出國報告（出國類別：考察）

法國 IFREMER 國家海洋開發研究院參訪交流

服務機關：國家海洋研究院

姓名職稱：陳建宏院長、楊文昌主任、

陳麗雯副研究員

派赴國家/地區：法國

出國期間：112 年 5 月 7 日至 5 月 13 日

報告日期：112 年 6月 7 日

摘要

為掌握海域基礎資訊，提升國內海洋調研能量，為執行海洋調查船之規劃及興建、深入瞭解先進國家大型研究船內部規劃及科研儀器空間配置考量，本院規劃前往海洋科學探勘先進國家，參觀研究船並參訪所屬研究及運維單位。本次參訪最主要目的為前往法國 Brest 參訪世界六大海洋研究機構的法國海洋開發研究院(Ifremer)，以及法國研究船隊專責運維公司 Genavir。並藉由實地參訪與本專案大型研究船需求最為接近的法國整合性地質地物研究船(R/V Pourquoi Pas?)，以親身體驗研究船本身空間配置的方式，瞭解研究船為操作海洋科研儀器所設計的各項機具細節，讓我們爾後的調查船設計更為完善。並於 Brest 參訪法國極地研究所(IPEV)，了解法國於極地探研進行中的各項研究任務，以作為本院極地研究站運維之參考。另進一步地地藉由返回巴黎時，與法國海洋十年科研執行長及法國總理府海洋事務秘書總處專員會晤交流，以瞭解全球永續科學倡議重心及法國海洋政策研究之發展方向，以利參考國際觀點於本院將來海洋研究之方向。

本次參訪法國考察由陳建宏院長帶隊、海洋科學及資訊研究中心楊文昌主任、陳麗雯副研究員，以及船舶中心(Ship and Ocean Industries R&D Center, SOIC)主要設計團隊李宗衛副處長、陳淑樺工程師隨行，參訪行程如下：

日期	行程
5/7-5/8	去程 (台北-巴黎)
5/9	1、 參訪 Ifremer 與研究船隊研究專案負責人交流 2、 於 Ifremer 與法國研究艦船主要營運商 Genavir 之管理人員交流船隊營運模式 3、 參訪法國極地研究所(Institut Polaire Francais, IPEV)
5/10	4、參觀 R/V Pourquoi Pas?研究船
5/11	5、 於 Sorbonne University entrance at Place Jussieu 索邦巴黎第六大學，與推動國際海洋永續研就網絡(Ocean Knowledge Action Network, Ocean KAN)執行長進行交流會談 6、 於駐法代表處，與法國總理府主管海洋事務秘書總處研究事務專家以及科技部代表處相關人員進行交流
5/12-5/13	回程 (巴黎-台北)

本次參訪對於本院執行海洋調查船之設計整體規劃的方向、海洋船隊的建立與運維、海洋科學政策發展方向等皆甚有助益，本次的參訪行程能夠順利成功，要特別感謝法國海洋開發研究院(Ifremer)國際處的 Dr. Nan-Chin Chu 及科技部駐法台北代表處 Dr. Jin-Yi Lin 的鼎力相助在溝通協調及行程安排上，以及海洋委員會各級長官的支持、外交部與科技部於駐法台北代表處的協助，更重要的是法國海洋開發研究院(Ifremer)、極地研究所(IPEV)、法國海洋研究船(R/V Pourquoi Pas?) 、Ocean Knowledge Action Network 及法國總理府海洋事務秘書總處的無私分享、熱情交流，以他們關注海洋永續利用的視角、透視海洋研究觀點、落實在海洋探測調查研究上，滋養我們國家海洋研究院朝向國際級的研究機構成長。

目次

一、 目的

掌握海域基礎資訊乃為「海洋國家」不可或缺的要項，許多海洋強權國家均已建構國家級的專責船隊及探艘平台，負責執行海洋調研及國家臨時所需海上工作。海洋基礎資訊收集所需之海洋觀測探勘的最大平台即是調查船，不論是近岸、近海、遠洋、淺水與深海之生態監測及水文觀測網的建置、海洋地形測繪及底質探測採樣等均須大量使用調查船(圖 1)，才能夠完善觀測與探測任務達成初始資料庫的建置，同時於後續進行監測或進一步探勘等亦須仰賴調查船的運作。反觀目前國內海洋調研任務能量有限待提升，存在著調查船調度不敷需求外、欠缺先進技術引進以及國內大型探測設備的提升等問題。國家海洋研究院為推動「海洋基礎資料調查船興建計畫」之需要，以「海洋基本法」與「國家海洋政策白皮書」之國家法律與政策為依據，規劃建置 4,000、300 及 100 噸級調查船各一艘，用以執行國家海域基礎資料調查及資源探勘等國家海洋政策任務。

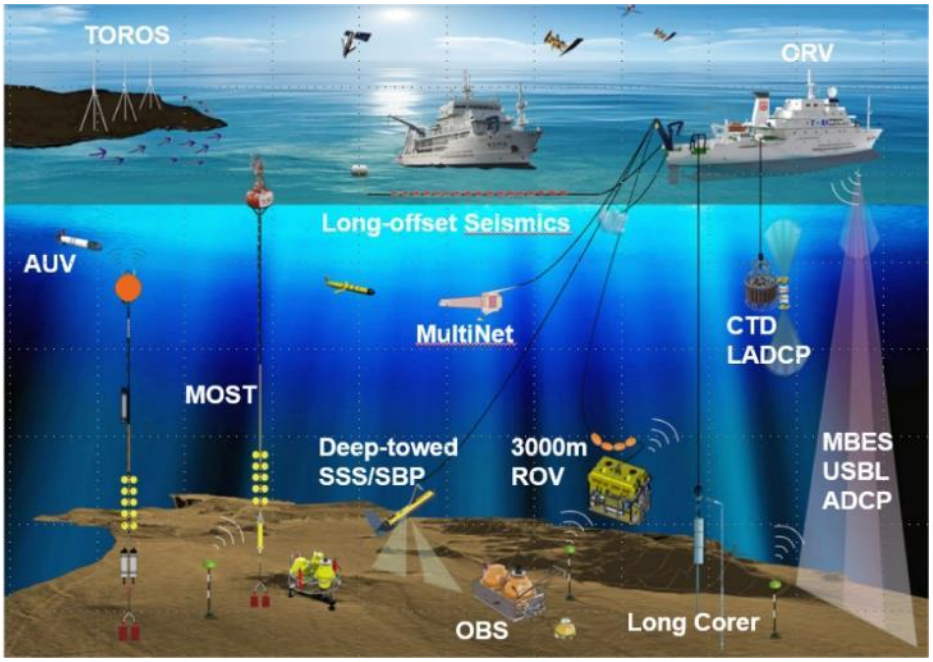


圖 1、海洋調查船功能示意圖 (Credit: TORI website)

二、 參訪過程

(一) 參訪法國海洋開發研究院(Ifremer)

簡介：

Ifremer 位於法國西隅鄰接大西洋東岸 Brest 半島(圖 2)，其為法國重要海洋產業、海軍基地及貿易港，身處歐洲戰略地位極為重要的海港(圖 3)。Ifremer 的組織架構主要包含總部及各個研究中心、海洋研究站，並統整管理全法國的大型遠洋研究船、沿海小型船舶及各類水下載具設備之國家海洋研究船隊(French Oceanographic Fleet, FOF)。在海洋研究經驗汲取上，學習調查船建構的各項考量設置，及其海洋調查船隊(簡稱 FOF)的管理，更是本院執行調查船計畫、完備海洋調查能量最重要的目標。

尤其，法國在政府積極推動領導下，2020 年 1 月 1 日起，Genavir 成為法國海洋艦隊主要運營商，唯一股東即為 Ifremer，如此將調查研究的資料探測收集以及分析報告，清楚地區分開來管理、專業明確有效率的分工模式，為目前各海洋強權國家中唯一大刀闊斧、當為而為的海洋研究船專業運作模式。也正是我們調查船建構完成之前，迫切需成立行政法人以運維研究船隊之重要理想目標。

交流：

在場與會者有，Ifremer、本院及 SOIC 代表之外，身為海洋地質地物研究領域的科技部駐法台北代表處 Dr. Jin-Yi Lin 組長亦前來參加討論，現場討論熱烈而和諧，著實增進雙方海洋科學研究單位的瞭解。首先，由本院院長略述本院成立宗旨以及調研執行的重點方向(圖 4)，接著由海洋科學及資訊研究中心楊文昌主任代表介紹本院分享歷年海洋科學研究成果 (圖 5) 再由 Ifremer 不同領域首長介紹其研究調查團隊組成、主要科研方向、船體科儀設計及計畫審視策略等各方面分享(圖 6)。

圖 2、Ifremer 所在位置 (Credit: Google map)

圖 3、Brest 港口的軍艦停泊照

圖 4、陳院長簡介國海院及重點方向

圖 5、楊主任報告國海院歷年研究執行成果

首先，由 Ifremer 海洋調查船隊 FOF 的船隊主任 Mr. Olivier LEFORT (圖 6)介紹其旗下各研究船隻及其特長。不同研究船的操作模式雖有所不同，但基本上各式研究船為配合一般測繪任務皆裝載船載式多音束測深系統、專業 GPS 天線及水文基本探測系統。

- Ifremer 共有 6 艘深海研究船(Deep-Sea & Oversea vessels)能夠在所有大洋進行海洋整合式探測調查: Marion Dufresne、Pourquoi Pas? 及 L' Atalante、Thalassa、Antea、Alis (圖 7)。

- Ifremer 還有 5 艘沿海近岸船隻(Coasta Vessels)部署在英吉利海峽、大西洋和地中海，進行各種沿海到近岸探測任務：L 'Europe、Thalia、Côtes de la Manche、Tethys II 和 Haliotis (圖 8)。

- 及 7 艘小型研究站船隻(Station vessels)，沿著法國大陸海岸探測停泊執行任務。這些泊岸式小型區域性測量任務及觀測作業使用的研究站船隻執行當地近岸調查任務 Antedon II（馬賽）、Sepia II（維姆勒）、Nereis（旺德爾港）、Neomysis（羅斯科夫）、Albert Lucas（布雷斯特）、Planula IV（阿卡雄）和 Sagitta III（尼斯）(圖 9)。

- 於深海任務的關鍵設備中， Ifremer 有自主研發的深水潛艇(Deep-water submersible vehicles)，包含 Nautile 有人潛艇(圖 10)，以及歐洲唯一可達 6000 米深的水下機器人 Vitor 6000，可以達到深海中的精確測量、收集樣本，協助打撈等任務(圖 11)。

圖 6、Ifremer 各議題簡報代表

圖 7、Ifremer 的 6 艘深海研究船

圖 8、Ifremer 的 5 艘沿海近岸船隻

圖 9、以 Sagitta III 為例，主要主配合當地 Villefranche 海洋在 20 海浬內的觀測站任務，從事與生物學、海洋生態學、生物地球化學、地震學和海洋學領域的觀測研究及教學活動。

圖 10、Ifremer 自主研發的 Nautile 載人潛艇觀察可觀測深達 6,000 米，除攝像鏡頭及兩個機械手臂外，還能搭載很多設備（水採樣器、動物抽吸器、化學分析儀），多用於研究生物多樣性和氣候變化對深海的潛在影響，以及海洋地質的觀測及採樣作業，單次下潛可達八小時，有利於了解海底季節變化並觀察海底各種特殊現象。(Credit: Ifremer FOF website)

圖 11、Ifremer 自主研發的 Victor 6000 無人載具可觀測深達 6000 米，除可工作長達 15,000 小時不會疲憊外，更可攜帶高達 150 公斤的設備，除穩定抗流的深海觀測能力之外亦可進行大型岩石採樣。(Credit: Ifremer FOF website)

接著，**Ifremer** 海洋調查船隊的船隊副主任 Mr. Christine David-BEAUSIRE (圖 6)清楚介紹各研究船的調查船次申請流程及各種申請單位的相關規定。

- 以科研教育申請:需要經過評選競爭，但倘若申請過了就可免費使用研究船(失敗隔年可以再投)。
- 以支援國家政策型研究申請：無須經過評選，但必須先有部分經費已確認。
- 與業界合作的研究船期申請：無須經過評選，但必須先有大部分或全部經費及規畫皆已確認。
- 倘若於 N 年 9 月以前如期繳交研究船使用申請計畫書(通常可以申請超過一個月的探測船期)，定於該年 12 月開始審閱，其執行期間約為 N+2 至 N+4 年，研究成果發表須於 N+4 至 N+10 的六年間，**一般研究船的調查完成後的最佳亮點期多半是發生於航次結束後五年左右**。
- 因為船隻會造成海洋汙染，因此長遠目標是多利用 Smart ship，尤其在 2030-2035 年會大力執行，此外，在科研儀器探測上，則是鼓勵使用自主水下載具（Autonomous Underwater Vehicle，AUV）以減少碳足跡(圖 12)。

然後由 **Ifremer** 海洋調查船隊(簡稱 FOF)的船隊營運組長 Mr. Goulwen PELTIER (圖 6)介紹在各研究船船次申請後的期程安排，也就是 **Genavir** 在營運管理時必須考量的重點。

- Ifremer 每年共有 450 日的大洋航次、及 960 日的區域性及近岸航次可供各界申請。
- Genavir 會將計畫主持人提出的探測規畫全權承擔，並負責將規劃的進度實現。
- 各研究船至少兩組人，部分是固定職位，但許多是伴隨任務發生徵召自各國的約聘雇員，以供彈性調度。
- 國際研究合作：跨國合作研究必須要等到工作許可才能進行申請，預期此類研究船申請時間平均長達 1.5 年（至少在航行前 8 個月提出）
- 聲學環保考量：限制聲學造成哺乳動物影響的時間，降低噪音作用及時間長度。

- 技術和運營考量：會幫研究團隊建立 SOP 取得最佳數據收集，以達到科學要求
- 科學時間的限制：研究船調度須配合考量某些探測研究的最佳施測季節期間。
- 地理空間分布考量：調度船隻常常需要考慮航次距離，以減低航行距所造成的碳影響及生態作用。

最後，由 Ifremer 海洋調查船隊(FOF)的研究船設計規劃組組長 Mrs. Sarah DUDUYER (圖 6)介紹在 Ifremer 設計規劃組的組成，以及各研究船科儀及船體相關整合運維的作法。

- 研究船基本上會安排兩組團隊輪值
- 該部門有 30 名員工，工作量可分為 75%操作設備、15%做研發，另有 10%行政人力。前述人力又可分為兩組，分別專司 NE（設備的建造、現代化與升級）和 ASTI（聲學資料處理）各研究船至少兩組人，部分是固定職位，但許多是伴隨任務發生徵召自各國的約聘雇員，以供彈性調度。
- 研究船建造期程約為 4 年，約 5 年會整修一次，20 年大修一次(圖 13 以 Thalasa 維修歷程為例)。
- Ifremer 會負責整體儀器搭載於船艦上的設計，以及操作界面的整合規劃(圖 14)，並且不斷精進儀器在逐年使用中(圖 15)。
- Ifremer 會重視環保及全球變遷等因素，精進聲學並以關切海域環境氣候變遷，執行監測觀察為新船建置考量(圖 16、17、18)。

圖 12、Ifremer 自主研發的 6000 米級 AUV，能夠自主運動、下潛及通訊、支援各種各學設備，並可由船上遠端觀看探測結果。(Credit: Ifremer FOF website)

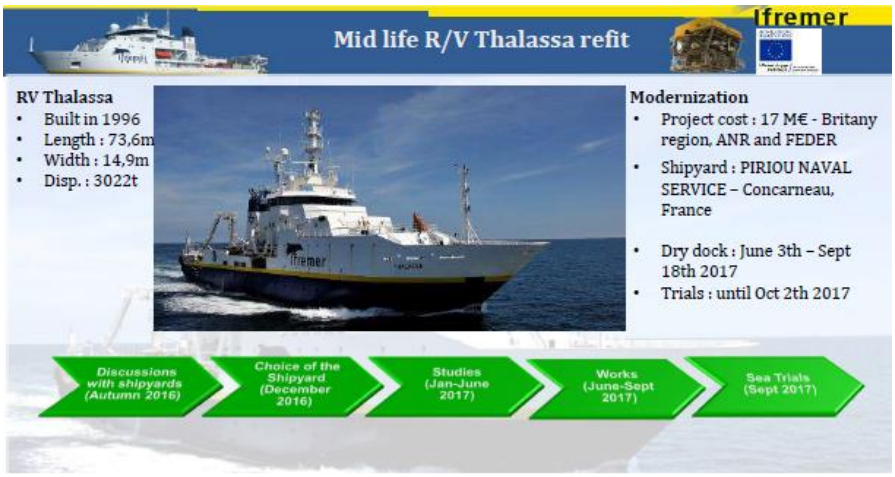


圖 13、以 2803 噸的 Thalasa 為例，約 5 年維修一次、20 年會進行大修審視狀況一次。

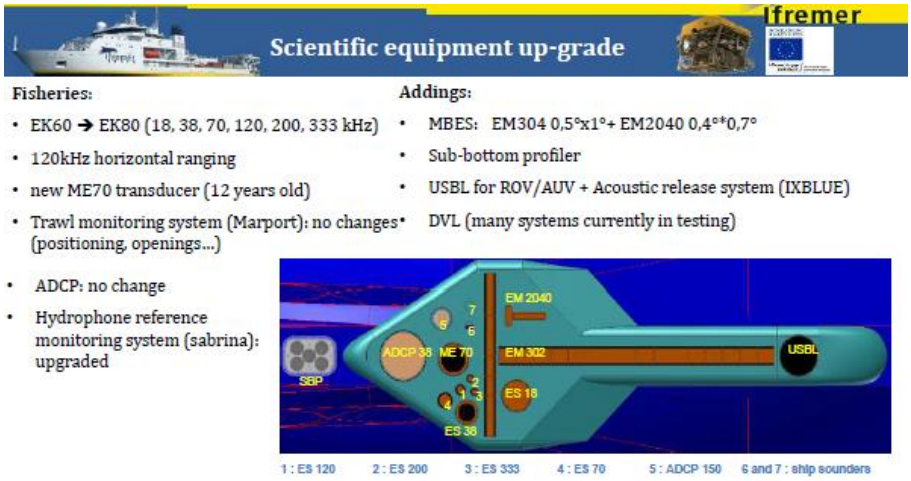


圖 14、Gondola 的各音鼓分布有基本設計規劃

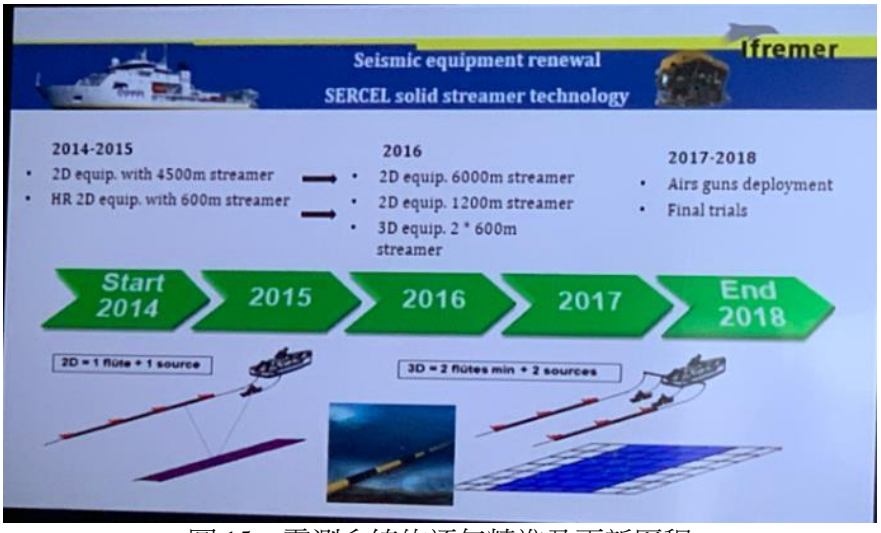


圖 15、震測系統的逐年精進及更新歷程

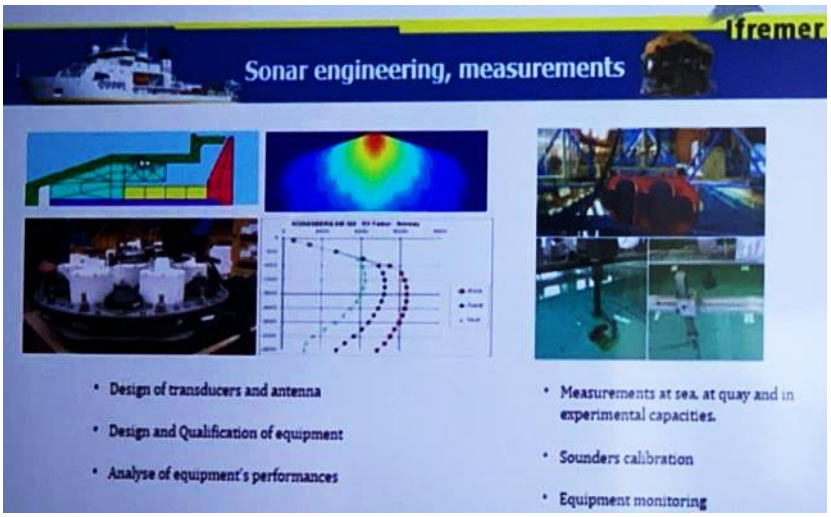


圖 16、研究船上針對運用聲學監測相關的模擬級設計

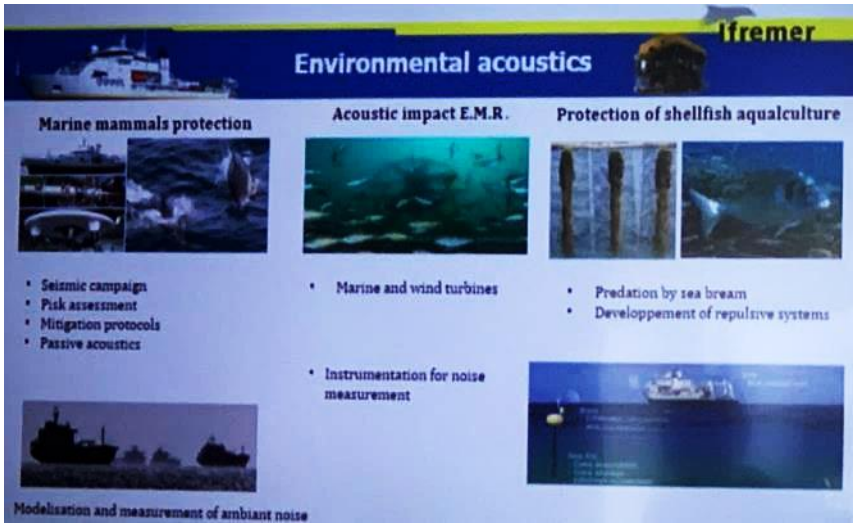


圖 17、預計 2025 年驗收的 45-45m 長新船將具有各項環境聲學監測的功能

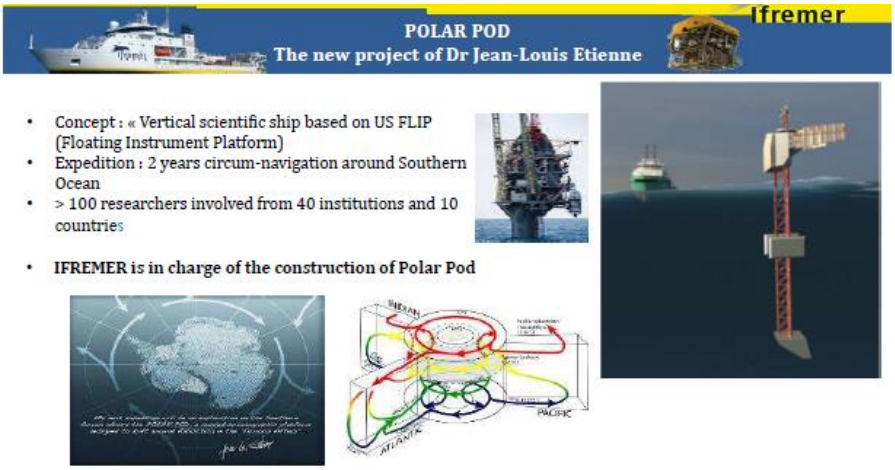


圖 18、運用飄移式平台式船體的設計觀測北極海流

(二) 與法國海洋艦隊營運商 Genavir 交流

簡介：

自 2020 年 1 月 1 日起，Genavir 成為一個以 Ifremer 為股東的公司，是當今法國海洋艦隊的主要運營商。Genavir 是一家通過 ISM*（國際安全管理規範）和 ISO 9001 認證的海上航行公司，是法國航運公司專業協會 (Armateurs de France) 的成員。

Genavir 負責管理、操作和維護沿海和近海船舶，以及各類海上專用於科學研究的設備，如：Nautile 載人潛艇、ROV、AUV、地震設備、長岩心…等。此外，其他海洋探測收集的海洋物理水文及海洋生態環境等數據，該公司還會協助確保資料的採集品質、鑑定和處理。 並且，整體上該公司在聲學研究設備的操作方面擁有領先的專業知識：多音束測深儀、電流計、重力儀、溫鹽計……及其所有電子探測儀器。

Genavir 所屬艦隊遍布全球所有海域，有 226 名為長期聘僱的法國國船員組成，根據探測工作量約聘固定期限的海事人補充，其人才需求涉及所有領域：通用官員、甲板、發動機、電子技術人員以及水手、機械師和酒店員工。Genavir 為同時經營各種水下航行器和科學設備，例如：Nautile 載人潛艇、Victor ROV、Ariane HROV、多頻道反射震測、多音束測深儀等，旗下共有 65 名固定人員（機械師、電子工程師、IT 專家等）可以在執行此設備的任務期間登船/機器並獲取科學數據。

Genavir 在兩個 Ifremer 中心設有兩個部門：在 Brest 是負責船舶行政的總部、軍備和操作指導部所在的地方，也是許多科研設備管理的所在地。另外，在 La Seyne-sur-Mer，則為主要水下航行器實施的運營部門所在地。簡要來說，Genavir 提供海事領域的所有服務，完善組織海上科學航行探測並協助設計科學船隻的項目管理。

交流：

由 Genavir 的總經理 Mrs. Eric DERRIEN 以及研究船運維主任 Mr. Reny BALCON (圖 19)介紹在 Genavir 研究船運維的模式及特色。

- Genavir 提供海事領域的所有服務，負責管理、運營和維護沿岸和近海的各式研究船舶，包含海上科研的各項服務管理。
- 在工程師和相關領域專家組成的專業技術團隊，可以在研究船上達到 24 小時輪替探測不間斷作業模式。此外還有研究人員、即時探測人員以及資料處理人員可以滿足資料妥善收集同步品管的需求(圖 20)。
- 在穩定成熟的運作模式及應對下，疫情蔓延期間所真正影響到的航次天數總共才 48 天。
- Genavir 將收集探測資料以高品質輸出視為研究船服最高宗旨，結合最佳工程師、探測人員、以及電子技師優化探測成果。

圖 19、Genavir 交流討論代表人員

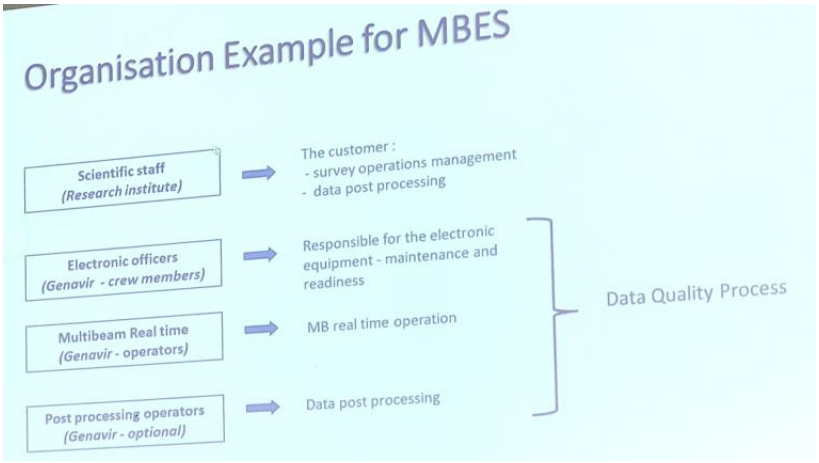


圖 20a

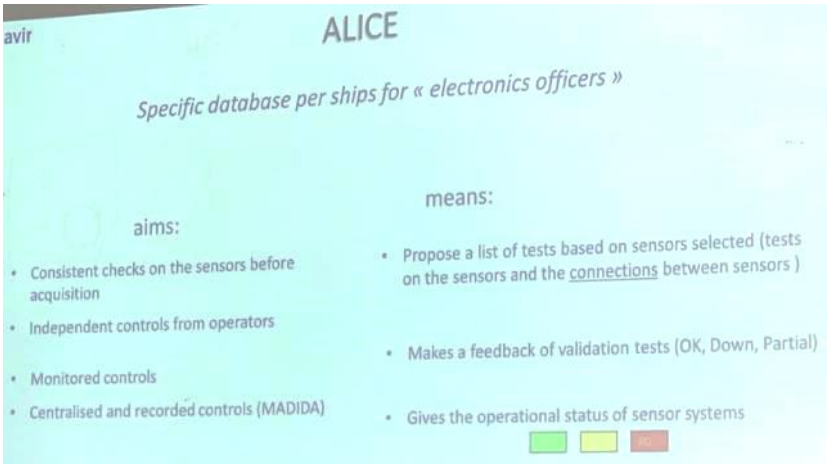


圖 20b

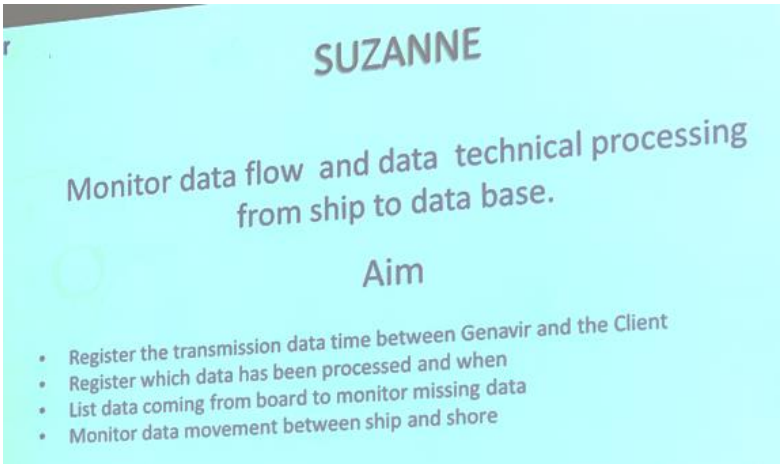


圖 20c

圖 20、就多音束水深任務為例，Genavir 設有研究人員、電子人員、即時探測人員以及資料處理人員，其策略重要目標乃希望在船上資料收集的同時就會有資料採集的品管以及處理的同步任務執行中，下船後就能交出基本處理的成果給研究人員分析使用。

(三) 參訪法國極地研究所(IPEV)

簡介：

法國極地研究所約有 30 名正式員工，負責管理與北極、南極和亞南極島嶼的基礎設施、規劃和物流組織相關的所有業務，有專職行政財務部運維研究所的預算及契約，在北極，這些研究站由一家挪威私營公司管理，一般是由“北極科學行動”部門的人員在夏季加入越冬隊(圖 21)。

研究所運維主由董事會主導，四年輪值一次，負責決定年度運營計劃和相應的預算編列，包括必要時的人員招聘等事項，並有職權任命或招聘極地科學技術計劃委員會 (Council for Polar Science and Technology Programmes, CPST)成員，CPST 主要工作為負責執行計畫的申請審查，評估後地球科學技術價值給極地研究所，成員是根據在極地地區開展的科學計劃的不同參與者中的技能選出的，包含五名與研究所任務相關的主要科學領域的法國專家和五名外國專家。此外，研究所本身，還會就這些項目的實施、研究所的科學和技術行動以及研究所的國際地位提出建議，以建構各項科學和後勤合作政策。

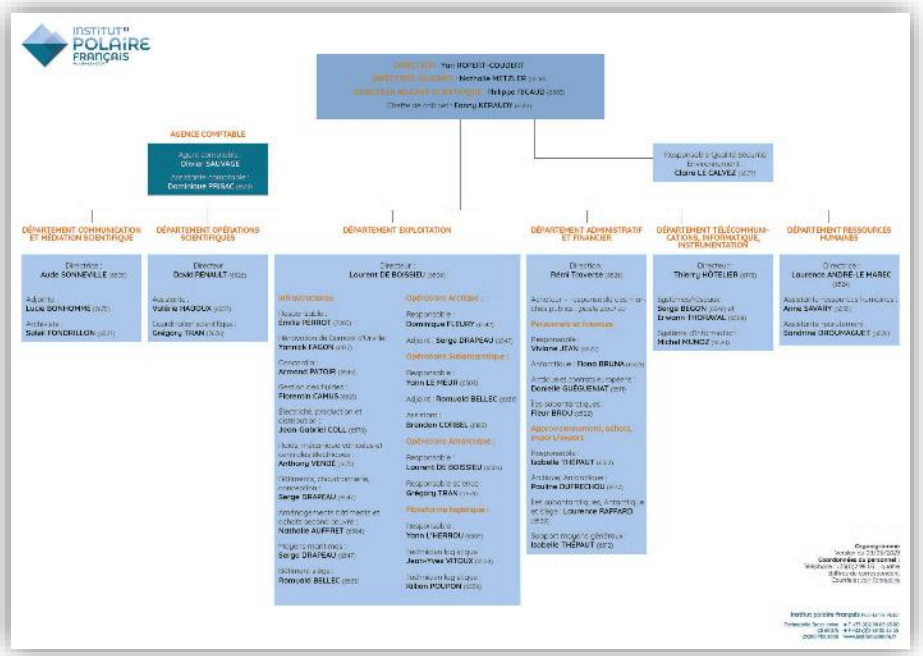


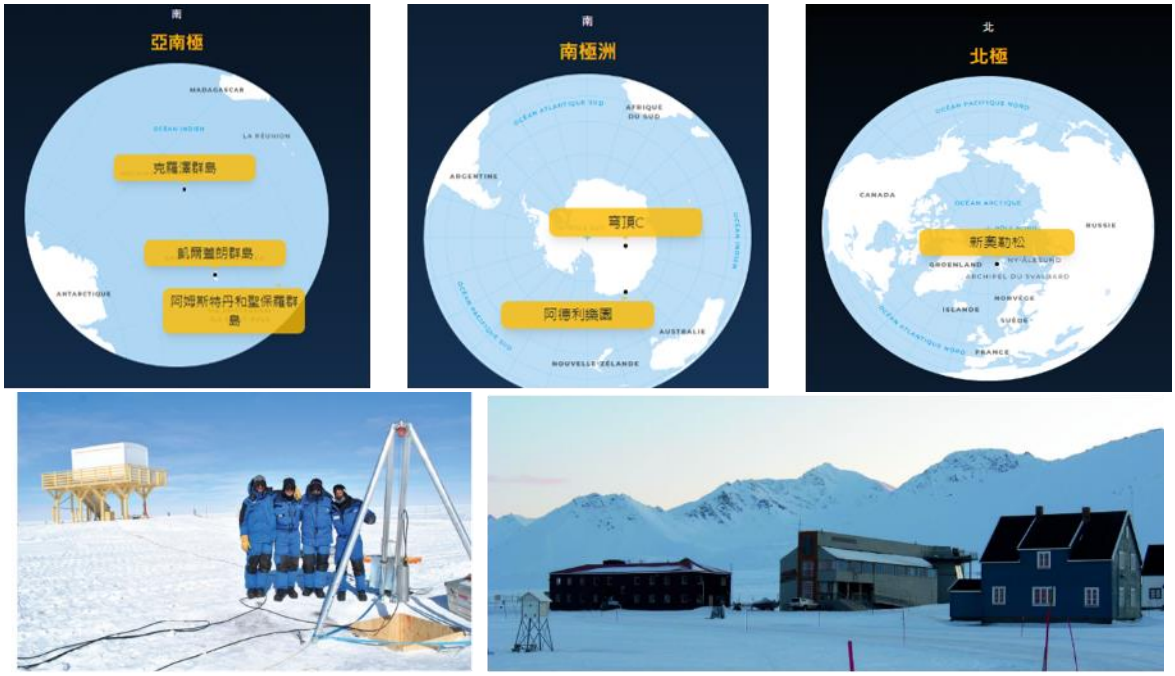
圖 21、法國極地研究所組織成員表(Credit：IPEV website)

交流：

法國極地研究一樓維展示各類極地研究船模型(2020 年已整合至 Ifremer 下) (圖 22)，以及北極研究站的模型(圖 23)，由該中心副主任 Mrs. Nathalie MELZIER 為我們全程解說，讓我們可以直接瞭解極地研究船的外貌形態以及研究站的規模以及設施分布概況。並藉由影片及網站解說該中心於極地研究的經驗(圖 24)，本院亦分享我們在冷岸群島所成立的「臺灣極地研究站，TaiArctic」，以地球物理儀器以及自製海洋資料浮標，對於陸上的冰川、冰震，以及弗洛姆海峽的融冰與海象之探測經驗(圖 25)。

圖 22、曾多次來臺灣執行長岩心採樣作業的 R/V Marion Dufresne 瑪麗安・杜帆妮號

圖 23、該中心所建構的北極研究站模型



斯匹次卑爾根群島屬於北極最北端的群島之一，西海岸的新奧勒松是各種現代北極研究活動的國際中心。

IPEV派駐研究人員在島上放探空氣球、採冰芯、採海水、記錄鳥類、海洋生物等資料採集

圖 24、此北極研究站(AWIPEV)為德國阿爾弗雷德·魏格納極地與海洋研究所 (AWI) 以及法國極地研究所保羅·埃米爾·維克多 (IPEV) 在新奧勒松共同運營的

圖 25、與法國極地研究所交流合照

(四) 參訪法國海洋研究船(R/V Pourquoi Pas?)

簡介：

- Pourquoi Pas? 為 6600 噸，長度達 107.6 公尺的多功能海洋研究船，船東為 **Ifremer**，由營運商 **Genavir** 管理船舶事務，相關科學研究資料由 **Genavir** 執行資料蒐整及品質管控。
- 2005 年由法國海軍出資 45% (5,400 萬歐元)、**Ifremer** 出資 55% (6,600 萬歐元)所協力製造(圖 26)，因此法國海軍每年使用天數約 130-150 天，**Ifremer** 平均使用天數約為 180 天，主要活動領域為大西洋、地中海及印度洋。
- 可容納 40 名科研人員，為多學科應用之船隻，配備可測達萬米水深的多波束測深儀及許多聲學設備及各式實驗室(圖 27)，其所執行任務包含各項海洋物理、水文水質、地球物理、海床測繪、海洋生物、長岩心沉積物採樣、深海救援、以及發射深海潛艇（遙控無人水下載具 Victor 6000 或是有人自主水下載具 Nautile）裝置，能夠於同一航次中搭載兩個潛艇系統或重型設備。

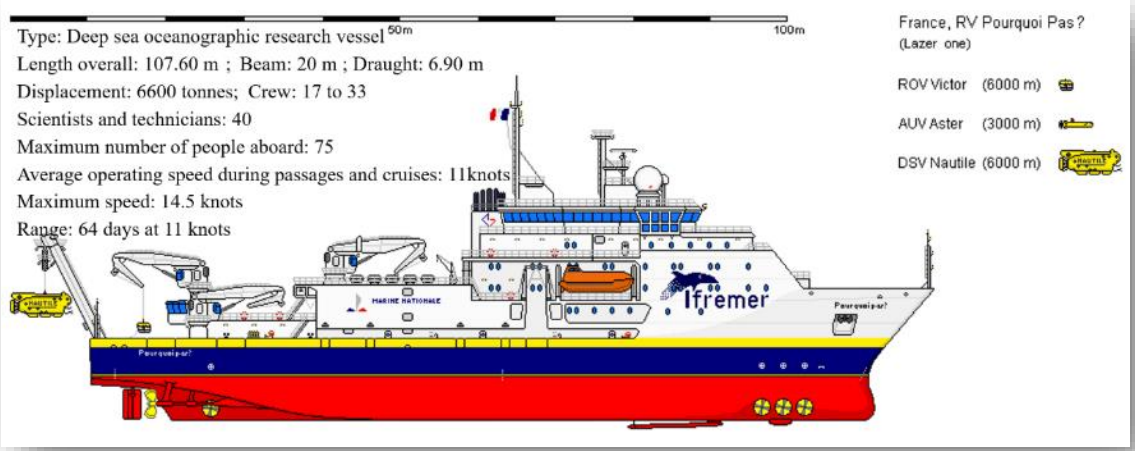
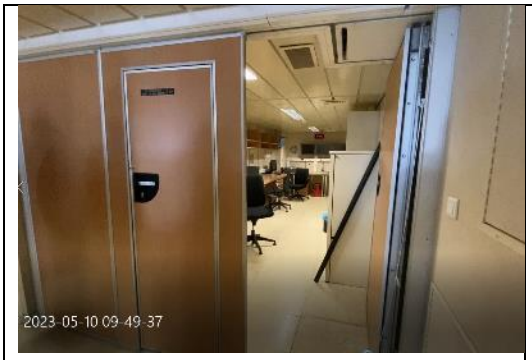
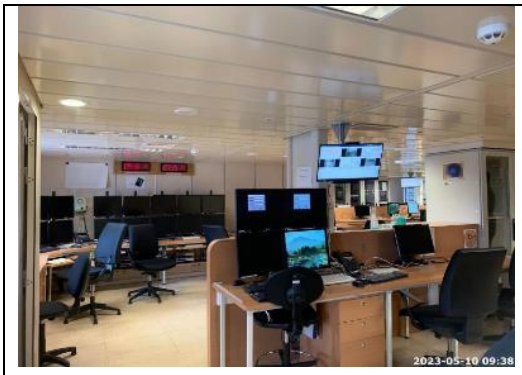


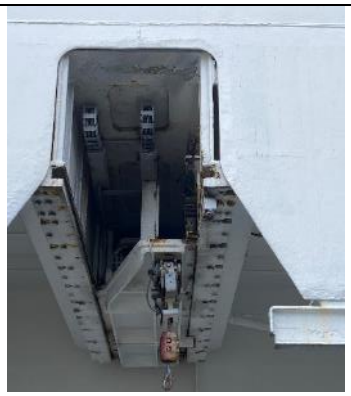
圖 26、Pourquoi Pas? 研究船為海軍與 Ifremer 共同出資建造

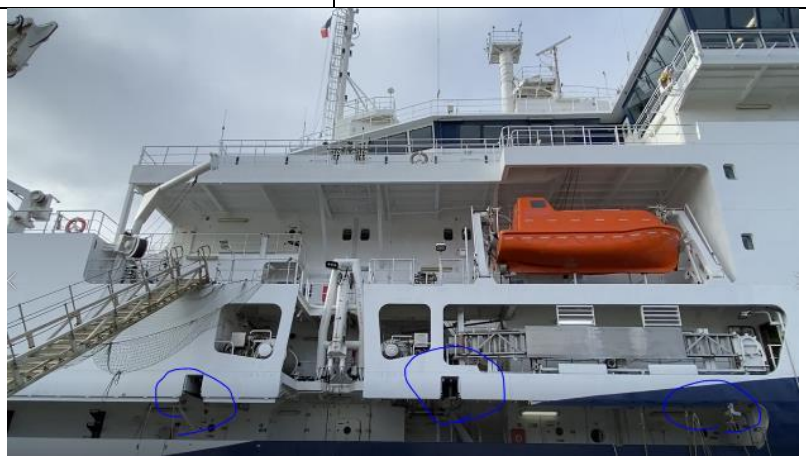
- 全船有 wifi、雷達波段 X 及 S、VHF 輻射計、風速計、DGPS 兩套(導航及科研用)、用 Gonio Argos 400P 的天線、綜合導航系統
- 此研究船是採用 DP2 (DP 2 類製造商 Converteam)，但詢問之下是直接徵召有經驗熟悉操作的人，因此不用特殊訓練就能上手。
- 在該船隊穩定成熟的運作模式及應對下，疫情蔓延期間真正影響到的航次天數總共才 48 天。

	
前駕駛臺	後前駕駛臺
	
駕駛台兩旁延伸設計可使觀察操作	駕駛臺附近的獨立工作小間
	
以可拆式門板組成 ROV 控制隔間	ROV 隔間緊鄰艙門以利掌握艙外狀

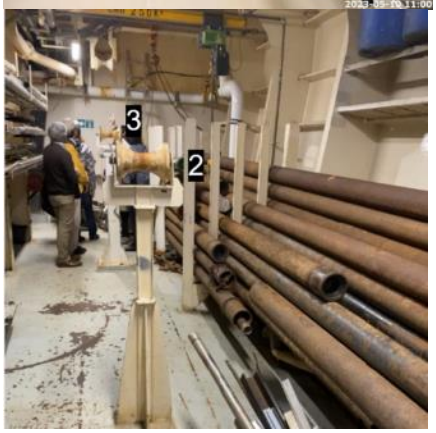
	
任務監看儀控室	資料隔離的機房在儀控室旁邊
	
輕隔間出獨立資料處理空間	乾式水文實驗室(~10 平方公尺)
	
岩心冷藏室	樣品儲放室
	
多用途濕式水文實驗室(~35 m^2)	上有纜線鑽孔用伸縮槑把 CTD 帶進

	
遊戲間	休憩室
	
餐廳	船員及一般研究探測團隊為雙人房
	
首席研究人員單人房	餐廳旁的休閒吧臺
	
月池 moon pool	販賣機

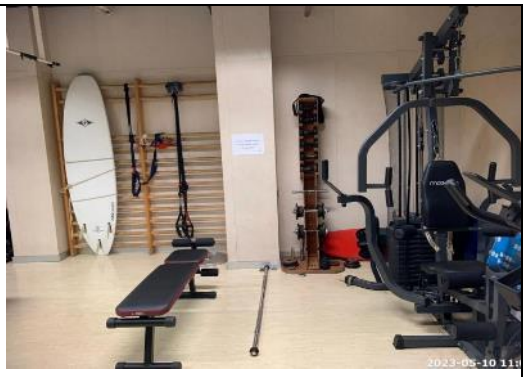




針對長岩心由船側邊吊起及收放所加裝軌道及托繩



運用簡單數個斜排列的滑軌，以高(1)、中(2.3)、低(4)托架將長岩心之外鋼管遞送到主甲板層

	
深海絞機(8000m)	下艙健身房

	
機艙工具間	安靜室(3 臺動態記錄儀,2 臺重力儀)

	
儀器準備室	四台柴油發電機機(1460kW)，兩臺交流電動機(1650kW)，4 個橫向推進器(3 前 1 後)、柴油容量 1233m^3、飲水容量 25m^3

(五) 參訪索邦巴黎第六大學(Sorbonne University) Ocean Knowledge Action Network

簡介與交流：

- Ocean Knowledge Action Network (**Ocean KAN**)致力於跨國海洋科學合作夥伴，以連結國際研究網絡，分享永續海洋理念，協助治理並推動各單位縱橫合作，其與法國塞舌爾大學藍色經濟研究所、臺灣的中央研究院、巴西聖保羅聯邦大學、美國海洋保護協會、加拿大太平洋西北地區的圖拉基金會、加納大學區域研究所都已建立了此類合作夥伴關係 。

- Dr. Linwood Pendleton 是國際知名的海洋政策、環境經濟學者，過往研究強調共同規劃海洋科學以應對氣候挑戰任務，導向科學 (mission-oriented science) 的重要性，必須透過共同規劃 (co-design/ co-production) 科學進行永續科學的規劃與設計，連結終端使用者 (end-user) 與科學家，以開放科學 (Open Science) 方式加以推動，Dr. Linwood 分享許多與臺灣原住民和當地社區合作夥伴的經驗，院長期許我們身為研究與國家重要角色，可以藉由國家海洋研究院的海洋資料庫扮演鏈結角色，在分享收集海域各項資訊的同時，進一步地促進海洋永續研究，並對海域環境關懷做一份貢獻 (圖 27)。

圖 27、在巴黎第六大學討論交流台灣以及世界各國的永續發展現況

(六) 與法國海洋部研究專家 Dr. Gilles LERICOLAIS 及科技部駐法代表與 Dr. Jin-Yi Lin 於台北駐法代表處交流訪談

簡介與交流：

- Dr. Gilles LERICOLAIS 以他曾身處 Ifremer 海洋地質地物研究人員 9 年，以及擔任中央機關(祕書總處的研究事務專家) 3 年海洋科學事務官的經驗，分享目前國際趨勢及法國海洋事務的建構方向(圖 28)。

- 法國海洋部，法國總理府下主管海洋事務的祕書總處，大致以國家海域調查、海事經濟活動、海洋環境維護三個方向為重要任務職掌，除連結海巡功能來建構國家的海洋策略活動。當中組成亦包含法國海洋委員會(The France Ocean Committee, CFO)，委員們在當中扮演著提出專業思維及解決方案的重要角色。

- 法國海洋部整合不同領域專長針對以下海洋環境議題優先著手，包含生物多樣性、水質、海洋運輸、船艦及遊艇、水產養殖技術、可再生海洋能源、海岸人工化、海洋廢棄物、及藍色經濟等相關研究。

- 法國於 2022 年發布首個極地戰略，加強對極地科研全球環境變遷的投入之外，法國總統馬克宏並於該年海洋大會上宣布，法國將申辦 2025 年聯合國海洋大會，以凝聚國際社會的力量正視海洋對氣候變遷的影響，發揮守護海洋生命的作用。

圖 28、在巴黎第六大學討論交流台灣以及世界各國的永續發展現況

三、 心得及建議

- 海洋科研與陸上行政有很大的不同，其組織考量需要不斷挑戰科技研發的可能性，並創造船隊存在的價值外，更要同時考量跨領域、跨國際的整合應用服務，因此機構運營商 (Ifremer) 、技術管理員 (Genavir) 、科學計畫項目負責人(PI)的三方責任權利的平衡，會主導海域調查的分配及成功性。因此，造船過程中船隊的營運及技術團隊位處相當關鍵的位置，本院倘若能夠確定落實此兩團隊後再完成交船或造船配置，將會有利於後續驗收及營運作業，完善調查船建造及船隊的品質。

- Ifremer 旗下各研究船之建造皆為確定任務需求及研究目標後再著手設計，先擬定任務需求後才決定船舶大小及噸位，因此任務需求不會因船型限制而限縮。另，為確實符合研究團隊需求，科儀設備為 Ifremer 自行採購後再由船廠安裝整合，並依照研究船用途全客製化船舶，其規劃設計期程至少需 15 個月來執行需求蒐整、收斂及設計，規劃設計完成後才執行招標建造。本院在設計初步階段或許可以廣納意見，但在建造之前一定要收斂以確保不重蹈新海研船變更設計的覆轍。

- Ifremer 所屬 45%有海軍資源是國家資源，在特定或緊急情況下可能需要執行公共服務任務（尤其是安全、搜索殘骸），優點是經費來源穩固、缺點是部分航次任務可能會有部分要著重軍事相關服務，研究空間限縮，因此機關調查與任務型研究是航期分配需考量的一點。此外，在 Ifremer 海洋研究船上工作的項目負責人，也可能同時是 Ifremer 在職的研究員，可能有機會扮演 PI 與 Ifremer 審議的雙重角色。因此，本院建構的調查船，除了跨域研究的能量眾所矚目之外，公家機關的期許自然也不在話下，如何擬定使用費率以及使用天數的平衡，將是本院船隊運維的另一個重要考驗。

- Future Earth 國際科學計畫是由中央研究院李遠哲前院長擔任世界科學院 (The World Academy of Sciences, TWAS) 院長時推動，是針對全球環境變遷與永續發展的全球性科學平台。未來地球中華民國委員會 (Future Earth Taipei) 由中央研究院永續科學中心協助運作，以對接國際的 Future Earth，促進跨科學 (transdisciplinary)解決方案以及權益關係人參與的永續發展研究，並定期舉行會議，加強與國內外合作夥伴的聯繫和互動，疫情間國際 Future Earth Ocean KAN International Project Office (IPO) 的執行長 Dr. Linwood Pendleton 曾以預錄影片進行視訊連線討論。顯見在我們臺灣已經有部分研究教育單位與 Ocean KAN 有良好的鏈結並時常有實體永續活動不斷安排著(圖 29)，身為國家海洋研究單位之首的研究機構，必須要思考如何在跨學科研究領域中佔領要角，而不是設限於公務人員身分固守城牆、消極參與其他研究單位的各項跨領域推廣活動，才能夠增加國際視野以及掌握鏈結國際的契機。

- 自 2022 年 4 月 5 日法國政府通過首個極地戰略，針對 2030 年部署法國對南北兩極的行動策略，以應對氣候和地緣政治的挑戰，表現法國執行極地研究的決心。當中包含極地研究經費加倍、成立法國籍地基金會(需每年籌集 1000 萬歐元資金)、建立負責極地事務的部際委員會，加強法國在北極理事會的地位、並發起南極冰川風險評估十年項目加強國際合作，以保護南北極地環境及永續發展。當中可以想見的是我們可以藉由與法國或是歐盟的科研合作，往極區靠近，或許可以藉著國際友好以及參與北極的研究，獲得理事會的青睞而成為正式觀察員。

- 法國總理府下主管海洋事務的祕書總處自然應接著相關思維，以科研角度位國家提出策略研究方針。Dr. Gilles LERICOLAIS 介紹法國海洋政策綱領內容，最不可忽視的重點仍是法國欲實驗海洋脫碳的決心，由理解海洋影響氣候變化、以至於影響到地球上各物種，法國早已體認到保護海洋的成本是相當可觀的。因此，Dr. Gilles LERICOLAIS 以及 Dr. Jin-Yi Lin 提醒我們，馬克宏已宣布要聯合哥斯達黎加一起申辦組織 2025 年的聯合國海洋大會，或許藉由法國的邀請可以是一次臺灣鏈結參與國際海洋策略的一大契機。

圖 29、2023 年 5-6 月間國際永續活動在臺灣的倡議活動

其他交流照片

院長向 Ifremer 代表贈禮

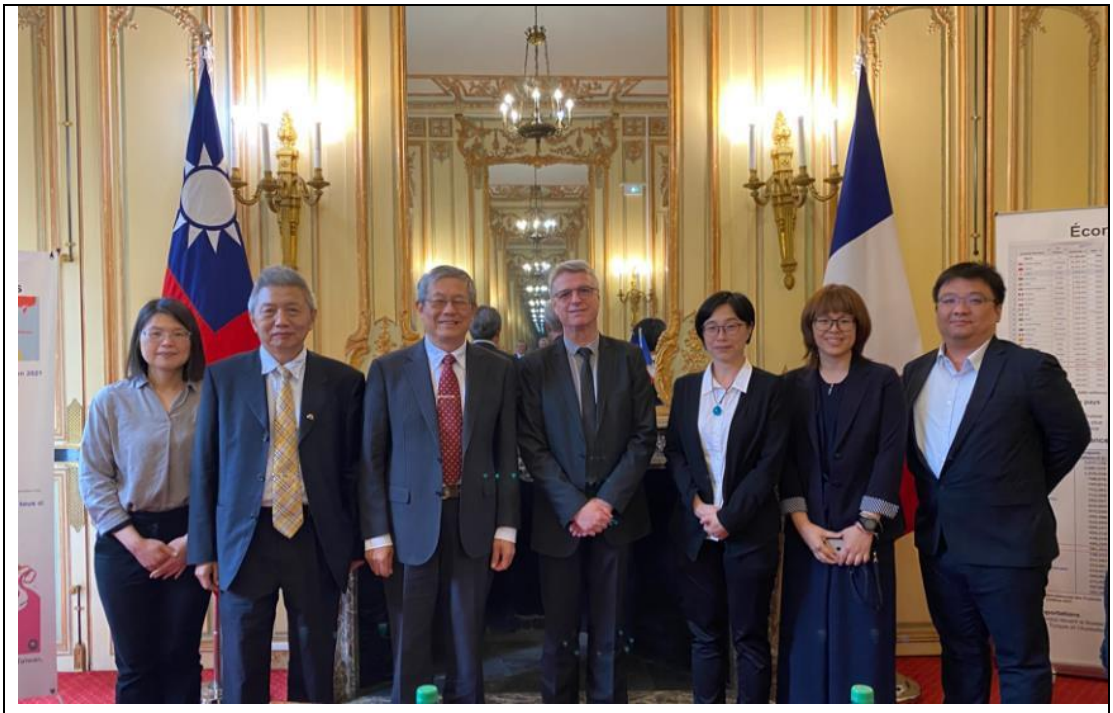
SOIC 向 Ifremer 代表贈禮

與 Genavir 互相贈禮合照

研究船上的贈禮

參觀完研究船的團體照

與 Dr. Linwood Pendleton 的互相贈禮交流照片



於駐法代表處同仁的合影及參敘

附錄 (摘錄報告)

- 法國海洋研究船隊簡介

IMAGINONS LA FLOTTE OCEANOGRAPHIQUE FRANCAISE A L'HORIZON 2035

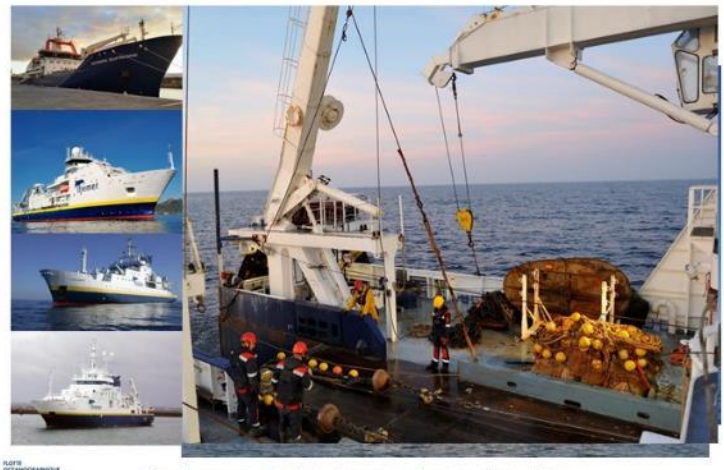
The French Oceanographic Fleet

OLIVIER LEFORT
DIRECTOR

IMAGINONS LA FLOTTE OCEANOGRAPHIQUE FRANCAISE A L'HORIZON 2035

Key figures

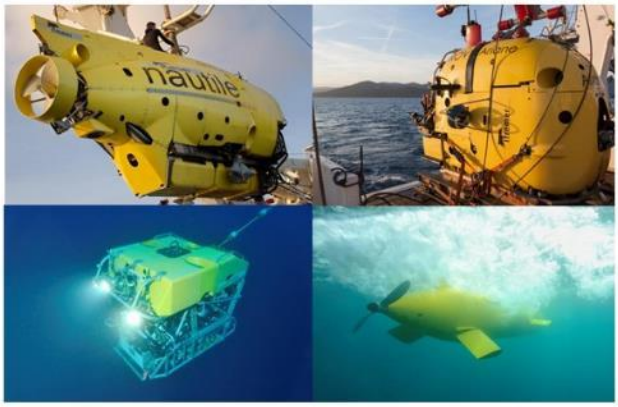
Four ocean-going vessels

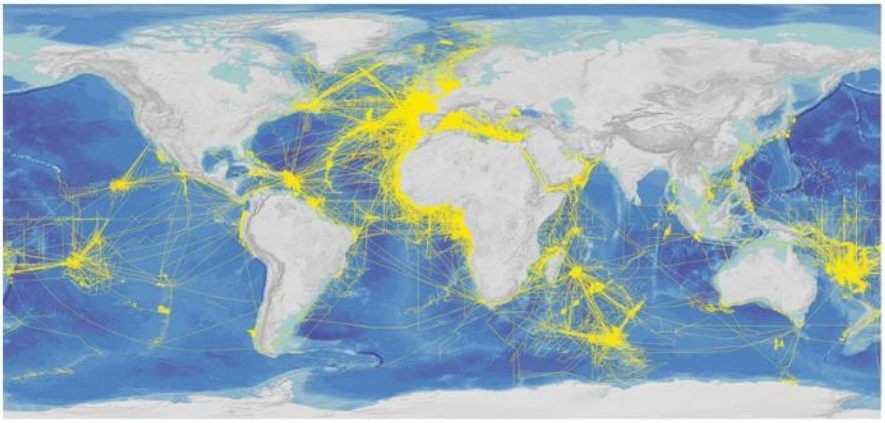


One regional vessel operating in West Pacific

Five coastal vessels and seven station vessels operating in mainland France.

World-class submarine systems.

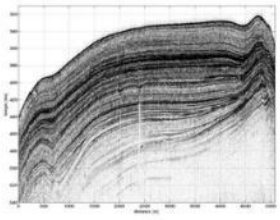




Trajets des campagnes effectuées par la Flotte océanographique française depuis 1929 (© Gebco, 2014)

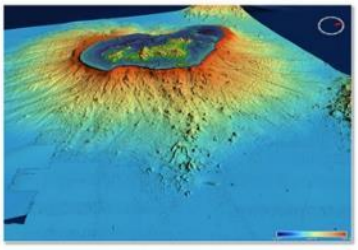
Facilities at the service of various scientific subjects on all the oceans

Seismic. Imaging the seabed several kilometres deep to learn about the mantle and its deformations: seismic risks (societal) / tectonics (research).

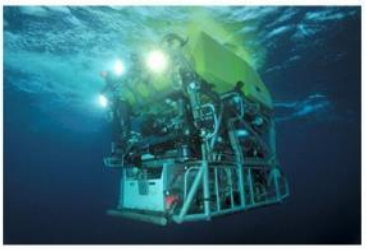


Profil sismique obtenu avec un sondeur de sédiments

Core drilling. A 69.7 m core like the one acquired during the Crotale campaign in 2019 makes it possible to trace the parameters of the climate over 1 million years, i.e. several climatic cycles, and thus to make progress in understanding the link between the climate and CO_2 sequestration.



Levé bathymétrique du volcan de Mayotte



Victor6000

Bathymetric sounders and AUVs. Multi-scale mapping, bottom facies (geology, preparation of ROVs dives..), but also hydrographic work.

HOV (Nautile) and ROVs. Tools for working on the bottom to take samples (geology, mineral resources, deep environment).

Work in the water column.
The acquisition of physico-chemical and biological parameters makes it possible to measure the evolution of the CO2 pump in the Southern Ocean or to quantify the evolution of the Gulf stream and its associated branches by deploying moorings, carousels and CTDs.
The use of depth sounders in the water column makes it possible to evaluate fish stocks or biomass (plankton), or even identify plumes (gas hydrates, etc.), or to measure currents.

Atmospheric measurements. The installation of atmospheric sensors on a ship such as the Marion Dufresne will enable the acquisition of experimental data on the ocean-atmosphere interface in the Southern Ocean in order to validate the models.

Campagne OISO sur le Marion Dufresne

Campagne WACS, affleurement d'hydrates de gaz

A unified French oceanographic fleet now operated by Ifremer alone

Previously operated by CNRS, Ifremer, IRD and IPEV, TGIR has been operated by Ifremer since 1 January 2018.

The Oceanographic Fleet Directorate (DFO, 85 people), manages the infrastructure.

- At the interface with the scientific teams, the Pôle Opérations Navales (PON) makes it possible to submit campaign requests, plans the campaigns, ensures that they are carried out and assesses their quality a posteriori.
- With a large R&D capacity, the Ships and Embedded Systems (NSE) and Submarine Systems (SM) units are in charge of carrying out construction and modernization projects for ships and submarine systems, and acquiring and developing the scientific and IT equipment needed to collect, bank and process the data acquired.

Once the ships and equipment have been purchased, developed or built, most of them are entrusted in operation to **Genavir** (330 people, including about 210 sailors), which is responsible for preparing, organizing and carrying out the campaigns in the naval resources programme drawn up by the DFO.

Genavir is also in charge of the acquisition and validation of scientific digital data collected during the campaigns, which it then transmits to Ifremer's Scientific Information System for the Sea (SISMER).

The **CNRS** (DT-INSU), arms and operates the station ships which are distributed on the French mainland.

Louis Dreyfus Austral Seas (LDAS), is the owner of the Marion Dufresne on behalf of the TAAF. Ifremer sub-charters this vessel to the TAAF for 217 days per year during 3 predefined time slots. The management of the vessel's scientific equipment is entrusted to Genavir, which also acts as Ifremer's representative on board the vessel.

Successes based on R&D teams and a culture of innovation

Ulyx. An innovative 6000m AUV, which is currently undergoing its first trials, capable of self-adaptation (return to identified targets, for more detailed surveys for example). A first in scientific AUVs that prefigures systems with embedded intelligence.

L'AUV 6000 m Coral

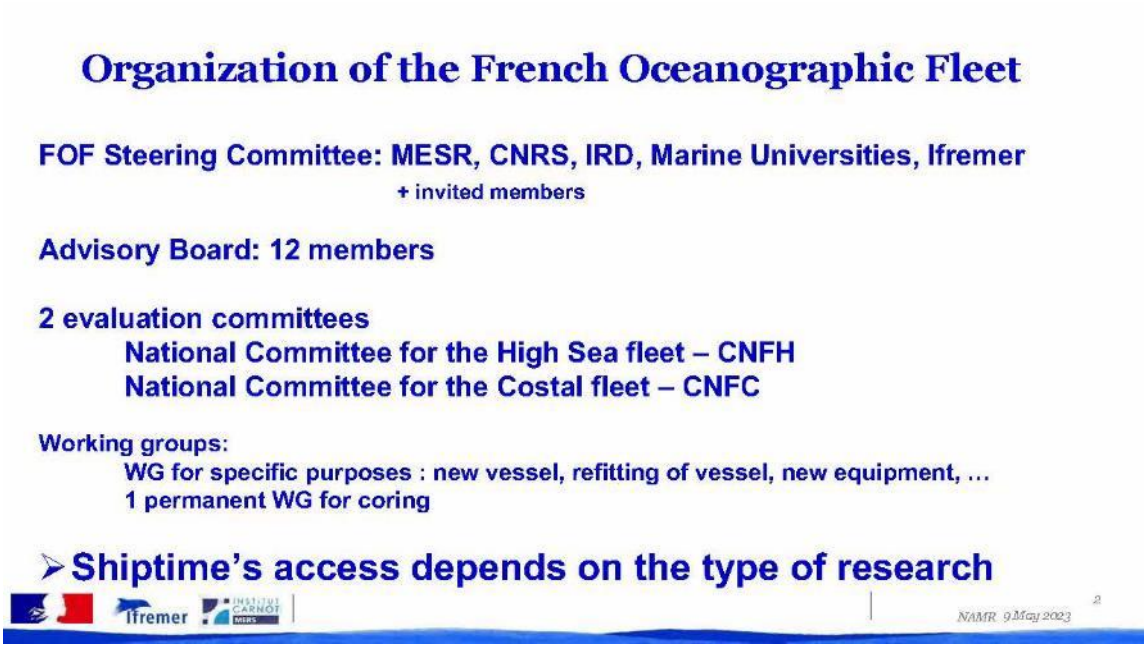
Campaigns of the future. Telepresence, immersive dives and multi-engine scenarios including Ulyx, and multi-engine working configurations capable of communicating with each other (optical communications under development).

A capacity to support the use of scientific equipment based on R&D (use of reflectivity for bottom detection, etc.).

Campagne Telepresence à bord de L'Europe

IZON 2035 IMAGINONS LA FLOTTE OCÉANOGRAPHIQUE FRANÇAISE À L'HORIZON 2035 IMAGINONS LA FLOTTE OCÉANOGRAPHIQ

➢ 研究船隊與科研團隊的相關性

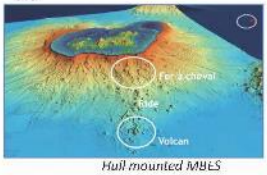


Access to ship-time of the French Oceanographic Fleet-1

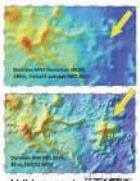
research to support the public policy: no evaluation but must be partially funded

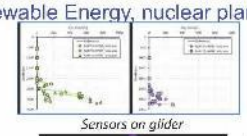
- fishes stock estimation
- EEZ extension (UNCLOS rules)
- environmental monitoring for Marine Renewable Energy, nuclear plant
- monitoring of a new submarine volcano

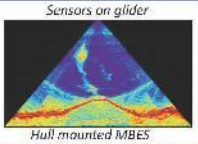
…



Hull mounted MBES


AUV mounted MBES


Sensors on glider


Hull mounted MBES


Camera on ROV


©ifremer


©REVOSIMA

research in cooperation with industry: no evaluation but must be partially or totally funded and coherent with our roadmap

- development of sensor or methodology, geological or biological environnments on margins, …

Access to ship-time of the French Oceanographic Fleet-2

scientific, teaching or technological researches: evaluation but free if successfull

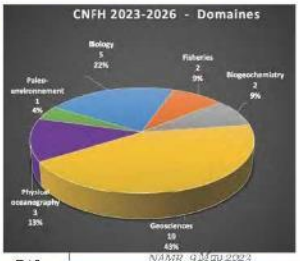
1 tender each year ; opened to the French scientific organims

2 evaluation committees of 23 members from various disciplines and organisms

National Committee for the High Sea fleet – CNFH
National Committee for the Costal fleet – CNFC

Two main actions

- **ranking and selection of proposals thanks to external reviews**
- **assessing the scientific valorisation 4 years after the survey**



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A proposal is a long and complex process

Proposal to CNFH tender of year N:

tender 2023: deadline in September 2023, result in December 2023

Proposal Priority 1: could be scheduled between N+2 to N+4 (2025-2027)
Proposal Priority 2: could be scheduled only N+2 (2025)
Proposal Rejected: could re-submitted next year

The year of the realisation of the survey depends on DFO

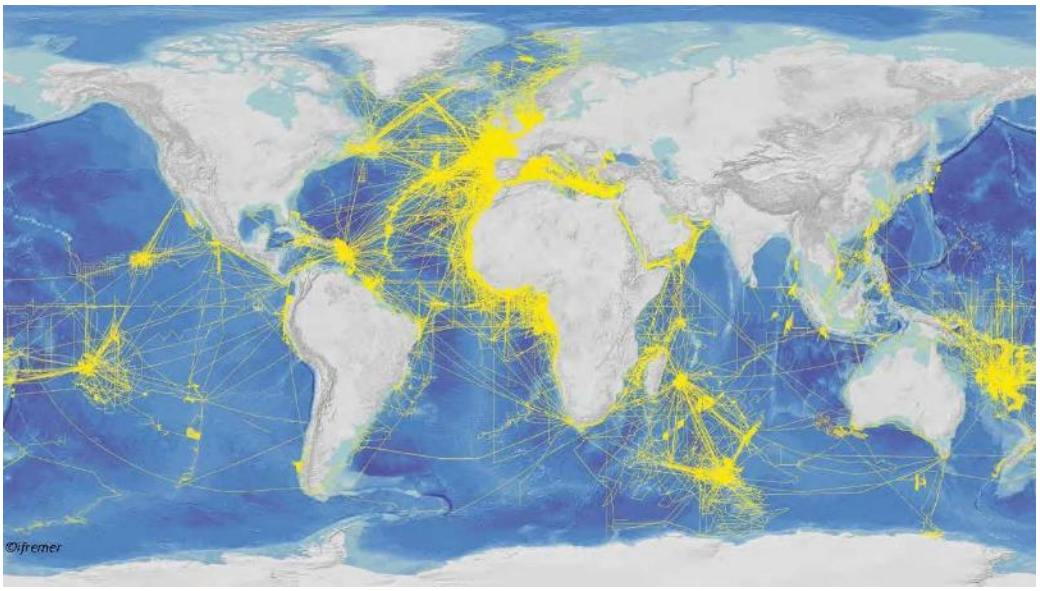
between N+2 to N+4
scientific team must find additional founds: travel, analysis, PhD, …

Results and publications:

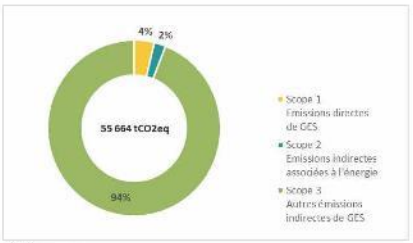
within 2 to 6 years after the survey ie between N+4 to N+10
peak of publications is 5 years after the survey

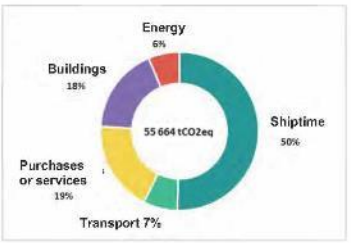
➢ **Highsea survey: 1 month of work at sea within a 10 years process**

Proposal preparation
CNFH tender
Survey préparation
Survey
post-survey



2019 Ifremer Greenhouse Gas Budget





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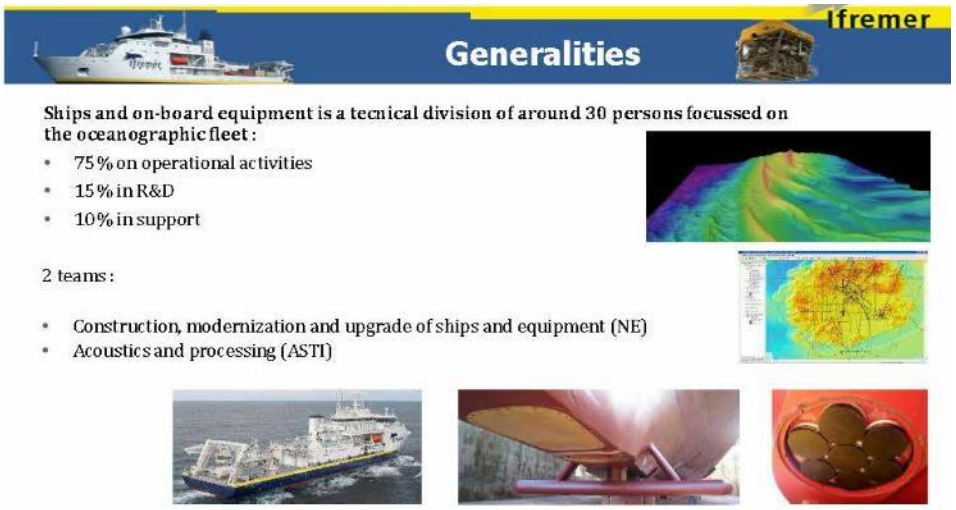
Important issue for the fleet: shiptime represents 50% of the CO2 budget

FOF launched a one year consultation of the French scientific community to define the fleet of the futur

➢ Ifremer 船載科儀介紹



Main constructions & modernizations

Ifremer

Construction

Pourquoi pas? 2005

Polar Pod – 2024/2025

New multipurpose vessel around 40m - 2025

Modernization

Atalante 2008-2009

L'Europe - 2014

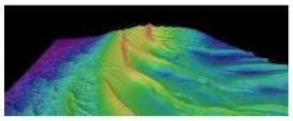
Thalassa - 2017

Pourquoi pas? 2024-25

Perimeter

Ifremer

- Scientific equipement (sonars, coring,..)
- Informatic (server, network, data storage,..)
- Acquisition and visualisation software
- Data processing software
- Telecommunication
- Acoustics (sonar systems, transducers, measurementss,..)



Mid life R/V Thalassa refit

Ifremer

RV Thalassa

- Built in 1996
- Length : 73,6m
- Width : 14,9m
- Disp. : 3022t

Modernization

- Project cost : 17 M€ - Britany region, ANR and FEDER
- Shipyard : PIRIOU NAVAL SERVICE – Concarneau, France
- Dry dock : June 3th – Sept 18th 2017
- Trials : until Oct 2th 2017

Discussions with shipyards (Autumn 2016) → Choice of the Shipyard (December 2016) → Studies (Jan-June 2017) → Works (June-Sept 2017) → Sea Trials (Sept 2017)

Objectives

The R/V Thalassa is an oceanographic ship mainly dedicated to the missions of public service in the field of fish **stock assessment** and physical oceanography.

The aim of this modernization is to enlarge the capacity of the vessel in the fields of **marine geosciences** and deep sea environment.

The objectives of the modernization are:

- to ensure the remedial and curative maintenance at mid-life of the vessel,
- to modify vessel accommodation,
- to replace all obsolete scientific equipment by up-to-date ones,
- to provide a reliable and efficient platform appropriate to the coming 20 years of marine science.

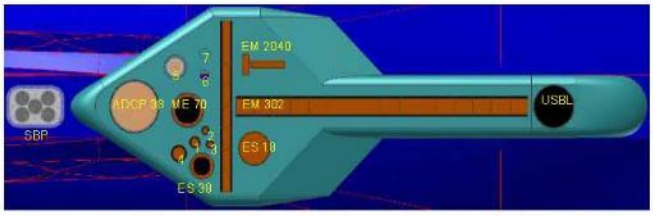
Scientific equipment up-grade

Fisheries:

- EK60 → EK80 (18, 38, 70, 120, 200, 333 kHz)
- 120kHz horizontal ranging
- new ME70 transducer (12 years old)
- Trawl monitoring system (Marport): no changes (positioning, openings...)
- ADCP: no change
- Hydrophone reference monitoring system (sabrina): upgraded

Addings:

- MBES: EM304 0,5°x1°+ EM2040 0,4°*0,7°
- Sub-bottom profiler
- USBL for ROV/AUV + Acoustic release system (IXBLUE)
- DVL (many systems currently in testing)



The new fairing

No gondola => same draft kept

A fairing under the keel

Large maintenance

- New gensets – Caterpilard 2*1500KVA & 2 * 1000 KVA
- New main propulsion converters (Thyristors to IGBT),
- New Power Management System (PMS)

- Sheep steel central trawl track replace by a new one (10mm has reduced to 7mm)

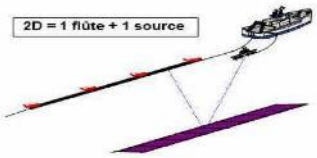
Seismic equipment renewal
SERCEL solid streamer technology

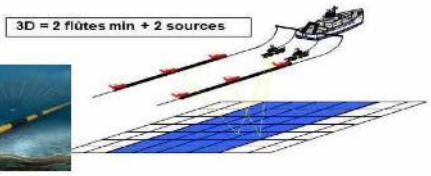
2014-2015
- 2D equip. with 4500m streamer
- HR 2D equip. with 600m streamer

2016
- 2D equip. 6000m streamer
- 2D equip. 1200m streamer
- 3D equip. 2 * 600m streamer

2017-2018
- Airs guns deployment
- Final trials

Start 2014 → 2015 → 2016 → 2017 → End 2018

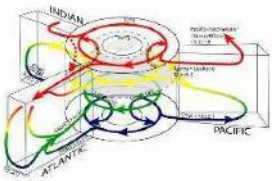




POLAR POD
The new project of Dr Jean-Louis Etienne

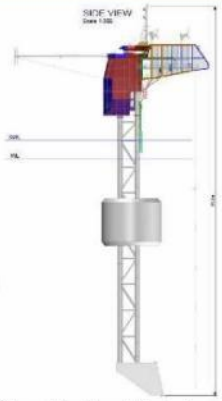
- Concept : « Vertical scientific ship based on US FLIP (Floating Instrument Platform)
- Expedition : 2 years circum-navigation around Southern Ocean
- > 100 researchers involved from 40 institutions and 10 countries

- **IFREMER is in charge of the construction of Polar Pod**



POLAR POD

- 22m length
- 80m draft
- 60m air draft
- 1000 t
- 8 persons
- <1,5 knts drift speed
- 4 wind turbines (2,5 kW)
- Emergency DA
- Emergency propeller (200 kW)



Towed horizontally to the gyre

Environmental conditions

- Mean wind : <65 knts
- Gust : 136 knts
- Max waves Hs=19 m

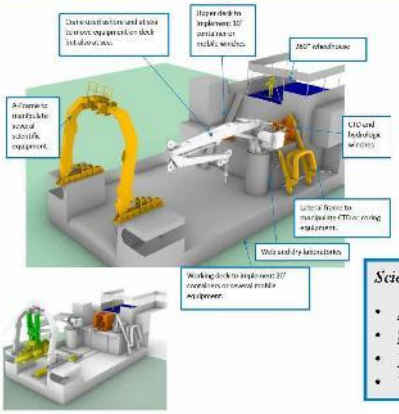
New regional vessel

- New regional research vessel planned for mid-2025.
- Middle length between 35 to 45 m,
- 22 person on board including seamen.
- Multidisciplinary scientific campaigns (hydrography, oceanography, geochemistry, submersibles deployment, seismic acquisition, fishering…).
- Main operations: Atlantic ocean, Channel and West Indies punctually .

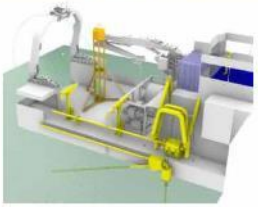
Project

- Objectives: - most flexible and modular than possible.
  - most compact than possible
  - reduce CO2 emission, up to 30-50% compare to a classic design
- Planning: - ongoing purchase procedure
  - Signature with shipyard : being of 2023
  - Middle of 2025: vessel ready for scientific campaigns.

New regional vessel



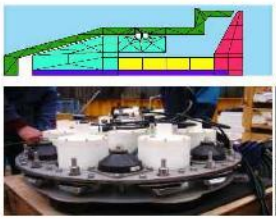
Deck objectives



Scientific equipment – to be confirmed

- ADCP : 75 and 300 kHz.
- Single beam ES : several frequencies of EK80
- Multi beam ES : EM712 1°x 2° or 1° x 1°
- Various others equipment for laboratory – pocket ferrybox, SBE21 …

Sonar engineering, measurements

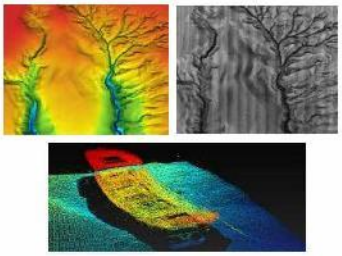


- Design of transducers and antenna
- Design and Qualification of equipment
- Analyse of equipment's performances

- Measurements at sea, at quay and in experimental capacities.
- Sounders calibration
- Equipment monitoring

Sonar data processing and R&D

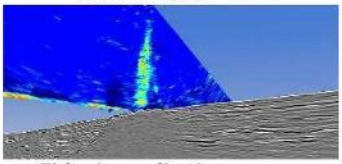
Bathymetry and backscatter



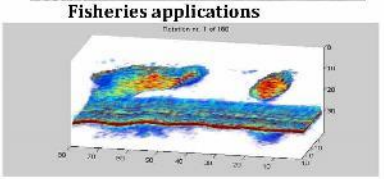
- Detection of gas
- Fusion with hathymetric and seismic data

- Estimation of biomass
- Species identification

Water column



Fisheries applications



- **Multi sensors processing software development GLOBE – In progress**

Environmental acoustics

Marine mammals protection

- Seismic campaign
- Risk assessment
- Mitigation protocols
- Passive acoustics

Modelisation and measurement of ambiant noise

Acoustic impact E.M.R.

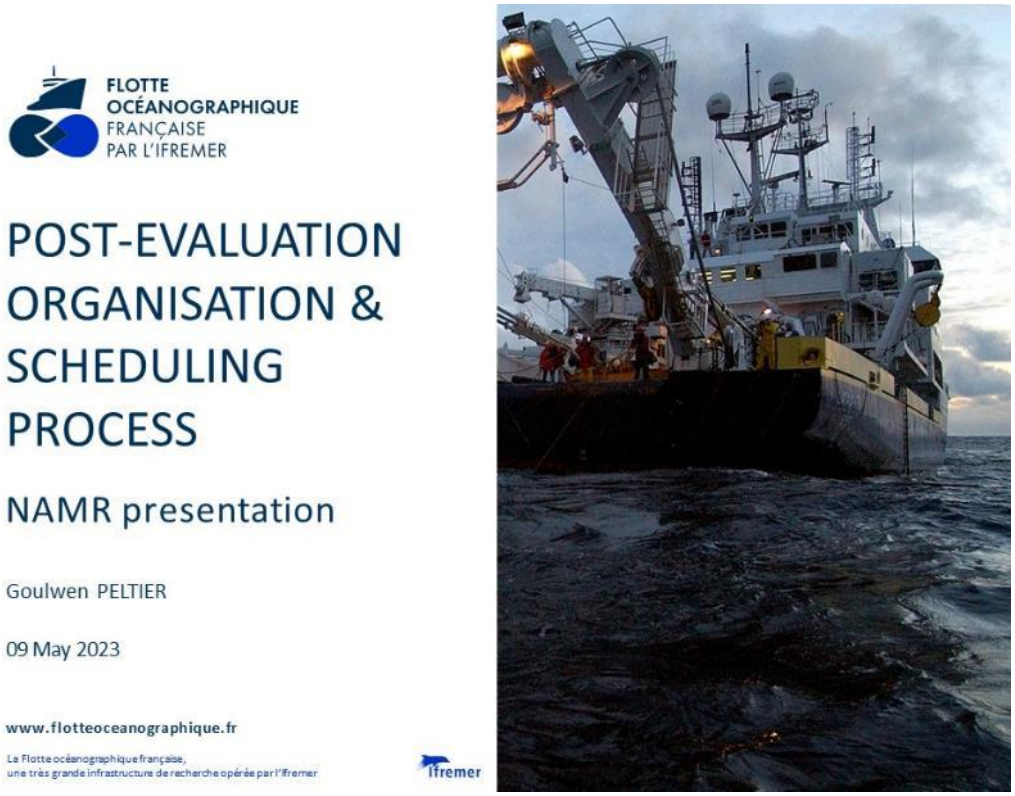
- Marine and wind turbines

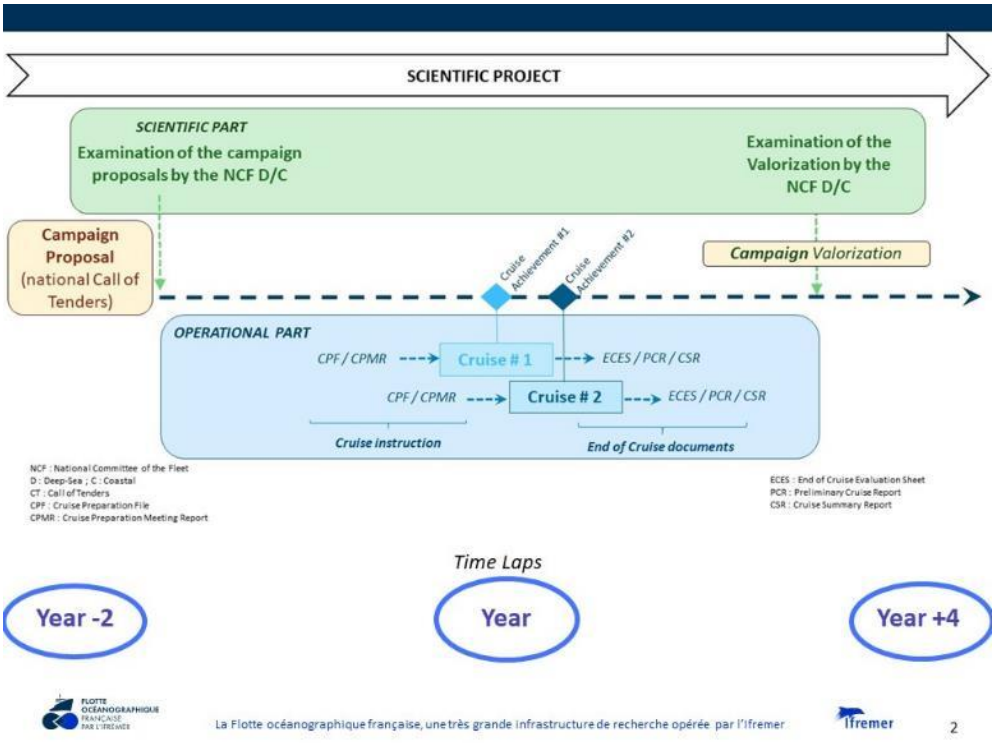
- Instrumentation for noise measurement

Protection of shellfish aqualculture

- Predation by sea bream
- Developpement of repulsive systems

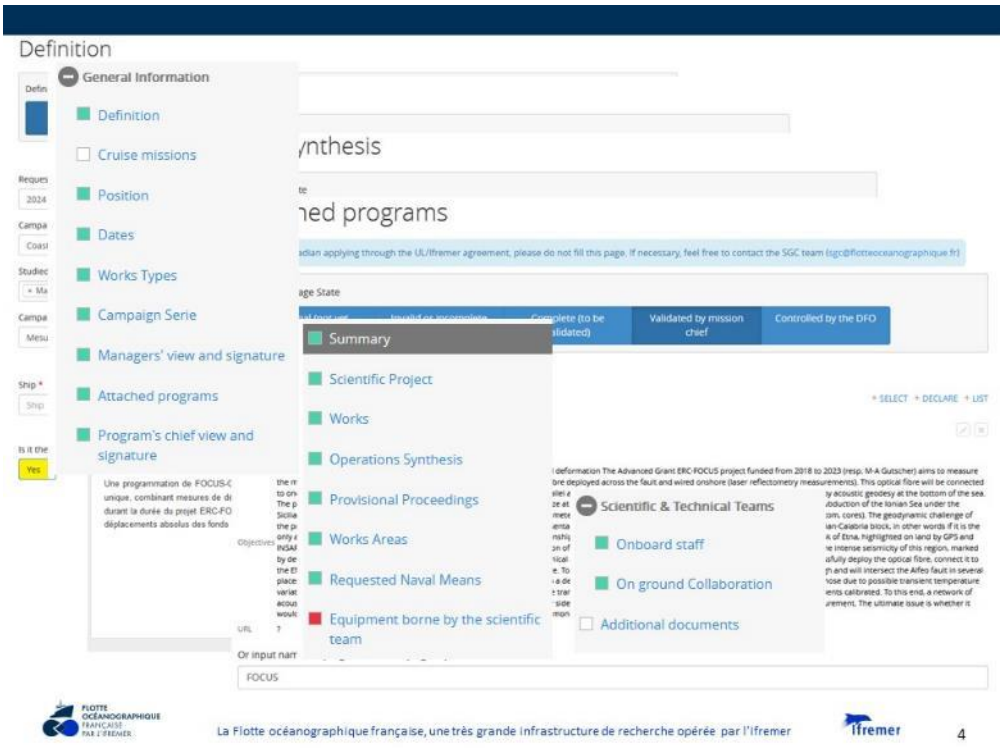
➢ Ifremer 研究航次規劃安排介紹

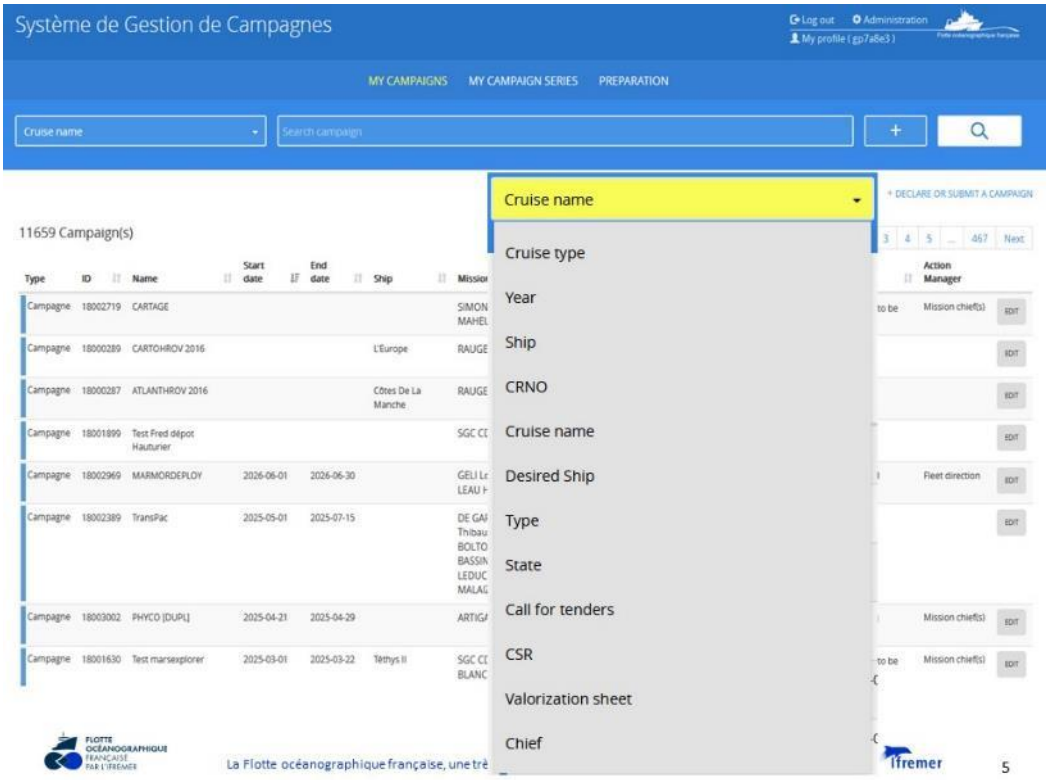




SGC : Système de Gestion des Campagnes
Campaign Management System

- A Workflow for the whole campaign, from the proposal to the valorization
- A semi-automatized system helping for the cruise treatment
- Interfaced with our planning software : Visual Planning
- Automaticaly saving cruises history
- Data collected processed, qualified then directly sent to the National database for cruises : SISMER (Système d'Information Scientifique pour la MER)
  = *Scientific Information Systems for the Sea*


Definition
General Information
Definition
Cruise missions
Position
Dates
Works Types
Campaign Serie
Managers' view and signature
Attached programs
Program's chief view and signature
Summary
Scientific Project
Works
Operations Synthesis
Provisional Proceedings
Works Areas
Requested Naval Means
Equipment borne by the scientific team
Scientific & Technical Teams
Onboard staff
On ground Collaboration
Additional documents
Validated by mission chief
Controlled by the DFO
FOCUS
La Flotte océanographique française, une très grande infrastructure de recherche opérée par l'Ifremer
4


Système de Gestion de Campagnes
MY CAMPAIGNS
MY CAMPAIGN SERIES
PREPARATION
Cruise name
11659 Campaign(s)
Cruise name
Cruise type
Year
Ship
CRNO
Cruise name
Desired Ship
Type
State
Call for tenders
CSR
Valorization sheet
Chief
5

Campaign Instruction

Once the evaluation is passed (P1 : achieavable for three years i.e. Y, Y+1, Y+2 / P2 : achievable for one year i.e. Y), all details of each cruise are examined in terms of their diplomatic & operational constraints, their requirements, and the adequacy of the FOF's resources to meet them.
Such can concern:

- Diplomatic requests : Depending on the work area (French of foreign EEZ) some special requirements can happen such as scientific collaboration, MoU, Foreign observers on board, acoustic evaluation and impact mitigation on mammals, ...

→ **Anticipation time up to 1,5 years before sending work permit request (minimum 8 months before cruise)**

- Acoustic constraints : Some works may hamper mammal lives, specially in migration areas, constraining the time of less acoustic impact (ASTI assessment)
- Technical & operationnal constraints : Finding the best tool for the best data collection. Finding the best mean to achieve the scientific requirements (one multidisciplinary cruise, or several monodisciplinary cruises)
- Scientific temporal constraints : Some cruises must be achieved at specific times (bloom, bad weather), some students, part of the scientific program, will leave their functions, ...
- Geographical criteria : some cruises far away shall be part of an optimized tour ...
  → Carbon impact ! (eco speed...)

Schedule construction

The FOF objectives are, per year :
450 day on Deep Sea Vessels / 960 days on Regional and Coastal Vessels

When all details are known, a first attempt of schedule is set, including Navy time, fishery surveys, dry docks, charters, etc...
If needed, exchanges are made between the ship operation department and the PIs in order to fit on technical and operationnal arrangements.
Informal exchanges are made with our subsidiary and operator of the FOF vessels Genavir to light as much as possible how operational constraints can be overcome.

→ Spring of Y-1

Genavir then reply with their comments (crew repartition, logistical delays,...) and offer a general quotation for the whole schedule (apart Marion Dufresne).

→ Early Summer

Exchanges continue in order to converge with financial limitations and scientific expectations.

→ Early Fall

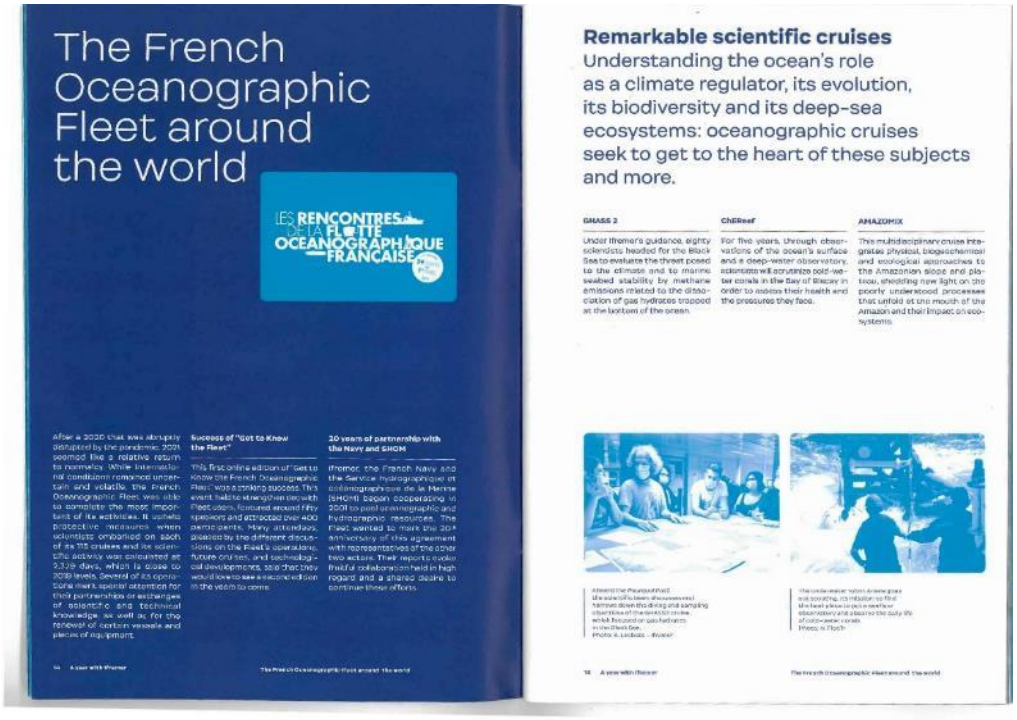
Finally the schedule in contracted once the funding is granted by the Ministry.

→ Early Winter Y-1

... Then Genavir assume the achievement of the schedule, refering to the ops Dept and the PIs...

Finally we collect feedbacks to monitor the quality of the cruise achieved.

➢ Ifremer 年報研究亮點



The French Oceanographic Fleet around the world

LES RENCONTRES DE LA FLOTTE OCEANOGRAPHIQUE FRANÇAISE

Success of "Get to Know the Fleet"

This first online edition of Get to Know the French Oceanographic Fleet was a striking success. This event held to strengthen the with Fleet users, featured around fifty speakers and attracted over 400 participants. Many attendees, disabled by the different discussions on the Fleet's operations, future cruises, and technological developments, so that they would love to see a reconnection in the years to come.

30 years of partnership with the Navy and SHOM

Ifremer, the French Navy and the Service hydrographique et océanographique de la Marine (SHOM) began cooperating in 2001 to pool oceanographic and hydrographic resources. The Fleet wanted to mark the 20th anniversary of this agreement with representatives of the other two actors. Their reports evoke fruitful collaboration held in high regard and a shared desire to continue these efforts.

Remarkable scientific cruises

Understanding the ocean's role as a climate regulator, its evolution, its biodiversity and its deep-sea ecosystems: oceanographic cruises seek to get to the heart of these subjects and more.

GHASS 2

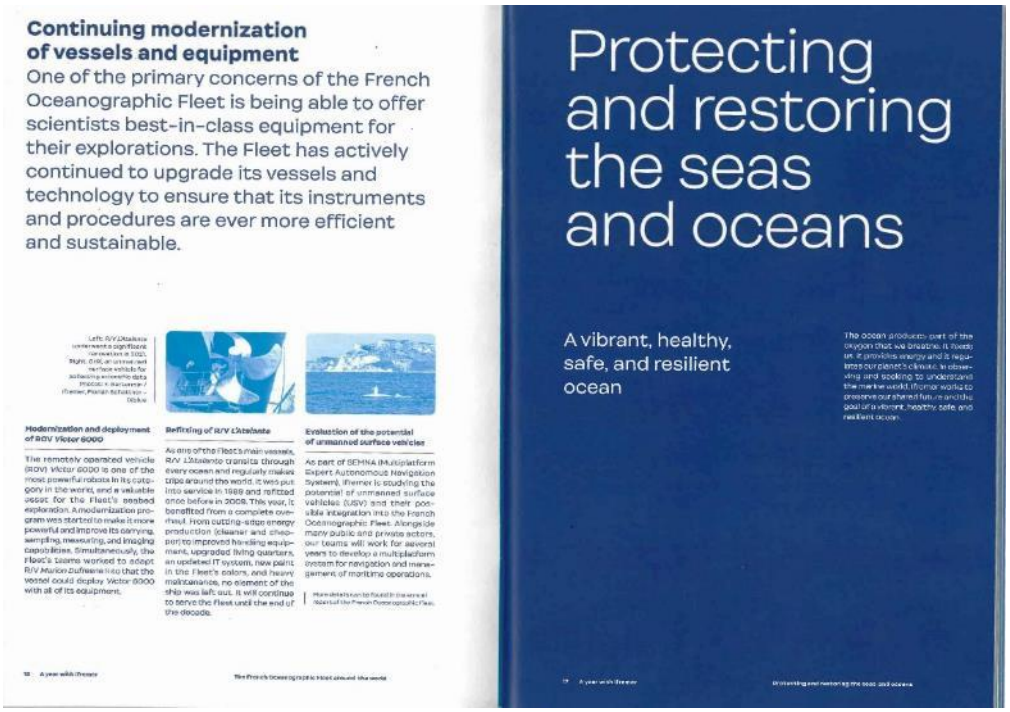
Under Ifremer's guidance, eighty scientists headed for the Black Sea to evaluate the threat posed to the climate and to marine seabed stability by methane emissions related to the dissociation of gas hydrates trapped at the bottom of the ocean.

CheReef

For five years, through observations of the ocean's surface and a deep-water observatory, scientists will scrutinize cold-water corals in the Bay of Biscay in order to assess their health and the pressures they face.

AMAZOMIX

This multidisciplinary cruise integrates physical, biogeochemical and ecological approaches to the Amazonian slope and plateau, shedding new light on the poorly understood processes that unfold at the mouth of the Amazon and their impact on ecosystems.



Continuing modernization of vessels and equipment

One of the primary concerns of the French Oceanographic Fleet is being able to offer scientists best-in-class equipment for their explorations. The Fleet has actively continued to upgrade its vessels and technology to ensure that its instruments and procedures are ever more efficient and sustainable.

Modernization and deployment of ROV Victor 6000

The remotely operated vehicle (ROV) Victor 6000 is one of the most powerful robots in its category in the world, and a valuable asset for the Fleet's seabed exploration. A modernization program was started to make it more powerful and improve its carrying, sampling, measuring, and imaging capabilities. Simultaneously, the Fleet's teams worked to adapt R/V Marion Dufresne so that the vessel could deploy Victor 6000 with all of its equipment.

Refitting of R/V L'Atalante

As one of the Fleet's main vessels, R/V L'Atalante transits through every ocean and regularly makes trips around the world. It was put into service in 1989 and refitted once before in 2008. This year, it benefited from a complete overhaul. From cutting-edge energy production (cleaner and cheaper) to improved handling equipment, upgraded living quarters, an updated IT system, new paint in the Fleet's colors, and heavy maintenance, no element of the ship was left out. It will continue to serve the Fleet until the end of the decade.

Evaluation of the potential of unmanned surface vehicles

As part of SEMNA (Multiplatform Expert Autonomous Navigation System), Ifremer is studying the potential of unmanned surface vehicles (USV) and their possible integration into the French Oceanographic Fleet. Alongside many public and private actors, our teams will work for several years to develop a multiplatform system for navigation and management of maritime operations.

Protecting and restoring the seas and oceans

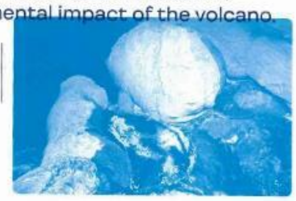
A vibrant, healthy, safe, and resilient ocean

The ocean produces part of the oxygen that we breathe. It feeds us, it provides energy and it regulates our planet's climate. In observing and seeking to understand the marine world, Ifremer works to preserve our shared future and the goal of a vibrant, healthy, safe, and resilient ocean.

Anticipating and preventing climate and weather events and reducing and overcoming their impacts

Ongoing monitoring and investigation of underwater volcanic activity in Mayotte

In parallel with operations led by the network monitoring the Mayotte volcano (REVOSIMA), the scientific cruise GeoFLAMME and dives performed by submersible *Victor 6000* yielded remarkable data to help researchers understand the formation, evolution, and environmental impact of the volcano.



This brand-new active volcano, located at a depth of over 3,000 meters and discovered off the coast of Mayotte in 2019, remains a center of attention. Scientists rarely have the opportunity to observe a geological phenomenon like this in real time.

The MAYOBS18 cruise in 2021 continued the work of the series of monitoring operations already carried out by the REVOSIMA network by using a corer to sample sediment in different areas around the island. The physical and mechanical properties of the sediment will be analyzed in order to assess the stability of Mayotte's underwater slopes and improve tsunami risk modeling.

At the same time, the GeoFLAMME scientific cruise focusing on the underwater volcano was carried out on R/V *Pourquoi Pas?*. For forty days, seventy scientists explored the 820-meter volcano. Thanks to ROV *Victor 6000*, they were able to obtain samples and the first ever images of the entirety of the volcano, two meters from its surface. This crucial data will be used by volcanologists seeking to learn more about lava flows and morphology. The images even showed the first signs of life colonizing some areas of the volcano.

GeoFLAMME Coordinated by Ifremer and the Institut de physique du globe de Paris, along with the CNRS, the BRGM and the Université de Paris Saclay, the cruise was facilitated by assistance from many laboratories and institutions. Carried out in partnership with the REVOSIMA network, the cruise was financed by the French Ministry of Higher Education, Research and Innovation through the French Oceanographic Fleet, with support from Ifremer and interdisciplinary research institutes (Université de Bretagne Occidentale).

26 A year with Ifremer — Protecting and restoring the seas and oceans

Placing seafloor seismometers quickly and precisely

The Marine Geosciences research unit at Ifremer has perfected their "Ballast-Cage," a system that can place seismometers on the ocean floor more quickly and precisely than before in order to let them take passive measurements.

The study of continental and oceanic crusts and underwater volcanoes relies on knowledge of the geometry and nature of geological layers, which in turn requires the use of geophysical measurement tools like ocean bottom seismometers (OBS). These devices are typically placed via free fall, which has the two major downsides of imprecise positioning and a relatively long descent time. While this method is acceptable for active seismic applications, it is very unsatisfactory for passively monitoring seismic events. The seismometer's position must be known and precise for these applications since it can't be calculated after the fact from the data collected.

Facing this situation while attempting to monitor the Mayotte volcano, Ifremer's researchers devised an apparatus that could solve these problems. The OBS is placed in a 450-kilogram cage that serves as ballast and makes it possible to direct the seismometer in real time. The seismometer's position can be adjusted as it descends and the research vessel's winch can be used at full speed, which is a welcome advantage on scientific cruises where time is of the essence.

The Ballast-Cage was successfully tested during the MAYOBS18 cruise. Six sets of seismometers were placed at 1,480 meters and 3,135 meters deep in the exact spots that the scientists had requested. These results suggest that Ifremer could benefit from the Ballast-Cage system during other similar operations.

27 A year with Ifremer — Protecting and restoring the seas and oceans

Successful deployment of two innovative inclinometers off the coast of Nice

The TIPS (Temperature, Inclination, Pressure Sensors) rods developed during the MODAL project and tested off the coast of Nice offer new possibilities for measuring submarine landslides.

The ability to measure ground movement on natural slopes is essential for understanding and potentially mitigating landslide phenomena. The underwater environment has fared poorly in this respect because no equipment had yet been devised for these conditions.

This need has now been filled by the National Research Agency's MODAL project, which mobilized Ifremer's multidisciplinary teams within the MERS Carnot Institute. Starting with flexible rods normally used for geotechnical surveying, engineers and technicians created instruments capable of measuring the slope, interstitial pressure, and temperature of underwater sediments. Two prototypes covered in electronics (thirty pressure sensors, forty five accelerometers, and seventy five temperature sensors) were assembled at Ifremer, then placed offshore of the Nice airport in an area known for its instability. The operation was performed during the MaRoLIS expedition with R/V *Pourquoi Pas?* and the Penfeld penetrometer, a geotechnical measuring device used to drive the rods into the sediment. The TIPS were connected to the EMSO-Ligure Nice seafloor observatory which has been providing them with electricity and recording their data in real time.

This is a significant advancement in the study of active processes that may lead to underwater slope instability. It opens up new possibilities for characterizing these phenomena.

INSTITUT CARNOT MERS

28 A year with Ifremer — Protecting and restoring the seas and oceans

Tracking and limiting the impacts of pollution, human activities, and chemical, physical and biological contaminants

Using paleogenetics to trace plankton evolution and assess ecosystem resilience

By studying ancient DNA buried in seafloor sediments, scientists have been able to show the impact of industrial-era pollution, especially from intensive agriculture, on plankton—which may have escalating consequences for all marine ecosystems.

Organisms leave traces of the DNA in the sedimentary layers that make up the ocean floor. By extracting cores from the seafloor and analyzing the DNA in each layer, scientists can trace the evolution of plankton and thus evaluate the resilience of coastal ecosystems that are impacted by human activity.

This study of ancient DNA (paleogenetics) was carried out in the Bay of Brest by Ifremer biologists aboard R/V *Thalia*, making it the first marine operation of its kind in France.

Sampled from three distinct areas, the sediment cores yielded a wealth of plankton species spanning roughly the past 1,400 years. Analysis of the cores showed that the greatest changes dated back to WWII and the 1980s–1990s, first due to bombings (heavy metals) and then to chronic pollution primarily from intensive agriculture. The study revealed an increase in toxic microalgae abundance as well, particularly for the dinoflagellate *Alexandrium minutum*, starting in the 1980s.

Published in the journal *Current Biology*, these results attest to the irreversibility of the changes that have affected coastal marine plankton, but leave open the question of the environment's capacity for resilience following these types of disruptions.

The challenge of toxic microalgae for public policy

This study was performed as part of the PALMIRA project (Paleoecology of *Alexandrium minutum* in the Bay of Brest), which was launched in 2017 upon the request of the Brittany regional authorities. The initial aim was to determine whether the works undertaken on the new polder in the port of Brest might encourage toxic blooms of the microalga *Alexandrium minutum*. In providing an answer to this research question, the scientists demonstrated the feasibility and utility of paleogenetics in the study of coastal ecosystems.

29 A year with Ifremer — Protecting and restoring the seas and oceans