

國際海洋資訊

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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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深化國際合作 建立海洋治理與技術之 跨國交流

主任委員：李仲威

海洋廢棄物課題為亞太地區最重視且迫切的環境議題之一，我國於海洋領域積極深化國際合作，海洋委員會於今年（2022）3月24日至25日在國立海洋科技博物館舉辦「APEC運用創新科技監測海洋廢棄物能力建構研習營」，邀請APEC經濟體夥伴分享海廢監測與模擬的創新技術，亦與國際夥伴分享我國「向海致敬」政策結合國內科技產業優勢之創新海洋廢棄物監測與模擬技術，探討跨國夥伴關係的合作效益，並提供各經濟體對於治理海洋廢棄物未來可能發展之方向。

海洋永續發展是全球共同面對的議題，除會議交流外，我國亦與理念相近國家及友邦多方合作，如本期介紹我國友邦帛琉。其中說明我國於2012年起協助帛琉水產養殖之研發與執行，和帛琉農漁暨環境部漁業局共同輔導漁民，建立臭肚魚箱網養殖模式；此外，雙方亦於2019年3月簽署海巡合作協定，進行包括公務互訪、船艦敦睦、訓練經驗分享、國際會議邀訪、共同辦理海上救助及執法演練演訓、共同執行海上聯合巡航、犯罪情資交換等，協助帛琉建構海事安全的能力。

帛琉以海洋觀光聞名於世，其觀光產業占國內GDP 51%、就業人口40%，為維護經濟發展與生態保育間之平衡，帛琉政府採用入境填寫「帛琉誓詞」（Palau Pledge）、永續漁業、《帛琉國家海洋庇護區法》（Palau National Marine Sanctuary Act, PNMSA）、生態旅遊公約與綠色費用徵收、以價制量等政策，積極打造海洋永續的旅遊方式。而帛琉海域珊瑚礁生物極為豐富，帛琉國際珊瑚礁中心（Palau International Coral Reef Center, PICRC）執行永久性珊瑚礁監測計畫，進行珊瑚礁復育研究，亦是重要的海洋研究課題，值得我國參考借鏡。



圖說／帛琉洛克群島

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

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

採訪撰文／鍾嘉雯（台灣經濟研究院助理研究員）

關鍵字／海洋廢棄物、創新科技、監測、模擬

本著APEC 2022年度「開放、連結、平衡」（Open, Connect, Balance）之主題精神，海洋委員會於3月24日至25日在國立海洋科技博物館（簡稱海科館）舉辦「APEC運用創新科技監測海洋廢棄物能力建構研習營」（簡稱APEC研習營），邀請跨國夥伴進行專題演講，介紹創新的海廢監測與模擬技術以及區域夥伴的海廢監測行動方案，並邀請與會者實地參訪，認識我國行動裝置即時辨識海廢的創新系統並實際體驗，期望藉由本次工作坊，與國際夥伴共同達成永續環保的亞太環境目標。



圖1／與會貴賓開幕典禮大合照

圖片提供／海洋委員會

APEC研習營3月24日在海科館國際會議廳揭開序幕，由元智大學高仁山副教授開場介紹工作坊及與會貴賓，開幕典禮則由海洋委員會蔡清標副主任委員、海科館陳素芬館長致詞。蔡副主委表示，在追求經濟與環境共存的議題中，海洋廢棄物已成為亞太地區最重視且迫切的環境議題之一，需要各經濟體攜手共同對海洋廢棄物制定政策及解決方案；我國政府以「向海致敬」作為施政出發點，結合國內科技產業優勢，以技術創新結合海洋廢棄物監測與模擬，可更快速且精準地掌握海洋廢棄物動向，作為治理與清理的依據，希望本次會議能與國際夥伴分享我國的成果。而陳素芬館長則分享海科館從2014年開始對海洋生態保育、監測及工程技術的努力，並歡迎與會者在兩天的工作坊中盡情參訪博物館與周遭的美麗環境。



圖2／海洋委員會蔡清標副主任委員進行開幕致詞（左）、研習營首日專題討論（右）
圖片提供／海洋委員會

創新技術、分享案例：海廢監測與模擬

第一天的主題演講為「源點到同步匯流：創新的海廢監測與模擬技術」（From Source to Sink: The Innovative Technology of Monitoring and Modeling for Marine Debris），由聯合國環境管理小組（Expert Consultant of UN Secretariat of the Environment Management Group, EMG）的專家顧問Patrycja Enet和前聯合國環境署經濟科國際環境技術中心主任的Keith Alverson獨立顧問進行分享。

Patrycja Enet專家顧問分享主題為「由源至匯：海洋垃圾與塑膠污染」（Marine Litter & Plastic Pollution - From Source to Sink）。Enet說明，面對嚴重的海廢污染問題，聯合國提出許多計畫、專案與倡議，且另有14個周邊組織來協助各國及組織來制定必要的法規架構、擬定行動政策、培訓人才等，以及提供系統性的解決方案來減少海洋廢棄物。解決海廢問題必須從監測做起，各國進行資訊交流、知識分享與合作，瞭解海洋廢棄物的來源以及影響，才能有效因應海洋廢棄物污染的挑戰。

Keith Alverson獨立顧問介紹「海中之塑：評估解方」（Plastic in the Ocean: Evaluating Solutions）。Alverson表示，沒有「最佳實踐方案」或「最佳技術」，具體的方案取決於如何克服在地的限制以及面對哪一項塑膠產品，而且每個城市都應該建立一個減量、再利用、回收循環（Reduce, Reuse, Recycle）的廢棄物管理系統，並藉由對塑膠材料流向的持續研究與監測系統來制定政策與行動。

主題演講後，由國家海洋研究院陳建宏院長主持，國立中央大學太空及遙測研究中心曾國欣副教授、美國國家海洋暨大氣總署（NOAA）應變與復原辦公室（Marine Debris Program）Hillary Burgess監測專員、韓國船舶與海洋工程研究所Jung-Yeul Jung首席研究員進行專題討論，主題為「量化海廢—APEC區域內的海廢監測與模擬實務案例分享」（Quantification of Marine Debris: Practice of Monitoring and Modeling in APEC Region）。

曾國欣教授介紹臺灣使用衛星、遠端監測與影像辨識的監測海洋技術以及海廢監測平臺Marine Debris Detection (網址<https://foresight-data.herokuapp.com/debris>)：Burgess監測專員說明NOAA從2006年成立應變與復原辦公室，開始調查及預防海廢帶來的負面影響，並於2011年開始進行海洋監測與評估計畫 (Marine Debris Monitoring & Assessment Project, MDMAP)，透過與社區合作來進行沿海地區的監測；Jung首席研究員則分享韓國利用物件監測演算法 (You Only Look Once, YOLOv5)，來分類及量化海灘上的廢棄物，並且利用衛星圖進行遠端遙測、預估廢棄物漂浮範圍及海底廢棄物數量。



圖3／參訪波流遙測站、操作無人機辨識海洋廢棄物（上）；現場操作並利用手機拍下廢棄物照片，上傳海廢監測平臺（下）

圖片提供／鍾嘉雯（上）、海洋委員會（下）

海廢創新技術應用示範

APEC研習營首日下午延續上午的海廢監測與模擬實務分享，安排海科館的參訪行程以及海洋垃圾監測創新技術應用示範。由主辦單位帶領與會者參訪海科館、潮境公園，以及近岸海域岸基微波

(X-band) 即時波流遙測站，國家海洋研究院海洋產業及工程研究中心賴堅戊研究員，介紹國海院建置之即時波流遙測站，其為微波海洋雷達系統，依據回波影像監測範圍內之海洋特徵及其時空變化。

而曾國欣副教授則帶領團隊實地操作無人機現場辨識海洋廢棄物，並邀請與會者利用手機拍照，上傳海洋廢棄物照片至海廢監測平臺，全臺上傳之海洋廢棄物照片可改善AI電腦的精準度與有效度，讓AI建模更加正確，也邀請所有人共同參與。當天最後邀請與會者欣賞海科館海洋劇場「生物飛行之謎」(Conquest of The Skies) 8K影片。

實踐行動、邁向共創：夥伴合作與協力

次日的主題演講為「最佳實踐—區域夥伴的海廢監測行動方案」(Best Practice-Regional Partnership on Action Plan of Marine Debris Monitoring)，由海洋保育署黃向文署長和美國海洋保護協會(The Ocean Conservancy, TOC) 潔淨海洋計畫Nicholas Mallos資深總監進行分享，探討在海洋廢棄物和海廢技術方面進行國際合作之必要性。

海洋保育署黃向文署長介紹「海洋廢棄物監測和清理行動計畫之夥伴關係」(Partnership on Marine Debris Monitoring and Cleanup Action Plan)，緣起於1986年TOC發起的國際淨灘行動(International Coastal Cleanup, ICC)，而我國的海廢行動則是自NGO組織開始行動，實基於科學依據，並由政府規劃系統性行動。2017年政府及公民團體成立海洋廢棄物治理平臺並共擬海廢行動計畫，2019年則研擬新版之臺灣海洋廢棄物治理行動方案，邀請海洋公民科學家共同參與海廢回收與調查，並於港口設置海洋廢棄物及廢網具暫置區，以便在地漁民回收廢棄漁網；另邀請29家海廢回收再利用業者加入「海廢再生聯盟」，由公私協力建置完善合作機制，共同推動海廢再利用。

TOC的Nicholas Mallos資深總監介紹「建構監控和預防海洋廢棄物之能力」(Building Capacity to Monitor and Prevent Marine Debris)，指出海洋塑膠污染是全球性的議題，因此需要努力減廢至2015年的水準(少於8百萬噸)。而APEC經濟體則是此一問題的要角，由TOC發起的ICC在35年間已於全球募集1,700萬名志工，在153國進行淨灘活動，並且使用統一的ICC表格記錄清除的廢棄物項目，藉此進行全球海廢的熱點與項目統計。另外，廢棄漁具倡議組織(Global Ghost Gear Initiative, GGGI)利用APP彙集全球最多的廢棄漁具數據，並與聯合國糧農組織(FAO)達成協議，開始訪問漁民以蒐集廢棄漁具之資訊。

3月25日之專題討論「邁向共創APEC海廢協力監測平臺」(Toward a Mutual Monitoring Platform of Marine Debris for APEC Region)，由元智大學高仁山副教授主持，印尼海洋事務和漁業部海洋研究中心Devi Dwiyantri Suryono資深研究員、國家海洋研究院賴堅戊研究員、泰國海洋和沿海資源部學術與國際研究處Jiraporn Charoenvattanaporn處長暨漁業生物學家，以及越南自然資源與環境部地質礦產司Nguyen Thanh Thao代理司長等人進行分享。

國家海洋研究院賴堅戊研究員介紹如何利用海洋廢棄物監測系統進行海廢監測和溯源，在全球氣候變遷下，海洋塑膠廢棄物與微塑膠從源至匯的路徑和流向尚不清楚，而臺灣採用海洋雷達技術來監

測海洋廢棄物的流向，包括利用AI技術估算年度的海洋廢棄物熱點並改進淨灘計畫，以及預測海洋廢棄物之流向，並於入海前攔截。Charoenvattanaporn處長介紹「支持政策制定者決策的泰國海廢研究」(The Study of Marine Debris in Thailand to Support the Policy Maker Decision)，包括研究海廢及微塑膠對海洋生物之影響，監測、辨識與標記河口和珊瑚礁上的海洋廢棄物，以及熱點區域的清理和減量。Thao代理司長介紹「越南的海洋垃圾監測」(Marine Litter Monitoring in Vietnam)，參考NOAA、聯邦科學與工業研究組織(Commonwealth Scientific and Industrial Research Organisation, CSIRO)及聯合國教科文組織政府間海洋學委員會(UNESCO-IOC)等研究方法，說明在越南清化省Da Loc commune紅樹林發現的塑膠廢棄物，以微塑膠居多；並撰寫海岸垃圾監測指南，選擇隨機區域蒐集與分類海廢樣本，進行數據分析後更新指南。Suryono資深研究員則分享「支持海洋環境管理的全球海廢監測」(Global Monitoring of Marine Debris to Support Marine Environment Management)，介紹2018年印尼的海洋廢棄物行動計畫，在河川及海岸皆進行監測與清除，也進行社區之環境教育，利用海洋科學研究，瞭解海洋垃圾的來源、組成、密度、動態和分布，最後總結此計畫可以改善海廢之管理機制，也有助於規劃海廢的區域行動。

結語

海洋廢棄物已成為亞太地區最重視且迫切的環境議題之一，本次會議邀請APEC經濟體夥伴分享海廢監測與模擬的創新技術，不僅將我國的成果與國際夥伴分享，亦探討跨國夥伴關係的合作效益，如何透過新興科技減少合作之困難，提供各經濟體對於治理海洋廢棄物未來可能發展之方向，共同見證APEC經濟體間透過數位科技的力量，於海洋廢棄物議題中開放與協作，成功跨越地域限制，克服全球疫情困境，圓滿完成本次研習營。



圖4／與會者現場合影
圖片提供／海洋委員會

國合會在帛琉的援外成果

撰文／蔡明哲（財團法人國際合作發展基金會，駐帛琉技術團團長）

關鍵字／水產養殖、海洋資源復育、永續藍色經濟

隨著第7屆「我們的海洋大會」（OOC）於帛琉舉辦，也讓臺灣長期投入與落實於帛琉的各項技術合作計畫成果，一一展現在80幾個國家及500餘位來自政府、公私部門及非營利組織等機構專家學者面前，共同見證我國對於帛琉與海洋議題的豐碩援助成果。

帛琉人民依海維生，經統計約有80%以上的居民為廣義漁民並從事與海洋相關的經濟漁業活動，帛琉海洋資源局（Bureau of Marine Resources，現今漁業局）更於2008年6月提出了水產養殖和漁業行動計畫（Aquaculture and Fisheries Action Plan），框定帛琉海洋和沿岸資源的永續經濟發展和18項管理行動策略。為回應帛琉海洋發展及管理政策所請，我國即於2012年協助帛琉水產養殖工作之研發與執行。並且，為了擴大援助計畫的廣度與深度，更於2021年起由財團法人國際合作發展基金會（International Cooperation and Development Fund, Taiwan ICDF，簡稱國合會）執行「帛琉水產計畫」（下稱水產計畫），聚焦水產養殖商業模式建立及永續漁業資源建構。截至目前為止，已成功協助帛琉科羅州（Koror）及恩切薩爾州（Ngchesar）進行臭肚魚箱網養殖及商業販售（圖1），且完成當地草蝦苗（*Penaeus monodon*）的繁養殖研發工作[1]。同時，也積極結合理念相近國家共同挹注資源來提升帛琉沿岸漁業資源永續管理能力，更於2022年2月與美國國際開發總署（USAID）共同派員到帛琉考察沿岸漁業資源現況，並與帛琉農漁暨環境部（Ministry of Agriculture, Fisheries, and the Environment, MAFE）Steven Victor部長凝聚臺、美及帛三方未來合作共識。



圖1／水產養殖為帛琉新興的藍色產業，恩切薩爾州的臭肚魚箱網養殖更是當地重要海水魚養殖經濟物種
圖片提供／駐帛琉技術團

帛琉水產養殖發展

為因應帛琉提出海洋相關管理方針，日本於2019年協助帛琉成立海水養殖示範中心（Palau Mariculture Demonstration Center），長期派駐水產養殖專家執行帛琉當地碑礫貝繁育工作，並提供沿海碑礫貝養殖場所需種苗，以維持當地糧食安全。但碑礫貝常遭掠食者捕食，導致實際活存率

低，影響後續商業模式建立，致目前帛琉60%以上的硨磲貝養殖場陸續歇業。有鑒於此，帛琉進一步著手重組與推動更務實與積極的海洋專責部會與一系列政策，來促進帛琉在地化「藍色經濟」的轉型與永續發展。

帛琉總統惠恕仁（Surangel S. Whipps, Jr.）於2021年4月的第1次國內施政報告中表示，MAFE工作重點為加強國內漁業管理，並透過該部重組後的局室分工，加強帛琉從海岸線到專屬經濟海域（EEZ）的永續漁業發展，進一步確保糧食的永續來源，同時也為COVID-19疫後復甦預做準備。

帛琉政府於同年10月5日頒布第463號行政命令進行組織改造，並定義MAFE機構功能與納增海洋資源局的功能性與轄管職責。MAFE職責為探索、調查開發、管理及保護帛琉所有沿近岸海洋資源，首任部長由前自然保護協會（The Nature Conservancy, TNC）主席Mr. Steven Victor擔任並領導該部運用永續生態模式增加漁業和農業產量來支持帛琉人的生計，同時兼顧環境保護的工作。

臺灣駐帛琉技術團依循帛琉國家漁業發展需求，與MAFE下漁業局攜手合作，於「帛琉國家水產中心」（Palau National Aquaculture Center）挑選當地保（復）育及具商業潛力之海水養殖品種進行研發、繁育及推廣等工作，並且致力於輔導帛琉漁民建立臭肚魚箱網養殖模式，以提高漁民收入及增加當地糧食生產為主要計畫目標。

臺灣駐帛琉技術團水產計畫，現已輔導4戶核心養殖戶建構商業化臭肚魚海上箱網養殖模式。透過一對一的養殖教育訓練，如箱網維護、飼料投餵訓練及建立飼養記錄等，提升臭肚魚養殖戶單口箱網養殖產能達38%，產量增加使得推廣戶收入提升16%。為進一步提升帛琉藍色經濟產業發展與茁壯，臺灣駐帛琉技術團未來將持續運用臺灣海水繁養殖之優勢技術，協助建構當地臭肚魚苗、虱目魚苗及草蝦苗生產模式。除此之外，為減輕帛琉沿岸魚類過度捕撈問題及保育珍貴海洋資源，水產計畫配合帛琉漁業局及地方州政府進行臭肚魚苗放流（圖2），提升沿岸漁業資源永續韌性。

位於帛琉巴貝圖阿普島（Babeldaob）東邊的恩切薩爾州，為水產計畫推廣臭肚魚箱網養殖規模最大的養殖區，州長Mr. Richard Nigiratrang表示在臺灣駐帛琉技術團的輔導下，水產養殖產業已逐漸茁壯成長並增加該州額外收入。箱網養殖的肥美臭肚魚售價為市場價格的2倍（每磅4美元），每到收成日，岸邊擠滿搶購臭肚魚的人潮，魚產經常是供不應求的狀況。州政府也表示現有養殖規模雖不足以支撐該州養殖成本收益，但未來將積極尋求水產養殖基地建立及擴展養殖規模，並願意持續投入州政府資源來維持養殖發展工作之進行。

臺灣駐帛琉技術團不僅和帛琉政府部門合作執行計畫，未來也將透過結合國際組織、帛琉學術單位及民間部門研發技術與資源，協助帛琉全面提升水產養殖產業發展，為帛琉後疫情時代的國內觀光市場需求及海洋資源保育預做準備，讓具有「上帝水族箱」美譽的帛琉得以在國際上永續發光發熱。

帛琉的海洋資源策略與規範

帛琉在 2009 年議會通過《鯊魚保護法》（Shark Haven Act），禁止在帛琉領海、鄰接區以及 EEZ 進行商業性捕鯊或割鰭作業，續於 2012 年頒布帛琉國內漁業法規（Palau Domestic Fishing Law）[2] 來規範帛琉國內海域漁獲捕撈，其中包含各類魚種、漁法以及相關出口限制等規定（表 1）。也於 2015 年時通過《帛琉國家海洋庇護區法》（Palau National Marine Sanctuary Act, PNMSA），爾後帛琉 EEZ 的 80% 劃作海洋保護區，全面禁止在保護區內所有開發行為，包括捕撈及開採，其餘的 20% 區域則劃為「國內漁捕區」（Domestic Fishing Zone, DFZ），僅供國內漁獲需求及相關有限的商業捕撈。此舉雖一躍成為全球的典範，但帛琉議會也意識到如此嚴峻的保護限制已成為帛琉漁業經濟發展的重大阻礙，因此，慮及在地漁民的經濟利益，已在 2019 年通過修正法案，鬆綁帛琉漁民在 DFZ 的作業限制，也允許當地居民進行適度的開發與運用。

目前帛琉於漁業資源管理政策方向仍有爭議，帛琉中央政府、地方政府及傳統領袖對於漁業資源管理與海洋資源保育，分別持有不同的看法。舉例來說，帛琉全國設立 16 個州並存有傳統領袖設立保護區的傳統保育「Bul」的概念，各州及其傳統領袖依其傳統規範與傳統知識進行區域性保育活動，以致保護區存在模糊規範地帶與問題，中央政府僅能不定期以巡邏船監測來防止非法捕撈作業。

兩年多來疫情衝擊帛琉賴以維生的觀光產業，導致帛琉重要經濟來源收入下滑，影響國家收入及人民生計。針對經濟上的重大影響，帛琉中央政府目前想適度放寬漁撈規範，並透過明確有效的沿海漁業資源監控機制，來探討開放經濟捕撈區的可能性，以達兼顧保育、經濟及資源永續的三贏策略。



圖2／長鰭鬼肚魚苗放流活動，取經自臺灣漁業沿岸重點經濟魚苗放流經驗，臺灣每年針對不同沿岸魚類進行魚苗放流
圖片提供／駐帛琉技術團

表1／帛琉各海洋物種的規範與捕撈季節（依2012帛琉漁業規範更新）

物種	捕撈區域	捕撈限制原因	禁捕期
棕點石斑魚 Meteungerel'temekai (<i>Epinephelus fuscoguttatus</i>)	全禁止	繁殖季	4至7月
清水石斑魚 Ksau'temekai (<i>Epinephelus polyphekadion</i>)	全禁止	繁殖季	4至7月
藍點鰐鯢 Tiau (<i>Megaptera novaeangliae</i>)	全禁止	繁殖季	4至7月
鰐鯢 Tiau (<i>Plectropomus leopardus</i>)	全禁止	繁殖季	4至7月
橫斑刺鰐鯢 Mokas (<i>Plectropomus laevis</i>)	全禁止	繁殖季	4至7月
臭肚魚 Meyas (<i>Siganus canaliculatus</i>)	全禁止	繁殖季	2至3月
陸頭鸚哥魚 Kemedukl, berdebed, fahorari hamaduhiri (<i>Bolbometopon muricatum</i>)	全禁止	數量稀少	全年
曲紋唇魚 Maml (<i>Cheilinus undulatus</i>)	全禁止	數量稀少	全年
水族觀賞魚	全區域	永續資源	許可證 20張上限
龍蝦 Rock lobsters a. 雜色龍蝦 Bleiached (<i>Panulirus versicolor</i>) b. 密毛龍蝦 Raiklius (<i>Panulirus penicillatus</i>) c. 長足龍蝦 Melech (<i>Panulirus longipes femoristriga</i>)	全區域	甲殼總長度 3.5英寸	捕撈規格 限制
紅樹林蟹 Mangrove crab Emang (<i>Scylla serrata</i>)	全區域	18個月大外殼 6英寸	捕撈規格 限制
椰子蟹 Coconut crab Ketat, yefi (<i>Birgus latro</i>)	全區域	甲殼4英寸	捕撈規格 限制
海龜 Sea turtles a. 綠蠵龜 Melob, woru green turtle (<i>Chelonia mydas</i>) b. 玳瑁 Ngasech, hachab hawksbill turtle (<i>Eretmochelys imbricata</i>)	全區域	甲殼長度34 英寸、雌龜 與玳瑁	1、5至 8及12月
磚磙貝 Giant clams a. 大磚磙 Otkang (<i>Tridacna gigas</i>) b. 鱗磚磙 Ribkungal (<i>Tridacna squamosa</i>) c. 扇磚磙 Kism (<i>Tridacna derasa</i>) d. 長磚磙 Melibes (<i>Tridacna maxima</i>) e. 圓磚磙 Oruer (<i>Tridacna crocea</i>) f. 菱磚磙 Duadeb (<i>Hippopus hippopus</i>) g. 瓷口磚磙 Duadeb (<i>Hippopus porcellanus</i>)	全區域	禁止出口	禁止出口
珠母貝 Blacklip pearl oyster Chesiuch (<i>Pinctada margaritifera</i>)	全區域	外殼直徑 4英寸	8至12月
鐘螺 Trochus 馬蹄鐘螺 Semum (<i>Trochus niloticus</i>)	全區域（或 依州規範）	底部直徑 超過3英寸	捕撈規格 限制
海參 Sea cucumbers a. 烏圓參 Bakelungal-chedelkelek (<i>Holothuria nobilis</i>) b. 黃乳海參 Bakelungal-cherou (<i>Holothuria fuscogilva</i>) c. 糙海參 Molech (<i>Holothuria scabra</i>) d. 白底輻肛參 Bachelid (<i>Actinopyga mauritiana</i>) e. 烏皺輻肛參 Eremrum (<i>Actinopyga miliaris</i>) f. 梅花參 Temetamel (<i>Thelenota ananas</i>)	全區域	無規定	禁止出口
儒艮 Dugong Mesekiu (<i>Dugong dugon</i>)	禁止	族群數稀少 (50至100)	禁止
海綿、硬珊瑚及海岩石 Sponges, hard corals and marine rock	禁止	重要棲地環境	禁止出口

資料來源／Palau Domestic Fishing Laws (2012) [2]

帛琉崛起藍色經濟願景

帛琉自2021年設立MAFE以來，積極構思除漁獲捕撈外的可行經濟收入替代方案，並藉由辦理第7屆「我們的海洋大會」（00C）會議期間呼籲藍色經濟發展與生態平衡的重要性，也期盼透過科學研究調查來有效管理與監控海洋資源。帛琉觀光經濟可以說是完全仰賴海洋資源，故帛琉商會（Palau Chamber of Commerce）副主席Ms. Irene Olkeriil不斷強調帛琉政府需提出沿海漁業資源永續的長遠解決方針，呼籲應透過水產養殖方式來進行漁業資源補充及提供商業觀光內需，以降低沿海漁業資源的衰退速度。此外，帛琉傳統文化甚少有女性參與實際的漁業工作，倘能提供當地女性參與水產養殖工作的機會與訓練，也可以提高當地女性參與漁業的比例，共同為當地漁業發展盡一份心力。

國合會除了派遣駐帛琉技術團執行水產計畫外，更提出4項承諾以回應本（第7）屆00C，包括「永續小型漁業與水產養殖」、「解決海洋污染」、「以海洋為核心的氣候變遷解決方案」以及「創造藍色經濟」等4大行動領域，並獲00C審核通過，總投入金額達1,200萬美元，展現臺灣協助友邦推動社會、經濟及環境的永續發展，並為海洋環境保育貢獻心力的決心[3]。

結論

回顧臺灣水產養殖歷史可以回溯至17世紀末，始於1960年代陸續確立各種人工繁養殖技術[4]及於1980年代開創草蝦養殖王國的封號，另我國援外發展更已超過一甲子，其中水產技術援外計畫曾擴及中南美洲、加勒比海、非洲、中東及南太島國等區域國家，也從最基本「食」的需求，提升到顧及「膳食營養」及「商業模式」的質與量產技術建立。國合會透過執行各項技術合作計畫，協助理念相近國家與友邦屢屢突破技術瓶頸，而帛琉的海洋保育與水產養殖發展，更在國合會的水產計畫投入下，已達到臭肚魚、草蝦人工養殖及海龜保育等重要里程碑，未來臺灣駐帛琉技術團將與帛琉政府及各國際組織外部資源更緊密進行合作，增加技術及資金投入，朝強化帛琉海洋永續發展的目標邁進。

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帛琉海洋觀光產業

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關鍵字／帛琉、海洋觀光、永續旅遊

世界經濟合作發展組織（OECD）指出，海洋資源及相關產業活動的經濟產值，估計每年為全球增加1.5兆美元的產值，每年提供280萬個就業工作；而海洋觀光（maritime and coastal tourism）就占了26%（OECD, 2016）。如何兼顧海洋經濟發展與環境資源之開發利用，達到持續促進永續海洋產業目標，已是現今極為重要之議題。

擁有豐富海洋自然環境資源的帛琉共和國（Republic of Palau），是全球3大夢幻島嶼度假地之一，自1985年開放觀光至今，觀光產業已占國內生產毛額（GDP）51%^[1]、稅收總額的15%、就業人數的40%；相對地也造成當地環境承受極大的壓力。當永續旅遊已成為全世界觀光的主流趨勢，2017年帛琉首創以「帛琉誓詞」（Palau Pledge）作為遊客入境程序，提醒每一位旅人尊重與愛護當地的環境資源，並頒布各項環保法令，為海洋永續提出解決之道。帛琉在積極發展海洋觀光之同時也維護在地自然環境，塑造島嶼國家發展永續海洋觀光產業新型思維。

帛琉自然環境與經濟活動

帛琉是由340多個火山岩小島組成的群島國家（其中只有9個島嶼有人居住），地處西太平洋密克羅尼西亞群島，土地面積489.5平方公里^[2]。大部分的島嶼都被堡礁（barrier reefs）和裙礁（fringing reefs）所環繞，形成了一個深度多元的廣闊潟湖，面積超過1,200平方公里^[3]。帛琉的珊瑚礁多樣性，與菲律賓、印尼、澳洲的最高珊瑚礁多樣性區域相當^[4]。帛琉的珊瑚礁魚類的數量更是超過1,300種並且還擁有700多種珊瑚和海葵、13種鯊魚，以及瀕危的海洋哺乳動物「儒艮」（Dugong）。

被譽為「海上花園」之洛克群島（Rock Islands），位於帛琉群島中段，由隆起的珊瑚礁組成。2012年洛克群島南部潟湖（Rock Islands Southern Lagoon）被登錄為世界遺產，此島區因有海灣泥



圖1／海洋觀光遊憩是帛琉最具吸引力的旅遊行程
圖片提供／林饒愷、Belau Diving

沙淤積產生的潟湖，形成獨特的生態系統，再加上綠意盎然的珊瑚礁環繞著碧藍清澈的海水，是海洋觀光最精華的區域。遊客在湛藍的海洋中，與水母、鯊魚、海豚共遊，划著獨木舟探索環礁與紅樹林間之自然奧秘，搭乘直升機鳥瞰蕈狀礁岩之大自然傑作，以及在無人島雪白的貝殼沙灘上享受陽光，是帛琉最具吸引力的海、陸、空三棲遊程（圖1）。

帛琉旅遊人口成長，導致基礎建設、資源與環境承受極大壓力

根據統計，2005年至2015年的帛琉遊客人數暴增，2016年更高達15萬人次，較2010年成長70%。遊客暴增導致潛點出現過於擁擠、潛水客與遊客踩踏及觸摸珊瑚之亂象叢生；此外，遊客為了與海洋生物互動，追逐海龜，餵食珊瑚礁魚類等不當行為，使得魚類減低啄食珊瑚礁藻類與植物碎屑等攝食活動，造成珊瑚礁因藻類滋長附著而死亡，在在均加速了珊瑚礁衰退的情況。

1994年後，帛琉不再依循美國保育政策，發生了使綠蠵龜、椰子蟹與狐蝠等瀕危物種成為遊客餐桌上的食材、遊客對玳瑁、砵磤貝與鐘螺等具地方特色的「生物寶石」製品情有獨鍾，以及大量的遊客對民生用水與海鮮食材的需求日益增加，使沿海地區過度開發並帶來日益嚴重的污染與廢棄物問題。雖然旅遊業對當地收入貢獻很大，提供沿海社區居民許多就業機會，但是也帶來了許多生物保育與環境保護等挑戰。

帛琉海洋保育政策與海洋遊憩資源保護

一、永續漁業政策

帛琉海域漁業資源豐富，其與周圍8個鄰國擁有全球第3大的鮪魚漁場，鮪魚捕獲量占全球一半以上，每年約有40億美元的產值。早期，外國漁船只需付低廉的「入漁費」就可進入該海域捕魚，但這卻只能為帛琉政府帶來每年約500萬美元的微薄漁業利益。之後，帛琉身為太平洋島嶼論壇（PIF）的加盟國，為了保護當地漁業資源，強制外國漁船裝設船舶監控系統（VMS），監督漁船動態及漁獲通報，禁止有漁業合作之外國籍漁船在沿岸24浬海域內進行漁撈作業，對鯊魚的捕撈及混獲訂立極高的罰則。若發現有違法切割鯊魚魚鰭、魚尾或身體任何部分，違者最高可以處罰25萬美元。

「BUL」是帛琉自古流傳的「禁漁」傳統，藉由推估魚群的產卵期，在繁殖期間關閉該區海域。「BUL」可讓海洋生物順利繁衍，是傳統保育自然資源的良方。2015年帛琉總統簽署《帛琉國家海洋庇護區法》（Palau National Marine Sanctuary Act, PNMSA），將80%的帛琉專屬經濟海域（EEZ）範圍，約475,077平方公里，劃設成為海洋庇護區（Marine Sanctuary）禁止商業捕撈，用以保育及復育庇護區內的魚群及鯨豚等，其餘20%的海域僅供當地漁業、遊客垂釣，以及部分外國漁業活動等使用。政府透過衛星監控庇護區內漁船動態，並分析船舶路徑監控庇護區，並嚴格禁止拖網、電魚、炸魚，以及水肺潛水打魚等漁捕行為。這些作為使海洋庇護區內的魚群數量，在短短2年內就恢復到未規劃庇護區時的2倍，生態復育的成效頗為驚人（圖2）。



圖2／海洋保護區生態復育成效驚人
圖片提供／林曉憶、Belau Diving

二、設立專屬保護區

帛琉政府為了保護海洋生態並兼顧經濟發展，積極推動生態旅遊及海洋休閒遊憩活動，成立海洋保護區（Marine protected areas, MPAs），已成為帛琉政府最成功之海洋保育政策。最早，在1956年，創立Ngerukewid群島野生動物保護區。接續頒布《海洋保護法》（Marine Protection Act）、《國家保育法》、《保護區網路》（Protected Areas Network）與《帛琉國家海洋庇護區法》，並相繼成立「鯊魚保護區」、「海洋哺乳動物保護區」與「海洋禁捕區」。

以帛琉成立全球第1座「鯊魚保護區」為例，禁止水域內所有商業性獵捕鯊魚，讓17種鯊魚在此保護區內安心成長繁衍。保護鯊魚成為一個重要吸引遊客的觀光亮點，每年專程前來和鯊魚共遊的遊客，約有8,600人，透過潛水旅遊所產生的經濟價值約1,800萬美元，比起捕撈、殘殺這些鯊魚所得到僅有10,800美元的經濟價值，相差甚遠。

除了鯊魚保育之外，為了養護受傷海豚，於2001年耗資約250萬美元建造的太平洋海豚灣（Dolphins Pacific）海豚研究中心，發展出「觸摸海豚」與「海豚共游共潛」等特色體驗遊程，提供遊客瞭解海豚生態習性。帛琉海域曾經紀錄約有2,000隻儒艮，目前估計僅剩50至200隻。帛琉透過「Ngederrak儒艮保護區」之設置，使儒艮群數量緩慢增加。海洋是最大的碳匯體（carbon sink），海洋浮游植物可比4座亞馬遜雨林，吸收地球40%碳排量，帛琉環礁區蘊藏豐富的海洋植物和海洋生物，大多數的島嶼限制遊客登島，進而保育保護區內珍貴的海洋資源。

三、推動生態旅遊公約與徵收綠色費用

帛琉總統在成立海洋保護區後，表示「他的國家要推動潛水、浮潛和生態旅遊，作為降低商業捕

撈的替代收入」。生態旅遊的推動，除進行負責任與保育的旅遊方式外，並期望同時能給予當地社區和生態系統益處。因此，帛琉政府訂立「社區發展生態旅遊公約」，進行遊客總量管制措施，培養在地居民成為解說員及生態旅遊種子教師，活動前後對遊客施行環境教育，並將營利所得之20%作為「回饋社區基金」，以提供推展環境教育、生態保育及社區福利之用。

相較於生態旅遊，一般的遊程對促進環境保護及增加社區利益之成效有限，但帛琉政府針對從事以海洋為基礎的觀光休閒活動（如潛水與浮潛等），向遊客收取15美元的環境稅（Green fees），以提供環境基礎設施改善（如污水處理）之經費。在機場徵收每位遊客100美元的環保稅（Pristine Paradise Environmental Fee, PPEF），作為政府維護海洋保護區的費用及支持國內各機構運作。遊客出海及到水母湖潛水，也要繳100美元的許可證申請費用，除掌握進入水母湖的人數外，也能作為水警巡邏及日常的維護費用。

四、以價制量，歡迎尊重帛琉環境的高消費遊客

帛琉總統於2018年4月的聲明中強調：「透過極大化投資收益（生態與環境保育），以及多樣化的觀光客來源，我們將能一次拾回我們對於高價值觀光的願景。」期待的觀光客是可以待久一點、消費多一點，並且能夠尊重帛琉的環境。因此，提出議案：「要提高遊客消費水準，只允許高端、高價的渡假村和旅館在島上設立，且為了高消費的遊客應規劃相對應的休閒活動。」對於投資高品質觀光事業的外商，提供最高達40%的租稅減免，全力打造高端、高價值、低環境衝擊的觀光環境。以2015年大量旅客湧入帛琉觀光為例，短時間湧入大量的旅客導致島嶼的環境惡化，迫使帛琉政府採取航班減半之策略來減少遊客湧入人數。

五、帛琉政府永續觀光政策

帛琉首創以「帛琉誓詞」作為遊客入境程序。要求旅客在入境時必需在護照上簽署此誓言，並於飛往帛琉的航班上播放《巨人》宣傳影片及分送相關資料袋，強調違反誓詞行為最高罰款100萬美元。帛琉政府拍攝《巨人》宣傳影片，暗示外來的遊客像片中的巨人一樣，隨意破壞帛琉生態，因此當地小朋友不願和巨人做朋友。因為當地生態一旦遭到破壞，往往需要好幾年的時間，才可能恢復正常。藉由推廣觀光的同時，也能傳達當地自然環境保護與生態保育的觀念。

帛琉政府為延續並鼓勵遊客持續實踐永續旅遊，推出「Ol'au Palau」App，為全球首款可記錄旅人足跡的App。藉由此App累積「永續行為」的點數，包含：使用友善海洋防曬乳、食用在地食材生產的料理、避免使用一次性塑膠產品、回答帛琉環境及文化層面的問題，以及造訪具有重大歷史意義的景點等行為，換取帛琉以往未曾提供過的深度旅遊行程。並且，於旅遊過程中，規範禁用塑膠餐具，以植物編織成碗盤來施行「無痕飲食」（Traceless Diet），落實更永續旅遊的消費行為。

帛琉政府針對外國人投資提出《外人投資法》（The Foreign Investment Act）與《外人投資法施行細則》，明定旅行導遊、釣魚導遊、潛水導遊、水上運輸服務業及旅遊業等，限由帛琉人經營或

由帛琉人持股51%以上與外人合資企業經營。為避免外國投資者以營利為目的，進而犧牲帛琉當地自然資源與生態環境，因此外商投資需取得「外商投資許可證」外，申請某些涉及環保項目者，尚需獲得「環境品質保護委員會」（Environmental Quality Protection Board, EQPB）或帛琉「海事局」（Palau Maritime Authority, PMA）之許可執照。違反規定私自營業者，處1年以上徒刑或併科25,000美元以上罰金。以避免外國投資者以營利為目的進而犧牲帛琉當地自然資源與生態環境。

表1／帛琉保育大事記

年 代	政 策 與 做 法
1956 年	創立Ngerukewid群島野生動物保護區
1994 年	通過《海洋保護法》（Marine Protection Act）
1996 年	頒布《國家保育法》，保護陸地和海洋野生動物
1998 年	制定保護海龜的法規
2003 年	《保護區網路》（Protected Areas Network）為帛琉建立保護區框架，並獲得技術援助、監控資金 帛琉13個州設置至少26個保育區
2006 年	承諾2020年至少保護30%的海洋環境和20%的陸地環境 禁止底部拖網捕撈
2009 年	帛琉建立了世界上第1個鯊魚保護區 向每位觀光客收取15美元環境稅（Green Fee）
2010 年	帛琉宣布建立海洋哺乳動物保護區
2012 年	洛克群島南部潟湖成為聯合國教科文組織世界遺產
2013 年	《儒艮保護法》（Dugong Protection Act）簽署為法律
2014 年	總統在聯合國會議宣布對帛琉國家海洋庇護區（PNMS）的承諾
2015 年	簽署《帛琉國家海洋庇護區法》（PNMSA）
2017 年	水母湖內的黃金水母大量減少，暫關閉近兩年進行復育 帛琉首創以「帛琉誓詞」（Palau Pledge）作為遊客入境程序
2018 年	於離境外籍旅客之機票內增收環保稅（PPEF）100美元 通過全面禁止進口或販售有害化學物防範產品，觀光客若攜帶被禁止的防範產品會被帛琉海關直接沒收
2020 年	設立帛琉國家海洋庇護區（PNMS），由帛琉的自然資源、環境及觀光部、司法部及帛琉國際珊瑚礁中心共同承擔運作職責。前兩者制定管理規則與法律支援，後者負責科學性的研究工作和教育活動

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帛琉海洋事務機構：致力海洋保育和永續旅遊為本的海洋治理

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關鍵字／帛琉、海洋事務機構、海洋保育、永續旅遊、海洋治理

帛琉（Republic of Palau）擁有豐富多元的海洋生態系，觀光是國家重要的產業。為保護海洋環境和確保觀光永續發展，海洋事務相關機構－「農漁暨環境部」的漁業局和環境局、觀光局，以及海事安全和魚類暨野生動物保護處－各司職掌，分別掌管漁業、環境保護、負責任旅遊，以及海上執法等業務，並訂定明確的政策和管理措施，包括《保護區網路法》、《帛琉國家海洋庇護區法》、禁止使用和製造對珊瑚有害的防曬產品等。尤其，自2020年1月1日起80%的專屬經濟海域（exclusive economic zone, EEZ）（面積達475,077平方公里）納入國家海洋庇護區，禁止任何漁捕活動，顯示帛琉政府致力海洋保育的決心，建立以海洋保育與永續旅遊為品牌的國家。

帛琉政府體制簡介

帛琉是一個島嶼國家，人口約1萬8千人，位於西太平洋密克羅尼西亞群島，由340多個火山岩小島組成，陸地總面積489.5平方公里[1]。帛琉的海岸線長約1,519公里，大部分由珊瑚礁圍繞著，其專屬經濟海域（EEZ）面積約60萬平方公里[2]。帛琉擁有豐富多樣的海洋生態系，包括珊瑚礁、紅樹林、海藻床、沙灘，以及舉世聞名的水母湖，其中約有1,300種魚類、超過700種珊瑚，以及162種鳥類[3]。

帛琉是民主共和國，有16個州。政府體制為三權分立總統制，總統為國家和政府的最高元首，每4年由人民選舉產生。現任總統為惠恕仁（Surangel S. Whippa, Jr.），於2021年1月21日就任。內閣（2017-2021）設有8部，部長由總統任命並須經國會同意，分別是國務部（Ministry of State）、司法部（Ministry of Justice）、公共基礎暨產業部（Ministry of Public Infrastructure and Industries）、財政部（Ministry of Finance）、衛生暨公共服務部（Ministry of Health and Human Services）、教育部（Ministry of Education）、人力資源、文化、觀光及發展部（Ministry of Human Resources, Culture, Tourism & Development），以及農漁暨環境部（Ministry of Agriculture, Fisheries, and the Environment, MAFE）[4]。

在帛琉政府機構中，與海洋事務相關的機構包括「農漁暨環境部」轄下的「漁業局」（Bureau of Fisheries）和「環境局」（Bureau of the Environment），「人力資源、文化、觀光及發展部」轄下的「觀光局」（Bureau of Tourism），以及「司法部」轄下「公共安全局」（Bureau of Public Safety）的「海事安全和魚類暨野生動物保護處」（Division of Maritime Safety and Fish & Wildlife Protection）。本文介紹該等單位及海洋相關政策和規定，以瞭解帛琉海洋治理的內容。

海洋事務機構

一、農漁暨環境部

農漁暨環境部（MAFE）是帛琉主要的海洋治理機構，主責農業、漁業和環境，致力使帛琉成為糧食安全的國家。該部治理的4個核心價值為人民、環境、科學和服務；治理方法涵蓋6個面向，包括政策、機構能量、應用導向的研究和發展、推廣服務、進入市場，以及知識管理。MAFE轄下設有農業局、漁業局和環境局[5]，其中以漁業局和環境局的工作職掌和海洋事務較為相關。

「漁業局」掌管探測、調查、發展、管理和保育近岸（near shore）和近海（offshore）海域的海洋資源，下設有3個處，分別是「養殖處」、「沿海漁業處」（coastal fisheries），以及「大洋漁業處」（oceanic fisheries）。各處的主管項目分述如下：

- **養殖處**：研發養殖技術、培育水產種苗和仔魚、促進永續和經濟可行的養殖漁業發展、提供養殖戶技術和推廣服務，以及建立養殖戶資料庫。
- **沿海漁業處**：規劃、發展和管理沿海漁業；協助擬訂沿海漁業管理計畫；收集重要的沿海漁業資料；參與沿海海洋資源研究和監測活動；探討和研究漁業永續發展；持續聚魚器（Fish Aggregation Devices）計畫；建置從事沿海漁業漁民的資料庫；以及研擬合適的沿海漁業捕撈控制規則和規定。
- **大洋漁業處**：探測、調查、發展、管理和保育近海生物及非生物資源；建立總允許捕撈量和限制漁獲努力量；分配捕魚天數；協商和核發漁捕協議文件；協助國內發展近海漁業。

「環境局」掌管自然環境保護和稀有生物保育，下設有2個處，分別是「保護區和保護物種處」和「森林、陸地和水資源管理處」。前者之職掌與海洋事務較為相關，主管項目包括：保護生物多樣性、維持重要生態系的功能，以及透過保護區網路的建置，維護文化和自然資源；研擬國家型計畫，使用合宜手段，提升保護區的效果；促進關鍵指標物種的研究和管理；透過夥伴合作，致力瀕危物種的保護；控制和根除（如果可能的話）外來物種；協調保護區網路辦公室（Protected Area Network Office）。

為保護漁業資源及有效管理保護區，帛琉政府近年來採取許多措施，例如，2003年通過《保護區網路法》（Protected Areas Network Act），建置全國保護區網路，並設立一個獨立的非營利組織——保護區網路基金（Protected Areas Network Fund, PAN Fund）。該基金設有保護區網路辦公室，負責執行保護區管理工作。帛琉所有16州都有加入保護區網路，目前總計有29個海洋保護區和10個陸地保護區加入[6]。保護區網路基金（PAN Fund）的經費，部分來自國際旅客需繳納的環保稅（Pristine Paradise Environmental Fee, PPEF）。自2018年1月1日起，每位旅客需繳納100美元環保稅[7]，並且其中的30美元用於保護區網路[8]。此外，2015年通過《帛琉國家海洋庇護區法》（Palau National Marine Sanctuary Act, PNMSA），自2020年1月1日起，80%專屬經濟海域（EEZ）（面積475,077平方公里，約13個臺灣面積）納入海洋庇護區，禁止任何形式的採捕性活動，包括漁

業活動；其餘20%專屬經濟海域（EEZ）為國內漁捕區（Domestic Fishing Zone, DFZ，117,572平方公里），供商業捕撈及國內漁業活動[9]。

二、觀光局

「觀光局」轄屬於人力資源、文化、觀光及發展部。帛琉觀光產業產值占國內生產毛額（Gross Domestic Product）高達51%[3]。帛琉擁有世界一流的珊瑚礁生態，每年吸引許多國外旅客前來從事潛水、浮潛等水上活動。政府以推動發展高端旅遊（high-end tourism）為經濟發展重點。帛琉的觀光活動和海洋環境息息相關，因此觀光政策和法規為該國海洋政策重要的一環。

觀光局於2016年訂定「責任旅遊政策綱領」（Responsible Tourism Policy Framework），以推動責任旅遊，促進觀光永續發展。該綱領明示責任旅遊的願景為「原始的天堂－所有人的帛琉（A pristine Paradise. Palau for everyone.）」[3]。該綱領明訂多項管理措施，茲將觀光相關的管理措施和法規摘列如下：



圖1／帛琉29個海洋保護區和10個陸地保護區
圖片來源／<https://www.palaupanfund.org/pan-sites.html>

- 中央政府、州政府和私部門團體共同協調有關旅遊發展、管理、執法和行銷等事項。
- 建立旅遊地管理系統，收集市場資訊、社經和環境衝擊等資料，以作出有效決策及必要的政策改善。
- 建立永續承載量範圍，決定環境、文化和社區的可接受衝擊程度。
- 合宜課徵使用者費，以減少低端旅遊市場。
- 提供誘因鼓勵高價值住宿和設施的投資，以及既有設施的再投資。
- 訂定適合帛琉環境的建築法規，並確實執法。
- 提高資源回收，並鼓勵社區和業界參與。
- 透過教育和公私部門協力，逐步淘汰用於包裝和顧客活動的塑膠袋。
- 觀光船舶船主協會管理規定（Regulation Governing the Boat Owners Association for Tourism）。
- 旅遊業管理規定（Regulation Governing Tour Operators）。
- 責任旅遊教育法（Responsible Tourism Education Act of 2018）。
- 防曬乳液法規（Sunscreen Regulations），自2020年1月1日起禁止進口、製造和販售對珊瑚有毒的防曬乳液[10]。
- 遊客入境時，必須在護照上簽署「帛琉誓詞」（Palau Pledge），承諾於帛琉期間，愛護帛琉生態環境[11]。

三、海事安全和魚類暨野生動物保護處

「海事安全和魚類暨野生動物保護處」轄屬於司法部的公共安全局，主要負責海上執法。帛琉海洋巡守人力及船隻不足，所以開放保護區給非營利組織進行研究，以期透過研究進行保護區的監控。例如，2021年該處和帛琉國際珊瑚礁中心（Palau International Coral Reef Center, PICRC）合作，在帛琉國家海洋庇護區（Palau National Marine Sanctuary, PNMS）水域共同進行執法監測活動及環境DNA（eDNA）科學研究[12]。

為發展海巡合作及打擊跨國海上犯罪，我國與帛琉政府於2019年3月簽署海巡合作協定，內容包括公務互訪、船艦敦睦、訓練經驗分享、國際會議邀訪、共同辦理海上救助及執法演練演訓、共同執行海上聯合巡航、犯罪情資交換等。我國以透過人員訓練與海上巡護等方式，協助帛琉建構海事安全的能力[13]。此外，我國2021年11月贈送2艘多功能船舶，以協助帛琉提升海上執法及救難能量[14]。今年（2022）4月召開的「我們的海洋大會」（Our Ocean Conference），我國特別委派海洋委員會海巡署「台南艦」前往帛琉，在大會期間，與帛琉海巡船艦協同執行海上巡防任務[15]。

民間團體

除上述的政府單位外，帛琉尚有許多民間或半官方團體與政府共同合作推動海洋生態保育和復育。這些團體，除有政府基金補助外，亦有來自企業、外國政府等資金的贊助，如前述的保護區網路

基金（PAN Fund）、帛琉國際珊瑚礁中心（PICRC）、帛琉海水養殖示範中心（Palau Mariculture Demonstration Center）。

結論

帛琉主要海事機構包括「農漁暨環境部」的「漁業局」和「環境局」、「人力資源、文化、觀光及發展部」轄下的「觀光局」，以及「司法部」轄下「公共安全局」的「海事安全和魚類暨野生動物保護處」。由機構名稱，即易看出上述單位的職掌範疇，分別是漁業、環境保護、觀光永續發展，以及海上執法。此外，帛琉亦尚有許多民間團體，如保護區網路基金、帛琉國際珊瑚礁中心等，一起和政府合作，共同推動海洋保育和復育等事務。

為保護漁業資源和海洋環境，以及追求永續旅遊，帛琉政府訂定明確的政策和管理措施，包括《保護區網路法》、《帛琉國家海洋庇護區法》、「責任旅遊政策綱領」、追求以自然原始體驗為主的高端旅遊市場、禁止使用和製造對珊瑚有害的防曬產品，以及遊客簽署「帛琉誓詞」等。尤其，自2020年1月1日起80%的專屬經濟海域（EEZ）納入帛琉國家海洋庇護區（PNMS），禁止任何採捕活動，是一項非常前瞻全面的海洋治理措施，顯示帛琉致力海洋保育的決心，建立以海洋保育與永續旅遊為品牌的國家。

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帛琉珊瑚礁的研究與保育

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關鍵字／帛琉、珊瑚礁、保育、永續發展、文化、傳統智慧

帛琉至今仍然擁有多樣和健康的珊瑚礁，並以人與自然共存共榮文化、領先國際的環境保護和生態旅遊而聞名。這些成就與其因優良地理位置而擁有豐富多樣的棲地與生物種類、政府與國民與時俱進具有高度環保意識、帛琉國際珊瑚礁中心（Palau International Coral Reef Center, PICRC）和帛琉保育協會（Palau Conservation Society）等關鍵機構，以及與先進國際組織的交流合作等密切相關。帛琉經由傳統智慧的集水區整合管理，涵蓋自土地利用到海洋棲地，來保護自然資產、建立和有效管理海洋保護區網路、深耕研究與教育、以及管理實務和生活結合等，非常值得參考學習以提升臺灣珊瑚礁的研究與保育，並促進自然生態和社會經濟的永續發展。

帛琉的海洋生態與社會經濟

帛琉地處太平洋西北部密克羅尼西亞群島西部，擁有340多個島嶼，總人口約1萬8千人，以及2千年悠久的人類歷史。傳統的主要食物是芋頭和珊瑚礁魚類，社會經濟發展主要以旅遊業、自給農業和漁業為基礎，旅遊業的經濟貢獻大約占其每年國內生產毛額的一半，旅遊相關活動主要圍繞在其多樣且豐富的海洋生態中進行，包括潛水、浮潛等[1]。



圖1／健康的珊瑚礁提供立體、複雜、多樣且持續增長的生物棲所
圖片提供／樊同雲



圖2／健康的珊瑚礁擁有高生物度多樣性與生產力
圖片提供／樊同雲



圖3／造礁珊瑚分枝之間的隱蔽空間成為各種生物的庇護所，尤其是魚類
圖片提供／樊同雲

帛琉以人與自然和諧發展的文化、環境保護和生態旅遊等領先國際，其廣泛為人稱道的作為，包括：遊客入境時必須在護照簽署「帛琉誓詞」，承諾在島上以對生態和文化負責的方式行事。政府已經建立了世界上最大的海洋保護區之一、禁止旅遊經營者使用一次性塑膠產品、自2020年起採用世界上最嚴格的防曬產品禁用成分來保護海洋環境、2021年致力成為世界第1個碳中和國家等。因此，帛琉開創了永續旅遊的新典範，在促進利用自然生態資源作為旅遊業和經濟成長的驅動力，與保護環境以維繫當代和後代的文化和社會發展之間，取得平衡[2]。

帛琉具有豐富海洋資源的基礎，受惠於優良的地理位置，主因為其位於菲律賓以東和印尼以北、地處世界上海洋生物物種多樣性最高之珊瑚金三角區域的東北部。帛琉與其他島嶼之間，由於相隔了數百公里的開闊水域，限制了海洋生物的散布與交換，以致帛琉的物種數目較少。雖然如此，帛琉仍擁有豐富多樣的各類島嶼和生物棲地，例如密克羅尼西亞地區最大的熱帶雨林、紅樹林、海草床和珊瑚礁等，使其極高密度的熱帶海洋棲地和生物多樣性備受推崇，擁有700多種珊瑚、300種海綿、200種刺胞動物和近1,300種珊瑚礁魚類，很早即被國際讚譽為世界7大水下奇觀之一，也被稱為上帝的水族箱[2][3]。

關鍵的研究、教育與保育機構

「帛琉國際珊瑚礁中心」在推動帛琉珊瑚礁研究與保育上，受到國際重視且扮演關鍵角色[4]。其以增強海洋管理能力，維持人類發展並激勵世界為願景；以成為卓越中心，提供高品質和有影響力的研究、教育和機會，以支持帛琉海洋資源的管理為使命。同時，研究與教育為其工作主要方向，研究領域包括帛琉國家海洋庇護區（Palau National Marine Sanctuary）與漁業等，教育方面包括學校學程與水族館導覽行程等。該中心也提供各種實習機會，給以績效為導向且敬業的個人，來激勵下一代海洋倡議者和守護者。而志工計畫是讓公眾參與協助管理和保護帛琉海洋環境，並使其增加海洋保護知識、發展工作技能，以及有機會回饋社區。

「帛琉國際珊瑚礁中心」經政府授權管理帛琉國家海洋庇護區，經由加強保護以實現資源永續利用，並協調研究、推廣和教育活動，以促進成功管理，進而造福當前和未來世代的帛琉人。在其水族館中，遊客可近距離觀賞帛琉豐富且美麗的多種海洋生物，探索紅樹林、海草和珊瑚礁等不同特性的海洋生態系，以及進一步瞭解帛琉獨特的野生動物如何適應這些生態系統[4]。同時，遊客可透過實作活動和活體動物接觸，親身體驗帛琉的海洋奇觀！水族館經由活體動物展示、教育解說和實驗室操作，並結合當地生物研究、動物接觸和海洋保護等多元課程，讓遊客和學生將所學帶入日常生活。

「帛琉保育協會」是一個擁有完整生態系統觀點，致力於整合海洋和陸地環境，以及解決和協調跨部門問題的國家級非政府組織[5]。該協會具有與國內外、官方和民間不同單位協調的關鍵功能，其以「健康的各種生態系統才有健康的帛琉」（Healthy Ecosystems for a Healthy Palau）為願景，與社區合作以保存國家獨特的自然環境和永續利用自然資源，並延續經濟和社會的復原力（resilience）。核心價值為尊重帛琉文化以指導每一項活動，並且相信當社區管理好自己的資源

時，最能實現保育。也尊重科學，接受保育和氣候變遷的科學依據，相信保護區、資源利用規劃和適應性管理是當前和未來保護自然資源的有效方法。保持對永續發展的信念，相信在人類需求和環境之間，可以找到可持續的平衡。維持正直、信守承諾，努力對自己、合作夥伴和社區誠實，並且扮演民間保育文化精神領袖的關鍵角色[2]。

帛琉是美國、摩納哥（Monaco）、日本、韓國等許多先進國家，進行國際合作研究的優先選擇地點[4]。珊瑚礁研究基金會是由一群致力於珊瑚礁和其他熱帶海洋環境研究和教育的海洋科學家，於1991年在帛琉創立[6]。該基金會宗旨是探索熱帶海洋環境，進行原創性研究，以獲得正確瞭解和做出與保育、氣候變遷和資源管理相關明智決策所需的知識。其研究主題包括與保育決策相關的海洋環境動態、物種多樣性、群聚分布和生物地理學的限制，以及環境和氣候變遷的短期與長期監測等，而目標是解決生態所承受的威脅，並瞭解珊瑚礁內的生物多樣性、分布和引人注目的生態事件。

整合與前瞻的保育

帛琉珊瑚礁保育的重大成就，是於2013年建立了一個由13個海洋保護區組成的生態復原網路，為州政府、中央政府和管理團體之間的合作提供框架，以有效保護海洋生物多樣性。而且，帛琉國際珊瑚礁中心每兩年會調查每個海洋保護區之內與之外的資源狀況，評估保護網路的效果，並且向州政府提出明智的管理建議，用以改善海洋和陸地保護區之間的聯繫、建立對氣候變遷的長期適應能力，並且在過程中與主要權益相關者團體合作，以確保海洋保護區滿足所有帛琉人的需求[4]。

雖然帛琉人比其他國家的人更具環保意識，然而近年來由於遊客數量急遽增加，土地開發也迅速擴展，使得土壤過度侵蝕與流失，導致沿海珊瑚礁遭受流域土地泥沙沉積物污染的威脅。研究顯示，用於種植人口主要食物芋頭的天然濕地——芋頭田，具有能夠捕獲90%沉積物的能力，可防止過多的泥沙進入海洋，進而保護沿海珊瑚礁及其漁業避免受到陸地徑流的負面影響，因此其可作為從山脊到岸礁（from ridge to reef）的集水區整合管理，涵蓋土地使用到海洋棲地來保護自然遺產之傳統智慧的良好案例[7]。

與世界各國相似，氣候變遷對帛琉也構成許多威脅，包括珊瑚白化、強降雨、海平面上升、乾旱和颱風活動增加等。帛琉已經歷氣候變遷的明顯負面影響，包括更強的颱風、降雨模式改變和乾旱、海水侵入低地農場和家庭，以及海洋酸化、珊瑚白化和颱風破壞導致的珊瑚死亡等。尤其，以旅遊產業為主的帛琉，也因為珊瑚白化危及海洋生物生存和破壞遊客希望看到的美景，而對生態、漁業和經濟造成重大損失[2]。

帛琉在調適與適應氣候變遷衝擊珊瑚礁方面的努力，包括在1998年全球首次珊瑚大白化事件之後，為瞭解海洋暖化的衝擊，開始與美國加州大學聖地亞哥分校史克列普斯（Scripps）海洋研究院合作，啟動了現場海水溫度監測網路。二十多年來已發展到70多個監測站點和150多個儀器，所得資料已能夠預測深度變化對珊瑚可能造成的熱緊迫[8]。同時，也進行珊瑚礁長期監測，結果顯示在無

干擾的情況下，珊瑚礁從大白化受損再恢復到以珊瑚為主的健康狀態，至少需要9至12年的時間[9]。此外，也正在研究將具有高耐熱性的珊瑚，作為復育或選擇性繁殖的來源，以提高珊瑚礁對氣候暖化的適應力，並且透過首次建立群島範圍的耐熱性珊瑚地圖，經由人為協助散布，將耐熱基因引入其他族群，為適應未來氣候環境的珊瑚族群預作準備[10]。

結論

帛琉至今仍然擁有多樣且健康的珊瑚礁，此保育成就與其有效控制農業和經濟發展導致海岸侵蝕、污染、人為破壞和過度捕撈等所造成的負面影響，密切相關。雖然，帛琉過去曾經發生棘冠海星侵擾、珊瑚白化、珊瑚疾病、沉積物和颱風破壞等事件，造成珊瑚礁受損的情形，但其珊瑚礁大多數已從干擾中復原，顯示具有很強的復原力。近年之監測結果與國際調查，均顯示帛琉珊瑚群聚的活珊瑚覆蓋率仍有約5成，而且在一些海洋保護區中則更高；與其他地區珊瑚礁相比，帛琉處於相當良好的狀態。因此，帛琉珊瑚礁研究與保育的經驗與智慧，非常值得我們和國際參考學習，以提升臺灣和世界各地珊瑚礁的永續發展。

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全球大型禁漁區之一：帛琉國家海洋庇護區

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關鍵字／帛琉、海洋保護區、國家海洋庇護區

帛琉是一個位處西太平洋的群島國家，國土組成包括340多個火山岩小島，陸域總面積約489.5平方公里[1]。帛琉專屬經濟海域（exclusive economic zone, EEZ）面積約60萬平方公里，有豐富的紅樹林、海草床、珊瑚礁、潟湖等生態系統，以及珊瑚礁魚類、珊瑚、巨型蛤蜊、水母、海龜、儒艮（海牛）等生物資源[2]。

帛琉海洋資源長期支持國民的物質生活、商業漁捕與觀光活動[3]，然而，受氣候變遷與人類活動影響，若不進行管理恐難以維持永續利用的水平[4]。帛琉海洋資源養護之行動於1956年，由70個島嶼所組成的Ngerukewid群島設立野生動物保護區（Wildlife Preserve）濫觴，成為第1個重要里程碑。1994年，通過包括禁止捕撈隆頭鸚哥魚（bumphead parrotfish）漁業的《海洋保護法》（Marine Protected Act），是帛琉獨立之後的第1個海洋物種保育規定。自此，帛琉積極發展海洋資源養護計畫，以保護海洋資源、促進生態旅遊、確保生產力為目標，並陸續通過一系列包含漁業活動管制規範在內的海洋資源養護措施。譬如，2003年通過的《保護區網路法》（Protected Areas Network Act），至2013年為止建立包含13座海洋保護區（Marine protected areas, MPAs）在內的生態網絡，作為中央政府、州政府與相關管理單位的合作框架[5]；並在2015年之前，全面禁止底拖漁船、分別對鯊魚與海龜等制定物種養護措施[2]。

2014年，聯合國大會通過17項永續發展目標，其中目標14與養護與永續利用海洋生物資源相關[6]。為了回應全球迫在眉睫的海洋問題與帛琉自身的海洋資源永續利用的困境，時任帛琉總統Tommy E. Remengesau, Jr.在聯合國大會上宣告將建立「帛琉國家海洋庇護區」（Palau National Marine Sanctuary, PNMS）之承諾[2]。

2015年，帛琉通過《帛琉國家海洋庇護區法》（Palau National Marine Sanctuary Act, PNMSA），建立PNMS，是一座包含80%帛琉EEZ（面積約475,077平方公里）的禁採捕海洋庇護區（no-take marine sanctuary），同時將其餘20%帛琉EEZ劃設為國內漁捕區（domestic fishing zone, DFZ），僅允許為糧食安全與國內市場所需的傳統與國內漁業活動，以及部分外國漁業活動[7]。《帛琉國家海洋庇護區法》自2020年1月1日起生效，PNMS與DFZ正式啓用（圖1）[8]。PNMS內全面禁止採捕，DFZ禁止大部分外國漁船活動，因此，創造絕佳機會試驗帛琉能否在氣候變遷的環境下，以及養護海洋資源的同時，確保糧食安全與經濟發展。尤其，帛琉的經濟社會生活長期仰賴海洋資源，有87%家戶的主要經濟來源與漁業有關[3][9]，觀光客總數在2015年超過帛琉當地人口的9倍

[3]。沿岸漁業以國內漁船進行珊瑚礁漁業（reef fisheries）為主，每年大約有865公噸珊瑚礁漁獲進入本地市場；EEZ內的漁業活動，主要是外國漁船，尤其臺灣和日本的延繩釣漁船及日本的圍網漁船為大宗，每年大約提供165至284公噸近海（offshore）漁獲至帛琉本地市場，也是當地近海魚類的主要來源[10]；海洋觀光主要以珊瑚礁魚類與鯊魚為主要的觀賞物種[3]。2020年起，珊瑚礁魚類的漁獲量下降，使國內漁業糧食需求壓力開始出現，並轉換至近海魚類[3]。有研究透過空間模擬，指出未來在帛琉周邊海域洄游的鮪魚與鯊魚數量可能會下降[11]，使帛琉在海洋資源養護與國內漁業經濟發展平衡上面臨挑戰。

PNMS與DFZ的主管機關，是帛琉的自然資源、環境及觀光部（Ministry of Natural Resources, Environment and Tourism, MNRET）。MNRET權責包括制定PNMS及DFZ內生物資源之保育、管理及捕撈規範，協調和締結外國漁船捕魚協議，依法核發外國漁船捕魚許可，監測DFZ之魚群數量並設定總允許捕撈量，以及檢查DFZ內捕撈之漁獲等。因此，MNRET部長有義務提出年度報告，內容為帛琉海域之相關活動，包括所有漁業協議及許可、漁業活動之稅收、具捕魚許可權益人該年捕撈之數量及類型、魚群之可持續生產量、以及監測和執法情形[10]。PNMS與DFZ的日常維運，由帛琉科研單位——帛琉國際珊瑚礁中心（Palau International Coral Reef Center, PICRC）提供相關資訊、經驗，以協助各單位執行海洋環境活動、提供海洋環境相關之教育資源及發展計畫，以及協助帛琉傳統部落首領執行傳統保育措施[7]。

《帛琉國家海洋庇護區法》通過至今，分別在2017年與2019年進行兩次修法，最新的2019年的修法有3項值得留意的重點，包括：

- 一、增加PICRC在PNMS和DFZ擁有更主動的角色，包括協助相關研究、教育及活動、賦予PICRC作為MNRET幕僚機關，以及主責提供關於DFZ保育管理措施之建議等[7]。
- 二、增列觀光稅，過境旅客需繳100美元的環保稅（Pristine Paradise Environmental Fee, PPEF），取代原本之環境影響費用。環保稅所得用來回饋國內，配額方式為：5%作為漁業保護信託基金、5%作為PICRC維運基金、12.5%為州政府稅收、25%給帛琉國際機場、30%為綠色基金用於環境維護、以及22.5%為國家財政部稅收[7]。
- 三、將商業目的漁業出口稅，分為鮪旗魚類及其他魚種漁獲類等兩類。其中，鮪旗魚類徵收每公斤50美分之稅收，而其他魚種漁獲類則徵收每公斤35美分之稅收[7]。

從帛琉的《帛琉國家海洋庇護區法》及其海洋資源利用經驗來看，採取實質管理措施可能是促進永續發展的必要手段。然而，在施行的同時，需考慮本地既有海洋使用者可能面臨的經濟損失與當地市場漁獲的供需問題。珊瑚礁生態系統是當地海岸（nearshore）漁業與觀光業的共同資源，珊瑚礁漁業轉型，有機會能創造更高附加價值的漁產品或品牌。在EEZ漁業活動部分，目前以外國漁船為主，培育本地近海漁業人才與船隊，可能有助於減緩EEZ海洋資源外流的狀況。

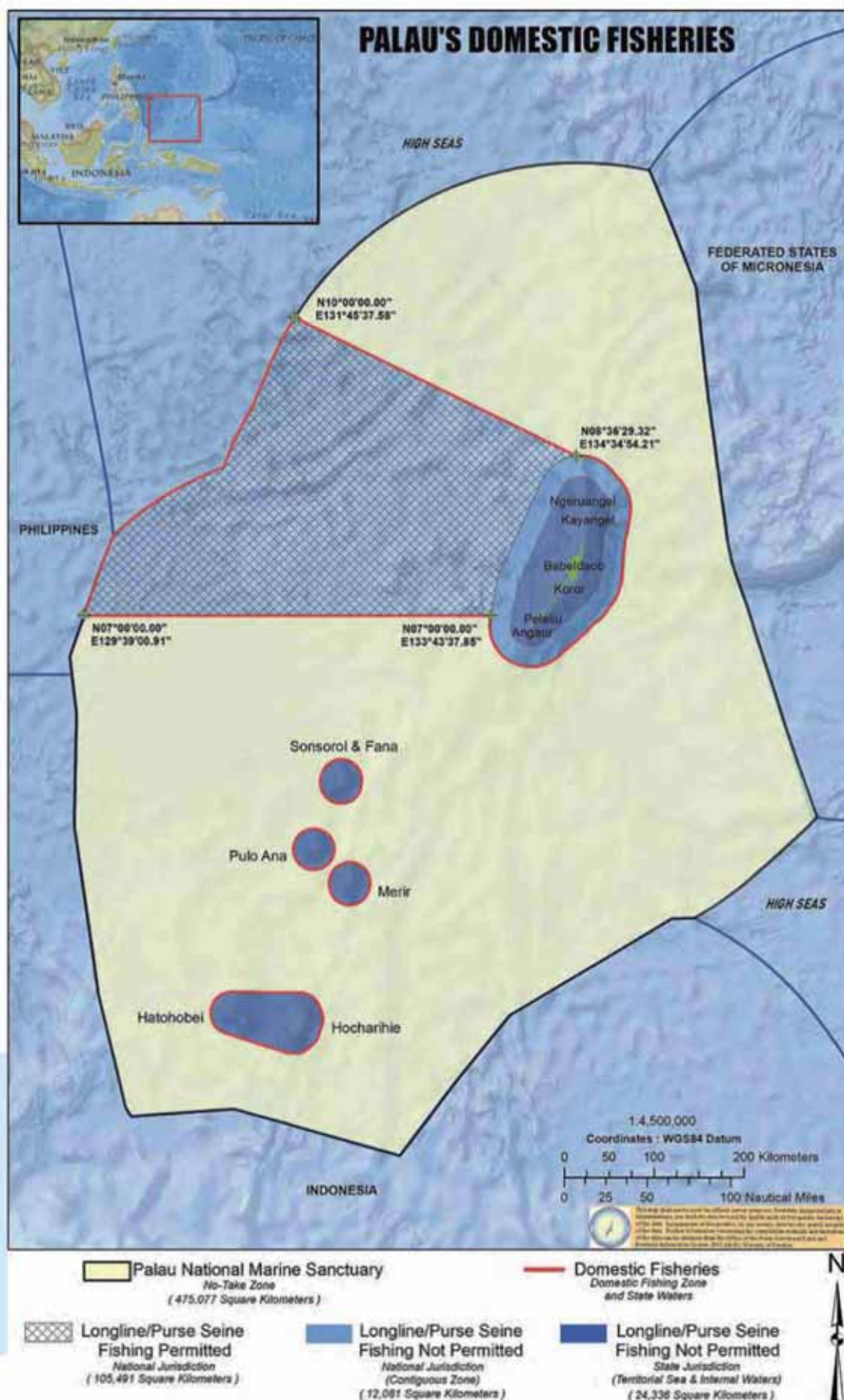


圖1/帛琉PNMS與DFZ區劃圖
圖片來源/[12]

結語

帛琉的《帛琉國家海洋庇護區法》及「帛琉國家海洋庇護區」，在養護海洋生物多樣性之目標上展現相當的企圖心，其制度設計或可成為我國在EEZ進行資源養護、劃設及管理大型MPA之借鏡。惟，此法案與庇護區的生效與成立時間尚短，相關發展及實施成效有待未來持續追蹤與觀察。



圖片來源／Pride Advertising Agency Ltd.

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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

Chia-Wen Chung (Assistant Research Fellow, Taiwan Institute of Economic Research)

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

Ming-Zhe Tsai (Head of the Technical Mission in Palau, International Cooperation and Development Fund [ICDF])

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
Meteungerel'temekai (<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>Cheilinus 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. Ribkungal (<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 Chesiuch (<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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Translated by Linguitronics

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, de-tailed, 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

dedicated to managing protected areas. All 16 states have now joined the Protected Areas Network [6]. In total there are 39 protected areas sites, of which 29 are marine protected areas and 10 are terrestrial protected areas [7]. Funding of the PAN Fund comes partly from Palau Pristine Paradise Environmental Fee (PPEF) collected from international visitors. Starting Jan. 1, 2018, every visitor coming to Palau will be assessed a \$100 environmental fee with \$30 earmarked for protected areas network [8]. Moreover, the Palau National Marine Sanctuary Act, PNMSA was passed in 2015 and On January 1, 2020, 80% of Palau's EEZ was designated as Palau National Marine Sanctuary (PNMS, the area is 475,077 square meters), where all forms of extractive activities including fishing is banned. The remaining 20% of the EEZ was designated as Domestic Fishing Zone (the area is 117,572 square meters), where commercial and domestic fishing is allowed [9].

II. Bureau of Tourism

The Bureau of Tourism is under the auspice of HRCTD. Tourism industry contributes 51% of gross domestic product (GDP) [3] . With world-wide known fabulous coral reef systems, Palau attracts numerous international visitors annually to engage in diving, snorkeling and other types of water activities. Promoting high-end tourism is the focus of economic development. Tourism in Palau is highly associated the marine environment and tourism polices and regulations therefore constitute a key part of marine polices.

Bureau of Tourism adopted the Palau Responsible Tourism Policy Framework in 2016 as way to promote responsible tourism and ensure sustainable development of tourism. The Framework specifies a clear vision of responsible tourism - 'Ensuring a pristine paradise. Palau for everyone [3]'. It also lays out several management measures. The management measures and regulations associated with tourism is summarized as below.

Figure 1/ 29 marine protected areas and 10 terrestrial protected areas in Palau
Source/ <https://www.palaupanfund.org/pan-sites.html>



- 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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Keywords: Palau, Marine Protected Areas (MPA), National Marine Sanctuary

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

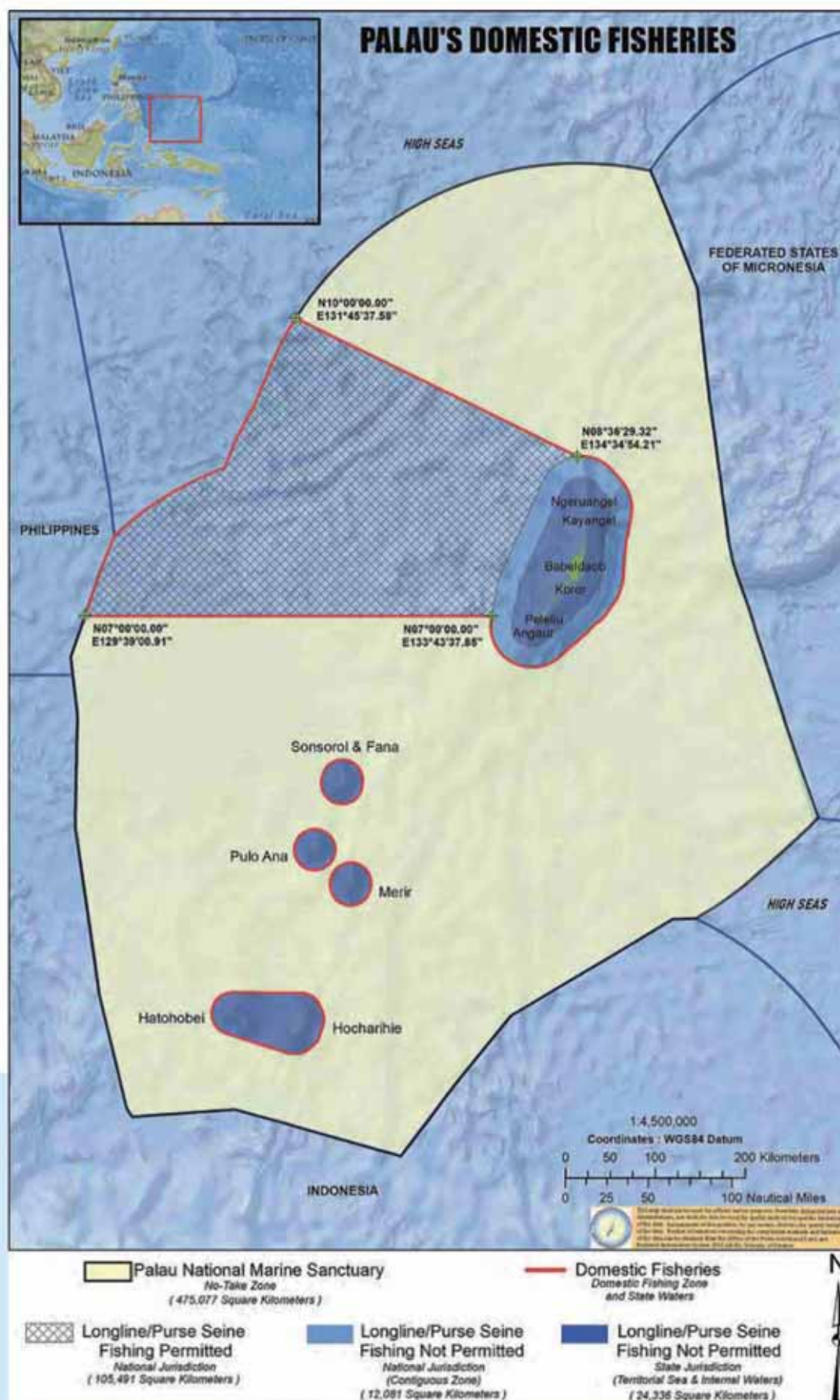


Figure 1 / Palau PNMS and DFZ Zoning Map
Source / [12]

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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