Case Study Report on Sustainable Utilization of Marine Biological Resources in the Asia-Pacific Region

APEC Ocean and Fisheries Working Group

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APEC Project: OFWG 04 2025S

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APEC#226-OF-01.3

Acknowledgments

The completion of this case report would not have been possible without the continued support of participating APEC economies, APEC Secretariat and APEC Ocean and Fisheries Working Group, as well as the contributions of the Department of International Cooperation, Ministry of Natural Resources of China, and the project oversees team of APEC Marine Sustainable Development Center / Third Institute of Oceanography, MNR, China.

Special thanks to the co-sponsors of the project—Indonesia; Russia; Thailand; and all other APEC member economies—for their contributions to the report's preparation, namely, YANG Wei, JIANG Yuhuan, LIN Ruijuan, DU Jianguo, CHEN Fenggui, WANG Antao, FENG Jun, CAI Biling, CAI Feng, ZHANG Haifeng, CHEN Bin, LIU Jianhui, LIU Zhenghua, ZHOU Qiulin, LAI Min, Nguyen Thu Tra, Jinhee Seo, ZHANG Wei, Nelson GUILLERMO, WONG Thye Sing, TANG Xu, ZHU Hui, Lutfi Hardian MURTIONO, Rene Charles KEPEL, Kar Hoe LOH, Piero VILLEGAS APAZA, Van Nguyen NGUYEN, etc.

We also extend our gratitude to international organizations, including the APEC Small and Medium Enterprises Working Group and the African Union Commission, as well as experts from nine non-APEC economies—Azerbaijan, Egypt, the Gambia, South Africa, Nigeria, Colombia, Cuba, Micronesia, and Tonga—for their participation and contributions.

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Executive Summary

The Asia-Pacific region boasts abundant and diverse marine biological resources, serving as a vital foundation for numerous industries. The sustainable utilization of these resources is crucial for the region's socio-economic development and ecological health. However, with economic growth and population expansion, marine biological resources face local and global challenges. Through case studies, this report provides an in-depth analysis of the current status, challenges, and solutions in the utilization of marine biological resources across the Asia-Pacific region.

Key Findings

APEC economies have explored diverse practices in the sustainable utilization of marine biological resources, with some regions achieving remarkable results. For example:

- Australia adopts the “Marine Bio-Industry 3.0+” concept, leveraging economy-level research centers to advance synthetic biology, seaweed biorefining, and the utilization of seafood processing waste, thereby establishing a circular economy model.
- Brunei Darussalam's SMEs apply a closed-loop model where “business supports public welfare, and public welfare empowers business”. Combining technological innovation with community participation, they play a vital role in coral restoration and ecotourism.
- China's Xiamen Northeast Coast has implemented the Complex Living Coast model, achieving coordinated development in coastal protection, ecology, and economy while advancing industrial applications in marine biomedicine.
- Indonesia develops mangrove ecotourism through diversified approaches including government management and community autonomy, while optimizing seaweed cultivation techniques to enhance industrial value.
- Malaysia establishes marine protected areas and implements fishery conservation measures, achieving synergy with fisheries management to balance resource exploitation and ecological preservation.

- Peru's marine research institutions build multidimensional ecological data systems to support scientific decision-making for bay pollution control, balancing ecological protection and economic development.
- Viet Nam combines policy regulation of fishing vessels and fishermen with alternative livelihoods, promotes artificial reefs and marine protected areas to alleviate resource pressure, while exploring aquaculture model transformation to reduce environmental impacts.

However, case studies of individual practices in some economies, as well as information shared by experts during workshop discussions and exchanges, reflected several frequently challenges or sustainability issues that they have been or need to be addressed:

- Ecological-economic conflicts, such as the potential impacts of fisheries development and port construction on marine ecosystem resource sustainability.
- Policy implementation bottlenecks, such as insufficient coverage of protective measures and lack of financial support for fishermen's livelihood transitions.
- Technical and data gaps, including financing needs for SMEs, requirements to enhance technological innovation in marine biological resource utilization, and demand for regional data-sharing mechanisms.
- Insufficient cross-border collaboration, as issues like illegal, unreported, and unregulated (IUU) fishing, overfishing and plastic pollution necessitate regional coordination, while monitoring networks and joint research among economies remain underdeveloped.

Recommendations

To address common challenges, the report proposes a series of recommendations to enhance collective efforts, particularly by strengthening the ecological foundation of marine biological resources, advancing blue economy innovation, and improving sustainable resource management. These initiatives aim to inject new momentum into driving sustainable economic growth and achieving the vision of shared prosperity in the Asia-Pacific region.

- To strengthen the ecological foundation of marine biological resources, strengthening regional cooperation is crucial. Interested economies could coordinate their policies for the protection and management of marine biological resources, while enhancing information sharing and technical exchanges. By establishing joint monitoring mechanisms, interested economies can track real-time changes in marine ecosystems, providing a basis for scientific decision-making.

- To promote blue economy innovation, interested governments, enterprises and scientific research institutions could form a joint force, increase investment, and support the research and application of cutting-edge technologies. Universities and scientific research institutes could carry out interdisciplinary research, cultivate compound innovative talents, and inject new vitality into the sustainable utilization of marine biological resources.

- To improve the sustainable management of marine resources, it is necessary to raise public awareness of marine conservation and encourage the participation of all sectors of society in the protection and management of marine biological resources.

Conclusion

In summary, the utilization of marine biological resources in the Asia-Pacific region presents both opportunities and challenges. The research and discussions at the 8th Blue Economy Forum reaffirmed APEC's shared commitment to advancing blue economy growth across the region. This process demonstrates that some economies have reached an understanding: joint efforts are still required in the sustainable utilization of marine biological resources to address issues such as insufficient integrated management capabilities, inadequate infrastructure and technology, and insufficient collaboration. These efforts aim to promote sustainable economic development and the responsible use of marine biological resources , thereby laying a solid foundation for the vision of regional common prosperity.

China, as the proposing APEC economy of the 8th APEC Blue Economy Forum project, expressed its gratitude for the positive contributions of the APEC Secretariat, co-sponsoring economies, and partner organizations. The case studies and Forum outcomes can directly support the APEC OFWG 2025 work plan and subsequent

initiatives and activities to promote high-quality development of the APEC Blue Economy.

1. Introduction

1.1 Background

The ocean serves as a foundation of human survival and development, a strategic frontier for high-quality growth, and a blue engine propelling economic advancement across the Asia-Pacific region. This area boasts the world's largest marine biodiversity, including half of the planet's largest islands, the longest and most diverse coral reef systems, over half of global mangrove areas, and the highest seagrass diversity.[1] These marine and coastal ecosystems are valuable natural resources, which not only withstand some of the most severe environmental conditions, providing habitats for terrestrial and marine biodiversity, but also provide a variety of ecosystem services related to carbon sequestration, coastal protection, natural products and tourism, supporting the safety, coastal protection, well-being, food and economic security of hundreds of millions of people.[2]

However, some highly biodiverse coastal and marine ecosystems in the Asia-Pacific region are facing increasing natural and human pressures, adversely affecting marine ecosystems. Changes or declines in coastal ecosystem structure and function indirectly lead to the loss of food sources and economic opportunities, while exacerbating the negative impacts of coastal natural disasters. Meanwhile, the cumulative effects of land-based marine pollution, ocean warming, and acidification pose significant challenges to the recovery of marine species and populations, the restoration of coastal habitats, and the management of marine ecosystems in the Asia-Pacific coastal areas. It is essential to conduct systematic assessments and promote conservation efforts, sustainable utilization, and management of marine biological resources and coastal ecosystems in the region.

In recent years, the blue economy has emerged as a driving force for innovation and economic growth, providing robust support for addressing core challenges such as the changing ocean environment, protecting marine ecosystems and ensuring food security

[1] IPBES. The IPBES regional assessment report on biodiversity and ecosystem services for Asia and the Pacific. Karki M, Senaratna Sellamuttu S, Okayasu S, and Suzuki W (eds). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 2018, 612 pages.

[2] APEC Ocean and Fisheries Working Group. APEC Marine Sustainable Development Report III. APEC, 2024.

for coastal communities. Developing the blue economy and promoting sustainable economic development have become a shared vision among APEC members. The 4th APEC Ocean-Related Ministerial Meeting (AOMM4) affirmed OFWG's common view on blue economy as a crucial pathway to advancing the sustainable management and protection of marine, coastal, and ecosystem resources. The 5th AOMM reaffirmed this common view and encouraged APEC economies to increase the awareness of sustainable economic opportunities and environmental stewardship in the blue economy. Therefore, the blue economy carries the common future of the Asia-Pacific region. By improving the understanding of the economic and social value of the ocean and marine ecosystems and resources, APEC economies can advance blue economy development and support the implementation of the APEC Putrajaya Vision 2040 and the Aotearoa Plan of Action. Together, we can build a clean, beautiful, prosperous, and sustainable blue home for future generations.

Against this backdrop, the OFWG has guided the implementation of seven editions of the "APEC Blue Economy Forum" project. Since 2011, it has attracted participation from over 1,100 representatives from 21 economies and launched demonstration projects and development pathway initiatives for the blue economy, continuously improving cooperation for sustainable marine management among member economies and driving the transformation of blue economy concepts into practical actions. The "8th Blue Economy Forum" project (Project Number: OFWG 04 2025S), approved in 2025, is implemented by China and co-sponsored by three APEC economies—Indonesia; Russia; and Thailand—to support APEC in advancing goals such as sustainable economic growth, blue economy development, and regional food security. As the core activity of the project, the 8th APEC Blue Economy Forum, held in Xiamen on 6-7 November 2025, focused on the theme of "Sustainable Utilization of Marine Biological Resources and Coastal Zone Resources". It brought together representatives from 10 APEC economies—Australia; Brunei Darussalam; China; Indonesia; Korea; Malaysia; Peru; Russia; Thailand; and Viet Nam—and 9 non-APEC economies—Azerbaijan, Egypt, the Gambia, South Africa, Nigeria, Colombia, Cuba, Micronesia, and Tonga—along with representatives from international organizations such as the APEC SME Working Group and the African Union Commission, totaling over 130 participants. This event provided an important platform for stakeholders to exchange practical experiences, share technological innovations, and explore expanded regional

cooperation.

To deepen APEC economies' scientific understanding of sustainable marine biological resource utilization, advance regional cooperation in this field, and strengthen capacities for marine and coastal ecosystem conservation, this report was developed under the 8th APEC Blue Economy Forum project. Grounded in an analysis of sustainable utilization concepts and assessment of Asia-Pacific practices, it synthesizes stakeholder insights from case studies and expert consultations. The study identifies challenges and opportunities in this domain, providing recommendations for future development.

1.2 Objectives

This case study report aligns with the objectives of the 8th APEC Blue Economy Forum, which seeks to promote best practice sharing and enhance capacity to protect coastal habitats and sustainably utilize marine biological resources for advancing the blue economy in coastal areas. By facilitating open discussions on these approaches, it addresses member economies' needs while aligning with key principles outlined in relevant APEC Leaders' Declarations and Ministerial Statements. The primary objective is to bridge gaps in knowledge sharing, policy coordination, and technological innovation among member economies, while fostering private sector participation in the blue economy - particularly in sustainable marine resource utilization and coastal zone management.

The project aims to:

(1) promote innovative collaboration for the sustainable utilization of marine resources in the APEC region;

(2) establish a policy-technology-industry dialog platform among governments, research institutions, and enterprises through the meeting to protect critical coastal habitats, and promote cooperation in the sustainable utilization of marine resources;

(3) extract replicable innovative models to promote knowledge sharing through case studies on the sustainable utilization of regional marine biological resources.

1.3 Material and Methods

This case study report is primarily based on and integrates data from four complementary sources. The research was built upon four complementary sources of

information:

(1) Pre-forum Research. Through literature review, data collection and analysis, the paper defines the conceptual connotation, importance and policy relevance of sustainable utilization of marine biological resources in the APEC region.

(2) Compilation of case studies. During the project implementation, including the forum sessions, representatives from participating economies shared practical insights that supported the case analysis in this study.

(3) Forum Information Exchange. A seminar was held with the participation of representatives from 10 economies and 9 non-economies, as well as experts from other organizations, to share scientific research progress, exchange technological achievements, and conduct policy dialog on the sustainable utilization of marine biological resources.

(4) Stakeholder Consultation. Consultations, interviews and questionnaires were conducted with economic experts, corporate representatives, and other stakeholders to gather and supplement information.

2. Overview: Sustainable Use of Marine Biological Resources in APEC Region

The exploration and sustainable utilization of marine biological resources not only have important scientific significance and economic value, but also are indicators of global natural resource development and technological innovation. The sustainable utilization of marine biological resources is crucial to the economic development and ecological environment health of the Asia-Pacific region.

2.1 Core Concepts of Sustainable Use

Sustainable use of marine biological resources is a complex concept, but its core connotation can be explained as responsibly utilizing marine resources to meet the needs of the current generation, without damaging the ability of future generations to meet their own needs, thereby ensuring the health, integrity, and productivity of the marine ecosystem.

Specifically, this concept encompasses three interrelated dimensions of ecological,

economic and social sustainability.

Ecological sustainability emphasizes that the exploitation and utilization of marine biological resources (such as fish, shellfish, algae, etc.) must be carried out within the threshold of their natural regeneration capacity, so as to maintain the population integrity and protect the structure and function of the ecosystem.

Economic sustainability entails developing and utilizing marine biological resources to generate sustainable economic benefits that support the long-term prosperity of related industries and communities. Specifically, this means rejecting short-sighted practices like IUU fishing and overfishing and pursuing long-term, stable economic returns within sustainable limits. It requires enhancing resource efficiency through improved management, reduced waste, value-added processing (e.g., deep processing), and eco-tourism, rather than relying solely on increased catch volumes. Additionally, it involves factoring in any ecological impacts of fishing activities into market prices to ensure they reflect true ecological impacts.

Social sustainability requires that the utilization of marine biological resources safeguards the livelihoods and well-being, and cultural heritage of coastal communities and practitioners. The sustainability of these resources is important for global food security and livelihood protection.

2.2 Importance for Asia-Pacific Region

The sustainable use of marine biological resources is not only related to the food security, economic development and social stability of the Asia-Pacific region, but is also important for addressing the threats or challenges of global environmental change.

Ensuring regional food security

The Asia-Pacific region provides more than 60% of the world's catch and more than 80% of the world's aquaculture products. These aquatic products are an important source of animal protein for people in many economies in the Asia-Pacific region and underpin the food security of hundreds of millions of people.

Since 2019, the per capita fish consumption in APEC economies has increased significantly, with the annual per capita supply of fish and seafood remaining at around 32 kilograms, higher than the global average of about 20 kilograms. Economies with

higher levels include Hong Kong, China; Indonesia; Japan; Korea; Malaysia; etc.[3]

Supporting Economic Development and People's Livelihood

Marine fisheries are a pillar industry of the marine economy in some Asia-Pacific economies and provide employment for tens of millions of coastal residents across the entire value chain. Industries related to the high-value utilization of marine biological resources (such as marine biomedicine) were once among the industries in China's marine economy with a growth rate exceeding 25%.

Driven by global marine fisheries conservation, marine aquaculture has emerged as a key driver of transformation in fisheries and aquaculture[4]. From 2015 to 2019, the average share of marine aquaculture output in APEC economies' GDP rose from 0.22% in 2015 to 0.28% in 2020. Notably, Chile alone accounted for nearly 4% (2019), while other economies maintained below 0.5%.[5] Technological progress has become increasingly pivotal in driving the rapid and sustainable economic development of marine aquaculture.

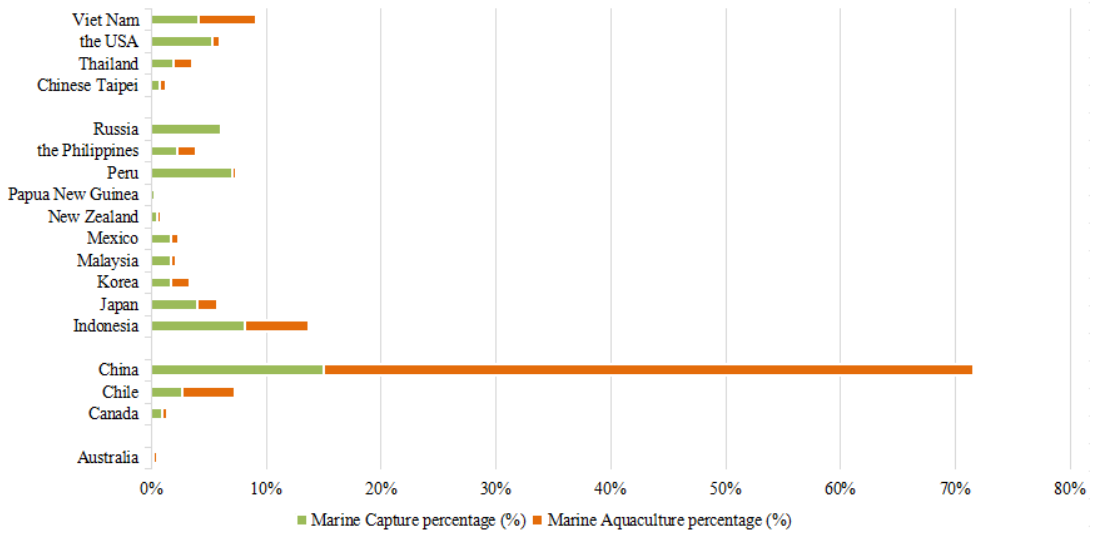


Figure 1 Proportion of marine capture and aquaculture of APEC economies in the world

[3] Calculation based on FAOSTAT Food Balances database from FAO, available from: http://www.fao.org/faostat/en/#data/FBS, 2022.

[4] OECD. The Ocean Economy in 2030. OECD Publishing, 2016.

[5] Calculation based on FAOSTAT Food Balances database from FAO, available from: http://www.fao.org/faostat/en/#data/FBS, 2022.

Fisheries and aquaculture activities provide an important source of income and livelihood for coastal communities. The traditional fisheries in coastal areas also carry rich cultural values. These industries offer numerous job opportunities for coastal communities and serve as the backbone of livelihood for many fishing families.

Preserving Ecosystem Health and Biodiversity

The Asia-Pacific region, particularly the East Asian Sea area, contains one-third of the world's coral reefs and mangrove forests, serving as a vital global repository of biodiversity. A healthy marine ecosystem not only sustains the regeneration capacity of fishery resources but also helps mitigate some impacts of marine environmental threats and challenges.

Addressing Shared Challenges and Promoting Regional Cooperation

The Asia-Pacific maritime region confronts multifaceted challenges including IUU fishing, overfishing, marine pollution (e.g., microplastics), and habitat degradation. These transboundary issues necessitate coordinated efforts . Coastal ecosystems such as mangrove forests, coral reefs, salt marshes, and seagrass beds provide critical ecosystem services, including habitats for key marine biological resources and coastal protection. As a global hub for mangrove distribution, the Asia-Pacific region hosts approximately 47% of the world's mangrove area (136,000 km²), with Southeast Asia accounting for nearly one-third of global mangrove coverage. Indonesia alone contains about 20% of the world's mangrove forests. Implementing nature-based approaches to restore coastlines and beaches can significantly enhance coastal protection and adaptive capacity.

2.3 Alignment with APEC Vision

This project directly supports APEC's strategic priorities as outlined in the APEC 2040 Putrajaya Vision, the Aotearoa Plan of Action, the Bangkok Goals on Bio-Circular-Green (BCG) Economy, and APEC Leaders' Declarations. The alignment is demonstrated by the following:

(1) APEC 2040 Putrajaya Vision and the Aotearoa Plan of Action: This project contributes to building a resilient and balanced economy in the APEC region by fostering sustainable utilization of marine resources and advancing blue economy practices. It promotes knowledge sharing and technological innovation in sustainable utilization of marine resources and management of coastal zones, directly supporting

the vision and the plan's goal of strong, balanced, sustainable and inclusive growth throughout the APEC region.

(2) Bangkok Goals on BCG Economy: The project supports responsible resource management by advocating for sustainable practices in marine resources utilization, such as reducing environmental degradation through innovation. Case studies on sustainable utilization of marine resources exemplify the integration of bio-circular-green principles, minimizing waste and promoting resource efficiency.

(3) The project also builds on the foundation laid by previous APEC Leaders' Declarations and AOMM, such as the Beijing Agenda (2014) and Xiamen Declaration (2014), which underscored the importance of enhanced cooperation on blue economy among member economies.

(4) This project aligns with the "Sustainable fisheries, aquaculture and use of coastal and marine resources" plan outlined in the strategic pillars and priority work areas of OFWG Strategic Plan 2024-2025. The project also aligns with the expected outcomes of OFWG 2025 Work Plan by addressing three strategic priorities: 1) Strengthen regional resource management and the sustainable utilization of marine resources through collaborative efforts among APEC economies, by sharing best practices in marine biological resource management; 2) Continue to improve the understanding of oceans, including impacts of the changing ocean environment, the critical role of sustainable fisheries and aquaculture, and marine ecosystem restoration and conservation; 3) Build capacity and empower stakeholders in the oceans and fisheries sectors on a voluntary basis, fostering resilient economic growth in the ocean economy.

3. Case Study: Sustainable Use of Marine Biological Resources of APEC Economies

This section presents representative and diverse case studies from APEC economies, showcasing their progress and best practices in coastal zone and marine biological resource utilization. The data primarily comes from expert insights shared by member economies. By synthesizing existing knowledge from websites, open databases, and scientific literature, we can analyze regional development trends, gain deeper insights, and provide references for future policy-making. This approach enhances policy

coordination and facilitates the broader adoption of successful models across the APEC region.

3.1 Circular Blue Bio-economy: Practices in Australia

The marine biotechnology industry has evolved through three distinct phases. The first phase, fisheries, remained largely stable since the 1980s with stagnant growth. The second phase, marine agriculture, continues to expand but faces mounting challenges—particularly in regions with intensive farming practices—where climate change, coastline degradation, and ecological pollution have constrained growth potential. In both the first and second phases, 90%-95% of marine biotechnology products were limited to seafood, reflecting a narrow product range. Yet marine biodiversity and resources offer far more: marine pharmaceuticals, nutritional supplements, biomaterials, bioenergy, and eco-friendly products encompass nearly all application fields. The next-generation marine bio-industry will transcend seafood production limitations, ushering in "Marine Bio-Industry 3.0+". This phase will significantly expand product categories, catalyze new industries, and demonstrate growth potential far surpassing the first two phases. For APEC economies, this marks a pivotal opportunity to develop more sustainable, value-added, and innovation-driven economic models.

3.1.1 Conceptual framework: circular economy

The linear economy and circular economy differ fundamentally: The former operates through a "resource extraction → product manufacturing → consumption → disposal" cycle, perpetuating environmental pollution (e.g., severe plastic pollution). In contrast, the circular economy centers on a "resource → product → reuse → remanufacturing → recycling" model, enabling closed-loop resource flows for clean, green, and regenerative outcomes. As the linear economy nears its end, the circular economy emerges as both a strategic imperative and a practical reality—every economic activity can transition to circular models. Only through circular transformation can the new economy achieve sustainable development. The blue bioeconomy fundamentally addresses the sustainable and regenerative utilization of marine biological resources. For all APEC economies, incorporating "restorative" and "regenerative" principles during the design phase could establish a foundation for sustainable development.

To build a design-driven circular bioeconomy, we must first establish sustainable development as the ultimate goal and define four fundamental sustainability benchmarks. First, economic sustainability: While human-centric economic activities are understandable, no business should prioritize profits alone at the expense of the greater good. Second, environmental sustainability: Issues like water pollution, air pollution, and ecological degradation have become deeply ingrained, making it clear where problems lie and how to address them. Third, social sustainability: This is crucial for equitable ocean utilization in areas with weaker innovation and development capabilities. Fourth, ethical sustainability: Though often overlooked, this aspect becomes vital in our AI-driven, synthetic life, and quantum computing era, where technology is fundamentally reshaping human cognition, behavior, and collaboration. These four benchmarks form the foundation for driving technological and commercial innovation. Existing tools like economic analysis, life cycle assessment, and social-ethical evaluation can support these goals. A design-driven circular bioeconomy requires integrating these considerations from the project's inception, rather than addressing them as after-the-fact fixes.

3.1.2 Development progress: Australia marine bio-industry

Australia boasts vast space, abundant resources, and rich biodiversity. The ocean is undoubtedly a unique asset for Australia. Currently, Australia's marine industry remains relatively small, with a total scale of approximately AUD 120 billion. Its bioeconomy is still dominated by fisheries (within the agricultural sector), meaning the "new-generation marine bioproducts" industry is valued at only AUD 5.2 billion (around RMB 25 billion).

In 2021, the Australian government established the Marine Bioproducts Cooperative Research Center (MB-CRC), whose core mission is to drive research and development in industry and marine sectors, supporting the growth of Australia's third-generation marine bio-industry. Its value chain model comprises three key projects, focusing on cultivating marine bioproducts rather than seafood: first, advanced manufacturing—using green and clean technologies to produce marine products for the global market, not just domestically; second, talent development—as talent is central to an innovation-driven economy, the "Connect, Educate, and Train (CET)" program aims to nurture the next generation of leaders for the blue bioeconomy, reforming and enhancing the workforce system. The goal is for 70% of participants in the research center to remain

in the industry, accelerating the translation of knowledge and technology into industrial outcomes.

Currently, the Centre has partnered with 11 Australian universities and research institutions with expertise in related fields, bringing together over 60 industry partners. Through co-funding with the government, research institutions, and universities, the center plans to invest AUD 270 million in R&D over 10 years (excluding infrastructure). By innovating across the entire value chain and supply chain, it seeks to advance industry development through full-chain scientific innovation. Guided by global market demand, the focus is on innovative, certified marine bioproducts, promoting advanced marine manufacturing and sustainable marine biomass production.

The goal is to establish a new AUD 2 billion industry within 10 years, creating 10,000 jobs. With Australia's population of 27 million, this target is equivalent to adding a new agricultural-scale industry domestically—and by utilizing just 10% of the resources currently used for seafood production, it aims to develop a high-value-added new industry in a greener, cleaner, and more sustainable manner.

3.1.3 Field case studies: trends and potential

(1) Production of marine natural products via synthetic biology

Over the past 300 years, the known number of marine species has shifted from slow growth to exponential increase, now exceeding 350,000. With advances in deep-sea exploration technology, this figure is expected to continue rising rapidly in the future, laying a resource foundation for developing new industries. Since its beginnings in the 1970s, the discovery of marine natural products has shown exponential growth over the past 30 years, driven by advancements in biodiversity discovery and analytical technologies. Currently, 17 marine-derived drugs have been approved globally, with individual annual sales reaching billions of US dollars. By 2025, it is projected that 28 such drugs will enter clinical stages, while over 100,000 candidates are in preclinical research, highlighting significant potential.

Traditional production relies on cultivating deep-sea organisms, which is challenging due to difficulties in cultivation and scarce genetic resources. In contrast, synthetic biology enables scalable production by introducing deep-sea genetic resources into microbial cell factories. This mature technology indicates that the industrial conditions for developing high-end marine products and drugs using deep-sea resources are now

in place.

(2) Biorefining based on macroalgae (Seaweed)

The global seaweed industry has significant untapped potential. While seaweed is abundant in island areas, its annual global production of about 36 million tons (half of global agricultural output) contributes only 5% to the marine bio-industry's value, indicating vast room for growth. Achieving 100% utilization through biorefining is crucial: extracting components via physical/chemical fractionation and converting them into end-products or novel chemicals through enzymatic, catalytic, or fermentation processes for diverse applications.

Seaweed is categorized into brown, red, and green algae (mixed types are common on Australian coasts). Current derivatives like alginate and agar (used in yogurt, ice cream, etc.) remain limited. Beyond direct consumption (e.g., salads, sushi nori), seaweed holds promise for more high-value products.

Brown Algae Biorefining

Traditionally, 3 tons of brown algae yield 1 ton of alginate, leaving 2 tons as waste. Non-green methods risk pollution and yield USD 25,000 with 20% margins. Biorefining, despite triple the processing costs, produces high-value outputs—food-grade alginate, fucoidan, liquid fertilizers—boosting value sixfold and margins tenfold. Alginate's use in 3D-printed biomaterials for medical applications further enhances its value, demonstrating how innovation improves economic viability.

Red Algae Biorefining

Red algae are a key source of agar. Biorefining extracts agar, medical pigments, and enzymes, with residues used as animal feed, showcasing potential for high-value products. Advancing to premium products requires innovation focused on whole-biomass utilization, supported by funding and industry assessment.

(3) Utilization of Seafood Processing Waste

Globally, approximately 50% of the material in seafood processing becomes waste (e.g., when consuming fish, heads, viscera, and bones are often discarded). Without proper treatment technology, this waste poses environmental challenges for many economies. Taking Australia's renowned lobster industry as an example: in early processing, 50%-60% of lobster shells and viscera were discarded, incurring high

disposal costs (companies paid around AUD 150 per ton). However, from a scientific perspective, the components of lobster shells (protein, oil, minerals, polysaccharides) are valuable, not waste.

Technology enables the comprehensive utilization of lobster processing waste: extracting products like lobster protein peptides, chitin polysaccharides, and lobster oil. This not only eliminates disposal fees but allows for purchasing the waste at AUD 3,000 per ton to develop high-value-added products. For instance, lobster oil has a unique flavor; adding 3%-5% to cooking oil creates a product that can sell for ten times the price of olive oil (as a condiment). Lobster protein peptides are highly nutritious. Lobster chitin can serve as a fat blocker (capable of adsorbing ten times its weight in oil, suitable for people needing to control fat intake). Lobster minerals can be made into calcium supplements. Regarding economic feasibility, SuperPro simulation shows that for integrated processes, the investment payback period can be as short as 1.5 years and no more than 3 years. Integrated processes also yield the highest output value and return on investment. This fully illustrates that through technological innovation, seafood processing waste can be transformed from an "environmental burden" into an "economic growth driver."

3.1.4 Implications for APEC

APEC economies are at a crucial stage in developing the new-generation marine bioeconomy (Marine Bio-industry 3.0+). The ocean is our unique resource and value carrier. To realize this value, we must rely on innovation and collaboration while squarely addressing challenges. The future development approach should be centered on design-driven principles—starting from the four pillars of sustainable development, integrating economies' policy design and industry design, and securing technical support through collaboration.

3.2 Enterprises Driving Sustainable Marine Resource Use: Practices in Brunei Darussalam

3.2.1 Role of SMEs

The blue economy holds vast potential, with an estimated annual value of USD 2.5 trillion. Yet challenges such as overfishing, coral reef degradation, and pollution persist. A key issue is how to scale the blue economy sustainably by leveraging Small and

Medium-sized Enterprises (SMEs) with policy support. In the APEC region, SMEs make up 90% of businesses. They are agile and quick to adopt new research and technologies. By forming cross-border partnerships, SMEs can achieve scale and serve as vital connectors between science, policy, governments, and local communities—often bridging gaps where research or policies fail to reach people directly.

3.2.2 Brief introduction to the utilization of marine resources in Brunei Darussalam

Brunei Darussalam has a 161-km coastline, rich oil and gas reserves, and high biodiversity, including 45 sq km of coral reefs within the Coral Triangle. Its waters host historical shipwrecks and abundant marine life, yet remain under explored by divers.

The economy relies heavily on oil and gas (60% of GDP), but diversification has been sought since the 1980s. This need has grown as some major energy companies reduce their presence in Brunei.

Fisheries are valued at around USD 2 billion. From 2009 to 2019, illegal fishing caused an estimated USD 26 million in losses, while fish stocks continued to decline. This global pattern underscores the urgency of placing sustainability at the heart of policy and action.

3.2.3 Examples of SMEs participating in the blue economy

Brunei Darussalam plays a key role in transitioning from a "brown economy" to a "blue economy," though this shift is still in its early stages. Therefore, dialogue between industry and government on strategies and pathways for advancing the blue economy transition is crucial. The following case of a local Bruneian enterprise, the Poni Group, illustrates how SMEs can engage in blue economy development.

Over 15 years, the Poni Group has grown into an integrated enterprise combining recreational diving, marine engineering, and ESG innovation, forming a "business supports public good, public good empowers business" closed-loop model. Part of the profits from its business segments (marine engineering and recreational diving) flow into a foundation dedicated to marine conservation and community initiatives. The social impact generated by these activities attracts more corporate clients and government partnerships, driving continued business growth. The group now employs over 50 staff. Its core division, Poni Marine, handles marine engineering, environmental consulting, and agricultural logistics, while its foundation focuses on

coral restoration, habitat protection, and humanitarian support—such as aiding orphans and serving the deaf, hard-of-hearing, and visually impaired communities.

Key Practices and Outcomes

1) Education & Ecological Restoration: Integrates coral education into dive courses and has taken over 8,000 students snorkeling and transplanting corals. Established Brunei Darussalam's first coral propagation initiative, with three nurseries to date.
2) Brunei Ocean Week: Expanded from 9 events in 2023 (1,000 participants) to 15 events in 2025 (3,000 participants). Engaged the Crown Princess in the "Great Blue Hope" activity to raise visibility. Trained police, fire, and military dive teams in coral protection and brought ocean awareness to cities through art and photo contests across 50+ schools.
3) World Oceans Day: Hosted a flagship event attracting 2,000 attendees, deployed 120 artificial reef balls (including two with His Majesty's signature), partnered with 50+ schools on the "Ocean Guardians" youth program, and provided grants for blue economy innovation.
4) Deep Community Engagement: Offers accessible ocean experiences for the deaf and visually impaired, distributes free life jackets to local fishermen, and involves them in building eco-concrete reef balls. Creates jobs through mangrove planting and uses IoT tools for community-led monitoring.
5) Technology-Driven Innovation: Monitors illegal trawling via satellite and AI; uses machine learning to optimize reef placement. Runs an innovation center providing ESG advisory, decarbonization, and smart city solutions, while helping businesses offset carbon via mangrove planting.

Future Plans

1) Establish Borneo's first coral gene bank and deploy 5,000 artificial reef balls in five years to combat illegal trawling.
2) Strengthen regional cooperation with Sarawak, Sabah, and Indonesian Borneo.
3) Launch a marine education center and coral research facility by next year; expand the Blue Economy Innovation Center through youth and university partnerships.
4) Introduce crowdfunding via bank and telecom apps to support large-scale monthly

mangrove planting.

5) Start Brunei Darussalam's first community-led mangrove program in 2026, using IoT and mobile tools for monitoring.
6) Apply AI and drones for biodiversity assessments and provide technical training for maritime emergency response.
7) Develop a blue economy industrial park and produce modular oyster hatcheries for export across ASEAN.
8) Pilot the Tidal Thrive oyster breakwater project and seek joint funding with government and international agencies.
9) Aim to trade oyster carbon credits by 2028 to support corporate carbon neutrality.

3.2.4 Implications for APEC Cooperation

Regarding how APEC can support SMEs in advancing the blue economy, several key insights emerge: First, for Brunei Darussalam, access to financing remains one of the biggest obstacles. SMEs need easier pathways to blue finance—a channel that currently faces significant challenges. Second, cross-economy collaboration is crucial. Forums such as the APEC Blue Economy Forum are highly valuable in this regard. Greater SME participation would help expand partnerships and unlock business opportunities. Third, digitalization serves as a key enabler, as it lowers the cost of capacity building. Accelerating close collaboration between local and international scholars, universities, and other institutions—while strengthening public-private partnerships—is essential to achieving tangible progress. Fourth, innovation platforms should be encouraged. Universities and government agencies can launch entrepreneurship incubation programs and establish regional innovation platforms to increase support for SMEs and enhance their connectivity. Finally, youth empowerment is fundamental. Cultivating future leaders in the maritime sector will strengthen the workforce driving the blue economy and form a core force for industry advancement.

3.3 Coastal Protection and Utilization of Marine Biological Resources: Practices in China

The steadily growing marine economy has become a key driver of China's economic development. In 2024, the marine product accounted for 7.8% of GDP, with the tertiary

marine industry showing the most significant growth. In terms of industrial structure, coastal tourism represents the largest sector within the marine economy, contributing 36.9% in 2024. Modern marine services have now become the core engine of China's blue economy.

Balancing ecological conservation with resource utilization is crucial for the sustainable development of the marine economy. Currently, a key focus lies in the protection and restoration of coastal zones and marine ecosystems, which helps expand the scope of the blue economy and strengthen resilience against future global environmental challenges.

3.3.1 Pathways for composite living coasts to promote blue economy development

China's coastal development models have been continuously innovating, shifting from traditional hard and soft structures toward nature-based solutions. The core objectives are to enhance the efficiency of marine resource utilization, foster emerging marine industries, reduce economic losses and risks, promote the transformation and upgrading of marine industries, and ultimately achieve a win–win outcome of ecological conservation and high-quality economic development.

An energetic coast comprises three core elements: disaster resilience (protecting geomorphology and infrastructure from hazards), ecosystem vitality (the health and self-restoration capacity of coastal ecosystems), and economic dynamism (the potential for growth, innovation, and adaptability in economic activities). The Complex Living Coast (CLC) represents a high-quality coastal zone development model. By establishing a synergistic, positive-feedback loop among coastal protection, ecological services, and economic development, it integrates ecological security, economic vitality, and social well-being—ultimately advancing the harmonious coexistence between humans and nature.

A typical success story is the Northeast Coast of Xiamen: before 2006, the Guanyinshan coast had degraded due to human activity and global climate change. Since the implementation of conservation projects in 2007, disaster resilience, ecological vitality, and economic dynamism have progressively improved, forming a virtuous cycle. Its spatiotemporal evolution followed this pathway: 1 year to build coastal disaster prevention and mitigation capacity, 5 years to enhance ecosystem services, and 10+ years to achieve long-term, high-quality socioeconomic development of the coastal

zone.

3.3.2 Exploration of marine biotechnology and industrial applications

The marine biomedicine and bioproducts industry is a key focus area for China in developing strategic emerging marine industries and an important component of promoting high-quality development of the blue economy. In recent years, China has made significant progress in the marine biomedicine and bioproducts sector, producing over 80% of the world's chitosan and sodium alginate. A number of scientific and technological achievements have been industrialized, including marine enzyme preparations such as lysozyme, protease, lipase, and esterase. Marine functional materials with properties such as hemostasis, wound healing, antibacterial activity, and surgical anti-adhesion have also entered the industrialization phase.

Case 1: Application of marine probiotics in oral care

The prevalence of periodontitis in China exceeds 80%, and it is linked to systemic diseases such as cardiovascular conditions and Alzheimer's. The global oral care market is projected to reach nearly USD 50 billion by 2025, yet existing probiotic products show limited efficacy. Traditional treatments (mechanical cleaning, antibiotics) face limitations, including incomplete removal of biofilm and microbial imbalance.

The research team isolated nearly 200 strains from marine samples (seawater, sediment) and identified two highly effective lactic acid bacteria: HJ-S2 (Lactiplantibacillus plantarum, sourced from a plant stem at 200 meters depth) and DS31 (Lacticaseibacillus casei, isolated from large yellow croaker). Experimental validation confirmed that both strains tolerate oral lysozyme and hydrogen peroxide environments. Their supernatant effectively inhibits/removes pathogenic biofilms. In animal studies, they improved periodontal tissue pathology, reduced alveolar bone loss, increased bone density close to the positive control (compound metronidazole) and healthy groups, while also lowering inflammatory factor levels. These marine probiotics offer an innovative solution for oral care, with strong potential to address market gaps and broad application prospects.

Case 2: High-value industrialization of marine bioengineered enzymes

The high-value industrialization of marine bioengineered enzyme preparations represents a key innovation in the enzyme industry, meeting specialized demands across multiple sectors. As biological catalysts, enzyme preparations are widely used

in over 20 industries, including pharmaceuticals, food, and textiles. However, enzymes from traditional sources (plants, animals, terrestrial microbes) often perform poorly under extreme industrial conditions. Marine microbial enzymes, shaped by unique high-salinity, high-pressure, and extreme-temperature environments, possess superior properties not found in land-based enzymes, making them a core new enzyme source.

This field is supported by a globally leading marine microbial resource bank (containing 5,000 strains, with extensive international research collaboration) and driven by cutting-edge R&D technologies. These include high-throughput screening (processing billions of samples daily) and gene recombination to efficiently harness marine enzyme potential. Core products, such as a novel amylase derived from deep-sea hydrothermal vent archaea, outperform traditional enzymes by maintaining high activity across a broader pH range (4–6.5) and at temperatures above 90°C, while generating fewer high-molecular-weight fragments. An enzyme-probiotic delivery technology has also been developed to enhance acid tolerance.

For industrialization, a hundred-ton-scale bioreactor preparation system has been established, covering separation, concentration, and drying processes. The products are adaptable to specialized applications in various industries, offering strong market prospects and paving a new path for high-value development in the enzyme industry.

3.3.3 Ecosystem-based coastal resilience enhancement technology

China is progressively shifting towards green protective measures over traditional grey infrastructure for coastal defense. The ecosystem-based coastal resilience enhancement approach is an innovative coastal management model that integrates natural ecological elements with engineering defense logic. At its core, it incorporates natural ecosystems such as oysters, coral reefs, salt marshes, and mangroves into the coastal defense system to replace or supplement traditional hard structures. This enhances the coast's resilience to climate change impacts like sea-level rise while delivering ecological benefits and supporting blue economy development.

The approach is studied through a multi-method framework combining field observations, flume experiments, and numerical modeling. Research focuses on key mechanisms including wave energy attenuation, coastal safety quantification, sediment transport dynamics, and erosion control. The derived computational models incorporate nonlinear characteristics of intertidal shallow-water systems and seasonal vegetation

variations (e.g., optimal wave dissipation during spring growth), accurately capturing the synergy between ecosystems and engineered defenses. For example, studies show that mangroves can significantly dissipate storm wave energy, with wave energy attenuation rates reaching up to 35% during the strongest typhoons observed.

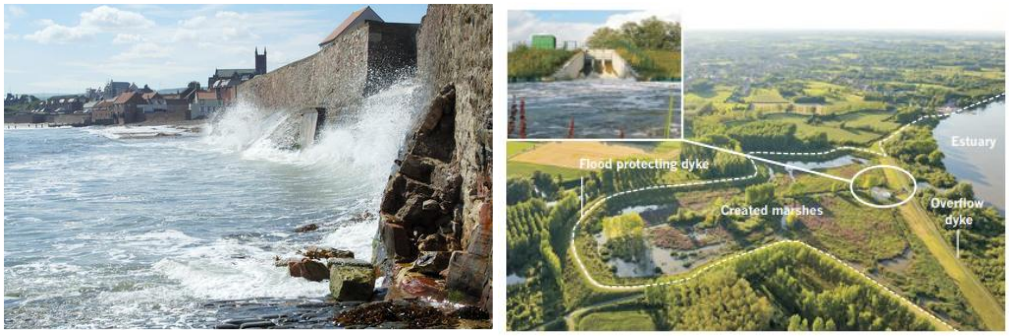


Figure 2 Traditional coastal protection - dikes (Left) and Nature-based coastal defense (Right)

Source: Presentation by the China expert at the 8th APEC Blue Economy Forum

Research has found that vegetation acts as a natural wave energy regulator, altering the nonlinear characteristics of waves by suppressing high-frequency waves and stimulating low-frequency ones. There is a significant exponential relationship between vegetation coverage and wave energy attenuation. In terms of vegetation density regulation, the study has challenged conventional understanding by revealing a peak threshold for balancing sediment supply and deposition: excessive density obstructs nearshore sediment input, leading to insufficient net deposition, while insufficient density results in fast water flow that hinders sediment settling. Optimal outcomes require precise parameter regulation. The application of vegetation can reduce overtopping volume by approximately 15%, allowing the crest elevation of structures to be lowered from the traditional 3 meters to 2 meters, thereby significantly saving engineering costs. Furthermore, to address the engineering challenge of protecting the toe of the structure, innovative solutions have proposed reshaping the beach slope to relocate the wave breaking point farther from the toe, replacing costly hard protection measures and effectively mitigating scouring risks.

The ecosystem-based coastal defense approach offers multiple benefits: it not only provides core protective functions such as wave energy attenuation and erosion mitigation but also enhances biodiversity and supports carbon sequestration. As a multifunctional integrated approach, it offers an innovative pathway for coastal regions

to adapt to climate change, combining ecological value with engineering resilience.

3.3.4 Implications for future development

Coastal zones are of irreplaceable importance. Ecologically, they support rich biodiversity, serve as critical habitats for numerous species, facilitate nutrient cycling, and provide nursery grounds for marine life. In terms of protection, they naturally buffer against storms, erosion, and sea-level rise, while also playing a vital role in carbon sequestration—an increasingly crucial function. Economically, coastal zones underpin fisheries, aquaculture, and tourism, generating substantial livelihoods and offering diverse recreational opportunities. Furthermore, they perform supporting functions such as water purification and habitat connectivity, enhancing overall environmental quality and resilience. They also hold cultural heritage and serve as sources of inspiration, offering educational and aesthetic value.

However, coastal zones face mounting pressures: coastal urbanization, erosion, pollution, overfishing and aquaculture expansion, climate change and sea-level rise, deforestation and wetland reclamation, and accumulation of debris and marine litter.

Consequently, there is an urgent need to: restore degraded areas through nature-based solutions; balance ecosystem conservation, restoration, and sustainable utilization; redesign management systems for heavily modified coastlines; and integrate landscape and health assessments into frameworks for Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP).

3.4 Sustainable Resource Utilization and Development: Practices in Indonesia

3.4.1 Mangrove Ecotourism in Indonesia

Indonesia possesses abundant mangrove resources, covering a total area of 3.31 million hectares. Of this, 0.64 million hectares are in critical condition, while 2.67 million hectares are in good condition. Mangroves not only serve as a crucial barrier for maintaining ecosystem balance and protecting biodiversity but also generate significant economic benefits for local communities. Ecotourism has become an important direction for their sustainable utilization.

Case 1: Outer Islet of Bunaken National Park

This site is located on the outermost islet of Bunaken National Park and is directly

managed by the Bunaken National Park Authority under Indonesia's Ministry of Forestry. It is a nature reserve featuring unique terrestrial and aquatic ecosystems, tasked with protecting ecosystems, maintaining life support systems, and preserving plant and animal species diversity. Eight mangrove species have been identified within the site.

Case 2: Jeflio Island

The mangrove area on Jeflio Island is autonomously managed by the Kelim branch of the local Moi indigenous community, which holds traditional communal rights over the land, including the mangrove areas. Four mangrove species have been identified here. The site has a "highly suitable" tourism suitability index with a daily carrying capacity of 52 visitors.

Case 3: Jailolo Bay

Jailolo Bay is managed by the local government and classified as a coastal park. It is zoned into core zones, utilization zones (including tourism and community sub-zones), and sustainable fishery zones (including fishing and aquaculture sub-zones). Twenty-one mangrove species have been identified. All stations except the Guria site have a "suitable" tourism suitability index. The total daily carrying capacity is 2,632 visitors, supporting diverse activities such as trekking, fishing, boating, bird watching, picnicking, and camping. Villages like Matui and Gamlamo are among the six areas with the highest carrying capacity.

Case 4: Three Villages in South Minahasa Regency

This case involves the villages of Blongko, Kapitu, and Sondaken in South Minahasa Regency, North Sulawesi Province. Each village employs a differentiated management model suited to its characteristics:

Blongko Village: Operated by a local management group using a community empowerment model (suitable for villages with economic vulnerability but strong social capital).

Kapitu Village: Operated through a multi-stakeholder collaboration model (suitable for villages with economic stability and sufficient human capital).

Sondaken Village: Managed by the Bunaken National Park Authority, incorporating a planting-based "safety net" component (suitable for villages with

extreme economic vulnerability). Station 2, damaged by land reclamation, has been rehabilitated through Rhizophora planting led by an NGO. Station 3, jointly managed by the community and the park, has undergone mangrove restoration and has been rezoned as an ecotourism destination.

Summary of four cases

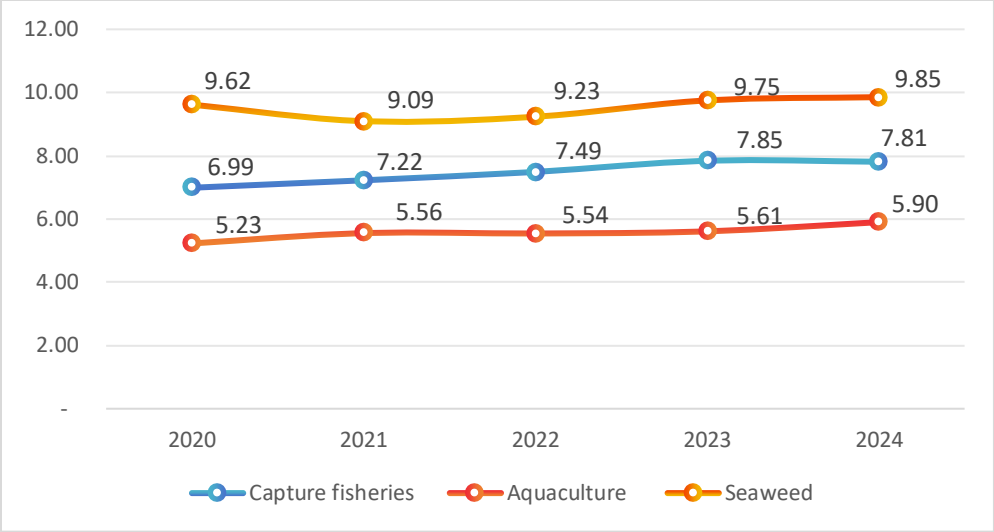
Eastern Indonesia is rich in mangrove biodiversity. The ecotourism cases presented demonstrate a diversity of management models (government management, community autonomy, multi-stakeholder collaboration, etc.). All cases have achieved a balance between ecological conservation and economic development, providing valuable practical experience for the sustainable utilization of global mangrove resources.

3.4.2 Sustainable Seaweed Aquaculture in Indonesia

Indonesia's vision, "Advancing Indonesia Together Towards a Golden Indonesia 2045", encompasses eight major missions, known as the "Eight Goals." Among these, the fifth mission pertains to the development of fisheries and aquaculture, continuous downstream development, and fostering natural resource-based industries to enhance added value. The sixth mission focuses on promoting development originating from villages and grassroots levels to drive economic growth, equity, and poverty eradication. Our development targets are to achieve an 8% economic growth rate and a 0% poverty rate. To realize this vision, the Ministry of Marine Affairs and Fisheries of Indonesia has implemented five key blue economy programs: Expansion of marine conservation areas; Implementation of quota-based fishing; Sustainable aquaculture development in marine, coastal, and inland waters; Enhanced monitoring and management of coastal zones and small islands; Clean-up of marine plastic waste through participatory actions involving fishers.

(1) Status of sustainable aquaculture in Indonesia

Sustainable aquaculture holds significant importance for the blue economy, particularly in protecting marine ecosystems, reducing poverty, and supporting economic growth. Indonesia's marine and fisheries production (including fish and seaweed) remains relatively stable, at approximately 20–25 million tons annually. The overall potential area for aquaculture (covering brackish, freshwater, and marine waters) is estimated at 17.91 million hectares. However, the current utilization rate is only about 6%, indicating immense room for future growth, especially in marine aquaculture.



(million tons)

Figure 3 Indonesian Fisheries Production

Source: Presentation by the Indonesia expert at the 8th APEC Blue Economy Forum

Indonesia's aquaculture sector focuses on five major species: shrimp, seaweed, tilapia, lobster, and crab. The economy is committed to achieving development goals such as promoting sustainable aquaculture, enhancing farming efficiency and production, increasing revenue through both domestic and export sales, and improving the welfare of fish farmers. This is pursued through strategies including: revitalizing and demonstrating aquaculture systems to enhance productivity; establishing aquaculture villages; developing locally sourced feed ingredients; improving product value and market access; developing broodstock centers; strengthening human resources, regulations, and oversight; and enhancing downstream sectors (such as cold storage and fish processing units).

The Indonesian Government supports and regulates sustainable aquaculture development through multiple regulations, including the Fisheries Law (No. 31/2004), the Fishermen Protection and Empowerment Law (No. 7/2016), and the Spatial Planning Regulation (No. 21/2021), among others.

(2) Market prospects and current status of seaweed farming in Indonesia

Global Market Situation

The total global demand for seaweed is projected to reach 40 to 43 million tons by 2029. Direct food consumption remains the largest demand segment, accounting for over half of the total demand. Additionally, demand for uses such as aquaculture feed and other applications also shows significant growth potential.

The seaweed market is projected to expand significantly by 2030. Short-term markets include biostimulants, animal feed, and pet food. In the medium to long term, the market will develop around areas such as nutraceuticals, textiles, bioplastics, and construction materials. This forecast reflects the need to diversify seaweed applications.

Overview of Seaweed Production in Indonesia

In 2024, Indonesia produced 9.8 million tons of seaweed (wet weight). Seaweed farming in the economy is predominantly smallholder-based, providing substantial employment opportunities—both direct and indirect—in coastal regions, with approximately 254,000 seaweed farming households. The main seaweed production centers are largely located in eastern Indonesia, such as Sulawesi, Maluku, and the Nusa Tenggara islands. Key cultivated seaweed species include Kappaphycus alvarezii, Sargassum spp., Gracilaria spp., and Eucheuma denticulatum. China and Europe are the primary export destinations for Indonesian seaweed. In 2024, seaweed exports consisted mainly of dried raw material, carrageenan, and agar. While Indonesia is home to about 911 seaweed species, local communities currently cultivate only six main species, including K. alvarezii, K. striatum, E. denticulatum, Gracilaria spp. (two common types), and Ulva spp. Several other species show promising potential for future cultivation, such as Sargassum spp., Halymenia spp., Gelidium spp., and Meristiella spp.

Figure 4 Seaweed Production in Indonesia

Source: Presentation by the Indonesia expert at the 8th APEC Blue Economy Forum

(3) Strategies to Enhance Seaweed Farming Productivity

Improving Seed Quality

Establish seaweed tissue culture laboratories to supply high-quality seeds. Techniques such as somatic embryogenesis, callus induction, and regeneration can significantly improve both the quality and quantity of seeds.

Optimizing Farming Models

Promote the modeling of seaweed farming by adopting facilities such as eco-friendly buoys, floating houses, and wooden boats. Optimizing planting density and environmental adaptability can enhance yield per unit area.

Infrastructure Support

Revitalize seaweed aquaculture villages and breeding centers by providing essential equipment and technical support. Simultaneously, strengthen downstream industries—such as the development of cold storage facilities and processing units—to increase product added value and market competitiveness.

3.5 Transformation Pathways of the Fishery Economy: Practices in Malaysia

Malaysia boasts healthy marine ecosystems including coral reefs, mangroves, and seagrass beds. Every state in Malaysia has maritime boundaries, providing extensive coastal resources. Along these coastlines are numerous fishery landing ports equipped with facilities for fishing operations and catch landing, making these areas vital for fishery production.

3.5.1 Overview of the marine industry

In terms of economic contribution, the fisheries sector accounts for approximately 1-2% of Malaysia's GDP and plays a significant role in sustaining the livelihoods of coastal communities. From a production structure perspective, marine capture has shown stagnation from 1990 to 2024, whereas aquaculture has gained increasing importance. Annual marine capture production has remained relatively stable at around 1.3 million metric tons, while aquaculture production has expanded by more than 200% over the same period. In freshwater aquaculture, catfish (37%, valued at USD 62.52 million), red tilapia, and other catfish species dominate. In brackish water aquaculture, seaweed constitutes more than 56% of production, with an estimated valued of USD 17 million. Sea bass is the primary culture fish species, and tiger prawn and white shrimp fry as core seedlings. Regarding trade, imports increased by over 200% from 2000 to 2023. The top three export destinations are China (25%); Singapore; and Korea, while the top three import sources are China (22%); Indonesia; and Viet Nam.

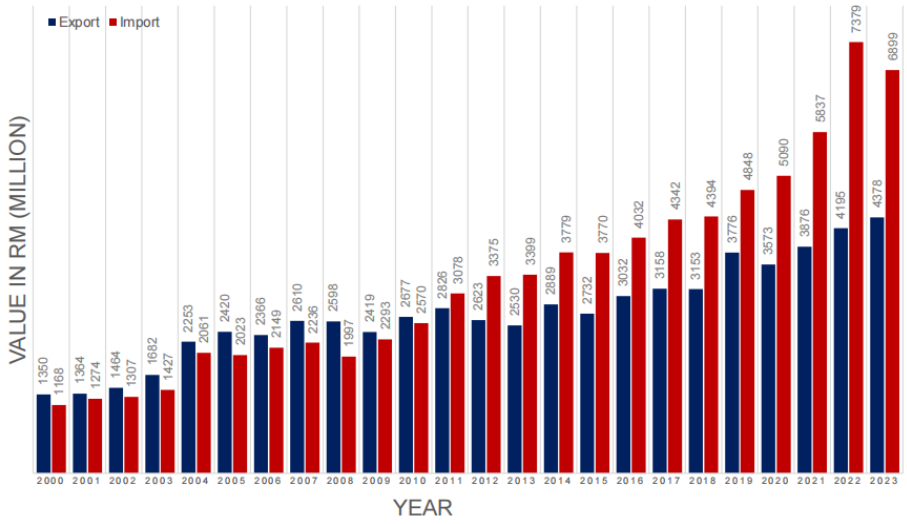


Figure 5 Value of export and import of fishery commodities

Source: Presentation by the Malaysia expert at the 8th APEC Blue Economy Forum

Seaweed accounts for over 56% of total mariculture production, with an estimated value of approximately USD 17 million. Among cultured fish species, sea bass is predominant, while tiger prawn and white shrimp are key varieties in aquaculture production. Over the past two decades, Malaysian authorities have provided more detailed landing data, categorized into five types: silver pomfret, Chinese silver pomfret, small pomfret, golden pomfret, and black pomfret in a case study in the pomfret fisheries in Malaysia. The initial landing volume of silver pomfret increased by over 200% from 2005 to 2024. However, the quantity of Chinese silver pomfret has declined, dropping by about 59% from 3,824 metric tons in 2015 to 1,474 metric tons in 2024. In aquaculture production, golden pomfret does not represent the highest production output; the highest is cockle, with a yield of 16,000 metric tons. Silver pomfret is similar to Golden pomfret, but Malaysia has not developed farming techniques for it in the past. We hope to introduce fully artificial breeding and aquaculture technologies of silver pomfret from China in the near future.

3.5.2 Sustainability issues

Common challenges among many Asia-Pacific member economies include overfishing and overexploitation of marine resources, which place severe stress on marine ecosystems; impacts of climate change; coral bleaching incidents; prevalence of illegal, unreported, and unregulated (IUU) fishing; and major pollution issues such as marine plastic debris. Degradation of coastal habitats and loss of biodiversity further constrain

industry sustainability.

To address the above challenges, the Malaysian government has implemented a series of measures, including establishing 51 marine protected areas (with a total area of 3,800 square kilometers) and enforcing closed fishing seasons to protect marine ecosystems, while simultaneously promoting the development of aquaculture. Additionally, management of the exclusive economic zone has been strengthened by reducing the number of fishing vessel licenses from 50,000 to 43,000 between 2022 to 2024.

3.5.3 Future development outlook

Fisheries constitute a vital industry for food security, livelihood maintenance, and socio-economic stability in Southeast Asia. Their sustainable development serves as the foundation of the blue economy. Building a resilient blue economy in the future must prioritize the protection and restoration of marine ecosystems, leveraging healthy ecology to enhance industrial competitiveness. It also necessitates strengthening partnerships and regional cooperation, improving shared marine monitoring mechanisms, and implementing science-based, resource-conserving integrated fisheries management. Enhancing aquaculture technological capabilities, advancing the research and development of potential species for farming to achieve sustainable resource utilization, integrated economic planning, coordinated actions among regional stakeholders, and empowering coastal communities are key to advancing Malaysia's blue economy transformation in fisheries.

3.6 The Blue Economy Pathway: Practices in Peru

The blue economy refers to a sustainable ocean economy, where economic activity is in balance with the long-term capacity of ocean ecosystems to support this activity and remain resilient and healthy. While tasked with generating economic benefits for the economy, these benefits must also be able to extend to future generations. As an economy deeply connected to the ocean, particularly the Pacific, Peru boasts over 3,000 kilometers of coastline in South America, with nearly one-third of its population residing in coastal areas. Facing the Pacific, Peru has a significant demand for fish and seafood. While developing tourism, maritime routes, and ports in coastal regions, it must also address issues related to biological resources and protected areas to ensure the overall security of the entire marine and coastal ecosystem. Although the blue

economy is a relatively new term in Peru, and its concepts and methods have not yet been fully applied, many ocean-related activities have long been in practice.

3.6.1 Marine fisheries

The fishing industry in Peru is a vital sector for the economy and was once commended as "one of the world's most sustainable fisheries," primarily relying on a single species—anchovy. Its development has experienced significant fluctuations: in the 1970s, it was the world's largest fishery, but later, production plummeted to nearly zero, only gradually recovering by the late 1990s. Since then, influenced by climatic phenomena like El Niño, production has been variable. However, over the past five to seven years, the annual anchovy catch has stabilized between 3 and 4 million tons. Currently, the industry focuses predominantly on fishmeal production, securing the supply of raw materials. Nonetheless, concerns have arisen regarding the over-reliance on a single species and the lack of product diversity. In recent years, Peru has begun promoting product diversification, with plans to develop nutritional products for direct human consumption, such as vitamins and proteins.

3.6.2 Marine conservation

Since the end of the last century, as human activities at sea have increased, multinational initiatives for the protection of the marine and coastal environment have been developed, such as the Action Plan for the Protection of the Marine Environment and Coastal Areas of the Southeast Pacific (1981). Peru's marine protected natural areas primarily include the System of Islands, Islets, and Guano Points Reserve, and Land-Ocean Areas. To balance fisheries and ecological conservation, Peru has established a marine protected area system over the past year, with proposals for a northern zone near the Ecuadorian border currently under consideration. Future efforts will require scientific support to reconcile conflicts between fishing zones and protected areas, ensuring sustainable development.

3.6.3 Marine ports

Peru has numerous maritime ports, with Callao being the most important for cargo. Other major coastal ports include Paita, Matarani, Chimbote, and General San Martin. Additionally, Chancay, the large, recently constructed megaport near Lima, is expected to become a major hub for trade between South America and Asia. The Port of Callao is ranked 37th worldwide in the 2024 container port efficiency ranking (ascending from

56th in 2020) and 68th globally in UNCTAD's Shipping Connectivity Index (LSCI). Regionally, it is one of the most efficient in Latin America.

3.6.4 Marine clean energy

Peru is advancing the construction of offshore wind farms as a key development priority, while placing high importance on the potential ecological impacts of such projects. It emphasizes the need to establish a robust decision-support system grounded in science to balance energy development with ecosystem conservation. Peru possesses significant wind power generation potential, particularly in its coastal regions, and is actively developing this resource. Several wind power plants are currently operational or under construction, such as the largest wind farm—Punta Lomitas in Ica. Wind energy, as a renewable resource, contributes to energy security, diversifies the power grid, and promotes the local economy, although its existing potential remains untapped.

3.6.5 Marine monitoring and management

Multidimensional Ecological Monitoring System

Application of Satellite Technology: Utilizes comparisons of satellite imagery from different years (e.g., 2006 vs. 2021) to monitor pollution from sources such as urban sewage and fishmeal plant discharges; maps coastlines and passages to identify and track spatiotemporal changes in habitats and ecosystems.

Field Observation Methods: The Peruvian Sea Institute (IMARPE) employs research vessels and scuba diving to conduct direct observations of marine habitats and collect primary ecological data.

Data-Driven Scientific Decision-Making

Information is critically important for sound decision-making in coastal management. IMARPE leads data collection and analysis to ensure decisions are well-informed. Based on acquired information such as biological types, substrate types, and coverage rates, it conducts statistical and ecological analyses. It also assesses the impacts of projects on artisanal fishing activities within relevant zones. By reconciling conflicts between energy development and ecological conservation, this approach renders decision-making more scientific and rational, thereby enhancing its quality.

3.6.6 Governance practices in Paracas Bay

Paracas Bay was once severely polluted by fishmeal plants and domestic sewage. From

2008 to 2014, through the construction of pipelines and treatment plants, water quality improved significantly. Dolphins and seabirds have now returned, and tourism has subsequently grown—a success attributed to science-based decision-making supported by data.

Marine governance requires long-term research to prevent new pollution zones and must coordinate cross-sectoral conflicts. For instance, to address tensions between oil exploration and fisheries, analysis of seasonal data revealed lesser impacts during winter, leading to the recommendation of conducting exploration in that season to minimize disruption.

Furthermore, all data (including whale sightings, pollution levels, fisheries information, etc.) is made publicly available. The public can use online tools to overlay different data layers for spatiotemporal correlation analysis. This fosters transparent governance and science-based decision-making, advancing the sustainable development of both marine ecology and the economy.

3.7 Moving Toward Sustainable Marine Fisheries: Practices in Viet Nam

Fisheries play an extremely important role in Viet Nam. It ranks among the top three globally in terms of fishery exports. Export materials are sourced from both marine capture and aquaculture. Considering more about the marine resources or the environment, is precisely an in-depth issue to explore in efforts to transition toward a sustainable blue economy.

3.7.1 Marine capture

Viet Nam is a major global fishing economy, with a marine capture output of approximately 4 million tons, ranking seventh worldwide. However, between 2000 and 2020, the fish stock within its exclusive economic zone declined from 5 million tons to less than 4 million tons. The current annual catch remains in the range of 3.3 to 3.7 million tons. To protect resources, Viet Nam has adopted scientists' recommendations, incorporating a target to "reduce the annual catch to 2.5 million tons by 2020" into its economic plans and implementing catch reduction measures.

The change in the number of fishing vessels directly reflects the effectiveness of these measures. While the fleet peaked at 125,000 vessels in 2009, it has since declined continuously, dropping to less than 80,000 vessels by 2023. This trend stems from three

main factors: 1) Policy-wise, the government has halted approvals for new fishing vessel licenses, allowing only the natural expiration of old ones. 2) Market-driven, minimal profitability in fishing has prompted some fishermen to cease operations and shift to other industries. 3) Labor-related, other sectors in Viet Nam have created numerous new job opportunities, making younger generations reluctant to engage in offshore fishing, thus diverting the workforce to more attractive fields. The reduction in fishing vessels is therefore both a result of policy intervention and a response to market forces and shifts in labor structure.

To manage fishery resources, a plan approved two years ago includes four core measures:

- Marine Protected Areas (MPAs): The strictest and most effective measure, 9 MPAs are currently operational, with 27 more planned.

- Seasonal Fishing Closures: Not implemented as comprehensive seasonal bans economy wide; only limited seasonal closures are enforced in specific designated zones.

- Fishery Reserves: Distinct from other measures as they are effective year-round rather than seasonally, aiming to protect specific species.

- Artificial Reefs: Protect fishing grounds from destructive trawling—a practice extremely harmful to ecosystems and fish stocks. Deploying artificial reefs can prohibit fishing in designated areas. Existing cases demonstrate that fish biomass in surrounding areas can increase significantly and rapidly.

Currently, all measures cover about 3% of the exclusive economic zone, covering nearly all coastal areas. The key issue in the current implementation is promoting fishermen's occupational transition, which requires more funding sources for alternative livelihood programs.

3.7.2 Marine aquaculture

Viet Nam is the world's fourth-largest aquaculture economy without cultivation seaweed. Its main species, such as catfish and shrimp, rely on fishmeal feed, with large quantities imported from Peru and processed for export to markets like Malaysia and the United States. Aquaculture models span freshwater, seawater, and brackish water systems.

3.7.3 Marine ecology

While pursuing the development of its marine economy, Viet Nam is actively addressing the issue of eutrophication: long-term monitoring shows that in 2000, the density of phytoplankton in coastal waters was only 15,000 cells per liter, but has now risen to 100,000 or even millions of cells per liter. This provides a critical basis for targeted environmental management. Establishing a regional and integrated marine environmental monitoring and management system has become an important opportunity for promoting sustainable development.

3.7.4 Implications for APEC cooperation

Viet Nam's fisheries sector is steadily developing, while actively exploring a balanced approach between ecological conservation and industrial growth, with a focus on comprehensively assessing its overall impacts and integrated value. The concepts of the blue economy or circular economy hold significant value, and the exchange and mutual learning of experiences among stakeholders are highly meaningful. Additionally, discussions on marine ecological governance within the region remain insufficient. There is an urgent need within the Asia-Pacific region to integrate monitoring data, deepen joint research, and enhance regional cooperation to collectively address cross-border marine environmental risks and challenges.

4. Discussion: Challenges and Opportunities

Based on the outcomes exchanged and shared through case studies of various economies, questionnaire surveys, and thematic seminars on the sustainable utilization of marine biological resources, the current challenges and future development potential for the sustainable utilization of marine biological resources towards blue economic growth in the APEC region are briefly analyzed as follows.

4.1 Challenges

One primary challenge is the promoting both economic development and environmental protection. Many economies have invested substantial resources in ocean-related industries such as port construction, fishery development, and clean energy. However, these activities can exert pressure on marine ecosystems,

environmental quality, and fish stocks, necessitating a balance with ecological conservation needs. Furthermore, the impacts of the changing ocean environment increasingly require effective integration into comprehensive strategies for marine resource management.

Another significant challenge lies in the implementation of conservation measures. Despite the establishment of marine protection plans and regulations in numerous economies, substantial difficulties persist during execution. For instance, resolving conflicts between fishing exclusion zones and protected areas requires solid scientific justification and consensus among multiple stakeholders. In fishery resource management, bottlenecks exist in areas such as funding, stakeholder coordination, and public acceptance. Some measures also have limited coverage, failing to meet government targets, while problems like difficulties in facilitating fishermen's career transitions and the enforcement pressure on local governments remain urgent issues to be addressed.

Data collection and science-based decision-making present further hurdles. While various methods are employed in practice for ecological monitoring and data collection—such as using satellite technology and on-site observations—and while data-driven processes are applied in ocean management, there remains a need for more comprehensive, long-term data and technical support. This is important for obtaining the latest and detailed data to serve scientific analysis and enhance the accuracy of decisions, particularly when addressing complex issues like the long-term impacts of human activities on marine ecosystems and coordinating efforts across different industries.

Finally, the current potential for regional cooperation in the Asia-Pacific region remains untapped. Given that the marine environment is a shared global resource, cross-border issues such as IUU fishing, marine plastic pollution and overfishing urgently require regional or sub-regional collaboration. At present, there is still room for improvement in the in-depth discussion and coordinated action on the governance of marine ecology and resources in the Asia-Pacific region. It is important to integrate monitoring data, carry out joint research, and strengthen inter-regional cooperation to achieve sustainable economic development of the ocean.

4.2 Opportunities

The Vast Prospects of the Blue Economy

Moving beyond traditional fishing, the blue economy places greater emphasis on sustainable management and high-value utilization. This includes developing responsible and efficient aquaculture and leveraging technological means to enhance resource use efficiency. It also encourages the development of high-value-added products such as marine drugs and functional foods derived from marine biological resources, as well as promoting environmentally friendly industries like ecotourism. This aligns with global trends and the long-term needs of various economies.

Increasingly Robust Regional Cooperation Platforms

Cooperation platforms and exchange mechanisms, both within and beyond the APEC framework, are becoming more diverse and mature. For instance, the APEC Marine Sustainable Development Center continuously promotes forums and project cooperation in the blue economy field, providing support for advancing blue economic development and collaboration consistent with the APEC marine cooperation framework. International events like the Xiamen International Ocean Week are also growing more active, serving as important platforms for showcasing regional cooperation achievements, releasing cutting-edge technologies, and launching specific projects.

Strengthening Role of Technological Innovation

Frontier technologies such as artificial intelligence are being applied in the marine sector. Examples include the deep-sea habitat intelligent cognition and exploration multimodal large model (DePTH-GPT) and the "Skyocean" AI ocean model jointly released by China and Peru, as well as the China-Europe Blue Development Investment Fund, which focuses on areas like marine information and digital twins, and deep-sea intelligent equipment. Technological innovation and intelligent drive provide strategic opportunities for the transformation and development of the blue economy.

Deepening Multi-stakeholder Collaborative Governance

Current international and regional marine governance increasingly emphasizes multi-party collaboration. This means that diverse forces—including governments, enterprises, research institutions, international organizations, and the public—address

the complex challenges in the sustainable economic development of marine resources and environments through closer cooperation. Such collaboration leads to more efficient resource integration, more innovative solutions, and broader development prospects.

5. Recommendations for Further Actions

Based on background research, case analyses, expert reports, and discussions among member economies, the 8th APEC Blue Economy Forum has reached an understanding on accelerating the sustainable utilization of marine biological resources among APEC economies. Building on the current development landscape, challenges, and opportunities, participating experts have identified three interconnected areas for collective action to support the APEC Putrajaya Vision and its Action Plan. These efforts aim to promote sustainable economic development and innovation of coastal and marine resources and ecosystems, and contribute to building an open, dynamic, resilient, and peaceful Asia-Pacific community. The outcomes will also facilitate the implementation of the Bangkok Goals on Bio-Circular-Green (BCG) Economy, translating concepts such as resource efficiency, circular production, and ecosystem restoration into concrete actions in the blue economy domain. This will advance high-quality growth of the blue economy in the Asia-Pacific region and foster resilient and sustainable economic development of the ocean.

5.1 Strengthen Responsible Use of Marine Biological Resources

Workshop participants discussed the following as examples of actions economies could voluntarily take according to their own priorities. To strengthen marine ecological foundations, economies could:

- Protect and restore marine ecosystems, prioritizing key habitats;
- Implement ecosystem-based marine spatial planning, establish and manage marine protected area networks, and enhance responsible marine and coastal resource management;
- Consider coordinated and comprehensive development of land and sea to promote the coordinated progress of land and marine ecological environment

protection;

- Promote blue infrastructure such as eco-seawalls, artificial reefs, and oyster reefs to support resource recovery, strengthen coastal resilience, and provide habitats and refuges for marine life;
- Promote cross-economy biodiversity conservation and sustainable use in the Asia-Pacific region.

5.2 Promote Technological Innovation in the Blue Economy

- Promote technological innovation to transition toward efficient, and sustainable practices to reduce pressure on marine biodiversity;
- Promote the intelligent and digital transformation of the blue economy to support decision-making and monitoring of marine biological resources management;
- Advance conservation-oriented blue technology innovation;
- Develop blue investment and financing systems with innovative financial tools for marine resource protection, explore the business model of blue credit;
- Strengthen joint scientific research and promote cooperation on the protection and sustainable management of biological resources across economies in the Asia-Pacific region.

5.3 Enhance Sustainable Management of Marine Resources

- Strengthen policy dialogue and coordination among economies;
- Support the development of port and other related special plans to promote the integrated development of various economic sectors in coastal areas;
- Facilitate and strengthen effective communication and exchange between the scientific and industrial communities, and enhance public-private partnerships to engage multiple stakeholders;
- Support vocational education related to the blue economy, strengthen the training of talents and skills in marine biological resources management, and create an environment for new entrants in the maritime field;

- Empower Micro, Small and Medium-sized Enterprises (MSMEs) and communities with technical, financial, and market access support;
- Promote community-based participatory management;
- Enhance the public's ocean literacy and awareness in coastal communities, facilitate knowledge sharing and best practices to exchange successful experiences and data on marine resource restoration.

6. Conclusions

APEC economies have achieved significant progress in advancing the blue economy. From an industrial development perspective, the rise of responsible aquaculture, high-value-added product development, and environmentally friendly industries has found a balance between economic growth and environmental protection. The improvement of regional cooperation platforms has built bridges for economies to exchange ideas, cooperate, and share resources, enabling all parties to leverage their strengths on a broader stage. The driving force of technological innovation has injected strong momentum, facilitating the rapid transformation of the blue economy in the era of intelligence.

However, it is also crucial to recognize that numerous challenges remain on the path towards promoting the sustainable utilization of marine biological resources among APEC economies. In terms of ecological foundations, the protection and restoration of typical ecosystems remain a long-term and arduous task, with issues such as the degradation of marine habitats and marine pollution still severe in some places. While technological innovation has yielded results, further efforts are needed in areas like translating outcomes into practical applications and building capacity to ensure more economies and industries can benefit. Regarding the sustainable management of marine biological resources, work on policy coordination, talent development, and support for micro, small, and medium-sized enterprises (MSMEs) and communities requires deeper and more meticulous advancement.

In the future, economies could continue to work together, guided by the understanding reached during the 8th APEC Blue Economy Forum project. Sustained efforts could be made in the three collective action areas: consolidating the ecological foundation of marine biological resources, promoting technological innovation for the

blue economy, and enhancing the sustainable management of marine biological resources. By continuously improving cooperation mechanisms, increasing investment in science and technology, and strengthening talent cultivation, we can jointly promote high-quality growth of the blue economy in the Asia-Pacific region. This will contribute to achieving a resilient and productive ocean and to building an open, dynamic, resilient, and peaceful Asia-Pacific community.

Appendices

Appendix A: Forum Agenda

Agenda of the 8th APEC Blue Economy Forum

Date: 6–7 November 2025

Venue: Tongwen Hall, Xiamen International Conference Center Hotel， Xiamen, China

5 November 2025	
Registration	
6 November 2025	
Time	**Activities**
Opening Ceremony	
11:30- 11:45	Opening Remarks of the 8th APEC Blue Economy Workshop
Keynote Session	
11:45- 12:45	**1.Blue Circularity in the Sustainable Use of Biological Resources** Economy: Australia
	2.Sustainable Utilization of Coastal Zone Resources: Diagnosing, Managing, and Restoring Shoreline Health Economy: Columbia
	3.A Vibrant Coastline for Resilience and Ecological–Economic Harmony Economy: China
12:45- 14:30	**Working Lunch** Visit the Exhibition Booths on Marine Biological Resource Utilization – Promote technical exchange and product showcasing
Thematic Session	
14:30- 16:00	**1.Sustainable Seaweed Culture in Indonesia** Economy: Indonesia

	2.State of the Blue Economy in Peru Economy: Peru
	3.Fisheries Economics Research in Malaysia Economy: Malaysia
	4.Promoting Blue Economy through Sustainable Utilization of Marine Resources in Viet Nam Economy: Viet Nam
	5.Application of Marine Probiotics in Oral Health Economy: China
	6.Marine Sourced Enzymes: New Generation of Oceanography Biotechnology Economy: China
16:00- 16:10	**Tea Break**
16:10- 17:10	**7.Sustainable Use of Marine Resources: Participation of SMEs** Economy: Brunei Darussalam
	8.Mangrove Ecotourism in Eastern Indonesia Economy: Indonesia
	9.Towards Coastal Resilience with Ecosystem-Based Coastal Dikes? Economy: China
	10.Coastal Protection Coastal Protection by Mangroves: Observation and Prediction Economy: China
Conclusion and Discussion	
17:10- 17:50	Discussion of the Recommendations on the Sustainable Use of Marine Biological Resources in the Asia-Pacific Region: the 8th APEC Blue Economy Forum

17:50- 18:00	Conclusion
7 November 2025	
Field Visit	
09:30- 12:00	Field visit to Xiamen Biomedical Port On-site visits to XIAMEN BLUE BAY SCIENCE & TECHNOLOGY CO., LTD

Appendix B: Questionnaire

Questionnaire on Sustainable Utilization of Marine Biological Resources in the Asia-Pacific Region

The following questionnaire on the Sustainable Utilization of Marine Biological Resources in the Asia-Pacific Region is part of the work for the self-funded project: 8th APEC Blue Economy Forum (OFWG 04 2025S). Answering the questions will assist us in conducting a survey on the current status of sustainable utilization of marine biological resources in the Asia-Pacific region and subsequently compiling a case study collection. The estimated completion time is approximately 8 minutes.

1. **Name of your APEC Economy:** _____

2. **Main sectors of utilization of marine biological resources in your economy. Select all that apply, and for each sector selected, please score its relative importance (1 is low, 5 is high):**

Sectors	Score (from 1 to 5)
□ Commercial fishing □ Aquaculture (e.g., fish, shellfish, algae) □ Food processing □ Biomedical development (e.g., marine drugs, health products) □ Ornamental organism trade □ Ecotourism □ Genetic resources research □ Other (Please specify): _____	

3. **Please provide a typical case study on sustainable utilization of marine biological resources that can be publicly shared in your economy (Select one):**

Case study	Brief description
□ Shareable information available online	Please provide link (s):
□ No online information currently available	Please provide a written description or attach separately:

4. Please provide information on the management of marine biological resources conservation and sustainable use in your economy (Select one):

Information	Brief description
□ Have specialized integrated management agency □ No single competent authority, but it involves multiple sectors	Name: _____ including: _____

5. **Please provide publicly shareable information on relevant regulations, policies, and plans at the economy level :**

Information	Brief description
□ Shareable information available on official website(s) □ No formal regulations, policies, or plans currently documented	Please provide link(s): _____ Please provide a written description or attach separately: _____

6. Has your economy established a long-term database for the dynamic monitoring of marine biological resources?

Database	Brief description
□ Database has been established □ Plan to establish the database □ Unplanned	Data coverage: □ number of species □ habitat change □ catch □ other:_____ Expected time: _____

7. Level of dependence on marine biological resources for livelihoods in coastal communities in your economy (Select one):

□ High dependence (> 50% of income)
□ Moderate dependence (20%-50%)
□ Low dependence (<20%)

8. **What are the major challenges faced by your economy regarding the sustainable utilization of marine biological resources? Please select up the major challenges and rate their priority for action (1 is low, 5 is high):**

Challenges	Score (from 1 to 5)
□ Resource decline due to overfishing □ Aquaculture diseases and environmental pollution □ Climate change impacts (e.g., acidification, warming) □ IUU (Illegal, Unreported, Unregulated) fishing □ Inadequate policies and regulations □ Insufficient technology and funding □ Lack of cross-border cooperation mechanisms □ Biodiversity loss □ Market volatility affecting industry stability □ Insufficient scientific research support □ Weak monitoring and enforcement capacity □ Low community participation □ Other (Please specify): _____	

9. **What are the prioritized development areas for sustainable utilization of marine biological resources in your economy in the future? Select all that apply and score the level of priority (1 is low priority, 5 is high priority):**

Development areas	Score (from 1 to 5)
□ Eco-friendly aquaculture □ Development of distant-water fishery resources □ Deep-sea/polar biological prospecting □ High-value marine biomedicine and functional foods □ High-value-added products (e.g., pharmaceuticals, cosmetics) □ Carbon-sequestering marine ranching □ Smart fisheries (IoT/AI applications) □ Other (Please specify): _____	

10. **How do you score the following measures that need strengthened cooperation with other APEC economies. Select all that apply and score the level of priority (1 is low, 5 is high):**

Measures	Score (from 1 to 5)

□ Joint scientific research and technology sharing □ Unified resource monitoring and assessment standards □ Collaborative mechanisms to combat IUU fishing □ Blue economy investment and financing platforms □ Joint talent cultivation □ APEC regional policy coordination □ Other (Please specify): _____	

11. **Other suggestions or cooperation intentions for strengthening the conservation and sustainable utilization of marine biological resources in the APEC region (Open-ended question):**