出國報告（出國類別：訪問）

113 年度海洋環境技術交流參訪計畫
出國報告

服務機關：海洋委員會海洋保育署
姓名職稱：李筱霞 組長
陳鴻文 科長
楊蕙禎 科長
陳語謙 科員
派赴國家/地區：日本/東京及北海道
出國期間： 113 年 04 月 07 日至 04 月 13 日
報告日期： 113 年 05 月 10 日

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摘要

海洋委員會海洋保育署(以下簡稱海保署)借鏡日本在海洋污染防治、海洋污染應變、海洋廢棄物治理及運作方式，本次拜訪單位包括環境省、東京大學大學院新領域創成科學研究科海洋環境工程系、國立研究開發法人海洋研究開發機構、日本 ENEOS 石油公司、日本 CCS 調查株式会社及其 CCS 示範試驗中心，進行雙方經驗交流並建立互動及夥伴關係，透過拜訪及參觀來了解日本在海岸的廢棄物治理及法令規範，碳捕捉與封存許可證制度相關規定及未來趨勢、在海洋監測、海域生態系調查及洋流觀察、深海調查及相關模擬研究結果等，而透過海洋研究、教育、推廣及資訊公開、商業化及法律化等方式，讓更多企業、民眾認識海洋生態環境保護(育)及國家減碳的目標及未來趨勢。透過本次參訪也期待未來臺日雙方能有更多的互動或是彼此參加辦理會議、論壇、研討會、工作坊等合作交流機會。

壹、 目的

為了解日本對於海洋污染防治、海洋污染應變、海洋廢棄物治理的應對方式，透過人員實地拜訪環境省(Ministry of Environment, MoE)、東京大學大學院新領域創成科學研究科海洋環境工程系、國立研究開發法人海洋研究開發機構(Japan Agency for Marine-Earth Science and Technology, JAMSTEC)、日本 ENEOS 石油公司及日本 CCS 調查株式会社(Japan Carbon dioxide Capture and Storage Co., Ltd., JCCS)及其 CCS 示範試驗中心等單位，分享彼此工作經歷並建立緊密的夥伴關係，期本署與日本海洋管理、研究相關防救機關（構）、民間組織能建立合作及交流管道，俾未來作為規劃設計海洋相關政策時的參考。

貳、 過程

一、 參訪團員名單

本次參訪由本署派 4 員，國立高雄科技大學派 5 員，共計 9 員前往日本進行交流活動。

表 1 臺日海洋保育相關議題交流活動出國人員名單

編號	姓名	職稱	機關名稱/單位
1	李筱霞	組長	海洋委員會海洋保育署海洋環境管理組
2	陳鴻文	科長	海洋委員會海洋保育署海洋環境管理組
3	楊蕙禎	科長	海洋委員會海洋保育署綜合規劃組
4	陳語謙	科員	海洋委員會海洋保育署海洋環境管理組
5	陳政任	特聘教授	國立高雄科技大學環境與安全衛生工程系特聘教授兼南區毒災應變諮詢中心主任
6	蔡宗岳	副教授	國立高雄科技大學環境與安全衛生工程系副教授
7	許昺奇	教授	國立高雄科技大學環境與安全衛生工程系教授兼環境健康與生物科技研究中心主任
8	楊惠甯	資深專案經理	國立高雄科技大學南區毒災應變諮詢中心
9	劉蓁	專案副理	國立高雄科技大學南區毒災應變諮詢中心

二、 訪問行程

出國期間自 113 年 4 月 7 日至 113 年 4 月 13 日，為期 7 天 6 夜之行程，參訪地點包括環境省、東京大學、JAMSTEC、日本 ENEOS 石油公司及日本 CCS 調查株式会社及其 CCS 示範試驗中心。

表 2 訪問整體行程表

天數	日期	地點	行程概述
第 1 日	4 月 7 日 (星期日)	臺灣桃園機場→抵達日本東京成田國際機場	去程。
第 2 日	4 月 8 日 (星期一)	拜會環境省(MoE)	由環境省說明微型塑膠未來政策及現況。2015 年針對沿岸、潮間帶微型塑膠調查，近期針對河川，同時透過文字及 BAR CODE 瞭解日本海岸的廢棄寶特瓶多受哪些國家影響，及針對日本現行碳捕捉與封存（Carbon capture and storage, CCS）許可證制度相關趨勢。
		參訪東京大學	由東京大學說明目前日本浮動式離岸風電的發展、海洋再生能源設施對環境影響的研究、日本對於碳捕捉及封存(Carbon capture and storage, CCS)動態及挑戰、模擬沿海、近海開發的波浪及洋流，及沿海洋流觀測與帆船隊。本署則由綜規組楊蕙禎科長簡單介紹海洋保育署及近期重要政策，包含去年海污法修法、海洋廢棄物治理、海洋保護區網絡、重要海域生態系調查、藍碳生態系調查，以及關鍵物種調查，

天數	日期	地點	行程概述
			以符合海洋保育署潔淨海洋、健康棲地及永續資源願景。
第 3 日	4 月 9 日 (星期二)	拜會國立研究開發法人海洋研究開發機構 (JAMSTEC)	由 JAMSTEC 藤倉克則專案副總監介紹昆明-蒙特婁生物多樣性框架，日本推動現況及 2021 年 8 月北太平洋西部海底火山噴發浮石擴散預測。本署則由綜規組楊蕙禎科長簡單介紹海洋保育署及近期重要政策，包含去年海污法修法、海洋廢棄物治理、海洋保護區網絡、重要海域生態系調查、藍碳生態系調查，以及關鍵物種調查，以符合海洋保育署潔淨海洋、健康棲地及永續資源願景。
第 4 日	4 月 10 日 (星期三)	拜會日本 ENEOS 石油公司	由 ENEOS 公司介紹成立沿革、營業項目、重大溢油事件影響及相關法規規定資材備便量能。本署則由綜規組楊蕙禎科長簡單介紹海洋保育署及近期重要政策，包含去年海污法修法、海洋廢棄物治理、海洋保護區網絡、重要海域生態系調查、藍碳生態系調查，以及關鍵物種調查，以符合海洋保育署潔淨海洋、健康棲地及永續資源願景。
第 5 日	4 月 11 日 (星期四)	東京成田機場→抵達北海道新千歲國際機場	東京至北海道路程。
第 6 日	4 月 12 日	拜會日本 CCS 調	由國際部長澤田嘉弘介紹 JCCS 公司，包

天數	日期	地點	行程概述
	(星期五)	查株式会社(JCCS)及其 CCS 示範試驗中心	括成立時間、受委託之專案、二氧化碳來源及封存，以及碳捕捉與封存(Carbon capture and storage,CCS)示範計畫執行成果。
第 7 日	4 月 13 日 (星期六)	北海道新千歲機場→臺灣桃園機場	返程。

三、 工作紀要

(一) 拜會環境省(MoE)

由環境省說明微型塑膠未來政策及現況。2015 年針對沿岸、潮間帶微型塑膠調查，最近針對河川，同時透過文字及 BAR CODE 瞭解日本海岸的廢棄寶特瓶多受哪些國家影響，及針對日本現行碳捕捉與封存（Carbon capture and storage, CCS）許可證制度相關趨勢。相關會議資料如附錄一所示。

其出席人員及針對上開議題說明如下：

1. 環境省出席人員

本次出席人員為環境省水及大氣環境局海洋環境課，包括藤井好太郎 室長、長谷代子 室長佐輔、堀野上貴章 課長佐輔、藤岡勝之 主查及瀨戶內大樹 主查。

圖 1 環境省人員名片

2. 針對塑膠污染(包含微型塑膠)之管理政策及現況說明

日本環境省訂有海岸海洋垃圾收集相關法規，在資源回收方面亦訂有綠色生產及消費者端相關法律，實際執行由地方自治體推動，因地方自治體位處第一線，最為直接，地方自治團體須提出海岸清除計畫或調查計畫，由中央政府補助經費。環境省主要調查海灘、潮間帶、大陸棚及海底塑膠微粒，研究塑膠微粒對生物系及生物體的影響；塑膠微粒對水生生物的影響亦由環境省執行，對人體影響則由厚生省執行。

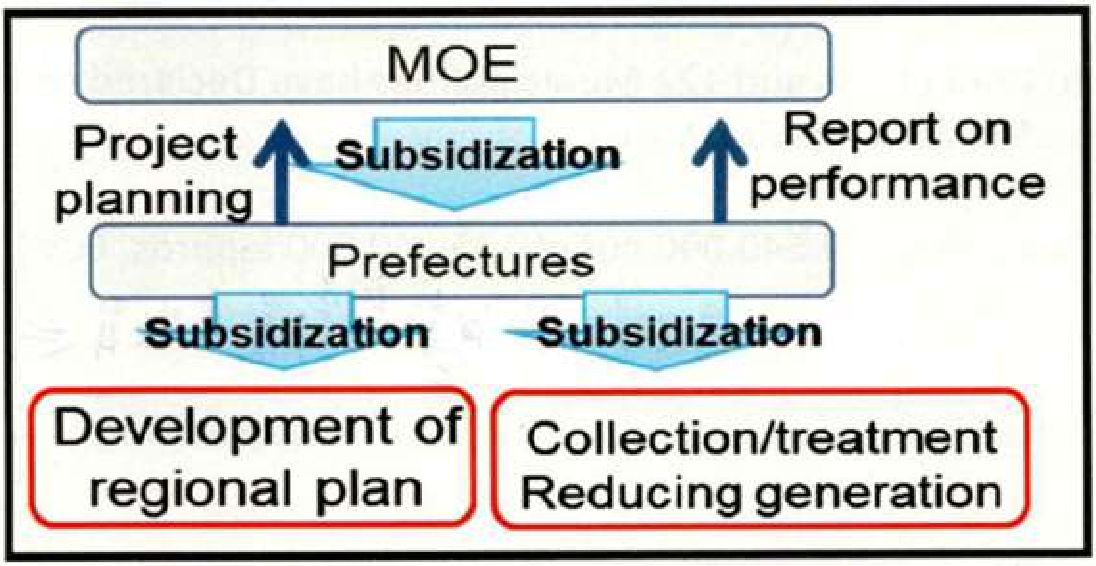


圖 2 環境省海岸垃圾補助計畫補貼流程

日本環境省調查塑膠微粒相關觀察資料將置於海洋為塑膠資料平台(Atlas of Ocean Microplastics, AOMI)，網址 https：//aomi.env.go.jp/，分享給各國相關資料，預計 5 月開放，臺灣也可使用；在遙測技術部分，使用最多為無人機觀測，未來開發固定照相機或衛星來監控，及辦理更多相關研討會，並在 G20 架構上與各國合作。

3. 海底二氧化碳封存的許可證制度及日本 CCS 相關趨勢

根據倫敦議定書有 55 個締約方(日本非屬締約國)，2009 年修正議定書內容關於二氧化碳封存海底需經三分之二締約方批准才生效，締約方可申請出口二氧化碳。日本透過防止海洋污染和海上災害防救法落實倫敦議定書內容。而高濃度之二氧化碳 (CO_2) 才能排放至海洋，且這個許可須由環境省核准才能允許，因此目前為環境省主導日本 CCS 碳中和政策，並說明未來技術將商業化，但後續工作則轉到經濟產業省主辦。

有關二氧化碳處置許可證需由環境部長核發，另對於二氧化碳處置許可標準及流程需符合 1.地質結構應對海洋環境無負面影響。2.不能影響處置區域環境。3.除海底處置外無其他適當處置方式。4.申請人應具備持續處置監測的技術和財務能力。

其中許可制度之程序 1.申請文件提交(需公開徵求意見 1 個月)。2.發放處置許可。3.二氧化碳處理、儲存及監測(許可期限最長 5 年)。另針對監控有三階段，包含定期監測、預防性監測及緊急監測。

目前苫小牧 CCS 計畫自 2016 年 4 月許可自 2021 年 3 月總注入噸數為 30 萬噸・分別注入兩個海洋地質層深度，分別為 1,000~1,200 m 及 2,400-3,000 m・主要監測二氧化碳分壓 (*p*CO2) 及溶氧 (DO) ，監測值以 95%信賴區間為界限質，低於界限值僅需進行第一階段的監控，如果高於界限值就須進行第二階段的監控，監測皆由政府部門執行。

日本碳中和目標主要從潔淨能源到碳捕捉及封存技術來達到 2050 年碳中和的要求，但由於可能部分企業會無法達到此目標，因此日本政府推行 CCS 技術示範計畫來推展成商業模式並法律化，目前已訂定相關法律，還在國會審查當中，後續工作則會交由經濟產業省執行，許可制度還是由環境省審查。

4. 雙方交流

- 本署詢問環境省有關海洋環境調查年度預算及系統性調查規劃、日本研發塑膠微粒及海洋廢棄物清除技術現與設備現況，是否制訂船舶生活垃圾紀錄簿、邀請日方未來雙方常態性辦理產官學研討會、油污染應變處理單位、日本 CCS 未來政策方向、二氧化碳海洋處置有無規範、監測界線值如何訂定及規範及後續監測由政府部門辦理是否徵收費用？
- 環境省回應摘要如下：

(1) 每年編列 2 億日幣執行塑膠微粒及海洋垃圾調查，調查內容由 12 位專家針對前年結果提出建議。

(2) 船舶管理為國土交通省業務，有規範船上產生的垃圾不得丟棄，燃燒垃圾要紀錄燃燒量；環境省的廢棄物管理法非單純海洋廢棄物管理。日本漁業管理部門在法律上禁止漁民丟棄垃圾，經發現即勸導，年輕一代漁民對環境較為關心，多以強化宣導為主。

(3) 塑膠微粒目前日本政府沒有投資相關技術，但有鼓勵企業推動綠色生產，減少排放到海洋，另國土交通省有掃除船可以清除海洋廢棄物。

(4) 一般事故由海上保安廳聯絡及通知相關單位或委外處理，主要由船主負責；大型事故由中央部會內閣長官統籌處裡。

(5) CCS 政策初始由環境省主導，後續交由經濟產業省主辦，惟海域工程達一定規模以上皆需環評審查，未來開發單位申請相關工程案件環評審查，將透過專家學者組成的委員會審查，仍會遵循環評審查程序，以及相關監測。

(6) 目前已有針對二氧化碳處置法規草案，送議會審議中，後續會提供資料給貴署參考。

(7) 有關監測界線值以海水標準之平均值 95%微信賴區間，至於規範係由專家會議決定。

(8) 後續監測向申請人徵收費用成立基金，由基金支付後續監測費用。

(9) 針對塑膠微利回收申請資料及調查指南進行資料提供參考：針對河川、湖泊為塑膠調查指南、海洋表面微塑膠監測方法指南資料、一般水底沉積物海洋處置申請指南、一般水底沉積物入海許可申請文件準備指南等資料檔案下載網址如下

- 河川：

  https：//www.env.go.jp/content/900543325.pdf (日文)

  https：//www.env.go.jp/en/water/marine_litter/guidelines/Guidelines_for_River_Microplastic_Monitoring_Methods_Marge.pdf (英文)

- 海洋：

  https：//www.env.go.jp/press/files/jp/114043.pdf （英文のみ）

  （その背景の説明など：https：//www.env.go.jp/page_00929.html ）

- 一般水底土砂の海洋投入処分申請の進め方に係る指針：

https：//www.env.go.jp/content/900542453.pdf （日文）

- 一般水底土砂の海洋投入処分許可申請書類等作成の手引：

https：//www.env.go.jp/content/900543726.pdf（日文）

5. 拜訪照片

	
與環境省合影	環境省簡報
	
討論雙方常態性辦理產官學研討會	詢問環境省二氧化碳處置問題
	
本署贈送年報及禮品	會後交流

圖 3 環境省交流活動照片

(二) 拜會及參訪東京大學

由東京大學提供該校海洋技術環境學系說明，海洋技術環境學佐藤教授陪同本署及高雄科技大學介紹東京大學校園。另在議題探討方面包括目前日本浮動式離岸風電的發展、日本對於碳捕捉及封存(Carbon capture and storage, CCS)動態及挑戰、模擬沿海、近海開發的波浪及洋流，與沿海洋流觀測與帆船隊。本署則由綜規組楊蕙禎科長簡單介紹海洋保育署及近期重要政策，包含去年海污法修法、海洋廢棄物治理、海洋保護區網絡、重要海域生態系調查、藍碳生態系調查，以及關鍵物種調查，以符合海洋保育署潔淨海洋、健康棲地及永續資源願景。相關會議資料如附錄二所示。

其出席人員及針對上開議題說明如下：

1. 東京大學出席人員

本次出席人員為日本東京大學大學院新領域創成科學研究科之佐藤 徹 教授、高木健 教授、鈴木英之 教授、多部田茂 教授，以及小平翼博士。

圖 4 東京大學人員名片

2. 日本浮動式離岸風電的發展(鈴木英之教授)

(1) 日本離岸風電及浮式離岸風機發展歷程：因日本地理環境上具備中等風速和颱風頻繁區域，有很大的潛力可以發展固定式及浮動式風機。根據 2020 年日本風力發展協會（Japan Wind Power Association, JWPA）評估，近岸水深 50m 以內，預計有 128W 採用固定式風機；424W 的浮動式風機可在水深超過 50m 區域安裝，且也提出風機大型化之必要性。

(2) 開發成本及開發計畫：原本因離岸風電開發成本過高而暫緩，直到 2011 年福島第一核電廠事故，政府單位開始重視離岸風電開發計畫，由經濟產業省主導「2011 至 2021 年福島計畫」。在 2013 年 2MW 順風號風機營運；2015 年 7MW 油壓號風機營運；2016 年 5MW 順風號風機營運。

(3) 除了經濟產業省外，2010 至 2016 年間，環境省也主導賦予計畫（goto project），後因投入成本過高而取消；另 2014-2024 年產業技術綜合開發機構也執行北九州市計畫（Kita-Kyushu project），也因資金短缺暫緩。在技術水準上，東京大學評估，目前日本離岸風電技術多可以商業化。

(4) 日本政府推動離岸風電開發政策係因應 2050 全球淨零排放政策，企圖建立一個碳中和的社會，期望 2040 年前完成 30 至 45GW 的風電開發商業化。

(5) 在法規政策上，2018 年推動第五次基本能源計畫（5th Basic Energy Plan），主軸為再生能源應成為核心動力來源；第三次海洋基本計畫（3rd Basic Plan on Ocean）強調領海利用規則的必要性。2019 年促進利用海域發展海洋再生能源發電設施法（act on promoting the utilization of sea areas for the development of marine renewable energy power generation facilities），修改範圍至經濟海域；2022 年第六次基本

能源計畫（6th Basic Energy Plan），目標則為計畫成行，全日本固定式及浮動式離岸風電分為執行區塊、預備區塊、準備區塊，目前預備區塊中有四個場域正在競標中。

(6) 日本浮動式離岸風電技術的挑戰：曾考慮運用石油平台改造，可惜平台過大且過重，加上過去曾有事故發生，技術上進化為輕型平台，惟仍未克服平台技術經驗不足問題；在海纜及浮桶繫線上的問題，物理方面是淺水中動態反應的張力幅度，以及降低深水區的施工成本；生態部分，則是海纜及繫繩的生物附著影響海纜構造，環境層面則是海水溫度、營養鹽及洋流等課題。鈴木英之教授表示，日本有信心，後續可靠經驗累積來提升技術成熟度。

3. 海洋再生能源設施對環境影響的研究(多部田茂教授)

(1) 說明研究背景：從食物鏈及棲地變化對離岸風電周邊海洋生物的影響，以日本北海為模型場域，加入物種和功能組、生物量、生產和消費、飲食結構、死亡、船隊和漁獲量等變動因子推估浮游生物群，結果顯示，有風機場域的北海，不論在數量、分佈、種類上都較無風機區域具生物多樣性。再從 2010 年已知的生物量推估到 2030 年，結果顯示大部分物種基本上符合實際分佈，特別是靠近海岸的地方。接著分析風機範圍內的海洋保護區中的珊瑚礁生態系食物鏈，風機周邊出現大量經濟魚類及其捕食者的熱點，多部田教授表示該科學結果，有機會讓風機場域成為其他有效保育措施之區域（Other Effective conservation measures, OECMs）。

(2) 水下聲學及攝影：監測特定魚種，因才執行兩年，尚不足以推估。在食物鏈上，多部田教授除了物種、浮游生物外，也參與海洋深層水、營養鹽、溫差等項目，主要是生態系與食物鏈是複雜的多重架構，不同的參數會有不同影響。

4. 日本對於探捕捉及封存動態及挑戰(佐藤徹教授)

(1) 動態：2050 年實現碳中和、商業法、長期路線圖及選定 5 個儲存地及 2 個出口港口。

(2) 挑戰：放寬管制標準及控制水中二氧化碳濃度。

(3) 歐盟於 2050 年將德國波昂二氧化碳排放量為零，菅義偉首相於 2020 年 10 月 26 日施政演說中，將於 2050 年實現碳中和，在 C0P20(第 20 屆聯合國氣候峰會)日本宣布 2030 年減量 46%，2050 年實現零排放，有關碳捕捉及封存(Carbon capture and storage, CCS)商業法於 2024 年 5 月提交國會，規範經濟部產業省將試鑽權及儲存權授予選定廠商(即採委辦評選方式)，試鑽權及儲存權視為財產，對於儲存作業人員要求必須監控儲存庫溫度及壓力，2030 年啟動 CCS(碳捕捉及封存)，從每年二氧化碳排放量 0.24 公噸降至每年 0.12 公噸。

(4) 選定(A)苫小牧(B)東北地區西海(C)新瀉東部地區(D)大都會區(E)北九州至西九州區等 5 處儲存地，以及近海馬迴及大洋洲二處出口港口。

(5) 依據防止海洋污染與海上災害法規定 CCS(碳捕捉及封存)業者需獲得環境省許可，僅限二氧化碳濃度為 99%或以上氣體，並且強制監測海水中之二氧化碳濃度，由於海水中二氧化碳濃度並非恆定，PCO_2(二氧化碳分壓)及 DO(溶氧)飽和度具有很好的相關性，如果數據超過 95%信賴區間上限，會要求重新進行第二次濃度監測，苫小牧 PCO_2 變化非常大，共花費 5 億日幣再執行調查。

5. 模擬沿海、近海開發的波浪及洋流(高木健教授)

(1) 資源評估標準：解析度 1 km 為最佳，同時收集太平洋 20 年以上資料，不同評估階段所需的模型(A)評估圖(B)型號(C)觀察(D)驗證(E)技術報告(包含年平均、月變化及潮汐資料等)。

(2) 日本在海洋開發所面臨挑戰：包括惡劣海況(颱風、炸彈旋風等)、黑潮及黑潮引起之強流。

(3) 溫差發電選址部分結合可用資源、地理、氣象並考量海洋及社會限制。

6. 沿海洋流觀測與帆船隊(小平翼博士)

(1) 研究動機：石油及事故造成放射性物質外洩，在討論海洋環境變化時，了解海洋流場與過程是很重要的。

(2) 將海洋流觀測技術帶入帆船比賽:帆船比賽是奧林匹克運動資訊化程度較高的項目，海洋洋流資訊在資訊戰中具有差異化作用，帆船比賽在半徑 1 公里的圓形區域內進行(空間規劃),比賽時間 30 分鐘,關鍵在於能否預測這段時間的洋流。

(3) 影響海洋表層漂流的元素包括：GPS(全球定位系統)感應器、數據通訊及視覺化及水下浮體(包含浮體和錐套)。

(4) 應用：由生物可分解塑膠製成小型海面漂流器已被廣泛利用，最大限度減少因風壓阻力和波浪效應而產生滑移。另利用多點部屬漂流桿方式重複測量洋流，公民參與持續密集的觀察洋流，總測量次數 834 次，收集洋流資訊，因此造就日本帆船隊最佳成績第七名。

7. 雙方交流

- 本署詢問日本東京大學有關選擇浮動式及固定式離岸風機開發場域條件、開發範圍是否有避開環境敏感區域、及臺灣目前也正在發展風機及 OECM 認定標準，日本東京大學研究結果顯示大部分物種基本上都符合其實際分佈，詢問有哪些物種?另外是否具有代表性?本署亦分享及說明有關小型海面漂流器可運用於海洋污染事件發生時，能第一時間掌握污染物流向，作為優先防堵應變之參考等。
- 東京大學回應摘要如下：

(1) 水深目前是固定式及浮動式離岸風機的考量基準，日本目前尚未有海域空間規劃，不過相關開發行為及範圍皆會經過最嚴格的環境省

的環評審查作業，其中就包含提到的相關利害關係人。有關環境敏感區域部分，其實目前風機開發範圍內有 30%位於海洋保護區，但日本民眾較不關切海洋保護區議題。日本的漁民比較沒有這方面問題，漁民如果知道有海纜或設施，都會自主避開。當然開發之前，相關單位都會與漁民溝通，相關設施盡量避開魚群範圍。

(2) 物種是採普查方式，所有物種資料都分析，沒有針對特定物種。主要是搜集過去資料庫中的各式物種包含魚類，另外珊瑚調查的案子，目前僅有在較南邊的日本，甚至沖繩才比較有機會。

8. 議題探討及校園參訪照片

	
名片交換	東京大學議題討論
	
介紹日本浮動式離岸風電	沿海流觀測說明

	
問題與討論	本署介紹
	
本署贈送禮品	校園參訪

圖 5 東京大學交流活動照片

(三) 拜會國立研究開發法人海洋研究開發機構(JAMSTEC)

由 JAMSTEC 藤倉克則專案副總監介紹昆明-蒙特婁生物多樣性框架，全球趨勢 2030 前有 30%的海域及陸地受到保護(30x30)。日本原在愛知目標下，希望 2020 年前有 20%海域受到保護，迄今卻僅有將近 14%的海洋保護區及 2021 年 8 月北太平洋西部海底火山噴發浮石擴散預測。相關會議資料如附錄三所示。

本署則由綜規組楊蕙禎科長簡單介紹海洋保育署及近期重要政策，包含去年海污法修法、海洋廢棄物治理、海洋保護區網絡、重要海域生態系調查、藍碳生態系調查，以及關鍵物種調查，以符合海洋保育署潔淨海洋、健康棲地及永續資源願景。

其出席人員及針對上開議題說明如下：

1. JAMSTEC 出席人員

本次會議出席人員包括河野健 理事、龜井雅彥 部長、杉浦毅 課長、藤倉克則 專案副總監、美山透 主任研究員、飯島瑞枝 研究員，以及張育綾 副主任。

圖 6 JAMSTEC 人員名片

2. 日本政府深海劃設海洋保護區及 30x30 (藤倉克則專案副總監)

(1) 緣起：日本原在愛知目標下，希望 2020 年前有 20%海域受到保護，迄今卻僅有將近 14%的海洋保護區。近年來，在近岸海域較無劃設海洋保護區的可能性，所以日本政府開始向深海劃設海洋保護區。因此，機構配合政府政策，在日本專屬經濟海域內的深海區域探索重要海域生態資源。研究機構的科學數據非常重要，不論未來是否要劃設海洋保護區或改認定為保護區外其他有效保育措施之區域

（Other Effective area based Conservation Measures, OECMs），也因此被賦予很重要的責任。

(2) 現階段研究：藤倉克則專案副總監說明機構雖有研究船、各式設備，研究資源目前充足，但考量深海調查非常昂貴，普及化調查設備有其必要性，因此開始自行研發。藤倉主任介紹一套可裝設環境DNA(eDNA)、溫鹽深儀(CTD)、水下探測載具(ROV)、水下聲學等裝置，取名為「登陸者(Lander)」，Lander 也可依研究需求拆解組裝。未來設備將商業化，裝置上的設備都可外在購買，除 eDNA 採水是機構自行研發。因 eDNA 採水的水量相當多，深水水壓、洋流等不確定因素很多，因此機構研發一套自動過濾的採水設備，透過減少水量，減少水壓影響因子；且過濾後的水，就可直接進實驗室分析，非常便捷。另外，在水下聲學及攝影方面，目前運用上，發現一種深海魚種，JAMSTEC 也為其命名，目前全世界僅有 7 尾。

圖 7 水下監測裝置(Lander)

(3) 本署表示臺灣與日本面臨同樣問題，近岸海洋保護區劃設難度較高，雖長期執行近岸 3 浬 eDNA 採水，未來有機會將會拓展至 12 浬，機構既然可以裝設 eDNA 本署非常樂觀其成，希望有機會與日本合作，

惟稍早報告設施及架構費用，但維護成本不知道多少，且使用年限大概多少？另外，Lander 可否裝置水下噪音設備？

(4) 藤倉主任表示，維護成本非常低，如稍早所說這些設備都可在外購買，所以維護沒有問題，eDNA 設備未來商業化後，維護也不會是問題。相關設備可以自行組裝及客製化，若有機會也希望可跟臺灣合作。

3. 2021 年 8 月北太平洋西部海底火山噴發浮石擴散預測(張育綾副主任)(以視訊連線方式進行說明)

(1) 研究緣起：2021 年 8 月 13 日至 15 日福德岡野之場發生海底火山噴發，日本海上保安廳也利用無人機觀測，並發現漂浮物(浮石)等，海洋項觀測船(二福丸號)也蒐集福德岡之場西北約 300 公里太平洋上的浮石，衛星觀測到浮石抵達沖繩，平均每秒移動速度為 0.19-0.21m。

(2) 研究過程：收集 1993-2020 年相關風阻、時間及浮石分散狀況，模擬浮石大部分時間抵達沖繩及台灣，但也有小部分例外。

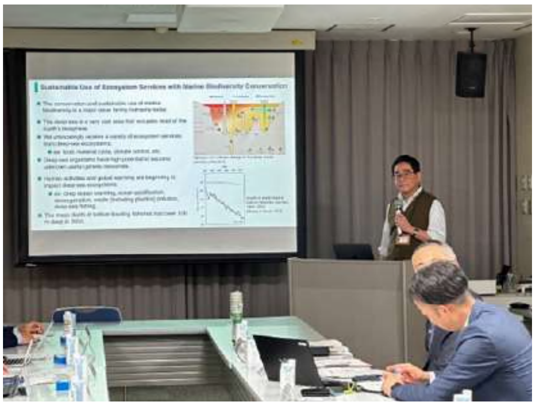
(3) 研究結果：經過模擬討論最佳風阻仍是一個未解決的問題，目前與美方進行水箱實驗，已獲得最佳風阻，用於改善數值模擬。

4. 雙方交流

- 本署詢問 JAMSTEC 有關福德岡之場發生海底火山噴發造成浮石，第一時間造成臺灣海域環境問題，另外我們也將模擬應用於海洋油及化學品污染，主要優先掌握污染物流動方向以便及時應處，想請問日方是否有相關油及化學品模擬系統，或是對此專精之專家資訊可提供參考及就教。
- JAMSTEC 回應如下：日方無相關油及化學品模擬系統，也無對油及化學品模擬專精之專家。
- 本署分享在海洋保護區網絡部分，張育綾副主任與東京大學教授，同樣提問臺灣海洋保護區 8.38%怎麼計算的。本署回答因臺灣沒有

公告專屬經濟海域，所以在海洋保護區面積比例上是用 12 浬為分母，如果參考國際網站將所算的臺灣 EEZ 範圍，海洋保護區面積比例恐僅有 1%。另外，本署配合國際 30x30 趨勢，正在研擬 OECM，打算透過 OECM 整合海洋保護區網絡。

5. 議題探討及拜訪照片

	
JAMSTEC 簡報	問題與討論
	
問題回覆	本署介紹
	
會後交流	本署贈送禮品

	
JEMSTEC 展覽廳參觀	水下浮標偵測器
	
水下監測裝置(Lander)	會後合照

圖 8 JAMSTEC 交流活動照片

(四) 拜會日本 ENEOS 石油公司

由 ENEOS 公司介紹成立沿革、營業項目、重大溢油事件影響及相關法規規定資材儲備量能。本署則由綜規組楊蕙禎科長簡單介紹海洋保育署及近期重要政策，包含去年海污法修法、海洋廢棄物治理、海洋保護區網絡、重要海域生態系調查、藍碳生態系調查，以及關鍵物種調查，以符合海洋保育署潔淨海洋、健康棲地及永續資源願景。相關會議資料如附錄四所示。

其出席人員及針對上開議題說明如下：

1. ENEOS 出席人員

本次會議出席人員包括環境安全部吉田孝 副部長、環境安全部推進小組富田賢一 經理、環境安全部推進小組島袋義仁，以及環境安全部推進小組村上順。

圖 9 ENEOS 人員名片

2. 公司介紹成立沿革及營業項目(環境安全部推進組經理富田賢一)

(1) 該公司於 1888 年 5 月 10 日成立，資本額為 300 億日圓，目前員工有 8,981 人。

(2) 主要營業項目為石油產品精煉與銷售、天然氣進口與銷售、石油化學產品製造與銷售、電力與氫氣供應。

3. 重大溢油事件影響

(1) 1971 年利比亞籍 Juliana 號油輪在日本本州西海岸新潟擱淺漏油，因為此一漏油事件，1973 年由相關企業組成石油聯盟(Petroleum Association of Japan, PAJ)與其他產業共同合作。

(2) 1974 年因水島煉油廠儲槽倒塌外洩，日本政府於 1976 年訂定石油工業區防災法，強制規定設置油污染設備，並且成立海上災害防止中心(Maritime Disaster Prevention, MDPC)。

(3) 1989 年發生於阿拉斯加威廉王子灣 Exxon Valdez 油輪洩漏，1990 年由經濟產業省訂定重大油污染應變計畫，儲備油污資材設備，並每年召開相關國際研討會。

(4) 1997 年於福井縣外海，俄羅斯籍 Nakhodka 油輪沉沒導致重油外洩，因此修改災害管理基本法。

(5) 1997 年於川崎發生巴拿馬籍油輪 Diamond Grace 擱淺油污外洩，此時也開始運用模擬系統，預測油污流動方向加強應變。

4. 緊急應變能量

(1) 相關法規規定資材整備量能：依據日本石油工業園區防災法，對於典型煉油廠需具備 2,160 公尺攔油索，工作船需搭配可處理 $30m^3/hr$ 洩油量之汲油器，另依據國土交通省海洋污染與災害預防法，針對典型石化煉油廠需具備 1,000 公尺以上攔油索及可處理 $64m^3$燃油之油分散劑。

(2) 另 ENEOS 公司說明，為因應事故污染發生時之緊急應變，ENEOS 公司內部已成立應變小組並定期維護設備，同時進行員工培訓及演練、參加石油聯盟有關國際海事組織 (International Maritime Organization,IMO)LEVEL 3 訓練，及參加海上保安廳排出油防除協議會。

5. 雙方交流

- 本署詢問 ENEOS 公司有關輕質油污染有無處理?其他國家船舶發生海難造成油污染時，ENEOS 公司是否會協助? ENEOS 公司應變指引是否可提供參考?油污資材設備國際研討會可否邀請臺灣參加?公司是否有針對外海船對船油駁作業?MDPC 成立後，當事故發生時，ENEOS 公司與 MDPC 之關係，以及事故發生時，所使用之油污染擴散模擬係由哪個單位進行及使用哪套模擬軟體進行模擬，MDPC 受訓費用政府是否有補助，受訓人員是否有要求回訓。
- ENEOS 公司回應如下：

(1) 應變部分由 MDPC 負責，公司不是很清楚。

(2) 其他國家船舶造成油污事件，均由海上保安廳通知，第一時間他們也會先處理，若屬重大污染海上保安廳會通知 MDPC 處理。

(3) 應變指引係屬公司內部資料，不方便予本署參考提供。

(4) 油污資材設備國際研討會部分，以往臺灣均有參加，但因疫情改為線上參與。

(5) 公司目前並無外海船對船油駁作業該項業務。

(6) 當公司發生油污事故後，第一時間係由公司進行應變作業，若洩漏量達公司無法負荷程度，將通知 MDPC 前往處理。

(7) 油污染擴散模擬係由 PAJ 負責，該套模擬軟體亦由 PAJ 所開發。

(8) 受訓費用由公司自行支付，無政府補助；政府無核發執照，所以無需回訓。

6. 議題探討及拜訪照片

	
ENEOS 公司簡報	問題與討論
	
問題回覆	本署介紹

	
本署贈送禮品	會後合照

圖 10 ENEOS 交流活動照片

(五) 拜會日本碳補捉與封存調查株式會社(JCCS)

由國際部長澤田嘉弘介紹 JCCS 公司，包括成立時間、受委託之專案、二氧化碳來源及封存，以及 CCS 示範計畫執行成果。相關會議資料如附錄五所示。

其出席人員及針對上開議題說明如下：

1. JCCS 出席人員

本次會議出席人員包括顧問澤田嘉弘 國際部長及國際部田中次郎 擔當部長。

圖 11 JCCS 人員名片

2. 公司成立時間及目前接受委託專案(國際部長澤田嘉弘)

(1) JCCS 公司於 2008 年 5 月 26 日成立，股東有 33 家公司，苫小牧 CCS 示範計畫是日本第一個碳捕捉和封存的示範計畫，業務項目包含碳封存和捕捉、研究和開發、可行性研究及示範性研究，截至 2024 年 4 月，員工數有 106 人。

(2) 目前接受委託的專案：

A. 新能源產業技術綜合開發機構(NEDO)委託，自 2012 年開始執行苫小牧 CCS 示範計畫。

B. 新能源產業技術綜合開發機構(NEDO)委託，自 2021 年開始執行二氧化碳船舶運輸研究、開發及示範計畫。

C. 環境省委託，透過二氧化碳回收促進循環碳社會模式計畫。

D. 經濟產業省及環境省委託，二氧化碳潛力儲存點調查。

(3) CCS 二氧化碳來源及封存:苫小牧 CCS 示範計畫其二氧化碳來源為煉油廠製氫裝置所產製，組成有 50%為二氧化碳、40%為氫氣、其餘氣體 10%，經 1.4 公里管線傳送到碳封存場，利用酸鹼中和方式進行二氧化碳捕捉和脫附，再注入砂岩及火山岩兩種不同質地，砂岩質地注入深度為水深 1,000-1,200 公尺，火山岩注入深度為水深 2,400-2,800 公尺，整套設施消耗的能源為傳統式的 1/3 或 1/2，並採對海洋環境、魚場較無干擾、影響較小及便宜的岸上注入法。

圖 12 苫小牧 CCS 示範模型看板說明

(4) CCS 示範計畫執行成果

A. 2016 年開始注入，2019 年達到 30 萬噸，2019 年後即未再注入；火山岩質地部分因穿透性差，注入壓力大約 380 磅，只注入 2 次約 98 噸即停止，整體而言火山岩測試為失敗的。

B. 因日本為地震好發國家，亦考量地震因素並加以監測，在海底設置 OBC 偵測廊，2018 年北海道地震後，觀測地震前後震動的位置都差不多，且震度 5 級左右均沒有發現損害，顯示

地震對封存不會產生影響。

C. 苫小牧 CCS 示範計畫以快速回應及專業解釋降低民眾的疑慮，如地震發生後即在網頁發布地震對封存的影響，並開放民眾參觀及盡可能完整揭露訊息，相關資訊亦於市政廳揭露。

圖 13 苫小牧 CCS 示範工廠全貌

3. 雙方交流

➢ 本署詢問

(1) JCCS 有關苫小牧 CCS 示範計畫注入二氧化碳前後是否執行環境生態相關項目，監測的項目有哪些?是否訂定相關數值? 2019 年後未再注入二氧化碳，是進入觀察期階段嗎?如果是，預期觀察時間多久?5 年、10 年還是 15 年?目前執行遭遇困難是什麼?地震是因板塊運動應力累積，斷層破裂後釋放能量而造成，請問對地震監測是為瞭解地震是否影響封存還是擔心封存壓力及相關作業會造成斷層或板塊運動?另日本對各項作業都相當謹慎，是否有曾想定過發生風險時(例如墨西哥灣鑽油井噴發事件)如何應變?

(2) 詢問有關 CCS 工程是否需要經過環境影響評估審查？陸地封存的可行性？CCS 有無相關補償金？及 CCS 船舶轉運安全疑慮等部分。

➢ JCCS 回應如下：

(1) 注入前後環境背景及監測項目有海水 pH、海灘海底二氧化碳分壓、前中後觀察底棲及生物種類(並無顯著變化)。

(2) 目前選擇以 30 萬噸係考量苫小牧 CCS 為示範場址並研究可行性，商業部分需要以 100 萬噸做為評估，觀察時間尚未決定，預計 5 年一次計畫更新，目前場址可繼續注入，對未來是否繼續尚無目標，後續改到經濟產業省，修法改善。

(3) 很多人對封存會造成地殼變化引起地震有所疑慮，本公司主要關注注入時間的露出，壓力偏高就會停止，2019 年停止注入後就回到注入前的壓力，後續將持續長期觀測。

(4) 即使很小的鑽井技術，也是受到嚴格的環評規範，加上 CCS 為新的工程技術，相關環評委員特別關心施工後 CO_2 洩漏對海域環境及生態影響，即使跟委員們強調由於是鑽井封存，安全性較高，CCS 封存技術在國外也很成熟，但因為是日本第一起示範案件，仍花很多時間與委員們溝通，達到環評各項要求。

(5) 由於目前日本法規規定只能於海洋處置，故僅能封存於海洋深層鹽水層。

(6) 由於 CCS 亦屬鄰避設施，JCCS 於設廠前與當地民眾透過良好的溝通及說明，且 1 年舉辦 1 場說明會，充分達到資訊揭露，目前暫無補貼當地居民相關補償金。

(7) 船舶轉運的部分預計於今(113)年開始進行，目前仍在研究及試驗階段，後續將持續關注相關安全問題。

4. 議題探討及拜訪照片

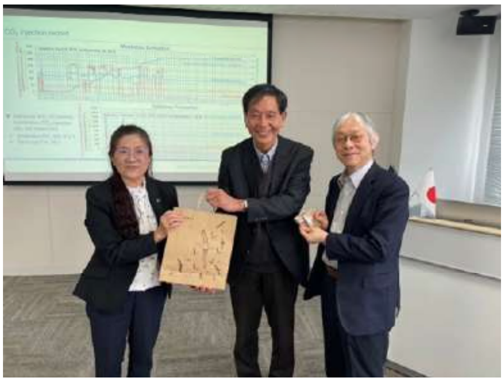
	
JCCS 簡報	問題回覆
	
現地解說(CO_2輸送)	現地解說(CO_2注入)
	
CO_2注入井	海上觀察及工作平台
	
會後合照	本署贈送禮品

圖 14 JCCS 交流活動照片

參、 心得及建議

一、 心得

此次拜考察拜會日本環境省、東京大學、JAMSTEC、ENEOS 石油公司及 JCCS 等單位，了解了日本在海洋環境保護相關政策及措施，尤其針對海洋保護區的管理與推動政策、海洋環境技術研究計畫及產官學合作模式、深海研究工具設計和水下無人載具、石油供應和海洋污染應變政策制定和應對措施等，這將對我國未來的海洋保護工作提供寶貴的參考，更特別的是因應全球氣候風險及達到我國減碳政策及目標，本次更參觀了日本的碳捕捉與封存示範試驗中心，了解了他們在碳捕捉和封存領域的研究技術和政府合作模式，因為臺灣針對 CCS 之發展技術目前尚在處於先導試驗及觀察階段，不管技術層面、地質調查、海事工程等都仍需持續精進、整合及蒐集。由於臺灣及日本皆為四面環海及地震頻繁之國家，如未來引進及開發海底二氧化碳封存技術及驗證場域計畫時，針對海域及海洋之環境影響評估及風險預測時，務必審慎觀察及估，同時也需建立相關法規、標準制度及觀察期，包括地質探勘、海事工程及環境監測等技術；另一方面，中央機關、地方政府、研究機構、環保團體、產業、民眾等面向，都需多方進行溝通及接受度的調查，並根據後續結果進行訊息公開，並製作相關宣導教材及活動，降低大眾對新技術的疑慮。以目前臺灣現況針對海底碳捕捉及封存技術實屬還有一大段路要走，因此，提出以下二點建議。

二、 建議

(一) 持續強化及建置海洋污染緊急應變能量

依據日本石油工業園區防災法、國土交通省海洋污染與災害預防法皆有制定需具備之緊急應變資材及數量，而目前臺灣在重大海洋污染緊急應變計畫中雖已明訂相關船舶、應變資材整備，但針對 HNS 污染之緊急應變器材尚顯不足，因此建議除了持續採購增購應變器材、資材之建置之外，

在培訓方面亦需持續需提升本國海洋緊急應變之能力，除了增加 IMO 油污訓練人力之外(IMO Level 0 至 IMO Level 3)之外，針對 OPRC-HNS Operational Level 及 Manager Level 的人員訓練來提昇本署專業能力，並可積極與國際、民間業者、團體合作建立區域型應變機制來完備海上應變體系。

(二) 建立臺日產官學之聯繫管道

本次考察拜會日本海洋管理、研究相關防救機關（構）、民間組織等單位，進行海洋環境政策、海洋環境調查及管理等經驗交流，亦建立了產官學不同單位之聯繫管道。建議在未來舉辦國際研討會、論壇或是工作坊時，可以邀請這次拜會的專家、學者共同參與，期待未來與日本有更多的合作機會。

肆、 附件清單

附件一、環境省相關會議資料

附件二、東京大學相關會議資料

附件三、國立研究開發法人海洋研究開發機構相關會議資料

附件四、日本 ENEOS 石油公司相關會議資料

附件五、日本 CCS 調查株式会社相關會議資料

環境省相關會議資料

Permitting system for CO_2 sequestration in sub-seabed geological formations and Related trend on CCS in Japan

April 5, 2024

Marine Environment Division
Environmental Management Bureau
Ministry of the Environment

The London Protocol

The London Protocol and Objective

- To protect and preserve the marine environment from all sources of pollution and take effective measures to prevent, reduce and eliminate pollution caused by dumping or incineration at sea of wastes or other matter.

- In the protocol, Contracting Parties shall prohibit the dumping of any wastes or other matter with the exception of those listed in Annex 1.

55 Contracting Parties (as of March 2024)

<u>Amendment of the Protocol (CCS)</u>

2006	CO_2 sequestration in sub-seabed geological formations is listed in Annex 1.
2009	The London Protocol was amended to allow for cross border transportation of CO_2 for sub-seabed storage. (The amendment must be ratified by two thirds of contracting parties to enter into force.)

Contracting Parties that have declared a provisional application can export CO_2.

Permitting system of dumping at sea in Japan

Act on Prevention of Marine Pollution and Maritime Disaster

Japan has been implementing the provisions of the Protocol domestically mainly through the Act on Prevention of Marine Pollution and Maritime Disaster.

- The disposal of wastes at sea is prohibited in principle.
- Only when a permit is issued by the Minister of the Environment, the limited exceptional types of "wastes" can be disposed at sea.
- "Wastes" mean things unnecessary for humankind in Japanese Law.

Permit for the disposal of CO_2 for CCS

The Act is covering the disposal of CO_2 for CCS.

Prohibition of disposal of oils, noxious liquid substances and wastes under the seabed.

Except for

1. Oily matter resulting from exploration of mineral resources in the seabed and sub-seabed
2. Gases consisting overwhelmingly of CO2

⇨ Permit issued by Minister of the Environment is required.

The permitting criteria and process for CCS

Permitting criteria for CCS

- Geological structure should **prevent negative impact on the marine environment**.
- The situation **should be monitored to identify pollutions**.
- **No possibilities to affect the environment** in the disposal area.
- **No alternative appropriate disposal ways other than disposal** under the seabed.
- An applicant should **have technical and financial capability** to implement disposal and monitoring continuously.

Permitting process

1. Submission of Application Documents

   Public comment for 1 month

2. Issuance of a Disposal Permit
3. Disposal and Storage of CO_2, and Monitoring
4. Renewal of a Disposal Permit

※**Permit is for a maximum of** 5 years

Three monitoring phases

Phase 1 : Regular monitoring

Exceed the threshold

Phase 2 : Precautionary Monitoring

Exceed the threshold

Monitoring to judge whether negative effect occurred/would occur.

Phase 3 : Contingency monitoring

Continuous monitoring until no negative effect is confirmed.

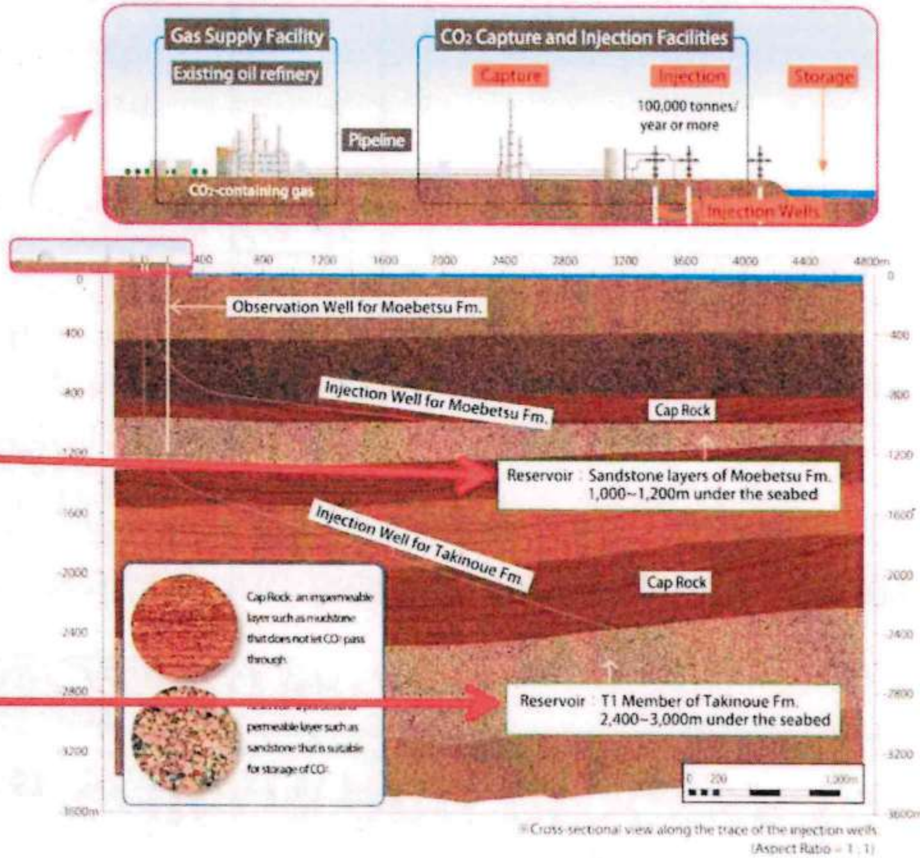
Tomakomai CCS demonstration project

Applicant	Ministry of Economy, Trade and Industry
Permitted period	2016.4 - 2021.3 (5 years)
Injection period	2016.4 - 2019.3 (3 years)
Total amount	300,000 tonne (100,000 tonne/year)
CO2 Source	Petroleum refining plant

Reservoir (aquifer)

Moebetsu Fm.
1,000~1,200m

Takinoue Fm.
2,400~3,000m



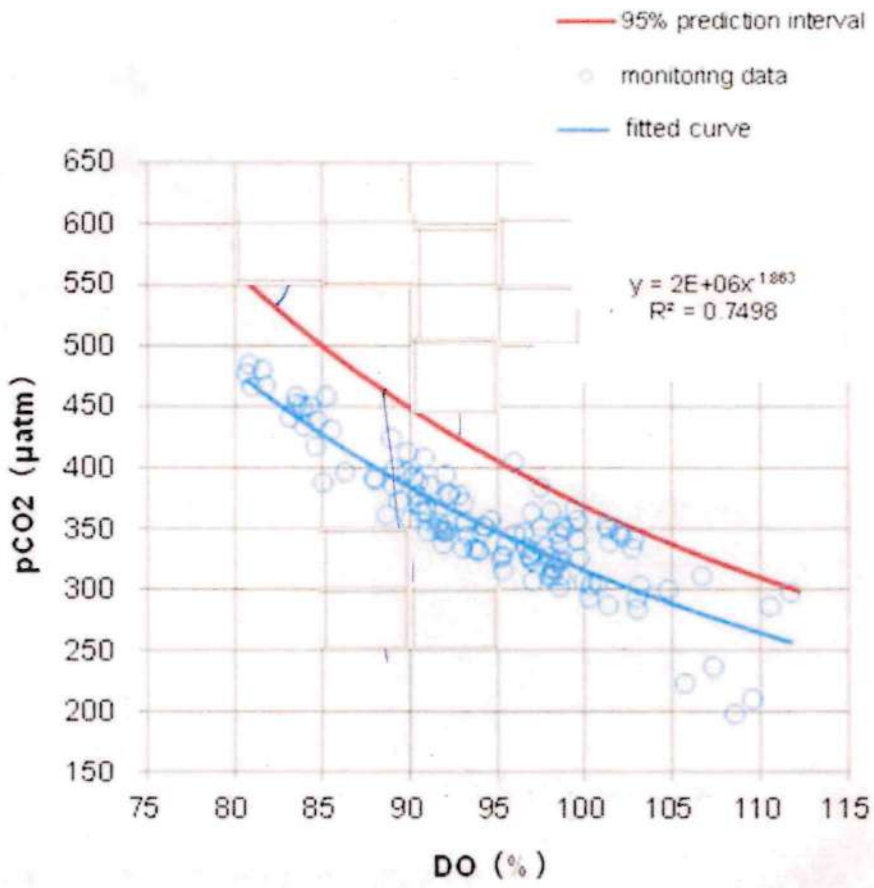
Source: Japan CCS Co., Ltd HP
http://www.japanccs.com/en/business/demonstration/index.php

Environment monitoring

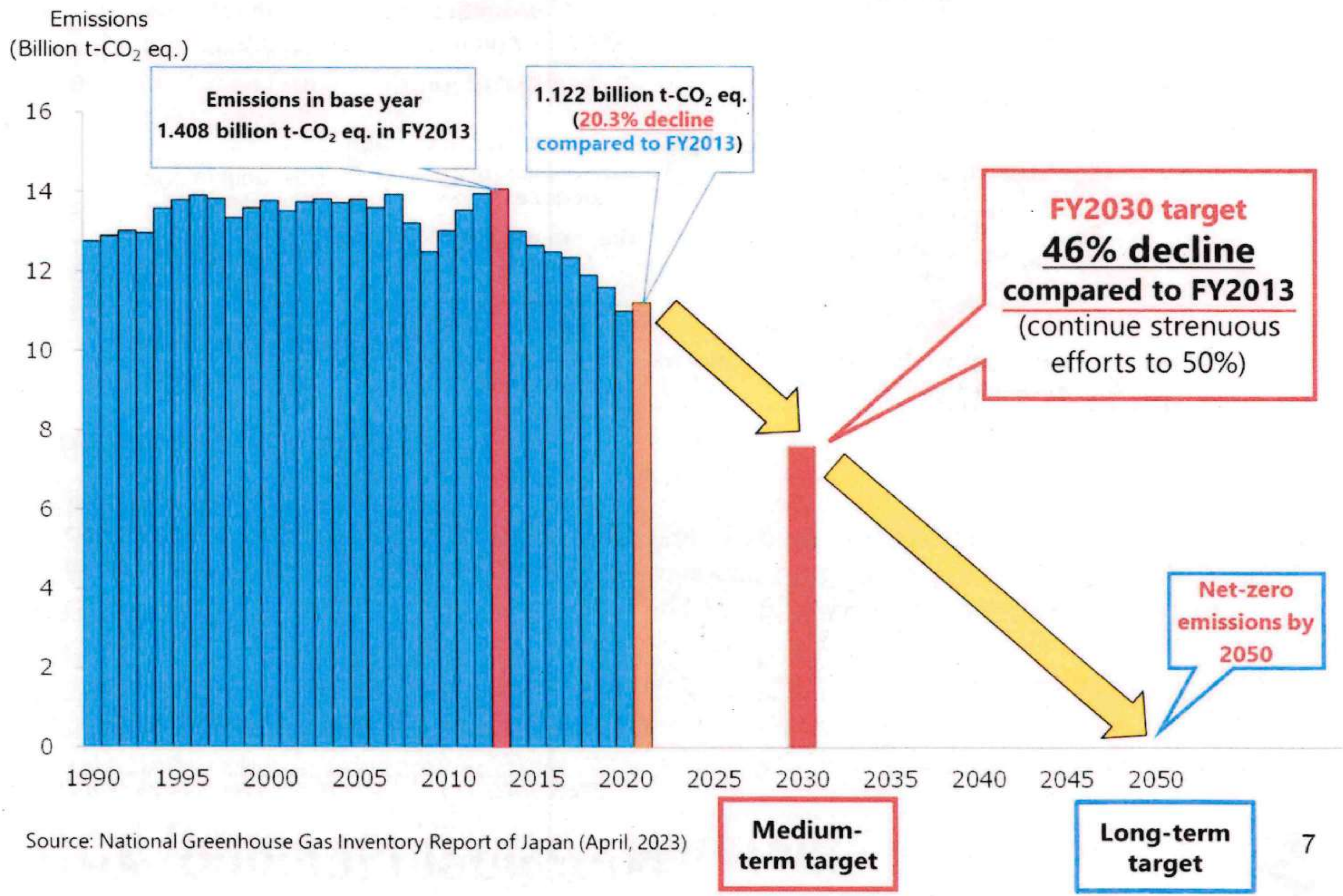
Parameters measured in Tomakomai

- ➢ Relationship between ***pCO₂*** and ***DO*** was considered as valid for the threshold.
- ➢ The method of setting the threshold for water column sampling in Tomakomai area was considered.

- Relationship between pCO_2 and *DO* (dissolved oxygen saturation[%])
  - pCO_2 is inversely correlated with *DO*.
  - Stable throughout a year
- *DIC* (Dissolved Inorganic Carbon)
  - Increased linearly with the amount of leaked CO_2
  - Strongly affected by air-sea exchange
  - Differed from year to year even in the same season
- *pCO2* (carbon dioxide partial pressure)
  - Fluctuated due to respiration and photosynthesis of marine organism
  - Increased non-linearly with the amount of leak CO_2



Japan's Medium- and Long-term Targets for GHG Reduction

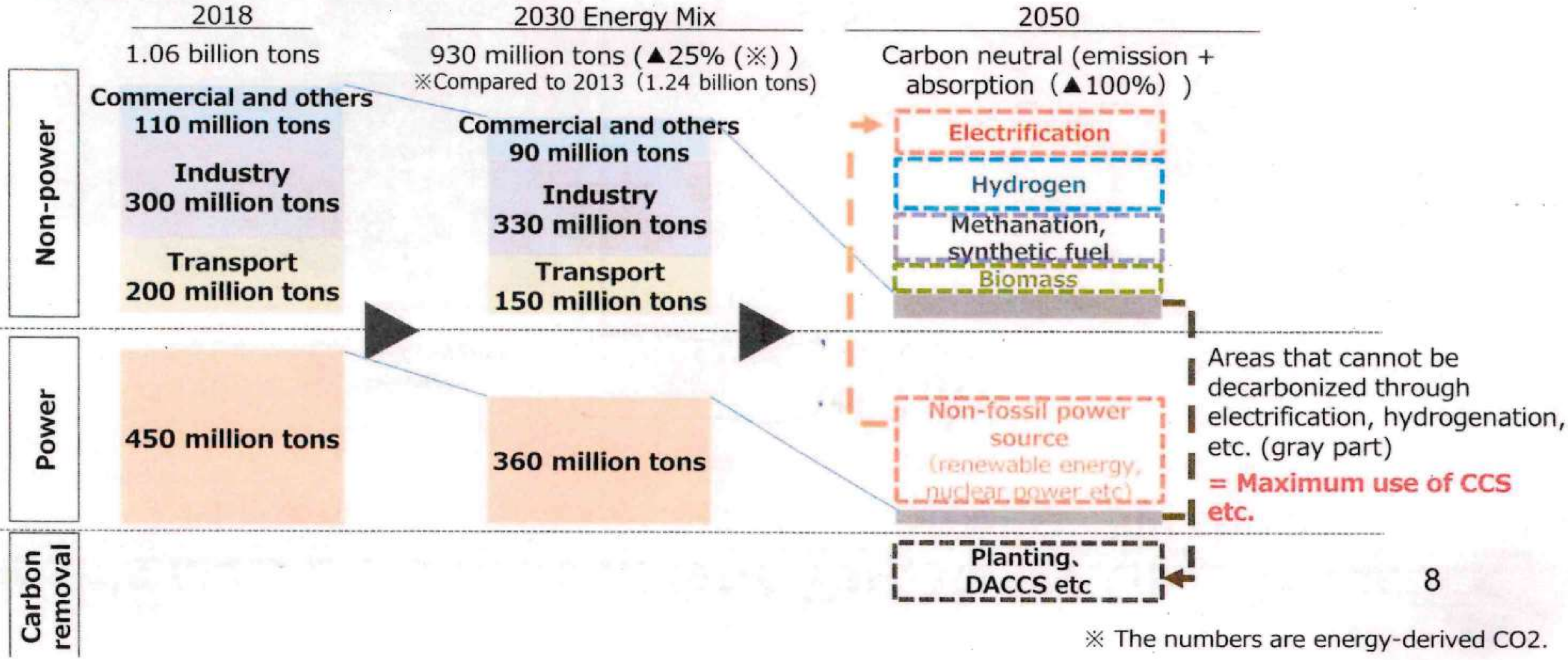


Source: National Greenhouse Gas Inventory Report of Japan (April, 2023)

CCS policy for Carbon Neutrality in Japan

- To achieve carbon neutrality in 2050, **<u>CCS is necessary to abate emissions in areas where CO_2 emissions are unavoidable</u>**.
- The CO_2 capture amount volume of Japan in 2050 is expected **<u>about 120 to 240 million tons</u>**, based on the IEA report and the goals of each country.
- GX Promotion Strategy (Cabinet decision: July 2023) states that **<u>to develop business environment for starting CCS by 2030</u>**, advanced CCS Projects will be supported and discussions on **<u>developing relevant legal frameworks will be accelerated</u>** to have systemic measures in place.

Before allocation of power and heat

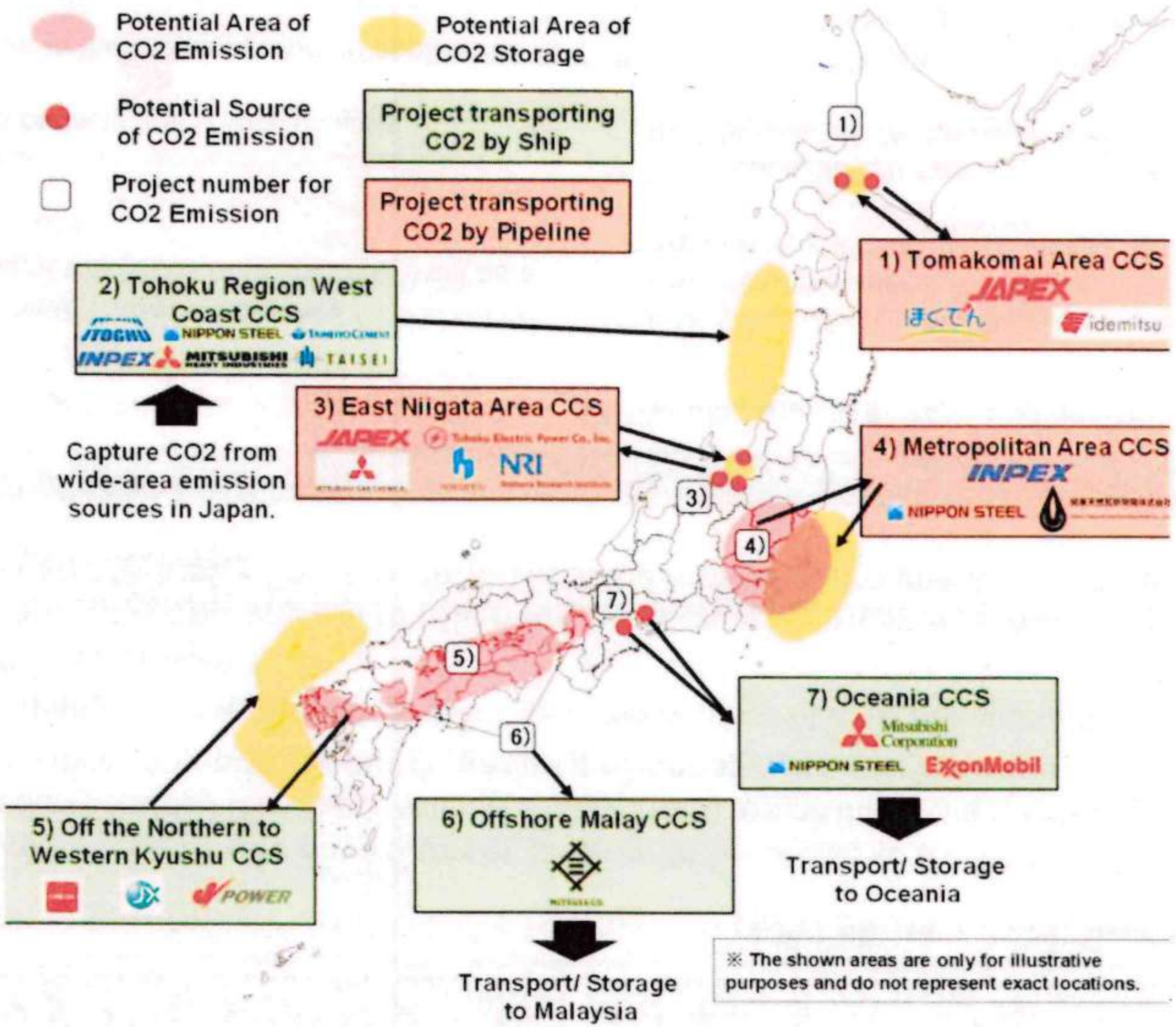


※ The numbers are energy-derived CO2.

Japanese Advanced CCS Project

7 role model projects selected by JOGMEC

(Japan Organization for Metals and Energy Security)



Source: JOGMEC Website https://www.jogmec.go.jp/english/news/release/news_10_00036.html

Overview of the draft Act on Carbon Dioxide Storage Businesses

(13th February 2024, Cabinet Decision)

- Japan plans to create **a business environment for private businesses to start CCS business by 2030** (GX Promotion Strategy, Cabinet decision in July 2023), **establishing a permit system for storage projects** while **maintaining public safety and conserving marine environment**.
- The **current permission system** under the Act on Prevention of Marine Pollution and Maritime Disaster **will be integrated into the new Act**.
- **The Minister of the Environment will jointly manage necessary measures with the Minister of the Economy, Trade and Industry** from the viewpoint of the marine environment conservation.

1. Permit system for exploratory excavation and storage business, business regulations related to storage business

1. *Permit system for exploratory excavation and storage business*

The Minister of Economy, Trade and Industry

- **Designates the area** where the reservoir may exist as a "specific area"
- Announce an **open call for exploratory excavation and CO2 storage** projects in the specific area,
- **Grants permission** to the most appropriate applicants.
- **Need agreement with the Minister of the Environment** in designation of specific area and permit of a storage. .

(2) Regulations for storage business operators

The Minister of Economy, Trade and Industry

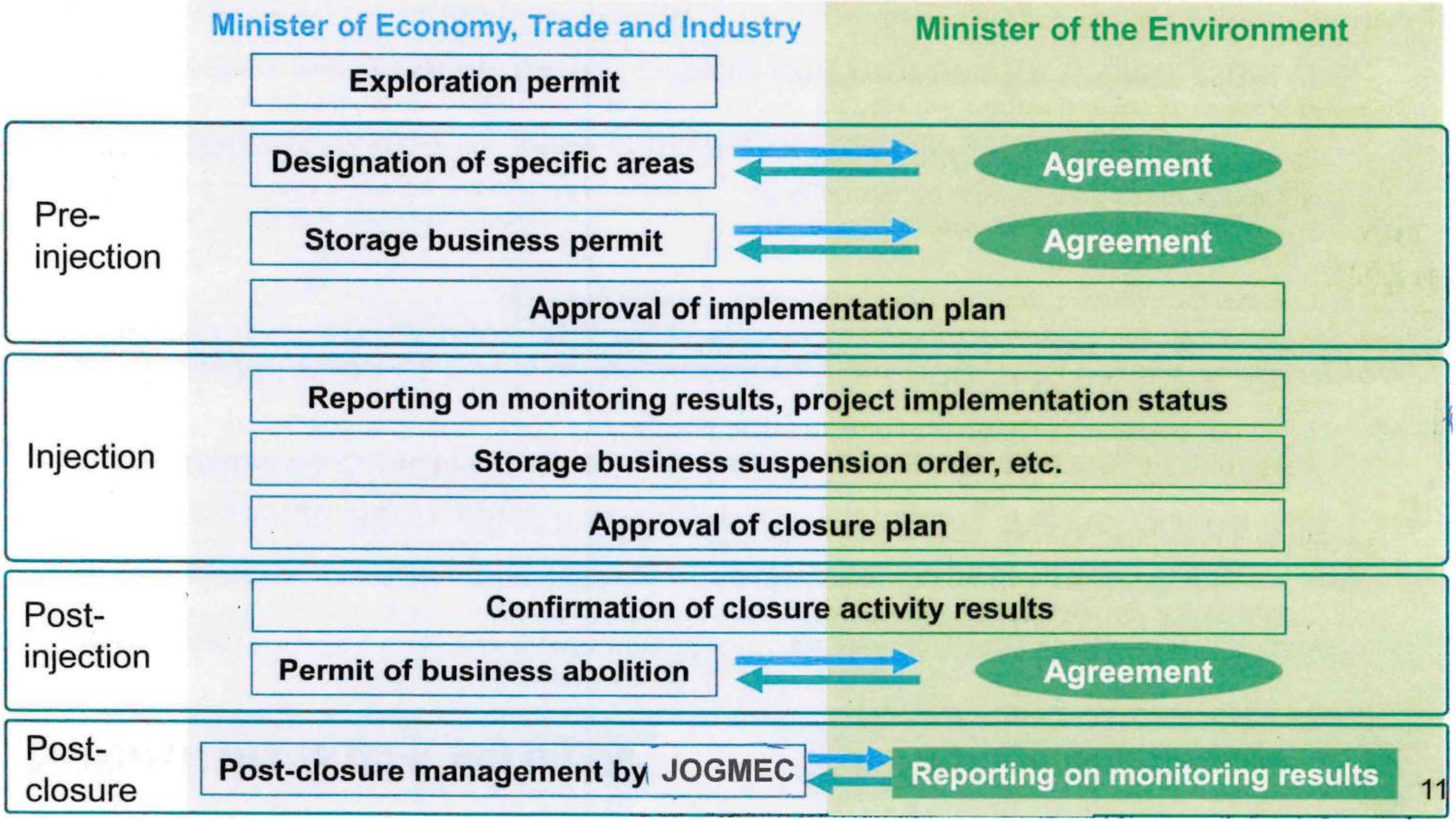
- **Approves** the specific "**implementation plan**" for exploratory excavation and storage projects
- In the case that **storage is in the sea** area**, approval by the Minister of the Environment** is required.
- Impose the **obligation to monitor** the temperature and pressure of the storage reservoir so that leakage of stored CO2 can be identified. .

2. Authorization of closure plan, post-closure management by JOGMEC

- After business abolition is permit, **projects will be taken over and managed by JOGMEC**

Conservation of the marine environment under a new act on CCS

- In February 2024, Cabinet Approval was made on ***the Act on Carbon Dioxide Storage Businesses***. The Minister of the Environment will be jointly responsible for taking necessary measures for conservation of the marine environment under this Act.
- **Acceptance of Article 6 amendment** will be also consulted with the Diet.



Schedule and Future consideration

Schedule

- The act on Carbon Dioxide Storage Businesses is under the domestic diet consideration. After the approval by the diet, the Act will be fully operated in 2 years.
- The ratification of 2009 amendment of the London Protocol is also under the discussion in the diet.

Future consideration ***(in terms of marine environment protection)***

- Develop the detailed permit criteria and process for project closures.
- Methodology of environmental impact assessments in designation of specific area.
- Promote public consensus around project sites.

環境省
Ministry of the Environment

Measures against plastic pollution, including microplastics

Office of Policies against Marine Plastics Pollution,
Marine Environment Division,
Ministry of the Environment, Japan

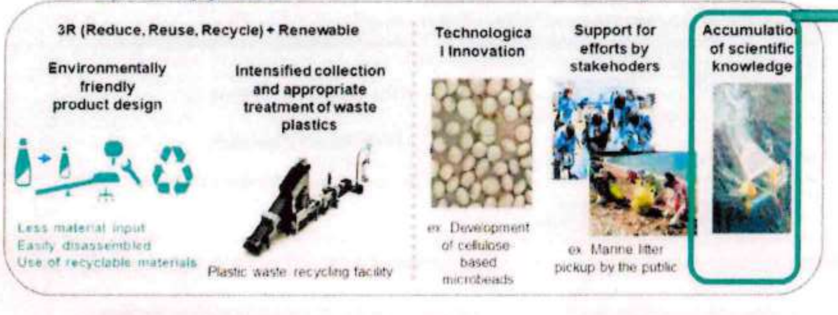
Policies against Marine Plastics Pollution in Japan

Legal / Policy Framework

- the Act on Promoting the Treatment of Marine Debris (2009, amended in 2018) → **the Basic Policy on the Comprehensive and Effective Promotion of Measures Against Marine Debris** under the Act (2009, 2019)★--- Promotion Council for Marine Litter Policy
- **Resource Circulation Strategy for Plastics** (2019)★ ; **Japan Action Plan for Marine Plastic Litter** (2019)
- Act on Promotion of Resource Circulation for Plastics (2021 (enforced in 2022))★
  - + the Act on Prevention of Marine Pollution and Maritime Disaster (1970, amended in 2017) etc.
  - + Waste management related laws ...

Measures

Life cycle approach **Science based approach**



- ◆ Monitoring
- ◆ Data Harmonization
- ◆ Inventory of discharged amount (estimation)
- ◆ Ecological Impact Assessment

- Policy making
- Progress tracking and effectiveness assessment

Basic Policy on the Comprehensive and Effective Promotion of Measures Against Marine Debirs

https://www.env.go.jp/content/900542989.pdf

環境省

①Streamlined treatment of Marine Debris

- Municipalities from upstream to downstream should cooperate and tackle marine litter (not only coastal resp.)
- Promote treatment of floating litter etc, which cause problems to local residents and/or economic activities such as those of the fishing industry and tourism industry, through gaining cooperation from fishery operators, etc.

②Effective Reduction of Generation of Marine Debris

(1) Establishment of Recycling Society through Promotion of 3R

- Reduce the generation of waste plastics by reducing single-use plastic containers, packaging and products.
- Promote effective, efficient and sustainable recycling, usage of biodegradable plastics and recycled materials, and ensure appropriate disposal of waste plastics

(2) Reduce the flow of microplastics into the sea

- Business entities should make efforts to reduce the usage of microplastics to prevent them from flowing into the sea by reducing the usage of microbeads contained in rinse-off scrubbing products
- The government will promote research and surveys on the distribution/discharge and impact on ecosystems of microplastics in marine areas, rivers, lakes, and other public waters.

③Ensure Appropriate Division of Roles and Coordination among Various Actors

(1) Enhance nationwide coordination among the national and local governments, individuals, private organizations, and business entities

(2) Promote active participations through commendation, etc.

(3) Enhance coordination among researchers

Plastics Smart

④Ensure International Coordination and Promote International Cooperation

(1) Actively engage in global initiatives

(2) Promote coordination and cooperation among the related countries in Asia etc

(3) Support measures to reduce the generation in the developing countries

(4) Establish monitoring and research network on a global scale

Japan's Resource Circulation Strategy for Plastics

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Key Strategies

Basic Principle: "3Rs + Renewable"

Reduce	➢ Reduce single-use plastics ("pricing" such as mandatory charge on plastic bags etc.) ➢ Promote substitutes for Petroleum based plastics
Recycle	➢ Easy-understanding and effective segregation at source and recycling of plastic ➢ Thorough collection of fishing equipment onshore ➢ Minimize costs and maximize effective use of resources ➢ Develop domestic resource circulation system given embargoes of Asian countries
Recycled materials Bio-plastics	➢ Improve usage potential by technical innovation and infrastructure development ➢ Stimulate demand by green public procurement, and usage incentives etc ➢ Handling of chemical ingredient information ➢ Use bio-plastics such as burnable waste bags ➢ Bio-plastic introduction roadmap and integration with recycling system management

[Target]

<Reduce>

(1) Cumulative reduction of 25% of single-use plastics by 2030

<Reuse/Recycle>

(2) Reusable/recyclable design by 2025

(3) Reuse/recycle 60% of containers and packaging by 2030

(4) 100% effective use of used plastics by 2035

<Recycling and Bio-Plastics>

(5) Double the use of recycled amount by 2030

(6) Introduce 2 million tons of bio-plastics by 2030

Marine Plastic Litter	Aiming for prevention of marine pollution caused by outflow of plastic waste (marine plastic zero emission) ➢ Proper disposal and eliminate littering and illegal dumping ➢ Collection and proper treatment of coastal drift litter ➢ Data collection of marine waste by advanced monitoring methods ➢ Microplastic discharge reduction thorough reduction of microbeads in scrub products by 2020 etc ➢ Promote alternative innovation
International Cooperation	➢ Support emerging countries by tailor-made comprehensive support of soft and hard infrastructure and technology ➢ Develop global monitoring and research network; marine plastic distribution, study ecological impact, standardization of monitoring methods etc
Infrastructure development	➢ Establishment of social systems by soft and hard recycling infrastructure and supply chain structuring ➢ Technology development (renewable resource substitutes, innovative recycling technologies, consumer lifestyle innovation) ➢ Study and research on impact of microplastics, discharge conditions, discharge reduction measures ➢ "Plastics Smart" movement ➢ Promote recycling industries ➢ Information infrastructure (ESG investment, ethical consumption) ➢ Infrastructure for global collaboration

◆Not only **solve worldwide resource** and **environmental issues**, but also contribute to **economic growth** and **employment creation**
⇒ Contribute to **sustainable development**

◆**Promote investment and innovation of technology and consumer lifestyle through collaboration with all the stakeholders**

Act on Promotion of Resource Circulation for Plastics (Act No. 60 of 2021)

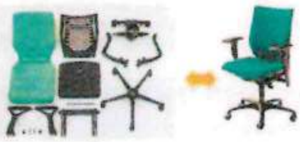
This Act addresses whole lifecycle of plastics

1. Design/Manufacturing — Design for the Environment

- The government certifies products designed in accordance with the statutory guidelines for design for the environment and procures preferentially the certified products (under the Act on Promoting Green Procurement).

Reduce: replaceable bottle

Recycle: design for disassembly



Renewable：100% recycled plastic

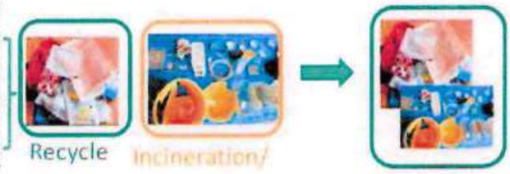
2. Sales/Provision — Reduction of Single-use Plastics

- Retailers and service providers are required to reduce single-use plastics through, for instance,
- rewarding programs for consumers who refuse single-use plastics
- charging for single-use plastics
- switching to alternative materials

Retailers and restaurants
● forks ● spoons ● knifes ● muddlers ● straws
Hotels
● hairbrushes ● combs ● razors ● shower caps ● toothbrushes
Dry cleaners
● hangers ● clothes covers

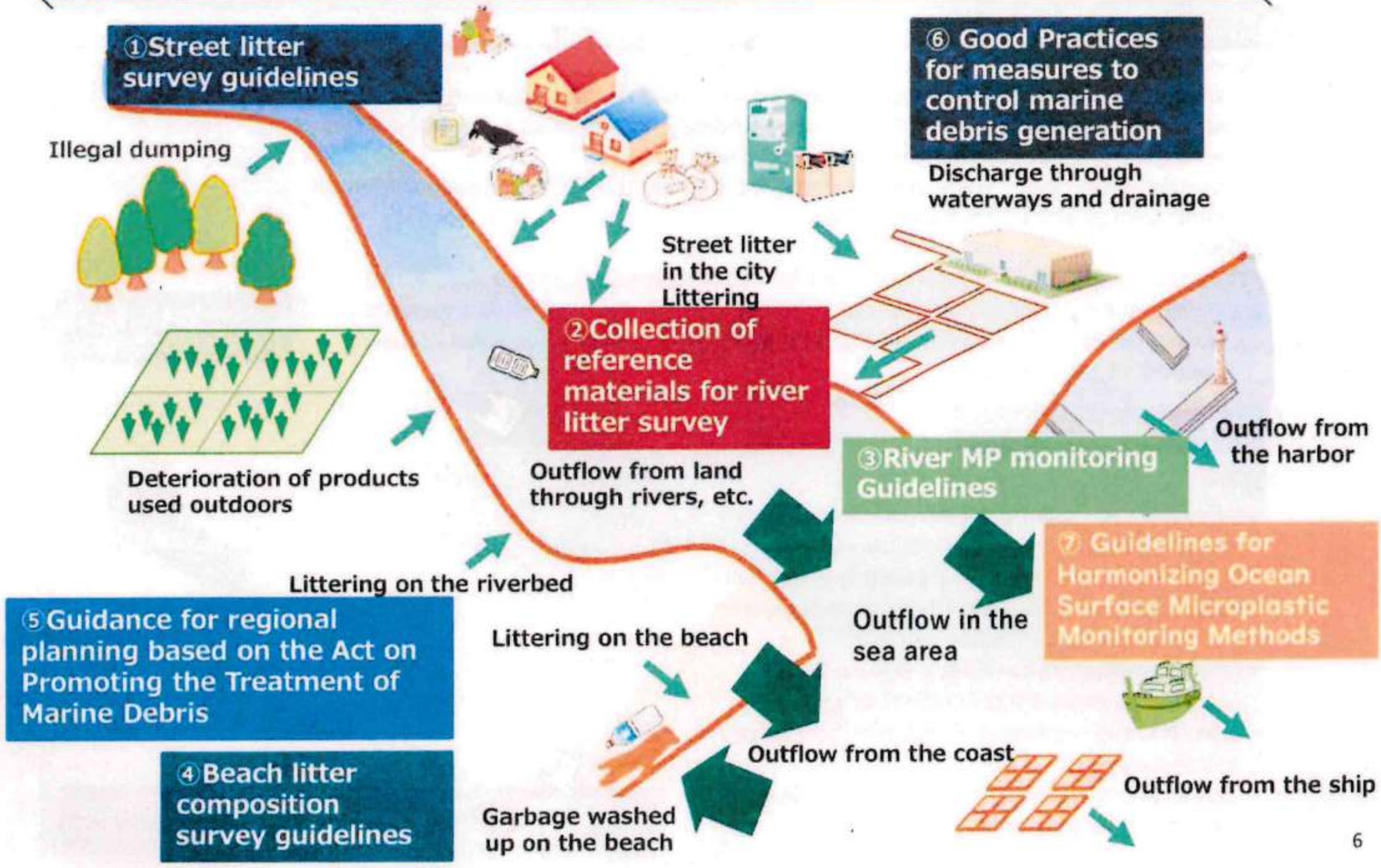
3. Discharge/Collection/Recycling

		Before the enforcement	After the enforcement
House holds	containers and packaging	Recycle	Recycle
	products	incineration/landfill	Recycle
Industrial Waste		proper management	3Rs(Reduce, Reuse, Recycle)



Assessment of leakage in the environment

MOE's survey/monitoring/clean-up guidelines related to plastics floating into the Marine environment



Assessment of leakage

Periodic surveys on Marine Litter including plastics organized by MOEJ

Beach litter 2010～

Collect and summarize the amount, types, and composition of beach litter, and the language of plastic bottles on beaches.
(28 sites in total with some sites surveyed periodically)

(Survey method)
- All beach litter of 2.5 cm or larger within a 50-meter survey area is collected and classified at beaches that are not frequently cleaned.
- From 2020, the survey entity was change from MOEJ to local governments to expand survey sites and continuous surveys at the same sites to understand the changes over time.
- From 2014 to 2019, microplastics were also collected to examine PCBs and other harmful chemicals adsorbed on microplastics.

Survey sites (2015～2019)

Floating macro litter (Visual observation) 2014～

Count floating macro litter on the sea surface in coastal and offshore areas of Japan to estimate the density and amount of litter in each area.
(Coastal: approx.15 sites/year, Offshore: approx.600 sites/year)

(Survey method)
- Coastal surveys are conducted by visiting a total of 13 bays in turns.
- Offshore surveys are conducted in the waters of east of the Philippines, and the area up to around 150 degrees east longitude.
- The number, type, and size of litter are counted visually from a vessel.

Ocean Surface microplastics 2014～

Survey distribution of floating microplastics in coastal and offshore areas of Japan.
(Coastal: approx.15 sites/year, Offshore: approx.100 sites/year)

(Survey method)
- Collect floating microplastics by net during cruises for floating macro litter survey.
- Identify material using infrared rays, count the number using microscope, etc.
- From 2014 to 2019, laboratory analysis to examine PCBs and other harmful chemicals adsorbed on microplastics were conducted (every year for coastal samples, depending on the year for offshore samples).

cont. next page

Seafloor litter 2014～

Collect seafloor litter in coastal and offshore areas of Japan to estimate the density of litter by sea area.

(Survey method)
- Coastal surveys are conducted by classifying litter collected by bottom trawling during fishing operation.
- Offshore surveys are conducted in the East China Sea, off Oarai and off Tomakomai. Litter is collected by surveys using bottom trawling.

Assessment of leakage

Periodic surveys on ocean surface microplastics organized by MOEJ

Coastal waters

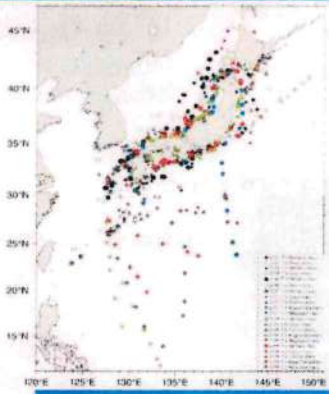
2015～2019
- Conducted surveys by visiting a total of 13 bays in the coastal area in turns to understand the distribution status of ocean surface microplastics. (In some sites, surveys were conducted multiple years in a row.)
- Conducted laboratory analysis to examine the amount of PCBs and other harmful chemicals adsorbed on microplastics.

2020～
- Conduct fixed-point observations four times a year (spring, summer, fall, and winter) at three sites in coastal areas facing the open sea, which are affected by ocean currents, in order to understand annual changes and seasonal and sea-specific characteristics.

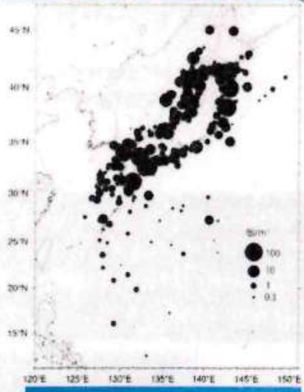
Survey sites (2015～2019)

Offshore waters

2014～
- Conduct surveys on the amount and types of ocean surface microplastics. Surveys for approx. 100 sites per year using five vessels have been conducted with the cooperation of four universities in Japan since 2017.
- The survey covers offshore waters around Japan, as well as the southern and eastern seas, and the area up to around 180 degrees east longitude.
- Conducting surveys in the Philippine Sea, off Kagoshima, and east of Hokkaido



Survey sites (2014～2019)



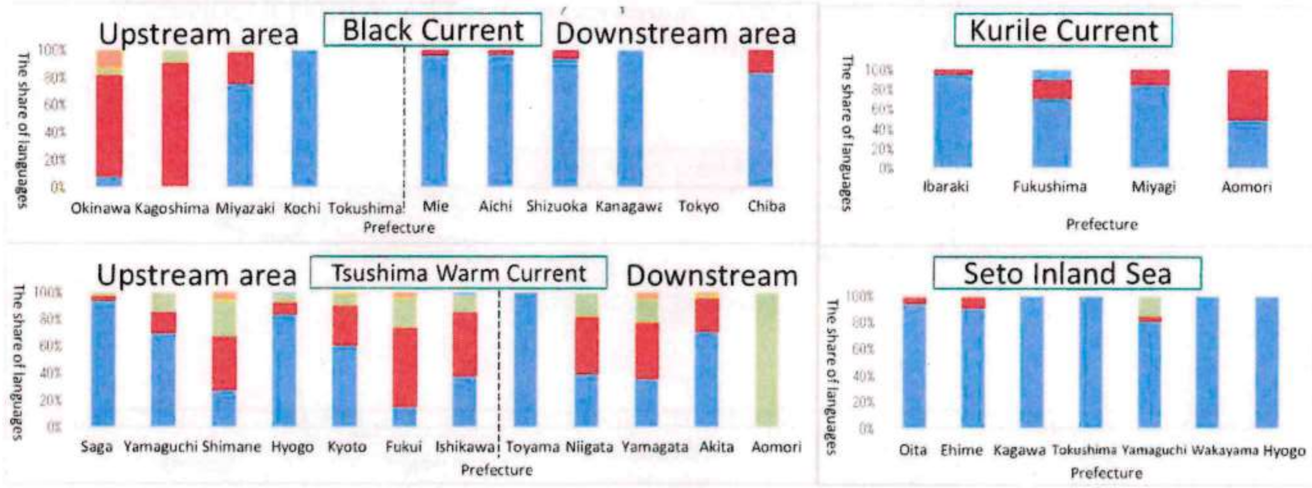
Density distribution (2014～2019)

Assessment of leakage

Where is it coming from? (based on PET bottle label languages)

Result of analysis in FY 2021

JP CN_ROC KOR RU Others



Black (Kuroshio) current:

Okinawa, Kagoshima: more than 70 % is in Chines.

Others: more than 70% is in Japanese

Kurile (Okhotsk) Current: more than 50% is in Japanese in all prefectures

Seto Inland Sea: more than 80% is in Japanese

The latest data is available at: https://www.env.go.jp/water/post_80.html

Ecological impact

Ecological impact assessment -- Working Structure FY2022~

[Risk Assessment Committee]

- Based on reliable findings, organize categories (particle size, material, shape) and methods (SSD, key studies, etc.) to evaluate risk, and examine no-effect concentration
- Examine estimated environmental concentrations based on the gap between the real environment and laboratory experiments

1. Exposure ← Effects ← **2. Physical properties** → Effects → **3. Adverse effects**

Subcommittee for Exposure Assessment

- Collect environmental measurement (monitoring) data and advanced literature on particle size less than 300 μm
- **Identify the gap between the marine environment and laboratory experiments** (concentration conversion, particle size, material, shape)
- **Examine estimation methods for fine MPs** (300 μm or smaller) **based on the monitoring/research data (300 μm or larger)**
- Consider application to risk assessment

Subcommittee for Adverse Effects

- Collect information on testing to assess the effects of particles
- **Discuss reliability criteria for the literature /research papers**

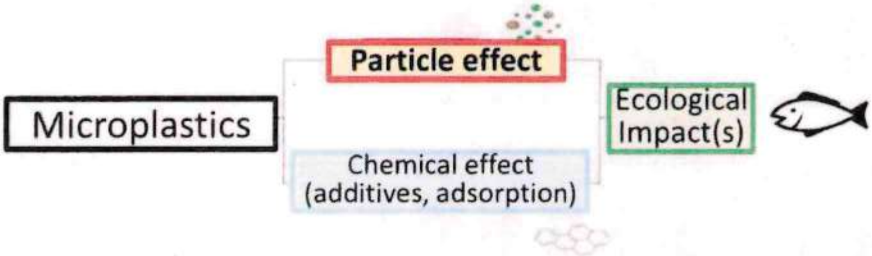
(About 2 reports/person/2weeks) x 2 sets

- Consider application to risk assessment

Ecological impact

Assessement of the Ecological impact of Micro plastics on Living Organisms and Ecosystems

- Focus on [aquatic organisms x **particle effect**], which involves a large amount of information.



Target organisms / Impact	Aquatic organisms	Benthic organisms	Seabirds, sea turtles, mammals, etc.	Human
Particle effect	✓			
Additives				
Absorbed chemical substance				

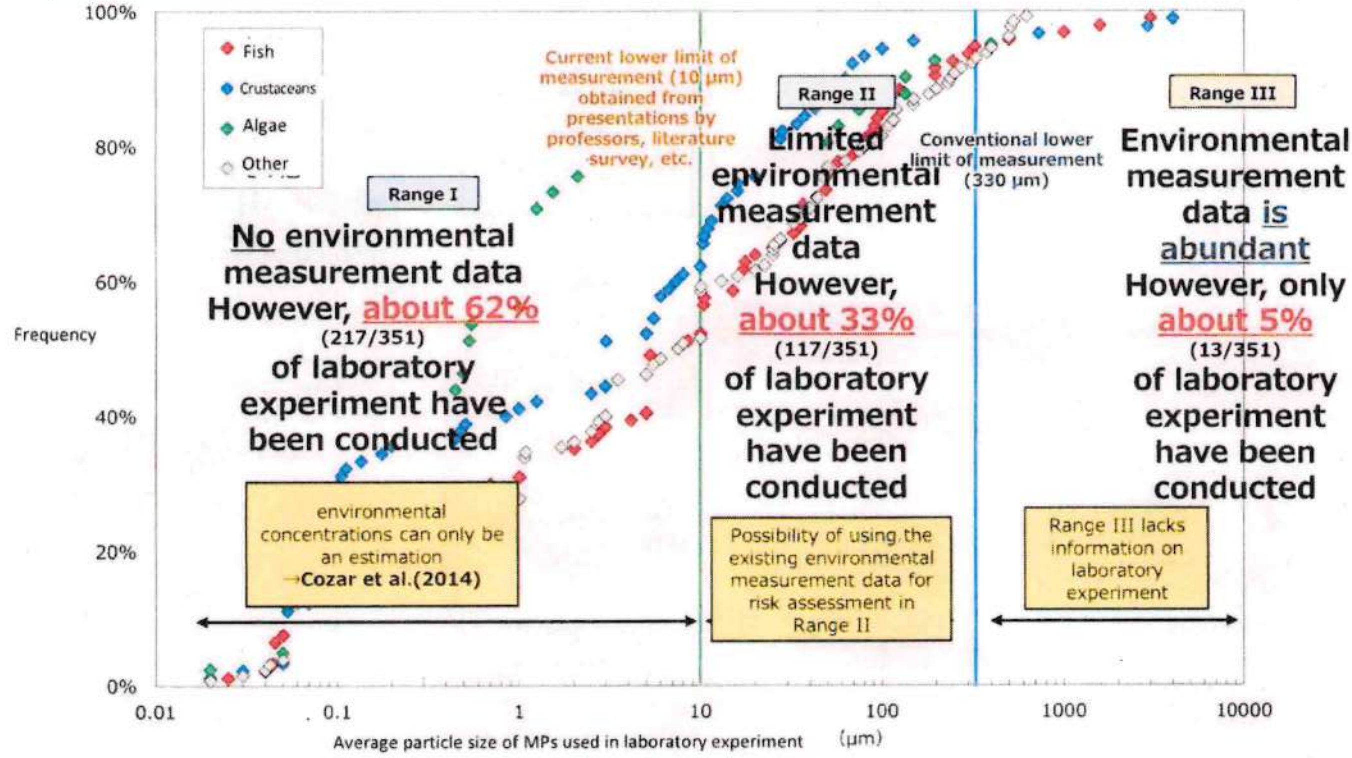
Ecological impact

Gap & Challenges in comparing real environment and laboratory experiment

	Real Environment (data in Ocean surface) MOEJ research data	Labo Experiment (Aquatic organisms) Research papers	Challenges
Particle Size	➢ > 330μm due to technology limitation ➢ Variation in size	➢ nano～10μm ➢ Single size	➢ Smaller size in labo experiment (difference in 1 ~3 digit) ➢ Different sizes ⇔ Single size
Polymer	PE,. PET are many	PS is mainly used	➢ Various polymer types (PE, PET) ⇔ PS
Shape	Fibers, fragments are many	Beads are mainly used	➢ Various shapes (fibers, fragments) ⇔ beads
Unit (density)	Mainly in numbers of particles (particle/m^3)	Mainly in volume (μg/L)	➢ Conversion (numbers ⇔ volume) is needed

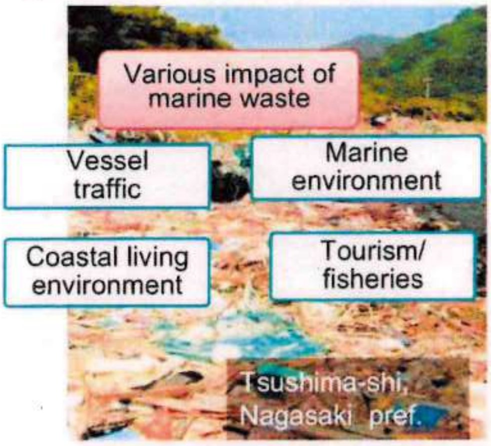
Ecological impact

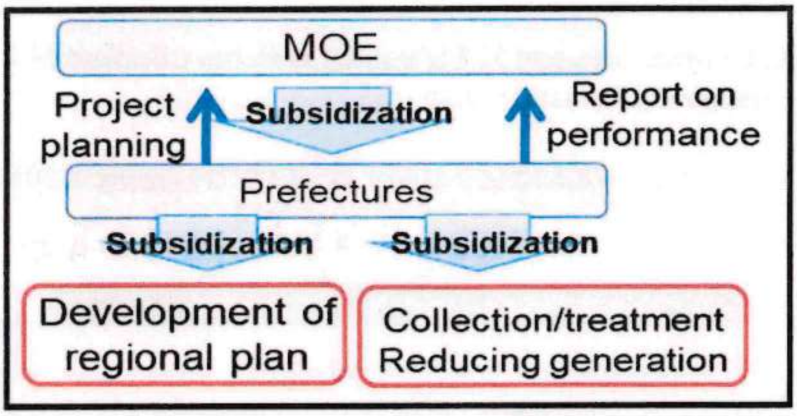
[Summary as of FY 2022] Status of linkage between actual environment and laboratory experiments (particle size)



- Classification only focused on particle size; material and shape are mixed. Endpoints vary from molecular to individual level.

Domestic Promotional Programs for Local Governments

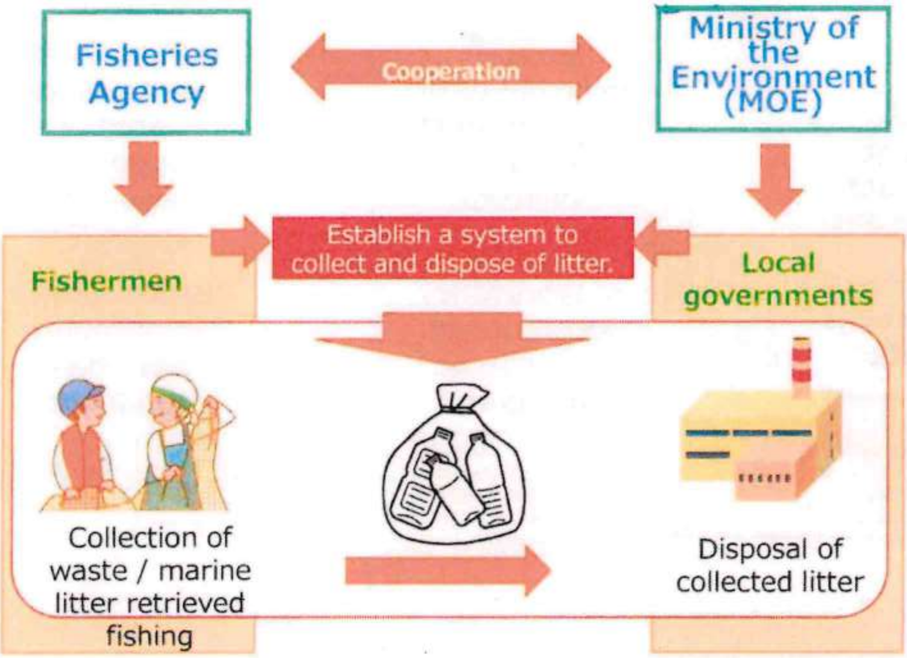




- Cause of marine / coastal waste: land based as well as sea based
- Supporting through subsidization of municipalities' projects on:
  the collection/treatment of marine / coastal waste; the measures to reduce waste generation.

Subsidy rate: 70 to 90% since FY2009
Special tax allocation for burden of local government: 80%

Domestic Promotional Programs – Cooperation with Fishery Agency



2020

https://www.env.go.jp/recycle/misc/guideline/gyogyokei/post_55.html

2023

https://www.env.go.jp/content/000156825.pdf

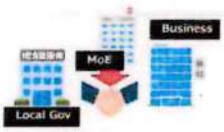
Domestic Promotional Programs – Cooperation with Local government

20 Prefectures and 122 Municipalities have Declared to realize Zero Plastic Waste (as of July 31, 2022)

Population: 74,540,000 out of 125,440,000 (approx. 60%)

Local Blue Ocean Vision Program

Encouraging Stakeholder Cooperation



MoE supports local governments that collaborate with local private entities to implement model projects under the **"Local Blue Ocean Vision program".**

More than 20 Projects since 2021 (as of 12. 2023)

Why it works

- Businesses are willing to contribute (SDGs, plastics)
- LGs aware of public interest and concerns

← **Learning-by-doing may be too risky (lack of methodology)**

Expert advice and framing it as "Nat Gov pilot proj" provides reassurance, platform for coop.

Not in it for the money!

(approx. 10,000 USD/proj)

Cooperation with Business sectors

- **Demonstration project support program on the innovative substitute material technologies** (about 4 billion JPY for FY2023)

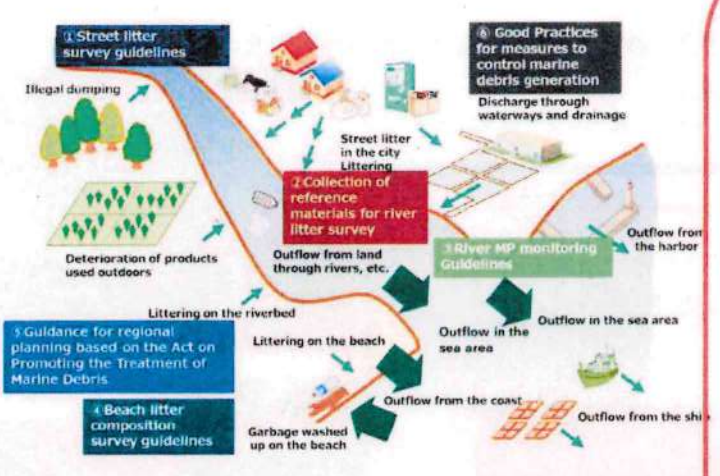
https://www.env.go.jp/press/press_01282.html

※ Marine Biodegradable Plastics; Bioplastics; Cellulose; Paper etc.

- **Good Practices for Reducing Microplastics**

https://www.env.go.jp/water/post_113.html
https://www.env.go.jp/content/900539104.pdf

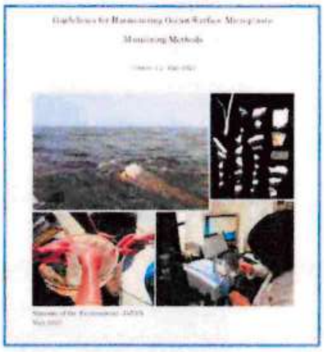
MOE's Guidelines related to plastics discharged into Ocean



- Survey & Monitoring of plastics in the environment (Beach, Floating, Sea Floor, River, Lake)
- International cooperation:
  - Capacity building on plastic waste management
  - Technical training of monitoring of plastics
  - G20 report on Actions against Marine Plastic Litter
  - Knowledge sharing through RKC-MPD, ERIA

Ocean surface microplastic monitoring guidelines and database AOMI

Guidelines for Harmonizing Ocean Surface Microplastic Monitoring Methods



- ✓ Published the Guidelines in May 2019, based on the comparison study of sampling and analysis methods through the demonstration projects and discussions at an international expert .
- ✓ The Guidelines were prepared with the view of enabling researchers of ocean surface microplastic monitoring to adopt similar monitoring protocols and therefore interpret their results with a level of comparability.

(Guidelines web page: https://www.env.go.jp/content/000170493.pdf)

Atlas of Ocean Microplastics (AOMI)

- ✓ Developing a marine plastic litter mapping database (AOMI)
  - ◆ contains comparable global monitoring data in line with the guideline
  - ◆ provides harmonized datasets and 2D maps on ocean surface MPs distributions.
- ✓ The database will be released in this May.

(AOMI web page: https://aomi.env.go.jp/ (To be released))

Marine Litter Monitoring with remote sensing technologies

Guidelines for Marine Litter Monitoring Using Remote Sensing Technologies

◆ To improve the **comprehensiveness and efficiency** of marine litter monitoring, harmonizing monitoring technologies that enable continuous and efficient monitoring over wide areas is essential.

Fields	Data acquisition methods								Image analysis methods			
	On-site		Remote sensing							Automatic		
			Platform									
			Stationary camera	UAV	Aircraft	Satellite	Vessel	Others				
			Sensor									
	Collecting (manual, net, ROV, etc.))	Visual	RGB	RGB	Multispectral/hyperspectral, RGB, LIDAR	Multispectral/hyperspectral	RGB, LIDAR	RGB, LIDAR	Manual (Visual)	Object Detection by bounding box	Semantic segmentation	Others
Beach (Dune)			5	[illegible]	2	3	1		[illegible]	[illegible]	[illegible]	
Sea surface				64	4	7			[illegible]	[illegible]		
Sea water column						2			[illegible]			
Sea floor												
Estuary											[illegible]	
Riverbank/lake beach				1		5					[illegible]	
River surface			1	6					[illegible]			
River water column												
River floor												
Land												

Table: **Number of major studies** on marine litter monitoring using remote sensing technology and **Scope of the guidelines** [red] = Target of the guidelines ver. 1.0 (2024)

International Workshop on Marine Debris Data Harmonization 2023

OVERALL GOAL

To enhance the level of data
- including associated metadata identification

For supporting global data harmonization for selected key marine debris indicators

➡ **Underpin the successful mitigation of plastic pollution**

OUTCOME:

- **A coordinated network** of ocean surface microplastic data providers initiated under the auspices of GOOS and IMDOS, with an agreement to adhere to agreed common sampling protocol and metadata and data requirements.
- **Draft metadata and a data requirements sheet** based on the data sheet provided by MOE Japan, the European Marine Observation and Data Network (EMODnet), and NOAA National Centers for Environmental Information (NCEI), and any other potential large data integrators.
- **Recommendations for standardized metadata and data requirements for the UNEP** GPML Digital Platform data matrix.
- **Roadmap** towards a federated data management system for ocean surface microplastics and selected global-scale marine debris indicators.

UNEP GPML Data Harmonization CoP

GPML: Global Partnership on Plastic Pollution and Marine Litter

Global Commitment and Cooperation

Osaka Blue Ocean Vision (June 2019)

"We aim to reduce additional pollution by marine plastic litter to zero by 2050 through a comprehensive life-cycle approach that includes reducing the discharge of mismanaged plastic litter by improved waste management and innovative solutions while recognizing the important role of plastics for society."

G20 Report on Actions against Marine Plastic Litter (2019~)

5th Report in 2023:

- Actions reported: by **30 countries** and **10 organizations**
- 21 countries have national action plans on marine plastic litter, and 16 countries have specific indicators to measure progress of efforts on MPL.

2023 G7's commitment to end plastic pollution

Sapporo Env. Ministers Mtg: April 15-16; Hiroshima Summit: May 19-21, 2023

<Summit and Env Ministers communiques>

*"We are **committed to end plastic pollution**, with the ambition to reduce additional plastic pollution to **zero by 2040**."*

<Env Ministers>

*"…we are also committed to playing an **active and constructive role** to make **substantial progress in the negotiations** and bring us closer to specifying the key provisions of an **ambitious international legally binding instrument** on plastic pollution…"*

INC negotiation on Plastic Treaty (November 2022 ~ end of 2024)

Source: MOEJ

東京大學相關會議資料

Ocean Space Planning Laboratory

Meeting with delegation form Taiwan 8th April 2024

Development of Floating Offshore Wind in Japan

Hideyuki Suzuki
Department of Systems Innovation
School of Engineering
The University of Tokyo

CONTENTS

Offshore Wind in Japan and Technology Development of Floating Offshore Wind Turbines

Offshore Wind in Japan

Wind in Japan

- Moderate wind speed and typhoon
- Higher at northern waters

Source: World Bank Group

Large Energy Potential

Energy potential of offshore wind in Japan

77% of the potential exist in deeper waters and must be developed by floating offshore wind turbine.

-128GW by Bottom-Fixed type (water depth < 50m)

-424GW by Floating type (water depth ≧ 50m)

Estimated by JWPA (2020)

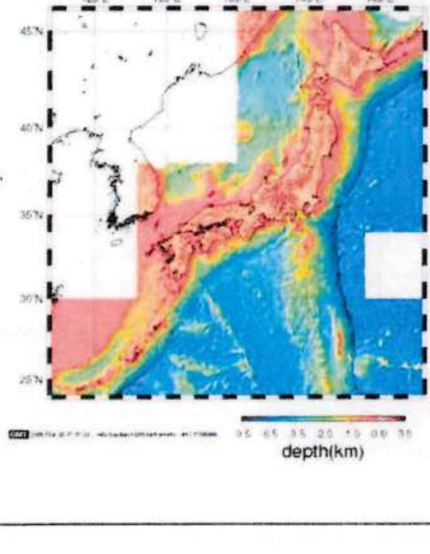
Necessity of Floating Offshore Wind Turbine

Bathymetry around Japan

- Water depth sharply increases with distance from shore.
- Sea area suitable for bottom-fixed wind turbine is limited

Larger FOWT is necessary for high efficiency

Catch higher wind speed at higher altitude and offshore



Seafloor topography around Japan

Great East Japan Earthquake and Accident of Fukushima Nuclear Power Plant

- Although renewable energy is pure domestic energy, it has been considered as unstable and unreliable.
- Suddenly gained attention due to the accident of Fukushima nuclear power plant (2011).

Technology Demonstration Project in Japan

Fukushima project (2011-2021)

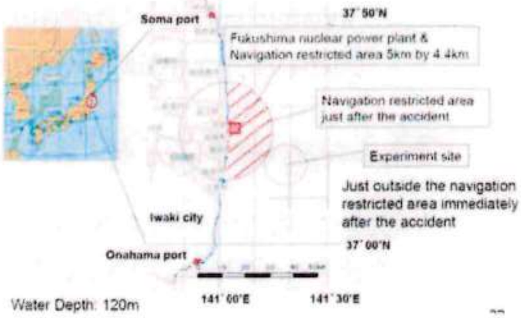
supported by METI

Floating substation
Floater: Advanced spar
(Operation started in 2013)

Wind turbine: 2MW Downwind type
Rotor diameter: 80m
Hub height: 66.2m
Floater: Semisubmersible
(Operation started in 2013)

Wind turbine: 7MW Hydraulic
Rotor diameter: 167m
Hub height: 105m
Floater: V-shape semisubmersible
(Operation started in 2015)

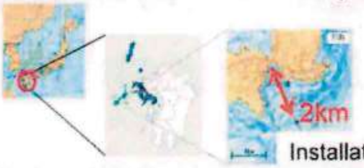
Wind turbine: 5MW downwind
Rotor diameter: 126m
Hub height: 86.4m
Floater: Advanced spar
(Operation started in 2016)



Goto Project (2010-2016)

supported by MOE

- Technical option for GH gas reduction
- Moved into commercial phase



Installation site

Wind turbine:
2MW Downwind type
(Operation started 2013)

Kita-Kyushu project (2014-2024)

supported by NEDO

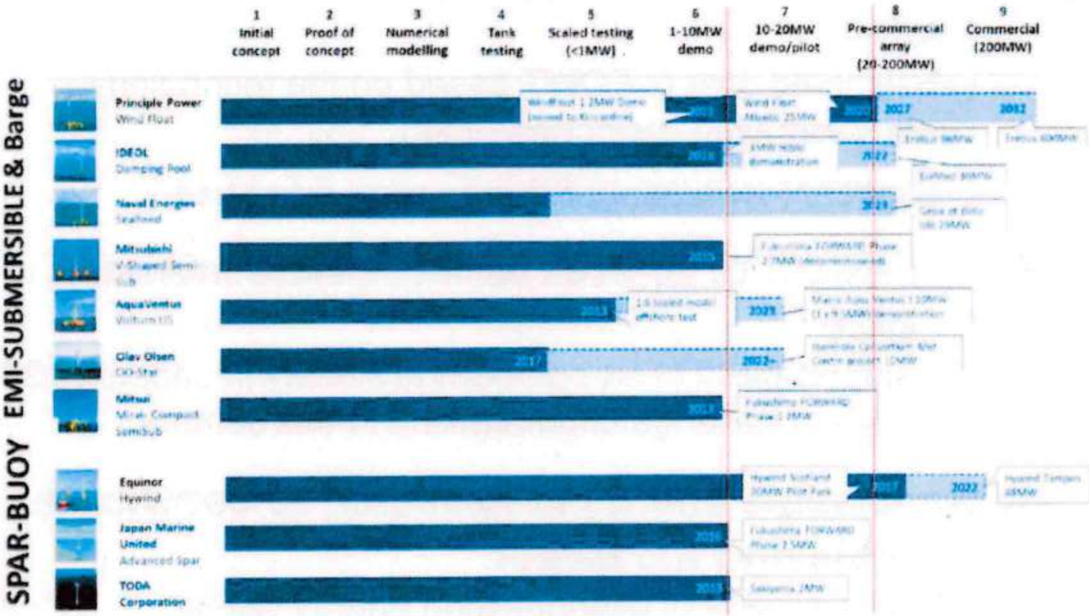
- Cost reduction

Site : Kitakyushu

Wind turbine: 3MW two blade
(Operation started 2019)

Technology Readiness Level

TRL（Technology Readiness Levels）



Source: Carbon Trust

Policy of Japanese Government for Promoting Offshore Wind

Establishment of Carbon Neutral Society

- **Estimated cost of FOWT just after Fukushima Project**
  - ･Estimated cost of FOWT based on the technology demonstration project was high
  - ･Skeptical view about offshore wind was raised
- **Statement of brief of former prime minister in 2020**
  - ･Establishment of carbon neutral society in Japan by 2050
  - ･A major challenge of humankind in this century.
- **Renewable energy is expected to contribute to achieving the target**

  30 to 45 GW of offshore wind energy will be commercialized by 2040

Japanese Government is determined to promote offshore wind

Basic plans and Acts

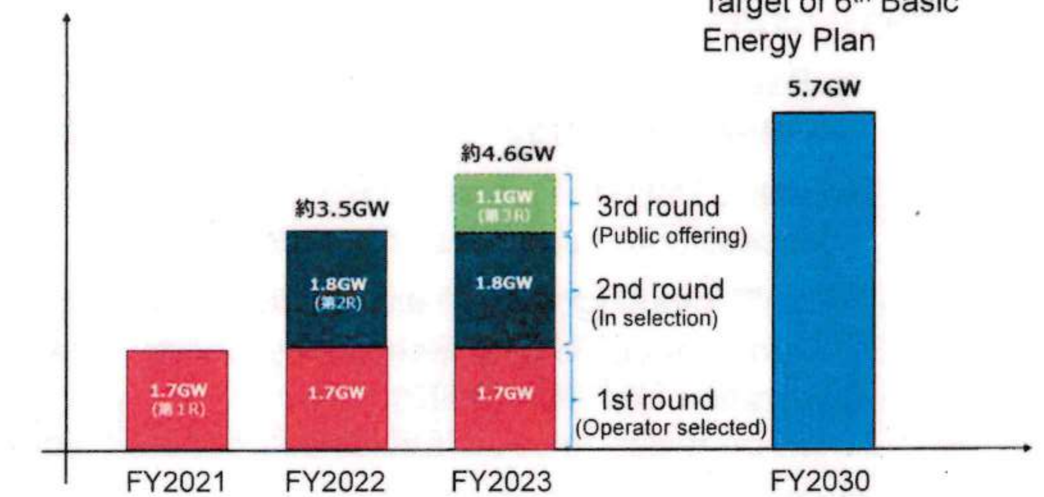
- 5th Basic Energy Plan (2018)
  Renewable energy should be a core power source
- 3rd Basic Plan on Ocean (2018)
  Necessity of rule for use of territorial sea
- Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities (2019)
  To be revied to cover Exclusive Economic Zone
- 6th Basic Energy Plan (2022)
  Promotion of project formation

Projects of fixed and Floating WT

4.59MW

	区域名	万kW※1	
Promoting Area	①長崎県五島市沖（浮体）	1.7	第1ラウンド公募 事業者選定済 約170万kW
	②秋田県能代市・三種町・男鹿市沖	49.4	
	③秋田県由利本荘市沖	84.5	
	④千葉県銚子市沖	40.3	
	⑤秋田県八峰町能代市沖	36	第2ラウンド公募 約180万kW（うち事業者選定済 約[illegible]万kW）
	⑥秋田県男鹿市・潟上市・秋田市沖	31.5	
	⑦新潟県村上市・胎内市沖	68.4	
	⑧長崎県西海市江島沖	42	
	⑨青森県沖日本海(南側)	60	第3ラウンド公募 約110万kW（事業者公募中 1/19~7/19）
	⑩山形県遊佐町沖	45	
Promising Area	⑪北海道石狩市沖	91～114	
	⑫北海道岩宇・南後志地区沖	56～71	
	⑬北海道島牧沖	44～56	
	⑭北海道檜山沖	91～114	
	⑮北海道松前沖	25～32	
	⑯青森県沖日本海（北側）	30	
	⑰山形県酒田市沖	50	
	⑱千葉県九十九里沖	40	
	⑲千葉県いすみ市沖	41	
Preparation Area	⑳北海道岩宇・南後志地区沖(浮体)		
	㉑北海道島牧沖(浮体)		
	㉒青森県陸奥湾		
	㉓岩手県久慈市沖(浮体)		
	㉔富山県東部沖(着床・浮体)		
	㉕福井県あわら沖		
	㉖福岡県響灘沖		
	㉗佐賀県唐津市沖		

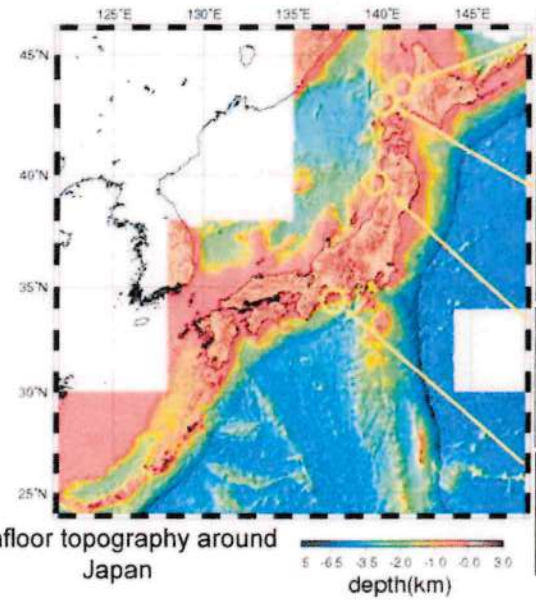
Introduction Target of Japanese Government



Green Innovation Fund Phase II

New Technology Demonstration Projects of FOWT

Leading projects for large scale development



Seafloor topography around Japan

HAMAMASU
Wind speed: 8.5-9.5m/s
Water depth: 70-80m
Distance from shore: 8.0-9.5km

GANWU・MINAMISHIRIBESHI
Wind speed: 6.5-8.5m/s
Water depth: 50-500m
Distance from shore: 10.0km

NANBU
Wind speed: 7.5-8.0m/s
Water depth: 400m
Distance from shore: 20-30km

TAHARA・TOYOHASHI
Wind speed: 8.5-9.0m/s
Water depth: 80-130m
Distance from shore: 14-18km

Challenges in Technology

17

Challenge in Floater Concept

- **Compact lightweight and easy to construct concept**

1) Floater technology developed in Oil-Gas industry
- Relatively massive and heavy concepts
- Concept based on past experiences of accidents

Courtesy: Seadrill

2) Lightweight concepts

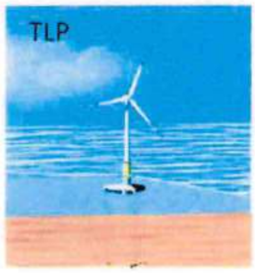
Maturity of technology by experiencing various problems typically related to aging degradation

Courtesy: Principle Power

Courtesy: Stiesdal

New floater concepts are coming in

- Tension Leg Platform with small footprint
- Tower supported by guywire and/or pillar
- Single point mooring & weathervane



X1 Wind

source : X1 Wind

TetraSpar

source : Stiesdal

EOLINK

source : EOLINK

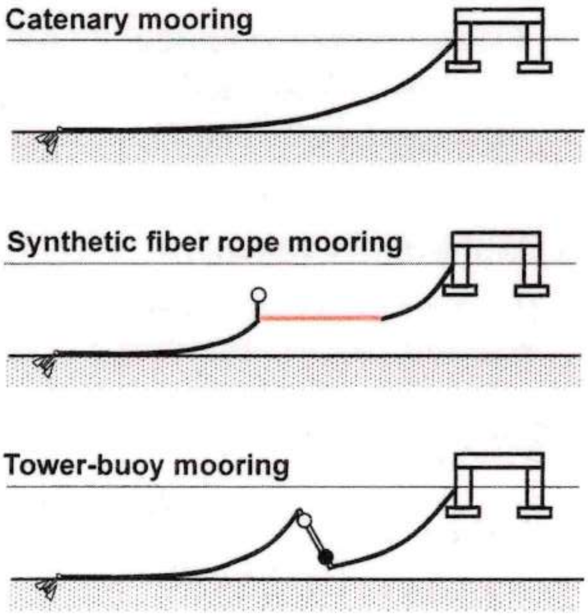
OPTIFLOW

source : Glocal

Challenge in Station Keeping System

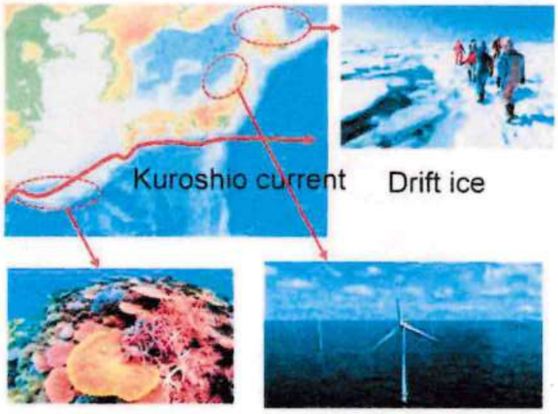
Challenge in mooring system in shallow and deep waters

- Significant increase of tension amplitude by dynamic response in shallow waters
- Low cost concept for deep waters



Marine Growth

- **Fast marine growth**
  - Damage to dynamic cable
  - Water temperature, nutrients, flow



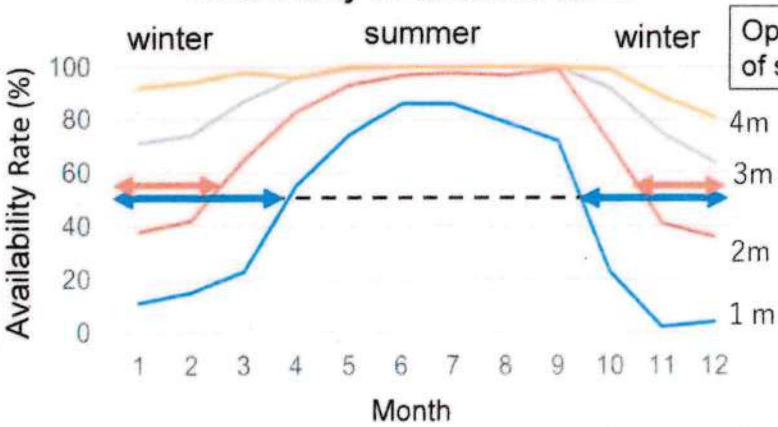
Coral reef

Availability of Offshore Work in Northern Japan

- **Reduction of downtime in offshore transport, assembly, installation, and maintenance**

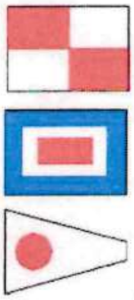
  Development of work vessels which can operate in harsh environmental condition is necessary

Availability of Offshore Work



Estimated availability rate based on NOWPHAS offshore AKITA observation in 2012

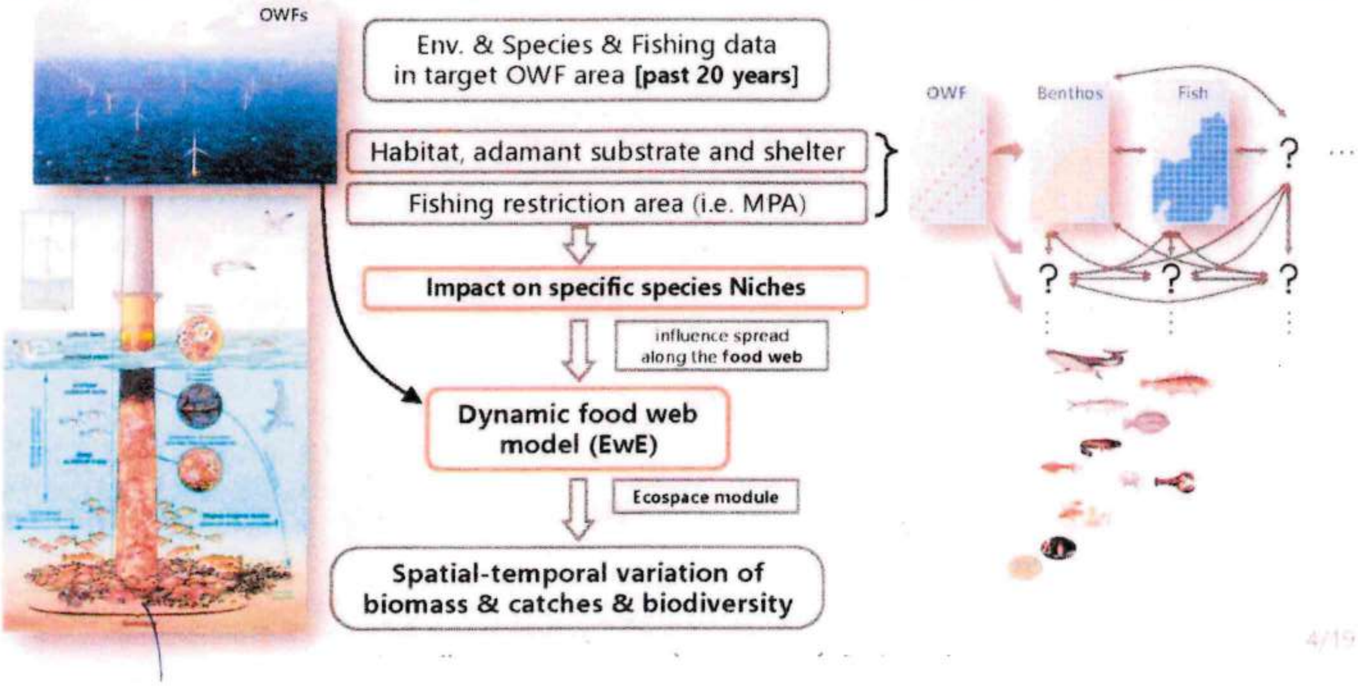
END



Research on environmental impacts due to marine renewable energy facilities

Shigeru TABETA
Dept. Environment Systems
Graduate School of Frontier Sciences

Impact evaluation of offshore wind farms (OWFs) on marine species based on food web model and habitat changes



Case study: Target OWFs in North Sea

OWF: Greater Gabbard (England)
Location: North Sea, Suffolk Coast
Year: 2012 (operation till now)
Monopile foundations installed: 2010
Capacity: 504 MW (**140** turbines)
Pile foundation: D = 6 m Scour protection: R = 20 m
Distance to shore: 23 km Area: 146.2 km²
Water depth: 20–32 m Average wind speeds: 9 m/s

OWF: London Array (England)
Location: North Sea, Suffolk Coast
Year: 2013 (operation till now)
Monopile foundations installed: 2011
Capacity: 630 MW (**175** turbines)
Pile foundation: D = 5.7 m Scour protection: R = 20 m
Distance to shore: 20 km Area: 122 km²
Water depth: 25 m Average wind speeds: 8 m/s

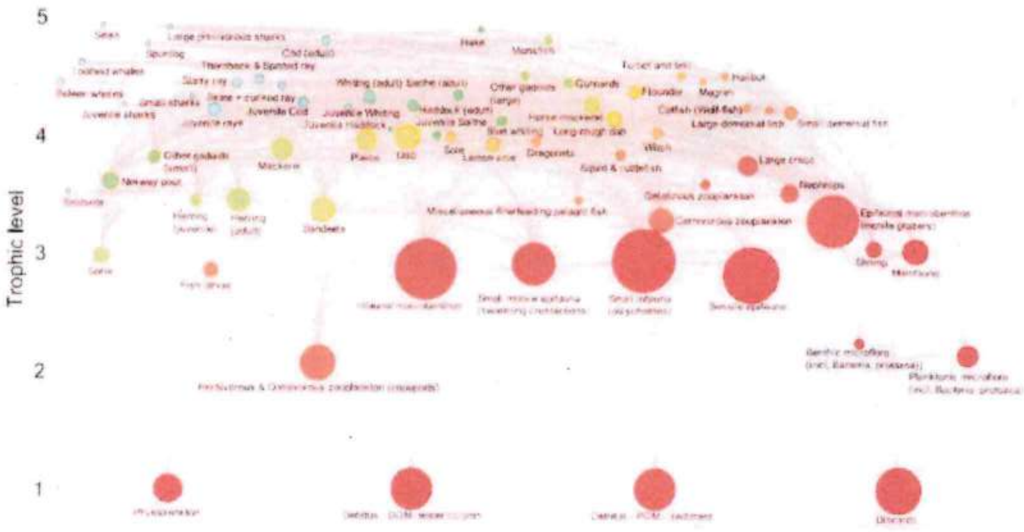
Build and balance the Ecopath with Ecosim model in North Sea

Original data

- Species & Functional groups
- Biomass
- Production & Consumption
- Diet composition
- Mortality
- Fleets & Catches
- ...

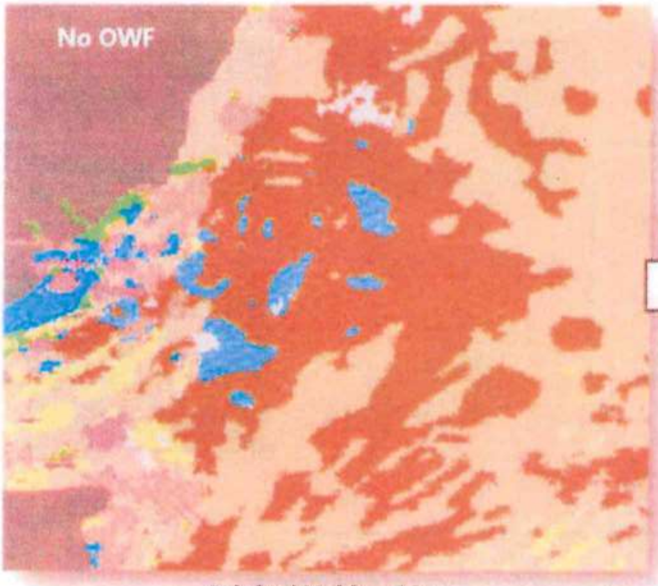
(Data from CMEMS, ICES, Mackinson(2007))

Flow diagram ⇨

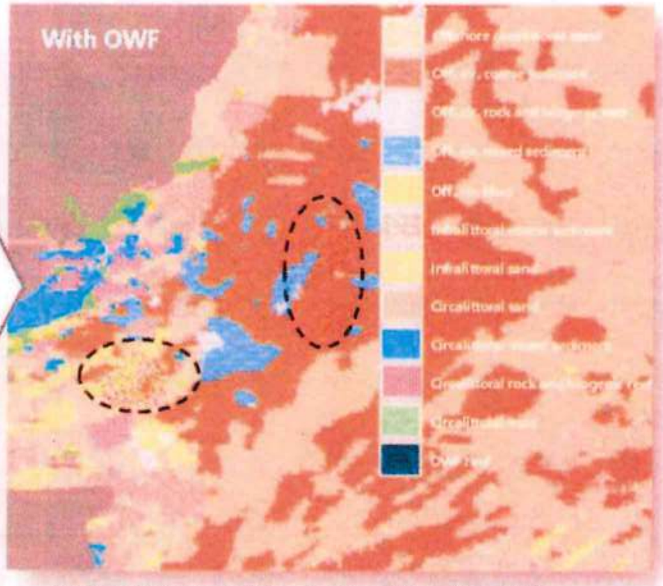


- Use the state of marine ecosystem in North Sea from 2000 as the baseline for building EwE model.

Maps: Habitat (based on subsea sediment type)



Original Habitat Map
(Data from **EMODnet**)



Habitat types will be changed in OWF grids.
(**Reef** and **hard substrate** will be introduced by OWF piles)

Case A - No OWF (control group)

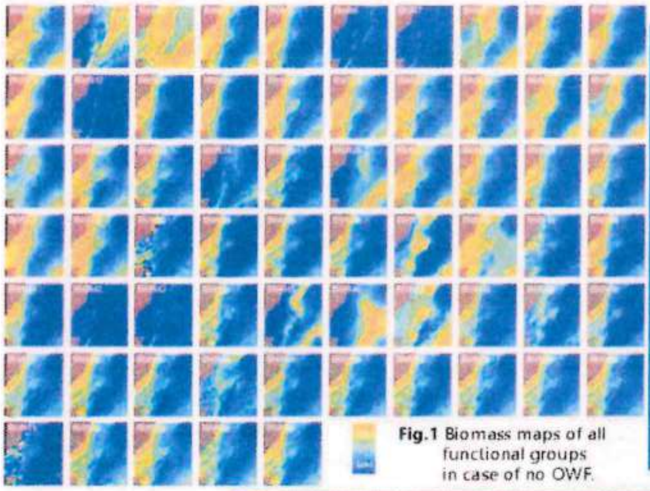


Fig.1 Biomass maps of all functional groups in case of no OWF.

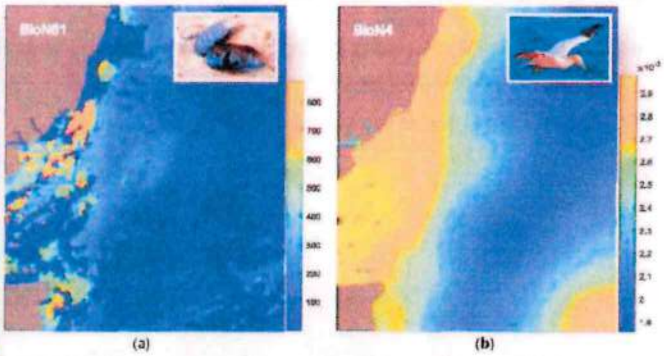


Fig.2 Biomass distribution of (**a**) sessile epifauna (in lower trophic level), and (**b**) seabirds (in higher trophic level).

- **The biomass maps in the 20th year (total simulation period is 2010-2030).**
- **Most of the species basically conforms to the actual distribution, especially where near to shore.**

With OWF (Reef + MPA)

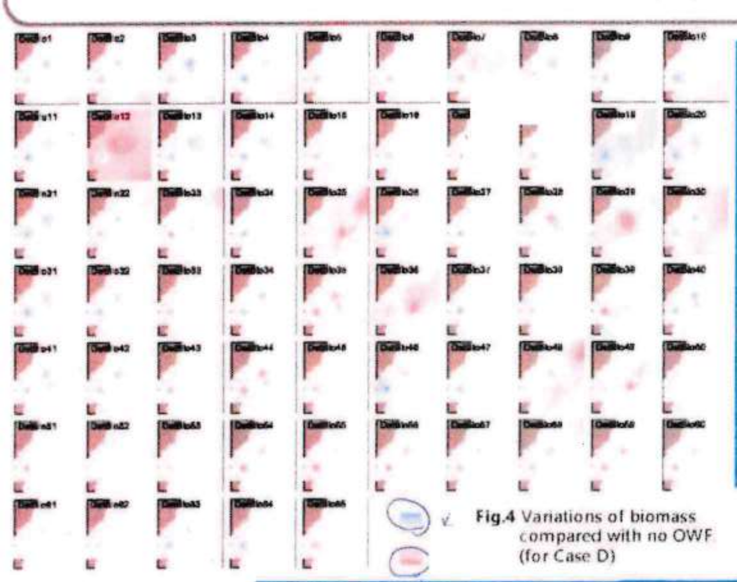
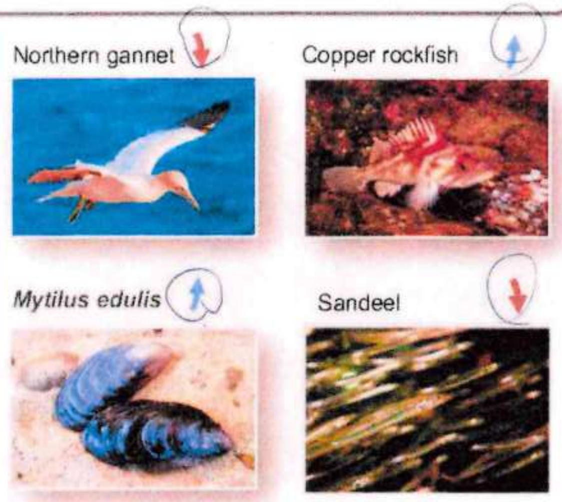


Fig.4 Variations of biomass compared with no OWF (for Case D)



◆ Local hot spots appeared at OWF sites for most of the commercial fishes and their predators.

Catches near to Greater Gabbard OWF.

◆ In case of Reef+MPA, the total catches in Zone B and C have a rise of 12.4% and 6.3% respectively. It is close to the previous study (Ghassen Halouani, 2020).

◆ Spillover effect reduces with distance from OWF.

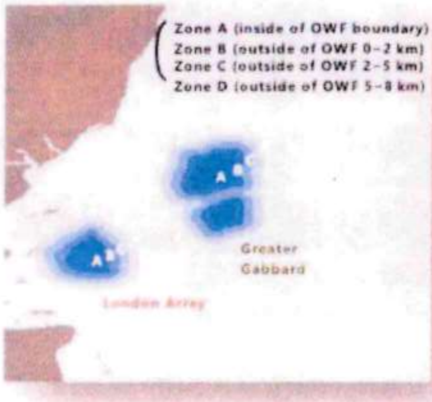


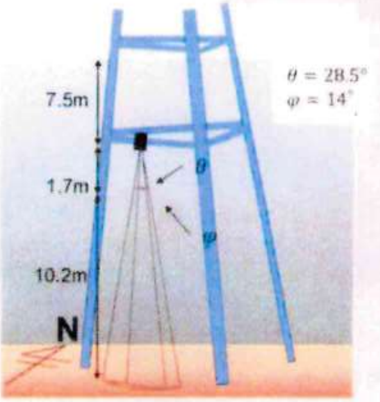
Fig.14 Catches in different zones.

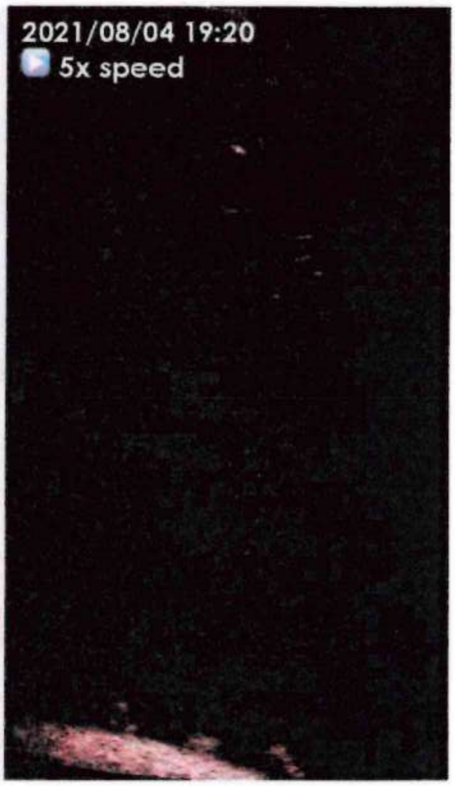
Monitoring of Fish behavior in the Vicinity of Artificial Marine Structures Using Acoustic Video Cameras

- DIDSON(Sound Metrics)
  - *1.8MHz 96 beams*
  - *Frame rate 5fps*

Monitoring period

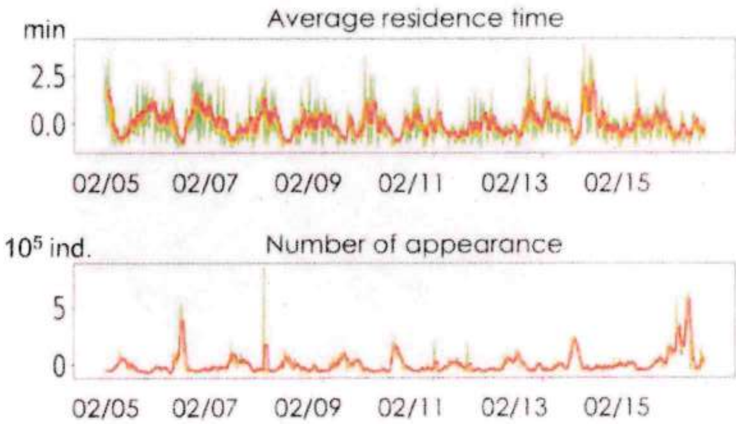
2020/12/07~2021/12/13



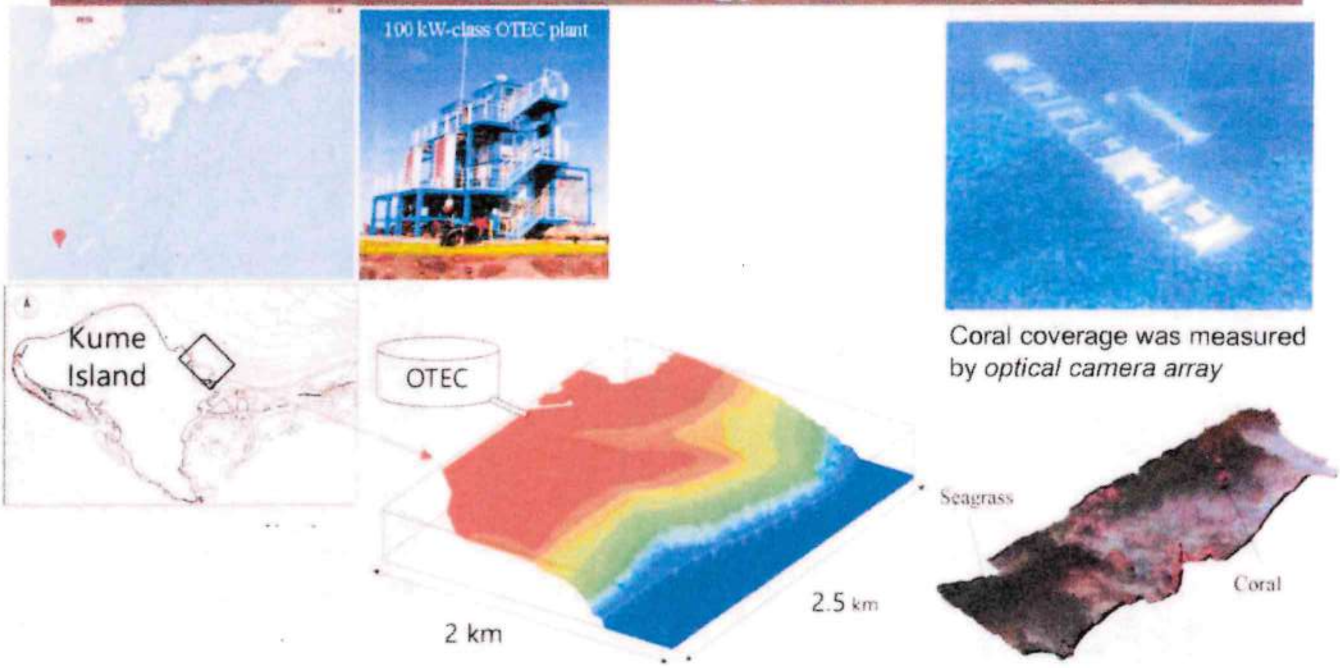


Tacking individual fish

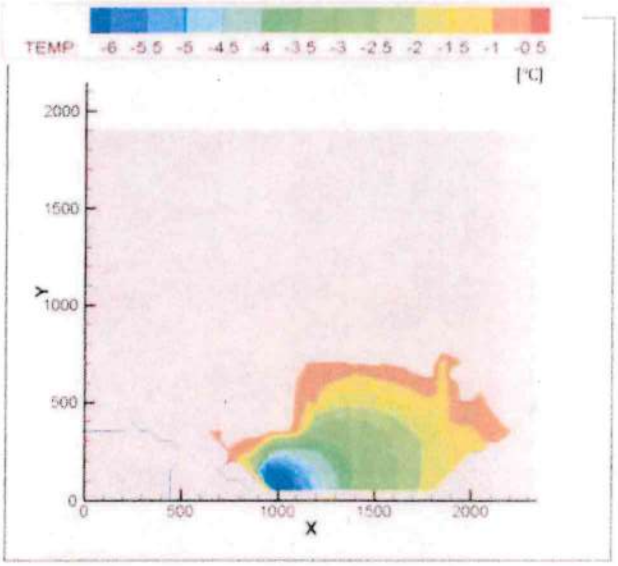
- residence time around structures is useful for investigating attraction effect
- Track individuals by template matching



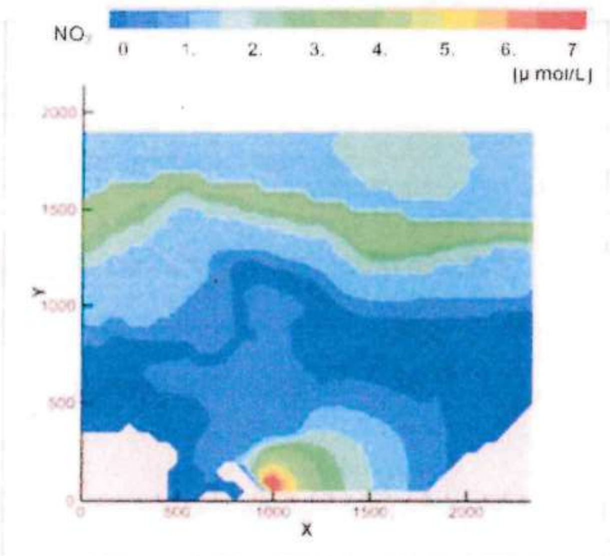
Prediction of environmental influence due to discharged water from ocean thermal energy conversion (OTEC)



Simulations of discharged water behavior

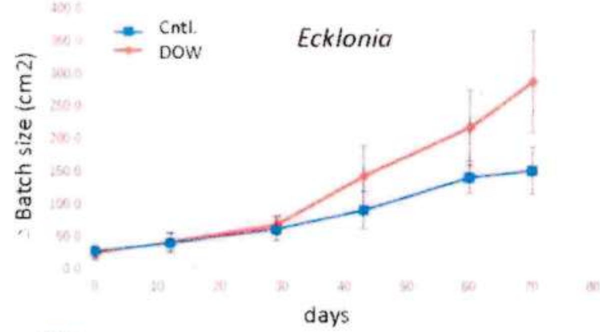


Change of temperature in bottom layer



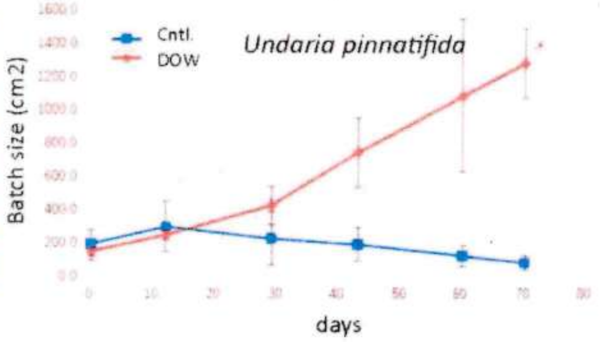
Nitrate concentration in bottom layer

Utilizing OTEC discharge water for seaweed culture



initial

35days later

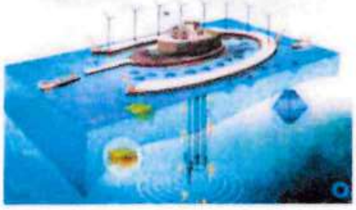


Conceptual Design and Inclusive Impact Assessment for a Multi-purpose Floating Structure

Multi-purpose offshore platforms

TROPOS
(EU-FP7 project, 2012-2015)

Integrated a range of functions from the transport, energy (OTEC), aquaculture and leisure sectors.



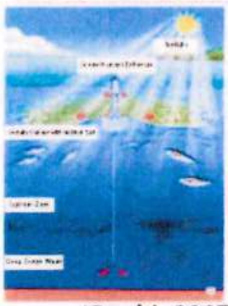
The Blue Growth Farm
(EC project, 2018-2021)

Automated aquaculture and renewable energy production systems are integrated for profitable applications.

OTEC on floating platforms

(Lockheed, 2014)

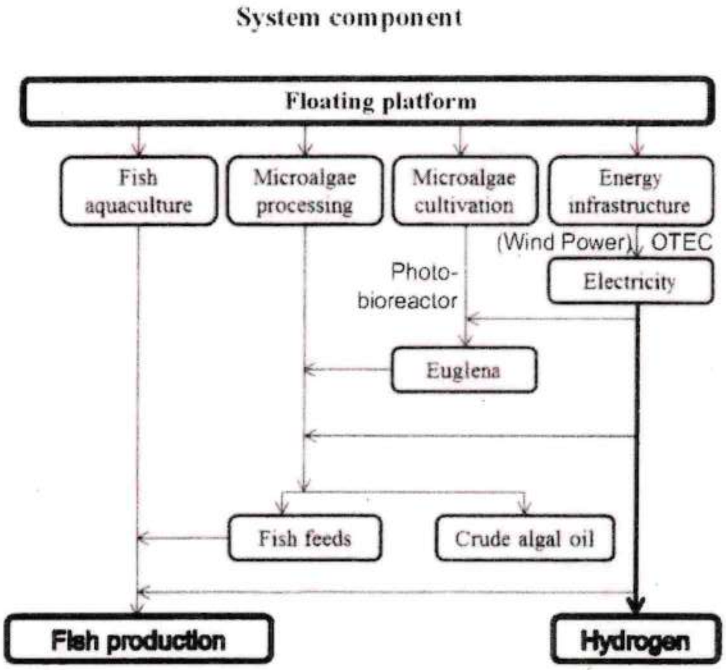
Artificial upwelling

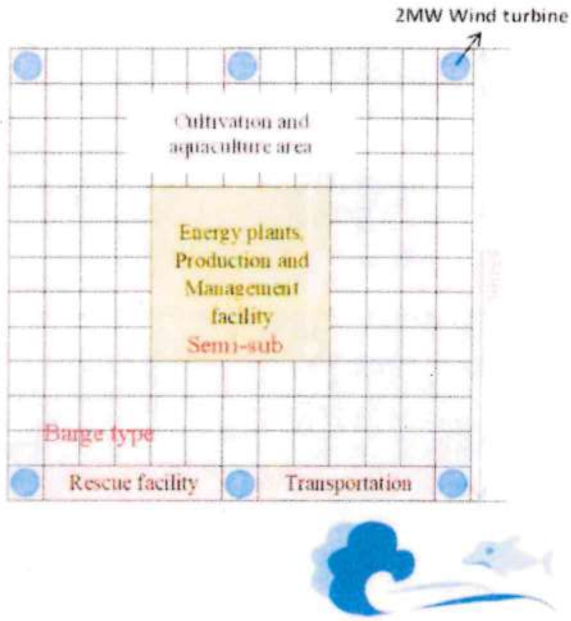


(Ouchi, 2007)

(Pan et al., 2019)

Conceptual Multi-purpose Offshore Platform





Sustainability Assessment by Inclusive Impact Indicator (*Triple-I*)

$$III_{light} = (EF - BC) + \gamma(C - B)$$

$III_{light} < 0$: Sustainable
$III_{light} > 0$: Not sustainable

	Power generation	Products		EF (10^3gha)	BC (10^3gha)	Cost (10^9 Yen)	Benefit (10^9 Yen)	III_{light} (10^3gha)
Plan 0	12.5MW OTEC	Tuna, biofuel	worst	11.48	-8.78	8.22	-6.62	4.71
			best	8.43	-21.76	8.22	-6.63	-11.32
Plan 1	12.5MW OTEC 6×2MW wind turbines	Seabream, hydrogen	worst	10.64	-13.13	8.53	-10.46	-4.78
			best	8.69	-26.10	8.49	-13.75	-24.09
Plan 2	23MW OTEC	Seabream, hydrogen	worst	10.59	-15.53	8.73	-11.19	-6.11
			best	8.64	-37.45	8.66	-14.48	-36.20

Recent Movements and Some Challenges of CCS in Japan

Toru Sato
Professor, Dept Ocean Technol., Policy, and Environ., University of Tokyo

- **Recent Movements of CCS in Japan**
  - Carbon Neutral by 2050
  - CCS Business Act
  - Long-Range Roadmap
  - Selected 5 Storage Sites and 2 Export Ports
- **Challenges of CCS in Japan**
  - Necessity of Deregulation
  - CO2 Concentration in Seawater

Carbon Neutral by 2050

- COP25 (2019) Bonn, Germany
  - EU: zero CO2 emissions within the region by 2050
- Policy Speech by the Prime Minister Suga (26 Oct. 2020)
  - CARBON NEUTRAL in 2050
- COP26 (2021) Glasgow, UK
  - Japan declared to reduce emissions by 46% by 2030 and zero emissions by 2050

(Yomiuri)

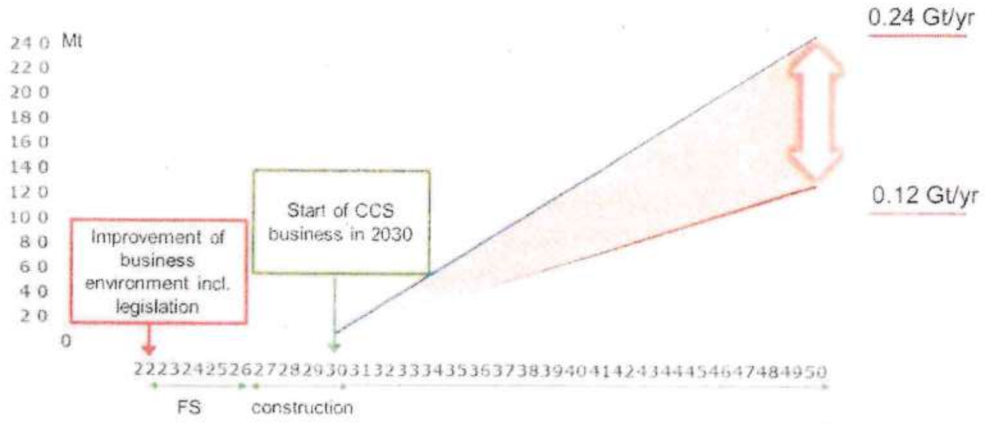
(UNFCCC)

CCS Business Act
(submitted to the Diet held in May 2024)

- **Creation of the permit system of test-drilling and storage business**
  - The minister of METI appoints possible reservoirs as "special area", collects possible storage operators, and gives a permission to the most appropriate one.
  - The minister of METI sets test-drilling right and storing right to the selected operator. The test-drilling right and storing right are regarded as "deemed property".
- **Regulations for storage operators**
  - Storage operators must monitor the temperature and pressure, *etc.* of reservoirs.
  - Storage operators must reserve funds for the monitoring after closing their wells.
  - Under the condition that the CO2 is stored safely, JOGMEC will succeed the operations for the reservoirs including monitoring from the operators.

(extracted and translated by T. Sato from METI, 2024)

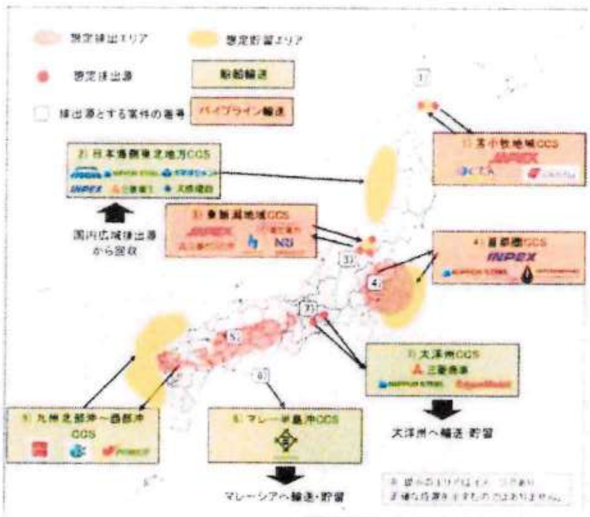
Long-Range Roadmap



(extracted and translated by T. Sato from METI, 2024)

5

Selected 5 Storage Sites and 2 Export Ports

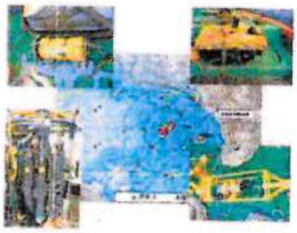


(JOGMEC)

6

Necessity of Deregulation

- London Convention (IMO) (2004)
  - Only sub-seabed underground
  - Only gas with CO_2 concentration of "overwhelmingly" high
- Act on Prevention of Marine Pollution and Maritime Disaster (MoE) (2005)
  - CCS operators need to get permissions from Minister of Environment
  - Only gas with CO_2 concentration of 99% or more.
  - Mandatory monitoring of CO_2 concentration in seawater
  - Not mentioned on the time period of monitoring. External?

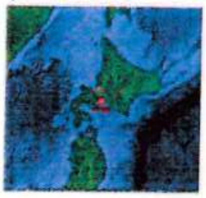


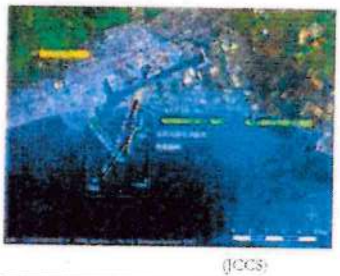
7

Necessity of Deregulation

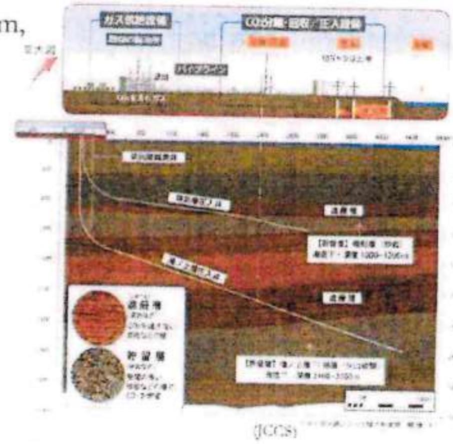
Tomakomai Project

Offshore 3km, WD50m, depth:1000m+3000m, 0.1Mt/y, since 2016





(JCCS)



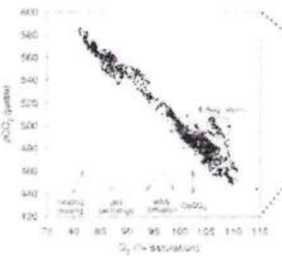
(JCCS)

8

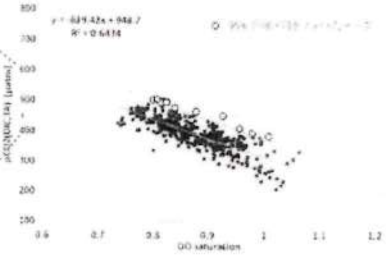
Necessity of Deregulation

- CO_2 concentration in seawater is not constant due to biological activities
- pCO_2 and DO saturation usually have very good correlation (De Grandpre et al., 1997).
- MoE requires to re-conduct to monitor CO_2 concentration, if some data exceed the upper end of the 95% prediction interval.

- However, the variation of pCO_2 at the Tomakomai site is very large.



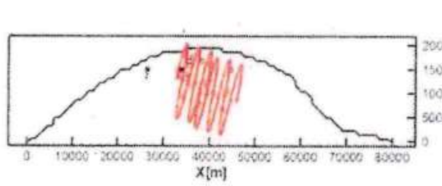
DeGrandpre et al(1997)



off Tomakomai, Japan (MoE)

Necessity of Deregulation

- What happened off Tomakomai
  - High pCO_2 data ware monitored one month after the start of CO_2 injection in May 2016.
    - Stopped CO_2 injection from May 2016 to Jan 2017.
    - Re-conducted monitoring + more precise investigation with large cost.
      - Bubble investigation by a side-scan sonar
      - Carbon isotope ratios: C^{13} and C^{14}

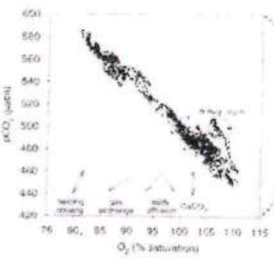


Marine Pollution Protection Act will be merged to CCS Business Act and those treated in Marine Pollution Protection Act will be co-supervised by the minister of MoE.

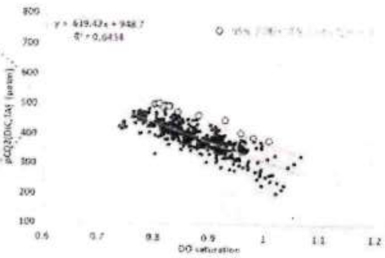
CO_2 Concentration in Seawater

Detection of High CO2 Concentration

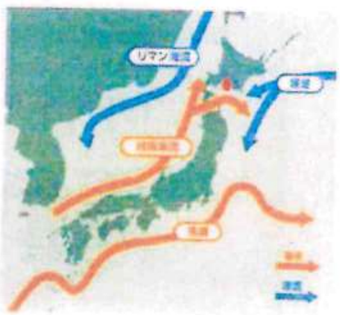
- Variation of pCO2 at the Tomakomai site is very large.



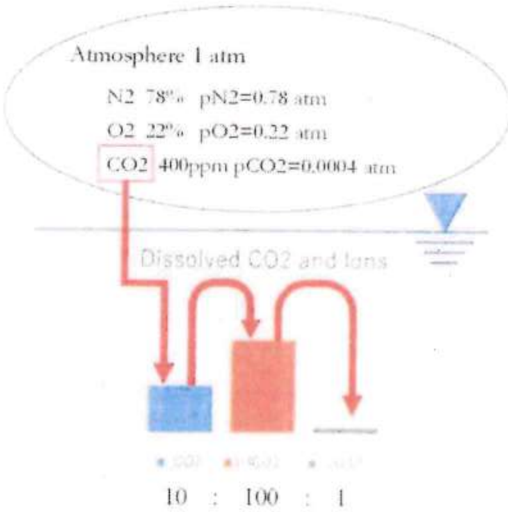
DeGrandpre et al(1997)



off Tomakomai, Japan (MoE)



CO2 Dissolution in Seawater

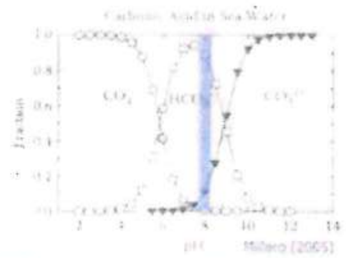


$CO_2 + H_2O \leftrightarrow HCO_3^- + H^+$

$HCO_3^- \leftrightarrow CO_3^{2-} + H^+$

$DIC = [CO_2] + [HCO_3^-] + [CO_3^{2-}]$

$pCO_2 = K_0[CO_2]$



The ratio between is about 10 : 100 : 1 mainly depending on pH in seawater.

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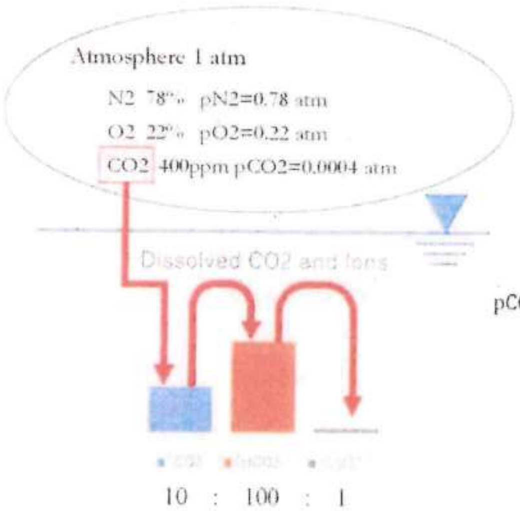
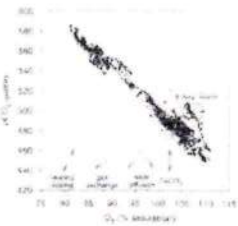
CO2 Dissolution in Seawater





DeGrandpre et al(1997)

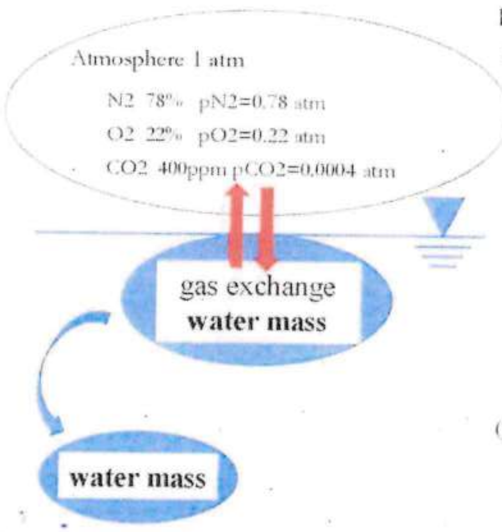
$$pCO_2 = -\left(k\frac{K_0}{\beta H_{O2}}pO_{2eq}\right)\frac{DO}{DO_{eq}} + \left(a_0 pCO_{2eq} + kb_0\frac{K_0}{\beta H_{O2}}pO_{2eq}\right)$$

$$\beta = \frac{[H^+]^2 + K_1[H^+] + K_1K_2}{[H^+]^2}$$

pCO2-[O2 saturation] correlation never be a simple linear function.

14

CO2 Dissolution in Seawater



DIC (Dissolved Inorganic Carbon) = $[CO_2] + [HCO_3^-] + [CO_3^{2-}]$

DO (Dissolved Oxygen) = $[O_2]$

Equilibrium to the atmosphere
without biological activity

DIC_{eq}

DO_{eq}

Non-equilibrium to the atmosphere
without biological activity

$DIC_0 = a_0 DIC_{eq}$

$DO_0 = b_0 DO_{eq}$

a_0 and b_0 depends on water mass

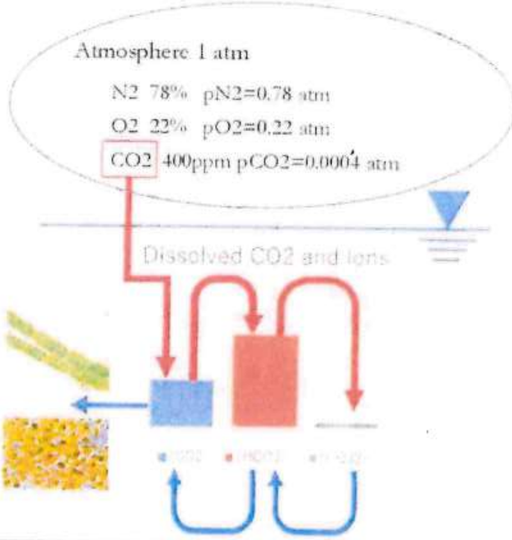
(How long the water contacted to the atmosphere in the past)

$DIC_{eq} = f(T, S, TA)$ TA: Total Alkalinity

$TA = [HCO_3^-] + 2[CO_3^{2-}] + [H_2BO_3^-] + [OH^-] - [H^+]$

15

Biological Activity - respiration and photosynthesis



$$\Delta DIC = -k\Delta DO$$

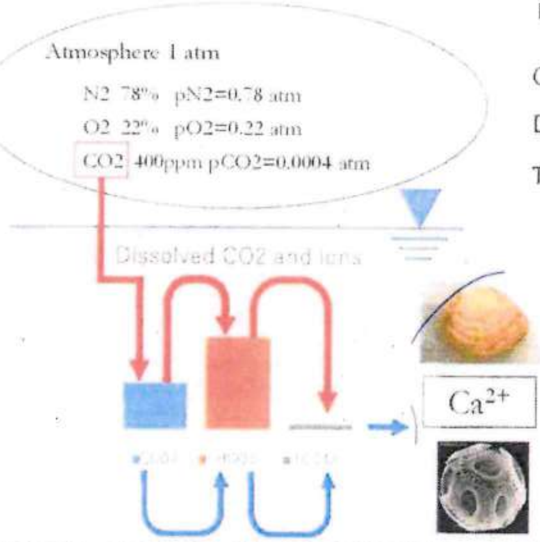
$k = 0.722 \pm 0.05$ from Chen and Pytkowicz (1979)

$$DIC = DIC_0 + \Delta DIC$$
$$DO = DO_0 + \Delta DO$$
$$DIC_0 = a_0 DIC_{eq}$$
$$DO_0 = b_0 DO_{eq}$$

$$DIC + kDO = DIC_0 + kDO_0$$

16

Biological Activity - formation of calcium carbonate



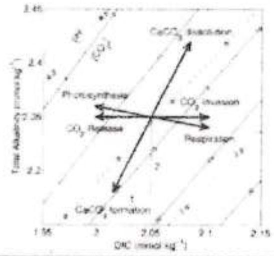
Formation/dissolution of $CaCO_3$

$$Ca^{2+} + CO_3^{2-} \leftrightarrow CaCO_3$$

$$DIC = [CO_2] + [HCO_3^-] + [CO_3^{2-}]$$

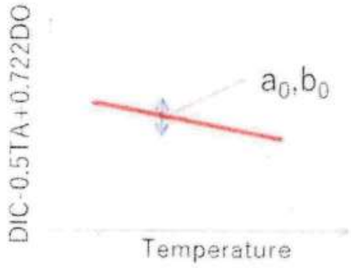
$$TA = [HCO_3^-] + 2[CO_3^{2-}] + [H_2BO_3^-] + [OH^-] + [H^+]$$

$$\Delta DIC_{calcium} : \Delta TA_{calcium} = 1 : 2$$

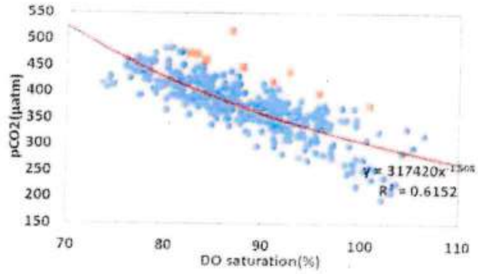


Biological Activity - formation of calcium carbonate

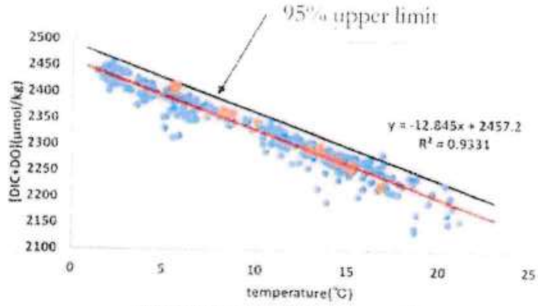
$$DIC - 0.5TA + 0.722DO = DIC_0 - 0.5TA_0 + 0.722DO_0 = C_2\ (a_0, b_0, T)$$



Application Results of Tomakomai



pCO2 - DO saturation correlation



{DIC-0.5TA+0.722DO} - T correlation

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Seepage Judgment by Machine Learning

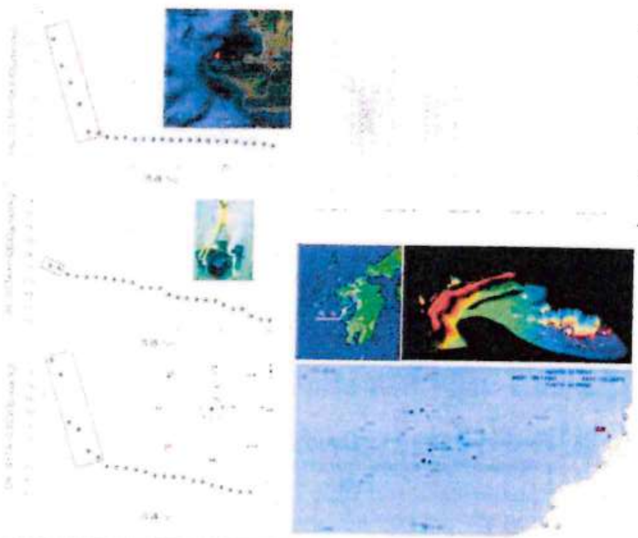


Table 3.7 Judgements results of data measured off Tateyama by FNN model

	Tateyama Oct 11th, 2022	Tateyama May 17th, 2023	Tateyama May 18th, 2023
Total number of judgement data	19	23	18
Number of data judged as **abnormal (1)**	19	23	18
Number of data judged as **normal (0)**	0	0	0

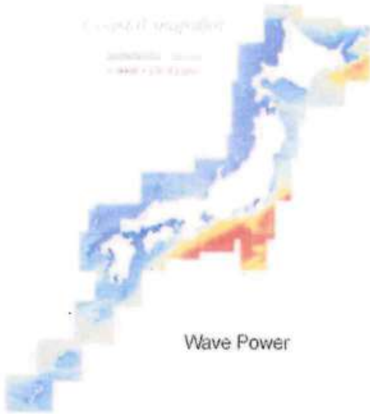
Table 3.8 Judgements results of data measured in Tachibana Bay by FNN model

	Tachibana 2020	Tachibana 2021	Tachibana 2022	Tachibana 2023
Total number of judgement data	19	60	16	41
Number of data judged as **abnormal (1)**	2	60	0	41
Number of data judged as **normal (0)**	17	0	16	0

20

Modeling waves and currents for coastal and offshore development

Takuji Waseda
Applied Physical Oceanography Group
Dept. Ocean Technology Policy and Environment
The University of Tokyo

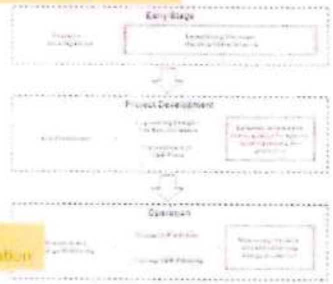


Assessing wave energy resources

Government supported project to develop a 1km wave database

Standards for resource assessment

Assessment of Tidal Energy Resource, EMEC Equimar protocols

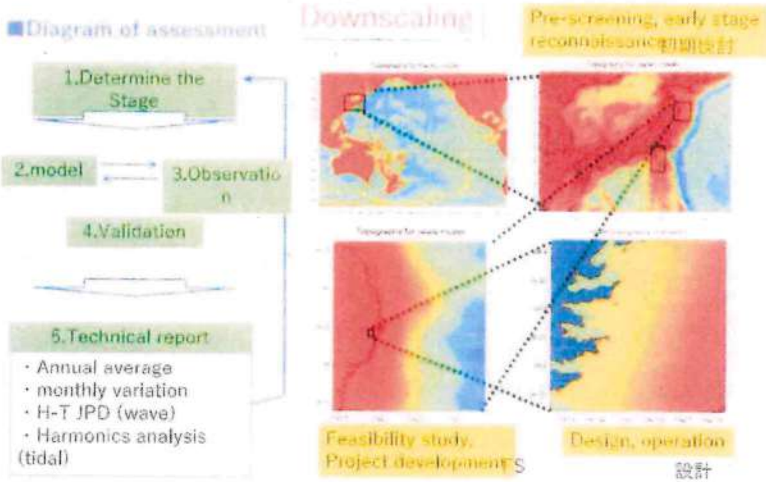


IEC 62600-101 TS : (unpublished)
... energy resource assessment and characterization

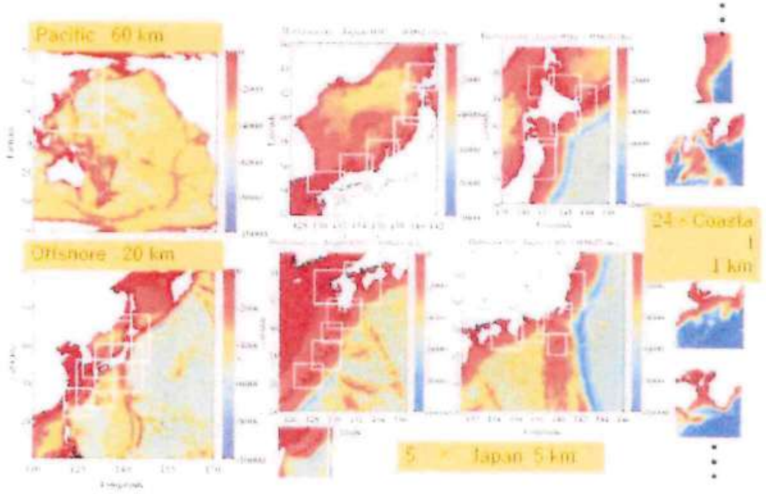
		1.Reconnaissance	2. F.S.	3.Design
Period		[illegible]	[illegible]	[illegible]
Model	Model			3rd G Wave model
	Resolution	5km	500m	50m
	Time step	3hrs	3hrs	1hrs
	Wind date	3hrs/10km	3hrs/25km	1hr/5km
Obs.	period	1year	1year	1year
	Number of	3	5	5

Bankability

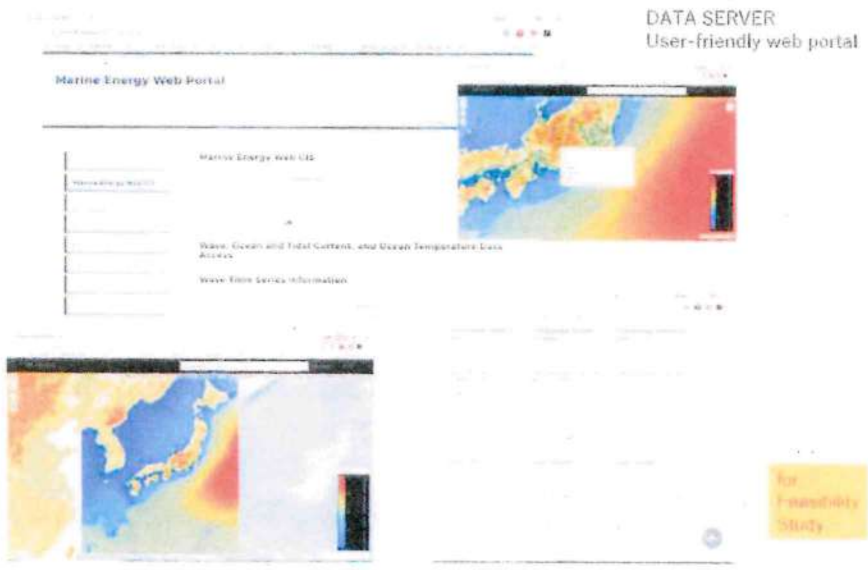
Models required at different stages of assessment

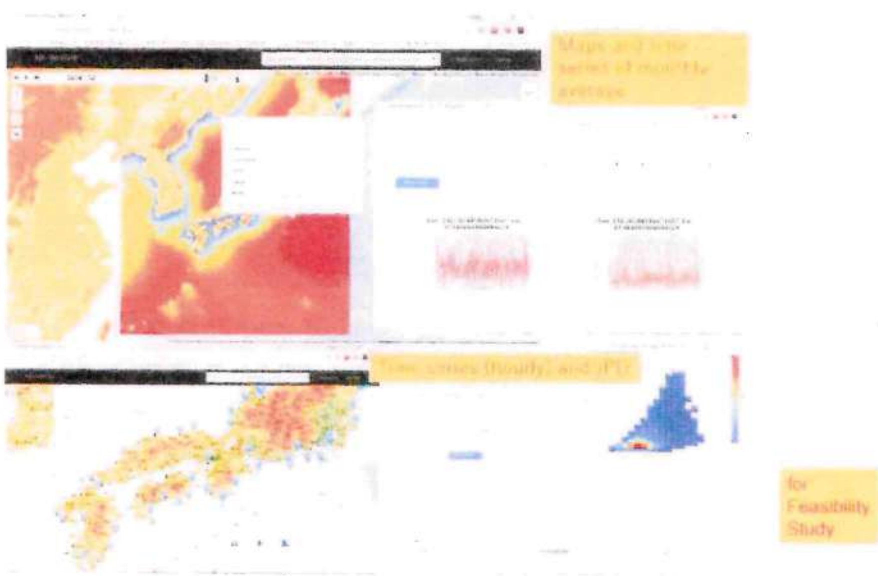


Wave model: four-tiered nested model



DATA SERVER
User-friendly web portal



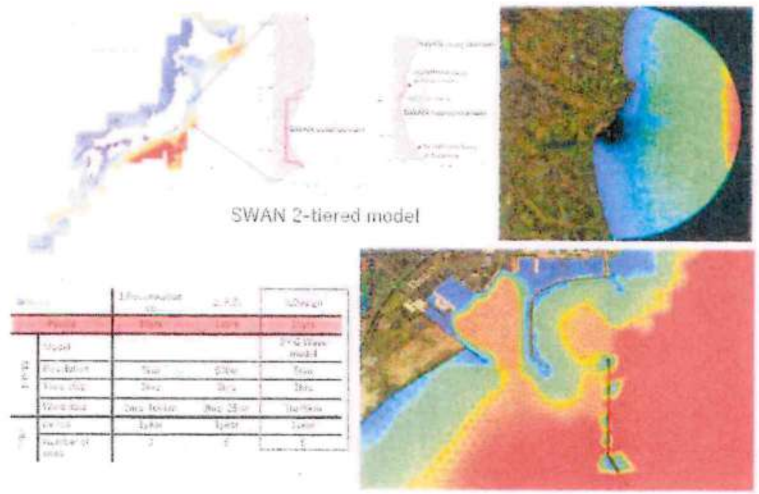


Coastal/Offshore developments in Japan
– Downscaling

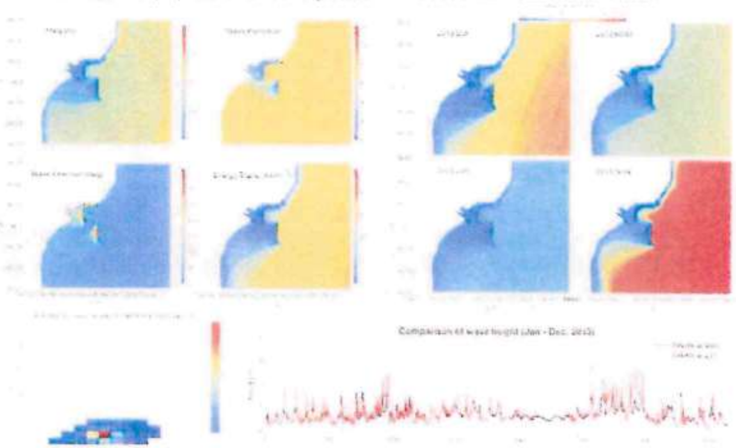
Wave power

Wind power: development of SOV-CLV etc.

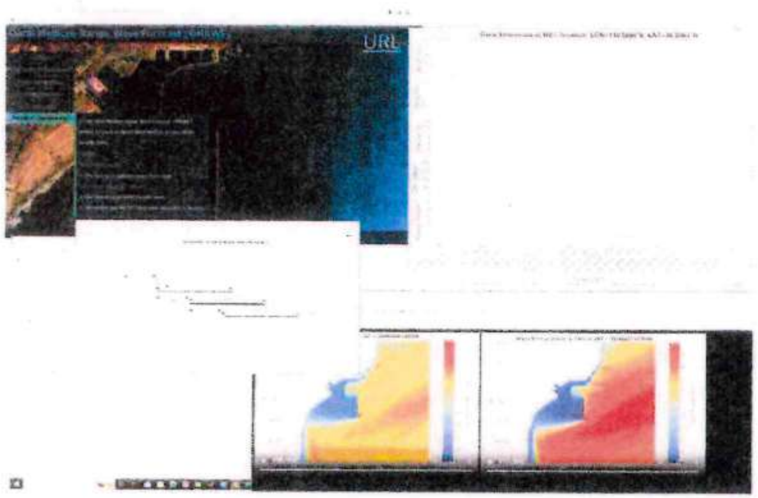
Downscaling: design and operation stage



Downscaling: design and operation stage

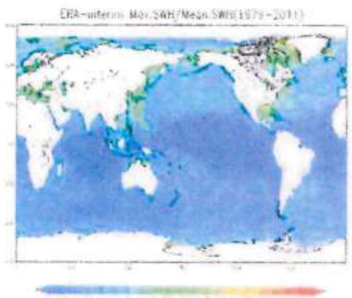


Forecast

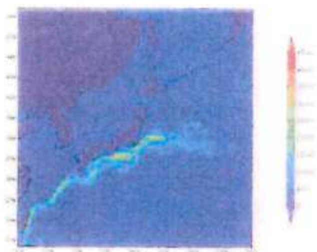


Challenges in ocean development in Japan

- Extreme events: severe sea states (Typhoon, bomb cyclone etc.)
- Strong current caused by the Kuroshio *and/or tides*



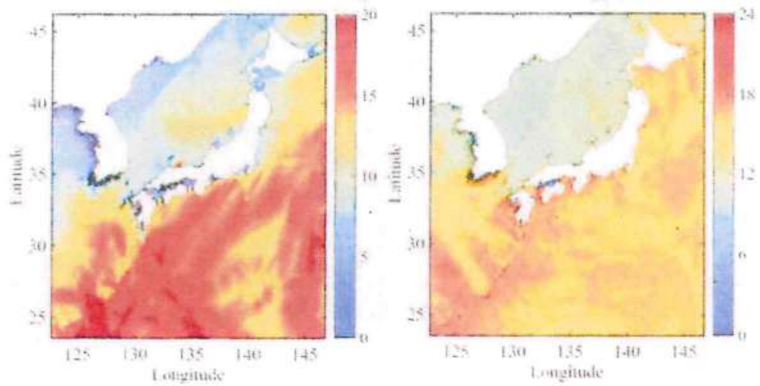
Max(Hs)/ave(Hs) from ERA-interim (Wada 2013)



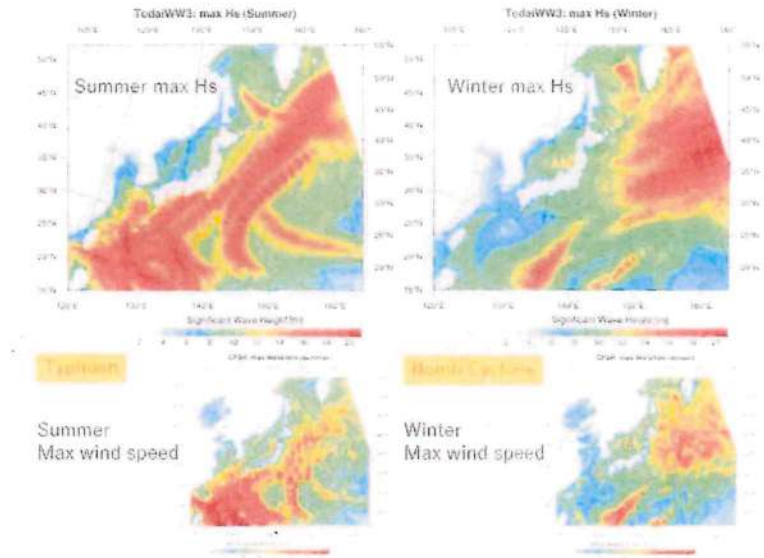
Current power estimated from JCOPE2/JAMSTEC max. speed

Maximum values (Significant wave height, energy period)

Extreme value analysis: X-year return period values



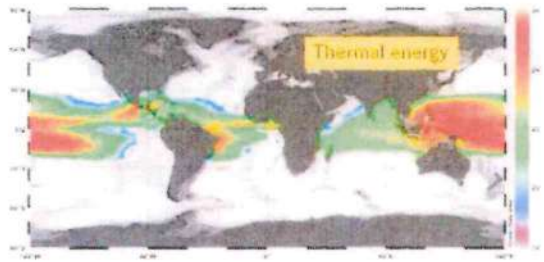
Offshore 20km, Japan 5km, Coastal 1km models

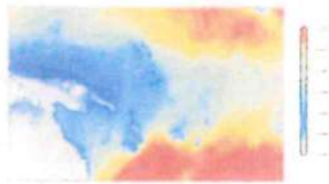


Harnessing energy from ocean water

Operational Ocean Thermal Energy Converter (OTEC) in Kume Island, Japan
http://otecokinawa.com/

Background: wave power



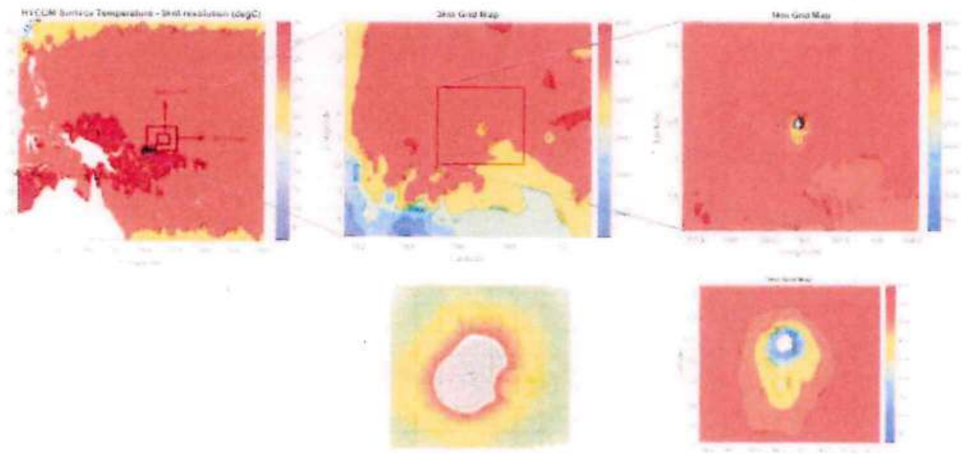


Rajagopalan & Nihous

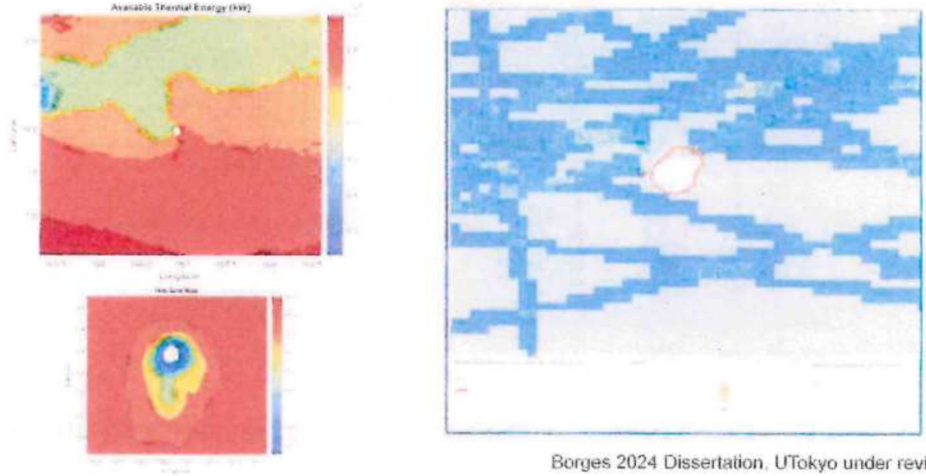
Assessing thermal energy

Pilot project for the island of Nauru

Downscale ocean model (HCOM 9km > ROMS 3km > ROMS 1km)



Site-selection: combining available resource, geographical/ meteorological/oceanographic constraints and societal constraints



Borges 2024 Dissertation, UTokyo under review

Modeling waves and currents for coastal and offshore development

Takuji Waseda
Applied Physical Oceanography Group
Dept. Ocean Technology Policy and Environment
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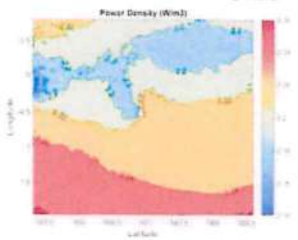
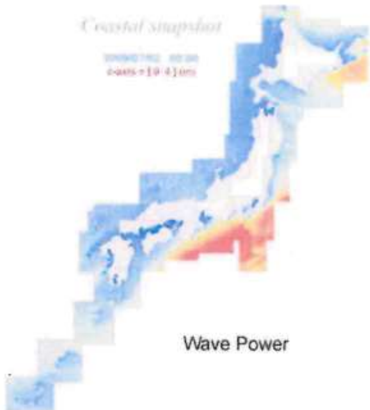




APPLIED PHYSICAL OCEANOGRAPHY

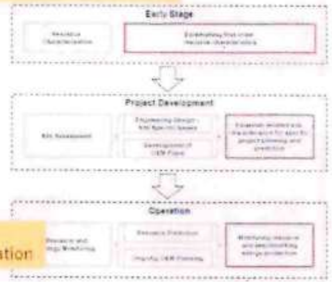
Assessing wave energy resources

Government supported project to develop a 1km wave database

Standards for resource assessment

Assessment of Tidal Energy Resource, EMEC Equimar protocols

Stage	Category	Aim	Area	Constraints	Permit
Stage 1	Regional assessment	Site screening	Region or country	Limited constraints identified	No
Stage 2a	Site assessment	Pre feasibility	Whole estuary, channel etc.	Major constraints identified	No
Stage 2b	Site assessment	Full feasibility	Localized area in a channel estuary etc.	All constraints identified and assessed	Applied for
Stage 3	Site assessment	Design development	Localized area in a channel estuary etc.	All constraints assessed	Obtained



IEC 62600-101 TS : (unpublished)
Wave energy resource assessment and characterization

■Wave		1.Reconnaissance	2. F.S.	3.Design
Period		10yrs	10yrs	10yrs
Model	Model			3rd G Wave model
	Resolution	5km	500m	50m
	Time step	3hrs	3hrs	1hrs
	Wind data	3hrs/100km	3hrs/25km	1hr/5km
Obs.	period	1year	1year	1year
	Number of	3	5	5

Bankability

Models required at different stages of assessment

■Diagram of assessment

1.Determine the Stage

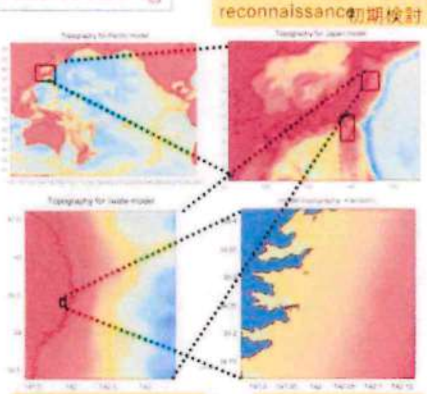
2.model ⇄ 3.Observation

4.Validation

5.Technical report

- Annual average
- monthly variation
- H-T JPD (wave)
- Harmonics analysis (tidal)

Downscaling



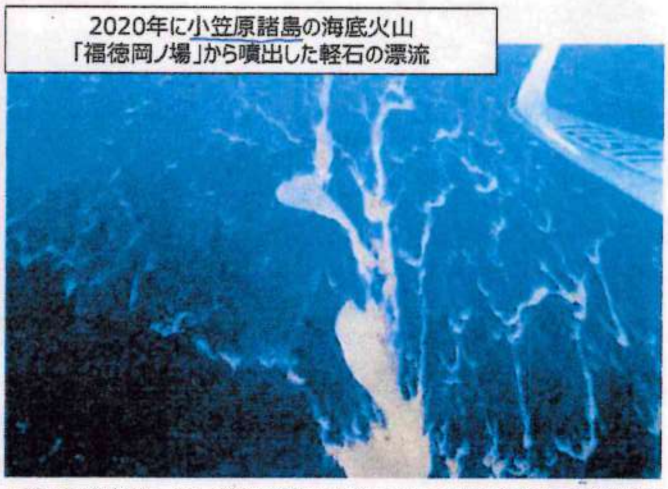
Observation of coastal ocean surface currents with a sailing team

東京大学 大学院新領域創成科学研究科 海洋技術環境学専攻
講師 小平翼

海洋表層ドリフターの大規模展開による海洋流動場の把握

- 海の"漂流" ー 事故時の原油流出、瓦礫流出、放射性物質の拡散…etc
- 海洋環境の変動を論じる上で、海洋の流動場、そしてプロセスの把握は非常に重要

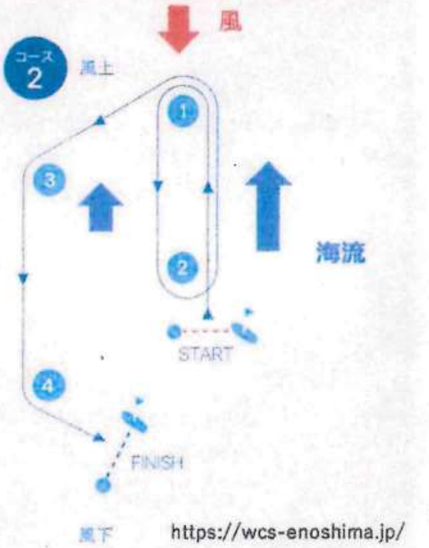
The oil seen from space by NASA's Terra satellite on 24 May 2010



出典：海上保安庁ホームページ(https://www.kaiho.mlit.go.jp/info/topics/post-864.html)

海流情報の提供によるセーリング競技支援

- セーリング競技はオリンピック競技の中でも情報戦略性の高いスポーツ
- 風は感知可能、かつ、データも豊富なので **情報戦では海流情報が差別化因子**となる



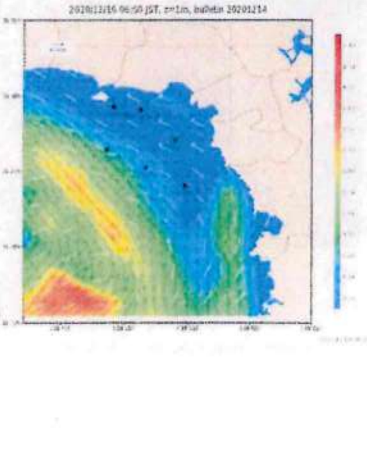
背景：海洋情報の提供によるセーリング競技支援

東京大学　早稲田研
（観測の実施・機器製作・データ解析）

東京大学 IIS 藤井研　DLX OMNI Project
（デザインを通じた技術の社会実装，観測機器製作）

セーリング競技支援

日本セーリング連盟
（観測機会の提供, **2020年度は計10回**）

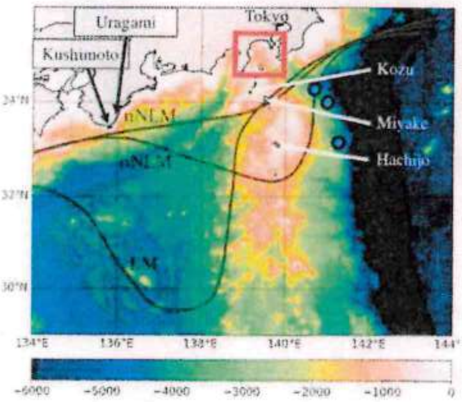


JAMSTEC APL
（高解像度　海流モデル）

導入：関心を寄せている流れの時空間スケール

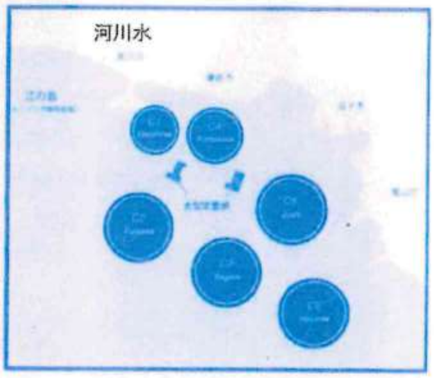
- セーリング競技のレースは半径1km程度の円形のエリアで実施される（空間スケール）。
- レースの時間は30分程度で、その間の流れを予測できるかがポイント（時間スケール）。
- 江ノ島の流れは複雑：湾外の黒潮の影響を強く受ける一方、規則的な潮流は限定的。

衛星海面高度計(~20km解像度)

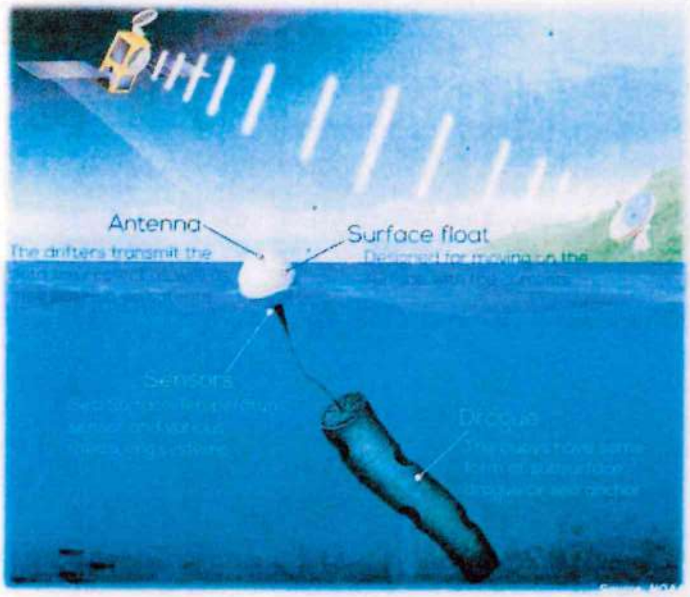


HFレーダー (~ 1.5km解像度)

???



導入：海洋表層ドリフター

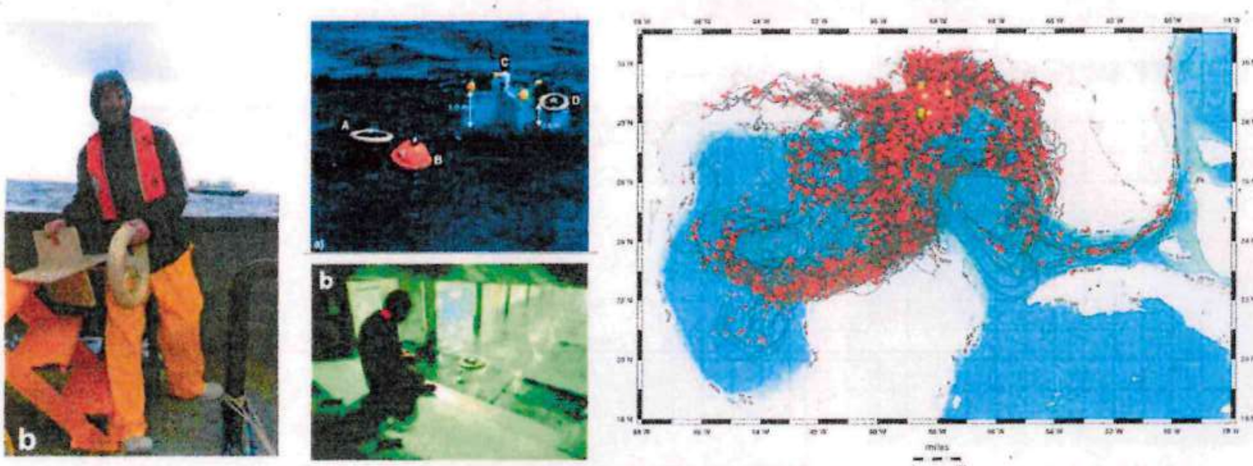


海洋表層 ドリフターの要素

1. GPSセンサー
2. データ通信・可視化
3. 没水浮体 (フロート & ドローグ)

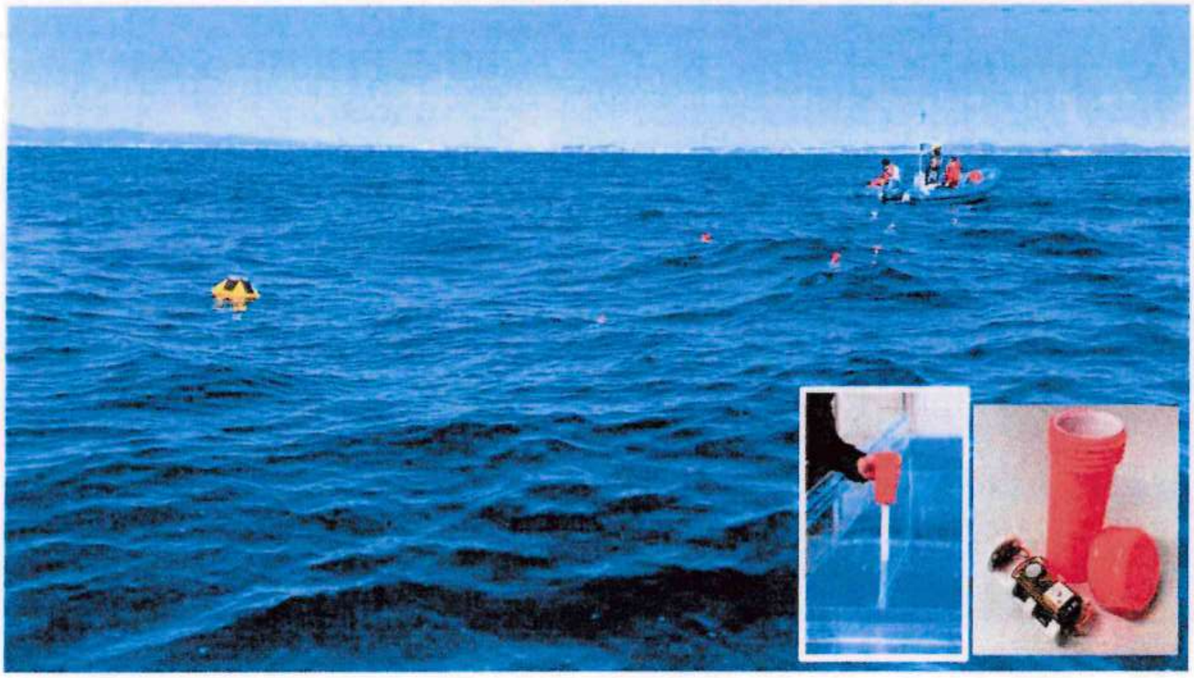
導入：小型海洋表層ドリフター（CARTHE ドリフター）

- 小型の海洋表層ドリフター開発の動き（水槽試験、実海域展開）
  - 既存のドリフターに比べ小型で、生分解性プラスチックを用いている。
  - 大規模展開し、成果は D'Asaro et al., (2018)などで発表されている。



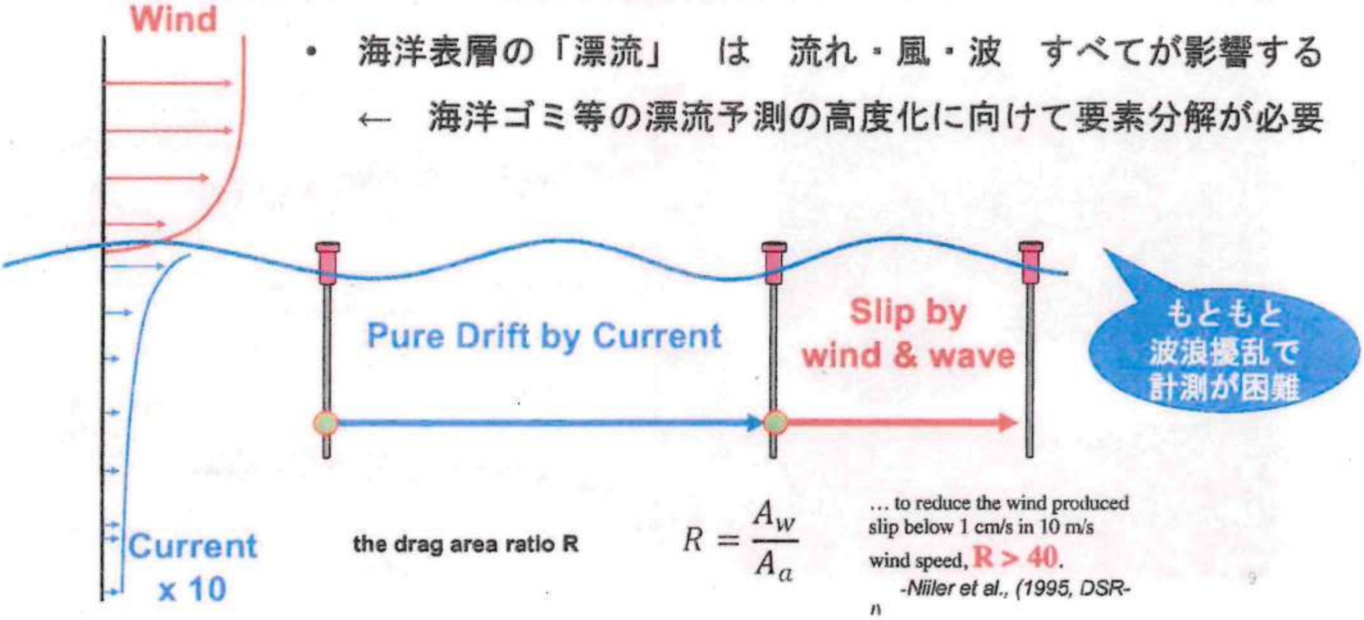
Noveli et al., (2017) "A Biodegradable Surface Drifter for Ocean Sampling on a Massive Scale"

導入："超"小型海洋表層ドリフター の開発



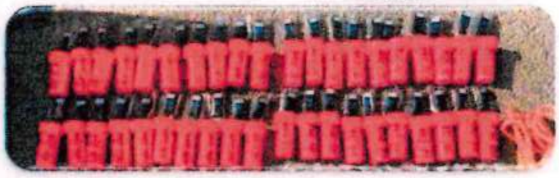
導入：海洋表層ドリフター

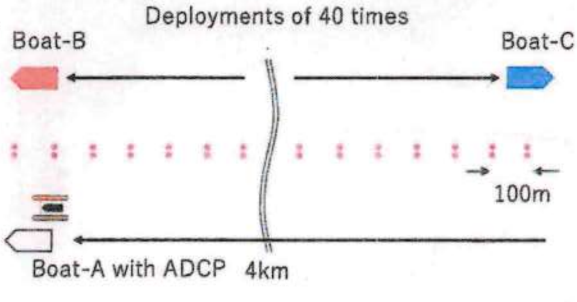
- 海洋表層ドリフター：風圧抵抗・波浪影響 による "Slip" を最小化する設計
  - 海洋表層の「漂流」 は 流れ・風・波 すべてが影響する
  - ← 海洋ゴミ等の漂流予測の高度化に向けて要素分解が必要

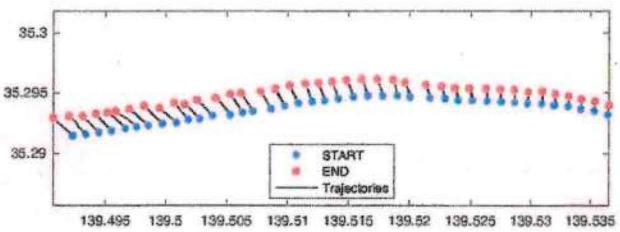


簡易浮体の多数展開 ー 既存の観測手法との比較

- 市販のGPSロガーを棒形状の付帯に内蔵して、100m毎に40点で同時漂流。
- 曳航 ADCP (1200kHz, 九州大学所有) 計測と比較し、同等の結果が得られた。







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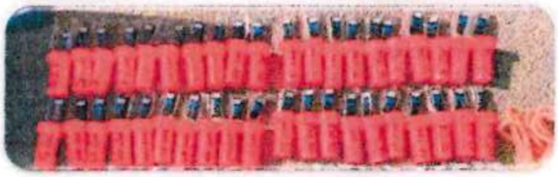
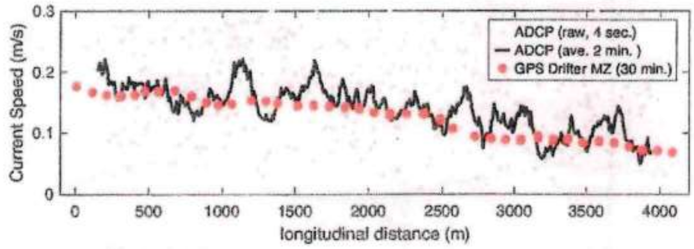
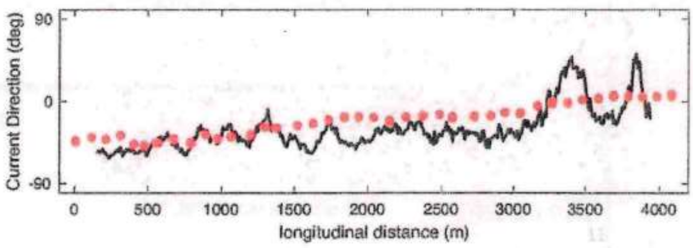
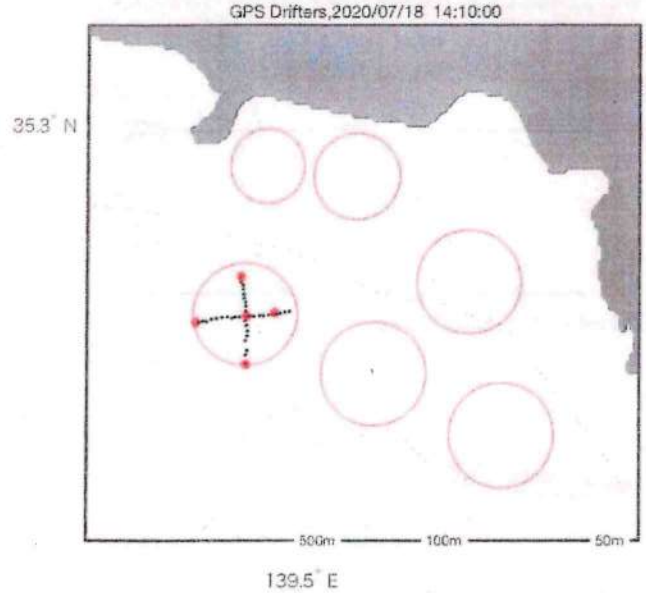


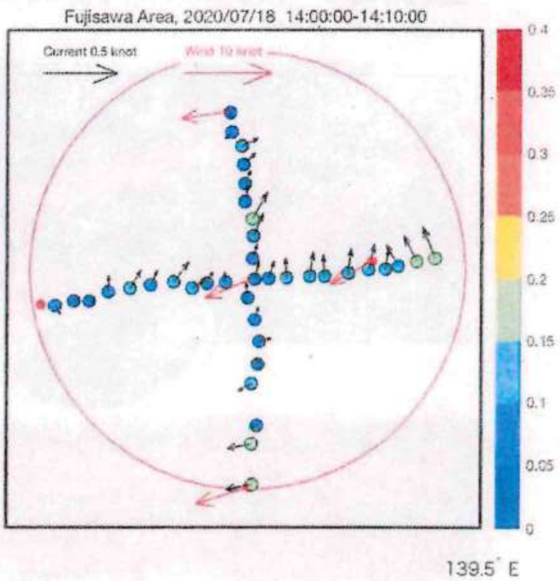




結果：2020/7/18 の 例

- レース海面における多点展開の例





ノウハウの共有 —> 海域利用者（セーリング連盟）による流れの計測

- 漂流棒の多点展開という方法が実施できることを示した → 繰り返し計測

自作ドリフター、市販ドリフター
電磁流速計での検証

手法の共有

市民参加型の継続的・集中的 な潮流観測
—総計測回数 834回—

日本セーリングチームの最高成績は7位入賞

Discussion

モニタリングポストの必要性

- 空間的に密なデータは取得できたが、時間 的に連続したデータは限定的

対話の必要性

- Researcher － Coach － Player における情報の伝達、

謝辞 本研究活動は下記の団体と共同して実施しました。

- 日本セーリング連盟
- JAMSTEC APL
- 九州大学 応用力学研究所
- 東京大学 IIS 藤井研 DLX OMNI Project

本研究活動は下記の助成を受けて実施しました。

- 東京大学 スポーツ拠点 (FY2018-2019)
- 東京大学大学院教育学研究科附属海洋教育センター － 海洋教育基盤研究プロジェクト(海洋学) (FY2020)
- 科学研究費助成事業 (若手研究 21K14357)

國立研究開發法人海洋研究開發機構相關會議資料

Program for the visit to
Japan Agency for Marine-Earth Science and Technology

Date & Time: 15:00-17:00, Tuesday, April 9th, 2024

Address: JAMSTEC Headquarters
2-15 Natsushima-cho, Yokosuka-city, Kanagawa 237-0061, Japan

List of Guests:

1. Ms. Hsiao-Sia Li, Director of Marine Environmental Management Division of OCA
2. Mr. Hung-Wen Chen, Section Chief, Marine Environmental Management Division of OCA
3. Ms. Hui-Chen Yang, Section Chief, Marine Environmental Management Division of OCA
4. Mr. Yu-Chein Chen, Officer, Marine Environmental Management Division of OCA
5. Prof. Jenq-Renn Chen, Distinguished Professor, Department of Safety, Health and Environmental Engineering, National Kaohsiung University of Science and Technology
6. Prof. Ping-Chi Hsu, Professor, National Kaohsiung University of Science and Technology
7. Associate Prof. Tsung-Yueh Tsai, Associate Professor, National Kaohsiung University of Science and Technology
8. Ms. Hui-Ning Yang, Senior Manager, National Kaohsiung University of Science and Technology
9. Ms. Chen Liu, Manager, National Kaohsiung University of Science and Technology
10. Prof. Toru Sato, Professor, Graduate School of Frontier Sciences, The University of Tokyo

JAMSTEC Participants:

1. Dr. Takeshi KAWANO, Executive Director
2. Dr. Katsunori Fujikura, Director, Marine Biodiversity and Environmental Assessment Research Center (BioEnv), Research Institute for Global Change（RIGC）
3. Dr. Toru MIYAMA, Senior Researcher, Environmental Variability Prediction and Application Research Group, Application Laboratory, Research Institute for Value-Added Information Generation (VAiG)
4. Dr. Yu-Lin Eda CHANG, Researcher, Environmental Variability Prediction and Application Research Group, Application Laboratory, Research Institute for Value-Added Information Generation (VAiG)
5. Mr. Masahiro KAMEI, Director, Marine Science and Technology Strategy Department (MaSTS)
6. Mr. Tsuyoshi SUGIURA, Manager, International Affairs Section, Marine Science and Technology Strategy Department

Program:

TIME	ITEM	SPEAKER / FACILITATOR
15:00	Arrival at JAMSTEC headquarters	
15:00-15:05	Welcome remarks Self-introduction	Dr. Takeshi KAWANO All participants
15:05-15:20	Introduction of JAMSTEC	Mr. Masahiko KAMEI
15:20-15:35	Introduction of OCA and National Kaohsiung University of Science and Technology	Prof. Jenq-Renn Chen
15:35-15:50	Projection of pumice dispersion from the August 2021 submarine volcano eruption	Dr. Yu-Lin Eda CHANG (Online)
15:50-16:05	Simplified Monitoring Method for Deep-sea Marine Protected Areas	Dr. Katsunori Fujikura
16:10-16:45	Tour at the Exhibition Hall	Mr. Tsuyoshi Sugiura
16:50-17:00	Wrap-up	All participants

Language: English

Handout List:

1. JAMSTEC Brochure
2. JAMSTEC Overview
3. Application Laboratory Brochure
4. Arctic Research Vessel Brochure

Ocean Conservation Administration, Taiwan
15:35-15:50, April 9th, 2024, @JAMSTEC Headquarters

Simplified Monitoring Method for Deep-sea Marine Protected Areas (MPAs)

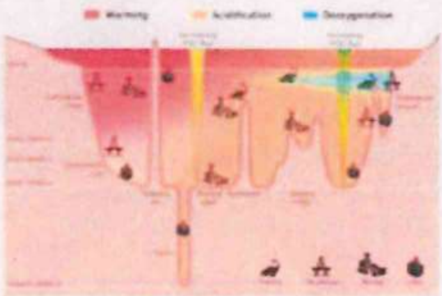
FUJIKURA, Katsunori

Marine Biodiversity and Environmental Assessment Research Center (BioEnv)

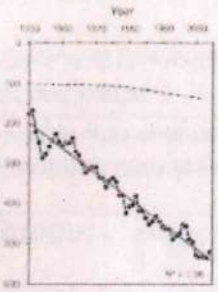
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Sustainable Use of Ecosystem Services with Marine Biodiversity Conservation

- The conservation and sustainable use of marine biodiversity is a major issue facing humanity today.
- The deep sea is a very vast area that occupies most of the Earth's biosphere.
- We unknowingly receive a variety of ecosystem services from deep-sea ecosystems.
  - ex: food, material cycle, climate control, etc.
- Deep-sea organisms have high potential to become unknown useful genetic resources.
- Human activities and global warming are beginning to impact deep-sea ecosystems.
  - ex: deep ocean warming, ocean acidification, deoxygenation, waste (including plastics) pollution, deep-sea fishing.
- The mean depth of bottom trawling fisheries has been 520 m deep in 2004.



Humans and climate change in the deep ocean (Levin & Le Bris 2015)



Depth of world marine bottom fisheries catches, 1950–2004 (Watson & Morato 2013)

Establishment of Marine Protected Areas (MPAs) & Other Effective Area-based Conservation Measures (OECM) for Conservation and Sustainable Use of Marine Biodiversity

- **Convention on Biological Diversity (CBD) / COP10 / Aichi Biodiversity Targets**
  By 2020, at least 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider seascapes.
- **SDGs14.5**
  By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.
- In Japan, marine protected areas (MPAs) were established on the deep-sea floor in addition to shallow water areas.
- Because MPAs could be established on the deep-sea floor, 13.3% of Japan's EEZ could be designated as MPAs.
- **Convention on Biological Diversity (CBD) / COP15 / Kunming-Montreal Global Biodiversity Framework**
  30by30: Ensure and enable **that by 2030 at least 30 per cent of — marine and coastal areas**, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures, ---.
- **Many countries, including Japan, need to new establish MPA/OECMs in deep water.**

Marine protected areas (dark blue). UNEP-WCMC and IUCN (2023) www.protectedplanet.net.

Marine protected areas in Japanese waters. UNEP-WCMC and IUCN (2023) www.protectedplanet.net.

Scientific Role for Marine Protected Areas (MPA) & Other Effective Area-based Conservation Measures (OECM)

- The Convention on Biological Diversity (CBD) recommended that Ecologically or Biologically Significant Sea Areas (EBSAs) be extracted before designating MPAs.
- Since the deep-sea ecosystem will change even after MPAs designation, we need to manage suitability of MPAs based on scientific information.
- Accumulation of deep-sea biodiversity and environmental data is essential not only for current MPAs management but also for achieving 30by30.

However, opportunities for deep-sea research are limited due to the high cost, specialized large platforms, and manpower required.

A simple and low-cost deep-sea survey method is needed.

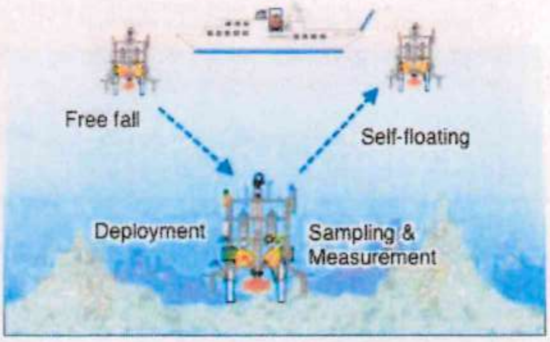
Scientific criteria of EBSAs

Uniqueness or Rarity
Special importance for life history stages of species
Importance for threatened, endangered or declining species and/or habitats
Vulnerability, Fragility, Sensitivity, or Slow recovery
Biological Productivity
Biological Diversity
Naturalness

Simple and low-cost Free-Fall Deep-Sea Ecosystem Observation Equipment **Lander**

- Advances in molecular biological techniques have allowed environmental DNA analysis to reveal the presence of marine life (including invertebrates and fishes) in seawater and sediments.
- Environmental measurement equipment has also become smaller and lighter.
- As a simple and low-cost deep-sea survey tool, we developed a Free-Fall Deep-Sea Ecosystem Observation Equipment, **Lander**.

- The lander is,
  - 1) sink free-fall from the ship,
  - 2) observe on the seafloor,
  - 3) collect samples on the seafloor, and
  - 4) Self-float with the weights released.
- No need for specialized operators.
- No need for large Research Vessel.



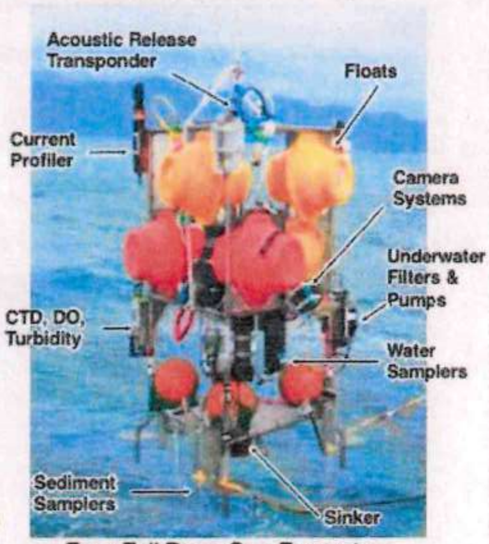
Operation of the Lander

Simple and low-cost Free-Fall Deep-Sea Ecosystem Observatory **Lander**

General specification of the Lander

Size	Width 1.5 m, Height 2.35 m
Shape	Triangular prismatic
Weight in air	452 kg
Weight in water	22 kg
Buoyancy	-60 kg
Maximum use depth	2000 m
Observable time	12-24 h (Max. 1 year)
Price	**0.22 mil. $**

- The lander can collect samples (seawater, sediment, and seawater filtrate) allowing environmental DNA analysis of deep-sea life at depths of up to 2000 m.
- It can also measure environmental factors, including water temperature, salinity, pressure, turbidity, and current direction and velocity.

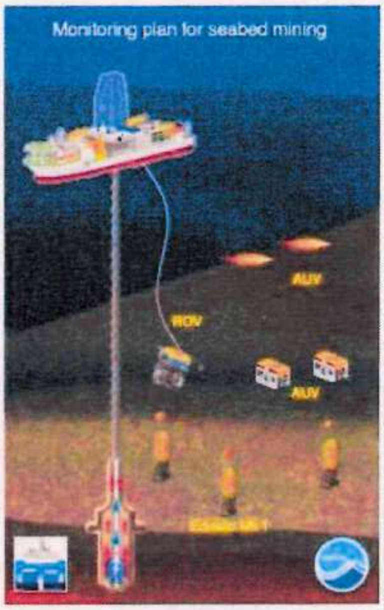


Free-Fall Deep-Sea Ecosystem Observatory, Lander

Other types Free-Fall Deep-Sea Ecosystem Observatory **Lander**

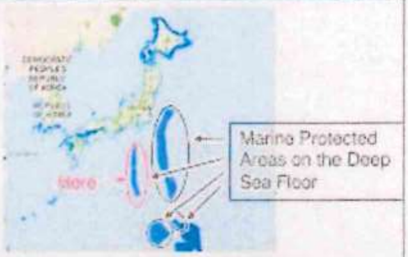
- JAMSTEC has also developed other types of Landers, Edokko Mark 1.
- These have limited functionality but are less expensive.
- Other Lander, Edokko Mark 1 series are now available as a commercial product.
- This project will make the monitoring system combined with marine robotics such as autonomous underwater vehicles.

Edokko Mark 1 series:	
Basic device	Video camera unit
Add-on devises	CTD, Hydrophone, Current meter, Incubation tools, etc.
Operational Depth (max)	4000-8000 m



Observation of Deep-sea Marine Protected Areas (MPAs) Using the Lander

- We use landers to investigate deep-sea ecosystems in MPAs on the deep-sea floor of Japanese waters.
- We were able to obtain data on prokaryotic, meio-benthos, mega-benthos, and fish diversity with environmental DNA from seawater and sediment collected by the lander.
- Environmental data was also obtained.
- With these data, the suitability of the MPAs can be evaluated based on the EBSA criteria.
- By environmental DNA analysis, a large deep-sea fish, *Narcetes shonanmaruae* of which only seven individuals have been collected worldwide, was detected in a deep-sea MPA.
- This fish is the top predator in the deep-sea ecosystem and controls the ecosystem.
- This fish is an indicator species for assessing the suitability of the marine ecosystem at this site.
- **The Lander is an effective equipment for deep-sea ecosystem monitoring.**



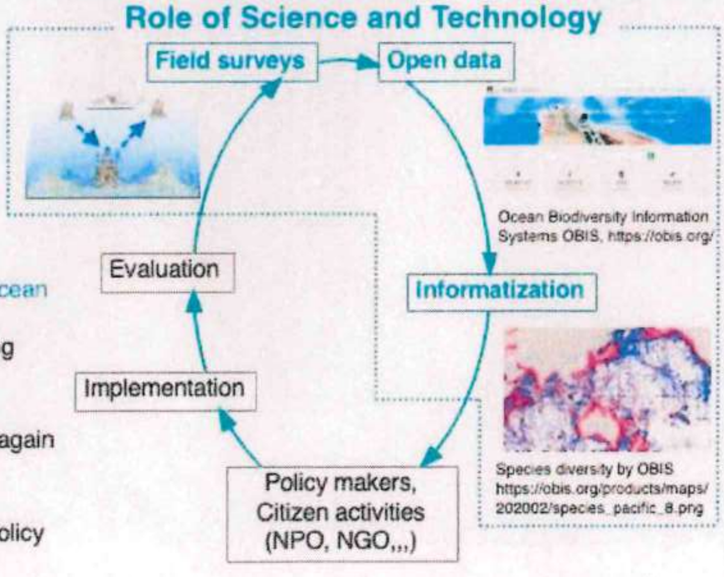
Research area of Japanese MPA. UNEP-WCMC and IUCN (2023) www.protectedplanet.net.

Large deep-sea fish, *Narcetes shonanmaruae* (total length 2.5 m) ©JAMSTEC

Fujiwara et al. (2022)

The Role of Science and Technology for the Conservation and Sustainable Use of Marine Biodiversity

- Teamwork among scientists, engineers, policy makers, and citizens is crucial for the conservation and sustainable use of biodiversity.
- The role of scientists and engineers is to collect data by field surveys, publish the data as open data, and provide information from the data to policy makers and the public.
- International marine life databases such as Ocean Biodiversity Information Systems OBIS, a UNESCO/IOC project, are useful for publishing data.
- After policies and citizen activities are implemented, field surveys will be conducted again to collect data in order to evaluate their effectiveness.
- It is important that scientists and engineers, policy makers, and citizens form such a cycle.



JAMSTEC Overview

Towards an integrated understanding of the Ocean, the Earth and Life

9 April 2024

JAMSTEC

Japan Agency for Marine-Earth Science and Technology

JAMSTEC in Brief

*Founded in 1971**

***2021 marked our 50th anniversary**

About 900 employees *(ca. 320 scientists, 200 engineers, 40 maritime crew, 150 admin. staff, 200 support staff), as o April 2023*

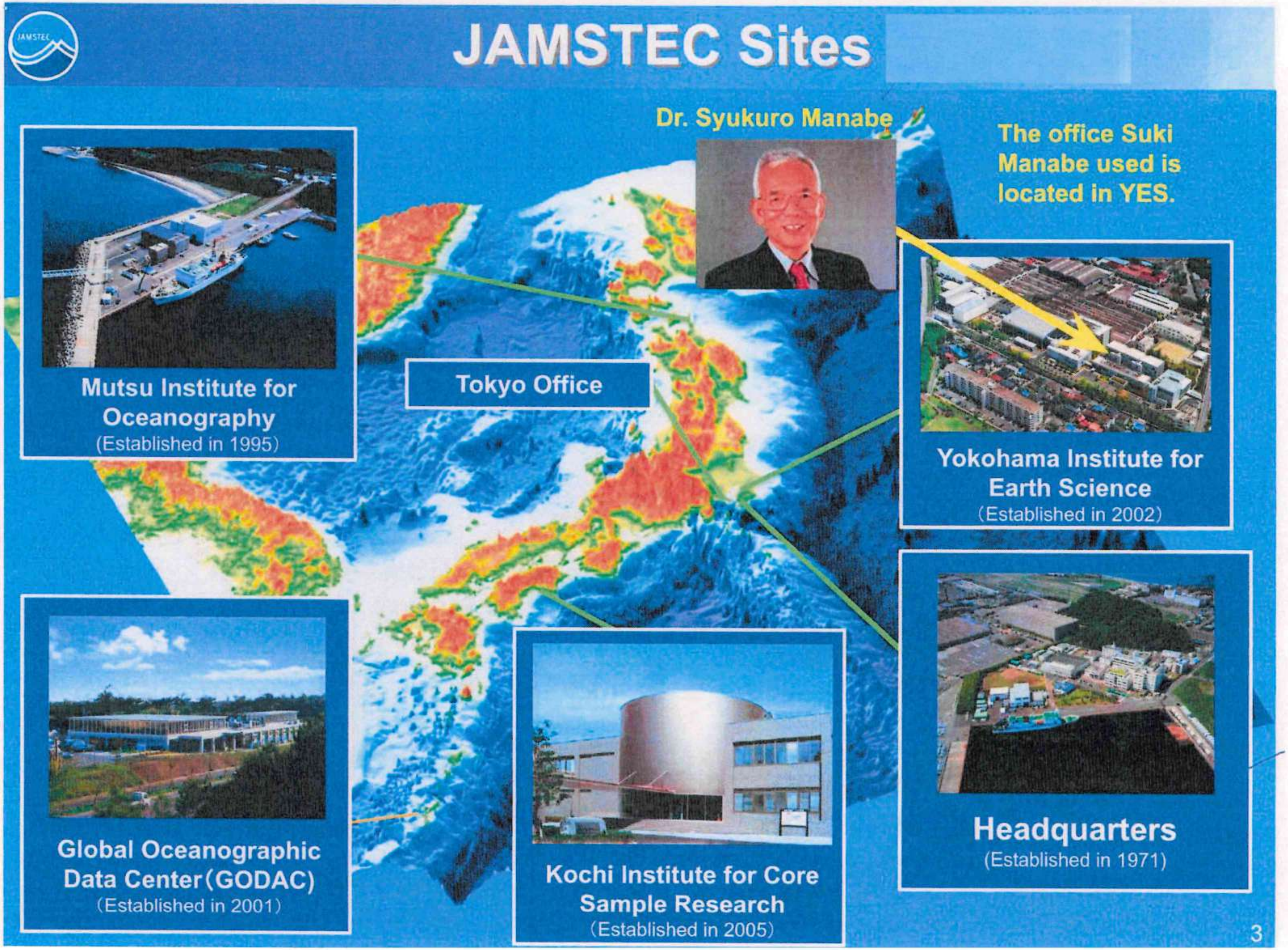
Consists of 5 "Institutes" and 2 "Departments" for R&D

6 research vessels, one submersible & several under-water vehicles *(Research Icebreaker is under building)*

Ca. 550 peer reviewed journal papers per year

Budget in 2023: 37 billion yen (Approx. $246 million)

Under the jurisdiction of MEXT


JAMSTEC
JAMSTEC Sites
Dr. Syukuro Manabe
The office Suki Manabe used is located in YES.
Mutsu Institute for Oceanography
(Established in 1995)
Tokyo Office
Yokohama Institute for Earth Science
(Established in 2002)
Headquarters
(Established in 1971)
Global Oceanographic Data Center (GODAC)
(Established in 2001)
Kochi Institute for Core Sample Research
(Established in 2005)
3

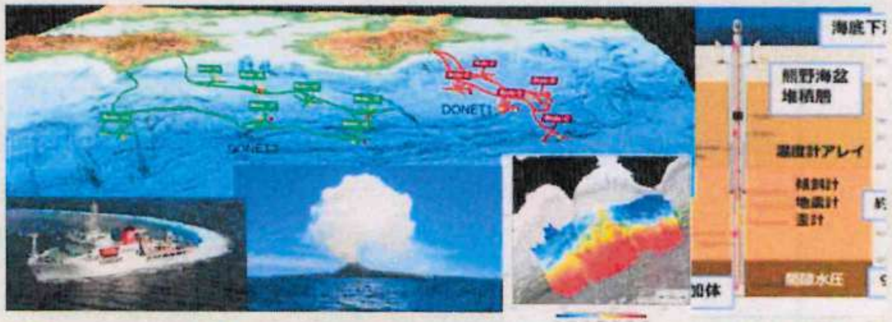
Institutes for R&D

Research Institute for Global Change (RIGC)

Understanding the current status and projecting the future of the global change.

Research Institute for Marine Resources Utilization (MRU)

Understanding material circulation and origin of marine resources to ensure sustainable use



Research Institute for Marine Geodynamics (IMG)

Elucidating the actual conditions of earthquakes and volcanic activity to lead to disaster mitigation.

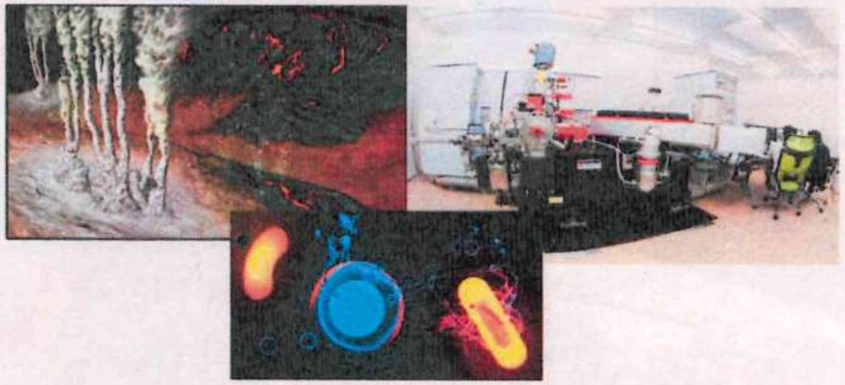
Research Institute for Value-Added-Information Generation (VAiG)

Developing methodologies for integrating the vast amounts of data generated by JAMSTEC R&D activities, and mathematical analysis methods for efficiently processing the resulting integrated data.

Institutes for R&D

Institute for Extra-cutting-edge Science and Technology Avant-garde Research (X-star)

Understanding the principle of how the Earth could become a rare planet of diverse living forms and exploratory and challenging research and technological development for the future.



Institute for Marine-Earth Exploration and Engineering (MarE3)

The integrated operation and management of JAMSTEC's oceanographic research platforms such as vessels and ROVs/AUVs. And promoting International Ocean Discovery Program (IODP) which is an international marine research collaboration that explores Earth's history and dynamics using scientific ocean drilling platforms.

Engineering Department

Research and Development of the technology for marine robots, ocean observation systems, and related technology.

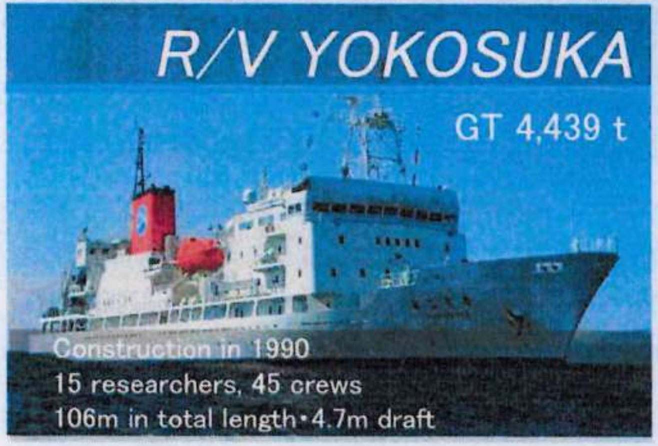
Project office for Arctic Research Vessel (PARV)

Promoting the successful construction and operation of the new JAMSTEC Arctic Research Vessel and ensuring that the vessel will be able to meet these goals as soon as it enters into service.

JAMSTEC Fleet

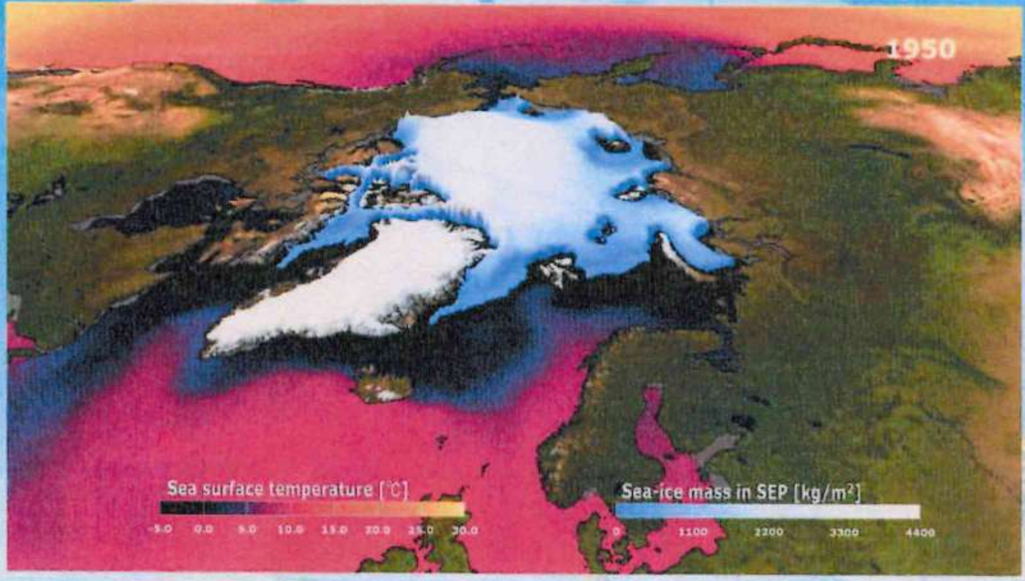
These vessels are utilized by researchers nation-wide for research and development purposes as defined in the med-term plan. In addition, we operate these vessels as we cooperate with other research institutions and universities on research expedition.

GT: Gross tonnage



Japan's New Research Icebreaker "MIRAI II"

Japan's new Research Icebreaker for Arctic Research will be launched in FY2026. She will be an "International Platform for Arctic Research".



- Understand the state of heat & freshwater budget and the biogeochemical cycle in the Arctic Ocean
- Reveal the atmosphere-sea ice-ocean interaction processes
- Understand changes in biological production and ecosystems
- Observational studies of meteorology, climate, and atmospheric chemistry
- Develop advanced instruments for sea ice observation
- Paleoenvironmental reconstruction and clarify the tectonic history of the Arctic region

Length	128 m
Beam	23 m
Depth	12.4 m
Draught	8 m
Gross tonnage	13,000 tons
Ice breaking capability	Up to 1.2m thick first-year ice at 3.0 knots
Polar Class	PC4
Accommodation	97 persons

International Corporation

NORWAY
- University of Bergen (UiB)
- University of Tromso The Arctic University of Norway (UiT)

THE NETHERLANDS
- Royal Netherlands Institute for Sea Research (NIOZ)

GERMANY
- Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research (AWI)
- Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences (GFZ)

UK
- The National Oceanography Centre and The University of Southampton (NOC, UoS)

FRANCE
- L'Institut Français de Recherche pour l'Exploitation de la Mer (Ifremer)

SAUDI ARABIA
- King Abdullah University of Science and Technology (KAUST)

TAIWAN
- National Applied Research Laboratories (NARLabs)

INDIA
- CSIR - National Institute of Oceanography (CSIR-NIO)
- The Ministry of Earth Sciences of the Republic of India (MoES)

INDONESIA
- Meteorological, Climatological, and Geophysical Agency (BMKG)

AUSTRALIA
- Geoscience Australia (GA)
- The Commonwealth Scientific and Industrial Research Organisation (CSIRO)

NEW ZEALAND
- Institute of Geological and Nuclear Sciences Limited (GNS)

CANADA
- Canada Department of Fisheries and Oceans Science Sector (DFO)
- Natural Resources Canada

U.S.A
- University of Hawai'i (UH)
- University of Alaska Fairbanks (UAF)
- Scripps Institution of Oceanography, UC San Diego(SIO)
- National Oceanic and Atmospheric Administration U.S. Department of Commerce of the United States of America (NOAA)
- Lamont-Doherty Earth Observatory, Columbia University (LDEO)

- European Consortium of Ocean Research Drilling (ECORD)
- Australian and New Zealand International Ocean Discovery Program Consortium (ANZIC)

22 institutions & 2 consortiums.
Several more are under coordination.

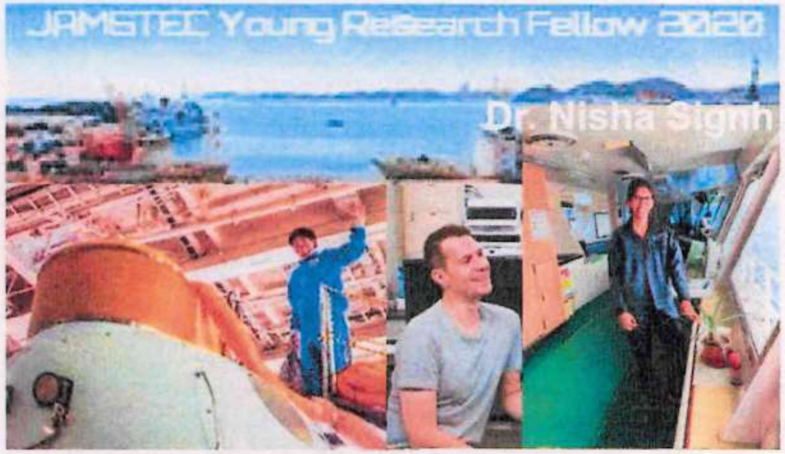
As of December 2023

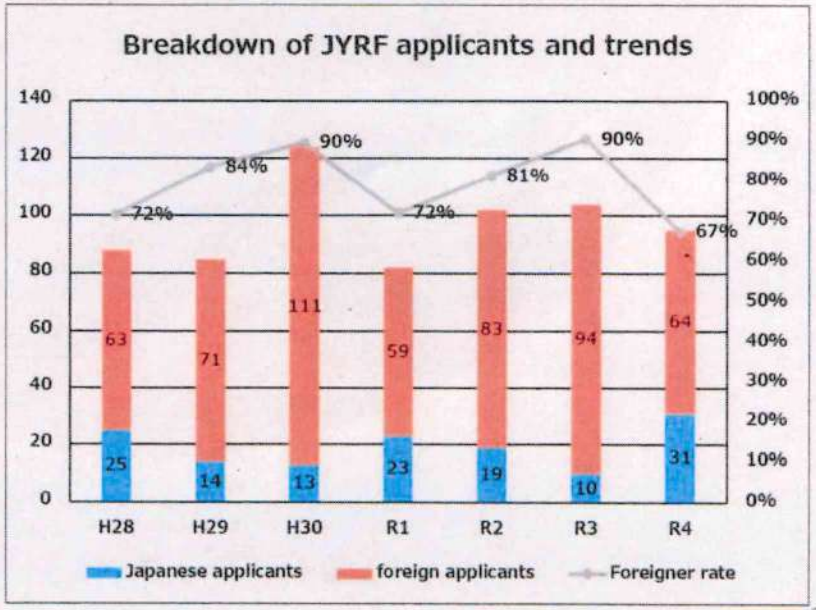
Programme for young researchers

Operation of the JAMSTEC Young Research Fellow (JYRF) scheme

- A programme for outstanding young researchers with a Ph.D. (within five years of receiving the degree) to develop their research agendas into more outstanding achievements. They conduct their own research at JAMSTEC. A mentor, rather than a supervisor, is assigned to support their research activities. The term of appointment is three years.
- Those hired under this system receive start-up funding and basic research funding (1,000,000 yen in the first year and half that amount in the second and subsequent years).
- The proportion of foreign applicants has been over 70% since the system began, with applications coming from around 30 different countries. The public call for proposals and the selection process are conducted entirely in English.
- This may be due to the fact that the call for applications is not restricted to the target fields of study and the introduction of web-based interviews at the time of the interview.
- In addition, international exchange events are organised within JAMSTEC, such as the 'International Day', to encourage interaction between staff members.

Approximately 4–6 persons per year. A total of 44 people have been employed so far.






Thank you.
10

Projection of pumice dispersion from the August 2021 submarine volcano eruption in the western North Pacific

Yu-Lin Eda Chang (Application Laboratory)

Iona M. McIntosh, Toru Miyama, and Yasumasa Miyazawa

Information about eruption from JMA:

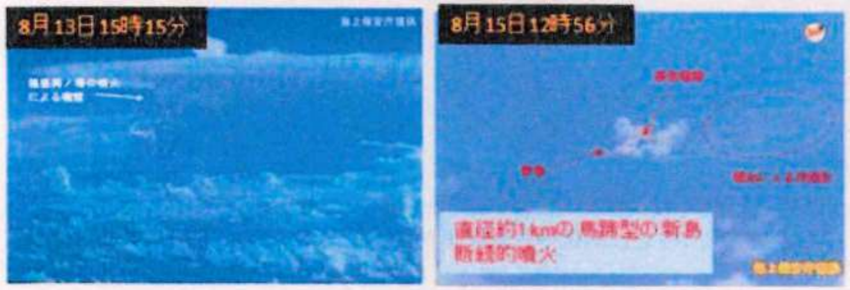
福徳岡ノ場の活動状況等

› 最新の火山活動の状況（福徳岡ノ場）

これまでの火山活動状況等

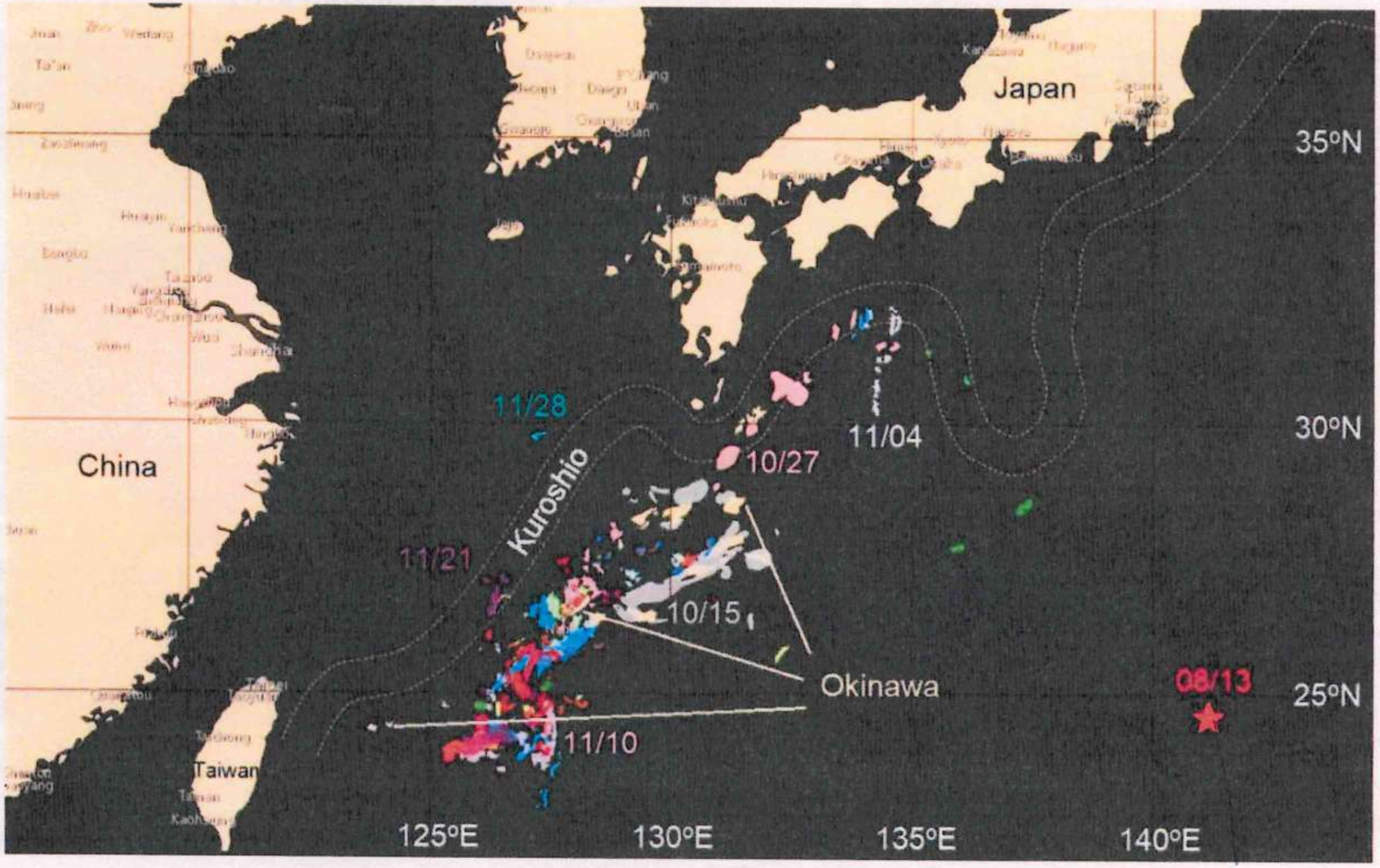
- 8月13日から15日にかけて、福徳岡ノ場の海底噴火を確認。気象衛星ひまわりによると噴煙高度は最大で約16,000m。
- 8月13、15日に海上保安庁が航空機による観測を実施。15日の観測では活発な噴火活動が続いており、新島の形成と浮遊物（軽石等）を確認。
- 8月22日に、福徳岡ノ場から西北西約300kmの太平洋上で、海洋気象観測船「啓風丸」により漂流している軽石を採取。また、10月4日には沖縄県大東諸島に軽石が漂着しているとの通報を受け、地方気象台が軽石の漂着を確認。
- 福徳岡ノ場では1986年にも噴火が発生しており、この時には高さ12,000mの白い噴煙が確認され（海上自衛隊）、長径600m、高さ15mの新島が形成（その後消失）。

噴火の様子（海上保安庁による機上観測）



福徳岡ノ場の周辺海域で採取した浮遊物（軽石）

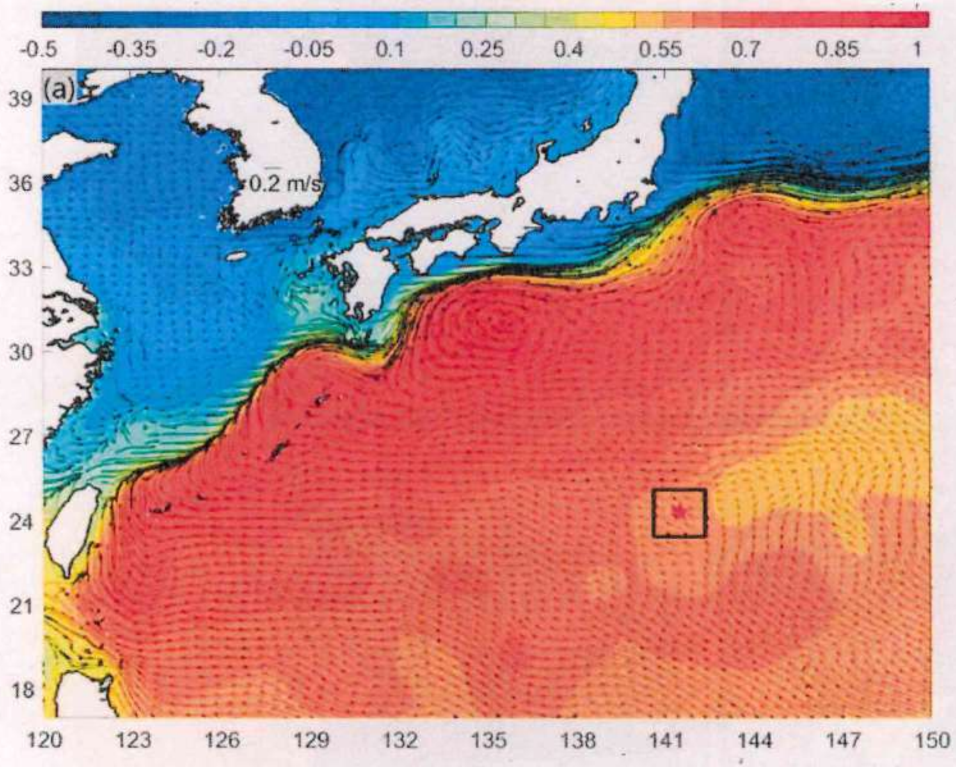
Satellite observed pumice arrival at Okinawa

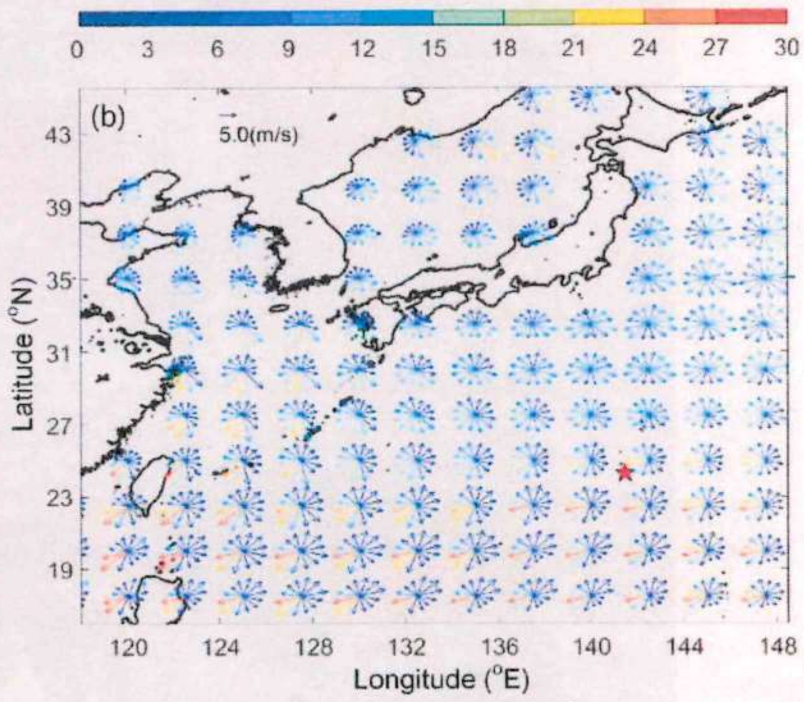


The averaged pumice traveling speeds were 0.19-0.21 m/s.

For long-term projection, we may use existing historical re-analaysis data

Ocean: JCOPE2M (1993-2020)
Wind: NCEP-Reanalysis (same period)

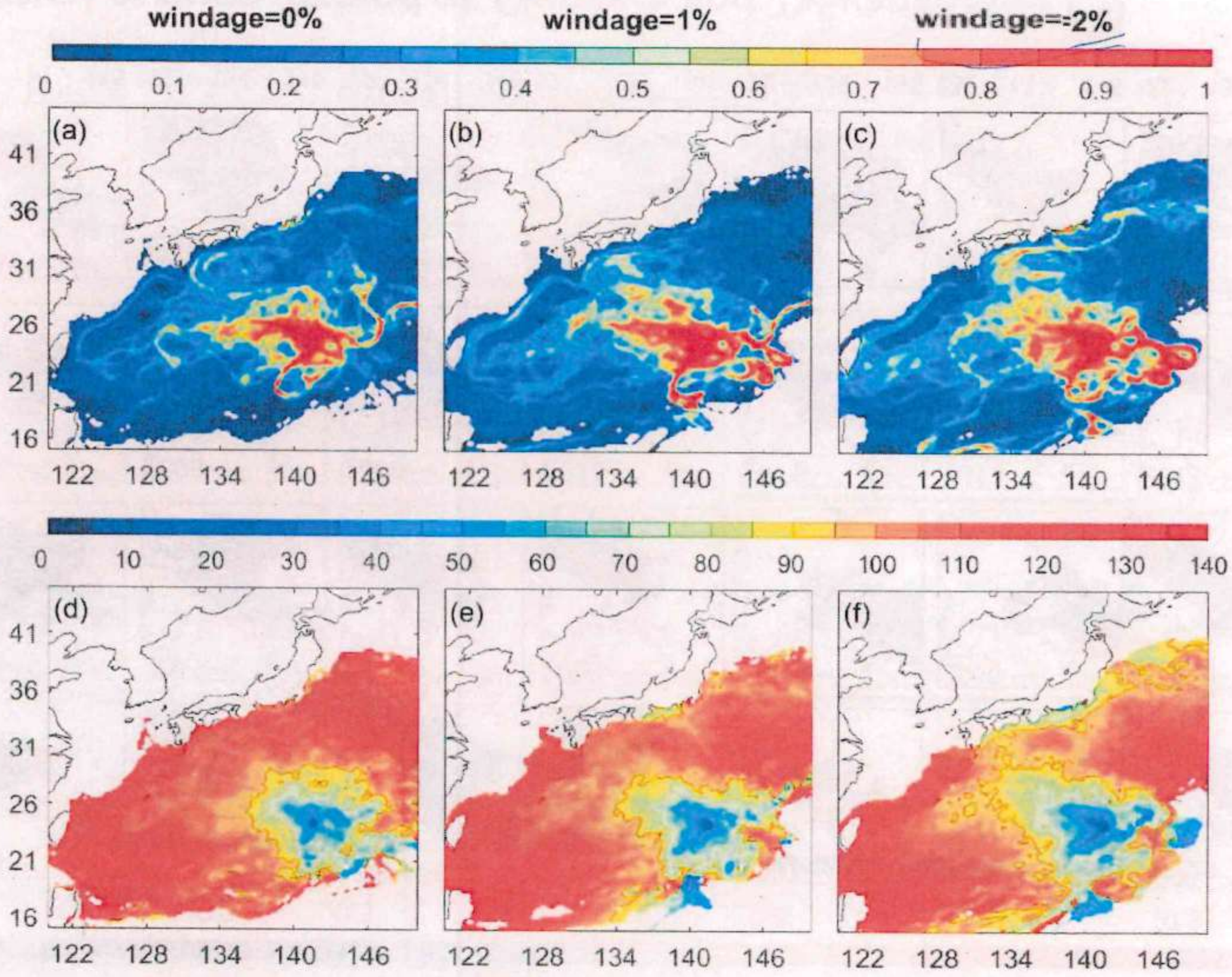




Release plan:
Location: within 20km x 20km square from the eruption site
Date: 13, 14, 15 August of 1993-2020

1993-2020
Mean wind=(-2.87, -1.09) m/s
Mean speed=5.2 m/s

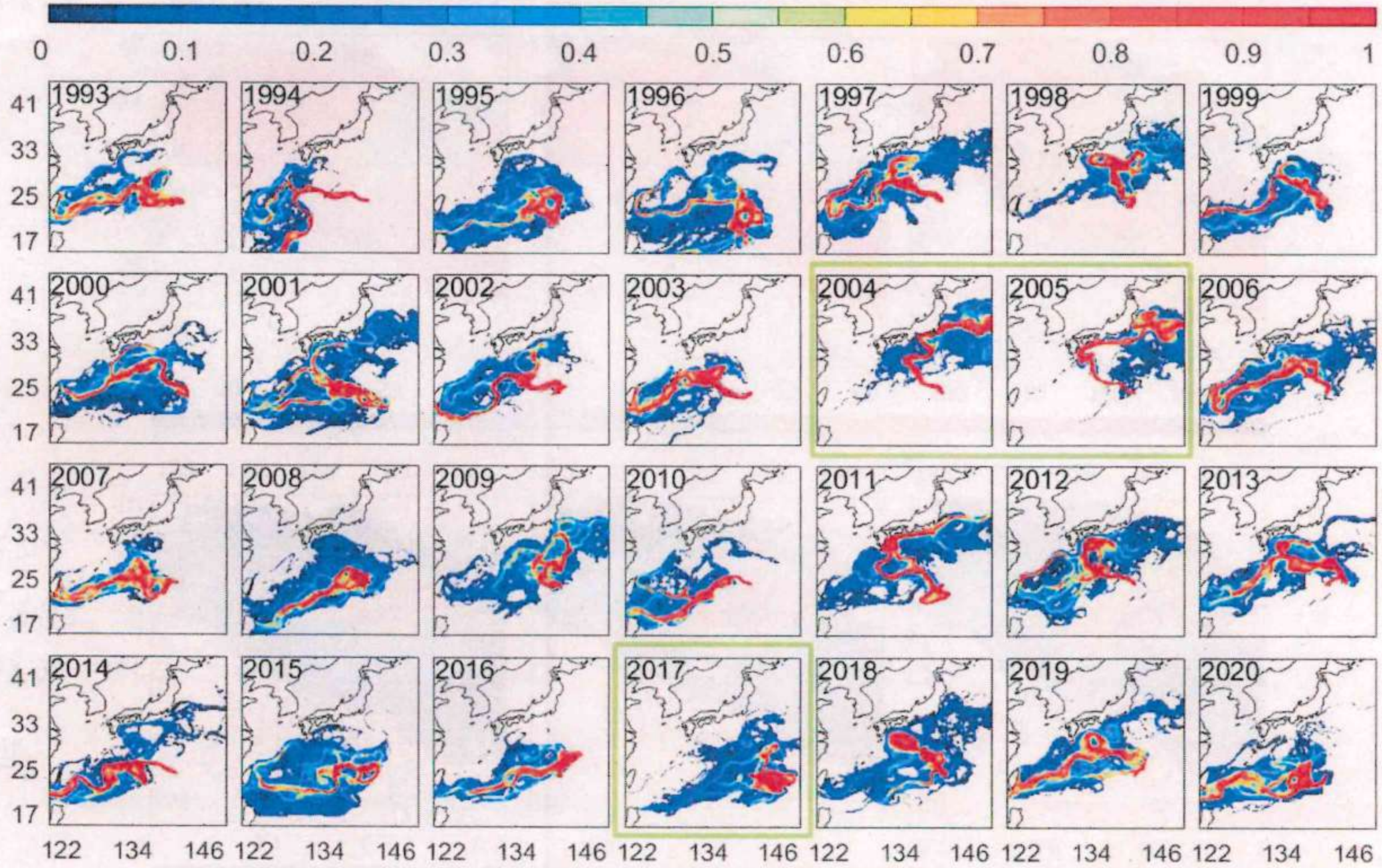
1993-2020 ensemble visitation frequency and time evolving map



The mean ocean current speed was about 0.1 m/s

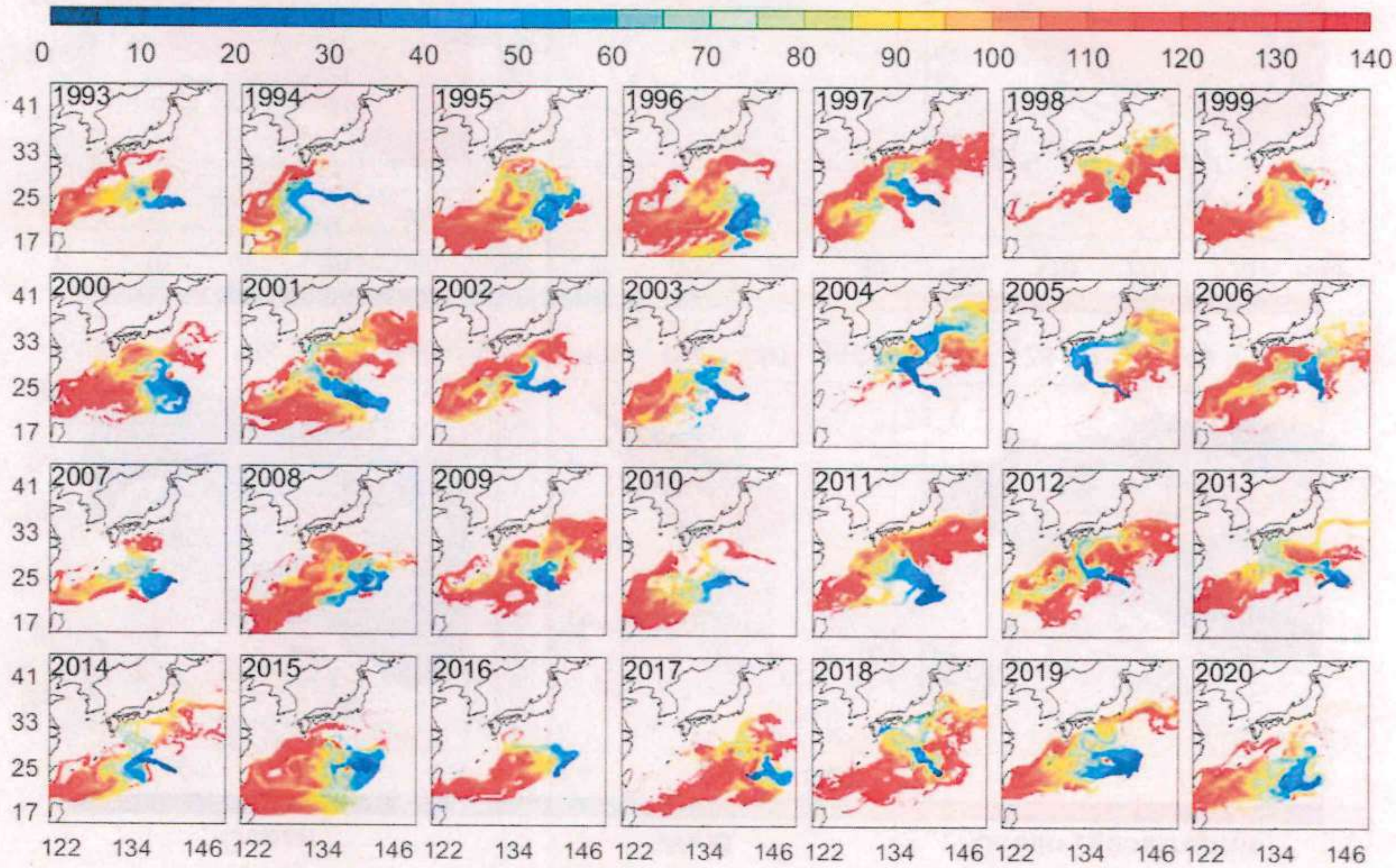
- Pumice mean traveling speed (0.19-0.21m/s)=S_{ocean} (0.1m/s)+S_{wind}(0.09-0.11 m/s)
- Estimated windage=S_{wind}/wind speed (5.2m/s)~1.7-2.1%

1993-2020 virtual pumice dispersion (visitation frequency)



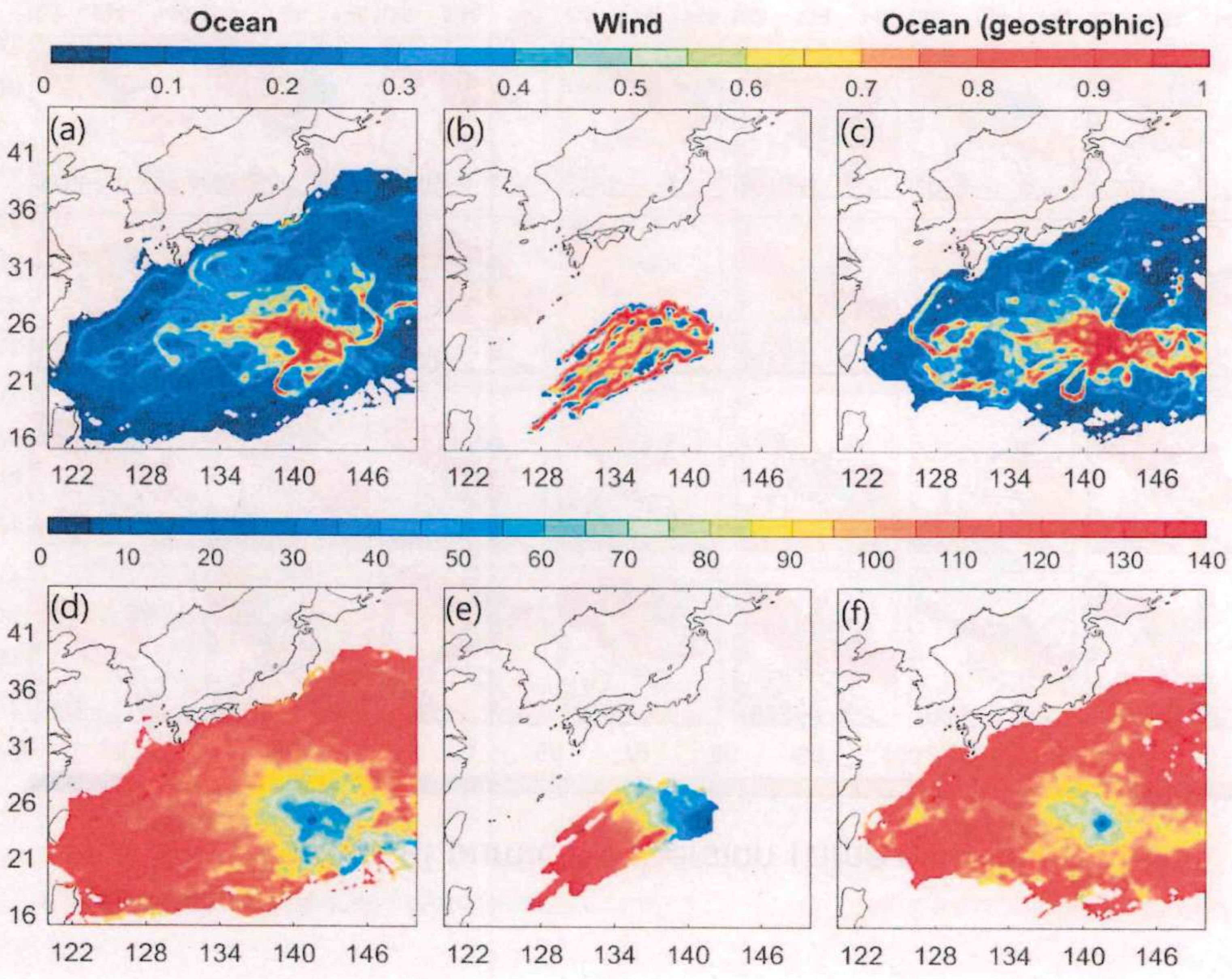
- Virtual pumice arrived at Okinawa and Taiwan most of the years
- Exceptions were observed as well

1993-2020 virtual pumice dispersion (time evolving map)

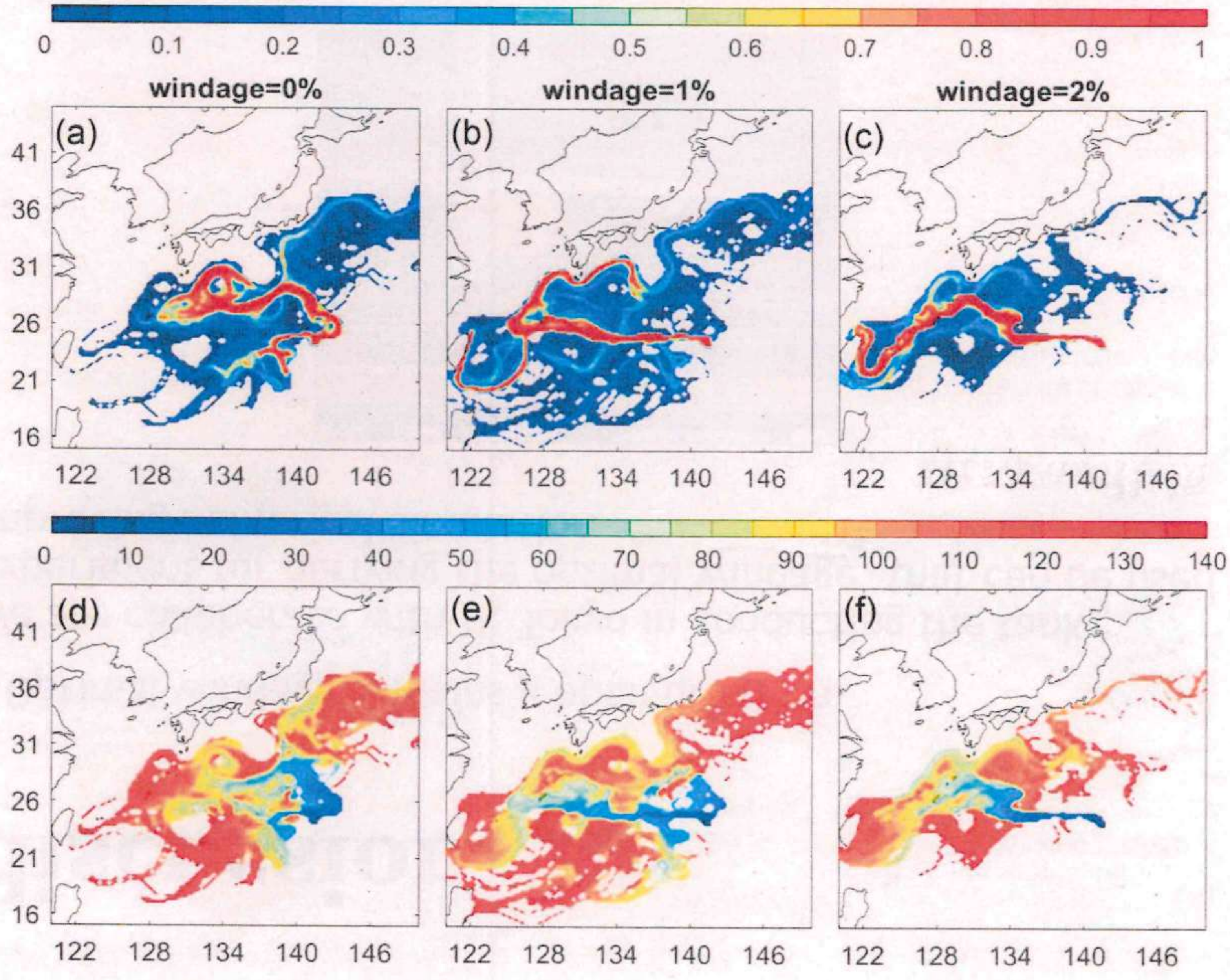


In 2004 and 2005, virtual pumice went north in a narrow band in 30-40 days

Contribution from ocean and wind



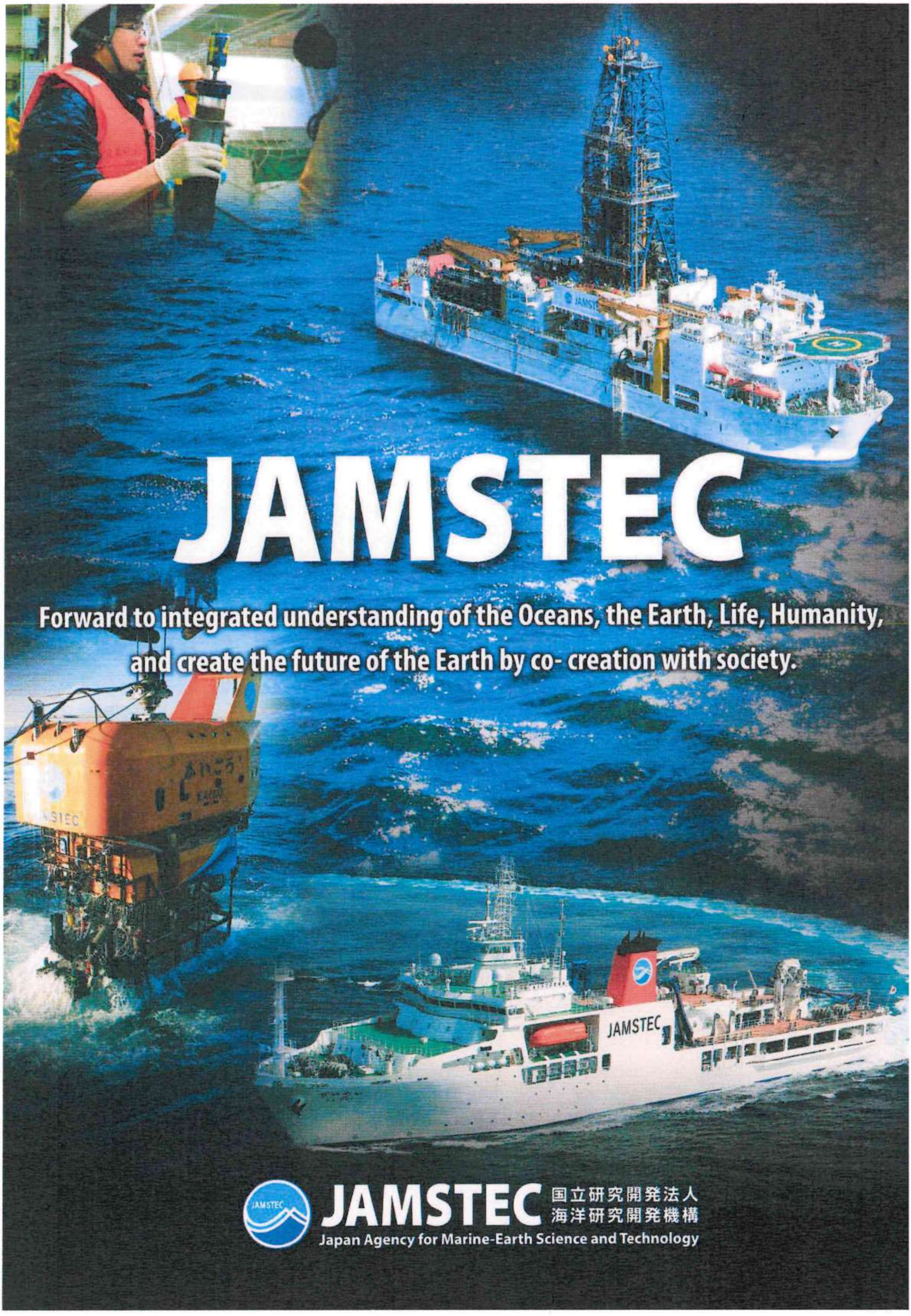
Case of 2021


0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
windage=0%
windage=1%
windage=2%
(a)
(b)
(c)
41 36 31 26 21 16
122 128 134 140 146
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
(d)
(e)
(f)

discussion

- Optimal windage remains a open question

We are collaborate with U. Tokyo in conducting the tank experiment for deriving the optimal windage, that can be used for improving numerical simulation


JAMSTEC
Forward to integrated understanding of the Oceans, the Earth, Life, Humanity,
and create the future of the Earth by co- creation with society.
JAMSTEC
国立研究開発法人
海洋研究開発機構
Japan Agency for Marine-Earth Science and Technology

About JAMSTEC

History of JAMSTEC

October	1971	Japan Marine Science and Technology Center established
May	1989	Research vessel HAKUHO MARU completed
April	1990	Deep sea survey support vessel YOKOSUKA completed
April	1990	SHINKAI 6500 deep sea research system completed
October	1995	Mutsu Institute for Oceanography opened
March	1997	Deep sea research vessel KAIREI completed
October	1997	Oceanographic research vessel MIRAI completed
November	2001	Global Oceanographic Data Center (GODAC) opened
April	2002	Earth Simulator recorded the world's highest computing performance.
August	2002	Yokohama Institute for Earth Sciences opened
April	2004	Japan Agency for Marine-Earth Science and Technology established
July	2005	Deep sea drilling vessel CHIKYU completed
October	2005	Kochi Institute for Core Sample Research opened
April	2009	2nd mid-term plan launched
August	2011	Dense oceanfloor network system for earthquakes and tsunamis (DONET1) full-scale operation launched
March	2012	Autonomous underwater vehicles YUMEIRUKA, OTOHIME and JINBEI completed, SHINKAI 6500 upgraded
October	2012	JAMSTEC long-term vision formulated
April	2014	3rd mid-term plan launched
April	2015	Change in status to National Research and Development Agency
March	2016	Wide-area seabed research vessel KAIMEI completed
March	2016	Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET2) deployment completed
April	2016	DONET2 transferred to National Research Institute for Earth Science and Disaster Resilience (NIED)
April	2017	Deep sea debris database made publicly available
September	2017	Deep-sea Bio Open Innovation Platform established
October	2018	First single-pilot operation of SHINKAI 6500
April	2019	4th mid-term plan launched
October	2021	JAMSTEC 50th anniversary

Organization Chart

Executive Directors

President	Executive Director	Auditor
Hiroyuki Yamato	Koichi Morimoto Takeshi Kawano Shin'ichi Kuramoto	Satoshi Kikuchi Mieko Mio

- Research Institute for Global Change (RIGC)
  - Global Ocean Observation Research Center (GOORC)
  - Institute of Arctic Climate and Environment Research (IACE)
  - Earth Surface System Research Center (ESS)
  - Research Center for Environmental Modeling and Application (CEMA)
  - Marine Biodiversity and Environmental Assessment Research Center (BioEnv)
  - Center for Coupled Ocean-Atmosphere Research (CCOAR)
  - Mutsu Institute for Oceanography (MIO)
- Research Institute for Marine Resources Utilization (MRU)
  - Biogeochemistry Center (BGC)
  - Research Center for Bioscience and Nanoscience (CeBN)
  - Submarine Resources Research Center (SRRC)
- Research Institute for Marine Geodynamics (IMG)
  - Subduction Dynamics Research Center (SDR)
  - Research and Development Center for Earthquake and Tsunami Forecasting (FEAT)
  - Volcanoes and Earth's Interior Research Center (VERC)
- Research Institute for Value-Added-Information Generation (VAiG)
  - Center for Mathematical Science and Advanced Technology (MAT)
  - Application Laboratory (APL)
  - Center for Earth Information Science and Technology (CEIST)
  - Global Oceanographic Data Center (GODAC)
- Institute for Extra-cutting-edge Science and Technology Avant-garde Research (X-star)
  - Super-cutting-edge Grand and Advanced Research (SUGAR) Program
  - Kochi Institute for Core Sample Research (KOCHI)
- Engineering Department
- Project Office for Arctic Research Vessel (PARV)
- Research Support Department
- Institute for Marine-Earth Exploration and Engineering (MarE3)
  - Planning and Coordination Department
  - Operations Department
  - Fleet Maintenance and Engineering Department
  - Drilling Projects Support Office
- Planning Department
- Marine Science and Technology Strategy Department
- General Affairs Department
- Human Resources Department
- Finance and Contracts Department
- Information Security and System Department
- Safety and Environment Management Office
- Audit Office
- Project Team
- Office of Economic Security Promotion

Institutes and Offices

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Tokyo Office
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Kochi Institute for Core Sample Research
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Yokohama Institute for Earth Sciences
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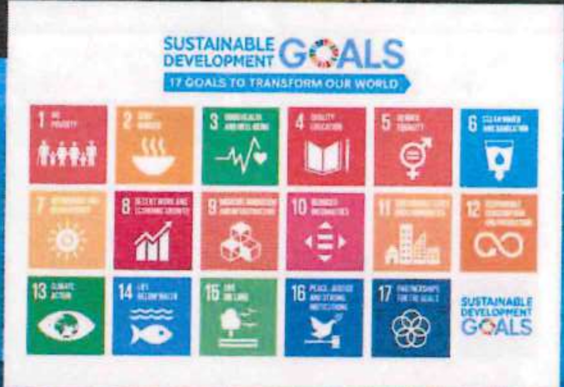
Yokohama-city, Kanagawa, 236-0001, JAPAN
TEL +81-45-778-3811

We will promote research and development towards solution of global issues by understanding the current status and projecting the future of the global change.

To contribute to the resolution of global issues such as climate change, ocean acidification, and plastic pollution, we will lead international projects to conduct integrated research on oceans at all depths and on the close interactions of oceans with the atmosphere and land masses. We will apply the data obtained from this research to formulate both short-term seasonal predictions and mid- to long-term predictions covering centuries.

We will actively disseminate our research results through international frameworks such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, the UNESCO Intergovernmental Oceanographic Commission (IOC), the Intergovernmental Panel on Climate Change (IPCC), and the Arctic Council (AC). We will contribute to the achievement of the United Nations Sustainable Development Goals (SDGs), in particular Goal 13 (climate action) and Goal 14 (life below water), as well as Japanese government policies.



1 Observing and understanding ocean environmental change and developing observation technologies

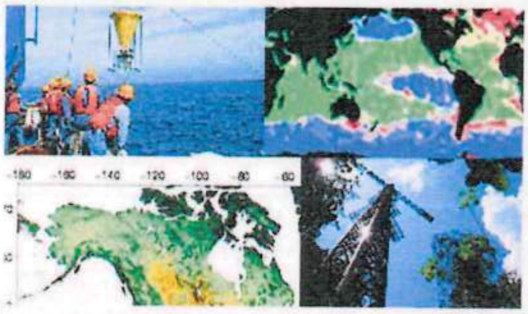
We will maintain our conventional ocean observation network while at the same time working to develop a new optimized observing system that integrates various observation platforms, including research vessels, drifting floats, and moored systems. Our goal is to understand the physical and chemical states of the ocean and their temporal development, and to uncover the mechanisms of various oceanic phenomena with the aim of producing more reliable forecasts. We also plan to miniaturize and automate observation instruments to better monitor the global ocean.

2 Understanding environmental change in the Arctic region and developing technologies for making observations under sea ice

The impacts of global warming are currently most conspicuous in the Arctic region, and we will conduct observation and prediction research there to better understand interactions between oceans and sea ice and other aspects of Arctic climate systems, and help reduce prediction uncertainties. To this end, we will also develop underwater drones and other new observation technologies to enable us to observe what is going on beneath sea ice, a difficult endeavor up to now.

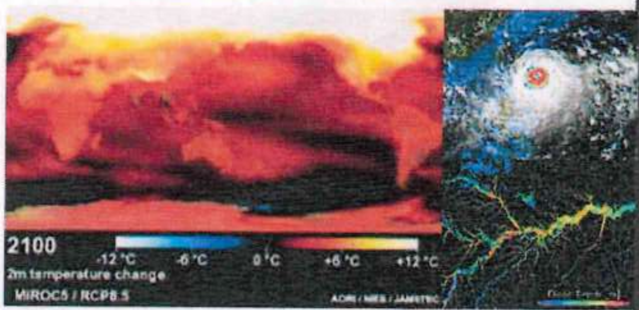
3 Understanding ecosystems/geochemistry dynamics linking Earth surface sub systems to reveal their interactions with human activities

Based on oceanic and atmospheric observations, lab experiment and model simulations, we understand and evaluate the impacts of ocean acidification, warming, hypoxia, and environmental pollution on changes and processes of ecosystems/geochemistry linking Earth surface sub systems (ocean/atmosphere/land systems) to reveal their interactions with human activities. We also focus on "hotspot" areas, Arctic region, and on Tsugaru Strait driving/representing global or near-Japan climate and environmental changes.



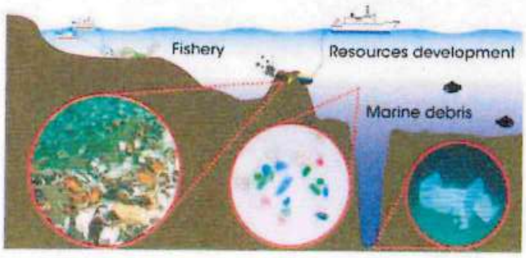
4 Projection of global environment

We work on further sophistication of the simulation models that have been developing at JAMSTEC to better project the environment on various temporal and spatial scale. We promote collaborations among different models taking the best of them, in order to obtain novel insights on phenomena ranging from short-term events such as torrential rain and typhoon, medium-term ones such as El Nino, and long-term ones such as global warming, including interactions among them.



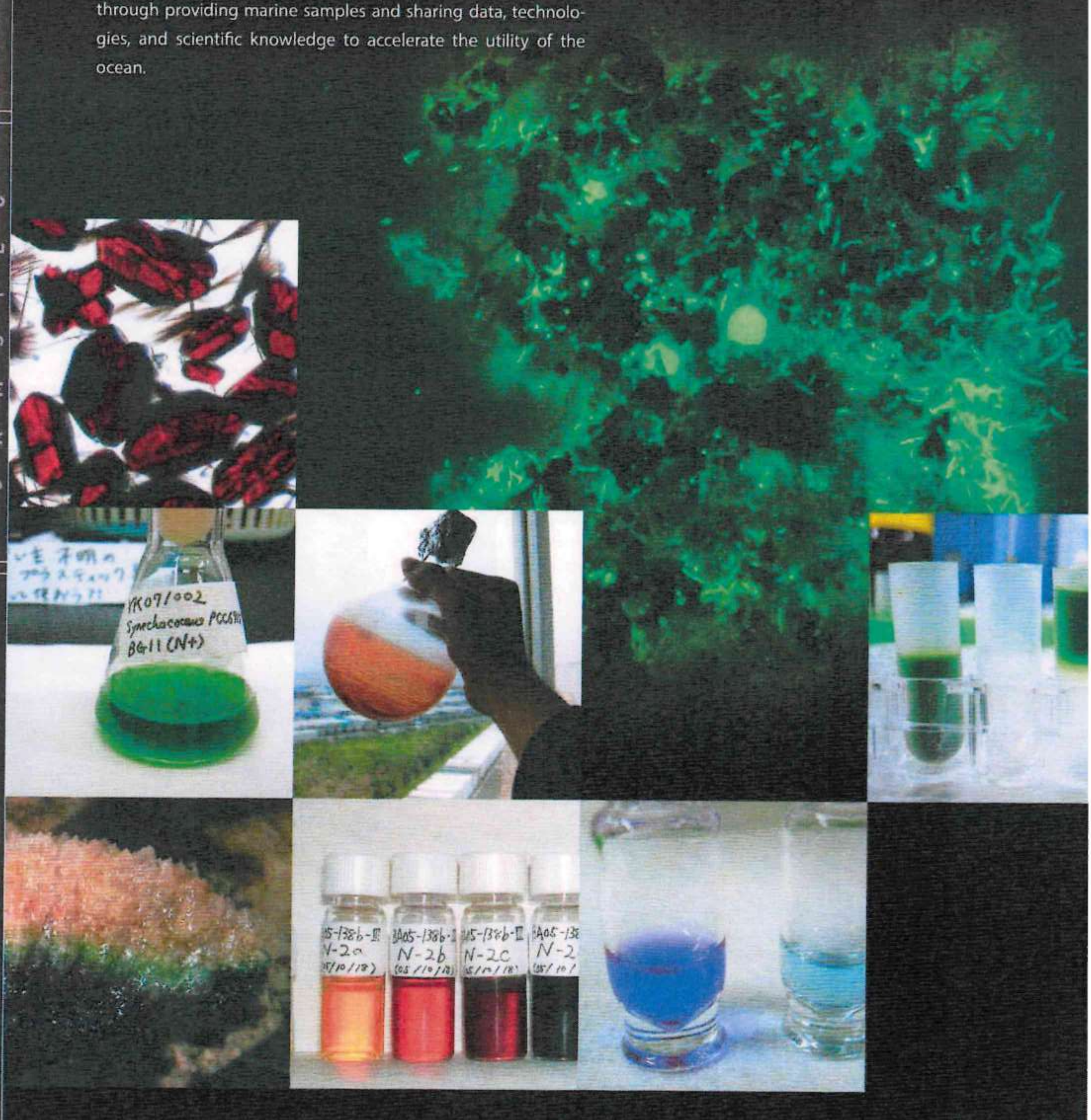
5 Assessing the impact of human activity and global environmental change on biodiversity

In order to evaluate the impacts of human activities on the marine ecosystems, we will seek to understand the changes in marine biodiversity, which are sensitive to variations of the global environment. Particularly to fill the current data and knowledge gaps in the deep-sea ecosystems, we will develop analytical methods for environmental DNA and measuring methods of pollutants such as microplastics. Through these approaches, we aim to establish and upgrade the integrated environmental impacts assessment measures.



Understanding material circulation and origin of marine resources to ensure sustainable use

Our primary goal is to understand the formation processes of marine resources, including organisms, minerals, and energy resources found in the ocean. In addition to conducting the research that contributes to the sustainable use of oceans, we will seek collaborations with other institutions and industries through providing marine samples and sharing data, technologies, and scientific knowledge to accelerate the utility of the ocean.



1 Effective use of marine organisms and biological functions

We will endeavor to develop a precise understanding of oceanic material circulation through conducting chemical and molecular biological analyses of marine biological, geological, and other specimens, identifying the environmental, physiological, and evolutionary factors controlling circulation, and developing a quantitative understanding of marine bio-resources. We will also investigate the unique capabilities acquired by organisms in the process of adapting to extreme deep-sea environments. We will contribute to society by disseminating the environmental analysis technologies and methodologies developed by JAMSTEC.


Collecting sediment from the bottom of the Challenger Deep (depth: 10,896 m) in the Mariana Trench. Our efforts will hopefully lead to the discovery of novel microbial resources.

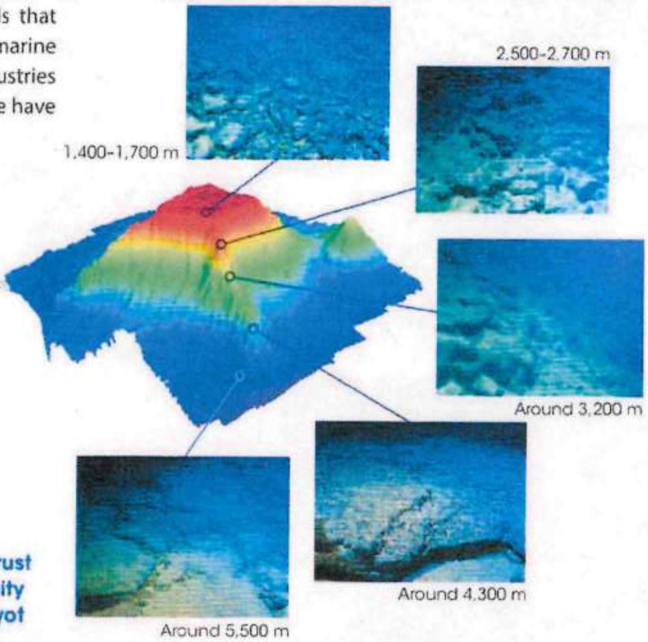

Photosynthetic bacteria inhabiting gypsum deposited by seawater evaporation


Nano EA (elemental analyzer) / IRMS (isotopic mass spectrometer) capable of measuring the smallest amounts of trace sample isotopes by this type of device worldwide

2 Effective use of submarine resources

We have sought to shed light on the processes by which submarine resources are formed by conducting field research, collecting and analyzing specimens, analyzing data, and developing numerical models. These efforts have shown that both physical and chemical processes influence the concentration of elements in complex ways over a broad spatiotemporal scale. We will conduct research and development using these research methods to identify correlations between chemical and physical processes and to apply the knowledge gained to build submarine resource formation models that would enable us to theoretically pinpoint promising marine locations. We will also support the development of marine industries by broadly disseminating the knowledge and technologies we have acquired among relevant industries.

Takuyo-Daisan Guyot
Crusts spread all over the seabed at all depths




An area rich in manganese nodules discovered around Minamitorishima at a depth of 5,500-5,800 m


A ferromanganese crust collected in the vicinity of Takuyo-Daisan Guyot

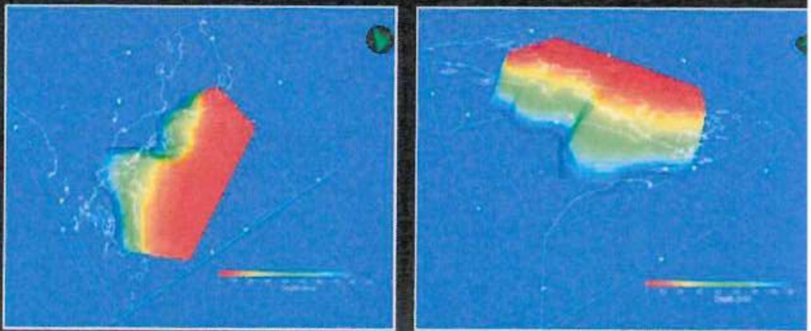
This cobalt-rich crust, which is a type of ferromanganese crust, is 13 cm thick. (It was collected by the remotely operated KAIKO Mk-IV.)

Illuminating Earthquakes and Volcanic Activities for Disaster Mitigation

To reveal earthquakes and volcanic activities, the scientists and staff of the Research Institute for Marine Geodynamics will conduct large-scale observations around Japan and the western Pacific using JAMSTEC vessels and various state-of-the-art marine exploration technologies. In particular we will conduct geophysical-geological surveys in the Nankai Trough, Japan Trench, Kuril Trench, and other tectonically active zones that may be subject to a forthcoming megathrust earthquake or volcanic eruption. Moreover, we will develop, improve, and upgrade the methods and systems to acquire and process data.

Furthermore, in line with SDGs 11 (sustainable cities and communities), our institute will contribute to disaster mitigation by sharing the scientific knowledge we have gained with society. We will also endeavor to conduct observational surveys and apply our research results in countries that are vulnerable to frequent natural disasters such as earthquakes, tsunamis, and volcanic activities.

Remotely operated vehicle HYPER-DOLPHIN collecting rocks



Three-dimensional plate geometry model of the Nankai Trough subduction zone viewed from SW and NW of Japan.
Vertical exaggeration is 2.5.

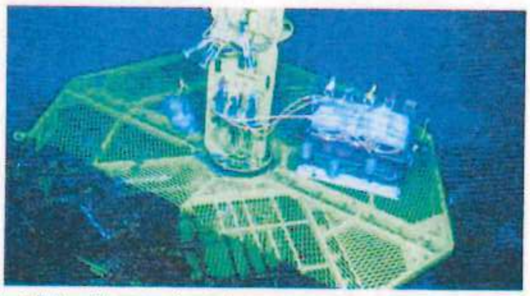
1 Understanding seismogenic zones through offshore survey and observation

Compared with onshore earthquakes, we still know very little about offshore events. To improve this situation and make a better understanding of the current status of seismic activity, we develop and deploy a real-time observation system of seafloor crustal deformation and seismic activity. Focusing on regions having high urgency and importance as the presumed source area of large earthquakes and tsunamis, we conduct seismic surveys and observations to investigate three-dimensional crustal structure, seismic activity, the physical properties of faults, paleoseismic record, and other factors. The data we have obtained from our surveys and observations are broadly shared with relevant institutes and universities.

A laboratory on board vessel KAIMEI

2 Understanding about the generation process and forecasting of earthquake and tsunami

To contribute monitoring of the current status and long-term evaluation of seismogenic zones, we will accumulate and disseminate knowledge that promotes our understanding of earthquake generation mechanisms and our ability to grasp and forecast the status of the inter plate locking and slipping based on the latest data obtained from observations and research on seismogenic zones. To this end, we will integrate various data to improve the precision of our seismogenic zone models and upgrade our real-time tsunami forecasting system.

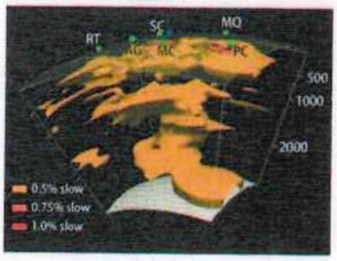


Installation of long-term borehole monitoring point C0006G (just after the KS-18-J04 HYPER-DOLPHIN connected the DONET cable)

3 Understanding current status of the Earth's interior and forecasting its variation as a cause of volcanic activity and the Earth's evolution

Submarine volcanic eruptions have caused sudden, large-scale disasters. Because of their huge impact on the human society and global environment, forecasting their occurrence and evaluating their impact on the environment are of vital importance. To address these issues, we will conduct ocean drilling surveys using our Deep-sea Scientific Drilling Vessel CHIKYU and investigate the internal structures of the Earth that control volcanic activity, the mechanisms controlling circulation of fluids and energy within the Earth, and magma supply systems from both single volcano and global perspectives.

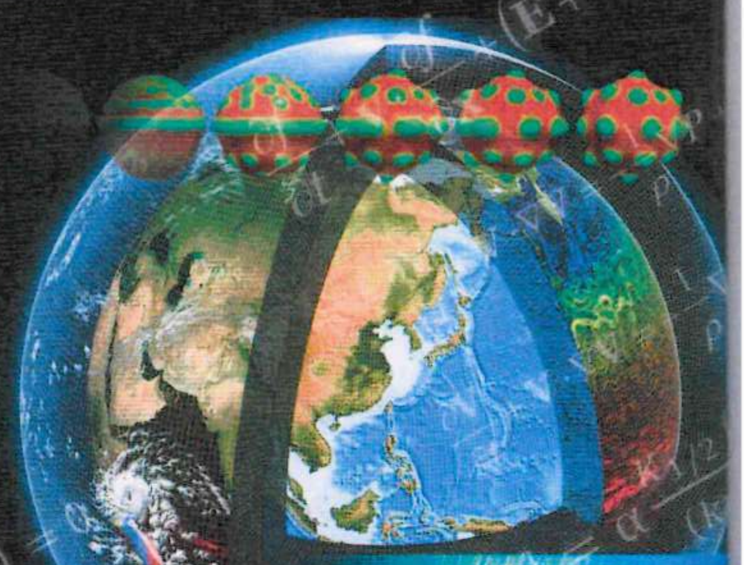
Investigation of oceanic volcanoes



Behavior and circulation of solid, fluid and volatile components in the Earth's mantle (top) and a seismic tomographic image of a mantle upwelling flow beneath French Polynesia in the South Pacific (bottom)

Probing unknown causal relationships hidden in Earth systems

To identify interrelationships between changes in Earth systems and human activity, we will develop methodologies for integrating the vast amounts of data generated by JAMSTEC R&D activities, and mathematical analysis methods for efficiently processing the resulting integrated data. We will also support the resolution of policy issues and development of sustainable socioeconomic systems by generating and disseminating information tailored to various needs. We will additionally endeavor to expand this initiative to encompass other relevant organizations both in Japan and overseas so as to build a framework for generating even more advanced and useful information.



1 Research and development of numerical analysis and verification methodologies

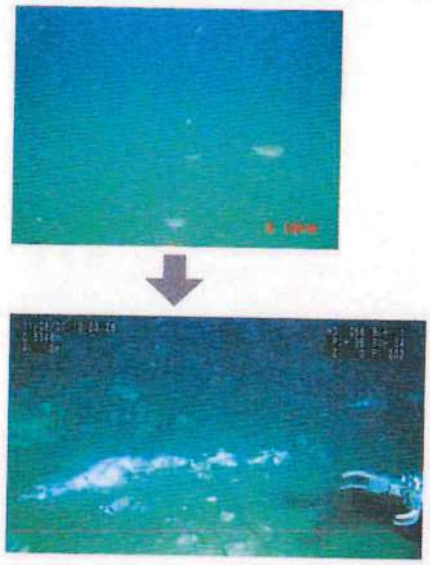
We will develop data conversion tools to unify the formats of research and development-generated data sets for the various phenomena comprising Earth systems that are based on very different scales of time, space, and other parameters. In order to mathematically process data that has been integrated by unifying formats, we will then carry out time evolution calculation and data assimilation, and develop a large-scale repository of numerical analysis methodologies of various kinds including AI and other advanced functions. As a part of repository development, we will also develop verification technologies to guarantee the quality of the numerical analyses it is used for.

2 R&D on the the use of numerical analysis results to generate advanced and optimized information

We will develop a four-dimensional virtual earth as a large-scale data system equipped with advanced data analysis functions and capable of efficiently aggregating and managing data generated by the numerical analysis repository and other sources. Using this four-dimensional virtual earth, we will seek to discover and elucidate the complex relationships between intertwined Earth systems, and based on those relationships, generate information optimized to best serve user needs, making it more valuable to society as a whole.

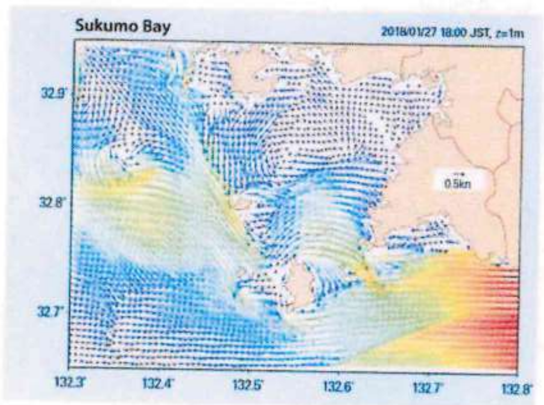
3 Development and operation of an execution platform optimized for information generation

As an execution platform for the numerical analysis repository and four-dimensional virtual earth, we will build a high-speed computing system capable of handling the huge amount of information stored in the data server, connecting the system and server through a high-speed network. To further advance and support enrichment of this platform, we will also focus on security and compatibility in its development and operation so as to facilitate sharing and collaboration with other organizations and gain more users as a result.



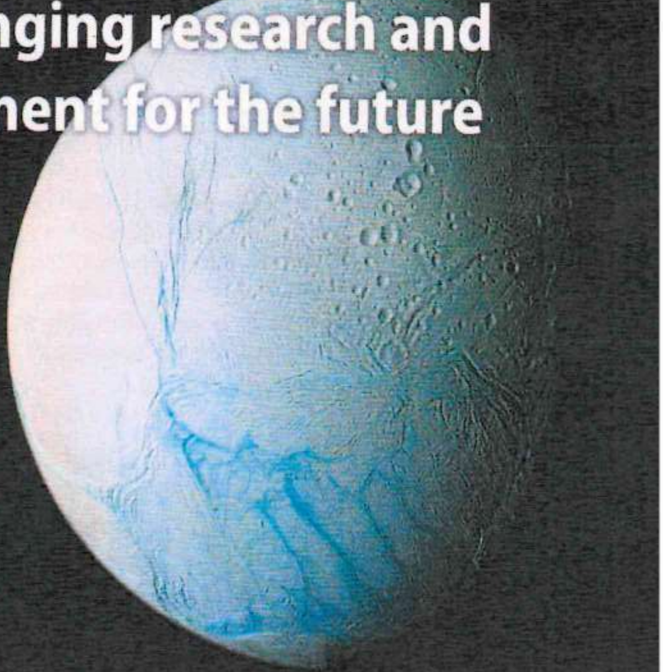
Effect of crustal movement on biota (microbial community)
(Formation of a bacterial mat (white part) in conjunction with outflow of spring water from a seabed)

Comprehensive assessment of the health of the marine environment

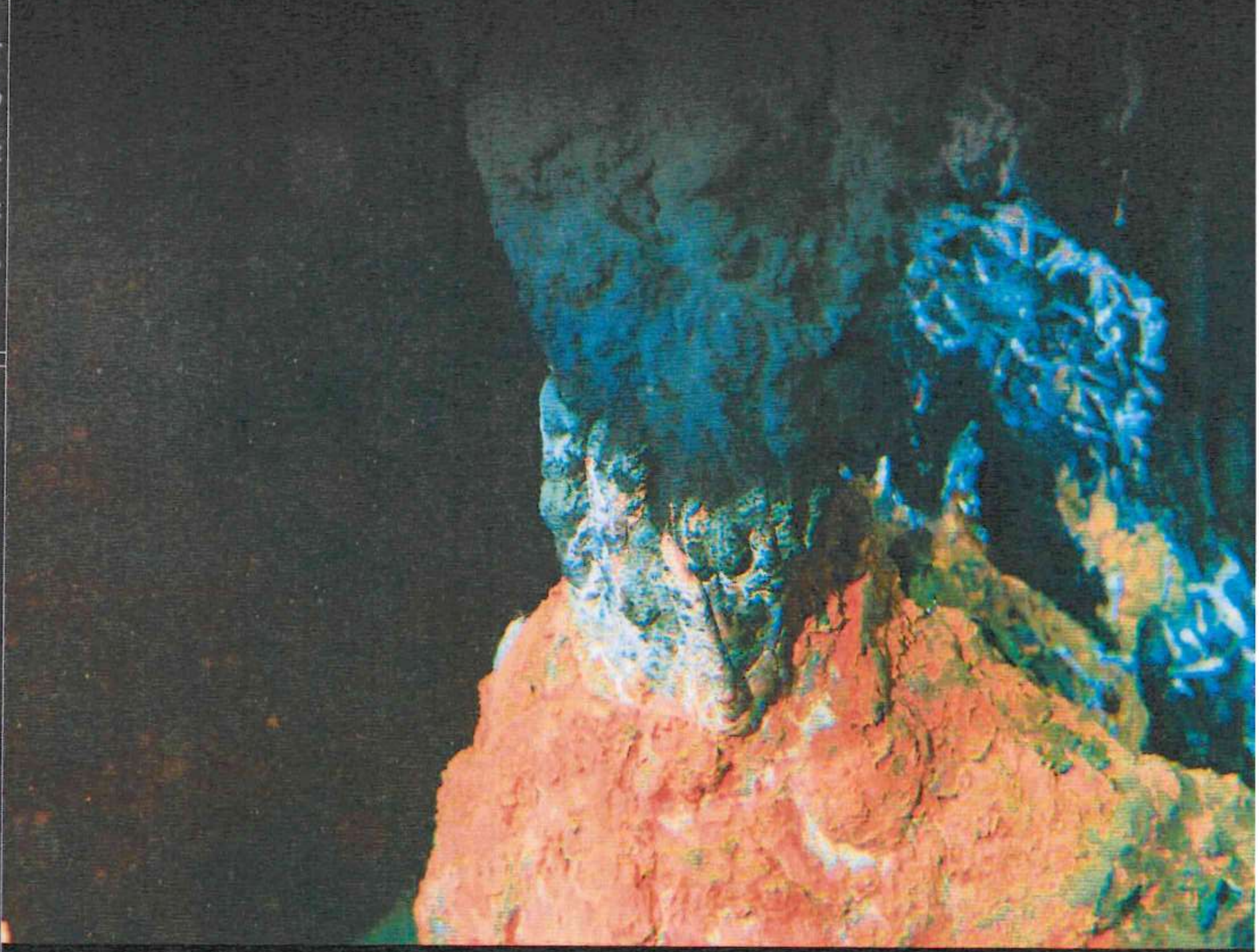


For fisheries and agriculture
Providing fishermen with fishery area forecast information

Exploratory and challenging research and technological development for the future



Our exploratory and challenging research and development on deep-sea extreme environments, or so to be called the Earth's last frontiers, will build a scientific, technological, and intellectual platform which will lead to generating diverse knowledge and innovation to support future Japan as a maritime nation. It is expected to raise public interest in science and technology, and contribute significantly to the promotion of Japan's science and technology policies. We also lead JAMSTEC basic research and development, promote research collaboration between different fields, and accelerate mission achievement.

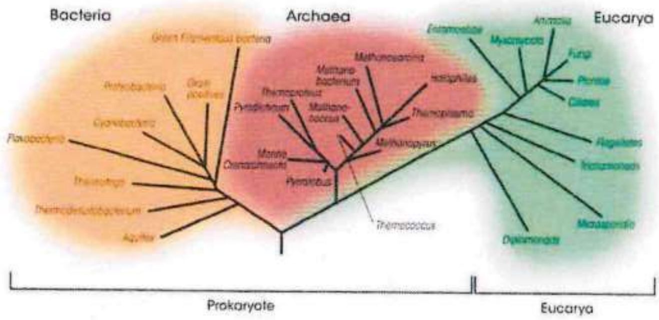


Black smoker in the Beebe Hydrothermal Vent Field of the Mid-Cayman R
the Caribbean Sea

1 Basic, exploratory and challenging research based on out-of-the-box thinking

We will conduct challenging and highly speculative research with the aim of making breakthroughs and generating systematic understanding that will lead to future paradigm shift in science. Japan has already gained worldwide recognition for the originality of its exploratory research on the role of the ocean in the origin of life and the co-evolution of life and the environment, and on microbial dark matter (unknown microbes occupying dark and extreme environments) and the physiological functions supporting such life forms; by focusing on these themes, we will establish a new academic field in which Japan will lead the world.

Illustration of deep sea hydrothermal activity of 4 billion years ago may have looked



The three domains of the tree of life

Image of the birth of life in a small hole inside a deep sea hydrothermal chimney

2 Building the future of oceanographic technology through pioneering technological development research

With the goal of producing outcomes that transform oceanographic technology, we will engage in highly speculative and pioneering technological development research rather than endeavoring to extend existing technologies. We will focus in particular on developing original technologies that combine new exploratory technologies such as measurement using laser processing and electrochemical processing, and ultra-high resolution nanoscale analysis.

Ultra-high resolution nanoscale analysis (NanoSIMS)

Development of deep sea organism identification technology using underwater laser processing technology

Institute for Marine-Earth Exploration and Engineering (MarE3)

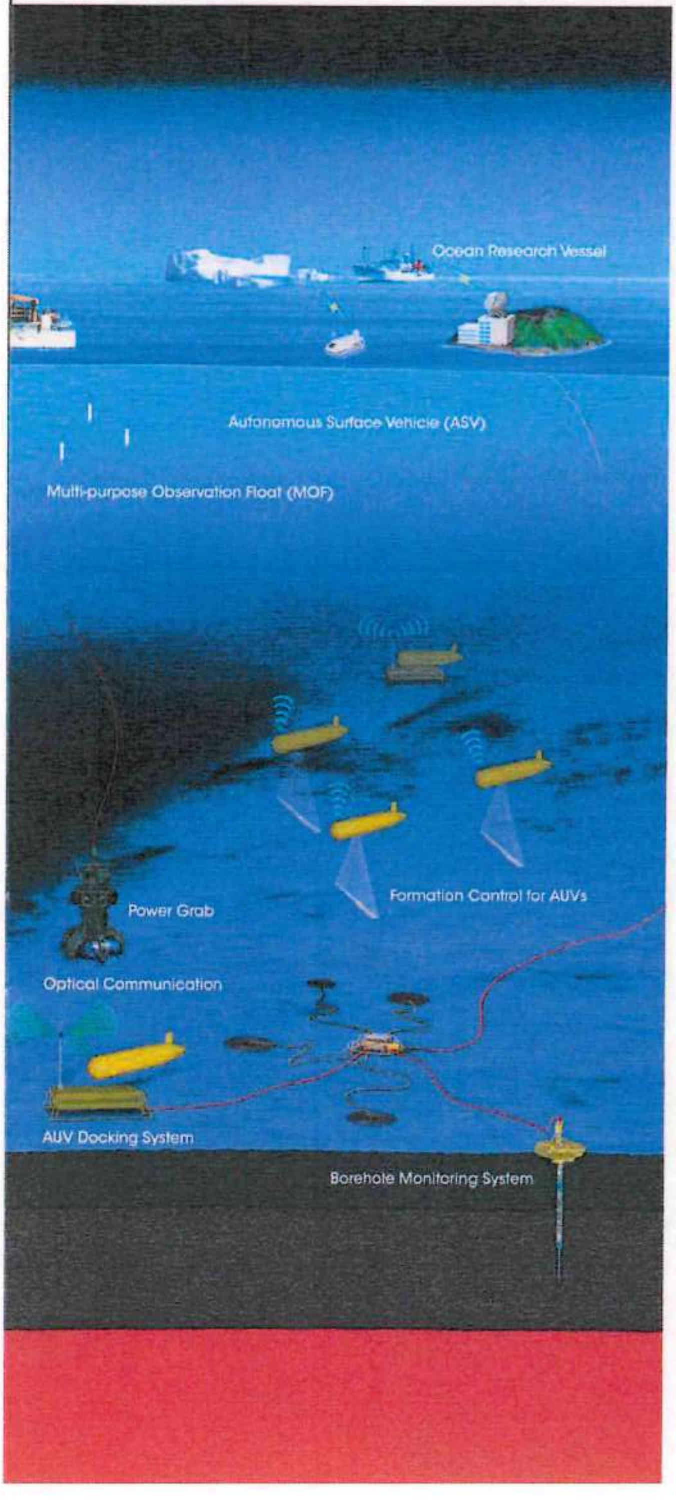
Advanced technology bringing new insights of the Earth and its oceans

Oceans occupy about 70% of the Earth's surface, and are a significant source of dynamic global change. A wide range of important marine-Earth research targets, including ocean deeps, tectonic subduction zones (with related earthquakes and volcanic eruptions), hydrothermal vents, and the deep subseafloor, are the primary targets of our world-leading scientific research and development program. Implementing this, while also supporting Japan's ocean policies, we will maintain and improve our advanced capabilities for investigation and observation of the world ocean and seas. We promote the continual technological development and operation of our marine research facilities, capable of supporting research across large and diverse fields of investigation, as part of the greater scientific and research community.

1 Ocean research platform-related technology development

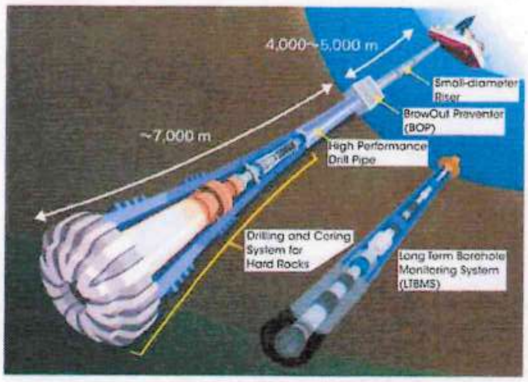
Addressing social issues related to oceans based on scientific knowledge and data requires the utilization of high-precision observation and research capabilities to appropriately understand and monitor marine environments. To that end, we will further equip ourselves with both remotely operated and autonomous underwater vehicles capable of supporting investigation over wide areas and deep zones, and will continue to consider development of the next generation of manned research submersibles. We will also continue to develop fundamental cutting-edge observation systems, sensors, and other relevant technology.

Implement remotely operated and autonomous underwater vehicles



2 Development of ultra-deep water and ultra-deep drilling technologies

Ultra-deep water and ultra-deep drilling and related technologies, and borehole observation technologies are required to investigate mechanisms of earthquake generation, the subseafloor biosphere and its functions, and to carry out future mantle drilling. We will accordingly develop these necessary technologies in stages.



Development of ultra-deep water and ultra-deep drilling technologies

3 Operation of ocean research platforms

We will operate safe, efficient, and stable ocean research platforms that addresses R&D and societal needs. We will continue to upgrade the functions and performance of our equipment and facilities, and incorporate newly developed methodologies and technologies to enable the implementation of sophisticated research and observation. We will also provide users of our oceanographic research platform with scientific and technical support.

Research Facilities

Length 210.0m

Gross tonnage 56,752 tons

Complement 200 persons

Commissioned 2005

Deep-sea Drilling Vessel **CHIKYU**

Length 100.5 m

Gross tonnage 5,747 tons

Complement 65 persons

Commissioned 2016

Research Vessel **KAIMEI**

Length 105.2 m

Gross tonnage 4,439 tons

Complement 60 persons

Commissioned 1990

Support Vessel **YOKOSUKA**

Length 128.5 m

Gross tonnage 8,706 tons

Complement 80 persons

Commissioned 1997

Oceanographic Research Vessel **MIRAI**

Length 100 m

Gross tonnage 4,073 tons

Complement 89 persons

Commissioned 1989

Research Vessel **HAKUHO MARU**

Length 66 m

Gross tonnage 1,635 tons

Complement 41 persons

Commissioned 2013

Research Vessel **SHINSEI MARU**

Total Peak Performance 19.5 PFLOPS

Total Memory 556.5 TiB

Shared Storage Capacity 61.4 PB

Interconnect Bandwidth 200 Gb/s (for two-way)

(Yokohama Institute for Earth Sciences)

Earth Simulator

Storage capacity

About 250km at a maximum

Storage environment

Temperature about 4 degrees

Humidity about 80%

(Kochi Institute for Core Sample Research)

Core Repository

J A M S T E C

Depth capability
6,500 m

Complement
3 persons

Length
9.7 m

Weight in the air
26.7 tons

Manned Research Submersible

SHINKAI 6500

Depth capability
4,500 m

Length
3.0 m

Weight in the air
5.5 tons

Remotely Operated Vehicle (ROV)

KAIKO

Depth capability
4,500 m

Length
3.0 m

Weight in the air
4.3 tons

Remotely Operated Vehicle (ROV)

HYPER-DOLPHIN

Depth capability
3,500 m

Length
10.0 m

Weight in the air
7.0 tons

Autonomous Underwater Vehicle (AUV)

URASHIMA

Depth capability
3,000 m

Length
4.0 m

Weight in the air
1.7 tons

Autonomous Underwater Vehicle (AUV)

JINBEI

Depth capability
6,000 m

Length
3.3 m

Weight in the air
1.2 tons

Deep Ocean Floor Survey System

DEEP TOW

Collaboration with others

Through collaborations with countries, universities, private industry, and other parties, we actively participate in joint projects, personnel and information exchanges, and networking events with the aim of developing, enhancing, and raising the profile of our intellectual property. We will further pursue cooperation and collaboration with regional marine industry promotion and human resource development measures, and promote activities aimed at achieving the goals of collaborative initiatives with private industry and other stakeholders.

XPRIZE competition entry brought together 23 organizations from industry, academia and government.

International cooperation

We actively engage in SDGs and other international frameworks, and will take on leadership roles as required. We also seek to drive the further growth of oceanographic research and technology and strengthen Japan's research and development capabilities in the field by building effective structures for cooperation with overseas organizations. We will continue to operate "CHIKYU" for international scientific drilling programs such as the Integrated Ocean Drilling Program (IODP), and will pursue a range of initiatives to drive scientific drilling projects.

Researchers discussing core samples collected on an IODP cruise

Human resource development

We will pursue efficient and effective initiatives to nurture young talent in the field of marine science and technology and expand the human resource base by leveraging connections with other organizations. We will actively disseminate information on our human resource development initiatives through our website and other means in a way that encourages young people to consider a career as a researcher or technician.

Young researchers participating in a course on analytical techniques

Public relations

We conduct positive public relations according to the purposes to promote public awareness and understanding of our activities. We will pursue clear and effective public relations initiatives by leveraging the facilities and equipment of our sites and working with the media, private industry, and other parties.

GIGA School online lecture

Databases

The following databases are available on the JAMSTEC website.

Data Catalog

JAMSTEC Grid Data Archive System

JAMSTEC Document Catalog

Data Research System for Whole Cruise Information (DARWIN)

BISMaL (Biological Information System for Marine Life)

JAMSTEC E-library of Deep-sea Images (J-EDI)

Documents and Reports

- Earth Simulator Research Results Repository
- JAMSTEC Repository
- JAMSTEC's Patent List

Images and Samples

- JAMSTEC E-library of Deep-sea Images (J-EDI)
- Marine Biological Sample Database
- Deep Seafloor Rock Sample Database (GANSEKI)
- COre Electronic Database of Ocean floor (COEDO)

Marine Observation Data

- Argo JAMSTEC
- TRITON web
- Indo-Pacific*
- Subsurface ADCP mooring dataset
- JAMSTEC Compact Arctic Drifter (J-CAD, POPS)*
- JAMSTEC OceanSITES
- Database for time-series stations K2 and S1
- Paleoclimate-Ocean Database
- Extremo Base
- Image database of planktonic foraminifera
- Okinotorishima Island Observations*

Terrestrial Observation Data

- Cryosphere Data Base

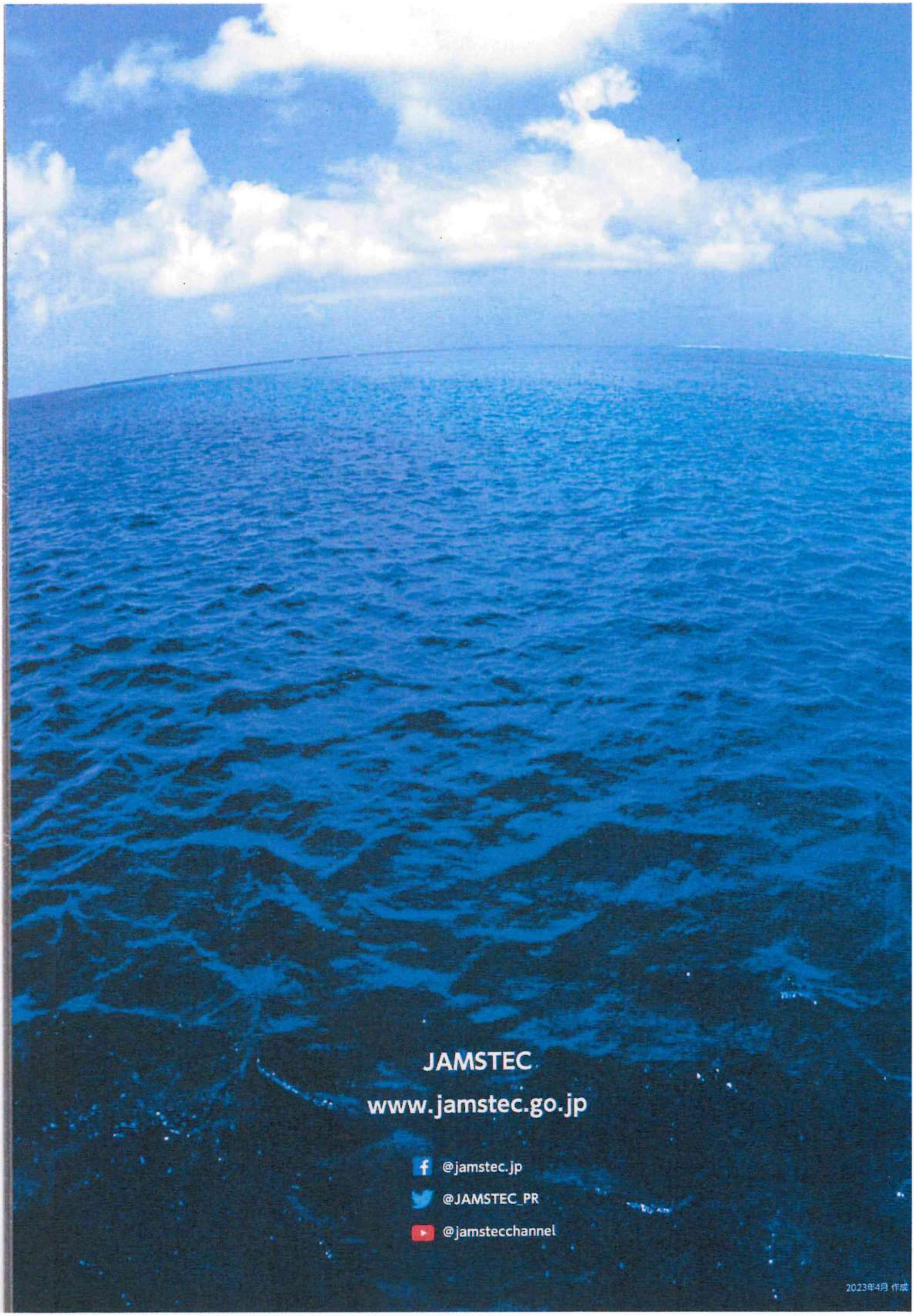
Earthquake and Geoscience Data

- Crustal Structural Database Site
- JAMSTEC Ocean-bottom Seismology Database (J-SEIS)
- Google Earth as geoscience data browser project

Forecasts and Simulations

- Global Chemical Weather Forecast System
- Japan Coastal Ocean Predictability Experiment (JCOPE) System (ocean weather forecasts)
- Low-latitude Climate Prediction Research
- ALERA (AFES–LETKF experimental ensemble reanalysis)
- ALERA2
- General Ocean Circulation Model for the Earth Simulator Center (OFES)
- Estimated State of Global Ocean for Climate Research

*Japanese only


JAMSTEC
www.jamstec.go.jp
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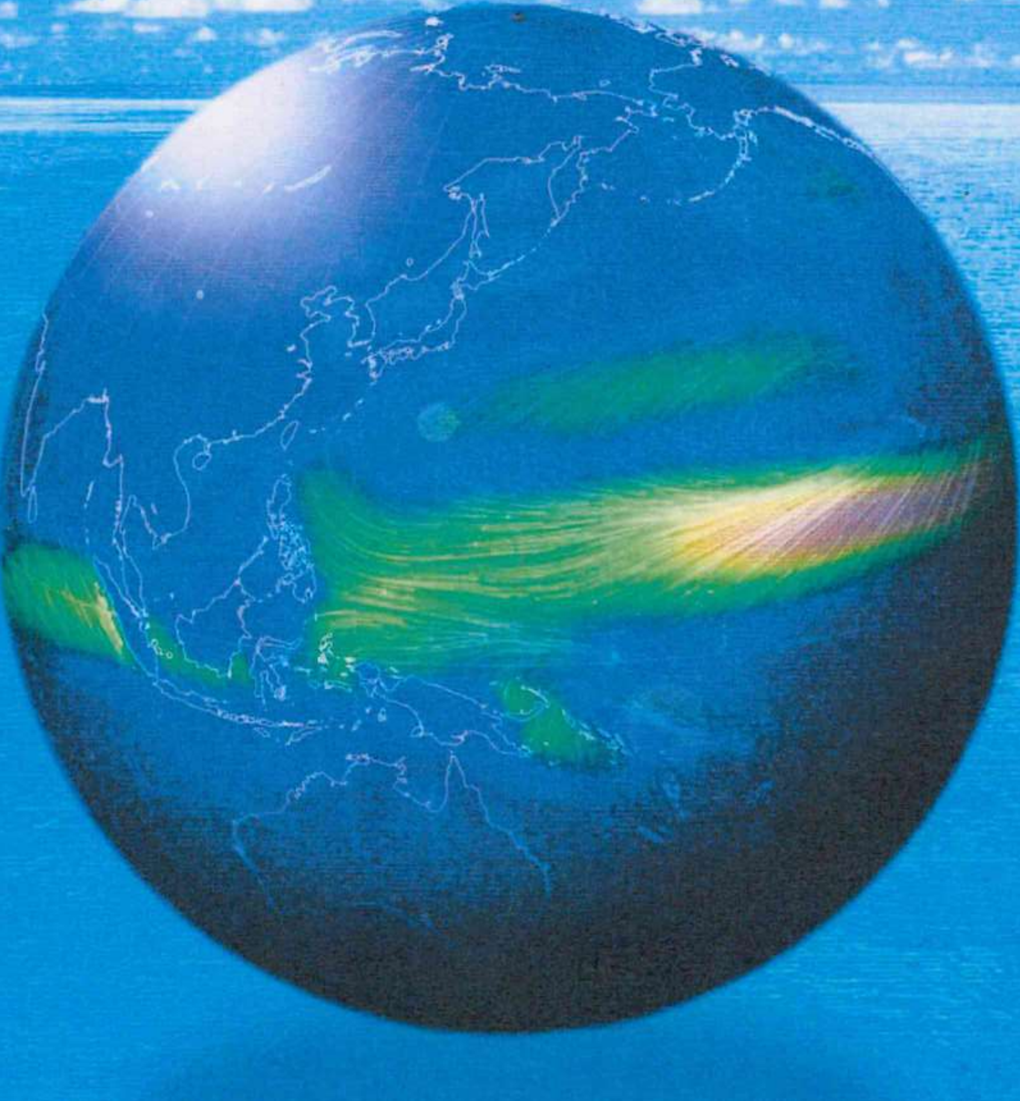
@jamstecchannel
2023年4月 作成

APL aims for realizing innovation through mutual enlightenment and sustainable research.

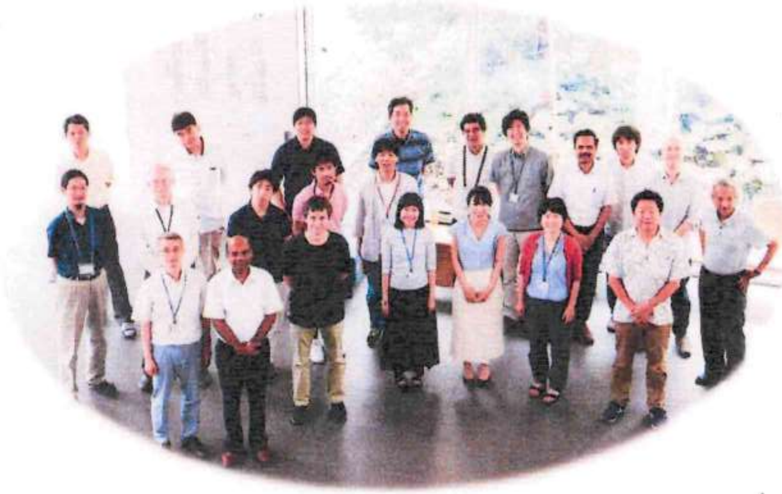
Application Laboratory

Innovations from Earth Science



JAMSTEC

Application Laboratory (APL) endeavors to realize a sustainable world through innovations and prudent interactions between science and society.



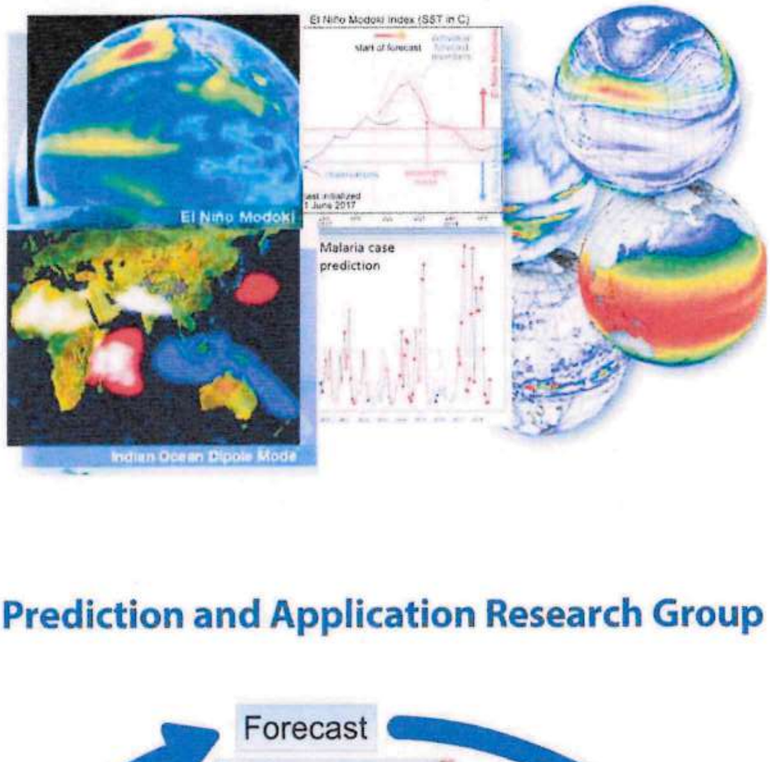
The Application Laboratory a premier research establishment in JAMSTEC aims to contribute to the society by developing numerical simulation technologies and by finding ways and means to apply ensemble model predictions for the benefit of human health, agriculture, fisheries, water management, and air and water quality.

Director, Application Laboratory ***Swadhin Behera***

CVPARG Climate Variability Prediction and Application Research Group

Group Leader *Masami Nonaka*

We carry out climate predictions that aim to forecast events, such as El Niño, up to two years in advance using the state-of-the-art coupled ocean-atmosphere model *SINTEX-F*. The model can calculate the evolution of atmosphere and ocean simultaneously, and its forecast skills rank as one of the highest among the world's leading prediction centers. These forecasts can be displayed through the publicly accessible APL web page. We are currently working on societal applications of these prediction data, including efforts toward reducing the spread of infectious diseases in South Africa and India, and toward energy management in Japan. Our vision is to develop a prediction system that can predict climate events with time scales from one month to one decade. We also strive to predict the midlatitudes, which remain one of the grand challenges of climate prediction, by improving the SINTEX-F system and developing a multi-model prediction system together with CFES, another prediction model operated by APL.



EVPARG Environmental Variability Prediction and Application Research Group

Group Leader *Yasumasa Miyazawa*

Our group performs research on both the ocean and the atmosphere. The oceanic component aims to understand the detailed variability of the ocean currents in the global ocean. The atmospheric component studies air-sea interactions focusing on atmospheric convective processes to understand the generation mechanisms of clouds and rainfall and their possible impacts on oceanic and climate predictability. In order to understand predictability of ocean currents, especially that around Japan, we perform and validate daily ocean forecasts (JCOPE). Using the ocean forecast information, we investigate biogeochemical/marine ecosystem phenomena including plankton and fish behaviors. Our forecast information is currently utilized by various stakeholders and will be improved by further including newly available observations, partly provided from the stakeholders themselves.

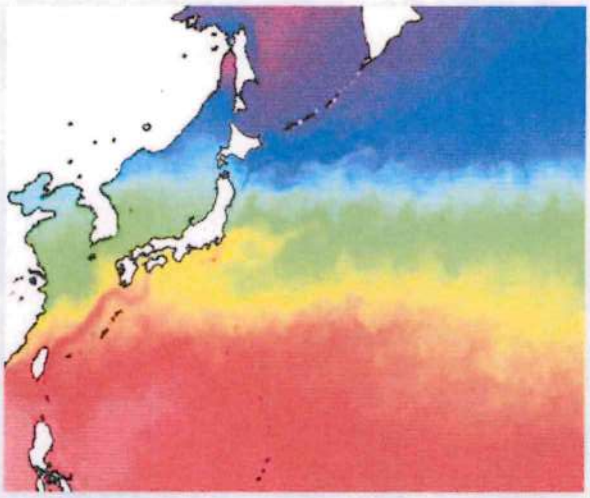
APL provides beneficial predictions for the world

The forecasts are available on the following pages.

http://www.jamstec.go.jp/apl/
http://www.jamstec.go.jp/virtualearth/

Regional Ocean Prediction (JCOPE)

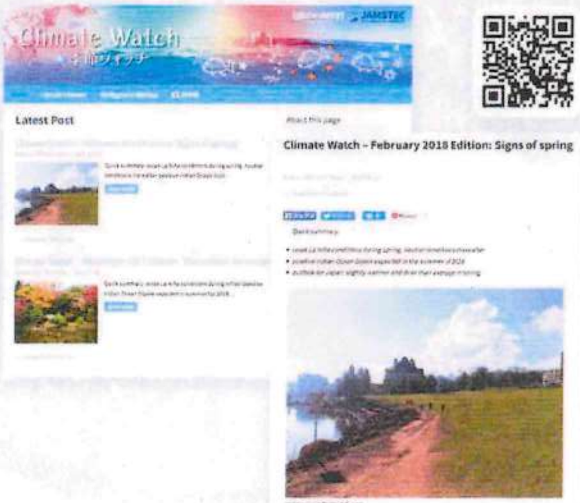
Ocean forecasts from the sea surface to the seafloor are achieved by using global ocean observation data from satellites, ships, floating buoys and so on. These forecasts are utilized by cargo ships and the Japanese off-shore fishing industry.



Climate Watch

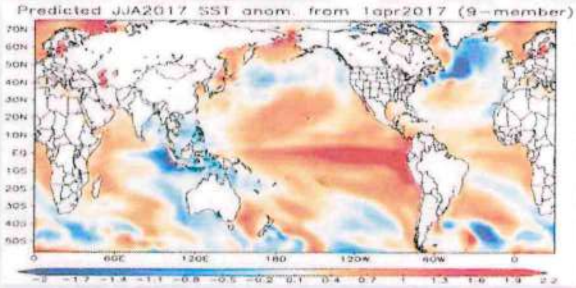
APL maintains a webpage dedicated to the discussion of seasonal forecasts and current climate events, called *Climate Watch*. The site contains regular updates of the SINTEX-F seasonal predictions (both in English and Japanese) as well as posts on various topics of current interest, such as the Peru flooding in March 2017 or the extreme warming off the coast of southwest Africa in January 2016.

http://www.jamstec.go.jp/aplinfo/climate/?lang=en



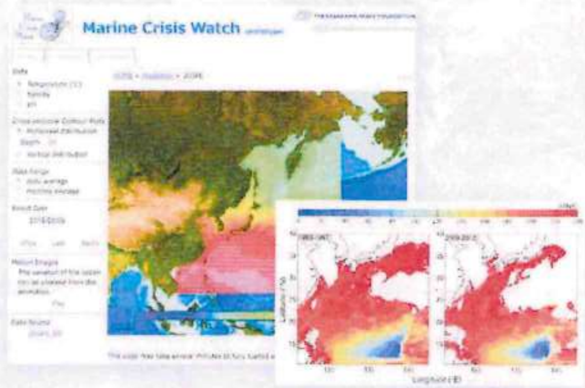
Seasonal Prediction (SINTEX-F)

The SINTEX-F coupled model system is used to predict the occurrence of tropical climate variability such as El Niño, La Niña, and the Indian Ocean Dipole (IOD). The predictions are global and therefore also provide forecast information (e.g., about the severity of winter and summer seasons) in the mid-and high-latitudes. We are also currently testing a decadal prediction system to investigate long-term variations in various regions around the globe, including the southern Atlantic and Indian Oceans.



Fishery and Biogeochemical Studies

In one of our recent projects we have used the JCOPE system to investigate the long-term population decline of eel and how it is related to changes in ocean currents. Other projects include the development of an ecosystem model (including parameters related to the carbon cycle) that uses JCOPE ocean-current forecasts as input and forecasts ocean acidity in the coastal regions of Japan.

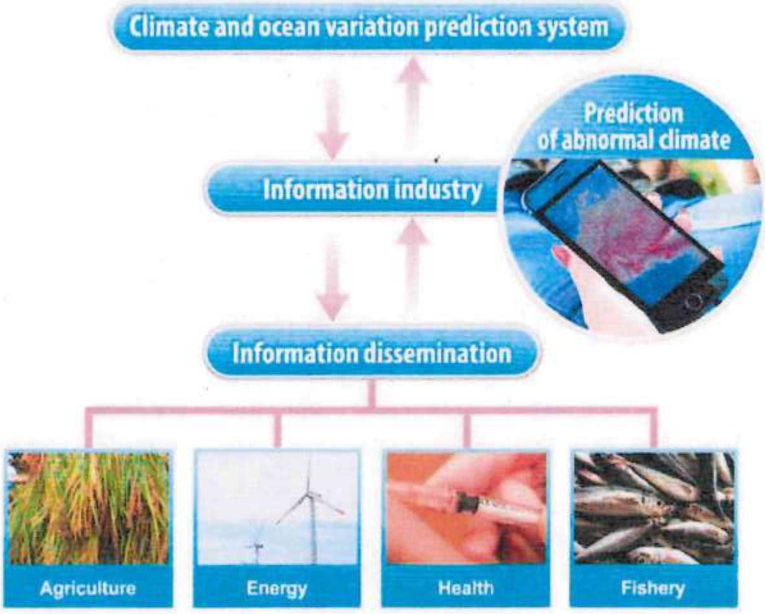


Kuroshio-Oyashio Watch

Using the results from JCOPE, this website discusses recent predictions, scientific issues, and hot topics regarding phenomena in the coastal regions around Japan, especially in the Kuroshio and the Oyashio.

http://www.jamstec.go.jp/aplinfo/kowatch/e/

Earth Simulator
is a large vector supercomputer, which is particularly suitable for simulations of the atmosphere, oceans, and other fluids.



Application potential of model prediction data to various fields

Our predictions are used globally in various sectors

Climate predictions for agriculture

In 2006, the positive Indian Ocean Dipole (IOD) mode resulted in drought and brought enormous damage to Australia's agriculture. The SINTEX-F system predicted this event months ahead. Also, IOD and subtropical IOD play an important role in the rainfall variability of eastern and southern Africa. Risks can be mitigated if droughts are foreseen based on seasonal forecasts and countermeasures are taken. Hence, SINTEX-F predictions have been used for crop and livestock management in Australia and Africa.

Climate predictions for human health

Infectious diseases, largely associated with climate variations, pose immense health risks in many parts of the world. In collaboration with the Institute of Tropical Medicine at Nagasaki University, APL scientists have investigated the climate link to some of the infectious diseases (malaria, respiratory and diarrheal diseases) in southern Africa under the AMED/JICA SATREPS framework. Regional rainfall variations as well as climate phenomena such as La Niña and Indian Ocean Subtropical Dipole are found to be linked with malaria incidence in South Africa. A malaria early warning system has been developed based on these pieces of information and skillful SINTEX-F predictions. Diarrheal diseases in the region are also seen to be linked with the regional temperature and rainfall variations, and thus there is potential to develop an early warning system for these diseases as well.

We are also investigating the potential to predict cholera outbreaks in India under a trilateral framework, *Towards a Sustainable Earth* (TaSE), involving institutes in the UK and India.

Ocean and climate predictions for energy sector

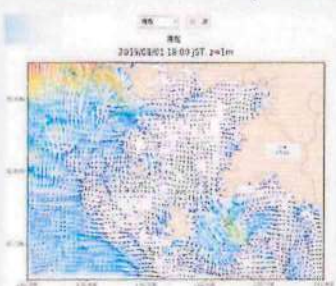
Ocean and atmospheric conditions influence several renewable as well as conventional energy sectors. APL researchers are working on projects to understand the usefulness of ocean predictions in renewable energy generation and climate predictions in energy management.

SIMSEA

The Sustainability Initiative in the Marginal Seas of South and East Asia (SIMSEA), initiated by Application Laboratory, is an international alliance of natural and social scientists working together to meet the regional challenges of biodiversity conservation, sustainability of marine ecosystem services, and protection of human well-being in light of population pressure, environmental degradation, and climate change/variability. The overall goal is to generate knowledge that can bring about transformative change toward sustainability in the marginal seas of South and East Asia, and to contribute toward sustainability at the global level.

SUKUMO

Co-working with local stakeholders in Sukumo Bay, Kochi Prefecture, APL has developed a fine-resolution (200m) ocean prediction system (SUKUMO500) that provides hourly updates via the APL website. The information has been used for fishery activity as well as oil spill removal. Local stakeholders have provided in-situ observation data in order to evaluate and improve the ocean prediction system. Interaction between local stakeholders and scientists will benefit the integrated coastal management in Sukumo Bay.



Application Laboratory http://www.jamstec.go.jp/apl/

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2019.08

NEXT CHALLENGE

— Japan's first Arctic research icebreaker —

JAMSTEC 国立研究開発法人 海洋研究開発機構

Japan Agency for Marine-Earth Science and Technology

https://www.jamstec.go.jp/e/

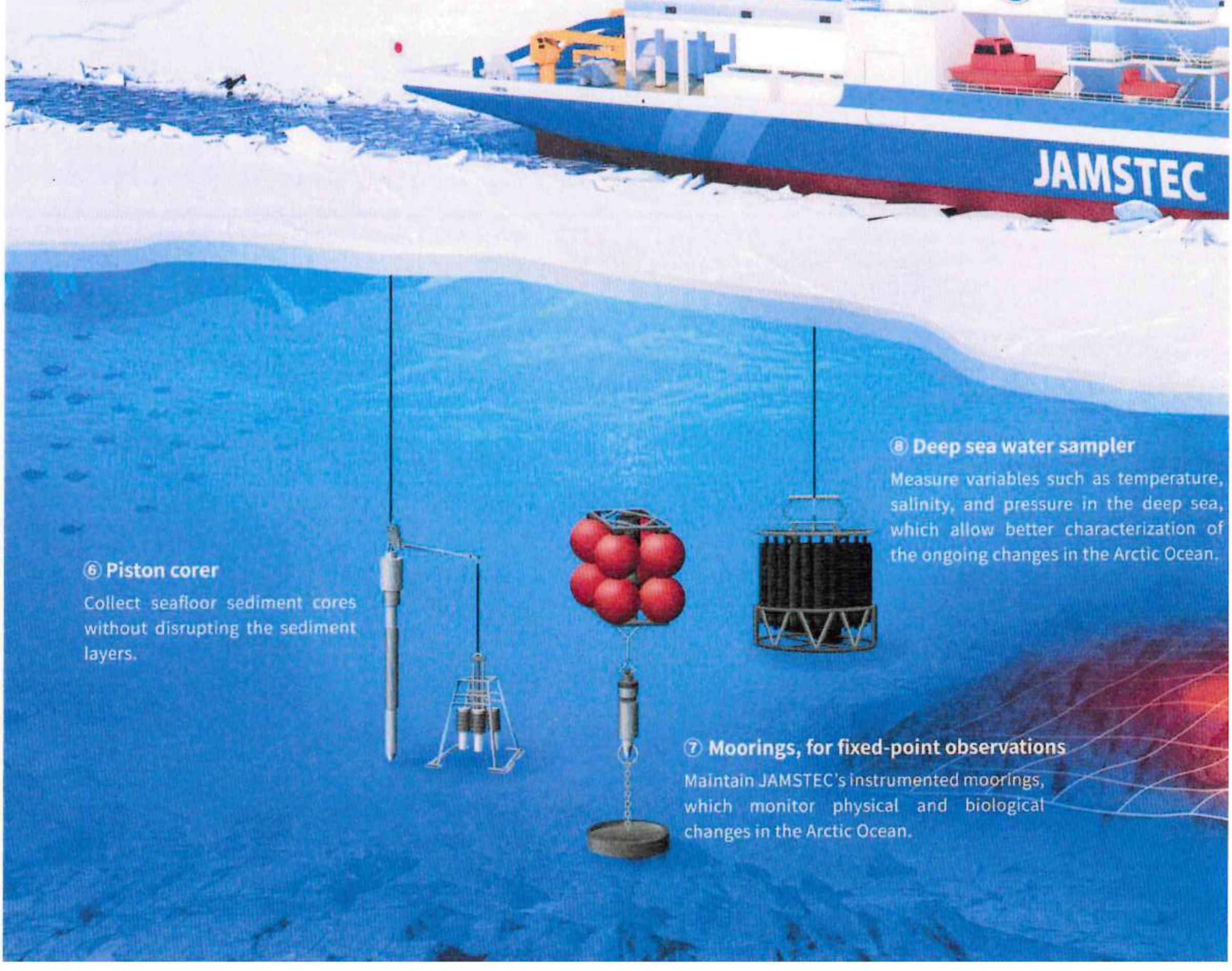
Japan

The Arctic faces many difficult challenges, including environmental changes that have led to the loss of sea ice; we need to learn how to manage the increased economic activities resulting from these changes. These environmental changes are causing far-reaching effects, some of which are seen as extreme weather systems outside of the Arctic region, e.g. extreme snowfall occurring in Japan. As such, the changing Arctic environment is really a global concern.

Japan, as a nation affected by these changes, and as a world leader in scientific research, has a responsibility to form a commitment to scientific investigations into the changing environment of the Arctic.

Japan is building an Arctic research vessel with icebreaking capabilities and world-class scientific facilities to fulfill these commitments. This research vessel will promote the importance of Arctic science and work towards sustainable development of the Arctic region.

Furthermore, Japan remains committed to developing the next generation of scientists and engineers to utilize this research vessel and plans to develop further and deeper collaborations with our international partners.



s first Arctic research icebreaker

③ Rainfall/snowfall observations using a meteorological radar system

Measure weather variables over the Arctic Ocean such as the wind speed, speed and size of raindrops and snowflakes inside clouds by doppler radar.

⑤ Sea-ice observation via autonomous on-ice and under-ice vehicles

Non-destructive observation above and below the sea ice to:

- Measure ice thickness and floe shape, and
- Observe the marine environment under the ice.

④ Hull and superstructure monitoring of the ship

Collect data on the ships' ice load continued safe operations and maintenance.

⑩ Seafloor surveys via ROV/AUV

Underwater data and sample collection via autonomous underwater vehicles.

⑨ Echo sounder surveys

Surveys of bathymetry and biological resources via echo sounders in the Arctic Ocean.

※This schematic illustration introduces the observation function. It may differ from actual conditions and operations.

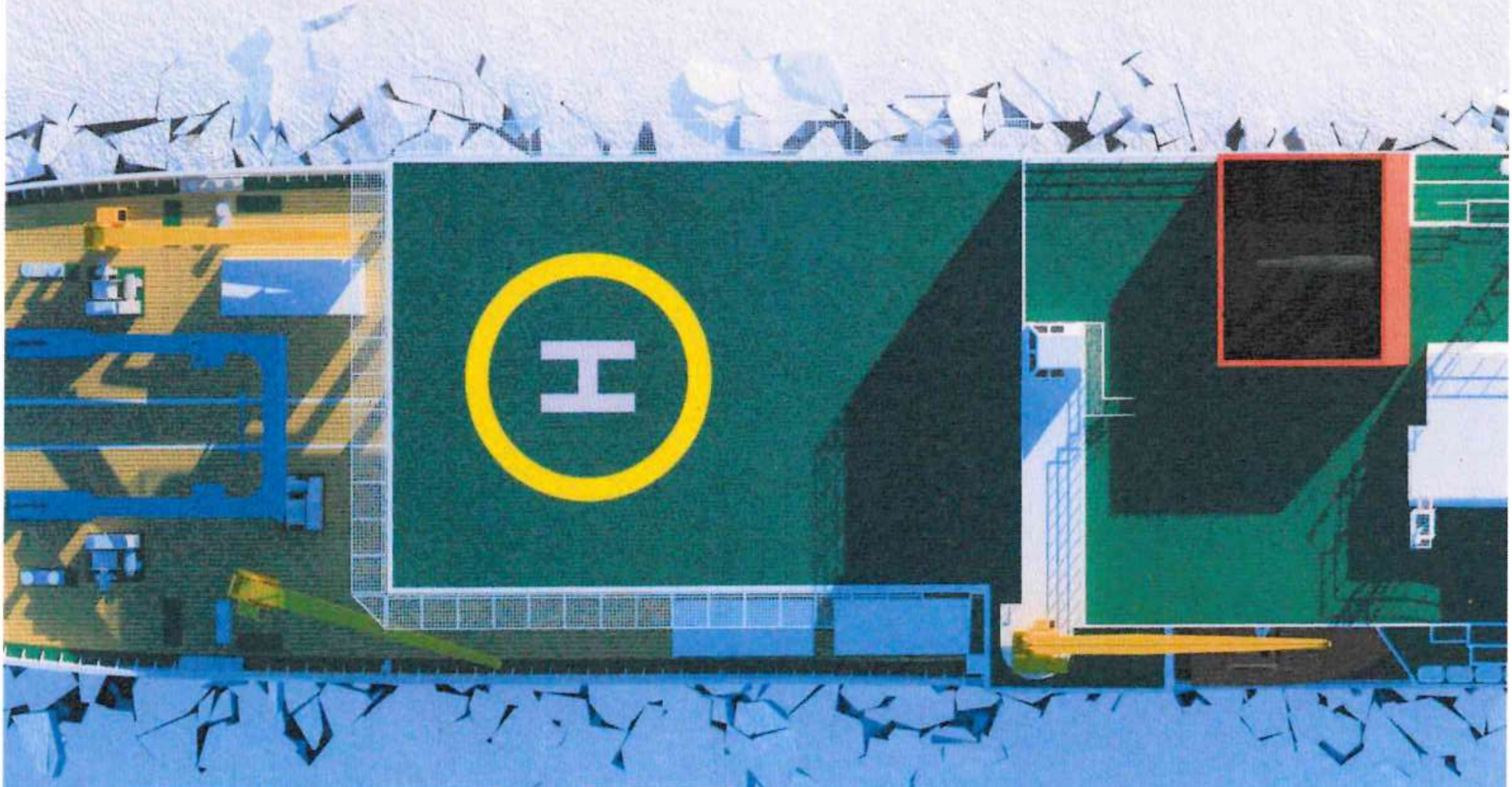
○ Major Features

- High-precision and multi-parameter observation equipment for atmospheric, oceanic, meteorological, and biological research
- Fuel-efficient hull shape for ice-breaking, ice-resistant performance, and navigation in ice-free areas
- Equipped with an advanced ice-sea navigation support system
- Dual-fuel engine to reduce environmental impact
- Dynamic positioning system
- Facilities for deployment and operation of Unmanned Underwater Vehicles (ROV, AUV, etc.)
- Helicopter facilities for safety and sea ice observation
- Ideal research and analysis environment with a variety of laboratory spaces and excellent network infrastructure
- Living & working environment for multinational teams
- Potential for multi-use and expandable functions (e.g. operation and assistance in natural disaster-affected areas)

○ Main specifications (planned)

Length	128m
Beam	23m
Depth	12.4m
Draft	8m
Gross tonnage	13,000 tons
Ice-breaking capacity	capable of continuously breaking 1.2 m of flat, one-year ice at a speed of 3.0 knots
Ice Class	Polar class PC*4
Generator Diesel	approx. 5,600kW x 3, Dual fuel diesel (DFD) approx. 2,600kW x 1
Propulsion	Variable pitch propeller
Accommodation	99 (34 crew, 65 scientists/engineers)
Completion (planned)	November, 2026

＊The International Association of Classification Societies (IACS) has established uniform rules for certifying a ship's ability to withstand ice in ice-covered sea areas. Polar Class 4 is defined as "capable of navigating year-round operation in thick first-year ice, which may include old ice inclusions."



WEB

The intro movie

YouTube channel

October, 2023

③ ENEOS Group Policy

① ENEOS Group Safety Philosophy

We will give top priority to safety and compliance in all of our business activities.

② ENEOS Group Environmental Policy

The ENEOS Group and its employees will follow the basic policies outlined below as part of efforts to help build a sustainable society.

1. Comply with environmental laws and regulations;
2. Contribute to the formation of a decarbonized society; and
3. Contribute to the formation of a resource recycling society
4. Promote environmental conservation in business activities;

3 ENEOS Group Safety Policy

The ENEOS Group and its employees will follow the basic policies outlined below so that "nobody gets hurt" and "to eliminate accidents".

1. Thoroughly abide by all rules
2. Consistently implement all occupational health and safety activities; and
3. Enhance crisis management capabilities.

① Major Oil Spill incidents and influence

Incident	Influence
【1971】 Juliana (Niigata)	【1973】 PAJ Oil Spill Cooperative (POSCO) • mutual support organization PAJ and other industries
【1974】 Tank collapse and spill into sea from Mizushima Refinery	【1976】 Prevention of Disasters in Petroleum Industrial Complexes Law legislated • Mandatory OSR equipment Prevention of Marine Pollution and Disaster Law renewed • Maritime Disaster Prevention Center (MDPC) established
【1989】 Exxon Valdese (Alaska)	【1990】 Major Oil Spill Response Program • METI subsidy • Stockpiling OSR equipment • R&D Program • International Conference (workshop)
【1997】 Nakhodka (Fukui)	Basic Act on Disaster Management amended
【1997】 DiamondGrace (Kawasaki)	

② OSR Equipment

- Prevention of Disasters in Petroleum Industrial Complexes Law (FDMA)

  for typical refineries

  ✓Oil boom(max 2,160m), working boat for extension

  ✓Oil skimmer(capacity 30kL/h), working boat for recovery and transportation

- Prevention of Marine Pollution and Disaster Law (MLIT)

  for typical refineries with petrochemicals

  ✓Oil boom(1,000m), dispersant/adsorbent/gelator (total quantity enable to treat 64kL fuel oil)

  ✓Adding to persistent oil (e.g. heavy oil), emergency response manual is required for harmful oil

① Preparedness

- Refineries established response team and maintain equipment, ER manuals in accordance with regulation
- Training and drills are planed and conducted

② HQ Support

- Interface between PAJ activities and help to introduce simulation tools
- Thru SHE management system, review effectiveness and advice opportunities for improvement

③ Other Resources

- Participation to PAJ program / training at stockpiling base, IMO Level 3

  MDPC offers several training course, ER support program (e.g. MDSS)

  JCG organized mutual aid locally (排出油防除協議会), alternating POSCO's function

Reference

① PAJ

② MDPC

③ JCG

- National Strike Team

④ Clean Sea and Beach Foundation

Participant List

① Taiwan OCA

- Ms. **Hsiao-Hsia Li** 李 筱霞 OCA(海洋保育署) 海洋環境管理組 組長 Director, Marine Environmental Management Division
- Mr. **Hung-Wen Chen** 陳 鴻文 OCA(海洋保育署) 海洋環境管理組 科長 Section Chief, Marine Environmental Management Division
- Ms. **Hui-Chen Yang** 楊 蕙禎 OCA(海洋保育署) 海洋環境管理組 科長 Section Chief, Marine Environmental Management Division
- Mr. **Yu-Chein Chen** 陳 語謙 OCA(海洋保育署) 海洋環境管理組 科員 Officer, Marine Environmental Management Division
- Prof. **Jenq-Renn Chen** 陳 政任 NKUST(國立高雄科技大學) 教授
- Prof. **Ping-Chi Hsu** 許 昺奇 NKUST(國立高雄科技大學) 教授
- Associate Prof. **Tsung-Yueh Tsai** 蔡 宗岳 NKUST(國立高雄科技大學) 副教授
- Ms. **Hui-Ning Yang** 楊 惠甯 NKUST(國立高雄科技大學) 資深經理 Senior Manager
- Ms. **Chen Liu** 劉 蓁 NKUST(國立高雄科技大學) 經理 Manager

② ENEOS, SHE Dept

- Takashi Yoshida, Deputy Manager
- Jun Murakami, Safety & Compliance Group Manager
- Kenichi Tomita, Manager, Safety & Compliance Group
- Yoshihito Shimabukuro, Safety & Compliance Group

日本 **CCS** 調查株式会社相關會議資料

Agenda

9:30－10:20 Video of Tomakomai Project

Presentation on Tomakomai CCS Demonstration Project

10:20－10:50 Tour of facilities

10:50－11:20 Q&A

11:30 End of Tour

JCCS
Japan CCS Co., Ltd.

■ Video

JCCS
Japan CCS Co., Ltd.

JCCS company profile and project framework

Company Profile

Date of Incorporation: May 26, 2008
Capital: 242.5 million JPY
Capital reserve: 242.5 million JPY
Shareholders: 33 companies
Electric power, city gas, petroleum, plant design/construction, trading, etc.

Business Description:
Implementation of surveys, research and development, feasibility studies, demonstration projects pertaining to CO_2 capture, utilization, transportation and storage (CCUS) technologies.

No. of Staff: 106 (as of April 2024)

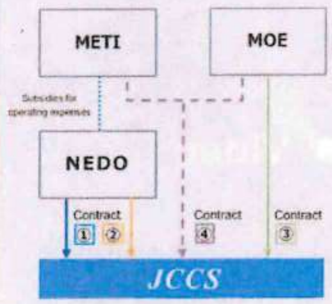
Commissioned Projects/Project Framework

① **Tomakomai CCUS Demonstration Project** (FY2012~)
Consignor: **New Energy and Industrial Technology Development Organization (NEDO)**

② **Research, Development and Demonstration Projects on CO_2 ship transportation** (FY2021~) ※4 co. consortium
Consignor: **New Energy and Industrial Technology Development Organization (NEDO)**

③ **Project to Promote the Creation of Circular Carbon Society Model through CO_2 Recycling** (FY2021~)
※6 co. consortium
Consignor: **MOE**

(Previous Commissioned Project)
④ **Investigation of Potential CO_2 Storage Sites**
(FY2014~FY2023)
Consignor: **METI** ・ **MOE**
Ministry of Economy, Trade and Industry (METI)
Ministry of the Environment (MOE)



※Each project is conducted by establishing an expert committee comprised of experts in each field which provides advice and technical guidance.

Outline of Presentation

- Overview of Tomakomai CCS Demonstration Project
- Key Results of Tomakomai Project
- Public Engagement
- Summary

JCCS
Japan CCS Co., Ltd.

Overview of Tomakomai CCS Demonstration Project

JCCS
Japan CCS Co., Ltd.

Project Overview

Main objectives and tasks

- Demonstrate a full-chain CCS system from capture to storage
- Demonstrate that the CCS system is safe and reliable
- Remove concerns about earthquakes by the data collected;
    - No influence by natural earthquakes on CO_2 stored
    - No perceptible earth tremors induced by CO_2 injection
- Disclose project information and data and enhance understanding of CCS by local residents

Tomakomai CCS Demonstration Center, Tomakomai City, Hokkaido

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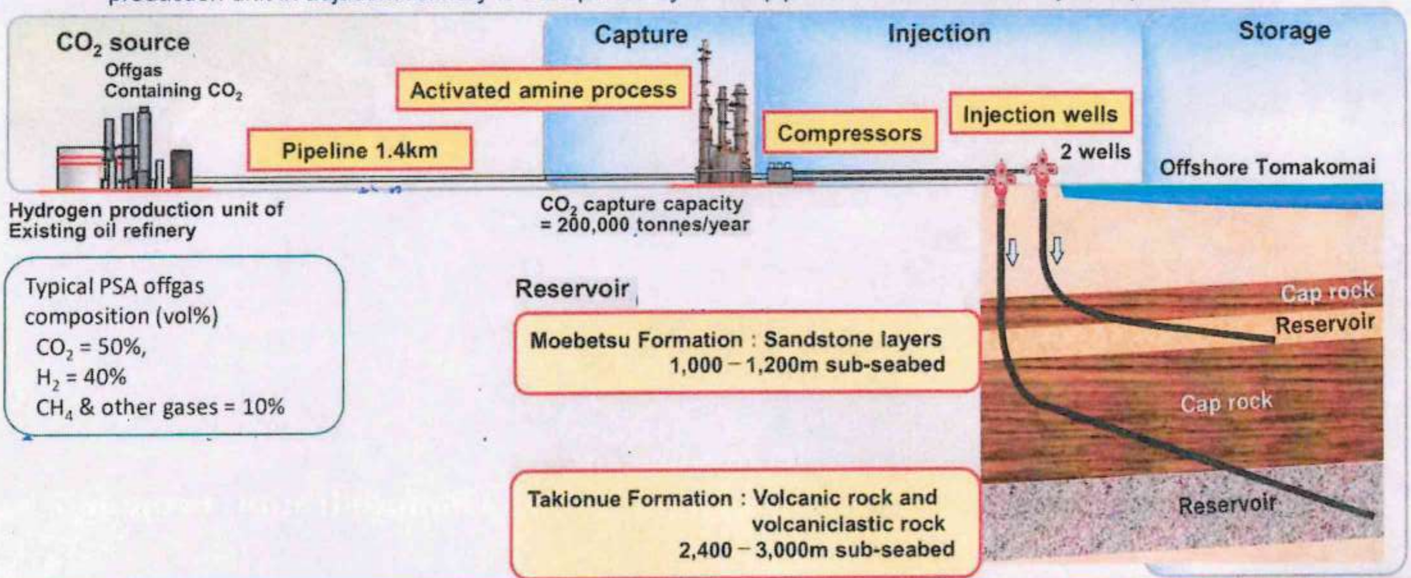
Project Scheme

- A portion of PSA (Pressure Swing Adsorption) offgas containing approximately 50% CO_2 generated by a hydrogen production unit in adjacent refinery is transported by 1.4km pipeline to Tomakomai Project capture facilities.



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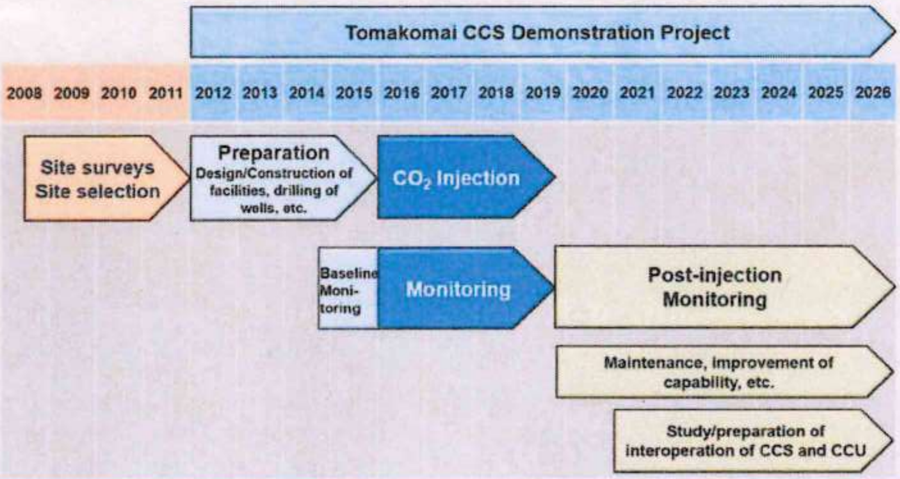
Project Schedule

- Constructed demonstration facilities **from FY2012 to 2015**
- Started injection **at scale of 100 thousand tonnes** per annum **from April 2016**
- Achieved initial target of **300 thousand tonnes cumulative injection on November 22, 2019**
- Monitoring is being continued



※Years are Japanese Fiscal Years (April to March)

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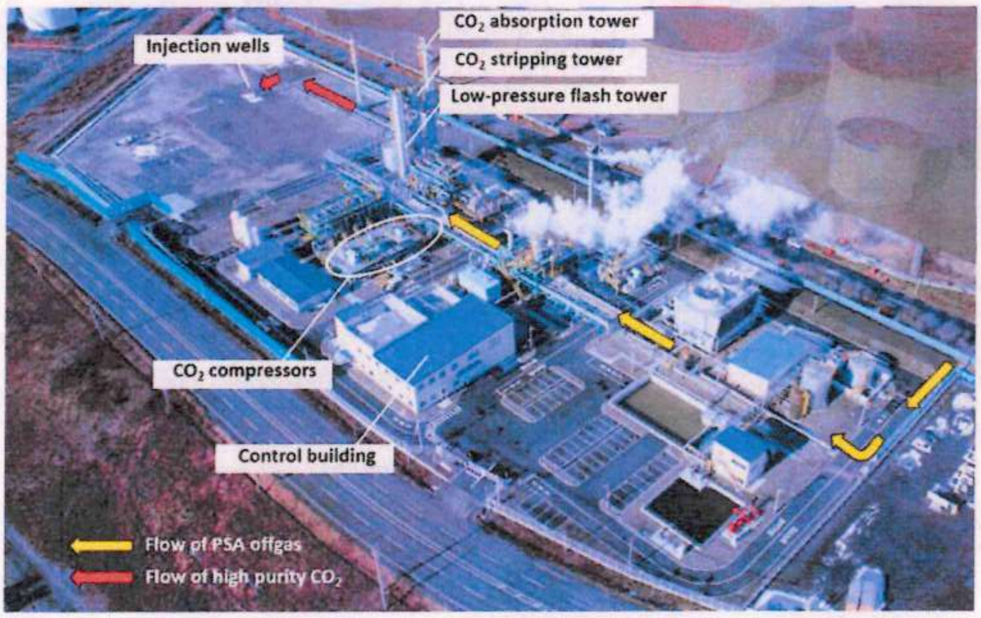
Bird's Eye View of Tomakomai Capture/Injection Facilities



- CO_2 rich gas from refinery is sent to CO_2 absorption tower
- Captured CO_2 is compressed and sent to injection wells

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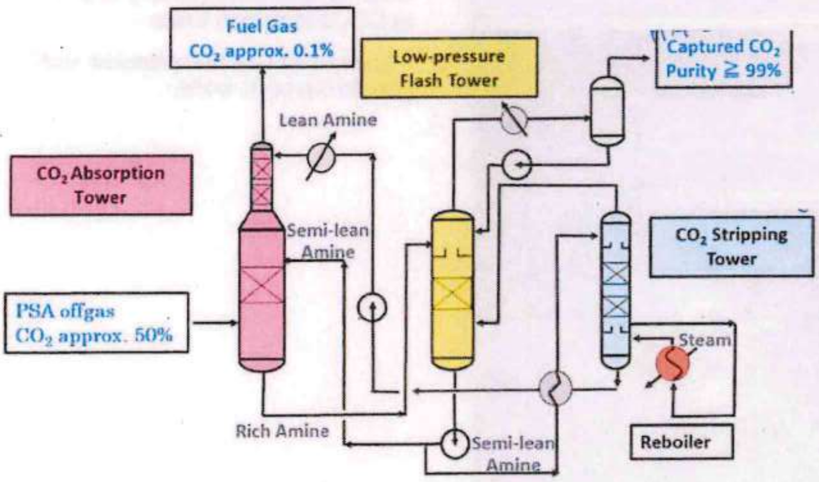
Key Results of Tomakomai Project

CO_2 Capture Process

Two-stage absorption process



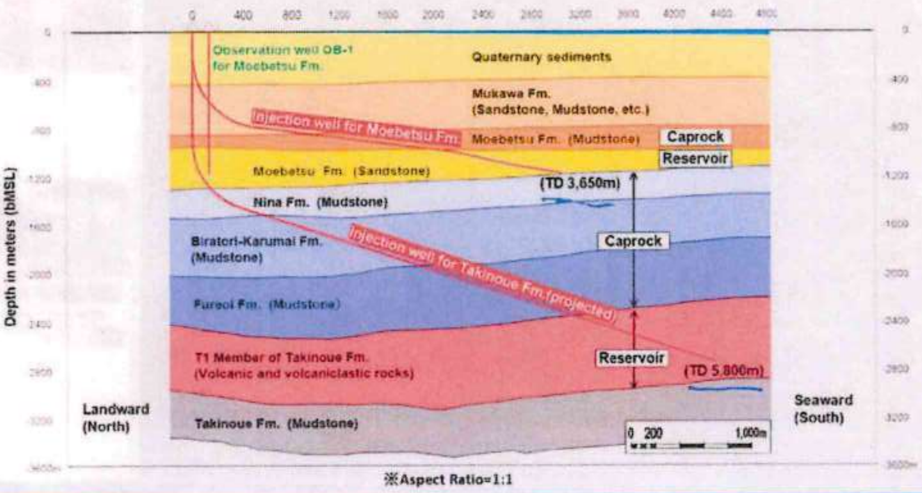
CO_2 Capture Results

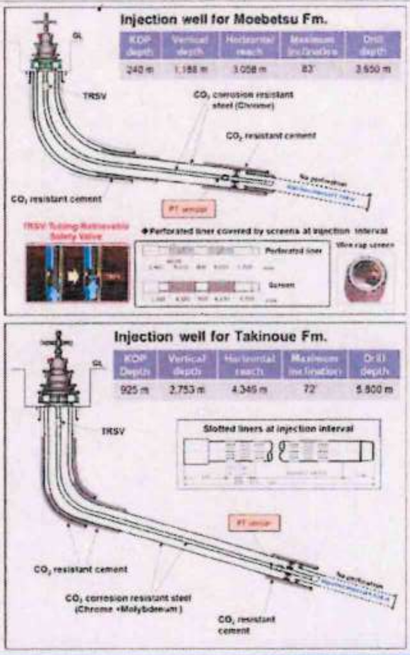
	FY2016	FY2017	FY2019
CO_2 recovery (t/h)	25.3	24.3	26.4
Reboiler duty (GJ/t-CO_2)	0.923	0.882	0.915

- Achieved reboiler duty of 0.882 - 0.923GJ/t-CO_2; (1/2 to 1/3 of conventional one stage absorption process)

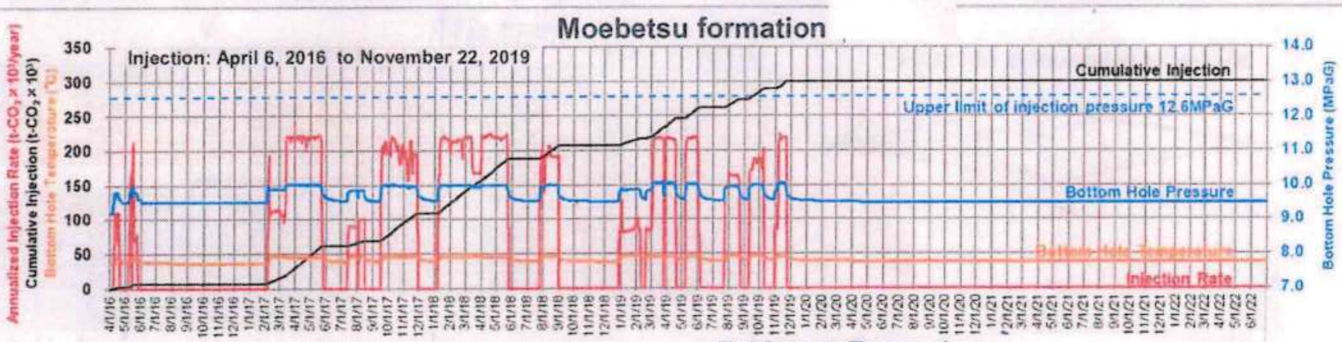
Geological Cross Section / Injection Wells

- The captured CO_2 is compressed and stored 3-4km offshore in two sub-seabed reservoirs at different depths – Moebetsu and Takinoue formations by two independent injection wells
- Deviated CO_2 injection wells drilled from onshore to offshore sub-seabed
  - Cost reduction of drilling, operation and maintenance
  - No disturbance on marine environment and harbor operation

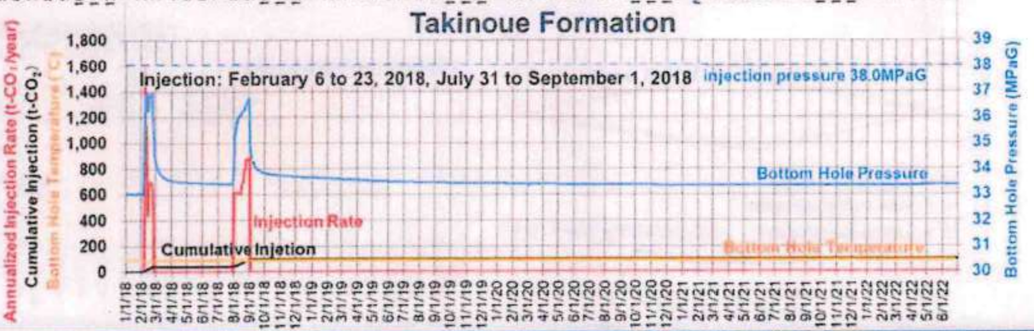




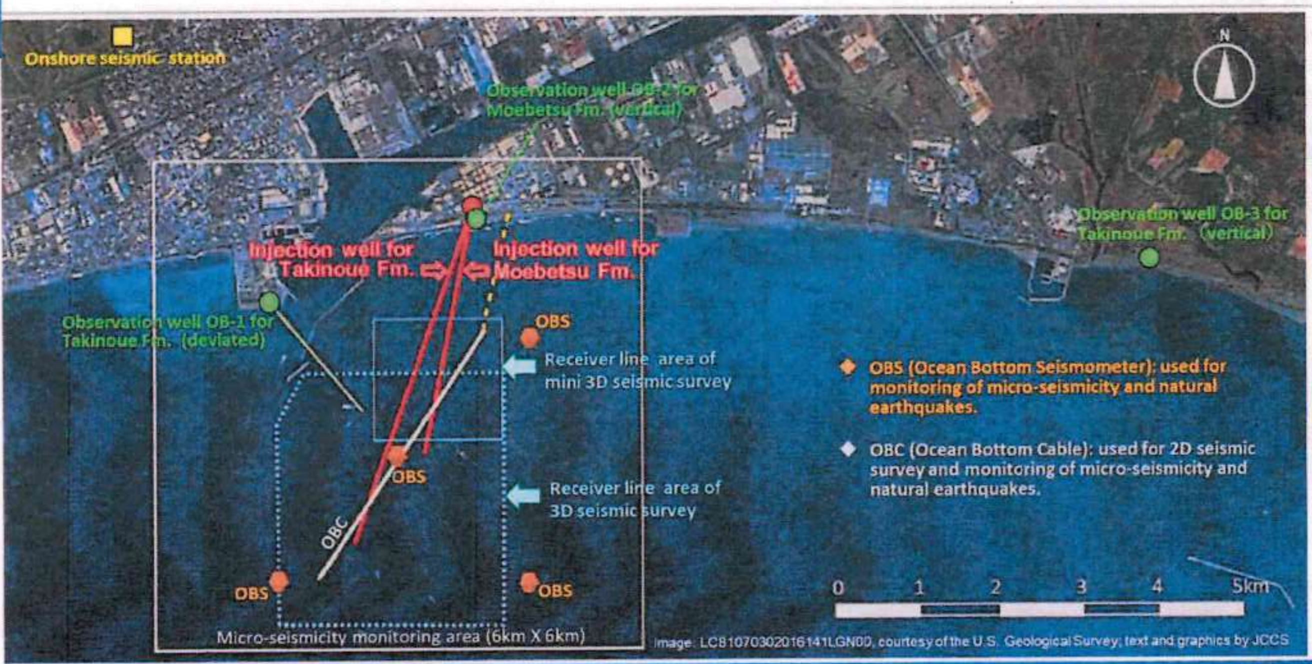
CO_2 injection record



- Achieved 300,110 tonnes cumulative CO_2 injection into two reservoirs
  - Moebetsu Fm. 300,012 t
  - Takinoue Fm. 98 t



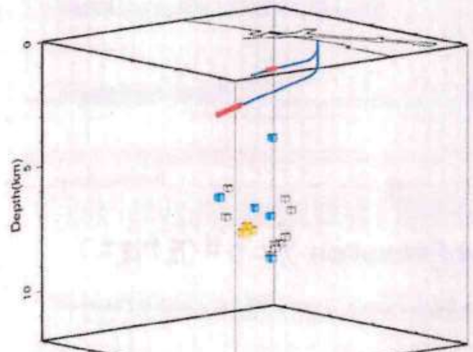
Location of Monitoring Facilities



Note : As a result of optimization study of seismicity monitoring system, operation of onshore seismic station and OBSs were discontinued after JFY 2021.

Results of Micro-seismicity Monitoring

3D view of hypocenters of events



Pre-injection events
Events during injection
Post-injection events

※Detectability: Mw ≥ - 0.5

List of events

Pre-injection events

No.	Date	Estimated Depth	Mw
1	4/09/2015 15:03	6.64 km	0.14
2	4/13/2015 14:00	5.97 km	0.14
3	4/17/2015 07:06	8.17 km	0.20
4	4/17/2015 07:09	8.19 km	0.19
5	4/17/2015 07:13	8.33 km	0.28
6	4/17/2015 07:18	7.57 km	0.17
7	5/10/2015 08:27	8.59 km	-0.04
8	8/10/2015 19:08	6.76 km	0.23
9	8/20/2015 23:20	8.18 km	0.44

Events during injection

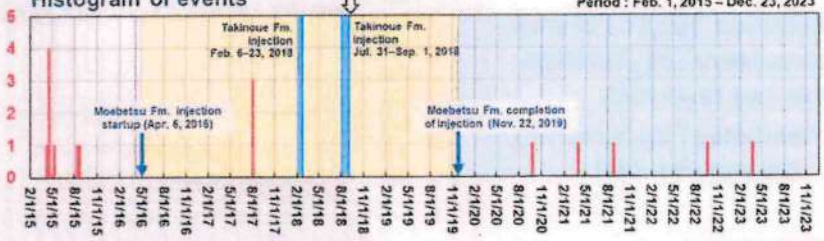
No.	Date	Estimated Depth	Mw
10	8/02/2017 13:35	7.80 km	0.50
11	8/02/2017 13:36	7.78 km	0.33
12	8/02/2017 13:55	7.70 km	0.33

Post-injection events

No.	Date	Estimated Depth	Mw
13	9/24/2020 11:53	5.86 km	0.59
14	4/01/2021 04:23	7.45 km	0.23
15	8/24/2021 16:03	6.50 km	0.13
16	9/18/2022 14:04	4.35 km	0.12
17	3/22/2023 10:26	8.37 km	0.43

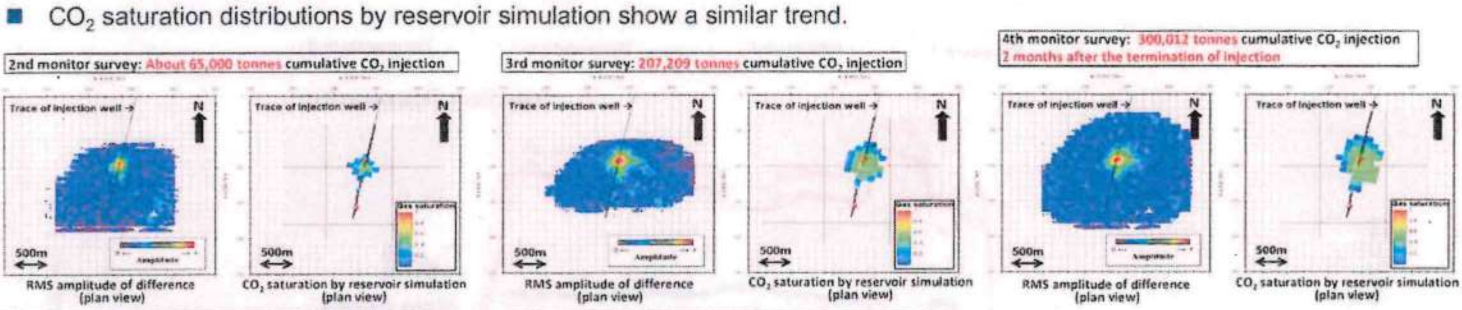
Histogram of events

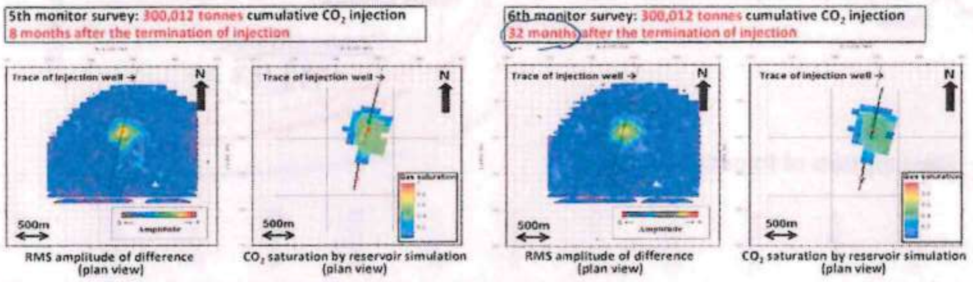
Period : Feb. 1, 2015 – Dec. 23, 2023



3D seismic survey results: comparison of 2nd to 6th time-lapse 3D seismic surveys

- 3D seismic surveys detected evolution of CO_2 plume in Moebetsu Formation.
- CO_2 saturation distributions by reservoir simulation show a similar trend.

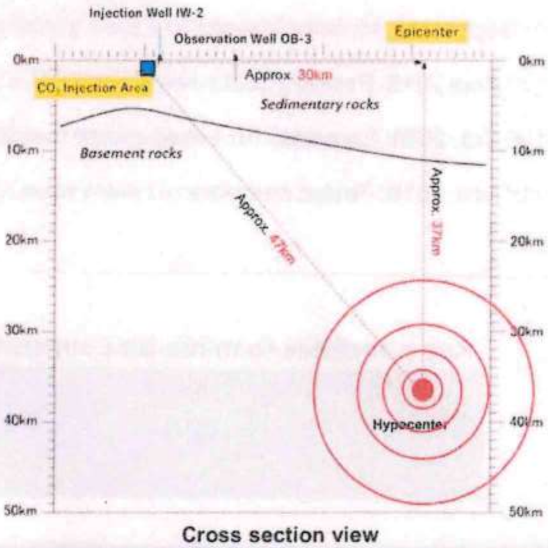




RMS (Root Mean Square) amplitude of difference of monitor survey and baseline survey at the depth of the reservoir (970 to 1050 msec)

2018 Hokkaido Eastern Iburi Earthquake

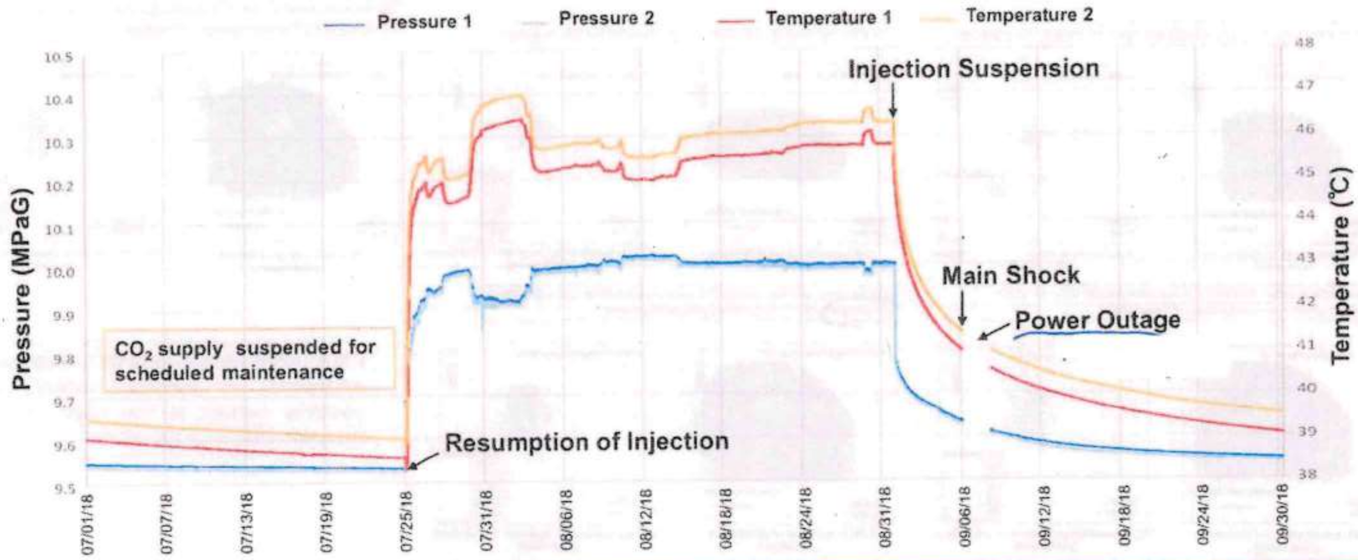
- At 3:07am Sept. 6, 2018, a moment magnitude 6.6 earthquake at 37km depth occurred in central eastern part of Iburi region of Hokkaido. Acceleration of 158 gal was observed at Tomakomai CCS Demonstration Center; no damage was incurred by facilities.



Cross section view

2018 Hokkaido Eastern Iburi Earthquake

- Bottom hole pressures, temperatures of Moebetsu Formation injection well before/after earthquake



Measures taken by JCCS after the Hokkaido Eastern Iburi Earthquake

- 6th Sept. 2018: Moment Magnitude 6.6 earthquake occurred
- 12th Sept 2018: Posted JCCS's views on JCCS on HP
- 19th Oct. 2018: Convened an expert review meeting
- 21st Nov. 2018: Posted summary of review meeting on HP

Key points on JCCS HP

1. **No relationship between CO_2 injection and earthquake**
2. **No CO_2 leakage**

※ Report on Expert Review Meeting:
(https://www.japanccs.com/wp/wp-content/uploads/2019/09/Research-Report-on-Impacts-of-Hokkaido-Eastern-Iburi-Earthquake-on-CO2-Reservoir_2nd-edition.pdf)

Key principles to minimize concerns of local community and general public:

- *Respond quickly*
- *Include technical explanation*

Public Engagement

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Public Outreach Activities

Voice of Tomakomai Citizens

1. Information Disclosure
Thorough disclosure should be made

2. Safety/CO_2 leakage
Want more detailed information on risk of CO_2 leakage
→ Monitoring & Disclosure Plan

3. Dissemination to Young Generation
Should consider efforts to involve young generation

Outreach Activities

1. Site Tours
2. Panel Exhibitions
3. CCS Forum for Tomakomai Citizens
4. Information Disclosure System
5. Mini seminars for students
6. Kids' lab classes/site tours

Cumulative Outreach Activities (2012-2023)

1. Site Visitors: 16,481 people (2,397 people from overseas)
2. Panel Exhibitions: 105 times
   Booths in Environmental Exhibitions: 68 times
3. CCS Forums: 10 times
5. Mini seminars: 244 times
6. Kids' lab classes: 38 times

Project being conducted with understanding and support of local community

Outreach Activities:

Panel Exhibition in Tomakomai

Kids' lab class

Site Tours

Information disclosure system in Tomakomai City Hall

JCCS
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Summary

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Summary

Results and Lessons Learned

- Operation of **full chain CCS system from capture to storage conducted successfully, target of 300,000 tonnes of CO_2 injection achieved.** Monitoring operations being continued.
- CO_2 capture process comprising two-stage absorption system with low pressure flash tower achieved **significantly lower capture energy than conventional system**
- Deviated injection wells from onshore site into offshore reservoirs saved drilling cost, avoided disturbance of marine environment and harbor operation
- Safety and reliability of CCS system demonstrated
- Concerns about **earthquakes and induced seismicity** addressed
  - Natural earthquakes have not caused damage to reservoirs; no data suggesting connection between CO_2 storage and earthquakes
  - Important to respond as quickly as possible, and to include technical data to minimize concerns.
- Project being conducted with **understanding and support of local community**
  - Importance of information disclosure and diligent efforts to secure understanding of local stakeholders

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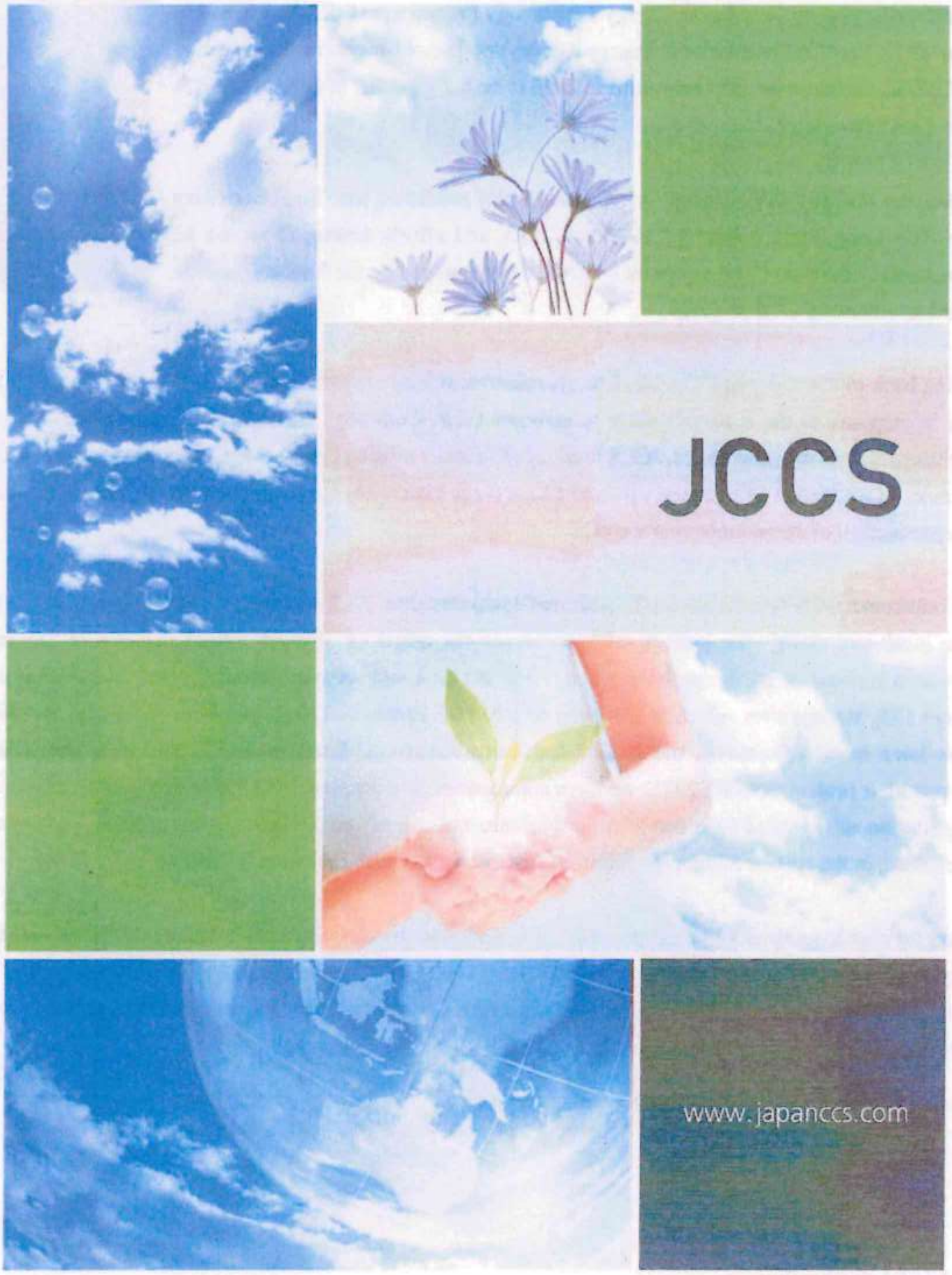
Thank you for your attention

This presentation is based on results obtained from a project commissioned by the New Energy and Industrial Development Organization (NEDO)

JCCS

Japan CCS Co., Ltd.

http://www.japanccs.com/


JCCS
www.japanccs.com

A MESSAGE FROM THE PRESIDENT

From Japan to the World
~ with a view towards the social implementation of CCS ~

The expectations towards CCS as a global warming countermeasure are increasing internationally year by year. In the Energy Technology Perspectives 2023, published in January 2023, the IEA (International Energy Agency) projected the contribution needed from CCUS to achieve net zero emissions in 2050 to be 6.2 gigatons of CO_2 per year in its Net Zero Scenario.

In Japan, the Ministry of Economy, Trade and Industry published the "Final Summary of the CCS Long Term Roadmap" in March 2023, and efforts aiming to secure 13 million tonnes of annual CO_2 storage by 2030 are being pursued by the 7 model projects adopted as advanced CCS projects.

Looking back to 2008, Japan CCS Co., Ltd. (hereinafter JCCS) was established through investment by the private sector in response to the national policy to promote CCS. Currently, as projects commissioned by the Japanese government and public institutions, JCCS is engaged in four projects; large-scale CCS demonstration in Tomakomai, Hokkaido, investigation of potential offshore CO_2 storage sites, CO_2 ship transportation demonstration, and survey of the production of sustainable aviation fuel.

The Tomakomai CCS Demonstration Project was commenced in 2012, and with the understanding and cooperation of the local community, the project safely achieved the target of 300,000 tonnes cumulative sub-seabed CO_2 injection in November 2019, confirming that "CCS is a safe and secure system". In the investigation of potential offshore CO_2 storage sites which was started in FY2014, surveys of each site were conducted steadily, and the results have been reflected in the CCS Long Term Roadmap. Furthermore, in the CO_2 ship transportation demonstration project from FY2021, we have commenced construction of facilities that will enable bi-directional transportation of liquefied CO_2 between the Maizuru and Tomakomai terminals. In addition, we have also been participating in the survey of the production of sustainable aviation fuel since FY2021.

Aiming for carbon neutrality in 2050, we view as our mission the contribution towards the realization of the national policy to establish the social foundation for CCUS by 2030. To this end, harnessing the technology and know-how that we have nurtured on CCS, we will unite our efforts to continue our role in reaching out to the international community.

We ask for your continued understanding and support.

June 2023

Toshiaki Nakajima
President
Japan CCS Co., Ltd.

COMPANY PROFILE

Company Name:	Japan CCS Co., Ltd.
Address:	SAPIA TOWER 21F, 1-7-12 Marunouchi, Chiyoda-ku, Tokyo 100-0005 Japan
URL:	https://www.japanccs.com
Date of Incorporation:	May 26, 2008
Business Description:	Implementation of investigations, research and development, feasibility studies and demonstration projects pertaining to carbon dioxide capture, utilization, transportation and storage technologies.
Capital:	JPY242,500,000
Capital Reserves:	JPY242,500,000

Shareholders:

Hokkaido Electric Power Co., Inc. Tohoku Electric Power Co., Inc.
Tokyo Electric Power Company Holdings, Inc. Chubu Electric Power Co., Inc.
Hokuriku Electric Power Company The Kansai Electric Power Co., Inc.
The Chugoku Electric Power Co., Inc. Shikoku Electric Power Co., Ltd.
Kyushu Electric Power Co., Inc. The Okinawa Electric Power Co., Ltd.
Electric Power Development Co., Ltd. JFE Engineering Corporation
NIPPON STEEL ENGNEERING CO., LTD. CHIYODA CORPORATION Toyo Engineering Corporation
JGC Holdings Corporation INPEX CORPORATION Japan Petroleum Exploration Co., Ltd.
Mitsui Oil Exploration Co., Ltd. Idemitsu Kosan Co., Ltd. COSMO OIL Co., Ltd. ENEOS Corporation
ITOCHU Corporation Sumitomo Corporation Marubeni Corporation Mitsubishi Corporation
JFE Steel Corporation NIPPON STEEL CORPORATION
Osaka Gas Co., Ltd. Tokyo Gas Co., Ltd. MITSUBISHI GAS CHEMICAL COMPANY, INC.
Mitsubishi Materials Corporation Marubeni-Itochu Steel Inc.
(33 companies, as of November 15, 2022)

■ FOUNDATION OF JCCS

Japan CCS Co., Ltd (JCCS) was founded in May 2008 when a group of major companies with expertise in CCS-related fields, including electric power, petroleum, oil development, and plant engineering, joined forces to answer the Japanese government's policy to advance CCS as a countermeasure against global warming. JCCS is a special purpose company dedicated explicitly to developing integrated CCS technology.

■ KEY BUSINESS OBJECTIVES

1. Conduct comprehensive investigations and demonstrations of carbon dioxide capture, utilization, transportation and storage projects in Japan
2. Conduct investigation of potential CO_2 storage sites in Japan
3. Integrate opinions from the private sector for early establishment of laws, regulations and technical standards applicable to CCUS in Japan
4. Conduct promotional activities for CCUS deployment in Japan
5. Cooperate with foreign organizations for promotion of overseas CCUS demonstration projects
6. Collect the latest information on CCUS and collaborate with overseas CCUS research organizations

PROJECTS

■ Commissioned Projects/Project Framework

① Tomakomai CCUS Demonstration Project (FY2012~)

Consignor: **New Energy and Industrial Technology Development Organization (NEDO)**

② Investigation of Potential CO_2 Storage Sites (FY2014~)

Consignor: **METI** · **MOE**

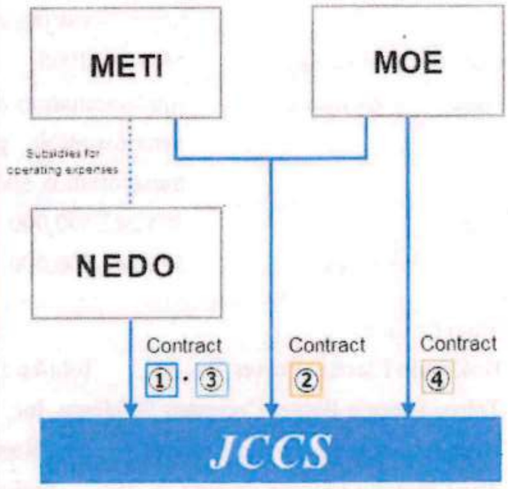
Ministry of Economy, Trade and Industry (METI)
Ministry of the Environment (MOE)

③ Research, Development and Demonstration Projects on CO_2 ship transportation (FY2021~) ※4 co. consortium

Consignor: **New Energy and Industrial Technology Development Organization (NEDO)**

④ Project to Promote the Creation of Circular Carbon Society Model through CO_2 Recycling (FY2021~)
※6 co. consortium

Consignor: **MOE**



※Each project is conducted by establishing an expert committee comprised of experts in each field which provides advice and technical guidance.

■ Tomakomai CCS Demonstration Project (JFY2012~)

With a view towards implementing a CCS demonstration project, Japan CCS conducted geological surveys to confirm that the Tomakomai site was suitable for CO_2 storage. Although there was a large body of subsurface geological data amassed from oil and gas exploration in this area over many years, marine 3D seismic surveys were conducted in 2009 and 2010, and two survey wells were drilled in 2010 and 2011 for further confirmation.

As a result of detailed analysis and evaluation of the newly acquired data, Japan CCS confirmed that the geological structure of the Tomakomai site was suitable for CO_2 geological storage and that the demonstration project could be conducted safely.

Japan CCS summarized the results in the report "Comprehensive Reservoir Evaluation at the Tomakomai Site", and submitted the report together with the "Demonstration Test Plan at the Tomakomai Site (Draft)" to METI in October 2011. An expert evaluation committee was held by METI, and in February 2012, METI conducted a public tender of the "FY2012 CO_2 Reduction Technology Demonstration Test Project (pertaining to obligatory assurance of national subsidization for a multiyear construction project)" for the four years until FY2015, which resulted in Japan CCS being selected as the contractor.

During the four years from FY2012 to FY2015, Japan CCS designed and constructed facilities for capturing high-purity CO_2 from gas containing CO_2 generated from a hydrogen production unit of a refinery and injecting the CO_2 into the subsurface. In addition, one existing survey well was converted to an observation well, and two observation wells and two injection wells were drilled.

At the same time, in order to confirm that the CO_2 injection into the reservoir does not affect the surrounding environment, Japan CCS installed a monitoring system for formation and earthquake data and obtained baseline data prior to injection. In addition, since the formations where CO_2 is stored are under the seabed, Japan CCS conducted a preliminary survey of seawater and marine life in accordance with the Act for the Prevention of Marine Pollution and Maritime Disasters.

Having completed this preparatory work, from April 2016, Japan CCS commenced injection of CO_2 into a formation about 1,000 meters below the seabed in the port area of Tomakomai as well as monitoring during injection, with the aim of achieving 300,000 tonnes cumulative injection. The monitoring work being conducted includes monitoring the behavior of the injected CO_2 (migration, distribution), marine environmental surveys, etc., to confirm that there is no seepage of CO_2, as well as continuous monitoring of micro-seismicity and natural earthquakes. On November 22, 2019, the CO_2 injection reached the target of 300,000 tonnes, and injection was terminated the same day. Monitoring work is being continued after termination of injection.

The Japanese government has set out a policy to utilize Tomakomai as a demonstration base for carbon recycling and is advancing studies aiming towards the interoperation of CCS and CCUS.

SCHEDULE

Contract Period: JFY2012~

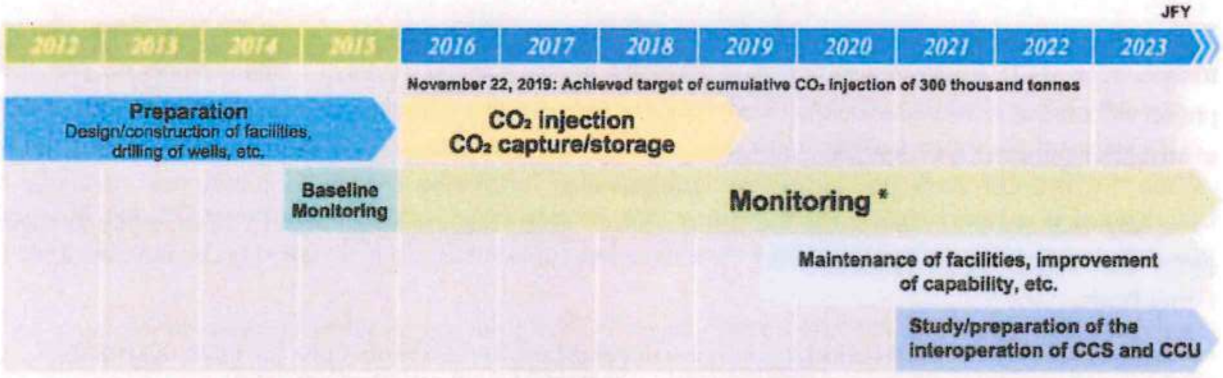
- From JFY2012 to JFY2015: Preparation

  Activities including the design and construction of facilities, drilling of wells, and preparation for demonstration operation were carried out.

- From April 2016 to November 2019: CO_2 injection and monitoring of CO_2

  On November 22, 2019, the target of 300 thousand tonnes of CO_2 injection was achieved, and injection was terminated.

- From November 2019: Post-injection monitoring, maintenance of facilities, improvement of capability, etc.
- From JFY2021: Study/preparation of the interoperation of CCS and CCU



(*) Monitoring the behavior (migration, distribution) of the injected CO_2, continuous monitoring of micro-seismicity and natural earthquakes, marine environmental monitoring to detect for possible CO_2 seepage are being conducted.

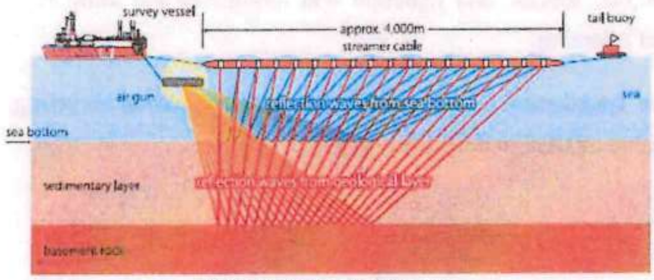
※Years are in Japanese Fiscal Years (JFY- April of calendar year to March of following year)

■ Investigation of Potential CO_2 Storage Sites (JFY2014~)

In order to conduct CCS, a geological formation that can stably store a large amount of CO_2 is required. According to surveys conducted between FY2005-2012, the geological formations in Japan are estimated to have a total storage potential of about 240 billion tons of CO_2. Although the total storage potential is considered to be sufficient, more detailed investigation is required to determine how suitable individual candidate sites are for storage.

For this reason, the Ministry of Economy, Trade and Industry and the Ministry of the Environment jointly launched the "Investigation of Potential CO_2 Storage Sites" from FY2014. Japan CCS has been entrusted with and has continued the implementation of this project.

In this project, we start investigating candidate sites using existing data and literature. Next, the geological structure is delineated by seismic surveys, etc., and this data is utilized to narrow down the areas suitable for storage. At candidate sites with expectations for large storage capacity, detailed investigation is carried out on issues such as whether the stored CO_2 will leak, whether the geological structure is stable, and the amount of CO_2 that can be stored, and sites with higher potential are extracted.



Conceptual diagram of seismic survey


Lowering airgun into the sea


Lowering streamer cable into the sea

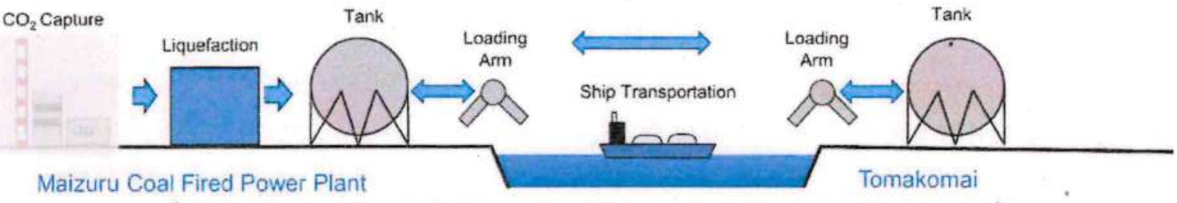
■ Research, Development and Demonstration Projects on CO_2 Ship Transportation (JFY2021~)

In June 2021, a consortium of 4 companies*1 including Japan CCS was jointly commissioned by the New Energy and Industrial Technology Development Organization (NEDO) to conduct "CCUS R&D and Demonstration Related Projects / Large Scale CCUS Demonstration at Tomakomai / Demonstration of CO_2 Transportation / Technology Development and Demonstration of CO_2 Ship Transportation".

With a view towards the social implementation of CCUS around 2030, which envisages the long-distance/mass transportation of CO_2 from emission sources to utilization/storage points at a scale of 1 million tonnes per year, the project will conduct research and development leading to cost reduction of transportation technology, as well as aim to establish liquified CO_2 transportation technology through demonstration tests and related investigations.

CO_2 captured in another project *2 will be liquefied in a terminal in the Kansai Electric Power Co., Inc. Maizuru Power Plant and transported back and forth between a terminal in the Hokkaido Electric Power Co., Inc. Tomakomai Power Plant.

*1 4 companies: Japan CCS Co., Ltd., Engineering Advancement Association of Japan, ITOCHU Corporation, NIPPON STEEL CORPORATION
*2 Another project: NEDO Project "Research on Application of Advanced Solid Absorber on Coal Combustion Flue Gas"



Scope of Demonstration Project by a ship with 999 gross tonnage

Note: Figure adapted from METI

■ "Project to Promote the Creation of Circular Carbon Society Model through CO_2 Recycling" by the Global Environment Bureau, Ministry of the Environment (JFY2021~)

In August 2021, a consortium of 6 companies[*1] including Japan CCS was jointly commissioned to conduct "Project to Promote the Creation of Circular Carbon Society Model through CO_2 Recycling" by the Global Environment Bureau, Ministry of the Environment.

In achieving the targets of the Paris Agreement, there are high expectations for environmental innovations including CO_2 capture, storage and recycling, making renewable energies into mainstream power sources, expanding the use of hydrogen, and decarbonization of fuels. Also, in the aviation industry, the International Civil Aviation Organization (ICAO) has defined CO_2 emissions reduction targets in CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) and aiming for the use of SAF[*2] in aviation as an effective means of reduction strongly urges its stable production and supply.

The P2C[*3] plant being studied in this project will use artificial photosynthesis technology to reduce the CO2 captured from emission sources into CO, which will then be reacted using the FT synthesis[*4] process with hydrogen originating from renewable energy to produce liquid fuels such as jet fuel, light oil, etc.

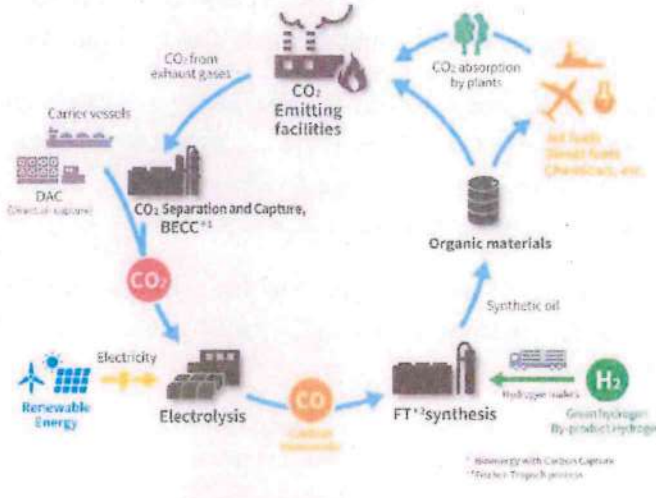
P2C is expected to significantly reduce the amount of CO_2 emissions and greatly contribute to achieving carbon neutrality.

*1 6 companies: Toshiba Energy Systems & Solutions Corporation, Toyo Engineering Corporation, Toshiba Corporation, Idemitsu Kosan Co., Ltd., Japan CCS Co., Ltd., All Nippon Airways Co., Ltd.

*2 SAF: Sustainable Aviation Fuel (jet fuel produced from sustainable supply sources with low-CO_2 emissions in the process from the production and collection of raw materials to combustion)

*3 P2C: Power-to-Chemicals (a CCU/carbon recycling technology that uses renewable energy, renewable hydrogen, etc. to convert CO_2 into products with high environmental value. P2C significantly contributes not only to the reduction of CO_2 emissions but also the dissemination of renewable energy.

*4 FT synthesis: Fischer-Tropsch synthesis (a series of technologies that synthesize liquid hydrocarbons from CO and hydrogen by utilizing a catalytic reaction)



Regional Circular Carbon Society Model (Illustration)

Japan CCS Co., Ltd.

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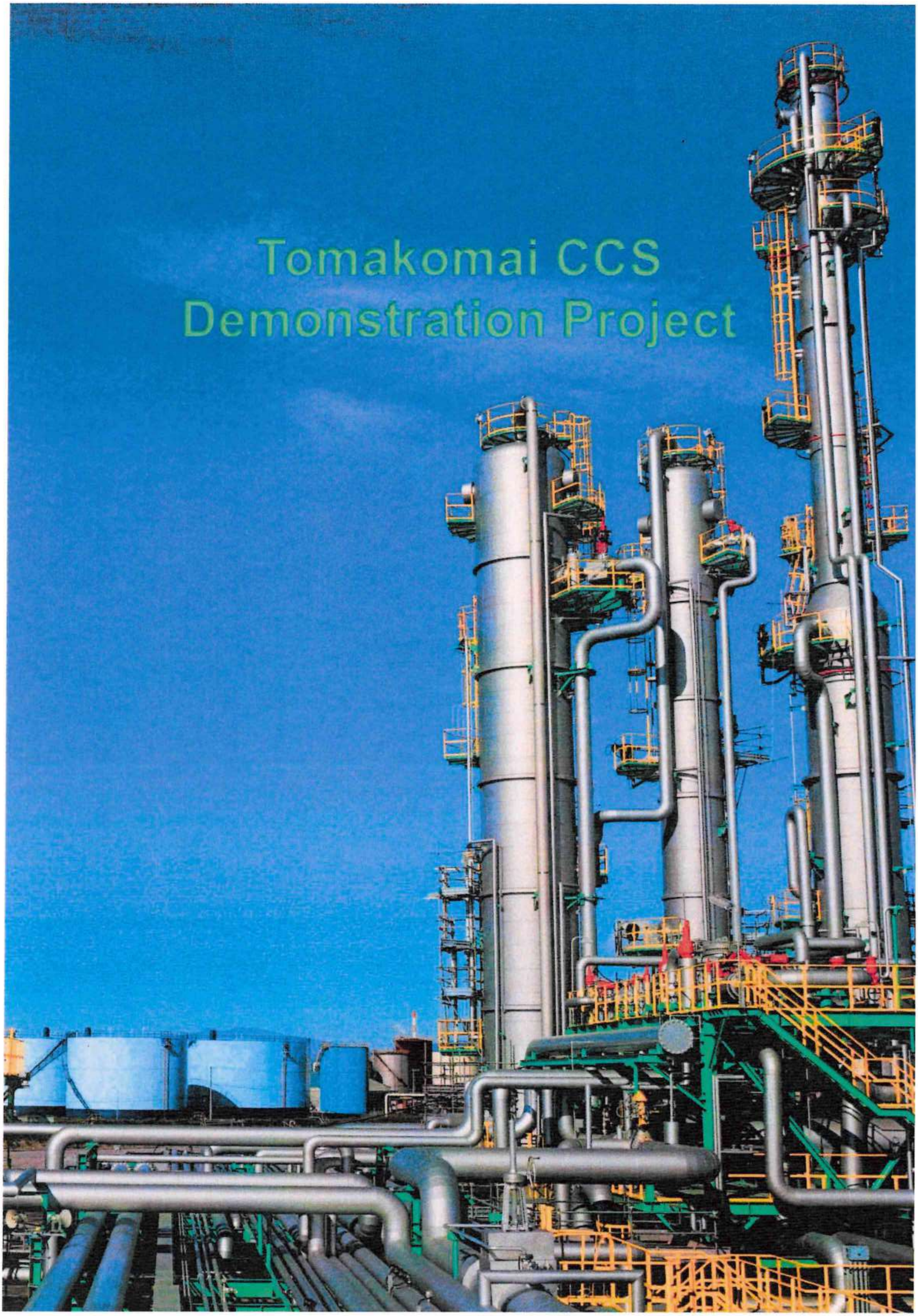

Tomakomai CCS
Demonstration Project

Project at a Glance

Project Description

The Tomakomai CCS Demonstration Project is Japan's first full-chain CCS demonstration project being conducted by Japan CCS Co., Ltd. (JCCS) in Tomakomai City, Hokkaido Prefecture, Japan. The project has been conducted over a 10-year period from JFY 2012 to 2022. The Implementation of the project was commissioned to JCCS by the Ministry of Economy, Trade and Industry (METI) between JFY2012 and 2017, and from JFY2018 by the New Energy and Industrial Technology Development Organization (NEDO) with subsidies from METI. The objective is to demonstrate the viability of a full CCS system, from CO_2 capture to injection and storage. After a 4-year period of the construction of facilities, the demonstration operation commenced in April 2016 by capturing, injecting and storing approximately one hundred thousand tonnes/year or more of CO_2 in offshore reservoirs in the Tomakomai port area. On November 22, 2019, the project successfully achieved the target of 300,000 tonnes cumulative sub-seabed CO_2 injection, confirming the safety and reliability of CCS.

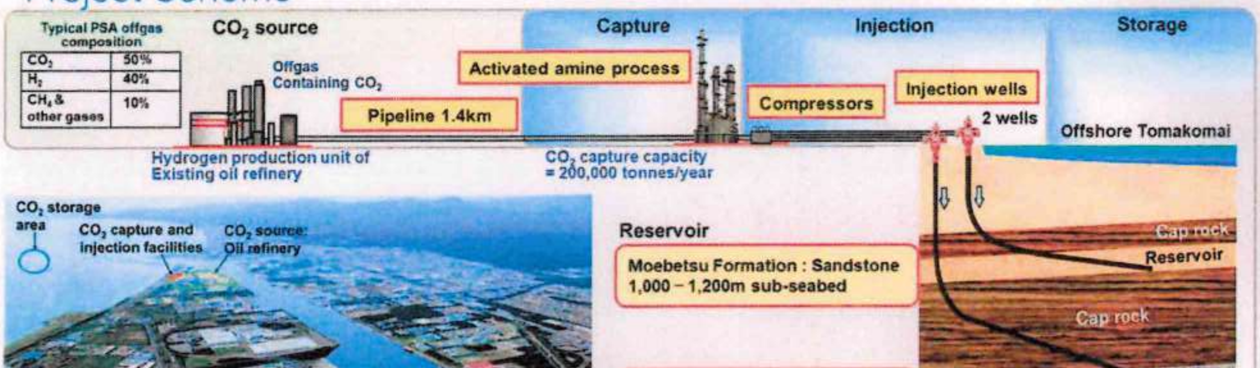
The post injection monitoring stage is being conducted under the commission of NEDO.

Project Site: Tomakomai City, Hokkaido

Main CCS Parameters

CO_2 Source	Capture Type	Reservoir	CO_2 Injected	Storage Type
Hydrogen production unit in oil refinery	Industrial separation/ Chemical absorption	Sandstone layers at 1,000-1,200m depth Volcanic and volcaniclastic rocks at 2,400-3,000m depth	Cumulative injection: 300,110 tonnes Injection period: Apr. 6, 2016 - Nov. 22, 2019	Deep saline aquifers under seabed

Project Scheme



Objectives & Tasks

- Demonstrate an integrated CCS system from capture to storage
- Confirm existing technologies adopted in the system work properly and efficiently
- Demonstrate that the CCS system is safe and reliable
- Confirm effectiveness of METI site selection guideline by demonstrating no leakage
- Remove concerns about earthquakes by the data collected
  - Natural earthquakes have no effect on stored CO_2
  - No perceptible tremors are caused by CO_2 injection
- Confirm that guidelines for building and improving geological models are appropriate
- Prepare technical standards of operation and safety for practicalization of CCS technology
- Disclose project information & data and enhance understanding of CCS by the general public
- Clearly define areas to be improved or solved for commercialization

Progress to Date & Demonstration Schedule

Selection of Tomakomai Area

Tomakomai was selected from among 115 candidate sites as a result of comprehensive investigations and site surveys and was authorized by the Evaluation Committee organized by the Ministry of Economy, Trade and Industry of Japan (METI). The data collected by detailed site surveys were used to establish a geological model and to perform simulation of long-term CO_2 behavior prediction. The results obtained revealed that the geological structures and formations in the Tomakomai area were highly suitable for geological CO_2 storage.

Schedule: - Contract Period: From JFY2012 to JFY2023 -

- From JFY2012 to JFY2015: Preparation

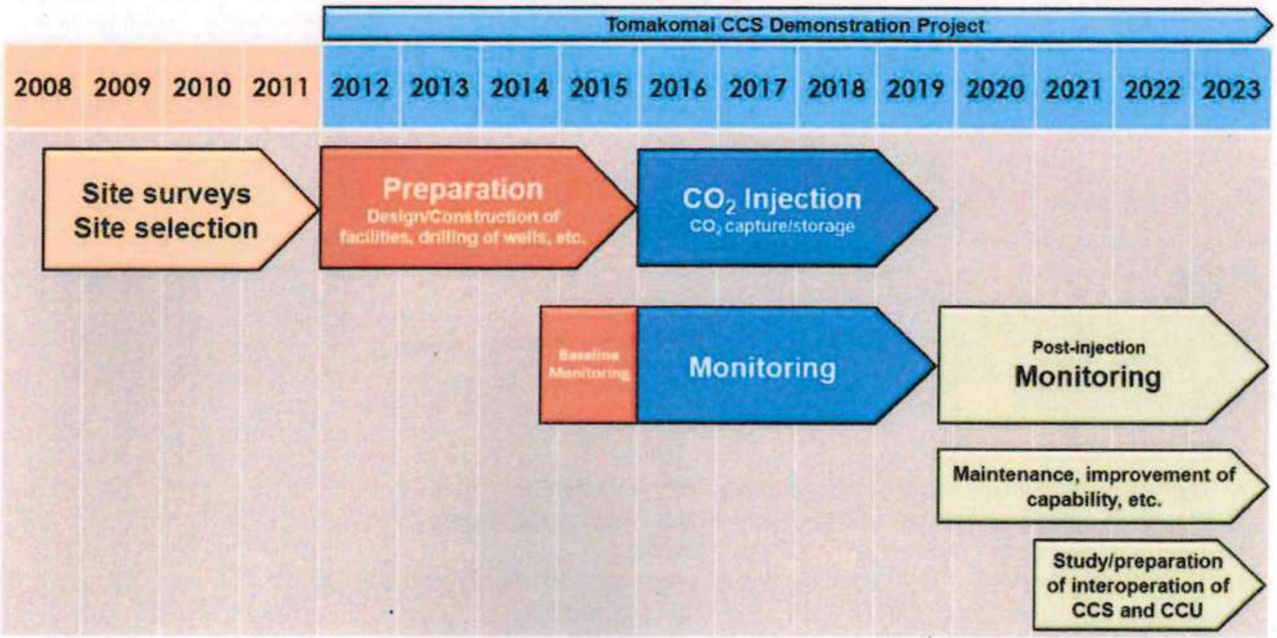
  Activities including the design and construction of facilities, drilling of wells, and preparation for demonstration operation were carried out.

- From April 2016 to November 2019: CO_2 injection and monitoring of CO_2

  On November 22, 2019, the target of 300 thousand tonnes of CO_2 injection was achieved, and injection was terminated.

- From November 2019: Post-injection monitoring, maintenance of facilities, improvement of capability, etc.

- From JFY2021: Study/preparation of the interoperation of CCS and CCU

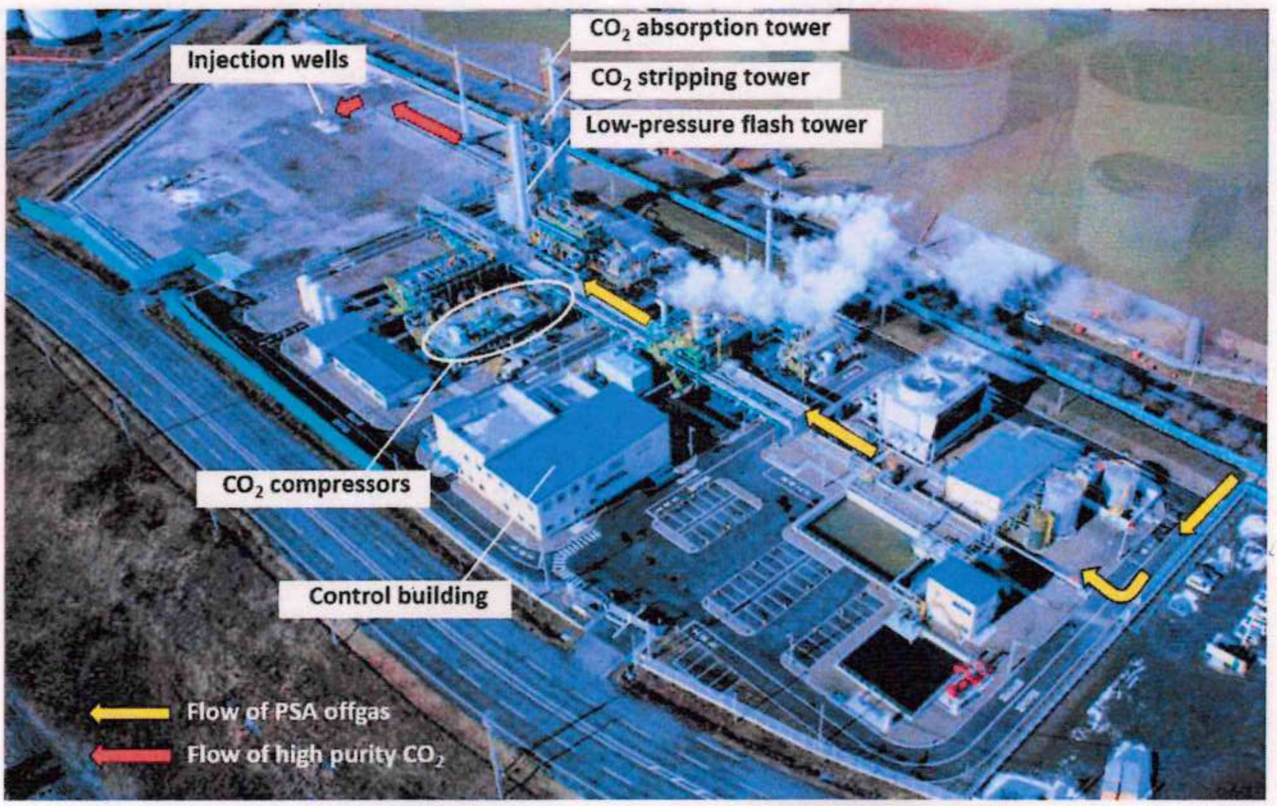


Main Features of Tomakomai Project

Main Features

- First full cycle CCS system deployed in Japan
- Low energy CO_2 capture process → Page 4
- First case of deviated CO_2 injection wells drilled offshore from onshore site → Page 5, 6
  - Cost reduction of drilling, operation and maintenance compared to offshore drilling
  - No disturbance on marine environment and harbor operation
- Extensive monitoring system → Page 7
  - Confirm safety and stability of CCS system
  - Remove concerns about earthquakes
- CO_2 storage governed by Act on Prevention of Marine Pollution & Maritime Disaster (Japanese law reflecting London Protocol) → Page 8
- First case of CCS near urban area; extensive public outreach activities engaging local government, residents and industry → Page 10

Bird's Eye View of Tomakomai Capture/Injection Facilities

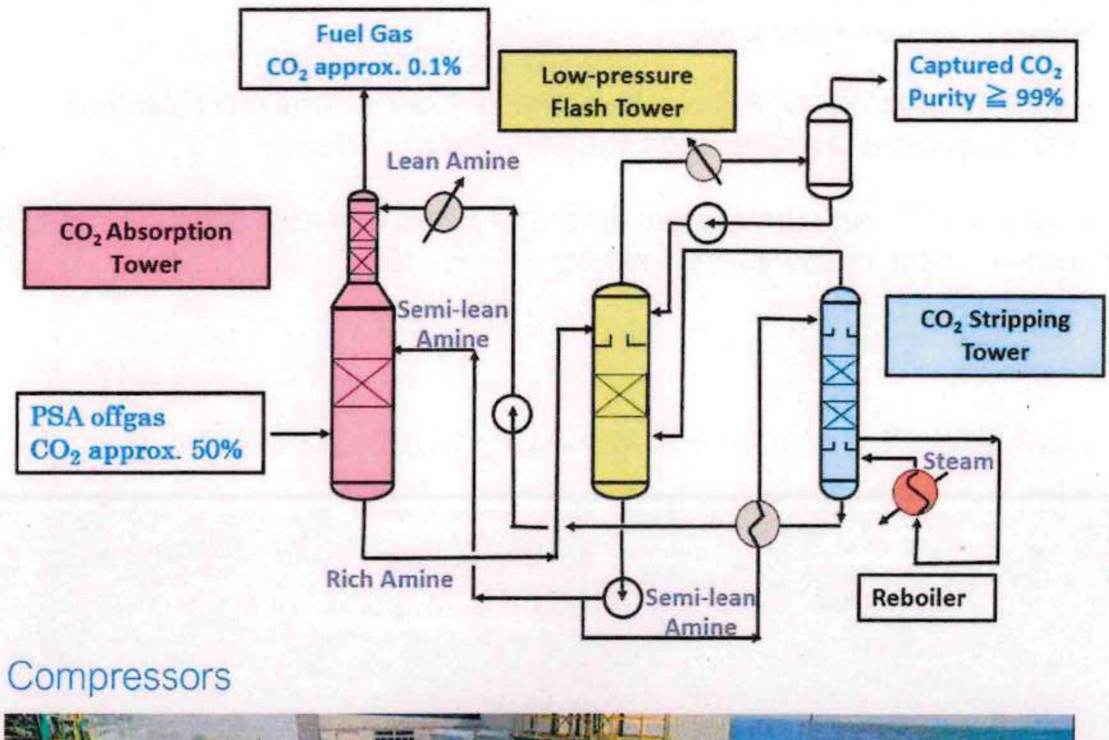


Two-stage Absorption System with Low-pressure Flash Tower

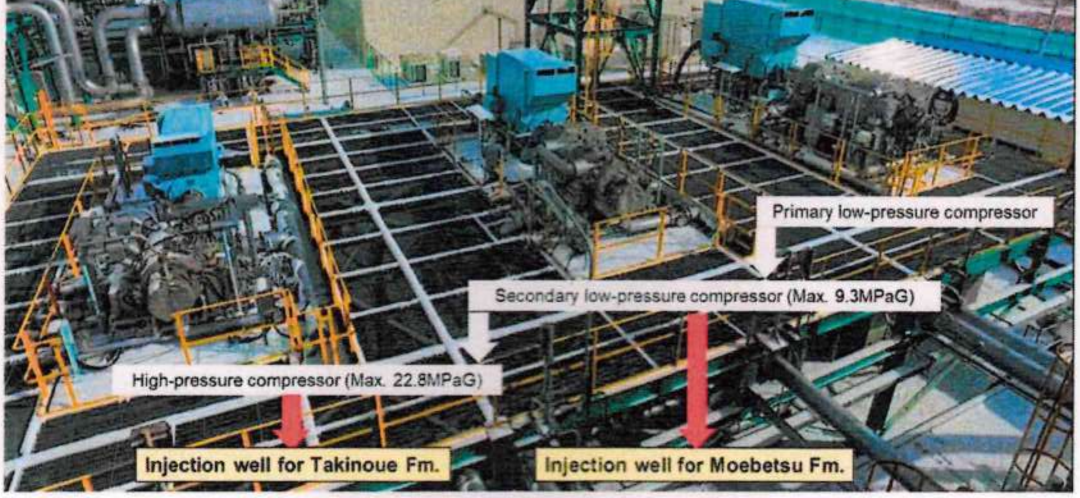
- Depressurization in Low Pressure Flash Tower strips substantial portion of CO_2
- Energy consumption is 1/2 to 1/3 of conventional CO_2 capture process

The CO_2 source is a hydrogen production unit (HPU) of an adjacent oil refinery, which supplies off gas containing approximately 50% CO_2 from a Pressure Swing Adsorption (PSA) hydrogen purification unit. In the capture facility, gaseous CO_2 of 99% purity or more is recovered by a commercially proven amine scrubbing process. A two-stage absorption system including a low-pressure flash tower reduces the amine reboiler duty in the capture system, and achieved a reboiler duty of 0.882 - 0.923GJ/t-CO2 which is 1/2 to 1/3 of a conventional one stage absorption process.

Two-stage absorption process



CO_2 Compressors

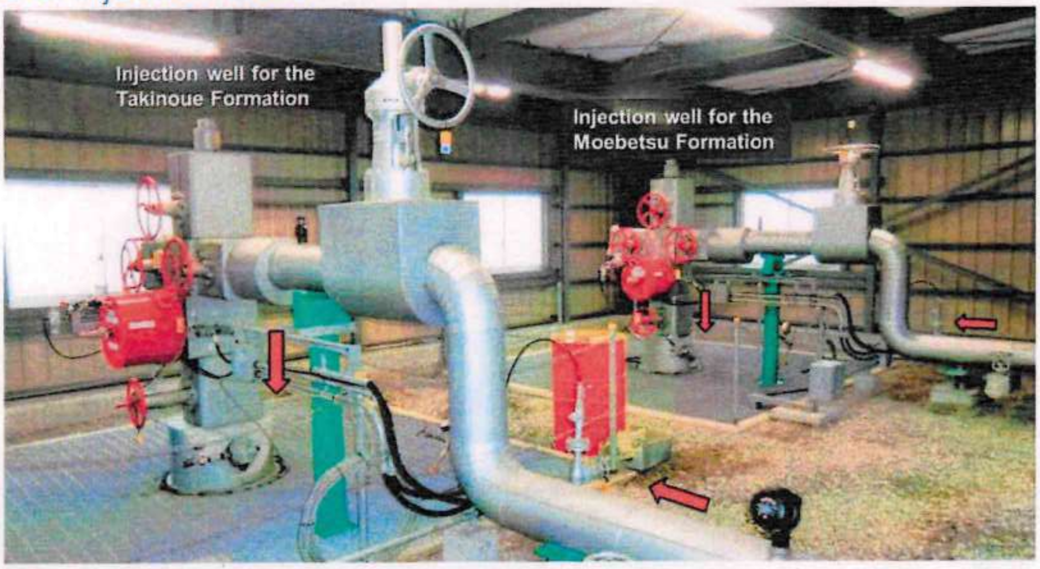


Injecting from Onshore to Offshore

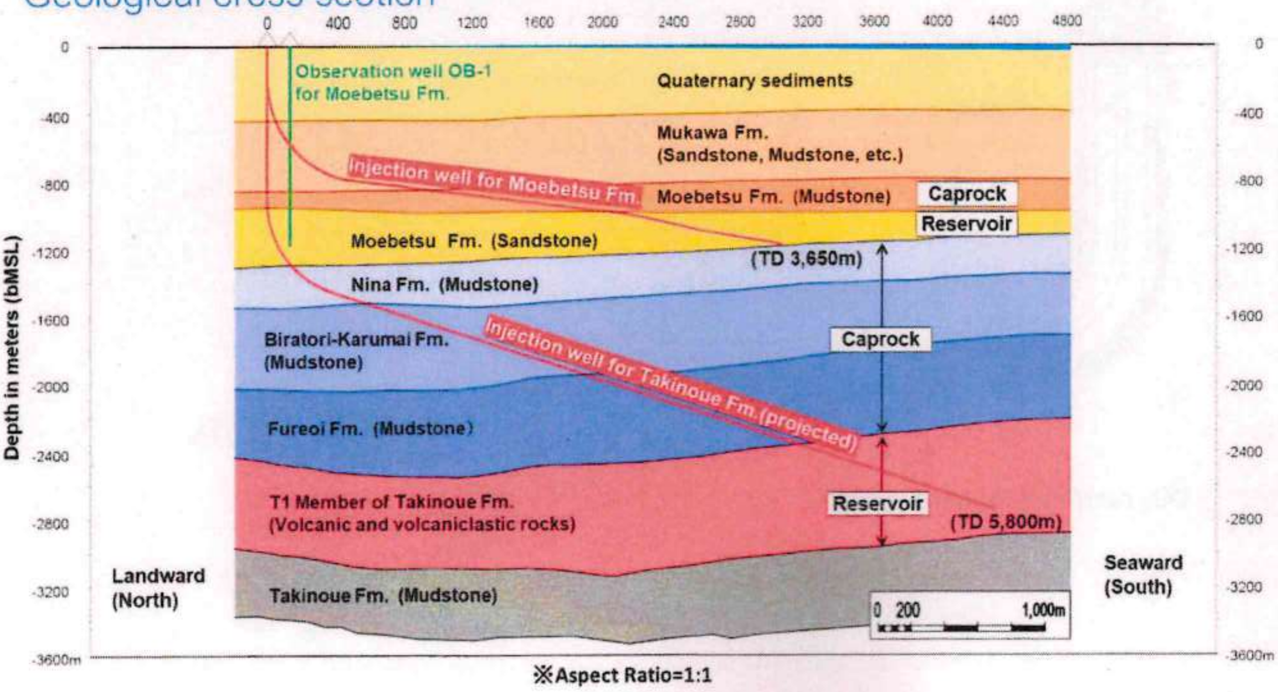
- Deviated wells from onshore to offshore
  - Cost reduction of drilling, operation and maintenance compared to offshore drilling
  - No disturbance on marine environment and harbor operation

At the onshore injection facility, the CO_2 is compressed and injected into two different offshore reservoirs by two separate deviated wells. The storage points are located 3 to 4km offshore. The shallow reservoir (**Moebetsu Formation**), a saline aquifer mainly composed of sandstone located approximately 1,000m below the seabed, was reached by an extended reach drilling (ERD) well with a maximum inclination of 83 degrees, vertical depth of 1,188m and horizontal reach of 3,058m. A perforated liner covered by sand control screens was set over the injection interval of almost 1,200m in length in order to minimize sand flow back into the well. The deep reservoir (**Takinoue Formation**) is a saline aquifer composed of volcanic and volcaniclastic rocks located approximately 2,500m below the seabed. The deep injection well has a maximum inclination of 72 degrees, vertical depth of 2,753m and horizontal reach of 4,346m.

Heads of injection wells



Geological cross section



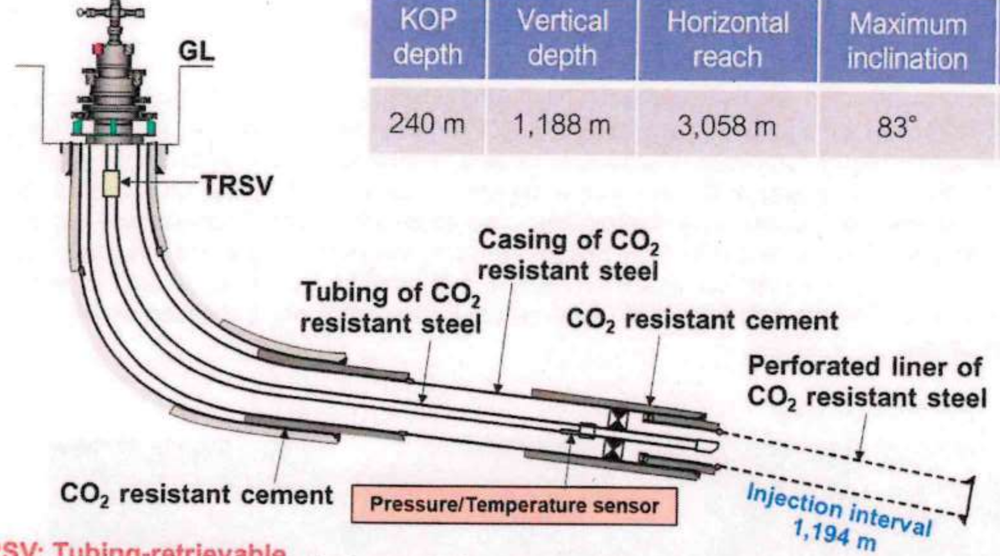
※Aspect Ratio=1:1

Schematic Diagram of Injection Wells

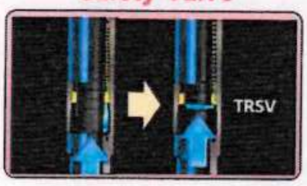
Injection Well for Moebetsu Formation

Drilling: 12th Mar. 2015 - 22nd Jun. 2015

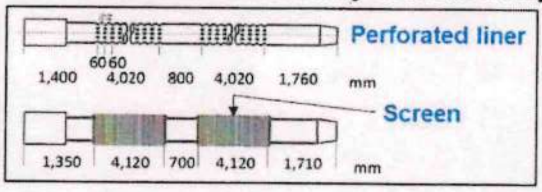
KOP depth	Vertical depth	Horizontal reach	Maximum inclination	Drill depth
240 m	1,188 m	3,058 m	83°	3,650 m



TRSV: Tubing-retrievable safety valve



Perforated liner covered by screens at injection interval



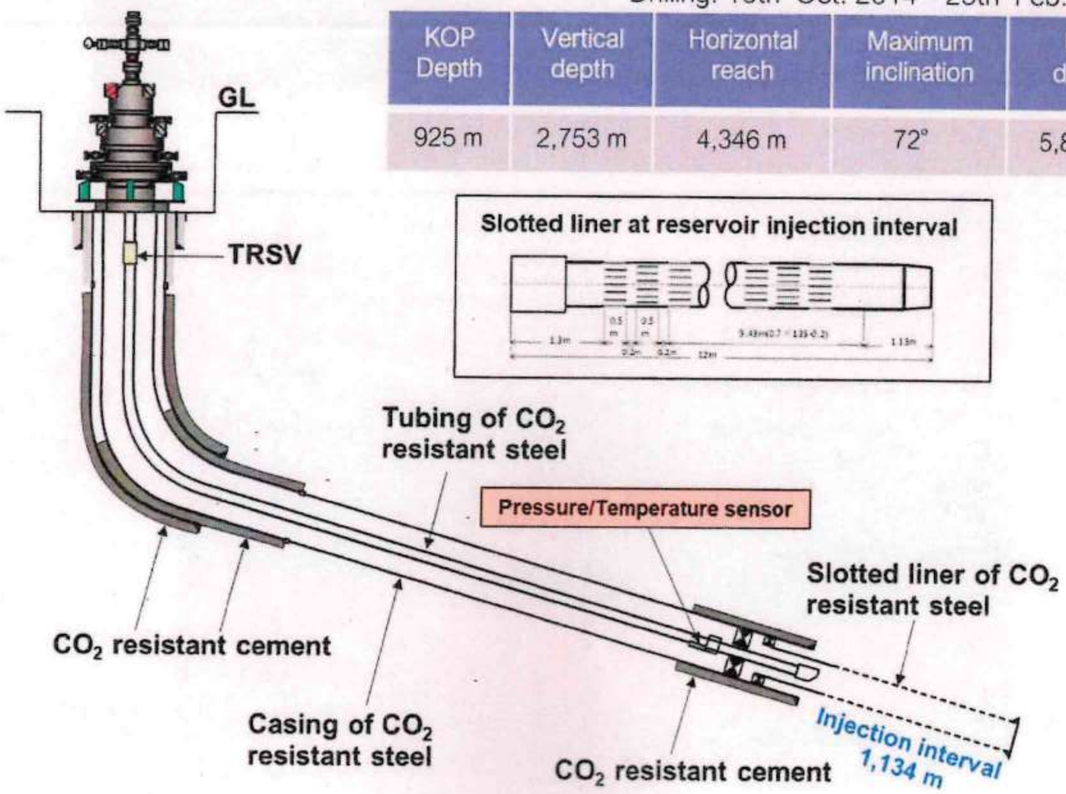
Wire rap screen

Injection Well for Takinoue Formation

Drilling: 19th Oct. 2014 – 25th Feb. 2015

KOP Depth	Vertical depth	Horizontal reach	Maximum inclination	Drill depth
925 m	2,753 m	4,346 m	72°	5,800 m

Slotted liner at reservoir injection interval



Objectives of Monitoring and Verification

- Confirm the safety and stability of CO_2 injection
  - The CO_2 behavior in the reservoirs is being monitored continuously to detect for any CO_2 leakage.
  - Seismic surveys to delineate the subsurface CO_2 distribution, and monitoring of the injected CO_2 volume, formation pressure and temperature are being conducted.
  - Baseline seismic surveys were conducted during the site survey and preparation phases, and time lapse 2D and 3D seismic surveys are being conducted.
  - The monitoring is being used to update a simulation model to predict CO_2 behavior.
- Verify that natural earthquakes do not affect the stored CO_2, and that CO_2 injection does not cause any increase in perceptible tremors
  - Monitoring of natural earthquakes and micro-seismicity is being conducted.
- Monitor the marine environment
  - Marine environmental surveys are being conducted on ocean currents, water quality, seabed mud, marine organisms, etc., in accordance with the "Act on Prevention of Marine Pollution and Maritime Disaster".

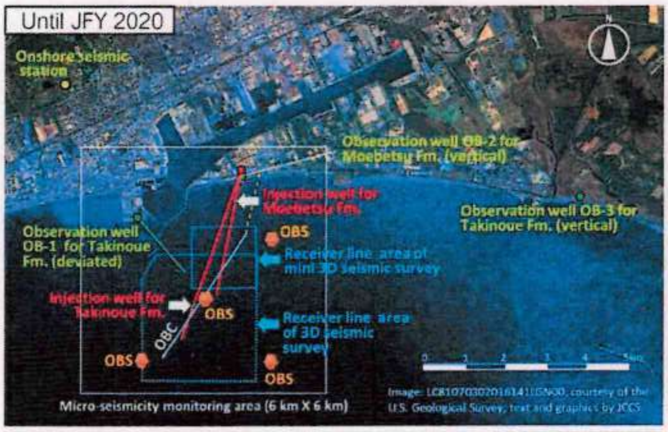
Monitoring System

An extensive monitoring system comprising 3 observation wells, 4 ocean bottom seismometers, 1 ocean bottom cable, wellbore temperature/pressure, and flow meters was established to continuously measure the temperature and pressure of the reservoirs, the flow of CO_2 into the reservoirs, and to monitor natural earthquakes and micro-seismicity.

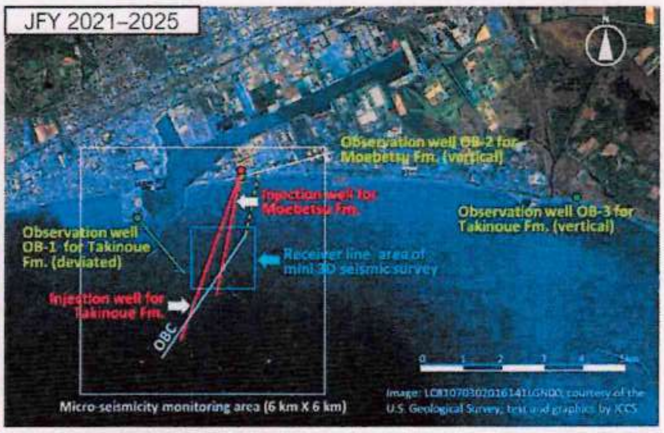
As a result of an optimization study of the seismic observation system, it was confirmed that highly accurate micro-seismicity monitoring is possible without the onshore seismic station and OBSs. Therefore, it was decided to stop the operation of the onshore seismic station and OBSs from FY2021.

Monitoring equipment/work and monitored items

Equipment/Work	Monitored Items
Sensors in injection facility	Temperature, pressure, injection rate
Injection wells •Well head pressure gauge •Downhole pressure/temperature sensor	 Pressure Pressure, temperature
Observation wells •Downhole pressure/temperature sensor •Seismic sensor	 Pressure, temperature Seismicity
Ocean bottom cable (OBC)	Seismicity, receiver for 2D seismic survey
Ocean bottom seismometer (OBS)	Seismicity
Onshore seismic station	Seismicity
2D seismic survey 3D seismic survey 2D seismic survey plus mini-3D survey Mini-3D survey	Distribution of CO_2 in reservoir
Marine environmental survey	Marine data (physical and chemical properties, biological habitat, etc.)

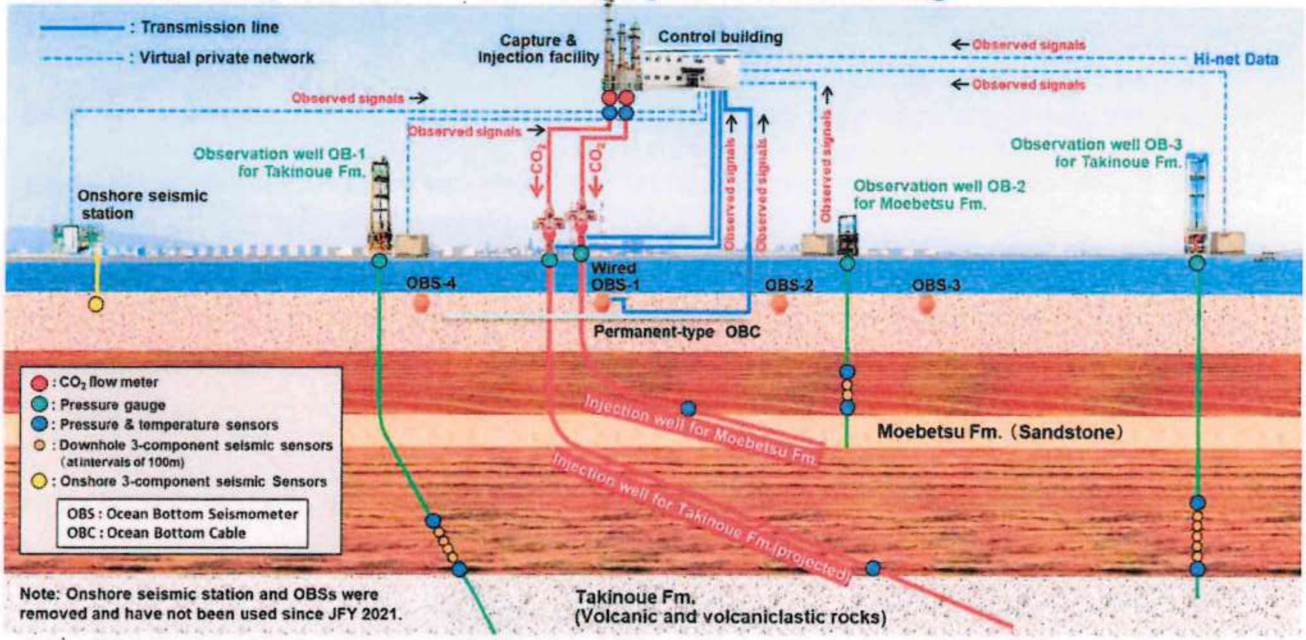


- Onshore seismic station
- Three observation wells
- OBC
- Four OBSs
- Combination of 2D, 3D and 2D + mini-3D seismic survey



- Three observation wells
- OBC
- Mini-3D seismic survey

Schematic Diagram of Sensors Deployed for Monitoring



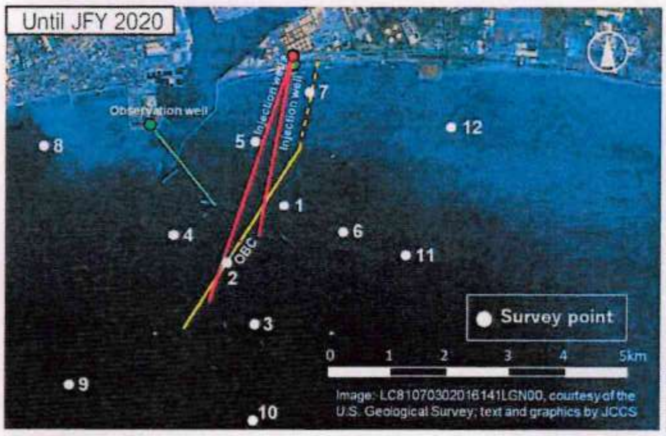
Marine Environmental Surveys

Subsea CO_2 geological storage is regulated by the "Act on Prevention of Marine Pollution and Maritime Disaster", enforced to reflect the London 1996 Protocol. Marine environmental surveys were conducted in FY2013 and FY2014; from FY2016, seasonal surveys are being conducted quarterly.

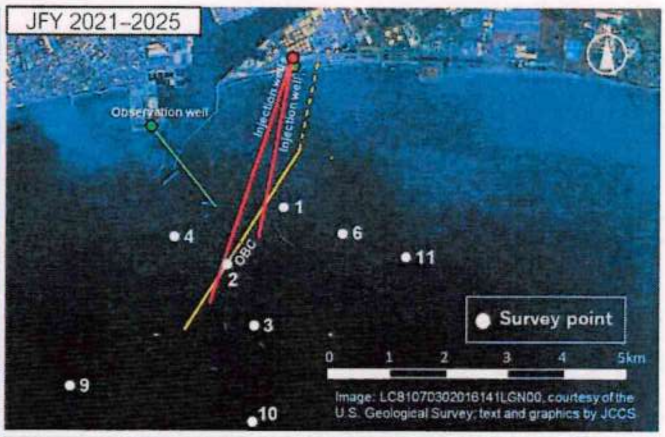
Marine environmental surveys have been conducted under the five-year injection permit (FY2016–2020 and FY2021–2025) from Ministry of the Environment (MOE) which requires the implementation of a "monitoring plan" approved by MOE.

After evaluating the performance and effectiveness of the marine environmental survey results, the implementation items were reduced with the approval of the Ministry of the Environment.

Four survey points shallower than 10 m water depth were excluded because their chemical properties are very unstable by vertical mixing of sea water and atmosphere, and the number of survey points was reduced from 12 to 8. Chemical measurements of sea bottom sediments and benthos observation were changed from mandatory to when necessary.



- Seasonal survey at 12 survey points
- Chemical measurements of seawater
- Chemical measurements of sea bottom sediments
- Plankton observation
- Benthos observation
- Seismic survey (once a year)
- Pressure and temperature at the injection wells and the observation wells



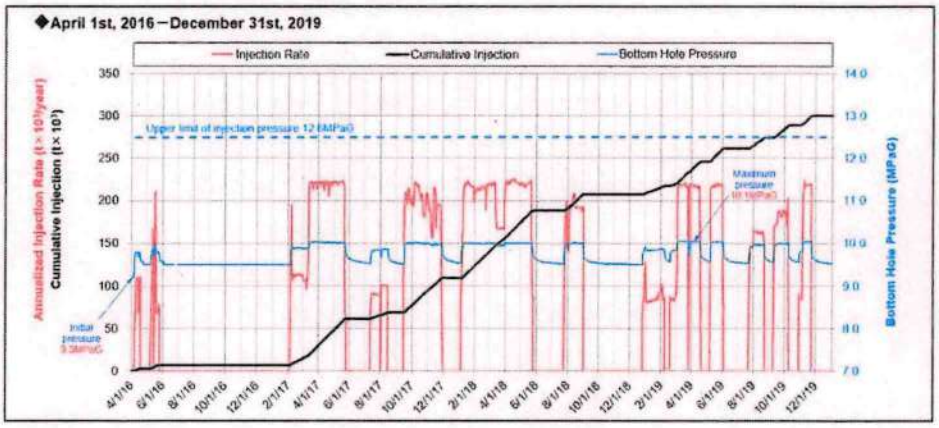
- Seasonal survey at 8 survey points
- Chemical measurements of seawater
- Chemical measurements of sea bottom sediments (conducted as needed)
- Plankton observation
- Benthos observation (conducted as needed)
- Seismic survey (twice in 5 years)
- Pressure and temperature at the injection wells and the observation wells

Key Results

Results of CO_2 Injection

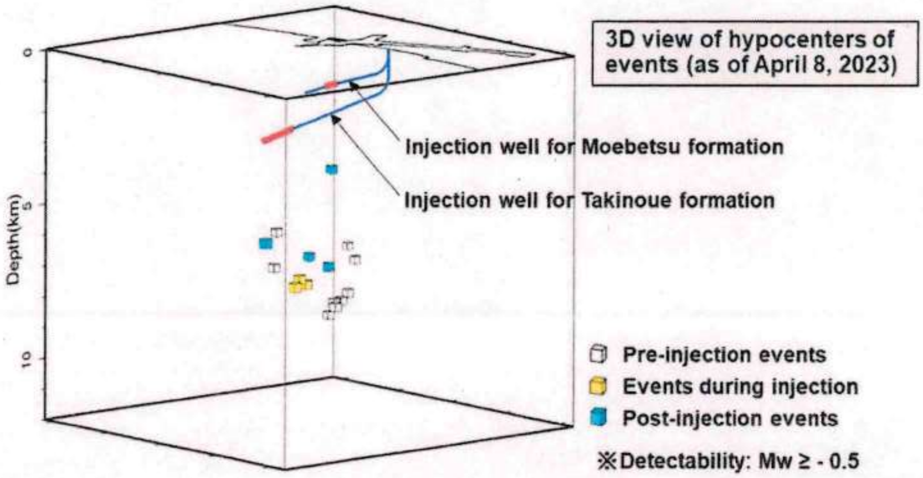
- Achieved 300,110 tonnes cumulative CO_2 injection into 2 reservoirs at different depths (Moebetsu Formation – 300,012 tonnes, Takinoue Formation – 98 tonnes).
- The maximum bottomhole pressures recorded during injection in the Moebetsu Formation were much lower than the upper limit set to avoid destruction of the overlying cap rock.

Injection record of Moebetsu Formation

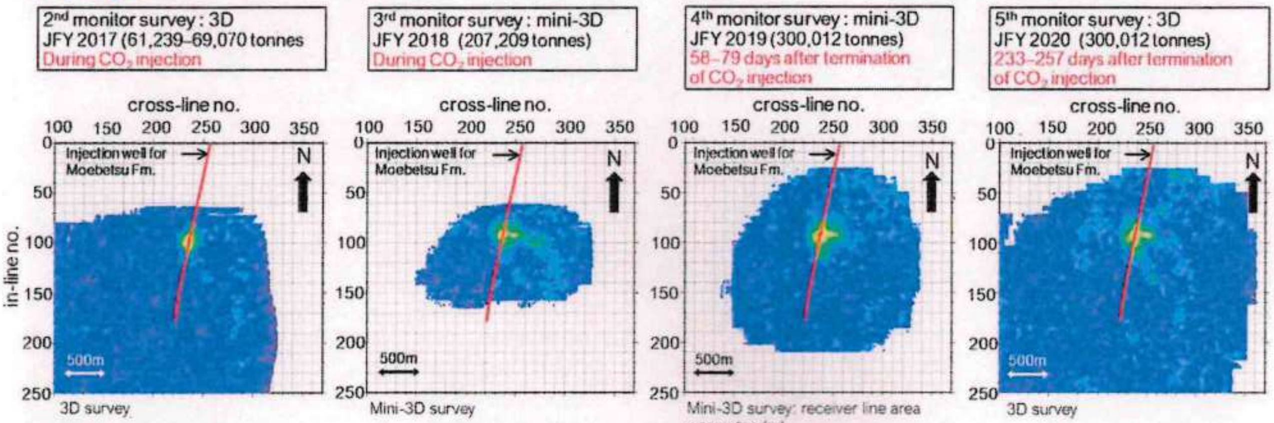


Results of Micro-seismicity Monitoring

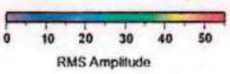
- No micro-seismicity or natural earthquakes attributable to CO_2 injection were detected in vicinity of injection area.



3D seismic survey results: comparison of 2nd to 5th time-lapse 3D seismic surveys



RMS (Root Mean Square) amplitude of difference of monitor survey and baseline survey at the depth of the reservoir (970 to 1050 msec)



In Tomakomai City

Tomakomai City has a population of 169,000 and as the operation is taking place in the port area, intensive stakeholder engagement has been implemented since FY2011. Securing the strong support of the Tomakomai government, a wide range of activities; providing information on JCCS's website, exhibitions and forums for residents, receiving site visits, engaging in consultation and collaboration with government officials and fishery cooperatives, conducting interviews with local and national media, etc., is being carried out.

Tomakomai CCUS/Zero Carbon Promotion Association

- Activities
  - Attraction of CCS Demonstration Project to Tomakomai
  - Information communication to Tomakomai citizens on CCS, etc.
- Chairman : Tomakomai City Mayor
- Secretariat : Tomakomai City
- Members : All major corporations in Tomakomai and industrial associations including Tomakomai Fishery Cooperative

Association Meeting

Newsletters

Various Activities for local communities

Panel Exhibitions

CCS Forums

Site tours & Lectures

CCS courses for senior citizens

Science classes & site tours for school children