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創造「開放、連結、平衡」的海洋——

APEC運用創新科技監測海洋廢棄物能力建構研習營報導

Creating an "Open, Connected, Balanced" Ocean—

The Report On the Workshop On Capacity Building

On Marine Debris Monitoring By Using Innovative Technologies in APEC Region

帛琉海洋資訊

Palau Ocean Information



海洋委員會
Ocean Affairs Council

發行

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Strengthening Ties in International Cooperation, Establishing Cross-Country Exchanges On Ocean Governance and Technology

Translated by Linguitronics

Minister of the Ocean Affairs Council: Chung-Wei Lee

Marine debris has become one of the most important, most urgent environmental issues for the Asia-Pacific region. Thus, Taiwan is actively working to strengthen international cooperation in the marine field. Towards that aim, the Ocean Affairs Council (OAC) held the "Workshop on Capacity Building on Marine Debris Monitoring by Using Innovative Technologies in APEC Region" at the National Museum of Marine Science and Technology from March 24 to 25 this year (2022), to which it invited APEC economic partners to give presentations on innovative marine debris monitoring and modeling technologies. It was also a venue in which the Taiwanese government's policy on "Salute to the Seas", combining the advantages of its technology industry with technological innovations in marine debris monitoring and modeling, could be shared, and the cooperative benefits of transnational partnerships could be discussed. Furthermore, it provided a possible future path for each economy to tackle marine debris.

For example, in this issue, we are introducing one ally of Taiwan—Palau. Since 2012, Taiwan have been assisting Palau in the research and development and implementation of aquaculture, and have been working with the Bureau of Fisheries of the Palauan Ministry of Agriculture, Fisheries, and Environment, guiding Palauan fishermen in the establishment of a net-cage model for mottled spinefoot. The two parties also signed an agreement on maritime patrol cooperation in March, 2019, which includes mutual visits, vessel relations, training experience sharing, international conference invitations, joint maritime rescue and law enforcement drills and training, joint maritime patrols, and crime intelligence exchange, all of which will help build Palau's maritime security capabilities.

The island's tourist industry accounts for 51% of its GDP and 40% of employment. Thus, seeking economic development and ecological balance, Palau introduced the Palau Pledge as an entry procedure for visitors to Palau, sustainable fisheries, the Palau National Marine Sanctuary Act (PNMSA), Convention of Ecotourism, implementation of Green Fees, and using price as a control mechanism, as well as other such policies, to create sustainable marine tourism. Being a haven for coral reef species, it established the Palau International Coral Reef Center (PICRC), which implements long-term plans for coral reef monitoring and handles scientific research and educational activities relating to coral reefs. As an important topic in marine research, it is worthy of our attention and reference here in Taiwan.



The Palau Rock Islands

Source/ <https://www.state.gov/wp-content/uploads/2019/04/Palau-2117x1406.jpg>

Creating an "Open, Connected, Balanced" Ocean—The Report On the Workshop On Capacity Building On Marine Debris Monitoring By Using Innovative Technologies in APEC Region

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Translated by Linguitronics

Keywords: Marine debris, innovative technology, monitoring, modeling

In the spirit of APEC 2022 "Open, Connect, Balance", the Ocean Affairs Council (OAC) held the "Workshop on Capacity Building on Marine Debris Monitoring by Using Innovative Technologies in APEC Region" (the APEC Workshop) at the National Museum of Marine Science and Technology (NMMST) from March 24 to 25, to which it invited multinational partners to give presentations on innovative marine debris monitoring and modeling technologies, as well as action plans of regional partners for marine debris monitoring. Participants were also invited to visit the site and learn more about Taiwan's innovative system for real-time identification of marine debris by experiencing it in practice. It is hoped that this workshop can promote cooperation with international partners to achieve the goal of sustainable environmental protection in the Asia-Pacific region.



Figure 1/ Group photo of guests at the opening ceremony
Image by Ocean Affairs Council

The APEC workshop kicked off on March 24 at the International Conference Hall of the NMMST. Associate Professor Ren-Shan Gao of Yuan Ze University introduced the workshop and guests. Vice Chairman Ching-Piao Tsai of the OAC and Director Su-Fen Chen of the NMMST. Vice Chairman Tsai said that in the mutual pursuit of economy and environment, marine debris has become one of the most important and urgent environmental issues for the Asia-Pacific region, one that requires all economies to work together to formulate policies and solutions. The Taiwanese government, for its part, has taken "Salute to the Seas" as its starting point for its policy. Combining the advantages of the domestic technology industry with technological innovations in marine debris monitoring and modeling, it can understand trends in marine debris with speed and accuracy, and then use this as the basis for governance and cleaning. It is also hoped that Taiwan's results can be shared with international partners at the conference. The Director of the NMMST, Ms. Su-Fen Chen, shared the efforts of the Museum in marine ecological conservation, monitoring and engineering technology since 2014. She also invited the participants to visit the museum and the beautiful scenery during the two-day workshop.



Figure 2/ Opening remarks by Vice Chairman Ching-Piao Tsai of the OAC (left); Panel Discussion 1 (right)
Images by Ocean Affairs Council

Innovative technologies, shared cases: Marine debris monitoring and modeling

The keynote speech on the first day was on From Source to Sink: The Innovative Technology of Monitoring and Modeling for Marine Debris, delivered by Patrycja Enet, Expert Consultant of UN Secretariat of the Environment Management Group, EMG, and Keith Alverson, Former Director of International Environmental Technology Centre, UNEP and Independent Consultant.

Patrycja Enet shared on the topic Marine litter & plastic pollution - from source to sink. She explained that the United Nations has put forward many plans, projects, and initiatives in the face of severe pollution from marine debris, and that 14 neighboring organizations assist countries and organizations in developing the necessary regulatory frameworks, creation of action policies, and training of talent to provide a systematic solution for reducing marine debris. Yet, to solve the problem of marine debris, one must begin from monitoring, information exchange, knowledge sharing, and cooperation among countries, to understand the sources and impact of marine debris. Only then can one begin to effectively respond to pollution from marine debris.

Keith Alverson, independent consultant, presented Plastic in the Ocean: Evaluating Solutions. He says there is no "best practice" or "ideal technology", and that the actual solution depends on how local constraints are overcome and which plastic products are addressed. Each city should establish a Reduce, Reuse, Recycle (3R) waste management system and develop policies and actions through ongoing research and monitoring systems on the flow of plastic materials.

The keynote speech was followed by a panel discussion on Quantification of Marine Debris: Practice of Monitoring and Modeling in APEC Region, moderated by President of the National Academy of Marine Research (NAMR) Jiahn-Horng Chen, Associate Professor Kuo-Hsin Tseng of the Center for Space and Remote Sensing Research of National Central University (NCU), Monitoring Coordinator for the Marine Debris Program under the National Oceanic and Atmospheric Administration (NOAA) Hillary Burgess, and Associate Professor of Korea Research Institute of Ships & Ocean Engineering Jung-Yeul Jung.

Associate Professor Tseng introduced Taiwan's marine monitoring technology using satellites, remote monitoring, and image recognition, as well as the Marine Debris Detection (<https://foresight-data.herokuapp.com/debris>) monitoring platform. Monitoring Coordinator Burgess explained during the panel that the NOAA began investigating and preventing the negative impacts of marine debris in 2006 with the establishment of its Office of Response and Restoration, and that its Marine Debris Monitoring & Assessment Project (MDMAP) began in 2011 to monitor coastal areas in collaboration

with communities. Associate Professor Jung shared the results of the You Only Look Once, YOLOv5 object monitoring algorithm used to classify and quantify debris on beaches, and added that satellite maps are used to remotely monitor and estimate the scope of floating areas of debris and amounts of debris on the seafloor.



Figure 3/ Visiting to Wave Current Telemetry Station and operating UAS to identify marine debris (top); On-site operation, with use of cell phones to take photos of the debris and upload them to the Marine Debris Detection monitoring platform (bottom)
Images by Chia-Wen Chung (top), OAC (bottom)

Demonstration of Application of Innovative Technology in Marine Debris Monitoring

The afternoon of the first day of the APEC workshop continued the morning session on marine debris monitoring and modeling practices; a visit to the NMMST was arranged, where there was a demonstration of the application of innovative marine litter monitoring technology. The host took the participants on a visit through the NMMST, Chaojing Park, and the shore-based microwave (X-band) real-time wave current telemetry station in coastal waters. Jian-Wu Lai, a researcher at the Marine Industry and Engineering Research Center, NAMR introduced the real-time wave and current telemetry station established by the NAMR a microwave oceanographic radar system that monitors the ocean features and temporal and spatial changes within the range based on echo images.

Associate Professor Tseng led the team in an actual demonstration of UAS to identify marine debris on site, and invited participants to take photos with their mobile phones and upload marine debris photos

to the Marine Debris Detection monitoring platform. Such photos uploaded from all over Taiwan can improve the accuracy and effectiveness of AI computation and make AI modeling more accurate. Everyone was also invited to participate. At the end of the day, attendees were invited to watch the 8K video *Conquest of The Skies* at the Ocean Theatre of the NMMST.

Practical Action towards Co-creation: Partnership and Collaboration

The second day's keynote speech, "Best Practice-Regional Partnership on Action Plan of Marine Debris Monitoring," was delivered by the Director-General Hsiang-Wen Huang of the Ocean Conservation Administration, OAC, and Senior Director Nicholas Mallos of Trash Free Seas Program, The Ocean Conservancy (TOC), to discuss the need for international cooperation in marine debris and marine debris technologies.

Director-General Huang introduced the Partnership on Marine Debris Monitoring and Cleanup Action Plan. Since the International Coastal Cleanup (ICC) was launched by TOC in 1986, the marine debris action in Taiwan has been initiated by NGOs, based on scientific evidence, and actions were planned systematically by the government. In 2017, government and civic organizations established a marine debris governance platform and jointly developed the Action Plan of Marine Debris Governance in Taiwan; citizen marine scientists were invited to participate in marine debris recycling and surveying, and a temporary storage area was set up for marine debris and waste nets at ports, where local fishermen could recycle discarded fishing nets; furthermore, 29 marine debris recycling operators are also invited to join the "Marine Debris Recycling Alliance", a public-private partnership whose purpose was to build a sound cooperation mechanism to jointly promote the reuse of marine debris.

TOC's Senior Director Nicholas Mallos introduced Building Capacity to Monitor and Prevent Marine Debris, in which he recognized the global issue that requires efforts to reduce marine plastic pollution to 2015 levels (less than 8 million metric tons). The APEC economies are at the forefront of this issue, and the ICC, initiated by TOC, has raised 17 million volunteers worldwide over 35 years who have carried out beach cleanups in 153 countries; and these have kept track of waste removal projects using the standardized ICC form to compile the sea waste hotspots and projects worldwide. In addition, the Global Ghost Gear Initiative (GGGI) has compiled the largest amount of discarded fishing gear data in the world using the app and has reached an agreement with the Food and Agriculture Organization of the United Nations (FAO) to begin surveying fishermen for information on discarded fishing gear. APEC can use such new tools and indicators to help countries fight marine debris.

The panel discussion on March 25, "Toward a Mutual Monitoring Platform of Marine Debris for APEC Region," was moderated by Associate Professor Ren-Shan Gao of Yuan Ze University, with the participation of Senior researcher Devi Dwiyantri Suryono of Marine Research Center, Ministry of Marine Affairs and Fisheries; Research Fellow Jian-Wu Lai of Marine Science and Information Research Center, NAMR, OAC; Director Jiraporn Charoenvattanaporn of the Office of Academic and International Studies, Ministry of Marine and Coastal Resources, Thailand and Fishery Biologist; and acting director Nguyen Thanh Thao of the Department of Geology and Mineral Resources, Ministry of Natural Resources and Environment, Vietnam.

Research Fellow Lai introduced the operation of the marine debris monitoring system for marine debris monitoring and tracing. Within the context of global climate change, the paths and flows of marine plastic waste and microplastics from source to sink is still unclear. Taiwan uses marine radar technology to monitor the flow of marine debris, including using AI technology to estimate annual marine debris

hotspots and improve beach cleanup plans, as well as predict the direction of marine debris and intercept it before it ever enters the sea. Director Charoenvattanaporn spoke on The Study of Marine Debris in Thailand to Support The Policy Maker Decision, which touched on research on the impact of marine debris on marine life and microplastics, monitoring, identification, and marking of marine debris on estuaries and coral reefs, and clean-up and reduction in hotspots. Acting director Thao shared on Marine Litter Monitoring in Vietnam, referencing the NOAA, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and the UNESCO-IOC, to study plastic waste in mangrove forests in Da Loc commune, Thanh Hoa Province, Vietnam, most of which are microplastics, it also included writing of coastal debris monitoring guidelines, selection of random areas to collect and classify marine debris samples, and improving the guidelines after data analysis. Senior researcher Suryono shared on the topic of "Global Monitoring of Marine Debris to Support Marine Environment Management" and introduced Indonesia's marine debris action plan from 2018. In said plan, monitoring and removal are carried out in rivers and coasts, and environmental education is implemented for the community; it uses marine scientific research to understand the source, composition, density, dynamics, and distribution of marine debris, which helps improve the management mechanism of marine debris and planning of regional actions for marine debris.

Conclusion

Marine debris has become one of the most important, most urgent environmental issues for the Asia-Pacific region. This workshop invited APEC economic partners to share innovative technologies for marine debris monitoring and modeling, not only to share Taiwan's results with international partners, but also to discuss the benefits of cooperation in transnational partnerships, reduce difficulties of cooperation through emerging technologies, provide various economies with possible future development paths for marine debris management, and witness the power of digital technology among APEC economies. Opening up and collaborating on marine debris issues, we can successfully go beyond mere geographical restrictions, conquer the dilemma of the global epidemic, and bring the workshop to a successful end.



Figure 4/ Group photo of attendees
Image by Ocean Affairs Council

Foreign Aid Achievements of TaiwanICDF in Palau

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Translated by Linguitronics

Keywords: Aquaculture, Marine Resource Rehabilitation, Sustainable Blue Economy

At the 7th "Our Ocean Conference" (OOC) held in Palau, the results of Taiwan's long-term investment and implementation of various technical cooperation projects in Palau were presented to more than 500 institutions, experts, and scholars from government, public and private sectors, and non-profit organizations hailing from more than 80 countries, giving full testament to the fruitful results, both in Taiwan's assistance to Palau and in ocean issues.

The people of Palau depend on the sea for their livelihood. According to statistics, more than 80% of the island's residents are in a broad sense fishermen and engage in economic fishery activities related to the ocean. Thus, in June 2008, the Bureau of Marine Resources (now the Bureau of Fisheries) proposed the Aquaculture and Fisheries Action Plan, which outlines the sustainable economic development and 18 management action strategies for Palau's marine and coastal resources. In response to the request from Palau's marine development and management policy, Taiwan assisted Palau in the R&D and implementation of aquaculture in 2012. Then, to expand the scope and depth of the assistance program, the International Cooperation and Development Fund (TaiwanICDF) has implemented the "Aquaculture and Fisheries Action Plan" since 2021, focusing on the establishment of aquaculture business models and the construction of sustainable fisheries resources. Up to this point, the ICDF has successfully assisted Koror and Ngchesar in Palau in the net-cage cultivation and commercial sale of mottled spinefoot and completed the research and development of local giant tiger prawn (*Penaeus monodon*) [1]. In addition, it is also actively combining resources from countries with similar philosophies to jointly introduce resources to improve the sustainable management of fishery resources along the Palau coast. In February 2022, the United States Agency for International Development (USAID) jointly sent personnel to Palau to inspect the current situation of coastal fishery resources and forged a consensus on future cooperation among Taiwan, the United States, and Palau with the Palauan Minister of Agriculture, Fisheries, and the Environment, Steven Victor.



Figure 1/ Aquaculture is an emerging blue industry in Palau, and net-cage aquaculture of the mottled spinefoot is an important economic species for marine fish farming in the state of Ngchesar

Images by Technical Mission in Palau

Aquaculture Development in Palau

In response to Palau's ocean-related management policy, Japan assisted Palau in establishing the Palau Mariculture Demonstration Center in 2019, and permanently stationed aquaculture experts to carry out local breeding of giant clams in Palau and provide the seedlings required by offshore giant clam farms to maintain local food security. However, the actual survival rate is low due to frequent predation, which affects the establishment of the subsequent business model, resulting in more than 60% of the giant clam farms in Palau going out of business. In light of this, Palau is promoting a more pragmatic and proactive marine agency and a series of policies to facilitate the transformation and sustainable development of Palau's localized "blue economy".

On October 5, 2021, the Government of Palau issued Executive Order No. 463 which reorganized and defined the functions of the Ministry of Agriculture, Fisheries, and the Environment (MAFE) and incorporated into it the functions and responsibilities of the former Bureau of Marine Resources, which is responsible for exploring, investigating, developing, managing, and protecting all coastal marine resources in Palau. Its first minister was Mr. Steven Victor, former President of The Nature Conservancy (TNC), who led the Ministry to increase fisheries and agricultural production to support the livelihoods of the Palauans using a sustainable ecological model, while at the same time protecting the environment.

In his first domestic policy address in April of the same year, Palauan President Surangel S. Whipps, Jr. stated that the ministry's focus was on strengthening management of domestic fisheries, and that the reorganized allocation of labor within the ministry would enhance the development of sustainable fisheries in Palau from its coastline to the Exclusive Economic Zone (EEZ), further ensuring sustainable sources of food, and preparing for recovery from COVID-19.

The Technical Mission in Palau, in collaboration with the Bureau of Fisheries under the MAFE, is working with the Palau National Aquaculture Center to develop, breed, and promote local conservation and commercial potential marine aquaculture species, and is committed to guiding Palauan fishermen in the establishment of a net-cage model for mottled spinefoot. The main objective of the project is to improve fishermen's income and increase local food production.

The Technical Mission's Aquaculture Plan has provided guidance to four core farmers to establish a commercial mottled spinefoot net-cage aquaculture model. Through one-on-one education and training on aquaculture, such as net maintenance, feeding training, and establishment of breeding records, the productivity of single-opening net fish farmers has been increased by 38%, and the increase in production has led to a 16% increase in the income of the respective farmers, further strengthening the development and growth of Palau's blue economy industry. In the future, it will continue to utilize the technological strengths in Taiwan's sea aquaculture and breeding to establish a local production mode of seed for mottled spinefoot, milkfish, and giant tiger prawn. In addition, in order to reduce overfishing along the coast of Palau and to protect precious marine resources, the Aquaculture Plan cooperates with the Palau Bureau of Fisheries and the local state government to conduct seed stocking to enhance the resilience and sustainability of coastal fishery resources.

Ngchesar, located on the eastern side of Babeldaob Island of Palau, is the largest aquaculture producer in the aquaculture program that promotes the net-cage aquaculture of mottled spinefoot. Mr. Richard Nigiratrang has also said that under the guidance of the Technical Mission in Palau, the aquaculture industry has gradually become more robust and increased the state's surplus income, with net-cage raised mottled spinefoot selling for twice the market price (\$4 per pound). Each catch day, the shore is crowded with people rushing to buy mottled spinefoot, and the catch often lags behind demand. The

state government also continued to say that the existing scale of aquaculture is not enough to support the state's aquaculture cost revenue, but in the future will actively seek to establish aquaculture bases and expand the scale of aquaculture, and is willing to continue to invest state government resources to maintain aquaculture work.

The Technical Mission in Palau not only cooperates with the Palau government to implement the plan, but also combines the R&D, technologies, and resources of international organizations, Palauan academic institutions, and the private sector to assist Palau in the overall development of the aquaculture industry and prepare the domestic tourist market and marine resource conservation for the post-pandemic era, so that Palau's reputation as "God's aquarium" can continue to shine on the international stage.

Palau's Marine Resource Strategy and Regulations

The Palau General Assembly passed the Shark Haven Act in 2009, a law which prohibits commercial shark fishing or finning in Palau's territorial waters, adjacent areas, and EEZ; and in 2012, the Palau Domestic Fishing Law [2] was enacted to regulate fishing in Palau's domestic waters. These regulations cover various fish species and fishing laws and place restrictions on exports (Table 1). In 2015, the Palau National Marine Sanctuary Act (PNMSA) was passed, designating 80% of Palau's jurisdictional waters as an MPA, with a total ban on all development activities, including fishing and mining, within the area. The remaining 20% of the area was designated as a Domestic Fishing Zone (DFZ) restricted to domestic fishing needs and limited commercial fishing. Although this has become a model for the world, the Palau General Assembly recognizes that such stringent restrictions for marine protection have become a major impediment to the economic development of the Palauan fishing industry. Therefore, in consideration of the economic interests of local fishermen, an amended bill was passed in 2019 to ease the restrictions on Palauan fishermen's operations in the DFZ, and to allow local residents to make appropriate development and use of the area.

There is still controversy surrounding the current policy direction of fisheries resources management in Palau. The central government, local government, and traditional leaders in Palau hold different views on fisheries resource management and marine resource conservation. For example, there are 16 states and traditional leaders in Palau who have established the traditional concept of conservation, "bul", and each state and its traditional leaders carry out regional conservation activities according to their traditional norms and knowledge, resulting in ambiguous norms and problems in the protected areas. The central government can only use patrol boats to perform occasional monitoring to prevent illegal fishing operations, but in fact there is no mandatory regulation nor efficacy in law enforcement.

For more than two years, the pandemic has reduced revenue in Palau's tourist industry, an important source of economic income, and has affected the national income and livelihood of the people. In view of the significant economic impact, its central government is now trying to appropriately relax fishing regulations and explore the possibility of opening up economic fishing areas through a clear and effective mechanism for monitoring coastal fisheries resources. In that way, it can achieve a mutually beneficial strategy for conservation, economy, and resource sustainability.



Figure 2/ The white-spotted spinefoot seeding activity is conducted based on the experience of Taiwan's coastal economic seed fish release. Taiwan conducts seedings for different coastal fish each year

Image by Technical Mission in Palau

Table 1/ Regulations and fishing seasons for various marine species of Palau (updated based on the 2012 Palau fisheries regulations)

Species	Fishing Area	Reasons for restrictions on fishing	Closed fishing season
Meteungerelet'emekai (<i>Epinephelus fuscoguttatus</i>)	Total ban	Breeding season	April to July
Ksau'temekai (<i>Epinephelus polyphekadion</i>)	Total ban	Breeding season	April to July
Tiau (<i>Megaptera novaeangliae</i>)	Total ban	Breeding season	April to July
Tiau (<i>Plectropomus leopardus</i>)	Total ban	Breeding season	April to July
Mokas (<i>Plectropomus laevis</i>)	Total ban	Breeding season	April to July
Meyas (<i>Siganus canaliculatus</i>)	Total ban	Breeding season	February to March
Kemedukl, berdebed, fahorari hamaduhiri (<i>Bolbometopon muricatum</i>)	Total ban	Scarce quantity	Year-round
Maml (<i>Chellinus undulatus</i>)	Total ban	Scarce quantity	Year-round
Aquatic ornamental fish	Entire area	Sustainable resources	Maximum of 20 licenses
Rock lobsters a. Bleiached (<i>Panulirus versicolor</i>) b. Raiklius (<i>Panulirus penicillatus</i>) c. Melech (<i>Panulirus longipes femoristriga</i>)	Entire area	Total shell length of 3.5 inches	Catch specification restriction
Mangrove crab Emang (<i>Scylla serrata</i>)	Entire area	18-month-old with outer shell of 6 inches	Catch specification restriction
Coconut crab Ketat, yefi (<i>Birgus latro</i>)	Entire area	Shell of 4 inches	Catch specification restriction
Sea turtles a. Melob, woru green turtle (<i>Chelonia mydas</i>) b. Ngasech, hachab hawksbill turtle (<i>Eretmochelys imbricata</i>)	Entire area	Shell length 34 inches, female turtles, and hawksbill sea turtles	January, May to August, and December
Giant clams a. Otkang (<i>Tridacna gigas</i>) b. Ribkungel (<i>Tridacna squamosa</i>) c. Kism (<i>Tridacna derasa</i>) d. Melibes (<i>Tridacna maxima</i>) e. Oruer (<i>Tridacna crocea</i>) f. Duadeb (<i>Hippopus hippopus</i>) g. Duadeb (<i>Hippopus porcellanus</i>)	Entire area	Export ban	Export ban
Blacklip pearl oyster Chesiuuch (<i>Pinctada margaritifera</i>)	Entire area	Outer shell diameter of 4 inches	August to December
Trochus Semum (<i>Trochus niloticus</i>)	Entire area (or according to the state regulations)	Bottom diameter over 3 inches	Catch specification restriction
Sea cucumbers a. Bakelungal-chedelkelek (<i>Holothuria nobilis</i>) b. Bakelungal-cherou (<i>Holothuria fuscogilva</i>) c. Molech (<i>Holothuria scabra</i>) d. Badelchelid (<i>Actinopyga mauritiana</i>) e. Eremrum (<i>Actinopyga miliaris</i>) f. Temetamel (<i>Thelenota ananas</i>)	Entire area	Not regulated	Export ban
Dugong Mesekiu (<i>Dugong dugon</i>)	Prohibited	Scarce populations (50 to 100)	Prohibited
Sponges, hard corals and marine rock	Prohibited	Critical Habitat	Export ban

Source / Palau Domestic Fishing Laws (2012) [2]

Palau's Vision of a Rising Blue Economy

Since the establishment of the MAFE in 2021, Palau has been actively considering viable alternatives to fishing for economic income. And by calling for the importance of blue economic development and ecological balance during the 7th OOC, it also looks forward to the effective management and monitoring of marine resources through scientific research and investigation. In addition, Palau's tourist economy is arguably completely dependent on the ocean, so Palau Chamber of Commerce Vice President Ms. Irene Olkeriil continues to emphasize the need for the Palauan government to propose long-term solutions for the sustainability of coastal fisheries resources, and calls for the replenishment of fisheries resources through aquaculture and the meeting domestic demand for business tourism, which can effectively reduce the depletion rate of coastal fisheries resources. In addition, there are few women in the traditional Palauan culture who are involved in the actual fishing industry. If opportunities and training can be provided to local women so that they can participate in aquaculture work, it would increase the proportion of local women participating in the fishing industry and contribute to its development.

In addition to sending the Technical Mission in Palau to implement the aquaculture project, TaiwanICDF also proposed four commitments in response to the OOC, in the four areas of action, namely "Advancing Sustainable Small-Scale Fisheries and Aquaculture," "Tackling Marine Pollution," "Confronting the Ocean-Climate Crisis or Towards an Ocean Solution for Climate Change," and "Creating Sustainable Blue Economies," and the commitments were approved by the OOC. The commitments have garnered a total investment of US\$12 million. This demonstrates Taiwan's determination in assisting its allies in promoting balanced social, economic, and environmental development, and in contributing to global sustainable recovery and marine environmental conservation [3].

Conclusions

The history of aquaculture in Taiwan can be traced back to the late 17th century. In the 1960s, various artificial breeding techniques were established [4] and in the 1980s it earned the title of the "kingdom of giant tiger prawn breeding" in the 1980s. In addition, Taiwan has 60 years in foreign aid development, and the aquatic technology foreign aid plan has expanded to countries in Central and South America, the Caribbean, Africa, the Middle East, and South Pacific island countries, addressing issues from the most basic need of "food" to the establishment of mass production technology that takes into account "nutrition" and "business models". Through the implementation of various technical cooperation plans, the TaiwanICDF has repeatedly assisted nearby countries and allies in breaking through technical bottlenecks. Palau's marine conservation and aquacultural development, due to the efforts invested by the Aquaculture Plan, has hit important milestones, such as the conservation of mottled spinefoot, giant tiger prawns, and sea turtles. In the future, the Technical Mission in Palau will cooperate more closely with the Palauan government and external resources of various international organizations, increase investment from technology and capital, and move towards the goal of strengthening the sustainable development of Palau's oceans.

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The Coastal and Marine Tourism Industry in Palau

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Keywords: Palau, Marine Tourism and Sustainable Tourism

According to the Organisation for Economic Cooperation and Development (OECD), the marine resources industry and related economic activities are estimated to add US\$1.5 trillion to global output each year and add 2.8 million jobs annually; of which maritime and coastal tourism accounts for 26% (OECD, 2016). Finding a way to balance the development of the ocean economy and the utilization of environmental resources to achieve the goal of a sustainable marine industry is an important issue nowadays.

The Republic of Palau, one of the world's top 3 dream resort islands, has been open to tourism since 1985. The island's tourist industry accounts for nearly 51% of its GDP [1], 15% of its tax revenue, and 40% of employment; however, it has also created enormous pressures on the local environment. At a time when sustainable tourism has become mainstream and worldwide trend, Palau pioneered the Palau Pledge in 2017 as an entry procedure for tourists, reminding tourists to respect and care for local environmental resources; it has also promulgated various environmental protection laws to propose solutions for marine sustainability, actively developed marine tourism while preserving the local natural environment, and shaped the island nation to develop a new sustainable mindset for the coastal and marine tourist industry.

Natural Environment and Economic Activities in Palau

Palau is an archipelago consisting of more than 340 islands (only 9 of which are inhabited) located to the southwest of Micronesia; the archipelago extends more than 489.5 kilometers [2]. Most of the islands are surrounded by barrier reefs and fringing reefs, which form an expansive lagoon of varying depths that covers over 1,200 square kilometers [3]. The diversity of its coral reefs is comparable to the highest reef diversity areas in the Philippines, Indonesia, and Australia [4]. There are more than 1,300 species of coral reef fish, over 700 species of coral and anemone, 13 species of shark, and the dugong, an endangered marine mammal of the Pacific and Indian Oceans.

The Rock Islands, composed of coral reefs and located in the middle of the Palau Islands, is known as the "Garden of the Sea". The island's lagoon from the sedimentation of the bay forms a unique ecosystem that is surrounded by green coral reefs and blue and clear waters. It is Palau's most essential area for marine tourism, and the Rock Islands Southern Lagoon (RISL) was registered as a World Heritage Site in 2021. Visitors can swim with jellyfish, sharks, and dolphins in the blue ocean, explore the atolls and mangroves in canoes, take a helicopter to get a bird's eye view of the mushroom-shaped reefs, and enjoy the sunshine on snow-white sand beaches of Ngermeaus island, which is the most attractive sea, land, and air tour in Palau (Figure 1).

The growth of Palau's tourist population has put enormous pressures on the island's infrastructure, resources, and environment

According to statistics, the number of visitors to Palau skyrocketed from 2005 to 2015, reaching 150,000 in 2016, a 70 percent increase from 2010. This has led to overcrowding in diving sites; added to that are the divers and tourists trampling and touching corals. Interact with marine life, following turtles, or



Figure 1/ The most appealing tour in Palau is the marine tourism tour
Images by Jao-Chuan Lin, Belau Diving

feeding coral reef fish, as well as other inappropriate behavior, reduces the pecking of algae and plant debris by small fish, causing the death of coral reefs due to the growth and attachment of algae, and thereby accelerating the decline of coral reefs.

Palau, which stopped following U.S. conservation policies after 1994, has brought endangered species, such as the green sea turtle, coconut crab, and fruit bats to the tables of tourists. Visitors are attracted to "bioprecious" products with local characteristics, such as hawksbill sea turtle, giant clams, and top snails. And then there is the increasing demand from tourists for fresh water and seafood ingredients, overdevelopment of coastal areas, and the growing problem of waste. While tourism contributes significantly to local income and provides many jobs in coastal communities, it also presents many challenges to environmental conservation.

Palau Marine Conservation Policy and Protection of Marine Recreational Resources

I. Sustainable Fisheries Policy

The waters surrounding Palau are rich in fishery resources, and its eight neighboring countries have the third largest tuna fisheries in the world, accounting for more than half of the world's tuna catch, with an annual production value of about US\$4 billion. Early on, foreign fishing boats only needed to pay a low "fishing fee" to enter the sea area to fish, though this would only bring about US\$5 million in fishing benefits to the Palau government every year. In order to protect its local fishery resources, Palau, as a member of the Pacific Islands Forum (PIF), mandates foreign fishing vessels to install Vessel Monitoring Systems (VMS) to monitor their movements and catch notifications, prohibits fishing operations by foreign fishing vessels within its 24 nautical mile coastal area, and sets high penalties for shark fishing and bycatch. The people responsible for sharks found to have been illegally de-finned, detailed, or have any part of their bodies cut off can be fined up to US\$250,000.

The Palauan tradition of "BUL", or "no fishing", is a way of preserving the natural environment by estimating the spawning period of fish and closing the waters of the area during the breeding season, giving the creatures the chance to reproduce. In 2015, the President of Palau signed the Palau National Marine Sanctuary Act (PNMSA), which designates 80% of Palau's EEZ, approximately 475,077 square kilometers, as a Marine Sanctuary, where commercial fishing is prohibited. This is meant to conserve and rehabilitate the fish and cetaceans within the sanctuary, while allowing for the remaining 20% of the sea only to be used by the local fishing industry and tourists for fishing. The government monitors the sanctuary by monitoring the movement of fishing vessels and analyzing their navigational paths; it strictly prohibits fishing methods such as bottom trawling, electrofishing, and explosive fishing, as well as diving for fish with diving cylinders. This has enabled the fish population in the protected area to reach twice the size of the non-protected area in just 2 years, and the ecological restoration has been amazingly effective (Figure 2).



Figure 2/ Ecological restoration through MPAs has had amazing results
Image by Jao-Chuan Lin, Belau Diving

II. Set up an Exclusive Protection Zone

In order to protect the marine ecology and economic development, the Palau government has been actively promoting eco-tourism and marine recreational activities; the establishment of Marine Protected Areas (MPAs) has become the most successful marine conservation policy of the Palau government. The Ngerukewid Island Wildlife Preserve was established in 1956. It has promulgated the Marine Protection Act, National Conservation Act, Protected Areas Network, and PNMSA, and has followed up with the establishment of the Shark Sanctuaries, Marine Mammal Sanctuaries and No-Take Zones.

For example, the world's first shark sanctuary was established in Palau to stop all commercial shark fishing activities in the waters, allowing 17 species of sharks to thrive in Palau without fear. Shark protection has become an important tourist attraction, and 8,600 tourists come to swim with sharks annually; the economic value generated through diving tourism is about US\$18 million, compared to the economic value of US\$10,800 from fishing and killing these sharks, a difference of more than many times.

In addition to shark conservation, the Dolphins Pacific, built in 2001 at a cost of about \$2.5 million to protect injured dolphins, has developed characteristic tours such as "dolphin petting" and "swimming and diving with dolphins" to provide visitors with an understanding of the ecological habits of dolphins. There were once about 2,000 dugongs recorded in Palauan waters, but now only 50 to 200 are estimated to remain. Through the establishment of the "Ngederrak Dugong Reserve", the dugong population is slowly increasing. The ocean is the largest carbon sink, as it absorbs 40% of the earth's carbon emissions, with marine phytoplankton comparable to four Amazon rainforests. The Palau atoll is rich in marine plants and marine life, and most of the islands are restricted from visitors to preserve the precious marine resources in the protected area.

III. Promotion of Eco-Tourism Conventions and Green Fees

Following the establishment of the MPAs, the President of Palau stated that "The country wants to promote diving, snorkeling, and eco-tourism as an alternative to the income derived from commercial fishing". The promotion of eco-tourism aims to provide benefits to local communities and ecosystems, in addition to responsible and conservation-minded tourism. Therefore, the Palau government has formulated the "Convention on Community Development of Ecotourism" to control the total number of tourists, train local residents to become guides and ecotourism seed teachers, and provide environmental education to tourists both before and after the event; it also gives 20% of the profits to the "Giving Back to the Community Fund" to promote environmental education, ecological conservation, and community welfare.

Compared to eco-tourism, regular tours have limited effect on promoting environmental conservation and increasing community benefits. However, the Palau government charges a US\$15 green fee for visitors engaged in ocean-based tourism and recreational activities, such as diving and snorkeling, to fund environmental infrastructure improvements, such as wastewater treatment. A Pristine Paradise Environmental Fee (PPEF) of \$100 per visitor is levied at the airport to cover the government's costs in maintaining the MPAs and to support the operations of domestic organizations. Visitors going out to sea and diving in Jellyfish Lake are also required to pay a US\$100 application fee for a permit, which not only keeps track of the number of people entering the lake, but also contributes to marine police costs in patrols and daily maintenance.

IV. Using Price as a Control: Welcoming High-Spending Visitors who Respect the Environment of Palau

In his statement, the President of Palau emphasized that "By maximizing the return on investment and diversifying the sources of tourists, we will be able to regain our vision of high-value tourism once and for all," by which the president expects tourists to stay longer, spend more, and respect the environment of Palau. Therefore, a motion was proposed "to raise the level of tourist spending and allow only high-end, high-priced resorts and hotels to be established on the island with similarly priced leisure activities for high-spending tourists." It provides up to 40% tax exemption to foreign investors who invest in high-quality tourism businesses, and makes every effort to cultivate a high-end, high-value, low environmental impact tourist environment. The influx of tourists to Palau in 2015, for example, led to the deterioration of the island's environment and forced the Palauan government to adopt a strategy of halving flights to reduce the number of tourists.

V. Palau Government Sustainable Tourism Policy

The "Palau Pledge" was first introduced as an entry procedure for visitors to Palau. Passengers are required to sign the oath on their passports upon entry into the country, are shown the "Giant" promotional video, and are given information packets on flights to Palau, emphasizing that violators of the oath are subject to a fine of up to US\$1 million. The Palau government made a promotional video "Giant", suggesting that foreign tourists, like the giant in the film, are recklessly destroying the Palauan ecology, and that is why, in the film, local children do not want to be friends with the giant. Because once the local ecology is damaged, it often takes years to restore it to normal. By promoting tourism, it can also convey the concept of conservation of the local natural environment and ecology.

In order to continue and encourage visitors to practice sustainable tourism, the Palau government has launched the "Ol'au Palau" App, the world's first app that records travelers' footprints and accumulates points for "sustainable behavior", including: using sea-friendly sunscreen, eating dishes made from local foods, avoiding the use of disposable plastic products, answering questions about Palau's environment and culture, and visiting sites of historical significance. Once enough points are accumulated, the user can exchange them for an in-depth itinerary, one never offered before in Palau. In addition, plastic cutlery is banned during travel, and plant-based dishware is used to implement a "traceless diet" for more sustainable travel.

The Government of Palau has proposed the Foreign Investment Act and its Enforcement Rules, which stipulate that travel guides, fishing guides, diving guides, water transportation services, and tourism businesses are to be operated only by Palauans or by joint ventures with foreigners in which Palauans own 51% or more of the shares. Foreign investors are required to obtain a foreign investment permit, and for certain environmentally-relevant projects, a permit from the Environmental Quality Protection Board (EQPB) or the Palau Maritime Authority (PMA) is required. Anyone who violates the regulations

and operates a business privately will be punished by imprisonment of at least one year or a fine of at least US\$25,000. This is to dissuade foreign investors from sacrificing the natural resources and ecological environment of the region for profit.

Table 1/ Timeline of Conservation in Palau

Era	Policies and Practices
1956	Establishment of Ngerukewid Island Wildlife Preserve
1994	Passed the Marine Protection Act (MPA)
1996	Promulgates national conservation laws to protect terrestrial and marine wildlife
1998	Established regulations to protect sea turtles
2003	The Protected Areas Network (PAN) established a framework for Palau's protected areas and received technical assistance as well as funding for monitoring
	Palau has at least 26 conservation areas across 13 states
2006	Commitment to protect at least 30% of the marine environment and 20% of the terrestrial environment by 2020
	Bottom trawling is prohibited
2009	The world's first shark protection area was established in Palau
	A \$15 Green Fee is charged to each visitor
2010	Palau announces establishment of Marine Mammal Sanctuaries
2012	Rock Islands Southern Lagoon becomes a UNESCO World Heritage Site
2013	The Dugong Protection Act is signed into law
2014	Palauan President Announces Commitment to Palau National Marine Sanctuary at United Nations Conference
2015	Signing of the Palau National Marine Sanctuary Act
2017	The gold jellyfish in Jellyfish Lake are decreasing greatly, so the lake was closed for nearly two years for rehabilitation
	The Palau Pledge was first introduced as an entry procedure for visitors to Palau
2018	The Pristine Paradise Environmental Fee (PPEF) of US\$100 added to the airline ticket of departing foreign passengers
	The import and sale of harmful chemical sunscreens is completely banned, and banned sunscreens brought by tourists will be confiscated by the Palau Customs
2020	The Palau National Marine Sanctuary (PNMS) was established as a joint venture between the MNRET, the Ministry of Justice, and the PICRC. The first two establish rules and legal support, while the latter is responsible for scientific research and educational activities

Source/ Palau National Marine Sanctuary (2015) [5]; made by Jao-Chuan Lin

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Marine Affairs Institutions of Palau: Dedication to Marine Conservation and Sustainable Tourism-based Ocean Governance

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Keywords: Palau, marine affairs institutions, marine conservation, sustainable tourism, ocean governance

Palau, officially the Republic of Palau, boasts bountiful and diverse marine ecosystems. Marine tourism is an important industry in terms of revenues generated. In order to protect marine environments as well as ensure sustainable development of tourism, Palau's institutions of marine affairs, including Bureau of Fisheries, Bureau of the Environment, Bureau of Tourism, and Division of Maritime Safety and Fish & Wildlife Protection, are in charge of fisheries, environmental protection, responsible tourism, and enforcement at sea, respectively. Marine Policies and management measures are clearly stipulated on the governmental agenda, such as the Protected Areas Network Act, National Marine Sanctuary Act, and the ban on the import, manufacture and sale of reef-toxic sunscreens. In particular, on January 1, 2020, 80% of exclusive economic zones (the area is 475,077 square kilometers) is designated as Palau National Marine Sanctuary, where all types of fishing are banned. This demonstrates Palau's dedication to marine conservation and establishing a country with a brand of marine conservation and sustainable tourism.

An overview of Palau's government system

Palau is an island nation, a home to 18,000 people, at the western margin of Micronesia in the west Pacific. The nation has approximately 340 islands with a total area of 489.5 square kilometers [1]. The total coastline stretches for over 1,519 kilometers and is often surrounded by adjoining coral reef systems. The exclusive economic zone (EEZ) covers an approximate area of 600 thousand square meters [2]. Palau has bountiful and diverse ecosystems, encompassing multiple habitats, from coral reefs, mangroves, seagrass beds, and sandy marine environments, to a famous jellyfish lake. It features approximately 1,300 species, over 700 species of coral, and 162 bird species [3].

Palau is a democratic republic. It has 16 states and the government builds on a political system under which the three branches of government (executive, legislative, and judicial) are kept separate as the presidential system. The President is the both head of state and head of government and is elected every four years. The incumbent President is Surangel S. Whipps, Jr., who took office in January 21, 2021. The cabinet consists of eight ministries, including Ministry of State, Ministry of Justice, Ministry of Public Infrastructure and Industries, Ministry of Finance, Ministry of Health and Human Services, Ministry of Education, Ministry of Human Resources, Culture, Tourism & Development (HRCTD), Ministry of Agriculture, Fisheries, and the Environment (MAFE) [4].

Among an array of governmental institutions, the ones that deal with marine affairs include: Bureau of Fisheries and Bureau of the Environment both under the auspice of MAFE; Bureau of Tourism under the auspice of HRCTD, and Division of Maritime Safety and Fish & Wildlife Protection under the auspice

of Bureau of Public Safety, Ministry of State. This article is to introduce the policies and management measures associated with marine affairs adopted by these institutions to understand the things they deal with pertaining to the ocean governance.

Institutions associated with marine affairs

I. Ministry of Agriculture, Fisheries, and the Environment

The MAFE is a main agency governing the ocean. It is in charge of agriculture, fisheries and the environment and has an important task of putting Palau on a path of becoming a food secure nation. The ministry upholds four core values: people, environment, science, and service. The approach focuses on six areas: policy, institutional capacity, applied research and development, extension services, accessibility to market, and knowledge management. Under the MAFE, there are three agencies, which are Bureau of Agriculture, Bureau of Fisheries, and Bureau of the Environment [5]. The latter two have responsibilities in relation to marine affairs.

Bureau of Fisheries is responsible for exploring, surveying, developing, managing and conserving all near shore and offshore marine resources. Under the Bureau, there are three divisions: Division of Agriculture, Division of Coastal Fisheries, and Division of Oceanic Fisheries. The tasks under each division is described below.

- Division of Agriculture: conduct aquaculture research and development, produce seedlings and fingerlings for aquatic species, facilitate the development of sustainable and economically viable aquaculture fishery, provide technical and extension services to aquaculture farmers, and develop database of aquaculture farmers.
- Division of Coastal Fisheries: plan, develop, manage on coastal fisheries; support development of coastal fisheries management plans; collect data on key coastal fisheries; participate in research and monitoring activities related to coastal marine resources; explore and research sustainable development of fisheries resources; maintain a Fish Aggregating Device (FDA) program; develop database of coastal fishers; develop appropriate coastal fisheries harvest control rules and regulations.
- Division of Oceanic Fisheries: explore, survey, develop, manage and conserve offshore living and non-living resources; establish the total allowable catch and limits on fishing efforts; allocate fishing days; negotiate and issue fishing agreements; support the development of offshore domestic fishery.

Bureau of the Environment is in charge of protection of Palau's natural environment and conservation of precious resources. Under the Bureau, there are two units: Division of Protected Areas and Species and Division of Forest, Land & Water Management. The tasks of the former are relevant to marine affairs, which include: conserve biodiversity, maintain critical ecosystem functions, and sustain cultural and natural resources through a network of protected areas; develop state programs with appropriate tools to enhance effectiveness of protected areas; promote research and management of key indicator species; promote protection of endangered species through collaboration with partners; control and if possible, eradicate invasive species; and coordinate the Protected Area Network Office (PAN Office).

In order to protect fisheries resources and effectively manage protected areas, the Palau's government has taken a number of measures in recent years. As an illustration, the Protected Area Network Act was passed in 2003. With this Act, a nation-wide protected areas network as well as an independent nonprofit organization- PAN Fund was established. The PAN Office was established in The Fund and is

- Tourism development, management, enforcement, and marketing is coordinated between national and state governments and private sector organizations.
- A destination management system is established to gather market information, and information on social, environmental, and economic impacts of tourism to enable effective decision-making and necessary policy reforms.
- Sustainable carrying capacity ranges are established and determine acceptable levels of environmental, cultural, and community impacts.
- User fees levied appropriate assist in reduction of low-end market.
- Incentive are offered to encourage investment in high-value accommodations and recreational facilities, or reinvestment in existing facilities.
- A building code appropriate to Palau's built environment is in place and enforced.
- Recycling is enhanced and community and business participation in this initiative is encouraged.
- Plastic bags for packaging and customary events are phased out via a combination of education and public and private-sector initiatives.
- Regulations Governing the Boat Owners Association for Tourism, BOAT.
- Regulation Governing Tour Operators.
- Responsible Tourism Education Act of 2018.
- Regulations Prohibiting Reef-toxic Sunscreen (briefly, Sunscreen Regulations). Starting January 1, 2020, import, manufacture, and sale of reef-toxic sunscreen are prohibited [10].
- Upon entry, visitors need to sign a Palau pledge on the passport to show the commitment to protecting the ecological environment during their stay in Palau [11].

III. Division of Maritime Safety and Fish & Wildlife Protection

Division of Maritime Safety and Fish & Wildlife Protection is under the auspice of Bureau of Public Safety, Ministry of Justice. It is in charge of enforcement at sea. Due to insufficient manpower of patrolling and an insufficient number of boats, the Division cooperates with nonprofit organizations in conducting research in the waters of protected areas, serving as a way to monitor protected areas. For example, in 2021, the Division in cooperation with Palau International Coral Reef Center conducts joint enforcement surveillance and eDNA research in the PNMS [12].

In order to cooperate in maritime patrolling and crack down transnational crimes at sea, Palau's government and our government signed the Agreement on Coast Guard Cooperation in March 2019. The items for cooperation are: exchanging business visits, conducting Coast Guard ships' port visit, exchanging training programs, inviting personnel to attend international conferences, conducting joint exercises of maritime search and rescue and maritime law enforcement, conducting joint fisheries patrol, and exchanging information in the area of law enforcement [13]. In addition, Taiwan embassy in Palau handed over 2 coastal multi-purpose boats to Palau to enhance its capacity on maritime law enforcement as well as search and rescue [14]. In the Our Ocean Conference held in April 2022 in Palau, our government particularly dispatched 'Tainan Boat', affiliated with Coast Guard Administration, Ocean Affairs Council, to Palau and conducted joint patrol with the Palau' boats [15].

Civil organizations

In addition to the institutions mentioned, several civil or semi-official organizations also cooperate with the government in promoting marine ecological protection and restoration. These organizations not only have subsidies from the government, but also have donations from business as well as foreign governments. The organizations are such as PAN Fund, PICRC, Palau Mariculture Demonstration Center (PMDC) etc.

Conclusion

The main institutions on marine affairs include Bureau of Fisheries, Bureau of the Environment, Bureau of Tourism, and Division of Maritime Safety and Fish and Wildlife Protection. By the name of the institution, it is easy to understand the scope of its responsibilities, which is fisheries, environmental protection, sustainable tourism development, and law enforcement, respectively. In addition, there are civil organizations in Palau (e.g., PAN Fund, PICRC) in cooperation with the government in the push for the marine conservation and restoration.

In order to protect fisheries resources and marine environments, and achieve sustainable tourism, Palau's government make clear policies and management measures, including Protected Areas Network Act, National Marine Sanctuary Act, Responsible Tourism Policy Framework, Sunscreen Regulations, pursuing the high-end market based on the pristine experiences, and signing the Palau Pledge by visitors. In particular, a forward-looking and comprehensive initiative, closing 80% of Palau's EEZ to all forms of extractive activities on January 1, 2020, vividly demonstrates Palau's dedication to marine conservation and building a nation with a brand of marine conservation and sustainable tourism.

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Research and Conservation of Coral Reefs in Palau

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Keywords: Palau, coral reefs, conservation, sustainability, culture, traditional wisdom

Palau still has diverse and healthy coral reefs. It is famous for its culture of harmony with nature, and leading role of environmental protection and eco-tourism. These achievements are due to its excellent geographical location with rich marine habitats and biodiversity, modern people with high environmental awareness, as well as crucial institutions such as the Palau International Coral Reef Center and Palau Conservation Society, and their collaboration with advanced international organizations. The coastal resources are protected through traditional wisdom on integrated management of watersheds and marine ecosystems. The marine protected area network has been established and effectively managed. The research and education well combined with management practice and daily life. The Palau model is worthy for Taiwan to improve the research and conservation of coral reefs, as well as to promote the sustainable development of nature and human.

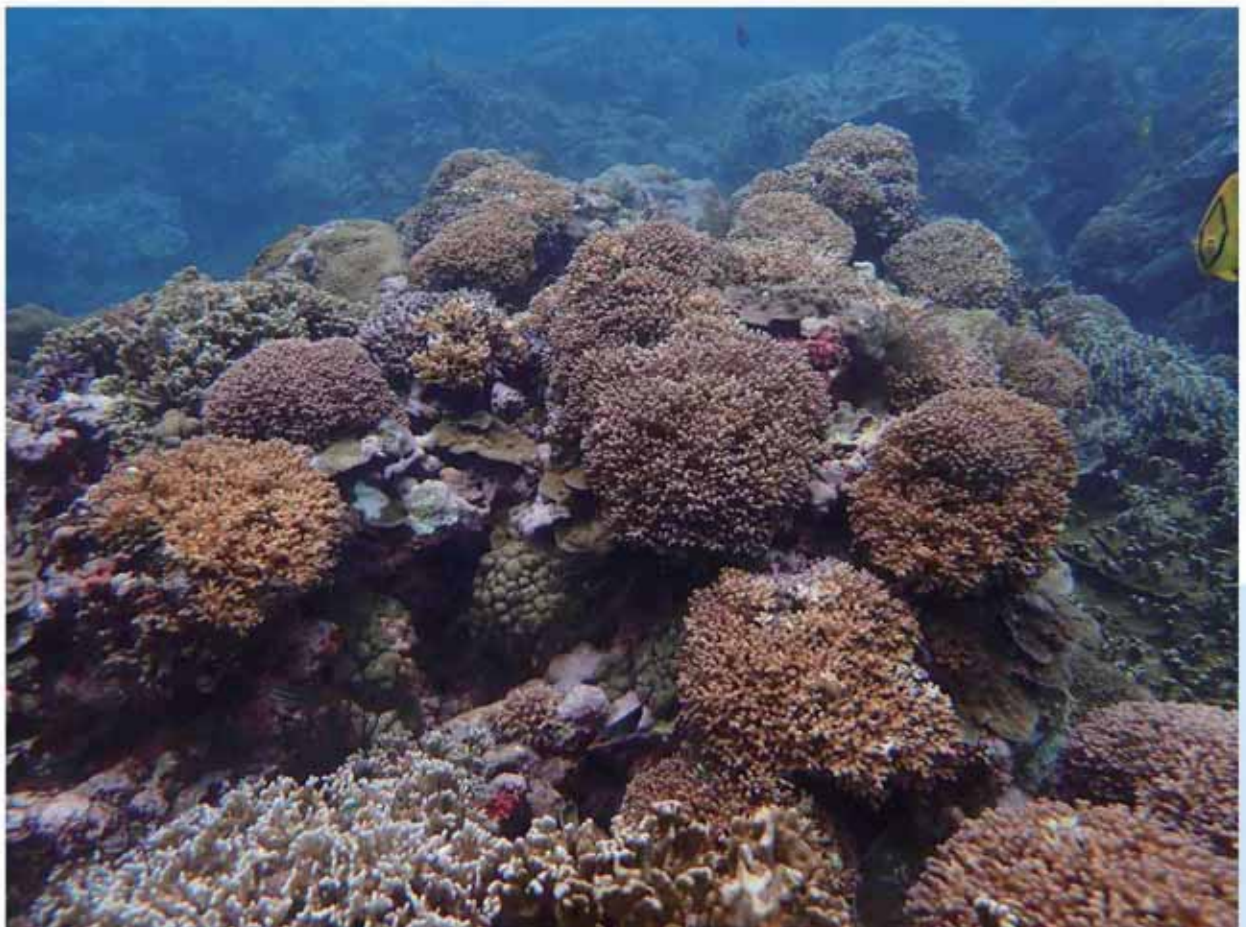


Figure 1/ Healthy coral reefs provide three-dimensional, complex, diverse, and continuously growing habitats
Image by Tung-Yung Fan

Marine ecology and social economics

Palau has 340 islands and is located in the west Micronesia of the northwest Pacific Ocean. The population is about 18,000 people with long history of 2,000 years. The traditional food is taro and reef fish. The main industries are tourism, subsistence farming and fishery. The tourism based on marine resources contributes about half of annual gross domestic product [1].

Palau leads the world in culture of harmony between people and nature, environmental protection and eco-tourism. Tourist entry must be signed in the passport promising to act in an ecologically and culturally responsible manner on the islands. The government has established one of the largest marine protected areas in the world. The single-use plastic products have been banned. The world's strictest national standards on sunscreen products have been adopted to protect the marine environment since 2020. Palau committed to becoming the first carbon neutral country in 2021. Palau has created a new paradigm for sustainable tourism with balancing environmental protection and economic growth to sustain the development of present and future generations [2].

Palau's rich marine resources benefits from its excellent geographical location. It is located east of the Philippines and north of Indonesia, where is the coral golden triangle with the highest marine biodiversity in the world. There are variety of islands and ecosystems, such as rainforests, mangroves, seagrass beds and coral reefs. There are 700 species of coral, 300 species of sponges, 200 species of cnidaria and nearly 1,300 species of reef fish. It has been internationally acclaimed as one of the seven underwater wonders of the world, also known as God's aquarium [2][3].



Figure 2/ Healthy coral reefs have high biodiversity and productivity
Image by Tung-Yung Fan



Figure 3/ Cryptic spaces between branches of reef-building corals become shelters for various organisms, especially fish
Image by Tung-Yung Fan

Key institutions for research, education and conservation

The Palau International Coral Reef Center plays a key role in promoting the outstanding research and conservation of coral reefs [4]. Its vision is to empower ocean stewardship, sustain people and inspire the world. The missions are becoming an excellent center providing high-quality and impactful research, education and support the management of marine resources. The research themes include Palau National Marine Sanctuary and fisheries, while education includes school programs and aquarium trips. The internship opportunities are also offered to performance-oriented and dedicated individuals to inspire the next generation of ocean initiatives and guardians. The volunteer program is to engage the public to help manage and protect marine environment, and to increase marine conservation knowledge, develop job skills, and have the opportunity to give back to the community.

Palau International Coral Reef Center was authorized to manage Palau National Marine Sanctuary. It enhances protection and coordinates research and education to promote successful management and sustainable use of resources for the current and future generations. In its aquarium, visitors can see Palau's rich and beautiful marine life, explore various marine ecosystems such as mangroves, seagrass and coral reefs, as well as understand the adaptation of Palau's unique wildlife to these ecosystems [4]. Through live animal displays, educational explanations, and laboratory experience, the visitors and students can bring what they learn to everyday life.

Palau Conservation Society is a national non-governmental organization with a holistic ecosystem perspective. It dedicates to integrate marine and terrestrial environments [5]. It plays the key function of coordinating different institutions from international to domestic, and from government to private sectors. Its vision is healthy ecosystems for a healthy Palau. It works with communities to preserve the nation's unique natural environment and sustain economic and social resilience. The core value is respect for Palauan culture to guide every activity with the believe that best conservation is achieved when communities manage their own resources. It respects the science

and believes that protected areas, resource use planning and adaptive management are effective ways to conserve natural resources. It believes a sustainable balance can be found between human needs and the environment. It maintains integrity, keeps promises, and strives to be honest, thus play a key role as a spiritual leader in civic conservation culture [2].

Palau is the priority location for international collaborative research in many advanced countries such as the United States, Monaco, Japan, and Republic of Korea [4]. For example, the Coral Reef Research Foundation was established in Palau in 1991 by a group of marine scientists dedicated to the research and education of coral reefs and other tropical marine environments [6]. The goal is to understand the tropical marine environment and conduct original research to gain the knowledge needed to understand and make wise decisions on conservation, climate change and resource management. Research topics include marine environmental dynamics relevant to conservation policy; short- and long-term monitoring of environmental and climate change.

Integrated and forward-looking conservation

A major achievement in coral reef conservation in Palau was the establishment of a network of 13 marine protected areas for ecological restoration in 2013. It provides a framework for cooperation between state government, central government, and private sectors to effectively protect marine biodiversity. Every two years, the Palau International Coral Reef Center surveys the status of resources within and outside each marine protected area, assesses the effectiveness of conservation networks, and makes informed management recommendations to the state government to improve the relationship between marine and terrestrial protected areas as well as to build long-term resilience to climate change. It works with key stakeholder groups to ensure that the effort meets the needs of all Palauans [4].

Although Palauans are more environmentally conscious than people from other countries. However, the dramatic increase in the number of tourists in recent years and the rapid expansion of land development have resulted in excessive soil erosion, and coastal coral reefs are threatened by the sediment pollution from the watershed land. Research shows that natural wetlands used to grow taro can capture 90% of the sediment, prevent excess sediment into the ocean, thereby protect coastal coral reefs and their fisheries. It can serve as a good example of traditional wisdom for the integrated management of watersheds from ridge to reef, covering land use to marine habitats to protect natural heritage [7].

Palau, similar to other countries, was threatened by the impacts of climate change including coral bleaching, heavy rainfall, sea level rise, drought and increased typhoon activity. Palau has already experienced the negative impacts of climate change, including stronger typhoons, altered rainfall patterns and droughts, seawater intrusion into lowland farms and homes, as well as coral mortality caused by ocean acidification, coral bleaching, and typhoon damage. The tourism industry had heavy losses due to coral bleaching endangered marine life and beauty that attract tourists [2].

Palau had made efforts to acclimatize and adapt to the impact of climate change on coral reefs. After the world's first mass coral bleaching event in 1998, in order to understand the impact of ocean warming, the on-site seawater temperature monitoring network was launched in cooperation with the Scripps Institute of Oceanography at the University of California, San Diego. Over the past two decades, more than 70 monitoring sites and more than 150 instruments have been developed, and the accumulated data have been able to predict the possible thermal stress on corals [8]. Long-term monitoring of coral reefs has been established, and results have shown that in the absence of disturbance, it takes at least 9 to 12 years for coral reefs to recover from major bleaching damage to a

healthy state dominated by coral [9]. Corals with high heat tolerance are being studied as a source of restoration or selective breeding to improve the resilience of coral reefs to ocean warming. Through the establishment of the first island-wide map of heat tolerance corals, the heat tolerance genes can be introduced into other populations to enhance corals adapted to the future environment [10].

Conclusion

Palau still has diverse and healthy coral reefs. This conservation achievement is closely related to the effective control of negative impacts of coastal erosion, pollution, damage, and overfishing caused by agricultural and economic development. Although coral reefs damaged by outbreak of crown-of-thorns starfish, coral bleaching, coral disease, sediment, and typhoon in the past. Coral reefs have recovered from most disturbances, showing potentially high resilience. In recent years, monitoring and international surveys have shown that the live coral coverage in Palau is about 50%, and is higher in some marine protected areas, indicates the coral reefs are quite healthy. The experience and wisdom of coral reef research and conservation in Palau is worth learning from us to enhance the sustainable development of coral reefs in Taiwan and around the world.

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One of the World's Largest No-Take Zones: Palau National Marine Sanctuary (PNMS)

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Palau is an archipelagic country located in the western Pacific Ocean. Its territory consists of about 340 volcanic rock islands, with a total land area of about 489.5 square kilometers [1]. Palau's exclusive economic zone (EEZ) covers an area of about 600,000 square kilometers and is home to a diverse ecosystem, containing mangroves, seagrass beds, coral reefs, and lagoons, as well as biological resources such as coral reef fish, corals, giant clams, jellyfish, sea turtles, and dugongs (manatee) [2].

Palau's marine resources have long supported the material life of the people, as well as commercial fishing and tourism [3]. However, affected by climate change and human activities, resources may not be sustainably utilized if they continue to lack proper management [4]. The Wildlife Preserve was established on the 70-island Ngerukewid Islands as a marine protected area in Palau in 1956, when it became the first important milestone in Palau's MPAs. The 1994 Marine Protected Act which bans bumphead parrotfish fisheries was the first marine conservation regulation since the independence of Palau. Since then, Palau has actively developed marine resource conservation programs to protect marine resources, promote eco-tourism, and ensure productivity. A series of marine resource conservation measures including regulations on fisheries were also successively passed. For example, the adoption of the Protected Areas Network Act in 2003 authorizes to establish an ecological network that includes 13 MPAs as of 2013 as the cooperative framework among the central government, the state governments, and other management units [5]. A complete ban on bottom trawling as well as species conservation measures for sharks and sea turtles were also implemented before 2015 [2].

In 2014, the United Nations General Assembly adopted 17 sustainable development goals (SDGs); SDG 14 is related to the conservation and sustainable use of marine biological resources [6]. In response to urgent global marine problems and the dilemma of Palau's own sustainable utilization of marine resources, Palau President, Tommy E. Remengesau, Jr., announced the commitment of establishing the Palau National Marine Sanctuary (PNMS) at the United Nations General Assembly [2].

In 2015, Palau passed the Palau National Marine Sanctuary Act (PNMSA) to establish the PNMS, a no-take marine sanctuary that covers 80% (about 475,077 square kilometers) of the Palau EEZ, while the remaining 20% of the Palau EEZ was designated as a domestic fishing zone (DFZ), only allowing traditional and domestic livelihoods fisheries whose purposes are for food security and for contributing to the domestic market, as well as limited foreign fishery activities [7]. The PNMSA came into effect on January 1, 2020, at the same time, the PNMS and DFZ was officially launched (Figure 1) [8]. With a total ban on fishing within the PNMS and a ban on most foreign fishing vessels in the DFZ, an excellent opportunity was created to test whether Palau was able to ensure food security and economic development in the context of climate change while conserving marine resources, especially when Palau's economic and social life has long relied on marine resources, with 87% of households' main source of income related to fisheries [3][9], and the total number of tourists in 2015 exceeded the local population of Palau by 9 times [3]. Coastal fisheries are mainly reef fisheries carried out by domestic

fishing vessels, and about 865 metric tons of coral reef fish enters the local market every year; fishing activities in the EEZ are mainly carried out by foreign fishing vessels, especially longline fishing vessels from Taiwan and Japan and purse seine fishing vessels from Japan, which altogether provide about 165 to 284 metric tons of offshore fish to the local market in Palau each year; they are also the main sources of offshore fish for the local market [10]. Coral reef fish and sharks are the main ornamental species [3] of coastal and marine tourism. The catch of coral reef fish has declined since 2020, causing pressure for domestic fisheries which began to shift to offshore fish to meet food demand [3]. Through spatial simulation, some studies have pointed out that the number of tuna and sharks migrating in the waters around Palau may decrease in the future [11], creating challenges for Palau in the balance between marine resource conservation and domestic fishery economic development.

The competent authority of the PNMS and DFZ is the Ministry of Natural Resources, Environment and Tourism (MNRET) of Palau. Responsibilities of the MNRET include formulating the conservation, management, and fishing regulations of biological resources in the PNMS and DFZ, coordinating with foreign fishing vessels on the signing of fishing agreements, issuing fishing licenses for foreign fishing vessels in accordance with the law, monitoring the number of fish stocks in the DFZ and setting the total allowable catch, and inspecting catches within the DFZ. Therefore, the Minister of Natural Resources, Environment and Tourism is obligated to submit an annual report on the relevant activities in the Palau waters, including all fishery agreements and licenses, taxation of fishery activities, the quantity and types of fish caught by licensed fishers in the year, the sustainable production yield of fish stocks, and the monitoring activities as well as enforcement situations in the waters of Palau [10]. In terms of the daily maintenance of PNMS and DFZ, the Palau International Coral Reef Center (PICRC), a scientific research unit in Palau, provides relevant information and experience to assist associated units in carrying out marine environmental activities, providing marine environment related educational resources and development programs, as well as assistance to Palauan traditional tribal leaders in implementing traditional conservation measures [7].

Since the passage of the PNMSA, two amendments have been made, in 2017 and 2019, respectively. The latest amendment in 2019 has three points worth noting.

- I. One point is to enhance the functions of the PICRC in PNMS and DFZ, including assisting in research, education, and activities, empowering PICRC as the staff agency of MNRET, and providing advice on conservation and management measures in the DFZ [7].
- II. The second point is to add a tourist tax. Transit passengers are required to pay a US\$100 Pristine Paradise Environmental Fee (PPEF), which replaces the original environmental impact fee. Income from the PPEF is used to give back to the local community; the allocations of the fee are as follows: 5% of the fee goes to Fisheries Conservation Trust Fund, 5% to the PICRC Maintenance Fund, 12.5% to the state governments as tax, 25% to the Palau International Airport, 30% to the Green Fund for Environmental Maintenance, and 22.5% to the national treasury as tax [7].
- III. The third point is to divide the commercial fishery export tax into two categories: tuna/marlin and other types of fish. Tuna/marlin is taxed at US\$0.50 per kilogram, while other types of fish are taxed at US\$0.35 per kilogram [7].

According to the PNMSA and the experience of Palau in the utilization of marine resources, taking substantial management measures may be a necessary means to promote sustainable development. However, the economic losses of local marine users and the supply and demand problem of fish for the local market must be taken into consideration when implementing the measures. The coral reef

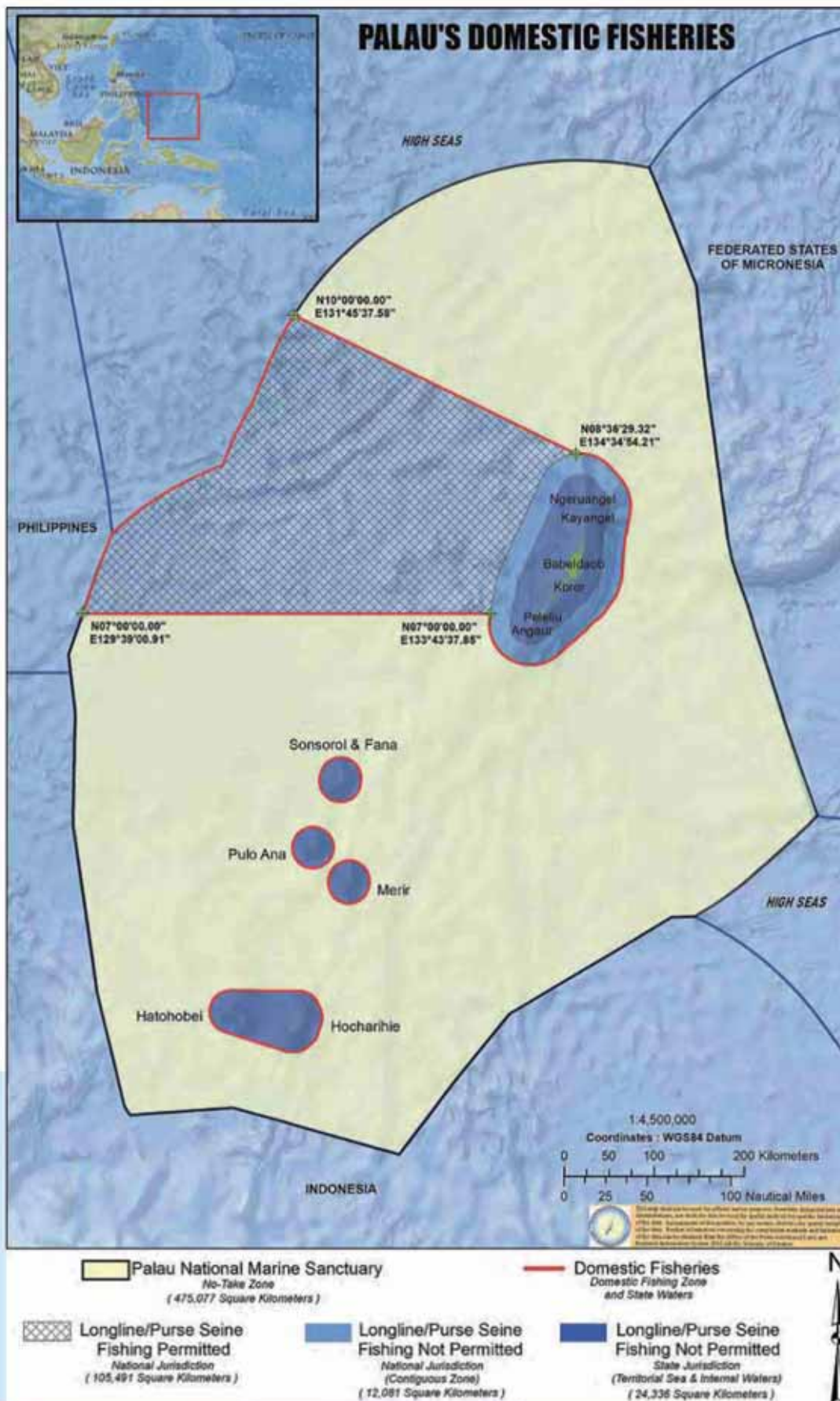


Figure 1 / Palau PNMS and DFZ Zoning Map
Source / [12]

ecosystem supplies common resource for local nearshore fishery and tourism. Once transformed, the reef fisheries may have the chance to create higher value-added fishery products or brands. Current fishery activities in the EEZ are mostly conducted by foreign fishing vessels, and the fostering of talents and fleets of local offshore fisheries may help to alleviate the current outflow of marine resources from the EEZ caused by foreign fishing vessels.

Conclusion

Last but not least, Palau's PNMSA and PNMS show their ambition on conserving marine biodiversity. The design of PNMSA and PNMS could be reference for Taiwan to strengthen relevant laws and plan for a larger MPA network. Both PNMSA and PNMS are new designs, it is worthy to further study their development and effectiveness on marine conservation in the future.

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