國際海洋資訊 International Ocean Information

藍色經濟特輯

March 2021 Blue Economy Special Issue

海洋旅遊
Marine Tourism
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Marine Energy
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海洋委員會 Ocean Affairs Council 發行

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面向世界 發展我國永續藍色經濟！

主任委員：李仲威

「藍色經濟」代表著永續經營的海洋經濟，並強調人類活動和海洋的調和與共生。本期為《國際海洋資訊》之「藍色經濟特輯」，介紹歐美等國與我國在海洋旅遊、海洋能源、運輸與造船、海洋生物資源、新興產業之現況發展與未來趨勢。

「海洋旅遊」單元介紹臺灣主要的海洋觀光產業以及海洋觀光永續政策，臺灣具備發展海洋觀光休閒的4S元素：沙灘、海水、陽光與海鮮，近年來在遊艇觀光和郵輪觀光方面皆有龐大商機，政府亦提出「藍色公路十年綜合發展規劃」（2021～2030）；「海洋能源」單元介紹全球海洋能源創新技術與策略現況，點出海洋能源發電均化成本比預期低、洋流能及波浪能技術發展快速、溫差能、鹽差能和洋／潮流能10年內有發展潛力等未來發展重要趨勢；「運輸與造船」單元則介紹海洋運輸、船舶建造與營運之產業動態分析，如歐盟船舶產業近年逐漸改變商業模式以降低成本，亦與新興行業（如離岸風電）合作創造產業新契機，美國造船產業則以建造軍用艦艇為主，而臺灣海洋運輸為我國海洋經濟最高產值行業，造船方面在政策面推動國艦國造，同時積極推動離岸風電產業，遊艇製造亦有全球前段班實力；「海洋生物資源」單元介紹海洋生物資源如何永續發展利用；「新興產業及趨勢」單元則介紹海洋再生能源、藍色生物經濟、海洋礦物、海水淡化，海事防禦以及海底纜線等新興產業面對的挑戰與未來發展的潛力，以及COVID-19疫情下聯合國貿易和發展會議（UNCTAD）建議推動之綠色成長趨勢以及Ocean Panel提出之藍色經濟5大優先措施。以上單元囊括歐美等國重點海洋產業，可供我國未來藍色經濟產業永續發展之參考。

圖說／遊艇觀光為海洋觀光產業關鍵產業之一（圖為美國加州Marina del Rey遊艇碼頭）
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臺灣海洋觀光永續發展

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關鍵字／海洋觀光、遊艇、郵輪、跳島觀光

海洋觀光產業係指以海洋資源為基礎的旅遊活動，讓遊客從中獲得娛樂、健身、消遣、休閒等目的，進而產生經濟效益和社會效益的產業行為，亦為下一個打造優質觀光品質的關鍵產業之一。本篇介紹臺灣海洋觀光產業及休閒遊憩活動，包括遊艇觀光以及郵輪觀光，並介紹臺灣海洋觀光永續政策。

自從臺灣設立「觀光立國」願景而於2002年推動「觀光客倍增計畫」，臺灣觀光市場逐年穩定成長，遊客人數、產值或是世界排名均有良好表現[1]。由觀光表現來看，2019年來臺旅客約1,184萬人次，較2018年成長7%，觀光產值也增長至144億美元，規模雖低於全球的GDP貢獻10%，卻也占臺灣整體GDP約4%且逐年進步，整體觀光旅遊規模在「世界觀光旅遊委員會」（WTTC）的世界排名為第37名，就算是2020年初的嚴重特殊傳染性肺炎（COVID-19）疫情衝擊了全球觀光市場，導致全球觀光市場衰退的同時，臺灣觀光產業的世界排名仍然成長到第36名。

2020年疫情造成的封城鎖國，讓許多人無法出國。然而，人們對於觀光與休閒旅遊的需求仍舊存在，造成臺灣國內旅遊的風潮興起，成為了政府引導發展優質觀光設施及服務品質的重要契機。其中，海洋觀光為下一個打造優質觀光品質的關鍵產業之一。

根據「國際海岸與海洋觀光協會」（The International Coastal and Marine Tourism Society, ICMTS）的「海洋觀光」（Coastal and marine tourism）定義：「海洋觀光為離開居住地，旅行到海洋環境及海岸區域所從事的遊憩活動。」因此，海洋觀光產業係指海洋資源為基礎，透過海上旅遊、濱海旅遊和海底旅遊等活動，讓遊客獲得娛樂、健身、消遣、休閒等目的，進而產生經濟效益和社會效益的產業行為。因此，從地理位置及海洋資源來看，都能發現臺灣是一個發展海洋觀光的良好地區。

臺灣位於太平洋與歐亞大陸交會點，四面環海，週遭海域面積為陸地的5倍，全國自然海岸線約1,105公里，海洋觀光資源豐富，具有發展海洋觀光休閒的4S元素：沙灘（Sand）、海水（Sea）、陽光（Sun）與海鮮（Seafood）[2]。臺灣也擁有全球少見的海水溫泉、豐富的海洋魚類約3,000種，占全球魚種的十分之一，珊瑚礁區蝶魚共43種，鯨豚種類至少29種，占全世界鯨種（79種）的三分之一以上[3]。但是，因為特殊的政治處境與「重陸輕海」政策，造成海洋活動較少被民眾所接觸。直到1988年內政部發布「臺灣地區海上釣魚活動管理辦法」才開始海上休閒遊憩風氣，例如海釣、帆船、風帆、衝浪、獨木舟、水上摩托車、拖曳傘、風箏衝浪、遊艇、郵輪等活動。臺灣雖然發展海洋觀光的時間較晚，但在各項海岸、海面上及海面下的遊憩活動卻有快速成長及龐大的觀光商機[4]，例如近10年流行的海洋休閒遊憩活動，遊艇觀光或是郵輪觀光（cruising tourism）即屬之。接續介紹如下。

臺灣海洋觀光產業及休閒遊憩活動

黃釋緯、陳璋玲（2019）認為臺灣海洋產業活動共有11項（圖1），合計產值約211.4億美元[5]。其中，海洋觀光、遊憩業占了9.09%（約192萬美元），包含提供海岸、海面上及海面下等3大類觀光活動、遊憩服務，及其附屬設施經營管理、用品與設備產銷、旅行服務之行業，活動類型有魚與生物資源導向活動（如觀光漁港）、近岸與水域遊憩活動（磯釣、潮間帶活動、戲水活動、水上活動）、海洋教育活動（宗教活動、藝文活動）、船舶遊覽活動（遊艇參訪、郵輪旅遊、賞鯨生態旅遊）、生活體驗活動（海岸漁業體驗、近海漁業體驗）。臺灣海洋觀光產業近年來較具規模的活動以郵輪觀光較為亮眼，根據臺灣港務公司統計，搭乘郵輪旅客人次從2015年的56萬人連年成長，2016年66萬人次、到2018年約94萬人次，臺灣國際郵輪協會（ICCT）吳勛豐理事長說，2019年更超過102萬人次，年產值超過1.8億美元[6]。

另外，臺灣海洋觀光人次，藉由整合臺灣觀光局資料，收集與海洋遊憩相關景點之遊客人數，共有9個主要觀光遊憩據點、離島國家公園與國家級風景特定區（海洋生物博物館納入墾丁國家公園範疇），及21個其他海洋與近岸觀光遊憩景點之旅客可納入統計，在2016～2018年合計達52,560,606人次。

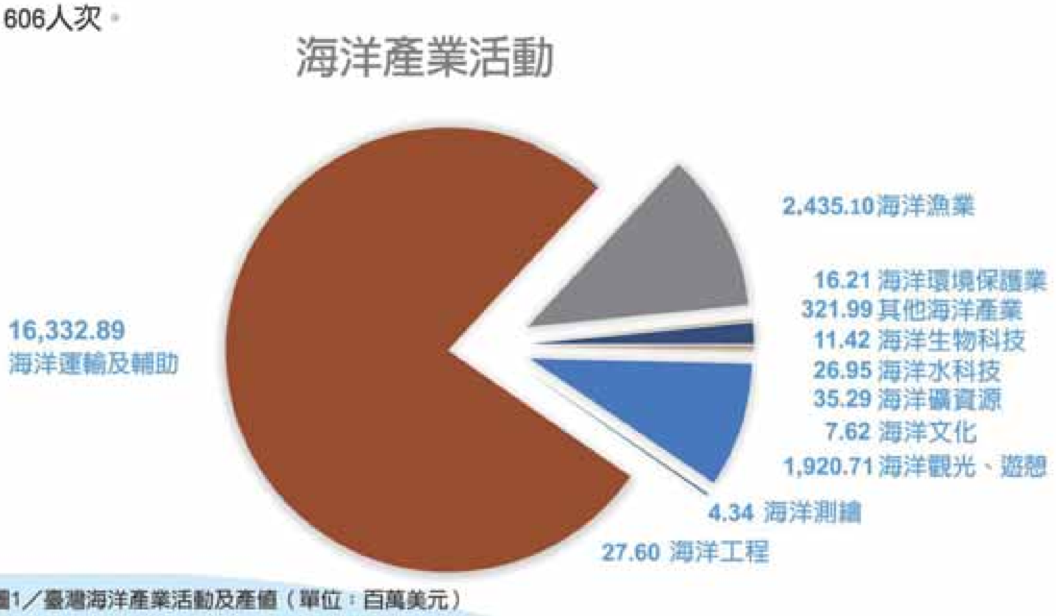

圖1／臺灣海洋產業活動及產值（單位：百萬美元）
資料來源／黃釋緯、陳璋玲（2019）[5]

遊艇觀光

臺灣遊艇產業於1958年開始發展，初期在淡水河畔由幾家木造舢舨廠商與喜愛遊艇的業餘專家共同合作，開始木造遊艇生產設計及建造[7]，臺灣遊艇因而具備：1.精良的木工技術、2.業者勤勉、追求平價、模仿領悟性強，深受在臺美軍的喜愛，進而外銷到美國西海岸而逐漸打出知名度，很快風靡全球海上休閒遊樂市場。為了出口便利性，第一波廠商不但在淡水開始擴充，新進業者也在高雄設廠，北部以基隆港為出口中心，約有7家廠商；南部則群聚在臺南、高雄，以高雄港為出口中心，約20餘家業者，主要集中在高雄臨海、大發、旗津。

發展迄今，臺灣遊艇產業以遊艇製造業聞名於世界，為世界遊艇製造前10大的製造國，主要以外銷為主；政府及民間各界也積極推動各類水上遊憩活動、競賽、擴大辦理親水活動。另外，根據Boat International在2019年的各國大型遊艇訂單總長度排名統計，以義大利14,374公尺居首位，依序為荷蘭、土耳其、英國及德國，臺灣則以1,852公尺排名全球第6，居亞洲第1。在2019年全球遊艇接單前20名廠商中，臺灣「東哥企業」與「嘉鴻遊艇」分別排名全球第7與第9。

表1／各國大型遊艇訂單總長度及世界排名

全球國家排名	國家	訂單總長度（公尺）	全球廠商排名	廠商	訂單總長度（公尺）
1	義大利	14,374	1	Azimut-Benetti	3,537
2	荷蘭	4,334	2	Sanlorenzo	3,063
3	土耳其	3,071	3	Feadship	1,217
4	英國	2,119	4	Sunseeker	1,038
5	德國	1,974	5	Lurssen	1,032
6	臺灣	1,852	6	Amels-Damen	931
7	中國	989	7	Alexander Marine（東哥，中華民國）	928
8	美國	959	8	Heesen Yachts	730
9	挪威	353	9	Horizon（嘉鴻，中華民國）	709
10	阿聯酋	344	10	Overmarine	514

資料來源／黃琴斐（2020）[8]

表2／臺灣遊艇出口值與地區

統計期間	出口值（千美元）	美國	澳洲	義大利	日本
2015	173,154	132,813	13,542	-	9,390
2016	174,391	129,445	8,455	-	978
2017	149,612	115,783	4,476	1,252	6,182
2018	167,788	123,164	22,221	-	5,146
2019	231,554	159,011	31,961	8,495	6,019
與去年同期比較增減率					單位：%
2015	1.4	57.3	-2.5	-	-62.7
2016	0.7	-2.5	-37.6	-	-89.6
2017	-14.2	-10.6	-47.1	-	532.1
2018	12.1	6.4	396.4	-	-16.8
2019	38.0	29.1	43.8	-	17.0

資料來源／黃琴斐（2020）[8]

同時，臺灣遊艇外銷市場表現亮眼，2019年出口值約2.3億美元，占整體船舶出口值之57%，年增38.0%。其中，遊艇廠商多與美國簽訂長期合約，出口因而以美國為主，占68.7%居首，澳大利亞占13.8%次之，另義大利占3.7%，日本占2.6%。

臺灣遊艇消費市場以會員制為主，集中在高所得的金字塔族群。以亞果遊艇集團2020年為例，它在高雄港、臺南安平港、澎湖馬公港設有遊艇碼頭，現約有600位會員，會員費集中在5萬美元，最高的會員費為34萬美元。同時，成立樂活海洋學院（Lohas ocean maritime academy），以遊艇及帆船結合生活藝術，引領會員享受海洋生活，並以臺南安平港為基地，打造150個泊位、結合飯店住宿、高檔villa渡假村、主題商城，以及週邊安平文化老街等，定期嘉年華會與不定期遊艇體驗，形成完整的遊艇水域及陸域活動，在臺北亦有類似小規模的遊艇俱樂部，而臺中市政府與臺中港務分公司亦積極籌劃藍色公路遊艇及郵輪活動當中。

郵輪觀光

亞洲為近年新興的郵輪藍海市場，臺灣因地理位置成為亞洲第2大客源市場，具有發展郵輪市場潛力之利基[9]。在2019年，亞洲郵輪市場有39個郵輪品牌營運於亞洲水域，共部署79艘郵輪，乘客數超過402萬。2013年到2019年間，航行亞洲及彎靠亞洲各地的航程保持持續增長，從2013年的861航次增加到2019年的1,917次。2019年，亞洲彎靠最多的目的地國家依序是日本（2,681）、中國（809）及馬來西亞（561）和泰國（550）；如以單獨港口排名，依序是新加坡（400）、臺灣基隆（284）和中國上海（276）；母港來回最多者，則是中國、臺灣和新加坡。全球發展郵輪旅遊前3大的國際郵輪公司，如美洲嘉年華（Carnival Cruises）、皇家加勒比海（Royal Caribbean International, RCI），以及挪威假期（Norwegian Cruise Line）。亞洲地區以雲頂郵輪集團較為知名，旗下包含水晶、星夢及麗星郵輪（Star Cruises）。其中，麗星郵輪將臺灣列為郵輪母港進行營運，2019年以臺灣基隆港為主要郵輪進出港，旅遊行程以來回返往的旅遊客為主，並且年複合成長率（compound annual growth rate, CAGR）在31%左右[10]。

然而，由於COVID-19的影響，市場有大幅衰減之勢，惟此係屬全球性風險，臺灣郵輪觀光的因應作法，則是在此段時間以扎根方向推動，例如持續郵輪港埠服務設施興建、讓港口城市地面接待行程優化等[10]。臺灣交通部觀光局除訂定「境外郵輪彎靠臺灣獎勵要點」外，亦鼓勵結合航空的Fly Cruise、碼頭－景點間完善交通服務，包含落實政府郵輪南北雙母港政策，基隆港和高雄港港埠設施優化計畫，以及整合航港、觀光資源推動客運海上藍色公路。另外，加強港口國際行銷，用以擴大郵輪周邊產業在臺商機。

臺灣旅行社為因應COVID-19疫情，積極與星夢郵輪（探索夢號）合作，在2020年7月推出跳島玩法，於2020年8～9月出遊，成為全世界數一數二復航的國際郵輪，行程由基隆出發，遊澎湖、金門、馬祖[11]。5天4夜行程的房價，分海景房（約400美元）、露臺房（約500美元）及皇宮套房（約900美元）3類，原訂的5航次在48小時內完售，累積逾4,000位候補，因而加開4航次，每航次只開放50%的載客量（原3,630人）。同時，制定「八重防控保障」：登船離船、客房區域、公共區域、食品衛生、活動演出、新風系統、醫療設施、船員防護等核心防控，以確保旅客和船員的安全健康，此類郵輪跳島行程將會成為新型態的觀光模式。

臺灣海洋觀光永續政策

臺灣政府為永續發展海洋觀光產業，提出「藍色公路十年綜合發展規劃」（2021～2030），從「航」、「港」、「船」、「遊」、「貨」5大面向，擬定短、中、長期計畫，預計在未來10年，政府結合民間資金投入8.4億美元（新臺幣500億元）。針對航運、港埠、船舶等提出各類公共運輸、汰舊／獎勵補助及更新，在藍色公路的海運與海洋休閒旅遊方面，預估將：1.獎助航次載客量期間，可增加船票收入770億元（新臺幣，以下同），離島地區每年增加就業機會至少100名；2.郵輪跳島行程增加離島觀光收入48億元；3.郵輪進出港旅客量成長至每年200萬人次，郵輪經濟效益達1,200億元；4.郵輪自有品牌將創造300個工作機會；5.藉著舉辦國際級帆船競速賽事，並擴大舉辦遊艇行銷活動，結合各縣市政府既有觀光資源及特色活動。例如，臺南安平港發展遊艇碼頭可提供3,700個工作機會，土地開發效益及引入民間投資達100億元。最後，綜覽國內外海洋觀光產業的永續發展，積極進行跨域整合，推動海洋產業結構轉型與創新發展，海洋文化的教育培育，以及海洋環境生態的永續管理，當為未來臺灣海洋觀光發展之核心[2]。

參考資料

[1] 周永暉、歐陽忻憶、陳冠竹（2018），臺灣觀光2020永續發展策略，臺灣當代觀光，1（1），1-20。

[2] 吳英偉、蕭登元、劉喜臨（2019），我國海洋觀光產業與發展之研究，海洋委員會委託研究
https://www.oac.gov.tw/ch/home.jsp?id=45&parentpath=0,4&mcustomize=research_view.jsp&dataserno=201908200013

[3] 趙雨姿、蔡佩君、楊達鑫、吳秉叡（2009），臺灣海洋經濟發展之研究，行政院經濟建設委員會
http://ws.ndc.gov.tw/Download.ashx?u=LzAwMS9hZG1pbmlzdHJhdG9yLzEwL3JlbGZpbGUvNTg2OC83NTUzLzAwMTE4ODFfMTgucGRm&n=MTYu5Y%2Bw54Gj5rW35rSL57aT5r%2Bf55m85bGV5LmL56CU56m2LnBkZg%3D%3D&icon=..pdf

[4] 陳瑋玲（2007），臺灣海洋觀光遊憩研究之回顧與評析，稻江學報，2（2），46-68。

[5] 黃釋緯、陳瑋玲（2019），海洋產業統計與經濟推動策略規劃，海洋委員會委託研究
https://www.oac.gov.tw/ch/home.jsp?id=45&parentpath=0,4&mcustomize=research_view.jsp&dataserno=201908200024

[6] 胡順惠（2019），郵輪旅遊發大財！年產值破50億元，2020年估創百萬人次巔峰
https://www.ettoday.net/news/20190716/1491290.htm&ct=ga&cd=CAIyIjBjZjgyNWQxYWIyNzFmZmM6Y29tLmhrOnpoLVRXOkhLOkw&usg=AFQjCNGfRJqAcgT7YjH3F_iNzqSsDNscDw

[7] 怡興工程顧問有限公司（2016），臺灣遊艇基地整體評估規劃，交通部航港局
https://www.motcmpb.gov.tw/ServerFile/Get/71a128b8-d72c-44f0-9662-2fc55fb32099?DLCount=1

[8] 黃琴斐（2020），產業經濟統計簡訊354期，經濟部
https://www.moea.gov.tw/mns/DOS/bulletin/wHandBulletin_File.ashx?file_id=21480

[9] 交通部（2020），藍色公路十年綜合發展，（臺北市：臺灣），交通部。

[10] 劉喜臨（2020），臺灣郵輪觀光年鑑2020，（高雄市：臺灣），國立高雄餐旅大學

[11] 吳雨潔（Jul. 27, 2020），直擊全球第一艘復航的國際郵輪，跳島旅遊如何玩的安心?天下雜誌
https://www.cw.com.tw/article/5101319?template=fashion

全球海洋能源技術創新及推動策略現況

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關鍵字／海洋能源、發電均化成本、永續發展目標

國際對海洋能源定義包括運用海洋資源的新興再生能源如潮汐、波浪、洋流及溫差能等形式，及離岸風電、傳統石油與天然氣[1]。當前海洋能源除了技術發展，如何有效導入政府政策，是海洋能源及相關產業發展的重要契機。本文簡述主要海洋能源技術與特性，並介紹當前國際海洋能源技術發展趨勢及政策規劃概況。

臺灣東臨太平洋，西以臺灣海峽與中國相望，本島南北長約377公里，東西寬約142公里，海岸線全長約1,200公里，若包含澎湖群島總長約1,520公里。在東北季風及黑潮等有利的條件下，潮汐、波浪、洋流及溫差能等海洋能源的蘊藏量豐富，然由於成本及技術因素，上述海洋能源發展仍處於研發與示範階段。

發展海洋能源對於調適氣候變遷有所助益，可以減少對傳統化石能源發電的依賴，達成減少二氧化碳排放；其次，海洋能源發展可以運用於航運、冷凍空調及海水淡化等藍色經濟發展，除了增加其就業人口外，也可達成聯合國永續發展目標（SDGs），包括核心目標7和核心目標14，解決與再生能源發展及海洋永續發展之課題。而且，海洋能源技術相對於風力及太陽能等間歇性能源更加穩定，可以做為基載能源，使國家能源更加穩定。

國際海洋能源之發展，由於不同地理環境的海域存在著不同的海象特性，加上我國多颱風、暴雨的氣候，其他國家相同的工程或技術，並不一定適用我國海域。目前我國的海洋能源技術研發主要集中在學校及工研院等智庫，除了蒐集我國的地理環境及海象特性，建立海洋能源發展在地性之條件與限制外，也進行相關技術之開發及示範。海洋能源係屬新創再生能源之一，除了技術研究發展外，如何以政府政策引領產業投入，將是海洋能源產業發展之契機。

主要海洋能源技術與特性

海洋能源（ocean energy）大多係受到地球、月球與太陽間的引力關係及地球自轉的影響產生的能量。主要能源類型依其發電特性分為5大類：潮汐能（tidal barrage/range）、洋／潮流能（tidal stream / tidal current）、波浪能（wave energy）、溫差能（ocean thermal energy conversion, OTEC）、鹽差能（salinity gradient）。首先，潮汐為海域中海水週期性的往返流動與漲退，所引起的永久穩定存在之海流。潮汐能係利用潮差的位能轉換成電能，由於經濟效益、地理環境限制等影響，潮汐發電受到諸多限制，例如潮差應達5公尺以上才有經濟效益，法國朗斯河口的潮汐發電廠，潮差達13.5公尺。另外，潮汐發電機必須在海灣建築水壩，工程用地難找且成本較高，且還會面臨庫區淤積、設備腐蝕等問題。

洋流能與潮流能通稱為海流能，洋流能主因海水溫度鹽度差與地球自轉所造成的，海流會循環週期性的在各大洋間流動，在赤道較為溫暖的海水受風、科氏力、地形的影響，會流向南北極冷卻、下

沉後，再回流到赤道形成洋流。洋流能擷取能源的方式類似於風力發電，利用海洋中的海流驅動渦輪機再轉換成電能。潮流能則是利用漲落潮水推動渦輪機進行發電，大部分設備浸沒在水下，無須建設水壩，工程用地成本降低，且相較於海流在深海施作，潮流擷取設備離岸較近，維修操作較容易；且渦輪機組受潮流轉動速度較低，對水文環境及海洋生物影響輕微。目前較成熟的渦輪機組分為垂直軸、水平軸、振盪水翼及套管式。

波浪能係以發電機組裝置將波浪的動能轉換成電能。波浪轉換系統通常可分為3部分。第1部分為擷取系統，將分散的入射波浪聚集於一區域上，提高波浪的振幅與能量密度。第2部分為轉換系統，把獲取的波浪能量轉換成電能，第3部分則是儲能系統。

溫差能是利用海洋表層海水與深層海水之溫差熱能，轉換成電能之發電方式。一般而言溫差在20℃間，有較佳的利用價值，在赤道至南北緯30度之間之海洋，比較具有適合發展溫差能之條件。溫差電廠主要分為陸基式、淺灘式及浮動式3種。

鹽差能係利用河流出海口之鹹、淡水鹽度的濃度差異，釋出化學能並將其轉化為可用的電能。目前兩個主要的測試或應用的發電技術分別為PRO（pressure retarded osmosis）和RED（reversed electro dialyses）。

表1／各類海洋能源之特性

類別	能量來源	能源豐沛區	能量要素	穩定性	開發成本
潮汐能	由地球表面海水因太陽及月亮的引潮力產生	介於緯度45°~55° 間的大陸沿岸	與潮差的平方及港灣面積成正比	非常規律	較高
洋／潮流能	由地球自轉及海水溫度、鹽度分布不均引起的密度、壓力梯度或海面上風的作用產生	北半球兩大洋西側	與速度的平方及流量成正比	比較穩定	低
波浪能	由海面上風的作用產生	北半球兩大洋東側	與波高的平方及波動水面面積成正比	較不穩定，週期約為1~10s	較高
溫差能	由海洋表面與深層吸收太陽輻射熱量不同及大洋環流熱量輸送而產生	低緯度大洋	與具有足夠溫差海區的暖水量及溫差成正比	相當穩定	高
鹽差能	指海水和淡水之間或兩種含鹽濃度不同的海水之間的化學電位差能	海水和江河淡水相交界之處	能量比溫差能還要大，無論白天晚上都能夠發電	較不穩定	高

資料來源／郭玉樹等人（2019）[2]

未來海洋能源發展重要趨勢

隨著技術之進展，根據「國際再生能源總署」（International Renewable Energy Agency, IRENA）報告[1]列示以下重要發展趨勢：

一、潮汐能是目前布建最多的海洋能源，但洋流能及波浪能為技術發展快速的海洋能源

2020年已有高達2.83GW裝置容量的海洋能源電廠正在規劃或示範中，到2030年時，可商業化的裝置容量更高達10GW。攔水型潮汐能是目前布建最多的海洋能源，占全部海洋能源的比重高達98%，總裝置容量為521.5MW，主要設置在韓國（254MW）和法國（240MW），二國電廠總裝置容量為494MW，而加拿大（20MW）、中國（4.1MW）和俄羅斯（3.4MW）占比相對較低。然而因潮汐能之設置受地形影響很大，過去10年來，並無新設電廠。

全球營運中的洋流能及波浪能為12.91MW，此二種發電技術正以超過1MW的規劃持續建置中，以波浪能占大多數（10.6MW），洋流能的技術進步快速且已漸達到可商業化的階段，而波浪能也正朝向更高階的技術階段，但是相較之下，雖有小規模長時間運轉案例，多數仍處於示範階段。

二、溫差能、鹽差能及洋／潮流能在10年內具有發展潛力，但波浪能技術發展分岐

以上能源類型以往屬於小規模布建，目前也開始朝向擴大規模方向，但是前3種技術主要仍處於研發階段，主要投入為研究機構或是大學，少有企業投入。當前重視海洋能源且願意投資規劃部署的國家約有31個國家，其中歐洲國家占比超過一半，其次是亞洲國家。水平軸機組是較為成熟的洋流能技術，也是目前各國規劃中的主要機組技術，然而另一風箏型技術之應用也不容小覷，主要是其可運用於比較低流速的環境，此使水平軸機組能否為主流技術，仍有待觀察。相較之下，波浪能技術並無收斂現象，目前幾乎有10種不同的技術同時在發展中，但仍可觀察到兩個不同的方向：一是機組容量及電廠規模朝向大型化，另一則是建置較小容量或是特定目的的設備，例如提供離岸風電平臺電力或將海水抽到岸邊進行海水淡化。

三、海洋能源的發電均化成本（Levelized Cost of Electricity, LCOE）比預期低

在早期的生命週期階段，所有的海洋能源發電均化成本不容易預測與具有不確定性。目前的洋流每度電力發電成本介於0.2～0.45美元；波浪能則是介於0.3～0.55美元。目前的開發成本仍有可能再次下降，例如洋流能在2022年到2030年之間可以下降到每度發電成本為0.11美元。波浪能在2025年到2030年間則可以下降到0.22～0.165美元[1]。

四、有效保障收益及政策補助是海洋能源的關鍵因素

如上所述，由於海洋能源的發電均化成本仍較現在的風力、太陽光電、生質能發電成本高。因此，除技術突破外，能否提供融資的環境或是提供降低發電成本的創新性融資機會，將是海洋能源發展不可或缺的一環。在提供相對應的資源後，海洋能源發展將躍升為藍色經濟的重要項目，並可以和在海洋的傳統能源（石油、天然氣）、離岸風力、漁業與海水淡化等產業產生綜效。另一方面，海洋

表2／建議行動和利益相關者識別

建議行動	利益相關者	影響
改善商業案例	政策制定者產業 電力系統業者	使用海洋能源為藍色經濟提供動力，並與其他離岸產業（例如：港口、貨運、海水淡化、石油與天然氣等）結合
	電力系統業者 能源規劃業者	將海洋能源納入成為可整合VRE和儲能的可預測能源來源
	政策制定者	與其他VRE裝置（例如：波浪能和離岸風電）的聯合招標
	政策制定者 地方主政者	推廣在離島、沿岸社區和微電網上的應用
	專案開發商 政策制定者	量化並考慮其他優點、規避成本、外部因素（例如：創造就業機會、緩解氣候變遷或保障能源供應等）
改善財務支援取得方式	政策制定者 主管機關 金融機構	建立專門針對海洋能源的創新性財政收入支援方案（例如：本地投資、獎勵、容量型的資金、技術到位的指數型資金）
	政策制定者	推廣混合型融資，鼓勵私人股權投資基金投資有利社會並有助於實現永續發展的專案，同時為投資者提供財務報酬
	金融機構 私人投資者	投資於海洋能源技術
	政策制定者	改善營收和資本支援方案涵蓋所有開發階段（研發、部署、營運）
	金融機構（多邊捐助者）	增加開發中國家和小島型開發中國家的資金取得方式
建立並加強資源和場址評估	主管機關	為現場評估和鑑定制定法規程序和架構
	政策制定者	進行有效率的海洋空間規劃（MSP），並從區域和國家層級整合海洋能源
		將對應的能源蘊藏量納入氣候和能源策略之中
	能源規劃業者	使用先進的建模工具
	資料擁有者	改善對基準資料的存取和交換，並滿足對更多資料的需求
	電力系統業者 開發商	將對本地電網容量和需求的評估加入現場評估之中
	主管機關	提供環境衝擊評估的指導和架構
建立供應鏈	私人產業 沿岸社區	運用本地專業知識並建立供應鏈（納入當地企業）
	成熟的離岸產業	調整相關離岸產業的供應鏈
推動海洋能源政策和法規方案	政策制定者	將海洋能源納入長期的國家和/或區域能源藍圖及國家自定貢獻（NDC）
		建立具有國家目標的明確政策
	主管機關	與金融機構往來並提供支援
		消除許可流程中的瓶頸
透過改善技術的可靠性和效率將風險降至最低	國際組織	採用國際電工委員會的技術規格和原型／元件／類型／專案認證的進階開發（即能源分導系統、基座、錨泊設備等）
	政策制定者 主管機關	開發及推廣使用現有評估架構來追蹤及比較開發進度，例如階段關卡指標
	公用事業 私人產業	開發創新的混合型再生能源系統，以與其他技術整合及共用平臺
	資產擁有者	收集和共用效能資料
	技術製造商 開發商	透過部署陣列來擴大製造規模
	技術製造商	使用可與其他再生能源發電技術相容的模組化設計
加強合作開發海洋能源	國際組織（如IRENA）	分享最佳實務和經驗教訓（在海洋能源產業和其他離岸產業中）
	政策制定者 國際組織（如IRENA）	強調利益相關者的合作關係並建立國際合作
	電力系統業者 私人產業	與當地電網業者合作，升級及改造基礎建設，以實現海洋能源的連接
	教育機構 大學	透過教育計畫提高員工技能
	政策制定者 公民社會	儘早諮詢民眾並與民眾互動

資料來源／IRENA （2020）, 19-20 [1]

能源在海島國家或是離島區域的能源發展具有利基，由於傳統能源管線等基礎建設在離岸區域，成本皆相對較高，因此海洋能源在政策補助及永續發展的誘因下，不僅可以降低其發電均化成本，也可以吸引企業投資（企業社會責任與永續發展）。

五、發展海洋能源可以與海洋防護設施整合

由於氣候變遷，造成未來海平面上升的風險增加，將海洋能源設施與相關海上水壩、海堤、橋梁等設施整合一起，是氣候變遷減緩與調適的可行方案。其成本效益的分析，也可以透過標準化的模式，在不同階段下進行評估。

六、國際合作及多邊合作是海洋能源發展的重點

當前海洋能源技術發展有待突破，如何透過國際知識與資訊共享以及國際合作，是海洋技術提升的關鍵；與既有成熟的海洋能源如石油、天然氣及離岸風電廠商合作，則可以有效降低技術瓶頸或是健全其產業供應鏈管理，降低海洋能源相關營運上的風險。

政府政策支援是海洋能源成功關鍵

海洋能源發展的核心在於如何降低其技術成本，使之能與其他各類再生能源競爭。如何建立其各自的商業模式，並加上政府提出各種不同的財務工具，可有效降低對海洋能源的投資風險，大致上分7大行動策略（表2），包括加強示範案例、改善取得資金支持、海洋資源及場址之評估、建立供應鏈、加速海洋能源政策及法規建立、降低技術風險及改進效率、加強合作開發海洋能源等，並規劃對不同的權益關係者提供對應的發展應用措施，以促進海洋能源發展。

結語

海洋能源具有促進永續發展的特性，相較於現行的離岸風電或太陽能等間歇性再生能源，具有穩定發電的效益，可以做為基載能源，配合前者發展，更具維持能源穩定功能。海洋能源發展是藍色經濟發展重要的一環，臺灣四面環海，具有發展海洋能源的利基。然國際海洋能源發展，仍面臨各種不同課題，除了技術外，如何降低發電成本，如何提供財務支持與獎勵政策，皆是政府應該優先考慮的策略。政府的政策，有義務建立良好的海洋能源產業發展環境。

參考資料

[1] IRENA (2020), Innovation Outlook Ocean Energy Technologies
https://cisp.cachefly.net/assets/articles/attachments/84174_irena_innovation_outlook_ocean_energy_2020.pdf
[2] 郭玉樹等（2019），海洋科技發展中長期先期規劃研究，海洋委員會委託研究。

海洋運輸與造船產業動態分析

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海洋運輸對全球經濟至關重要，是國際物流中重要的運輸方式之一，其運輸量占全部國際運輸量的比例大約在80%以上[1]。此外，國際海運的溫室氣體（Greenhouse Gas, GHG）排放只占全球每年排放量的3～4%[2]，故海洋運輸為有效的節能運輸方式。海洋運輸是海洋產業中緊扣相連的一環，船舶建造與維修則是充滿創新與競爭之產業，並與全球景氣息息相關。本篇介紹歐、美、臺海洋運輸、船舶建造與維修產業動態分析與報導。

海洋運輸倚靠自然環境、船舶航行與港口設施，具有以下特點[3]：

一、天然航道

海洋運輸船舶以天然海域航行，不受道路、鐵路軌道的限制。隨著政治、貿易環境以及海洋環境條件的變化，可彈性調整航線完成海運任務。但也因為如此，容易受海洋環境的影響，航班不易準確，海上遇到惡劣海況的可能性也大。

二、單船載運量大

隨著國際航運業的發達，現代化的造船技術日益進步，船舶逐漸往大型化發展。極大型油輪（Ultra Large Crude Carrier, ULCC）可達50萬噸以上，大型貨櫃輪的最大載量已超過2萬個TEU（Twenty-foot Equivalent Unit，20呎標準貨櫃）。

三、單位運輸成本低廉

海上運輸為天然航道，港口設施一般為政府的公共建設，因此海運公司可以節省投資大量的基礎設施。且船舶運載量大、使用壽命週期長、運輸距離遠，單位運輸成本較低，為大宗貨物的往來提供了方便、有利的運送條件。

過去幾十年來，全球景氣循環變化，大幅影響海洋運輸業發展。當景氣好轉時，海洋運輸的運費也跟著上漲；但景氣低迷，有時其運費收入甚至不敷營運及租金成本支出。其中，航運價指數為影響海運業者獲利的重要指標，航運對油價的敏感度相當高，舉凡油價走勢與附加費用之收取，都是影響公司獲利的重要關鍵[4]。

船舶是海洋運輸主要交通工具，貨船的主要類別有：貨櫃輪、散裝船、油輪等。近年船舶建造與營運有以下趨勢：

一、船體大型化趨勢：由於造船工程技術進步，船舶的尺寸不斷增加，期望透過擴大單船載運量來降低運輸成本，但也影響了港口業及其周圍的基礎設施。由於2015年新蘇伊士運河啟用，2016年巴拿馬運河拓寬完成，大型船舶可航行通過新運河，以貨櫃輪為例：根據法國海運諮詢機構

Alphaliner調查統計[5]，至2019年底，7,500TEU～9,999TEU的貨櫃輪占總運能的18%，10,000TEU以上的大型貨櫃輪占約36%（達到573艘）。

二、船齡年輕化趨勢：至2020年初，船齡20年以上船舶僅占貨櫃輪總艙位數的7%，15年以上的船舶則占13%[5]。一般船舶設計營運壽命約15～20年左右，亦會受到營運狀況調整，提早進行報廢、拆除。

造船廠的新船訂單情況，也同樣隨海運行業的營運情形而變化，當景氣繁榮或船舶需求增加時，新造船價格上升，船東下訂新船時，訂單甚至需排到多年後；但景氣下滑或市場船舶過多時，新造船價格下跌，鮮少船東下訂。不過，仍有遠見或膽識的航運業者，在營運及運價低迷時期，積極購置新船與調整船隊規模，俾在景氣反轉時，能取得獲利先機。

除了船舶使用之正常保養外，在一定運轉週期後，須回到造船廠進行上架保養與大修。另外，近年因應節能趨勢或法規要求，現有船舶須進行節能及污染防治設備之加裝作業。

歐盟相關產業動態

海洋運輸在歐盟經濟貿易中扮演了關鍵角色，估計約占歐盟對外貿易的75%到90%之間，和歐盟對內貿易的三分之一。2018年，超過4.1億人次的郵輪和渡輪乘客在歐盟港口上、下船，比前一年增長5.6%。同年，通過短途海運往返歐盟主要港口的貨物總重量（不包括遠洋航線）為18億噸。總體而言，海運業工作約占歐盟藍色經濟工作職缺的8%（約41萬人），附加價值毛額（Gross value added, GVA）之16%（約356億歐元）及利潤（Profit）的20%（約188億歐元）。海洋運輸直接僱用人員年平均工資估計接近41,800歐元（約新臺幣143萬元），比2009年增長11%。歐盟各國中，德國在海運業居領先地位，貢獻了32%的工作職缺和33%的GVA；其次是義大利，分別提供了17%的工作職缺和13%的GVA[6]。（附加價值毛額〔GVA〕：為了衡量經濟體某一區域，或產業所創造的商品服務價值，算法與國內生產毛額〔GDP〕息息相關，為GDP減去產品稅收加上產品補貼[7]。）

在造船方面，如英國、德國、法國、義大利、荷蘭、西班牙等國，主要產品為高技術與高價值船舶，如：超大型豪華遊艇、巨型郵輪、離岸工作支援船，其品牌設計與製造能力，在全球造船業占有重要角色。近年來，旅客船（渡輪和郵輪）、離岸工作船和其他非貨運船舶（other non-cargo carrying ships, ONCCV），這兩類船舶占歐盟新造船訂單的95%以上（圖1）。歐盟造船業面臨中國與韓國等國的造船企業競爭，原因在於亞洲國家政策的大力支持和造船市場價格的下跌（例如散裝船、貨櫃輪與油輪等）。近年除了歐洲和亞洲的船廠直接競爭外，亞洲新船訂單數目下降，間接影響在歐洲的設備供應鏈，原因為亞洲船廠所安裝設備主要由歐洲企業所提供。由於歐洲海事發展歷史悠久與設有權威機構，在先進的海事導航設備研發居於世界領先地位，另外，世界最大的貨櫃船運經營業者埃彼穆勒─快桅集團（A.P. Møller-Mærsk Gruppen）總部即設在丹麥哥本哈根。

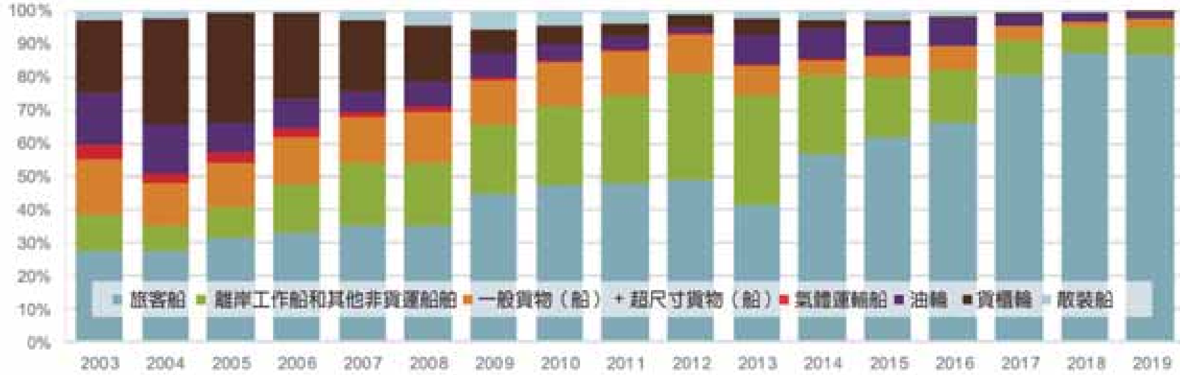

圖1／歐洲造船廠之船舶種類訂單歷年百分比
圖片來源／The EU Blue Economy Report 2020 [6]

雖然經濟和金融危機，對全球船舶產業的衰退有深遠影響，歐盟近年逐漸進行商業模式改變與勞動力外包，調整生產計畫和供應鏈來降低成本，圖2數據顯示，從2013年起有逐漸復甦跡象，但在經歷了連續數年的增長之後，2019年歐洲造船廠的總訂單量有所下降[6]。總體而言，歐盟船舶建造與維修行業占2018年歐盟藍色經濟總額工作職位的6%（32萬人，85%於造船業，15%於相關機械設備業），GVA的8%（173億歐元），利潤的5%（47億歐元）。歐洲各國中，英國以14%的工作職缺和21%的GVA領先於造船和維修業，緊隨其後的是德國，分別占12%的工作職缺和18%的GVA[6]。

圖2／歐盟船舶建造和維修行業經濟規模變化（單位：百萬歐元）
圖片來源／The EU Blue Economy Report 2020 [6]

歐盟造船產業亦對於藍色經濟活動提供了資金、技術、專門知識，例如捕撈漁業、近海水產養殖、非生物資源、海洋再生能源、沿海旅遊和海上防衛等。歐盟造船與設備行業，特別是與新興行業合作，提供了新的機會，例如離岸風電場的工作支援船、海洋結構物與其他海洋技術等。

美國相關產業動態

美國海洋運輸行業包括從事遠洋貨運、海上客運服務、海洋運輸服務、倉儲和導航設備製造的業務，占美國海洋經濟之就業人數的15%（約50萬人）及美國國內生產總值（GDP）的20.2%（約596億美元）。儘管美國海運業在海洋經濟中所占的比例低於其旅遊業、休閒或近海礦業，但在海洋經濟是不可或缺的組成部分，船舶運送的貨物按價值計算，占美國國際貨運貿易的34%，按重量計算則占73.4%。在2017年，每位員工的平均年工資為全美最高，達69,000美元（約新臺幣193萬元）。海運業在加州（California）提供約21.1%的就業機會和25.9%之GDP。其餘的則分布在全國各地，集中在主要海港地區。倉儲是海運業就業人數最大的組成部分，2017年占該行業總就業人數的52.8% [8]。

造船及維修行業包括一般船舶、休閒小船、商業捕撈船、渡輪和其他海上船舶的建造、維護保養和修理。其產業特性是大型造船廠集中在美國某些區域，但小型船建造和維修較均勻分布在全國，主要在商業捕魚區和休閒小船盛行地區。2017年，造船業在美國海洋經濟中占就業人數的4.8%（約16萬人），占美國GDP的6.6%（約184億美元）。每名員工的年平均年工資為69,000美元，遠高於全國平均水平的55,000美元。2017年，維吉尼亞州（Virginia）對造船業的就業人數貢獻最大，占全國造船業總數的22.2%。華盛頓州（Washington）是造船業之GDP的最大貢獻者，占全國造船業總量的21%[8]。

由於全球一般貨船銷售利潤不高，加上美國國內人力成本較高，故美國國內造船廠以建造美國海軍軍用艦艇為主；著名的民營造船廠如：紐波特紐斯造船公司（Newport News Shipbuilding Company, NNS）（圖3），為全美唯一建造航空母艦的造船廠，也是美國兩大核能潛艇製造商之一。另外，有些造船廠並不直接參與設計與製造新船，只承接船艦維修之工作。

圖3／紐波特紐斯造船公司網站
圖片來源／https://nns.huntingtoningalls.com/ [9]

臺灣相關產業動態

臺灣因島國位置，進出口貿易超過95%需仰賴海運，海洋運輸業為我國海洋經濟產值最高行業（占海洋產業GDP之40%以上）[10]，2019年臺灣國際商港累計貨櫃裝卸量1,530萬TEU，國際商港貨物裝卸量7.3億計費噸，相較於2018年略低，主要原因為鄰近各國港口崛起以及中美貿易戰影響，此外，國際商港進出港旅客人次約150萬人，其中，國際郵輪旅客增至105萬人，呈漸增趨勢，主要原因為基隆港逐漸轉型為兼顧觀光休閒、郵輪運旅，並積極推動成為國際郵輪母港，使得旅客人數再創近年新高。同年，兩岸海運直航貨櫃裝卸量249萬TEU，兩岸海運直航貨物裝卸量約1.2億計費噸，兩岸海運直航旅客人次約228萬人，國內商港進出港旅客人次約340萬人[11]，顯示配合發展離島建設政策，兩岸及國內海運交通占有相當比重。另外，國內重要航商包含：貨櫃航商長榮、陽明海運等，2020年世界運能排名分別為第7與第9[5]，以及散雜貨航商裕民、台航、中鋼運通等，均為提供國際貨物運送之重要角色[12]。

臺灣大型造船廠，以台灣國際造船公司（簡稱台船）為代表，其前身為中國造船（中船），以貨櫃輪、散裝船、軍艦及特種船舶製造為主，歷經再生計畫與民營化後，以多角化的經營為目標。中型船廠則有中信造船、龍德造船與三陽造船等，以建造海巡艦艇、公務船、交通船、遠洋漁船為主。近年，因應臺灣之國艦國造、潛艦國造政策，財團法人船舶暨海洋產業研發中心與中、大型造船廠合作，陸續承接多艘海軍船艦與潛艦設計、製造，厚植本土國防造艦能力。此外，臺灣遊艇廠，如嘉鴻、嘉信、東哥、大瑞遊艇，因臺灣氣候適合生產以玻璃纖維強化塑膠（FRP）製造技術之遊艇，從代工生產到提供客製化服務，走向巨型遊艇市場，臺灣製造的遊艇訂單總長度達到全球第6[13]，可見臺灣遊艇製造實力受國際肯定。船舶螺槳廠，如般若、瑞孚宏昌，宏昇螺旋槳等，專門生產民用及軍用船舶螺旋槳。另近年為提倡綠電，減少燃煤發電之廢氣排放，臺灣政府結合民間公司包含造船廠及相關機電產業，積極推動離岸風電產業，以期提高臺灣能源的自主率。整體而言，2017年臺灣船舶建造與維修產值為新臺幣420億元[14]，造船及維修行業就業人數約為2.5萬人[15]。

綠色海運

溫室氣體（GHG）引起的溫室效應問題，在1997年聯合國氣候變遷條約的《京都議定書》中，將國際海運GHG相關的排放量減少議題，委由國際海事組織（International Maritime Organization, IMO）處理。IMO於2008年開始著手GHG排放減量的工作，並於2013年1月1日起開始執行國際海運的排放量規定；2018年，IMO達成了第一個全球協議：2050年將航運的總溫室氣體排放量減少至少50%（與2008年相比），其具體的作法為使用能源效率設計指標（Energy Efficiency Design Index, EEDI）來表現消耗能源效率，EEDI指數越高，能源效率越低。EEDI涉及到船型、螺槳、推進系統與各種減低排碳設備等設計的改良。IMO要求新建船舶必須經過拖航水槽的船模試驗，確認符合EEDI廢氣排放標準後才能建造。

另外，IMO宣布「限硫令」於2020年1月1日起實施[1]，所有船舶於排放管制區（Emission Control Areas, ECA）航行時，必須使用含硫量低於0.1%之低硫燃油；且船舶於非排放管制區航行

時，必須使用含硫量低於0.5%之低硫燃油，以降低硫氧化物（SOx）的排放量，這項規定將會使航商船舶燃油成本增加，部分船舶則透過加裝脫硫洗滌器（scrubber），來降低硫氧化物排放。現有的ECA包括波羅的海（SOx，1997年通過；2005年強制實施）、北海（SOx，2005年7月通過；2006年強制執行）[16]、北美ECA包括美國大部分地區[17]、加拿大沿岸（NOx和SOx，2010/2012）[18]和美國加勒比海ECA，包括波多黎各和美屬維爾京群島（NOx和SOx，2011/2014）[19]。此外，根據「防止船舶污染國際公約（MARPOL）」附件VI的協議，可指定其他區域為排放管制區。

結論

海洋運輸為國際物流中重要的運輸方式，並且帶動了進、出口貿易、旅遊及製造業的蓬勃發展，另外，為了有效地減少污染，造船業透過創新的設計，與海運業導入氣候航程運用，經過適當的航路規劃減少能源消耗。未來，海洋運輸與造船產業將以更靈活的策略，面對世界經濟變化與全球氣候變遷。

參考資料

[1] International Maritime Organization (2020)
https://www.imo.org/ (Jan. 11, 2021)

[2] International Maritime Organization (2014), Third IMO Greenhouse Gas Study
https://www.imo.org/en/OurWork/Environment/Pages/Greenhouse-Gas-Studies-2014.aspx (Jan. 11, 2021)

[3] 唐淵（2004），《國際物流學》（中國物資出版社），第1版。

[4] 產業價值鏈資訊平臺（2021），〈交通運輸及航運產業鏈簡介〉
https://ic.tpex.org.tw/introduce.php?ic=T000 (Jan. 11, 2021)

[5] ALPHALINER (2021), The Worldwide Reference in Liner Shipping
https://www.alphaliner.com/ (Jan. 11, 2021)

[6] European Union (2020). The EU Blue Economy Report 2020
https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/2020_06_blueeconomy-2020-ld_final.pdf (Dec. 8, 2020)

[7] 范秉航（2006），〈附加價值定義與內涵〉，台灣經濟研究院。

[8] NOAA (2020). NOAA Report on the U.S. Marine Economy
https://coast.noaa.gov/data/digitalcoast/pdf/econ-report.pdf (Dec. 8, 2020)

[9] Newport News Shipbuilding (2021)
https://nns.huntingtoningalls.com/ (Jan. 11, 2021)

[10] 陳豐霖（2016），〈艦船與海洋工程產業特性與發展前景〉，台灣國際造船公司。

[11] 交通部統計查詢網（2021）
https://stat.motc.gov.tw/mocdb/stmain.jsp?sys=100 (Jan. 11, 2021)

[12] 行政院（2020），〈海運（國情簡介-交通運輸）〉
https://www.ey.gov.tw/state/A44E5E33CDA7E738/f71d5650-83bc-4b76-908d-e1fd89d72c72 (Jan. 11, 2021)

[13] 中華徵信所（2015），〈TOP5000產業風雲-MIT遊艇銷量全球第六〉
http://www.credit.com.tw/newcreditonline/Epaper/IndustrialSubjectContent.aspx?sn=114&unit=318 (Jan. 11, 2021)

[14] 財團法人船舶暨海洋產業研發中心（2018），〈船舶電子報-2017年台灣船舶產業產出分析〉
https://www.soic.org.tw/%E8%88%B9%E8%88%B6%E9%9B%BB%E5%AD%90%E5%A0%B1/ (Jan. 11, 2021)

[15] 陳宗慶（2017），〈臺灣船舶產業概況〉，工商時報
https://www.chinatimes.com/newspapers/20170525000136-260210?chdtv (Jan. 11, 2021)

[16] International Maritime Organization (2014), Sulphur Oxides
http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-(SOx)-%e2%80%93-Regulation-14.aspx (Jan. 11, 2021)

[17] Marine Link (2012), California SECA Regulations Upheld by Supreme Court
https://www.marinelink.com/news/regulations-california346396.aspx (Jan. 11, 2021)

[18] Diesel Net (2011), Emission Standards International: IMO Marine Engine Regulations: Background
https://dieselnet.com/standards/inter/imo.php (Jan. 11, 2021)

[19] International Maritime Organization (2014), Special Areas under MARPOL
http://www.imo.org/OurWork/Environment/PollutionPrevention/SpecialAreasUnderMARPOL/Pages/Default.aspx (Jan. 11, 2021)

海洋生物資源產業現況與展望

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關鍵字／海洋生態、漁業資源、生物科技、海域空間規劃

臺灣四面環海，擁有豐富的海洋資源，具有發展「藍色經濟」（blue economy）得天獨厚的優勢。所謂藍色經濟，即是以海洋相關產業為基礎的經濟活動，包括海洋工程與能源、海洋化學與礦業、海洋生物資源與休閒遊憩，在永續經營發展的概念下研發利用。現今的藍色經濟更加強調海洋資源的合理使用，其中生物資源產業的發展，更扮演著舉足輕重的角色，從傳統的漁業資源開發利用，到新興海洋生物科技與休閒觀光產業的發展，皆是目前藍色經濟眾所關注的重要議題；其他海洋相關產業如工程開發、能源利用與造船運輸，更是脫離不了與海洋生態及資源保育的關聯性，因此海洋生物資源產業如何永續發展，已成為目前「藍色經濟」最重要課題之一。

圖說／魚苗放流增進沿近海漁業永續發展
圖片提供／臺灣海洋保育與漁業永續基金會及廖正信教授研究團隊

海洋與海岸是地球上最具生產力的生態系統，提供「藍色經濟」中海洋產業發展最重要的基礎。尤其，臺灣陸域資源有限，如何充分永續利用海洋生物資源並兼顧生態保育，減少對於海洋環境的污染與衝擊，一直是眾所關切的焦點議題。海洋生物資源產業以利用海洋生物為基礎，包括以生化科技瞭解海洋生物奧秘，進而開發應用在生物技術、生物保育與製藥產業等領域；漁業生物資源的採捕利用，則應關注生物多樣性與保育及海洋生態環境評估等，以防止生物資源過度開發，並兼顧經濟發展與生態保育平衡；在生態經營則融合生態資源保育、生態旅遊規劃等觀光要素，以區域自然資源作為海洋觀光產業發展基礎，可協助海洋生物資源保育與人為開發行為的管理。

歐美海洋生物資源產業

美國「藍色經濟」以6大海洋相關產業為主，包括生物資源利用、海洋工程、海洋運輸、能源與採礦、造船與休閒觀光等。2010年後，在投資案、就業機會、薪資所得與產品製造及服務上，皆呈現明顯上升的趨勢；相較於2016年水準而言，海洋生物資源利用產業的增長幅度最高，包括商業性捕撈、養殖與水產品加工行銷。雖然就業機會、薪資所得與產品製造僅占美國整體經濟一小部分，但以重要性而言，海洋生物資源產業供給美國大部分的水產品食用需求，加上水產品加工與產銷經營等，海洋生物資源產值已可媲美最具高生產力的養殖漁業[1]。

在美國「藍色經濟」與藍色革命的概念下，海洋生物與水產資源利用，更有維持沿岸與海洋生態系統健康的重要性，在漁業資源保育及海洋生物重要棲地與孵育場維護，更是具有海洋文化傳承的重要意涵，許多傳統皆是建立在相關海洋活動與生物資源利用。現階段「藍色經濟」已朝向「藍色科技」（blue technology）領域發展。廣義來說，藍色科技可定義為設計提供任何改善海洋環境相關的技術與服務，例如航海技術與船舶建造、海洋資料蒐集與科學研究所需要使用的電子儀器和機械技術及支援軟體，強調透過海洋活動與實際作為，改善海洋環境開發所可能帶來的影響，透過創新，以貢獻於整體「藍色經濟」的發展[2][3]。

歐盟「藍色經濟」在生物資源利用產業方面，以發展海洋漁業及沿岸觀光旅遊為主，同時強調經濟活動必須落實永續管理與環境調適，以減輕人為活動對海洋的影響，提升海洋與沿海地區生態系統的復原力。其中，與海洋直接相關的即是捕撈漁業（包括沿岸家計型與遠洋大規模商業船隊）和養殖漁業（包括海水與淡水養殖魚蝦類），可視為「藍色經濟」最主要的生物產業，其他生物資源產業如海洋水產品生產與加工、保存及銷售管道的建立、後端生物科學技術的應用，及更廣義包含任何再生性水產生物資源利用的經濟活動，例如食物添加物、動物飼料、製藥、化妝品與能源利用等，構成了藍色生物經濟（Blue Bio-Economy）產業鏈[4]。

近年歐盟捕撈漁業產量持續上升，與漁業資源改善及魚價上升、成本降低所增加的工作機會密不可分，專家評估此種經濟成長表現還可繼續維持下去[4]。目前僅地中海捕撈漁業前景值得堪慮，在尚未達到永續漁業狀況（Sustainable Fishing Condition），經濟成長幅度的表現十分有限；相較之下，養殖漁業雖然產值有所提升，但過去10年的養殖產量已呈現停滯不前的狀態。考量歐盟國家未來對於水產食品需求的提升，故可合理期待養殖漁業產量在未來仍有成長空間。現階段歐盟海洋生物

資源產業仍以再生性漁業資源為主，供給食物、飼料、生物相關產品與加工、運銷及生物能源等產業鏈，歐盟現為全球水產品前5大的供應與進口國家，可支撐維持歐盟整體水產品加工與運銷產業。

歐盟「藍色經濟」最為關鍵的一環即是從「產地直達餐桌」（Farm to Fork）政策的實行，其概念基礎為確保糧食供給系統對環境的永續性，希望藉此改變歐盟體系對於糧食的生產與消費習慣，在不犧牲健康食物的安全、品質與供給，達到對於海洋環境最小的衝擊影響[4]；此一政策貫徹了食物產銷管道的每個環節，包括從生產加工到銷售食用及國際貿易，以減少運送、儲存、包裝等非必要性的浪費。預計2050年時，歐盟糧食系統的環境永續性，可成為全球的標準。該政策也將啓動新的程序來推廣創新食品與飼料產品，包括藻類製造的水產品等，因此歐盟農漁民未來將扮演極為關鍵的重要角色。近年經濟發展危機與健康意識抬頭，推廣「產地直達餐桌」政策，可有效對應氣候變遷、保留生物多樣性並維持環境永續；同時可持續性糧食系統也具有自然體系復原力，支持相應產業的經濟復甦[4]。

在「藍色經濟」未來發展生物資源和生物技術領域，以非傳統開發的海洋生物及相關商業性應用為主，包括大型藻類（海藻）、微生物（微藻類、細菌和真菌）和無脊椎動物（例如海星、海參與海膽）。而藻類和無脊椎動物可視為支持沿海地區經濟活動發展最重要潛力生物資源之一，儘管過去已有利用藻類和無脊椎動物作為食品、飼料或肥料等產品，但發展極具創新潛力的商業應用，已是目前生物資源產業重點開發目標，尤其具有高附加價值的生物活性化合物提取，在藥用藥物及化妝品具有相當高價值的市場潛力。其他生物材料或生物燃料與創新應用，也是現階段研發重點。藻類和無脊椎動物具有促進糧食系統可持續性的潛力，可減低過度利用傳統海洋生物資源的壓力，去除水環境過剩營養物質，已成為提供降低環境危害最佳的解決方案[4]。

臺灣海洋生物資源產業

臺灣近年來積極發展「藍色經濟」，除了傳統的海洋工程與運輸產業外，海洋休閒與觀光遊憩是目前重點開拓的新興領域。然而，這與海洋生態與水產生物資源的永續利用息息相關，許多旅遊觀光甚至漁村文化體驗都以此為基礎；尤其在臺灣沿近海漁業資源日漸匱乏之下，如何保育生態環境並增裕漁業資源，已是當前海洋保育重要研究課題。未來應配合創新生物科技與漁業科學的輔助，積極整合固有社會文化資源，大力開創臺灣特有「藍色經濟」的海洋生物資源產業。

以近年所推動的沿海栽培漁業區為例，在「藍色經濟」或所謂「藍色革命」理念基礎下，整合自然環境、漁業資源、經濟發展與社會文化，促使原本傳統的漁村經濟產業轉型，同時接軌周邊觀光與商業資源，達成栽培漁業區可以自主管理及永續經營之目標[5]。目前新北市卯澳栽培漁業區即是良好典範，由政府權責機關、漁村社區、漁會、漁民與學者攜手合作，從改善海洋生態服務功能，並強化漁業資源水準為基礎，共同復育卯澳灣豐饒與健全的海洋生態環境，使卯澳漁村成為與海洋共生、慢活適居、風情漁村之栽培漁業區[6]。

栽培漁業區重要功能在增裕復育漁業資源，對於放流魚種資源的調查與監控相對重要，以卯澳地區經常放流之點帶石斑、銀紋笛鯛、黑鯛、黃鰭鯛與嘉鱲而言，透過水中即時監測系統與水肺潛水目視調查顯示，放流物種在示範區內的適應狀況良好，也可觀察到放流物種的外溢效果。同時，統計調查發現魚類物種種數有逐年增加趨勢，在冬夏季魚類群聚組成有所變動，顯示栽培漁業區內放流魚種對於野外自然棲地的利用情形良好，放流效益顯而易見[7]。

在「藍色經濟」生物資源產業中，保育型漁業在帶動社區經濟轉型及漁村永續發展上扮演極為重要的角色；除了前述海洋生態環境復育與漁業資源增裕外，亦可推動兼具在地特色水產品發展創新產業。以卯澳漁村為例，當地石花菜年產量3萬公斤而言，已被評估可建構具有特色的完整產業，包括每年吸引1萬觀光人次以上的消費及漁村休閒體驗，如能配合漁業產銷班、漁村社區與農村再生計畫，並進一步具體規劃在地漁民積極參與資源復育及海洋教育推廣，推動觀光型漁業工廠園區，當可建立具有在地特色「藍色經濟」生物資源產業[6]。

除了栽培漁業區外，臺灣目前也積極藉由魚苗放流推動「藍色經濟」生物產業成長，同時配合效益評估科學研究與調查，建立放流種苗基因庫，鑑別物種並評估基因窄化風險、野外族群遺傳結構等相關檢測，並根據漁獲樣本評估實施放流所帶來的漁業資源，估計種苗放流可貢獻的漁獲產量及生態、經濟及社會效益[8]。在常見放流物種最適棲地與放流場域環境評估方面，利用棲地模式解析放流種苗時空分布，搭配棲地適合度及海表水溫、葉綠素濃度、深度和流速等環境因子及漁獲體長分析，提供魚苗放流科學化管理建議。以黑鯛為例，建議最適放流為每年4月至9月於彰化崙尾灣至嘉義沿岸，9月至10月則為苗栗沿岸水域；四絲馬鮁則建議應於第3至第4季雲林至嘉義沿海區域放流；布氏鯧鰺則以第3季於嘉義沿海一帶放流魚苗為佳[9]。

生物資源產業另一個發展重點為生物科技之創新與應用，針對重要水產生物放流物種之野外捕撈與養殖放流族群，建立多型性基因資料庫及鑑定檢測標準，輔助放流魚種效益評估，釐清遺傳風險與基因窄化之疑慮。目前常見放流魚種基因多樣性數值分析結果顯示，多數族群處於雜交配種狀態，基因多樣性指標程度高，無基因窄化與遺傳風險之問題，可有效增裕沿近海重要漁業資源，使海洋生態與生物獲得喘息與恢復之機會[10]。

圖說／重要經濟魚種於沿岸海域進行養殖實驗
圖片提供／蘇楠傑教授研究團隊

另一方面，最近研究也積極突破冷水性物種養殖技術關鍵，在節能減碳與能源有效使用及促進養殖產業轉型目標下，運用沿岸液化天然氣工廠產生冷能所建構新型態冷水養殖場，是目前「藍色經濟」新興生物資源產業。冷水性物種包括大西洋鮭魚、仿刺參、皺紋盤鮑、紅翎藻、海木耳、滸苔、蕨藻與牙鮃之繁養殖及生產技術，已開創高價冷水性物種新型態養殖模式，可減少冷水性魚類進口量，並減緩陸地資源與地下水過度利用之壓力，未來如能爭取設立海洋科技園區，輔導並改善養殖產業環境，應能強化臺灣特有海洋養殖產業的競爭力[11]。

結語

「藍色經濟」的發展，在不同產業間存在著相互依賴關係，例如海洋能源開發、運輸與休閒航運觀光、藍色生化科技與養殖，皆須與海洋生態維護及漁業資源利用存在相互依賴的關係，同時在重視環境永續的概念下，致力於降低海洋活動對環境所造成的負面影響。相信包含離岸風力發電、石油天然氣開採、海洋養殖漁業、海洋生物科技及海洋觀光休閒等，都是極具發展空間的海洋產業，可作為未來臺灣「藍色經濟」發展主力產業。目前海洋產業發展在海域空間使用上呈現多元競合的態勢，急需建立整體性海域空間規劃（Marine Spatial Planning, MSP），加以協調釐清產業間資源競爭與潛在衝突，以利在經濟發展與環境保護及資源利用取得最佳平衡點。

參考資料

[1] William Nicolls, Connor Franks, Teresa Gilmore, Rachel Goulder, Luke Mendelsohn, Edward Morgan, Jeffery Adkins, Monica Grasso, Kate Quigley, Jennifer Zhuang, Charles Colgan (2020), Defining and measuring the U.S. Ocean Economy. Bureau of Economic Analysis, Department of Commerce, U.S.
https://www.bea.gov/system/files/2020-06/defining-and-measuring-the-united-states-ocean-economy.pdf

[2] National Oceanic and Atmospheric Administration (2020), Report on the U.S. marine economy
https://coast.noaa.gov/data/digitalcoast/pdf/econ-report.pdf

[3] National Oceanic and Atmospheric Administration (2020), Report on the U.S. marine economy: Regional and state profiles
https://coast.noaa.gov/data/digitalcoast/pdf/econ-report-regional-state.pdf

[4] European Commission (2020), The EU blue economy report. Publications Office of the European Union, Luxembourg
https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/2020_06_blueeconomy-2020-ld_final.pdf

[5] 李國添、鄭學淵、藍國瑋、陳義雄（2020），《臺灣栽培漁業區之跨域統合暨漁場環境調整改善》期末報告，行政院農業委員會漁業署委託研究（高雄市：臺灣）。

[6] 莊慶達（2017），《臺灣栽培漁業示範區之社經調查與經營管理模式建構》，臺灣沿海藍色經濟成長推動計畫成果研討會，2017年10月20日（基隆市：臺灣）。

[7] 陳義雄、劉育瑋、劉恩諭（2017），《魚類群聚時空變化與放流魚種定棲群聚分析》，臺灣沿海藍色經濟成長推動計畫成果研討會，2017年10月20日（基隆市：臺灣）。

[8] 廖正信、蘇楠傑、呂明偉、黃章文、徐德華、許為元（2020），《種苗放流效益評估》期末報告，臺灣海洋保育與漁業永續基金（臺北市：臺灣）。

[9] 李明安、蘇楠傑、藍國瑋、張懿、吳龍靜（2018），《臺灣沿海場域漁業活動及環境調查與放流物種資料建立》期末報告，行政院農業委員會漁業署委託研究（高雄市：臺灣）。

[10] 黃章文、林正輝、呂明偉、龔紘毅、邱品文、曾令銘、徐德華、潘婕玉（2017），《重要水產生物基因標誌研究-建立放流魚種基因多型性分子標誌資料庫》，臺灣沿海藍色經濟成長推動計畫成果研討會，2017年10月20日（基隆市：臺灣）。

[11] 冉繁華、陳秀男、翁韶蓮、鄭安倉、李孟洲（2020），《液態天然氣（LNG）冷排水養殖模場之經營模式及營運策略之研究》期末報告，行政院農業委員會漁業署委託研究（高雄市：臺灣）。

歐盟新興海洋產業：跨越傳統　邁向科技導向

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關鍵字／歐盟、科技、創新海洋產業

海洋產業類別多元，漁業、航運、港口、造船修船、固定式離岸風電以及海洋觀光等是大家所熟悉的傳統產業。除了這些傳統藍色經濟活動外，歐盟近年來發展科技導向的海洋創新產業，包括：海洋再生能源、藍色生物經濟、海洋礦物、海水淡化，海事防禦以及海底纜線。本文介紹這些新興產業發展現況，及其面對的挑戰和未來發展的潛力。（本文內容主要摘錄自European Commission (2020). The EU Blue Economy Report 2020. Publication Office of the European Union. Luxembourg.）

海洋再生能源

海洋再生能源係指使用不同科技來生產再生能源，包括離岸風電（固定式和浮體式）、波浪和潮汐能、浮體式太陽光電，以及氫氣生產。除固定式風電已發展先進技術外（大都設置在50公尺以下淺水區），其他能源生產的技術仍在發展初期。於此階段，海洋再生能源以科技研發和商業化發展為重，但其市場和供應鏈尚未建立。

一、浮體式離岸風電

浮體式離岸風電是強化歐洲取得海洋能源領先地位的成長中產業。2019年全球總裝置量45MW（百萬瓦）中，歐洲占比最大（70%）。浮體式風電科技的發展和商業化，將為歐洲開啓取得風能最豐富地點的可能性。在歐洲，80%的風能在超過水深60公尺的海面上，固定結構於此區域的海底成本太高。預估歐洲浮體式離岸風電有4,540GW（百萬瓩）潛力，其中3,000GW位於深水區域（100公尺至1,000公尺）。目前已發展的傳統離岸風電大部分位於北海和波羅的海淺水區，和此區域並不相鄰。

浮體式風電使用繫住於海床的浮式基座，例如柱狀浮筒（Spar-buoy）、半潛式平臺（Semi-submersible Platform）、張力腿平臺（Tension Leg Platform, TLP）、平底船（Barge）或多功能平臺（multi-platforms）等。雖然目前沒有哪一類型是主流，但柱狀浮筒概念已被運用於一個商業計畫（30MW Hywind Scotland）。值得注意的是，透過歐盟贊助各項計畫，許多浮體式離岸風電科技已從概念落實到商轉前的階段，這對浮體式離岸風電發展是非常重要的。尤其，目前有兩個試驗性計畫正在證明深水區域中浮體式科技的能力，一個是法國2MW浮體式原型（Floatgen Project），另一個是葡萄牙25MW浮體式風場（WindFloat Atlantic）。

浮體式離岸風電發展的主要挑戰，是高投資和財務成本。因此，其未來發展必須降低成本，增加產能。目前只有40MW的浮體式風電在運作，預計2020年至2022年間將再增加300MW。

二、波浪和潮汐能

波浪和潮汐能在歐洲的潛力大，其在去碳化能源的供給、增加能源穩定提供和促進沿岸區域經濟成長上扮演重要的角色。大西洋沿岸海域的發展潛力最大，依據理論推估，歐洲波浪能每年約2,800TWh（十億度），潮汐能約50TWh。預期在短中期的未來（即2030年以前），歐洲的海洋能源發展將大大依賴波浪和潮汐能。

截至2019年年底，全球海洋能源裝置容量為55.8MW，大部分（39.5MW）位於歐洲。歐洲在波浪和潮汐能開發是領先者，其主導全球58%的潮汐能開發商和61%的波浪能開發商。目前能源開發仍在研發階段，但有一些技術已經進展到首創示範和商業化之前的階段。尤其，潮汐能科技進展最大，示範計畫已能產生50GWh（百萬度）電力。就性能表現而言，尤其在電力生產方面，波浪能科技發展係較潮汐能科技落後。

2007年至2019年，波浪能和潮汐能的總研發經費累積至38.4億歐元，其中大部分（27.4億歐元）來自私人部門。預期波浪和潮汐能源科技仍持續開發且科技成本將降低，在不久的將來海洋能源裝置容量可明顯成長。依據國際能源總署（International Energy Agency, IEA）市場情境評估，2030年前歐洲的波浪和潮汐能裝置容量，可能介於0.5GW和2.6GW之間。

三、浮體式太陽光電

浮體式太陽光電裝置（floating solar photovoltaic installations）開啓了利用傳統太陽光電裝置的新機會，且可減少對土地的影響。浮體式光電包括浮體結構和設置在此結構上的傳統太陽能板。目前為止，大部分浮體式光電設置在湖面和水力發電蓄水池附近。

鋪設浮體式光電於海面上需克服幾項挑戰，其和浮體結構在海面的存活度，以及海洋環境（如藻類生長、污染、鹽沉積物）對光電轉換系統的影響有關。2019年底，最先進的浮體式光電正研發中，荷蘭（Oceans of Energy, TNO）和法國（HelioRec）分別進行示範計畫，驗證科技設計、光電轉換效率和在惡劣環境下結構的存活度。前述的荷蘭系統（17kW）已能禁得起不同程度風暴和波高大於5公尺的環境。此外，開發商目前正尋求更大可達50kW的系統規模計畫。

圖說／浮體式光電設施
圖片提供／陳璋玲

浮體式光電商業化仍存在一些挑戰，包括長期的技術可靠性、成本和既有電網整合，以及次電力站設立等。尤其在惡劣和偏遠環境下，技術可行性和生產成本更需進一步證明。此外，浮體式光電對於歐盟綠能政策（EU Green Deal）貢獻的評估，以及在和其他海洋使用互動下，如何確認適合鋪設光電的位置都是浮體式光電商業化必要的關鍵。

四、離岸氫氣生產

離岸氫氣生產具備幾項優點，包括大規模且低成本的運輸和儲存氫氣，以及將既存的海上鑽油氣平臺轉型為氫氣生產。但目前最大的技術挑戰在於開發和海洋環境相容的電解模組（electrolyser module），且能和中繼再生能源電場結合，有效率地運作和達到氫氣高生產率。目前已有數項計畫探討氫氣生產和離岸能源結合的可能性，例如ITEG計畫結合2MW潮汐渦輪、500kW氫氣電解模組，和岸際能源貯存管理系統。

藍色生物經濟

藍色生物經濟和生物科技（統稱藍色生物經濟）係指海洋生物作非傳統的商業應用，而有別於海洋生物的傳統使用，例如食物、餌料、肥料等。這些海洋生物包括大型藻類（海藻）、微生物（微藻、細菌、真菌）和無脊椎動物（如海星、海參、海膽）。萃取自海洋生物的生物活性複合物質（bioactive compounds）有很高的市場潛力，例如可作成營養食品、藥物和化粧品。其他的創新使用尚包括生物材料（biomaterials）或生質燃料（biofuels）。除了商業價值外，藻類和無脊椎動物亦有助於食物系統永續，減緩對已過度捕撈物種的壓力，以及從水中移除過多的營養物，為環境健全提供了解決的方法。

歐盟支持在地化行動的創新政策，透過「智慧專門化策略」（Smart Specialization Strategies）的設計和執行來落實此政策。目前全歐有12個會員國、53個區域透過智慧專門化策略和藍色生物科技連結；其探討的主題廣泛，包括能源生產（例如微藻生產生質柴油）、農業（如微藻處理液體糞肥）、氣候變遷（如開發微藻產品、增加吸納二氧化碳能力）、藥物（如微藻作為營養成分，增強人類和動物免疫力）、環境改善（如微藻細菌處理廢水）、生物材料等。

然而，此一新興的產業仍面臨許多挑戰和阻礙。其中，最常被提及的是：複雜法規和行政程序、市場規模小、消費者的瞭解和接受度，缺乏獎勵機制以促進環境服務提供、缺乏歐洲本土的認證和一致化市場規格要求、缺乏資金贊助機制，以及減少廢物產生的生產鏈最佳化等課題。

海水淡化

海水淡化是普遍常用的技術，也是提供水資源的另一選項，可減緩淡水資源壓力。此一技術常用於淡水資源缺乏的地區，如大型沿岸城市（如西班牙巴塞隆納和阿利坎地）、島嶼等。長期而言，在氣候變遷對淡水資源的影響下，預期海水淡化和水再利用的需求將會增加。尤其2050年前，預期歐盟大部分地區將面臨嚴重水資源缺乏，包括地中海沿岸地區、法國、德國、匈牙利、北義大利、羅馬尼亞、保加利亞等地區，水情將會十分嚴峻。

2019年歐盟總計有1,573座海水淡化廠，每天生產6.9百萬立方公尺淡水（即每年25億立方公尺）。74.2%的海水淡化量能位於地中海盆地，有821座淡化廠，每天生產5.1百萬立方公尺淡水。淡化廠生產的淡水，64.4%提供公共用水，由市政府管理、24%用於工業、9.5%用於農業灌溉、2.1%用於生產飲用水，供遊客設施使用。

逆滲透（Reverse Osmosis）是目前最普遍使用的海水淡化技術，歐洲約有85.5%的海水淡化產量是使用此一技術。海水淡化的資本投入和營運成本和廠區大小規模、海水淡化技術，以及處理海水的鹽度等因素有關。成本大小則決定水的價格。使用逆滲透技術，平均1,000公升淡化水的成本為0.86歐元，亦即每日提供歐盟5.9百萬噸淡化水的成本為5.1百萬歐元，或1年18.6億歐元。若將所有技術的淡化成本計入，則每年成本為22億歐元。歐盟的海水淡化廠大部分由歐洲工程公司設計和興建。然而，淡化關鍵技術（如逆滲透膜）的市場，卻大部分主導的公司並非為歐洲公司，歐盟的逆滲透技術研發只占技術發明的5%。

海洋礦物

海洋礦物包括砂和礫石、金屬（如錳、錫、銅、鋅、鈷）和溶解於海水中的化學元素（如鹽和鉀）。採砂是長久以來的活動，而開採其他礦物和金屬是新興產業。尤其，高科技金屬對於創新的環境科技開發扮演重要的角色，能提升能源效率和減少溫室氣體排放。然而，在海水和海床中萃取礦物和金屬也面臨許多挑戰，包括貯藏地點繪製、發展適合的開採科技，以及採取合宜的減緩和管理措施，以處理不可逆的環境衝擊。

截至2019年年底，國際海床組織（International Seabed Authority, ISA）共核發30張生效的探勘合約／執照，分配至8個開採區，分布於大西洋、太平洋和印度洋。歐盟國家中，比利時、法國、德國、保加利亞、捷克、波蘭和斯洛伐克等國贊助大西洋區域的合約。到目前為止，在「區域」（Area，係指國家管轄範圍以外的海底及其底土），或在歐盟會員國管轄區域內，尚未有任何一個商業探勘案。雖然業者對採取海洋礦物的未來發展前景大致有信心，但是在深的海床採礦（例如富含錳礦和鈷礦的海床位於水深800～2,500公尺），前景仍很不確定，尤其是採礦程度需多大才能達商業規模、採礦高成本，以及可能的環境衝擊和環境永續仍不清楚。

海洋防禦

海洋防禦主要焦點在海軍。歐洲海軍有564艘現役軍艦，總噸位1.5百萬噸。依據歐盟防禦局（European Defence Agency）統計資料，2017年海軍人員有177,090人，較2006年的277,309人少。

海軍每年有超過100億歐元用於建造新船，40億多歐元用於維修。海軍造船工業是創新導向產業，且是所有新興產業中，投資於研發和創新的強度最大。估計每年有8.7%的海軍產業銷售額用於研發和創新。

海軍帶來的經濟效益和就業機會，亦頗為可觀。以西班牙為例，1歐元投資於海軍，即產生2.3歐元生產額，增加2.2歐元附加價值毛額（gross value added, GVA）和2.3倍就業機會。這些數據，皆高於西班牙所有公共行政部門的相關數據。

海底電纜

海底電纜是重要的基礎設施，傳遞全球99%的國際資料交易和通訊，包括每日超過10兆歐元的金融交易。海底電纜對於歐盟經濟和全球經濟非常重要。目前全球有378條海底電纜，總長度1.2百萬公里，其中205條和歐盟國家相連。

一般而言，海底電纜使用年限為25年，但由於可傳輸更大容量且低成本的電纜不斷推出，因此海底電纜通常未達使用年限前即被替換或棄置。不再使用的電纜其處理方式有三：1.留置於海底床呈不活動狀態；2.回收及再利用作為電纜原材料（raw materials）；3.重新定位作新路徑使用。歐盟大部分海底電纜係在2000年代初期或之前鋪設，意味著未來幾年這些電纜將換新。

電纜船主要用於鋪設和維修海底電纜。大部分電纜船有裝置遙控潛水器（remotely operated vehicle, ROV）和挖溝設備，以執行電纜鋪設和維修工作。全球有54艘電纜船，其中21艘註冊於歐盟。由此數據來看，歐盟在海底電纜產業已扮演重要的角色。

圖說／電纜船進行海底電纜舖設，提供全球資料交易和通訊重要管道
圖片提供／陳瑋玲

結論

歐盟前瞻地發展科技為導向的海洋產業，可見其對海洋資源（生物和非生物）開發與使用的重視，此和歐盟「海洋策略架構指令」（Marine Strategy Framework Directive）將海洋視為具有經濟潛能的資產互為呼應。

我國四面環海，長期發展傳統海洋產業之餘，亦應邁向發展科技導向的海洋產業，尤其是和再生能源政策相關的浮體式離岸風電和浮體式光電產業。我國應持續觀察全球及歐盟各項產業之技術動態，並且參考個案開發經驗，優先針對關鍵技術探討研究，找出適合我國發展海洋產業的技術與相關設備，同時與歐盟一樣關切海洋生態與環境議題。如此，我國發展創新、科技導向的海洋產業始能逐步落實。

參考資料

[1] European Commission (2020). The EU Blue Economy Report 2020. Publication Office of the European Union, Luxembourg.

COVID-19疫情下國際藍色經濟政策趨勢

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關鍵字／COVID-19、藍色經濟、永續發展、氣候變遷

自2020年初以來，「嚴重特殊傳染性肺炎」（COVID-19）引發全球大流行疫情，迅速擴散至全球多國。本文參考國際組織所提出之文獻資料，歸納疫情下之國際藍色經濟政策趨勢，期能提供我國未來推動藍色經濟政策之參考。

前言

依據世界衛生組織（World Health Organization, WHO）統計[1]，截至2021年1月26日，全球有224個國家和地區，累計超過9,879萬名確診個案。COVID-19疫情重創全球經濟與貿易，依據世界銀行（World Bank）2021年1月估計，2020年全球經濟成長率負4.3%[2]，另聯合國貿易和發展會議（United Nations Conference on Trade and Development, UNCTAD）估計，COVID-19疫情導致2020年全球整體貿易下降27%[3]。

在COVID-19疫情期間，UNCTAD[3]、經濟合作暨發展組織（Organization for Economic Cooperation and Development, OECD）[4]及國際永續海洋經濟高階小組（High Level Panel for Sustainable Ocean Economy, Ocean Panel）（2020）[5]等國際組織均認為，在COVID-19疫情期間，海洋旅遊業、海運及漁業等藍色經濟相關產業雖受到重大衝擊影響，同時亦為藍色經濟發展契機。

創造健康海洋環境與促進資源永續是藍色經濟發展的基礎，在COVID-19疫情期間，強化藍色經濟在經濟、社會、環境面的韌性與降低脆弱度，解決海洋塑膠廢棄物、海洋化學污染、溫室氣體排放及資源過度開發等環境問題，確保海洋生態與海洋產業之永續發展，可逐步達成聯合國「永續發展目標」（Sustainable Development Goals, SDGs）及《巴黎協定》（Paris Agreement）之減碳目標，同時推動藍色經濟亦能加速全球經濟復甦，因此上述國際組織相繼提出藍色經濟綠色成長措施與優先措施等[3][4][5]。

藍色經濟綠色成長措施具有高成本效益特性，對經濟復甦與成長有所助益，值得優先推動。依據Ocean Panel於2020年之分析，在永續藍色經濟方案的投資報酬率約為500%，即每投資1美元，至少可獲得5美元報酬。具體而言，在2020年至2050年期間，在恢復和保育海岸與海洋生態系統、離岸風電、海運減碳措施及永續漁業等4項領域，若全球投資2～3.7兆美元，將產生經濟、環境及健康等效益高達10.3～26.5兆美元，估計約有高達400～615%的投資報酬率（以30年的淨效益8.2～22.8兆美元來計算）[5][6]。

本文參考相關文獻資料，歸納COVID-19疫情下國際藍色經濟政策趨勢，期能提供我國未來推動藍色經濟政策之參考。

COVID-19疫情下國際藍色經濟政策趨勢

一、藍色經濟之綠色成長措施

UNCTAD（2020）提出，在COVID-19疫情下推動永續發展之藍色經濟，有助維護海洋生態系統功能健全，並對經濟成長與促進就業有所貢獻。具體而言，建議政府應朝向永續藍色經濟轉型，在海洋產業中強化推動各項綠色成長措施[7]：

（一）重新思考漁業補貼，轉型支持小型責任漁業永續

全球超過2億捕撈漁業人口，且近9成漁民生活在開發中國家，目前各國政府為照顧捕撈漁業漁民生計，對漁業用油採取優惠油價補貼政策。然而，在COVID-19疫情以來，國際油價處於近年低點，捕撈成本逐漸下降，加上漁業貿易減少，建議重新思考漁業補貼之適切性，將耗油量大且低效率之漁船汰舊換新，轉向支持小型責任漁業與永續治理，以促進捕撈漁業之永續發展。

（二）推動永續發展之沿岸與海洋觀光2.0措施

旅遊觀光業是小島型開發中國家（Small Island Developing States, SIDS）重要的經濟來源之一，COVID-19疫情導致國際入境人數大量減少，使SIDS國家觀光產業面臨重大衝擊，建議推動海洋與沿岸觀光2.0措施，其核心在於落實各項海洋觀光之永續發展措施，包括：結合在地生態環境與文化特色、發展生態旅遊、低碳觀光及體驗活動等。

（三）數位化海運貿易程序與流程

由於COVID-19疫情造成全球供應鏈危機，UNCTAD提出加強國際貿易與運輸便捷化之10項行動計畫，包括：確保航運運輸不受中斷、維持港口開放、保護重要貨品之國際貿易與加速通關及貿易便捷化程序、促進跨境運輸、確保過境權、保障透明度和提供最新資訊、實現流程電子化、商務法律問題與爭端解決、託運人與運送人之保障及強化技術支援等[8]。

上述行動計畫若導入數位化措施，將對海運業之貿易便捷化發展有所助益，例如：「海關資料自動化系統」（Automated System for Customs Data, ASYCUDA）已為100多個國家和地區提供電子化單一窗口、現代化報關系統、數位化貿易解決方案等協助。

二、藍色經濟5大優先措施（Ocean Panel）

Ocean Panel（2020）提出COVID-19疫情下藍色經濟5大優先措施，此5大優先措施之成本效益相對其他措施高，值得優先推動[5]：

（一）恢復和保育海岸與海洋生態系統

海岸棲地保護、溼地維護、生態造林工程、珊瑚礁與藻礁保育等恢復和保育海岸與生態工程，有助維護海岸與海洋生態系統功能健全，減緩洪水和風暴潮的影響，過濾且改善水質，並提高小型與養殖漁業的生產力。建議政府可透過公共財政、公債或民間投資等方式，挹注資金恢復和保育海岸與海洋生態系統，將為生態旅遊、捕撈漁業及海岸社區發展帶來長期發展潛力。

（二）建置與維護海岸地區污水排水與廢水處理基礎設施

污水排水、廢水處理與優養化直接相關，若未妥善處理，長期將導致水源性疾病、魚類資源損失、破壞海域生態等，威脅公共衛生、糧食安全及產業發展。建議政府採取激勵與監管並行之雙軌方式，前者如編列公共財政經費，改善污水排水與廢水處理之基礎設施，後者如加強管理特定高污染產業、落實海岸緩衝區措施及減少使用低效率肥料與化學品等。

（三）推動永續社區型海水養殖

永續社區型海水養殖為未來發展趨勢之一，其特色在於由社區形成自給自足之系統，撙節用水與能源，減少飼料、肥料及藥劑投入，有助維護養殖環境生態系統，提高海水養殖效能，並落實永續發展。建議政府協助優化海水養殖環境，並提供補助或優惠融資措施，鼓勵推動永續社區型海水養殖。若為新興海水養殖技術，則有賴建立能力建構與培訓機制，以及社區交流平臺等，共同促進永續社區型海水養殖發展。

（四）落實海運淨零碳排

全球貿易量主要依賴海運，加上海運是成本較低之運輸方式，若海運業可逐步導入天然氣燃料、氫能、電能與儲電設施等低碳之船舶與設備，將有助減少海運的碳排放量與改善海洋酸化問題。建議政府可推動補貼、融資優惠、減稅、投資獎勵等財務誘因政策，或優先推動低碳公用船舶、獎勵民營公司投資低碳船舶及相關設備、建設低碳港埠基礎設施等政策。

（五）發展海洋再生能源

依據國際能源總署（International Energy Agency, IEA）之統計[9]，全球鼓勵推動綠能低碳政策，全球離岸風電裝置容量將於未來20年內成長15倍。海洋再生能源產業將創造綠色就業機會，並可厚植海事工程、離岸工程、工程船、海洋科技等相關海洋再生能源產業。政府宜制定明確且一致政策，並推動財政金融措施，以促進海洋再生能源產業發展。

結論

COVID-19疫情造成海洋旅遊業、海運業及漁業等藍色經濟受到衝擊，同時亦為藍色經濟發展新契機，國際藍色經濟政策鼓勵轉型與創新，朝向海洋環境永續與低碳之發展，以逐步達成聯合國永續發展目標及《巴黎協定》之減碳目標，並同時可作為全球經濟復甦之動能。

我國藍色經濟發展在海洋觀光遊憩產業、海運業及漁業等已有階段性成果，但在海洋生物科技、海洋再生能源、海洋水科技及海洋工程等國際認定的新興海洋產業領域上的表現，尚有相當大的成長空間。未來宜參考COVID-19疫情下國際藍色經濟政策趨勢，滾動檢討「向海致敬」政策，規劃推動藍色經濟之海洋產業轉型與創新。

參考資料

[1] World Health Organization (2020), Coronavirus disease (COVID-19) pandemic https://www.who.int/emergencies/diseases/novel-coronavirus-2019 (Jan. 26, 2021)

[2] World Bank (2021), Global Economic Prospects (Washington, DC: World Bank).

[3] UNCTAD (2020), The COVID-19 Pandemic and the Blue Economy: New Challenge and Prospects for Recovery and Resilience https://unctad.org/system/files/official-document/ditctedinf2020d2_en.pdf (Jan. 26, 2021)

[4] OECD (2020), Sustainable Ocean for All: Harnessing the Benefits of Sustainable Ocean Economies for Developing Countries (Paris: OECD).

[5] The High Level Panel for a Sustainable Ocean (2020), A Sustainable and Equitable Blue Recovery to the COVID-19 Crisis (Washington, DC: World Resources Institute).

[6] Mansi Konar, Helen Ding and Kristian Teleki (Jul. 13, 2020), 4 Investments to Secure Ocean Health and Wealth https://www.wri.org/blog/2020/07/investments-ocean-health-wealth (Jan. 26, 2021)

[7] UNCTAD (2020), COVID-19 offers opportunity to save our ocean https://unctad.org/news/covid-19-offers-opportunity-save-our-ocean (Jan. 26, 2021)

[8] UNCTAD (2020), Ten-point plan to bolster global transport, ease trade during COVID-19 https://unctad.org/news/ten-point-plan-bolster-global-transport-ease-trade-during-covid-19 (Jan. 26, 2021)

[9] International Energy Agency (2020), World Energy Outlook 2020 https://www.iea.org/reports/world-energy-outlook-2020 (Jan. 26, 2021)

Stepping Forward into the World: Developing Taiwan's Sustainable Blue Economy!

Translated by Linguitronics

Minister of the Ocean Affairs Council: Chung-Wei Lee

A blue economy symbolizes a sustainable marine economy that emphasizes the harmony and symbiosis between human activities and the ocean. This issue of "International Ocean Information", the "Blue Economy Special Issue," offers an introduction to the current development and future trends of ocean tourism, ocean energy, transportation and shipbuilding, marine biological resources, and emerging industries in Europe, the United States, Taiwan and other countries across the world.

The "Marine Tourism" section introduces Taiwan's primary coastal and marine tourism industry and sustainable marine tourism policies. As Taiwan is equipped with the 4S elements (sand, sea, sun and seafood) for the development of marine tourism and leisure, in recent years, huge business opportunities in yacht tourism and cruise tourism have emerged while the government has also proposed a 10-year comprehensive development plan for reinforcing Taiwan's blue highway (2021-2030); The "Marine Energy" section gives a glimpse into the current status of global marine energy innovation technologies and strategies, and highlights important trends, including the fact that the average cost of marine energy power generation is lower than expected, tidal stream energy and wave energy technologies are undergoing exponential development, and that ocean thermal energy conversion, salinity gradient and tidal energy all exhibit development potential within the next decade. The "Transportation and Shipbuilding" section gives a dynamic analysis of the marine transportation, shipbuilding and vessel operation industries. For example, the European Union's shipbuilding industry has gradually shifted its business model in recent years to reduce costs while also establishing cooperations with emerging industries (such as offshore wind power) to create new industry opportunities; the shipbuilding industry in the U.S., on the other hand, has focused almost exclusively on building military vessels. As Taiwan's maritime shipping industry is the sector with the highest output value of the nation's marine economy, the government has been promoting the building of navy vessels domestically and at the same time taken the initiative to drive the offshore wind energy industry even as the yacht industry rises to the forefront among global peers and competitors. The "Marine Bio-Resources" sections sheds light on using marine biological resources for sustainable development, while the "Emerging Industries and Trends" section introduces the challenges and future development potential of emerging industries such as marine renewable energy, blue bioeconomy, marine minerals, seawater desalination, maritime defense, and submarine cables as well as the green growth trends recommended by the United Nations Conference for Trade and Development (UNCTAD) and the 5 priority measures for developing the blue economy proposed by the Ocean Panel. As the above sections span key marine industries in Europe, the United States and other countries, they serve as valuable reference for the future sustainable development of Taiwan's blue economy industry.

Sustainable Development of Taiwan's Coastal and Marine Tourism

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Keywords: Coastal and marine tourism, yacht, cruise, island hopping tourism

The lockdown caused by the 2020 epidemic has prevented many people from going abroad. However, people's demand for sightseeing and leisure travel still exists, which has caused the rise of domestic tourism in Taiwan and become an important opportunity for the government to guide the development of high-quality tourist facilities and improvement in service quality. Among such developments, coastal and marine tourism is one of the key industries in which high-quality tourism must next be created. This article introduces Taiwan's coastal and marine tourism industry and leisure and recreation activities, including yacht tours and cruise tours, and introduces sustainability policies formulated for Taiwan's coastal and marine tourism.

Since Taiwan formed the vision of a becoming a nation of tourism and initiated its plan to double the number of tourists visiting the island in 2002, Taiwan's tourism market has grown steadily year by year, with significant performance in all aspects including number of tourists, output value, and world rankings [1]. From the perspective of tourism performance, about 11.84 million tourists came to Taiwan in 2019, an increase of 7% compared to 2018, and tourism output value also increased to 14.4 billion US dollars. Although the scale is lower than the global GDP contribution of 10%, it also accounts for about 4% of Taiwan's overall GDP, and is progressing year by year, while the overall scale of tourism is ranked 37th by the World Tourism Commission (WTTC). Even with the COVID-19 epidemic devastating the global tourism market in early 2020 and causing the global tourism market to decline, Taiwan's tourism industry still advanced to 36th in terms of world rankings.

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According to The International Coastal and Marine Tourism Society (ICMTS), coastal and marine tourism is defined as follows: Marine tourism consists of recreational activities that entail leaving one's place of residence and traveling to the marine environment and coastal areas. With marine resources as the basis, coastal and marine tourism is defined as offering tourists access to entertainment, fitness, recreation, and leisure, etc. through sea travel, coastal travel and underwater tourism, which in turn produces economic and social benefits. Therefore, from the perspective of geographical location and marine resources, it is clear that Taiwan is a region suited to the development of marine tourism.

Taiwan is located at the intersection of the Pacific Ocean and Eurasia, surrounded by seas. The surrounding sea area is five times that of land, and the natural coastline of the country is about 1,105 kilometers long. With abundant marine tourism resources, the country is equipped with the 4S elements for the development of coastal and marine tourism and leisure, including sand, sea, sun and seafood [2]. The island also features seawater hot springs, a rarity across the globe, about 3,000 species of marine fishes in the world accounting for one tenth of global fish species, 43 species of butterfly fish in coral reefs, and at least 29 species of cetaceans, accounting for more than one third of the world's whale species (79 species) [3]. However, due to the special political climate and the nation's policy of "emphasizing land over sea," the general public have had limited access to ocean activities. It was not until 1988 that the Ministry of the Interior issued the Regulations for the Management of Marine Fishing Activities in Taiwan that maritime leisure and recreational activities such as sea fishing, sailing, windsurfing, surfing, canoeing, jet skiing, parasailing, kite surfing, yachting, cruises and other activities became increasingly popular. In view of this, although Taiwan has been late in developing marine tourism, recreational activities on the coast, on the sea and under the sea have seen rapid growth and huge tourism business opportunities [4], such as the ocean recreational activities, yacht tours or cruising tourism that have become extremely popular in the past 10 years. In the following paragraphs, we will be giving a brief introduction to these activities.

Taiwan's coastal and marine tourism industry and recreational activities

Shi-Wei Huang and Chung-Ling Chen (2019) believe that there are a total of 11 marine industry activities in Taiwan (Figure 1) with a total output value of approximately US$21.14 billion [5]. The coastal and marine tourism/recreation industry accounts for 9.09% (about 1.92 million), including access to three types of tourism activities and recreational services – coast, sea and underwater, and the operation and management of their auxiliary facilities, production and sales of supplies and equipment as well as travel services. Types of activities include fish and biological resource-oriented activities (such as recreational fishing harbors), coastal and water recreation activities (rock fishing, intertidal activities, water activities, water sports), marine education activities (religious activities, art and cultural activities), boat tours (yacht visits, cruise travel, whale watching eco-tourism), and living experience activities (coastal fishery experience, offshore fishery experience). With sightseeing activities on recreational fishing boats as an example, the Fishery Agency has estimated that the total number of tourists going out to sea in 2013 was about 1.19 million, including about 400,000 persons engaging in whale watching on recreational fishing boats, 590,000 engaging in sea fishing, and 200,000 engaging in lagoon sightseeing with annual output value of the above activities coming to approximately US$67.85 million [6].

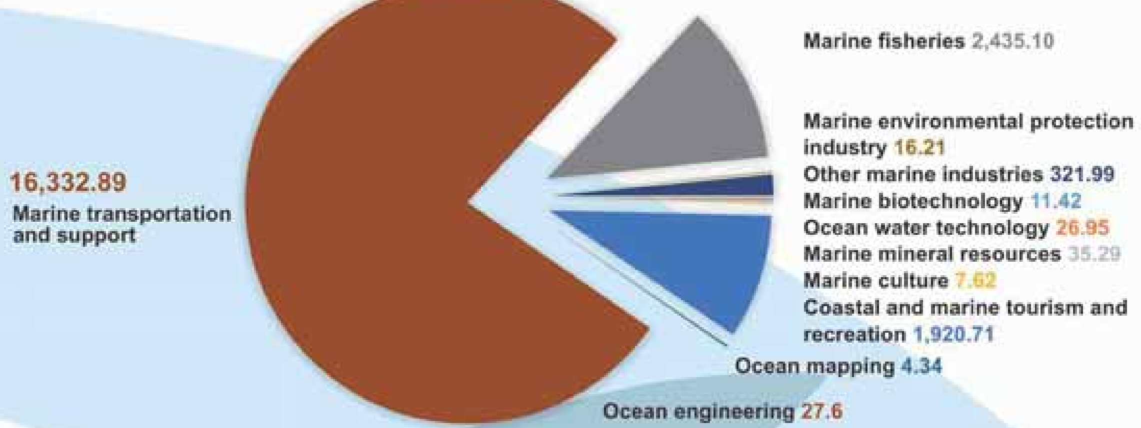

Figure 1/ Taiwan's marine industry activities and output value (Unit: million of U.S. dollars)
Source/ Shi-Wei Huang, Chung-Ling Chen (2019) [5]

In addition, the number of coastal and marine tourist visits in Taiwan reached a total of 52,560,606 from 2016 to 2018 after consolidating visitor data from 9 major tourist and recreational destinations, outlying island national parks and national-level scenic spots (the National Museum of Marine Biology & Aquarium is regarded as part of Kenting National Park), and 21 other marine and coastal tourist attractions.

Yacht sightseeing

Taiwan's yacht industry emerged in 1958. At the beginning, several wooden sampan manufacturers and amateur experts who love yachts worked together on the riverside of Tamsui to start the design and construction of wooden yachts [7]. Due to these origins, Taiwan's yacht industry is equipped with: 1. Sophisticated woodworking techniques; 2. Diligent manufacturers who pursue affordability and are strongly capable of emulating designs gained great popularity among the US military in Taiwan, and then exported to the west coast of the United States, gradually gaining renown, before sweeping the global market for marine leisure amusement. For export convenience, the first wave of manufacturers not only expanded the scale of their business in Tamshui, new entrants also set up factories in Kaohsiung. In northern Taiwan, about 7 manufacturers operated with Keelung Port as the center of export while, in the south, 20 businesses formed industry clusters in Tainan and Kaohsiung, with Kaohsiung Port as the center of export, with most manufacturers operating out of the Kaohsiung coastal areas, Dafa industrial zone, and Cijin.

Today, Taiwan's yacht industry has become world-renowned for its yacht manufacturing industry, which has enabled Taiwan to become one of the top 10 yacht manufacturing countries in the world. While locally manufactured yachts are mainly for export, the public and private sectors are also actively promoting various water recreation activities, competitions, and encouraging water activities among the general public. According to Boat International's 2019 ranking statistics for the total length of large yacht orders in various countries, Italy ranked first at 14,374 meters, followed by the Netherlands, Turkey, the United Kingdom and Germany. Taiwan ranked sixth in the world with 1,852 meters, no. 1 in Asia. Among the top 20 global yacht manufacturers in 2019, Taiwan's Alexander Marine Co., Ltd. and Horizon Yachts ranked 7th and 9th in the world respectively.

At the same time, Taiwan's yacht export market exhibited a stellar performance with an export value of approximately US$230 million in 2019, accounting for 57% of total ship export value, at an annual increase of 38.0%. Among them, most yacht manufacturers have signed long-term contracts with the United States. Therefore, exports are dominated by the United States, accounting for 68.7%, followed by Australia with 13.8%, Italy accounting for 3.7%, and Japan accounting for 2.6%.

Taiwan's yacht consumer market is dominated by clubs that operate on a basis membership and is concentrated in the high-income group at the top of the social ladder. Argo Yacht Club, for instance, has yacht piers in Kaohsiung Port, Tainan Anping Port, and Penghu Magong Port. With approximately 600 members, basic membership fees cost around US$50,000 while the highest membership fee is US$340,000. Meanwhile, the Lohas Ocean Maritime Academy was established to combine the art of life with yachts and sailing boats, enabling members to enjoy marine life. With Tainan Anping Port as the base, 150 berths, hotel accommodations, luxury villa resorts, theme shopping malls were built. These facilities as well as the nearby Anping Cultural Old Street, etc., regular carnivals and yacht experience activities offered from time to time form a complete system of yacht, water and land activities. There are also similar small-scale yacht clubs in Taipei, while Taichung City Government and Port of Taichung are also actively planning yacht and cruise activities along the blue highway.

Cruise sightseeing

Asia is an emerging blue ocean market for cruise ships in recent years, and Taiwan has become the second largest source market in Asia due to its geographical location and specific traits that imbue the country with great potential in developing the cruise market [9]. In 2019, the Asian cruise market consisted of 39 cruise brands operating in Asian waters with 79 cruise ships deployed and more than 4.02 million passengers. From 2013 to 2019, voyages to and stopovers in Asia continued to grow from 861 voyages in 2013 to 1,917 in 2019. The destination countries with the most stopovers in Asia are, in order, Japan (2,681), China (809), Malaysia (561) and Thailand (550). Individual ports with the most stopovers are, in order, Singapore (400), Keelung, Taiwan (284) and Shanghai, China (276), While home ports with the most number of inbound and outbound voyages are China, Taiwan, and Singapore. The world's top three international cruise companies for the development of cruise tourism include Carnival Cruises, Royal Caribbean International (RCI), and Norwegian Cruise Line. In Asia, the more well-known one is Genting Cruises Lines which includes Crystal, Dream Cruises, and Star Cruises; among them, Star Cruises currently lists Taiwan as the home port out of which its cruise ships operate. On the other hand, in 2019 Keelung Port was the main port for cruise ships coming in and out of Taiwan with travel itineraries mostly designed to accommodate tourists making stopovers. In terms of Keelung's cruise tourism development, the compound annual growth rate (CAGR) was about 31% [10].

However, due to the impact of COVID-19, the market is declining sharply. This is a global risk, nevertheless, and Taiwan's cruise tourism's response is to move towards the establishment of stronger foundations during this period, such as the continuous construction of cruise port service facilities and the optimization of port city ground reception itineraries, etc. [10]. Apart from formulating the Incentives for the Promotion of Visits to Taiwan by Overseas Cruise Ships, the Tourism Bureau of the Ministry of Transportation and Communications of Taiwan also encourages fly cruises that integrate cruise with air travel and comprehensive transportation services between cruise marinas and scenic spots, including implementation of the government's cruise ship north-south dual home port policy, optimization of port facilities in Keelung Port and Kaohsiung Port, and integration of port and tourism resources to promote passenger transportation via the maritime blue highway. In addition, the Bureau is also working to strengthen the international marketing of Taiwanese ports to help cruise peripheral industries expand their business opportunities in Taiwan.

In response to the COVID-19 epidemic, Taiwanese travel agencies have been actively cooperating with Dream Cruises (Explorer Dream), launching island hopping in July 2020 and sending passengers on their journey spanning August to September 2020, thus becoming the world's first international cruise ship to resume services following initial lockdown. Departing from Keelung, the cruise visited Penghu, Kinmen, and Matsu along the way [11]. The price of the 5-day 4-night itinerary is divided into three categories: sea view room (approximately US$400), terrace room (approximately US$500) and palace suite (approximately US$900). With the original 5 voyages sold out within 48 hours and more than 4,000 passengers waitlisted, 4 additional voyages were made available at only 50% passenger capacity (originally 3,630 people) each voyage. At the same time, the "eight-fold prevention and control guarantee" was formulated, including embarkation and disembarkation, guest rooms, public areas, food hygiene, event performances, fresh air systems, medical facilities, crew protection and other core prevention and control measures, to ensure the safety and health of passengers and crew. Following the success of this itinerary, island hopping by cruise is expected to become a new mode of sightseeing.

Sustainability Policies for Coastal and Marine Tourism in Taiwan

To ensure the sustainable development of the coastal and marine tourism industry, the Taiwan government has proposed a 10-year comprehensive development plan for the Blue Highway (2021-2030). Regarding maritime and marine leisure tourism along the Blue Highway, an estimated US$840 million will be allocated to update and subsidize various public transportation facilities such as shipping operations, ports, and vessels. It is estimated that: 1. During the period of subsidized passenger capacity, ticket revenue will increase by NT$77 billion, while at least 100 employment opportunities will become available in the outlying islands every year; 2. Island hopping by cruise will increase outlying island tourism revenue by NT$4.8 billion; 3. The number of cruise passengers entering and leaving Hong Kong will increase to 2 million persons per year, with cruise ships creating economic benefits reaching NT$120 billion; 4. Proprietary brands established by cruise companies will create 300 job opportunities; 5. By organizing international-class sailing racing events and expanding yacht marketing activities, combining the existing tourism resources and special activities offered by various county and city governments, for example, 3,700 job opportunities for example can be created at Anping Port in Tainan through the development of the yacht marina while land development benefits and private investments will amount to NT$10 billion. Lastly, an overview the sustainable development of the coastal and marine tourism industry at home and abroad suggests that it is necessary to actively carry out cross-domain integration to promote the transformation and innovative development of the marine industry, the education and cultivation of marine culture, and the sustainable management of marine environmental ecology, thus securing the core strengths supporting Taiwan's future development of coastal and marine tourism [2].

References

[1] Yung-Hui Chou, Hsin-Yi Ou-Yang, Kuan-Chu Chen (2018). "Taiwan Tourism 2020: A Sustainable Tourism Development Strategy", Taiwan Modern Tourism 1 (1), 1-20.

[2] Ryan Wu, Teng-yuan Hsiao, Wayne Liu (2019), Research on Taiwan's Coastal and Marine Tourism Industry and Development, granted by Ocean Affairs Council
https://www.oac.gov.tw/ch/home.jsp?id=45&parentpath=0,4&mcustomize=research_view.jsp&dataserno=201908200013

[3] Yu-Tzu Chao, Pei-Chun Tsai, Ta-Hsin Yang, Ping-Jui Wu (2009). Research on Taiwan's Marine Economy Development, the Council for Economic Planning and Development, Executive Yuan
http://ws.ndc.gov.tw/Download.ashx?u=LzAwMS9hZG1pbmlzdHJhdG9yLzEwL3JlbGZpbGUvNTg2OC83NTUzLzAw
MTE4ODFfMTgucGRm&n=MTYu5Y%2Bw54Gj5rW35rSL57aT5r%2Bf55m85bGV5LmL56CU56m2LnBkZg%3D%3D&icon=..pdf

[4] Chung-Ling Chen (2007). "Review and analysis of marine tourism and recreation studies in Taiwan", Journal of Toko University 2(2), 46-68.

[5] Shi-Wei Huang, Chung-Ling Chen (2019), Marine Industry Statistics and Economic Promotion Strategy Planning, granted by Ocean Affairs Council
https://www.oac.gov.tw/ch/home.jsp?id=45&parentpath=0,4&mcustomize=research_view.jsp&dataserno=201908200024

[6] 胡順惠（2019）．郵輪旅遊發大財！年產值破50億元．2020年估創百萬人次巔峰
https://www.ettoday.net/news/20190716/1491290.htm&ct=ga&cd=CAIyIjBjZjgyNWQxYWIyNzFmZmM6Y29tLmhrOnpo
LVRXOkhLOkw&usg=AFQjCNGfRJqAcgT7YjH3F_iNzqSsDNscDw

[7] Iy-Hsing Engineering Consultants Inc. (2016), 臺灣遊艇基地整體評估規劃, Maritime Port Bureau
https://www.motcmpb.gov.tw/ServerFile/Get/71a128b8-d72c-44f0-9662-2fc55fb32099?DLCount=1

[8] Chin-Fei Huang (2020), Industrial Economic Statistics Newsletter Vol. 354, Ministry of Economic Affairs
https://www.moea.gov.tw/mns/DOS/bulletin/wHandBulletin_File.ashx?file_id=21480

[9] Ministry of Transportation and Communications (2020). 10-year comprehensive development plan for reinforcing Taiwan's blue highway (2021-2030), (Taipei: Taiwan).

[10] Wayne Liu (2020), Taiwan Cruise Yearbook 2020, (Kaohsiung: Taiwan), National Kaohsiung University of Hospitality and Tourism.

[11] 吳雨潔（Jul. 27, 2020）．直擊全球第一艘復航的國際郵輪．跳島旅遊如何玩的安心?天下雜誌
https://www.cw.com.tw/article/5101319?template=fashion

Current Status of Global Marine Energy Technology Innovations and Promotional Strategies

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Keywords: Marine energy, Levelized cost of electricity, Sustainable development goals

The definition of marine energy as emerging renewable energy using marine resources are tidal, wave, tidal stream/current and ocean thermal energy conversion [1]. In addition to technological development of marine energy, how to effectively implant government policies are important opportunity for the development of marine energy and related industries. This article briefly describes the main marine energy technologies and characteristics, and introduces marine energy technology development trends and policy planning.

Taiwan faces the Pacific Ocean to the east and China across the Taiwan Strait to the west. It is about 377 kilometers long from north to south, and about 142 kilometers wide from east to west with a natural coastline approximately 1,105 kilometers long, or 1,520 kilometers if including the total length of the Penghu Islands. Under favorable conditions such as the northeast monsoon and the Kuroshio, marine energy reserves such as tides, waves, tidal currents, and ocean thermal energy conversion are abundant. However, due to cost and technical factors, development of the aforementioned marine energy resources is still in the stage of R&D and demonstration.

The development of marine energy contributes to responding to climate change, and can reduce dependence on fossil energy for power generation, thus achieving the reduction in carbon dioxide emissions. Secondly, the development of marine energy can be applied to development of the blue economy such as shipping, refrigeration and air-conditioning and desalination. In addition to increasing employment opportunities, advancement in this aspect can also help us achieve the United Nations Sustainable Development Goals (SDGs) including goals 7 and 14 as well as resolve issues related to renewable energy development and sustainable marine development. Moreover, marine energy technology is more stable than intermittent renewable energy sources such as wind and solar power, and can be used as a base load energy to enhance the stability of national energy supply.

In the development of marine energy across the world, due to the varying characteristics of seas in different geographical environments and Taiwan's climate of frequently occurring typhoons and torrential rains, the same engineering or technology in other countries may not necessarily apply to the cases of Taiwan. At present, Taiwan's marine energy technology research and development are mainly conducted by academic institutions and think tanks such as the Industrial Technology Research Institute. In addition to collecting data on Taiwan's geographic environment and conditions, sea state characteristics and meteorological data, and establishing the conditions and restrictions required for marine energy development, these institutions have also begun developing and demonstrating various marine energy technologies. As marine energy is an emerging renewable energy sources, apart from technological development, the effective introduction of government policies will be an opportunity for the development of marine energy and related industries. This article briefly describes the characteristics of marine energy, and introduces the latest international marine energy technology development trends as well as policy planning.

Primary marine energy technologies and characteristics

Most forms of marine energy consist of the energy produced by the gravitational relationship between the earth, moon and sun and the rotation of the earth. There are 5 energy types according to their power generation characteristics. Firstly, tidal barrage/range is the permanent and stable currents caused by the periodic flow and rise and ebb of water in the sea. Tidal barrage power generation entails converting the potential energy of tidal range into electrical energy. Due to factors such as limited economic benefits and geographical environment restrictions, tidal barrage power generation is subject to many restrictions. For example, tidal range should be more than 5 meters to have economic benefits. The tidal barrage power station at the mouth of the Rance River in France, for instance, has a tidal range of 13.5 meters. In addition, to place tidal barrage generators, dams must be built in the bay of a power generation site. Land for this type of project is difficult to find and the cost is high, and the facilities will ultimately run into problems such as siltation in the reservoir area and equipment corrosion.

Ocean current power generation can be divided into tidal stream power generation and tidal current power generation with ocean current mainly caused by the temperature difference of sea water in the ocean. Seawater will cyclically flow between the oceans. When the equator warms, seawater will flow to the north and south poles to cool down, sink, and then return to the equator. Energy is extracted from ocean currents in ways like that of wind power generation, using ocean currents to drive turbines and converting the energy generated into electricity. Tidal current power generation, on the other hand, uses rising and falling tidal water to drive turbines for power generation. As most of the equipment is submerged under water, there is no need to build dams, thus reducing the cost of project land. Meanwhile, compared with tidal stream power generation which takes place in the deep seas, tidal current power generation takes place offshore and is energy is transmitted back onto land, making maintenance easier to perform. The rotation speed of turbine units driven by tidal currents is also lower, effecting only a slight impact on the hydrological environment and marine life. At present, several technologically mature turbine units are available, including the vertical axis, horizontal axis, oscillating hydrofoil and jacket type.

A generator set is used to convert the kinetic energy of waves into electricity, and the wave conversion system can usually be divided into 3 parts. The first part is the capture system, which gathers scattered incident waves into an enclosed area to increase the amplitude and energy density of the waves. The second part is the conversion system, which converts the obtained wave energy into electricity, and the third part is the energy storage system.

Ocean thermal energy conversion (OTEC) is a method of generating electricity that uses the thermal energy of the temperature difference between ocean surface seawater and deep seawater to convert it into electricity. Generally speaking, temperature differences of 20°C have better utilization value, therefore oceans located between the equator and 30 degrees north and south latitude are more suitable for the development of ocean thermal energy conversion. OTEC power plants are mainly divided into three types: land, shelf and floating.

The salinity gradient power generation system uses the difference in the concentration of the salinity and freshwater salinity of the river's estuary to release chemical energy and convert it into electricity. Currently two main processes to make use of this potential energy are being tested and applied: pressure retarded osmosis (PRO) and reversed electro dialyses (RED).

Table 1/ Characteristics of various types of marine energy

Category	Energy source	Energy-rich area	Energy factor	Stability	Development costs
Tidal barrage/ range	Generated by the tidal force of the sun and moon driving sea water movement on the earth's surface	The continental coast between 45° and 55° latitude	Proportional to the square of the tidal range and the area of the harbor	Very regular	Higher
Tidal stream/ current	Generated by the density, pressure gradient, or wind on the sea surface caused by the rotation of the earth and the uneven distribution of seawater temperature and salinity	Western sides of the Pacific and Atlantic in the northern hemisphere	Proportional to the square of speed and flow	Relatively stable	Low
Wave energy	Generated by the wind on the sea	Eastern sides of the Pacific and Atlantic in the northern hemisphere	Proportional to the square of the wave height and the area of the undulating water surface	Relatively unstable with cycles of about 1~10s	Higher
Ocean thermal energy conversion	Generated by the difference in the absorption of solar radiation heat between the ocean surface and deep seas, and the heat transport of ocean circulation	Low latitude oceans	Proportional to the amount of warm water and temperature difference in sea areas with sufficient temperature difference	Quite stable	High
Salinity gradient	Uses the difference in the concentration of the salinity and freshwater salinity of the river's estuary to release chemical energy and convert it into electricity	The intersection area of sea water and fresh water	The energy is greater than OTEC, and it can generate electricity during the day and night	Relatively unstable	High

Source/ Yu-Shu Kuo et al. (2019) [2]

Important trends in future marine energy development

As technology advances, the International Renewable Energy Agency (IRENA) shows the following trends [1]:

I. Tidal barrage is the most widely deployed form of marine energy, but tidal stream and wave energy are the rapidest technology development

In 2020, marine energy power plants with total capacity of as much as 2.83GW are under planning or demonstration and that, by 2030, commercially viable capacity will reach 10GW. Tidal barrage is currently the most widely deployed form of marine energy, accounting for 98% of all marine energy. The total installed capacity is 521.5MW, mainly in Republic of Korea (254MW) and France (240MW) which have an installed capacity of 494MW, while Canada (20MW), China (4.1MW) and Russia (3.4MW) account for a relatively low proportion. However, because the installation of tidal barrage is greatly affected by topography, no new power plants have been installed in the past ten years.

Tidal stream and wave energy power plants currently operating across the globe amount to 12.91MW, out of which wave energy accounts for the majority (10.6MW) while plants utilizing these two power generation technologies are being continuously built with planned capacity of more than 1MW. As the technological progress of tidal stream energy is rapid and gradually moving towards commercialization, even though wave energy is also moving towards higher levels of technological advancement, the technology is relatively immature and mostly still in the demonstration stage.

II. Ocean thermal energy conversion, salinity gradient and ocean stream/current have development potential within 10 years, but wave energy is under technology divergence

The above energy types used to be small-scale deployments, but are now beginning to expand in scale. However, these three technologies are still in the research and development stage at research institutions or universities with little participation in the private sector. Currently, there are about 31 countries that value marine energy and are willing to invest in planning and deployment, of which European countries account for more than half, followed by Asian countries. The horizontal axis unit is a relatively mature tidal stream energy technology, and is also the main unit technology currently planned by various countries. However, the application of another kite-type technology cannot be underestimated, the main reason being that it can be used in environments with relatively low flow speed. As such, whether the horizontal axis unit continues to be the mainstream technology remains to be seen. In contrast, wave energy technology is advancing in all aspects with almost 10 different technologies currently under development simultaneously. Two different directions however can still be observed, one of which is the increase in unit capacity and power plant scale, and the other the construction of smaller capacity or specific purpose equipment, such as powering offshore wind power platforms or pumping seawater to the shore for seawater desalination.

III. The levelized cost of electricity of marine energy is lower than expected

In the early stages of power plant life cycle, the levelized cost of electricity for all forms of marine energy power generation is uncertain and difficult to predict. Currently, tidal stream electricity generation costs anywhere from US$0.2 to US$0.45 per kWh, while wave energy costs between US$0.3 and US$0.55. At this stage, moreover, development costs are still likely to fall again. For example, tidal stream power generation can drop to US$0.11 per kilowatt-hour of electricity generation between 2022 and 2030, while wave energy can drop to US$0.22-0.165 between 2025 and 2030. [1]

IV. Effective guarantee of income and policy subsidies are key factors boosting the development of marine energy

As mentioned above, the levelized cost of electricity generated from marine energy is still higher than the current cost of wind power, solar photovoltaic, and biomass power generation. Therefore, building a financing environment and creating innovative financing opportunities to reduce power generation costs is an indispensable part of the development of marine energy. After providing the corresponding resources, the development of marine energy will rise to become an important part of the blue economy, and can bring synergistic effects when utilized in combination with conventional ocean renewable energy (oil, natural gas), offshore wind, fishery, seawater desalination and other industries. On the other hand, marine energy is greatly suited to the energy development of island countries or outlying island regions. Since traditional energy pipelines and other infrastructure are of relatively higher costs in offshore areas, with incentives offered by policy subsidies and the premise of sustainable development, marine energy can not only reduce levelized cost of electricity, but also attract corporate investment (corporate social responsibility and sustainable development).

V. The development of marine energy can be integrated with marine protection facilities

Due to climate change, the risk of future sea level rise continues to increase. As such, integrating marine energy facilities with relevant offshore dams, seawalls, bridges, and other facilities are feasible solutions for mitigating or adapting to climate change. The cost-benefit analysis can also be evaluated at different stages through a standardized model.

VI. International cooperation and multilateral cooperation are the focus of marine energy development

Current marine energy technology development needs a breakthrough with appropriate use of international knowledge, information sharing and international cooperation the key to the improvement of marine technology. Cooperation with existing mature marine energy manufacturers such as oil, natural gas and offshore wind power can effectively reduce technical bottlenecks or improve management of the industrial supply chain and reduce operational risks related to marine energy.

Government policy support is crucial to the success of marine energy

The core issue of marine energy development lies in how to reduce its technical cost so that it can compete with other types of renewable energy. The establishment of individual business models applied in conjunction with various financial tools provided by the government can effectively reduce the risk of investment in marine energy. There are 7 major action strategies that provide different participants (stakeholders) with corresponding measures for promoting the development of marine energy: 1. Enhance the Business case; 2. Improve access to financial support; 3. Set up and strengthen resource and site assessment; 4. Build supply chain; 5. Boost ocean energy policy and regulartory schemes; 6. Minimise risks by improving reliability and efficency of the technology; 7.Develop capacity through enhanced co-operation [1].

Conclusion

Marine energy is inherently conducive to sustainable development. Compared with the offshore wind power, solar energy and other intermittent renewable energy sources currently utilized, it has the benefits of stable power generation, and can be used as a base load energy that complements the development of the former to maintain greater energy stability. The development of marine energy is an important part of the development of the blue economy. As Taiwan is surrounded by the sea, it is fully equipped to engage in the advancement of marine energy even as developments in other parts of the world still face various issues. In addition to technology, effectively reducing power generation costs, offering adequate financial support, and formulating incentive policies are all strategies that the government should give priority to considering its obligation to create a favorable environment for the development of the marine energy industry.

References

[1] IRENA (2020), Innovation Outlook Ocean Energy Technologies https://cisp.cachefly.net/assets/articles/attachments/84174_irena_innovation_outlook_ocean_energy_2020.pdf

[2] Yu-Shu Kuo et al. (2019). The preplanning of middle and long term proposal of the development of marine sciences and technology, granted by Ocean Affairs Council.

Dynamic Analysis of the Marine Transportation and Shipbuilding

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Keywords: Marine transportation, shipbuilding, ship maintenance

Ocean transportation is extremely crucial to the global economy and is one of the key modes of transportation in international logistics with its transportation volume accounting for more than 80% of total international transportation volume [1]. In addition, the global Greenhouse Gas (GHG) emissions of international shipping account for only about 3 to 4% of global GHG emissions [2], making marine transportation an effective and energy-saving method of transportation. Marine transportation is an important link in the marine industry, while shipbuilding and maintenance are industries full of innovation and competition closely intertwined with the global economy. This article offers a dynamic analysis and report of the marine transportation, shipbuilding and maintenance industries in Europe, the United States, and Taiwan.

Marine transportation relies on the natural environment, ship navigation and port facilities, and has the following characteristics [3]:

I. Natural waterways

Marine transport vessels sail in natural seas and are not restricted by roads and railway tracks. With changes in politics, trade environment and marine environmental conditions, shipping routes can be flexibly adjusted to complete shipping tasks. On the flip side, marine transportation is also easily affected by the marine environment, voyages are not always on schedule, and the possibility of encountering severe sea states is also high.

II. Large capacity per ship

With the development of the international shipping industry, modern shipbuilding technology has progressed exponentially with ships becoming increasingly larger. Ultra Large Crude Carriers (ULCC) can reach more than 500,000 tons, and the maximum load of large container ships has exceeded 20,000 TEU (twenty-foot equivalent unit).

III. Low unit transportation cost

Maritime transportation takes place on natural channels, and port facilities are generally government public constructions, allowing shipping companies to save substantially in terms of infrastructure investment. In addition, ships feature large carrying capacities, long service life cycles, long transportation distances, and low unit transportation cost, providing convenient and favorable transportation conditions for the movement of bulk goods.

Over the past few decades, changes in the global economic cycle have greatly affected the development of the marine transportation industry. When the economy improves, ocean freight rates also increase, but when the economy is sluggish, oftentimes freight income may not even cover operating and rental costs. Among them, the freight index is an important indicator that affects the profitability of the shipping industry. As shipping is predicated on the price of oil, trends in oil prices and the collection of additional fees are important aspects that affect the profitability of shipping operators [4].

Ships are the main means of ocean transportation with the main types of cargo ships being: Container ships, bulk carriers, and oil tankers, etc. In recent years, ship construction and operation have exhibited the following trends:

I. **Increasingly large hulls:** Due to advancements in shipbuilding engineering technology, ships continue to increase in size so as to reduce transportation costs by expanding the capacity of a single ship; this, however, also affects the port industry and the surrounding infrastructure, such as the opening of the New Suez Canal in 2015 and the expansion of the Panama Canal in 2016. Following their completion, large ships can now sail through the new canals, including container ships. According to survey statistics released by Alphaliner, a French maritime consulting agency [5], by the end of 2019, container ships of 7,500 TEU to 9,999 TEU accounted for 18% of total capacity, and large container ships of more than 10,000 TEU accounted for about 36% (reaching 573 vessels).

II. **Increasingly younger ages of ships:** By the beginning of 2020, ships of more than 20 years of age accounted for only 7% of the total capacity of container ships, while ships of more than 15 years accounted for 13% [5]. Generally, the designed service life of ships is about 15 to 20 years although, subject to adjustments in operating conditions, some vessels may be scrapped and dismantled ahead of schedule.

Shipyard orders for new ships also change with the operating conditions of the shipping industry. When the economy is flourishing or the demand for ships increases, the price of new ships will rise. At such times, shipowners who place orders may need to wait several years before their vessels are delivered. However, when the economy is declining or there are too many ships in the market, the price of new ships drops, and few ship owners place orders. However, shipping companies who still have vision or courage actively purchase new ships and adjust the size of their fleets during periods of low operating and freight rates, so as to obtain a profitable opportunity when the economy takes an upward turn.

In addition to regular maintenance, ships must be returned to the shipyard for maintenance and overhaul after a certain period of operation. In recent years, moreover, in response to energy conservation trends or regulatory requirements, existing ships are required to install energy conservation and pollution prevention equipment.

EU-related industry dynamics

Ocean transportation plays a key role in the EU's economy and trade and is estimated to account for between 75% and 90% of the EU's foreign trade and one-third of the EU's internal trade. In 2018, more than 410 million cruise and ferry passengers boarded and disembarked at EU ports, an increase of 5.6% over the previous year. In the same year, the total weight of cargo to and from the main ports of the EU via short-distance sea transportation (excluding ocean routes) was 1.8 billion tons. Overall, the maritime industry accounts for approximately 8% of the EU's blue economy job vacancies (approximately 410,000 people), 16% of gross value added (GVA) (approximately €35.6 billion) and 20% profit (about €18.8 billion). The average annual salary of direct employees in ocean transportation is estimated to be close to €41,800 (about NT$1.43 million), an increase of 11% over 2009. Among EU countries, Germany has a leading position in the maritime industry, contributing 32% of job openings and 33% of GVA, followed by Italy, providing 17% of job openings and 13% of GVA, respectively [6]. (Gross value added

[GVA] is to measure the value of goods and services created by a certain region or industry of an economy, product taxes and product subsidies are deducted from GDP [7]; in other words, GVA is closely related to gross domestic product [GDP].)

In terms of shipbuilding in nations such as the UK, Germany, France, Italy, the Netherlands, Spain and other countries, products are primarily high-tech and high-value ships, such as super-large luxury yachts, mega cruise ships, and offshore work support vessels. With impeccable brand design and manufacturing capabilities, these ship yards play an important role in the global shipbuilding industry. In recent years, passenger ships (ferries and cruise ships), offshore work ships and other non-cargo carrying ships (ONCCV), account for more than 95% of the EU's newbuilding orders [6]. The EU shipbuilding industry faces competition from shipbuilding companies in China, Republic of Korea and other countries due to the strong support of Asian policies and the drop in shipbuilding market prices (such as bulk carriers, container ships, and oil tankers). In recent years, in addition to the direct competition between European and Asian shipyards, the number of new ship orders in Asia has declined, indirectly affecting the equipment supply chain in Europe, the reason being that the equipment installed by Asian shipyards is mainly sourced from European companies. Due to the long history of maritime development in Europe and the establishment of authoritative institutions, it is a world leader in the research and development of advanced maritime navigation equipment. For instance, the headquarters of AP Møller-Mærsk Gruppen, the world's largest container shipping operator, is located in Copenhagen, Denmark.

Although the economic and financial crisis has a profound impact on the decline of the global shipbuilding industry, the EU has gradually shifted its business model and labor outsourcing in recent years, and adjusted production plans and supply chains to reduce costs. Figure 1 shows that there are signs of gradual recovery since 2013. However, after several consecutive years of growth, the total order volume of European shipyards has once again declined in 2019 [6]. Overall, the EU shipbuilding and maintenance industry accounted for 6% of total EU blue economy jobs in 2018 (320,000 people, 85% in shipbuilding, 15% in related machinery and equipment), 8% of GVA (17.3 billion Euros), and 5% of profits (€4.7 billion). Among European countries, the United Kingdom leads the shipbuilding and maintenance industry with 14% of job openings and 21% of GVA, followed by Germany with 12% of job openings and 18% of GVA [6].

Figure 1/ Changes in the economic scale of the EU shipbuilding and maintenance industry (unit: million Euros)
Source/ The EU Blue Economy Report 2020 [6]

The EU shipbuilding industry also provides funding, technology, and expertise for blue economic activities, such as capture fishery, offshore aquaculture, non-biological resources, marine renewable energy, coastal tourism, and maritime defense. The EU shipbuilding and equipment industry, especially in terms of cooperating with emerging industries, provides new opportunities, such as work support ships for offshore wind farms, marine structures and other marine technologies.

U.S.-related industry trends

The U.S. ocean transportation industry includes businesses engaged in ocean freight, ocean passenger services, ocean transportation services, warehousing and navigation equipment manufacturing, accounting for 15% of employment in the U.S. ocean economy (approximately 500,000 persons) and U.S. gross domestic product (GDP) 20.2% (approximately US$59.6 billion). Although the U.S. maritime industry accounts for a lower proportion of the marine economy in comparison with tourism, leisure, or offshore mining, it is an indispensable part of the marine economy. The goods carried by ships account for 34% of U.S. international freight trade by value, accounting for 73.4% by weight. In 2017, the average annual salary of each employee was the highest in the United States, reaching US$69,000 (approximately NT$1.93 million). The maritime industry provides approximately 21.1% of employment opportunities and 25.9% of GDP in California. The rest are distributed across the country, concentrated in major seaport areas. Warehousing is the largest component of employment in the maritime industry, accounting for 52.8% of the total employment in this industry in 2017 [8].

The shipbuilding and repair industry includes the construction, maintenance and repair of general ships, leisure boats, commercial fishing vessels, ferries and other marine vessels. The primary features of this industry are that large shipyards are concentrated in certain areas of the United States, but small ship construction and maintenance are more evenly distributed throughout the country, mainly in commercial fishing areas and areas where leisure boats are popular. In 2017, the shipbuilding industry accounted for 4.8% (approximately 160,000 persons) of employment in the U.S. marine economy and 6.6% of the U.S. GDP (approximately US$18.4 billion). The average annual salary per employee is US$69,000, which is much higher than the national average of US$55,000. In 2017, Virginia contributed the most to employment in the shipbuilding industry, accounting for 22.2% of the total shipbuilding industry in the country, whereas Washington State is the largest contributor to GDP in the shipbuilding industry, accounting for 21% of the total shipbuilding industry in the country [8].

Due to low sales profits of general cargo ships worldwide and high domestic labor costs in the United States, domestic shipyards in the United States mainly build U.S. Navy warships. Renowned civil construction shipyards such as Newport News Shipbuilding Company (NNS) [9] is the only shipyard in the United States that builds aircraft carriers and is also one of the two largest U.S. nuclear submarine manufacturers. Furthermore, some shipyards are not directly involved in the design and manufacture of new ships, but only undertake ship maintenance work.

Taiwan-related industry trends

Due to Taiwan's status as an island country, more than 95% of its import and export trade relies on shipping; as such, the marine transportation industry is the industry with the highest output value in Taiwan's marine economy (accounting for more than 40% of the marine industry's GDP) [10]. In 2019, Taiwan's international commercial ports accumulated 15,300,000 TEUs in terms of container throughput, while the cargo handling volume of international commercial ports is 730 million billable tons, which is slightly lower than in 2018, mainly due to the rise of ports in neighboring countries and the impact of the Sino-US trade war. Meanwhile, the number of inbound and outbound passengers at international ports is about 1.5 million. Among them, the number of international cruise passengers increased to 1.05 million, showing a gradual upward turn. The main reason is that Keelung Port has gradually transformed into a tourism and leisure, cruise transport, and actively sought to become a home port for international cruises, making the number of passengers hit a new high in recent years. In the same year, the container loading and unloading volume for direct shipping across the Strait was 2.49 million TEU, the loading and unloading volume for direct shipping across the Strait was about 120 million billable tons, the number of passengers for direct shipping across the Strait was about 2.28 million, and the number of passengers entering and leaving domestic commercial port was about 3.4 million [11], which shows that in conjunction with the development of outlying island construction policies, cross-strait and domestic maritime transport occupy a considerable proportion. In addition, important domestic carriers including container carriers Evergreen Marine and Yang Ming Marine Transport, etc., ranked 7th and 9th in transportation capacity globally in 2020 [5], and bulk carriers U-Ming Marine, Taiwan Navigation, China Steel Express, etc., play important roles in international cargo transportation [12].

Taiwan's large shipyards, with CSBC Corporation Taiwan (CSBC) as the representative (previously known as China Shipbuilding Corporation), focus primarily on manufacturing container ships, bulk ships, warships and special ships. After regeneration plans and privatization, the company now aims at diversified operations. Medium-sized shipyards including Jong Shyn Shipbuilding, LungTeh Shipbuilding, and San Yang Shipbuilding, mainly build coast guard cruisers, official ships, transportation ships, and ocean-going fishing vessels. In recent years, in response to Taiwan's national policies of building naval vessels and submarines domestically, the Ship and Ocean Industries R&D Center (SOIC) has cooperated with medium and large shipyards to successively undertake the design and manufacturing of many naval ships and submarines, thus reinforcing the vessel manufacturing abilities of Taiwan's navy. In addition, as Taiwan's climate is conducive to the production of yachts using glass fiber reinforced plastic (FRP) manufacturing technology, Taiwanese yacht manufacturers, such as Horizon Yachts, Monte Fino Yachts, Ocean Alexander and Tania Yacht, have been able to enter the market for super yachts with comprehensive services from OEM to customization. Today, the total length of orders for yachts manufactured in Taiwan has reached sixth in the world [13], showing that Taiwan's yacht manufacturing strength is recognized internationally. Ship propeller manufacturers, such as SOLAS, ZF Marine Group, and Hung Shen Propeller etc., specialize in the production of civil and military ship propellers. In recent years, to promote green energy and reduce waste gas emissions from coal-fired power station, the Taiwanese government has been actively building the offshore wind power industry in collaboration with the private sector, including shipyards and related mechanical and electrical industries, so as to increase Taiwan's energy independence rate. Overall, the output value of Taiwan's shipbuilding and maintenance industry was NT$42 billion in 2017 [14], while the number of employees in the shipbuilding and maintenance industry was approximately 25,000 [15].

Green shipping

To combat the greenhouse effect caused by the emission of greenhouse gases (GHG), the International Maritime Organization (IMO) was entrusted to undertake GHG-related emissions reduction in international shipping in the 1997 Kyoto Protocol, an extension of the 1992 United Nations Framework Convention on Climate Change. IMO started to work towards reducing GHG emissions in 2008, and began to implement emission regulations for international shipping on January 1, 2013. In 2018, IMO reached the first global agreement which specifies that, by 2050, total greenhouse gas emissions of the shipping industry will be reduced by at least 50% (compared to 2008). The specific method is to use Energy Efficiency Design Index (EEDI) to express energy consumption efficiency. The higher the EEDI index, the lower the energy efficiency. EEDI involves various design improvements in ship type, propeller, propulsion system and all kinds of carbon reduction equipment. IMO requires that new ships must undergo a model test within the towing tank to confirm that they meet EEDI emission standards before they can be built.

Furthermore, the IMO announced that the "Global Sulphur Cap" will be implemented on January 1, 2020 [1]. All ships must use low sulfur fuel oils (LSFO) with a sulfur content of less than 0.1% when navigating in the Emission Control Area (ECA); and when navigating in non-emission control areas, low-sulfur fuel oils with a sulfur content of less than 0.5% must be used to reduce sulfur oxides (SOx) emissions. The regulations will increase the fuel cost of marine vessels. Some ships have installed Scrubbers to reduce sulfur oxide emissions. The existing ECA includes the Baltic Sea (SOx, adopted in 1997; enforced in 2005), the North Sea (SOx, adopted in July 2005; enforced in 2006) [16], the North American ECA includes most of the United States [17], the Canadian coast (NOx and SOx, 2010/2012) [18] and the US Caribbean ECA, including Puerto Rico and the U.S. Virgin Islands (NOx and SOx, 2011/2014) [19]. Based on the agreement in Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL), other areas can be added as emission control areas.

Conclusion

Ocean transportation is an important mode of transportation in international logistics that has driven the vigorous development of import and export trade, tourism and manufacturing. To effectively reduce pollution, moreover, the shipbuilding industry has introduced ship weather routing applications in conjunction with the maritime industry through innovative designs, reducing energy consumption through appropriate route planning. In the future, the marine transportation and shipbuilding industry will continue to adopt more flexible strategies in response to shifts in the global economy and climate change.

References

[1] International Maritime Organization (2020)
https://www.imo.org/ (Jan. 11, 2021)
[2] International Maritime Organization (2014), Third IMO Greenhouse Gas Study
https://www.imo.org/en/OurWork/Environment/Pages/Greenhouse-Gas-Studies-2014.aspx (Jan. 11, 2021)
[3] 唐淵（2004），《國際物流學》（中國物資出版社），第1版。
[4] 產業價值鏈資訊平臺（2021），〈交通運輸及航運產業鏈簡介〉
https://ic.tpex.org.tw/introduce.php?ic=T000 (Jan. 11, 2021)
[5] ALPHALINER (2021), The Worldwide Reference in Liner Shipping
https://www.alphaliner.com/ (Jan. 11, 2021)
[6] European Union (2020). The EU Blue Economy Report 2020
https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/2020_06_blueeconomy-2020-ld_final.pdf (Dec. 8, 2020)
[7] 范秉航（2006），〈附加價值定義與內涵〉，台灣經濟研究院。
[8] NOAA (2020). NOAA Report on the U.S. Marine Economy
https://coast.noaa.gov/data/digitalcoast/pdf/econ-report.pdf (Dec. 8, 2020)
[9] Newport News Shipbuilding (2021)
https://nns.huntingtoningalls.com/ (Jan. 11, 2021)
[10] 陳豐霖（2016），〈艦船與海洋工程產業特性與發展前景〉，台灣國際造船公司。
[11] 交通部統計查詢網（2021）
https://stat.motc.gov.tw/mocdb/stmain.jsp?sys=100 (Jan. 11, 2021)
[12] 行政院（2020），〈海運（國情簡介-交通運輸）〉
https://www.ey.gov.tw/state/A44E5E33CDA7E738/f71d5650-83bc-4b76-908d-e1fd89d72c72 (Jan. 11, 2021)
[13] 中華徵信所（2015），〈TOP5000產業風雲-MIT遊艇銷量全球第六〉
http://www.credit.com.tw/newcreditonline/Epaper/IndustrialSubjectContent.aspx?sn=114&unit=318 (Jan. 11, 2021)
[14] 財團法人船舶暨海洋產業研發中心（2018），〈船舶電子報-2017年台灣船舶產業產出分析〉
https://www.soic.org.tw/%E8%88%B9%E8%88%B6%E9%9B%BB%E5%AD%90%E5%A0%B1/ (Jan. 11, 2021)
[15] 陳宗慶（2017），〈臺灣船舶產業概況〉，工商時報
https://www.chinatimes.com/newspapers/20170525000136-260210?chdtv (Jan. 11, 2021)
[16] International Maritime Organization (2014), Sulphur Oxides
http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-(SOx)-%e2%80%93-Regulation-14.aspx (Jan. 11, 2021)
[17] Marine Link (2012), California SECA Regulations Upheld by Supreme Court
https://www.marinelink.com/news/regulations-california346396.aspx (Jan. 11, 2021)
[18] Diesel Net (2011), Emission Standards International: IMO Marine Engine Regulations: Background
https://dieselnet.com/standards/inter/imo.php (Jan. 11, 2021)
[19] International Maritime Organization (2014), Special Areas under MARPOL
http://www.imo.org/OurWork/Environment/PollutionPrevention/SpecialAreasUnderMARPOL/Pages/Default.aspx
(Jan. 11, 2021)

The Current Developments and the Prospects in Taiwan's Marine Bio-Resources Industries

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Keywords: Marine ecology, fishery resources, biotechnology, marine spatial planning

Surrounded by the ocean with abundant marine resources, Taiwan has an advantage in developing "blue economy" marine industries. The so-called "blue economy" includes relevant economic activities based on marine industries, such as engineering and energy, marine chemistry and mining, marine bio-resources and leisure and relevant tourism industries. Under the concept of sustainable development, the "blue economy" emphasizes a rational use of marine resources in recent years. The development of bio-resource industry therefore plays an important role in this field, covering traditional utilization of fishery resources to emerging industries in marine biotechnology and tourism. Other relevant marine industries, such as marine engineering and energy, ship building and transportation, highlight the importance of marine ecosystem recovery and conservation as well. However, how to develop the marine bio-resource industry sustainably has become one of the most important issues when talking about "blue economy" marine industries.

Fry release for sustainable development of coastal fisheries
Images by Taiwan Ocean Conservation and Fishery Sustainability Foundation and Research Team of Professor Chen-Hsin Liao

Coastal and marine ecosystems are among the most productive ecosystems in the world, supporting the development of "blue economy" marine industries. Land resources are limited in Taiwan; therefore it is more important to emphasize sustainable use of marine biological resources and conservation through the reduction of pollutant and lowering impacts on marine ecosystem from human activities. Marine bio-resource industry is based on the use of marine organism, including biochemical technology to understand the mystery of marine ecosystem life, and advanced into further development and application in biotechnology, conservation and pharmaceutical industries. The exploitation and utilization of fishery biological resources needs to take into account of biodiversity conservation, with marine ecological environment assessment, in order to prevent over-exploitation of biological resources and seek the prefect balance between economic development and ecological conservation. Ecological management integrates ecological conservation, ecological tourism, planning and other tourism elements. Regional natural resources should be taken as the basis for the development of marine tourism industry to assist in the management of marine living resources and conservation due to human activities and development.

Marine bio-resources industry in European and American

The "blue economy" of the United States is dominated by six marine-related industries, including biological resource utilization, ocean engineering, ocean transportation, energy and mining, ship building and leisure tourism. After 2010, there has been a clear upward trend in terms of investment cases, employment opportunities, salary income, and product manufacturing and services. Compared with the level of 2016, the marine bio-resource utilization industry has the highest growth rate, including commercial fishing, aquaculture and aquatic product processing and marketing. Although the employment opportunities, salary income and product manufacturing for marine bio-resource industries only account for a small part of the overall U.S. economy, this industry supplies most of the aquatic products for consumption in U.S. in terms of their importance on product processing and marketing. In this regard, the productivity is similar to the highly productive agriculture industry in U.S. [1].

In the United States, under the concept of "blue economy" and "blue revolution", the utilization of marine life and aquatic resources is much important than before in order to maintain the health of coastal and marine ecosystems. Conservation of fishery resources and marine habitats and feeding grounds is also important in inheritance of the marine culture. Many traditional marine industries are based on related marine activities and utilization of biological resources. Currently the "blue economy" has been developed towards the field of "blue technology"; in general, blue technology can be defined as the design and provision of any technology and services related to improving the marine environment, such as navigational technology and ship building, ocean data collection and scientific research needed electronic instruments, mechanical technology and supporting software. This emphasizes that improving or reducing possible impacts through development of marine activities and practical actions, which contributes to the development of the overall "blue economy" through innovation in industries [2][3].

The biological resource utilization in the "blue economy" industries in EU focuses on the development of marine fisheries and coastal tourism. It emphasizes that economic activities must implement under sustainable management and adjustment to the environment, to reduce the impact of human activities on the ocean and strengthen recovery ability for the marine and coastal ecosystems. Directly related to the ocean, marine capture fisheries (including coastal artisanal and large-scale commercial fleets) and aquaculture fisheries (including seawater and freshwater aquaculture fish and shrimp) are regarded as the most important bio-resource industries of the "blue economy". Other bio-resource related industries include aquatic product production and processing, preservation and sales marketing, and the application of biological science and technology; more broadly speaking, this includes any economic activity that uses renewable aquatic resources, such as food additives, animal feed, pharmaceuticals, cosmetics and energy utilization, which establishes the blue bio-economy industry [4].

The production from capture fisheries of EU has continued to increase in recent years, which highly relates to the recovery of fishery resources, the increase in fish prices and the decrease in cost with more employment. As assessed by experts, this growth in economic performance can continue for couple of years [4]. However, these benefits and economic performance have not yet been achieved in the Mediterranean Sea basin where most fisheries have not yet moved towards sustainable fishing conditions. In comparison, the EU aquaculture production has stagnated over the last decades. Considering the increasing demand of seafood products in the EU, it seems reasonable to expect growth of aquaculture products in EU. At this stage, the EU marine biological resource industry is still dominated by renewable fishery resources, mainly supplying food, feed, biological-related products and processing, transportation and marketing, as well as bio-energy industries. The EU is now the top five suppliers and importers of aquatic products in the world, supporting the EU's overall aquatic product processing and transportation industry.

The most critical part of the "blue economy" is the implementation of the "Farm to Fork" policy. The conceptual basis is to ensure the environmental sustainability of the food supply system, which is used to change the food production and consumption system in the EU. The impact on the marine environment could be reduced to a minimum level, without lowering the safety, quality and supply of healthy food [4]. This policy implements every link of the food production and marketing industries, from production and processing to sales of food, as well as international trade, reducing unnecessary waste in transportation, storage, and packaging. This will be able to establish a new food system in EU, as a global standard of sustainability, contributing to the objective of making Europe the first continent by 2050. In addition, this strategy will continue to include actions to launch a process to identify new innovative food and feed products, such as seafood based on algae. European farmers and fishers are key roles to managing this transition in "blue economy" in the future. The "Farm to Fork" strategy will strengthen the efforts to tackle climate change, environmental protection, and biodiversity preservation, in particular during the current health and economic crisis. Sustainable food systems are resilient by nature and support economic recovery ensuring a fair transition to all [4].

The future "blue economy" potential fields include blue bio-economy and biotechnology sector and the non-traditionally exploited groups of marine organisms and their commercial biomass applications. These organisms comprise macro algae (seaweeds), microorganisms (microalgae, bacteria and fungi) and invertebrates (e.g., sea stars, sea cucumbers, sea urchins). Algae and invertebrates are important biological resources that support the bio-based sectors and the development of economic activities in coastal areas. Although some of these biomass sources have been traditionally been used as food, feed or fertilizers in the past, new commercial applications using these resources, are under development in recent years. The extraction of high-value bioactive compounds has the highest market potential, e.g., for pharmaceuticals and cosmetics. Other innovative applications are also in the pipeline such as biofuel, the production of biomaterials and bio-mitigation services. Algae and invertebrates have the potential to contribute the sustainability of the food systems and releases pressure off of overexploited marine resources, in addition to their commercial benefits, and also provide environmentally sound solutions by removing nutrients in excess from the water [4].

Marine bio-resource industries in Taiwan

Taiwan has been actively developing a "blue economy" industry in recent years. In addition to the traditional marine engineering and transportation industry, marine leisure and tourism are currently the emerging industries in this field. However, all of that rely on the sustainability of marine ecology and aquatic resources, which many tourism and events relating to cultural experiences in fishing village are based on. In Taiwan, the coastal fishery resources have been exhausted gradually during the past decades. Conservation of marine environment and ecosystem and increasing the fishery resources has become one of the important research at present. Taiwan could develop unique marine bio-resources industry in "blue economy" by taking the advantage of innovative biotechnology and fishery science integrated with traditional social and cultural resources.

Taking the demonstration area of coastal cultivation fishery or fish farming developed in recent years as examples, the concept of "blue economy" or the so-called "blue revolution" aims to integrate the natural environment, fishery resources, economic development and social culture, which potentially promotes the transformation of the original traditional fishing village and their economic industry and integrates with tourism and commercial resources. This makes the cultivation fishery demonstration area to be independently managed to reach the goal of sustainable development [5]. The Mao'ao cultivation fishery demonstration area in New Taipei City can serve as an excellent example at present, which involves the cooperation of government authorities, fishermen and fishermen's associations, as well as researchers and scholars. The marine environment and fishery resources of Mao'ao Bay could be recovered by improving marine ecological functions and increasing fishery resources. This makes the Mao'ao fishing village a successful demonstration area of cultivation fishery in symbiosis with slow living and customs fishing village [6].

The most important contribution of the cultivation fishery demonstration area is to increase and recover fishery resources, in which it is essential to investigate and monitor the status of released fish. For regularly released species such as black sea bream, grouper, snapper, and porgy in Mao'ao area, they are well adapted in the ecosystem in the demonstration area, through the real-time monitoring system and visual survey by scuba diving, as well as the observation of overspill for the released species and increasing number of investigated species in the area year by year. The fish community varies between winter and summer, which reveals that the released species in the demonstration area are well using the natural habitats in the area, as an evidence of the fish farming benefit [7].

One of the most important parts in developing "blue economy" is to drive the fisheries toward conservation and lead transformation in economy and sustainable development for local fishing villages. In addition to marine environment and ecosystem recovery and the increase of fishery resources, we could also promote the development of innovative industries and aquatic products with local characteristics. The Mao'ao fishing village could be an excellent example; with annual production at 30,000 kg, the gelidium has been assessed as a potential leisure industry full with local characteristics to be developed further, which producing more than 10,000 tourists and experiences in fishing villages every year. Cooperated with fishery production marketing and fishing village regeneration plan, we could further educate the fishermen to actively participate in fishery resource recovery and marine education to establish tourism-oriented leisure parks relating to fishery and "blue economy" bio-resource industries with local characteristics [6].

Except for the cultivation fishery demonstration area, Taiwan is also actively promoting the growth of the "blue economy" biological industry through the release of fry, and establishing a gene bank for the released fry to identify species and assess the risk of inbreeding depression and genetic structure of wild populations, as well as other related tests, cooperated with benefit assessment and relevant scientific research and investigation. We also evaluate the production contributed from fry release and relevant ecological, economic and social benefits according to the catch information and increased fishery resources [8]. In terms of assessment of suitable habitats and location to release fry, research team used habitat models to analyze the temporal and spatial distribution of released fry. Analysis of environmental factors such as habitat suitability of sea surface water temperature, chlorophyll concentration, depth and current speed, and catch at length information is conducted to provide scientific management suggestions for fry releasing policy. Taking black sea bream as an example, it is recommended that the most suitable release location is along the coast from Changhua to Chiayi from April to September, and coastal area off Miaoli from September to October. The fourfinger threadfin is suggested to be released in the coastal area from Yunlin to Chiayi from quarter 3 to quarter 4 of the year. It is better to release fish fry of the snubnose pompano in the coastal area of Chiayi in the third quarter of the year [9].

The innovation and application of biotechnology will be potential fields to develop future bio-resources industries. Polymorphic gene database and identification and testing standards will be established for targeting important released fry for wild and breeding species, which could be used to assist and benefit the assessment of fry release, and clarify the concerns of genetic risk and inbreeding depression. Numerical analysis results of genetic diversity for regularly released fry show that most groups are in a state of hybridization, with high degree of genetic diversity and low risk of inbreeding depression and genetic risk. It is demonstrated that the increased coastal fishery resources could provide opportunity for the marine ecosystem to recover [10].

On the other hand, Taiwan is also actively developing breeding technology for key cold-water species. Under the goal of energy saving, carbon reduction, effective use of energy and promotion of the transformation of the aquaculture industry, a new type of fish farming using cold energy produced from coastal Liquefied Natural Gas (LNG) plant is the current "blue economy" emerging bio-resource industry. This includes the development of new type breeding model with breeding technology for high-priced cold-water species, such as Atlantic salmon, sea cucumber, abalone, sea fungus, flounder and algae. Implementation of the policy could reduce the import of cold-water fish product and alleviate the pressure of over-utilization of land resources and groundwater. The goal is to establish a marine science and technology park to help the promotion and improve the environment for "blue economy" bio-resource industries, which strengthens the competitiveness of Taiwan's unique marine aquaculture industry [11].

Conclusion

Every sector in "blue economy" relies on the support and outputs from the other sectors. For example, the development of offshore marine energy, transportation, coastal tourism, bio-technology and aquaculture highly depend on healthy marine ecosystems and the sustainable use of fishery resource. The impact of marine activities should be reduced to a minimum level following the concept of environmental sustainability. Many fields have been considered with great potential to be developed as future core industries in "blue economy", such as offshore wind power, oil and gas extraction, marine aquaculture and bio-technology and recreational fisheries. There are multiple competitions and cooperation among sectors in the use of marine space. Marine spatial planning (MSP) could be used as a powerful and suitable tool to solve the conflicts and problems from different sectors, reaching the balance between economic development, environmental protection and resource utilization.

References

[1] William Nicolls, Connor Franks, Teresa Gilmore, Rachel Goulder, Luke Mendelsohn, Edward Morgan, Jeffery Adkins, Monica Grasso, Kate Quigley, Jennifer Zhuang, Charles Colgan (2020), Defining and measuring the U.S. Ocean Economy. Bureau of Economic Analysis, Department of Commerce, U.S. https://www.bea.gov/system/files/2020-06/defining-and-measuring-the-united-states-ocean-economy.pdf

[2] National Oceanic and Atmospheric Administration (2020), Report on the U.S. marine economy https://coast.noaa.gov/data/digitalcoast/pdf/econ-report.pdf

[3] National Oceanic and Atmospheric Administration (2020), Report on the U.S. marine economy: Regional and state profiles https://coast.noaa.gov/data/digitalcoast/pdf/econ-report-regional-state.pdf

[4] European Commission (2020), The EU blue economy report. Publications Office of the European Union, Luxembourg https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/2020_06_blueeconomy-2020-ld_final.pdf

[5] Kuo-Tien Lee, Sha-Yen Cheng, Kuo-Wei Lan, Yi-Hsiung Chen (2020), "Cross-regional integration of Taiwan's cultivation and fishery areas and adjustment and improvement of fishing grounds" Final Report, Fisheries Agency, Council of Agriculture, Executive Yuan (Kaohsiung: Taiwan).

[6] Ching-Ta Chuang (2017), "Social economic investigation and management model construction of Taiwan cultivation fishery demonstration zone", Symposium on the achievements of Taiwan's coastal blue economic growth, Oct. 20, 2017 (Keelung: Taiwan).

[7] Yi-Hsiung Chen, Yu-Wei Liu, En-Yu Liu (2017), "Analysis of the temporal and spatial changes of fish stocks and the colonization of released fish species", Symposium on the achievements of Taiwan's coastal blue economic growth, Oct. 20, 2017 (Keelung: Taiwan).

[8] Chen-Hsin Liao, Nan-Jay Su, Ming-Wei Lu, Chang-Wen Huang, Te-Hua Hsu, Wei-Yuan Hsu (2020), "Benefit assessment of released fry" Final Report, Taiwan Ocean Conservation and Fishery Sustainability Foundation (Taipei: Taiwan).

[9] Ming-An Lee, Nan-Jay Su, Kuo-Wei Lan, Yi Chang, Lung-Ching Wu (2018), "Fishery activities and environmental surveys in coastal areas of Taiwan and establishment of released species data" Final Report, Fisheries Agency, Council of Agriculture, Executive Yuan (Kaohsiung: Taiwan).

[10] Chang-Wen Huang, Chen-Hui Lin, Ming-Wei Lu, Hung-Yi Gong, Ping-Wen Chiu, Ling-Ming Tzeng, Te-Hua Hsu, Jie-Yu Pan (2017), "Research on genetic markers of important aquatic products-Establishing a database of molecular markers for gene polymorphism of released fish species", Symposium on the achievements of Taiwan's coastal blue economic growth, Oct. 20, 2017 (Keelung: Taiwan).

[11] Fan-Hua Nan, Hsiu-Nan Chen, Shao-Lien Wen, An-Chang Cheng, Meng-Chou Lee (2020), "Research on the Operation Mode and Operation Strategy of Liquid Natural Gas (LNG) Cold Drainage Farm" Final Report, Fisheries Agency, Council of Agriculture, Executive Yuan (Kaohsiung: Taiwan).

EU's Emerging Marine Industries: Moving Beyond Traditional and Toward Technology-Driven Industries

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Keywords: EU, technology, innovative marine industries

Marine industries are diverse with traditional ones being commonly known by the public such as fisheries, maritime transport, port activities, shipbuilding and repair, fixed offshore wind and coastal tourism. Besides, developing these traditional blue economy activities, the European Union (EU) has launched to develop technology-driven innovative marine industries: marine renewable energy, blue bioeconomy, marine minerals, desalination, maritime defence, and submarine cables. This article provides an overview of these emerging industries, including the challenges faced and the potentials of their future development. (Most content of this article is excerpted from 'European Commission (2020). The EU Blue Economy Report 2020. Publication Office of the European Union. Luxembourg.')

Marine renewable energy

The marine renewable energy sector utilizes different technologies for the production of renewable energy: offshore wind (fixed or floating offshore wind), wave and tidal energy, floating solar energy and offshore hydrogen production. Fixed offshore wind has developed advanced technology. Other technologies are at an early stage of development, with a significant focus on technology research and development as well as commercialization. The market and supply chains of these technologies are not yet consolidated.

I. Floating offshore wind

Floating offshore energy is a growing sector that is strengthening Europe's leadership in ocean energy. With a total installed capacity of 45 MW in 2019, Europe's floating wind fleet is the largest worldwide (70%). The development and commercialization of floating wind technology will open up the possibility to harvest the most resourceful wind energy sites in Europe. Nearly 80% of the wind in Europe blows in waters that are at least 60 meters deep, where it is too expensive to fix structures to the bottom of the sea. It is estimated that the potential for floating offshore wind in Europe is about 4,540 GW, of which 3,000 GW would be located in deep sea locations (water depth between 100 m and 1,000 m). Moreover, the majority of shallow offshore regions for conventional offshore wind deployment are located in North and Baltic Seas that are not adjacent to this region.

Floating offshore wind employs a floating device anchored to the seabed, such as spar-buoy, semi-submersible platform, tension-leg platform (TLP), barge, and multi-platforms substructures. So far, no concept prevailed over the others. However, spar-buoy concept has already been deployed in a commercial project (the 30 MW Hywind Scotland). It is noted that through various instruments of EU-funding, several floating offshore wind technologies were brought from concept to a pre-commercial stage. This is pivotal, particularly when demonstrating the technology's capabilities in a deep water setting as in the case of a 2 MW floating prototype in France (Floatgen Project) and a 25 MW floating wind farm in Portugal (WindFloat Atantic).

Major challenges for the development of floating offshore wind are high investment and finance cost, and its future development must lower costs and increase output. Currently only 40 MW of floating wind capacity are operational. A further 300 MW are planned to be deployed between 2020 and 2022.

II. Wave and tidal energy

The potential of wave and tidal energy in Europe is vast, thus can play a key role in decarbonizing energy supply and increasing energy security and fueling economic growth in coastal regions. The theoretical potential of wave energy in Europe is about 2,800 TWh annually, whiles the potential for tidal current was estimated at about 50 TWh. It is expected that in the short-medium term (up to 2030), ocean energy development in the EU will be largely dependent on the deployment of tidal and wave energy converters.

At the end of 2019, the total global ocean energy installed capacity was 55.8 MW, with most of it located in EU waters (39.5 MW). The EU is the global leader hosting with 58% of the number of tidal energy technology developers and 61% of the wave energy developers. The development of ocean energy technologies is still primarily at the R & D stage, nevertheless some technologies have already progressed towards first-of-a-kind demonstration and pre-commercial projects. Tidal energy particularly had made the most significant stride forwards with over 50 GWh of electricity generated from demo projects. In contrast, wave energy technologies are lagging behind tidal energy in terms of performance, especially in terms of electricity generation.

Between 2007 and 2019, total R & D expenditure on wave and tidal energy amounted to a total of €3.84 billion with the majority of it (€2.74) coming from private sources. The continuous development of wave and tidal energy technologies and the reduction in technology costs are expected to lead to a significant increase of the deployed ocean energy capacity in the near future. Market scenario assessments from the international Energy Agency (IEA) show that the total European wave and tidal energy installed capacity could range between 0.5GW and 2.6 GW by 2030.

III. Floating solar photovoltaic energy

Floating solar photovoltaic (FPV) installations open up new opportunities for employing conventional photovoltaic installations whilst reducing the impact on land. FPV consists of a floating structure on which traditional solar panels are installed. To date, most FPV structures have been installed on lakes and in the proximity of hydro-power reservoirs.

Deploying FPVs at sea requires overcoming a number of challenges related to the survivability of the structure at sea, as well as understanding the influence of the marine environment such as of algae growth, pollution, and slat deposits on the conversion system. At the end of 2019, the state of the art of FPV offshore is predominantly at R & D and demonstration phase. Demonstrations are taking place in the Netherlands (Oceans of Energy, TNO) and in France (HelioRec), with the projects designed to validated technology design, to prove its efficiency conversion and survivability in harsh conditions. In terms of survivability, the 17 kW system designed Oceans of Energy, has withstood different storms with waved above 5 m high. In addition, developers are now looking to expand the project to reach a power rating of 50 kW.

A number of challenges remain to be addressed in order to facilitate deployment of FPV at a commercial scale such as long-term reliability, costs, integration in the grid system and the deployment of substations. In particular, the technical viability in the harsh and remote environment and the potential for FPV production costs still needs to be demonstrated. Furthermore, a key step required for the commercialization of FPB at sea is the assessment of its potential contribution to the EU Green Deal, and the interaction with other maritime uses to identify ideal sites for deployment.

IV. Offshore hydrogen generation

The generation of hydrogen offshore has a number of advantages. Hydrogen transportation and storage can be done at a large scale and a relatively low cost. Furthermore, offshore oil and gas platforms could be re-purposed for renewable hydrogen production. However, the foremost technical challenge is the development of an electrolyser module, which is compatible with the ocean environment, able to operate effectively and achieve high rates of hydrogen production when coupled with intermittent renewable power. A number of projects are already exploring the possibility of specific options for the coupling of offshore energy and green hydrogen production. For example, ITEG project combines the 2 MW tidal turbine with a 500 kW hydrogen electrolyser and an onshore energy storage and management system.

Blue bioeconomy

The blue bioeconomy and biotechnology sector (collectively called bioeconomy) refers to the non-traditionally commercial applications of marine organisms, which are different from the traditional applications such as food, feed or fertilizers. These organisms comprise macroalgae (seaweeds), microorganisms (microalgae, bacteria and fungi) and invertebrates (e.g., sea stars, sea cucumbers, sea urchins). The extraction of high-value bioactive compounds has high market potential e.g. for nutra/and pharmaceuticals as well as cosmetics. Other innovative applications are also seen in the production of biomaterials or biofuels. Besides their commercial benefits, algae and invertebrates have the potential to contribute to the sustainability of the food systems, release pressure off of overexploited marine resources, and remove nutrients in excess from the water, providing environmentally sound solutions.

The EU is supporting innovations of local action through the design and implementation of Smart Specialization Strategies. To date, 12 Members States and 53 regions present linkages to the blue biotechnology in the Smart Specialization Strategies. The topics covered is broad, including energy production (e.g., microalgae biodiesel production), agriculture (e.g., microalgae capable of handling liquid manure), climate change (e.g., production of new microalgae products, increasing CO_2 capture capacity), medicine (e.g., algae as nutrition component that strengthens the immune system in humans and animals), environmental remediation (e.g., treating waste water with microalgae bacteria), and biomaterial.

However, this emerging sector still faces several challenges and constraints. Among the most commonly cited are: complexity of the regulatory and administrative procedures, small size of the market, consumers' awareness and acceptance, lack of reward schemes for the provision of environmental services to the marine ecosystems, lack of European origin certification and harmonization of market requirements, the need for funding mechanisms, and the optimization of the production chain to reduce waste.

Desalination

Desalination is a common technology and an alternative for water supply that can alleviate the growing pressure on freshwater resources. It is used to overcome water shortages in areas where freshwater resources are limited, such as in big coastal cities (e.g., Barcelona and Alicante in Spain) and islands. In the long term, it is expected that with the impact of climate change on freshwater availability, demands for desalination and other water management solutions (e.g., water reuse) will increase. In particular, by 2050, many regions in the EU are expected to face severe water scarcity, including the coastal Mediterranean regions as well as regions in France, Germany, Hungary, Northern Italy, Romania and Bulgaria.

In 2019, there were a total of 1,573 desalination plants, producing a total of 6.9 million cubic meters per day (2.5 billion m³/day) of fresh water. 74.2% of the desalination capacity is located in the Mediterranean Sea basin, with 821 facilities supplying 5.1 million m³ /day of freshwater. Among the freshwater produced by desalination facilities, 64.4% is for public consumption managed by the municipalities, 24% for industrial applications, 9.5% for irrigation purposes, and 2.1% for the production of drinking water to serve tourist facilities.

Reverse Osmosis (RO) is currently the most widely used desalination technology in Europe with 85.5% of total capacity using this technology. Capital and operational costs associated with desalination plants depend on a number of factors, including the dimension of the plant, the type of technology employed, and the salinity of the water to be treated. The costs determine the price of water. The average cost of one cubic meter of desalted water produced using RO technology is of €0.86. This means that the daily cost of supplying 5.9 million m³ of desalted water in the EU with RO is of €5.1 million, or €1.86 billion a year. The total cost of desalination is estimated at €2.2 billion year when including all technologies. Most of European facilities have been designed and built by European engineering firms. However, when it comes to the key component such as RO membranes, the market is dominated by non-European players. The EU contribution to R & D on RO is only 5% of the inventions.

Marine minerals

Marine minerals include sand and gravel, metals (e.g., manganese, tin, copper, zinc and cobalt) and chemical elements dissolved in seawater (e.g., salt and potassium). While the extraction of sand is a long established activity, the extraction of other minerals and metals is an emerging sector. In particular, high tech metal play a critical role in the development of innovative environmental technologies for boosting energy efficiency and reducing greenhouse gas emissions. However, the extraction of minerals and metals, in seawater and on the seabed, has several challenges to face, including the mapping of reserves, developing appropriate technology, and taking adequate mitigation and management measures to deal with the irreversible environmental impacts.

As of the end of 2019, the International Seabed Authority (ISA) has 30 contracts/licences into force for exploration. They are allocated to eight explorative areas, spread across the Atlantic, Pacific and Indian Oceans. Among the EU Member States, Belgium, France, Germany, Bulgaria, Czechia, Poland and Slovakia have sponsored licences in the Atlantic. For the time being, no commercial deep seabed-mining project exist in the Area (The Area refers to the seabed and its subsoils beyond the limits of national jurisdiction.) nor in the areas under national jurisdiction of the EU Member States. Although the industry players have in general expressed confidence in future developments, the outlook for seabed mining at great depths (e.g., the seabed rich of cobalt and manganese deposits occur at depths of about 800-2,500 meters) remains uncertain. In particular, the extent to which the seabed will be tapped of its resources on a commercial scale, the high costs, and the potential environmental impacts and its sustainability are still unclear.

Marine Defence

The focus of the marine defence sector is navies. European navies account for at least 564 commissioned warships with a total tonnage of 1.5 million. According to data from the European Defence Agency, the total number of maritime personnel was estimated at 177,090 in 2017, showing a decrease from 2006 (277,309).

The yearly expenditure is more than €10 billion for naval shipbuilding and more than €4 billion for maintenance and repair. The naval shipping industry is an innovation-driven industry and is one of the sectors with the highest investment intensity in research, development and innovation (RDI). 8.7% of naval industry sales is invested in RDI every year.

The economic benefits and job opportunities brought from the navies are considerable. For instance, for every €1 invested in the Navy, €2.3 are generated for the Spanish economy. Additionally, it increases gross value added by €2.2 and multiplies employment by 2.3. These figures are higher than those for the entire Spanish public administration.

Submarine cables

Submarine cables are critical infrastructure, channeling more than 99% of international data transfer and communication, including more than €10 trillion in daily financial transactions. It is important for the EU's economy as well as the global economy. There are 378 cables in service in 2019, spanning over 1.2 million kilometers globally, with 205 ones connected to EU Member States.

In general, submarine cables are designed to last 25 years; however, because cables with a greater capacity continue to be released at lower cost, they are often replaced or abandoned before the end of their life cycle. The ways to deal with submarine cables that are no longer used include: 1. cables remain on the ocean floor in an inactive state, 2. cables are recovered and recycled for their raw materials, and 3. cables are repositioned to new routes. Most of the EU submarine cables were laid in the early 2000s or before, indicating that these cables will be replaced in the next years.

Cable ships are mainly used to lay and repair submarine cables. Most cable ships are equipped with remotely operated vehicles (ROVs) and ploughing equipment to carry out their repair and cable-laying services. There are 54 cable ships worldwide. Out of 54, 21 ships are registered in the EU. In light of this, the EU plays an important role in the submarine cable sector.

Conclusion

The EU foresightedly develop technology-driven marine industries, demonstrating its emphasis on the utilization of marine resources (living and non-living). This is in line with the EU Marine Strategy Framework Directive, which sees the seas as an asset with economic potentials.

Taiwan is surrounded with the sea. While we have long developed traditional marine industries, it is right to take steps to develop technology-driven marine industries, particularly the offshore floating wind and floating solar photovoltaic. In light of this, we should continuously watch recent technological progresses in various marine industries globally and in the EU and keep a close eye on the cases. Additionally, we should prioritize the research on critical technologies, develop the technologies and the associated equipment that are suitable for the development of marine industries, and just as the EU, similarly care about marine ecological and environmental issues. By doing so, the development of innovative and technology-driven marine industries will be progressively carried out.

References

[1] European Commission (2020). The EU Blue Economy Report 2020. Publication Office of the European Union. Luxembourg.

International Blue Economy Policy Trends Under the COVID-19 Epidemic

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Keywords: COVID-19, blue economy, sustainable development, climate change

Since the beginning of 2020, "Severe Pneumonia with Novel Pathogens (COVID-19)" has triggered a global pandemic, rapidly spreading to multiple countries across the globe. Based on the literature provided by international organizations, this article summarizes the international blue economy policy trends that have emerged under the epidemic in hopes of providing Taiwan with a basis for promoting blue economy policies in the future.

Introduction

According to World Health Organization (WHO) statistics [1], as of January 26, 2021, 224 countries and regions around the world have accumulated a total of more than 98.79 million confirmed cases. The COVID-19 epidemic has severely hit the global economy and trade. According to the World Bank's January 2021 estimate, the global economic growth rate in 2020 will be negative 4.3% [2]. Besides, the United Nations Conference on Trade and Development (UNCTAD) estimates that the COVID-19 epidemic has caused a 27% drop in overall global trade in 2020 [3].

UNCTAD [3], the Organization for Economic Cooperation and Development (OECD) [4], and the High Level Panel for a Sustainable Ocean Economy (Ocean Panel) (2020) [5] believe that although, during the COVID-19 epidemic, marine tourism, maritime shipping, fishery and other blue economy-related industries suffered the significant impact, opportunities for the development of the blue economy have also arisen.

Creating a healthy marine environment and promoting resource sustainability are the foundations for developing the blue economy. During the COVID-19 epidemic, we must strengthen the economic, social, and environmental resilience of the blue economy, reduce its vulnerability, and solve environmental issues such as marine plastic waste, marine chemical pollution, greenhouse gas emissions, and resource over-exploitation to ensure sustainable development of marine ecology and marine industries, thus gradually achieving the carbon reduction goals advocated by the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement. At the same time, as promoting the blue economy can also accelerate the recovery of the global economy, the above-mentioned international organizations have successively proposed blue economy green growth measures and priority measures [3][4][5].

Blue economy green growth measures are cost-effective and helpful to economic recovery and are worthy of prioritizing. According to an analysis conducted by the Ocean Panel in 2020, the return on investment of sustainable blue economy solutions is about 500%; for every US dollar invested, at least 5 US dollars can be obtained. Specifically, between 2020 and 2050, if global investments of US$2 to 3.7 trillion are placed in the four areas of restoration and conservation of coastal and marine ecosystems, offshore wind power, maritime carbon reduction measures, and sustainable fisheries, these efforts will generate economic, environmental and health benefits as high as US$10.3 to 26.5 trillion. It is estimated that there will be a return on investment of as high as 400 to 615% (calculated based on a 30-year net benefit of US$8.2 to 22.8 trillion) [5][6].

This article summarizes the international blue economy policy trends that have emerged under the COVID-19 epidemic in hopes of providing Taiwan with a basis for promoting blue economy policies in the future.

International blue economy policy trends under the COVID-19 epidemic

I. Green growth measures for the blue economy

UNCTAD (2020) proposes that the promotion of a sustainable blue economy under the COVID-19 epidemic will help maintain the marine ecosystem's functional integrity and contribute to economic growth and increased employment. Specifically, the government is recommended to transition towards a sustainable blue economy and strengthen various green growth measures in the marine industry [7]:

[I] Rethinking fishery subsidies and transitioning to supporting the sustainability of small-scale responsible fisheries

More than 200 million people are employed globally to capture fisheries, with nearly 90% of fishers living in developing countries. At present, in order to take care of the livelihoods of capture fishers, governments of various countries subsidize fishery fuel with preferential oil prices. However, since the COVID-19 epidemic, international oil prices have been at a low point in recent years, fishing costs have gradually decreased, and fishery trade has decreased. Government agencies are therefore recommended to rethink the applicability of fishery subsidies and consider replacing old and inefficient fishing boats with new ones, supporting small-scale responsible fisheries and sustainable governance to promote the sustainable development of capture fisheries.

[II] Promoting coastal and marine tourism 2.0 measures to ensure sustainable development

Tourism is one of the critical economic sources of small island developing countries (SIDS). As the COVID-19 epidemic has led to a significant reduction in the number of international arrivals, which has caused a significant impact on the tourism industry of SIDS countries, these countries are recommended to promote coastal and marine tourism 2.0 measures that focus on implementing various sustainable development measures for marine tourism, including integrating the local ecological environment and cultural characteristics, and developing eco-tourism, low-carbon sightseeing and experience activities.

[III] Digitalized maritime shipping trade procedures and processes

Due to the global supply chain crisis caused by the COVID-19 epidemic, UNCTAD has proposed 10 action plans to enhance the convenience of international trade and transportation, including ensuring uninterrupted shipping, keeping ports open, protecting international trade of critical goods, and speeding up customs clearance and trade facilitation, facilitating cross-border transport, ensuring the right of transit, safeguarding transparency and up-to-date information, promoting paperless systems, addressing early-on legal implications for commercial parties, protecting shippers and transport service providers alike, and prioritizing technical assistance [8].

If the above action plans include the introduction of digitalized measures, this will greatly enhance trade facilitation in the maritime industry. For instance, the "Automated System for Customs Data (ASYCUDA)" has assisted in more than 100 countries and regions with digitalized one-stop services, modernized customs declaration systems, and digital trade solutions.

II. Five priority measures for the blue economy (Ocean Panel)

The Ocean Panel (2020) has proposed five priority measures for the blue economy under the COVID-19 epidemic. As the cost-effectiveness of these five priority measures is higher than other measures, they are worthy of prioritizing [5]:

[I] Restoring and preserving coastal and marine ecosystems

Coastal habitat protection, wetland maintenance, ecological afforestation projects, coral and algal reef conservation, and other coastal and environmental restoration and conservation projects help maintain the functional integrity of coastal and marine ecosystems, reduce the impact of floods and storm surges, filter and improve water quality, and enhance the productivity of small and aquaculture fisheries. Governments are advised to utilize public finance, government bonds, or private investment to direct funds toward the restoration and preservation of coastal and marine ecosystems, which will bring long-term development potential for eco-tourism, fishing, and coastal community development.

[II] Investing in coastal and marine ecosystem restoration and protection

Sewage drainage and wastewater treatment are directly related to eutrophication. If not properly treated, over the long term, they will lead to water-borne diseases, loss of fish resources, damage to sea ecology, etc., threatening public health, food security, and industrial development. The government is advised to adopt a dual-track approach of both incentives and supervision. The former includes budgeting public funds to improve sewage drainage and wastewater treatment infrastructure. Simultaneously, the latter entails reinforcing the management of specific high-polluting industries, implementing coastal buffer measures, reducing the use of inefficient fertilizers and chemicals, etc.

[III] Promoting sustainable community-led marine aquaculture

Sustainable community-based marine aquaculture is a future development trend characterized by a self-supporting system formed by the community. It conserves water and energy, reduces the input of feed, fertilizer, and pharmaceuticals, helps maintain the ecological system of the aquaculture environment, and improves the efficiency of marine aquaculture, thus realizing sustainable development. The government is advised to assist in optimizing the mariculture environment by providing subsidies or preferential financing measures, thereby encouraging sustainable community-based marine aquaculture. Emerging marine aquaculture technologies, on the other hand, require the establishment of a capacity building and training mechanism as well as community exchange platforms to enhance the development of sustainable community-based marine aquaculture jointly.

[IV] Stimulating Investment in zero-emission marine transport

As global trade relies primarily on maritime shipping, and shipping is a relatively low-cost means of transportation, if the shipping industry can gradually replace old vessels with low-carbon ships and equipment using natural gas fuel, hydrogen energy, electricity, and power storage facilities, this will contribute to reducing the carbon emissions of maritime shipping and mitigate ocean acidification. Government agencies are advised to promote financial incentive policies such as subsidies, financing concessions, tax cuts, and investment incentives, or give priority to policies such as promoting the use of low-carbon public ships, encouraging private companies to invest in low-carbon boats and related equipment, and building low-carbon port infrastructure.

[V] Developing Sustainable Ocean-based renewable energy

According to statistics released by the International Energy Agency (IEA) [9], due to the promotion of green energy and low-carbon policies by countries worldwide, the global offshore capacity of installed wind power will grow by 15-fold in the next two decades. The marine renewable energy industry will create green employment opportunities and empower industries related to marine renewable energy, such as marine engineering, offshore engineering, engineering ships, and marine technology. As such, the government should formulate clear and consistent policies and promote fiscal and financial measures to encourage the marine renewable energy industry's development.

Conclusion

While the COVID-19 epidemic has caused an impact on sectors of the blue economy such as marine tourism, shipping, and fisheries, it also presents new opportunities for the development of the blue economy. Internationally, blue economy policies encourage transformation, innovation, and moving towards sustainable and low-carbon development of the marine environment to gradually achieve the UN SDGs and the Paris Agreement's goals. At the same time, these policies can serve as a driving force for the recovery of the global economy.

Taiwan's intermediary results of the blue economy in the marine tourism and recreation, shipping, and fishery industries have been achieved. Still, its performance in internationally recognized emerging marine industry sectors such as marine biotechnology, marine renewable energy, marine water technology, and marine engineering exhibits considerable room for growth. Going forward, related agencies are advised to refer to international blue economy policy trends that have emerged under the COVID-19 epidemic, review the "Salute to the Seas" policy on a rolling basis, and formulate plans to promote the transformation and innovation of marine industries that constitute the blue economy. (References: see P.30)

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