國際海洋資訊

International Ocean Information

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獨步全球的海洋遊憩風險資訊平臺～GoOcean

Global First Marine Recreational Risk Information Platform: GoOcean

泰國海洋資訊

Thailand Ocean Information

海洋委員會 Ocean Affairs Council 發行

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代理主任委員：周美伍

探索海洋、瞭解海洋，才能善用海洋資源，並打造永續的海洋生態。臺灣擁有多樣的海洋環境，如我國南沙群島的太平島擁有豐富的珊瑚礁生態，但棲息在太平島潮間帶的大型藻類分布資訊甚少，本期介紹國家海洋研究院（簡稱國海院）於太平島潮間帶的大型藻類生物相調查，該調查建立生物資訊、完善物種圖鑑，以增加國人對我國大型藻類的基礎認識。國海院的「GoOcean海洋遊憩風險資訊平臺」能夠整合各部門即時資訊，提出海洋遊憩安全風險警訊，供民眾評估海洋遊憩活動的風險等級，達到開放海洋的目標。蒐集海洋數據有助於全球面對氣候風險，本期「國際議題」介紹亞洲開發銀行（Asian Development Bank, ADB）的「太平洋島嶼地區海平面上升」（Sea-Level Change in the Pacific Islands Region）報告，針對容易受到海平面上升影響的島嶼地區，提出審慎評估的科學資料，作為太平洋地區的投資參考。

本期的主題國家泰國，受到聯合國永續發展計畫、東協區域整合加速推進等國際因素影響，尤其是歐盟的非法、未報告及不受規範（Illegal, unreported and unregulated, IUU）漁捕裁罰後，開始積極進行改革。在2015年陸續制定或修訂漁業、海洋資源及水域航行等相關法規，以國家力量整合海洋事務之分工及協調。此外，日前提出之塑膠廢棄物國家行動方案與路徑圖，從源頭減少塑膠廢棄物，並於雨季前導入都市廢棄物清理機制，以有效降低陸源性污染進入海洋的情況；環境正義基金會（Environmental Justice Foundation, EJF）則從2018年在泰國推動「海洋清網計畫」（Net Free Sea, NFS），透過泰國漁業司協助，建立讓地方社區願意投入的機制，將廢棄漁網回收再利用。從泰國之例可知，不論是政府或非政府組織，都可以對海洋保護做出貢獻，一起打造永續的海洋！

圖說／泰國第1個國家公園 Tarutao National Park
圖片來源／Tourism Authority of Thailand https://www.tourismthailand.org/Attraction/tarutao-national-park

獨步全球的海洋遊憩風險資訊平臺～GoOcean

撰文／賴堅戊（國家海洋研究院海洋產業及工程研究中心研究員）
關鍵字／海氣象資訊、海洋遊憩、海灘安全、風險資訊、向海致敬

海洋遊憩安全風險一直是「開放海洋」無法迴避的課題。「GoOcean海洋遊憩風險資訊平臺」是海洋委員會國家海洋研究院（簡稱國海院）遵循行政院「向海致敬」政策，呼應其5大目標及具體策略：「開放」（開放海洋、簡化管理）、「透明」（資訊透明、一站滿足）、「服務」（友善措施、完善設施）、「教育」（深化教育、普及體驗）及「責任」（風險明確、責任承擔）而開發設計。期望此獨步全球的海洋遊憩動態風險資訊科技服務，能為全民建立一個與海洋連結的創新服務平臺。

在《國際海洋資訊》雙月刊第8期中以「澳洲海灘危險分級與海灘安全資訊網」[1]為題，報導了有許多知名海灘度假勝地的澳洲如何降低遊憩海灘的安全風險。根據澳洲的經驗顯示，海灘水域環境的安全風險和危險因子，不僅和大浪、強勁海流、暗礁、裂流等海氣象環境有關，更和活動者自身的海洋水域知識、游泳能力和經驗等有關，因此進行海灘危險評估，並予以危險分級以及建置海灘安全資訊網站，作為海灘遊客的安全指引，是避免和減少安全風險的有效措施。

國海院參考澳洲、美國等海洋國家在海洋風險資訊服務的經驗，以提升我國民眾海域活動安全風險資訊透明為目標，從強化認識海洋（知海）出發、從鼓勵進入海洋（進海）出發、從享受海洋（愛海）出發，透過雲端物聯網技術，導入整合跨部門、跨平臺的前瞻海洋科技，提供海域遊憩活動的海氣象環境數據及安全風險資訊（資訊透明、風險明確），建置GoOcean海洋遊憩風險資訊平臺（圖1），供民眾從事海洋遊憩活動時參考及判斷。

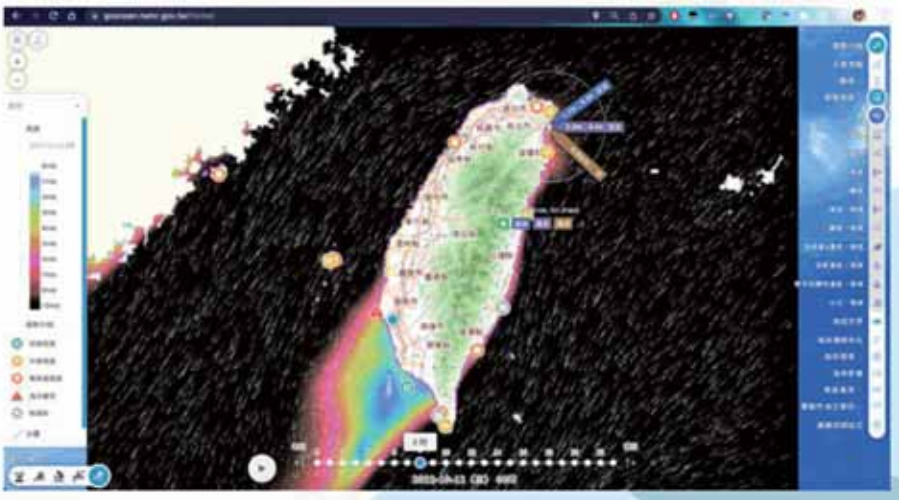

圖1／GoOcean海洋遊憩風險資訊平臺使用者介面
圖片提供／賴堅戊

在萬物相聯中的GoOcean智慧海洋工程

GoOcean系統整合了向海致敬前瞻基礎建設計畫新建置之海洋監測模擬系統，並介接交通部所屬中央氣象局、運輸研究所港灣技術研究中心、觀光局、經濟部水利署、環保署等我國涉海單位，以及歐盟哥白尼計畫（Copernicus Programme）等海氣象環境資料。整合的資料包括：一、VHF岸基波流遙測站；二、X-Band岸基波流遙測站；三、岸際氣象觀測站；四、錨碇／底碇海洋觀測站；五、歐盟開放衛星資訊產品；六、政府開放資料；七、數值海洋動力模式；八、數值海洋水質模擬模式；九、生物調查及水下影像；十、海岸即時影像等10大類資料，以物聯網概念進行規劃設計，網路架構如圖2所示。且為了提供良好的使用者體驗（User Experience, UX），該平臺使用者介面（User Interface, UI）採用視覺化人機介面設計開發，透過電子地圖使用者可立即瞭解各海域遊憩活動之海氣象及水域遊憩活動風險即時動態。靜態之海氣象資訊則採用渲染方式以線上地圖服務（Web Map Service, WMS）發布，動態之風、波、湧、流等海氣象資訊透過WebGL方式以瀏覽器前端繪製技術即時繪製，系統的資訊整合架構如圖3所示。

圖2／GoOcean物聯網系統網路架構圖
圖片提供／賴堅戊繪製

圖3／GoOcean系統資訊整合架構圖
圖片提供／賴堅戊繪製

獨步全球的動態海域遊憩活動運動能力分級

根據國海院於2021年邀集無動力海洋遊憩活動相關的專家、業者、學者進行多場次的共同討論及德爾菲法（Delphi method）統計分析[2]，就潛水、游泳、風浪板、獨木舟及衝浪等5類無動力遊憩活動，依照初級、中級、專家級及海況嚴苛等4種運動能力分級之海氣象環境因子進行分級規則。以衝浪活動的運動能力分級為例，如表1所示。因此，得以根據選定的時間及沙灘進行之動態海氣象條件進行運動能力分級，由系統自動判斷各類無動力海洋遊憩活動（潛水、游泳、風浪板、獨木舟及衝浪等項目）的能力分級建議，供民眾依自身能力評估風險等級，以利規劃適合自身條件的休閒活動。

表1／衝浪活動之運動能力分級

環境參數 \ 能力等級	初級	中級	專家級	海況嚴苛
浪高	<1.2公尺	<2.5公尺	<8.0公尺	≥8.0公尺
波浪週期	<7秒	<7秒	<12秒	≥12秒
碎波角	90度	45~90度	<45度	<45度
流速	<0.51 m/s	<0.51 m/s	<1.03 m/s	≥1.03 m/s

資料來源／賴堅戊整理

整合政府跨部門的即時安全風險資訊

海洋遊憩的安全風險，如長浪、閃電及紫外線傷害等，可透過現代化的監測技術對遠域感知，進而提出預警，在GoOcean平臺中介接政府各部門的即時資訊應用在海灘遊憩安全風險警訊的提醒。例如，介接交通部中央氣象局以及台灣電力公司的閃電落雷系統即時觀測資料，提供近6個小時內的閃電落雷資料，資料更新頻率每5分鐘1次，旨在避免前往海邊空曠區域旅遊的遊客遇上閃電打雷損及玩興，甚至受傷致命的風險。此外，整合自環保署和中央氣象局設於全國各地的紫外線測站每小時發布之紫外線監測資料，可供民眾出遊時參考，事先作好防護，避免在晴空萬里的好心情下，不知不覺因為豔陽造成曬傷而導致可能的皮膚或眼睛病變。另一方面，長浪對於操舟艇、衝浪以及釣魚等海域遊憩活動，往往是具有安全風險的海洋環境危險因子，為了達成長浪警戒的目的，GoOcean平臺利用波流遙測系統具有較為廣域、連續且即時的海洋觀測能力，將其觀測離岸數公里至數十公里外的波浪方向頻率譜，依風湧浪分離方法，將波浪的能量區分出局部風場所產生的風浪和廣域傳播中的長浪，並萃取出長浪的波浪特性（週期與浪高），最短可在5分鐘內更新長浪警戒資訊，以期藉由遠域的遙測發揮提早十數分鐘的長浪預警能力。綜合上述即時安全風險警訊，擷取曾經出現的長浪警戒及即時閃電資訊之畫面，如圖4所示。

支援國內海洋運動賽事

體育活動是凝聚國民向心力與展現國力的象徵，GoOcean除了期望透過海洋環境及安全風險資訊，輔助海洋遊憩活動的推廣，更期望透過雲端物聯網技術及資訊整合支援海洋運動賽事活動，將

圖4／GoOcean跨部門整合海域即時安全風險資訊範例
圖片提供／賴堅戊

更即時、更高解析度的海氣象環境資訊及海域活動風險資訊提供給賽事主辦單位及與賽選手參考，藉此記錄運動賽事期間的海氣象環境資訊及活動安全風險評估。例如在2022年9月30日至10月2日舉辦的佳樂水衝浪嘉年華以及2022年11月12日至20日在臺東舉辦的臺灣國際衝浪公開賽，該平臺都可為比賽地點開設監測系統並根據活動特性開發創新資訊服務，如圖5即為佳樂水衝浪嘉年華及臺灣國際衝浪公開賽之專案網頁頁面，不僅提供未來3天的海況預報，更整合即時觀測資訊供選手及主辦單位運用。

圖5／GoOcean 支援2022年佳樂水衝浪嘉年華及臺灣國際衝浪公開賽海洋遊憩風險資訊服務網頁
圖片提供／賴堅戊

結論

本文介紹了GoOcean海洋遊憩風險資訊平臺為強化民眾認識海洋（知海）、鼓勵民眾進入海洋（進海），提供導入整合跨部門、跨平臺、以人為本的前瞻科技服務。有別於海洋遊憩活動民眾過去以來仰賴國外數值預報所建構的海洋環境資訊平臺，該平臺以整合臺灣本土的海氣象環境調查、監測與預測數據為基礎，不僅具有較高解析度與精確度的優勢，並透過量化分級為我國熱門的海域遊憩活動提供安全風險資訊，透過GoOcean平臺之動態海氣象環境數據（資訊透明）與活動安全風險資訊（風險明確），民眾及遊憩業者得以找到適合自身能力分級的遊憩海域，進而享受海洋、提升愛海體驗，更期望未來能與海岸管理單位共同討論海灘活動管理策略調適，為海域遊憩的安全與蓬勃發展做出貢獻。

GoOcean平臺受眾對於資訊服務的可利用性以及UI/UX的滿意度，是平臺開發過程中不斷檢視與調整的。我國海洋遊憩活動過去受到「海禁」的氛圍影響，幸而近年隨著政府與民間共同對開放海洋的期待與努力而逐漸蓬勃，該平臺扣合社會發展提供創新應用系統，透過資訊系統整合10大類海氣象環境資訊來源，提供逐時更新、大尺度、高精度之海氣象環境資訊監測與預測，此外以遙測海洋雷達回波進一步嘗試開發的長浪監測資訊，將可能造成海域民眾安全危害的長浪警戒資訊更新週期縮短至5分鐘，可對降低海域安全風險發揮重要的影響。GoOcean平臺從作業化海洋監測技術發展以及應用在海洋遊憩風險的新創研發，為實現「科技輔政、科技惠民」提供了最好的實證。

根據系統後臺的統計，GoOcean平臺自2021年12月下旬開放測試迄今，註冊使用者中的活躍使用者達694名、平臺到訪已累積超過101,619餘次、使用者意見交流達75次以上、各類型資料點擊查詢的加總達207,130次、以及媒體、社群媒體分享、使用者的報導、推文之觸及數達78,413次以上，在疫情影響下每月的平均使用者數仍持續增加，顯見GoOcean平臺正逐漸成為我國愛海民眾從事海域遊憩活動不可或缺的環境資訊平臺。

參考資料

[1] 陳璋玲、董東璟、蔡政翰（2020），〈澳洲海灘危險分級與海灘安全資訊網〉，《國際海洋資訊》8：7-11。
[2] 國家海洋研究院（2021），《海洋運動能力分級與海洋環境條件關係調查分析成果報告》。
[3] GoOcean海洋遊憩風險資訊平臺。
https://goocean.namr.gov.tw/

南海海平面上升與氣候風險評估

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關鍵字／海平面上升、氣候風險、地球暖化

二氧化碳是造成地球暖化主因之一，這已是不爭的事實。聯合國政府間氣候變遷專門委員會（Intergovernmental Panel on Climate Change, IPCC）公布了氣候變遷第6次評估報告（Sixth Assessment Report, AR6），共發布3份工作小組（Working Group, WG）報告。第1工作小組（WG I）在2021年8月9日公布「物理科學基礎」（The Physical Science Basis）報告，第2工作小組（WG II）在2022年2月28日公布「衝擊、調適與脆弱度」（Impacts, Adaption and Vulnerability）報告，第3工作小組（WG III）在同年4月公布了「氣候變遷減緩」（Climate Change 2022: Mitigation of Climate Change）報告。以上3份報告對於減緩氣候變遷進展和承諾進行了最新一回合的全面評估，同時調查了影響全球碳排放的來源，評估各國因應氣候變遷的承諾，以及其對長期二氧化碳排放目標的影響。

根據IPCC資料顯示[1]，人為的溫室氣體排放總量正在持續增加中，2010～2019年的年均溫室氣體排放量屢創新高。不過，若以成長率觀察，相較於2000～2009年則呈現下降的趨勢。2019年全球人為溫室氣體排放量約為590億噸二氧化碳當量，較2010年增加12%，若以1990年為基準，則上升了54%。幾乎所有類別的溫室氣體排放量都在增加，其中以來自化石燃料與工業製程排放的二氧化碳增幅最大，其次是甲烷排放。在COVID-19對產業及人類活動影響下，全球2020年上半年二氧化碳淨排放量曾有下降趨勢，但是隨著疫情漸受控制，排放量又再度回升。

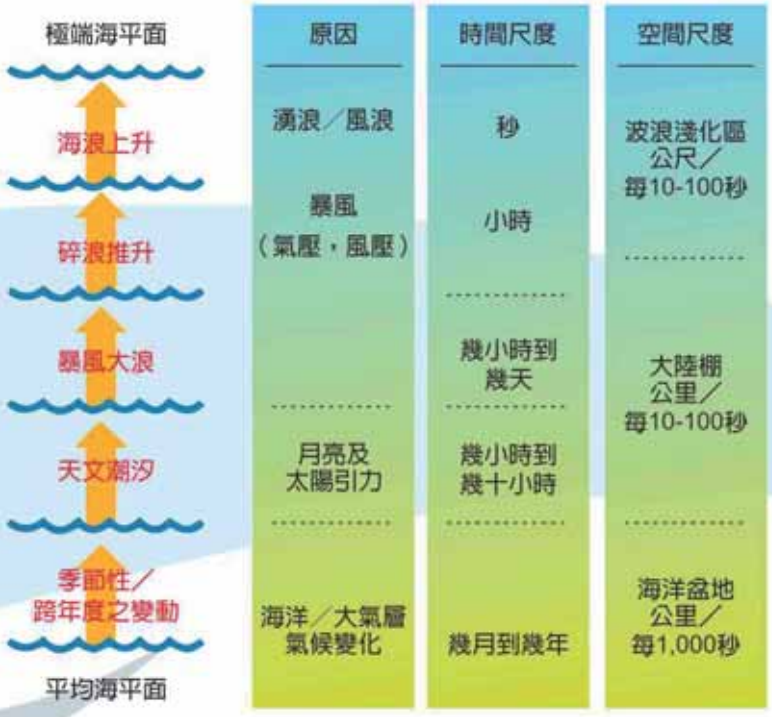

圖1／造成海平面上升的各種原因示例
資料來源／[2]

地球暖化為海平面上升主因

氣候變化如風浪、暴雨、颶／颱風，以及月亮與太陽的引力都可能造成海平面上升（sea-level rise, SLR）（圖1），然而此現象並非 成海平面上升主要原因，地球溫度上升，使得包括南北極冰川的融化速度高於以往，這才是SLR的主要原因。以下說明3個與全球氣候變遷有極大關聯性的SLR：首先，也是最主要的原因是海水的熱脹冷縮。在過去的25年來，約有50%的海平面上升是因為地球變溫暖，為海洋膨脹所造成的。其次是高山冰川融化，尤其是靠近南北極溫寒帶高山的冰川，原本在每年夏天都會自然地緩慢融化，因地球暖化以及極端氣候，冬雪夏融的平衡狀態變得不穩定，使得海平面上升明顯。最後是全球第1大島格陵蘭以及南極大陸冰蓋的持續減少。地球溫度上升使得覆蓋在格陵蘭島和南極大陸的巨大冰蓋加速融化，且格陵蘭島的冰蓋因海平面上的融水和海平面下的海水滲入，造成冰川加速流向大海，進一步造成海平面升高。

海平面上升造成更大的氣候風險

當前海平面上升的速度超過以往，海平面上升對於生態環境的主要影響，如造成含水層和農田的鹽害，以及有關的魚類、鳥類、植物棲息地的消失等。其次，在海面上升後，也使颶風或颱風襲擊陸地的程度更甚往常。例如近年的颶風運轉的速度相較過去緩慢，因而帶來更多的降雨，對海岸線掀起更大的海浪，海岸線沿岸低窪地區的居民，因為洪水而被迫遷往內陸或高地。以上原因一再地說明，地球暖化造成海平面上升之危害。如何推動節能減碳策略，減少二氧化碳排放及減緩海平面上升，日益迫切。另外，規劃適當的溫室氣體調適策略，也是因應海平面上升不可或缺的措施。

海平面上升是一個全球性的議題，以下介紹2022年7月亞洲開發銀行（Asian Development Bank，以下稱亞銀）所提交的減緩南太平洋海平面上升的規劃報告[2]。亞銀報告透過對於造成海平面上升的氣候風險與調適策略相關研究，提供未來太平洋島嶼地區（Pacific Islands Region, PIR）國家因應海平面上升之參考指引。亞銀報告的3大目標為：一、成立該區域的論壇以及基礎設施建設的融資；二、以專案計畫方式，推動再生能源建置與海洋及海岸管理；三、加強各國防災能力，當然也包括促進各國公共建設財政管理和相關統計、資料的蒐集能力等。

太平洋島嶼地區是海平面上升影響重災區

太平洋島嶼地區位於熱帶的西太平洋地區（圖2），高度暴露於熱帶氣旋和其他熱帶風暴中，且因各國的海岸線與陸地面積之比例高，對海平面、海浪和洋流的變化具高度敏感度，本區域大都多為低窪珊瑚環礁、珊瑚礁或火山組成的島嶼，易受到海平面上升的影響。基於此，亞銀報告提供給投資者在因應PIR海平面上升時，應採取的各項預防措施，包括各種研究資訊來源相關的優勢、劣勢和不確定性。回顧相關海平面上升的科學證據，提供有關太平洋島嶼地區海平面上升具公信力的資訊，以作為進一步調查和決策基礎，例如規劃永續居住地區的長期規劃及國家／地區的人口移動規劃等。

IPCC在2013年公布的第5次評估報告（AR5），指出在1986～2005年的基線下，在2100年時，海平面上升不可能超過1公尺。此資訊已被亞銀和其他單位廣為運用於評估或管理太平洋島嶼地區與海平

面上升相關的風險研究。然而，自AR5報告出版之後，後續各種的科學和證據研究回顧上，發現在未來維持海平面上升在1公尺內的評估設定中，在太平洋島嶼地區可能並不充分或完備，主要原因有5點：

一、儘管相關研究對所有太平洋島嶼地區位置的變化方向有很高的可信度，但變動幅度只有中度可信。考量氣候變遷的自然變化衝擊，顯示在2100年的海平面上升有可能超過1公尺。

二、自AR5之後的相關研究以及近期公布的AR6報告顯示，若改以新的資料，並將基線改為1995～2014年，海平面上升不僅大於1公尺，在2100年甚至可能超過2公尺。值得注意的是，到2100年海平面仍將持續上升，並非如AR5是控制在上升1公尺之內。

三、遠古的氣候記錄顯示，一個世紀內海平面上升5公尺雖然曾經發生過，但那是在數百年到數千年之內才會發生一次。專家學者的共識是在2100年內應該不會發生這種情況。但是AR6報告指出，在海冰懸崖穩定的情況下，預計到2300年地球海平面上升介於1.7公尺到6.8公尺之間是可能發生的，且如果海冰懸崖不穩定狀態發生，海平面上升可高達16公尺。

四、因暴風潮增加和海浪使得短期的海平面處於高水位的變化，使該區域沿海的水位顯著高於預期，特別是在西熱帶太平洋PIR海平面上升的情境（scenario）下。

五、根據2000年以來的資料顯示，太平洋島嶼地區各國大多數的島嶼都在下沉中，太平洋島嶼地區國家的土地在陸沉的情況下，會放大海平面上升的衝擊。

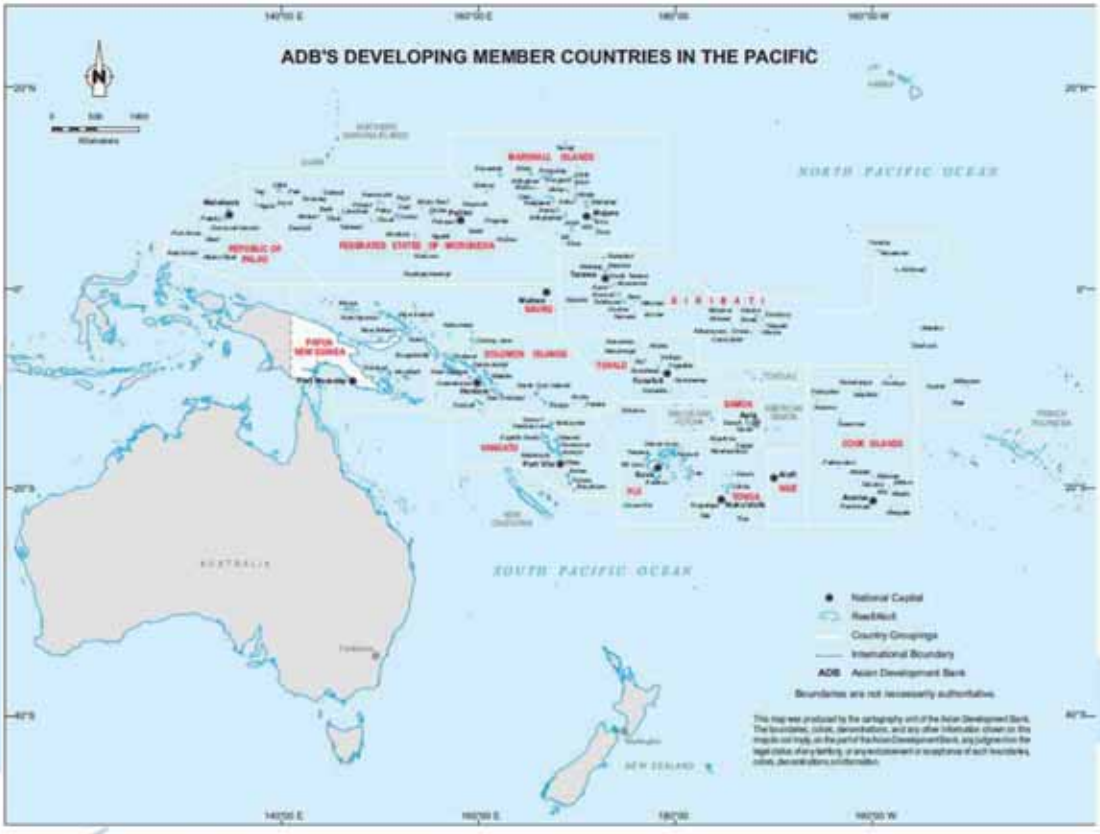

圖2／西太平洋地區島嶼國家，是易受海平面上升衝擊區域
資料來源／[2]

太平洋島嶼地區的海平面上升影響明顯

雖然意識到上述各種造成海平面上升的因素，亞銀報告採用一種較為簡易的方式，用較全球平均海平面上升更高的預防方法，並考慮氣候風險調適評估的高水位對太平洋島嶼地區影響的預測，同時也考慮更高等級的情境設定，假定海平面上升在2100年不會停止。亞銀報告建議在AR6的基礎下，以1995～2014年為基線，並考慮以下因素：

一、採用2100年海平面上升1公尺的情境，做為與現今研究比較的基礎。

二、短中期（20～30年內），以海平面上升50公分為情境。

三、長期到2100年以海平面上升2公尺為情境。

四、更長期超過2100年，海平面上升情境設定為超過2公尺。

基於上述的設定，表1為本區14個國家未來在2100年的海平面上升預測值，約在38公分至92公分之間。

表1／太平洋島嶼地區國家海平面上升預測值　（單位：公分）

國家	預測海平面上升值(1)	跨年度變動歷史值(2)	(1)的上限值+(2)
庫克群島	39-86	19	105
密克羅尼西亞	41-90	26	116
斐濟	41-88	18	106
吉里巴斯	38-87	23	110
馬紹爾群島	41-92	20	112
諾魯	41-89	23	112
紐埃	41-87	17	104
帛琉	41-88	36	124
巴布亞紐幾內亞	47-87	23	110
薩摩亞	40-87	20	107
索羅門	40-89	31	120
東加	41-88	18	106
吐瓦魯國	39-87	26	113
萬那杜	42-89	18	107

資料來源／[2]

海平面上升情境不僅適用於氣候保護設計的敏感性分析，亦可用於分析額外的成本和效益，以探討氣候調適方案的靈活度。亞銀報告建議將這些情境用於敏感性分析，而不是作為氣候保護的最低預防要求。具彈性的氣候調適管理方案，可以解決更高層級的海平面上升情境。考慮對長期路徑依賴性，也就是說，假設未來可能發生更高海平面水位（包括經濟在內的其他因素）的情境，對海岸基礎設施進行投資的決定，將影響後續的投資和開發，因此未來在相同等級的假設的各種研究，就無需再進行氣候風險評估。

結語

亞銀開發可靠的海平面上升預測資訊，將其納入太平洋島嶼地區中的氣候風險評估，並提出相關執行建議，包括定義計畫目標、任務、每項任務的期程以及完成任務所需的技能和人員需求。此海平面計算模式與智財權，已提供給越南研究使用，後續可確保亞銀成員國家使用這方法的一致性與透明度。

海平面上升的研究仍正不斷發展，如何評估及處理海平面上升既有推估的衝擊觀點也在發生變化，因應氣候變遷的調適策略，也是一個持續的過程。亞銀報告建議每5～10年重新審視各項（氣候變遷）證據，例如在IPCC新報告發布後即進行相關評估，以確認各項策略／意見是否因新證據而發生變化。

參考資料

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泰國海洋清網計畫：從海岸社區做起的海洋保護行動

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關鍵字／泰國、廢棄漁網、回收、海岸社區、海洋保護

國際非政府組織－環境正義基金會（Environmental Justice Foundation, EJF）於2018年在泰國推動「海洋清網計畫」（Net Free Sea, NFS），鼓勵沿海社區收集海中的廢棄漁網，以建立一個從地方社區收集漁網、回收商收購漁網及處理成粒狀物，到製造商製成產品的供應鏈。為此，環境正義基金會研擬一套作法，推動該計畫，包括社區加入計畫的步驟、提供比市場價格高的漁網收購價格、辨識目前可接受回收漁網的方法等。計畫實施約3年，已有若干海岸社區加入，同時亦有製造商使用由廢棄漁網回收的原料，製造成產品，形成循環經濟的案例。基於計畫的初步成果，基金會希望將「海洋清網計畫」擴大至其他國家，尤其是海洋塑膠污染較嚴重的西非國家。

泰國位於東南亞，海岸線長約3,148公里，東臨泰國灣（Gulf of Thailand），長約2,055公里；西臨阿得曼海（Andaman Sea），長約1,093公里[1]。泰國是全球主要的漁業國家之一，漁船數眾多，約5萬艘小型的家計型漁船，以及1萬艘從事商業捕撈的漁船。因此，漁網意外掉入或被丟棄於海洋的漁網數量頗為可觀，對海洋生物生存造成很大的威脅。泰國官方統計顯示，2015年至2017年間，擱淺的海龜和儒艮數量中，被漁網傷害之比例分別為74%和89%[2]，可見廢棄漁網問題的嚴重性。

為協助解決海中廢棄漁網問題，環境正義基金會於2019年在泰國推動「海洋清網計畫」，計畫經費來自「挪威零售商環境基金」（Norwegian Retailers' Environment Fund）。該基金會致力於保護自然環境，以及依賴此環境生存的人和野生動物[3]。基金會的總部設於英國倫敦，並在許多國家成立工作據點，推動許多海洋相關的行動，包括終止非法捕撈、打擊海上人權虐待和奴隸、保護生物多樣性、確保永續漁業等[4]。

「海洋清網計畫」的主要目的有3點：一、從自然環境中移除廢棄漁網和幽靈漁具；二、對於參與廢棄漁網收集的海岸社區，提供第二收入來源；三、建立海岸社區海洋保護意識[5]。為達成上述目的，「海洋清網計畫」致力建立一個連結地方社區、回收商、以及產品製造商的供應鏈。換言之，地方社區幫忙收集和清洗使用過的漁網（圖1），然後以保證價格賣給回收商。回收業者再進一步清洗漁網、切碎漁網，將漁網碎片融化成粒狀物（pellets）。這些粒狀物再送至製造公司，用以製造高品質的商品。本文介紹「海洋清網計畫」，以瞭解基金會如何引導海岸社區參與此行動，進而使社區有能力成為漁網回收的一環，同時也是海洋環境保護的一份子。

圖1／廢棄漁網回收再利用可製造新的產品
圖片提供／陳璋玲

「海洋清網計畫」概況介紹

「海洋清網計畫」主要係建置一套機制，使地方社區願意投入廢棄漁網收集和清除的工作，漁網再經回收再利用，製成新產品。此機制涉及擬訂社區加入該計畫的步驟、教導社區辨認可接受回收的漁網及清洗漁網的方法、提出減少漁網掉入海洋的作法、以及制定參與者應遵守的規定等[2]。

一、社區加入「海洋清網計畫」的步驟

- 如果您的社區有使用很多漁網，或者發現在您的社區有很多棄置漁網，請用Line連絡我們。
- 在您的社區找出一個連絡人，這位人士將負責審視社區的漁網收集情形。
- 在您的社區確認一處漁網收集的地點，這個地點可位於碼頭或漁船附近，但必須是有遮蔽的，以避免漁網被風吹走或沖入至海中。
- 和您的社區連絡人一起訂出從漁網收集地點到回收業者的相關後勤事宜。
- 基金會將協助設計符合您社區需求的記錄系統，記錄漁網收集數量等事宜。
- 基金會將培訓社區成員，教導如何清洗漁網。
- 基金會將和您協調出一個運送清洗過漁網的時程，如每個月或每兩個月一次。

二、教導如何辨識基金會接受的漁網

環境正義基金會目前只收集材質為尼龍（nylon）的刺網。此係因為尼龍材質的漁網耐磨且持久，適合作回收使用。至於其他材質的漁網，基金會未來將擴大接受回收。

為幫助漁民辨識哪些漁網是可接受或不可接受的，基金會特別製作一份指引，以圖和文字描述各類型的漁網。該指引亦提供各類型廢棄漁網的市場價格資訊。舉例來說，基金會目前接受的刺網，顏色為白色或藍色，網線細但堅硬，網目大小2.5～10公分。主要漁獲物為蟹類，廢棄漁網的市場價格為每公斤2～8泰銖（baht）（1泰銖≒0.85新臺幣，故約新臺幣1.7～6.8元），但基金會收購價格為每公斤10泰銖（約新臺幣8.5元）。另材質為聚丙烯（polypropylene）或聚乙烯（polyethylene）的拖網和漁繩則不接受。拖網的顏色為藍、黃、黑或紅色，網線粗或細都有，網目大小2.5～5公分，常用於商業捕撈，魚類為主要漁獲物，廢棄漁網的市場價格為每公斤2～5泰銖（約新臺幣1.7～4.2元）。

三、教導如何清洗漁網

廢棄漁網收集後，必須清洗和風乾。此可提升由廢棄漁網回收製成塑膠粒的品質，意味著回收業者未來也較可能接受漁網。基金會提供清洗漁網的技巧如下：

- 移除繩子和鉛子，但保留它們，因為還可賣給其他回收業者。
- 分開不同類型的漁網，留下基金會接受的漁網。
- 移除任何卡在漁網的魚或其他動物、小樹枝、葉子、小石頭或其他垃圾。
- 使用鹽巴或雨水清洗漁網，不要使用化學物或淡水。
- 風乾漁網並保存於乾淨且有遮護的地方。
- 裁剪、收集和搬運漁網時，建議戴上手套，以避免受傷。

四、教導如何避免漁網丟失於海中

避免漁網傷害海洋環境最簡單的方法就是在第一時間不讓漁網掉入海洋，或者儘快撿起掉入海洋的漁網。基金會提供避免漁網丟失於海中的作法如下：

- 向泰國漁業司（Department of Fisheries）或海洋和海岸資源司（Department of Marine and Coastal Resources）索取正確標示珊瑚體位置的地圖，並避免在此區域下網捕魚。
- 將旗幟放在海底物之上，以利看出可勾住漁網的地方。
- 如果發現網具遺失於海中，帶回至岸上。
- 如果發現漁網被珊瑚礁或海底物勾住，而取回漁網之過程困難或危險，請記下漁網的地理位置座標，並用Line通知基金會。
- 如果弄壞漁網，請不要丟入海中，而是留著並帶回岸上。
- 如果在岸邊修補漁網，務必確認不要的漁網不要掉入海中，保存並收好它，由基金會來回收。

五、參加者遵守的規則

環境正義基金會要求參加本計畫的社區遵守一些規則，以保護兒童、自然環境，以及確保參加者的福利。規則如下：

- 基金會對童工和貪污採取零容忍政策。若有人或社區有涉及該二項任一項的嫌疑，基金會保留立即終止本計畫和參與者關係的權利。

- 不可以燃燒漁網、漁繩，以及其他塑膠製品，因為燃燒這些物品會釋放有毒氣體，有害健康。
- 不可使用化學劑清洗漁網，因化學劑會污染環境和危害野生動物。建議使用海水或雨水清洗漁網。
- 「海洋清網計畫」供應鏈的任一環節，禁止雇用童工。但基金會鼓勵社區提供兒童實習或訓練，因可協助兒童建立技能和知識。然而此學習性質的工作不得干擾兒童上課，不得涉及長時間或夜間工作，也不得涉及處理危險的化學物品或操作具有危險性的機械、設備和／或工具等。
- 保證廢棄漁網的收購價格為每公斤10泰銖。基金會將暗地訪視確保該價格如實支付。
- 計畫僱用的人員薪資不得低於各省的薪資委員會（Wages Committee）依《泰國勞工保護法》（Thai Labour Protection Act）所訂之最低日薪資。
- 工作時數不得超過每日8小時，且在此工時期間，至少有1小時的休息時間。

「海洋清網計畫」的初步成果

「海洋清網計畫」執行約3年期間，透過泰國漁業司協助，已有一些沿岸漁業社區參與此計畫。截至2020年10月，已回收5.9噸漁網。基金會同時努力和多家泰國公司合作，鼓勵其使用由漁網回收再製造而成的塑膠粒，生產消費者產品，如水上運動用品和COVID-19相關產品，如面罩、推桿和殺菌瓶等[6]。

值得一提的是Qualy公司，此公司亦加入「海洋清網計畫」。Qualy設計產品的理念是尊重地球和同時改善人類生活。此公司利用廢棄漁網、寶特瓶、塑膠袋等，製造許多設計感十足的物品，包括文具用品、衛浴用品、廚房用品等（圖2）[7]。監督機制尚有賴會員國進一步協商。因此，全球塑膠協議能否如期完成並落實，皆有待觀察。

圖2／Qualy利用廢棄漁網、寶特瓶、塑膠袋等，製造許多設計感十足的物品
圖片來源／[7]

結論

「海洋清網計畫」是環境正義基金會在泰國發起並執行的海洋保護行動。此計畫藉由提供比市場價格高的漁網收購價格，鼓勵海岸社區收集廢棄漁網，同時也教導社區如何避免漁網丟失於海洋。這些作為有助於建立海岸社區的海洋保護意識。

此計畫實施約3年，已建立從海岸社區收集漁網、回收商再利用漁網並製成塑膠粒，到公司生產新產品的供應鏈，顯示此計畫已有初步成效。基金會未來將進一步擴大開發更多不同類型的商品，以及回收不同類型的廢棄漁網。基於在泰國實施「海洋清網計畫」的成功經驗，基金會希望未來擴大至其他國家，尤其是海洋塑膠污染嚴重的西非國家。

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泰國自然資源與環境部在國家整體海洋發展政策中的角色

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關鍵字／MONRE、海洋政策、整合性治理

雖然泰國擁有廣達31萬平方公里的專屬經濟海域，但過往以陸地為主的國家戰略思維，令其海洋與海岸政策不易整合，在2015年歐盟發出非法、未報告及不受規範（Illegal, unreported and unregulated, IUU）漁捕的黃卡警告後，才開始進行相關產業的全面改革。本文介紹泰國海洋政策的形成以及泰國自然資源暨環境部與海洋事務的整合性治理。

泰國海洋政策的形成

泰國國土面積達51.3萬平方公里（世界第50位），人口7,000萬（世界第22位）。就陸地東南亞而言，地處中南半島的核心位置，越戰時期是美國轟炸越南的主要空軍基地。就海洋東南亞而言，往西是安達曼海與印度洋，往南是暹羅灣與南海，控制麻六甲海峽北方，是連接太平洋與印度洋的樞紐。泰國身為東協創始國，長期親美，美國駐泰使館的面積與職員人數居東南亞國家之冠。但2013年中國成為泰國最大貿易夥伴，中泰軍事交流逐漸升高。美國的印太戰略與中國的一帶一路如果要成功，泰國都是居於關鍵性位置[1]。

長期以來，泰國在整體的國家安全防衛上都保持著一種陸地為主的國家戰略思維[2]，所以雖然泰國擁有廣達31萬平方公里的專屬經濟海域，過往的海洋與海岸政策卻不容易整合[3]。泰國在邁向已開發國家目標前進的過程中，工業化所引發的環境污染，以及曼谷及其產業群聚區與沿海地區之不平衡發展不斷加劇，使得永續發展與包容性成長之重要性日益凸顯，經濟發展、社會人力與環境資源三者之間的平衡也愈來越受到重視。

不過，更重要的驅力是來自國際因素方面，隨著聯合國永續發展計畫、東協區域整合加速推進、南海爭議、美國打擊人口販運，以及歐盟對IUU漁捕裁罰等國際制度的規範力量加強。尤其是2015年4月歐盟對泰國IUU漁捕發出黃卡警告後，泰國開始積極對漁業進行全面改革，除了迅速建立有力的新法律及政策架構外，還積極進行貸款安排與投入，以確保漁業成為更加永續的產業[4]。其中最重要的是成立跨部會的協調機構，「打擊非法漁捕指揮中心」（Command Center Combating Illegal Fishing），之後轉換成為著名的「泰國海洋執法協調中心」（Thai Maritime Law Enforcement Coordinating Center, Thai-MECC），成為海洋與海岸事務橫向聯繫的樞紐組織[5]。自此之後，IUU漁捕、非法移民、毒品走私、海洋環保與生態復育等議題日益成為泰國海洋事務管理的主要對象[6]。

圖1／泰國地處中南半島的核心位置，往西是安達曼海與印度洋，往南是暹羅灣與南海，控制麻六甲海峽北方，是連接太平洋與印度洋的樞紐
圖片提供／Pride Advertising Agency Ltd.

正是在這個內外變動的因素交織之下，泰國於2015年制定第1個國家發展長期計畫《20年國家戰略》（20-Years National Strategy, 2018-2037）中，提出了「安全、繁榮、永續」（Security, Prosperity, and Sustainability）3項規劃重點，制定了一系列有關海洋之計畫與政策。在安全方面，主要的國家級計畫有「國家海洋安全計畫2015-2022」，繁榮方面則是「第12個國家經濟與社會發展計畫2017-2022」，永續方面則有「環境管理計畫2015-2021」、「自然資源與環境部之戰略計畫2016-2021」與「泰國國家生物多樣性戰略與行動計畫2015-2021」等等[7]。

主要的國家級海洋法律在2015年之後被創立與修訂，例如《皇家漁業條例2015》（Royal Ordinance on Fisheries 2015）、《促進海洋與沿海資源管理法2015》（Promotion of Marine and Coastal Resources Management Act 2015）、《泰國水域航行法1913》（Navigation in Thai Waters Act 1913，2017年修訂），以及《國家海洋利益法2019》（National Marine Interest Act 2019），將這些關乎自然資源與環境的法律執行範圍從領海擴展到專屬經濟海域，甚至於公海合作範圍[8]。

從這些計畫與政策，泰國政府企圖通過各方參與管理，有效整合各領域國家力量去處理海洋安全傳統領域（如維護海洋利益、和平利用海洋、海洋國家安全等）與海洋安全非傳統領域（如海洋資源與環境之平衡和永續、發展海洋人力資源、知識與海域意識、海洋治理等議題）[9]。

自然資源暨環境部與海洋事務的整合性治理

海洋事務的整合性治理具有一定的難度。除了印尼，在東協國家中，都沒有設立海洋事務綜合管理的單一部會，泰國也不例外。因此上述的計畫與政策落實在治理機構的具體安排上，都按領域被分配到多個單一部門內，包括農業合作部、交通部、能源部、國防部、觀光暨體育部、內政部、海洋和海岸資源司（Department of Marine and Coastal Resources, DMCR），以及自然資源暨環境部（Ministry of Natural Resources and Environment, MONRE）等部會。

意識到資源開發必須與資源保護相協調，泰國政府於2003年成立MONRE，致力於促進泰國環境保護暨包容性發展。MONRE的願景為「將自然環境還給泰國人民，並致力於將自然資源與環境納入政府的國家議程，因為這些為社會和經濟發展奠定了基礎」，基於公眾參與和良好治理的原則，支持主動整合自然資源、環境保護暨生物多樣性的行政管理[10]。

MONRE通過一個2016年至2021年的5年戰略計畫推動5項主要策略

一、以綜合方法來保護、保留、回復和管理自然資源，確保響應發展並允許永續及公平之資源利用。

二、以綜合及有效的方式管理地表水和地下水。

三、透過參與式途徑進行維護和回復環境品質。

四、預防和減少自然災害和氣候變化之影響並促進適應力度。

五、提高組織管理以及自然資源和環境管理的效率[11]。

透過參與式途徑，MONRE扮演著支持社區暨私部門與公部門一起參與的橋樑角色，有效地促進泰國紅樹林之回復（1961年至1996年期間內，泰國失去了56%紅樹林覆蓋。1998年開始，泰國政府致力於紅樹林種樹事業。2002年至2012年期間，與其他東南亞國家相比，泰國之紅樹林砍伐速度明顯放緩[12]）、提升泰國海洋保護區覆蓋率（截至2022年，泰國海洋保護區共有246處，覆蓋率為其所轄海域面積之4.44%，為東協國家中第2[13]），確保泰國之東南亞國家海洋永續發展表現優良地位。

MONRE轄下成立各處與辦公室以處理各項業務，例如：自然資源和環境政策與規劃辦公室（Office of Natural Resources and Environmental Policy and Planning, ONEP）負責規劃和政策制定、環境影響評估以及環境保護區的建立；國家公園、野生動物和植物保護司（Department of National Parks, Wildlife and Plant Protection, DNP）負責管理海洋公園；海洋和海岸資源司為負責促進泰國紅樹林、珊瑚礁、海草和瀕危海洋物種等資源永續管理和保護的主要機構；污染控制司（Pollution Control Department, PCD）負責制定沿海水質標準、監測沿海水域，以及設立污染控制區。

因此，在各部會的分工當中，MONRE為負責各種海洋暨海岸之自然資源和環境管理的主要機構。海洋和海岸資源司則是主要負責海洋與海岸事務的主事單位。然而海洋和沿海的資源管理因為其特性經常不是單一部會能夠獨立完成。例如，海岸地區是水陸交會之處，這一特性既是海岸地區生產力特

別豐富的來源，也是污染與災害最頻繁發生的地方。按照聯合國的文件，海洋的污染有8成以上來自陸地，其中不只包括各式製造工業與沿岸城市廢水污染，還有各種森林開墾、農場與養殖業的肥料與排泄物所累積下來的非點源污染（non-point pollution），這些問題就不是海洋和海岸資源司可以管轄的範圍。

再如，在海洋保護區（marine protected area, MPA）與海洋國家公園的設置決策與管理維護上，海洋和海岸資源司都必須與同一部會的國家公園、野生動物和植物保護司、自然資源和環境政策與規劃辦公室，以及跨部會的漁業司（隸屬農業合作部）、海洋司（隸屬交通部）與公共工程與城鄉規劃司（隸屬內政部）進行協調分工。

為了解決部會之間橫向協調的問題，MONRE設立了一個「國家海洋與海岸資源委員會」（National Marine and Coastal Resources Committee）。這個委員會在組織上雖然位於海洋和海岸資源司「之下」，但實際上它是由總理擔任主席，海洋和海岸資源司司長只是擔任秘書角色。該委員會下設8個分會，有19位相關部會代表參加，12位與海洋海岸領域相關的獨立學者專家，有6位必須來自海岸社區。類似這種由總理擔任主席的橫向連結委員會還有漁業司底下的「國家漁業委員會」（NOF），以及涉及海洋國防安全議題，直屬總理辦公室的國家安全理事會辦公室（ONSC）的「國家海洋利益保護委員會」（NMIPC）與「海洋執法指揮中心」（Maritime Law Enforcement Command Center）[14]。

圖2／海洋與海岸的議題需要一個跨部門與跨領域的整合性管理機制，泰國設置自然資源暨環境部以進行縱向與橫向的組織聯繫
圖片來源／https://www.tourismthailand.org/Attraction/hat-thang-sai

不過即使有縱向與橫向聯繫的組織安排，但在海洋保護區面積占專屬經濟海域面積預定由現在的5%推至2030年的10%這個政策上，至今仍然爭論不休。主要是因為這項議題至少牽涉到3項法律：由國家公園、野生動物和植物保護司業管的《海洋國家法》、由自然資源和環境政策與規劃辦公室業管的《國家環境品質法》，以及由海洋和海岸資源司業管的《海岸法》。各項法律之間的競合產生業務重疊，或是多重執行，導致底層社區對法律允許與禁制項目的困惑與反彈。這也導致海洋保護區持續存在著資金短缺、管理效率不彰與社區（利害相關人）參與不足等問題[15]。因此，泰國的經驗可以提供臺灣借鑒之處在於，海洋與海岸的議題需要一個跨部門與跨領域的整合性管理機制，海洋委員會作為海洋事務的最高主管機關，應該是推動此一整合性管理機制的理想單位。

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探尋南沙　認識常見大型藻類多樣性

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關鍵字／南沙太平島、大型藻類、潮間帶、物種組成

南沙群島面積最大的天然島嶼為「太平島」，周邊海域珊瑚礁擁有豐富的海洋生物資源，目前研究方向大多以魚類與無脊椎動物資訊調查最多。另外一面，棲息在潮間帶的大型藻類分布資料甚少，為此須建立生物資訊，可藉由人為進行周邊岸際大型藻類生物相調查，因此有必要調查島嶼岸際大型藻類。國家海洋研究院（簡稱國海院）研究團隊從2021年7月起至2022年3月與7月共3季次大型藻類資料蒐集，完成80種南沙太平島常見大型藻類物種介紹（圖1），讓熱愛海洋探索與增進認識大型藻類的興趣，更深一層善用海洋，愛護海洋，珍惜海洋資源，符合維持海洋生態平衡的理想，營造一個生態、保護、繁盛優質的天然島嶼。

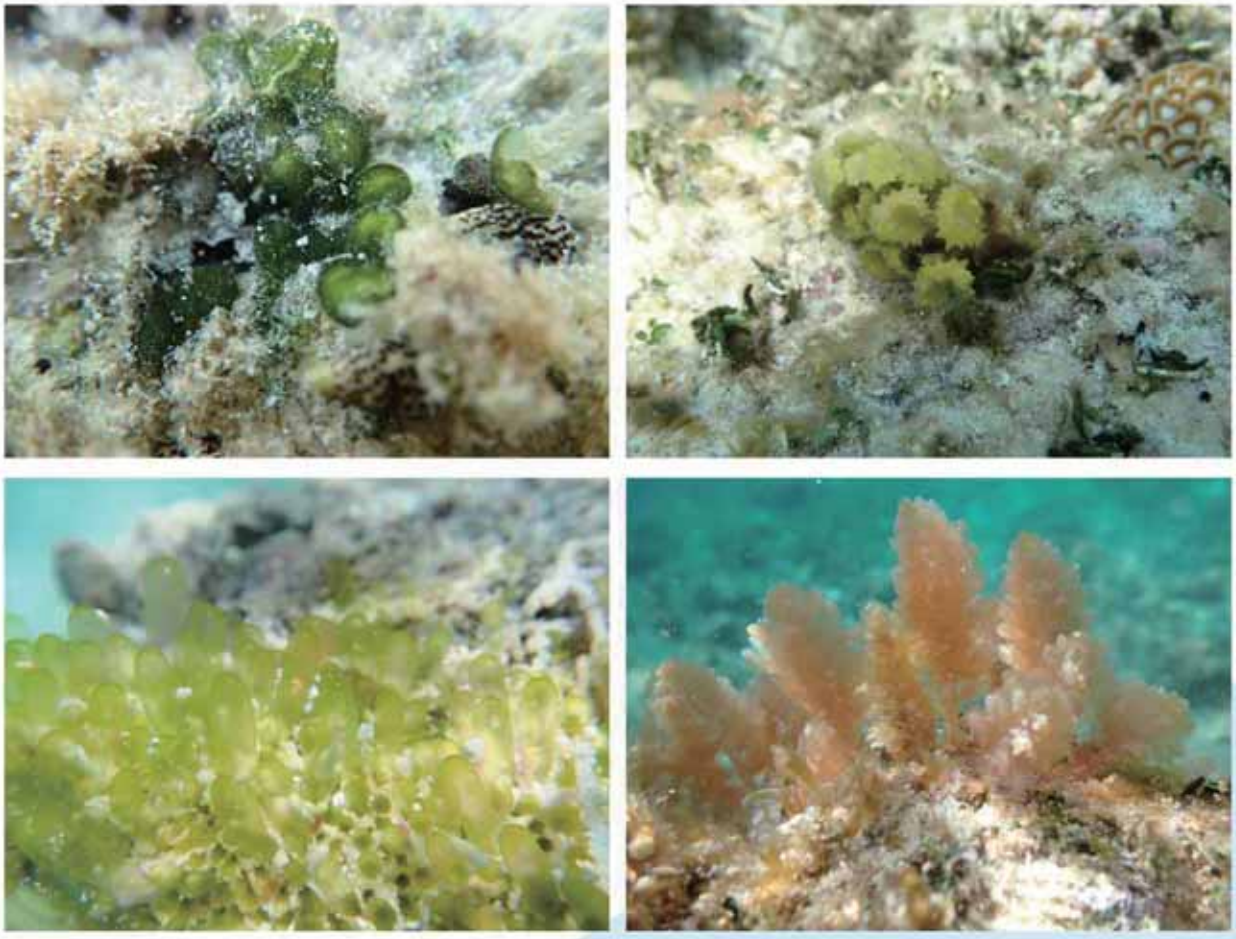

圖1／南沙太平島常見大型藻類分為4大類群：藍藻類-海雹菜（左上）；綠藻類-香蕉菜（左下）；褐藻類-小葉喇叭藻（右上）；紅藻類-紫杉狀海門冬（右下）

圖片提供／國家海洋研究院海洋生態及保育研究中心

大型藻類扮演基礎生產者的重要角色

大型藻類廣泛分布於潮間帶以下的透光層，除了透過光合作用及製造氧氣，外觀形態複雜且十分優美奇特，其種類繁多肉眼難以辨識，顏色與體形大小上有很大的差異，尤其是大型藻類種類組成有季節性的演替，通常以生長快速或生命週期短為關鍵特點，受到地形、底質、海溫、光照及營養鹽變化影響，被視為海洋食物鏈最重要的基礎生產者。既可提供藻食性魚類、蝦類、蟹類和其他海洋動物良好的棲息場所與食物來源，又可當作產卵與孵卵的基質，給予繁育幼體與隱蔽安全的優良環境，對於海洋生態系平衡擁有穩定作用與減緩溫室效應，進而影響海洋漁業資源之保育，也能夠為海洋生態系統中發揮淨化水質與維持生物多樣性等重要的作用，對於保護海洋生態環境而言具極重要之影響力。

探索南沙周邊海岸線

南沙太平島地理位置為相當重要海島地形，位於南沙群島，該島四面環海，面積約0.51平方公里，長1,360公尺，寬350公尺，環島全長2,850公尺。島上周邊岸際為沙灘地形，其四周海域為潮間帶，擁有寬廣的珊瑚礁所構成的地形，主要特點是光線充足，每天有著重複固定的潮汐週期，漲退潮間輪流交替，使沙質曝露於空氣中，隨海水沖蝕，形成波浪至四面八方翻滾的海岸線，造就漂沙頻繁的擾動，容易改變沙灘地形，亦常會被沙質掩蓋著珊瑚礁盤，因此不容易被發現海洋生物佇立於棲地生活。在島上不僅地理環境位置優越，蘊藏著豐富的漁業資源及海洋生物多樣性，海洋生態資源豐富，保有相當完整的海底森林，亦是周邊岸際海域典型珊瑚礁魚類匯集地，皆是海洋生態與保育研究的焦點議題。

一、潮間帶的分布

大型藻類常棲息於南沙太平島周邊岸際潮間帶的底質為珊瑚礁盤（圖2），其各岸際由淺至深處的面積寬廣不一，底質細分為4個地帶，依序以珊瑚砂帶、礁石帶、礁岩平臺帶及珊瑚貧瘠邊緣帶等4個地帶，離岸際越遠，出現大型藻類物種越豐富及多樣化。

- 正東面與正西面：潮間帶較寬廣，寬度約400～500公尺。
- 西北面與正北面：潮間帶寬廣介於中間，寬度約300～350公尺。
- 正南面與東南面：潮間帶寬度較窄，寬度約150～200公尺。

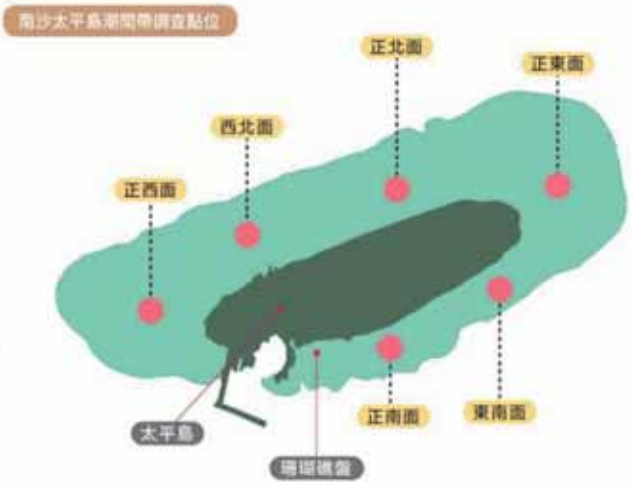

圖2／南沙太平島潮間帶調查點位
圖片提供／國家海洋研究院

二、查詢水文資訊

在南沙太平島採集或調查大型藻類最為理想的時間點是大退潮。首先要查明退潮的月份、日期及時間，下海前則需注意當日海流變化或當天的氣候變化，尤其是雷陣雨時，並不適宜浮潛或水肺調查。為檢視每日海流變化及潮汐預報，透過手機或電腦上網查詢國海院在2022年啓用之國家海洋資料庫及共享平臺（National Ocean Database and Sharing System, NODASS），擁有建構完整的海洋資料庫，可充分運用海洋資料及資訊服務，查詢水文相關資料，隨時注意各海域的變化（連結網址：https://nodass.namr.gov.tw/）。

三、探索潮間帶的時機點

南沙群島位於熱帶海洋氣候區，此區域夏季容易生成颱風，常伴隨著西南氣流的影響，使海水中夾雜著細沙，容易造成混濁之外，間接影響周邊海域使海況惡劣，非常不易執行水肺潛水調查，能見度極差。春季恰為相反，春季海況平緩且水質清澈，能見度極佳，是最適合探索海底大型藻類物種的時機。

資訊蒐集南沙大型藻類種類組成

一、鑑定方法與資料分析

依據國海院2020年「我國海洋生態調查監測網與監測規範建立整體規劃」報告書之生態系研究方法，為有效運用大退潮之有限時間，除現場確認方框內之海藻種類外，先用防水數位相機以垂直或微距離拍攝大型藻類色彩與外在形態，將所有拍攝之數位照片存入電腦，藉此翻閱有關大型藻類的書籍，並觀察藻體的生長棲地與形態描述，及建立該物種名錄與資訊蒐集。

二、統計結果

近2年國海院研究團隊調查南沙大型藻類種類組成資料，從2021年7月與2022年3月及7月份各進行一季次調查，共蒐集3季次南沙太平島6樣區潮間帶的大型藻類物種數，分別為4門40科76種、4門36科60種及4門24科45種，並將資料進行統計分析，合計4門40科80種（圖3）。此調查研究成果能更完整瞭解南沙各區域出現大型藻類的分布，可用於海洋生態及保育研究等相關研究。

圖3／2021-2022年南沙太平島6處樣區大型藻類共同物種
圖片提供／國家海洋研究院海洋生態及保育研究中心

探訪南沙太平島常見大型藻類

一、大型藻類科普教材

國海院研究團隊於2021年與2022年調查大型藻類物種與生物名錄資料。由於海上交通不易，且船班回程時間受限制，在兩趟的南沙旅程中，研究團隊把握這樣難得的機會，若每日上下午時間遇好天氣就攜帶著調查工具，利用水中潛水面鏡觀察水下生態環境，浮潛在島上周邊的潮間帶，透過防水數位相機採集、量測、拍攝生物相照片及記錄各潮間帶出現大型藻類物種組成。蒐整這2年該物種與生物資訊，完成南沙太平島80種常見大型藻類物種介紹（圖4），書本取為「南沙太平島常見大型藻類圖鑑」[1]，以作為海洋教育與科普題材。本書圖鑑亦彙整1981年至2022年記錄233種南沙太平島大型藻類生物名錄。以國海院研究團隊調查其中80種太平島常見大型藻類進行介紹，冀望能增加國人對太平島大型藻類有進一步的認識。

圖4／南沙太平島常見大型藻類圖鑑
圖片提供／國家海洋研究院

二、大型藻類4大家族

現今大型藻類的分類階層不斷更新，必須透過Algaebase網站[2]查詢每一種生物或者每個分類學上的生物群，才能符合學術的正確性。目前大型藻類分為4大類群：藍藻類（藍菌門Cyanobacteria）、紅藻類（紅藻門Rhodophyta）、褐藻類（淡色藻門Ochrophyta）及綠藻類（綠藻門Chlorophyta）。簡而言之，在南沙太平島周邊岸際潮間帶所觀察到大型藻類，從近岸進行類別說明，如藍藻類是最原始的生物，也是最簡單的一群藻類，顏色大多數為藍綠色，能忍受較乾旱與炙熱的棲地環境，大部分多生長於高潮線地帶；綠藻類是種類最多，顏色大都呈現綠色，喜愛強光，退潮時，常曝露於空氣中，棲息於較耐旱的環境，多分布於潮上帶；褐藻類顏色為黃褐色或淡黃色，主要生長在潮中帶及低潮線附近；紅藻類顏色通常呈紅色或紫色居多，不喜好強光，反而喜好弱光，常居住於低潮線附近或亞潮帶以下的區域（圖5）。

潮間帶大型藻類分布圖

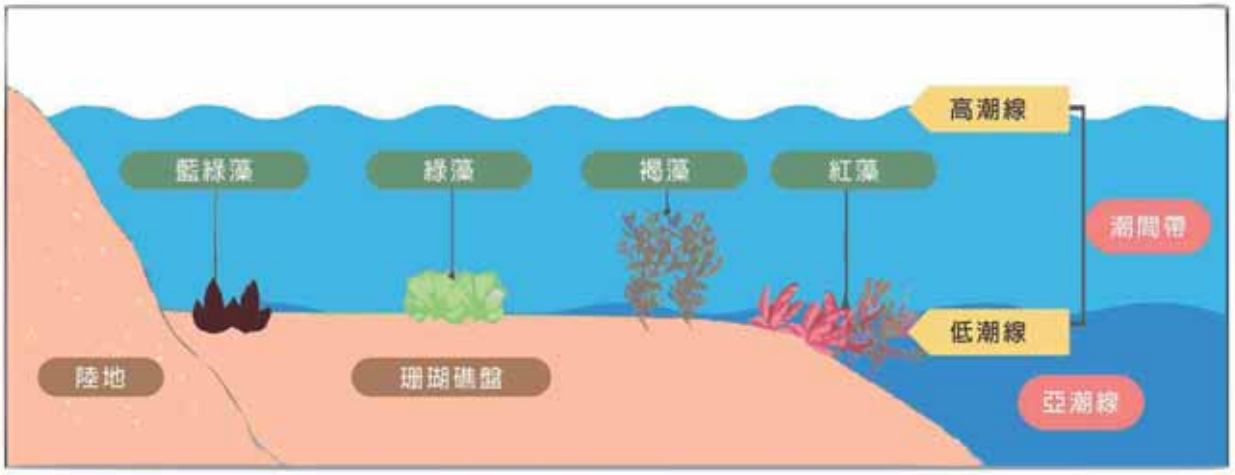

圖5／潮間帶大型藻類分布圖
圖片提供／國家海洋研究院

展望

國海院研究團隊於2021年與2022年調查南沙太平島周邊6樣區潮間帶的大型藻類物種名錄，已累計3季次物種組成資料，透過科學儀器量測6樣區的水文資料，其中最主要的發現是南沙的海水溫度介於25～30°C之間，與每日受到潮汐幅度變化，易受自然光照強弱影響，使大型藻類在原棲地物種會不穩定的生長與繁衍。與此調查同時，採集現有的原生種大型藻類，開發簡易組織培養技術，在南沙海洋研究站先進行短暫的種原保存後，運回至國海院的種原庫，以降低原生種消逝的風險。將來可結合人工種苗保存與棲地復育，藉由南沙太平島特有熱帶海洋性氣候進行階段性保存種苗的運送與空間置放，以便提供就地保種與異地保種所需，未來可建立海洋教育等科普相關知識。

- 記錄生物資訊：建立每一年原棲地物種名錄，永續提供大型藻類生物多樣性的資訊。
- 開發保種技術：發展大型藻類種苗培育與保種技術，以達到復育資源才能永續利用。

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泰國廢棄物處理與管理制度

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關鍵字／泰國、廢棄物、管理制度

全球人口數快速成長及伴隨的經濟發展與消費行為，已造成日益嚴重的海洋污染危機及後續廢棄物的管理問題。如同許多開發中國家，泰國在都市化、人口急速增長及經濟活動的快速發展下，正面臨廢棄物產量急速增長的危機，尤其塑膠類廢棄物的處理，更是現階段必須面對的重大挑戰。據估計泰國每年廢棄物總量在2025年前，將增加至目前水準的2倍以上[1-3]。在泰國或其他國家，任何社區或都市活動皆可能產生廢棄物，例如住家、企業公司、商業市場、機構設施、建築工程及街道打掃等都市服務。與亞洲其他發展中國家類似，泰國廢棄物接近50%為有機物質，如廚餘，其次為塑膠、紙類、衣物、木材、橡膠、皮革、玻璃或其他形式的廢棄物，但在定義上，一般廢棄物不包括有毒或感染性廢棄物及底泥等土壤物質[3] [4]。

泰國廢棄物的產生與處理

隨著經濟活動與都市開發的成長，泰國的廢棄物增加量和全球趨勢一致，大致上以每年2%的增加率快速上升[5]，雖然這僅是小幅度的成長，但是數量龐大的固體廢棄物丟棄於環境中，以及河流與海洋中隨處可見的塑膠廢棄物，仍舊對生活環境造成極大的影響，尤其泰國有限的土地空間與掩埋場，使得廢棄物管理問題正面臨重大挑戰[5]。據統計，曼谷都會區所產生的廢棄量占總廢棄量20～45%以上，其他都會地區約占30%，而都會城市以外的其他地區所產生的廢棄量則不到40%[5][6]。然而近年研究指出，泰國的塑膠使用量正以每年7～8%的速率增加，平均每人每天至少使用8個塑膠袋，全國1年約使用2億個塑膠袋[7][8]，這些難以分解的塑膠廢棄物，無疑對陸域與海洋環境造成極大的壓力。

泰國與其他大部分亞洲國家廢棄物組成，多是以可生物降解的有機物質為主，例如廚餘等食物廢棄物。平均而言，含水廢棄物可占總廢棄物重量一半以上，在泰國部分省份，例如Samutprakarn與Pattaya，含水廢棄物的平均占比甚至可高達70%[9]。先前研究指出，曼谷與其他都市區的廢棄物組成差異頗大，食物廢棄物的占比約在40～60%，但泰國其他不同城市之間，紙類（4～25%）與塑膠廢棄物（4～28%）的占比變動差異則相當明顯，與各個地區的消費習慣、生活型態與經濟條件密切相關[6]，舉例來說，曼谷地區經濟活動與商業行為活絡，平均每人每天約可產生1.5公斤廢棄物，相較而言，其他地區如Nonthaburi或Angthong，平均每人每天僅產生0.6公斤廢棄物。但對比曼谷或其他都會地區，熱門觀光景點與旅遊熱區，例如普吉島的Patong beach，平均每人每天可產生高達5公斤的廢棄物[1]，這些觀光地區遊客聚集的地點，一般廢棄物或塑膠廢棄物的數量遠高於住宅區，顯示觀光地區的消費行為大幅增加廢棄物的數量。

儘管目前尚未有明確的調查資料可區分觀光熱區的一般廢棄物或塑膠廢棄物的來源，但泰國污染控制司（Pollution Control Department, PCD）分析結果顯示，觀光地區與其他地區的塑膠廢棄物大約占廢棄物總量的17%，在熱門觀光地區，大部分的塑膠廢棄物都能被回收再利用，估計僅約10%的塑膠廢棄物無法在消費後端被回收，每年約產生1萬公噸的塑膠廢棄物[1]。在泰國，露天焚燒是一種簡單又相對經濟的方式，可有效減少未被回收廢棄物數量，因此民眾大多直接以焚燒方式來處理廢棄物。目前除了少數廢棄物被棄置無法處理外，超過9成以上未被回收的廢棄物，多是以露天焚燒的方式來處理[1]。

廢棄物的回收與再利用

由於塑膠產品價格便宜，泰國的塑膠消費量位居亞洲第1，每人每年平均使用40公斤塑膠產品，約有60%塑膠廢棄物來自零售或便利商店的塑膠袋使用，其餘40%則來自公共市場攤販的廢棄塑膠袋[10]。研究顯示，泰國對廢棄物未能有效管理，目前高達80%的塑膠廢棄物都屬於陸源性污染，透過河流、雨水沖刷、沙灘丟棄或都市排水系統流向海洋，甚至包括非法丟棄或未能妥善回收的廢棄物。其餘20%的海洋塑膠廢棄物則來自漁撈、箱網養殖或其他海上活動[11]。反觀日本儘管塑膠的生產量名列前茅，但是有效的廢棄物管理系統，使得塑膠廢棄物難以進入海洋環境[12]。

近年來泰國努力推行廢棄物回收再利用等相關活動，的確對廢棄物的減量達到明顯成效，尤其像是在曼谷等都會城市，即使人口數不斷上升，但廢棄物數量卻是呈現下降趨勢，可以歸功於廢棄物的有效回收再利用[6]。有鑑於此，泰國政府積極推動廢棄物回收再利用，尤其在廢棄物成長率偏高的幾個城市，像是曼谷或是鄰近區域的大城市等，持續鼓勵並改善廢棄物回收再利用的效率，以助於廢棄物數量的減少。儘管泰國每年有150萬噸以上的廢棄物被回收再利用，約占總廢棄物數量的10%以上，但事實上，每年仍舊有高達450萬噸的商業性可回收物質被丟棄，即使是像金屬、紙類、塑膠與玻璃等具有高度回收價值、可被工廠與工業生產再利用的廢棄物，估計仍有6成以上未能被回收再利用[12]。

泰國塑膠產品的消費使用從1970年代快速增加，更隨著全球範圍內，一次性塑膠袋的使用而大幅成長，在往後20～30年間造成嚴重的海洋塑膠污染危機。由於海洋塑膠存在跨邊界污染的問題，很可能嚴重破壞沿岸的海洋生物與生態，並對沿岸居住人類的健康安全產生威脅[13]。儘管大宗的塑膠包裝廢棄物會被直接送往接收站，但是相關研究指出，泰國僅回收約15～25%的塑膠廢棄物再利用[14]，由於大部分塑膠原料多用於製成包裝、瓶罐、箱盒或容器設備等需要長時間分解的產品，因此現階段而言，回收利用或改變包裝等，是最適合且有效的處理方式。

行動綱要與管理路徑圖

泰國日前提出國家行動方案（National Action Plan）與路徑圖（Roadmap），作為全國性塑膠廢棄物管理架構與指引方針，主要行動措施包括從源頭減少塑膠廢棄物、降低消費過程中一次性塑膠袋的使用及消費後端的塑膠廢棄物管理機制[1]；同時預計改善都市地區的廢棄物回收系統並提升郊

區城市的廢棄物回收效率，增建完善管理的廢棄物丟棄地點，包括公共廢棄場及其他管理的丟棄設施[15]。在3R（reduce, recycle, reuse：減量、回收與再利用）的原則下，泰國政府優先強化民眾循環經濟的意識並建立負責任的生產與消費觀念。

現階段廢棄物有效管理政策的推行包括雨季前導入都市廢棄物清除機制，以有效降低陸源性污染海洋的情況，同時具體強化廢棄物管理法規並監督措施執行的成效[15]。目前泰國塑膠廢棄物管理路徑圖時程表分為3個階段，2022年前屬於第1與第2階段，以停止使用危害性塑膠產品為主要目標，例如食物容器、塑膠吸管及過薄的塑膠袋與塑膠杯，第3階段則是在2027年前，完成目標塑膠廢棄物的完全回收再利用，以落實循環經濟與減塑的環保概念[15]，以此行動綱要建構泰國未來廢棄物管理具體路徑圖。

圖說／難以分解的塑膠廢棄物對陸域與海洋環境造成極大的壓力
圖片提供／Pride Advertising Agency Ltd.

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Steadfast Effort Towards Sustainable Seas

Translated by Linguitronics
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By exploring and understanding the ocean, we are able to use marine resources responsibly, while building sustainable marine ecosystems. Taiwan possesses unique marine environments such as the rich coral reef ecosystem at Taiping Island of the Nansha or Spratly Islands. However, information on the distribution of macroalgae in the intertidal zone is insufficient. As such, this issue introduces the biota survey of macroalgae in the intertidal zone of Taiping Island conducted by the National Academy of Marine Research (NAMR). The survey successfully established biological data and built a comprehensive compilation of species to enhance the general public's basic understanding of Taiwan's macroalgae. The "GoOcean" online platform of NAMR is able to consolidate real-time information from different departments and offer risk alert for different water recreational activities. This is helpful to the public in assessing the risk levels when engaging in these activities, and serves to achieve the goal of open ocean. Collecting marine data is also beneficial for the global effort against climate risks. The recent International Issues introduces the Asian Development Bank's (ADB) report, *Sea-Level Change in the Pacific Islands Region*. It provides diligently reviewed scientific data identifying islands and regions more susceptible to sea level rises, a valuable reference for investment in the Asia-Pacific region.

The country covered by the recent issue is Thailand. Due to sustainable development programs of the United Nations, expedited regional integration of ASEAN countries and influences of other international factors, especially penalties on illegal, unreported and unregulated (IUU) fishing imposed by the European Union (EU), Thailand has proactively undertaken reform measures. Since 2015, Thailand has formulated or amended regulations governing fishing, marine resources and water navigation as an effort to consolidate the division and coordination of duties at the national level. Furthermore, it has also proposed the National Action Plan and Roadmap on plastic waste management, which aims to reduce plastic waste at the source. The Action Plan and Roadmap delineates the municipal waste treatment mechanism to be adopted before the rain season to effectively reduce land-based pollution. In 2018, the Environmental Justice Foundation (EJF) implemented the Net Free Seas (NFS) project in Thailand. With assistance from Thailand's Department of Fisheries, the project has built mechanisms that make local communities more willing to engage in recycling by reclaiming discarded fishing nets for reuse. Thailand is a prime example of how both government and NGOs can work together to build sustainable seas by contributing towards marine conservation!

Figure/ Tarutao National Park, Thailand's first national park
Source/ Tourism Authority of Thailand
https:// www.tourismthailand.org/Attraction/tarutao-national-park

Global First Marine Recreational Risk Information Platform: GoOcean

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Translated by Linguitronics
Keywords: MetOcean, Marine Recreation, Beach Safety, Risk Information, Salute to the Seas Policy

The safety risks of marine recreation have always been an unavoidable issue in the open seas. GoOcean is a marine recreational risk information platform developed and designed by the Ocean Affairs Council, National Academy of Marine Research (NAMR) in compliance with the Executive Yuan's Salute to the Seas policy, including its specific strategies and 5 major goals: openness (open seas, simplified management), transparency (information transparency, one-stop satisfaction), service (friendly measures, comprehensive facilities), education (deeper education, accessible experience), and liability (clear risks, responsibility fulfillment). We anticipate that such marine recreational risk information service technology, the first of its kind, will provide islanders who have long been banned from the sea with an innovative platform to re-connect with the ocean.

The article titled "Australia's Beach Hazard Ratings and Beach Safety Website" [1] in issue 8 of International Ocean Information spoke about how many renowned recreational beaches in Australia have reduced their safety risks. The experience in Australia shows that safety risks and risk factors that exist in beach environments include big waves, strong currents, reefs, rip currents, and other weather- and environment-related factors; however, they are also associated with people's knowledge of ocean waters, swimming skills, and experience. As such, implementing hazard evaluations for beaches to assign hazard ratings and building a website for beach safety information are effective measures to avoid and reduce safety risks by offering safety guidance to beach goers.

The NAMR referenced the experience on marine risk information service of countries such as Australia and the US with the purpose of improving the availability of safety risk information for ocean enthusiasts in Taiwan. The GoOcean platform offers weather data for marine environments and safety risk information (information transparency, clear risks) by adopting cloud IoT technology to deploy cross-agency, cross-platform, forward-looking marine science and technology, providing reference and helping the general public determine whether to partake in recreational marine activities, as well as improving people's understanding of the seas (knowing the seas), encouraging them to enter the seas (entering the seas), and teaching them to enjoy the seas (loving the seas).

GoOcean's IoT Smart Ocean Engineering

GoOcean's system integrates the Salute to the Seas Forward-looking Infrastructure Development Program's newly installed anchor data buoys, ocean radars, meteorological instruments, coastal monitors, numerical hydrodynamic and water quality simulation and prediction system, and biological and underwater imaging system. It is also connected with the Ministry of Transportation and Communications' Central Weather Bureau, the Institute of Harbor and Marine Technology, the Ministry of Economic Affairs' Water Resources Agency, the Tourism Bureau, and other domestic marine organizations, as well as marine environment monitoring data from EU and US satellites. The

system's IoT-based design utilizes network architecture as shown in Figure 1. In order to provide a good user experience (UX), the platform's user interface (UI) adopts visualized human-machine interface design and development to allow users to immediately see real-time weather and recreational risks for marine recreational activities in various sea areas on an electronic map. Static weather data is rendered and issued through a Web Map Service (WMS) while dynamic marine weather data such as wind, waves, and currents are shown via WebGL in real-time by utilizing the browser's front-end rendering technology. The system's data integration architecture is as shown in Figure 2.

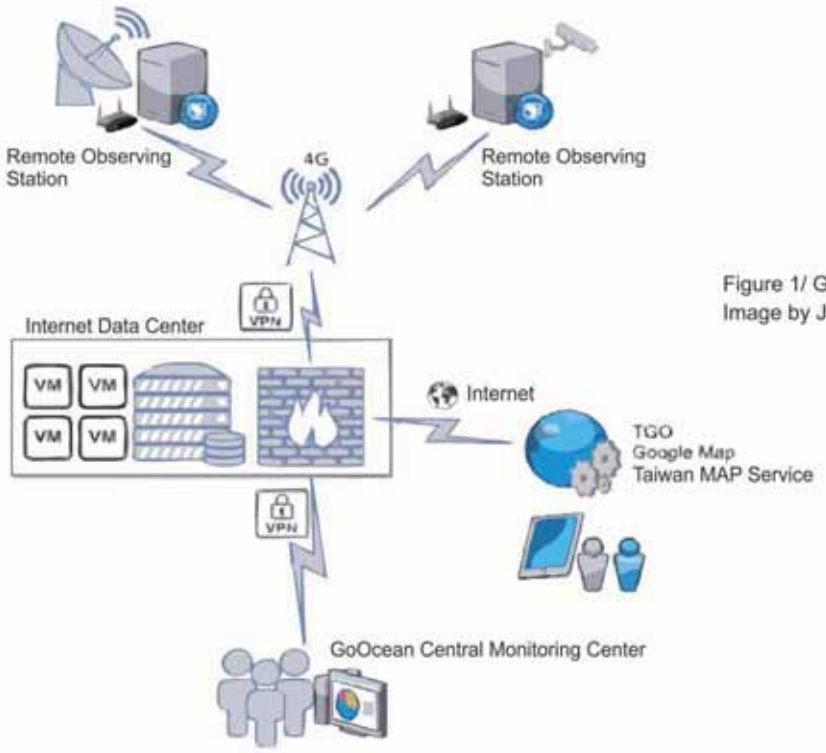

Figure 1/ GoOcean's IoT system network architecture
Image by Jian-Wu Lai

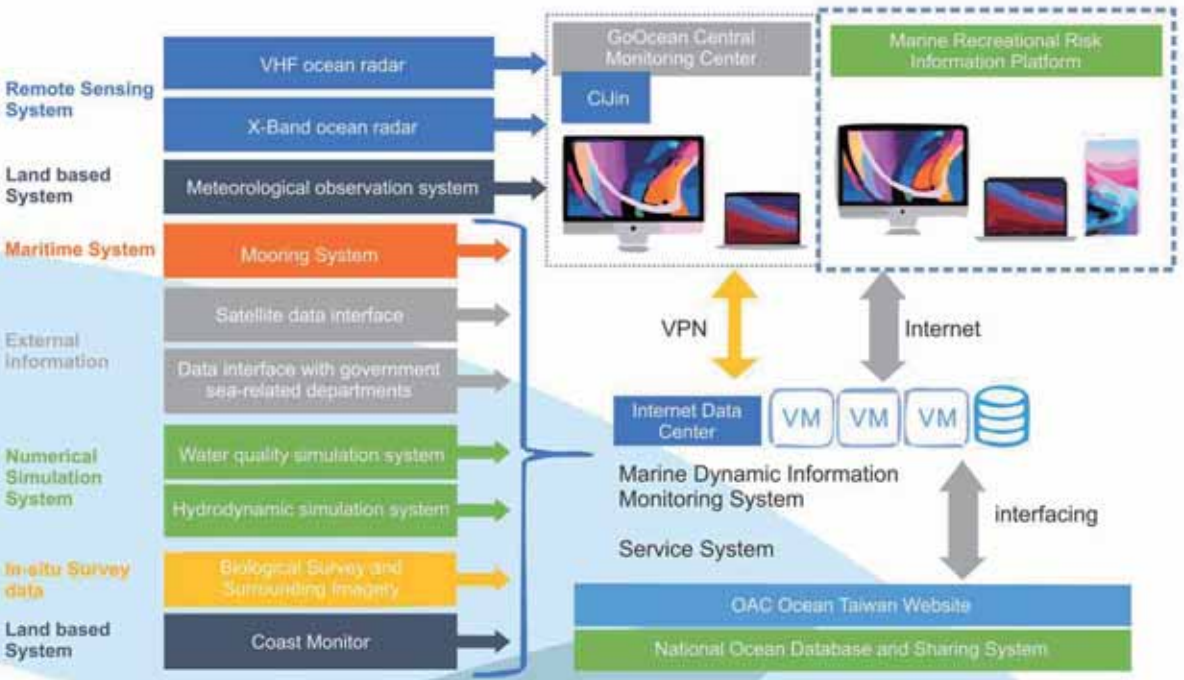

Figure 2/ GoOcean system data integrated architecture
Image by Jian-Wu Lai

First Dynamic Recreational Marine Activities Sports Rating

In 2021, the NAMR invited experts, businesses, and scholars related to unpowered marine recreational activities for multiple sessions of joint discussion, utilizing the Delphi method for statistical analysis [2]. They rated 5 types of unpowered recreational activities: diving, swimming, windsurfing, kayaking, and surfing. The rating rules are based on marine weather environment factors and there are 4 sports ability ratings: beginner, intermediate, expert, and severe sea conditions, as shown in surfing activity's rating Table 1. As such, we can perform sports ability ratings based on the selected time, beach, and dynamic marine weather conditions. The system automatically determines the recommended ability rating for various types of unpowered recreational marine activities (diving, swimming, windsurfing, kayaking, and surfing) so that the general public can evaluate their own capability and risk levels to plan appropriate recreational activities.

Table 1/ Sports Ability Rating of Surfing Activities

Ability Level / Environmental Parameters	Beginner	Intermediate	Expert	Severe Sea Conditions
Wave Height	<1.2 meters	<2.5 meters	<8.0 meters	≥8.0 meters
Wave Period	<7 seconds	<7 seconds	<12 seconds	≥12 seconds
Breaking Wave Angle	90 degrees	45~90 degrees	<45 degrees	<45 degrees
Ocean Current Velocity	<0.51 m/s	<0.51 m/s	<1.03 m/s	≥1.03 m/s

Compiled by Jian-Wu Lai

Integration of Cross-Agency Real-Time Safety Risk Information

Safety risks to marine recreation, such as swells, lightning, and ultraviolet (UV) rays, can be remotely detected using modern monitoring technologies. This allows GoOcean to provide early warnings by interfacing with the real-time data from various government agencies and applying them to safety risk alerts for recreational beaches. For example, interfacing with the real-time observation data of the lightning strike system from the Central Weather Bureau, Ministry of Transportation and Communications and Taipower Company provides lightning strike data for the past 6 hours at a data refresh frequency of once every five minutes. This allows travelers heading to wide spaces on beaches to avoid thunder and lightning from ruining their trip or even prevent the risk of fatal injury. Additionally, integration with the Environmental Protection Administration and Central Weather Bureau's hourly UV ray monitoring data from stations located across Taiwan provides reference to the general public when traveling, allowing them to make advance preparations and protect against and prevent sunburn, as well as potential skin or eye lesions, while enjoying wonderful weather and clear skies. On the other hand, swells are a hazard that often poses safety risks in marine environments for activities such as kayaking, surfing, and fishing. In order to successfully create a warning system for swells, the NAMR utilized the significant wide area, continuous, and real-time marine observation capabilities of the ocean radar system to observe wave direction, frequency, and spectrum for tens of kilometers off the coast. The separation method of wind waves and swells allows wave energy to be divided into wind and waves generated by local wind sites and swells propagated in a wide area. The wave characteristics (period and wave height) of swells are gathered and updated every 5 minutes through remote radars and early warnings are provided at little over 10 minutes in advance of swells. Combining the real-time safety risk alerts above, swell warnings and real-time lightning information can be captured as shown in Figure 3.

Figure 3/ GoOcean's integration of cross-agency real-time ocean safety risk information (Left: Swell Alert; Right: lightning)
Image by Jian-Wu Lai

Support for Domestic Marine Sporting Events

Sporting activities can make the people join as one and are symbolic of a nation's power. In addition to supporting the promotion of recreational marine activities through information related to marine environments and safety risks, GoOcean aims to utilize cloud IoT technology and data integration to support marine sporting events. By providing instantaneous, higher resolution marine weather data and marine risk information to event organizers and athletes, weather data during the sporting event can be recorded to facilitate safety risk evaluations. For example, monitoring systems were activated for the 2022 Jialeshuei International Surfing Festival hosted from September 30 to October 2 in Pingtung and the Taiwan Open of Surfing planned for November 12-20, 2022 in Taitung. The platform can also develop innovative data services based on event characteristics such as those shown on the event website of Jialeshuei International Surfing Festival in Figure 4. Not only was a 3-day forecast of sea conditions made available, but real-time observation data was integrated for reference and use by athletes and organizers.

Figure 4/ GoOcean supported the event website of the 2022 Jialeshuei International Surfing Festival (Top) and Taiwan Open of Surfing (Bottom)
Image by Jian-Wu Lai

Conclusion

This article introduces GoOcean, a marine recreational risk platform that enhances the general public's understanding of the seas (knowing the seas) and encourages them to enter the seas (entering the seas). The forward-looking, human-centric technology service enables cross-agency, cross-platform integration. In a departure from the marine environment information platforms built with foreign data that the general public previously relied on for marine recreational activities, GoOcean is based on the integration of weather reports, monitoring, and forecast data from Taiwan. This offers the advantages of higher resolution and accuracy, as well as quantified ratings of safety risk information for marine recreational activities popular in Taiwan. GoOcean's dynamic marine weather data (information transparency) and safety risk information for activities (clear risks) allow the general public and recreation businesses to find rated recreational waters suitable to their capabilities so they may improve their enjoyment of the ocean and learn to love the seas. In the future, the platform aims to work with coastal management agencies to discuss and adapt beach management strategies that will contribute towards the safety and prosperous development of marine recreation.

The target audience's satisfaction level towards the usability and UI/UX of GoOcean is something that is constantly being reviewed and adjusted throughout the platform development process. In the past, Taiwan's marine recreational activities were affected by the government and the public felt like they were banned from going to the sea. The hopes and efforts by the government and businesses to make the ocean accessible in recent years have led to a gradual flourishing. The platform leverages social developments to offer an innovative application system that integrates 10 major types of marine weather data sources to provide and issue wide-ranging, highly accurate weather forecasts. Moreover, new upgrades combine telemetry and marine radar data to provide swell warnings with a shortened update frequency of 5 minutes; swells are one of the major threats to public safety in sea areas. More importantly, the platform's technology and innovative applications have had a critical impact on marine safety, making it an optimal example of successful "technology-assisted governance that benefits the public".

Statistics from the system's back end since GoOcean's open testing started in late December 2021 shows that out of all registered users, there are as many as 694 active users. The platform has accumulated over 101,619 visits, users have exchanged opinions more than 75 times, data of all sorts has been queried 207,130 times, and there have been over 78,413 shares on the media, social media, user reports, and posts. The average number of monthly users has grown despite the impact of COVID-19, making it clear that GoOcean is gradually becoming an indispensable information platform for Taiwan's sea-loving inhabitants who participate in marine recreational activities.

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Assessment of Climate Risks and Sea Level Rise in South China Sea

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Translated by Linguitronics
Keywords: South China Sea, climate risks, global warming

Carbon dioxide (CO_2) is one of the primary factors causing global warming. This is indisputable. The UN Intergovernmental Panel on Climate Change (IPCC) published their Sixth Assessment Report (AR6) on climate change and released three Working Group reports in total. The Working Group I report (WG I) published, "*The Physical Science Basis*" on August 9, 2021; the Working Group II (WG II) published "*Impacts, Adaptions and Vulnerability*" on February 28, 2022; and the Working Group III (WG III) published "*Climate Change 2022: Mitigation of Climate Change*" April of the same year. The 3 reports offer the latest global assessment on the progress and commitments for climate change mitigation while also investigating sources of CO_2 emissions with global impact, evaluating nations' commitment to address climate change and their impact on long-term CO_2 emissions goals.

IPCC data shows [1] that the total volume of anthropogenic greenhouse gas (GHG) emissions continues to increase; average GHG emissions per year in 2010-2019 reached new records. However, inspection of growth rate shows a downward trend when compared to 2000-2009. In 2019, the total volume of anthropogenic GHG emissions was approximately 59 billion tons of CO_2 equivalent (tCO_2e), a 12% increase compared to 2010 and a 54% increase when compared to the baseline year of 1990. Nearly all types of GHG emissions are increasing; the largest increases are in CO_2 emissions from fossil fuels and industrial processes, followed by methane emissions. While the total volume of CO_2 emissions exhibited a downward trend in the first half of 2020 due to COVID-19, emissions have begun to rise again now that the pandemic is gradually coming under control.

Global Warming the Primary Factor for Sea Level Rise

Wind waves, storms and the gravity of the Moon and Sun may contribute to sea-level rise (SLR) (Figure 1), but not the main causes. The rise of temperature on the earth is melting glaciers in the North and South Poles at a faster pace than ever, making it one of the primary factors for sea level rise. The 3 following factors of sea level rise are extremely relevant to global climate change: The primary factor is the thermal expansion and contraction of sea water. Data shows that in the past 25 years, approximately 50% of the sea level rise was due to Earth's warming, caused by expansion of sea water. Next is the melting of alpine glaciers, particularly, alpine glaciers of temperate zones near the North and South Poles, which would naturally melt to a small extent every summer. Global warming and extreme climate have brought instability to the balance of snowing in winter and melting in summer, naturally causing a rise in sea level. Finally, it's the continued destruction of ice caps in Greenland, the world's largest island, and Antarctica. Global warming has accelerated the melting of massive ice caps covering Greenland and Antarctica. The infiltration of meltwater at sea level and sea water below sea level at Greenland's ice cap has accelerated glacier flow into the ocean, further exacerbating sea level rise.

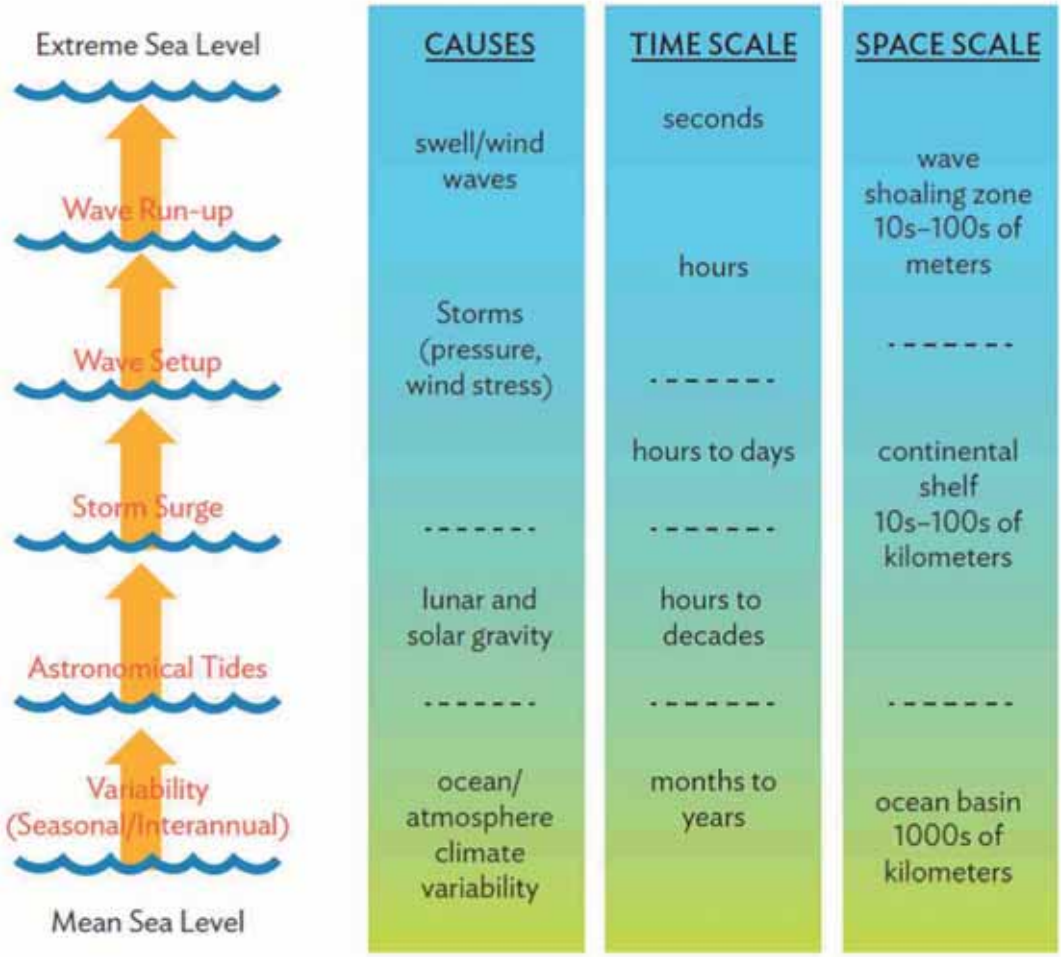

Figure 1/ Examples of various factors causing sea level rise
Source/ [2]

Greater Climate Risks Caused by Sea Level Rise

The sea level is rising at a faster rate than previously, impacting ecosystems in ways such as salt damage to aquifers and farmland and destruction of the habitats of fish, birds, and plants. Additionally, sea level rise has caused typhoons or hurricanes to make landfall more frequently than before. For instance, hurricane movement in recent years is slower than in the past and has caused increased rainfall as well as larger waves along coastlines. Inhabitants in low-lying regions of the coastline are being forced to move inland or to higher land due to floods. All of the above reinforces the credibility of the threat posed by sea level rise, in turn caused by global warming. The need to implement energy conservation and carbon reduction strategies to reduce CO_2 emissions and inhibit sea level rise grows urgently by the day. Also, the planning of appropriate GHG adaption strategies is indispensable for addressing the rise in sea level.

Sea level rise is a global issue. This article introduces the report *Sea Level Change in the Pacific Islands Region* [2], published by the Asian Development Bank (ADB) in July 2022. The report offers research data on climate risk and adaptation to serve as future guidance for countries in the Pacific Islands Region (PIR) to respond to sea level rise. The three major objectives planned in the report are: I. Establish a regional forum and financing for building infrastructure; II. Implement special projects to drive installation of renewable energy systems as well as marine and coastal management; and III.

Enhance the disaster preparedness of various countries, including developing the capacity for public financial management, statistical compilation, and data collection.

The Pacific Island Region Is Extremely Vulnerable to Sea Level Rise

The Pacific Island Region is located in the western tropical Pacific (Figure 2) and is highly exposed to tropical cyclones and other tropical storms. Countries therein have a high shoreline to land area ratio. As such, they are highly sensitive to changes in sea level, waves, and currents. Furthermore, the region's many low-lying coral atolls, reefs, or volcanic islands are especially susceptible to impact from SLR. In view of these factors, the report provides precautionary measures for investors in response to SLR, including research data from various sources that reflects advantages, disadvantages, and uncertainties. The report reviews scientific evidence on SLR and provides credible data related to SLR in the PIR as a basis for further investigation and decision-making, offering insights on matters such as long-term planning of sustainable settlements and national/regional population movements.

In 2013, IPCC published its Fifth Assessment Report (AR5) and suggested that SLR is unlikely to exceed 1 meter by 2100 relative to the 1986-2005 baseline used. This information has been widely used by ADB and other institutions to assess and manage research on SLR-related risks in the Pacific Island Region. However, subsequent review of science and evidence after the publication of AR5 has found that the presupposition of the assessment that SLR will stay within 1 meter in the future may not be accurate in the Pacific Island Region due to 5 main factors:

I. Although there is very high confidence in the direction of change for all Pacific Island Region locations, there is only medium confidence in the magnitude of change. Considering the impacts of natural fluctuations due to climate change, it seems possible that SLR may exceed 1 meter in 2100.

II. The recently published AR6 report and other research that has emerged since AR5 show that if new data is utilized and the baseline is changed to 1995-2014, SLR will not only exceed 1 meter but may possibly exceed 2 meters in 2100. It's especially worth noting that SLR will continue to rise in 2100 instead of staying within 1 meter as stated in AR5.

III. Paleoclimate records show that SLR of 5 meters within a century has occurred in the past, but such phenomenon only takes place once every several hundred to several thousand years. The consensus between experts and scholars is that such a rise will not occur before 2100, yet AR6 points out that without marine ice cliff instability, it is possible for SLR to rise between 1.7 to 6.8 meters by 2300; this can increase to 16 meters by 2300 with marine ice cliff instability.

IV. Short-term variability in high water levels associated with storm surge and waves could significantly increase regional coastal water levels above what is expected, especially with scenarios in the PIR and particularly in the western tropical Pacific.

V. Based on data collected since 2000, most islands in the Pacific Island Region are subsiding and, therefore, the impact of SLR will be magnified in Pacific Island Region nations where the land is sinking.

Figure 2/ Pacific Island Region nations in the west Pacific are vulnerable to impact from SLR

Source/ [2]

Significant Impact of Sea Level Rise in the Pacific Island Region

While recognizing all the factors that contribute to SLR impact, this report adopts a simpler method, a precautionary approach with higher global average SLR. This considers the expected impact of high water levels on the Pacific Island Region for climate risk adaptation while taking into account higher end scenarios that assume SLR will not stop in 2100. Therefore, this report utilizes AR6 premises, such as the baseline of 1995-2014, to recommend considering the following factors:

I. for all projects, a 1 m SLR scenario, for comparison with existing studies that have typically used a scenario of 1 m SLR by 2100;

II. for short- to medium-term projects (i.e., with a design life of 20–30 years), a scenario of 0.5 m SLR by 2050;

Table 1/ Estimated Value of Sea Level Rise in Pacific Island Region Nations (Unit: centimeters)

Country	Projected SLR (from Appendix 1)[a]	Historical Interannual Variability	Upper Bound of Projected SLR plus Historical Interannual Variability
Cook Islands	39–86	19	105
Federated States of Micronesia	41–90	26	116
Fiji	41–88	18	106
Kiribati	38–87	23	110
Marshall Islands	41–92	20	112
Nauru	41–89	23	112
Niue	41–87	17	104
Palau	41–88	36	124
Papua New Guinea	47–87	23	110
Samoa	40–87	20	107
Solomon Islands	40–89	31	120
Tonga	41–88	18	106
Tuvalu	39–87	26	113
Vanuatu	42–89	18	107

RCP = Representative Concentration Pathway, SLR = sea-level rise.

Source/ [2]

III. for long-term projects (i.e., with a design life greater than 30 years), a scenario of 2 m SLR by 2100; and

IV. for projects with an expected lifetime beyond 2100, scenarios of greater than 2 m SLR.

Based on the premises above, Table 1 places the 2100 SLR of 14 countries in the region at between 38-92 centimeters.

In addition to being applicable to sensitivity analysis for designing climate protection, SLR can be applied to analysis of additional costs and benefits to explore the flexibility of climate adaptation plans. The report recommends applying these scenarios to sensitivity analysis instead of acting as the minimum precautionary requirements for climate protection. Flexible climate adaptation and management plans can solve higher end SLR scenarios. Considering reliance on long-term pathways, or in other words, based on assumptions of potentially higher SLR (including economic and other factors), investment decisions on coastal infrastructure will impact subsequent investment and development; as such, subsequent climate risk assessments will not be required under the assumption of identical risk levels.

Conclusion

ADB has developed reliable forecast information in its climate risk assessment for the Pacific Island Region, included it in its assessment of climate risk in the Pacific Island Region, and proposed recommended actions, such as defining project objectives, tasks, and the required technical and labor requirements for each task at every stage. The calculation model and intellectual property of SLR has been provided to Vietnam to ensure the consistency and transparency of ADB member nations when utilizing this method.

SLR research is ongoing. The viewpoints on how to best handle current and estimated SLR impact are also changing, meaning the formulation of climate change adaptation strategies is a continuous process. This report recommends reviewing all evidence (of climate change) every 5-10 years, such as after the publication of new IPCC reports, as to evaluate and verify if there are changes in opinions due to new evidence.

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Net Free Seas in Thailand: A Marine Protection Initiative Starting from the Action of Coastal Communities

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Keywords: Thailand, discarded fishing nets, recycling, coastal communities, marine protection

Environmental Justice Foundation (EJF), an international non-profit organization, initiated the Net Free Seas project (NFS). This project encourages coastal communities to collect fishing nets discarded in the seas and thus builds a supply chain which links coastal communities who collect discarded fishing nets, recyclers who purchase the collected nets and made nets into pellets, and manufacturers who produce products by using the pellets. To this end, the EJF devised a series of actions to push for this project, including the steps for coastal communities to becoming part of the project, guaranteeing a buying price for nets higher than the market price, and the ways to identify nets that are currently accepted for recycling. The NFS project has been implemented for about three years with a few coastal communities' participation. In addition, manufactures also already used the materials recycled from fishing nets to produce products, presenting a case of circular economy. Based on this initial promising outcome, the EJF hopes to expand the NFS project to other countries, in particular the ones of West Africa, where marine plastic pollution is rife.

Thailand is located in Southeast Asia. The length of the coastline is 3,148 kilometers, bordering the Gulf of Thailand in the east and the Andaman Sea in the west. Thailand is one the world's largest fishing states with a huge number of fishing vessels up to 50,000 small fishing vessels and 10,000 commercial ships. The amount of fishing nets accidently lost or deliberately discarded into to the sea should be considerable, posing a great threat to marine life. As official Thai figures show, about 74% of sea turtles and 89% of dugongs stranded on the beaches between 2015 and 2017 had been injured by nets [1], showing the severity of discarded fishing nets.

In order to solve discarded fishing nets left of lost in oceans, the EJF initiated the NFS project with the funding coming from the Norwegian Retailers' Environment Fund. The EJF is dedicated to protecting the natural environment and the people and wildlife that depend upon it [2]. The headquarter is located in London, United Kingdom and several working stations are established in many countries. The EJF has initiated several campaigns which are relevant to the oceans, including ending illegal fishing, combating human rights abuses and slavery at sea, protecting marine biodiversity, securing sustainable fisheries, etc. [3].

The main objectives of the NFS project are threefold: I. remove fishing net waste and ghost fishing gears from the natural environment; II. provide communities with a secondary income which are engaged in collection of fishing nets; III. build environmental protection awareness among coastal communities [4]. To this end, the NFS project is dedicated to establishing a supply chain linking local communities, recyclers and product manufacturers. In other words, local communities help collect and clean used fishing nets (Figure 1) and then sell nets to recyclers with a guaranteed price. The used nets are then further cleaned, shredded and melted into pellets by recyclers. These pellets are sent to manufacturing companies to be used in the production of high-quality consumer products. This article aims to introduce the NFS project, shedding light on how the EJF guides coastal communities to participate in the NFS project and further empowers them to become part of the nets recycling solution and an actor in the marine environmental protection.

Figure 1/ Discarded fishing nets recycled and reused and can be made into new products
Image by Chung-Ling Chen

The overview of the Net Free Seas project

The NFS project is to establish a mechanism in which local communities are willing to collect and clean discarded fishing nets, and these nets are then recycled to be reused in the production of new products. This mechanism involves developing steps for local communities to join in the project, instructing communities on how to identify the nets that are accepted for recycling as well on how to clean fishing nets, proposing the ways to prevent fishing net loss at sea, and making rules that need to be complied throughout this project.

I. Steps for local communities to participate in the project

- If your community uses a lot of fishing nets or you find there are lots of discarded nets in your community, please get in touch with us on LINE.
- Find a person to be your focal point. This person will oversee net collection in your community.
- Identify a fishing net collection point in your community. This could be an area that is close to the pier or fishing boats but sheltered enough that nets won't be blow away to be washed into the sea.
- Work with your focal point to work out logistics from the net collection point to recyclers.
- The EJF will help you design a book-keeping system that is suitable for your community, recording the things pertaining to fishing nets collection.
- The EJF will train communities in how to clean the nets.
- The EJF will coordinate with you to develop a timescale in the transport of cleaned fishing nets.

II. Instruction on how to identify fishing nets acceptable for the NJF

The project currently only accepts gillnets made from nylon. It is because that nets made from nylon are extremely hard wearing and curable making them perfect for recycling. As for other types of net, the EJF will expand to accept them for recycling.

A guide containing maps and description pertaining to different types of nets was particularly made by the EJF to help fishers better identify what is and what is not acceptable for recycling. This guide also offers the information on the market price for different types of nets. As an illustration, gillnet accepted by the NJF is white or blue in color. The net is fine but stiff with the mesh size being 2.5~10 cm. The main catch of gillnet is crab. The market price for discarded nets is 2-8 baht/kg. However, the NFS buying price is 10 baht/kg. Another type of nets -trawl and fishing ropes made from polypropylene or polyethylene are not acceptable. Trawl is blue, green, black or red in color. It can be both fine and thick and is mostly used for commercial fishing with fish being the main catch. The market price for discarded nets is 2-5 baht/kg.

III. Instruction on how to clean nets

When being collected, fishing nets should be cleaned and dried. This increases the quality of pellets produced from the discarded nets and means that recycling factories are more likely to accept nets in the future. In line with this, some tips are offered on how to clean nets as seen below.

- Remove ropes and lead weights. However, don't throw them away since they might be sold out to other recycling partners.
- Separate the different types of nets and leave the nets that the NJF accepts.
- Remove any fish or other animals, twigs, leaves, pebbles or other debris from the nets.
- Clean the nets with salt or rainwater, not chemicals or freshwater.
- Dry the nets and keep them in a clean and sheltered place.
- The use of gloves is recommended while cutting, collecting and transporting the nets to avoid injuries.

IV. Instruction on how to prevent fishing net loss at sea

The easiest way to prevent damaging the marine environment is to stop nets from falling into the sea in the first place or to pick them out of the sea as quickly as possible. The ways to prevent fishing net loss at sea are offered as seen below.

- Get accurate maps from Department of Fisheries (DoF) or Department of Marine and Coastal Resources (DMCR) on where underwater coral formations lie and avoid placing nets there.
- Put flags over underwater formations so that you can see where you could snag the nets.
- If you find nets lost in the sea bring them back to shore.
- If you find a net caught on a coral reef or underwater formation but it is too difficult or dangerous to retrieve yourself, save the GPS coordinates of the location and notify the NFS them on LINE.
- If you damage your net at sea, please do not throw the net into the sea. Instead, keep it and bring it back to shore.
- If you repair your net at shore, make sure that your discarded net does not fall into the sea. Keep it and shore it so that NFS can recycle it.

V. Compliance rules for participants

The EJF asks the communities who participate in the NFS project to observe specific rules to protect children and the environment, as well as secure welfares for participants. These rules are presented below.

- The EJF operates a zero-tolerance policy towards the use of child labor or corruption. If individuals or communities are suspected engaging in either practice, the EJF reserves the right to terminate the relationship immediately.
- Nets, ropes and other plastic materials should never be burned as this can give off harmful fumes which are damaging to health.
- No chemicals should be used to clean nets since chemicals may contaminate the environment and harm wildlife. It is advised to use sea water or rainwater to clean nets.
- The use of child labor at any point in the NFS supply chain is forbidden. However, the EJF encourages communities to offer children internships or training as this can help children build their own skills and knowledge. Their work must not interfere with their schooling, not involve long working hours or working during the night, as well as handling of hazardous chemicals or dangerous machinery, equipment and/or tools.
- The buying price of discarded gillnets under the project is guaranteed at 10 baht per kilogram. The EJF will conduct unannounced inspections to ensure the price is paid.
- The wage of the person hired under the project must be no less than the minimum wage of each province per day determined by the Wage Committee under the Thai Labour Protection Act.
- Working hours should not exceed eight working hours per day and workers should receive a minimum one hour during this period.

Initial outcome of the NFS project

The project has been into practice for about three years. With the support of Thai Department of Fisheries, several coastal communities have participated in this project. By October 2020, a total of 5.9 tons of nets were already recycled. The EJF strives to cooperate with several Thai companies and encourages them to use pellets recycled from nets to produce consumer products, such as water sports products and COVID-19 related products such as face shields, push sticks and disinfectant bottles [5].

It is worth noting that Qualy is one of the companies that joins the project. It designs products with a focus on respecting our planet and in the meantime, improving people's life. Qualy used discarded fishing nets, PET bottles and plastic bags to manufacture a wide range of sleek products, including office supplies, bathroom supplies, and kitchen supplies (Figure 2) [6].

Figure 2/ Qualy used discarded fishing nets, PET bottles and plastic bags to make a wide range of sleek products

Source/ [6]

Conclusion

The NFS project is an initiative dedicated to marine environmental protection. It was developed and implemented in Thailand by the NJF. The project encourages coastal communities to engage in the collection of discarded nets by offering a buying price for nets higher than the market price. It also instructs communities to prevent fishing net loss at sea. These efforts help build awareness of marine protection among communities.

The project has been into practice for about three years. It has established a supply chain from communities collecting fishing net, recyclers reusing the nets and making them into pellets, to companies producing new products. This indicates promising results already achieved from the project. The NJF will further expand to develop more different types of products as well as recycle different types of fishing nets. In light of the project successfully running in Thailand, the NJF hopes to expand it to other countries, particularly the ones of West Africa, where marine plastics pollution is rife.

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The Role of the Ministry of Natural Resources and Environment of Thailand in the Overall National Marine Development Policy

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Keywords: MONRE, marine policy, integrated governance

Although Thailand boasts 310,000 square kilometers of exclusive economic waters, its past strategic mindset as a land power has made it difficult to consolidate its marine and coastal policies. It does not have an ambitious national marine policy, and only after the EU issued a yellow card warning for IUU (Illegal, unreported and unregulated) fishing in 2015 did Thailand begin its comprehensive reforms of related industries. This paper describes the formation of Thailand's marine policy and the integrated governance of the Ministry of Natural Resources and Environment and marine affairs.

The Formulation of Thailand Maritime Policy

Thailand has a land area of 513,000 square kilometers (50th in world ranking) and a population of 70 million (22nd in world ranking). In terms of inland Southeast Asia, Thailand is located at the heart of Indochina and housed the major air bases for US bombings in Vietnam during the Vietnam War. In terms of maritime Southeast Asia, to the west of Thailand are the Andaman Sea and the Indian Ocean; to the south, the Gulf of Siam and the South China Sea that controls the northern part of the Strait of Malacca, making the waters a hub that connects the Pacific Ocean and the Indian Ocean. As the founding nation of ASEAN, Thailand has long been pro-American and the U.S. embassy in Thailand has the largest of any Southeast Asian country concerning embassy grounds and staff. However, in 2013, China became Thailand's largest trading partner, and military exchanges between China and Thailand have gradually increased. Hence, Thailand is a key player for the success of both U.S. Indo-Pacific strategy and China's Belt Road Initiative [1].

For a long time, Thailand has maintained a land-based national strategy for its overall national security and defense [2]. Therefore, although Thailand has 310,000 square kilometers of exclusive economic waters, it does not have a macro national maritime policy. This has given rise to much difficulty for consolidating its marine and coastal policies in the past [3]. As Thailand progresses toward its goal of becoming a developed country, environmental pollution caused by industrialization and the growing imbalance between Bangkok's industrial clusters and coastal areas have highlighted the importance of sustainable development and inclusive growth, and the balance among economic development, social and human resources, and environmental resources has become increasingly important.

However, a more important driving force comes from international factors, such as the United Nations Sustainable Development Program, the accelerated regional integration of the ASEAN, the South China Sea dispute, the U.S. crackdown on human trafficking, and the EU's imposition of penalties on IUU fishing and other international regimes. In particular, after the EU issued a "yellow card" warning to Thailand for IUU fishing in April 2015, Thai authorities began a comprehensive reform of its fisheries industry, quickly establishing a robust new legal and policy framework, as well as active loan arrangements and investments to ensure that fisheries become a more sustainable industry [4]. The most important of these was the establishment of an inter-ministerial coordinating body, the Command Center Combating Illegal Fishing, which was later transformed into the renowned Thai Maritime Law Enforcement Coordinating Center (Thai-MECC) that served as a horizontal linkage

Figure 1/ Thailand is located at the heart of the Indo-China Peninsula. Its west lies the Andaman Sea and the Indian Ocean, while its south lies the Gulf of Siam and the South China Sea. The geographical location allows it to control the northern area of the Malacca Strait, which connects to the Pacific Ocean and Indian Ocean
Image by Pride Advertising Agency Ltd.

organization for marine and coastal affairs [5]. Since then, issues such as IUU fishing, illegal immigration, drug smuggling, marine environmental protection, and ecological restoration have increasingly become the main targets of Thailand's maritime affairs management [6].

It is in the midst of this confluence of internal and external changes that formulated Thailand's first long-term national development plan in 2015—the 20-Year National Strategy (2018-2037)—set out the three priorities of "Security, Prosperity, and Sustainability," and developed a series of ocean-related plans and policies. Regarding security, the main national-level plans are the National Maritime Security Plan 2015-2022; prosperity-related plans include the 12th National Economic and Social Development Plan 2017-2022; in matters of sustainability, programs include the Environmental Management Plan 2015-2021, the MONRE's Strategic Plan 2016-2021, and the Thailand's National Biodiversity Strategy and Action Plan 2015-2021 [7].

Major national marine laws were created and amended after 2015, such as the Royal Ordinance on Fisheries 2015, the Promotion of Marine and Coastal Resources Management Act 2015, the Navigation in Thai Waters Act 1913 (amended in 2017), and the National Marine Interest Act 2019 have been created and amended to extend the scope of enforcement of these laws relating to natural resources and the environment from the territorial sea. The National Marine Interest Act 2019 extends the scope of enforcement of these laws relating to natural resources and the environment from the territorial sea to the exclusive economic zone and even to cooperation on the high seas [8].

Through these plans and policies, the Thai government seeks to effectively integrate national efforts in various areas to address both traditional areas of maritime security (e.g., safeguarding maritime interests, peaceful uses of the sea, and maritime national security) and non-traditional areas of maritime security (e.g., balance and sustainability of marine resources and the environment, development of maritime human resources, knowledge and maritime awareness, and maritime governance) through participatory management [9].

The Ministry of Natural Resources and Environment and the Integrated Governance of Marine Affairs

Integrated management of marine affairs has a certain degree of difficulty. Save Indonesia, there is no single governmental body dedicated to integrated ocean affairs management among ASEAN countries, and Thailand is no exception. Therefore, the actual implementation of aforementioned plans and policies in government institutions are scattered across various ministries, including the Ministry of Agriculture and Cooperatives, the Ministry of Transportation, the Ministry of Energy, the Ministry of Defense, the Ministry of Tourism and Sports, the Ministry of Interior, the Department of Marine and Coastal Resources, and the Ministry of Natural Resources and Environment.

Recognizing that resource development must be coordinated with resource conservation, the Thai government established the Ministry of Natural Resources and Environment (MONRE) in 2003 to promote environmental conservation and inclusive development in Thailand. The vision of MONRE is "to return the natural environment to the Thai people and to work towards the incorporation of natural resources and the environment in the Government's national agenda as these provide the basis for social and economic development" [10]. MONRE supports the proactive integration of natural resources, environmental protection, and biodiversity administration based on the principles of public participation and good governance.

MONRE promotes five key strategies through a five-year strategic plan for 2016-2021: I. protect, conserve, restore, and manage natural resources in an integrated approach to ensure responsive development and allows for sustainable and equitable resource use; II. manage surface water and groundwater in an integrated and effective manner; III. maintain and restore the quality of the environment through participatory approaches; IV. prevent and reduce the impacts of natural disasters and climate change and to promote adaptation; V. improve the efficiency of organizational management and natural resource and environmental management [11]. Through a participatory approach, MONRE acts as a bridge to support community - private sector participation with the public sector, effectively promoting the restoration of mangroves in Thailand [12], increasing the coverage of Thailand's marine protected areas [13], and ensuring Thailand's remarkable position in sustainable marine development in Southeast Asia.

MONRE has established various divisions and offices to handle various activities, such as the Office of Natural Resources and Environmental Policy and Planning (ONEP), which is responsible for planning and policy development, environmental impact assessment, and establishment of environmental reserves; the Department of National Parks, Wildlife and Plant Conservation (DNP), which is responsible for managing marine parks; and the Department of Marine and Coastal Resources (DMCR), which is responsible for promoting mangroves, coral reefs, seagrasses, and endangered species in Thailand. The Department of Marine and Coastal Resources (DMCR) is the main agency responsible for promoting the sustainable management and protection of resources such as mangroves, coral reefs, seagrasses, and endangered marine species; and the Pollution Control Department (PCD) is responsible for setting coastal water quality standards, monitoring coastal waters, and establishing pollution control zones.

Therefore, MONRE is the main agency responsible for the management of natural resources and the environment in all types of marine and coastal areas. The DMCR can be described as the main unit responsible for marine and coastal affairs. However, the characteristics of marine and coastal resources management make it difficult for a single agency handle it alone. For example, the characteristics of coastal areas, where land and water meet, are particularly productive, but such terrain is where pollution and disasters occur most frequently. According to the United Nations, more than 80% of

marine pollution comes from land, including not only various manufacturing industries and coastal urban wastewater pollution, but also non-point pollution accumulated by fertilizers and excreta from various forest reclamation, farms, and aquaculture industries, which are beyond the jurisdiction of the DMCR.

Thailand marine protected areas (MPAs) serve as another example that illustrates this predicament. The Department of Marine and Coastal Resources must work with the Department of National Parks, Wildlife and Plant Conservation, Office of Natural Resources and Environmental Policy and Planning, and the interdepartmental Department of Fisheries (within the Ministry of Agriculture and Cooperatives), Department of Oceans (within the Ministry of Transportation), and the Department of Public Works and Town and Country Planning in making decisions about the establishment and maintenance of MPAs and marine national parks. The division of labor is coordinated between the Department of Fisheries (within the Ministry of Agriculture and Cooperatives), the Department of Oceans (within the Ministry of Transportation), and the Department of Public Works and Town and Country Planning (within the Ministry of the Interior).

To address the issue of horizontal coordination between the ministries, the Ministry of Natural Resources and the Environment has established the National Marine and Coastal Resources Committee (NMRC). The Committee is organized "under" the Department of Marine and Coastal Resources, but in practice it is chaired by the Prime Minister, with the Secretary of the Department of Marine and Coastal Resources solely acting as its secretary. The Committee has eight subcommittees, with nineteen representatives from relevant ministries and twelve independent academics and experts in the marine and coastal field, six of whom must come from the coastal community. Similar horizontal linkage committees chaired by the Prime Minister include the National Fisheries Committee (NOF) and agencies involved in maritime national defense and security issues, namely the National Maritime Interests Protection Committee (NMIPC) and the Maritime Law Enforcement Command Center (MLEC) of the Office of the National Security Council (ONSC), which is directly under the Prime Minister's Office [14].

Figure 2/ The marine and coastal issues require a cross-departmental and cross-regional integrative management mechanism. Thailand has established the Ministry of Natural Resources and Environment to undertake the vertical and horizontal liaising within the organization
Source/ https://www.tourismthailand.org/Attraction/hat-thang-sai

However, even though there are vertical and horizontal linkages, the policy of pushing the area of marine protected areas from the current 5% to 10% of the exclusive economic zone by 2030 is still under fierce debate. The main reason is that the issue involves at least three laws: the Marine National Act, administered by the Department of National Parks, Wildlife and Plant Conservation; the National Environmental Quality Act, administered by the Office of Natural Resources and Environmental Policy and Planning; and the Coastal Act, administered by the Department of Marine and Coastal Resources. The competition between these laws creates overlap or multiple enforcement, resulting in confusion and backlash from the underlying communities about what the laws allow and what they prohibit. This has also led to a continuing shortage of funding, ineffective management, and insufficient community (stakeholder) involvement in marine reserves [15]. Therefore, what Thailand's experience can offer Taiwan is that ocean and coastal issues require an integrated ocean and coastal management due to its interdepartmental and interdisciplinary characteristics. The Ocean Affairs Council (OAC), which is the highest authority for ocean affairs, should be the ideal institution to promote such an integrated management mechanism.

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Exploring Nansha
Get to Know the Diversity of Common Macroalgae

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Translated by Linguitronics
Keywords: Nansha Taiping Island, macroalgae, intertidal zone, species composition

Taiping Island, the largest natural island amongst the Nansha or Spratly Islands, is home to rich marine biological resources in the coral reefs of its nearby waters. The majority of current research focuses on fish and invertebrates while distribution data of macroalgae in the intertidal zone are sparse, making it imperative to establish relevant biological data. Surveys of macroalgae biota conducted in the surrounding shores can be utilized to understand the importance of a biological census; therefore, it is necessary to investigate native species of macroalgae at the island's shores. A research team from the National Academy of Marine Research (NAMR) gathered text and image data for macroalgae across three seasons, from July of 2021 to March and July of 2022. They successfully completed introductions for 80 common macroalgae species found in Nansha Taiping Island to raise interest and enhance knowledge on macroalgae among people who love to explore the oceans (Figure 1). On a deeper level, this allows better use and protection of the ocean by valuing precious marine resources and meeting the ideal of maintaining ecological balance in the ocean, as to ensure that the ecology in the natural island is protected and prospers.

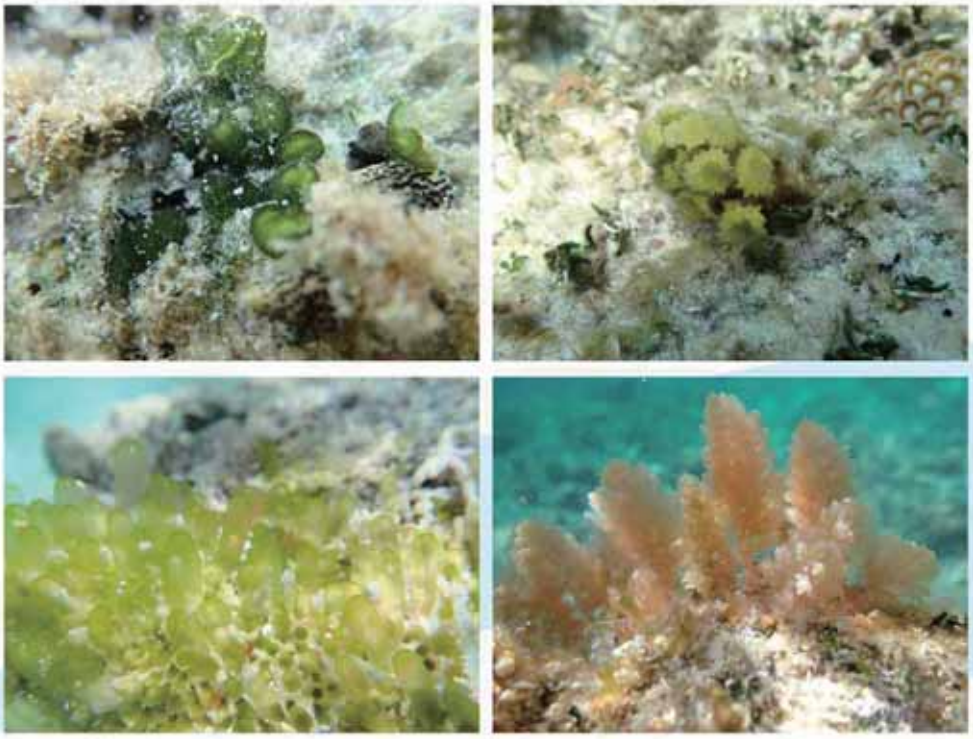

Figure 1/ Blue algae - *Brachytrichia quoyi* (upper left), Green algae - *Boergesenia forbesii* (lower left), Brown algae - *Turbinaria conoides* (upper right), Red algae - *Asparagopsis taxiformis* (lower right)
Images by Marine Ecology and Conservation Research Center, National Academy of Marine Research

Macroalgae play an important role as basal producers

Macroalgae are widely distributed in the photic zone below the intertidal zone. In addition to producing oxygen through photosynthesis, they possess a complex yet beautiful appearance and, while they differ greatly in color or size, it is difficult to distinguish among many species with the naked eye. The species composition of macroalgae has seasonal succession, in particular, and are crucially characterized by rapid growth or short life cycles only affected by changes in topography, substrate, sea temperature, light, and nutrients. They are viewed as the most critical primary producer of the marine food chain and provide good habitats and food sources for algae-eating fish, shrimp, crabs, and other marine animals; they are also used as substrate for spawning and hatching eggs as they provide a safe and excellent environment for breeding and sheltering larvae. In terms of balancing marine ecosystems, they have a stabilizing function and can delay the greenhouse effect, thereby affecting the conservation of the ocean's fishery resources as well as producing key effects such as purifying water and maintaining biodiversity in marine ecosystems. They play a decisive role in protecting marine ecology.

Explore the Coastline Around Nansha

The geographic location of Nansha Taiping Island consists of a key island topography located in the Nansha or Spratly Islands. The island is surrounded by the ocean on all sides and has an area of approximately 0.51 square kilometers, with a length of 1,360 meters, width of 350 meters, and a coastline of 2,850 meters. The island's beach terrain coastline is surrounded by an intertidal zone and topography formed by the superposition of extensive coral reefs. It is chiefly characterized by sufficient light and a fixed tide cycle that repeats daily. The alternating rise and fall of tides exposes sand to the air which erodes with seawater, forming a rolling wave-shaped coastline around the island. The frequent flow and disturbance of sand results in a beach terrain prone to change and coral reef plates that are often covered by sand; therefore, marine life settled in this habitat is difficult to identify. The island's superior geographical location hides a bounty of fishery resources and marine biological diversity. The rich ecological resources, intactly preserved undersea forests, and coastline that serves as gathering place for typical coral fish are all aspects that make it a focus of research in marine ecology and conservation.

I. Intertidal Zone Distribution

Macroalgae are commonly found in the intertidal zone at Nansha Taiping Island's coastline, where the substrate consists of coral reef plates (Figure 2). The width and area of both shallow and deep parts of the coastline are not uniform while the substrate can be further categorized into 4 zones in the order of the coral sand zone, reef zone, reef platform zone, and coral fringe zone. As one travels further from the coastline, the species of macroalgae become more abundant and diverse.

- Due east and due west: Wider intertidal zone with width of approximately 400-500 meters.
- Northwest and due north: Wide to medium intertidal zone with width of approximately 300-350 meters.
- Due south and southeast: Narrower intertidal zone with width of approximately 150-200 meters.

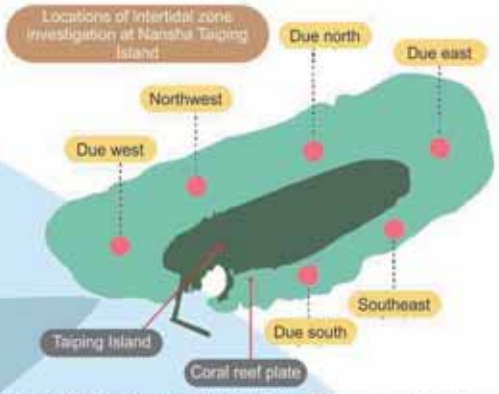

Figure 2/ Locations of intertidal zone investigation at Nansha Taiping Island
Image by NAMR

II. Hydrological Information Search

The ideal timing for investigating macroalgae or gathering samples at Nansha Taiping Island is during major low tides. First, the month, date, and time of low tides must be ascertained. Special attention must be paid to changes in sea current or weather before going into the water. Thunderstorms are momentous as they are a major deterrent for snorkeling or scuba diving investigations. To view daily changes in sea current and tide forecasts, a smartphone or computer can be used to visit the National Ocean Database and Sharing System (NODASS) established by NAMR in 2022. It offers a comprehensive marine database and allows for full utilization of marine data and information services to search for hydrological information and stay updated on changes in various sea areas (URL: https://nodass.namr.gov.tw/).

III. Timing for Exploring the Intertidal Zone

The Nansha Islands are located in a tropical marine climate zone prone to typhoons during summer. Due to southwesterly flows, the ocean water is often mixed with fine sand that causes turbidity and indirectly results in harsh conditions in the nearby seas. The poor visibility makes investigation via scuba diving extremely challenging. The opposite is true in spring as sea conditions stabilize and clearer waters allow for excellent visibility, making it the optimal time to study macroalgae species underwater.

Gathering Information on the Species Composition of Macroalgae in Nansha

I. Identification Method and Data Analysis

According to the ecological research method proposed in the 2020 NAMR report Overall Plan to Establish Marine Ecological Survey and Monitoring Network and Standards in Taiwan, it is necessary to utilize waterproof digital cameras to take vertical or micro distance photos of macroalgae to record their color and appearance as well as confirm the species of algae within the frame in order to effectively utilize the limited time available during major low tides. All of the digital photographs taken are stored inside a computer and compared to the algae habitats and descriptions from macroalgae books to establish a catalog and gather information on these species.

II. Statistical Results

Over the past 2 years, NAMR's research team has studied the composition of macroalgae species in Nansha, with quarterly surveys conducted in July of 2021 as well as March and July of 2022. The resulting numbers of macroalgae species identified in 6 sample areas of Nansha Taiping Island's intertidal zone during 3 separate seasons were 76 species in 40 families and 4 phylum, 60 species in

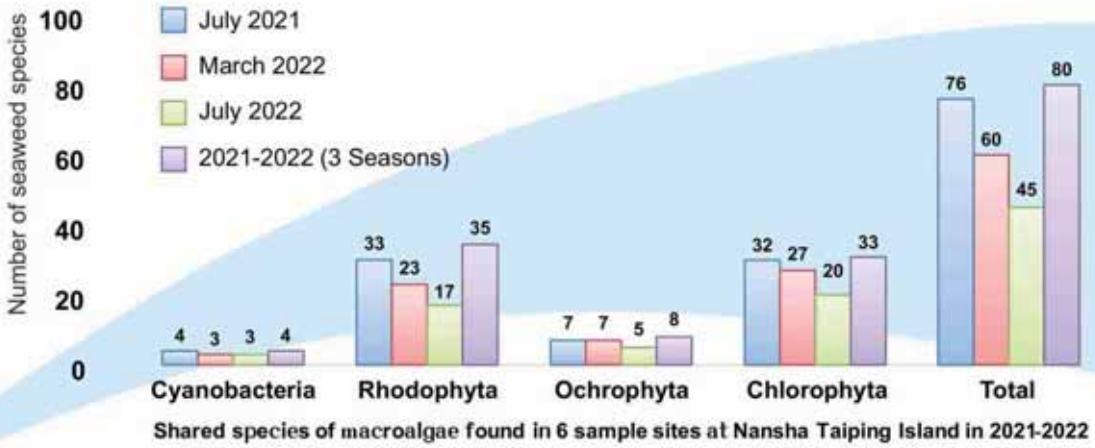

Figure 3/ Shared species of macroalgae found in 6 sample sites at Nansha Taiping Island in 2021-2022
Image by Marine Ecology and Conservation Research Center, National Academy of Marine Research

36 families and 4 phylum, and 45 species in 24 families and 4 phylum, respectively. Statistical analysis was performed on all of the data to analyze shared species, finding a total of 80 species in 40 families and 4 phylum (Figure 3). The results of this survey provide a more comprehensive understanding of macroalgae distribution in all zones and can be used in research of marine ecology and conservation.

Exploring Common Macroalgae Species in Nansha Taiping Island

I. Science Textbook of Macroalgae

NAMR's research team compiled a macroalgae species catalog in 2021 and 2022. Due to the challenges of marine transportation and restrictions to the return time of vessels, the research team grasped the rare opportunity to visit Nansha on two trips. They brought their investigation tools during good weather in the morning and afternoon and used underwater diving masks to observe underwater ecological environments. They snorkeled around the island's intertidal zone and recorded macroalgae species composition with waterproof digital cameras, samples, measurements, and photos. They completed the text and introductions for 80 common macroalgae species (Figure 4); the book is titled 80 Seaweeds of Taiping Island, Nansha Islands to meet the requirements of marine education and this scientific topic [1]. The book is a biological compilation of 233 types of macroalgae recorded in Nansha Taiping Island from 1981 to 2022. The 80 species of macroalgae investigated by NAMR's research team are introduced in the book in hopes of offering the public a further understanding of the macroalgae found in Taiping Island.

Figure 4/ 80 Seaweeds of Taiping Island, Nansha Islands
Image by NAMR

II. 4 Major Families of Macroalgae

Today, the taxonomy of macroalgae is constantly being updated and the website Algaebase [2] is essential to search for each species or every biota in taxonomic rank to conform with academic correctness. The 4 current major families of macroalgae are blue algae (Cyanobacteria), red algae (Rhodophyta), brown algae (Ochrophyta), and green algae (Chlorophyta). In summary, when describing the species of macroalgae observed in the intertidal zone of Nansha Taiping Island starting from those closest to the shore: Cyanobacteria are the most primitive organisms and simplest algae. They are primarily cyan in color and capable of enduring dryer and hotter habitats with most growing in high tide zones. Chlorophyta have the largest number of species, appear green in color, and prefer strong light. They're often exposed to the air during low tide, settle in more drought resistant environments, and are mostly distributed in the supratidal zone. Ochrophyta are

either brown or light yellow in color and mainly grow around the mid tidal zone and low tides. And Rhodophyta are commonly red or purple in appearance and do not like strong light. They prefer low light and are often found near low tides or below the subtidal zone (Figure 5).

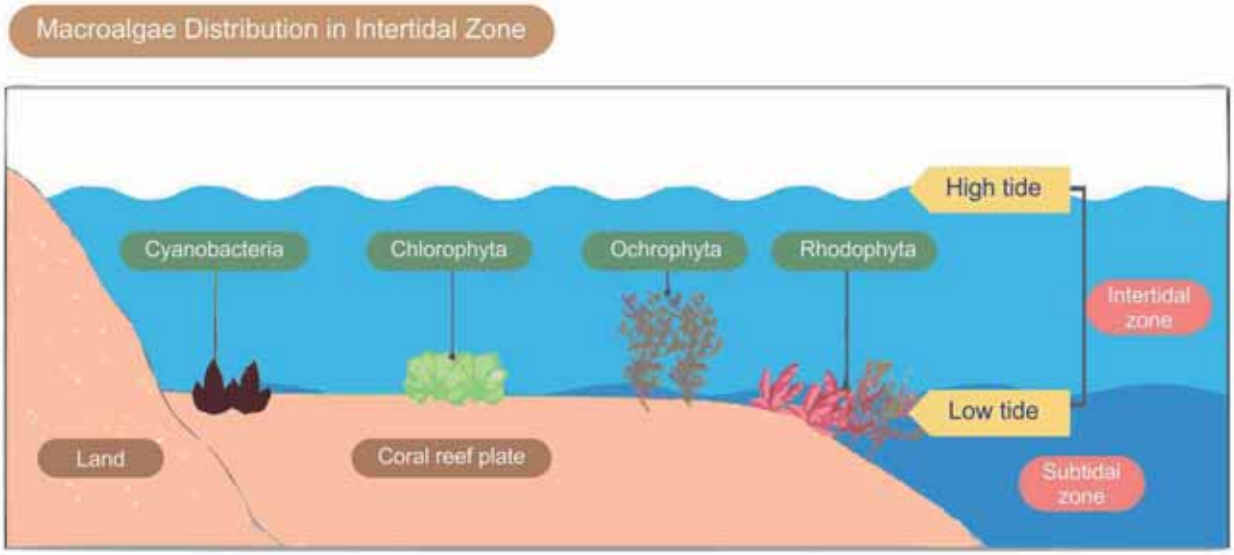

Figure 5/ Macroalgae Distribution in Intertidal Zone
Image by NAMR

Prospect

NAMR's research team studied Nansha Taiping Island in 2021 and 2022, making a list of macroalgae species sampled from 6 sites within the intertidal zone and accumulated species composition data across 3 seasons. After measuring the hydrological data of the 6 sample sites using scientific instruments, it was found that Nansha's seawater temperature is mainly between 25-30℃. The daily changes of tides and susceptibility to the strength or weakness of natural light causes macroalgae species to grow and reproduce in their habitat unstably. During the investigation, samples of native macroalgae species were taken to develop simple tissue culture techniques and temporarily preserve these species at Nansha Marine Station before transporting them back to NAMR's Germplasm bank. This reduces the extinction risk of native species and opens future opportunities to combine artificial seedling preservation and habitat restoration, utilizing Nansha Taiping Island's unique tropical marine climate to perform phasic preservation of seedlings for transport and placement, as to meet the needs of in situ and ex situ conservation. In the future, they can be utilized to develop marine education and other popular science related knowledge.

- Biological Information: Establish an annual list of native species in the habitat and provide sustainable data on the biodiversity of macroalgae.
- Seed Conservation Technology: Develop macroalgae seedling culture and seed conservation technology to achieve the sustainable use of restoration resources.

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Waste Management and Measures in Thailand

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Keywords: Thailand, waste, management and measures

The growth of global human population, associated with economic development and commercial consumption, has resulted in an accumulating un-negligible problem on waste management and consequently the marine pollution. Thailand, like many other developing countries, shows an increasing trend in the urbanization and rapid growth of economic condition and human population, but also faces a challenge in significant increase of waste generation, especially for the plastic waste production. It is estimated that annual amount of solid waste could double from the current levels by 2025 [1-3]. In Thailand or other Asian countries, any urban services or community activities, such as households, business enterprises, commercial markets, institutional facilities, construction, and municipal services, may generate solid waste. Similar with other developing countries, the waste is composed of a large proportion near 50% of organic materials, e.g., food waste, followed by paper, plastic, clothes, wood, rubber, leather, glass, and other solid forms of waste. However, it does not include hazardous and infectious waste or sewage in definition [3][4].

Waste generation and management

Along with increasing economic development and growth, the waste generation in Thailand is increasing as seen with the global trends. The increasing rate of waste volume is predicted to be 2% annually [5]. Although this is considered a small percentage, a large amount of waste leaking into the environment and plastic waste easily observed in the rivers and marine environment can still cause environmental concerns due to limited landfill space. Approximately more than 20% to 45% of the waste was generated from the Bangkok metropolitan area, about 30% from other municipality areas, and less than 40% from outside the municipality areas [5][6]. Studies show that the plastic usage in Thailand has increased by 7-8% per year. In average, every individual produces eight bags per day, which generates around 200 billion bags each year [7][8]. The plastic waste is regarded as hard to dissolved and definitely causes substantial pressure to the territorial and marine environment.

The waste in Thailand and most Asian countries is composed of highly biodegradable organic materials, of which a large proportion, larger than 50% in average, is high moisture content, such as common seen food waste. The component of waste in wet mass basis can reach up to 70% in some provinces of Thailand, for example Samutprakarn and Pattaya [9]. According to previous studies, the waste composition in Bangkok and other selected municipalities in Thailand varies substantially. In general, the solid waste is dominated by food waste; however, the proportions of paper and plastic waste range from 4-25% and 4-28%, respectively, among these cities and areas. This could be highly relating to the consumer patterns, lifestyle, and economic status [6]. For example, the high commercial and economic activities in Bangkok area lead to a 1.5 kg waste generation rate per person per day in average. In contrast, the waste generation rate in other municipalities such as Nonthaburi and Angthong is about 0.6 kg per person per day, less than half of that in Bangkok area. However, compared to Bangkok and other urban cities, every person could produce up to 5 kg waste in average per day in popular tourist areas in Thailand, such as Patong beach in Phuket [1]. The solid waste and plastic waste generated in tourist hotspot areas is higher than that produced by local resident populations, suggesting that the increase of waste could highly relate to commercial activities.

According there is no survey or relevant information to distinguish the origin of solid waste or plastic waste in the tourist hotspot areas, a research report shows that plastic content accounting for about 17% of the total solid waste in popular tourist areas or other adjacent districts, based on the analysis conducted by the Pollution Control Department (PCD) of Thailand. In the tourist hotspot areas, most plastic waste can be collected and recycling used. It is estimated that only 10% of the plastic waste remains uncollected after the consumer end, which generates about 10,000 tons of plastic waste per year [1]. Open burning is an easy and relatively cheap way to reduce the volume of uncollected plastic waste in Thailand. People usually handle the waste via open burning. Except for disposal on land, more than 90% of uncollected plastic waste is primarily openly burned [1].

Waste recycling and reuse

Because of the low cost of plastic products, Thailand is the highest plastic consumer per capita in Asia. In average, every individual in Thailand consumes 40 kg of plastic products in a year. Most of the products are plastic bags, of which retail and convenience stores can consume 60% of plastic bags and market vendors use the remaining 40% [10]. Studies showed that the waste management system in Thailand may be ineffective; approximately 80% of plastic waste belongs to land-based origin, which is transported through rivers, runoff, beach visitors, and drainage systems, into the ocean. This is not even including illegal dumping and uncollected plastic waste. The rest 20% of marine plastic waste comes from ocean fishing, aquaculture, and other activities [11]. Unlike Japan who produces high amount of plastic products, their successful waste management system has kept plastic waste hard to discharge into the marine environment [12].

Reusing and recycling activities have been encouraged actively by the Thailand government recently, which resulted in a substantial reduction of the waste. For example, the population in Bangkok increased year by year, but the quantity of waste decreased continually, which could be attributable to the reusing and recycling activities [6]. Therefore, the Thailand government encourages recycling activities in municipalities where solid waste generation rate is high or in the large municipalities such as Bangkok and other adjacent regions; their recycling activities should be maintained for improving recycling efficiency and reduction of the waste generation. More than 1.5 million tons of waste is recycled each year, accounting for more than 10% of the total waste generated. However, there are more than 4.5 million tons of commercially recyclable materials discarded in Thailand every year. In particular, approximately 60% of high potential recyclables, such as metals, paper, plastic, and glass, which can be potentially recycled and reused in various commercially manufacturing and industrial activities, are currently discarded [12].

The plastic consumption in Thailand began from 1970s and rapidly increased along with the worldwide trend of single-use plastic bags, which causes serious problems in marine plastic pollution in the following 20-30 years. Due to the transboundary risk to the ocean, marine plastic pollution seriously threatens marine wildlife and coastal ecosystems, and even more the health and livelihoods of the people living along the coast [13]. Although the majority of plastic packaging is directly sent to waste sites, research data showed that only 15-25% of the plastic waste was recycled in Thailand [14]. Most plastic is used for packaging, cans, boxes, tools, containers, equipment, and so on, which requires a long time to dispose the plastic. Therefore, reuse or changing the packaging may be the best suitable and efficient way to handle the plastic products.

Action plan and roadmap

The National Action Plan and Roadmap on plastic waste management was launched by the Thailand government to serve as a framework and direction for preventing and managing plastic waste. The main measures in the action plan include the reduction of plastic waste at sources,

reduction of single-use plastic products at consumption process, and plastic waste management post the consumption [1]. Meanwhile the Thailand government plans to improve waste collection in urban areas and develop an efficient waste collection system in rural areas, as well as well-managed disposal facilities including open dumpsites and controlled dumps [15]. On the 3R (reduce, reuse, and recycle) principle, the government first strengthens the concept of circular economy and develops responsible production and consumption.

As for the current stage, effective policy and management include the city-wide clean-up measures just before the start of the rainy season to reduce land-based marine pollution, as well as the improvement to integrate laws and regulations for supporting the implementation of measures [15]. The timeline of the roadmap can be divided into three phases. The aim of the first and second phases before 2022 is to stop using hard-degradable plastics such as foam food containers, plastic straws, and plastic bags and cups. The goal of the third phase is to 100% recycle targeted plastic wastes by 2027 to accomplish the conservation concept of circular economy and plastic reduction [15]. The action plan provides essential base to develop the roadmap of waste management in Thailand.

Figure/ The plastic waste is regarded as hard to dissolved and definitely causes substantial pressure to the territorial and marine environment
Image by Pride Advertising Agency Ltd.

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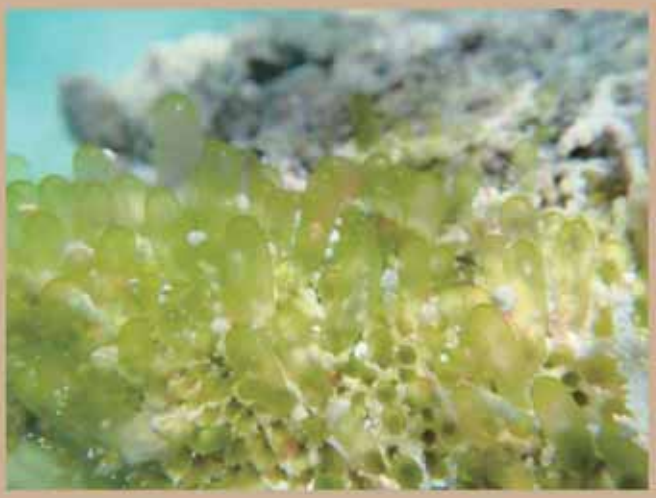

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