will intensify technical research and development and improve the technical level of ship construction in the polar region. Considering the problem that low temperature reduces steel bearing capacity, optimizing the hull structure design, developing special steel smelting technology for polar ships, and improving polar ship motion performance and structural characteristics will be critical. Structural optimization and development of special heating deicing equipment will be important for solving problems of ice formation in important parts of ships under low temperature. Additionally, we should promote the application of “smart shipping” technology for Polar Silk Road ship navigation, and develop the polar navigation safety intelligent decision support system with independent intellectual property rights.

We will develop technology for Arctic resources exploration and utilization. During oil and gas exploration,

high-latitude deep-sea oil and gas exploration technology, such as controlled source electromagnetics method, should be developed according to the characteristics of the uneven and heterogeneous seabed in the Arctic. For oil and gas drilling and production, it is necessary to accelerate drillship and drilling platform technology development suitable for polar sea drilling operations, including low temperature resistant materials, heating system, thick ice layer resistance, storm wave impact structure, and anchoring technology. In oil and gas transportation, it is necessary to accelerate the development of LNG ship construction technology with ice breaking capacity as well as the design and installation technology for underwater oil and gas pipelines in high-latitude sea areas. We will develop emergency response technologies for offshore platform accidents in polar areas, research early warning, emergency, and decision-making systems for oil spills and other emergencies, and develop emergency rescue equipment for platforms in polar areas. We will accelerate the design and construction of a fishery resource survey vessel with strong ice breaking and endurance capabilities in the Arctic sea area, and carry out surveys of major fishery resources in the Arctic.

We plan to develop general Arctic marine technology. We should focus on the development of polar navigation, communications, low-temperature materials, and other general technology. We should research and develop high reliability communication technology suitable for polar temperatures and antimagnetic storms, and develop a polar satellite communication system. Furthermore, we should research and develop polar navigation equipment, work with countries along the Polar Silk Road to develop a unified polar navigation standard, and develop inertial compass and inertial navigation equipment suitable for high-latitude areas. We should research the acquisition and application of polar acoustic parameters, the acoustic characteristics of polar ice guide and under ice, polar acoustic inversion, and develop communication, detection, positioning, and navigation technologies under ice cover. We should research and develop low-temperature steel and low-temperature coating technology, and develop new materials with low-temperature resistance, wear resistance, corrosion resistance, and easy welding. We should research and develop polar engineering building design and construction technology and a complete set of technical equipment.

#### **5.4 Conduct humanities and social science research on the Polar Silk Road to better participate in Arctic Ocean governance**

We intend to strengthen Arctic country studies. We should systematically study the International Arctic competition and cooperation situation, describe the geographical characteristics, Arctic development history, Arctic claims, Arctic competition, and cooperation behavior of Arctic countries and major near-Arctic countries, as well as analyze the interest demands and game situation hidden behind the state behavior. Country studies should consider the differences among the countries concerned on major Arctic issues, and be combined with the overall goal of promoting the construction of the Polar Silk Road in China, study and form differentiated cooperation strategies. We should select international topics that can gather the greatest consensus, advance proposals and international scientific plans that can be widely supported, and gradually expand China's voice in Arctic governance.

Carrying out social science research related to Arctic route development will be based on international Arctic shipping law, and we should strengthen the research on new Arctic shipping rules and China's countermeasures to new laws. Based on the national research results, the laws, regulations, and management regulations of Arctic waterway in countries along the Polar Silk Road, especially in Russia (Northeast route) and Canada (Northwest route) should be studied, and the typical cases of its route management be analyzed. Based on the interests of both sides, discussing the cooperation mechanism with the countries en route in route utilization, infrastructure construction, shipping safety management and emergency rescue, the feasibility of jointly building the "smart shipping" system of the Polar Silk Road, and jointly building the shipping information monitoring system, big data management center, and shipping service support system should be focused on. We should perform joint environmental risk analysis and environmental management mechanism research on the Polar Silk Road shipping development to realize sustainable development of the Arctic route.

We will conduct social science research related to Arctic resource development. We should study the long-term trend of international oil and gas supply and demand, and analyze and predict the impact of Arctic oil and gas development on international crude oil markets and global economic development. We should study and analyze the impact of Arctic oil and gas development on global climate change, marine sustainable development, and new energy technology progress. Additionally, we should study the relevant international rules for Arctic Ocean fisheries, analyze the competitive and cooperative situation of various stakeholders in the formation of the international management system of Arctic fisheries, while studying the impact of climate change on the

sustainable utilization of the Arctic Ocean fishery resources, and clarifying the proposition of China's development and protection of the Arctic Ocean fishery resources. We should study the legal regulation of fishery management in the countries along the Polar Silk Road, and actively strive for fishery entry rights for China by establishing joint fishery resources investigation projects, co-constructing fishery resources protection platforms, and jointly developing green fishing technologies.

## **6 Promotion measures**

Around the Polar Silk Road, promotion measures have the goal of improving China's Arctic marine science and technology innovation capacity, and strengthening bilateral and multilateral cooperation by means of jointly building scientific research infrastructure, launching international scientific plans, building a data sharing platform, and building Arctic scientific forum, with the internal power of building a new scientific and technological cooperation mechanism, to promote the Polar Silk Road marine science and technology cooperation.

### **6.1 Promoting international and bilateral polar scientific and technological cooperation**

Relying on the construction of the Polar Silk Road, we will strengthen Arctic scientific research cooperation with Russia and Nordic countries, further develop China's Arctic scientific layout by signing a memorandum of co-construction, jointly build scientific research institutions (platforms), and jointly implement scientific research projects. In cooperation with the strong Arctic research institutions in Germany, France, Britain, Canada, and other countries, a number of international joint laboratories and joint research centers should be established as the carriers of intergovernmental and bilateral international cooperation projects in Arctic science and technology.

### **6.2 Using multilateral polar science and technology cooperation and exchange platform**

Actively participating in the Arctic Council, Arctic Science ministerial conference, Arctic Circle forum, Arctic frontier forum, and other international polar deliberative platforms will be important. Relying on the construction of the Polar Silk Road, we will actively promote the construction of multilateral international cooperation platforms such as the Asian Forum for Polar Science, the China–Nordic Arctic Research Center, and the BRICs Polar Ocean Cooperation Framework to establish a network for Arctic research cooperation. We should strengthen exchanges and cooperation between (near) Arctic countries, promote Arctic scientific research infrastructure construction and data information sharing mechanisms, and promote joint improvement of the level of Arctic scientific research of all countries.

### **6.3 Enriching marine science and technology cooperation**

While actively seeking to foster intergovernmental cooperation, a multi-level marine science and technology cooperation model should be established. First, we should fully utilize universities and scientific research institutions and consolidate the foundation of marine scientific and technological cooperation along the Polar Silk Road through unit partnership, jointly undertaking scientific research projects, jointly building scientific research teams, and introducing and exchanging talent. Second, we should capitalize on the roles of the Ministry of Science and Technology, the Chinese Academy of Sciences, the Ministry of Agriculture, and other departments to actively establish cooperation with countries along the Polar Silk Road in industries and fields. Third, we should develop the role of China National Offshore Oil Corporation, China State Shipbuilding Corporation Limited, and other enterprises to enhance industrial and technical cooperation with countries along the line through mergers and acquisitions of foreign technology enterprises, construction of foreign projects, cooperation in marine development, purchase of foreign technologies, and recruitment of foreign research and development teams. Fourth, we will fully engage local governments and create a good atmosphere for maritime scientific and technological cooperation along the Polar Silk Road by establishing friendly city relations and holding international science and technology forums.

### **6.4 Taking the lead in launching the international great science plan for the Arctic Ocean**

We will exploit China's late development advantage and take the lead in launching China's leading international big science program for the Arctic. First, based on China's research advantages in the Qinghai Tibet Plateau, it took the lead in launching the "three poles" international science program, focusing on the response and role of the Arctic, Antarctic, and Qinghai Tibet Plateau to global change. Second, we can capitalize on the advantages of the platform formed by the Belt and Road co-construction. We will take the lead in "polar-tropical ocean" joint observation based on the respective advantages of tropical countries and Arctic countries in marine research, and explore the relationship and interaction between high-latitude and low-latitude oceans. Third, with the focus on

resource development and shipping support, leading to the plan of “Transparent Polar Silk Road”, we will realize comprehensive understanding of the sea areas along the Polar Silk Road.

### 6.5 Building Arctic Ocean big data platform

Relying on the Arctic international big science program, we will gradually establish a unified standard for ocean data observation and transmission. We will take the lead in building the Arctic Ocean Data Center open to the world, conducting research, and applying spatial data mining technology, time series analysis technology, multidisciplinary data association analysis technology, high-dimensional data processing technology, and visual analysis technology of polar scientific data using China’s ocean supercomputing platform. We will integrate and fuse Arctic multidisciplinary data, consolidate global observation data, and develop a global climate change and meteorological marine disaster monitoring and prediction system based on big data technology.

### 6.6 Strengthening the exchange and training of talents

Focusing on scientific researchers and engineering technicians, we will make use of visiting scholars, post-doctoral researchers, degree education, short-term exchanges, and other workers to vigorously promote the “going global” of scientific and technological talents and learn the Arctic research methods and skills of advanced countries. By holding international academic conferences, lectures, and symposiums, and jointly forming research teams, the exchange of excellent researchers from the Arctic research power will be increased, and a platform for thought collision and skill learning will be built. In response to the demand for Arctic marine scientific research in non-Arctic countries along the Belt and Road, we will strengthen the training of relevant marine researchers in non-Arctic countries along the Belt and Road initiative by means of studying abroad and enrolling in research groups, thereby strengthening the Arctic scientific research capabilities of the partner countries and increasing enthusiasm for both sides to cooperate in marine research.

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