國際海洋資訊

International Ocean Information

12
June 2021
雙月刊 | Bimonthly

臺灣洋流能發電近況與展望

Present Status and Future Prospects of Ocean Current Power Generation in Taiwan

德國海洋資訊

Germany Ocean Information

海洋委員會 發行
Ocean Affairs Council

國際海洋資訊 12 June 2021 雙月刊 Bimonthly
International Ocean Information

目錄 Contents

向德國取經
完善更好的海洋空間規劃

主任委員：李仲威

海洋空間在經濟、社會和環境面皆扮演多重角色，具備運輸、能源、研究、漁業等功能，在我國積極發展再生能源政策的情況下，如何合理運用海洋空間，讓環境保育、離岸能源與漁業發展得到調和而共存共榮，為我國目前關注的重要議題。德國設置北海和波羅的海的專屬經濟區（EEZ）後，由聯邦海事及水文局（BSH）進行海洋空間規劃，同時遵循歐盟的海洋空間規劃指南，與周邊國家進行協商，本期「產業動態」和「法規制度」分別從不同方向探討德國海洋空間規劃之策略與發展，可供參考。

除了離岸風電外，政府也積極推動洋流能研究，「專題報導」介紹國家海洋研究院2020年執行的洋流發電機組研製與測試場域選址規劃工作進度；「資訊新知」介紹德國基爾亥姆霍茲海洋研究中心從海床地質學到海洋氣象學的海洋科學跨領域研究；另外，德國的印太政策開始深化與印太國家的關係，其巡防艦至南海航行展現其積極外交思維，於本期「國際議題」有專文分析，值得我們持續觀察與關注。

圖說／德國漢堡港
圖片提供／陳令杰

臺灣洋流能發電近況與展望

撰文／鄭明宏（國家海洋研究院海洋產業及工程研究中心副研究員）
李傳宗（國家海洋研究院海洋產業及工程研究中心助理研究員）
廖建明（國家海洋研究院海洋產業及工程研究中心主任）
陳建宏（國家海洋研究院副院長）
邱永芳（國家海洋研究院院長）
關鍵字／洋流發電、浮游式發電機組、浮臺式發電機組、國際級洋流測試場

近年來隨著綠色能源逐漸受到重視，陸上風能與太陽能可用區域已陸續開發與飽和。為取得更多再生能源，復因臺灣具有四面環海的優越地理條件，海洋能源的開發亦逐漸受到重視。海洋能又可分成波浪能、潮汐能、海流能和溫差能等。廣義而言，海洋能還包括海洋上空的風能和太陽能及海洋中的生質能，這些都可以用來發電。在國際發展上，溫差能與潮汐能發電技術較為成熟且有商業化運轉案例，波浪能與洋流能發電技術仍屬新興發電技術。臺灣東部海域長年穩定流經的黑潮，據中央研究院徐遐生院士估計，臺灣可從黑潮取得約50GW的能量[1]。

臺灣洋流能發電研製最早從2014年第2期能源國家型科技計畫（NEPII）開始，至2018年該科技計畫結束。而2019年海洋委員會（以下簡稱海委會）執行「洋流能關鍵技術開發與推動」前期計畫[2]，國家海洋研究院（以下簡稱國海院）於2019年4月成立，並於2020年受海委會委託執行4年期「洋流能關鍵技術開發與推動」中長程計畫。國海院在2020年計畫推動上除延續前一年的研究成果以外，主要可分成兩大部分，其一為洋流發電機組研製與實海船拖測試（此部分又可分成浮游式及浮臺式兩種型態），另一則為進行臺灣東部海域國際級洋流發電測試場域選址和規劃。以下將分節介紹當前發展成果，最後則說明後續規劃。

浮游式發電機組發展

浮游式洋流發電機是藉由錨碇裝置將洋流發電機繫留於水層，再利用洋流推動發電機葉片進而產生電力。此種方式在國際上有日本NEDO（New Energy and Industrial Technology Development Organization）黑潮發電渦輪機開發計畫，從2011年開始由東京大學、IHI（Ishikawajima-Harima Heavy Industries）及三井物產戰略研究所三方合作，於2017年8月在口之島外海完成實海域測試，並在2018年至今持續開發500kW機組並進行長期的發電測試。在臺灣方面，從2015年至2017年3年期間臺灣大學、臺灣海洋大學、台灣經濟研究院等學研團隊與台灣國際造船公司共同合作，並於2018年1月9日在臺灣大學工程科學及海洋工程系館內拖曳水槽公開舉行了「800W浮游式黑潮發電渦輪機（FKT）模型機組水槽拖曳發電展示會」[2]。2019年海委會計畫支持完成10kW（單一發電機組）直驅式永磁同步發電機設計製造、海流發電FRP葉片設計分析與製造技術、被動式油壓補償水密軸封設

計製造技術等3項海流發電關鍵技術之開發工作[2]。至2020年，國海院偕同臺灣大學和臺灣海洋大學團隊一同完成傳動系統、電力後處理系統與控制系統規劃設計與建置，以及10kW發電渦輪機組整合細部設計、加工與組裝，建置一組10kW發電渦輪機組，並於當年10月6～7日於安平外海完成實海域船拖發電測試驗證及水密測試試驗[3]（圖1）。2021年繼續20kW浮游式洋流發電機組開發，並同時研製可控制該機組上浮下沉的浮力引擎關鍵技術，提供該機組於颱風通過時可自行下沉躲避惡劣海象，颱風通過後再回到最適合發電的位置。預計2022年完成20kW浮游式洋流發電機錨碇系統與實海測試，希冀藉此逐步完成商轉機組開發。

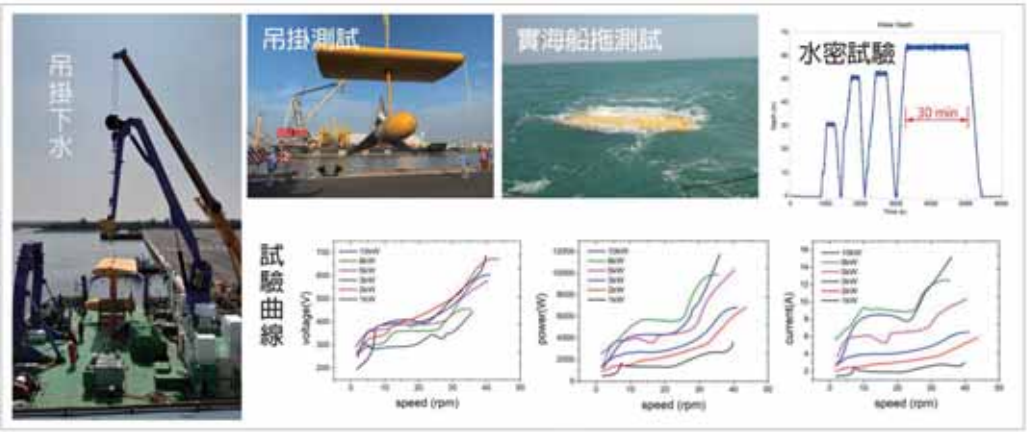

圖1／浮游式發電機實海船拖測試與水密試驗結果
圖片提供／國家海洋研究院

浮臺式發電機組發展

浮臺式洋流發電機組和前者不同，是將發電機組置於水面平臺上，其利用平臺下方的葉片受洋流推動，進而帶動上方發電機產生電力，其發電機組不置於水中，故不需水密設計。該型態是由萬機鋼鐵工業股份有限公司從2009年啓動洋流能發電之研發專案，在2014年起與中山大學產學合作執行科技部能源國家型計畫，進行洋流能發電機組實海域測試，2015年進行船拖測試及2016年進行錨碇測試，洋流能發電機組最低啓動流速僅需0.45m／s，流速為1.43m／s時最大有近33kW的發電功率產出。2016～2019年逐漸建置400kW的洋流發電示範機，國海院於2020年3月24～25日協同中山大學與萬機鋼鐵於安平外海進行400kW洋流發電機組實海發電測試（圖2）。在測試過程中渦輪機遭側流影響而旋轉，為解決測試過程中所遭遇的問題，於當時進行機組設計變更。並藉由ANSYS AQWA軟體分析，洋流發電機組在拖航過程中，對隨機波譜反應的掃頻統計發現，洋流發電機組在浪高1.1公尺、週期5秒的側浪條件下，渦輪機組會產生共振現象而造成翻轉，又透過實際觀測資料，在渦輪機組翻轉時，波浪最大週期為5.7秒，平均週期為4秒，由此結果研判，渦輪機組側翻之原因除了浮筒進水不平衡外，渦輪機組的自然共振頻率亦為主要原因之一。目前仍在進行相關機組修改，俟其完工後再進行實海測試以瞭解該發電效能[4]。

圖2／浮臺式發電機實海船拖測試
圖片提供／國家海洋研究院

洋流測試場域選址及規劃

規劃最適合洋流能測試場域也是一重要課題，國海院與中山團隊藉由SCHISM-WWM波流模式發展非結構式網格模式來計算臺灣東部高精度三維海流與波浪變化。臺灣海域除受潮汐作用下，並加入HYCOM（Hybrid Coordinate Ocean Model）的預報結果，將洋流及渦流的影響納入此系統以獲得該處海域更精確的海流狀況。再藉由2015年、2016年、2019年ADCP布放資料進行校正，以獲得高解析度海流模擬結果並作為選取最適海域參考依據。依據2019年海委會執行洋流能關鍵技術報告[2]選出東部海域3大適合區塊（圖3），於2020年再針對由北至南依序為A區、B區及C區等共3處最適海域範圍，依據上述海流模擬成果，地形、纜線路由距離及相關法定區位之空間分布評估，最終選擇A區作為洋流能測試場之優先區域範圍。

A區作為最優先洋流測試場域，因此進行該區域的海域底質調查。依據調查結果以及蒐集之底層剖面儀與多頻道反射震測資料綜合分析，進一步細分其第1、2區場址地形平緩且有較厚的沉積物，可有較多的錨碇方式可供選擇，但由於都鄰近臺東峽谷，應注意臺東峽谷持續侵蝕擴張而可能造成鄰近側的地質危害。而第3區場域，海床地形較其他二區略陡，且調查顯示較無沉積物堆積，採用重力式錨碇較為適合，須注意丘狀地形可能造成的錨碇不確定性。綜合3處海流、地形、坡度及布纜路徑距離之細部評估結果，並考量海域用地取得之現況，最終以最適海域A區中所評估分析之第1、2、3區等3區皆納為洋流能測試場之備選場域（圖3）。所列3區測試場域可因應不同之測試需求，然因第3區已取得海域用地許可，若以申請海域用地之難易度及加權分數第一順位為考慮，則以第3區為最優先規劃場址[5]。

除最適洋流測試場域選址外，國海院也針對洋流發電機組維運基地港進行初步評估，先就臺灣東南部主要漁港（伽藍 〔富岡〕漁港、新港漁港、大武漁港、金樽漁港、興海漁港與後壁湖漁港）依環境條件、初步配置及各項評估因子之評分基準進行分析、比較，初步發現伽藍（富岡）漁港為建議優選基地港址[6]。另外，測試場域中發電後之電力傳輸亦是另一重要課題，根據海底電纜輸電、製氫平臺轉換電能及電池儲能進行初步評估，其結果依據轉換效率、產業發展與環境生態三方面彙整於表1，考量目前規劃測試區域水深極深布纜不易，且海上製氫儲能當前轉換效能仍不高，故現階段建議採電池儲能之方式[7]。

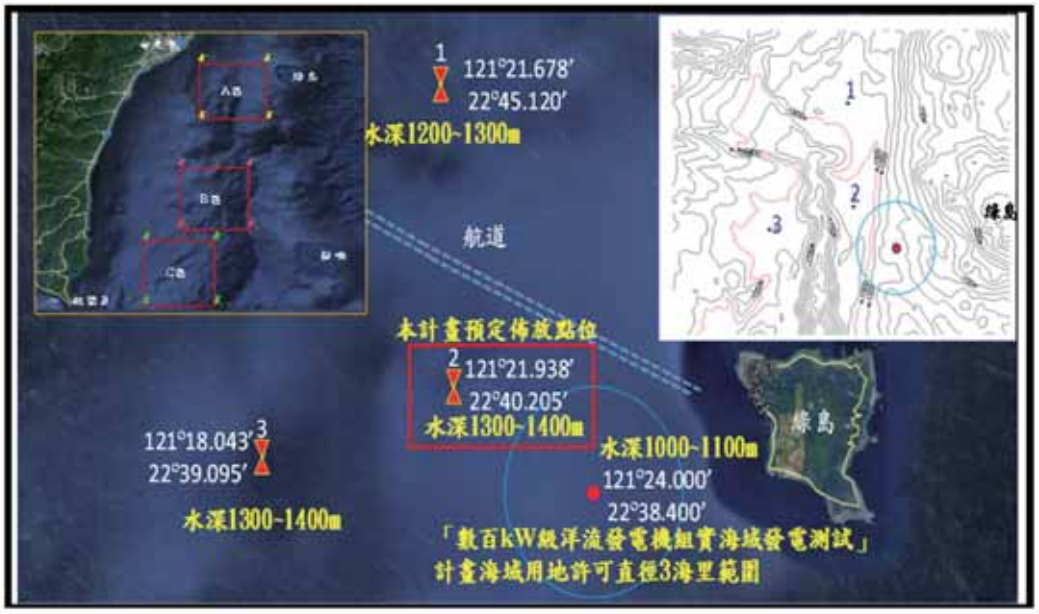

圖3／洋流能測試場最適規劃場址分析範圍
圖片提供／國家海洋研究院

表1／利用海底電纜輸電與製氫平臺轉換電能之分析比較[7]

運輸方案	液氫（LH_2）	鋰電池（Li-battery）	海底電纜
轉換效率	轉換效率較低，需要將發電機的輸出透過電力轉換壓縮成氫能，再經過氫能轉換回所需的動能（電能或是驅動機具的能量），因為經過多次轉換導致損耗較高。	轉換效率高，僅需要將發電機的輸出電力經過配電系統充至鋰電池中，再透過載具運回（損耗部分能量），損耗小。	轉換效率高，僅需要將發電機的輸出電力經過輸配電系統傳遞至使用者，損耗較小。
產業發展	臺灣已有製氫產業，但尚未發展為成熟產業。而在國外製氫產業也尚未成熟的情境下，在政府單位推動綠能產業的同時，若能同步發展製氫產業來帶動國內的產業發展方向，將有助於臺灣的能源自主。儲氫產業的發展，也能提升綠能的運用。	電池等儲能相關產業相對成熟，上中下游各個關鍵環節都有廠商切入，整體產業能量近乎完整，但對於某些關鍵電子元件或材料掌握度仍低。如何突破材料與製程技術以提高儲能密度及壽命是當前的關鍵問題。	臺灣目前沒有完整的海底電纜產業，但是在國外海底電纜產業完整，因此在布建與維護時，仍需外國廠商協助進行。
環境生態	由於製氫平臺浮動在海面上，因此對於環境較為友善，若製氫平臺以及自走式載具採用洋流發電機所生產的氫能動力，在能源運用上可容許較低的轉換效率，並可以降低碳排放，符合世界綠能潮流。	由於鋰電池相對有限循環充電次數，長期來看，不僅能源利用效率低，且使用後的鋰電池，若處理失當，其分解後的重金屬物質將污染環境。	海底電纜的布設將會影響海底生態，電纜維護時也需小幅破壞海底生態，因此，在布設時受到政府政策法規的規範，需要經過環境影響及水下文資評估，建設期程長。

結論

洋流能發電發展在國內外至今仍是處於研製階段，在臺灣東部雖黑潮流況穩定但水深較深，故在洋流發電機機組研發過程中仍有深海錨碇、動態電纜、避颱方式與防生物及腐蝕等課題。此外，本計畫亦已參考國際現有規範著手擬定相關洋流能機組測試流程及營運方式，規劃相關測試場域所需設施，逐步建置具認證公信力的洋流測試場域，吸引國外研製機組至臺灣測試，加速國內洋流能產業發展。

參考資料

[1] 黃聖凱（2015），海洋能源－潮流發電之探討，台船月刊，466，專題報導 https://www.csbcnet.com.tw/monthly_pub/466.html

[2] 國立中山大學（2019），洋流能關鍵技術開發與推動專業服務委託案（案號：OAC108001）成果報告書，海洋委員會委託計畫。

[3] 國立臺灣大學（2020），浮游式洋流發電機製作與實海測試專業服務委託案（案號：NAMR109008）成果報告書，國家海洋研究院委託計畫。

[4] 國立中山大學（2020），數百KW級洋流發電機組實海發電測試專業服務委託案（案號：NAMR109032）成果報告書，國家海洋研究院委託計畫。

[5] 國立中山大學（2020），臺灣洋流能海域測試場規劃評估專業服務委託案（案號：NAMR109009）成果報告書，國家海洋研究院委託計畫。

[6] 國立中山大學（2020），洋流發電配套方案與基地港規劃專業服務委託案（案號：NAMR109022）成果報告書，國家海洋研究院委託計畫。

[7] 國立臺灣大學（2020），洋流發電機自走式載具與避颱方案研擬專業服務委託案（案號：NAMR109007）成果報告書，國家海洋研究院委託計畫。

德國巡防艦至南海航行之戰略意義

撰文／林廷輝（海洋委員會委員、台灣國際法學會副秘書長）
關鍵字／德國、南海、自由航行、印太戰略

2020年11月，德國國防部長克朗普・凱倫鮑爾（Annegret Kramp-Karrenbauer）對外表示，德國聯邦軍隊將會強化在印太地區的存在[1]。2021年3月便有國際媒體引用德國政府高層官員的話語表示，一艘德國巡防艦將在8月啓程航向亞洲，並在回程時準備通過南海，倘若德國聯邦政府規劃沒有改變，將成為德國自2002年以來，第一艘越過南海的該國軍艦[2]。對此，中國外交部表達「各國在南海享有國際法所規定的航行與飛越自由，但不能以此為藉口危害沿岸國主權和安全」的立場；而持續在南海執行「自由航行計畫」（FONOPs）的美國（與德國自由航行意義不同），美國國務院官員立即表示：「我們歡迎德國支持在印太地區以法治為基礎的國際秩序」（We welcome Germany's support for a rules-based international order in the Indo-Pacific.）[3]。

圖1／將前往南海自由航行的同型德國軍艦F222
圖片來源／德國國防部網站

德國是歐洲國家，長期以來因為兩次世界大戰的經驗，戰後在海外的活動特別引起其他國家的關注，特別是軍事活動層面，常被解讀是否將對外採取軍事擴張策略，因此，歷屆德國政府均戰戰兢兢，較少將政治影響力擴展到歐洲以外的事物，特別是軍事活動，避免引起國際社會的疑慮。

不過，隨著國際情勢的轉變，中國無論在政治、軍事與經濟上的崛起，已造成以美國領導的國際體系受到挑戰，而德國則無法置身於事外，即使德國與中國雙邊貿易額在2019年將近1,900億美元，且德國對中國出超高達253億美元，受惠於中國的經貿成果，但堅持對人權價值理念仍不容妥協。

德國的印太政策：自由開放的重要性

2020年9月，德國外交部門發布「印太政策綱領」（Policy Guidelines for the Indo-Pacific）[4]，報告中說明了德國在印太地區的8項利益（Interests），並提出執行印太政策的7項原則（Principles），最後歸納出7項未來倡議（Initiatives）。德國在印太地區的8項利益，包括：

一、和平與安全：由於印太地區擁有核武國家包括中國、印度、巴基斯坦、北韓、美國等國，甚至加入擁有海外屬地的英國與法國，區域內的地緣政治中強權之間敵對的緊張程度，影響著全球穩定；

二、多樣性與深化關係：德國要將與印太國家的關係從經貿、投資發展擴展到政治領域；

三、非單極亦非兩極：因為任何霸權或兩極體系的結構，正如同冷戰期間一樣，只能被迫選邊站，印太國家得以自由選擇顯得更為重要；

四、開放的航道：全球貿易中高達9成以上都靠海運，四分之一的貨物要穿越麻六甲海峽，一天有將近兩千多艘船隻往返印度洋與南海之間，干擾海上貿易線將會影響歐洲的繁榮；

五、開放的市場與自由貿易：德國境內數以百萬的工作機會與印太地區的貿易息息相關，深信以法規為基礎的自由貿易，將會強化雙邊經濟繁榮；

六、數位轉型與連接：與印太國家合作之際，要考量科技、安全政策、經濟與社會風險；

七、保護我們的地球：確保印太地區的成長，對未來世代而言是環境友善，天然資源永續管理等；

八、以事實為基礎的資訊：社群媒體越來越重要，訊息溝通成為印太地區有效的外交政策工具，但必須打擊錯誤資訊的散布。

為此，德國提出以下幾個原則為前提，進一步推動與印太地區的合作，首先是歐洲行動，由於歐盟作為一個整體，因此德國印太政策也與歐盟的戰略一致；其次採取多邊主義，特別與東協國家在氣候變遷、環境保護、裁軍、軍備管制、核不擴散、保護人權等方面採取多邊合作架構；第三，以法規為基礎；第四，達成聯合國發展目標；第五，人權：經濟發展與尊重人權並不相斥，反而是一種補充；第六，包容性：德國支持納入所有區域國家，並非圍堵他國，以東協為中心的安全架構，納入其他主要行為者；第七，平等的夥伴關係。

軍事夥伴關係與海上實力展現

至於德國為何將焦點轉移至印太地區，德國國防部長克朗普・凱倫鮑爾在與新加坡國防部長黃永宏視訊時提到，全球政治與經濟中心已從跨大西洋地區轉移到印太地區，印太地區將對未來國際秩序有著重大的影響，而印太海上航道的暢通，對德國與歐盟的貿易而言是重要的，這也是為何德國要增

加在印太地區的軍事存在，因為這符合德國的自身利益。由於德國「蒂森克虜伯」（ThyssenKrupp）造船公司為新加坡海軍打造的218SG型柴電潛艦，已於2020年8月31日開始下水進行試航，這是新加坡下訂4艘潛艦（包括「無敵號」〔Invincible〕、「無瑕號」〔Impeccable〕、「光輝號」〔Illustrious〕及「獨特號」〔Inimitable〕等）中的第1艘試航潛艦，雖然均為傳統柴電動力潛艇，但在設計與裝備上將成為東亞地區最先進的潛艇之一；此外，新加坡的陸軍也採購數輛德製「豹2A4型」（Leopard 2A4）主力戰車。此外，德國為打擊對其不利的假新聞，也在新加坡成立「德國資訊中心」（German Information Centre），同時針對外國網軍攻擊形成的網路安全問題與新加坡國防部門合作。因此，未來當德國軍艦進入印太地區航行，新加坡樟宜基地自然會成為德國軍艦補給基地。

圖2／新加坡德製潛水艇
圖片來源／新加坡國防部網站

除新加坡外，日本也成為德國在印太地區尋求合作的重要軍事夥伴，特別是兩國在2021年3月22日於東京簽署〈日德資訊安全合作協定〉（Agreement Between the Government of Japan and the Government of the Federal Republic of Germany on the Security of Information），讓雙方更易於共享相關情報，也可以進行裝備品出口與聯合訓練，推動在印太地區的合作。由於德國在印太地區有安全利益，為了展現德國在區域內的軍事存在，未來也計劃透過部署德國軍艦，參與區域的軍事演習及訪問軍港[5]，當中也包括日本在內。

由於德國是歐洲聯盟的成員之一，在顧及到歐盟的「共同外交安全政策」（CFSP）上具有一致性，德國的軍事行動也必須考慮到「北大西洋公約組織」（NATO，北約組織）的整體性，因此，克朗普・凱倫鮑爾部長闡明，德國與印太國家軍事夥伴關係將在北約組織的架構下推動，這說明了德國軍艦在南海的自由航行，是從歐盟及北約組織的角度出發，歐盟在2021年4月19日通過「歐盟印太合作


圖3／德國潛水艇
圖片來源／德國國防部網站

戰略決議」（Council Conclusions on an EU Strategy for Cooperation in the Indo-Pacific）表示，將依據國際法，特別是1982年《聯合國海洋法公約》與各國海軍監測海事安全與自由航行；至於北約組織主張維護北極海域自由航行，並由美國、英國、挪威、丹麥等國編隊維護巴倫支海的自由航行權，在南海也同樣主張同等權利不受他國限制。

德國軍艦南海自由航行目的

過去300多年來，歐洲國家的經濟與印太國家緊緊相連，印太在全球產業供應鏈的地位不容小覷，這也是各國經濟繁榮的主要基礎，對德國來說，無論是印度洋或南海，在貿易航線上確保安全，對歐洲國家都是有利的。但由於政治與軍事因素，印太國家逐步面臨到因為領土糾紛而引起的敵對狀態，且在目前狀態下，對於領土主權與完整性的問題上，難以找到共同基礎，但對德國而言，考量以法規為基礎的全球秩序則是最重要的，多邊主義必須被考慮進去，雖然國家在理念與政策上有所差異，但只要透過時間不斷地互動，新的觀念將會產生，此際就可以達成共同行動，因此，德國支持和平與公正地解決爭端與衝突，國際法、《聯合國海洋法公約》則提供這樣的基礎。

德國在南海並無領土糾紛，且在地緣因素考量下，德國對印太事務與南海問題重視程度遠比歐洲事務為低，在七大工業國（G7）架構下，雖然支持日本提案，強調和平解決爭端，以及自由、無障礙且合法利用海洋的重要性。2016年4月，七大工業國外長會議在日本主導下通過〈海洋安保聲明〉，聲明中提到自由、安定的海洋是國際社會和平、安定、繁榮的基礎，並確認有必要基於相關國際法來維持經濟海域無障礙通航的權利和自由，但德國對於海洋議題主動提案的動力，遠比美國及日本為低，這與過往德國軍事力量以強大的陸軍為主軸，而當其擴張海權之際，世界各國為之恐懼有關，例如在一次大戰之前德國發展大海軍計畫，國會通過擴張海軍的相關法案，德皇威廉二世的「世界政策」（Weltpolitik, world policy）使其成為發動侵略戰爭的基礎，這也讓歷經兩次戰爭後的德國，不願引起其他國家的猜測，在對外事務上，特別是以軍事實力存在於全球其他海域，就顯得謹小慎微。

結語

德國已表明，在南海進行自由航行之際，並不會進入南海內島礁的領海範圍內，因此，德國軍艦最可能的路線將是在繁忙的貿易航線上，展現維護自由貿易航路暢通的實力。德國參與自由航行的主要目的除了展現對印太地區的重視外，更為了實現「助人助己」的積極外交思維。未來在英國脫離歐盟後，主導歐盟外交與安全政策的國家，多由法國、德國、義大利等歐洲大國為之，而法國在2021年2月將紅寶石級核潛艇「翡翠號」（Emeraude）潛艇和潛艇支援艦「塞納號」（Seine）派往南海行使自由航行權，相較德國的態度與立場，就顯得較為隱晦，為了與法國在外交與安全政策上展現一致，凸顯歐盟共同對外立場，德國在南海要表明的是對自由航行權此一價值上的主張，對於遵守國際法，海洋法與國際規則的基本價值，德國是與法國站在一起的。

後續值得觀察的是，中國對德國加入南海自由航行行列的回應與反擊作為，這將影響到德國下一步要採取的行動，雖然歐盟國家不得不面對印太地區新興市場的崛起，但歐盟國家長期以來對印太地區仍抱持有殖民母國的心態；不過，德國由於歷史因素，在印太海域作為相對制約，並不會超越法國與英國，但作為七大工業國、歐盟與北約的一員，也必須與相關成員國的立場一致，才能在多邊體系內占有一席之地。至於德國自由航行是否代表站隊美國，加入美國所領導的印太戰略架構下，由於德國與法國為首的歐盟仍採取外交自主性，在人權與國際規範等價值觀上雖然與美國一致，也對中國違反國際規範的作法不滿，但要因此說明加入自由航行行列就是與美國在印太區域內結盟，仍然言之過早。

參考資料

[1] Bundeswehr to Strengthen its Presence in the Indo-Pacific Region (Nov. 16, 2020), Federal Ministry of Defence
https://www.bmvg.de/en/news/bundeswehr-presence-indo-pacific-region-5012320 (Mar. 27, 2021)

[2] 中央社（2021年3月3日），〈德國官員：將派巡防艦行經南海 2002年以來首次〉
https://www.cna.com.tw/news/firstnews/202103030008.aspx

[3] U.S. Calls German Warship's Plan to Sail South China Sea Support for Rules-based Order (Mar. 4, 2021), Reuters
https://www.reuters.com/article/us-southchinasea-germany-usa-idUSKCN2AW016 (Apr. 13, 2021)

[4] Policy Guidelines for the Indo-Pacific Region (September 2021), The Federal Government
https://rangun.diplo.de/blob/2380824/a27b62057f2d2675ce2bbfc5be01099a/policy-guidelines-summary-data.pdf (Mar. 28, 2021)

[5] Germany Intends to Strengthen Security Cooperation with Japan (Dec. 15, 2020), Federal Ministry of Defence
https://www.bmvg.de/en/news/germany-intends-to-strengthen-security-cooperation-with-japan-4918446. (Mar. 28, 2021)

德國海洋空間規劃

撰文／德國在台協會
中文翻譯／萬象翻譯股份有限公司
本文是由德國聯邦海事及水文局（BSH）提供，並由德國在台協會彙整摘要及翻譯（英文）
關鍵字／海洋空間規劃、專屬經濟區、聯合國海洋法公約、德國聯邦海事及水文局

各界通常主要將海洋視為未開發的自由空間。不過，鄰近海洋沿岸的經濟區域和海洋沿岸本身，都面臨日漸沉重的開發使用壓力。除了航運及漁業等傳統用途以外，過去數十年來也出現各種新興利益，例如砂石開採、天然氣採收、管線及電纜鋪設、研究及軍事演習，以及迅速成長的離岸風電。前述種種不同經濟利益不僅互相糾結衝突，也對海洋環境造成威脅。

聯合國教育、科學及文化組織（United Nations Educational, Scientific and Culture Organization, UNESCO）對海洋空間規劃（Marine Spatial Planning, MSP）的定義如下：MSP是一種公開流程，負責分析及分配人類活動在海洋區域的空間及暫時分布情形，以達成通常透過政治程序指定的各種生態、經濟和社會目標。

德國海洋空間規劃

為了解決商業、科學與環境之間日漸升高的衝突情勢，德國針對北海及波羅的海專屬經濟區（Exclusive Economic Zone, EEZ）提出正式的海洋空間規劃，作為規劃工具協調各種使用利益及保護主張。其中的目標是記錄人類在海上的所有活動，解決現有的使用衝突，預防未來發生問題，並建立海洋環境保護區。最重要的是，海洋空間規劃可協助實行各項政治目標，例如德國的再生能源政策，以及國家能源轉型等等。

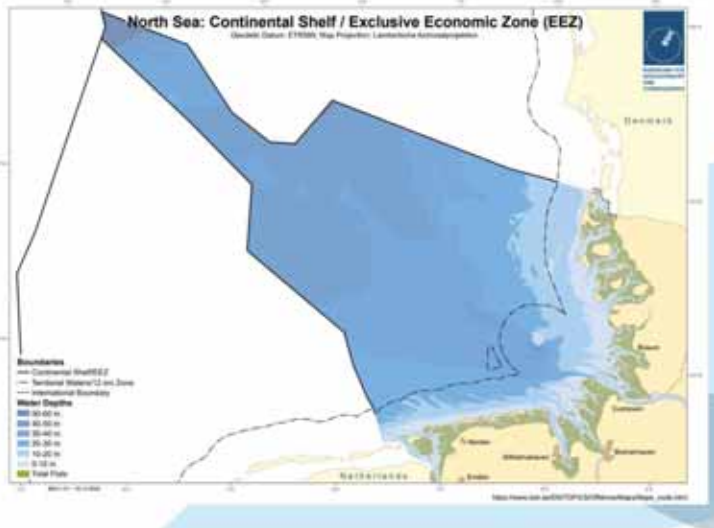

圖 1／北海：大陸礁層／EEZ
資料來源／BSH
https://www.bsh.de/EN/TOPICS/Offshore/Maps/_Anlagen/Downloads/NorthSea_ContinentalShelf_EEZ.pdf?__blob=publicationFile&v=5

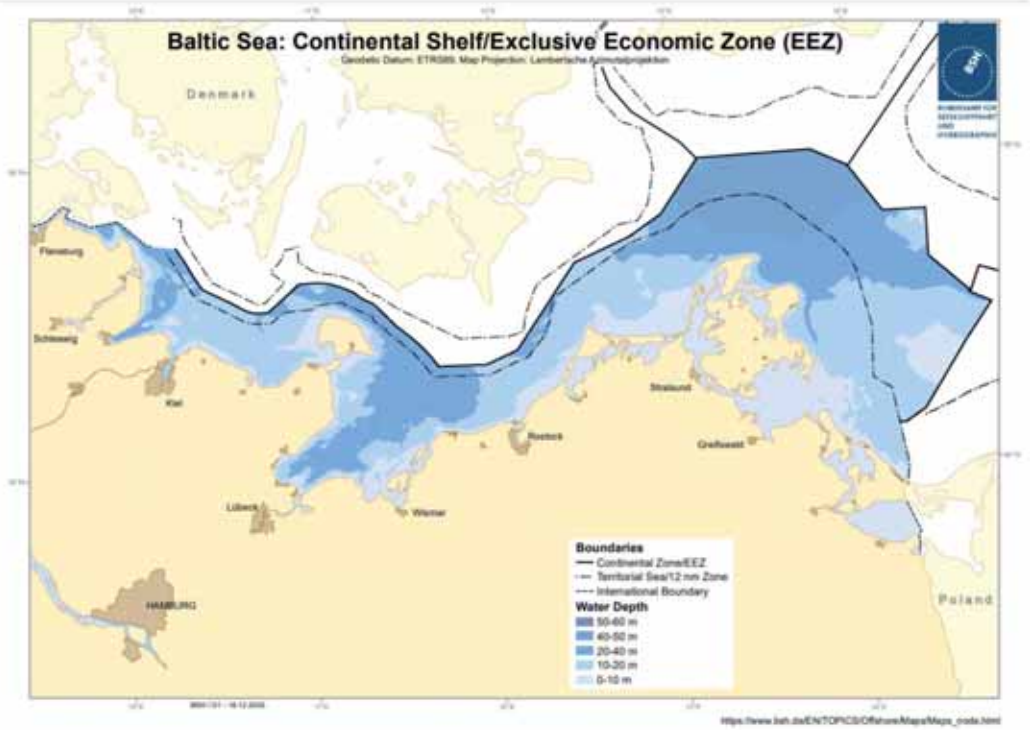

圖 2／波羅的海：大陸礁層／EEZ
資料來源／BSH
https://www.bsh.de/EN/TOPICS/Offshore/Maps/_Anlagen/Downloads/BalticSea_ContinentalShelf_EEZ.pdf?__blob=publicationFile&v=4

海洋空間規劃針對EEZ的使用及開發建立具約束力的規定。由於EEZ並不是德意志聯邦共和國的主權領土，因此必須遵守《聯合國海洋法公約》（United Nations Convention on the Law of the Sea, UNCLOS），包括航行與飛越自由，以及自由鋪設海底電纜及管線等等。因此德國海洋空間規劃可視為「有限制的空間規劃」。

德國EEZ的海洋空間規劃具有下列特點：

- 規範經濟和科學用途
- 確保安全及易於航運
- 保護海洋環境

海洋空間規劃是由德國聯邦海事及水文局（Bundesamt für Seeschifffahrt und Hydrographie, BSH）起草編撰。第一階段工作是建立現有使用主張清冊，因此BSH請地方主管機關列出目前在EEZ從事的各種活動及使用情形。BSH依據這些資料擬定第一份草案，並與利害關係人討論之後進行修訂。海洋空間規劃分別於2009年9月26日（北海EEZ）和2009年12月19日（波羅的海EEZ）施行。

德國海洋空間規劃訂定各種目標及原則，涵蓋航運、離岸風電、原料採收、管線及海底電纜、海洋研究、漁業及海洋環境等項目。計畫中針對航運、風電、管線及海底電纜和海洋研究等項目定義優先區域。優先區域會賦予特定單一項目特別重要的地位，在與其他用途競爭時獲得優先考量。優先航運區域是德國海洋空間規劃的基礎；這類指定區域會禁止不相符的用途，例如離岸風電（擁有自己的優先區域）。不過，德國為了在2030年之前達成離岸風電發電量25GW的目標，允許在離岸風電的指定區域以外興建離岸風場。

德國自發布第一份海洋空間規劃之後，離岸風電專案呈倍數成長。2009年的「Alpha Ventus」測試場是首座在德國EEZ裡興建的離岸風場。時至今日，北海及波羅的海已有20座離岸風場，共有1,167座風機運轉，發電量約5.3GW，另外還有4座風場正在興建中（2018年4月時）。離岸風場在2017年的發電量為17.4TWh。如果以德國漢堡市在2017年的12.1TWh耗電量為基準，離岸風電大約可涵蓋德國一到兩座大城市的電力需求。

圖 3／德國專屬經濟區（EEZ）的海洋空間規劃（Raumordnungspläne für die deutsche AWZ）
資料來源／BSH
https://www.bsh.de/EN/TOPICS/Offshore/Maritime_spatial_planning/maritime_spatial_planning_node.html

歐洲海洋空間規劃

除了德國的國家海洋空間規劃以外，歐盟也針對海洋空間規劃訂定準則，要求所有臨海的歐盟會員國在2021年之前擬定海洋空間規劃。會員國之間必須協調彼此的國家計畫，並考量各種跨國問題。個別空間規劃的目標，是透過海洋及沿海經濟／資源的永續開發，支持歐洲的「藍色成長」（Blue Growth）策略。這與歐盟的氣候保護及拓展再生能源法規不謀而合，以便維持平衡的海洋環境，同時完成歐洲運輸網路，也就是航運路線。

在北海地區，德國所有的鄰國（丹麥除外）均已訂定並施行海洋空間規劃。

在波羅的海地區，除了德國以外，只有立陶宛制定了海洋空間規劃，其他國家則處於不同的規劃階段。

由於歐盟沒有能力制定標準化的歐盟空間規劃，個別歐盟會員國必須自行採取適當措施，以達成跨國的海洋空間規劃。波羅的海海洋環境保護委員會（Baltic Marine Environment Protection Commission, HELCOM）及奧斯陸-巴黎公約（Oslo-Paris Convention, OSPAR）是兩個政府間組織，努力為整個波羅的海及北海地區實現各項目標。HELCOM希望進一步擴展跨部門合作，涵蓋海洋運輸、海洋空間規劃，以及整合沿海區域管理等領域。OSPAR目前則在北海地區領導國際合作，進行大西洋東北部的海洋環境保護。

德國聯邦海事及水文局（BSH）在2008年開始擬定空間規劃時，與荷蘭、丹麥、瑞典及波蘭等鄰國進行商討。BSH向前述鄰國提出德國海洋空間規劃的初版草案，讓各國有機會提出看法與建議。BSH除了在北海與波羅的海海洋空間規劃進行國際諮詢工作，自2009年起也成為歐洲間海洋空間規劃專案的合作夥伴，主要重點包括能源、航運及環境保護。

總而言之，海洋空間規劃可提供重要的全新發現，特別是在離岸風場興建及海纜鋪設等方面。能源、漁業及自然保育等部門目前正擬定長期的空間規劃。未來空間規劃的基礎，將建立在全新的國家與國際法規架構、歐洲鄰國之間的持續合作，以及過去15年來建立的廣大資料庫之上。

德國海洋相關部門與海洋政策

撰文／陳怡凱（國立成功大學法律學系副教授）
關鍵字／海洋部門、德國海洋政策

有效的海洋政策要求有效的制度結構。但在德國，海洋政策無論是法規的制定或執行，事權皆無法專一，這是受制於分層負責之政治制度結構所使然：涉及海洋領域之政策在德國是令出多門之多頭馬車結構。德國在聯邦與各邦中關於保護與利用海洋資源與生活空間上欠缺共同的政治權責機關來負責任。藉助於歐盟整合性之海洋政策而使得德國也引進了此種整合性政策[1]，本文底下將以「德國專屬經濟海域與領海之整合性海洋政策」為例來說明[2]。

德國國家組織行政結構與管轄權

一、德國是聯邦國家組織結構[3]

根據《德國基本法》第20條第1項，德國是聯邦國家。從此種聯邦國原則導引出：在德國規範權限與行政結構與組織結構被分配到聯邦與各邦。聯邦的最高機關是聯邦議會、聯邦參院、聯邦總統、聯邦憲法法院以及聯邦政府。此外，人民須擁有在邦的層面上被選出的代表。他們是德國16個邦的邦議會。邦議會議決邦法律，以及選出邦總理[3]。

二、立法管轄權：聯邦專屬權、競合權、框架立法權

基於聯邦國組織，而使立法權原則上放在各邦（《基本法》第70條第1項）。反之，聯邦於下面的領域擁有此種立法權限，其基於統一規範的必要性而享有專屬立法權（《基本法》第71條、73條）（專屬於聯邦之權限）、競合立法權（《基本法》第72條、第74條）（聯邦與各邦共同權限），以及框架立法權（《基本法》第75條）（聯邦只作原則性立法，留給各邦去作細節性立法）[3]。

三、德國海洋政策相關領域之立法管轄權

與整合性的海洋政策有關的領域，既有專屬權、競合權，也有聯邦的框架立法權，而且也有一些海洋政策領域是歸屬於聯邦的專屬管轄權。國防、航空交通、聯邦鐵路交通是屬於聯邦專屬立法權[1]。反之，《經濟法》（包括採礦、工業、能源）以及《農業法》、《公海捕魚法》、《近海捕魚法》、《海岸保護法》、《海床法》、《船舶航行法》、《內陸河航行法》、《內陸河道法》、《道路交通法》以及《垃圾經濟法》，全部都是屬於聯邦的競合立法權[1]。海港與河港是屬於各邦的專屬立法權限。文化遺產以及某一些觀光事項是屬於各邦之專屬權的領域。屬於聯邦框架立法之領域有：自然保護、空間秩序與水利供應保護[1]。

四、德國聯邦與各邦之執行管轄權

在德國，關於行政任務之執行原則上是屬於各邦。聯邦法律由誰執行？分成聯邦自己執行、聯邦法律由邦當作是自己的事務來執行、聯邦委託邦執行[3]。聯邦法律之執行大多由各邦為之。依此在各邦行政中應區分：邦法律之執行、聯邦法律之執行與聯邦委託行政。聯邦法律之邦自我執行之權限是從《基本法》第83條中所產生，而且是原則案型（原則情形），因為除非德國憲法有明文規定聯邦自己執行或聯邦委託行政，否則聯邦法律一概由邦來執行，這稱為邦自我執行[3]。在此種邦自我執行（邦執行聯邦法律）時，邦並非要聽命於聯邦的指示，聯邦只能在法律監督之框架中作行政行為合法性之監督。反之，如果是聯邦委託行政，則各邦要受到聯邦之法律監督與專業監督。此種在《基本法》中所被規範的領域（聯邦委託行政之領域），比如涉及國道管理之行政[1]。

五、德國海洋政策相關領域之執行管轄權

就整合性的海洋政策相關的領域之執行是分派到前述各種不同的行政執行類型。屬於聯邦法律聯邦自己執行的領域是關於：國防、航空交通、聯邦鐵路交通、航海與水運航道之行政任務。屬於聯邦委託行政的是：聯邦國道行政（各邦受到聯邦的委託而來管理）。其他的行政執行任務屬於各邦的權限，是以各邦自我行政來執行聯邦法律，或者是基於邦法律的執行。特別要指出的是關於在專屬經濟海域中的行政任務之特別執行，其主要被分派給聯邦的自我行政。反之，在大陸礁層領域的採礦權之行政，是由各邦的邦採礦局來管理，來為採礦法上的行政[1]。

海岸領域的行政結構與管轄權

聯邦部會：海洋領域以各部門的責任劃分，特別是分派到：「聯邦外交部」、「聯邦內政部」、「聯邦財政部」、「聯邦經濟、科技部」、「聯邦食品、農業部」、「聯邦國防部」、「聯邦交通、建設與都市發展部」、「聯邦環境、自然保護與核子安全部」以及「聯邦教育、研究部」。聯邦官署與機構負責海洋領域的有：「聯邦執行行政」、「聯邦海事警察」、「聯邦漁業研究局」、「聯邦風險評估、漁業監督局」、「聯邦水資產局」、「聯邦海事及水文局」、「聯邦水利與航海行政」、「聯邦自然保護局」、「聯邦放射線保護局」以及「聯邦環境局」。靠海之海岸各邦部會與邦的官署負責海岸海域之各種不同的行政任務。應加以強調的是：克勞斯塔爾-采勒費爾（Clausthal-Zellerfeld）（在下薩克森邦〔Niedersachsen〕）與史特拉爾松（Stralsund）（在麥克倫堡-佛波門邦〔Mecklenburg-Vorpommern〕）這兩個主管採礦、能源、與地質的邦地方官署，它們負責履行大陸礁層之聯邦採礦法的任務[1]。

德國聯邦政府海洋政策之決策特徵

德國關於海洋政策的決策由於欠缺統籌全局的專責機關，因此常陷入各單位各自為政，並且造成彼此的利益互相衝突。例如聯邦政府所創設的協調者的職位，是在常務次長（Staatssekretär）位階而放在經濟部，並且單純只有管轄海洋的經濟而已[4]。「聯邦環境、自然保護與核子安全部」為了

轉換歐盟海洋保護指令，而獨立於「聯邦食品、農業部」所代表的漁業政策之外，並且也獨立於「聯邦經濟、能源部」所領導之「航行政策」之外，來自行為轉換[4]。即使在國內層面，「聯邦食品、農業部」在引進關於國內海洋保護領域管理的規則方面，也擋住了「聯邦環境，自然保護與核子安全部」之介入，並且關於漁業政策上單獨只主張自己的目的。只有遭受到數個自然保護組織的共同控訴時，才可能使環境保護規則的規定向前推進[4]。關於深海採礦、離岸風力發電與其他的局部領域，大體上也都是如此互相各自為政。各種分歧不協調之產生，是由來於介於聯邦政府關於國際海洋政策與國內實務之間重大的分歧。不只是一整年都欠缺關於均衡的海洋保護區之管理計畫，而是也包括附屬產業與休閒漁業之管制與控制的欠缺[4]。魚類與海洋食物之進口可能來自非法的來源、塑膠垃圾以及其他的有害物質之產生、農業與交通過度的壟利取向、在航海上的社會福利制度之削減，還有衆多其他的面向都使這種各自為政的缺失變得更清楚[4]。

德國專屬經濟海域與領海之整合性的海洋政策

一、整合性的海洋政策

德國的行政結構與政治結構具有非常強烈的部門性分化的特色。各該專業政策所追求的目的主要是單一主題之專業目的做到最佳化。德國需要帶有整合性切入點之海洋政策，而且無論在聯邦或各邦的層面上都要採用：各該專業政策強烈地要將空間上的觀點以及與其他專業政策的交互影響納入考慮[2]。透過在整合性海洋政策的框架中所進行的討論，使大家明瞭海洋對於歐洲與德國環境與經濟的重要性，總體而言使海洋的觀點變得強大了。特別是在經濟領域之區域發展（比如北部德國）以及在北德沿海各邦強烈的海洋研究，整合性的海洋政策追求參與，其帶有把各種不同的專業政策整合到海洋政策。從宏觀性的觀點出發，整合性的海洋政策帶有參與。此種參與性的切入點，強化了民主思想，包括在政策的實踐上[2]。

二、海洋發展計畫[5]

德國海洋政策的策略性框架目的與重點是放在海洋的發展計畫中。這是一種整合性的德國海洋政策的策略。此種發展計畫自2011年以來就已經存在了[5]。此種發展計畫構成一種政治平臺，它把國家與非國家的海洋行動者納入決定的過程。屬於工作結構與決定結構的是：在資源討論、跨部會的工作小組與海洋相關的小組之網絡化並且把德國相關政治層面互相加以聯繫起來，在這種框架中，透過海洋發展計畫加以協調與操控。除此之外，還持續不斷的與各種團體與組織進行關於整合性海洋政策之對話。

發展計畫最主要是追求下列的目的：

- 強化德國海洋經濟的競爭能力，並且有利於就業的潛能。
- 北海與波羅的海在2020年之前要達到良好的環境狀態，並且使它們成為最乾淨並且最安全的海洋。
- 德國就全球生態發展負擔起共同責任，並且積極的支持對抗環境變遷[2]。

三、德國整合性的海洋政策之重要的基石：海洋空間秩序

德國整合性海洋政策之重要基石，特別是在考慮到空間面向的觀點底下，是海洋空間秩序。引進海洋空間秩序對於在德國北海與波羅的海的專屬經濟區的利用產生重大的影響。特別是採用風力發電園區、主要航道、海底電纜管道路線何者為優先的海面使用。它是首度把所有在北海與波羅的海的海洋利用做總體性的觀察，以及使在專屬經濟海域中的利用具有新的透明性[2]。

Bremen Überseestadt Beach Park, Germany
圖片提供／Pride Advertising Agency Ltd.

Hamburg Germany
圖片提供／Pride Advertising Agency Ltd.

德國專屬經濟海域的海洋空間秩序強化了海洋面積的使用之可回復性的切入點（所做的對海面的干預又可以再度地回復原狀）。在這個意義下，出於環境、航海與風力能源之利益被協調以及衝突被化解。在北海與波羅的海之專屬經濟海域的空間秩序框架中，特別是介於各個行動者之間的衝突，為了氣候政策的脈絡下而推動風力能源以及航海之傳統利用之間之衝突，透過風力發電之優先使用海面之確定，以及主要航道的確定而來解決[2]。

除了在聯邦層面上的手段，在德國整合性的海洋政策，也在北部德國靠海的各邦之層面實踐，包括：布萊梅邦（Bremen）、漢堡邦（Hamburg）、下薩克森邦（Niedersachsen）、麥克倫堡-佛波門邦（Mecklenburg-Vorpommern）、什列斯威-霍爾斯坦邦（Schleswig-Holstein）。整合性的海洋政策於德國靠海的各邦中，特別是透過與海洋有關的專業領域之整合，以及透過與陸地有關以及與海洋有關的計畫之間的整合而被彰顯出來[2]。

參考資料

[1] Stefan Lütkes/Heike Holzfuß/ Wulf Hülsmann/ Thomas Bosecke (Redaktion), Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Hrsg.), Integriertes Küstenzonenmanagement in Deutschland, Nationale Strategie für ein integriertes Küstenzonenmanagement (Bestandsaufnahme, Stand 2006) , 2006.

[2] Bundesinstitut für Verkehr und digitale Infrastruktur (Hrsg.), Nutzen der Berücksichtigung räumlicher Belange in Fachpolitiken am Beispiel der integrierten Meerespolitik, MORO Forschung 2/2015.

[3] Peter Badura, Staatsrecht, 7. Aufl., 2018.

[4] Kai Kaschinski, Besser spät als nie, Transparenz, Partizipation und Kohäreny als Schlüsselaspekte einer internationalen Meerespolitik, in: Forum Umwelt und Entwicklung/ VENRO/ terre des hommes Deutschland/ Global Policy Forum/ Open Knowledge Foundation Deutschland (Hrsg.), Deutschland und die UN-Nachhaltigkeitsagenda, Noch lange nicht nachhaltig, 2016.

[5] Bundesministerium für Wirtschaft und Energie (Hrsg.), Maritime Agenda 2025, Für die Zukunft des maritimen Wirtschaftsstandortes Deutschland, 2017.

德國海洋研究機構－基爾亥姆霍茲海洋研究中心

編撰／陳佳琳（國立成功大學水利及海洋工程學系助理教授）
許順彥、廖敬元、蔡聖德、黃文歆、侯丞謙（國立成功大學水利及海洋工程研究所碩士生）
關鍵字／德國、基爾亥姆霍茲海洋研究中心、板塊構造學、沉積物

德國位於歐洲大陸要衝，在地區分類上屬於西歐或中歐，北與丹麥相連，東面與波蘭和捷克接壤，東南毗鄰奧地利，西南毗鄰瑞士，西同法國、盧森堡和比利時相界，西北毗鄰荷蘭。其領土大部分位於北緯47至55度，東經5至16度間。德國北瀕北海，東北偏北臨波羅的海 。德國海岸線全長2,389公里，約為臺灣1.5倍。德國大部分海岸線集中在北部區域：德國全國只有什列斯威-霍爾斯坦邦（Schleswig-Holstein）、下薩克森邦（Niedersachsen）與麥克倫堡-佛波門邦（Mecklenburg-Vorpommern）3個邦擁有海岸線。雖然德國大多數工業區、大城市與主要發達經濟帶都分布於內陸，但德國沿海擁有全球目前裝機容量最大的海洋風力發電，海洋旅遊產業單位產值在歐洲國中排名靠前[1]。此外，德國人也以熱愛大自然聞名，都市綠化率極高，也是歐洲再生能源大國，是可持續發展經濟的榜樣，同時也強調環境保護與自然生態保育。

圖1／基爾亥姆霍茲海洋研究中心地理位置
圖片來源／Google Maps

研究中心簡介與人才培育

基爾亥姆霍茲海洋研究中心（GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, GEOMAR），是歐洲海洋科學領域的3大領導機構其中之一，並且與鄰近的英國國家海洋學中心（National Oceanography Centre, NOC）以及法國海洋開發研究院（The French Research Institute for Exploitation of the Sea, IFREMER）共同組織了「G3 group」（簡稱G3）國際海洋研究中心。基爾亥姆霍茲海洋研究中心，是一個領先獨步全世界的大型海洋研究中心，座落於德國基爾，原先稱之為萊布尼茲海洋科學研究所（Leibniz-Institut für Meereswissenschaften），於2004年由邦及聯邦政府聯合成立。他們原是萊布尼茲學會的管轄單位，2012年撤出該學會後併入亥姆霍茲聯合會，並改為現名。此外它也是世界魚類資料庫聯合會（The FishBase Consortium）中參與方的協調者。該研究所參與全球所有與大洋相關的海洋研究，在氣候動力學、海洋生態學和生物地球化學、洋底動力與循環等領域成就突出。該研究所和基爾大學合作頒發學位，並營運基爾水族館和智能庫「Lithothek」[2]。近期日本福島核廢水排放議題，基爾亥姆霍茲海洋研究中心於2012年發表的研究亦被廣泛提及討論。研究使用數值模擬追蹤^{137}Cs的擴散情形，並指出在3至6個月內就會影響整個太平洋[3][4]。

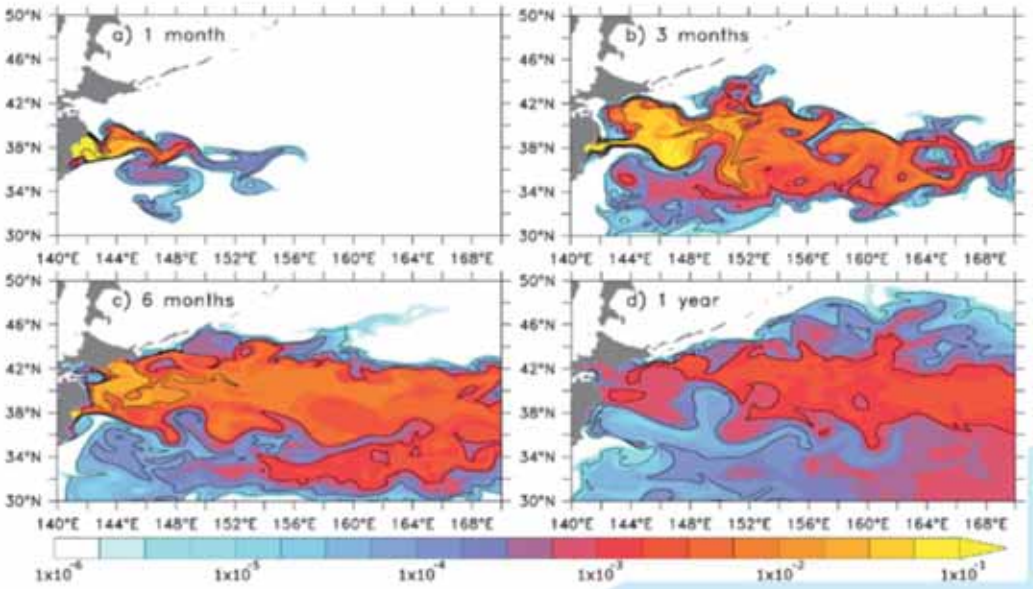

圖2／Sequence of relative surface tracer concentration
圖片來源／Behrens, E., F.U. Schwarzkopf, J.F. Lübbecke and C.W. Böning, 2012 [4]

基爾亥姆霍茲海洋研究團隊致力於研究位於海床上，海洋之中又或是海洋邊緣的物理，化學，生物以及地質的變化，以及它們與大氣間的交互作用，其中也致力於縮小基礎科學與實務上的落差，並

且憑藉著廣泛的研究計畫獨步全球。基爾亥姆霍茲海洋研究中心是德國聯邦政府（90%）和什列斯威-霍爾斯坦邦（10%）政府共同資助的公法人，並且於2020年擁有約1,000名員工，以及約為8,000萬歐元的年度預算。涵蓋海床地質學到海洋氣象學，此機構的目的是對現代海洋科學中的所有議題進行跨領域研究，範圍遍布世界各地[5]。

除此之外，基爾亥姆霍茲海洋研究中心擁有3艘海洋研究船（ALKOR, LITTORINA and POLARFUCHS），船上搭載先進的儀器設備，例如載人潛水器（JAGO）與水下無人載具（KIEL6000、PHOCA和ABYSS），基爾亥姆霍茲海洋研究中心也同時擁有數個研究實驗室，搭配極高性能的電腦計算設備和一個引人入勝的水族館。自從2017年底以來，基爾亥姆霍茲海洋研究中心亦在非洲的西方海域的維德角群島（Cap Verdean Islands），設立了一個科學後勤站：維德角群島海洋科學中心—明德盧（Mindelo）[5]。

近期重大研究成果

一、自然研究所發現轉型斷層對海底地形塑造產生積極作用[6]

來自德國基爾亥姆霍茲海洋研究中心的研究人員2021年3月17日於國際科學期刊《自然》雜誌上發表了一項最新的研究成果，其中就指出了轉型斷層在板塊構造學中所扮演的一個極度重要的全新角色。地球內部的作用力，沿著海底山脈與大洋中脊將地殼板塊推移，並且形成新的海床，進而促使大陸板塊向周圍移動。數百萬年以來，地球內部運動所造成的強大作用營力，一直不斷的在重塑大陸以及海洋盆地的形狀。儘管如此，板塊構造學之先驅阿爾弗雷德・韋格納（Alfred Wegener）先生先前於1915年所發表的板塊構造論，直至上世紀1960年代才被群眾廣為接受，為我們的星球構造提供了一個統一的觀點。而板塊構造論會需要耗時如此之久才被大眾所認可，其中有兩個簡單的原因。首先，地層深藏在大海最深遠的底部，高深莫測卻也令人神往。再者，其運動過程的受力，作用於海床的下方深處，隱匿於我們視野之外，故難以觀測。正因如此，直至今日許多板塊構造的細節之處仍然難以釐清。

如今，來自德國基爾亥姆霍茲海洋研究中心、中國深圳南方科技大學以及瑞士GeoModelling Solutions GmbH的5位科學家於《自然》上發表了一項研究，基爾亥姆霍茲海洋研究中心的Ingo Grevemeyer教授指出關於板塊構造學的基本假設是中洋脊的巨型偏移量。迄今為止，偏移量在板塊構造學中被認為單純地扮演了被動的角色。然而該研究明確顯示，它們在海床塑造的過程中發揮了積極作用。

簡單閱覽一下全球海底概況圖（圖3），以利於理解這一項研究。可以發現甚至在地圖解析度不足的情況下，也能輕易地辨別出長達幾萬公里的中洋脊，它們正代表著地球板塊的邊界。來自地函的熱對流從板塊之間邊界中央湧出後，快速冷卻形成新的海洋地殼並且推動年老地殼造成移動，這是板塊保持移動的動力源。

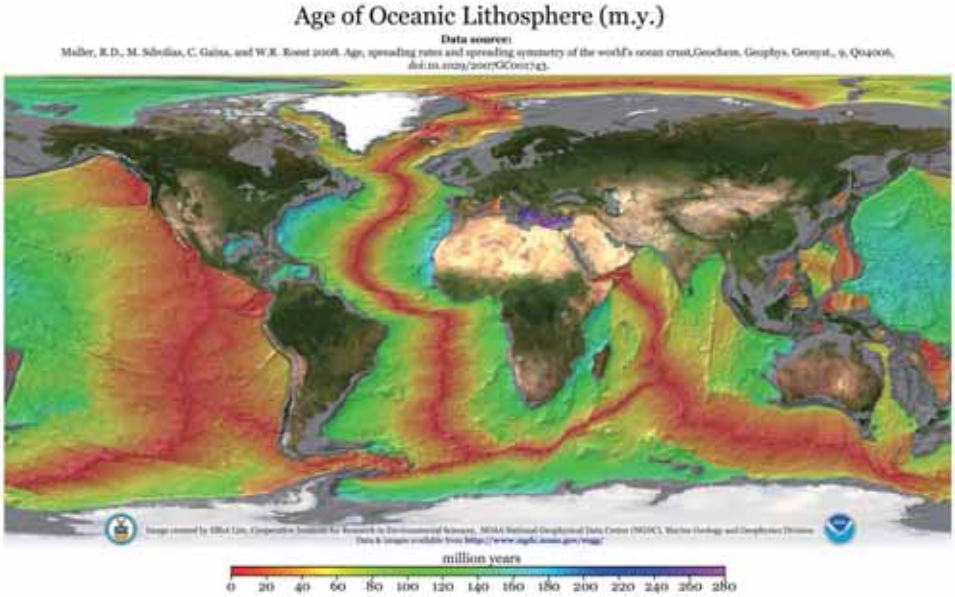

圖3／2008全球海底概況圖（顏色標明地殼年代）
圖片來源／Mr. Elliot Lim, CIRES & NOAA/NCEI
https://www.ngdc.noaa.gov/mgg/image/crustalimages.html

不過，中洋脊並沒有形成連續的線條，它們幾乎是以規律的間隔被裂谷所截斷。海脊各個部分在斷面首尾處都有一定的偏移量。來自基爾亥姆霍茲海洋研究中心的Lars Rüpke教授指出這些就是轉型斷層，因為地球是一個球體，板塊運動反覆引發轉型斷層形成，進一步造成這些海脊偏移。

地震有可能會發生在轉型斷層處，它們會在海洋板塊之上留下長長的痕跡線條，即是所謂的地層斷裂帶。然而，截至目前為止的衆多研究都認為兩個板塊只是在轉型斷層處相互滑動，而在整個動力過程中，並不會生成或是破壞海床。目前研究的作者已經檢視了所有海洋盆地中40條轉型斷層的現有地圖。此研究的共同作者，來自基爾亥姆霍茲海洋研究中心的Colin Devey教授如此說道：「在所有的例子當中，我們皆能發現轉化谷（tranform valley）要遠比相鄰的斷裂帶深了不少，而過去此斷裂帶一直被單純的視為轉化谷的延續。」該研究團隊甚至還在轉化谷（圖4）與中洋脊的交會處觀察到了廣泛的岩漿活動痕跡[7]。

對此，研究團隊們利用相當複雜的數值模式，找到了可以對該現象的合理解釋。綜上所述，板塊邊界沿轉型斷層隨著深度越發地傾斜，進而造成了剪切作用的具象化。這必然造就海床的延伸，形成了深邃的轉化谷。隨後在外角至大洋中脊的岩漿作用將峽谷處填起，使得斷裂帶淺化。因故，在角部所形成的海洋地殼是唯一由二級火山活動所生成的地殼。但這對於地殼的組成，舉例來說例如其中金屬分布有什麼影響，截至目前為止仍然不得而知。由於轉型斷層是板塊邊界的一種基本類型，亦是海洋活動板塊邊界處所常見的現象之一，故此新發現不僅對於板塊構造論是一個很不錯的補充，更對於認識我們的地球擁有重要的意義。

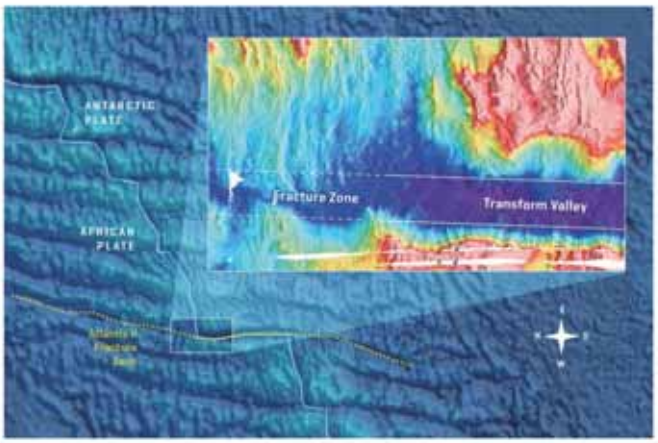

圖4／轉化谷
圖片來源／https://www.geomar.de/en/news/article/ein-neuer-blick-auf-die-plattentektonik

二、沉積物是北極峽灣的營養媒介[8]

雖然海洋中的藻類和其他浮游植物（phytoplankton）的體型並不大，但它們在地球的氣候系統中扮演重要的角色。它們利用大量的碳產生其他物種賴以維生的氧氣，這種浮游植物需要光、碳、養分和鐵等元素的供應來存活，上述各元素當中鐵在海洋中是非常少見的，也因此海洋中富有鐵源的地方，浮游植物就有機會好好地繁殖。

在北極圈內，冰川的末端是鐵的重要來源。近年來冰川受到氣候變遷的影響，變化得非常迅速，此變化對北極水域中的營養鐵供應量和浮游植物生長產生的影響一直是大家關注的議題。基爾亥姆霍茲海洋研究中心所領導的國際研究團隊針對此問題進行了調查。中心的Katja Laufer-Meiser教授以斯瓦爾巴群島（Svalbard）上的幾個峽灣為例進行研究，結果顯示不僅冰川本身提供的鐵源，峽灣底部的沉積物，也可能存在供給浮游植物使用的鐵源[9]。

雖然過去有關該主題的研究均表示，冰川對峽灣的水體以及附近相鄰的海洋有直接的影響，Laufer-Meiser教授基於研究結果解釋大部分從冰層進入水中的鐵不能被浮游植物直接使用，其最初會以結晶形式沉積在峽灣底部的沉積物中，生化作用可將某部分沉積的鐵轉化為養分的形式，重新回到海水之中。令人驚訝的是，該研究在沉積物中發現，最高的營養鐵含量竟然不是在冰川的末端，而是在離峽灣更遠的地方。這與學界普遍期望的結果相反，並且過去也從未發現過此現象。該研究團隊是透過降低外部峽灣地區的沉降速率（sedimentation rates）觀察到這一個現象。由於鐵的轉化主要發生在最上層的海床層，因此才有更多的時間，讓年輕的物質把鐵覆蓋在上面，其過程如圖5。因此，外部峽灣地區的生物與非生物之轉化過程才會比位於冰川附近更明顯。

該研究也說明「沉積物」是潛在促成生化作用的重要因子。另外冰川退縮到陸地上不僅改變了冰川養分的直接供應量，也間接影響了沉積物內部的反應。眾所周知，冰川的退縮會影響浮游植物的生長，進而使整個峽灣生態系統的生產力下降，冰川後退也改變了峽灣沉積物中的生化特性。研究結果總結，這種生物潛在利用度較低的鐵抵達表頂層是另一個負面反饋的機制，並且會間接地影響氣候變遷。

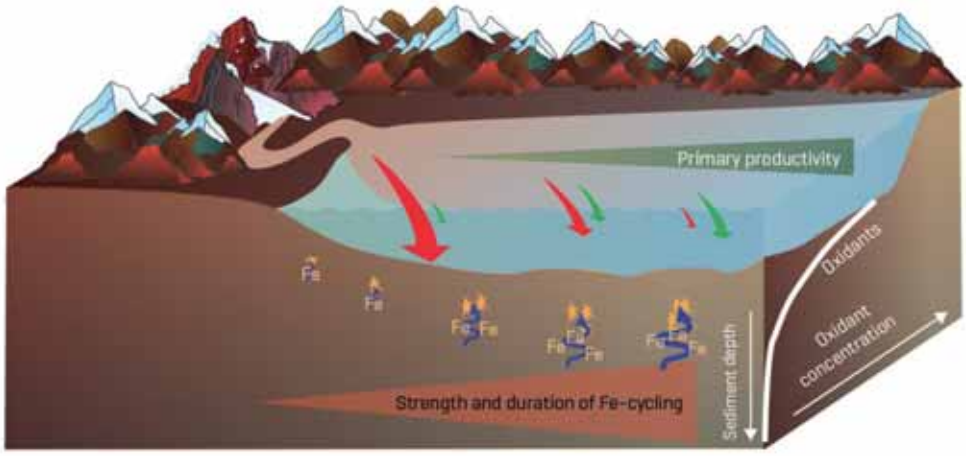

圖5／蝕轉化圖
圖片來源／https://www.geomar.de/en/news/article/sedimente-als-naehrstoff-vermittler-in-arktischen-fjorden

結語

基爾亥姆霍茲海洋研究中心亦活躍於許多個國際組織，像是德國海洋研究聯盟（German Alliance for Marine Research, DAM）、德國海洋研究協會（German Marine Research Consortium, KDM）、德國氣候協會（German Climate Consortium, DKK）、歐洲海洋理事會（European Marine Board）以及全球海洋觀察夥伴關係（Partnership for Observation of the Global Oceans, POGO）。基爾亥姆霍茲海洋研究中心與基爾大學一同攜手培育未來的海洋科學家，另外也與世界各地的其他大學共同合作。該中心的研究成果及國際合作模式值得臺灣海洋研究單位借鏡參考，希望能進一步引起民眾對於海洋研究的興趣，深入瞭解地球物理過程之間的相互關係，發掘未知的知識及海洋資源。

參考資料

[1] https://www.kibase.com/news/585334.html
[2] https://zh.wikipedia.org/wiki/%E5%9F%BA%E5%B0%94%E4%BA%A5%E5%A7%86%E9%9C%8D%E5%85%B9%E6%B5%B7%E6%B4%8B%E7%A0%94%E7%A9%B6%E4%B8%AD%E5%BF%83
[3] 自由時報，〈福島核廢水確定排入海 德國研究：57天內恐汙染大半太平洋！〉，2021年4月13日
https://news.ltn.com.tw/news/world/breakingnews/3498435
[4] Behrens, E., F.U. Schwarzkopf, J.F. Lübbecke and C.W. Böning, 2012: Model simulations on the long-term dispersal of ^{137}Cs released into the Pacific Ocean off Fukushima. Environmental Research Letters, 7
http://dx.doi.org/10.1088/1748-9326/7/3/034004
[5] https://www.geomar.de/en/centre/about-geomar
[6] Grevemeyer, I., L. H. Rüpke, J. P. Morgan, K. Iyer, C. W. Devey (2021): Extensional tectonics and two-stage crustal accretion at oceanic transform faults. Nature
https://doi.org/10.1038/s41586-021-03278-9
[7] https://www.geomar.de/en/news/article/ein-neuer-blick-auf-die-plattentektonik
[8] Laufer-Meiser, K., A. B. Michaud, M. Maisch, J. M. Byrne, A. Kappler, M. O. Patterson, H. Røy & B. B. Jørgensen (2021): Potentially bioavailable iron produced through benthic cycling in glaciated Arctic fjords of Svalbard. Nature Communications 12, 1349 (2021)
[9] https://www.geomar.de/en/news/article/sedimente-als-naehrstoff-vermittler-in-arktischen-fjorden

德國《空間規劃法》與海洋空間規劃

撰文／陳貞如（國立政治大學法律系副教授）
關鍵字／空間規劃法、海洋空間規劃、歐盟海洋空間規劃指令

由於海洋在經濟、社會和環境三面向所扮演的多重角色，使得海域使用往往充滿使用者的利益衝突問題，「海洋空間規劃」（maritime spatial planning）之作用係在平衡不同利益的競爭關係，作為一種具前瞻性的計畫工具，協調不同用海者之利益。在德國亦是如此。

德國主要沿海係位於北海和波羅的海兩個區域性海洋中，其位於北海之內水和領海有大約12,500平方公里，專屬經濟區則有約28,500平方公里；於波羅的海之內水和領海有大約10,900平方公里，專屬經濟區有大約4,500平方公里[1]。相較於其他歐洲沿海國家，德國並非傳統海洋國家。其傳統用海並不多見，原本不被用作大規模工業開發用途的海洋，維持開放且原始，但隨著工業發展，科技進步，經濟需求等因素，不但是12浬領海範圍甚至到200浬專屬經濟區（Exclusive Economic Zone）範圍均已成為開發目標。故而其海洋空間規劃可區分成兩部分，透過不同海洋分區中國家管轄權之差異，以及其是否涉及國際性，而區分為：（一）以內水和領海為範圍，涉及國內的部分；以及（二）以專屬經濟區為範圍，涉及國際的部分。兩部分分述如下。

以內水和領海為範圍，涉及國內的部分

在內水和領海部分，主要位於沿海3邦，包含：下薩克森邦（Niedersachsen）、麥克倫堡-佛波門邦（Mecklenburg-Vorpommern），以及什列斯威-霍爾斯坦邦（Schleswig-Holstein）。由地方政府依據《空間規劃法》（Raumordnungsgesetz）之一般規範進行內水和領海海域空間規劃，將各該海域分別整合進相關沿海各邦就其陸上空間規劃一併進行。此3邦之海域空間規劃，可分析如下：

什列斯威-霍爾斯坦邦發展計畫（Schleswig-Holstein Landesentwicklungsplan），作為一個空間規劃計畫，其內容涵蓋陸上和海域空間規劃之目標與原則，具有法律上拘束力。以永續空間發展為指引，使對於空間之社會和經濟需求與其生態功能可維持平衡。海岸地區的不同利用亦應彼此適應，以達到平衡。整合性海岸管理計畫亦為其中重要一環。該邦發展計畫於2010年生效，最新一次修改則在2019年進行。在此一作為「傘計畫」（Dachplan）地位的邦發展計畫架構下，另有5個區域型計畫（Regionalpläne），未來預計調整成3個區域型計畫，主要考量是各區不同之發展特色。透過空間規劃設定原則和目標，再由區域型計畫主管機關加以權衡。前述邦發展計畫和區域型計畫由邦計畫主管機關制定，透過公民參與和協商程序，也包含邦計畫委員會（Landesplanungsrat）之參與，最終由邦議會（Landtag）通過。在分區的考量上，區分優先區（Vorrangsgebieten）、保留區（Vorbehaltssgebieten）和合適區（Eignungsgebieten）3類，例如作為風力發電、水資源保護或自

然和休閒之用。優先區係指用於特定的、在空間上具有重要功能或用途的區域，若與其優先功能或用途不兼容之其他用途應被排除在外；保留區則係指當該區域有重要功能或用途時，若存在多元用途之衝突時，應特別重視這些該區的重要功能或用途；在合適區，則是在空間規劃中指定特定合適區域供作相關用途，在空間規劃之其他區域中，即排除此等用途之使用[2]。

至於麥克倫堡-佛波門邦發展計畫，在2003年至2005年之間首先擴及12浬領海部分進行規劃，2005年正式採用。另於2013年至2015年之間進行修正，2016年完成修正採納。此一計畫，每5年進行評估，亦正建立監控系統中[3]。

下薩克森邦發展計畫，則主要包含風力發電、自然保育、海上電力傳輸和海運之相關條款。就其沿岸地區和領海，強調適用相關原則，包含：永續發展、考慮不同利害關係人之觀點以及可逆措施之採取。目前，此一計畫曾經過歷次修訂存在不同版本。此計畫亦有國際性因素存在，故除國內公衆參與和諮商外，另需與荷蘭進行協商[4]。

以專屬經濟區為範圍，涉及國際的部分

在專屬經濟區之海域空間規劃，由聯邦政府所管轄，由德國聯邦海事及水文局（Bundesamt für Seeschifffahrt und Hydrographie, BSH）負責執行德國於北海和波羅的海專屬經濟區之海洋空間規劃。其專屬經濟區之海洋空間規劃立法依據仍為《空間規劃法》，本法於2004年修正擴大適用範圍至專屬經濟區，另於2017年修正以回應2014年歐盟第89號指令《歐盟海洋空間規劃指令》（EU Directive for Maritime Spatial Planning, 2014/89/EU）之規範。

不同於內水和領海，德國之專屬經濟區非完全屬於德國管轄範圍，屬於國際水域，此一海域之空間規劃勢必必須遵守《聯合國海洋法公約》（UN Convention on the Law of the Sea，簡稱《公約》）。例如，依據《公約》第58條第1款應確保相關國家在沿海國專屬經濟區仍應享有之海洋自由，包含：航行和飛越的自由，鋪設海底電纜和管道的自由，以及與這些自由有關的海洋其他國際合法用途，諸如同船舶和飛機的操作及海底電纜和管道的使用有關的並符合本《公約》其他規定的那些用途。因此在專屬經濟區之空間規劃，應屬「有限的空間規劃」（eingeschränkte Raumordnung）。此部分之空間規劃規範和用途主要限於有關經濟與科學用途、確保航海的安全和便利，以及保護海洋環境[5]。

早在2009年，在德國聯邦海事及水文局的協助下，德國聯邦內政部（Bundesminister des Innern, für Bau und Heimat, BMI）即已開始進行此一水域之海洋空間規劃，2019年開始進行相關計畫之修正，以回應前述《歐盟海洋空間規劃指令》，要求所有沿海會員國於2021年前完成海洋空間規劃。於此等規範架構下，德國的專屬經濟區海洋空間規劃亦建立在廣泛的協商過程，其過程包含相關主管機關、協會或私部門的意見均會被納入計畫過程的不同階段進行評估。直至今日，新回合的計畫修正仍在進行中。

而在專屬經濟區，依據海域不同，可以區分成兩項計畫，包含：一、在北海之德國專屬經濟區海域空間規劃（Raumordnung in der deutschen ausschließlichen Wirtschaftszone in der Nordsee, AWZ Nordsee-ROV）；二、在波羅的海之德國專屬經濟區海域空間規劃（Verordnung über die Raumordnung in der deutschen ausschließlichen Wirtschaftszone in der Ostsee, AWZ Ostsee-ROV）。在規劃上，涵蓋其他新用途和傳統用海，共有10大用途，包含：海運、非生物資源開發、管道和海底電纜、海洋科學研究、能源生產（尤其是風能）、漁業和海水養殖、海洋環境、軍事用途、休閒和旅遊，以及彈藥堆放場和沉積物沉積場。在波羅的海部分，另有丹麥、德國間之非曼海峽（Fehmarnbelt）通過之用途。透過計畫，建立框架，建立明確目標和原則。其中更認為離岸風力發電因為有助於國家海洋永續利用和保護之策略，欲調和此種海洋新用途與傳統用海之衝突。此等計畫除強調廣泛的國內公眾參與，由於本區具國際性，因此和鄰國之協商，亦不可或缺，包含通知海域空間規劃之意圖、提供書面訊息供相關草案協商、召開國際協商會議，乃至於依據《跨國環境影響評估公約》進行策略性環境影響評估之協商程序，包含瞭解對鄰國海洋環境，特別是保護區之負面影響。計畫最終除將通過執照發給和項目許可之相關規範外，亦包含相關地圖和分區用之地理坐標[6][7]。

圖說／德國聯邦內政部、海事及水文局2020年9月公布德國在北海和波羅的海專屬經濟區的空間規劃草案

圖片來源／BSH

https://www.bsh.de/DE/THEMEN/Offshore/Meeresraumplanung/Fortschreibung/_Anlagen/Downloads/Entwurf_Raumordnungsplan.pdf?__blob=publicationFile&v=8

結語

由以上介紹可以看出德國海域空間規劃之特色，包含：

一、確定邊界：由於德國在1960年代和1970年代，已陸續分別完成和相關鄰國之重疊海域劃界協議，包含丹麥、荷蘭、瑞典、波蘭和英國，其專屬經濟區之外界線已然確定，使其在海洋治理上無庸再面對可能存在的海域爭端。

二、單一立法：透過《空間規劃法》適用於內水和領海，進而擴大至專屬經濟區。此種立法方式亦可供他國參考。其優點在於行政機關熟稔相關法制，從陸到海，再依據其特性加以區分，可快速上手。但其因素也或許在於原本其專屬經濟區即不像其他海洋國家一樣廣闊。此外，在中央與地方權限區分上，與人類活動密切相關的內水和領海範圍劃歸地方管轄，亦能呼應陸海整合性管理之精神。

三、採用《公約》分區：延續《空間規劃法》之發展過程和邏輯，在其海域空間規劃上，僅以領海外界區分，內水領海和專屬經濟區，亦較能在適用《公約》規範時，兼顧整合性管理之精神。

四、注重功能性分區和各區優先順序：空間規劃上，透過功能和用途之設計，加以考量適用優先順序，形成具有階層性之框架和制度。

五、重視國內外公衆參與：在計畫過程中，透過專業機關之擬定，經由公開諮詢程序，重視公私部門之參與和協商，最後透過立法部門審議通過，落實民主原則。在存在國際性因素時，亦進行與鄰國之協商程序。

前述種種德國海域空間規劃之特色，值得吾人在進行我國之海域空間規劃時參考。

參考資料

[1] European MSP Platform (2021). Germany
https://www.msp-platform.eu/countries/germany (Apr. 15, 2021)

[2] Schleswig-Holstein (2021). Landesentwicklungsplan Fortschreibung
https://www.schleswig-holstein.de/DE/Landesregierung/Themen/PlanenBauenWohnen/Fortschreibung_LEP/Projekt/projekt_node.html (Apr. 15, 2021); European MSP Platform (2021). Maritime Spatial Plan for the Territorial Sea of Schleswig – Holstein
https://www.msp-platform.eu/practices/maritime-spatial-plan-territorial-sea-schleswig-holstein (Apr. 15, 2021)

[3] Mecklenburg-Vorpommern (2021). Aktuelles Programm
https://www.regierung-mv.de/Landesregierung/em/Raumordnung/Landesraumentwicklungsprogramm/aktuelles-Programm/ (Apr. 15, 2021)

[4] European MSP Platform (2021). The Spatial Planning Programme for the Territorial Sea of Lower Saxony
https://www.msp-platform.eu/practices/spatial-planning-programme-territorial-sea-lower-saxony (Apr. 15, 2021)

[5] Bundesamt für Seeschifffahrt und Hydrographie, Meeresraumplanung
https://www.bsh.de/DE/THEMEN/Offshore/Meeresraumplanung/meeresraumplanung_node.html (Apr. 15, 2021)

[6] European MSP Platform, Maritime Spatial Plan of the German EEZ in the North Sea
https://www.msp-platform.eu/practices/maritime-spatial-plan-german-eez-north-sea (Apr. 15, 2021); Bundesministerium der Justiz und für Verbraucherschutz, Bundesamt für Justiz, Verordnung über die Raumordnung in der deutschen ausschließlichen Wirtschaftszone in der Ostsee (AWZ Ostsee-ROV), BGBl. I 2009, Nr. 78, S. 3861 vom 18. Dezember 2009, S. 1 – 31.

[7] European MSP Platform, Maritime Spatial Plan of the German EEZ in the Baltic Sea
https://www.msp-platform.eu/practices/maritime-spatial-plan-german-eez-baltic-sea (Apr. 15, 2021); Bundesministerium der Justiz und für Verbraucherschutz, Bundesamt für Justiz, Verordnung über die Raumordnung in der deutschen ausschließlichen Wirtschaftszone in der Nordsee (AWZ Nordsee-ROV), BGBl. I 2009, Nr. 61, S. 3107 vom 25. September 2009, S. 1 – 34.

Learning from Germany to Better Engage in Marine Spatial Planning

Translated by Linguitronics

Minister of the Ocean Affairs Council: Chung-Wei Lee

Ocean space plays crucial roles from multiple aspects, including economic, social and environmental, and offers a variety of functions such as transportation, energy, research, fishery, etc. As Taiwan actively develops and promotes renewable energy policies, reasonable use of ocean space so that adequate planning for environmental conservation, offshore energy and fishery development, etc., can be made has become one of the most important issues that our nation must consider. Following Germany's establishment of its Exclusive Economic Zone (EEZ) in the North Sea and the Baltic Sea, the Federal Maritime and Hydrographic Agency (BSH) proceeded with marine spatial planning and conducted international negotiations with neighboring countries in accordance with the EU Marine Spatial Planning Directive. In the "Industry Dynamics" and "Regulatory Systems" sections of this issue, we discuss the strategy and development of Germany' maritime spatial planning from different perspectives to serve as reference for Taiwan's formulation of similar plans.

In addition to offshore wind power, Taiwan's government is also actively promoting ocean current energy research. In this issue's "Special Report," we introduce the development process of ocean current generator sets conducted by the National Academy of Marine Research in 2020 as well as the selection and planning of test sites. Meanwhile, the "Latest News" section introduces the marine science interdisciplinary research from seabed geology to marine meteorology conducted by the GEOMAR Helmholtz Centre for Ocean Research Kiel in Germany. Furthermore, Germany's Indo-Pacific policy has also led to the deepening of its relations with countries in the Indo-Pacific region. For instance, in this issue's "International Issues" section, we analyze the active diplomatic thinking and approaches manifested by the Germany's plans to send a frigate through the South China Sea--a topic that is well worthy of our attention and observation.

Port of Hamburg, Germany
Image by Ling-Chieh Chen

Present Status and Future Prospects of Ocean Current Power Generation in Taiwan

Ming-Hung Cheng (Associate Researcher at the Marine Industry and Engineering Research Center, National Academy of Marine Research), Chuan-Tsung Lee (Assistant Researcher at the Marine Industry and Engineering Research Center, National Academy of Marine Research), Jian-Ming Liau (Director of the Marine Industry and Engineering Research Center, National Academy of Marine Research), Jiahn-Horng Chen (Vice President of the National Academy of Marine Research), Yung-Fang Chu (President of the National Academy of Marine Research)
Translated by Linguitronics
Keywords: Ocean current power generation, Floating Kuroshio Turbine, Floating Platform Kuroshio Turbine, international ocean current test site

Over the past few years, with green energy becoming the focus of attention, all available land for onshore wind and solar energy have been successively developed and now reached full utilization. To obtain more renewable energy and due to the superior geographical conditions surrounded by the sea, Taiwan has turned its attention to marine energy. Marine energy can be further divided into wave energy, tidal energy, ocean current energy, and thermal energy conversion. Broadly speaking, ocean energy also includes wind and solar energy generated above water and biomass energy harvested from the ocean, all of which can be used to generate electricity. In terms of international development, thermal energy conversion and tidal energy power generation technologies are relatively mature and utilized in commercial operations while the power generations of ocean wave and current energy are still regarded as emerging technologies. According to estimates made by Dr. Frank H. Shu, an Academician of the Academia Sinica, Taiwan can obtain about 50 GW of energy from the Kuroshio, an oceanic current that flows steadily through the seas of eastern Taiwan all year round [1].

The earliest instance of development of Taiwan's ocean current power generation began in the National Energy Program-Phase II (NEPII) which was initiated in 2014 and completed in 2018. In 2019, the Ocean Affairs Council implemented the "Development and Promotion of Key Technologies for Ocean Current Energy" preliminary project [2]. Following the establishment of the National Academy of Marine Research (NAMR) in April 2019, NAMR was entrusted by the Ocean Affairs Council in 2020 to carry out the 4-year "Development and Promotion of Key Technologies for Ocean Current Energy" project. Building upon previous achievements, the outcomes attained by NAMR in 2020 can be divided into two main parts, one of which is the development of ocean current energy generator and actual tow tests performed at sea (this part can be further divided into two categories: floating and floating platform), while the other concerns site selection and planning of an international test site of ocean current energy in the eastern waters of Taiwan. Present development results will be shown in the sections below followed by a description of subsequent plans.

Development of Floating Kuroshio Turbine

Floating Kuroshio Turbine are installed by mooring power generators to the sea bed using anchoring devices so they remain floating in the water. The ocean current then propels the generator blades to generate electricity. Internationally, this approach to power generation has been utilized in the Kuroshio power plant development plan supported by the New Energy and Industrial Technology Development Organization (NEDO) of Japan. Starting in 2011, the University of Tokyo, IHI, and Mitsui & Co., Ltd. established a three-party collaboration, completing actual field tests in the waters off of Kuchinoshima in August 2017. From 2018 until today, the organizations have been continuing to develop 500 kW units and performing long-term power generation tests. In Taiwan, following a three-year collaboration among the academic and research teams of National Taiwan University, National Taiwan Ocean University, and Taiwan Institute of Economic Research in conjunction with CSBC Corporation from 2015 to 2017, the project team unveiled to the public an "800 W Floating Kuroshio Turbine (FKT) Power Generation Model Unit Water Tank Towing Power Generation Set" in January 9, 2018 in the department building of National Taiwan University's Department of Engineering Science and Ocean Engineering [2]. In 2019, the Ocean Affairs Council supported the development of three key technologies for power generation, including completion of the design and manufacture of 10 kW (single generator set) direct-drive permanent-magnet synchronous generators, design analysis and manufacturing technology of FRP blades for ocean current power generation, and design and manufacturing technology of passive hydraulic compensation watertight shaft seals [2]. In 2020, in conjunction with National Taiwan University and National Taiwan Ocean University, the NAMR completed the planning, design and construction of the transmission, power post-processing and control systems as well as the integrated detailed design, processing and assembly of the 10 kW power generation turbine unit. The team also built a set of 10 kW power generation turbine units, and completed power generation test verification and watertight testing towing field tests off the shores of Anping from October 6 to 7 of the same year [3]. In 2021, the NAMR will proceed with the development of a 20 kW Floating Kuroshio Turbine while at the same time probing into key technologies for buoyancy engines that can control the floating and sinking of the unit, providing the unit with the ability to avoid harsh sea conditions when typhoons pass through by submerging and then return to the most suitable position for power generator when the storm leaves. The 20 kW Floating Kuroshio Turbine anchorage system and field tests are expected to be completed in 2022 in anticipation of gradually completing the development of units viable for commercial operations.

Development of Floating Platform Kuroshio Turbine

Floating platform Kuroshio Turbine are different from the abovementioned floating type in that the power generator are placed on a surface platform. Blades below the platform are propelled by the ocean current, driving the generator above to generate electricity. The generator is not submerged under water, therefore it does not need to feature a watertight design. This approach has been utilized in the R&D project for ocean current power generation initiated by Wanchi Steel Industrial Co., Ltd. in 2009. In 2014, the company furthermore established a collaboration with National Sun Yat-Sen University (NSYSU) to implement a National Energy Program funded by the Ministry of Science and Technology that entails conducting field tests at sea of ocean current power generation units. Towing tests performed in 2015 and mooring tests in 2016 showed that the minimum start-up flow rate of the ocean current energy generator set is just 0.45m/s while maximum power output is nearly 33 kW when the flow rate is 1.43m/s. From 2016 to 2019, a 400 kW ocean current power generation demonstration machine was installed on a phase-by-phase basis. In 2020, the NAMR cooperated with National Sun Yat-sen University and Wanchi Steel in conducting a power generation field test at sea for ocean current generating units with several hundred-kilowatt capacity off the coasts of Anping from March

24 to 25 of that year (Figure 1). During the test, the turbine experienced rotation due to the influence of side flow. To resolve the issues encountered during the test, unit design was modified at that time. Through analysis generated by ANSYS AQWA software, sweeping statistics on random wave spectrum response of the ocean current generator set during the towing process revealed that the ocean current generator produces a side wave with a wave height of 1.1 meters and a period of 5 seconds, resulting in overturning of the turbine unit due to resonance. Furthermore, actual observation data showed that when the turbine unit is overturned, the maximum wave period is 5.7 seconds with an average period of 4 seconds. These results indicate that the main causes of turbine unit rollover are due to not only the imbalance of pontoon water intake, but also the natural resonance frequency of the turbine unit. Relevant unit modifications are still being carried out, and field tests at sea will be conducted once again after modifications are completed to further understand power generation efficiency [4].

Figure 1/ Floating platform generator towing field test
Images by National Academy of Marine Research

Site selection and planning of ocean current test sites

Planning the optimal site for ocean current energy testing is also an important aspect. To this end, the NAMR and NSYSU team developed an unstructured grid model based on the SCHISM-WWM wave current model to calculate high-precision three-dimensional ocean currents and wave changes in eastern Taiwan. In addition to tidal conditions in Taiwan, HYCOM (Hybrid Coordinate Ocean Model) forecast results were added to incorporate the influence of ocean currents and eddies into this system to obtain more accurate current conditions in the sea area. ADCP deployment data from 2015, 2016, and 2019 were additionally used for calibration to obtain high-resolution ocean current simulation results that can be used as references for selecting the most suitable sea area. According to the 2019 OAC Executive Ocean Current Energy Key Technology Report [2], three suitable zones in the eastern seas of Taiwan were selected. In 2020, these three optimal sea areas were further reordered from north to south into Zone A, Zone B and Zone C. Based on the results of above-mentioned simulations, terrain-related test site anchoring stability and cable routing distance, relevant legal location and spatial distribution evaluations of the three optimal sea areas, Zone A was selected as the priority area for conducting ocean current energy field tests.

Zone A, as the highest priority test site of ocean current energy, was then further subdivided into smaller sections for conducting seafloor substrate quality surveys in this area. According to the survey results and comprehensive analysis of the collected sub-bottom profiler and multi-channel reflection seismic data, the topography of the site in Sections 1 and 2 is flat with thicker sediments, thus providing a greater variety of anchoring methods to choose from. However, as both sections are in proximity to Taitung Canyon, it should be noted that the continuous erosion and expansion of Taitung Canyon may cause geological hazards on the adjacent side. In Section 3, the seabed topography is slightly steeper than that in the other two sections, indicating that there is less sediment accumulation based on field observation. Gravity anchoring is therefore more suitable, but attention must be paid to the uncertainty

of the anchorage caused by the hilly terrain. Integrating the detailed evaluation results of the currents, topography and cable routing distance and slope of these three sections, and considering the current status of land acquisition in the sea area, all three sections 1, 2, and 3 of Zone A, the optimal sea area, are following evaluation and analysis included as alternative fields for conducting ocean current energy testing. The test sites located in the three sections listed can accommodate different testing needs. However, as the sea area land use permit for Section 3 has already been obtained, considering the difficulty of applying for land use in sea areas and Section 3's leading weighted score, the section remains the highest priority planned testing site [5].

Table 1/ Analysis and comparison of using submarine cable power transmission and hydrogen production platform to convert electrical energy [7]

Transportation plan	Liquid hydrogen (LH_2)	Lithium battery (Li-battery)	Submarine cable
Conversion efficiency	Conversion efficiency is low. The output of the generator needs to be converted and compressed into hydrogen energy using electricity, and then converted back to the required kinetic energy (electric energy or energy for driving tools) using hydrogen energy, resulting in higher loss due to multiple conversions.	Conversion efficiency is high. The output power of the generator only needs to be charged into the lithium battery through the power distribution system, and then transported back using a vehicle (some energy is lost), resulting in lower loss of energy.	Conversion efficiency is high. The output power of the generator only needs to be transmitted to the user through the transmission and distribution system, resulting in lower loss of energy.
Industry development	Taiwan already has a hydrogen production industry, but the sector has not yet reached maturity. As hydrogen production industries in other countries around the world are also not yet fully mature, government units should consider simultaneously developing the hydrogen production industry when promoting the green energy industry to redirect the orientation of domestic industrial development, which will be conducive to Taiwan's level of energy autonomy. The development of the hydrogen storage industry can also enhance the use of green energy.	Energy storage-related industries such as batteries are relatively mature, with manufacturers in each key link of the upstream, midstream, and downstream segments of the supply chain. Nevertheless, while the industry's overall structure is almost complete, we still lack access to certain key electronic components and materials. As such, the key issue at present is overcoming challenges in materials and process technology to improve energy storage density and life.	Taiwan has currently not yet established a complete submarine cable industry as other countries have; therefore, the assistance of foreign manufacturers will still be required in terms of both deployment and maintenance.
Environmental ecology	Since the hydrogen production platform floats upon the surface of the sea, it is more environmentally friendly. Under this premise, if the hydrogen production platform and self-propelled vehicle can utilize the hydrogen power produced by ocean current generators, lower conversion efficiency in energy use is acceptable as this approach can reduce carbon emissions in accordance with international green energy trends.	Due to the relatively limited number of recharge cycles of lithium batteries, not only is energy utilization efficiency low in the long run, heavy metal substances produced after the decomposition of the used lithium batteries will pollute the environment if the batteries are not properly processed and recycled.	The layout of submarine cables will affect submarine ecology, and cable maintenance will also slightly damage submarine ecology. The deployment of cables is therefore subject to government policies and regulations as well as environmental impact and underwater resources assessment, resulting in relatively longer construction periods.

Apart from the selection of the optimal ocean current energy test site, the NAMR has also conducted a preliminary assessment of the ocean current generator set maintenance base port. Following analysis of the environmental conditions, preliminary configuration and scoring benchmarks of various evaluation factors of main fishing ports located in southeastern Taiwan (Jialan [Fugang] Fishing Harbor, Hsin-kang Fishing Harbor, Ta-wu Fishing Harbor, Jinzun Fishing Port, Xinghai Fishing Port and Houbihu Fishing Port), Jialan (Fugang) Fishing Harbor has been preliminarily identified as the recommended site for establishing a base port [6]. After power has been generated in the test site, the issue of power transmission is another important aspect of ocean current energy. Results from a preliminary assessment of submarine cable power transmission, hydrogen production platform electric energy conversion and battery energy storage are as shown in Table 1 according to the three aspects of conversion efficiency, industrial development, and environmental ecology. Considering that it is relatively difficult to deploy cables in the test site currently selected due to extremely deep water depths, and the current conversion efficiency of offshore hydrogen production and energy storage remains relatively low, battery energy storage is recommended at this stage [7].

Conclusions

Power generation of ocean current energy is still in the development stage both in Taiwan and internationally. Although the Kuroshio Current is a stable source of marine energy in eastern Taiwan, the water depth is relatively deep. Therefore, to develop power generator suited to this environment, challenges such as deep-sea anchors, dynamic cables, typhoon avoidance methods as well as antifouling and anticorrosion must still be overcome. Meanwhile, the project has formulated ocean current power generator testing procedures and operating methods referencing existing international regulations. Plans for facilities required at relevant test sites have also been made to facilitate the establishment of ocean current energy test sites with international credibility so that overseas manufacturers may select Taiwan as the test site for their prototypes, thus accelerating the development of Taiwan's ocean current energy industry.

References

[1] 黃聖凱（2015），海洋能源－潮流發電之探討，台船月刊，466，專題報導 https://www.csbcnet.com.tw/monthly_pub/466.html
[2] 國立中山大學（2019），洋流能關鍵技術開發與推動專業服務委託案（案號：OAC108001）成果報告書，海洋委員會委託計畫。
[3] 國立臺灣大學（2020），浮游式洋流發電機製作與實海測試專業服務委託案（案號：NAMR109008）成果報告書，國家海洋研究院委託計畫。
[4] 國立中山大學（2020），數百KW級洋流發電機組實海發電測試專業服務委託案（案號：NAMR109032）成果報告書，國家海洋研究院委託計畫。
[5] 國立中山大學（2020），臺灣洋流能海域測試場規劃評估專業服務委託案（案號：NAMR109009）成果報告書，國家海洋研究院委託計畫。
[6] 國立中山大學（2020），洋流發電配套方案與基地港規劃專業服務委託案（案號：NAMR109022）成果報告書，國家海洋研究院委託計畫。
[7] 國立臺灣大學（2020），洋流發電機自走式載具與避離方案研擬專業服務委託案（案號：NAMR109007）成果報告書，國家海洋研究院委託計畫。

The Strategic Significance of German Frigate's Navigation in the South China Sea

Ting-Hui Lin (Member of the Oceanic Affairs Council, Deputy Secretary-General of the Taiwan Society of International Law)
Translated by Linguitronics
Keywords: Germany, South China Sea, free navigation, Indo-Pacific strategy

In November 2020, German Defense Minister Annegret Kramp-Karrenbauer openly stated that the German Federal Army will be strengthening its presence in the Indo-Pacific region [1]. The following March, quoting the words of high-level German government officials, international media disclosed that a German frigate will be setting off for Asia in August and passing through the South China Sea on its return journey. If the German federal government's plans remain unchanged, this frigate will become Germany's first warship to cross the South China Sea since 2002 [2]. In response, the Ministry of Foreign Affairs of the People's Republic of China expressed its stance that "all countries enjoy the freedom of navigation and overflight provided by international law in the South China Sea, but this cannot be used as an excuse to endanger the sovereignty and security of coastal states." Meanwhile, the United States, which has been continuing to implement its free of navigation operations (FONOPs, a concept that differs from the free navigation undertaken by Germany) in the South China Sea, immediately released a State Department statement indicating "We welcome Germany's support for a rules-based international order in the Indo-Pacific [3]."

Figure 1/ The F222, a German frigate of the same model as the vessel that may navigate in the South China Sea
Source/ German Ministry of Defense website

Germany is a European country that has, over the years, been the center of attention for other countries due to its role in the two world wars, particularly in terms of its the post-war activities abroad. Military activities, moreover, are often interpreted as possible preludes to overseas military expansion. As such, German government administrations that have come into power these past few decades have been careful to not extend their political influence to regions outside Europe, especially military-wise, so as to avoid arousing doubts in the international community.

However, as the international political climate continues to change, China's rise in terms of political, military and economic power has become a threat to the international system led by the United States, and Germany is now unable to remain aloof. Even though bilateral trade between Germany and China reached nearly US$190 billion in 2019 with Germany enjoying a trade surplus as high as US$25.3 billion, Germany has persisted in defending the fundamental value of human rights despite benefiting greatly from China's economic and trade achievements.

Germany's Indo-Pacific policy: The importance of freedom and openness

The German Ministry of Foreign Affairs issued the "Policy Guidelines for the Indo-Pacific" [4] in September 2020, clearly stating Germany's eight interests in the Indo-Pacific region, proposing to implement the 7 principles of the policy in the Indo-Pacific region, and finally summarizing the 7 initiatives to be made in the future. The eight interests that Germany has in the Indo-Pacific region include:

I. Peace and security: With multiple countries owning nuclear weapons in the Indo-Pacific region, including China, India, Pakistan, Democratic People's Republic of Korea, the United States and other countries and even the United Kingdom and France, which have overseas territories, the degree of hostility between powers in the geopolitics of the region greatly affects global stability.
II. Diversifying and deepening relations: Germany aims to expand its relations with the Indo-Pacific countries from economic, trade and investment development to the political field.
III. Neither unipolar nor bipolar: Since the structure of any hegemony or bipolar system could lead to countries being forced to choose sides, just as they were during the Cold War, it is therefore even more important for the Indo-Pacific countries to be able to choose freely.
IV. Open shipping routes: This is of interest as more than 90% of global trade is by sea, and a quarter of the goods must cross the Strait of Malacca. With more than 2,000 ships traveling between the Indian Ocean and the South China Sea a day, disruption of these maritime trade routes will affect the prosperity of Europe.
V. Open markets and free trade: Millions of job opportunities in Germany are closely related to trade in the Indo-Pacific region, and Germany's Federal Government firmly believes that rules-based free trade enhances prosperity on both sides.
VI. Digital transformation and connectivity: Germany must consider technology, security policies, and economic and social risks when working with Indo-Pacific countries.
VII. Protecting our planet: Germany is interested in ensuring that the growth of the Indo-Pacific region is environmentally friendly and natural resources are sustainably managed for future generations.
VIII. Access to fact-based information: This highlights the increasing importance of social media, pointing to the fact that while information communication has become an effective foreign policy tool in the Indo-Pacific region, the spread of misinformation must be forcefully combated.

For these reasons, Germany proposes the following principles as a prerequisite to further promoting cooperation with the Indo-Pacific region. The first is European action, meaning that, as the EU is a whole, Germany's Indo-Pacific policy is also consistent with the EU's strategy. Secondly, Germany adopts multilateralism, especially in terms of a multilateral cooperation framework with ASEAN countries in the areas of climate change, environmental protection, disarmament, arms control, nuclear non-proliferation, and protection of human rights. The third and fourth principles are "the rules-based order" and achieving the "United Nations Development Goals", while the fifth states that economic development and respect for human rights are not mutually exclusive but are complementary goals requiring a holistic approach, and the sixth calls for inclusivity as Germany supports inclusive regional cooperation initiatives and does not consider containment and decoupling strategies to be conducive. As such, the ASEAN-centric security architecture offers a valuable framework for involving key actors. Lastly, the seventh principle calls for "a partnership among equals."

Military partnership and maritime power display

As for why Germany has shifted its focus to the Indo-Pacific region, German Defence Minister Kramp-Karrenbauer mentioned in a video conference with Singapore's Minister of Defence Ng Eng Hen that the global political and economic center has shifted from the transatlantic region to the Indo-Pacific region; consequently, the region will have a major impact on future international order. As the smooth flow of the Indo-Pacific sea lanes is vital to Germany's trade with the European Union, this is the reason why Germany intends to expand its military presence in the Indo-Pacific region--because the move is conducive to Germany's own interests. On the other hand, the 218SG diesel-electric submarine built by ThyssenKrupp, a German shipbuilding company, for the Singapore Navy was launched on August 31, 2020 for trial sailing. Among the four submarines ordered by Singapore (including the "Invincible," "Impeccable," "Illustrious," and "Inimitable,") this is the first submarine to be tested in waters. Although all the vessels are traditional diesel-electric submarines, they will become the most advanced submarines in East Asia in terms of design and equipment. Meanwhile, the Singapore Army has also purchased several German-made Leopard 2A4 main battle tanks. Furthermore, to combat network security issues arising from information war sparked by foreign counterparts, Germany established the "German Information Centre" in Singapore while also cooperating with Singapore's Ministry of Defence on cyber security. Based on all of the above, Singapore's Changi Base will naturally become a German warship supply base when German warships enter the Indo-Pacific region in the future.

Figure 2/ Singapore's German-made submarine
Source/ Singapore Ministry of Defence website

Apart from Singapore, Japan has also become an important military partner of Germany as it seeks cooperation in the Indo-Pacific region. In particular, the two countries signed the Agreement Between the Government of Japan and the Government of the Federal Republic of Germany on the Security of Information in Tokyo on March 22, 2021, facilitating the sharing of relevant information between the two parties and enabling them to conduct equipment export and joint training to promote cooperation in the Indo-Pacific region. Since Germany has security interests in the Indo-Pacific region, in order to demonstrate Germany's military presence in the region, the country also plans in the future to deploy German warships to regional seas, participate in regional military exercises and visit naval ports [5], including those of Japan.

Moreover, as Germany is a member of the European Union and must act consistently with the EU's "Common Foreign Security Policy" (CFSP), Germany's military operations must also take into account the integrity of the "North Atlantic Treaty Organization" (NATO). Therefore, Minister Kramp-Karrenbauer stated that the military partnership between Germany and the Indo-Pacific countries will be promoted under the framework of NATO, which shows that the free navigation of German warships in the South China Sea is viable from the perspectives of the European Union and NATO. For instance,

on April 19, 2021, the Council of the EU approved conclusions on an EU strategy for cooperation in the Indo-Pacific, stating that according to international law—particularly the 1982 UN Convention on the Law of Sea, it supports monitoring of maritime security and freedom of navigation by the navies of various nations. Meanwhile, the NATO upholds maintaining free navigation in the Arctic Sea, designating the US, UK, Norway and Denmark to engage in joint operations to maintain freedom of navigation in the Barents Sea, and is also committed to ensuring similar rights are exercised in the South China Sea without foreign intervention.

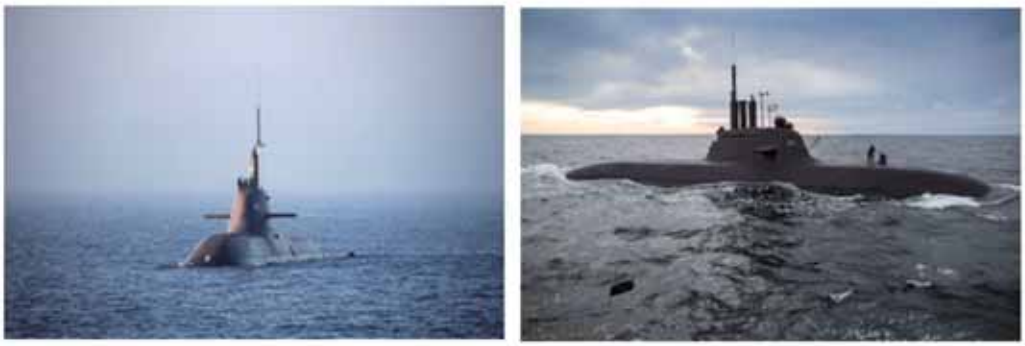

Figure 3/ German submarine
Source/ German Ministry of Defense website

The purpose of free navigation by German warships in the South China Sea

Over the past three centuries, the economies of European countries have been closely intertwined with those of Indo-Pacific nations, and Indo-Pacific's position in the global industrial supply chain cannot be underestimated as this also the main basis for the economic prosperity of all countries. For Germany, ensuring the safety of trade routes in either the Indian Ocean or the South China Sea is beneficial to European countries. However, due to political and military factors, countries in the Indo-Pacific regions are facing a growing series of hostilities caused by territorial disputes causing it to be difficult to find a common basis for territorial sovereignty and integrity under current circumstances. For Germany, nonetheless, a global order based on laws and regulations is of utmost importance; under this premise, therefore, multilateralism must be taken into consideration. Although countries may uphold different ideas and policies, as long as they remain in interaction with each other, over the course of time new ideas will emerge, contributing to reaching a shared action. As such, Germany supports the peaceful and fair settlement of disputes and conflicts provided by international laws and the United Nations Convention on the Law of the Sea.

Since Germany has no territorial disputes in the South China Sea and due to geographical considerations, Germany pays far less attention to Indo-Pacific affairs and South China Sea issues than European affairs. Under the framework of the seven major industrial countries (G7), although Germany supports the Japanese proposal, it places an even greater emphasis on the peaceful resolution of disputes and the importance of free, barrier-free and legal use of the ocean. In April 2016, at a meeting attended by foreign ministers of the world's seven major industrial nations, the Statement on Maritime Security was adopted as led by Japan. The statement recognizes that "free, open and stable seas are a cornerstone for peace, stability and prosperity of the international community," and reaffirms that international law must be utilized to maintain the right and freedom of barrier-free navigation in economic seas. Germany's motivation for making active proposals on maritime issues is however far lower than that of the United States and Japan. This is in contrast to the German military power that

used a powerful army as the main axis in the past to expand its maritime power and overshadow countries all over the world with fear. Before WWI erupted, for instance, Germany formulated Plan Z and caused the parliament to pass related bills for expanding the navy, while Kaiser Wilhelm II's "Weltpolitik" (world policy) became the basis for launching a war of aggression. Germany, after experiencing the devastation of two world wars, is now thus unwilling to arouse the speculation of other countries, appearing extra cautious in terms of foreign affairs, especially the presence of its military strength in other sea areas of the world.

Conclusion

Germany has stated that during free navigation in the South China Sea, it will not enter the territorial waters of the inner islands and reefs of the South China Sea. Therefore, the most likely route for German warships will be on busy trade routes, and the focus will be on demonstrating the ability to maintain the smooth flow of free trade routes. The main purpose of Germany's participation in free navigation is not only to exhibit the importance it attaches to the Indo-Pacific region, but also to realize the active diplomatic approach of "helping others and helping oneself." In the future, after the United Kingdom follows through with Brexit, countries that will dominate the EU's foreign and security policies will be mostly European powers such as France, Germany, and Italy. Although France already dispatched Ruby-class nuclear submarine "Emeraude" and the submarine support ship "Seine" to the South China Sea in February 2021 to exercise the right of freedom of navigation, France's stance on this matter appears to be more obscure compared with Germany's attitude and position. In order to show consistency with France in its foreign and security policies and highlight the EU's common foreign stance, what Germany seeks to make clear in terms of the South China Sea issue is the value proposition of the right of freedom of navigation. As such, in terms of the fundamental value of abiding by international law, the law of the sea and international rules, Germany stands with France.

What is worth observing in the follow-up is that China's response and counterattack to Germany's entry into the South China Sea will affect Germany's subsequent actions. Although EU countries are obligated to face the rise of emerging markets in the Indo-Pacific region, EU countries have over the long term maintained the mentality of being colonial home countries to nations in the Indo-Pacific region. Due to historical factors, however, Germany's actions are relatively constrained in the Indo-Pacific waters, and the extent to its activities will not surpass those of France and the United Kingdom. As a member of G7, the European Union and NATO, nonetheless, Germany's stance must be consistent with that of other member states in order to maintain a place in the multilateral system. As for whether Germany's freedom of navigation represents support of the United States' policies and forms a part of the Indo-Pacific strategic framework led by the United States, the European Union, led by Germany and France, still adopts diplomatic autonomy. Although consistent with the United States in terms of values such as human rights and international norms, and although equally dissatisfied with China's practices violating international norms, it is still too early to tell whether joining the ranks of free navigation signifies an alliance with the United States in the Indo-Pacific region.

References

[1] Bundeswehr to Strengthen its Presence in the Indo-Pacific Region (Nov. 16, 2020), Federal Ministry of Defence https://www.bmvg.de/en/news/bundeswehr-presence-indo-pacific-region-5012320 (Mar. 27, 2021)
[2] 中央社（2021年3月3日），〈德國官員：將派巡防艦行經南海 2002年以來首次〉 https://www.cna.com.tw/news/firstnews/202103030008.aspx
[3] U.S. Calls German Warship's Plan to Sail South China Sea Support for Rules-based Order (Mar. 4, 2021), Reuters https://www.reuters.com/article/us-southchinasea-germany-usa-idUSKCN2AW016 (Apr. 13, 2021)
[4] Policy Guidelines for the Indo-Pacific Region (September 2021), The Federal Government https://rangun.diplo.de/blob/2380824/a27b62057f2d2675ce2bbfc5be01099a/policy-guidelines-summary-data.pdf (Mar. 28, 2021)
[5] Germany Intends to Strengthen Security Cooperation with Japan (Dec. 15, 2020), Federal Ministry of Defence https://www.bmvg.de/en/news/germany-intends-to-strengthen-security-cooperation-with-japan-4918446. (Mar. 28, 2021)

Marine Spatial Planning in Germany

German Institute Taipei

Keywords: Marine Spatial Planning, EEZ, UNCLOS, BSH

The sea is often regarded as a predominantly free and untouched space. However, the economic zone adjacent to the coastal sea and the coastal sea itself are under a growing pressure to be used. In addition to the traditional usage of shipping and fishing, new interests have emerged during the past decades, e.g. sand and gravel mining, gas extraction, laying of pipelines and cables, research purposes and military exercises as well as the rapidly increasing offshore wind energy. These different economic interests are not only colluding with each other but also threatening the marine environment.

The United Nations Educational, Scientific and Culture Organization (UNESCO) definition for Marine Spatial Planning (MSP) is as follows: MSP is a public process of analysis and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that are usually specified through a political process.

Germany's marine spatial planning

In order to settle the growing conflict of business, science and environment, Germany has introduced an official marine spatial planning for exclusive economic zone (EEZ) in the North and Baltic Sea region. It serves as a planning tool to coordinate utilization interests and protection claims. It aims to record all human activities on the sea, resolve existing conflicts of utilization and to prevent future problems. Furthermore, it establishes protection zones for the marine environment. Last but not least, the marine spatial planning helps implementing political aims like Germany's renewable energy policy as well as the national energy transition.

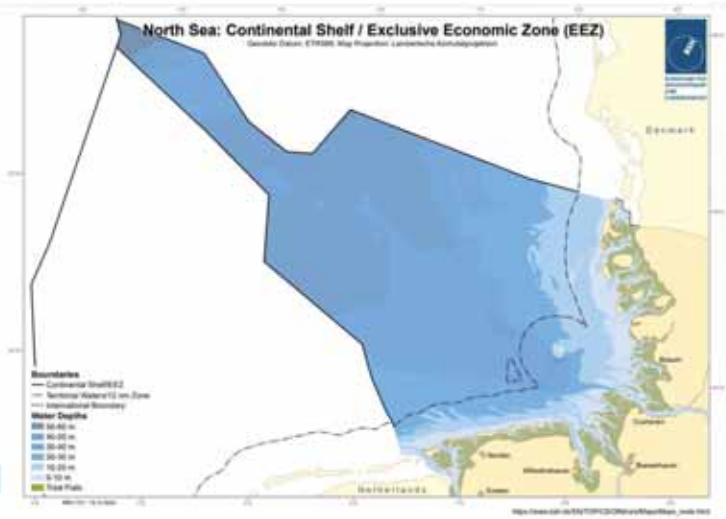

Figure 1/ North Sea: Continental Shelf / EEZ
Source/ BSH
https://www.bsh.de/EN/TOPICS/Offshore/Maps/_Anlagen/Downloads/NorthSea_ContinentalShelf_EEZ.pdf?__blob=publicationFile&v=5

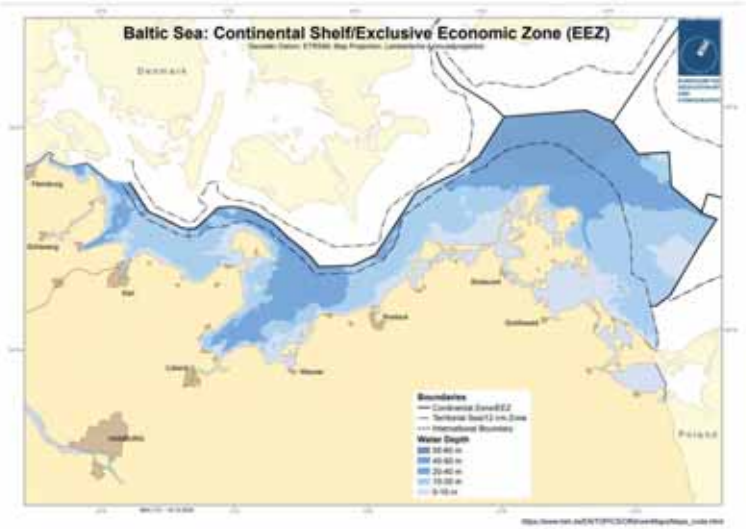

Figure 2/ Baltic Sea: Continental Shelf / EEZ
Source/ BSH
https://www.bsh.de/EN/TOPICS/Offshore/Maps/_Anlagen/Downloads/BalticSea_ContinentalShelf_EEZ.pdf?__blob=publicationFile&v=4

The spatial plans establish binding rules for the usage and development of the EEZ. As the EEZ is not part of the sovereign territory of the Federal Republic of Germany, the United Nations Convention on the Law of the Sea (UNCLOS) must be respected, including freedom of navigation and overflight as well as freedom to lay submarine cables and pipelines. The German marine spatial planning is therefore considered a "restricted spatial planning".

Marine spatial planning in the German EEZ is
- regulating the economic and scientific use
- ensuring safety and ease of shipping
- protecting the marine environment.

The spatial plans were drawn up by the Federal Maritime and Hydrographic Agency (BSH). In the first stage, an inventory of existing usage claims has been created. For this purpose, the BSH asked local authorities to list activities and utilizations currently taking place in the EEZ. Based on these findings, BSH did write a first draft which has been revised after discussions with stakeholders. On 26th September 2009 (EEZ in the North Sea) and on 19th December 2009 (EEZ in the Baltic Sea), the marine spatial planning came into force.

Germany's marine spatial planning comprises aims and principles for shipping, offshore wind energy, raw material extraction, pipelines and submarine cables, marine research, fisheries and the marine environment. The plan defines priority areas for shipping, wind energy, pipelines and submarine cables as well as marine research. Priority areas give particular importance to one function in case it is competing with another utilization purpose. Priority shipping areas are the foundation of Germany's marine spatial planning. These designated areas are off-limits for incompatible usage such as offshore wind which has its own priority areas. However, in order to achieve Germany's target to produce 25 gigawatts from offshore wind energy by 2030, it is permissible to construct offshore wind parks also outside their designated areas.

Since the publication of the first marine spatial plan, offshore wind projects in Germany have multiplied. In 2009, the "alpha ventus" test field was the first offshore wind farm under construction in the German EEZ. Today, there are 20 offshore wind farms in the North and Baltic Sea with a total of 1,167 wind turbines in operation –delivering an output of about 5.3 gigawatts. Four more wind farms are currently under construction (as of April 2018). In 2017, offshore wind farms were producing 17.4 terawatt hours (TWh) of electricity. Taking the electricity consumption of 12.1 TWh in Hamburg (2017) as a benchmark, offshore wind energy can approximately cover the electricity needs of one to two bigger cities in Germany.

Figure 3/ Marine spatial planning for the German exclusive economic zone (EEZ) (Raumordnungspläne für die deutsche AWZ)
Source/ BSH
https://www.bsh.de/EN/TOPICS/Offshore/Maritime_spatial_planning/maritime_spatial_planning_node.html

European marine spatial planning

In addition to Germany's national marine spatial planning, there are EU guidelines on marine spatial planning. They oblige all EU coastal nations to draw up marine spatial plans by 2021. The member states must ensure to coordinate national plans and consider cross-border issues. The individual spatial plans are intended to support the European strategy of "Blue Growth" through sustainable development of the marine and coastal economy/resources. It is in line with EU legislation on climate protection and expansion of renewable energies upholding a balanced marine environment while completing a European transport network, i.e. shipping routes.

In the North Sea region, all of Germany's neighboring countries besides Denmark have already drawn up and implemented their marine spatial plans.

In the Baltic Sea region, apart from Germany, only Lithuania has introduced a marine spatial plan. The other countries are at different stages of planning.

Due to the lack of EU competence for a standardized European spatial plan, the individual EU member states have to arrange themselves to achieve a cross-border marine spatial planning. The Baltic Marine Environment Protection Commission HELCOM and the Oslo-Paris Convention OSPAR are two intergovernmental bodies to pursue aims for the entire Baltic and North Sea. HELCOM intends to further expand cross-sectoral cooperation in the areas of maritime transport, marine spatial planning and integrated coastal zone management. In the North Sea, OSPAR is currently leading international cooperation for marine environmental protection in the North-East Atlantic.

When the "Bundesamt für Seeschifffahrt und Hydrographie" (BSH) was drawing up spatial planning in 2008, it conferred with Germany's immediate neighbors, the Netherlands, Denmark, Sweden and Poland. BSH presented the first draft of Germany's marine spatial plan to them and gave them the opportunity to submit comments and suggestions. In addition to these international consultations on marine spatial planning in the North and Baltic Seas, the BSH has been a partner in Inter-European projects on marine spatial planning since 2009 with a focus on energy, shipping and environmental protection.

In conclusion, marine spatial planning led to important new findings especially for the construction of offshore wind farms and cable laying. Long-term spatial plans are now being drawn for the sectors of energy, fishing and nature conservation. Future spatial planning will be based on the creation of new national and international legal frameworks, the ongoing cooperation between European neighbors, and a broad data base created in the last 15 years.

This article is provided by Bundesamt für Seeschifffahrt und Hydrographie (BSH) and summarized and translated by German Institute Taipei.

Germany's Marine Related Agencies and Maritime Policy

Yi-Kai Chen (Associate Professor, Department of Law, National Cheng Kung University)
Translated by Linguitronics
Keywords: marine agency, German maritime policy

An effective marine policy requires an effective institutional structure. In Germany, however, duties and responsibilities are segregated in terms of both the formulation and implementation of laws and regulations due to a political system structure that is subject to hierarchical responsibility; specifically, in Germany, each of the fields involved in maritime policy are under the jurisdiction of different agencies. As such, Germany lacks a common political authority overseeing the protection and use of marine resources and living space in the Federation and the states. In conjunction with the European Union's adoption of the Integrated Maritime Policy, nevertheless, Germany has also introduced such an integrated policy [1], as illustrated in the following content on the "integrated maritime policy of Germany's exclusive economic zone and territorial sea" [2].

The administrative structure and jurisdiction of the German state organization

I. Germany is a federal state organization [3]

According to Article 20, Item 1 of "the Basic Law for the Federal Republic of Germany", Germany is a federal state. It can be derived from this federal state principle that, in Germany, authority, administrative structure and organizational structure are respectively assigned to the federation and the states. The highest organs of the Confederation are the Federal Parliament, the Federal Council, the Federal President, the Federal Constitutional Court, and the Federal Government. Furthermore, the people are entitled to representatives elected at the state level. These are the state parliaments of the 16 German states responsible for stipulating state laws and electing the states' minister presidents [3].

II. Legislative jurisdiction: Federal exclusive rights, co-opetition rights, framework legislative rights

In accordance with the organization of the federal state, legislative power is placed in each state in principle (Article 70, Item 1 of "the Basic Law"). On the other hand, the Federation has legislative powers in the following areas, and based on the necessity of unified regulations it enjoys exclusive legislative powers (Articles 71 and 73 of "the Basic Law") (powers exclusive to the federation), co-opetitive legislative powers (Articles 72 and 74 of "the Basic Law") (authority shared concurrently between the Federation and the states), and the framework legislative power (Article 75 of "the Basic Law") (The Federation only makes principled legislation, leaving it to the states to make supplementary legislation) [3].

III. Legislative jurisdiction in areas related to German maritime policy

The fields related to integrated marine policy include exclusive rights, co-opetition rights, and federal framework legislative powers; some areas of marine policy also fall under federal exclusive jurisdiction. National defense, air traffic, and federal rail traffic are exclusively federal legislative powers [1]. Meanwhile, "economic law" (including mining, industry, energy) and "agricultural law", "high seas fishing law", "offshore fishing law", "coastal protection law", "seabed law", "ship navigation law", "inland

river navigation law", "inland waterways law", "the Road Traffic Law" and "the Circular Economy Act" are all federal co-opetitive legislative powers [1]. Seaports and river ports are the exclusive legislative authority of each state. Cultural heritage and certain tourism matters are the exclusive right of each state. Areas that fall under federal framework legislation are: nature conservation, spatial order, and water supply protection.

IV. Executive jurisdiction of the German Federation and the states

In Germany, the implementation of administrative tasks belongs to each state in principle. Who enforces federal laws? Authority is divided into three types: implementation by the federation itself, federal law executed by the state as its own affairs, and federal law executed by the states as entrusted by the federation [3]. The enforcement of federal laws is mostly done by states. Accordingly, the powers of state administrations are categorized into enforcement of state laws, enforcement of federal laws, and federal entrusted administration. State administrations' power to execute federal laws in their own right is derived from Article 83 of "the Basic Law", and it is a principle case (principle situation), because unless the German constitution expressly stipulates that the federal government executes federal laws itself or the federal government entrusts such execution to the state administration, all federal laws are executed by the states; this is known as executing federal laws in their own right [3]. When such a state executes federal laws in its own right (the state implements federal laws), the state does not have to comply with the instructions of the federal government. The federal government can only supervise the legality of administrative actions within the framework of legal supervision. On the contrary, if the administration is entrusted by the federal government, all states must be subject to federal legal and professional supervision. Such fields are regulated in "the Basic Law" (fields of federally entrusted administration), including administration involving national road management [1].

V. Enforcement jurisdiction in areas related to Germany' maritime agenda

The implementation of areas related to the integrated maritime policy is assigned to the various types of administrative implementation mentioned above. The areas that belong to federal law executed by the federation itself concern administrative tasks for national defense, air traffic, federal rail traffic, navigation and waterways. Affairs executed by the states on federal commission include federal highway administration (states are entrusted by the federation to manage such highways). Other administrative execution tasks belong to the jurisdiction of each state, and each state executes federal laws in its own right or based on the execution of state laws. In particular, it should be pointed out that the special execution of administrative tasks in the exclusive economic zone is mainly assigned to federal administration. On the contrary, the administration of mining rights in the field of continental reefs is undertaken by the state mining bureaus of each state, which perform administration based on mining laws and regulations [1].

Administrative structure and jurisdiction in the coastal areas

Federal agencies: Marine affairs is divided based on the responsibilities of each department, and powers of execution are especially assigned to the "Federal Foreign Office," "Federal Ministry of the Interior," "Federal Ministry of Finance," "Federal Ministry of Economics and Technology," "Federal Ministry of Food and Agriculture," "Federal Ministry of Defense," "Federal Ministry of Transport, Building and Urban Development," "Federal Ministry of Environment, Nature Conservation, and Nuclear Safety", and "Federal Ministry of Education and Research." The federal government agencies and agencies responsible for maritime affairs include: "Federal Executive Administration," "Federal Coast Guard,"

"Federal Research Centre for Fisheries," "Federal Institute for Risk Assessment, Institute of Sea Fisheries under the Federal Office of Agriculture and Food," "Federal Institute of Hydrology," "Federal Maritime and Hydrographic Agency," "Federal Waterways and Shipping Administration," "Federal Agency for Nature Conservation," "Federal Office for Radiation Protection," and "Federal Environment Agency." The state ministries and government offices on the coasts close to the sea are responsible for various administrative tasks in the coastal waters. It should be emphasized that the state local government offices in charge of mining, energy, and geology located in Clausthal-Zellerfeld (in Niedersachsen) and Stralsund (in Mecklenburg-Vorpommern) are responsible for enforcing the Federal Mining Act on continental reefs [1].

The characteristics of decision-making for the maritime policy by the German federal government

Due to the lack of a dedicated agency for overall planning of maritime policy decisions in Germany, government units often act on their own, resulting in conflicts of mutual interests. For example, the position of coordinator created by the federal government is placed in the Ministry of Economic Affairs at the rank of Deputy Chief Executive (Staatssekretär), with jurisdiction covering only the marine economy [4]. In order to realize the EU Marine Directive, the "Federal Ministry of the Environment, Nature Conservation and Nuclear Safety" is not subject to the fishery policy represented by the "Federal Ministry of Food and Agriculture", and is also independent of the "navigation policy" enforced by the "Federal Ministry for Economic Affairs and Energy" for the purposes of policy implementation [4]. Even at the domestic level, the "Federal Ministry of Food and Agriculture" has also blocked the intervention of the "Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety" in introducing regulations on the management of domestic marine protection, and firmly adheres to its own stances in terms of fisheries policies. The formulation of provisions of environmental protection rules was only advanced after several natural conservation organizations jointly complained [4]. Regarding deep-sea mining, offshore wind power, and other localized areas, all agencies act independently of each other in a similar manner. Various disagreements and inconsistencies arise from the major disagreements between the federal government's international maritime policy and domestic practices. Not only does Germany lack a balanced management plan for marine protected areas throughout the year, but is also unable to manage or control affiliated industries and recreational fisheries [4]. The import of fish and marine food may come from illegal sources, the production of plastic waste and other harmful substances, the excessive profitability of agriculture and transportation, the reduction of the social welfare system at sea, and many other aspects have highlighted the downfalls of this lack of administrative coherence [4].

An integrated maritime policy in Germany's exclusive economic zone and territorial waters

I. Integrated ocean policy

Germany's administrative structure and political structure exhibit the characteristics of very strong departmental differentiation. Germany's administrative structure and political structure are characterized by a very strong departmental differentiation. The goal pursued by each professional policy is mainly to optimize the professional purpose of a single subject. Germany needs a maritime policy with an integrated entry point, and the policy must be adopted at both the federal and state levels with each professional policy strongly taking into consideration spatial perspectives and

interaction with other professional policies [2]. Through discussions under the framework of an integrated ocean policy, all parties concerned gain an understanding of the importance of the ocean to the environment and economy of Europe and Germany, ultimately solidifying and reinforcing the ocean perspective. Particularly in the regional development of economic areas (such as Northern Germany) and the strong maritime research conducted by the North German coastal states, the integrated maritime policy drives participation by consolidating various professional policies into one unified maritime policy. From a macro perspective, an integrated ocean policy involves participation. This kind of participatory approach strengthens democratic thinking, including policy implementation [2].

II. Ocean development plan [5]

The strategic framework, purpose and focus of the German maritime policy is placed the maritime development plan. This is an integrated German maritime policy strategy, and this kind of development plan has existed since 2011 [5], constituting a political platform that includes state and non-state maritime actors in the decision-making process. The work structure and decision structure are as follows: Resource discussions, inter-agency working groups and maritime-related groups are networked and connected to the political aspects of Germany. Under this framework, coordination and control are carried out through the maritime development plan. In addition, dialogues on integrated ocean policies are carried out on an ongoing basis with various groups and organizations.

Hamburg Hafen, Germany
Image by Pride Advertising Agency Ltd.

The main purpose of the development plan is to pursue the following objectives:

- Strengthen the competitiveness of the German maritime economy and benefit the potential for employment.
- The North Sea and the Baltic Sea must reach good environmental conditions before 2020 AD, making them the cleanest and safest of oceans.
- Germany assumes joint responsibility for global ecological development and actively supports the fight against environmental changes [2].

III. Important cornerstones of Germany's integrated maritime policy: Marine spatial order

An important cornerstone of Germany's integrated maritime policy, especially considering the perspective of space, is marine spatial order. The introduction of marine spatial order has a significant impact on the use of the exclusive economic zones in the North Sea and the Baltic Sea in Germany. In particular, whether wind power parks, main navigation channels, and submarine cable pipeline routes is entitled priority for use of the sea surface is a topic of discussion. This marks the first time that all marine uses in the North Sea and the Baltic Sea are comprehensively observed, endowing use of the sea in the exclusive economic zone with a new level of transparency [2].

Marine spatial order in the exclusive economic zone of Germany reinforces the importance of ensuring reversibility of use of the sea area (i.e. intervention on the sea surface can be restored to its original state again). In this sense, the interests of the environment, navigation, and wind energy are coordinated and conflicts are resolved. Under the framework of establishing marine spatial order in the exclusive economic waters of the North Sea and the Baltic Sea, especially with regard to the conflicts between various actors, the conflicts between the promotion of wind energy and the traditional use of navigation within the context of the nation's climate policy are resolved by giving wind power priority use of the sea surface and determining main waterways [2].

In addition to measures at the federal level, Germany's integrated maritime policy is also implemented at the level of the maritime states in northern Germany, including: Bremen, Hamburg, Niedersachsen, Mecklenburg-Vorpommern, and Schleswig-Holstein. The integrated maritime policy is manifested by the maritime states of Germany, especially through the integration of maritime-related professional fields, and through the integration of land-related and ocean-related projects [2].

References

[1] Stefan Lütkes/Heike Holzfuß/ Wulf Hülsmann/ Thomas Bosecke (Redaktion), Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Hrsg.), Integriertes Küstenzonenmanagement in Deutschland, Nationale Strategie für ein integriertes Küstenzonenmanagement (Bestandsaufnahme, Stand 2006) , 2006.
[2] Bundesinstitut für Verkehr und digitale Infrastruktur (Hrsg.), Nutzen der Berücksichtigung räumlicher Belange in Fachpolitiken am Beispiel der integrierten Meerespolitik, MORO Forschung 2/2015.
[3] Peter Badura, Staatsrecht, 7. Aufl., 2018.
[4] Kai Kaschinski, Besser spät als nie, Transparenz, Partizipation und Kohäreny als Schlüsselaspekte einer internationalen Meerespolitik, in: Forum Umwelt und Entwicklung/ VENRO/ terre des hommes Deutschland/ Global Policy Forum/ Open Knowledge Foundation Deutschland (Hrsg.), Deutschland und die UN-Nachhaltigkeitsagenda, Noch lange nicht nachhaltig, 2016.
[5] Bundesministerium für Wirtschaft und Energie (Hrsg.), Maritime Agenda 2025, Für die Zukunft des maritimen Wirtschaftsstandortes Deutschland, 2017.

Germany Executive Agency for Marine Research - GEOMAR Helmholtz Centre for Ocean Research Kiel

Compiled by Jia-Lin Chen (Assistant Professor, Department of Hydraulic & Ocean Engineering, National Cheng Kung University), Shun-Yan Hsu, Ching-Yuan Liao, Sheng-De Tsai, Wen-Hsin Huang, Cheng-Chien Hou (Master Degree Students, Department of Hydraulic & Ocean Engineering, National Cheng Kung University)
Translated by Linguitronics
Keywords: Germany, GEOMAR Helmholtz Centre for Ocean Research Kiel, plate tectonics, sediment

Germany is located at the center of the European continent and is defined as part of Western or Central Europe in terms of regional classification, bordering Denmark to the north, Poland and the Czech Republic to the east, Austria to the southeast, Switzerland to the southwest, France, Luxembourg and Belgium to the west, and the Netherlands to the northwest. Most of its territory lies between 47 and 55 degrees north latitude and 5 to 16 degrees east longitude. Germany borders the North Sea to the north and the Baltic Sea to the north-northeast. The total length of the nation's coastline is 2,389 kilometers, which is about 1.5 times that of Taiwan. Most of the German coastline is however concentrated in the northern states of Schleswig-Holstein, Niedersachsen and Mecklenburg-Vorpommern, the only three states with coastlines within the entire country. Although most of Germany's industrial zones, large cities and major developed economic belts are located inland, the German coast has the world's largest installed capacity of ocean wind power; meanwhile, the unit output value of Germany's marine tourism industry ranks among the top European countries [1]. German citizens are known for their love of nature. The nation has an extremely high urban greening rate, and is also a major renewable energy country in Europe and a model for sustainable economic development that places great emphasis on environmental protection and natural ecological conservation.

Figure 1/ Geographical location of GEOMAR Helmholtz Centre for Ocean Research Kiel
Source/ Google Maps

Introduction to the research center and its talent cultivation policy

GEOMAR Helmholtz Centre for Ocean Research Kiel (referred to as GEOMAR) is one of Europe's three leading institutions in the field of marine science, and is a member of the "G3 group" of national marine research centers comprising the National Oceanography Centre (NOC) in neighboring UK and The French Research Institute for Exploitation of the Sea (IFREMER) located in France. GEOMAR is a large-scale marine research center that performs globally pioneering research. Located in Kiel, Germany, it was originally named the Leibniz Institute of Marine Sciences (Leibniz-Institut für Meereswissenschaften), and was jointly established by the state and federal governments in 2004. GEOMAR was originally under the jurisdiction of the Leibniz Institute. After withdrawing from the Institute in 2012, the entity merged into the Helmholtz Association and was given its current title. In addition, it also acts as the coordinator of participating parties in the FishBase Consortium. The institute is engaged in all ocean-related marine studies across the globe, and exhibits outstanding achievements in the fields of climate dynamics, marine ecology and biogeochemistry, as well as ocean bottom dynamics and circulation. The institute also jointly confers degrees with the University of Kiel, and operates the Aquarium GEOMAR and "Lithothek," the central hub for the investigation of sediment cores and rock samples [2]. Furthermore, with regard to the recent debate on wastewater released from the Fukushima Nuclear Power Plant into the ocean, a 2012 study conducted by GEOMAR has been widely cited and discussed. In the study, data simulation was used to track the dilution of ^{137}Cs, and the findings indicated that the entire Pacific Ocean suffered impact within 3 to 6 months [3][4].

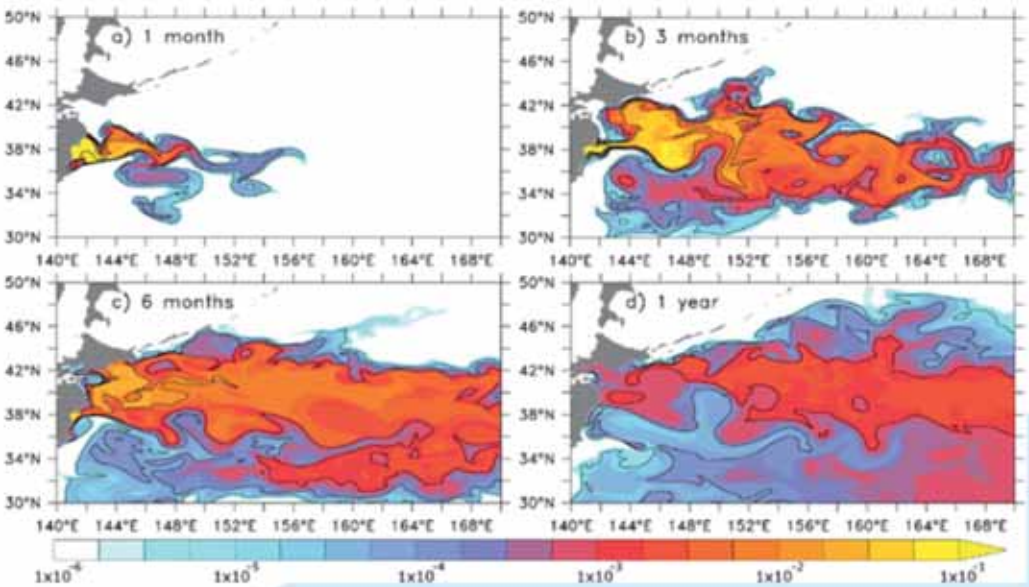

Figure 2/ Sequence of relative surface tracer concentration
Source/ Behrens, E., F.U. Schwarzkopf, J.F. Lübbecke and C.W. Böning, 2012 [4]

GEOMAR's marine research team is dedicated to studying physical, chemical, biological, and geological changes in the seabed, in the ocean, or at the edge of the ocean, as well as their interactions with the

atmosphere. It is also committed to narrowing the gap between fundamental science and practical applications, and leads the world in terms of the diversity of its research projects. GEOMAR is a public legal entity jointly funded by the German Federal Government (90%) and the State of Schleswig-Holstein (10%). In 2020, it had approximately 1,000 employees, and an annual budget of approximately €80 million. Through research spanning topics from seabed geology to marine meteorology, the purpose of this institution is to conduct cross-disciplinary research on all topics in modern marine science on a worldwide basis [5].

GEOMAR furthermore operates 3 oceanographic research vessels (ALKOR, LITTORINA and POLARFUCHS) equipped with advanced instruments and equipment, such as manned submersibles (JAGO) and autonomous underwater vehicles (KIEL6000, PHOCA and ABYSS). the Institute also features several research laboratories that run concurrently, and is equipped with extremely high-performance computer/computing equipment as well as a fascinating aquarium. At the end of 2017, GEOMAR additionally set up a scientific logistics station in the Cape Verdean Islands in the western waters of Africa, The Ocean Science Centre Mindelo (OSCM) [5].

Recent major research outcomes

I. Nature study finds transform faults play active role in shaping ocean floors [6]

Researchers from the GEOMAR Helmholtz Centre for Ocean Research Kiel in Germany published new study findings in the international journal Nature on March 17, 2021, pointing out that transform faults play an extremely important and previously unknown role in plate tectonics. The forces inside the earth push the crustal plates along the submarine mountains and mid-ocean ridges, forming new seabeds which in turn move around the continental plates. For millions of years, the powerful forces created by the movement of the Earth's interior have been constantly reshaping the shape of continents and ocean basins. Nevertheless, the continental drift hypothesis previously published by geophysicist and meteorologist Alfred Wegener in 1915 was not widely accepted by the masses until the 1960s. Today, however, it provides us with a unified view of the structure of our planet. It has taken so long for theory of plate tectonics to be recognized by the public for two simple reasons. First of all, the stratum is hidden deep in the deepest bottom of the sea, unpredictable but also fascinating. Furthermore, the force during its movement acts on the depths below the seabed, which is hidden from our field of vision and is as such difficult to observe. For these reasons, it is still difficult to clarify the details of many plate structures even to this day.

Recently, however, five scientists from the GEOMAR Helmholtz Centre for Ocean Research Kiel in Germany, Southern University of Science and Technology in Shenzhen, China, and GeoModelling Solutions GmbH in Switzerland published in the international scientific journal Nature a study in which Dr. Ingo Grevemeyer of GEOMAR pointed out that the basic assumption of plate tectonics is that transform faults are large offsets in the mid-ocean ridges. So far, these offsets have been assigned a purely passive role within plate tectonics. However, this research clearly shows that they play an active role in shaping the ocean floors.

A brief look at a global overview map of the seabed (Figure 3) will facilitate understanding of this study. It can be found that even in the case of insufficient map resolution, we can identify mid-ocean ridges tens of thousands of kilometers long and which represent the boundaries of the earth's plates. After the hot materials from the earth's mantle gushes out from the center of the boundaries between the plates, they rapidly cool to form a new oceanic crust and push around the old crust. This is the force that drives the movement of tectonic plates.

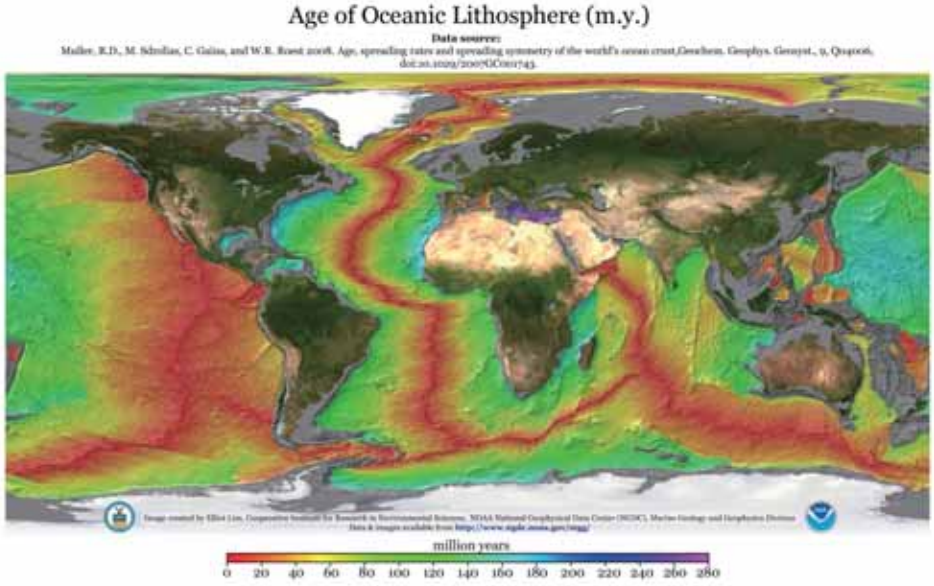

Figure 3/ 2008 global overview map of the seabed (colors indicate crustal age)
Source/ Mr. Elliot Lim, CIRES & NOAA/NCEI
https://www.ngdc.noaa.gov/mgg/image/crustalimages.html

However, the mid-ocean ridges do not form continuous lines, but are cut off by rift valleys at almost regular intervals. Each part of the ridge has a certain offset at the beginning and end of the section. Professor Lars Rüpke from GEOMAR indicated that these are the transform faults, and as the earth is a sphere, repetitive plate movement triggers the formation of transform faults, further causing these ridge offsets.

Earthquakes may occur at the transform faults, and they will leave long marks on the oceanic plates that are otherwise known as fracture zones. However, many studies so far have assumed that two plates only slide along the transform fault, and that the seabed is neither generated nor destroyed during the entire dynamic process. The authors of the current study have reviewed existing maps of 40 transform faults in all ocean basins, and Professor Colin Devey of GEOMAR, the co-author of this study, has stated that, "In all the examples, we can find that the transform valleys are much deeper than the adjacent fracture zones. In the past, the fracture zone has been simply regarded as a continuation of the transform valley." The research team even observed extensive traces of magma activity at the intersection of the transform valley (Figure 4) and the mid-ocean ridge [7].

In this regard, the research team used sophisticated numerical models to find a reasonable explanation for this phenomenon. According to the above, the plate boundary becomes increasingly tilted at depth along the transform fault, leading to materialization of the shearing effect. This will inevitably lead to the extension of the seabed, forming a deep transform valley. Subsequently, magmatism at the outer corners to the mid-ocean ridges fills up the valleys, causing the fracture zones to become shallower. For this reason, the oceanic crust formed at the corners is the only crust formed by two-stage volcanism. The effect this has on the composition of the earth's crust, for example, the distribution of metals, is as yet unknown. Since transform faults are a fundamental type of plate boundary and one of the common phenomena at oceanic active plate boundaries, this new discovery not only enriches our theory of plate tectonics, but also has important significance for understanding our planet.

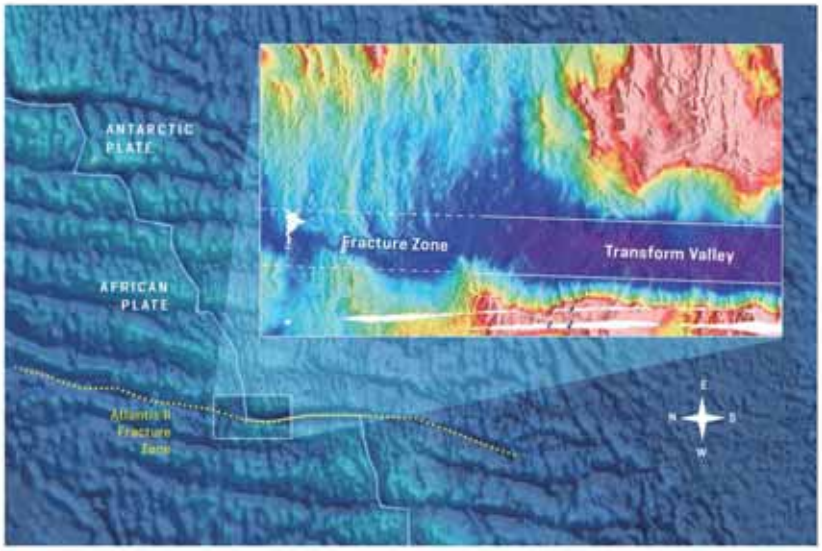

Figure 4/ Transform valley
Source/ https://www.geomar.de/en/news/article/ein-neuer-blick-auf-die- plattentektonik

II. Sediments are nutrient mediators in Arctic fjords [8]

Although algae and other phytoplanktons in the ocean are not large in size, they play an important role in the earth's climate system. Utilizing large amounts of carbon, they produce the oxygen that other species depend on. These phytoplanktons need the supply of light, carbon, nutrients, iron and other elements to survive, but as iron is rarely found in the ocean, phytoplanktons tend to thrive and reproduce well in places in the ocean that are rich in sources of iron.

In the Arctic Circle, glaciers that terminate in the sea are an important source of iron. In recent years, however, glaciers have been heavily impacted by climate change and are undergoing rapid changes, and the impact of these changes on the supply of nutrient iron and the growth of phytoplankton in the Arctic waters has always been a topic of concern. An international research team led by GEOMAR probed into this issue with Dr. Katja Laufer-Meiser of GEOMAR performing a study of several fjords on Svalbard. The results showed that not only is the glacier itself a source of iron, but the sediment at the bottom of the fjord is also a possible source of iron for use by phytoplanktons [9].

Although previous studies on this topic have shown that glaciers have a direct impact on the waters of the fjord and the adjacent ocean, Dr. Laufer-Meiser explained based on the research results that most of the iron entering the water from the glacier ice cannot be directly used by phytoplankton. Instead, it is initially deposited in crystalline form in the sediments at the bottom of the fjord before biochemical processes convert some of the deposited iron into the form of nutrients that are released back into the sea. Surprisingly, the study found in the sediments that the highest concentration of nutrient iron is not at the end of the glacier, but at a place further away from the fjord. This is contrary to the results generally expected in the academic world, and the phenomenon has never been discovered in the past. The research team observed this phenomenon by reducing the sedimentation rates in the outer fjord areas. Since the transformation of iron mainly occurs in the uppermost layer of the seabed, there is more time for younger substances to cover the iron. The process is shown in Figure 5. Therefore, the biotic and abiotic transformation processes in the outer fjords will be more obvious than those located near glaciers.

The study also shows that "sediment" is an important factor that potentially contributes to biochemical effects. In addition, the retreat of glaciers to land not only changes the direct supply of nutrients from the glaciers, but also indirectly affects the internal reactions of sediments. As we all know, the retreat of glaciers will affect phytoplankton growth, thus reducing the productivity of the entire fjord ecosystem. Now, this study additionally shows the retreat of glaciers also changes the biochemical characteristics of fjord sediments. The results of the study concluded that with less potentially bioavailable iron reaching the upper sediment layers, another negative feedback mechanism is formulated that will indirectly amplify the effects of climate change.

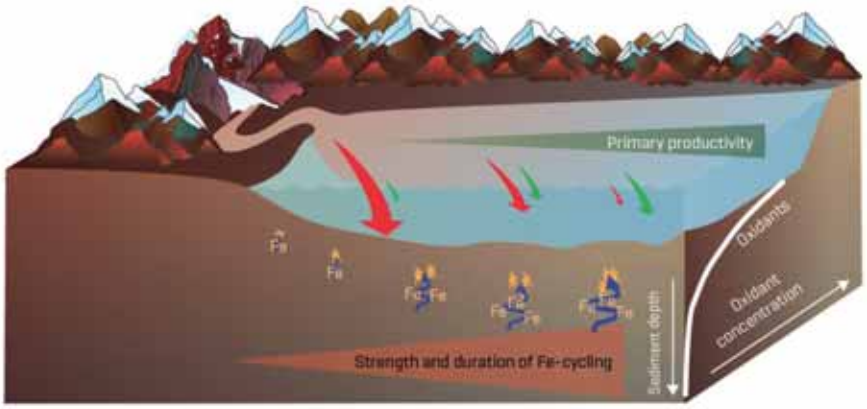

Figure 5/ Iron conversion diagram
Source/ https://www.geomar.de/en/news/article/sedimente-als-naehrstoff-vermittler-in-arktischen-fjorden

Conclusion

The GEOMAR Helmholtz Centre for Ocean Research Kiel is also an active member of many international organizations, such as the German Alliance for Marine Research (DAM), the German Marine Research Consortium (KDM), the German Climate Association (German Climate Consortium, DKK), European Marine Board, and Partnership for Observation of the Global Oceans (POGO). GEOMAR and the University of Kiel also work together to cultivate future marine scientists while cooperating with other universities around the world. The institute's research outcomes and approaches to international cooperation are worthy of reference by Taiwan's ocean research institutes as we strive to spark public interest in marine research. This will enable Taiwan's communities to gain a deeper understanding of the interrelationships between geophysical processes as we continue on our journey of discovering new knowledge and invaluable ocean resources.

References

[1] https://www.klbase.com/news/585334.html
[2] https://zh.wikipedia.org/wiki/%E5%9F%BA%E5%B0%94%E4%BA%A5%E5%A7%86%E9%9C%8D%E5%85%B9%E6%B5%B7%E6%B4%8B%E7%A0%94%E7%A9%B6%E4%B8%AD%E5%BF%83
[3] 自由時報，〈福島核廢水確定排入海 德國研究：57天內恐汙染大半太平洋！〉，2021年4月13日
https://news.ltn.com.tw/news/world/breakingnews/3498435
[4] Behrens, E., F.U. Schwarzkopf, J.F. Lübbecke and C.W. Böning, 2012: Model simulations on the long-term dispersal of ^{137}Cs released into the Pacific Ocean off Fukushima. Environmental Research Letters, 7
http://dx.doi.org/10.1088/1748-9326/7/3/034004
[5] https://www.geomar.de/en/centre/about-geomar
[6] Grevemeyer, I., L. H. Rüpke, J. P. Morgan, K. Iyer, C. W. Devey (2021): Extensional tectonics and two-stage crustal accretion at oceanic transform faults. Nature
https://doi.org/10.1038/s41586-021-03278-9
[7] https://www.geomar.de/en/news/article/ein-neuer-blick-auf-die-plattentektonik
[8] Laufer-Meiser, K., A. B. Michaud, M. Maisch, J. M. Byrne, A. Kappler, M. O. Patterson, H. Røy & B. B. Jørgensen (2021): Potentially bioavailable iron produced through benthic cycling in glaciated Arctic fjords of Svalbard. Nature Communications 12, 1349 (2021)
[9] https://www.geomar.de/en/news/article/sedimente-als-naehrstoff-vermittler-in-arktischen-fjorden

Germany's "Federal Spatial Planning Act" and Maritime Spatial Planning

Chen-Ju Chen (Associate Professor, Department of Law, National Chengchi University)
Translated by Linguitronics
Keywords: Federal Spatial Planning Law, Maritime Spatial Planning, EU Directive for Maritime Spatial Planning

Due to the multiple roles played by the ocean in the economic, social and environmental aspects, the use of sea areas often entails conflicts of interest among users. "Maritime spatial planning" has the effects of balancing the competitive relationships of different interest, coordinating the interests of different sea users as a forward-looking planning tool. This is also true in Germany.

Germany's main coastal system is located in the two regional oceans of the North Sea and the Baltic Sea. In the North Sea, internal waters and territorial waters comprise an area of approximately 12,500 square kilometers, while the Exclusive Economic Zone is approximately 28,500 square kilometers; within the Baltic Sea, internal and territorial waters are approximately 10,900 square kilometers while the Exclusive Economic Zone has an area of approximately 4,500 square kilometers [1]. Compared to other European coastal countries, Germany is not a traditional maritime country. The nation rarely engages in traditional uses of the sea. As the sea was not originally used for large-scale industrial development, it remains open and pristine. However, with industrial development, technological advancement, economic demand and other factors beginning to escalate, the entire ocean expanse ranging from territorial waters within 12 nautical miles to the entire Exclusive Economic Zone within 200 nautical miles has become a target of development. Under this premise, Germany's maritime spatial planning can be divided into two parts, which are described as follows.

Domestically, within the scope of internal waters and territorial waters

Germany's internal waters and territorial waters are mainly located in the three coastal states, including: Niedersachsen, Mecklenburg-Vorpommern, and Schleswig-Holstein. The local governments of these states engage in the spatial planning of inland waters and territorial waters in accordance with the general specifications of the "Federal Spatial Planning Act" (Raumordnungsgesetz), and integrate their respective sea areas into their overall policies for land use and spatial planning. Spatial planning for the sea areas of these three states can be analyzed as follows:

The Schleswig-Holstein State Development Plan (Schleswig-Holstein Landesentwicklungsplan), as a spatial planning plan, covers the objectives and principles of land and sea spatial planning, and is legally binding. Guided by sustainable spatial development, the aim of the plan is to balance the social and economic needs of space and its ecological functions. Different uses of coastal areas should also be adapted to each other to achieve a balance; as such, an integrated coastal management plan plays a crucial part of the process. The state's development plan came into effect in 2010, and the latest revision was made in 2019. Under the framework of this state development plan, which is regarded as having "Dachplan" status, 5 regional projects (Regionalpläne) have been formulated which are expected to be adjusted to 3 regional projects in the future with the main considerations being the different development traits of each district. Principles and goals are set through spatial planning, and then weighed by the regional planning authority. The aforementioned state development plans and regional

plans are formulated by the state planning authority through public participation and consultation procedures, including the participation of the State Planning Committee (Landesplanungsrat), and finally approved by the State Council (Landtag). In terms of zoning, sea areas are categorized into three types, priority areas (Vorrangsgebieten), reserve areas (Vorbehaltssgebieten) and suitable areas (Eignungsgebieten), just as sea areas for wind power generation, water resources protection, or nature and leisure are distinguished from each other. Priority areas refer to areas used for a specific, spatially important function or purpose, and other uses that are incompatible with its priority function or purpose should be excluded; reserve areas mean that, when the area has important functions or uses, special attention should be paid to these important functions or uses of the area if there is a conflict of multiple uses; in terms of suitable areas, if specific suitable areas are designated for related uses in the spatial planning, other areas in the spatial planning shall exclude use for these purposes [2].

As for the Mecklenburg-West Pomerania State Development Plan, plans for sea areas within the scope of 12-nautical mile territorial waters were made between 2003 and 2005 and formally adopted in 2005. Further amendments were made between 2013 and 2015, and adopted in 2016. This plan is evaluated every 5 years, and a monitoring system is also being established [3].

The Lower Saxony State Development Plan comprises primarily relevant provisions on wind power generation, nature conservation, offshore power transmission and shipping. Regarding its coastal areas and territorial waters, it emphasizes the application of relevant principles, including: sustainable development, due consideration of the views of different stakeholders, and the adoption of reversible measures. To date, this plan has undergone numerous revisions and has different versions. As the plan also involves international factors, negotiations with the Netherlands were also necessary so in addition to domestic public participation and consultation [4].

Internationally, within the scope of the Exclusive Economic Zone

Maritime spatial planning in the Exclusive Economic Zone is under the jurisdiction of the federal government, and the German Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH) is responsible for the implementation of the Germany' maritime spatial planning in the North Sea and Baltic Sea Exclusive Economic Zones. The legislative basis for the maritime spatial planning of German Exclusive Economic Zone is still the "Federal Spatial Planning Act," which was amended in 2004 to extend the scope of application to the Exclusive Economic Zone. Another amendment was made in 2017 in response to the framework promulgated under the 2014 EU Directive for Maritime Spatial Planning (2014/89/EU).

Compared with its internal waters and territorial waters, the German Exclusive Economic Zone is not entirely within the country's jurisdiction. As Exclusive Economic Zones essentially belong to international waters, spatial planning for this sea area must be made in accordance with the UN Convention on the Law of the Sea. For example, in accordance with Article 58(1) of the Convention, it is necessary to ensure that relevant countries still enjoy the freedom of the seas in the Exclusive Economic Zones of coastal states, including: freedom of navigation and overflight, freedom to lay submarine cables and pipelines, and other international lawful uses of the ocean related to these freedoms, such as those related to the operation of ships and aircraft and the use of submarine cables and pipelines as well as others uses that comply with other provisions of this Convention. Therefore, spatial planning in the Exclusive Economic Zone should entail only "limited spatial planning" (eingeschränkte Raumordnung), as the specifications and uses of this sea area are primarily limited to related economic and scientific uses, ensuring the safety and convenience of navigation, and protecting the marine environment [5].

As early as 2009, the German Federal Ministry of the Interior (Bundesminister des Innern, für Bau und Heimat, BMI) began to carry out maritime spatial planning for this sea area with the assistance of the German Federal Maritime and Hydrographic Agency. Relevant amendments were performed in 2019 in response to the aforementioned "EU Directive for Maritime Spatial Planning," which requires all coastal Member States to complete maritime spatial planning by 2021. Under this normative framework, Germany's maritime spatial planning for its Exclusive Economic Zone is also being established in an extensive consultation process which includes incorporating the opinions of relevant authorities, associations or private sectors into the different stages of the planning process for evaluation. As of today, new versions of the plan are still under revision.

In the German Exclusive Economic Zone, plans can be divided into two types depending on the location of the sea area, including: 1. Spatial Planning for the Germany' Exclusive Economic Zone in the North Sea (Raumordnung in der deutschen ausschließlichen Wirtschaftszone in der Nordsee, AWZ Nordsee-ROV); 2. Spatial Planning for the Germany' Exclusive Economic Zone in the Baltic Sea (Verordnung über die Raumordnung in der deutslichen aus Wirtschaftszone in der Ostsee, AWZ Ostsee-ROV). In terms of planning, 10 major uses have been identified, covering both other new uses and traditional sea use, including shipping, non-living resources development, pipelines and submarine cables, marine scientific research, energy production (especially wind energy), fisheries and mariculture, marine environment, military use, leisure and tourism, and ammunition storage sites and sediment deposition sites. In the Baltic Sea, passage between Denmark and Germany through the Fehmarn Belt (Fehmarnbelt) constitutes another form of sea use. Through planning and the formulation of a framework, clear goals and principles are established. Among them, it is believed that offshore wind power is conducive to the country's strategy of sustainable use and protection of the ocean; therefore, it is in Germany's interest to reconcile the conflict between this new use of the ocean and other traditional uses. These plans not only emphasize extensive domestic public participation, negotiations with neighboring countries are also indispensable due to the highly internationalized nature of the region. These negotiations include informing the intention of maritime spatial planning, providing written information for negotiation of relevant drafts, and convening international consultative conferences. These gestures even extend to engaging in negotiation procedures for strategic environmental impact assessments based on the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention), including understanding the negative impacts on the marine environment of neighboring countries, especially protected areas. Ultimately, the plans will serve as the basis of relevant regulations for license issuance and project permits as well as provide geographic coordinates for relevant maps and zoning [6][7].

Draft maritime spatial plans for EEZ in the North and Baltic Seas (2020)
Source/ BSH
https://www.bsh.de/DE/THEMEN/Offshore/Meeresraumplanung/Fortschreibung/_Anlagen/Downloads/Entwurf_Raumordnungsplan.pdf?__blob=publicationFile&v=8

Conclusion

From the above descriptions, we can derive a clear picture of the characteristics of German maritime spatial planning, including:

I. Determination of boundaries: Since the 1960s and 1970s, Germany has successively completed the delimitation of maritime overlapping areas with neighboring countries, including Denmark, the Netherlands, Sweden, Poland and the United Kingdom, thus delineating the outer boundary of its Exclusive Economic Zone and facilitating maritime governance by eliminating the possibility of maritime disputes in these aspects.

II. Single legislation: The "Federal Spatial Planning Act" applies to German internal waters and territorial waters, and is further extended to its Exclusive Economic Zones. This approach to legislation can also serve as a reference for other countries. The advantage is that administrative agencies are familiar with the relevant legal system. When the plans then are extended to the further sea area, the implementation can thus be accelerated. Yet, this may due to that the German Exclusive Economic Zone is not as vast as that of other maritime countries. In addition, in terms of the distinction between central and local governmental jurisdictions, internal waters and territorial waters closely related to human activities are placed under local governmental jurisdiction. This approach echoes the spirit of integrated land-sea management.

III. Adoption of Conventional zoning: Following the development process and logic of the "Federal Spatial Planning Act," Germany's maritime spatial planning only distinguishing between internal waters/territorial waters and Exclusive Economic Zones enables Germany to take into account the spirit of integrated management while incorporating the frameworks provided by the Conventions.

IV. Giving due consideration to functional zoning and the priority of each area: In Germany's maritime spatial planning, the design of functions and uses as well as due consideration of the priority of application help to formulate a hierarchical framework and system.

V. Valuing domestic and foreign public participation: Throughout the entire process, plans were formed by professional agencies then placed under public participation and consultation procedures, showing that Germany values the participation and negotiation of the public and private sectors. The plans are then deliberated and approved by the chambers of parliament, thus realizing the principles of democracy. When plans involve international factors, Germany also conducts negotiation procedures with neighboring countries.

In sum, the aforementioned characteristics of German maritime spatial planning are worthy of reference when we carry out maritime spatial planning for Taiwan.

References

[1] European MSP Platform (2021). Germany
https://www.msp-platform.eu/countries/germany (Apr. 15, 2021)
[2] Schleswig-Holstein (2021). Landesentwicklungsplan Fortschreibung
https://www.schleswig-holstein.de/DE/Landesregierung/Themen/PlanenBauenWohnen/Fortschreibung_LEP/Projekt/projekt_node.html (Apr. 15, 2021); European MSP Platform (2021). Maritime Spatial Plan for the Territorial Sea of Schleswig – Holstein
https://www.msp-platform.eu/practices/maritime-spatial-plan-territorial-sea-schleswig-holstein (Apr. 15, 2021)
[3] Mecklenburg-Vorpommern (2021). Aktuelles Programm
https://www.regierung-mv.de/Landesregierung/em/Raumordnung/Landesraumentwicklungsprogramm/aktuelles-Programm/ (Apr. 15, 2021)
[4] European MSP Platform (2021). The Spatial Planning Programme for the Territorial Sea of Lower Saxony
https://www.msp-platform.eu/practices/spatial-planning-programme-territorial-sea-lower-saxony (Apr. 15, 2021)
[5] Bundesamt für Seeschifffahrt und Hydrographie, Meeresraumplanung
https://www.bsh.de/DE/THEMEN/Offshore/Meeresraumplanung/meeresraumplanung_node.html (Apr. 15, 2021)
[6] European MSP Platform, Maritime Spatial Plan of the German EEZ in the North Sea
https://www.msp-platform.eu/practices/maritime-spatial-plan-german-eez-north-sea (Apr. 15, 2021); Bundesministerium der Justiz und für Verbraucherschutz, Bundesamt für Justiz, Verordnung über die Raumordnung in der deutschen ausschließlichen Wirtschaftszone in der Ostsee (AWZ Ostsee-ROV), BGBl. I 2009, Nr. 78, S. 3861 vom 18. Dezember 2009, S. 1 – 31.
[7] European MSP Platform, Maritime Spatial Plan of the German EEZ in the Baltic Sea
https://www.msp-platform.eu/practices/maritime-spatial-plan-german-eez-baltic-sea (Apr. 15, 2021); Bundesministerium der Justiz und für Verbraucherschutz, Bundesamt für Justiz, Verordnung über die Raumordnung in der deutschen ausschließlichen Wirtschaftszone in der Nordsee (AWZ Nordsee-ROV), BGBl. I 2009, Nr. 61, S. 3107 vom 25. September 2009, S. 1 – 34.

國際海洋資訊

12 June 2021 雙月刊 Bimonthly

International Ocean Information

發行：海洋委員會

地址：806610高雄市前鎮區成功二路25號4樓

電話：(07)3381810

E-mail：master@oac.gov.tw

網址：https://www.oac.gov.tw/

執行：財團法人台灣經濟研究院

地址：104222臺北市中山區德惠街16-8號7樓

電話：(02)2586-5000分機888

傳真：(02)2595-7131

網址：http://www.tier.org.tw/

發 行 人：李仲威

副發行人：蔡清標、周美伍

總 編 輯：劉國列

編輯委員：黃向文、邱永芳、謝亞杰、沈建中、許啓業、王茂城、黃世偉、陳裕興、林麗英、陳致延、賴依雯

編輯顧問：高家俊、王毓正

執行主編：鍾嘉雯、陳璋玲

執行編輯：黃釋緯、洪承豐、李茗家、謝惠子

美編設計：不賴的廣告

電話：(02)2783-0978

傳真：(02)2783-3033

Published by Ocean Affairs Council

Address：4F., No. 25, Chenggong 2nd Road, Qianzhen District, Kaohsiung City 806610, Taiwan

Telephone：(07)3381810

E-mail：master@oac.gov.tw

Website：https://www.oac.gov.tw/

Executive：Taiwan Institute of Economic Research

Address：7F., No. 16-8, Dehuei St., Jhongshan District, Taipei City 104222, Taiwan

Telephone：(02)2586-5000 Ext.888

Fax：(02)2595-7131

Website：http://www.tier.org.tw/

Publisher：Chung-Wei Lee

Associate Publisher：Ching-Piao Tsai, Mei-Wu Chou

Editor-in-Chief：Kuo-Lieh Liu

Editorial Board：Hsiang-Wen Huang, Yung-Fang Chiu, Ya-Chieh Hsieh, Chien-Chung Shen, Chad C.Y. Hsu, Mao-Chen Wang, Shin-Wei Huang, Yu-Hsing Chen, Li-Ying Lin, Chih-Yen Chen, Yi-Wen Lai

Reviewer：Chia-Chuen Kao, Yu-Cheng Wang

Managing Editor：Chia-Wen Chung, Chung-Ling Chen

Executive Editor：Shi-Wei Huang, Cheng-Li Hung, Ming-Chia Lee, Hui-Tzu Hsieh

Designed by Pride Advertising Agency Ltd.

Telephone：(02)2783-0978

Fax：(02)2783-3033

讀者意見回饋，請來電(02)2586-5000分機888或E-mail至d11743@tier.org.tw

國際海洋資訊

12
June 2021
Bimonthly

International Ocean Information

封面：德國漢薩帆船節於Warnemünde港舉辦；封底：臺灣浮臺式洋流發電機組

中華民國110年6月出版（每雙月出版）
中華民國108年8月創刊
ISSN 2706-638X （紙本）
ISSN 2706-6398 （電子）
中華郵政高雄雜字第236號執照登記為雜誌交寄
高雄郵局許可證 高雄字第2084號

線上全文

海洋委員會 Ocean Affairs Council 發行

台灣經濟研究院 Taiwan Institute of Economic Research 編印

贈閱