2026 Funding Scheme for Scientific Research and Innovation – Key R&D Projects (in Response to National Needs) Application Guidelines for the Field of Coastal Zone Environments

I. Background

The coastal zone is a critical ecological barrier that connects land and sea, and also a vital space for economic and social development. The national 14th Five-Year Plan emphasizes strengthening land-sea coordination and advancing governance in key marine areas. The outline of the 15th Five-Year Plan includes a dedicated section on the ocean, calling for the accelerated development of an "integrated smart monitoring system spanning land, sea, air, and space". The Ministry of Ecology and Environment's Plan for the Digital and Smart Transformation of the National Ecological Monitoring Network further clarifies the direction of the digital and smart transformation of the marine ecological monitoring network. The plan requires the establishment of a structure comprising "a sensing network, a data center, and a visualized analysis platform" and the introduction of large model technologies to enhance capabilities in smart sensing and monitoring, intelligent assessment and analysis, and decision support. Using digital and smart technologies to address the challenges in coastal zone governance has become an urgent necessity for supporting the development of a maritime power and realizing the "Beautiful China" vision.

Macao has aligned its Third Five-Year Plan with national strategies. The city is promoting green transformation through the Long-term Decarbonisation Strategy of Macao and the

Environmental Protection Plan for Macao (2026-2030), while building an ecological barrier in collaboration with Hengqin based on the Guangdong-Hong Kong-Macao Greater Bay Area Ecological Protection Plan and the Master Plan for the Territorial Space in the Guangdong-Macao In-Depth Cooperation Zone in Hengqin.

II. Overall Objectives

In response to the critical national demand to enhance the capacity to safeguard coastal zone environments, the scheme seeks to prioritize developing an autonomous marine observation and demonstration system for Macao and its surrounding waters, and increasing the capacity to improve the marine ecology and forecast and issue early warnings for ecological disasters. Additionally, through research on common technologies for coastal zone protection, the scheme aims to provide strategic technological support for building a maritime power and an ecological civilization.

III. Research Direction

Research Direction: Key Technologies and Applications for Digital and Smart Coastal Zone Governance

(1) Collect historical data and conduct supplementary surveys to obtain baseline data that reflects marine, hydrographic, meteorological, and ecological factors in Macao and its surrounding waters.

(2) Use remote sensing technology to develop high-precision remote sensing inversion models for hydrographic and

ecological parameters in Macao's coastal zone and to generate high-quality remote sensing monitoring datasets.

(3) Use artificial intelligence (AI) to optimize ecological monitoring schemes for Macao's waters and to establish a quasi-real-time land-sea-air-space-ecology monitoring system for the coastal zone.

(4) Use data assimilation methods to develop an intelligent, high-resolution, coupled physical-ecological forecasting system for Macao and its surrounding waters, and to construct high-precision reanalysis datasets of the evolutionary processes of Macao's coastal zone environments.

(5) Investigate the spatiotemporal distribution characteristics, environmental capacity, and causes of eutrophication in Macao's nearshore waters. Establish a system for the high-precision simulation of response measures and contingency plans for eutrophication in Macao's nearshore waters.

(6) Use marine digital twin technology to create a high-resolution marine digital twin system for Macao's surrounding waters, providing intelligent decision support for disaster prevention, mitigation, and marine conservation.

Assessment Indicators:

(1) A weekly remote sensing inversion dataset of hydrographic and water quality parameters from the past ten years, with a spatial resolution of at least 500 m, shall be obtained. The parameters must include chlorophyll, suspended sediment, particulate organic carbon, sea surface temperature, and surface current fields. The relative error compared to in-situ observations should be less than 30%.

(2) A coupled physical-ecological numerical modeling system for Macao's surrounding waters with a horizontal resolution of at least 200 m and at least eleven vertical layers shall be developed.

(3) An hourly historical reanalysis dataset of marine ecological factors covering a period of at least ten years shall be obtained. The factors must include temperature, salinity, nitrogen, phosphorus, dissolved oxygen, chlorophyll a, and plankton. The root-mean-square error for sea temperature must be less than 0.6°C and the root-mean-square error for water levels must be less than 15 cm.

(4) A quasi-real-time monitoring system for coastal zone environments shall be established. The monitoring parameters must include flow velocity, water level, temperature, salinity, nitrogen, phosphorus, dissolved oxygen, chlorophyll a, plankton,

and eDNA. An operational intelligent forecasting system shall also be constructed to provide forecast products for coastal zone environments (especially regarding eutrophication in the nearshore waters) and ocean dynamic parameters at six-hour intervals over the following five days within a ten-minute timeframe.

(5) A high-resolution marine digital twin visualization platform for Macao and its surrounding waters shall be developed. The digital twin base resolution should be at least 100 m to enable the dynamic display and interactive querying of key hydrographic, meteorological, and ecological parameters. The system response time should not exceed five seconds.

(6) At least one decision-support report on coastal zone protection shall be produced. This report should propose one or more feasible digital and smart management solutions and early warning strategies.

(7) A Technology Readiness Level (TRL) of at least 6 shall be achieved, and the project outcomes shall be made available to the relevant Macao authorities for demonstration applications.

IV. Application Requirements

(1) The lead applicant must be a Macao institution, and collaboration with a state-level research institution in the Chinese

mainland is required. If an enterprise participates, it must contribute at least 10% of the grant amount.

(2) The project duration is four years. The maximum funding amount per project is MOP 15 million.

V. Contributing Experts

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