國際海洋資訊
International Ocean Information

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長時海洋環境監測的海洋雷達觀測網
Oceanographic Radar Observation Network for Long-term Marine Environmental Monitoring

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站在海洋永續發展的基石上 打造海洋國家

主任委員：李仲威

如何永續經營海洋，合理利用海洋空間與資源分配，是各國都需要認真考慮的重要議題，許多國家以海洋空間規劃（marine spatial planning, MSP）來擬定整體之海洋政策，如本期介紹之葡萄牙，由於政府各部門在海洋資源運用方面有不同目標，面對離岸風電產業與漁業間的競合，MSP可在永續思維下建立協調機制，以達到有效的海洋治理；葡萄牙海洋部提出2021-2030年之國家海洋策略（National Ocean Strategy, NOS），除遵從國際海洋規範外，亦特別回應歐盟「藍色增長策略」（Blue Growth Strategy），以取回葡萄牙之海洋主權。聯合國政府間海洋學委員會（Intergovernmental Oceanographic Commission, IOC）和歐盟執委會海事暨漁業總署（The Directorate-General for Maritime Affairs and Fisheries, DG MARE）則在2021年公布「海洋空間規劃國際指南」，從設定情境到執行後之監測、評估和調整分為6個階段，提供各國政府和海洋空間規劃人員擬定海洋空間計畫的實際工具，並提升跨國合作的海洋空間規劃。「法規制度」則介紹跨國合作擬定、保護西北大西洋海洋環境以因應重大油污事件的《里斯本協定》（Lisbon Agreement）。

海洋的科學研究與資源應用，亦是永續海洋的核心之一。本期「專題報導」介紹我國海洋雷達觀測網之建置與技術發展，可監測周邊海域表面洋流場，蒐集環境資訊作為海洋科學研究之基礎；「資訊新知」則介紹離岸風電關鍵之海上變電站技術，以及深海開發所需之浮式變電站發展現況。在聯合國「海洋科學促進永續發展十年」的此刻，臺灣在海洋雷達及浮式變電站方面的研發與應用，將是我國未來推動海洋永續，提升海洋實力的重要基石。

圖說／葡萄牙馬德拉自治區（Autonomous Regions of the Madeira）
圖片來源／https://pixabay.com/photos/portugal-madeira-ponta-do-sol-4823826/

長時海洋環境監測的海洋雷達觀測網

撰文／賴堅戊（國家海洋研究院海洋產業與工程中心研究員）
關鍵字／遙感探測、洋流、波浪、海嘯、邊界流、海洋觀測系統

海洋環境的長期監測，不論在海洋事務的應用還是在全球環境變遷議題上，都是重要的決策參考依據。海洋觀測隨著技術發展，從點到面到立體的發展，或從岸際、船載、岸基、錨碇、機載到星載，可說是日新月異，而推動整合各式觀測系統與建置整合海洋觀測網亦成為近代海洋觀測技術及應用的重要課題。二次世界大戰結束後，防空雷達的雷達手和科學家發現了無線電波與海面波浪的交互作用機制並逐漸完成理論模型。由於海洋雷達相對傳統實海調查，有範圍廣、連續、近即時且較低運作成本的優勢，因此自1970年代起，美國、德國、日本、中國等國，陸續投入開發專門用來連續觀測風場、洋流流場、波浪場及海嘯傳遞等海洋特徵的海洋雷達及演算法。隨著海洋雷達觀測網的建置，也為二維平面海洋觀測開啟了新頁。

2000年代，以美國為首的國家，快速建置海洋雷達系統，並且在美國、墨西哥及加拿大構築海洋高頻雷達觀測網。在同一個年代，臺灣也在海洋學界推動下於「海洋學門未來十年研究規劃建議書」中，規劃以18套高頻雷達站來長期觀測臺灣周遭海域的洋流，建置工作由科技部交付財團法人國家實驗研究院台灣海洋科技研究中心（Taiwan Ocean Research Institute, TORI）執行，並於2016年達成環島觀測網的建置。其雷達站網及觀測成果如圖1所示，使我國成為世界第1個能長期監測周邊海域表面洋流場的國家。

根據地球觀測組織（Group on Earth Observations, GEO）於2019年的統計，世界各國所建置的高頻海洋雷達站應該已超過400座，其中亞太地區即占了近140座，且逐年持續增加中[1]。在世界各國的努力下，世界氣象組織（World Meteorological Organization, WMO）和聯合國教育科學及文化組織（United Nations Educational, Scientific and Cultural Organization, UNESCO）轄下之政府間海洋學委員會（Intergovernmental Oceanographic Commission, IOC）共同發起的海洋學和海

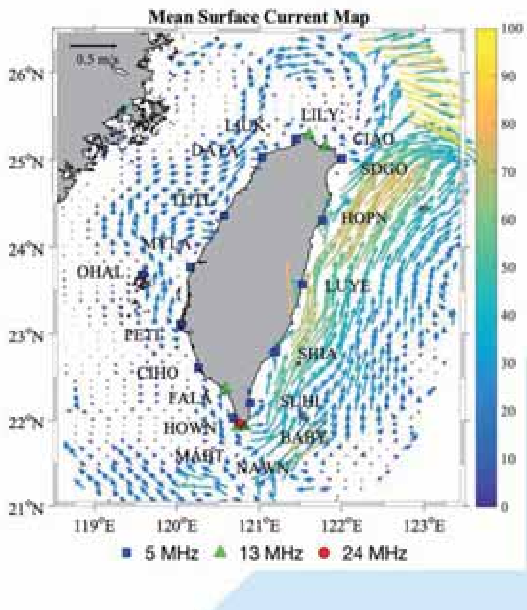

圖1／國家實驗研究院台灣海洋科技研究中心建置我國第一代環臺岸基雷達測流網
圖片提供／賴堅戊繪製

洋氣象學聯合委員會（Joint Technical Commission for Oceanography and Marine Meteorology, JCOMM），於2017年的JCOMM-5會議中第25號決議[2]，採納GEO建議將高頻海洋雷達觀測網納入海洋觀測系統一環的意見，不僅實現對大範圍的、近即時的、連續的海洋波流監測，以強化對海洋科學研究、海洋事務應用及地球環境變遷等課題所需之環境基礎資訊，對無線電遙測海洋的技術發展更是重大的鼓舞。

無線電波的海洋監測技術

隨著19世紀人類在電磁學上的突飛猛進，利用無線電波反射與散射特性來進行遠程飛機、船舶的監控成為二次世界大戰的重要技術。到了戰爭結束，擔任警戒任務的海防雷達作業兵反應雷達訊號總是受到不明原因的干擾。直到1955年克倫比（Douglass D. Crombie）揭示了「數十公尺波長的電磁波與海洋表面粗糙度的相互作用，會產生Bragg共振及後向散射現象[3]」，克倫比的研究對於成天盯著螢幕的雷達兵所發現的干擾給出了一個合理的物理解釋，也開啟了無線電波應用在超視距海況探測的新頁。而後，在1968年至1972年間，美國國家海洋暨大氣總署（National Oceanic and Atmospheric Administration, NOAA）工作的巴里克博士（Donald E. Barrick）完成了海面粗糙度對無線電波的後向散射機制的理論推導，為高頻無線電波探測海洋表面建立了堅實的理論基礎[4]。而在無線電頻率較高、波長為數公分等級的微波雷達方面，自1978年Mattie和Harris確認了X-band雷達確實適用於海面波紋之觀測[5]，Young等人（1985）用從X-Band航海雷達發現，根據一序列之雷達回波影像建立三維能譜，並利用波浪分散關係作為擷取訊號及分離雜訊，可進行海面波譜與表面流速的推定，建立了微波航海雷達兼具遙測海態的理論基礎[6]。

海洋雷達利用無線電回波的訊號中萃取、反演我們關心的目標物（如船舶）或海洋環境特徵（風、波、流），和多數的觀測系統一樣，海洋雷達會受到環境影響和物理限制。一般而言，高頻雷達可以沿地球曲率於海面傳遞，因此又有超視距雷達的稱號，高頻雷達使用5MHz無線電波主頻，高頻雷達對波浪和海流的有效觀測範圍可達120公里和240公里。若使用30MHz較高主頻的系統，則僅有20公里和40公里。而無線電波頻率達GHz等級之微波雷達，則因為無線電波傳遞方式不同，則通常僅能提供視距3～5公里範圍內之海況觀測資訊。相關資訊整理如表1所示。而海洋雷達在海態訊息的距離方向解析度方面，則主要受通訊傳播委員會核配之無線電波調變頻寬限制，在臺灣，5MHz的系統通

表1／海洋雷達觀測範圍

系統	海態反演訊號依據	最大觀測範圍（公里）		
		波浪*	海流*	潛在影響因素
高頻雷達	都卜勒譜	600/主頻(MHz)	1,200/主頻(MHz)	海面重力波特徵、無線電干擾、電離層、大氣逆溫層波導管效應、觀測網合成幾何精度等
微波雷達	回波影像	3~5	3~5	海面毛細波特徵、無線電干擾、無線電波掠角、降雨等

*高頻雷達的波浪及海流最大觀測距離受所使用主頻影響，此處提供概估公式以利瞭解
資料來源／賴堅戊整理

常能取得數十kHz的調變頻寬，而30MHz的系統則能取得數百kHz的調變頻寬，因此前者的空間解析度為數公里等級，而後者則可達到較精細的數百公尺等級，這樣的解析度限制也影響了對海洋不同尺度特徵的觀測應用。因此，在美國NOAA整合海洋觀測系統（Integrated Ocean Observing System, IOOS）的海洋雷達觀測網是由5MHz和13MHz系統所組成的雙層架構，在廣域離岸200公里範圍內提供6公里的解析度，而在沿近岸數十公里範圍內則可提供1公里解析度的觀測產品[7]。

承先啟後的海洋雷達遙測新局

我國海洋雷達觀測網在海洋學界的倡議及國家實驗研究院台灣海洋科技研究中心多年資料釋出、技術研發及加值應用等努力，促成了一群「國研達人」們在海洋科學研究、訊號處理技術、儀器設備研發及海難搜救、污染擴散防治等國內相關科技發展。

近年我國為統合海洋事務及海洋科技發展成立海洋委員會，適逢聯合國推動「海洋科學促進永續發展十年」、中山科學研究院積極推動軍民通用科技產業加值應用、能源轉型中的海洋能源開發以及向海致敬政策等國內外助力，促使政府各部門本於權管推動岸基海洋雷達系統建置工作，以健全我國海域環境監測及防災科技應用，各部會技術官員及研究人員於2021年11月間聚集就觀測網的布建及共通資料格式進行交流，希望在政府開放資料政策下，促進跨機關資料流通，提升施政效能，與會人士稱這樣的交流聚會是「臺灣海洋雷達遙測小聯盟」。

在2019年至2024年間，政府各部門將有超過42座海洋雷達站陸續完成建置及運作，分別是交通部中央氣象局12座（高頻雷達6座、微波雷達6座）、交通部運輸研究所港灣技術研究中心3座（高頻雷達2座、微波雷達1座）、海洋委員會國家海洋研究院27座（高頻雷達12座、微波雷達15座）。此外，經濟部水利署在臺南七股亦有1座微波海洋雷達，政府各部門所構築的觀測站網，如圖2所示，相信這些遙測系統將在海氣象觀測、航運安全、海洋能源評估、海域遊憩風險及海難救助與污染擴散防治等面向發揮其長期觀測的效益。目前國內建置的各式海洋雷達之實況如圖3所示，其中左上為TORI使用的CODAR（Coastal Ocean Dynamics Application Radar）高頻集成式海洋雷達系統，左下則為港研中心、氣象局及國家海洋研究院等單位新建中的由夏威夷大學研發之陣列海洋雷達系統，右側則為微波海洋雷達系統。

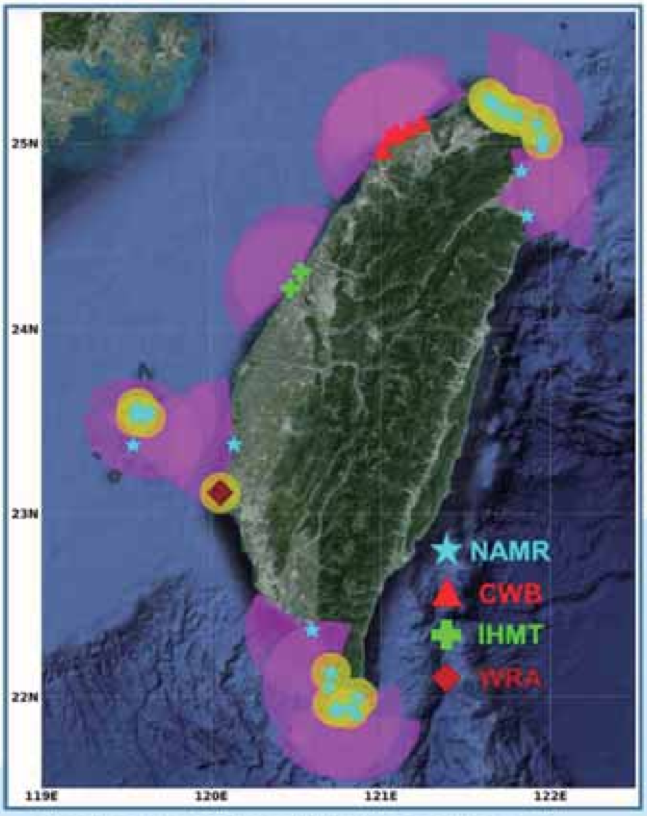

圖2／我國政府各部會建置中之海洋雷達觀測網覆蓋圖
圖片提供／賴堅戊繪製

目前海洋高頻雷達（如上述之CODAR及陣列海洋雷達）及微波雷達遙測的主產品以波浪場及表面海流流場為主，為使讀者理解其產品，在圖4中分別以我國目前已運作的枋寮、車城高頻線性陣列雷達及基隆外木山微波雷達為例，繪製其海態反演訊號依據（都卜勒譜或回波強度影像）以及其反演之波浪場與流場圖。其中，圖左為高頻陣列雷達觀測之成果，其單站觀測範圍約30公里。圖右則為微波雷達觀測成果，其單站觀測範圍約3公里，我們可以透過其產出之波浪場和表面流場，一窺有效觀測範圍內之海洋特徵及其時間與空間上變化，這是傳統以錨碇系統定點觀測或研究船於航線上觀測所無法取得的成果，也是海洋雷達遙測不可替代的優勢。除了波浪與海流的觀測外，在國內亦有海面風場、海嘯波傳遞、水深地形、船艦偵測等反演技術在陸續開發，未來將有希望能於作業化觀測網中新增成為定常的觀測產品。

圖3／我國採用之各式海洋雷達實況照例
圖片提供／賴堅戊

結語

回顧我國在海洋雷達的發展，近十年間廣納海洋學及通訊電子學的產官學研界的專家學者的參與，對於推進雷達應用在海洋長期探測以及軟、硬體自主開發都有了快速的成長。相信未來在政府跨部會的共同合作下，將可促進政府資源之有效利用、以我國獨特地理位置為基石的海洋科學研究之國際能見度及領先地位、提升我國海域從「點」到「面」的海洋觀測能力與資訊掌握，並充實國家海洋資料庫之內容。這些基礎設施的建置，除了在學術研究的價值外，更將助益於環保、航運、能源、漁業、防災、救災、休閒、娛樂、軍事、國防等多面向海洋資訊需求。

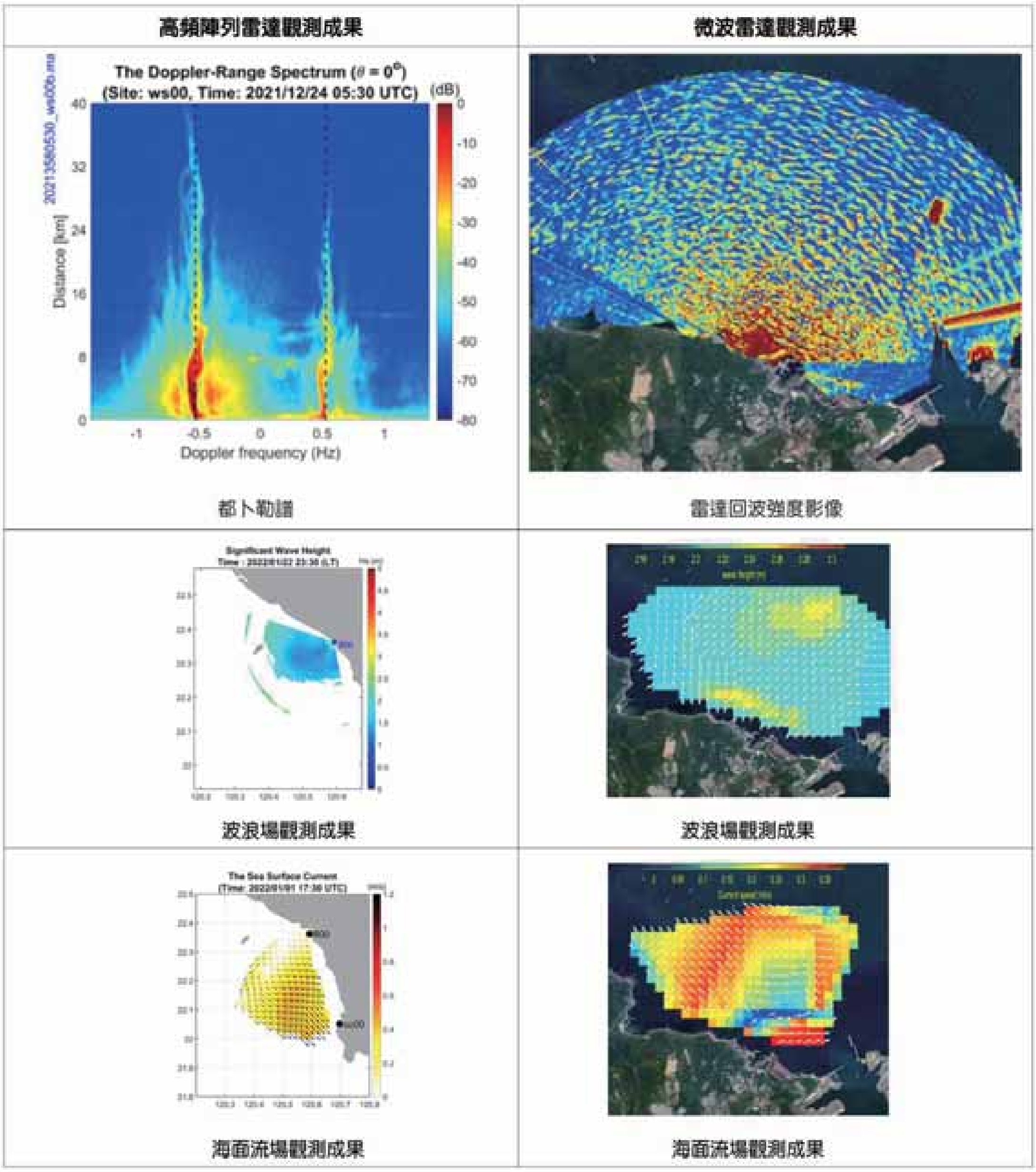

圖4／陣列高頻雷達及微波雷達海洋觀測成果例
圖片提供／賴堅戊繪製

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確保海洋繁榮之徑：海洋空間規劃國際指南

撰文／陳璋玲（國立成功大學海洋科技與事務研究所教授）
關鍵字／海洋空間規劃、海洋空間計畫、海洋永續發展

為促進全球藍色經濟發展和確保海洋永續，聯合國教育科學及文化組織政府間海洋學委員會（Intergovernmental Oceanographic Commission, United Nations Educational, Scientific and Cultural Organization, IOC-UNESCO）和歐盟執委會海事暨漁業總署（European Commission's Directorate-General for Maritime Affairs and Fisheries, DG MARE）於2021年共同提出「海洋空間規劃國際指南」（International Guide on Marine/Maritime Spatial Planning，英文簡稱MSPglobal Guide）。此文件延續IOC-UNESCO 2009年發布的「海洋空間規劃指南」（Guidance for Marine Spatial Planning），目的在協助政府和海洋空間規劃從業人員擬訂海洋空間計畫、提升跨國合作的海洋空間規劃（marine spatial planning, MSP），促進尚未實施海洋空間規劃的地區投入此項工作，以及提升各國和區域海洋空間規劃人員的能力。此文件指出海洋空間規劃的6個階段，包括設定情境、設計規劃過程、評估規劃、海洋空間計畫、海洋空間計畫執行，以及監測、評估和調整。每個階段列出詳細的工作事項，作為海洋地區啟動和推動MSP的指引。

圖1／MSP規劃空間供各種不同使用，可減少不同使用之間的衝突、創造效益和確保海洋永續
照片提供／陳璋玲

海洋空間規劃

海洋空間規劃是指對海洋地區進行空間規劃的過程，主要目的在分析海洋使用，以及分配各使用於特定海洋空間或於特定空間排除特定使用，以減少不同使用之間的衝突，創造最大效益，和確保海洋生態系韌性。MSP係生態系為基礎的，參與式的、涉及多部門的、跨界合作的規劃和管理海洋環境的方法，其有助於達成聯合國2030年議程的永續發展目標14（Sustainable Development Goals, SDGs 14）第二子目標。該子目標為以永續方式管理並保護海洋與海岸生態，避免重要負面衝擊，包括加強海洋恢復力，並採取復原行動，使海洋保持健康、物產豐饒。此外，MSP為規劃的區域帶來經濟和社會效益，且檢視經濟、社會和環境目標三者之間可能的妥協並找出平衡方案。跨國界的MSP更可促成國際協定的達成，例如《生物多樣性公約》（Convention on Biological Diversity, CBD）和《巴黎協定》（Paris Agreement）。

本文介紹IOC-UNESCO和DG MARE共同研提的「海洋空間規劃國際指南」。該指南描述MSP過程的6個階段，以及詳列各階段的工作事項，可作為不同海洋空間尺度（包括跨國界尺度）的海洋空間規劃指引。

「海洋空間規劃國際指南」

「海洋空間規劃國際指南」指出，海洋空間規劃過程涉及不同部門對海洋使用的目標如何達成一致、制定法規和管理措施、利益關係人參與、確保經費來源，以及檢視海洋空間規劃的成果和調整計畫等。MSP包括6個階段：設定情境、設計規劃過程、評估規劃、海洋空間計畫、海洋空間計畫執行，以及評估和調整海洋空間計畫。

第一階段：設定情境

設定情境指須對相關法規和機構架構、利益關係人、可得經費來源，以及規劃海洋資源需求等背景資訊有一定程度的瞭解和確認。此階段的工作項目包括成立海洋空間規劃工作小組、確認既有的國內法規和體制架構、確認可適用於國家和／或國家採納的國際法規和協定、確認關鍵利益關係人、確認經費來源、確認地方、國家或區域層次（包括跨區域）對海洋資源規劃的需求、以及思考在既有海洋和海岸治理和法律架構下納入MSP。

成立工作小組的目的是籌劃流程，整合不同部門的看法和專業，以準備啓動MSP。成員由各相關機構和部門、海洋空間規劃專家、公民團體等利益關係人組成。小組擬訂工作事項範疇的文件，列出小組的角色和負責的事項、會議安排、工作時程等。此外，小組亦檢視既有海洋空間規劃和永續藍色經濟相關的法規和機構架構，並評估政府部門是否有規劃海洋和海岸的能力。

小組檢視的文件包括國家海洋政策、藍色／海洋策略、部門政策、部門管理計畫、整合性海岸管理、再生能源目標、區域或地方發展計畫（尤其是海洋地區）、氣候變遷調適策略，以及國際法規文件等。尤其，MSP有助達成國際法規文件的目標，而得以解決跨國界面臨的海洋議題，如氣候變遷和非法、未報告及不受規範漁業（illegal, unreported and unregulated fishing, IUU fishing）等。相關的國際法規文件包括《聯合國海洋法公約》（United Nations on the Law of the Sea）、「2030永續發展議程」（United Nations 2030 Agenda for Sustainable Development）、《氣候變

化綱要公約》（United Nations Framework Convention on Climate Change）、《魚群協定》（United Nations Fish Stocks Agreement）、聯合國糧農組織《促進公海漁船遵守國際養護與管理措施協定》（FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas）等。

此階段必須確認關鍵的利益關係人，及確保透明和公平地參與MSP。另利益關係人因隨時間改變，需隨時更新名單。此外，亦須確認地方、國家或跨界區域不同空間尺度對海洋資源規劃的需求。需求是推動MSP的重要驅動力，通常來自於下列情境：不同使用之間和使用和自然環境之間發生衝突、不同使用之間產生協同效果、推動特定海洋部門或整體海洋經濟策略，以及推動區域為基礎的海洋保育（例如海洋保護區網等）。

第二階段：設計規劃過程

設計規劃過程係指列出MSP的主要步驟，以及規劃如何使MSP工作有效率地進行。此階段需注意的事項包括成立規劃小組和規劃技術小組；界定規劃界線和時間期程；確定規劃原則、初步願景和目標；研擬監測和評估計畫；評估風險和應變計畫等。

規劃原則通常包括永續管理、生態系原則、預防性原則、參與和透明、高品質資料和資訊、跨國整合和協商、陸地和海岸空間規劃的一致性，以及因地制宜規劃。監測和評估計畫涉及監測指標的選擇，聯合國出版物—指標簡介（An Introduction to Indicators）提出設計指標的標準，說明指標應具備的特性，包括相關性、可測量／可檢驗、科學性、易明瞭和解釋、可比較，以及成本效益等。因此，監測指標須具備上述特性，以能正確量測MSP執行成果。

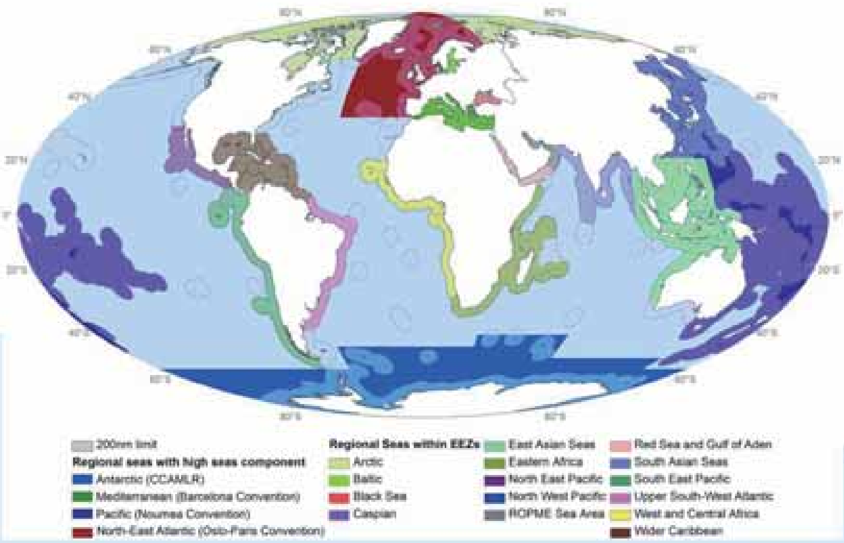

圖2／區域海洋計畫可做為跨國合作的海洋空間規劃的國際治理機構
圖片來源／[2]

第三階段：評估規劃

本階段的重點放在界定不同海洋空間規劃的尺度、確認擬規劃海洋空間的現況、分析其未來狀況和趨勢，以及建置公共資訊系統。

決定海洋空間規劃的尺度時，考量的因子包括海域的國際治理體制、海洋生態系和物種空間分布及動態變化、人類海上活動的範圍、毗連領土的政治／行政組織。海域相關的國際治理體制如區域海

洋計畫（Regional Sea Programmes），鮪類區域漁業管理組織（Regional Fisheries Management Organizations）等。海洋空間的現況係指物理、生物、社會、經濟和治理等資訊。該等資訊數量龐大，因此有必要整理資訊於公共資訊系統內。另分析此海洋空間的未來狀況和趨勢時，須考量目前的、新增加的，以及未來新興的海洋部門對海洋空間的需求。

第四階段：海洋空間計畫

本階段涉及擬訂海洋空間計畫、公開諮詢民衆對計畫的看法，以及批准計畫。海洋空間計畫是一份政策文件，代表不同利益關係人同意的目標。計畫內容包括環境評估、海洋使用的空間分配、作海洋保育的優先區域、管理策略、組織架構、執行控管方式、預算和財務分配，以及建置海洋空間規劃的能量。有關能量建置部分，規劃人員必須學習如何區域劃分、如何進行環境衝擊評估、以及如何將計畫納入治理和法律架構等。

海洋空間計畫相關案例，如塞席爾透過海洋空間計畫，達成30%海洋保護區的目標（海洋保護區面積和專屬經濟海域的比例）。另屬跨國的國際治理機構—奧斯陸—巴黎公約委員會（Oslo and Paris Convention, OSPAR）制定海洋空間計畫，確認海洋保護區的區域作保育使用。

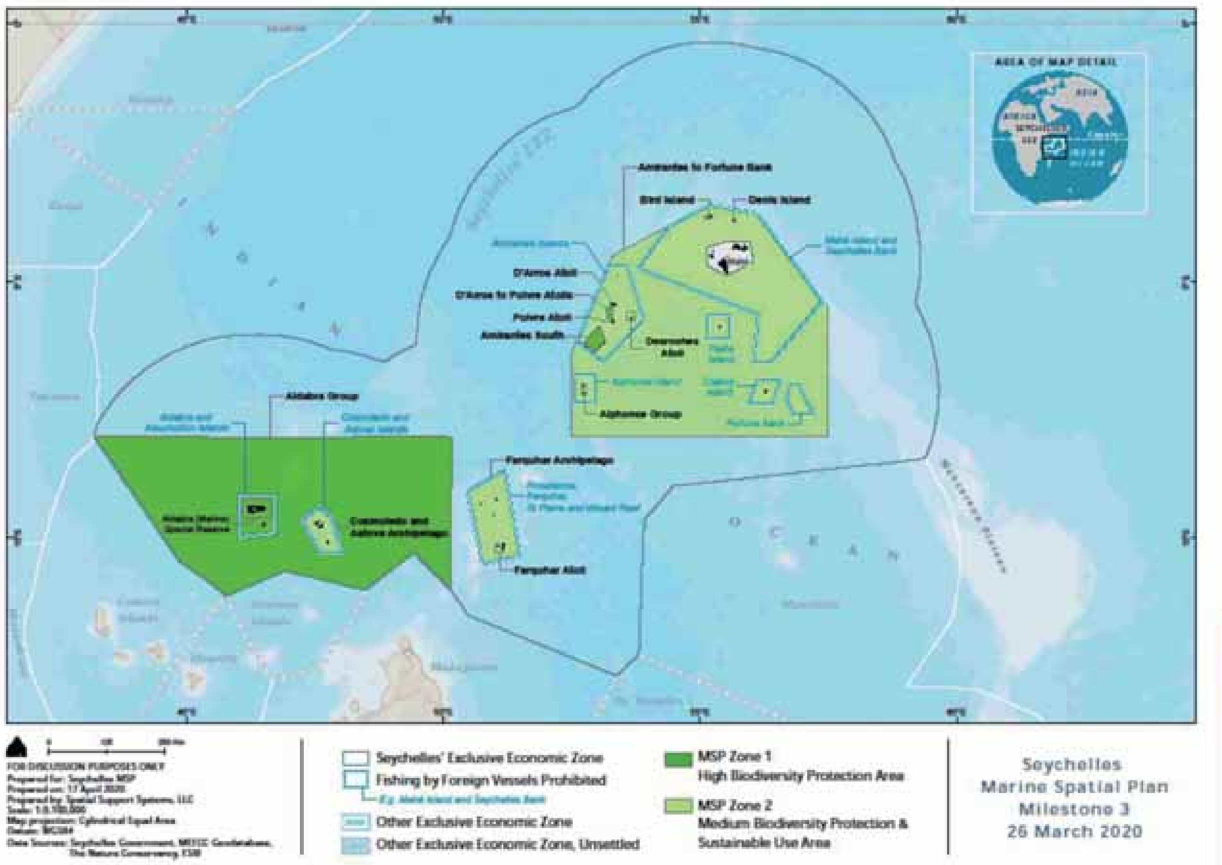

圖3／塞席爾透過海洋空間計畫達成30%海洋保護區的目標
圖片來源／[3]

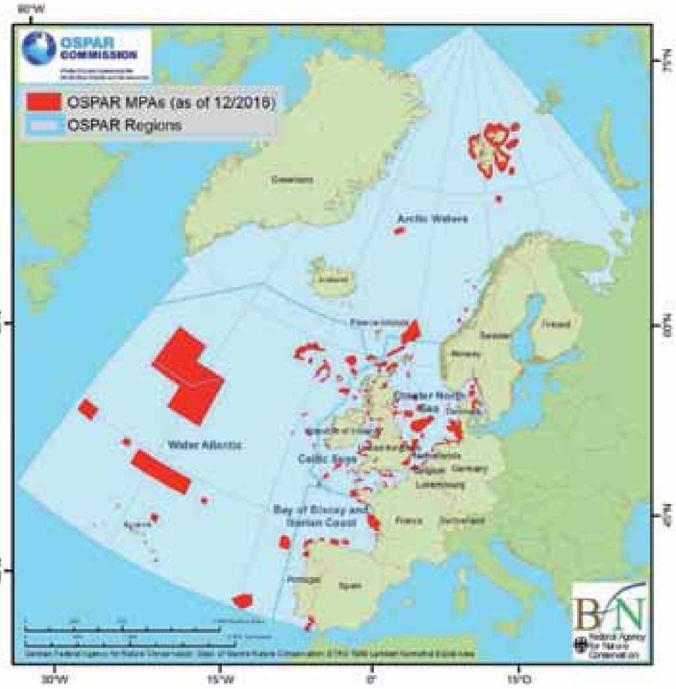

圖4／OSPAR海洋空間計畫確認海洋保護區的區域
圖片來源／[2]

第五階段：海洋空間計畫執行

本階段主要係使海洋空間計畫得以執行，涉及的工作包括訂定與海洋空間計畫執行相關的法規、設置不同部門之間定期的對話管道、訓練權責單位和海洋部門有關海洋空間計畫執行事宜。法規是執行和遵守海洋空間計畫的重要基礎。另屬跨國界的海洋空間計畫，則相關公約或協定是海洋空間計畫執行的基礎，通常需要兩國或多國之間有效率的溝通。

第六階段：監測、評估和調整

本階段進行MSP過程中每一階段的評估，以及海洋空間計畫執行成果的監測和評估。依據評估結果，進一步檢討MSP過程和海洋空間計畫，並進行適當的修正和調整。

結論

MSP是一個實務導向的工具，可促進全球海洋涵蓋更多樣及理性的使用，有利藍色經濟永續發展。在愈益擁擠海洋空間的情境下，MSP確實是一個鼓勵多元使用海洋的手段。海洋空間計畫分配特定區域／地點給予新增加的使用，以及新興的使用，因而增加投資者信心，同時提升科學、創新和科技的投資。

MSP已廣被認為和接受是海洋資源管理的手段，本文介紹的「海洋空間規劃國際指南」提供了地方、國家或區域實施MSP所需要的步驟，期待透過全球實施MSP，海洋永續發展的目標得以實踐。

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葡萄牙離岸風電政策與海洋空間規劃之競合關係

撰文／黃釋緯（台灣經濟研究院副研究員）
關鍵字／葡萄牙、離岸風電、海洋空間規劃

葡萄牙於2020年通過「國家能源與氣候計畫2021-2030」（Plano Nacional Energia e Clima 2021-2030, PNEC 2030），提出邁向2050年碳中和目標的中程路徑，PNEC 2030聚焦在溫室氣體減量、能源效率、再生能源、能源安全與能源市場（含能源貧窮）等議題，以創新研發及提升競爭力等策略，加速淨零碳排政策之力道。未來再生能源將占國家整體能源消費的47%。以發電量計算，約有80%電力來自再生能源，其中風力發電裝置容量占比最高，將由2020年的5.43GW，成長到2030年的9.3GW。

葡萄牙海岸線長，但離岸風電發展相對保守，只由0.03GW上升到0.3GW，雖然容量少，但是成長率達10倍之多，對於海洋空間影響不小。本文主要介紹離岸風電場址與海洋空間規劃之競合關係，透過對於海洋空間規劃法規與海洋相關產業發展各類規範與探討，提供臺灣海洋產業推動之借鏡。

離岸風場選址評估

葡萄牙在1986年於馬德拉島安裝了第一組電力發電機組，在2020年陸上風力發電總裝置容量達5.4GW，規劃到2030年裝超過9GW。又由於葡萄牙也是歐洲海岸線最長的國家之一，因此亦同時規劃離岸風電計畫。離岸風電的風場評估始於2006年，後續於2010年亦再次評估，二次的離岸風電潛力風場評估，雖然條件或有差異，然其最終場址仍是位於相同的地點（圖1）[1]。

圖1為6個可能的離岸風場評估。由於受到海洋空間規劃法（Plano de Ordenamento do Espaço Marítimo, POEM）影響及限制，如海岸發展對於人類活動及能源、地質現況的影響。首先，區域E和F無規劃風場位址之範圍中，因為該二個區域是旅遊勝地，如果設置風場，將會嚴重影響其自然生態保護區與水產養殖漁業發展。區域D除了受POEM影響外，亦受其他與環境相關法規規範影響。此區域除部分保護區外，與重要的人類活動重疊，設置風場對社會層面有高度衝擊。

區域C與POEM指定的風場位址有重覆部分，本區也是具潛力的優良風場，但由於靠近伯倫加斯（Berlengas）國家自然遺產保護區，同時也受可能的石油開採活動及水產養殖漁業活動影響。區域B也是POEM指定的近海風場位址之一，與區域C相同，影響到自然保護區與漁業等人類活動，若要開發風場，其許可的過程將是曠日廢時。最後，區域A是葡萄牙最佳的離岸風場場址，它除了被POEM列為離岸風場外，區域內無自然保護區，且對於石油開採及漁業的影響最小，是葡萄牙最佳離岸風電的開發位址[2]。

離岸風電設置規劃

葡萄牙所有的風電設置規劃皆於上述區域A（最北端近海區域），現有的風場共有5個（含淺水及深水區）。2019年首先在深水區Wind Float Atlantic共有3部風機商轉中，為全球第2個商轉的浮動式風機技術風場，總計發電裝置容量為25MW，估計可以提供約6,000戶家庭年用電量所需。然而表1的編號2、4、5總計428MW裝置容量的規劃已取消，編號7和8總計350MW則是未來到2030年的待開發區域。除了在近海開發外，也同時開始在離島（Porto Santo）進行離岸風機的規劃。離岸風機因為噪音與振動，會對野生物種產生負面干擾，影響當地的生態，雖然可以將機組設置進一步遠離海岸，但此舉將影響風機設置的成本與可行性，目前葡萄牙的離岸風力機組設置相對歐盟其他國家保守。

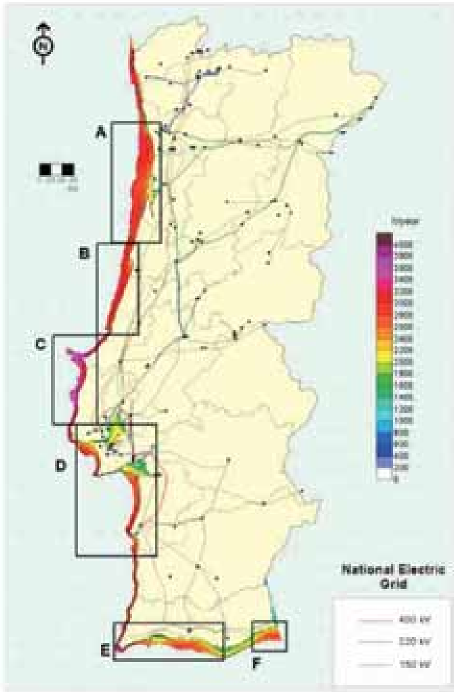

圖1／葡萄牙離岸風場潛力點
圖片來源／[1]

表1／葡萄牙離岸風電規劃一覽

風場名稱	裝置容量	運作情形	區位
1.WindFloat 1 Prototype (WF1)	2 MW	已除役	
2.Branca	301 MW	已取消	
3.WindFloat Atlantic (WFA)	25 MW	商轉中	
4.WindFloat Atlantic (WFA) - phase 2	125 MW	已取消	
5.DEMOGRAVI3	2 MW	已取消	
6.Offshore Island Porto Santo	10 MW	先期規劃中	
7.Emergent Demand 1	150 MW	待開發	
8.Emergent Demand 2	200 MW	待開發	

資料來源／[3]

葡萄牙海洋空間規劃情形

海洋空間規劃（Marine Spatial Planning, MSP），為各國用於海洋治理，與促進跨國界或跨部門管理之決策工具，其目的在於確保人類以安全的、永續的和有效率的方式進行各種海洋活動，並以模型工具分析或分配海洋人類活動的空間和時間分布，以實現永續發展的生態、經濟、社會三大目標。使用MSP做為海洋管理策略的優點是：在國際上，可以增加不同國家的跨境合作；在國內方面，在同一個空間下，可以減少產業間的衝突（離岸風電與漁業）性，並建立起不同的部門之間的協調機制，亦可在海洋產業發展過程中，儘量減少對於生態系統的破壞。

葡萄牙的國家海洋策略（National Ocean Strategy, NOS）政策規劃共有二期，分別為NOS2006-2016和NOS2013-2020。NOS2013-2020是海洋空間的綜合管理、資源開發中的預防措施以及所有人的有效參與的指導原則。NOS 2013-2020的5個主要目標分別為：

一、在現代、主動、積極主動和創新的架構下恢復國家海洋特性。

二、通過創造有利的條件吸引國家和國際投資，促進經濟成長、就業、社會凝聚力和領土完整，實現經濟、地緣戰略和地緣政治潛力。

三、於2020年，提升海洋部門對國民生產毛額的直接貢獻達至50%。

四、強化國家科技能力，刺激新產業領域的發展。

五、視葡萄牙為一個海洋國家，並且是歐盟大西洋地區綜理海洋政策和海事戰略核心的一部分。

為配合歐盟海洋空間規劃的指令，葡萄牙於2008年開始啟動海洋空間規劃（POEM）相關工作。初期計畫的主要目標在於調查葡萄牙海洋區域的現況及未來可能的活動與用途，包括中長期的開發活動，相關永續目標及各類海洋監測計畫，於2012年起進行公眾諮詢及提出國家級的MSP訂定原則與建議，2014年又根據國內及歐盟的相關法規規劃。葡萄牙的MSP目標是：促進海洋資源和生態系統服務的開發，考量跨世代公民於國家海洋空間利用的就業機會，同時確保不同海洋活動的相容性與永續性。在2019年提出新的海洋空間規劃（Plano de Situação do Ordenamento do Espaço Marítimo, PSOEM），將其空間規劃分為葡萄牙大陸、馬德拉島和擴展大陸棚3大部分。

圖2／葡萄牙海洋空間規劃範疇
資料來源／[4]

在MSP中納入永續發展的思維有兩種模式，第一種是硬性永續，完全以生態保護為重點；第二種是當前各國所採行的軟性永續，生態保護僅是MSP的一部分。第一種永續發展的核心重點包括漁業、能源、旅遊、航道安全等，第二種模式，是以永續發展為核心，目標在於促進海洋部門的經濟發展，將藍色經濟發展視為核心。綜言之，葡萄牙的MSP是以解決海洋空間利用對於環境課題的關注，但是環境問題不是MSP主要的目標，永續發展才是MSP的核心目標。如何維持海洋產業發展，兼容環境保護等管理政策（例如透過政策環境影響評估，取得平衡），才是MSP政策要解決的重要課題。

案例分析：葡萄牙離岸風電發展與漁業活動之競合

離岸風電是歐洲藍色經濟（海洋產業）發展最快速的項目，葡萄牙第1個離岸風場－Wind Float Atlantic（WFA），共裝置3部機組，總裝置容量為25MW，已於2019年商轉，是全球第2例浮動式離岸風機技術。WFA皆依葡萄牙MSP規範進行開發，但由於風場特定區域內，大都禁止捕魚或是漁船通行，將對於漁業活動甚至是船舶航行造成影響，WFA對於葡萄牙漁業文化造成不可避免的衝擊，以往的MSP並無法同時解決風機產業和漁業間之衝突。因應離岸風電規劃對漁業活動有關的社會、經濟方面的影響，建議在MSP規劃時，可考慮將漁業納入決策過程，規劃漁業友善的MSP政策。解決衝突的有效方案是要透過溝通，並在政策的決策過程中，讓不同部門間有更多的互信及透明度。

根據Braga（2020）[5]研究指出，葡萄牙在WFA的規劃設置過程中，小規模漁業用戶是無法參與重要的決策協商，只能透過事後的經濟補償緩解。而在補償過程中，又無法惠及該區域內的所有漁民，只補償給有加入屬於該區域內漁業協會的漁民。WFA對於漁民的影響是造成特定區域捕魚限制，另外，海底電纜也常造成鉤住漁具甚至造成漁船翻覆，離岸風機建造及運轉過程中，也會造成魚類生態改變，破壞傳統的漁場，可能導致漁民營運成本增加，影響生計。過去風電開發對於社會的衝擊，常常被排除於評估階段之外，導致不同利害關係人無法取得共識，只能利用經濟補償機制。如何在風電開發前期就導入利害關係人的溝通機制，是很重要的工作。在初期規劃階段，就應該要有融合解決利害關係人與開發者衝突的預防性策略。

表2／緩解離岸風電與漁業部門衝突的解決方案

預防衝突之方案	
1	計畫規劃階段納入所有利害關係人
2	協助辨識早期相關的社會服務之權衡關係
3	對專案進行生態系統衝擊評估
4	協助專案內受影響之相關弱勢產業
5	對於公眾進行相關諮詢與互動
6	強有力的管理機關或架構設計
7	提供更多科學專業資訊
8	建立合作聯盟

解決衝突之方案	
1	提供經濟補償
2	決策過程透明化
3	具公眾或利害關係人參與式的決策過程
4	提供（能源與漁業）共同管理的規劃
5	為生物物種設計遷徙廊道
6	允許漁船可通過風電區域

資料來源／[5]

結語

離岸風電是各國藍色經濟發展的重要政策之一，歐盟各國的MSP已有引入公衆參與制度，然而對於離岸風電與漁業之間的競合課題，不應只有經濟補償一途，資訊公開透明與公衆參與，是有效促進利害關係人與開發者對話的機制，也是海洋空間利用的雙贏策略。

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初探葡萄牙國家海洋政策

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葡萄牙國體為共和國（憲法第1條），採半總統制。究其憲法沿革，緣起於1974年發生之康乃馨革命（Revolução dos Cravos）。俟推翻社會主義獨裁者安東尼奧・德・奧利維拉・薩拉查（António de Oliveira Salazar）後，始於1976年制定。迨至2005年復修憲一次，終而成目前施行之憲政體制。葡萄牙政府由總理、副總理、各部部長及正副國務卿（Secretária de Estado）組成（憲法第183條）。其中國務卿制度較為特殊，皆以政務官任命。至其行政權來源，悉由部長授權而取得（憲法第186條第3項），並主政該部門中特別重要事務。如：海洋部下置有漁業國務卿（Secretária de Estado das Pescas），專責漁業事務。溯自1976年共和國成立後起算，目前則已改組至第22屆內閣（XXII Governo Constitucional de Portugal，自2019年迄今）。

葡萄牙海洋部門

葡萄牙政府中之海洋部（Ministério do Mar），嚴格來說，並非新成立機關。早於現代葡萄牙第三共和成立（1976年）之前即設有「海事部」（Ministério da Marinha），其下包括涉海部門與海軍。直到1976年新憲法制定，第一屆內閣部會中之「海事部」雖仍沿用原名稱（同上），但所轄管者已無海軍。而原承擔海軍功能之組織，則移至「國防部」（Ministério da Defesa Nacional）管理直到今日。葡萄牙之海上武裝力量（包括：海警）全由國防部（Ministério da Defesa Nacional）掌理，並授權海軍總局（A Direcção-Geral da Autoridade Marítima，DGAM）統籌調度[1]。嗣於1983年內閣改組，「海事部」一併更名為「海洋部」。此乃葡萄牙民主化後，首度以「海洋部」命名。然而僅維持短暫兩年，於1985年「海洋部」再次改稱「農水產食品部」（Ministério da Agricultura, Pescas e Alimentação，1985-1991），爾後陸續易名為「海洋部」（1991-1995）、「農業、農村發展與漁業部」（Ministério da Agricultura, do Desenvolvimento Rural e das Pescas，1995-2011）、「農業、海洋、環境與空間規劃部」（Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território，2011-2013）或「農業與海洋部」（Ministério da Agricultura e do Mar，2013-2015），迨2015年後復又恢復原名「海洋部」。由此可見葡萄牙歷屆內閣，一直徘徊於應否成立「海洋部」之討論上，而其政策軸心亦隨之變動。

表1／葡萄牙內閣海洋部門之變遷

時間	名稱	是否掌控武裝力量
-1976	海事部	是
1976-1983	海事部	否
1983-1985	海洋部	否
1985-1991	農水產食品部	否
1991-1995	海洋部	否
1995-2011	農業、農村發展與漁業部	否
2011-2013	農業、海洋、環境與空間規劃部	否
2013-2015	農業與海洋部	否
2015-	海洋部	否

資料來源／作者自行蒐集葡萄牙法規整理

海洋部之職責

參照葡萄牙近期法律規定，海洋部職掌事項包括：一、橫向協調海洋事務；二、監測國家海洋策略；三、促進海洋領域的科學知識、創新與技術發展；四、規劃、管理與開發海洋資源；五、促進漁業、海上運輸與港口的持續經濟發展；六、與海洋有關的歐洲基金運用作業[2]。至於海洋部下轄者，除前述之「漁業國務卿」外，亦依業務分工，設置以下5個機關：海事政策總局（A Direção-Geral de Política do Mar, DGPM）；自然資源、安全與海事服務總局；海事事故調查處與航空氣象局；馬德拉國際船舶登記處技術委員會；運營計畫管理局[3]。其中以「海事政策總局」肩負政治、經濟、金融及教育4大功能，並具支援「藍色基金會」（Fundo azul）運作的職權[4]，最為舉足輕重。

此外，葡萄牙法律又特別規範海洋部與其他各部會之關係，包括：海洋部與外交部（Ministro de Estado e dos Negócios Estrangeiros）共同處理涉外海洋事務；海洋部與農業部（Ministra da Agricultura）共同處理漁村發展、漁業融資、歐洲基金等事務，以及有關農業、海洋、環境與空間規劃等事宜；海洋部與基礎設施部（Ministro das Infraestruturas e da Habitação）共同處理港口管理事務；海洋部與科技部（Ministro da Ciência, Tecnologia e Ensino Superior）共同監督與教育與技術有關的基金會與機構；海洋部與國防部共同規劃大陸礁層及國家海事局的策略方針[5]。除海洋部外，內閣另設置「海事部際委員會」（Comissão Interministerial para os Assuntos do Mar, CIAM）[6]，由總理擔任主席，專案管理跨部會事務；至於海洋部部長，則負責協調海事部際委員會，且在總理因故不克出席時，有權代理總理行使主席職權[7]。

葡萄牙國家海洋策略

觀諸葡萄牙定期發布之國家海洋策略（目前最新版本為2021年至2030年[Estratégia Nacional para o Mar 2021-2030] [8]），具有雙重功能：遵從國際社會對於海洋之規範，及特別回應2012年歐盟「藍色增長策略」（Blue Growth strategy）。此外，為使葡萄牙取回海洋主權，將以下要務列為當前之重點策略目標（Strategic Goals）[9]：

一、應對氣候變化及污染，保護與恢復生態系統：葡萄牙擁有綿長的海岸線，首當其衝地遭到氣候變遷影響，故必須發展科學知識與技術能力，同時強化監測功效，挑選最受威脅之生態系統，並重點保護之，以期恢復原貌。

二、促進就業與永續藍色經濟成長：藍色經濟範疇，涵括所有與海洋有直接或間接關係之部門，以呼應歐盟規約，並將計畫建立於循環性、包容性、平等性及永續性等之基礎上，以吸引年輕人投入工作行列。

三、經濟脫碳，促進再生能源與能源自主發展：葡萄牙已批准《巴黎協定》（Paris Agreement），並承諾至2050年碳排放至少減量85%。同時配合聯合國2030年議程，特別著重永續發展目標（Sustainable Development Goals, SDGs）7、9、14，即採用低碳或零碳替代能源排放物（液化天然氣、氫氣及合成燃料），減少對化石燃料之依賴，以期轉型為綠色航運國。

四、投資確保永續生存與糧食安全：葡萄牙雖是人均魚類消費量最高國家之一，但卻進口75%海洋產品。考量安全與自治，應以永續之方式自給自足。此亦符合歐洲倡議（European initiative）「從農場到餐桌」（From Farm to Fork）之說。為達成此目標，必須提高水產養殖產量及生物技術，如使用3D列印等易於生產蛋白質之方法。預計於2030年之前，使葡萄牙成為領先世界之海洋科技國。

五、促進水之獲取與供應量能：鑒於公共供水及農業、製造業、娛樂業、工業與畜牧業用水日益增加，已對全球水資源造成巨大壓力，故獲得替代水源至為重要。其中可能選項（解方）之一為海水淡化系統，而其往往又與再生海洋能源息息相關，且具低碳排放量之特性，值得持續開發並提升其量能。

六、增進健康與福利：由於海洋生態系統具有製造氧氣並隔離二氧化碳之功能，亦提供人類食物，以及可被提煉成生物科技藥物或營養品之原物料，甚至得以成為各類休閒娛樂活動的場所，進而提高人民身體素質與心理健康，增加幸福感，故能形成國家未來海洋政策之重要環節。

七、提升海洋科學知識水準，激發相關科技發展與藍色創新：吸引公民參與海洋科學發展，乃政策上之優先選項。方法之一，為公民可支援參與海洋觀測系統。如：海上運輸業、旅遊業，以及漁業相關從業人員，皆能兼具蒐集海洋重要數據之功用，如地質、生物、遺傳基因與文化遺產等領域。同時亦應促進企業主、學術界、公共行為者與其他國家之良性合作關係，以收相輔而行之效。基於上述考量，葡萄牙亞速爾群島與馬德拉群島，得提供試驗場域予大西洋沿岸國，藉以突破海洋關鍵技術，進而提升國際地位。

八、提高與海洋有關之教育、資質及文化素養：於未來10年內，葡萄牙計畫增設海洋相關領域之教育與培訓機構，其質或量皆應有所提高，以吸引更多年輕人與女性從事海洋相關之職業。而文化層面更是聯合國2030年之議程重點，故應鼓勵民眾主動積極參與海洋事務，期能形成底蘊深厚之海洋文化。

九、激勵再工業化與海洋數位化發展：隨生產基地轉移至其他國家，包括葡萄牙在內之歐洲，逐漸失去以工業為基礎之生產能力，因此再工業化勢在必行。為此，政府必須推動海洋經濟建設，特別是靠近港埠之土地管理與利用，尤屬重中之重。同時應促進海洋數位化發展，用以簡化行政程序，並持續投注動能，吸引有志之士進入海洋產業。

十、確保安全及主權，強化國家治理與國際合作：葡萄牙應鞏固並加強與其他國家之合作關係，確保所控制之海域與領空主權，增加海洋遠端監測能力，促進多部門與跨國安全夥伴關係，並參與人道危機處理、搜救行動及資訊交流等活動。此外，尚需培養和大西洋諸國獨特之互利往來關係，如開啓並拓展與葡萄牙語系國家（Community of Portuguese Speaking Countries, CPLP）間之良性互動模式。

可惜的是，葡萄牙提供之海洋策略目標，多屬大方向之論述，較少著墨於執行細節與具體作法。惟特別值得注意者，乃該策略目標多次提及「亞速爾群島與馬德拉自治區」（Autonomous Regions of the Azores and Madeira），應非無的放矢。鑒於葡萄牙絕大部分專屬經濟海域，從屬於自治區管轄。因此，吾人如欲探究並借鏡該國之海洋政策，自應先行理解所轄自治區之法定權限及相關規範，避免囿於隅見而失之偏頗。

葡萄牙屬單一制國家[10]，然而只有該兩群島特別獲得憲法位階之自治區地位（憲法第225條）。然而受限於該國制憲之初，憲法本文對於自治區之具體自治事項及其範圍查無具體規範，因而引發多次激烈辯論[11]；直到2005年修憲後，憲法第227條始對自治區權限做出詳細之論述，並明定自治區享有部分主權與極大程度之自治權，甚至得以拓展至專屬經濟海域，並賦予自治區有權參與條約簽訂之過程，以及執行條約之權限，而自治區取得如此重大之權柄，意味著葡萄牙政府於決策過程中，必須同時與自治區就相關事項進行協商，而且自治區有權收到必要之信息，以形成意見。自治區亦有權公開發表自認妥適之興革建議[10]。

結語

將葡萄牙海洋部與我國海洋委員會相較，二者頗有不同之處。包含：一、葡萄牙海洋部缺少武裝力量，而武裝力量悉歸國防部管控；二、葡萄牙以法律明文規定海洋部與其他部會之權利義務關係，其中諸多次級機關，係由海洋部與其他部門共同監督；三、葡萄牙除海洋部外，內閣另設置「海事部際委員會」居間協調跨部事宜；四、葡萄牙專屬經濟區範圍，大多屬於自治區管轄，且自治區被賦予部分涉外權力，因此舉凡涉及地方自治制度者，海洋部皆須與自治區進行協商；五、葡萄牙內閣的部

門職權與名稱變動頻繁，其間又以屆臨重新組閣之際為最，故其海洋部於歷年頻經變更，以致政令動輒難以為繼，因而目前的海洋部，與其說是新設，不如認為係重設或暫設，較符實情。

緣此，就海洋部設立初衷與意義，業已正式啟動2021年至2030年葡萄牙國家海洋策略，揆其目的不僅著力於協助國家發展，更關乎海洋部可否如願交出亮眼成績，使其成為葡萄牙政府核心部門。綜觀前述2021年至2030年葡萄牙國家海洋策略之10項目標內容，都與科技及教育形成不可切割且緊密連結之關係。因此該國海洋部、科技部及教育部之間之體制互動與團隊合作，勢將成為國家海洋策略能否成功之關鍵因素。

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海上綠色能源輸送廊道樞紐——離岸風電之海上變電站規劃與發展

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關鍵字／海上變電站、浮動式變電站、電纜

隨著離岸風場的開發，風機的數量與發電量上也隨之增加。由於遠距離的低壓電力傳輸容易產生能量耗損，且數量過多的電纜亦容易對近岸海域環境造成影響，因此設置海上變電站能解決這些問題，使電力傳輸更有效率。

海上變電站的功能就是收集與輸出風力發電機產生的電力，是大型離岸風電場重要的組成。離岸變電站主要的功能就是穩定電壓及提高風機發電之傳輸效率，將風場內電纜匯集升壓後，併接於161kV台電特高壓系統，傳輸至陸上電網以供民生或工業使用。

陸上變電站與海上的變電站的差異為何？陸上變電站是電力系統輸送以及電力分配的重要環節，主要是為了滿足民生或工業所需電力用戶能夠獲得持續、安全、可靠供電的需求，在陸上變電站設計中已經通過長期的運行實踐，因此陸上變電站形成標準化與典型性設計，其建設與運行維護成本較為穩定。

海上變電站目前主要功能是將海上風電功率併入電網，強調的是在風電場有電能傳輸需求時能夠可靠地進行電力能量傳輸，減少電力輸送上岸的損耗，提升風機發電效率。然而，海上變電站長期位於風浪、海流、高鹽度等惡劣的海洋環境中，後續維護作業難度相較起來較大，因此海上變電站的建設施工、維護難度與成本相對於陸上變電站來說較高。

海上變電站現況與機組規劃

海上變電站為整座離岸風場的輸電樞紐，相較陸上變電站具有整體施工費用相對較低（包含電纜）、海纜引接數量少、用地取得較陸上變電站容易等優點，但其最主要缺點為維護相對較不容易，也因此在設計上與陸上變電站存在一定差異。在變電站電器設計原則包含可靠性、靈活性與經濟性3個面向，一般而言會使用兩臺主變壓器互為備援、或不同風場間互為備援機制，避免變壓器損壞時無法供電所造成的經濟損失，以達到持續且穩定供電的效果。且為滿足維護方便，使用設備應考慮模組化、小型化及抗鹽害等問題，並將設備緊湊化，減少設備所占面積[1]；另外海上變電站在設計上需考慮波浪條件、地震考量以及抗腐蝕等問題，以避免造成變電站上重要設施損毀。關於以上設計要求，可參考國際上的相關規範，如挪威船級社DNV（Det Norske Veritas）與美國驗船協會ABS（American Bureau of Shipping）等規範。

海上變電站的架構主要可分為3段，由上至下分別為變電設備段、轉接段以及下部結構[2]。由圖1可以看到變電站下部結構其實與風機的基礎支撐結構類似，目前最常用的海上變電站基礎就是單樁

式基礎（monopile foundation）和套筒式基礎（jacket foundation）。單樁式基礎之唯一大口徑鋼管樁，直接將上方結構重量傳遞至海床，為目前歐洲主流的水下基礎方案之一。

單樁式基礎一般用於具有堅實地盤之海床，其施工成本隨水深增加而增加，一般而言多用於水深小於20公尺之水域，此外除深度外也需考慮漂砂等情形。

套筒式基礎具有較複雜的衍架結構，因此製造較為費工，成本也較高，然而其具有較佳之穩定度。其主要使用於水深超過20公尺之水域，該水域一般而言較具有經濟效應。相較於其他形式基礎，套筒式基礎所使用之鋼材量較低，以臺灣彰化外海風場為例，若使用單樁式基礎，其設計重量將達套筒式基礎之2倍[3][4]。

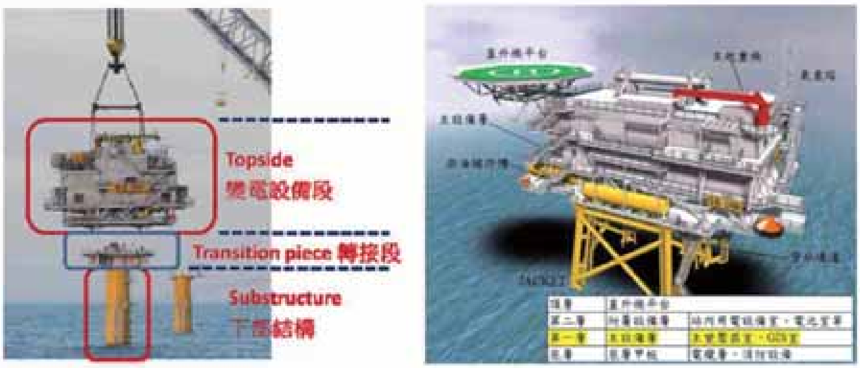

圖1／離岸變電站架構圖
圖片來源／[2]、[3]

圖2／單樁式基礎與套筒式基礎
圖片來源／[4]

以歐洲4層的200kV固定式海上變電站為例，實際可依風場規模大小及設備的形式進行調整，頂層為直升機平臺；第二層為附屬設備層，包含了內用電設備、緊急柴油發電機房、工具間及倉庫等；第一層為主設備層，包含主變壓器、電池室、通訊機房、低壓配電室及控制室等等；最底層為甲板層，底部高層位於極端高潮位下最大波高時波峰以上，具有救生設備庫、消防幫浦房等，同時也是海纜配置層。

海上變電站的設備規模會隨著風場的規模有所擴張，設備也更加完備。以歐洲的海上變電站為例，第一代變電站僅有單具變壓器，設備容量約100～150MW，重量約為1,000噸，並無規劃備用變壓器及電力電纜，因此設備發生事故時會導致電力完全無法輸出。第二代變電站配有多具變壓器，設備容量約200～300MW，重量約為3,000～4,000噸，並且規劃多回輸出電纜，為目前歐洲北海風場主要規劃的變電站形式。第三代變電站設備容量約600～800MW，若使用交流電傳輸會導致大量電力損耗，因此電力在匯集整流後，改採用高壓直流傳輸至陸域變電站。第三代變電站總重量高達15,000噸，因此採用站體自浮、自升的技術已克服吊裝問題[2]。

海上變電站實際應用

目前已運作中的海上變電站仍以歐洲風場為主，如英國London array離岸風場，London array風力發電場位於英國的泰晤士河口，距離肯特郡北方沿海外海約11公里處，該區域水深約為25公尺。London array 風力發電場總容量為630MW，由175臺西門子3.6MW風力發電機組與2座海上變電站構成，電廠內部由長達210公里的33kV陣列電纜（Array Cables）連接在一起，各風力發電機所發電力彙集至兩座海上變電站後，透過4條150kV對外海底電纜，傳輸至肯特郡北方沿海附近的陸上變電站[5]。

臺灣目前有許多風場正在進行設置（表2），而大彰化風場由於風場位置距離岸邊較遠，因此規劃設置海上變電站，目前正在興建中。大彰化風場位於彰化外海約35～60公里，其水深約為20～40公尺不等，其中大彰化西南與大彰化東南的發電容量分別約為300MW及600MW，而由沃旭能源所負責之兩座海上變電站分別於2021年12月與2022年1月完成通電測試[6]。

表1／變電站規格表

	第一代變電站	第二代變電站	第三代變電站
變壓器／並聯電抗器／交流-直流整流器	1/0/0	2/2/0	2/4/2
容量	100～150MW	200～300MW	600～800MW
Topside變電設備段	1,000噸	3,000～4,000噸	15,000噸
甲板（層）	2	3～4	7
變電站實體圖			

資料來源／[2]

海上變電站未來發展

隨著離岸風電的發展，風機的設置由陸地朝向海洋，在水深50公尺以下的淺海地區主要使用固定式基樁的方式固定。在淺海地區風場逐漸飽和之下，可開發之優良風場也隨之減少，未來必須往更深海的地區開發。因此現在有許多開發商開始瞄準更廣大的深海區領域，設置浮動式離岸風機，透過繫纜繩固定在海底，有助增加離岸風電設置範圍，且能夠運用外海較穩定的風能，達到更高效率。

伴隨著風力機大型化、離岸風場距離岸邊漸遠之趨勢，能降低電力傳輸損耗的海上變電站越來越受到重視，海上變電站的形式也不再侷限在固定式的基礎。日本福島計畫即是使用浮動式平臺作為基礎建造，也有其他國家針對浮動式變電站載臺進行研究（挪威BW Ideol、美國），因此可預期在海上變電站未來的發展仍然能夠朝向深海建造以浮動式的形式設置，以下為根據不同國家發展現況做介紹。

表2／臺灣離岸風場現況

	第一階段	第二階段遴選					
案場	台電一期	海能	允能一期	允能二期	大彰化東南	大彰化西南第一階段	彰芳一期
開發商	台電	JERA (49%) GIG (26%) SRE (25%)	Wpd (25%) Sojitz (27%) EGCO (25%) TotalEnergies (23%)		Ørsted		CIP (62.5%) Global Power Synergy (25%) 台灣人壽 (7.44%) 全球人壽 (5.06%)
裝置容量	109.2 MW	376 MW	320 MW	320 MW	900MW		100 MW
案場位置	彰化縣芳苑鄉西側外海約 7-9 公里處	苗栗縣海岸約 3-10 公里處	台灣西海岸約 8 至 17 公里		彰化外海東南方約 35.7 公里處	彰化外海西南方約 50.1 公里處	彰化外海約 9-15 公里處
水深	15-26 m	35-55 m	7-35m		深至 45 m		22-46 m
提供用電	9 萬戶家庭/年	38 萬戶家庭/年	60.5 萬戶家庭/年		100 萬戶家庭/年		65 萬戶家庭/年
併網	2021	2022	2021	2022	2022		2022
現況	風機已建置完畢	完成四串輸出海纜工程至苗栗近海海床	風機安裝中，第一期預估年底前併網		正在進行水下基礎安裝的前置作業		完成 48 支水下基樁安裝作業

資料來源／[7]

一、日本浮動式變電站

福島浮動海上風電場示範項目（Fukushima FORWARD）是福島從2011年地震和海嘯造成的核災難中恢復的象徵。該變電站被稱為Fukushima KIZUNA。變電站的電壓容量為25MVA，包括66kV氣體絕緣開關設備和22kV真空-絕緣開關設備。風力發電機產生的22kV電壓將由變電站升壓至66kV，並通過66kV海底電纜傳輸到陸地上。福島浮動式海上變電站除了變電功能外，還搭載有觀測塔以及停機坪等設施，可以提供附近海域風況調查[8][9]。

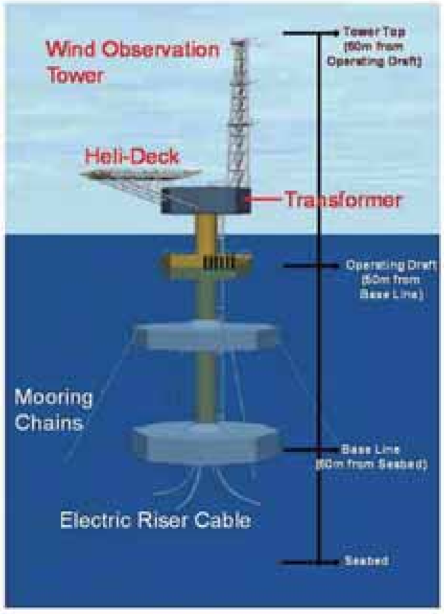

圖4／日本變電站概念圖
圖片來源／[8]

二、挪威浮動式變電站

Ideol和Atlantique Offshore Energy（AOE）共同發展浮動式變電站，其基礎採用駁船式（Barge）浮動平臺，駁船式浮動海上變電站經過設計（包含阻尼池專利設計），可在世界上最極端的環境中運行並提供最大的模組化。透過在碼頭區將上部結構安裝到載臺上，包含有備用發電機組、直升機停機坪、起重機等設備，在碼頭區進行測試和預調試，以及在沒有重型海上作業的情況下進行安裝，因此可顯著降低成本。此通用和模組化的浮式變電站預計將對海上變電站市場產生重大影響，並為即將在法國和世界各地進行的浮式商業招標做好市場準備。市場潛力巨大，預計到2030年全球將安裝115GW的海上裝置容量[10]。

三、美國浮動式變電站

近年來，美國已經開始設計浮動式變電站，圖6浮動式變電站是將浮動式風機的半潛式平臺加上固定式海上變電站的上部變電站結構組合而成。並且針對美國附近風場的海況條件進行數值驗證，結果顯示出此平臺的穩定度符合規範，並且能夠支持美國東北部和美國其他地方等更深水域的浮動風力發電場[11]。

圖5／挪威BW Ideol浮式變電站概念圖
圖片來源／[10]

四、臺灣浮式變電站

臺灣浮式變電站（圖7）已經由國立成功大學之研究團隊進行測試，團隊對於此平臺的穩定度特性以及繫纜系統等相關技術已有相當的經驗與掌握。依照研究試驗成果，此平臺在臺灣西部海域的波浪條件下，不論是常態海況或是極端海況，能保持一定的穩定性。變電站的輸出電纜在各種環境條件也皆能夠存活，不會受到海上環境影響而破壞。顯示出因應未來的趨勢，隨著更深海地區的風場設置，臺灣仍舊擁有設置浮動式變電站的潛能。

圖6／美國浮式變電站設計概念圖
圖片來源／[11]

圖7／臺灣浮式變電站模型圖
圖片提供／國立成功大學水利系

結語

隨著離岸風電的發展，風場規模逐漸擴大，海上變電站的需求也隨之提升，目的是要縮短風機電力輸送的距離以及傳送過程的損失。在離岸風場開發中占有重要的角色。除了固定式基礎的海上變電站之外，隨著近岸風場開發逐漸飽和，適合深海域使用的浮動式海上變電站也正在發展，使未來海上變電站的設置不會受到離岸距離與水深的影響，而最終成為海上綠色能源輸送廊道之樞紐。

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1990年《里斯本協定》（Lisbon Agreement）：葡、法、西、摩洛哥、歐盟合作擬定之海洋污染控制體系

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關鍵字／里斯本協定、海洋污染

1967年Torrey Canyon輪油污案發生後，國際海事組織（IMO）於1990年通過「油污染整備應變及合作公約」（OPRC公約），並於OPRC公約架構下成立6大區域應變中心，另尚有若干海污區域聯盟的存在，如為保護西北大西洋海洋環境於1972年成立的「OSPAR Commission」；以及本文同樣為保護西北大西洋海洋環境分別於1990年通過、2014年生效的《里斯本協定》（Lisbon Agreement）。

國際立法體系

1967年Torrey Canyon輪油污案發生後（洩漏量12萬噸、英吉利海峽），國際間制訂一連串的油污立法，涵蓋污控作業（MARPOL）、公海干預（Intervention）及補償（CLC+Fund）3層面。1989年3月24日Exxon Valdez輪油污案（洩漏量3.7萬噸、阿拉斯加）發生後，國際社會發覺在溢油事故準備、應變能力的國際立法尚有不足，國際海事組織（IMO）緊急於1989年10月決議開始研擬，並於1990年11月制訂通過「油污染整備應變及合作公約」（International Convention on Oil Pollution Preparedness, Response and Co-operation, OPRC）」。OPRC公約，一如其名，為各國油污應急體制及國際相互援助、多邊合作等方面設下全球基礎。在OPRC架構下，全球業已架構出NOWPAP MERRAC（西北太平洋區域）、REMPEITC-Caribe（加勒比海區域）、MEMAC（波斯灣區域）、REMPEC（地中海區域）、PEMSEA（東亞區域）、PERSGA/MEMAC（紅海／亞丁灣區域）等區域應變中心[1]。除前述OPRC公約架構下的區域合作的區域應變中心，尚有若干海污區域聯盟的存在，例如為保護西北大西洋海洋環境，由15個政府（比、丹、芬、法、德、冰、愛、盧、荷、挪、葡、西、瑞典、瑞士及英國）於1972年所成立的「奧斯陸─巴黎公約委員會」（OSPAR Commission，OSPAR為1972年OSlo棄置公約及1974年PARis陸源及離岸工業污染公約二者的簡稱，此二公約後來於1992年結合成OSPAR公約）；以及本文同樣為保護西北大西洋海洋環境，由4個國家所組成於1990年通過，2014年生效的《里斯本協定》。

1990年《里斯本協定》制訂背景：Khark 5輪及Aragon輪油污案

OPRC公約於1989年10月至1990年11月研擬過程中，於葡萄牙及摩洛哥外海，僅相隔10日連續發生2件重大油污事件：Khark 5輪案（1989年12月19日）及Aragon輪案（1989年12月29日）。

一、Khark 5輪案：1989年12月19日載重噸高達38.5萬噸的伊朗籍超大型油輪Khark 5號於摩洛哥西方112浬遭遇惡劣天候，船體破裂，引發爆炸起火，船上14個油艙有2油艙破裂，救火及拖帶作業相當困難，70,000噸原油外洩，油污達600平方公里。摩洛哥政府向英、法、西及葡請求協助，於浮油飄進摩洛哥海岸前，摩國政府及數百名歐洲志工使用大量分散劑分解浮油[2]。

二、Aragon輪案：1989年12月29日載重噸高達24萬噸的西班牙籍超大型油輪Aragon號因舵機故障拖救期間，於距摩洛哥360浬遭遇惡劣天候而嚴重受損，造成該輪第一號中央油艙洩漏約25,000噸墨西哥原油。乳化後的外洩原油3週後漂流至葡萄牙西南著名觀光聖地Madeira島，重創當地整個東部海岸。Madeira島本身不僅不具任何污染清除設備，葡萄牙本身亦不具足以應變如此嚴重的漏油應急能力。葡萄牙向歐盟委員會請求協助，數歐盟會員國組建應急小組及提供應急設備／物資，專機運往馳援。清除作業總計耗費7週，總計清除約15,000噸原油，回收的廢油最後運往荷蘭處理[3]。

1990年《里斯本協定》（Lisbon Agreement）

依下圖（圖1）ITOPF統計1967年至2021年國際所發生的油污事故[4]，東北大西洋海域一直是歷年油輪重大油污事故的熱點所在。鑑於Khark 5輪及Aragon輪案，以及參考當時已近研擬末期的IMO OPRC草案所極力創建的相互支援及國家合作等原則，與此二案最具重要利害關係的葡萄牙便向當時的歐體提議：葡萄牙、法國、摩洛哥、西班牙及歐體應達成一項區域性協議以因應能涵蓋東北大西洋海域的海洋污染事件。未待OPRC通過，前述諸國便於1990年10月17日與當時的歐體共同簽署《里斯本協定》，全稱為「保護東北大西洋沿岸及水域抵禦污染合作協定」（COOPERATION AGREEMENT for the protection of the coasts and waters of the north-east Atlantic against pollution）。2008年5月20日該協定進行議定書修正，修改南部界線。2014年2月1日西班牙才批准該協定，《里斯本協定》正式生效。《里斯本協定》是一能確保締約國於發生海上污染事故時能進行合作、該協定亦要求各締約國應建立自己的預防及控制體制，配備污染控制設備並制訂自己屬國的國家行動計畫。

圖1／ITOPF統計1967年至2021年國際所發生的油污事故
圖片來源／[4]

《里斯本協定》全文包括宗旨、27條文及2附件，其中第1條至第19條屬實質規範，第20條至第27條為最後條款，包括公約修正（§20）、秘書處費用承擔比例（§21）、批准接受、交存及生效（§22）、邀請他國加入（§23）、加入國生效（§24）、退出（§25）、各項通知（§26）及文字及存放（§27，以葡萄牙為協定存放國）。第1條至第19條屬實質規範之條旨及主要內容為：

第1條 「協定義務」：締約國可單獨或共同採取因應海洋污染事件之所有適當措施。

第2條 「定義」：針對污染事件、碳氫化合物，以及其他有害物質為定義。

第3條 「協定適用範圍」：原則上為各國專屬經濟區外界以內之東北大西洋地區。

第4條 「各締約國義務」：包括建置最低數量的應急設備、國家應急體系、生態敏感地區之保護、應急人力及設備資源表列、污染物回收儲存及處置，以及人員培訓。

第5條 「聯合行動方案」：各締約國應制訂聯合行動方案所需之各項方針，包括各項資訊、新技術及方法，主要污染事件之認定等。

第6條 「擴大適用」：聯合行動方案涵蓋裝載有害物質之貨櫃等集裝設備於海上喪失等情況。

第7條 「符合IMO規定」：政府人員及國籍船舶及平臺之船員等應符合IMO各項規定，包括避免污染、應急、事故通知等。

第8條 「協定區域之權責劃分」：污染所在區域之負責締約國應進行評估並將應急行動通知其他締約國。

第9條 「共同利益區域」：共同利益區域之商議，聯合行動之採行，主導、協調及協助。

第10條「援助之請求及配合」：請求援助時應指出需要援助之情況，受請求國應盡其努力盡力協助。

第11條「不得損及主權及主權權利」：宣示本協定之行使，不得損及《海洋法》下關於專屬經濟區及大陸礁層的主權及主權權利。

第12條「航運活動之監測及研究」：締約國相關航運部門應制訂航運監測方式並進行相關研究。

第13條「締約國費用負擔」：協定區域採使用國負擔原則，不論是被請求援助或自願性援助；共同利益區域採各自分擔原則；另規定協助之終止及費用之專家報告及審核。

第14條「不損及對第三方責任之求償」：第13條締約國費用負擔不影響或損及對第三方責任之求償。

第15條「締約國會議之召開」：定期召開，議事規則等之通過。

第16條「歐體表決權行使」：採一締約國一票，歐體本身無表決權。

第17條「締約國會議任務」：監督、檢查、特別敏感地區之認定等。

第18條「設立國際中心」：設在協定存放國，目的在能針對污染事件作出迅速反應。

第19條「國際中心功能」：各會員應急物資及設備流動性及互補性、增加庫存等之建議。

協定附件一：區域為任一締約國的專屬經濟區

協定附件二：為國際行動中心職責界定指南

短結

1990年《里斯本協定》通過後，之後於協定區域雖陸續發生1992年Aegean Sea輪油污案（西班牙La Coruna，74,000噸）及2002年Prestige輪案（西班牙 Galicia，63,000噸）二重大油污案，但協定必須4個原始締約國批准或接受後，方能生效，而西班牙一直到2014年2月1日才將批准書交存。《里斯本協定》2014年2月1日生效後，國際重大油污案已大幅降低，加上本有西北大西洋原有更大規模的OSPAR Commission運作，《里斯本協定》的運作率基本上是偏低的。依聯合國貿易及發展會議（UNCTAD）發布的「Review of Maritime Transport 2021」顯示2020年全球全年原油卸載量1,863.6百萬噸中，有1,060.2百萬噸（亦即將近57%）卸載於亞洲地區[5]，特別是東亞地區。我國周遭海域一直是原油貿易的熱點／路徑，相對地，也是海污事故易發生的熱點。我國目前雖有「重大海洋油污染緊急應變計畫」（2017年1月3日修正）可資適用，但僅限適用於我國。礙於國際政治現實，我國並未與鄰近國家簽署諸如本文所探討《里斯本協定》之類的區域性海污合作協議，污染無國界，這類區域性海污合作模式或可成為我國借鏡，在APEC基礎下，就災害應變及海洋保育等新興議題討論，與鄰近周遭國家為類似的海污合作協定。

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Building a Marine Country on the Cornerstone of Sustainable Marine Development

Translated by Linguitronics

Minister of the Ocean Affairs Council: Chung-Wei Lee

Sustainably managing our oceans and rationally utilizing marine space and resource allocation are crucial issues that all countries must soberly consider. Many countries use marine spatial planning (MSP) to formulate their overall marine policies. One such country, Portugal, is introduced in this issue. With each of its government departments having its own goals for marine use, and with coopetition between the offshore wind power industry and fisheries, MSP can establish a coordination mechanism based on sustainable thinking to achieve effective marine governance. In addition, the Portuguese Ministry of the Sea has proposed the National Ocean Strategy (NOS) for 2021–2030, which, aside from complying with international maritime norms, specifically responds to the EU's "Blue Growth Strategy" with the aim of regaining Portugal's maritime sovereignty. The Intergovernmental Oceanographic Commission (IOC) under the UN and the Directorate-General for Maritime Affairs and Fisheries (DG MARE) of the European Commission published the "MSPglobal International Guide on Marine/Maritime Spatial Planning" in 2021. It is divided into 6 stages, from setting the scene to monitoring, evaluation and adaptation after implementation. It provides practical tools both for governments and marine spatial planners to formulate marine space plans, and promotes cross-border cooperation in marine space planning. In this issue's "Regulatory Systems" we introduce the Lisbon Agreement, which was formulated in response to major oil spills through transnational cooperation with the purpose of protecting the marine environment of the Northwest Atlantic.

Marine scientific research and resource application also lie at the heart of sustainable oceans. This issue's "Special Report" introduces Taiwan's establishment and technological development of its ocean radar observing network, which can monitor surface ocean currents in the surrounding sea areas and collect environmental information that serves as the basis of marine scientific research; in our "Latest News" section, we introduce key offshore substation technologies for offshore wind power and the state of development of floating substations required for development in deeper sea areas. On this occasion of the United Nations "Decade of Ocean Science for Sustainable Development," Taiwan's R&D and application of ocean radar and floating substations will be an important cornerstone for Taiwan's promotion of marine sustainability and enhancing its marine power in the future.

Autonomous Regions of the Madeira
Source/ https://pixabay.com/photos/portugal-madeira-ponta-do-sol-4823826/

Oceanographic Radar Observation Network for Long-term Marine Environmental Monitoring

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Keywords: Remote Sensing, Ocean Currents, Waves, Tsunami, Boundary currents, Ocean Observing System

The long-term monitoring information of the marine environment is an important reference for decision-making, whether in the response to marine affairs or in the issue of global environmental change. With the development of technology, ocean observation from point to line to plane to three-dimensional development, from shore, ship, ground base, mooring, airborne to spaceborne, can be said to be changing with each passing day. Moreover, promoting the integration of various observation systems to build the integrated ocean observation network has also become an important subject in modern ocean observation technology and application. After the end of World War II, radar operators and scientists discovered the interaction mechanism between radio waves and sea surface waves and gradually completed theoretical models. Since oceanographic radar has the advantages of wide range, continuous, near real time and low operating cost compared with traditional field survey, since the 1970s, the United States, Germany, Japan, China and other countries have successively invested in the development of special-purpose oceanographic radar and sea-state algorithms for continuous observation of oceanographic features. And with the establishment of the oceanographic radar observation network, a new page has been opened for two-dimensional plane ocean observation.

In the 2000s, countries headed by the United States rapidly built oceanographic radar systems, and established marine high-frequency radar observation networks in the United States, Mexico and Canada. Almost in the same era, under the promotion of the ocean science community, Taiwan also planned to use 18 sets of high-frequency radar stations for long-term observation of ocean currents in the waters around Taiwan in the "Research Planning Proposal of Ocean Science Discipline Cluster for the Next Ten Years". The construction work was handed over by the government to the Taiwan Ocean Research Institute (TORI), National Applied Research Laboratories (NARLabs). In 2016, the establishment of the observation network around Taiwan was completed. Its radar station network and observation results are shown in Figure 1. It has become the first country in the world that can monitor the surface ocean currents in the surrounding seas for a long time.

According to the statistics of the Group on Earth Observations (GEO) in 2019, there should be more than 400 high-frequency oceanographic radar stations built by countries around the world, of which nearly 140 are in the Asia-Pacific region, and the number continues to increase year by year [1]. With the efforts of countries around the world, the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), co-sponsored by the World Meteorological Organization and the United Nations Educational, Scientific and Cultural Organization (WMO-IOC), held the JCOMM-5 meeting in 2017. The Resolution 25 adopted GEO's proposal to include the high-frequency oceanographic radar observation network as a part of the ocean observation system. This progress not only realizes large-scale, near-real-time, and continuous monitoring of ocean waves and currents, but also systematically strengthens the collection of basic environmental information required for topics such as global ocean scientific research, ocean affairs response, and global environmental changes. At the same time, it is a great encouragement to the development of radio telemetry ocean technology.

Ocean Monitoring Technology Using Radio Waves

With the rapid progress of human beings in electromagnetism in the 19th century, the use of radio wave reflection and scattering characteristics to monitor long-range aircraft and ships has become an important technology in the World War II. At the end of the war, the coastal defense radar operators on guard duty responded that the radar signal was always disturbed by unknown reasons. Until 1955, Douglass D. Crombie revealed that "the interaction of electromagnetic waves with a wavelength of tens of meters and the roughness of the ocean surface will produce Bragg resonance and backscattering phenomena [3]", Crombie's research provides a reasonable physical explanation for the interference found by radar soldiers staring at the screen all day, and opens a new page for the application of radio waves in the detection of sea conditions over-the-horizon. Then, between 1968 and 1972, Dr. Donald E. Barrick, who worked at the National Oceanic and Atmospheric Administration (NOAA), completed the theoretical derivation of the backscattering mechanism of the radio waves caused by sea surface roughness. The detection of ocean surface features by radio waves has established a solid theoretical foundation [4]. In terms of microwave radars with higher radio frequencies and wavelengths of several centimeters, Mattie and Harris have confirmed that X-band radar is indeed suitable for the observation of sea surface ripples since 1978 [5]. Young et al. (1985) found from the X-Band marine radar signal that a three-dimensional energy spectrum was established based on a sequence of radar echo images, and the wave dispersion relationship was used as the extraction signal and noise separation, which could be used for sea surface wave spectrum and surface current mapping. He established the theoretical foundation for the microwave radar's functions of both nautical navigation and remote measurement of sea state [6].

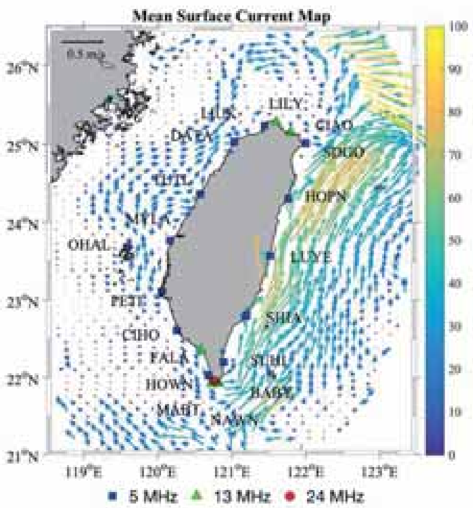


Figure 1/ The first generation of Taiwan's first-generation shore-based radar for surface current mapping network built by the TORI, NARLabs
Image by Jian-Wu Lai

Oceanographic radar uses radio echo signals to extract target objects we care about (such as ships) and invert marine environmental characteristics (i.e., wind, waves, currents). And like most observing systems, observations are subject to environmental influences and physical limitations. Generally speaking, high-frequency radar can be transmitted along the curvature of the earth on the sea surface, so it has the title of over-the-horizon radar. The effective observation range of waves and ocean currents by high-frequency radar using the main frequency of 5MHz radio waves can reach 120 kilometers and 240 kilometers, respectively. However, if the system using 30MHz frequency is only 20 kilometers and 40 kilometers. For microwave radars with radio wave frequencies up to GHz level, due to differences in radio wave transmission mechanisms, they can usually only provide observation information of sea conditions within a line of sight of 3 to 5 kilometers. The relevant information discussed above is organized as shown in Table 1. In terms of the range resolution of sea state information, oceanographic radar is mainly limited by the radio wave modulation bandwidth approved by the National Communications Commission. In Taiwan, a 5MHz system can usually achieve a modulation bandwidth of tens of kHz, while a 30MHz system can achieve a modulation bandwidth of several hundreds of kHz. Therefore, the spatial resolution of the former is at the level of several kilometers, while the latter can reach a finer level of hundreds of meters. Such resolution limitations also affect the application of radar systems to observation of oceanic features at different scales. Therefore, the oceanographic radar observation network of NOAA's Integrated Ocean Observing System (IOOS) in the United States is a two-layer structure composed of 5MHz and 13MHz. They provide observational products with a resolution of 6 km in the wide area (within a range of 200 km offshore) and 1 km resolution in the coastal waters (within a range of tens of kilometers offshore) [7].

Table 1/ Range Capability of Oceanographic Radar

System	Sea state inversion signal basis	Maximum observation range (km)		
		waves*	currents*	Potential influencing factors
High-frequency radar	Doppler spectrum	600/Freq (Freq. in MHz)	1,200/Freq (Freq. in MHz)	Sea surface gravity wave characteristics, radio interference, ionosphere, waveguide effect of atmospheric inversion layer, Geometric Dilution of Precision of observation network, etc.
microwave radars	Sea-echo image	3~5	3~5	Sea surface capillary wave characteristics, radio interference, radio wave grazing angle, rainfall, etc.

*The maximum observation distances of waves and currents of high-frequency radar are affected by the main frequency used. Here are approximate estimation formulae.

Source/ Jian-Wu Lai

Forward ahead into a new situation of oceanographic radar

The initiative of Taiwan's oceanographic radar observation network in the oceanographic community and the efforts of the TORI of the NARLabs for many years, such as data release, technology research and development, and value-added applications, have contributed to a group in ocean scientific research, signal processing technology, research and development of instruments and equipment, and domestic related scientific and technological development such as search and rescue, and pollutant dispersion.

In recent years, the Government of Taiwan has established the Ocean Affairs Council (OAC) to integrate ocean affairs and ocean science and technology development. It coincides with the decade of ocean science for sustainable development proclaimed by the United Nations, the National Chung-Shan Institute of Sciences and Technology actively promotes the value-added application of military and civilian general technology industries, the development of marine energy in the energy transition, and the policy of paying tribute to the sea. This has prompted various government departments to promote the construction of shore-based oceanographic radar systems to improve the application of marine environmental monitoring and disaster prevention technology in Taiwan. Technical officers and researchers from various ministries and associations will gather in November 2021 to exchange views on the deployment of observation networks and common data formats, hoping to promote cross-agency data flow and improve governance efficiency under the government's open data policy. The participants dubbed it a "Taiwan Oceanographic Radar Minor League".

Between 2019 and 2024, more than 42 oceanographic radar stations in various government departments will be built and put into operation successively, including 12 of the Central Weather Bureau (CWB) of the Ministry of Communications (6 high-frequency radars and 6 microwave radars), and 3 of the Institute of Harbor and Marine Technology (IHMT) of the Ministry of Communications (2 high-frequency radars, 1 microwave radar), and 27 of the National Academy of Marine Research (NAMR) of the OAC (12 high-frequency radars and 15 microwave radars). In addition, the Water Resources

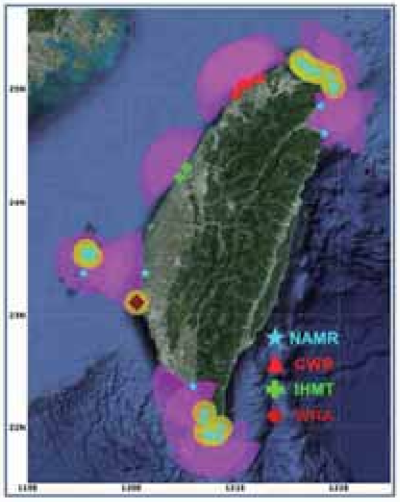


Figure 2/ The coverage map of the oceanographic radar observation network under construction by the various ministries of the Taiwan government
Image by Jian-Wu Lai

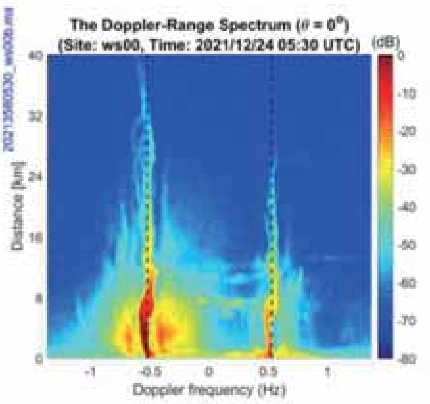
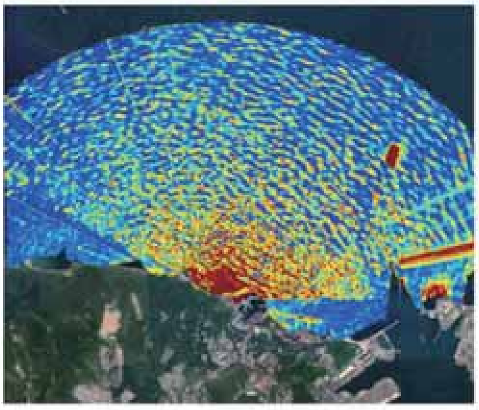
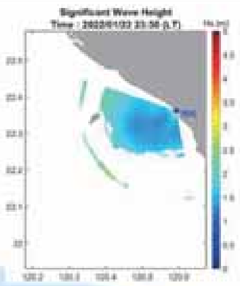
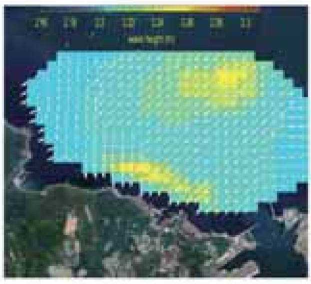
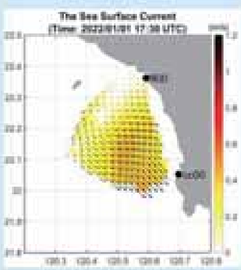
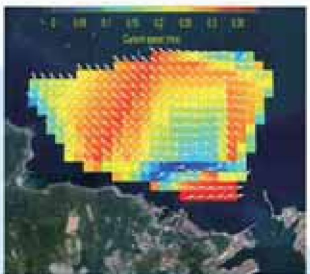
High-frequency array radar	Microwave radar
 Doppler Spectrum	 Sea-echo Intensity Image
 Wave Fields	 Wave Fields
 Ocean Surface Current Maps	 Ocean Surface Current Maps

Figure 3/ Examples of Ocean Observation Achievements by High-Frequency Array Radar and Microwave Radar
Image by Jian-Wu Lai

Bureau of the Ministry of Economic Affairs also has a microwave oceanographic radar in Qigu, Tainan. The observation station network constructed by various government departments is shown in Figure 2. It is believed that these telemetry remote sensing systems will give full play to the benefits of long-term observation in the aspects of metocean observation, navigation safety, marine energy assessment, marine recreation risks, marine disaster rescue and pollution prevention and response. Figure (P5) shows the current situation of various oceanographic radars built in Taiwan. The top left panel is the CODAR compact type radar system used by TORI, and the bottom left panel is the University of Hawaii Generic HF phase array radar which is being newly built by the IHMT, CWB and NAMR, and the microwave marine radar system on the right panel.

At present, the main products of ocean high-frequency array radar and microwave radar are wave field and ocean surface current maps. Take the high-frequency radars at cosat of PingTung and the microwave radar at coast of Keelung as examples, draw the basis of the sea state inversion signal (Doppler spectrum or echo intensity image) and the inversion wave field and surface current map diagram. As shown in Figure 3, the figures in the left panel are the results of the high-frequency array radar observation, and its single-station observation range is about 30 kilometers, and the figures in the right panel are the observation results of the microwave radar with the range in 3 kilometers. Through the wave field and surface current maps produced by radars, we can get a glimpse of the ocean features and their temporal and spatial changes within the effective observation range. These are achievements that cannot be achieved with traditional mooring system observation or research vessel observation on the route, and it can also be said to be an irreplaceable advantage of oceanographic radar. In addition to the observation of waves and currents, inversion technologies for sea surface wind field, tsunami wave transmission, coastal topography, and ship detection are also being developed in Taiwan. We can expect to be able to add regular observation products to the operational observation network in the future.

Epilogue

Looking back at the development of oceanographic radar in Taiwan, the participation of experts and scholars from the industry, government, academia and research fields in oceanography and communication electronics in the past ten years has contributed to the rapid growth of radar applications in long-term marine observation and the independent development of software and hardware. It is believed that in the future, under the joint cooperation of government departments, it will promote the effective utilization of resources, the international visibility and leading position of ocean scientific research based on Taiwan's unique geographical location and improve ocean observation ability and information mastery from "point" to "surface", and enrich the content of the national ocean database. The construction of these infrastructures, in addition to the value of academic research, will also benefit the marine information needs of environmental protection, navigation, energy, fishery, disaster prevention, disaster relief, leisure, entertainment, military, and national defense.

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A Roadmap to Secure Ocean Prosperity: International Guide on Marine/Maritime Spatial Planning

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Keywords: marine spatial planning, marine spatial plan, sustainable development of the ocean

Intergovernmental Ocean Commission of United Nations Educational, Scientific, and Cultural Organization' Intergovernmental Oceanographic Commission (IOC-UNESCO) and European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE) jointly propose International Guide on Marine/Maritime Spatial Planning (MSPglobal Guide), in order to promote blue economy developments and ensure ocean sustainability worldwide. MSPglobal Guide is a follow-up of the first IOC-UNESCO guide, Guidance for Marine Spatial Planning, published in 2009. The purpose of this guide is to assist governments and marine spatial planning practitioners in the development of marine spatial plans, improving cross-border and transboundary cooperation in marine spatial planning (MSP), promoting planning processes in regions where they are not yet launched and empowering planners in their own countries and regions. MSPglobal Guide lays out six phases concerning MSP, including setting the scene, designing the planning process, assessments for planning, the marine spatial plan, enabling the implementation of the marine spatial plan, and monitoring, evaluation and adaption. Work items of each stage has been specified, serving as a guide for initiating and engaging MSP in marine areas.

Figure 1/ MSP plans spaces for multiple uses, reducing conflicts between uses, generating benefits and ensuring ocean sustainability
Image by Chung-Ling Chen

Marine spatial planning

MSP is the process of planning the ocean space. Its purpose is to analyze ocean uses and allocate specific areas for the uses or exclude specific uses from specific areas, in order to reduce conflicts between uses and maximize benefits, while ensuring resilience of marine ecosystems. MSP is an ecosystem-based, participative, multisectoral, and transboundary cooperation approach in the planning and management of the marine environment. It contributes to achieving target 2 of Sustainable Development Goal 14 (SDG 14) of the United Nations 2030 Agenda. The target 14.2 says that sustainably manage and protect marine and coastal ecosystems to avoid significant, adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve a healthy and productive ocean.

In addition, MSP contributes to increased economic and social benefits of the areas being planned, and examines possible trade-offs between economic, social and environmental objectives in order to find a balance between them. At the same time, MSP can drive the achievement of many international agreements, such as the Convention on Biological Diversity (CBD) and the Paris Agreement on Climate Change.

This article gives an overview of MSPglobal Guide, jointly proposed by IOC-UNESCO and DG MARE. This guide describes six phases of the MSP process and details specific work items pertaining to each phase, serving as a guide for engaging MSP at difference scales of marine areas, including cross-border and transboundary areas.

MSPglobal Guide

MSPglobal Guide points out that the MSP process involves achieving agreements in objectives of various sectors, making regulations and management measures, participation of key stakeholders, securing the source of funding for MSP, and reviewing the results of MSP and modifying marine spatial plans. Specifically, MSP consists of six phases, including setting the scene, designing the planning process, assessments for planning, the marine spatial plan, enabling the implementation of the marine spatial plan, and monitoring, evaluation and adaption.

Phase I: Setting the scene

Setting the scene refers to having a basic understanding and recognition of the background information regarding the relevant rules, laws and regulations, and institutional frameworks, stakeholders, sources of funding available for the MSP process, and existing needs for planning ocean resources. Specifically, the work items at this stage include, but not limited to, creating an MSP working group, identifying existing national legal and institutional frameworks, identifying existing international laws, regulations and agreements applicable and/or adopted by the country, identifying key stakeholders, identifying sources of funding for MSP, identifying existing needs for planning ocean resources at local, national or regional scale, inducing transboundary aspects, and considering how MSP will be established within the existing governance and legal framework related to the coasts and ocean.

The purpose of the working group is to begin organizing the process and coordinate perspectives and expertise from multiple sectors for the launch of MSP. The group consists of the competent authorities, experts with experience in marine planning, members of civil society and relevant key stakeholders. Specifically, it develops a Terms of Reference document, outlining its roles and responsibilities, schedule of meetings, timeline, etc. In addition, it conducts a review of existing legal and institutional frameworks related to MSP and sustainable blue economy, and evaluate whether the concerned authorities have the capacity in coastal and marine planning.

The documents reviewed include national ocean policy, blue/ocean strategy, sectoral policies, sectoral management plans, integrated coastal zone management (ICZM), renewable energy targets, regional and/or local development programs (especially for coastal regions), climate change adaption strategies, and international legal instruments. In particular, at the global scale, MSP facilitates achieving international legal instruments and is thus able to solve transboundary marine issues such as climate change and illegal, unreported ad unregulated (IUU) fishing. Relevant international legal documents include United Nations on the Law of the Sea, United Nations 2030 Agenda for Sustainable Development, United Nations Framework Convention on Climate Change, United Nations Fish Stocks Agreement, FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, etc.

At this stage, key stakeholders have to be identified and transparent and equitable participation ensured. It is noted that key stakeholders change over time. The stakeholder list thus should be kept up to date. In addition, existing needs for planning ocean space and resources at local, national or cross-border/transboundary scale have to be identified. The needs are important drivers for the MSP process, which generally derive from the context: use-use and use-nature spatial conflicts, synergies between/among multi-uses, strategies to promote specific maritime sectors or the whole ocean economy, strategies to promote area-based conservation (e.g., network of MPAs).

Phase II: Designing the planning process

Designing the planning process refers to outlying the key steps of an MSP process and sets out how to proceed MSP work in an efficient way. The tasks needs to be taken care of at this stage include creating the planning team as well as the technical planning team, defining the planning boundaries and time frame, defining the planning principles, initial vision and goals, planning the monitoring and evaluation plan, and assessing risks and developing contingency plans.

Planning principles generally revolves around sustainable management, ecosystem approach, precautionary principle, participation and transparency, high-quality data an information, transnational coordination and consultation, coherent terrestrial and maritime spatial planning, planning adapted to characteristics and special conditions at different areas. The monitoring and evaluation plan involves the selection of indicators. The UN publication *An Introduction to Indicators* gives the criteria for designing indicator, which are relevant, measurable/verifiable, scientific, easily understood and interpreted, comparable, responsive, and cost-effective, etc.

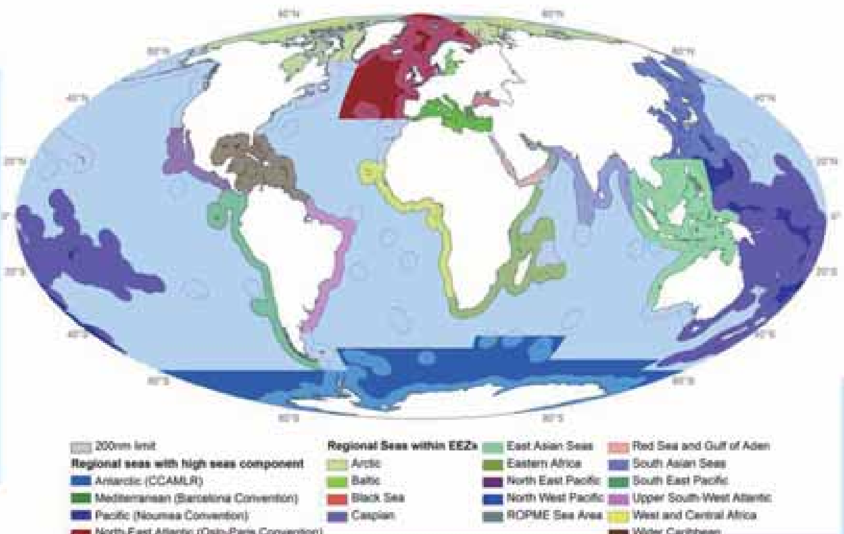

Figure 2/ Regional Sea Programs can serve as international legal institutions for cross-border cooperation in MSP
Source/ [2]

Phase III: Assessment for planning

This phase focuses on defining the different scales of planning, identifying existing conditions in the marine space being planned, analyzing its future conditions and trends, and development of public information systems.

The factors to consider when determining the scale of a plan include the international legal regime of marine waters, marine ecosystems and species distribution and dynamics, range of human activities at sea, and the political-administrative organization of adjacent territories. The relevant international legal regimes of marine waters are such as Regional Sea Programmes, tuna Regional Fisheries Management Organizations etc. Existing conditions refer to the current physical, biological, social, ecological and governance characteristics of the marine plan area. The amount of data and information is substantial and thereby there is a need to organize the data in a public information system. When analyzing future conditions and trends of the marine space being planned, new demands of ocean space from established, new and emerging maritime sectors should be taken into account.

Phase IV: The marine spatial plan

This stage concerns the development of the marine spatial plan, public consultation on the plan to solicit opinions from the public, and endorsement of the plan. The plan is a policy instrument that represents the agreed objectives among stakeholders. The content of the plan includes environment assessment, spatial allocation of marine uses, priority areas for marine conservation, various management actions, organizational frameworks, channels for implementation control, budget and financial allocation, and development of MSP capacities. As for capacity development, planners need to learn how to develop zoning, how to develop a strategic environment assessment, and how to place the marine spatial plan within the governance and legal framework, etc.

As an illustration, Seychelles used Marine Spatial Planning to Meet the 30 Per Cent Marine Protected Areas Target (i.e., the ratio of the area of MPAs over the area of EEZs). The OSPAR, a cross-border international legal regime, adopted a marine spatial plan which identified marine protected areas for the use of conservation.

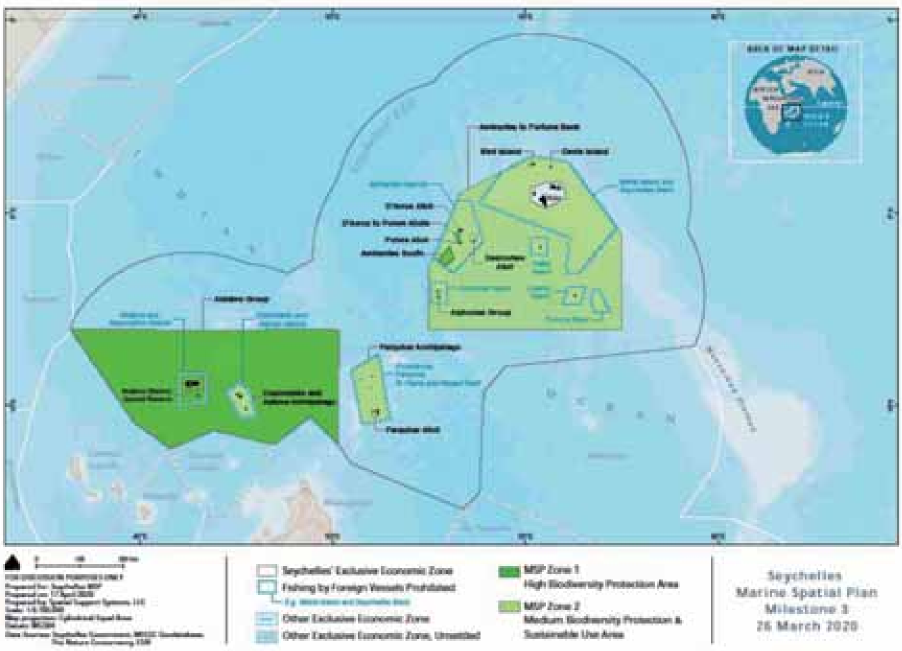

Figure 3/ Seychelles used marine spatial plan to meet the 30% MPAs target

Source/ [3]

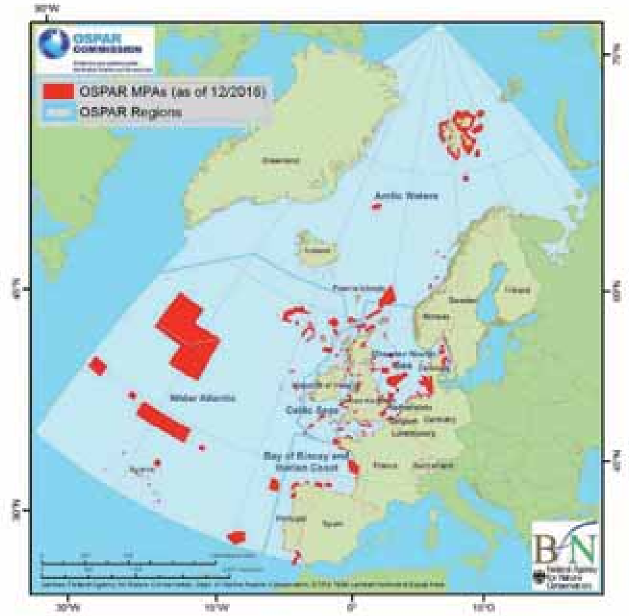

Figure 4/ The OSPAR marine spatial plan identifies areas for MPAs
Source/ [2]

Phase V: Enabling implementation of the marine spatial plan

This stage is to enable the implementation of the marine spatial plan. The tasks involved include establishing regulations relevant to the implementation of the plan, establishing a regular dialogue with sectors, training competent authorities and marine sectors on the matters regarding the implementation of the plan. The regulations are the important basis for the implementation of as well as compliance with the marine spatial plan. For transboundary marine spatial plans, the related conventions and agreements are the basis for the implementation. They often requiring efficient communication between two or more countries.

Phase VI: Monitoring, evaluation and adaption

At this stage, evaluation of each phase in the MSP process is conducted and the outcomes of the implementation of the marine spatial plan are monitored and evaluated. Based on the evaluation results, the MSP process as well as the plan is further reviewed, and revised and adapted accordingly.

Conclusion

MSP is a practical tool to promote a more inclusive and rational use of the ocean, facilitating the sustainable development of blue economy. In the context of increasingly crowded ocean spaces, MSP is indeed a tool to encourage multiple uses. The marine spatial plan allocates specific areas/sites for new and emerging uses, thereby increasing investor confidence and promoting investment in science, innovation and technologies.

MSP is widely regarded and accepted as an approach to ocean resource management. This article gives an overview of MSPglobal Guide. The Guide exactly describes the phases that are needed to engage in MSP at the local, national or regional scale. It is envisioned that via the implementation of MSP across the globe, the goal of sustainable development of the ocean can be achieved.

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Coopetition between Offshore Wind Power Policy and Marine Spatial Planning in Portugal

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Translated by Linguitronics
Keywords: Portugal, offshore wind power, marine spatial planning (MSP)

In 2020, Portugal passed a medium-term path towards carbon neutrality by 2050, namely its National Energy and Climate Plan for 2021-2030 (Plano Nacional Energia e Clima–"PNEC 2030"). PNEC 2030 focuses on GHG reduction, energy efficiency, renewable energies, energy security, and energy market (including energy poverty) and uses strategies to innovate, develop, and enhance competitiveness, thereby accelerating net-zero carbon emission policy. In the future, renewable energy will account for 47% of the Portugal's overall energy consumption, and about 80% of the electricity will come from renewable energies. Among which, capacity from wind power generation will account for the highest proportion, growing from 5.43GW in 2020 to 9.3GW by 2030.

Although Portugal has a long coastline, it is relatively conservative in the development of offshore wind power; it has risen by only from 0.03GW to 0.3GW. While the capacity remains small, the rate of growth is tenfold, which has a great impact on the marine space. This article mainly introduces the coopetitive relationship between offshore wind farms and marine spatial planning (MSP), and provides a reference for the promotion of Taiwan's marine industry through various norms and discussions on MSP regulations and development of marine-related industries.

Offshore Wind Farm Site Selection and Assessment

Portugal installed its first power generating units on Madeira Island in 1986. In 2020, the total installed capacity of onshore wind power generation reached 5.4GW, and it is planned to install more than 9GW by 2030. Also being one of the countries with the longest coastline in Europe, Portugal is also planning offshore wind power projects. Assessment of offshore wind power started in 2006, followed by re-assessment in 2010. In the second offshore wind power potential assessment, although the conditions may have been different, the final site was still chosen at the same location (Figure 1) [1].

The 6 assessment of possible offshore wind farms from Figure 1, subject to the influence and constraints of the Plano de Ordenamento do Espaço Marítimo, POEM (Marine Spatial Planning), such as the impact of coastal development on human activities, energy, and geological conditions. First of all, areas E and F are tourist attractions, so there are no wind farms planned for those areas. Were wind farms to be set up in those areas, it would seriously affect their natural ecological reserves and the development of aquaculture and fisheries. In addition to being affected by POEM, Area D is also affected by other environmental-related laws and regulations. With the exception of some protected areas, this area overlaps with major human activities. The installation of wind farms has a large impact at the social level.

Area C partially overlaps with the wind farm site designated by POEM. This area also has good potential for a wind farm, but borders the Berlengas Natural Reserve and is also subject to possible oil extraction activities as well as the impact of aquaculture and fisheries activities. Area B is also one of the offshore wind farm locations referred to by POEM. Similar to Area C, it impacts human activities, such as nature reserves and fisheries. If the wind farm is to be developed, the permit process will be time-consuming. Finally, Area A is the best offshore wind farm site in Portugal. In addition to being listed as an offshore wind farm by POEM, there is no nature reserve in the area, and it has the least impact on oil extraction and fisheries. It is the best site for development of an offshore wind farm in Portugal [2].

Offshore Wind Power Installation Plan

All wind power installation plans in Portugal are in Area A (the northernmost offshore area) mentioned previously; there are 5 existing wind farms (including those installed in shallow water and deep water). As of 2019 there are three wind turbines operating in deep waters in Wind Float Atlantic; it is the world's 2nd commercially operated windfarm to use floating wind turbine technology. With its total of 25MW, it is estimated that it can provide for the annual electricity consumption of about 6,000 households. However, planning for a total of 428MW installed capacity in nos. 2, 4, and 5 in Table 1 has been cancelled; a total of 350MW in nos. 7 and 8 is the area to be developed in the future to 2030. In addition to offshore development, the planning of further offshore wind turbines has also started on outlying islands (Porto Santo). Offshore wind turbines, due to their noise and vibration, will negatively interfere with wild species and affect the local ecology. Although the unit can be set further away from the coast, doing so would affect the cost and feasibility of their installation. Currently, Portugal is rather conservative in offshore wind turbine installation relative to the rest of the EU.

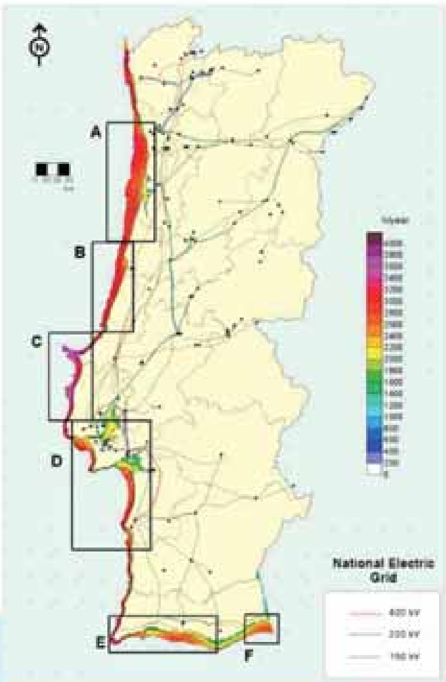
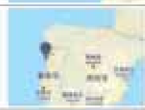


Figure 1/ Offshore Wind Farm Potential Site in Portugal
Source/ [1]

Table 1/ Portugal's Offshore Wind Power Plans at a Glance

Wind Farms	Installed Capacity	Condition	Location
1.WindFloat 1 Prototype (WF1)	2 MW	Decommissioned	
2.Branca	301 MW	Canceled	
3.WindFloat Atlantic (WFA)	25 MW	In Operation	
4.WindFloat Atlantic (WFA) - phase 2	125 MW	Canceled	
5.DEMOGRAVI3	2 MW	Canceled	
6.Offshore Island Porto Santo	10 MW	Planned	
7.Emergent Demand 1	150 MW	Under Development	
8.Emergent Demand 2	200 MW	Under Development	

Source/ [3]

The State of Marine Spatial Planning in Portugal

Marine Spatial Planning (MSP) is a decision-making tool for countries to govern the oceans and promote cross-border or cross-ministerial management; its purpose is to ensure that human activities on the ocean take place in an efficient, safe and sustainable way; it uses models and tools to analyze or allocate spatial and temporal distribution of marine human activities in order to achieve the ecological, economic, and social objectives of sustainable development. The advantages of using MSP as an ocean management strategy are: Internationally, cross-border cooperation between countries can be increased; domestically, in the same space, reducing the conflict between industries (offshore wind power and fisheries) and establishing a coordination mechanism between departments can also minimize damage to the ecosystem during development of the marine industry.

Portugal's National Ocean Strategy (NOS) has two phases: NOS2006-2016 and NOS2013-2020. NOS2013-2020 incorporates guidelines for the integrated management of marine space and precautions for resource development as well as guidance principles for the effective participation of all parties. The five main objectives of NOS2013-2020 are:

I. "reaffirm the national maritime identity in a modern, proactive and entrepreneurial framework."

II. "realising the economic, geostrategic and geopolitical potential of the national maritime territory, turning the Mar-Portugal into an asset with permanent economic, social and environmental benefits."

III. "in 2020, create conditions for attracting investment, both national and international, in all Ocean economy sectors, promoting growth, employment, Ocean sector in the national GDP in around 50%."

IV. "strengthen national scientific and technological capacity, stimulating development of new areas of action that promote the knowledge of the Ocean and effectively, efficiently and sustainably enhance its resources, use and activities as well as the ecosystem's services."

V. "consecrate Portugal on a worldwide level, as a maritime nation and as an unchangeable part of the IMP and of the EU maritime strategy, in particular for the Atlantic area."

In 2008, Portugal started POEM-related work in order to comply with the EU's Marine Spatial Planning directive. The main goal of the initial plan is to investigate the current situation and possible future activities and uses of the marine area in Portugal, including medium and long-term development activities, relevant sustainability goals, and various marine monitoring plans. MSP principles and recommendations at the highest level were formulated, and in 2014, it was planned according to relevant Portuguese and EU regulations. The objectives for MSP in Portugal are: Promoting the development of marine resources and ecosystem services, considering employment opportunities for citizens across generations in the use of the Portugal's marine space, and ensuring compatibility and sustainability of marine activities. In 2019, a new marine spatial plan, the Plano de Situação do Ordenamento do Espaço Marítimo (PSOEM), was proposed, which divided the spatial plan into three parts: the Portuguese mainland, Madeira Island, and the extended continental shelf.

There are two modes of thinking about incorporating sustainable development in MSP. The first is "hard sustainability," which focuses entirely on ecological protection; the second is "soft sustainability," the strategy currently adopted by various countries, in which ecological protection is only a part of MSP. The other core focuses of sustainable development still include fisheries, energy, tourism, and waterway safety. The second model is based on sustainable development, and its goal is to promote the economic development of the marine sector; it sees the development of the blue economy as the core. In

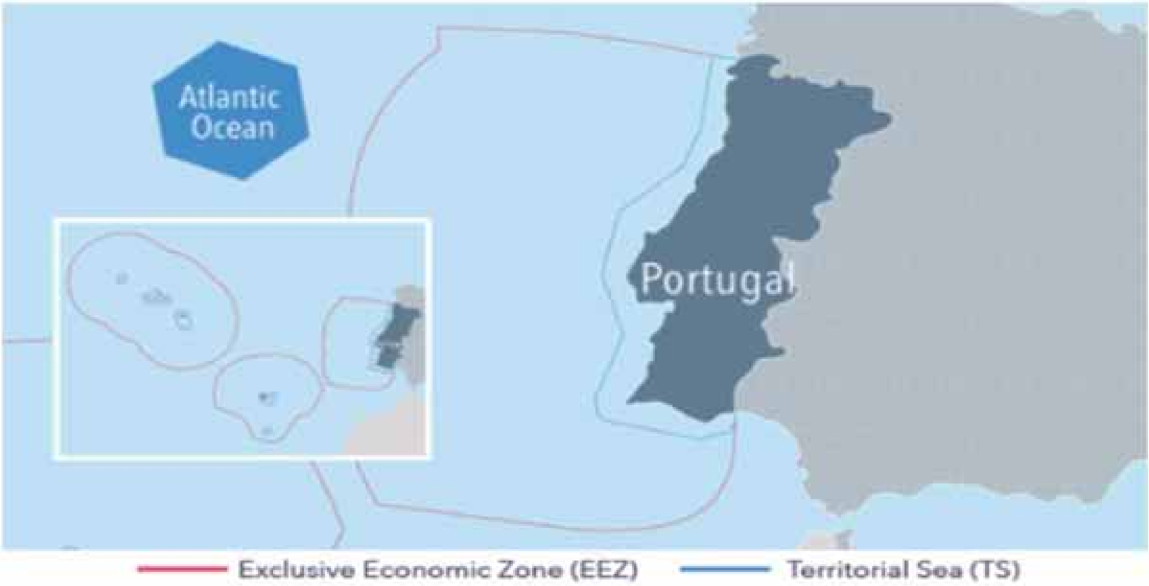


Figure 2/ Scope of Marine Spatial Planning in Portugal
Source/ [4]

summary, Portugal's MSP is set to solve environmental concerns in the utilization of marine space. That said, environmental issues are not the main goal of MSP. Its core goal is sustainable development. Maintaining the development of the marine industry, while maintaining compatibility with management policies for environmental protection (for example, using policy-oriented environmental impact assessment to achieve balance) are the important issues to be solved by MSP policy.

Case analysis: Coopetition between Offshore Wind Development and Fishing Activities in Portugal

Offshore wind power is the fastest growing item of the blue economy (marine industry) in Europe. Portugal's first offshore wind farm, Wind Float Atlantic (WFA), has a total of 3 units and a total installed capacity of 25MW, and began operating in 2019. It is the second wind farm in the world to use floating offshore wind turbine technology. WFA was developed in accordance with the Portuguese MSP specifications, but because fisheries or fishing boats are mostly prohibited in specific areas of the wind farm, it affects fishing activities and even ship navigation. WFA inevitably impacts on fishing culture in Portugal. MSP was unable to resolve the conflict between the wind turbine and fishing industries. To address the various social and economic impacts offshore windfarms may have on fisheries, it is recommended to consider allowing fisheries to participate in the decision-making process during MSP planning and to create MSP policies that are more fishery-friendly. Effective solutions are made through communication. And during the policy-making process, it is important to have more trust and more transparency amongst departments.

According to a study by Braga (2020) [5], small-scale fishery users were unable to participate in important decision-making consultation in the planning and installation processes of WFA, which could only be alleviated through after-the-fact economic compensation. However, compensation was not possible to be given to all fishermen in the area, but only to the fishermen who had joined the fishery associations in that area. In addition, the impact of WFA on fishermen is not only limited to fishing in specific areas. Submarine cables often catch on fishing gear or may even cause fishing boats to overturn. The construction and operation of offshore wind turbines also cause ecological changes in fish and destroy traditional fishing grounds, increasing the operating costs of fishermen and affecting their livelihoods as a result. On the other hand, the impact of wind power development on society is often excluded from assessment and planning, resulting in the inability of stakeholders to reach a consensus—thus, only the economic compensation mechanism can be used. Introducing mechanisms for communication among stakeholders in the early stages of wind power development is a very important task. At the initial planning stage, there must be preventive strategies that integrate and resolve conflicts among stakeholders and developers.

Table 2/ Solutions to Alleviate Conflicts Between Offshore Wind and the Fishery Sector

Strategic solutions planned to prevent the conflicts	
1	Participatory process early in the project, involving all the actors
2	Social services to help identify early trade-off
3	Integrated assessment of the ecosystem in the area of the project
4	Empowerment to the weaker sectors
5	Public consultation being less formal, having more space to creativity, new collaborative and interactive approach
6	Structures of governance need to be stronger creating a high-level policy
7	More scientific data and knowledge should be available
8	Creating an Alliance

Solutions to deal with the current conflict, trying to minimize as much as possible	
1	Financial compensations
2	Transparency in the process
3	Participatory development of a strategic plan with evaluation and revision
4	Co-management practices with a co-location of the two activities
5	Design migration corridors for the species
6	Allow fish vessels to transit in the offshore wind farms areas

Source/ [5]

Conclusion

Offshore wind power forms one of the important policies for the development of the blue economy in various countries. MSPs in a number of EU countries have introduced public participation systems. However, economic compensation should not be the only way to deal with coopetition issues between offshore wind power and fisheries. Information openness and transparency and public participation offer an effective mechanism for promoting dialogue between stakeholders and developers, and can achieve a win-win strategy for the utilization of marine space.

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A Preliminary Study on Portugal's National Marine Policy

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Keywords: Portugal, Ministério do Mar, National Ocean Strategy

Portugal, officially the Portuguese Republic (Article 1 of the Constitution), adopted a semi-presidential constitution in 1976 (revised 2005). The Constitution was established after the Carnation Revolution (Revolução dos Cravos) of 1974, which overthrew the socialist dictator António de Oliveira Salazar. The Portuguese government is composed of the Prime Minister, Ministers and Secretaries and Under Secretaries of State (Secretária de Estado) (Article 183 of the Constitution). The Under Secretary of State is responsible for the handling of particularly matters under its authority. For example, the Secretary of State for Fisheries (Secretária de Estado das Pescas) of Ministry of the Sea is responsible for fisheries matters. It is currently the 22nd government Cabinet in Portugal (XXII Governo Constitucional de Portugal, 2019-), since the establishment of the Republic in 1976.

Ministério do Mar (Ministry of the Sea)

The Ministry of the Sea of Portugal has been in the process of development over the past decades. Prior to the founding of the establishment of the Third Republic in 1976, there existed a "Ministério da Marinha", which was responsible for overall coordination of maritime and naval affairs. Bear in mind that Portuguese maritime armed force is presently managed by the Direcção-Geral da Autoridade Marítima (DGAM) under the Ministry of Defense (Ministério da Defesa Nacional) [1]. However, "Ministério da Marinha" has been reorganized and renamed several times since its origin. It has always been continued debates about whether the "Ministry of Sea" is really necessary or relevant to the situation.

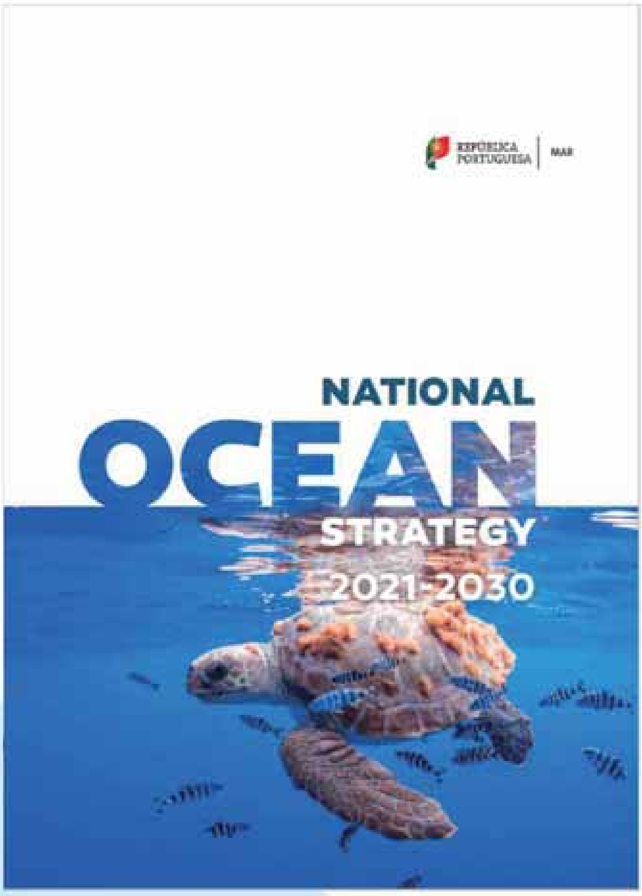

Figure 1/ National Ocean Strategy 2021-2030 Cover
Source/ https://www.dgpm.mm.gov.pt/enm-21-30

Table/ The history of the Ministry of the Sea

Time	Title	Armed Forces
-1976	Ministério da Marinha	Y
1976-1983	Ministério da Marinha	N
1983-1985	Ministério do Mar	N
1985-1991	Ministério da Agricultura, Pescas e Alimentação	N
1991-1995	Ministério do Mar	N
1995-2011	Ministério da Agricultura, do Desenvolvimento Rural e das Pescas	N
2011-2013	Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território	N
2013-2015	Ministério da Agricultura e do Mar	N
2015-	Ministério do Mar	N

Source/ Portuguese regulations

The roles of Ministério do Mar

The roles of the current Ministry of the Sea are provided for by law, namely Decreto-Lei n.º 251-A, and they are identified as follows: I. the coordination of cross cutting issues of the sea; II. the monitoring of the National Strategy for the Sea; III. the promotion of scientific knowledge, innovation and technological development in the area of the sea; IV. the management and exploitation of resources of the sea; V. the promotion of a sustainable use of the marine resources; VI. the management of European funds relating to the sea [2]. In addition to the aforementioned "Secretary of State for Fisheries", the Ministry of the Sea also includes 5 agencies: I. A Direção-Geral de Política do Mar (DGPM); II. A Direção-Geral de Recursos Naturais, Segurança e Serviços Marítimos; III. O Gabinete de Investigação de Acidentes Marítimos e da Autoridade para a Meteorologia Aeronáutica; IV. A Comissão Técnica do Registo Internacional de Navios da Madeira; V. A Autoridade de Gestão do Programa Operacional Mar 2020 [3]. Among them, the DGPM has four functions, namely, politics, economy, finance and education. It also supervises the "Blue Foundation" (Fundo azul) [4].

Portuguese law specifically regulates the relationship between the Ministry of the Sea and other ministries, such as the Ministro de Estado e dos Negócios Estrangeiros (jointly handle foreign affairs relating to law of the sea), the Ministra da Agricultura (jointly handle affairs relating to fishing, environmental and spatial planning), the Ministro das Infraestruturas e da Habitação (jointly handle affairs relating to port management); the Ministro da Ciência, Tecnologia e Ensino Superior (jointly handle affairs relating to maritime education and technology); the Ministro da Defesa Nacional (jointly handle affairs relating to continental shelf maritime safety) [5]. In addition, there is an inter-ministerial committee, namely, Comissão Interministerial para os Assuntos do Mar (CIAM) [6], which is chaired by the prime minister or the minister of the Ministry of the Sea [7].

National Ocean Strategy

Portugal regularly publishes the so-called National Ocean Strategy, and the current phase is expected to run from 2021 to 2030 [8]. The strategy has a dual function: it not only responds to the international community, particularly to the EU's "Blue Growth strategy" in 2012; it also allows Portugal to regain maritime sovereignty. The Strategic Goals of the National Ocean Strategy are generally as follows[9]:

I. "Fight Climate Change and Pollution and Protect and Restore Ecosystems": "Due to its extensive coastline and biogeographic position, Portugal must face the challenges of climate change". It is therefore necessary to develop scientific knowledge and technical capacity, while enhancing monitoring capacity to select the most threatened ecosystems in order to focus more intently on conservation and restoration.

II. "Foster Employment and a Circular and Sustainable Blue Economy": The blue economy includes "all sectors with a direct or indirect link to the ocean as a source, means, or target of business and its development." The development of the blue economy must be founded on healthy ecosystems by using "the principles of circularity, inclusiveness, equality, and sustainability."

III. "Decarbonise the Economy and Promote Renewable Energies and Energy Autonomy": By ratifying the Paris Agreement, Portugal committed to reduce emissions by at least 85% by 2050. Portugal will also follow the Sustainable Development Goals (SDG) 7, 9 and 14 of the UN 2030 Agenda, which focus on sustainably use.

IV. "Invest in Guaranteeing Sustainability and Food Security": "Portugal has one of the highest fish consumption per capita but about 75% of the ocean-based products consumed in the country are imported." Portugal must feed itself in a sustainable way for the sake of safety and autonomy, which is also in line with the European initiative "From Farm to Fork". It is necessary to increase aquaculture production to achieve this goal. Some biological technologies, such as the applications of 3D printing, are expected. Portugal will become one of the world's leading marine technology countries by 2030.

V. "Facilitate Water Access & Supply": "The growing use of water for public supply, agricultural and animal production, recreational uses, and industry, among others, has exerted an enormous pressure on global water resources." One of solutions of this problem is the desalination systems powered by renewable ocean energy.

VI. "Promote Health and Wellbeing": The marine ecosystem services that provide not only "oxygen and sequester carbon dioxide," but also "opportunities for various recreational activities" which "offer several benefits, including aesthetical satisfaction, the improvement of physical and mental health, and an added feeling of well-being." In addition, "the ocean is also a source of bioactive substances that can be produced by blue biotech from a plethora of marine organisms."

VII. "Stimulate Scientific Knowledge, Technological Development and Blue Innovation": The "use of ships allocated to maritime transport and touristic operations, as well as fishing vessels, as an opportunity to increase the amount of data collected and the area they span." In addition, Portugal can make "the best use of the specific conditions of the Azores and Madeira archipelagos", such as the development of scientific infrastructure abilities of Atlantic dimension.

VIII. Improve Education, Qualification, Culture and Ocean Literacy: "Portugal should increase the amount and quality of educational and training offer in all ocean-related areas." In addition, culture is important in the SDGs of the UN 2030 Agenda.

IX. Incentivize Reindustrialization and Productive Capacity and Ocean Digitalization: Portugal and European countries have been "losing industrial-based productive capacity." Portugal believed that reindustrialization is essential, and "ocean economy will play a key role."

X. Ensure Safety, Sovereignty, Cooperation and Governance: Portugal has unique relationship with the Atlantic countries, such as the Community of Portuguese Speaking Countries (CPLP).

NOS 2030

National Ocean Strategy 2021-2030

VISION

To promote a healthy Ocean as a path to achieve a sustainable blue development, people's wellbeing and to consolidate Portugal as a global leader in Ocean governance, supported in scientific knowledge.

10 STRATEGIC GOALS FOR THE DECADE

- SG1 Fight Climate Change and Pollution, Restore Ecosystems
- SG2 Foster Employment and a Circular and Sustainable Blue Economy
- SG3 Decarbonization, Renewable Energies and Energy Autonomy
- SG4 Food Security and Sustainability
- SG5 Water Access & Supply
- SG6 Health and Wellbeing
- SG7 Scientific Knowledge, Technological Development and Blue Innovation
- SG8 Education, Qualification, Culture and Ocean Literacy
- SG9 Reindustrialization, Productive Capacity and Ocean Digitalization
- SG10 Safety, Sovereignty, Cooperation and Governance

Figure 2/ National Ocean Strategy 2021-2030 General Infographic
Source/ https://www.dgpm.mm.gov.pt/enm-21-30

One thing to bear in mind is the regime of the autonomous regions of the Azores and Madeira, because the most part of Portugal's EEZ belongs to them.

While Portugal is a unitary country [10], its constitution allows special autonomy provisions for both regions. Since the original text of the constitution is unclear, there have been many debates about the scope of autonomous matters [11]. However, the constitution was amended in 2005, and the amendment of Article 227 provides detailed regulations governing the autonomous region.

The autonomous regions enjoy a great degree of autonomy. They enjoy the right to participate in foreign policy decision-making. For example, the autonomous regions enjoy the right to receive the necessary information, to express their opinions, and to make recommendations as they see fit. This means that the Portuguese government must consult with the autonomous regions in marine affairs [10].

Conclusion

There are several differences between Portuguese and Taiwanese marine department, and they are summarized as follows: I. The Portuguese Ministry of the Sea does not have the power to command the armed forces; II. Portuguese law stipulates all relations between the Ministry of the Sea and other ministries, and there are several agencies that are jointly supervised by the Ministry of the Sea and other departments; III. In addition to the Ministry of the Sea, there is an inter-ministerial committee for marine affairs; IV. the most part of Portugal's EEZ belongs to Portuguese autonomous regions, and the Portuguese government must consult with the autonomous regions in marine affairs; V. Ministerial changes in Portugal are much more frequent than Taiwan, and the 2021-2030 National Ocean Strategy not only means the development of marine policy but serve as evidence to support the significance of the Ministry of the Sea.

In closing, the 10 goals of the National Ocean Strategy are actually related to scientific, technological and educational issues. Therefore, the relationship between the Ministry of the Sea and relevant ministries is a key factor for success.

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Hubs on the Offshore Green Energy Transmission Corridor - Planning and Development of Offshore Wind Power Substations

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Translated by Linguitronics

Keywords: Offshore substations, floating substations, cables

Wind turbines and the amount of power they generate have increased along with the development of offshore wind farms. Energy loss occurs frequently over long-distance low-voltage power transmission, and a surplus of cables is likely to have an impact on the offshore environment. Substations offer a solution to these problems while making electricity generation more efficient.

The function of offshore substations is to collect and output power generated by wind turbines; they are an important component of large offshore wind farms. The main function of the offshore substation is to stabilize voltage and improve the power generation efficiency of the wind turbine. After the cables in the wind farm are collected and stepped-up, they are then connected to the 161kV Taiwan Power Company ultra-high voltage (UHV) system and transmitted to the onshore power grid for the daily use of people or industry.

What is the difference between onshore and offshore substations? Onshore substations are an important part of power system transmission and power distribution. Their purpose is primarily to meet the daily energy needs of domestic or industrial users with continuous, safe, and reliable power supply. Design of onshore substations have undergone many years of practical use; a standardized, typical design is formed for these stations, and their construction and operation and maintenance costs are relatively stable.

At present, the main function of offshore substations is to integrate the offshore wind power into the power grid. What should be emphasized is that when the wind farm has power transmission demand, it can reliably transmit power, while reducing the loss of power transmission as it goes ashore and improving the power generation efficiency of wind turbines. Also, for many years now, offshore substations have been located in harsh marine environments with wind and waves, ocean currents, and high salinity, which has made subsequent maintenance operations quite difficult. Therefore, the level of difficulty in construction and maintenance and the respective costs are higher than those of onshore substations.

Offshore substation status and turbine planning

Offshore substations serve as power transmission hubs for the entire offshore wind farm. Compared with onshore substations, the overall construction cost is relatively low (including costs for cables), there are fewer subsea cables, and land acquisition is easier than for onshore substations. However, there are disadvantages, the main one being: maintenance is relatively difficult, a factor that results in certain differences from onshore substations in terms of design. Electrical design principles of substations include reliability, flexibility, and economy. Generally speaking, two primary transformers are used as mutual backup or as backup between separate wind farms to avoid power supply failure when one transformer becomes damaged and prevent the resultant economic losses.

This achieves the effect of continuous, stable power supply. Also, in order to make maintenance convenient, factors such as modularization, miniaturization, and resistance to damage from saltwater should be considered for equipment; the equipment should also be compact enough to reduce the area it occupies [1]. In the design of offshore substations, necessary considerations include wave conditions, earthquake considerations, and corrosion resistance to avoid damage to important facilities at the substation. For the above design requirements, relevant international codes can be used as reference, including codes such as the Det Norske Veritas (DNV) and American Bureau of Shipping (ABS).

Structurally, offshore substations have three main sections; from top to bottom, these are: the topside substation section, the transition section, and the substructure [2]. As can be seen from Figure 1, the substation substructure is actually similar to the basic support structure of a wind turbine. The most commonly used offshore substation foundations are monopile foundations and jacket foundations. The monopile foundation is the only pile with a large-diameter steel pipe; it directly transfers the weight of the upper structure to the seabed. Currently, monopiles are one of the mainstream solutions for subsea foundation used in Europe. The monopile foundation is generally used on a solid seabed. Its construction costs increase along with the increase of the water depth. Generally speaking, monopiles are mostly used in waters with a depth of less than 20 meters. In addition to depth, littoral drift and other situations must also be considered. Jacket foundations have a more complicated truss structure, so manufacture is more labor-intensive and costs are higher, but they have better stability. Jackets are mainly used in waters with a depth of more than 20 meters and are more economical. Compared with other foundations, the amount of steel used in jacket foundations is lower. Looking at offshore wind farms in Changhua, Taiwan as an example, one can see that if a monopile foundation is used, its design weight will be twice that of the jacket foundation [3][4].

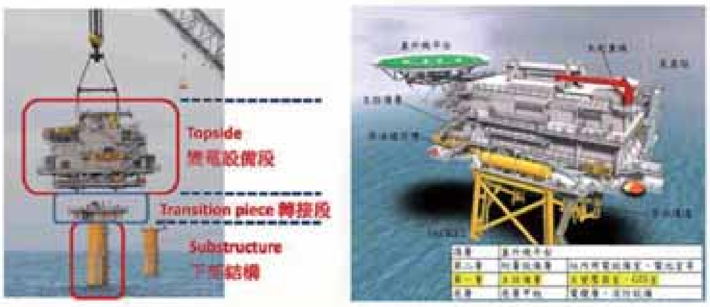

Figure 1/ Offshore Substation Structural Diagram
Source/ [2][3]

Figure 2/ Monopile Foundation and Jacket Foundation
Source/ [4]

Taking the 4-layer 200kV fixed offshore substation in Europe as an example: it can be adjusted according to the size of the wind farm and the form of the equipment. The top layer consists of a helicopter platform; the second, an auxiliary equipment layer that includes electric equipment, emergency diesel generator room, tool room, and storage room; the first, the main equipment floor that includes the main transformer, battery room, communications room, low-voltage power distribution room and control room; the lowest is the deck layer, whose highest layer at the lower part is above the peaks of the maximum wave height under extreme high tide levels, it includes life-saving equipment storage, firefighting pump rooms, and it is also the subsea cable configuration layer.

The scale of offshore substation equipment expands with the scale of the wind farm; and the equipment also becomes more complete. Looking at offshore substations in Europe as an example, one can see that the first-gen substations consisted of only a single transformer, their equipment capacity was about 100-150MW, and they weighed in at about 1,000 tons. There were no plans for backup transformers or power cables. Therefore, in the event of an equipment accident, power was completely unavailable for output. Second-gen substations were equipped with multiple transformers, had an equipment capacity of about 200-300MW, and weighed in at about 3,000-4,000 tons; in addition, they were planned for multiple output cables. This is currently the main planned substation form for North Sea wind farms in Europe. The equipment capacity of third-gen substations is about 600-800MW. Since AC transmission will cause a large amount of power loss, after power is collected and rectified, it is transferred to the land substation using high-voltage DC. The total weight of third-gen substations can be as high as 15,000 tons, so self-floating and jack-up technologies have been used in the station body to overcome lifting problems [2].

Table 1/ Substation Specification Sheet

	First-gen substation	Second-gen substation	Third-gen substation
Transformer/Shunt Reactor/ AC-DC Rectifier	1/0/0	2/2/0	2/4/2
Capacity	100～150MW	200～300MW	600～800MW
Topside Substation Section	1,000 tons	3,000～4,000 tons	15,000 tons
Deck (layer)	2	3～4	7
Substation body diagram			

Source/ [2]

Practical applications of offshore substations

Offshore substations currently in operation are still mostly in by European wind farms, such as the London array offshore wind farm in the United Kingdom. The London array wind farm is located at the outer Thames Estuary in the United Kingdom, about 11 km away from the north coast of Kent in waters with depth of about 25 meters. The London array wind farm has a total capacity of 630MW and consists of 175 Siemens 3.6 MW wind turbines and 2 offshore substations, as well as a network of approximately 210km of 33kV inter-array undersea cables. After the power generated is collected at two identical offshore substations, it is transmitted to an onshore substation near the north-east of Kent through four 150kV undersea export cables [5].

There are several windfarms currently being installed in Taiwan ; one such windfarm, the Greater Changhua wind farm, is located slightly farther from shore, and so an offshore substation has been planned and is currently under construction. The wind farm is located about 35 to 60 kilometers off the coast of Changhua, at a water depth of about 20 to 40 meters. Of which, the capacities of Greater Changhua South West and Greater Changhua South East are about 300MW and 600MW, respectively, and the two offshore substations under the charge of Ørsted will complete power-on tests in December 2021 and January 2022, respectively [6].

Future development of offshore substations

Following the development of offshore wind power, wind turbines are established from land to sea; fixed foundation piles are mainly used in shallow sea areas with water depths of less than 50 meters. As wind farms gradually populate shallow sea areas, the number of good wind farms that can be developed will also decrease. In the future, it will be necessary to develop in deeper sea areas. Therefore, many developers are now targeting wider deep-sea areas and setting up floating offshore wind turbines. Fixing to the seabed through tether cables helps to increase the scope of offshore wind power installation, and more stable wind energy in the open sea can be used to achieve higher efficiency.

Following the trend of large-scale wind turbines and offshore wind farms moving farther and farther off shore, offshore substations that can reduce power transmission loss have received increasingly more attention; also, the form of offshore substations is no longer limited to fixed foundations. The Fukushima, Japan plan uses a floating platform as the foundation for construction; and other countries have conducted research on floating substation platforms (such as BW Ideol in Norway, and the United States). Future development of offshore substations is expected to still be built using the floating form in the deep sea. The following is an introduction based on the development status in different countries.

I. Floating substation in Fukushima, Japan

Fukushima FORWARD is a symbol of Fukushima's recovery from nuclear power plant disaster caused by the 2011 earthquake and tsunami. The substation, known as Fukushima KIZUNA, has a voltage capacity of 25MVA, including 66kV gas-insulated switch equipment and 22kV vacuum-insulated switch equipment. The 22kV voltage generated by the wind turbine is boosted to 66kV by the substation and transmitted to land through the 66kV subsea cable. In addition to its function as a substation, the Fukushima floating offshore substation is also equipped with facilities such as observation towers and heliport, which are provided for wind condition surveying in the nearby sea area [7][8].

II. Norway floating substations

Ideol and Atlantique Offshore Energy (AOE) jointly develop floating substations based on the barge floating platform; the barge floating offshore substation is designed (including patented damping pool design) to operate in the world's most extreme environments and provide maximum modularity. Significant improvements can be achieved by installing the superstructure on the dock area, including equipment such as backup generators, helipads, cranes, etc., testing and pre-debugging on the dock area, and installing without heavy offshore operations, which can lower the respective costs. This versatile and modular floating substation is expected to have a significant impact on the offshore substation market; and it is preparing the market for bidding for floating substations in France and around the world. Market potential is huge, with 115GW of offshore installed capacity expected to be installed globally by 2030 [9].

III. US floating substations

In recent years, the United States has begun to design floating substations. In Figure 4, one can see that the floating substation is a combination of the semi-submersible platform of the floating wind turbine and the upper substation structure of the fixed offshore substation. Numerical verification has been carried out for the sea conditions near wind farms in the United States; results show that the stability of the platforms complies with specifications and that they are able to support floating wind farms in deeper waters, such as the those in the northeastern United States and other parts of the country [10].

Figure 3/ Norway BW Ideol Floating Substation Concept Diagram
Source/ [9]

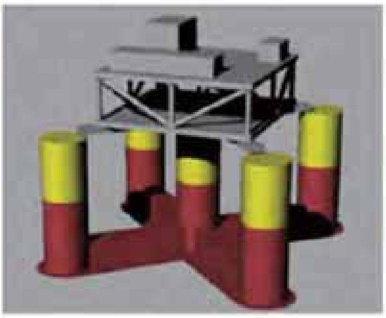

Figure 4/ United States Floating Substation Design Concept Diagram
Source/ [10]

Figure 5/ Taiwan Floating Substation Model Diagram
Images by Department of Hydraulic and Ocean Engineering, National Cheng Kung University

IV. Taiwan Floating Substation

This floating substation (Figure 5) has been tested by the research team of National Cheng Kung University. The team has considerable experience in the stability characteristics of the platform and related technologies such as the mooring system. According to the research and test results, the platform can maintain a certain level of stability under the wave conditions in the western waters of Taiwan, in both normal and extreme sea conditions. The output cables of the substation can also subsist in various environmental conditions and will not be damaged by the offshore environment. This shows that Taiwan, in response to future trends, still has the potential to install floating substations following the installation of wind farms in deeper sea areas.

Conclusion

Following the development of offshore wind power, the scale of wind farms has gradually expanded, and the demand for offshore substations has also increased. The purpose of offshore substations is to shorten the distance of wind turbine power transmission and the resultant loss in the transmission process. Thus they play an important role in the development of offshore wind farms. In addition to fixed-foundation offshore substations, floating offshore substations suitable for use in deep sea areas are also being developed, following the gradual saturation of nearshore wind farms. This means that the installation of offshore substations in the future will not be affected by offshore distance or water depth. They will eventually become hubs of the marine green-energy transmission corridor.

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1990 Lisbon Agreement: A Marine Pollution Control System Formulated by Portugal, France, Spain, Morocco, and the European Union

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Keywords: Lisbon Agreement, marine pollution

After the Torrey Canyon oil spill in 1967, the International Maritime Organization (IMO) passed in 1990 the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention), under which framework six regional response centers were established. The existence of several marine pollution area alliances, such as the OSPAR Commission established in 1972 to protect the marine environment of the Northwest Atlantic, and the Lisbon Agreement, adopted in 1990 and entered into force in 2014, aim to protect the marine environment of the Northwest Atlantic.

International Legislative System

After the Torrey Canyon oil spill in 1967 (120,000 tons of oil spilled into the English Channel), a series of oil pollution legislations were formulated internationally which covered three aspects: pollution control operations (MARPOL), high seas intervention (Intervention) and compensation (CLC+Fund). After the Exxon Valdez oil spill on March 24, 1989 (37,000 tons of oil spilled in Alaska), the international community found that international legislation on "oil spill preparedness and response capacity" was still lacking. The International Maritime Organization (IMO) urgently resolved to begin research in October 1989; then, in November 1990, the 1990 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) was formulated and passed. The OPRC Convention, as the name suggests, lays a global foundation for countries' oil pollution emergency response systems, international mutual assistance, and multilateral cooperation. Under the OPRC framework, regional response centers such as the NOWPAP MERRAC (Northwest Pacific), REMPEITC-Caribe (Caribbean), MEMAC (Persian Gulf), REMPEC (Mediterranean), PEMSEA (East Asia), PERSGA/MEMAC (Red Sea/Gulf of Aden) have been established around the world [1]. In addition to regional response centers operating in regional cooperation under the framework of the OPRC Convention, there are still other marine pollution regional alliances, such as those protecting the Northwest Atlantic. Fifteen governments (Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and England) formed the "OSPAR Commission" in 1972 (OSPAR is Oslo and Paris Conventions ["OS" for the Oslo Convention against dumping from 1972 and "PAR" for Paris Convention against land-based sources of marine pollution and the offshore industry from 1974]; the two conventions were later combined to form the OSPAR Convention in 1992). The topic of this paper, the Lisbon Agreement, was adopted by four countries in 1990 and entered into force in 2014, is also aimed at protecting the marine environment of the Northwest Atlantic.

Background of the 1990 Lisbon Agreement: the Khark 5 and Aragon oil spills

During the development of the OPRC Convention from October 1989 to November 1990, two major oil spills occurred in succession, only 10 days apart, off the coasts of Portugal and Morocco: Khark 5 (December 19, 1989) and Aragon (December 29, 1989).

I. The Khark 5 spill: On December 19, 1989, the Very Large Crude Carrier (VLCC) Iranian Khark 5, carrying a deadweight tonnage of up to 385,000 tons, encountered bad weather 112 miles west of the coast Morocco. The hull ruptured, causing an explosion and fire. Two of the 14 oil tanks on the ship ruptured, making extinguishing the fire and towing operations very difficult. Roughly 70,000 tons of crude oil spilled, covering 600 square kilometers. The Moroccan government requested assistance from England, France, Spain, and Portugal. Before the oil slick drifted to the coast of Morocco, the Moroccan government and hundreds of European volunteers used a large amount of chemical dispersant to break up the oil slick [2].

II. The Aragon spill: On December 29, 1989, the Spanish VLCC Aragon, carrying a deadweight of up to 240,000 tons, suffered severe damage 360 miles out from the Moroccan coast from bad weather during towing after the failure of its steering engine, resulting in the no. 1 central oil tank leaking roughly 25,000 tons of Mexican crude oil. After three weeks of emulsification, the spilled crude oil drifted to Madeira Island, a famous tourist destination in southwest Portugal, wreaking havoc across the entire eastern coast of the region. Not only did Madeira Island itself not have the necessary pollution cleanup equipment, but Portugal as a whole did not have the capacity to respond to such a severe oil spill. Portugal requested assistance from the European Commission, and several EU member countries formed emergency teams and provided emergency equipment/materials, which were transported to the rescue effort on dedicated aircrafts. The cleanup operation took a total of 7 weeks, and equaled the removal of a total of about 15,000 tons of crude oil; the recovered oil was then shipped to the Netherlands for processing [3].

The 1990 Lisbon Agreement

ITOPF has compiled statistics of oil spills that have occurred internationally from 1967 to 2021 [4]; waters in the Northeast Atlantic have always been a hotspot of major oil spills from oil tankers over the years. In light of the Khark 5 and Aragon incidents as well as the principles of mutual support and national cooperation proactively created with reference to the IMO OPRC draft that was nearly at the end of its development, Portugal, which had the most important stake in both incidents, appealed to the European Economic Community with a proposal: Portugal, France, Morocco, Spain and the European Economic Community should reach a regional agreement to deal with marine pollution incidents covering the waters of the Northeast Atlantic. Before the OPRC was passed, the contracting parties signed the "Lisbon Agreement" with the then European Economic Community on October 17, 1990. Its full title was "COOPERATION AGREEMENT for the protection of the coasts and waters of the north-east Atlantic against pollution." On May 20, 2008, the agreement was amended by a protocol to change the southern boundary. Spain did not ratify the agreement until February 1, 2014, which then brought the Lisbon Agreement into force. The purpose of the Lisbon Agreement is to ensure that the parties can cooperate in the event of marine pollution accidents. The agreement also requires that each party establish its own prevention and control system, equip itself with pollution control equipment, and formulate its own national plan of action.

The full text of the Lisbon Agreement includes the purpose, 27 articles, and 2 annexes, of which Articles 1 through 19 are substantive norms, Articles 20 to 27 are final clauses, including amendments to the convention (§20), proportions of secretariat expenses (§21), ratification, acceptance or approval or deposit, and entry into force (§22), invitation to accession (§23), entry into force of accession (§24), withdrawal (§25), denunciation (§26), and text and depositing (§27, with Portugal as the depositary country). Articles 1 through 19 are substantive norms, their main contents being:

Article 1 Agreement obligations: "The Contracting Parties to this Agreement ... undertake, individually or jointly ... to take all appropriate measures under this Agreement ... to deal with an incident of pollution at sea."

Article 2 Definitions: Defines pollution incidents, hydrocarbons, and other hazardous substances.

Article 3 Scope of agreement: In principle, the scope is the Northeast Atlantic region outside the exclusive economic zones of each of contracting state.

Article 4 Obligations of contracting states: Includes the establishment of a minimum amount of emergency equipment, national emergency response systems, protection of endangered sensitive areas, itemizing of equipment and human resources, recovery, storage and disposal of pollutants, and personnel training.

Article 5 Joint action plan: "The contracting parties shall jointly draw up and determine guidelines covering the practical, operational and technical aspects of joint action," covering information, new technologies and methods, and identification of major pollution incidents.

Article 6 Expanded application: The joint action plan also covers the loss of container equipment such as containers carrying hazardous substances at sea.

Article 7 IMO compliance: Government personnel and crew members of national ships and platforms shall comply with various IMO provisions, including pollution avoidance, emergency response, and incident notification.

Article 8 Division of powers and responsibilities in the agreement area: The contracting state party responsible for the area where the contamination is located shall conduct an assessment and notify other state parties of emergency action.

Article 9 Areas of joint interest: Negotiation, adoption, leadership, coordination, and assistance of joint actions for areas of joint interest.

Article 10 Requests for assistance and cooperation: Requests for assistance shall indicate the circumstances in which assistance is required; the requested state shall make every effort to assist.

Article 11 No prejudice to the sovereignty of States: Declares that the exercise of this Agreement may not prejudice the sovereignty and sovereign rights pursuant to international law concerning the exclusive economic zones and continental shelves.

Article 12 Monitoring and research of shipping activities: The relevant shipping authorities of the contracting states shall formulate shipping monitoring methods and conduct relevant studies.

Article 13 Contracting states' burden of cost: The agreement area adopts the principle of parties bearing the costs of their respective actions, whether it is requested assistance or voluntary assistance; the areas of joint interest adopt the principle of burden sharing; it also stipulates the termination of assistance and expert reporting and reviewing of costs.

Article 14 No prejudicing rights of the contracting parties to recover costs from third parties: "Article 13 ... may not in any circumstances be interpreted as prejudicing the rights of the Parties to recover from third parties the costs involved...."

Article 15 Meetings of the parties to the agreement: Approval of regular meetings, rules of procedure, etc.

Article 16 Exercise of European Economic Community voting rights: One vote per contracting state, the European Economic Community itself has no right to vote.

Article 17 Tasks of the meetings of the parties: Supervision, inspection, and identification of particularly sensitive areas, etc.

Article 18 Establishing an international center: Located in the depository country, its purpose is to be able to respond quickly to pollution incidents.

Article 19 Functions of the International Centre: Suggestions on the flexibility and complementarity of emergency supplies and equipment, and increasing inventory of each contracting party.

Annex 1 to the Agreement: Areas correspond to the exclusive economic zones of each contracting state
Annex 2 to the Agreement: Guidelines for defining the functions of the International Action Centre

A Short Summary

After the adoption of the Lisbon Agreement in 1990, two major oil spills, i.e., the 1992 Aegean Sea incident (74,000 tons spilled in La Coruna, Spain) and the 2002 Prestige incident (63,000 tons spilled in Galicia, Spain) occurred successively in the agreement area, but the agreement required the four original contracting states to have ratified or accepted the agreement before it could enter into force, and Spain had not ratified and deposited the agreement until February 1, 2014. Since the Lisbon Agreement came into force on February 1, 2014, the number of major international oil spills has been greatly reduced, and with the continued operation of the previous and larger OSPAR Commission in the Northwest Atlantic, so the operating rate of the Lisbon Agreement was basically low. According to the "Review of Maritime Transport 2021" released by the United Nations Conference on Trade and Development (UNCTAD), 1,060.2 million tons (or nearly 57%) of the 1,863.6 million tons of crude oil unloaded around the world in 2020 were unloaded in Asia [5], with most of that unloaded in East Asia. The sea area around Taiwan has always been a hot spot/frequent trade route for crude oil; consequently, it is also a hot spot for marine pollution accidents. Although Taiwan currently has a "Major Marine Oil Pollution Emergency Response Plan" (revised Jan. 3 2017), it is only applicable to Taiwan. Due to the realities of the international political scene, Taiwan has not signed on to regional marine pollution cooperation agreements with its neighboring countries like the Lisbon Agreement discussed here. But pollution knows no borders. Such regional marine pollution cooperation models can be emulated by Taiwan. On the foundation of APEC, Taiwan is engaged in discussions on topics such as disaster response and environmental protection, and it has similar marine pollution cooperation agreements with neighboring countries.

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