THE NIPPON FOUNDATION - GEBCO SEABED 2030 PROJECT

Compendium of Seabed Mapping Use Cases

SEABED 2030 - NLA INTERNATIONAL

BENEFITS ANALYSIS WORKSTREAM (PHASE 3)

Autumn 2024

SECTION: INTRODUCTION

CONTEXT

The Nippon Foundation-GEBCO Seabed 2030 Project's vision to map the world's oceans by 2030 is insightful and ambitious setting a challenging timeline to address the 80% of the oceans that have yet to be charted to the required gridded resolution. The "Wind in the Sails" (WITS) project supports the Seabed 2030 Project by providing empirical evidence to enable the development of a prioritised, targeted survey strategy. The aim of this three-phase project is to unite the global hydrographic community and operators within the marine and maritime domains around an agreed global seabed mapping priority list, underpinned by a robust evidence base that articulates the true need and value of mapping the seabed in its entirety to a defined gridded depth variable resolution.

WITS phases are: (Bold text current phase highlights the current phase of activity, Phase 3)

- Phase 1: Rapid evidence review and fast action priority list.

- Phase 2: Detailed modeling, benefit extrapolation and prioritisation of need.

- **Phase 3: Benefits analysis and targeted community engagement to determine Prioritisation.**

This document is a compendium of Seabed Mapping Use Cases and is a Phase 3 benefits analysis workstream project output.

BACKGROUND AND INTRODUCTION TO THE TWELVE SEABED MAPPING USE CASES

A dedicated WITS Seabed 2030 Benefits Analysis Workstream Workshop in Q1 2023, provided Seabed 2030 Community representative guidance on and identified around thirty key seabed mapping case study application areas that would usefully demonstrate, evidence and articulate seabed mapping benefits / value. In subsequent project meetings with Seabed 2030 management these thirty case study application areas were merged and condensed into a set of twelve use cases to be developed and documented by the WITS project team.

The twelve identified Use Cases together provide coverage and a focus on:

(i) Key marine challenge areas notably climate change, marine biodiversity and disaster management.

(ii) Case studies application topics with the Seabed 2030 international dimension in mind, relevant to Global North, Global South and Small Island Developing States interests and concerns.

(iii) Both established and emerging Ocean / Blue Economy sector interests, and

(iv) The associated hydrographic industrial and technological (innovation) development and associated human capacity building interests and missions.

The condensed twelve Use Cases are listed as follows:

- Use Case 1: Seabed Mapping Innovation
- Use Case 2: EEZ Seabed Mapping in the Absence of a National Hydrographic Organization
- Use Case 3: Subsea Cable Planning and Design
- Use Case 4: Tsunami Propagation and Storm Surge Modeling
- Use Case 5: Renewable Energy - Offshore Wind Energy
- Use Case 6: Climate Change Ocean Models
- Use Case 7: Small Island Developing States (SIDS) Sea Level Rise and Coastal Inundation
- Use Case 8: Marine Biodiversity
- Use Case 9: Small Island Developing States (SIDS) Marine and Coastal Development, and the Use of Seabed Mapping as a Foundation Data for Marine Spatial Planning
- Use Case 10: Government Policy
- Use Case 11: Ocean Discovery and Ocean Exploration
- Use Case 12: Seabed 2030 Driving Hydrographic Industry Expansion and Human Capital Benefits

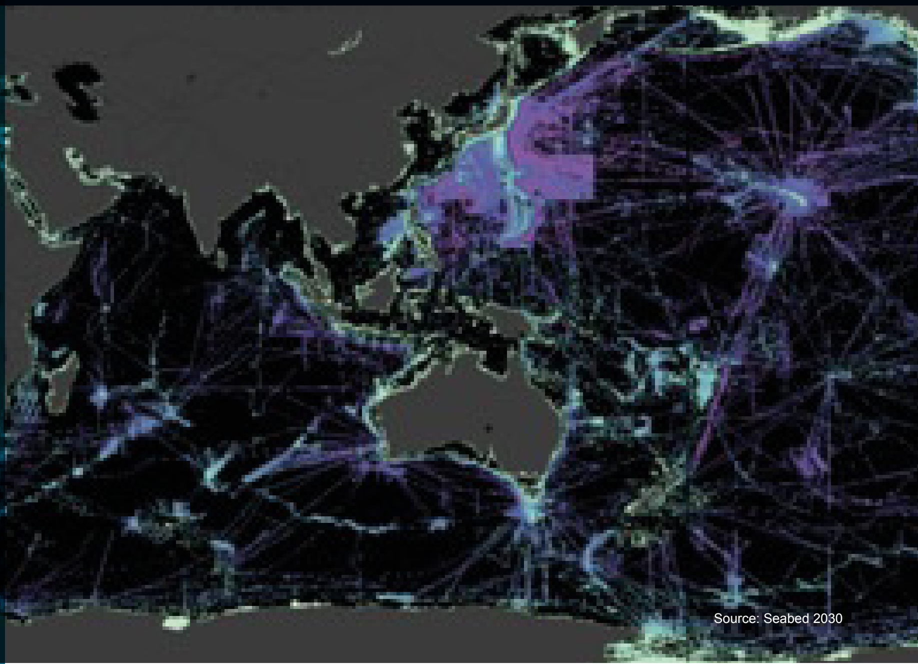
A standardised use case target content and reprographic layout approach was agreed with Seabed 2030 management, and up to five Industry Experts for each use case application subject area nominated and approached. Informing interviews with industry experts were held across a 4-month period, supplemented with desk study and wider use case production work by the WITS project benefits analysis workstream team. In parallel the use case subject areas were engaged on and validated with a wider international community presentation as part of the 2023 WITS Seabed Mapping Benefits Analysis and Prioritisation Engagement Survey rolled out across the IOC and International Hydrographic Organization membership in mid-2023, receiving 198 survey returns.

The resulting seabed mapping use cases presented in this compendium provide a seabed mapping industry and community body of evidence to inform the developing Seabed 2030 seabed mapping benefits analysis model, evidence the evolving Seabed 2030 business case, and to be available to support ongoing Seabed 2030 knowledge sharing activities, PR, and communications. The compendium also forms an important part of the Seabed 2030 Value Proposition Document developed by the WITS Project in 2023/4.

The seabed mapping use cases in this document are augmented by dedicated sections listing acknowledgements, references, and image credits to industry expert contributors for each individual Use Case. In addition, the supplementary reference sources and imagery used in the development and reprographic production of the twelve seabed mapping use cases are also listed.

SECTION: SEABED MAPPING USE CASES

USE CASE: SEABED MAPPING INNOVATION



Source: Seabed 2030

Seabed 2030 is a global initiative where industry, governments, researchers, scientists/academia and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

"To achieve global coverage seabed mapping requires a level of data acquisition and manufacture effort not seen before in the hydrographic survey community. Technology innovation and the adoption of some key emerging technologies are critical to achieving the Seabed 2030 mission"
Jamie McMichael-Phillips,
Seabed 2030 Director,

The Challenge

The world's oceans cover 70% of the Earth. This is about 362 million square kilometres of the total surface area. (Eakins and Sharman, 2010)

Data acquisition in some of the earth's most challenging operating environments; high seas, deep sea, polar sub-ice….

Seabed 2030 is a Global commitment to gather and share seabed mapping data, the sheer scale of this endeavour is a challenge.

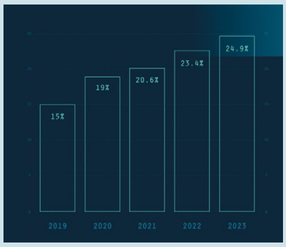
Seabed 2030 mission is a multi-year endeavour, in an ever-changing technology space.

Introduction

The world's oceans cover 70% of the Earth. This is about 362 million square kilometres of the total surface area (Eakins and Sharman, 2010). Seabed 2030 ambition is to source, acquire and collate global ocean coverage of seabed mapping by the end of year 2030. To date we have acquired, processed, and made seabed mapping available for use ~24.9% of the global ocean surface area. This equates to an ocean surface area of ~ 106 million Km², with ~256 million Km² remaining to be acquired, processed, and made available for use. This is a huge opportunity with effort required.

Leading Industry Experts have highlighted key emerging technologies and innovations supporting Seabed 2030 mission success, including across five key mission areas: (i) Platforms, (ii) Sensors, (iii) Emerging Survey Strategies, (iv) Data Processing / Data Production, and (v) Data Collation, Management and Publication.

Seabed 2030 ocean coverage has increased from 15% in 2019 to 24.9% in 2023, as announced in May 2023. In the year between 2022 and 2023 an additional 5.4 million square kilometres of new data – equating to an area twice the size of Argentina – was added to the definitive map of the world's ocean floor.



Source: Seabed 2030

Through leveraging current and emerging technology innovation at all stages of seabed mapping manufacture [acquisition, processing/production, and through to publication] we can achieve the Seabed 2030 ambition.

Our Market Research Shows:
88% of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030)".


Source: Fugro

Source: **Saildrone**


Source: SEABER

Highlight Emerging Technologies and Innovations supporting Seabed 2030 Mission

The Seabed Mapping community has historically experienced steady rate adoption of sensor technology enhancements, bringing through associated software enhancements through close working with equipment and software manufacturers and suppliers. Further, the community has been able to and leverage wider mainstream ICT enhancements and advances in hardware/compute, and do this rapidly for onshore operation elements, whilst offshore operation elements typically take longer timelines reflecting lag imposed by operating circumstances, e.g., the dependency on performant communication networks, batteries constraints, among others.

More recently however, we are seeing **key emerging technologies and innovations that are potential game changers for seabed mappers and anticipate that many of these will be mainstream and available to support Seabed 2030 mission timescales.** Most impactful, we are experiencing the **mainstreaming of cloud and maritime satellite communications** which are fundamentally benefitting data processing, publication and data storage and dissemination. Industry Experts also identify **two megatrends namely Autonomy and AI/Machine Learning** that are now coming through from successful research and demonstrations into day-to-day operation. An abundance of niche innovations and developments are also significant, in areas such as **battery capabilities and sensor miniaturisation**. Together these present real opportunities for seabed mappers reducing required effort, cost, and time, whilst optimising safety of operations, and ensuring data quality in line with required standards. Further realising scales of manufacture and efficiencies of operation not seen before.

Example Emerging Technologies and Innovations in selected mission areas include:

#Platforms: A portfolio of platform options are now at community disposal, including Satellite, Aerial, Surface, Underwater platforms, with key advances in power sources (Battery, Solar PV, and HVO Fuels), Autonomy and Communications.

#Sensors: Advances in Satellite Derived Bathymetry (SDB), LiDAR, Synthetic Aperture Sonars, sensor miniaturisation, multibeam echosounders, (e.g., calibrated multibeams (backscatter) and new multibeam geometries, software defined sonars, among others).
#Emerging Survey Strategies: Autonomous delivery systems, sparse arrays, and swarm (where a parent vessel coordinates a fleet of smaller vessels), and edge compute.
#Data Processing / Data Production: Cloud storage and compute, better integration of Sound Velocity Profile (SVP) data, better estimates of uncertainty and automated processing tools.
#Data Collation, Management and Publication: Cloud storage and compute, advances in marine data infrastructures and more infrastructure being implemented / available globally. Increasing standards mainstreaming and data fusion upon request and tailored to user needs. Also advances in satellite communications with enhanced bandwidth and availability, among others.

Industry Experts also emphasised the importance of governance and enablement through international and national government leadership to invest in and accelerate adoption. Key Agencies involved in seabed mapping, such as NOAA, NOC, UKHO, SHOM, among others are running research and innovation programmes, while International/National Bodies such as IOC and IMO are providing leadership on policy informing regulatory elements in support. Seabed 2030 also supports innovation alongside capacity building through day-to-day promotional activities, and targeted parallel activities of Nippon Foundation. Seabed 2030 industry partners such as **Vessel/Acquisition:** Fugro, Kongsberg, Ocean Infinity, QPS, Saildrone, SEA-KIT, Seatrek, SEABER, Terradepth, and **Software/ Processing:** Argans, Esri, Fugro, IIC Technologies, TCarta, and Teledyne CARIS are implementing technology advances and innovations into their operations, and as in many technology areas this occurs often at a faster rate of adoption compared to government counterparts.

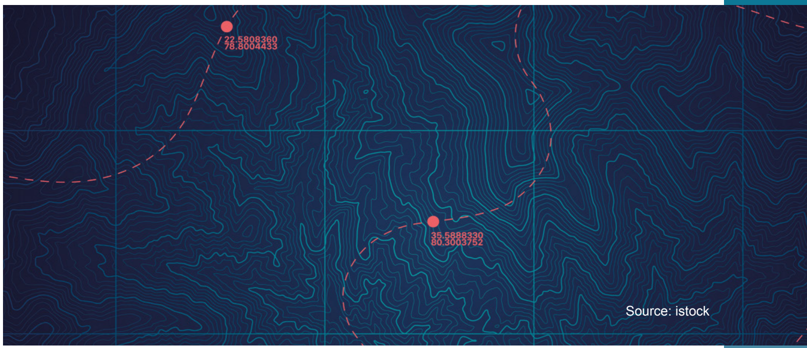
Industry Experts acknowledge emerging technologies and innovations are supporting and have a massive contribution to make towards the Seabed 2030 mission. They are buoyant and upbeat, stating we have the technologies, knowledge, capabilities, and capacity to achieve global ocean coverage of seabed mapping by 2030.

EMERGING TECHNOLOGY AND INNOVATION VALUE ADDED

The seabed mapping economic benefits and trend data associated with emerging technologies / innovation adoption are strong and to highlight a few key examples. Market intelligence by IMARC Group confirms the Global Hydrographic Survey Equipment Market is exhibiting strong levels of growth (5.78% CAGR) and is forecast to reach US$ 4.1 Billion by 2028. Here, unmanned vehicles, USVs and UUVs hold majorities of total market share positions in their respective categories.

Seabed 2030 Industry Experts anticipate resulting operating/ production efficiencies through emerging technologies and innovation adoption directly leading to savings benefits in cost and time, confirm that the Seabed 2030 mission (i) is achievable where adequate initiative funding is made available, and (ii) can induce significant cost and time savings. By applying a hybrid manned/ unmanned acquisition strategy approach savings in the order of 40% time and cost can be achieved, i.e., a Seabed 2030 initiative budget of US$3 Billion, compared to an entirely manned vessel strategy / approach costing US$5 Billion. [A resulting net saving of US$2 Billion through emerging technology adoption for Seabed 2030 mission].

In addition to the economic case, envrionmental and social benefits also result from emerging technology/innovation adoption, example highlights including: Environmental: Renewable power green fuel uptake [Solar PV, HVO fuels, and battery advances] by survey vessels leading to reducing carbon footprint; Social: Autonomy and communications advances bring capacity building opportunities through remote survey operations controlled from onshore, in turn opening up opportunities for new person profiles to become involved, e.g., parents with young families, disabled persons, among others who may have been deterred through the need to mobilise off-shore and for long periods at sea previously.


Source: istock

Market Intelligence and Insights, *source IMARC Group Market Research Report (Base Year 2022)*
Key Findings: The global hydrographic survey equipment market size reached US$ 2.9 Billion in 2022. Looking forward, IMARC Group expects the market to reach US$ 4.1 Billion by 2028, exhibiting a growth rate (CAGR) of 5.78% during 2023-2028.
#Highlight: the global hydrographic survey equipment market can be segmented into sensing systems, positioning systems, subsea sensors, software, unmanned vehicles, and others. **Currently, unmanned vehicles hold the majority of the total market share.**
#Highlight: the global hydrographic survey equipment market can be categorized into surface vessels, USVs and UUVs, and aircraft. **Currently, USVs and UUVs account for the majority of the global market share.**
#Highlgit: Based on the depth, the global hydrographic survey equipment market has been divided into shallow water and deep water, where shallow water currently exhibits a clear dominance in the market.

BENEFITS

- **Economic Benefits examples include:**
  - Prevailing cost reduction and operating/ manufacture efficiencies to achieve Seabed 2030 mission are evident and anticipated strong.
  - Strong* Direct and Indirect Economic Value anticipated resulting from Seabed 2030 mission. *[*Whilst anticipated strong, available evidences are being collated to be included in a Seabed 2030 Value Proposition]*
- **Environmental Benefits, examples include:**
  - Carbon reduction through adoption of green fuel/ renewable power sources and battery advances.
  - Use of remote survey and sensor miniaturisation approaches further reducing any insitu damage for instance in sensitive habitat areas.
- **Social Benefits, examples Include:**
  - Transition to onshore operations.
  - Capacity building through adoption of emerging technologies and novel approaches, first adoption in marine context, transitioning into terrestrial applications thereafter.

24.9%

Seabed 2030 seabed coverage progress (May 2023)

With an additional 5.4 million square kilometres of new data being added to the definitive map of the world's ocean floor, 24.9 per cent of the seabed is now mapped.

US$4.1 Billion

IMARC Group Market Research Report (Base Year 2022) findings:

The global hydrographic survey equipment market size reached US$ 2.9 Billion in 2022. Looking forward, IMARC Group expects the market to reach US$ 4.1 Billion by 2028, exhibiting a growth rate (CAGR) of 5.78% during 2023-2028.

82%

Our Market Research Shows:

Eighty-two percent of the Seabed 2030 Community identified: "63% would want to access and download seabed mapping data through a marine data portal, and 18% through a platform to create a tailored fused product for own needs"

Future Trend

The economic benefits and trending associated with emerging technologies/innovation adoption in seabed mapping are strong. Given the wide range of research underway and ongoing in Government, Industry and Academia, we see this trend continuing, bringing strong levels of opportunity and benefit for Seabed 2030 mission and delivery.

THE NIPPON FOUNDATION-GEBCO SEABED 2030

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: HIGH

Author suggested qualitative view.

Larry Mayer, Professor and Director, Center for Coastal and Ocean Mapping/NOAA-UNH Joint Hydrographic Center University of New Hampshire

”Our oceans are vast and despite 100 years of effort, our traditional approaches to studying the oceans using large, crewed research vessels, resulted in less than 25% of the seafloor being mapping and in the order of only 5% of the ocean volume explored. Emerging technologies Autonomy, Machine Learning, among others, present significant opportunities to expand and accelerate our seabed mapping coverage and support Seabed 2030 mission.” Larry Mayer, Professor and Director, Center for Coastal and Ocean Mapping/NOAA-UNH Joint Hydrographic Center University of New Hampshire.

Jamie McMichael-Phillips, Seabed 2030 Director

”To achieve global coverage seabed mapping requires a level of data acquisition and manufacture effort not seen before in the hydrographic survey community. Technology innovation and the adoption of some key emerging technologies are critical to achieving the Seabed 2030 mission” Jamie McMichael-Phillips, Seabed 2030 Director.

SEABED 2030 MAPPING INITIATIVE

Our mission is to inspire ocean mapping and deliver a complete seabed map for the benefit of people and the planet. Formed by The Nippon Foundation & GEBCO, Seabed 2030 is a global initiative where industry, governments, researchers, and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

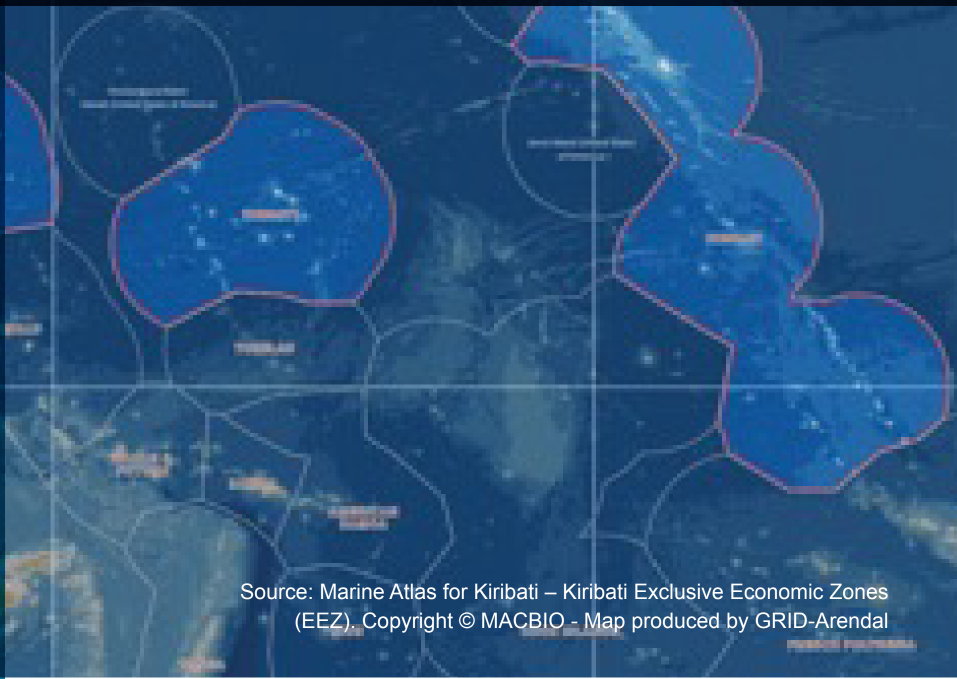
We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
CONTACT US:
enquiries@seabed2030.org

THE NIPPON FOUNDATION · GEBCO General Bathymetric Chart of the Oceans · IHO International Hydrographic Organization · unesco Intergovernmental Oceanographic Commission · 2021 2030 United Nations Decade of Ocean Science for Sustainable Development

USE CASE: EEZ SEABED MAPPING IN THE ABSENCE OF A NATIONAL HYDROGRPAHIC OFFICE

Coastal Nations without Sovereign Hydrography capabilities reap benefits through the use of GEBCO seabed mapping data, often as the only source of ocean depth data within their territorial waters, and for ocean areas not surveyed through PCA arrangements.



Source: Marine Atlas for Kiribati – Kiribati Exclusive Economic Zones (EEZ). Copyright © MACBIO - Map produced by GRID-Arendal

"Coastal Nations without Sovereign Hydrographic Capabilities are potentially important users for GEBCO products, with strong levels of need and requirements for seabed mapping." Jamie McMichael-Phillips, Seabed 2030 Director.

The Challenge

Support Nations in delivery of IMO International Convention of Life at Sea (SOLAS) commitments.

Provision of tailored capacity building towards establishing and enabling Sovereign Hydrography capabilities and competencies.

Focus Primary Charting Authority support towards Nation identified Maritime / Marine priorities and interests, including hydrographic services for:

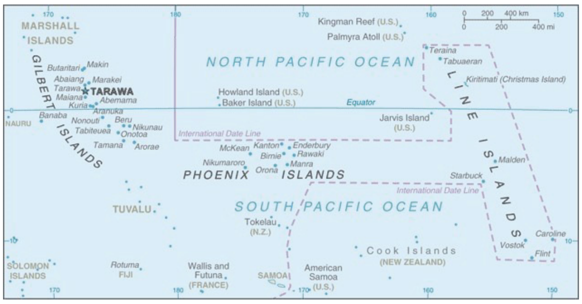
- Maritime infrastructure planning, construction, in-operation and/or future expansion.
- Ocean/ Blue Economy,
- Environment, climate change and climate adaptation,
- Disaster management and disaster risk resilience.

Introduction

The International Hydrographic Organization (IHO) Yearbook August 2023, identifies the rationale behind National Hydrographic Offices as "National hydrographic offices provide services to assist the safe and efficient navigation of ships. The principal service is the provision of nautical information, including nautical charts, Notices to Mariners, sailing directions, data for integrated navigation systems and other products and services. Further that the provision of accurate and up to date charts offers significant economic and commercial benefits through facilitation of maritime trade and other marine activities. It also helps to prevent accidents which may result in the loss of life and property and in pollution of the marine environment".

Many Coastal Nations do not have National Hydrographic Office where functions/ responsibilities may be within wider Maritime Agencies for example at departmental level. Example instances include Port Authorities, Office of Public Works, among other Maritime interest Agencies. Further, Coastal Nations may not have Sovereign Hydrographic capabilities and in these instances, support may be through Primary Charting Authority arrangements (or PCA).

PCA refers to an established Hydrographic Office or Charting Authority supporting another coastal state that does not currently possess the ability to produce its own charts and navigational products. The PCA enables the coastal state to fulfil all its safety of navigation obligations under IMO (International Maritime Organisation) Safety of Life at Sea (SOLAS) regulations. The delivery of seabed mapping through PCA arrangements is estimated to account for ~ 10% of the global ocean area, representing a large part of Seabed 2030 ambition to achieve a complete map of the ocean floor by 2030. Further, Nations without Sovereign hydrographic capabilities potentially have more demand/use for GEBCO grid data or seabed mapping data from other sources such as crowdsourcing within their territorial waters and EEZ, while PCA arrangements support SOLAS requirements, and other maritime priorities such hydrographic data collection towards Nation priorities such as new Port Infrastructure and other Ocean/Blue Economy interests. Seabed 2030 sees these Nations as priority customers with potential needs, requirements and use of GEBCO products and seabed mapping generally.



Source: Kiribati Map - The World Factbook, CIA

Source: istock - Kiribati

Seabed mapping solution

Many coastal nations do not have sovereign hydrographic survey capabilities and receive hydrography support through PCA arrangements. GEBCO seabed mapping may be the only source of ocean depth data within a Nation territorial waters/EEZ while PCA arrangements are established and executed to deliver survey priorities. A number of National Hydrographic Offices provide PCA support, including UKHO, SHOM, Netherlands, USA, Australia and New Zealand, among others. In the instance of UKHO, 63 Nations receive PCA support, with example Nations including: Pitcairn Pacific Islands, Fuji, Montserrat, Bahamas, Barbados, Belize, among others.

Supporting sustainable economic growth
As Primary Charting Authority for a number of coastal nations around the globe, UKHO undertake seabed mapping surveys to enable safe navigation and help communities manage their marine resources and environments to support sustainable economic growth. In Belize, UKHO used satellite methodology to efficiently capture data of large areas with no negative impact on ecosystems and marine life. This data has been shared with the Belizean government to support them in a range of environmental and scientific applications.
Source: UKHO Annual Report 2023

Industry expert Ian Davies (UKHO) identified examples of UKHO working with PCA Nation Partners including a number of Small Island Developing States (SIDS), such as **Vanuatu (Archipelagic State):** providing a number of surveys in key areas e.g., for Cruise Liner access to Ports, minimising associated insurance costs. **St Lucia:** Port development scoping, planning and support to funding bid. **Turks and Caicos:** Redevelopment to bring in Larger Ships and Marine Spatial Planning Portal guidance. **Guyana:** oil and gas exploration, facilitated dredging plan for shipping movements, and instrumental to the Nation rapid economic development. **Kiribati:** survey and support to improve island transport links between 4 islands in the Gilbert Islands and Kiribati fight the impacts of climate change, as well as enabling Ocean/Blue Economy opportunities such as tourism, among others.

Typical Range of PCA Services include:

- Assist in meeting SOLAS obligations for hydrographic services.
- Provide charting services.
- Provide hydrographic surveying services.
- Provide technical assistance and advice. E.g., on the governance and management of data.
- Advocate for support.
- Capacity building and training, e.g., in cartography.

PCA accessing and use of GEBCO seabed mapping data. Industry experts identified key applications of GEBCO seabed mapping data for PCA support including **Depth grid for risk modelling**, for instance in Turks and Caicos depth range from 6m down to 200m, with GEBCO informing risk profile. Use of GEBCO data as **an aid to planning and demonstrating to PCA Nation Partners the need for enhanced survey/other sensor acquisitions.** Further the inclusion of GEBCO products in various **Regional/Global grids for water depths.**

Kiribati Case Study,
source UKHO see here: https://www.admiralty.-co.uk/about-us/case-study/kiribati
The island chain of Kiribati, comprising 32 islands share an average height of just 2m above sea level. Kiribati is on the front line of climate change facing threat from sea level rise.

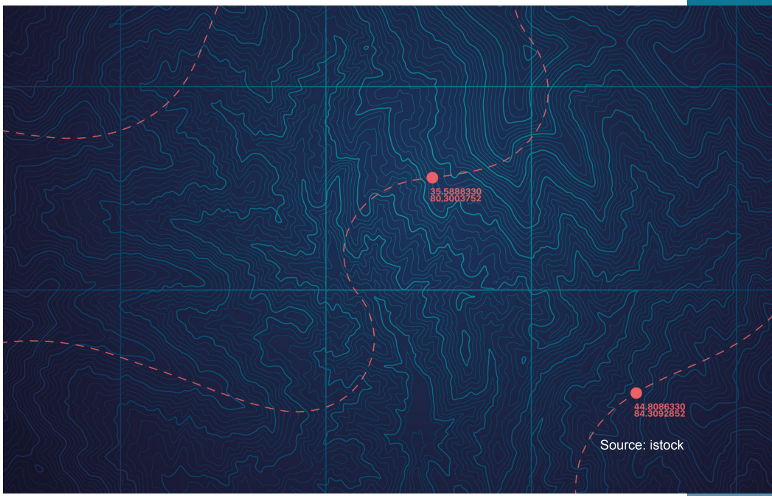
With sea level rise exacerbating the impact of storms, tsunamis and tidal surges, UKHO have been helping Kiribati to monitor and mitigate these effects by gathering vital data – starting with the surveys of islands and atolls spread over 3.5 million Km^2 of ocean. For this, UKHO captured data depicting the seabed with the use of satellite imagery; this method enabled UKHO to access remote areas of ocean, all while minimising the impact on marine habitats that surround the islands. This data was handed over to the Kiribati Government to help them identify areas most at risk to flooding and plan sea defences accordingly.

The data collected will also be used to enable the launch of the Kiribati Outer Island Transport Infrastructure Investment Project. Funded by the World Bank and Asian Development Bank, the project will help to improve maritime infrastructure in the outer islands and relieve the population pressure from its capital, Tarawa.

VALUE ADDED

Coastal Nations without Sovereign Hydrography capabilities reap significant benefit through the use of GEBCO seabed mapping data, often as the only source of ocean depth data within their territorial/EEZ waters ocean areas outside of surveys undertaken through PCA arrangements.

PCA providers use GEBCO data as a depth grid within their risk models and as an aid to hydrographic survey planning. Further, on a regional and global basis GEBCO data forms part of a foundational seabed map mosaic and is used to demonstrate to PCA customers key seabed features that are not present in their Nation knowledge.



Seabed mapping can provide significant value to Coastal Nations through:

- Support to SOLAS and Navigation International Commitments, enabling safety at sea and enabling ocean trading.
- Enabling socio-economic development and many areas of the Ocean/Blue Economy.
- Underpinning a wide range of Ocean and Marine Scientific Research, and
- Inform Nation preparation for and mitigation of global challenges such as climate change, sea level rise, and major disasters such as volcano, tsunami and tide surge flood events.

Use case industry experts identify Nation indirect economic value Economic Value ROI of between 1:8 and 1:10 for every US$ spent on PCA hydrographic surveys / good bathymetric data acquisition.

BENEFITS

• Support to SOLAS and Improved Navigation

Seabed maps enable governments to establish safer and more efficient shipping routes, reducing the risk of accidents and delays.

• Resources management

Detailed maps help identify and sustainably manage valuable resources like oil, gas, minerals, and fisheries.

• Environmental Protection

Seabed mapping supports the monitoring and conservation of vulnerable marine habitats and ecosystems.

• Disaster Preparedness

Accurate maps of the ocean floor contribute to better understanding of natural hazards, like tsunamis and coastal flooding, allowing for better preparedness and response.

87.7%

Our Market Research Shows:

Eighty seven percent of the Seabed 2030 Community state: **"High Seas seabed mapping** data is a very useful foundation data, supporting a wide range of ocean economy, marine and maritime activities / uses".

90.7%

Our Market Research Shows:

Ninety percent of the Seabed 2030 Community state: "Seabed mapping data has an important role to play in informing decisions and promoting the sustainable use of our ocean / marine resources".

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030)".

Looking Forward

Seabed mapping supports Nation Sovereign maritime commitments and interests and is an enabler of Ocean/Blue economy. The delivery of seabed mapping through PCA arrangements is estimated to account for ~ 10% of the global ocean area and represents a large part of Seabed 2030 ambition to achieve a complete map of the ocean floor by 2030.

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: HIGH

Author suggested qualitative view.

UKHO Helping Kiribati combat the effects of climate change

”PCA arrangement can really make a difference. For Government of Kiribati, UKHO has assisted Kiribati in combating the effects of climate change, by providing data gathering support in the low-lying island chain of Kiribati helps in the protection of 115,000 people from coastal inundation tempus.” Source UKHO, with work delivered in collaboration with the Foreign Commonwealth and Development Office, World Bank and Asian Development Bank

Jamie McMichael-Phillips, Seabed 2030 Director

”Coastal Nations without Sovereign Hydrographic Capabilities are potentially important users for GEBCO products, with strong levels of need and requirements for seabed mapping.” Jamie McMichael-Phillips, Seabed 2030 Director.

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We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
CONTACT US:
enquiries@seabed2030.org

THE NIPPON FOUNDATION-GEBCO SEABED 2030

USE CASE: SUBSEA CABLE PLANNING AND DESIGN

Source: istock

Subsea cables are critical infrastructure. There is a vast subsea cable network of power and telecommunications traversing the globe through our oceans. Seabed mapping is critical to subsea cable planning.

"Bathymetry will remain the baseline." Industry Expert

The Challenge

Identify the most efficient and cost-effective subsea cable route and design.

Understand the seabed terrain and geomorphology to:

- Identify subsea cable route geometries and cable seabed attachment point locations.
- Plan locations of cable junctions. Cable spurs, cable cross-over points and landing areas.
- Identify (to avoid) key seabed related risk areas and hazards (sea mount areas, trenches, and slopes).

Foundation data for wider route planning/ design studies such as environmental impact assessment, among others, and for 3d base map use across all subsea cable lifecycle stages.

Introduction

Subsea cables are critical infrastructure and include both telecommunication and power cables traversing the oceans and seas. They are critical to everyday quality of life, with telecommunications subsea cables supporting global digital communications and transactions, ranging from security to banking transactions. Such transactions underpin global GDP, value US$ trillions. Power subsea cables disseminate power from source to point of use, provide levels of energy resilience and security for and between nations. Further, any infrastructure in our oceans requires power and telecommunications connectivity, with industry experiencing ever-increasing demand for new cables to support key ocean applications such as offshore renewables, oil and gas, and other smaller yet important applications such as ocean-based sensor and monitoring networks, among others.

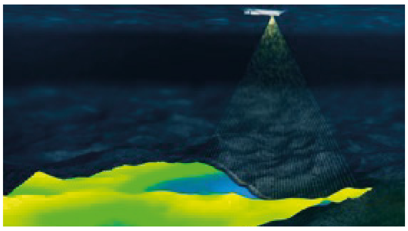
Telegeography, a telecommunications intelligence company, estimate as of early 2023, there are 1.4 million kilometres of submarine cables in service globally. For interest,one of the longest cable systems is the Southeast Asia - Middle East - West Europe 3 system (SE-ME-WE-3), with a total installed length (including branches) of almost 40,000 km, Source ICPC. A mature industry ecosystem participates in the subsea cable sector, including some 600 cable installation companies globally, specialist equipment manufacturers (e.g., specialist cable installation and maintenance vessels, ROVs, and cable ploughs, among others), with marine survey, engineering and consulting companies providing planning, engineering design, survey, environmental, finance and legal services supporting from planning, through design, installation, operation and decommissioning.

Cable routes cross oceans, join nations and regions with each other. A cable route may be multiple thousands of kms long and may be planned for an operating lifetime of multiple decades e.g., 20 – 30 years. Cables typically lie on, are attached to, or buried in the sea floor, and in some instances, they are suspended at known depths. Spurs run out to islands and to infrastructure such as oil platforms, renewable energy fields.

A single subsea cables route may involve many hundreds of US$ millions investment, through public/private investment. A consortium of telecommunications companies and investors will typically come together to finance and commission subsea cable works as individual major projects.

The seabed terrain and geomorphology are fundamental to determine subsea cable routes, and seabed mapping plays a critical role supporting project concept discussions, cable route planning, particularly during the Cable Route Desktop Study (DTS) phase, and thereafter as an input to inform other cable planning considerations such as EIA, decision-making through design and into operations and eventually de-commissioning lifecycle stages.

Source: Fugro



Source: Seabed 2030

Source: OceanIQ®

Cable route planning and design is highly dependent on Seabed Mapping

Subsea cables lifecycle key stages are: planning, design, manufacture, construction/installation, operation and maintenance, and decommissioning. Seabed mapping is used across all lifecycle stages as a foundation data and 3d base map backdrop in key systems. An industry expert captured this sentiment well stating: **"Bathymetry will always be the baseline."**

It is during the **seabed cable route planning and design stages** that seabed mapping is critical, and this includes **general bathymetry data such as the GEBCO Grid Data**, and later while informing more detailed design decisions, the use of **new acquisition bathymetry data, bespoke and commissioned on a subsea cable project case by case basis.**

The GEBCO Seabed Mapping is seen as foundational for subsea cable routing and widely use. This data is often the only 3-dimension data of the sea floor initially and readily available and is leaned on to support initial project concept discussions by consortia at formation stage, early business case development work, and all early planning work before budgets are allocated for follow-on work where new bespoke bathymetry survey will be commissioned. Further, in some instances when considering power and telecommunications cable spurs and connectivity to/between small island or remote ocean areas settings the GEBCO Grid data may be relied upon well into design stage or during design while new survey data is acquired.

Industry experts identify that GEBCO data is used at **initial route planning concept stage** alongside other key data on volcanicity, natural phenomena data such as earthquake risk data, and data on human activities such as vessel traffic **to identify potential issues the cable will have to deal with. The seabed mapping purpose here is to inform rough order of magnitude budgeting, considering deep water, shallow water, and connection to land elements, with the seabed mapping providing details on seabed morphology, and the need to avoid obvious obstacles, like seamounts. Also, to avoid/minimise cable break resulting from slope modification** (e.g., in earthquake, tremors, land slip events), the cable is run at right angle to slope. **GEBCO data is also used to inform more detailed bathymetry survey planning.**

A **Desk Top Study (or DTS), is commissioned for each Subsea cable project, typically in compliance with ICPC Recommendation No 9, 'Minimum Technical Requirements for a Desk Top Study'.** To summarise, the DTS examines the **impact on the planning, installation, and operation of the cable system: routing selection and landing, geology; climatology; seismology; oceanography; commercial operations; restricted areas and obstructions; biological factors; and regulatory factors**. Further, the DTS **identifies risks and risk mitigation for the subsea cable.**

Bathymetry plays a key role during the DTS, and here a depth differentiation occurs in practice. Within the area from the coastline out to 1000-1500 metres depth, and sometimes out to 2000 metres depth, multibeam bathymetry is used to identify objects, debris, and obstacles down to a meter cubed. Then at greater depths, side scan acquisition strategies may be adopted to provide detail on the seabed surface. **As an example, at 4000m depth, a 50-meter grid is considered ideal for subsea cable route planning purposes.**

At this stage bathymetry working in conjunction with other design data informs the cable route and wider design elements. For instance, the seabed mapping is an input to the EIA, and the cable route and design responds to seabed morphology, (structure and type). For instance, seabed type may determine cable route and laying strategies, such as burying cables in clay, determine any need for armouring the cable in gravel, rocks and/or use of concrete to ensure a stable base for the cable in places. **[The ideal seabed for cable routing is a benign and featureless seabed]. Undersea cable repeaters are positioned ~every 100 Kms and need to be installed flat and horizontal to the seabed, again informed by bespoke bathymetry survey-based seabed mapping data.**

Looking forward, Industry experts identified there are a number of major subsea cable projects in planning and anticipated going forward. Further, the subsea cable sector is experiencing a take off in demand both in the power sub-sector with the expansion of offshore renewable energy and in particular wind power adoption, and in the telecommunications sub-sector through public national telecommunications network investments and private investment by Big Tech / Global Players, such as Microsoft, Google, Baba, and Tencent, among others. **These trends suggest the demand for both GEBCO Seabed Mapping and the commissioning of more detailed bespoke bathymetry is only going to increase going forward.**

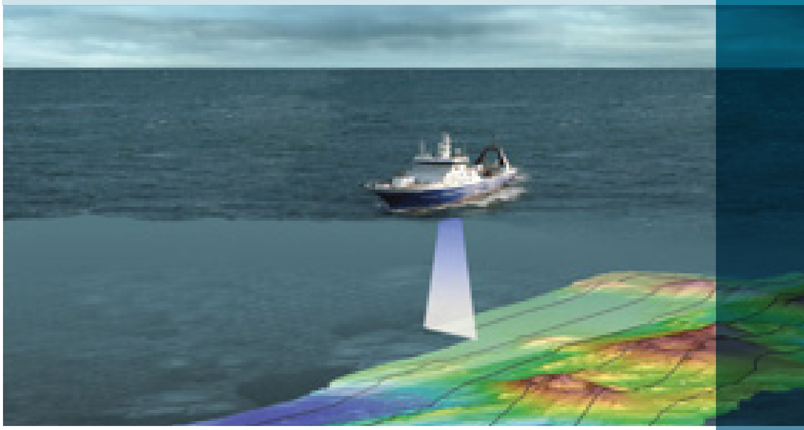
VALUE ADDED

Future Market Insights estimates, the global submarine cable market is expected to grow from US$ 3Billion to US$ 4.38Billion by 2030, with a global market growth rate (CAGR) of 4.8%. Key drivers include: Power: movement towards green energy (wind, wave, and tidal energy generators). Further ENOs interconnection between different countries for energy distribution and energy resilience purposes. Communication: regional/national connectivity use submarine cables, with 95% of transoceanic voice, data and internet traffic being carried by submarine cables [Source: ICPC]. Strong submarine cable sector growth is anticipated globally with highlight regions including: Europe, Middle East, Asia Pacific, and South America. Technology companies such as Google, Amazon, Facebook, Microsoft, Baba and Tencent, among others are major influencers.

Submarine Cables as a sector generally and specifically route planning and design is highly dependent on seabed mapping, including for foundation data purpose, providing 3-dimensional contextual reference, and as data intelligence to inform the optimal route locations and geometries, and to identify and mitigate key risks associated with seabed morphology (e.g., sea floor terrain, slopes, structures, obstacles and type).

Seabed mapping feeds into the planning and identification of the optimal subsea cable route, delivering cost efficiencies optimisation, and contributing to risk reduction and risk mitigation planning. The resulting route and design are then taken forward into implementation, via subsea cable manufacture, installation stages.

Cable routes are carefully surveyed and selected to minimise environmental impacts and maximise cable protection. Source ICPC.



Seabed mapping systems accurately chart depth, topography, slope angles and seabed type. Source: NIWA and ICPC.

Subsea cables account for approximately 10% of the overall CAPEX cost of developing an offshore wind farm, Source Fugro

BENEFITS

• Seabed Mapping Data Is A Foundation Data For Subsea Cable Sector

Seabed mapping is used across all subsea cable lifecycle stages as a foundation data and map backdrop in key systems.

• GEBCO Seabed Mapping Data

Is often the only 3-dimension data of the sea floor initially available and is leaned on to support initial project concept discussions by consortia at formation stage, early business case development work, and before budgets are allocated for follow-on work which typically includes new bespoke bathymetry survey works. GEBCO data is one of the first data used for cable route preliminary investigation and thereafter in DTS.

• Cable Route Planning And Design

Seabed mapping data provides the bathymetric baseline for subsea cable planning and design, providing key intelligence and insight on seabed topography, obstacles, and features, contributing towards ensuring an optimal subsea cable route and design goes forward into manufacture, installation, and operation.

95%

ICPC and Industry Experts State:

Ninety five percent of transoceanic voice, data and internet traffic is carried by subsea telecommunications cable.

96.6%

Our Market Research Shows:

A total of 96.6% of the Seabed 2030 Community identified strong levels of dependency on High Seas Seabed Mapping Grid Data, with 68.3% identified that Cable and Pipelines sectors have High Dependency on High Seas 'Seabed Mapping Grid Data'. [Meaning that Seabed 2030 high seas grid data is critical to the sector, a 'Must Have' position]. A further 28.3% identified that Cable and Pipelines sectors have Medium Dependency on High Seas 'Seabed Mapping Grid Data.' [Meaning that Seabed 2030 high seas grid data provides a level of enhanced value in the sector, a 'Good to Have' position].

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

Future Trend

Subsea cables are a strong sector and highly dependent on Seabed Mapping. Anticipated sector growth trends suggest sector demand for both GEBCO Seabed Mapping and the commissioning of more detailed bespoke bathymetry is only going to increase going forward.

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: MEDIUM

Author suggested qualitative view.

Source: istock

René d'Avezac de Moran, Fugro Service Line Manager – Hydrography, and ICPC Committee Member

"GEBCO seabed mapping data is widely used in the subsea cable sector. The data is an industry recognised data and widely used for cable route planning wherever a cable is planned." René d'Avezac de Moran, Fugro Service Line Manager – Hydrography, and ICPC Committee Member

Jamie McMichael-Phillips, Seabed 2030 Director

"The Subsea Cable Sector, including both power and telecommunications sub-sectors, are key users of GEBCO data and especially for cable route planning and design. Seabed mapping data provides the bathymetric baseline for planning and design teams providing key intelligence on seabed topography, obstacles, and features, contributing towards ensuring optimal subsea cable routing" Jamie McMichael-Phillips, Seabed 2030 Director

SEABED 2030 MAPPING INITIATIVE

Our mission is to inspire ocean mapping and deliver a complete seabed map for the benefit of people and the planet. Formed by The Nippon Foundation & GEBCO, Seabed 2030 is a global initiative where industry, governments, researchers, and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
CONTACT US:
enquiries@seabed2030.org

THE NIPPON FOUNDATION-GEBCO
SEABED 2030

USE CASE: TSUNAMI PROPOGATION AND STORM SURGE MODELING

Industry experts state seabed mapping is a critical input to tsunami propagation modeling, tsunami early warning and storm surge modeling, supporting better disaster preparation and planning, and enabling timely forecast of landfall locations and magnitude for individual events.

" Bathymetry data is enormously important and a critical data input for storm surge modelling. This modelling wouldn't be possible without it." Industry Experts"

The Challenge

Marine hazards tsunami and storm surge are natural phenomena and will continue to happen. Key challenges include how to plan for and manage coastal community response and identify where tsunami and storm surges are likely to occur and who will be affected.

Propagation models require seabed mapping data, providing intelligence on water depth and the shape of the seafloor. Closer to shore the seabed shape and 'seabed to surface' roughness help determine how energy may be dissipated and helps to better understand impacts.

NOAA research has identified that 90% of all tsunami deaths in the historic record occurred in the local or regional area within the first 3 hours of the event. Accordingly, early warning systems are critical to effective tsunami response and disaster management.

Tsunami and storm surge are both evaluated at Basin level, (Ocean/Seas). Tsunami early warning systems are located globally, centred on high-risk global regions.

Introduction

The low-lying coastal zone is currently home to around 680 million people (~ 10% of the global population), projected to reach more than one billion by 2050. Small Island Developing States (SIDS) are home to 65 million people. [UNESCO from Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), 2020]. Further, UNESCO state Marine Hazards such as tsunamis and storm surges, can be devastating for the coast and their communities, and that the risk of tsunami in some low-lying coastal areas and SIDS is very high. In addition to the human impact, tsunamis often result in lasting and damaging effects on marine ecosystems and coastal landscape, as well as causing long-term coastal erosion.

The United Nations Office for Disaster Risk Reduction (UNISDR) references to the significant loss of life and economic losses associated with tsunamis, notably for countries bordering the Indian and Pacific Oceans, over the last twenty years. A review of available data from tsunami events puts these losses at 251,770 deaths and US$280 billion out of recorded economic losses for earthquakes and tsunamis of US$661.5 billion (1998-2017). This compares with 998 deaths and US$2.7 billion in recorded losses from tsunamis over the previous twenty years when total recorded economic losses for earthquakes and tsunamis was US$410.9 billion (1978-1997).

Tsunamis are giant waves, are most frequently caused by earthquakes, but can also result from undersea landslides, volcanic eruptions, and very infrequently by meteorites or other impacts upon the ocean surface. Tsunamis are generated primarily by tectonic dislocations under the sea which are caused by shallow focus earthquakes along areas of subduction (where tectonic plates converge). Out in the depths of the ocean, tsunami waves do not dramatically increase in height. But as the waves travel inland, they build up to higher and higher heights as the depth of the ocean decreases. The speed of tsunami waves depends on ocean depth rather than the distance from the source of the wave. Tsunami waves may travel very fast and have been compared to the speed of a jet plane over deep waters, only slowing down when reaching shallow waters. Where shallow water coincides with coastal areas and in a tsunami path, the resulting impacts can be catastrophic.

A storm surge is the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by a storm's winds pushing water onshore as we often see during hurricanes and cyclone events. The amplitude of the storm surge at any given location depends on the orientation of the coastline with the storm track; the intensity, size, and speed of the storm; and the local bathymetry.

For both tsunami and storm surge having propagation models, real time now/forecasting with the ability to provide advanced warning of landfall through early warning systems are key disaster management and risk mitigation strategies and key to minimising crisis event impacts. Industry experts state that seabed mapping is a critical input to both tsunami propagation and storm surge models, enabling better disaster preparation and planning, and ultimately supporting timely intelligence on landfall to be available supporting a tailored response to events.

Seabed Mapping is a critical for Tsunami Propagation and Storm Surge Modelling and Underpins Early Warning Systems Location Planning

Tsunamis are classified according to their travel time and distance from source. A **local tsunami** is from a nearby source for which its destructive effects are confined to coasts less than 1 hour tsunami travel time, or typically within about 200 km from its source. A **regional tsunami** occurs in a particular geographic region, generally within 1,000 km and 1-3 hours tsunami travel time from its source, and **ocean-wide tsunamis,** are capable of widespread destruction, not only in the immediate region of its generation but across an entire ocean.

NOAA research identifies that confirmed tsunamis were generated by 80% earthquake, 7% Earthquake generated landslide, 6% volcanic eruption, 5% landslide, and 2% other mechanisms.

UNESCO IOC explain tsunami propagation, where: Tsunamis travel outward in all directions from the generating area (source), with the direction of the main energy propagation generally being orthogonal to the direction of the earthquake fracture zone. Their speed depends on the depth of water, so that the waves undergo accelerations and decelerations in passing over an ocean bottom of varying depth. In the deep and open ocean, they travel at speeds of 500 to 1,000 km per hour (300 to 600 miles per hour). The distance between successive crests can be as much as 500 to 650 km (300 to 400 miles). However, in the open ocean, the height of the waves is generally less than a meter (3 feet) even for the most destructive tsunamis, and the waves pass unnoticed. Variations in tsunami propagation result when the propagation impulse is stronger in one direction than in others because of the orientation or dimensions of the generating area and where regional bathymetric and topographic features modify both the waveform and rate of advance. Specifically, tsunami waves undergo a process of wave refraction and reflection throughout their travel. Tsunamis are unique in that the energy extends through the entire water column from sea surface to the ocean bottom. It is this characteristic that accounts for the great amount of energy propagated by a tsunami.

Propagation elements 'wave height' and 'speed' are dependent on water depth which is derived from seabed mapping. Seabed mapping/bathymetry data are critical data for tsunami propagation modelling providing:

1. Informing propagation speed controlled be depth.
2. When the tsunami goes to coast it will increase in amplitude. Amplitude is linked to seabed depth and slope.
3. Bathymetry backscatter data provides data on roughness which assist in the modelling of tsunami energy loss/dissipation.

DART® - ETD (Easy to Deploy) buoy system Deep Ocean Assessment of Tsunami (DART), Source: NOAA, https://nctr.pmel.noaa.gov/Dart/

Bathymetry backscatter will indicate roughness and in general reflects if the coast area is vegetated, e.g., mangrove / reef areas among others. Vegetation may be used as an adaptation to increase tsunami safety and mitigation. For instance, coastal ocean areas may be vegetated to dissipate energy and or introduce post event repair especially where silt concerns exist.

Further, as **Ocean seabed knowledge is enhanced through expansion of seabed mapping towards global coverage, the tsunami community will benefit significantly through having a better understanding of seabed landscape and with this an enhanced understanding on tsunami sources** [e.g., plate tectonics, seabed earthquake hazards, and the awareness of other seabed topographic features such seamounts and areas that may be susceptible to landslip based on their geomorphology. **Emerging technologies and innovation may also have a role to play to apply AI/ML to review seabed mapping data for tsunami risks.**

Tsunami Advanced Warning Systems Early warning systems are critical to effective tsunami response and disaster management, with 90% of all tsunami deaths occurring in local and regional areas within the first 3 hours of an event [NOAA research]. Global regions most at risk of Tsunami include the Pacific Ocean, the Indian Ocean, the Mediterranean Sea, and the Caribbean Sea, and within each of these region's UNESCO has supported the roll out and operation of early warning systems.

The early warning systems includes a sensor network where seabed mapping is used to inform the sensor network locations and anchor sites for individual sensors in the sensor array. One example network includes the Deep-ocean Assessment and Reporting of Tsunamis (DART®) system consisting of an anchored seafloor bottom pressure recorder (BPR) with a companion moored surface buoy for real-time communications. Siting decisions are made based on strategic locations, avoiding complex seafloor topography for sensor location and anchoring.

Storm surges occur more frequently than Tsunami's and we see storm surges with potential to occur anywhere globally, notably where ocean areas are susceptible to low pressure weather systems. Where coasts are steep and where water depth drops off quickly storm surges are smaller, and as with tsunami, storm surge has most impact in low-lying coastal areas. Regional examples include low-lying SIDS territories in the Pacific and Indian Oceans, Gulf of Mexico (Hurricane Season), and the Philippines (Typhoon season), when experiencing strong onshore winds and reduced atmospheric pressure. The North Sea coastal areas, in particular, the UK and the Netherlands are particularly susceptible to storm surge and here coastal engineering solutions have been implemented and are in operation, e.g., the Thames Barrier in London. The **Netherlands storm surge model** is a particularly interesting case.

NOAA state that powerful winds aren't the only deadly force during a hurricane. The greatest threat to life comes from the water — in the form of storm surge.

The Netherlands is a geographically low-lying country, with about 20% of its area and 21% of its population located below sea level. As much as 50% of its land lie less than one meter above sea level. With two thirds of its area vulnerable to flooding, flood control is an important issue for the Netherlands. The country has a system of embankments, dikes and sluice gates along the seafront and on the mouths of the rivers to prevent storm water from surging in from the sea.

Source: iStock - The Netherlands Oosterscheldekering Storm Surge Barrier

Industry experts stated: Bathymetry data is enormously important and a critical data input for storm surge modelling. Modelling wouldn't be possible without it.

Industry experts explained that the Netherlands storm surge modelling brings together data on wind and tidal forces with bathymetry. The model is used in 2 stages (i) for planning/design of protection strategy and scheme and (ii) before and during a storm surge event for early warning and determining any need for escalated emergency response and potentially evacuation.

The Netherlands Storm Surge Model uses data at a Basin level (Atlantic Ocean/North Sea, etc.), covering an area from Portugal in the south to Iceland in the north and back to intersect the European Coast. Such large geographic area extents are required as the model must take account of the scale at which low pressure weather systems behave. **For this basin area a 100m seabed mapping grid is appropriate for the storm surge model.** In delta regions, the storm surge will propagate into rivers, such as towards Rotterdam, and in these locations' better resolution than 100m is required. The resolution for these areas is variable and tailored to the local setting. The model needs to take reflect channel geometry, for instance flats in channel must be shown and multiple pixels for a channel are required. As a rule of thumb, the resolution required is higher than map production, and a resolution of 20m grid may be sufficient in some areas.

A tailored bathymetry model is constructed as one of the main storm surge modelling inputs. Significant time is spent by analysts and engineers looking at the data and adding additional detail, e.g., adding in any offsets if required. Having a good bathymetric model helps determine how much volume of water move through each area. Highlights here include: (i) the seabed/water channel cross section is important, and (ii) from a dynamic's perspective, a tide is a form of wave where the speed of the propagation is connected to depth [A greater depth has faster speed, where the propagation is acceleration squared multiplied by the depth]. As an example, the propagation time from Scotland to the Dutch Coast is typically 12 hours, and a 10% velocity change is equivalent to one hour in storm surge arrival time at coast.

Bathymetry data updates. To reflect any changes in the wider basin bathymetry model new seabed mapping coverage/gap areas are added in and the storm surge basin bathymetry model is updated every 2 years. While closer the Netherlands coast and in the delta areas, and to ensure any local changes are accommodated in the model, e.g., silts, deposits, harbour changes, etc., the coastal area bathymetry model is updated every 4 years. Any key engineering interventions can be rapidly added to the model at any time throughout the two- and four-year revision cycle.

For the storm surge model to be performant and reflect the specific coastal setting, seabed areas out to 20 metre depth require detailed modelling at higher resolutions while the wider basin area remains at the 100 m resolution referenced earlier. **Landside features** are also required in the model, to ensure terrain shape and features are included in the model landside. These include features such as crest of dykes, outer dunes geometries, among other hard features, which water flow into, over and around.

Engineering works typically require additional bathymetry survey work commensurate with the stage of design and build, and these are commissioned away from the storm surge modelling activities and by a variety of agencies as leading/involved in the design and construction of engineering schemes.

SEABED MAPPING VALUE ADDED

Seabed mapping is critical for tsunami propagation models and tsunami early warning systems. Globally, regions most at risk of Tsunami include the Pacific Ocean, the Indian Ocean, the Mediterranean Sea, and the Caribbean Sea, with early warning systems deployed.

A total of 264 confirmed deadly tsunamis have resulted in over 544,000 known (or confirmed) deaths globally, with damages and cost of running into US$ 100's millions to a US$ few billions of US$ for a single crisis event. In a SIDS context Tsunami can have devastating impact on Nation GDP.

UNISDR references the significant loss of life and economic losses associated with tsunamis, notably for countries bordering the Indian and Pacific Oceans, over the last twenty years, [Loss of life at 251,770 deaths and economic losses of US$280 billion].

Seabed mapping is also critical for storm surge modelling, and this modelling wouldn't be possible without bathymetry data. Bathymetry data is extremely important for having good storm surge modelling which ultimately is used to (i) determine landfall locations and height of water, (ii) model the surge effect/impact {on a shallow water shelf the surge effect is increased), (iii) plan/design any storm surge protection measures and inform any related engineering works, and (iv) in operation where present, to determine if/when a flood barrier is to be closed and opened, ultimately minimising commercial and economic risks.

Source: istock

The Seabed 2030 mission to achieve Global Ocean seabed mapping coverage will enable further advances in tsunami and storm surge models. These advances will be particularly important to vulnerable locations globally, areas such as shallow coastal areas and low-lying islands. **Oceans will be able to be considered 'catchments' for modelling purposes, and a fuller catalogue of source locations associated tsunami risk, such as tectonic plate, active underwater volcanoes, seamounts and underwater slopes at risk of displacement/slippage will be able to be identified. Seabed 2030 achieving it's mission will lead to better disaster planning, better targeting of alerts, and enhanced disaster response to tsunami and storm surge threats overall.**

BENEFITS

- **Tsunami Propagation Modelling**
Seabed mapping is critical for effective tsunami propagation modelling, The propagation speed of a Tsunami is controlled by depth and when the Tsunami goes to coast it will increase in amplitude linked to depth and slope. Bathymetry backscatter 'roughness' informs energy dissipation in the model at coastal areas.

- **Tsunami Early Warning Systems Sensor Network Planning and Sensor Sites**
Seabed mapping informs the network planning and location of Tsunami Warning System Sensors, e.g., anchored seafloor bottom pressure recorders (BPR), among others.

- **Storm Surge Modelling**
Seabed mapping is critical to storm surge modelling, providing depth and determining acceleration at basin level and determining channel water movement at coastal areas and dynamics into river system propagation. This determines the arrival time and height and volume of water at landfall, to , and when applicable the model informs the operation (open/closure) of flood barriers and other engineering operation decisions.

US $280 Billion

Tsunami Economic Losses [20 Year period]

UNISDR references US$280 billion due to tsunamis out of recorded economic losses for earthquakes and tsunamis of US$661.5 billion for the period 1998-2017.

91.7%

Our Market Research Shows:

A total of 91.7% of the Seabed 2030 Community identified strong levels of dependency on High Seas Seabed Mapping Grid Data, with 65% identified that Disaster Management and Disaster Risk Resilience sectors have High Dependency on High Seas 'Seabed Mapping Grid Data'. [Meaning that Seabed 2030 high seas grid data is critical to the sector, a 'Must Have' position]. A further 26.7% identified that Disaster Management and Disaster Risk Resilience sectors have Medium Dependency on High Seas 'Seabed Mapping Grid Data.' [Meaning that Seabed 2030 high seas grid data provides a level of enhanced value in the sector, a 'Good to Have' position].

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

Reinforcing the case for global ocean coverage of seabed mapping.
Given the fundamental role of seabed mapping in tsunami propagation modelling, there is a strong case for completing seabed mapping coverage for the Pacific Ocean, the Indian Ocean, the Mediterranean Sea, and the Caribbean Sea. Adding in other areas susceptible to storm surge, such as regions prone to hurricane, cyclone type events, as well as low lying coastal areas generally further reinforce the case for Seabed mapping completing global ocean coverage.

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: MEDIUM

Author suggested qualitative view.


Source: istock

Prof Dr. Ir. Martin Verlaan, TU Delft / Deltares, and George Spoelstra, GEBCO

" Bathymetry data is enormously important and a critical data input for storm surge modelling. This modelling wouldn't be possible without it." Prof. Dr. Ir. Martin Verlaan, Department of Mathematical Physics Delft University of Technology, and Senior Researcher Oceanography/Mathematics at Deltares and George Spoelstra, GGS Geo Consultancy BV (GGSgc) and GEBCO Chair of Technical Sub-Committee on Ocean Mapping.

Jamie McMichael-Phillips, Seabed 2030 Director

" Seabed mapping is fundamental to tsunami and storm surge propagation modelling underpinning early warning intelligence. Tsunami and Storm Surge are devastating natural occurring phenomena, impacting coastal communities and low-lying SIDS, with hundreds of millions of people vulnerable to these hazards globally. Seabed 2030 sees strong contribution and value from seabed mapping for these applications and looks forward to continuing to support the disaster management community as they address their marine and coastal interests and concerns." Jamie McMichael-Phillips, Seabed 2030 Director

SEABED 2030 MAPPING INITIATIVE

Our mission is to inspire ocean mapping and deliver a complete seabed map for the benefit of people and the planet. Formed by The Nippon Foundation & GEBCO, Seabed 2030 is a global initiative where industry, governments, researchers, and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

USE CASE: RENEWABLE ENERGY - OFFSHORE WIND ENERGY

Seabed mapping is a fundamental source of intelligence for ocean/marine energy exploitation including, renewable energy wind, wave, tidal, among others. The data informs sovereign rights, supports environmental baseline and ongoing monitoring, site options and planning decision-making, and the planning, design and development of safe offshore infrastructure and operations.

Source: istock

"Seabed 2030 user community globally have consistently identified Marine Renewable Energy as a priority sector for seabed mapping. With the global transition towards clean fuel, industrial decarbonisation, and with Nations working towards meeting their Net Zero commitments we expect to see this sector expand and with it the demand on seabed mapping to increase in support." Jamie McMichael-Phillips, Seabed 2030 Director

The Challenge

Support the energy sector global transition to Renewable Energy and Nations meeting their Net Zero commitments.

To have seabed mapping coverage and data available to support (i) the energy sector strategic transition planning (needed today and this decade), (ii) inform site suitability (options) studies, and (iii) site feasibility, planning and design, as well as (iv) baseline and ongoing monitoring of sites regards environmental and other operational interests and concerns.

Build into seabed mapping prioritisation logic reflecting the anticipated energy sector applicable ocean/marine renewable energy mix and likely geographies.

Introduction

IEA World Energy Investment 2023 reports estimates that around USD 2.8 trillion will be invested in energy in 2023. **More than USD 1.7 trillion of this is going to clean energy**, including renewable power, nuclear, grids, storage, low-emission fuels, efficiency improvements and end-use renewables and electrification. The remainder, slightly over USD 1 trillion, is going to unabated fossil fuel supply and power, of which around 15% is to coal and the rest to oil and gas. **For every USD 1 spent on fossil fuels (globally), USD 1.7 is now spent on clean energy.** Five years ago, this ratio was 1:1. This confirms a transition to clean energy away is underway.

Renewables and grids are the leading components of global power investment and are expected to account for more than USD 1 trillion of investment on their own in 2023. **Global spending on renewables hit a new record in 2022 at almost USD 600 billion**, driven by solar PV and wind (especially in China). There is expected to be ~10% increase in renewables investment in 2023 to more than **USD 650 billion.**

Offshore wind – **IEA** also identifies that renewable power remains the main outlet for non-core oil and gas company spending. Whilst the early focus was on wind and solar developments, there have now been large moves into offshore wind: For example, **TotalEnergies** announced in 2022 a project pipeline of 6 GW of offshore wind, taking the total to 11 GW, **Shell** also has around 9 GW in the pipeline and **Equinor** has ambitions to install 12-16 GW by 2030. If realised, these capacity additions would rival those of pure-play offshore wind developers such as **Ørsted** over the same period. European Majors are early movers, however notably in China, Brazil, India, Vietnam, and Taiwan there are significant investments underway in renewable energy, including offshore wind.

Seabed mapping is a foundation data and a key source of intelligence for marine energy resources management and exploitation generally. The data provides seafloor/topographic evidence towards Nation UNCLOS claims and has been used historically as an input to oil and gas exploration and enabling cost efficiencies for oil and gas operations. In this use case a spotlight is put on the transition to renewable energy with a focus on offshore wind energy. In particular we present industry expert perspective on offshore wind global capability inventory and the role seabed mapping plays in the evaluation of prospective renewable energy offshore wind sites and their associated infrastructure planning, design, and build. We reference a number of global studies and draw on an Ireland case study as reported by INFOMAR, as well as Industry Expert perspectives in support.

Marine Renewable Energy Sector Dynamics and a focus on Offshore Wind Energy

Ocean/Marine Renewable Energy Sector has a key contribution to make in the global transition away from the use of fossil fuel to clean energy, the reduction of carbon emissions and supporting Nations and Industry to meet their Net Zero commitments. Marine Renewable Energy sources include energy from wind (offshore fixed and floating), waves, currents, tides, salinity gradients, thermal gradients, marine biomass, and we can also include [floating] solar. Most of these sources are nascent where only offshore wind is fully industrialized/commercialised and in use at scale. In our use case the focus in on offshore wind energy (including seabed-fixed and floating).

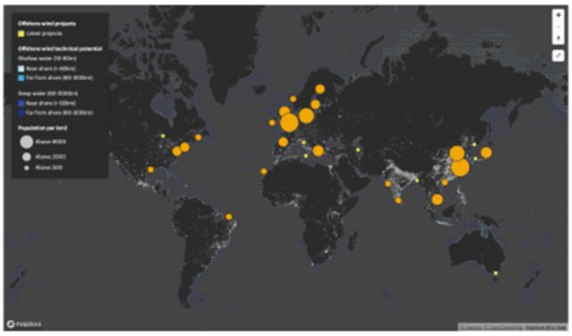
Ørsted, a renewable energy company headquartered in Denmark, cite **International Energy Agency (IEA)**, reporting that as much as **80% of the global offshore wind resource potential is in waters with depths exceeding 60 metres.** At these depths **floating wind becomes more economically attractive** and why Ørsted are expanding into floating wind, as a complement to their seabed-fixed business.

The **first commercial wind farm was set up in Denmark in 1991**, with early movement occurring in Europe, mostly taking advantage of the North Sea. The shallow coastal areas and sandbanks combined with stable wind resources make the North Sea an ideal area for renewable energy production and have made the North Sea a global hotspot for offshore wind energy production.

The **Global Wind Energy Council (GWEC)**, Global Wind Report 2023, reports that 8.8 GW of new offshore wind was fed into the grid last year, bringing **total global offshore wind capacity to 64.3 GW by the end of 2022.** Europe's total offshore wind capacity reached 30 GW, 46% of which is from the UK. With total installed offshore wind capacity reaching 34 GW in in terms of floating wind, Norway commissioned 60 MW of floating wind capacity in 2022, bringing the region's total installations to 171 MW, equal to 91% of global installations.

Seabed Mapping is foundational data and enables the Offshore Wind Energy Sector.

Seabed Mapping Industry Experts identified six key areas where seabed mapping supports and enables the offshore wind energy sector, including:



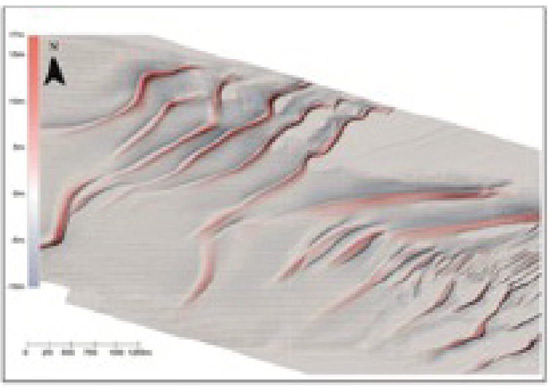
Source: IEA commissioned Imperial College London geospatial analysis study 'A detailed analysis of global offshore wind potential created as part of the Offshore Wind Outlook 2019' example UI and interactive map view

1). UNCLOS Article 76 Nation Claims: Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS) allows countries to claim an extended continental shelf to explore and exploit the resources of the seafloor beyond the 200 nautical miles of their exclusive economic zone. Seabed mapping informs the preparation of and case for claims, and where ratified enables Nation rights to exploit within the extended continental shelf area including the locating of offshore wind energy infrastructure.

2). Seabed mapping (depth data) is used to determine the technical potential for offshore wind, providing an initial strategic inventory of 'Regional Ocean' areas potentially suitable for offshore wind. In 2019, the IEA commissioned Imperial College London to provide a geospatial analysis study 'A detailed analysis of global offshore wind potential created as part of the Offshore Wind Outlook 2019' to assess the global technical potential for offshore wind energy. The resulting interactive map [example UI provided above] features offshore wind technical potential, classified by water depth and distance from shore, the latest offshore wind projects, and population density, with other operational parameters assumptions applied such as wind speed among others. In the analysis distance from shore was kept within 300 km from the nearest shoreline, based on the latest technology and cost associated with deployment. For instance, the length and construction methods for subsea transmission cables needed to bring the electricity generated to shore. Further, a water depth threshold was used, with analysis limited to less than 2,000 m depth. This parameter was sub-divided into two regions, the first being less than 60 m water depth which are suitable for fixed-bottom foundations, and the second between 60 - 2,000 m that are suitable for floating foundations, whilst noting that floating foundation technology in future would be able to be used in depths exceeding 2,000 m but was nascent at the time of the study.

3). Renewable Energy 'Local' Site Suitability and Risk Assessment [using MBES bathymetric survey].
INFOMAR has led the way in applying a bathymetric approach to inform offshore wind energy site suitability investigations. This is driven by INFOMAR stating: **'as Ireland looks to further develop its offshore wind capacity, understanding seabed sediments and subsurface structure with regard to siting offshore renewable energy is a first-order requirement and the first step of assessment towards a sustainable national marine energy development strategy.'** This assessment is critical as in UK and Ireland key projects have encountered adverse geological ground conditions that have resulted in their discontinuation. [Examples include UK – Celtic Array off the Northwest Coast (Anglesey), discontinued as result of "challenging ground conditions," and Ireland Arklow Bank experiencing scour, the physical process related to the movement of the seabed sediment as a result of the flow of water away from a structure.]

INFOMAR has applied a 'MBES bathymetry with (improved GPS positioning technology,' survey approach to map offshore geology and importantly better understand large sediment waves on the seabed and how they change over time. This approach enables highly detailed investigation on sediment transport on continental shelf locations globally, and in the INFOMAR instance an original INSS baseline survey was followed by resurvey, with the resulting high-accuracy bathymetric data being used to measure horizontal and vertical changes in bedform dimensions, and analysis of multibeam backscatter and sediment data to provide a better understanding of sediment distribution, sediment wave composition, allowing inferences on the forces necessary to initiate and sustain sediment transport. This approach is key to understanding sediment mobility and migration direction controlled by local hydrodynamic conditions, informing offshore wind energy location suitability and risk.



Source: INFOMAR sediment mobility study [2020] example output - faded red indicates area where sediment has accumulated while faded blue are areas with sediment deficit. Grey indicates areas with minimal sediment mobility.

4). Seabed mapping is a key input data for Offshore wind energy infrastructure, feasibility planning, design, and development.
Seabed mapping is a foundation data for feasibility planning. The seabed geometry and terrain, presence of seabed features and anomalies, as well as seafloor geology and sediment types are key factors informing offshore wind energy infrastructure site feasibility and design. This includes for both fixed infrastructures, where a turbine foundation and monopile are key, and floating, where anchor points locations, type and design are key.

The turbine foundation provides support for the wind turbine, transferring the loads from the turbine at the tower interface level (typically around 20m above water level) to the seabed. A monopile supports the static and dynamic loads of the wind turbine through firm anchoring to the seabed using the embedded part of the monopile.

The seabed map also provides a 2d/3d base map against which other thematic data is referenced, such as data used for environmental impact assessment, geotechnic data, among others. As detailed in item 3 (site suitability assessment), scour protection also forms a key part of the design. Scour protection prevents scour of the seabed caused by the speed-up of water moving around the foundation, which safeguards the performance/integrity of the foundation. The ground conditions have a consequential impact on the scour assessment and scour protection design, along with other key factors including waves, currents, water depth and the structure dimensions. All these need to be considered when estimating scour design strategies.
Of note, the overall design may require operation and/or decommissioning action at end of life to optimise use of infrastructure for wider marine uses, examples being encouragement of kelp farming, fishery nursery among others or at end-of-life removal and reinstatement of the seabed to previous condition. Further, in some instances the design may be extend an existing wind farm array. These types of activity may involve seabed mapping updating on a case-by-case basis, which may include seabed map feature mapping updates or warrant (new bathymetric survey/subsea inspection survey work) to be undertaken.

5) Offshore Wind Energy Array Offshore/Onshore Substations, Connections, Subsea Power/ Telecommunications Cable, and Connection to Grid Network Onshore. Seabed mapping is used at all stages of an Offshore Wind Energy subsea cable lifecycle and especially during the Desktop Study (DTS) Phase for cable routing optimisation. Seabed mapping is also used for the identification of suitable seabed attachment points, cable junctions, spurs, cable cross-over points and landing areas, noting also that one to many central hub power/telecommunications connection occur between wind turbines in the offshore wind energy array and there are offshore/onshore substation dedicated to the wind farm. The subsea cable and connectivity elements are of key importance, given the power/telecommunications cable element are typically in the order of 20% of the offshore wind energy infrastructure total cost.

6) Offshore Wind Energy Ancillary Services including specialist areas of business such as insurance, for example **Beazley at Lloyds**, a specialist in deep sea infrastructure, energy and marine insurance, and Seabed ‘landlord’ arrangements, one example being the **UK Crown Estate Commissioners**, where hectares of seabed are leased out to energy companies are worthy of note. In these there are requirements for energy companies/operators to demonstrate compliance with appropriate licensing authorities pre and post operation, including that any EIA requirements, before and after operation (in decommissioning) have been expedited. In these instances, **seabed mapping and charts form part of portfolio and formal record.**

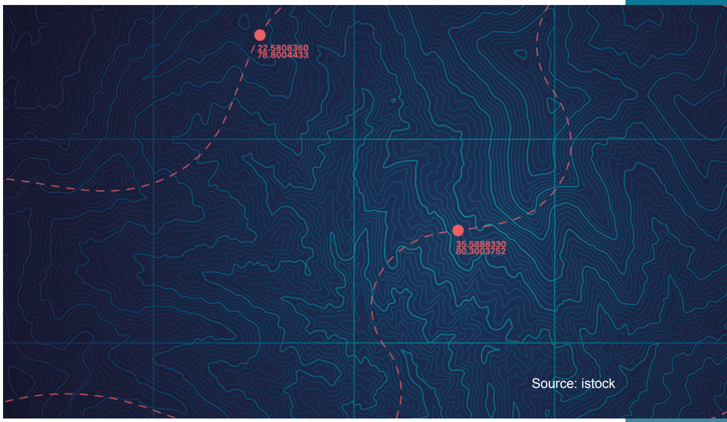
Looking forward. Whilst currently offshore wind energy sector activity is focussed on key locations in Europe [Denmark, France, Germany, Italy, Ireland, Norway, The Netherlands, and UK], APAC [China, India, Vietnam, Thailand], and also South America [Brazil], with the global drive towards Net Zero, requirements on industries to decarbonise and report on ESG, coupled with uncertainties due to fluctuating cost of energy, the seabed mapping community can expect to see sector interest elsewhere globally. Seabed 2030 mission to achieve global ocean seabed mapping coverage by 2030 will provide for the first time a complete baseline ocean depth, seafloor topography and data on features which will be readily available to support wind energy future requirements, and sector development and growth.

SEABED MAPPING VALUE ADDED

Seabed mapping data informs and underpins Offshore Wind Energy ‘transition option review,’ ‘site feasibility study and planning,’ ‘infrastructure design and build,’ production operation, and energy distribution via subsea cables network. **GWEC** reports that the global offshore wind market is expected to grow from 8.8 GW in 2022 (new connections) to 35.5 GW in 2027, bringing its share of total new global installations from today’s 1% to 23% by 2027. In total, 130 GW of offshore wind is expected to be added worldwide in 2023-2027, with expected average annual installations of nearly 26 GW. Beyond 2027, **GWEC** expects the growth momentum to continue as global commitments to net zero, coupled with growing energy security concerns, which have already brought the urgency of deploying renewables to the top of the political agenda.

Ørsted state a modern 1 GW seabed-fixed wind farm creates more than 18,400 direct and indirect jobs in development, construction, operation, and decommissioning. **Ørsted** state they expect floating wind to be similar. The above offshore wind energy market dynamics demonstrate significant economic, social, and national security value. These dynamics are likely to continue throughout the Seabed 2030 mission lifetime.

Additionally, there is significant environmental value, through the sector direct contribution to the fight against climate change, the global transition to clean energy and towards achieving net zero targets and commitments.



Source: istock

Future View: GWEC also reports in its Renewables 2022 report, that the **IEA** agency’s primary analysis of the renewable energy sector forecasts capacity additions reaching record highs through 2027, led by solar and wind. It expects annual additions to range from 350 GW in the main scenario to 400 GW in the accelerated case.

BENEFITS

- **Offshore wind energy site suitability strategic assessment review [Regional ocean and nation coastline level assessment].** A strategic review and production of an inventory of potential offshore wind site locations.

- **Seabed surveys, including geological and hydrographical surveys, aid engineers to analyse the subsea bed environment of the proposed wind farm site and export cable route to assess its geological condition and engineering characteristics.** This data is used for a wide range of engineering and environmental studies through the design and development phase.

- **Subsea cable route planning, including route optimisation and the identification of suitable seabed attachment points, cable junctions, spurs, cable cross-over points and landing areas, among others.**

90%

Our Market Research Shows:

A total of 90% of the Seabed 2030 Community identified strong levels of dependency on High Seas Seabed Mapping Grid Data, with 68.3% identified that Oil and Gas sector has High Dependency on High Seas ‘Seabed Mapping Grid Data’. [Meaning that Seabed 2030 high seas grid data is critical to the sector, a ‘Must Have’ position]. A further 21.7% identified that Oil and Gas sector has Medium Dependency on High Seas ‘Seabed Mapping Grid Data.’ [Meaning that Seabed 2030 high seas grid data provides a level of enhanced value in the sector, a ‘Good to Have’ position].

81.7%

Our Market Research Shows:

A total of 81.7% of the Seabed 2030 Community identified strong levels of dependency on High Seas Seabed Mapping Grid Data, with 55% identified that Offshore Wind Energy sector has High Dependency on High Seas ‘Seabed Mapping Grid Data’. [Meaning that Seabed 2030 high seas grid data is critical to the sector, a ‘Must Have’ position]. A further 26.7% identified that Offshore Wind Energy sector has Medium Dependency on High Seas ‘Seabed Mapping Grid Data.’ [Meaning that Seabed 2030 high seas grid data provides a level of enhanced value in the sector, a ‘Good to Have’ position].

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: “It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

Future Trend
Wind power is not just growing bigger, it is also spreading more widely. There is talk of a Wind Energy Boom. Economic drivers are becoming increasingly important as companies globally commit to Environmental, Social and Governance (ESG) goals that require them and their suppliers to decarbonise. The demand on offshore wind energy going froward will continue and likely increase and with this the sectoral use of seabed mapping.

THE NIPPON FOUNDATION-GEBCO SEABED 2030

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: HIGH

Author suggested qualitative view.


Source: istock

INDUSTRY EXPERT

”Any offshore engineering project needs an understanding of the seafloor. Bathymetry is foundational and provides a baseline and geographic reference. Seabed base map data is always needed, is fundamental to site selection, and used through design and development and into operations. The data is simply mission critical.” Industry Expert

Jamie McMichael-Phillips, Seabed 2030 Director

”Seabed 2030 user community globally have consistently identified Marine Renewable Energy as a priority sector for seabed mapping. With the global transition towards clean fuel, industrial decarbonisation, and with Nations working towards meeting their Net Zero commitments we expect to see this sector expand and with it the demand on seabed mapping to increase in support.” Jamie McMichael-Phillips, Seabed 2030 Director

SEABED 2030 MAPPING INITIATIVE

Our mission is to inspire ocean mapping and deliver a complete seabed map for the benefit of people and the planet. Formed by The Nippon Foundation & GEBCO, Seabed 2030 is a global initiative where industry, governments, researchers, and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
CONTACT US:
enquiries@seabed2030.org

THE NIPPON FOUNDATION GEBCO IHO unesco Intergovernmental Oceanographic Commission 2021 2030 United Nations Decade of Ocean Science for Sustainable Development

THE NIPPON FOUNDATION-GEBCO SEABED 2030

USE CASE: CLIMATE CHANGE OCEAN MODELS

Climate change refers to long-term shifts in temperature and weather patterns. Climate models enhance our understanding of climate change and provide climate future state predictions. They provide a better understanding of climate change and inform climate change impact assessment, climate change mitigation and adaptation planning.

" Seabed mapping has a key role to play towards informing climate ocean models. As a data input for the modelling of key elements such as sea-ice interaction in polar settings, sub-ocean processes, nearshore and coastal interactions, seabed mapping enhances our understanding and response to climate change." Jamie McMichael-Phillips, Seabed 2030 Director

The Challenge

Climate change is a global challenge.

Climate Models aim to understand and predict future conditions at large spatial scales. They consider atmospheric and oceanic factors along with sea ice and land-surface components.

Atmospheric/Oceanic models can be combined, and sub-models used to bring in additional data and modelling interests.

Models are used and tailored to reflect local setting and support work at smaller (more detailed) spatial scales. In this way climate change mitigation and adaptation measures can be reviewed and analysed.

Seabed Mapping data is/can be used to enhance climate models and our understanding of climate change. E.g., sea floor roughness is important for ocean mixing, among others.

Some Ocean areas and in particular the Polar regions present challenging operating conditions for seabed mapping data acquisition, yet we now have technologies and approaches that can be leveraged in support.

Source: istock

Introduction

United Nations defines **climate change as referring to long-term shifts in temperatures and weather patterns.** The shifts may be natural, such as through variations in solar cycle, or as a result of human activities, such as the burning of fossil fuels like coal, oil and gas. Climate change encompasses global warming, i.e., the long-term warming of our planet, and additionally refers to the broader range of changes that are happening to our planet. For instance, the UN identify that climate change consequences go beyond temperature rise, including, among others, intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity. Many of these consequences relate to our Oceans.

Climate change And Our Oceans. Climate change is impacting our Oceans. As the planet's greatest carbon sink, the ocean absorbs heat and energy released from rising greenhouse gas emissions trapped in the Earth's system. Today, the ocean has absorbed about 90 percent of the heat generated by rising emissions. As the **excessive heat and energy warms the ocean, the change in temperature leads to ice-melting, sea-level rise, marine heatwaves, and ocean acidification.**

UN presents the following key facts: **Sea-level Rise:** Sea level has continued to rise over the past decades due to increasing ice loss in the world's polar regions. Global mean sea-level reached a new record high in 2021, rising an average of 4.5 millimetre per year over the period 2013 to 2021 (UN reference WMO), compared to 2.1 millimetre per year during 1993-2002. Together with intensifying tropical cyclones, sea-level rise has exacerbated extreme events such as deadly storm surges and coastal hazards such as flooding, erosion and landslides, which are now projected to occur at least once a year in many locations. Such events occurred once per century historically. **Ocean Acidification:** Due to climate change, the ocean is warmer, more acidic and less productive today. The ocean has absorbed between 20 to 30 per cent of human-induced carbon dioxide emissions since the 1980s, exacerbating acidification. (UN reference IPCC). **Marine heatwaves:** Periods of unusually high ocean temperatures that threaten marine biodiversity and ecosystems and make extreme weather more likely – have doubled in frequency since 1982 and are increasing in intensity. Their frequency will increase with rising greenhouse gas emissions. (UN reference IPCC).

Rising temperatures **increase the risk of irreversible loss of marine and coastal ecosystems.** Today, widespread changes have been observed, including damage to coral reefs and mangroves that support ocean life, and migration of species to higher latitudes and altitudes where the water could be cooler. **UNESCO** warn that more than half of the world's marine species may stand on the brink of extinction by 2100. At a 1.1°C increase in temperature today, an estimated 60 percent of the world's marine ecosystems have already been degraded or are being used unsustainably. A warming of 1.5°C threatens to destroy 70 to 90 percent of coral reefs, and a 2°C increase means a nearly 100 percent loss - a point of no return.

Climate models enhance our understanding of climate change and provide climate future state predictions. In this use case we focus on the use of seabed mapping in quantitative climate ocean models, we reference recent polar bathymetry activities demonstrating the importance of seabed mapping to better understand and improving projections of future sea-level rise. We also signpost where governments and communities are using seabed mapping to enhance their climate change response informing their planning and implementation of climate change mitigation and adaptation action.

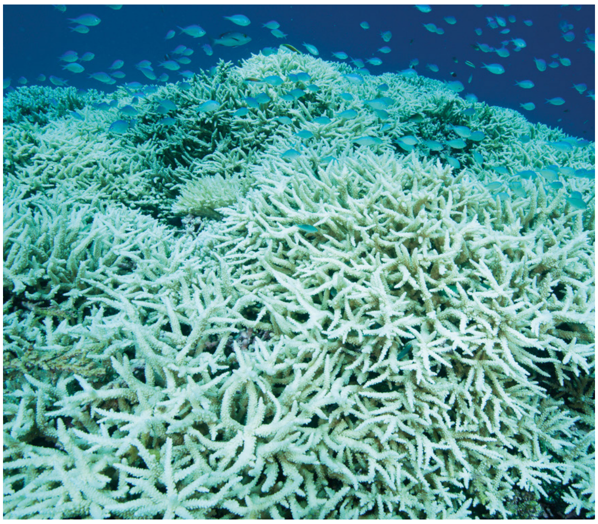
Climate Models – a Quantitative or Numerical Approach to understanding and predicting Climate Change

Numerical climate models use quantitative methods to simulate the interactions of the important drivers of climate, including atmosphere, oceans, land surface and ice. They are used for a variety of purposes from the study of the dynamics of the climate system to projections of future climate.

A **general circulation model (GCM)** is a type of climate model. It employs a mathematical model of the general circulation of a planetary atmosphere or ocean. **Atmospheric and Oceanic GCMs (AGCM and OGCM)** are key components along with sea ice and land-surface components. GCMs and global climate models are used for weather forecasting, understanding the climate, and forecasting climate change.

AGCMs (atmospheric) and OGCMs (oceanic) can be coupled to form an **atmosphere-ocean coupled general circulation model (CGCM or AOGCM).** With the addition of **submodels** such as a sea ice model or a model for evapotranspiration over land, AOGCMs become the basis for a full climate model. Submodels can be interlinked, such as land use, allowing researchers to predict the interaction between climate and ecosystems. This is where impact of local climate mitigation and adaptation measures can be modelled/ analysed. For instance, in **Nearshore areas**, submodels can be interlinked and potentially further tailored to reflect local variability of conditions, e.g., to take account of additional physical processes such as tides, local winds, and surface and internal waves. Adaptation measures can be considered in relation to the localised model, e.g., nature-based measures such as nearshore mangrove plantation, or hard infrastructure 'engineering' solutions such as the construction of groynes, seawalls, among others.

The use of seabed mapping in quantitative climate ocean models. The Climate Model General Circulation Model does not include seabed factors, with this model operating at planetary level and an associated large spatial scale (e.g., a grid cells ranging between 100 Kms in longitude and latitude in the mid latitudes, and up to 150 Km elsewhere). However, at these scales some countries e.g., in the Caribbean may not even be represented by model cells, see further below. As climate modelling moves towards **Regional Climate Model (or RCM) / Ocean and Sub- Ocean levels,** seabed factors become relevant, considered, and included. Further, the climate model spatial resolution becomes more detailed. Scientists overcome the 'Caribbean' problem by **"downscaling"** global climate information to the local or regional scale. This downscaling means taking information provided by the GCM or coarse-scale observations and apply them to a specific place or region. It is possible to "nest", or embed, RCMs within a GCM, which means scientists can run more than one model at the same time and get multiple levels of output simultaneously. We see this in the UK, the Met Office Hadley Centre for Climate Science and Services, running a Regional Climate Model for the UK using 25 Km x 25 Km grid cell size, providing UK coverage using 440 squares [HadRM3 Model]. In the Caribbean instance a Caribbean/intra-Americas domain is identified limiting the modelling to that domain. The output of the large-scale models are fed into the boundary of the domain model, ensuring the larger scale model information drives the finer-scale model (dynamically downscaling the model), doing the modelling at a finer scale. This approach is essential when considering **Small Island Developing States (SIDS).**



Source: istock

There are 10 to 15 big global climate modelling centres who produce simulation and results (and peer reviewed), and it is in these centres, where both regional modelling occurs and where seabed features are integrated, pending centre modelling focus and specialisms. Industry Experts state that Open Ocean Models are supplemented with 'nested' grids to both boost up spatial resolution and to take account of other relevant factors/areas of interest. Industry Experts have stated that for Open Ocean modelling the GEBCO grid is relevant and used.

Model 'nesting' allows for enhanced detail to be added in the global model context, and this is used for the inclusion of additional seabed mapping detail or supplementary specialist models being run in support. Examples include Ocean Circulation Models, e.g., NEMO3.6, informing marine temperature (and consequently ocean thermal expansion), and salinity, where both deep circulation of the ocean and mixing in the ocean are key processes. These models are supported by seabed surface texture (roughness of sea floor), geomorphology, e.g., for the presence of seamounts and other key subsea terrain features and water depth, to support model of mixing along sea bottom slope.

Shelf Seas, which are shallower than major oceans and generally no more than 200m deep, as found in Northern Europe, South America, Northern Australia and the Arctic amongst other places are treated as sub-ocean models. In these instances, circulation of water is locally driven. Where continental shelf joins the deep ocean, (again guided by seabed mapping), both water depth and ocean mixing dynamics change. Further, the presence of subsea waterfalls, some of which can be considerable in size and impact, e.g., 1,000s of metres heights, and other important localised features can be introduced to the regional/local model.

Source istock - Icebergs in Sermilik Fjord. East Greenland

Specialist models address Cryosphere factors and interactions. These include sea-ice model elements, for example, using the **LIM3 model** for snow-ice formation scheme, etc., and **Greenland Ice Sheet PISM** which handles the ice sheet dynamical and thermodynamical processes, including ice flow, subglacial hydrology, bed deformation, and the basal ice melt). Sea-ice models are a key climate model component, with sea-ice melt accounting for an estimated one-third of sea level rise, along with ocean thermal expansion, among other elements.

Industry Experts advised, the sea floor becomes very important in Fjords, and that bathymetry is needed around the ice sheet to enhance climate predictions associated with sea level rise as a result of ice sheet changes. The importance is recognised, where, Intergovernmental Panel of Climate Change (IPCC), state, with “Very High Confidence”, that Global Mean Sea Level (GMSL) is rising with acceleration in recent decades due to increasing rates of ice loss from the Greenland and Antarctic ice sheets.

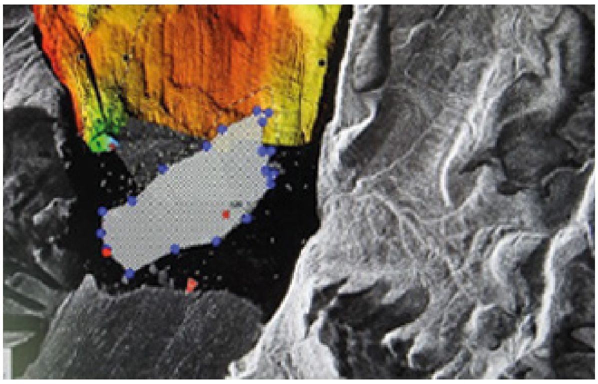
Industry Experts guide that seabed maps and bathymetry feed into glacier ice models, providing key data on the pathway between ice running into the ocean and withdrawing ice from the ocean, enabling enhanced ice mass loss predictions. Requiring a blend of bathymetry and oceanographic measurements, the shape and depth (or bathymetry) of the sea floor determine if there is a potential for subsurface warmer water to reach glaciers and cause melting. Where glaciers drain into fjords, the fjord may be deeper than 1000 meters, but may have a shallower sill at the entrance (formed when eroded materials accumulate) which can then act as a shield against inflowing warmer water, depending on its depth.

Industry Experts state, estimating the mass loss from discharge of Earth’s large remaining ice sheets in a warming climate is highlighted as glaciology’s grand challenge, constituting a large uncertainty in our predictions of future sea level rise. And that mapping the bathymetry of the Fjords where large glaciers drain is one of the most critical steps in assessing the future of a glacier and represents a compelling case for Seabed 2030/bathymetry survey acquisition.

Source: Oden on Expedition to the Ryder Glacier, photo taken by Professor Martin Jakobsson, 2019

As model interests move towards **Nearshore and Coastal settings, where the localised impact, mitigation and adaptation to climate change are of community interest,** wave and coastal dynamics, and specialist storm surge and flood models, among others become relevant.

The role of seabed mapping in these instances is described in detail in wider dedicated use cases. To highlight however in the climate change context, we see the use of satellite derived bathymetry (SDB), and the acquisition of airborne bathymetric LiDAR and/or boat based MBES surveys undertaken in support. From a modelling perspective surge propagation speed is linked to water depth, channel cross-sections, and coastal erosion studies are key. We also see energy dispersion factors becoming relevant, driven by seabed texture, geomorphology and the presence of other coastal features such as mangrove, potentially impeding



Source: Seabed data, captured by Professor Larry Mayer on the expedition to the 2019 Ryder Glacier, Greenland.

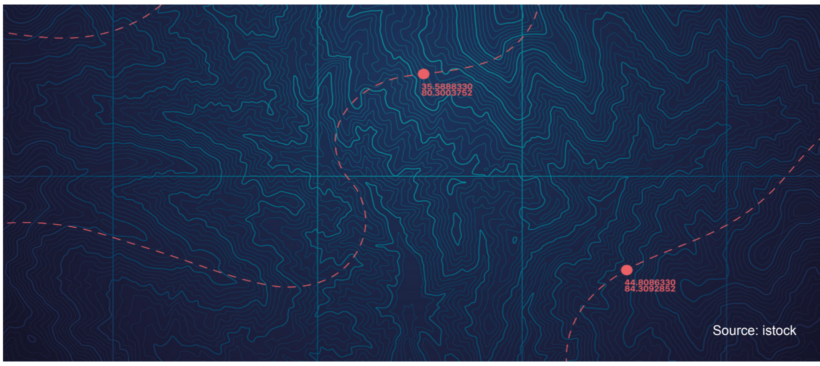
and reducing climate impacts on coastal areas. From a climate change and development of local community policy and planning perspective, **Integrated Assessment Models** are used to project future greenhouse gas emissions and climate impacts, alongside the benefits and costs of policy and implementation options that could be taken forward to tackle them. These take account of physical, economic and social data along with the climate model outputs, and essentially present a cost benefit analysis on local tailored climate mitigation and adaptation scenarios for decision-makers consideration.

SEABED MAPPING VALUE ADDED

The costs and opportunities associated with climate change are staggering. Deloitte's Global Turning Point Report, released during the Davos World Economic Forums Annual Meeting, 23 May 2023, finds that if left unchecked climate change could **cost the global economy US$ 178 Trillion over the next 50 years, or a 7.6% cut to global gross domestic product GDP in the year 2070 alone.** However, with global leaders uniting in a systematic net-zero transition, **the global economy could see new five-decade gains of US$ 43 Trillion, a boost of global GDP of 3.8% in 2070.**

As referenced in the SIDS Sea Level Rise and Coastal Inundation Use Case, UNCTAD reports that in the Caribbean alone, the **damage caused by climate-related and earth-related hazards** is estimated at US$ 12.6 Billion per year.

The United Nations Environment Programme state that climate adaptation is becoming more expensive as the magnitude of climate change sets in, estimating countries may need to spend up to US$ 300 Billion a year by 2030 and US$ 500 Billion by 2050.



Source: istock

Seabed mapping and bathymetry provides data intelligence on water depth, seabed features, seabed surface texture, and 3-dimensional profile/geometries, which collectively support a range of climate related modeling requirements from ocean to the local level. Further, and as reported here and in wider use cases, seabed mapping is also key input to other specialist models including sea level rise and coastal inundation, and models associated with extreme weather events cyclones and storm surge among others, which are becoming more frequent as a result of climate change.

As a data input to climate ocean modeling, providing enhanced intelligence on sea-level rise, sea-ice models, nearshore and coastal models (for mitigation and adaptation planning), seabed mapping/bathymetry has a key supporting role informing climate change response today and going forward.

BENEFITS

- **Data Input to Ocean Climate Models**

Providing Sea floor slope and surface roughness and geomorphology to inform and enhance ocean mixing model elements.

- **Enhancing Climate Regional/Specialist Models Ocean Models, including the potential to enhance Sea Level Rise predictions, (Marine parts of the Cryosphere)**

Enhanced sea-ice melt prediction through the use of bathymetry, and marine outlet glacier dynamics. Seafloor shape greatly influences the sub-ice shelf circulation and thereby glacier submarine melt rate. Especially the identification and characterisation of the areas where warmer ocean water reaches marine-terminating glaciers and has potential to cause melting. Potential to provide enhanced climate sea level rise predictions.

- **Near Shore and Coastal Climate Change Mitigation/Adaptation Planning and Implementation**

Bathymetry/coastal surveys to inform and support climate change mitigation and adaptation planning, design and implementation.

4.5mm

Global mean sea-level

Global mean sea-level reached a new record high in 2021, rising an average of 4.5 millimetre per year over the period 2013 to 2021 (UN reference WMO), compared to 2.1 millimetre per year during 1993-2002.

90%

Our Market Research Shows:

A total of 90% of the Seabed 2030 Community identified strong levels of dependency on High Seas Seabed Mapping Grid Data, with 58.3% identified that Climate Change sector has High Dependency on High Seas 'Seabed Mapping Grid Data'. [Meaning that Seabed 2030 high seas grid data is critical to the sector, a 'Must Have' position]. A further 31.7% identified that Climate Change sector has Medium Dependency on High Seas 'Seabed Mapping Grid Data.' [Meaning that Seabed 2030 high seas grid data provides a level of enhanced value in the sector, a 'Good to Have' position].

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

Future View

Today, we see Seabed mapping supporting climate change modelling in ocean, sea-ice, sub-ocean and near shore / coastal settings. As we look forward, we can see demand for seabed mapping increasing both (i) to better understand glacier and sea ice dynamics [In the polar regions], and (ii) to support modelling and climate mitigation/adaptation planning [In low-lying ocean, nearshore and coastal areas]. Complete ocean coverage GEBCO grid data will close a current key data gap and provide opportunities for climate sub-ocean and domain modelling at coverages and resolutions not possible today.

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: HIGH

Author suggested qualitative view.

Source: istock

Industry Experts Stated

For Open Ocean climate change modelling the GEBCO grid is relevant and used. [In Polar context], estimating the mass loss from discharge of Earth's large remaining ice sheets in a warming climate is highlighted as glaciology's grand challenge, constituting a large uncertainty in our predictions of future sea level rise. Mapping the bathymetry of the Fjords where large glaciers drain is one of the most critical steps in assessing the future of a glacier and represents a compelling case for Seabed 2030 / bathymetry survey acquisition." Industry Experts

Jamie McMichael-Phillips, Seabed 2030 Director.

"Seabed mapping has a key role to play towards informing climate ocean models. As a data input for the modelling of key elements such as sea-ice interaction in polar settings, sub-ocean processes, nearshore and coastal interactions, seabed mapping enhances our understanding and response to climate change." Jamie McMichael-Phillips, Seabed 2030 Director

SEABED 2030 MAPPING INITIATIVE

Our mission is to inspire ocean mapping and deliver a complete seabed map for the benefit of people and the planet. Formed by The Nippon Foundation & GEBCO, Seabed 2030 is a global initiative where industry, governments, researchers, and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
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USE CASE: SECTOR: CLIMATE CHANGE • USE CASE: SMALL ISLAND DEVELOPING STATES (SIDS) SEA LEVEL RISE AND COASTAL INUNDATION

Small Island Developing States (or SIDS) are particularly vulnerable to sea level rise and coastal inundation. Many SIDS are low-lying coastal states, where small changes in sea level rise can have significant and long-lasting impact.

"We see a lot of uses for Ocean mapping in our work on climate change, and our planning and response to sea level rise. From understanding what changes are occurring and predicted, and anticipating the pace at which it may occur, through to integrating this data into our land use and infrastructure forward planning work." Tion Uriam Republic of Kiribati Representative and Industry Expert.

The Challenge

Sea level rise is a global challenge and concern.

Coastal Inundation is the covering of normally dry land with water. This refers to the long-term result of sea level rise, as well as the shorter and more variable impacts of high-tide and storm surge flooding.

Understanding the sea level rise current position baseline, the future anticipated state and the pace at which change is likely to occur are fundamental to informing sea level rise response, mitigation and adaptation.

The global ability to access the range of ocean/coastal mapping technologies, including from satellite-derived bathymetry through to boat mounted multibeam echo sounders and GIS, supporting sea level rise mapping and analysis and for coastal engineering purposes, are an important part of a community robust response to both sea level rise and coastal inundation.

Capacity building to enable global communities to be well placed to leverage ocean mapping technologies and data in support of sea level rise and coastal inundation is needed.


Source: istock - South Tarawa atoll, Kiribati

Introduction

United Nations Security Council held a dedicated meeting on sea level rise in February 2023, recognising the impact of rising seas: already, creating new sources of instability and conflict, some nations coast-lines have already seen triple the average rate of sea level rise, and globally we will witness a mass exodus of entire populations on a biblical scale with ever fiercer competition for fresh water, land and other resources.

Globally, 900 million people live in coastal areas, and UN Security Council cited projections that between 250 and 400 million people will likely need new homes in new locations in fewer than 80 years.

Small Island Developing States, (or SIDS) are a distinct group of 39 States and 18 Associate Members of United Nations regional commissions that face unique social, economic and environmental vulnerabilities. Geographical regions where SIDS are located include: the Caribbean, the Pacific, the Atlantic, Indian Ocean and South China Sea (AIS). The aggregated population of all the SIDS is 65 million persons, ~ 1% of the world's population.

United Nations state that climate change has a very tangible impact on SIDS, citing Hurricanes Harvey, Irma, Maria, and Nate turning the 2017 tropical cyclone season into one of the deadliest and most devastating of all time, destroying communications, energy and transport infrastructure, homes, health facilities and schools. Further, that slow onset events such as sea level rise pose an existential threat to small island communities, requiring drastic measures such as relocation of populations, and the related challenges this poses. These challenges are compounded by limited institutional capacity, scarce financial resources and a high degree of vulnerability to systemic shocks.

In this use case, a range of Ocean and Coastal Mapping technology-based approaches are presented, demonstrating how they are applied in support of coastal infrastructure planning, design, and construction. These are particularly important for port/harbour development and the introduction of coastal inundation protections, such as coastal and flood defences. We also draw on two SIDS experiences, Tuvalu and Republic of Kiribati, highlighting how these Nations are using Ocean and Coastal Mapping supporting their response to sea level rise and coastal inundation.

Ocean and Coastal Mapping are Critical Data for Sea Level Rise and Coastal Inundation Planning and Adaptation

As **part of nation efforts to understand, plan and prepare for, mitigate and adapt to sea level rise, SIDS are drawing on Ocean Mapping support from a number of International/Regional/National Institutions,** including: United Nations (e.g., UN Development Programme), World Bank, and Asian Development Bank, towards policy studies, and provision of development project funding; with implementation support from Australia (e.g., through Geoscience Australia), New Zealand (e.g., through LINZ), and United Kingdom (e.g., through UKHO Primary Charting Authority (PCA) cooperation, among others. Seabed 2030 and IHO are also contributing to capacity building workshops and training delivery, and private sector companies e.g., Fugro and TCarta, among others, through commissioned contracts for survey and technical services delivery.

Modelling Sea Level Rise and Coastal Inundation: *Please note that Global Ocean Models are important in the context of Sea Level Rise and are addressed by a dedicated use case in this series.* CoastAdapt, an Australian Government Commissioned Information and Guidance Resource, state that coastal area of local scale modelling can provide a detailed view of coastal inundation and erosion risk across a range of spatial scales and under a range of climate and storm scenarios. The complexity of most models, as well as the input data required, limits their use to specific areas. CoastAdapt state there are two primary classes of models for predicting coastal inundation and erosion: (i) empirical, or data driven, and (ii) process-based numerical models.

Given the complexity and input requirements for these numerical models, (which note include seabed mapping depth, features and type elements), it is often impractical to use detailed models across large spatial scales. Instead, it is more practical to do a first-pass assessment using existing ‘bathtub' inundation predictions under different sea-level rise scenarios, then identify focus areas where a numerical model can then be used to provide additional insight. A bathtub model assumes that a (for example) 1 m rise in sea level will inundate all locations at or below an elevation of 1 m plus the highest astronomical tide.

When considering flood models and the movement of water across the terrestrial landscape (landside), data on the terrain, surface features (which act as obstacles to water movement), vegetation and land cover, ground hydrology properties, and drainage interact and are modelled in specialist software to determine flood pathway, depth, and speed.

Better resolution and accuracy terrain/elevation data leads to enhanced modelling outputs, and **airborne LiDAR bathymetry technologies** are considered ideal sources, (e.g., providing 4m, 2m, or 1m resolution data

Source: Fugro Airborne LIDAR Bathymetric System

on land/seabed in coastal area), noting that Secchi depth limitations persist regards feasibility. For low transparency/more turbid waters, boat based single/-multibeam echo sounding approaches are adopted.

Satellite data capabilities offer the ability to rapidly delineate flood area extents, either based on archive search or tasking during a coastal flood event itself. Satellite imagery can be paired up with GEBCO grid data for visualisation purposes and context understanding. A further benefit of satellite data is that large geographic areas can be covered rapidly, and repeat acquisitions undertaken over time, providing an ability to monitor progress on the ground and detect change.

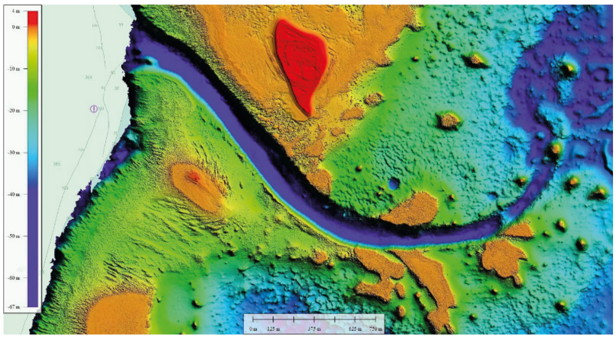
Satellite-Derived Bathymetry (SDB) is another coastal mapping technology approach being used by SIDS to inform coastal development, disaster management and disaster risk resilience. SDB may be considered ahead of and while a business case for commissioning LiDAR surveys is progressed, providing easy to access insight. A good example is **Republic of Kiribati,** who in cooperation with the **UKHO, as Primary Charting Authority**, and delivery partner **TCarta company** is using an SBD approach to better understand areas at risk of flooding and plan sea defences. Additionally, using a satellite approach, Kiribati is understanding the extent of mangrove and other coastal vegetation, that can contribute to coastal inundation adaptation and risk reduction.

Tuvalu Coastal Adaptation Project (TCAP) showcases the use of airborne LiDAR bathymetric technologies, [Source: Fugro, and UNDP TCAP project published details]. **The Tuvalu Coastal Adaptation Project (TCAP)** was launched in 2017, with the aim to reduce exposure to coastal hazards and to develop a long-term coastal adaptation strategy for the country. TCAP received backing from the global **Green Climate Fund** and was delivered in partnership with the **United Nations Development Programme. Fugro company** was implementation company providing a range of technical services.

A key task of the project was to **secure baseline data to elucidate the relationship between land elevation and sea level**, to **model future scenarios**, and to **inform design of coastal infrastructure**, as well as **development planning.**

Fugro's Airborne Lidar Bathymetry (ALB) technology was used, providing accurate Tuvalu national coverage of shallow (0 - 50 metres), nearshore and lagoon bathymetry and island topography. The survey plane also **captured aerial photographs** which when combined with the **LiDAR data** provided powerful **3-dimensional tool for use in marine/coastal hazards management.** The resulting products were fundamental to the understanding of marine hazards and are also used to analyse coastal processes, sea level rise, storm wave inundation, sediment movement, and to identify low-lying flood zones. The survey products also have a range of development uses such as resource management, conservation, safe navigation, adaptation and development planning.

Tuvalu found that "An individual home can be easily identified, with its location in relation to the shore and to sea level instantly measured. The team also observed during highest measured sea levels, 46 percent of the central built area of Fogafale is essentially below sea level — a fact which directly substantiates Tuvalu's reports of ever-increasing flooding due to sea level rise in their capital."



Source: Fugro Topo-bathymetric lidar of Tuvalu islands in the Pacific Ocean.

UNDP highlighted uses of the data, including:

- Brief outer island Kaupule (councils) about safer flood-free zones for building.
- The Government had integrated the data into its national recovery and vulnerability reduction plan for Tropical Cyclone Tino, which by official estimates severely affected more than half the population and led to a State of Emergency.
- The data was to be incorporated into navigation charts, crucial for safe ship operations and trade (presently there are where no updated charts for Tuvalu since the mid 1980s).
- Tuvalu's Department of Lands and Survey was using the data as its baseline for planning and was also incorporating it into its maritime boundaries work.
- The UNDP-supported Ridge2Reef project drawing on the data to support reef conservation work.
- A World Bank-backed project improving the climate resilience of Nanumaga's harbour and Funafuti's port was looking at using the data in their risk modelling around the impacts of storm surges.

In summary the UNDP stated (i) the Government of Tuvalu is now basing their long-term adaptation strategy, including land reclamation plans, on the data collected, and (ii) that the products from the LIDAR survey are truly a game changer, informing all aspects of development, including infrastructure planning and adaptation, and that (iii) in terms of the fight against climate change, the data is an incredibly empowering tool.

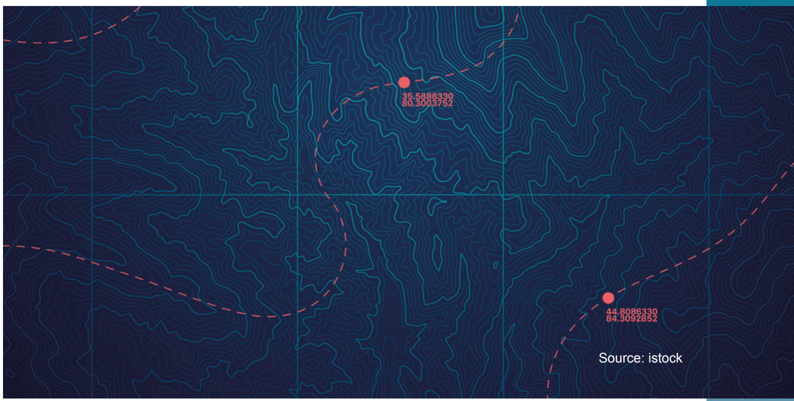
VALUE ADDED

Small Island Developing States (or SIDS) are particularly vulnerable to sea level rise and coastal inundation. Many SIDS are low-lying coastal states, where small changes in sea-level rise can have significant and long-lasting impact.

UNCTAD [May 2022] reported that SIDS' geographical conditions make them highly vulnerable to natural disasters, particularly those caused by climate change. In the Caribbean alone, the damage caused by climate-related and earth-related hazards is estimated at $12.6 billion per year. Further, SIDS major disaster events are becoming more frequent. Before the 2000s, SIDS endured fewer than ten major natural disasters per year. Yet over the past two decades, 20 major natural disasters have struck SIDS each year. These add to other climate-related phenomena most SIDS are prone to, such as coastal erosion, flooding and permanent land submersion resulting from rising sea levels.

Ocean and coastal mapping offers robust technology and data-driven support to Small Island Developing State fight against climate change, and response to sea level rise and coastal inundation threats.

As a key input to Global Ocean Models, storm surge, and tsunami propagation modelling, as addressed in other use cases prepared in this series, through to coastal inundation and flood modelling, informing and mapping baseline position, forward planning, and as a key 3-dimensional data input, seabed/coastal feature data, and land cover to the planning, designing and construction of hard infrastructure and nature based adaptation solutions, ocean and coastal mapping has a key supporting role today and going forward.



Source: istock

IMF, June 2023, referenced a World Bank (2017) estimation that adaptation costs exclusively for coastal protection in Kiribati—protecting the low-lying atolls from rising sea level through sea dike construction and port upgrade—could reach US$54 million (equivalent to 11 percent of GDP per year) in the 2040s.

BENEFITS

• Understand hight and 3-dimension context, closing a fundamental data gap

Including blue and green depth and elevation height, and as data supporting 3-dimension related decisions. A useful visual aid to support stakeholder and community engagement to demonstrate the extent of the challenge and future plans.

• Baseline and predict future scenario modelling and monitor change.

Contribute to key models, including Global Ocean Models, Storm Surge and Tsunami Propagation Modelling, Coastal Inundation and Flood Modelling, and through GIS analysis scenario impacts to inform and aid planning and decision-making. Capability to monitor progress and detect change through satellite monitoring and resurvey works.

• Inform development planning and the design and build of infrastructure and nature based adaptation solutions.

Provide 3d depth and elevation data input, seabed / coastal feature data, and land cover intelligence into the planning, design and construction of hard infrastructure and nature-based adaptation solutions.

3-D

3-Dimension

Ocean and coastal mapping approaches are the most efficient and effective way of introducing accurate 3-dimensional, (X, Y and Z) intelligence to inform sea level rise and coastal inundation planning and adaptation.

91.7%

Our Market Research Shows:

A total of 91.7% of the Seabed 2030 Community identified strong levels of dependency on High Seas Seabed Mapping Grid Data, with 65% identified that Disaster Management and Disaster Risk Resilience sectors have High Dependency on High Seas 'Seabed Mapping Grid Data'. [Meaning that Seabed 2030 high seas grid data is critical to the sector, a 'Must Have' position]. A further 26.7% identified that Disaster Management and Disaster Risk Resilience sectors have Medium Dependency on High Seas 'Seabed Mapping Grid Data.' [Meaning that Seabed 2030 high seas grid data provides a level of enhanced value in the sector, a 'Good to Have' position].

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

Look to the Future

The Ocean Mapping community has a range of technologies and methodologies at their disposal to support Small Island Developing States need for bathymetry and coastal mapping, and help in their flight against climate change, sea level rise and coastal inundation. Climate change, disaster management and risk resilience are vitally important application areas for ocean and coastal mapping, as shown by the excellent activities underway in the Republic of Kiribati and Tuvalu. As we increase our seabed mapping to achieve global coverage, more and more data will become available for use, coupled with the ability to draw on capacity building and hands on experience from countries including Kiribati and Tuvalu.

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: MEDIUM

Author suggested qualitative view.

Source: istock

Tion Uriam Republic of Kiribati Representative and Industry Expert.

”We see a lot of uses for Ocean mapping in our work on climate change, and our planning and response to sea level rise. From understanding what changes are occurring and predicted, and anticipating the pace at which it may occur, through to integrating this data into our land use and infrastructure forward planning work.” Tion Uriam Republic of Kiribati Representative and Industry Expert.

Jamie McMichael-Phillips, Seabed 2030 Director.

“The Republic of Kiribati and Tuvalu use of Ocean Mapping demonstrate so well the importance of and significant contribution that Ocean Mapping technologies and data make towards the fight against climate change, the planning and adaptation for sea level rise and threat of coastal inundation.” Jamie McMichael-Phillips,Seabed 2030 Director.”

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USE CASE: MARINE BIODIVERSITY

Biological diversity, or biodiversity, is defined as the variety of life, encompassing variation at levels of complexity from within species to across ecosystems. Marine biodiversity is the variety of life in our ocean.

"It is difficult to understand the ecosystem if you don't know it is a seamount…", "Once you have the bathymetry [The details on the water depth and seabed characteristics], then you can have the habitat." Industry Expert

The Challenge

NOAA identify the following most basic challenges and threats to marine biodiversity:
(i) Human population growth is out of proportion to natural resource availability,
(ii) Heavy consumption and excessive exploitation of natural resources (deep sea mining, drilling, etc.),
(iii) Lack of sufficient knowledge and understanding of species and ecosystems,
(iv) Destruction of ecosystems and habitats due to increased land use, overfishing, sea shipping and transportation,
(v) Ocean and waterways pollution and
(vi) Global climate change.

Seabed mapping is a fundamental part of our global response to marine biodiversity challenges we face today. Marine biodiversity hotspots are themselves highly dependent on seabed characteristics. Industry Experts state their work in the marine biodiversity field is highly dependent on and makes good use of seabed mapping. Marine biodiversity policy development and regulation delineation are informed by seabed mapping related intelligence.

Source: istock

Introduction

The **United Nations Convention on Biological Diversity defines biodiversity or biological diversity** as: "The variability among living organisms from all sources, including, inter alia [among other things], terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems." There are three conceptual levels of biodiversity associated with this definition:

1. Organisms' diversity refers to the diversity of species found in various habitats. This is the diversity of creatures and species populations, as well as how they interact.
2. Genetic diversity refers to the variety of genes found within a species, as well as processes like mutations, gene exchanges, and genome dynamics that occur at the DNA level and result in evolution.
3. Ecosystem diversity refers to a region's genetic, biological, and ecosystem diversity. This refers to the variety of species interactions and their surroundings.

The UN Convention further states: Biodiversity exists now as a result of billions of years of evolution, natural processes, and, more recently, human activities. The biodiversity of the Earth and the ocean was substantially larger before the arrival of Homo sapiens. Due to the exploitation of Earth's resources and exponential population increase, human activity has had a huge impact on the planet and its life.

UNESCO guide us on the importance of and need for our focus on biodiversity. UNESCO state '**Biodiversity is the living fabric of our planet.** It underpins human wellbeing in the present and in the future, and its rapid decline threatens nature and people alike. It is vital to transform people's roles, actions, and relationships with biodiversity, to halt and reverse its decline.' A UN Chronicle reports, introduces us to **Marine biodiversity, as the variety of life in the ocean and seas, and states it is a critical aspect of all three pillars of sustainable development, economic, social and environmental, supporting the healthy functioning of the planet and providing services that underpin the health, wellbeing and prosperity of humanity. Further that the ocean is one of the main repositories of the world's biodiversity, constituting over 90 per cent of the habitable space on the planet and contains some 250,000 known species**, with many more remaining to be discovered, at least two thirds of the world's marine species are still unidentified.

Biodiversity Hotspots Concept: NOAA promotes a biodiversity definition as used by ecologists, as the sum variation within the genes and the species of a given region. Where "Hotspots" are recognized as containing exceptional levels of endemic species (those that are found nowhere else) in regions seriously threatened by habitat loss. They may also include unique ecological and evolutionary boundaries. A number of marine ecosystems fit this definition of a biodiversity hotspot due to the uniqueness of the habitat (e.g., deep-sea hydrothermal vents, etc.); and others fit due to sheer numbers of species and the threat to these organisms (e.g., coral reefs).

To emphasise the importance of marine biodiversity and its cross-cutting interaction with another key global challenge climate change, UN state, that **Marine biodiversity is both significantly impacted by and a key part of our global response to climate change**, stating: (i) **Ocean habitats such as mangroves are some of the most carbon-rich ecosystems on the planet,** storing on average 1,000 tonnes of carbon per hectare in their biomass and underlying soils. (UNEP) (ii) Covering less than 0.1 percent of the world's ocean, **coral reefs support over 25 per cent of marine biodiversity** and serve up to a billion people with coastal protection, fisheries, sources of medicine, recreational benefits, and tourism revenues. (UNEP) (iii) **Wetlands such as mangroves, seagrasses, marshes, and swamps are highly effective carbon sinks that absorb and store CO2,** helping to reduce greenhouse gas emissions, and (iv) **Wetlands also serve as a buffer against extreme weather events.** They provide a natural shield against storm surges and absorb excess water and precipitation. Through the plants and microorganisms that they house, wetlands also provide water storage and purification.

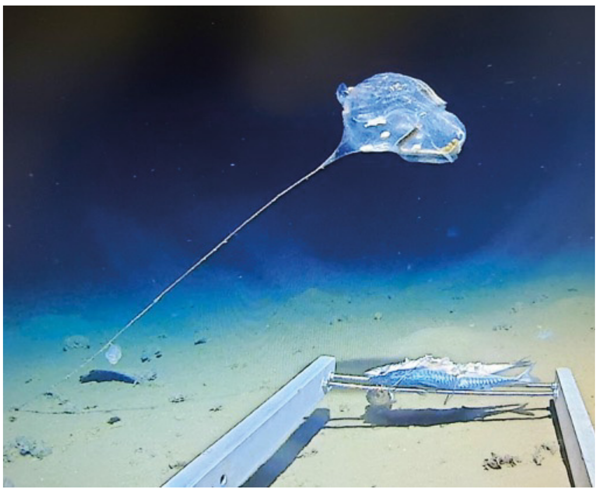
In this use case we highlight how **seabed mapping enhances our knowledge and understanding of marine biodiversity,** and how it is **fundamental to the mapping, monitoring, and protection of key marine biodiversity areas of interest.** We reference **Industry Expert experience and case study examples showcasing how seabed mapping supports our understanding towards biodiversity hotspots,** from coastal/near-shore and shallow water, to deep water, and through to the Ocean Hadal Zone. We expand on how **seabed mapping marine biodiversity support provides further benefit to other ocean/marine sectors,** such as marine science and research, ecosystem services, ocean discovery/exploration, and a number of areas of the Ocean/Blue economy, including fisheries, tourism, and biotechnology/bio pharmacy, clearly demonstrating the **significant contribution seabed mapping is making towards marine biodiversity, and a number of other related marine interests and concerns.**

Seabed Mapping is foundational for and used extensively for Marine Biodiversity purposes.

Seabed mapping enhances our knowledge and understanding of marine biodiversity.
Industry Experts state that seabed mapping is fundamental to understanding and interpreting the marine ecosystems. The **seabed characteristics and water depth determine the existence and feasibility of success of a habitat in any particular location.** A range of detail derived from seabed mapping/bathymetry are of interest to marine biologists, including water depth, seafloor type (flat, sediments, etc), key seabed landscape features, such as seamounts, abyssal plain, trench, subsea volcano etc, and specific details including slope, shape and corridors/channels that determine water movement and circulation. "Once you have the bathymetry [the details on the water depth and seabed characteristics], then you can have the habitat."

Seabed mapping supports the mapping, monitoring, and protection of key marine biodiversity areas of interest. Seabed mapping provides a 2d and 3d framework that allows the georeferencing and presentation of ecosystem, habitat, community and species data. Further seabed mapping supports the planning and implementation of marine biology specialist survey and sampling activity. For monitoring, seabed mapping supports the planning and development of a monitoring regime, from high level planning including identification of the type of equipment required, survey risk assessment and mobilisation planning, through to the recording, referencing and presentation of results. The 2d/3d elements may be used to inform **species distribution studies, habitat fragmentation investigation studies, and habitat zonation** work, which in turn provide an **evidence base to inform marine biodiversity policy and protections, and associated boundary delineation for monitoring and enforcement.** Whilst covered in wider use cases, it is important to also reference here the key part seabed mapping also provides as a **key input data to the modelling, analysis and assessment of marine biodiversity 'threats' and 'risks',** which may include climate change, storm event habitat and ecosystem destruction, among others, which may occur both as a result of both natural and human causes.

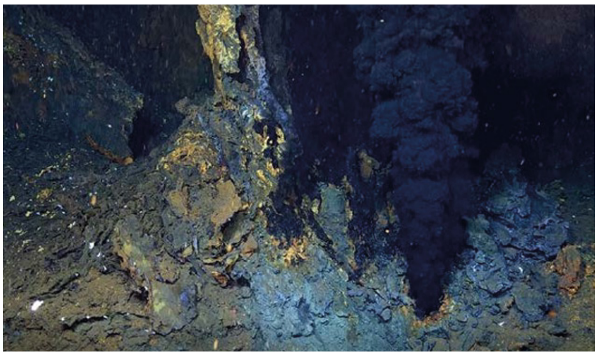
Marine biodiversity and associated scientific interests go hand in hand with **ocean exploration,** where the ocean exploration community include marine biology and science as key part of their expedition ethos and focus. New habitats and indeed new species are routinely discovered through exploration activities.
Showcasing Seabed Mapping supporting marine biodiversity hotspots. Industry Experts cited examples are numerous, but to look towards global interest ecosystems and habitats, and in the context of global coverage seabed mapping identification of sites/locations, highlight examples include (source: NOAA and Woods Hole Oceanographic Institution where stated):
Coastal/near shore, and the Continental shelf]: range of habitats exist in the littoral zone. Globally important marine biodiversity hotspots include shallow water coral reefs, mangrove, and seagrass fields, among others. Of note, mangrove and seagrass also have significant potential towards mitigation and adaptation to climate change (e.g., carbon capture, and coastal protection). **Deep Water Coral reefs:**



Source: Five Deeps Expedition: A new species, believed to be a Stalked Ascidian, discovered in the depths of the Java Trench.

Along with sponges, corals form some of the most important living habitats in the deep sea. **Seamounts:** Seamounts are underwater mountains that rise hundreds or thousands of feet from the seafloor. Woods Hole Oceanographic Institution state that Seamounts provide hard foundations for deep-sea life to settle on and grow. In addition, seamounts rising into the ocean create obstacles that shape ocean currents and direct deep, nutrient-rich waters up the sloping sides of seamounts to the surface. These factors combine to make seamounts fertile habitats for diverse communities of marine life, including sponges, crabs, sea anemones, commercially important fish, and deep-sea corals. An Industry Expert stated simply: “Seamounts are a flourish of life and the seabed mapping shows us where the seamounts are.”
Hadal Zone, Trenches: Woods Hole Oceanographic Institution state ocean trenches are steep depressions in the deepest parts of the ocean, with depths exceeding 6,000 meters (nearly 20,000 feet). Trenches make up the world’s "hadal zone”, and account for the deepest 45 percent of the global ocean. The deepest parts of a trench, however, represent only about 1 percent or less of the trench total area. The vast submarine slopes and steep walls of trenches make up much of the hadal zone, where unique habitats extending across a range of depths are home to diverse number of species, many of which are new or still unknown to science. Many of the organisms living in trenches have evolved surprising ways to survive in these unique environments. Recent discoveries in the hadal zone have revealed organisms with proteins and biomolecules suited to resisting the crushing hydrostatic pressure and others able to harness energy from the chemicals that leak out of hydrocarbon seeps and mud volcanoes on the seafloor.
Hydrothermal Vents: NOAA state, Hydrothermal vents are the result of seawater percolating down through fissures in the ocean crust in the vicinity of spreading centres or subduction zones (places on Earth where two tectonic plates move away or towards one another). The cold seawater is heated by hot magma and reemerges to form the vents. Seawater in hydrothermal vents may reach temperatures of over 700° Fahrenheit. Further, hot seawater in hydrothermal vents does not boil because of the extreme pressure at the depths where the vents are formed. Hydrothermal vents are critical to the regulation of global ocean chemistry, and they support complex ecosystems that have developed unique biochemical adaptations to specialist high temperatures and environmental conditions
Seabed mapping marine biodiversity support

Source Eva Ramirez-Llodra, et al Abstract, The Aurora Vent Field, Gakkel Ridge Revealed Paper [Arctic Ocean] – Evidence of hydrothermal venting on the ultra-slow spreading Gakkel Ridge in the Central Arctic Ocean has been available since 2001, with first visual evidence of black smokers on the Aurora Vent Field obtained in 2014. In 2021 the first ever remotely operated vehicle (ROV) dived to the hydrothermal vents under permanent ice cover in Arctic, enabling the collection of vent fluids, rocks, microbes and fauna. Providing a first description of the Aurora Vent Field, including three actively venting black smokers and diffuse flow on the Aurora Mound at ~3888 m depth on the southern part of the Gakkel Ridge (82.5 degrees North). Biological communities included new species of cocculinid limpet, two small gastropods and a melitid amphipod.



Source: Eva Ramirez-Llodra et al. Aurora Vent Field black smokers, the Enceladus black smoker

provides cross-cutting spillover benefit in other ocean/marine sectors. Industry Experts highlighted a number of examples where the foundational role of the seabed and seabed mapping, and associated marine biodiversity hotspots benefit wider marine sectors. Highlighted examples include, for wider **Ocean/Blue economy, fisheries** (where marine biodiversity hotspots are also fisheries nursery areas), **tourism (especially ecotourism and sustainable tourism segments), and biotechnology/bio pharmacy**, where the discovery of specialist biochemistry properties of species such as sponges, among others, have been leveraged by bio pharmacy industry to develop anti-viral, anti-cancer and pain killer drugs, among others.

A look to the future and what will complete ocean coverage of seabed mapping mean for marine biodiversity?

Industry Experts stated seabed mapping as a backdrop is an excellent storyteller and has a role to inform and educate the public on marine interests generally. Also, for more specialist concerns such as marine biodiversity and wider challenges such as climate change and marine pollution. The 3-dimensional nature of bathymetry data and the ability to present data in its local/spatial context lends itself well for the display and communication of analysis and information. The community is already using the GEBCO grid data as the reference framework for marine biodiversity catalogues and inventories and envisage this role will only increase as the GEBCO ocean coverage increases.

Industry experts also stated they looked forward to having access to global coverage seabed mapping through the Seabed 2030 mapping initiative, and that this will bring significant benefit to their work and community. The following key global coverage opportunities were identified:

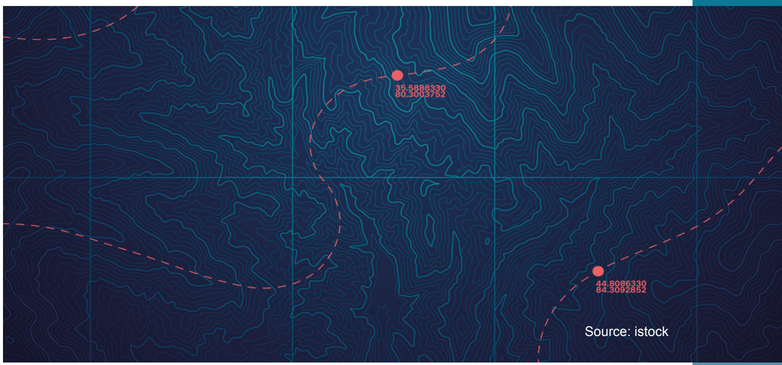
- To become a standard 2/3-dimensional model for the georeferencing and presentation of marine biodiversity and ecosystem services information, and for public publication and awareness building.
- Enhance global inventories of marine biodiversity hotspots and locations of interest.
- As a community being better informed on candidate marine biodiversity and potential habitat areas, with better targeting of areas for further research and study, and the ability to review a global ocean scape to help determine where best to go.
- It is known there are species to be discovered and vast areas of the oceans not explored. Access to global ocean seabed mapping coverage will open up the oceans for further discovery opportunities, especially where there is a potential for an AI/ML approach to be leveraged to run global search and analysis.

SEABED MAPPING VALUE ADDED

Seabed mapping is a foundation data and an important source for 2d and 3d geospatial referencing of biodiversity and habitat intelligence. Seabed mapping provides detailed on water depth, and a range of seabed characteristics useful for marine biodiversity, and wider marine and coastal ecosystem services purposes.The existence and sustainability of Marine biodiversity hotspots are highly dependent on water depth and a range of seabed characteristics including, geomorphology, slope, and texture, among others. Seabed landscape features determine habitat opportunities, e.g., coral, seamounts, abyssal plain, trench, hadal zone, among others.

Highlight seabed mapping support to marine biodiversity includes, among others:

1. The enablement and advancement of our knowledge and understanding of marine species, habitats and ecosystems.
2. Supporting the mapping and monitoring of marine biodiversity hotspots, habitats and areas of 'biodiversity' interest.
3. Aiding ocean discovery/exploration, enabling new ecosystem and species discovery.
4. Supporting the modelling, analysis and assessment of marine biodiversity 'threats' and 'risks', including climate change, habitat and ecosystem destruction, natural resources management, among others.
5. Informing policy and regulatory boundary delineations, e.g., Marine Protected Areas, among others.



Marine biodiversity provides significant economic value. Examples include **World Economic Forum,** reported in August 2021, that Worldwide, **mangroves** reduce risk to more than 15 million people and prevent more than $65 billion in property damages each year. **Smithsonian** state that, one hectare of **seagrass** (about two football fields) is estimated to be worth over $19,000 per year, making them one of the most valuable ecosystems on the planet. And **NOAA Office for Coastal Management** state that the **total economic value of coral reef services** for the U.S., including fisheries, tourism, and coastal protection is over $3.4 billion each year, and that annually, U.S. coral reefs provide flood protection benefits of $1.8 billion in averted damages to property and economic activity.

BENEFITS

• Enablement and advancement of our knowledge and understanding of marine species, habitats and ecosystems.

Supporting the mapping and monitoring of marine biodiversity hotspots, habitats and areas of 'biodiversity' interest, and the modelling, analysis and assessment of marine biodiversity 'threats' and 'risks'.

• Marine Biodiversity, supported by seabed mapping enables cross-cutting and spillover benefit in other ocean/marine sectors.

Including for Ocean Discovery/Exploration, Climate Change, and areas of the Ocean/Blue Economy including fisheries, Tourism, and biotechnology/bio pharmacy, among others.

• Future Marine Biodiversity Opportunities

Enhanced global inventories of marine biodiversity hotspots and areas interest through the use of seabed mapping. Ability to run global search and analysis for marine biodiversity purposes.

25%

Coral Reefs Support 25% of marine biodiversity.

Covering less than 0.1 percent of the world's ocean, coral reefs support over 25 per cent of marine biodiversity and serve up to a billion people with coastal protection, fisheries, sources of medicine, recreational benefits, and tourism revenues. (UNEP)

88.5%

Our Market Research Shows:

A total of 88.5% of the Seabed 2030 Community identified strong levels of dependency on High Seas Seabed Mapping Grid Data, with 57.4% identified that Marine and Coastal Ecosystem Services (including Biodiversity) sector has High Dependency on High Seas 'Seabed Mapping Grid Data'. [Meaning that Seabed 2030 high seas grid data is critical to the sector, a 'Must Have' position]. A further 31.1% identified that Marine and Coastal Ecosystem Services (including Biodiversity) sector has Medium Dependency on High Seas 'Seabed Mapping Grid Data.' [Meaning that Seabed 2030 high seas grid data provides a level of enhanced value in the sector, a 'Good to Have' position].

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

OVERALL

Marine biodiversity, along with climate change and marine pollution are the top three marine challenges of our time. The seabed and seabed mapping plays a very important enabling and supporting role towards marine biodiversity. With expanding seabed mapping coverage, so too will our knowledge of marine biodiversity increase. Further, we anticipate new and exciting marine biodiversity hotspots and opportunities will present themselves as we achieve global ocean seabed mapping coverage.

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: MEDIUM

ENVIRONMENTAL VALUE IMPACT: HIGH

Author suggested qualitative view.

Source: istock

Industry Experts

"The seabed geomorphology and characteristics, and water depth determines habitat success" Industry Expert
"It is difficult to understand the ecosystem if you don't know it is a seamount…", Industry Expert
"Once you have the bathymetry [the details on the water depth and seabed characteristics], then you can have the habitat." Industry Expert
"All the time we are georeferencing our work to the bathymetry. The bathymetry provides a reference frame, an indication of potential habitats, and supports the planning of habitat work and activities.", Industry Expert

Jamie McMichael-Phillips, Seabed 2030 Director.

" Marine biodiversity, along with climate change and marine pollution are the top three marine challenges of our time. The seabed and seabed mapping plays a very important enabling and supporting role towards marine biodiversity. With expanding seabed mapping coverage, so too will our knowledge of marine biodiversity increase. Further, we anticipate new and exciting marine biodiversity hotspots and opportunities will present themselves as we achieve global ocean seabed mapping coverage." Jamie McMichael-Phillips, Seabed 2030 Director

SEABED 2030 MAPPING INITIATIVE

Our mission is to inspire ocean mapping and deliver a complete seabed map for the benefit of people and the planet. Formed by The Nippon Foundation & GEBCO, Seabed 2030 is a global initiative where industry, governments, researchers, and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

THE NIPPON FOUNDATION-GEBCO

SEABED 2030

USE CASE: SMALL ISLAND DEVELOPING STATES (SIDS) MARINE AND COASTAL DEVELOPMENT, AND THE USE OF SEABED MAPPING AS A FOUNDATION DATA FOR MARINE SPATIAL PLANNING
• USE CASE REF ID: UC009

USE CASE: SMALL ISLAND DEVELOPING STATE (SIDS) MARINE AND COASTAL DEVELOPMENT, AND THE USE OF SEABED MAPPING AS A FOUNDATION DATA FOR MARINE SPATIAL PLANNING

SIDS are strong users of Ocean Mapping including GEBCO seabed mapping products. Uses are wide ranging, example including for Marine Spatial Planning, supporting areas of the Ocean /Blue Economy, and SIDS response to major challenges such as climate change, sea level rise and biodiversity, among others.

"Ocean mapping has supported the development of a number of Kiribati Ocean/Blue economy areas, including ports, maritime transport, maritime safety and navigation charts, submarine cables bringing high speed internet to Kiribati, tourism, fisheries, among others." Tion Uriam Republic of Kiribati Representative and Industry Expert.

The Challenge

Understand, map and visualise the State maritime/marine estate.

Inform the valuation, planning and management of a State's Ocean/Sea areas.

Pursue ocean socio-economic interests, and the sustainable exploitation of ocean/blue economy aligned with State priorities.

Support the implementation of a Regional/State's adopted approach to marine and coastal strategy and policy development and implementation, e.g., MSP, ICZM, and Integrated Seascape Management.

Support progress on a State's regional and international commitments and interests, e.g., MPAs, climate change, and biodiversity.

Capacity building needs, to be able to disseminate and make good use of data and information on marine matters both internal to a nation community and with regional partners.

Source: istock

Introduction

Small Island Developing States, (or SIDS) are a distinct group of 39 States and 18 Associate Members of United Nations regional commissions that face unique social, economic and environmental vulnerabilities. Geographical regions where SIDS are located include: the Caribbean, the Pacific, the Atlantic, Indian Ocean and South China Sea (AIS). The aggregated population of all the SIDS is 65 million persons, ~ 1% of the world's population.

SIDS face unique social, economic and environmental challenges. SIDS have remote geographies, face higher import/export costs for goods as well as less and irregular international traffic services. SIDS EEZs are on average 28 times the country land mass, meaning for many the majority of natural resources are ocean-based. Factors like small population size, remoteness from international markets, high transportation costs, vulnerabilities to economic shocks and fragile land and marine ecosystems make SIDS particularly vulnerable to challenges such as climate change, sea level rise, and biodiversity. SIDS ocean/blue economy areas may include capture fisheries, aquaculture, tourism, and agriculture where even small changes can have devastating impact, SIDS marine and coastal development needs to have cognisance of wider challenges they face, as well as areas of developing their ocean/blue economy sector and areas of interests.

SIDS have access to development support through International Institutions such as World Bank and the UN system, with UN support coordinated through the Office of High Representatives for the Least Developed Countries, Landlocked Countries and Small Island States, (UN-OHRLLS). In the case of accessing hydrographic survey support, a number of SIDS have access to Primary Charting Authority arrangements, through which a range of hydrographic survey, charting, and ocean mapping services are provided.

SIDS representatives and industry experts have identified a range of areas where access to ocean mapping, including GEBCO data, has supported marine and coastal development; supporting SIDS to proceed Ocean/Maritime infrastructure new development/expansion, and enhancement of their priority areas of the Ocean/Blue economy, also supporting action in key challenge areas such as sea level rise and biodiversity. In this use case we highlight the approach and example activities underway in Kiribati, a SIDS located in the Pacific Ocean, focussing on Maritime Infrastructure and the development of Ocean/Blue economy areas. [The SIDS context of climate change and sea level rise is addressed through a separate dedicated Use Case.]

Ocean Mapping Supporting Marine and Coastal Development – Republic of Kiribati Highlights

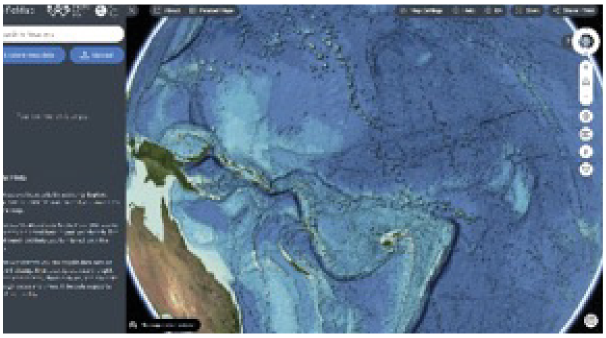
Kiribati SIDS Marine and Coastal Development Strategy and Policy Development. The Republic of Kiribati lies on the equator at the heart of the Pacific Ocean. Kiribati has a population of ~ 101,000, a land area of ~726 Km^2, an EEZ area of ~3,550,000 Km^2, and a Reef area: 1 967 Km^2. With a proportionally large EEZ area, and such a large reef area, the marine ecosystems represent key resources for Kiribati.

As **Marine and Coastal Biodiversity Management** are at the heart of Kiribati marine and coastal development, strategic planning has been delivered through a programme supported by IUCN called **MACBIO [Marine and Coastal Biodiversity Management in Pacific Island Countries].** The MACBIO programme has four pillars (i) **Marine ecosystem service valuation,** (ii) **Marine Spatial Planning,** (iii) **effective management,** and (iv) **dissemination.** As part of this programme, Kiribati Marine Ecosystem Services were valued at AUD 400 million, representing twice the value of Kiribati GDP (valued at 216 AUD Million), and within these two key areas of Kiribati Ocean/Blue economy were valued, inshore fisheries at AUD 45 million, and Tuna Licenses at AUD 53 million.

Kiribati Marine Spatial Planning Approach "Kiribati is committed to increase the benefit from its marine resources through marine spatial planning (MSP)", Kiribati approach guides that MSP, (i) is an inter-sectoral, public and participatory planning tool and process, (ii) seeks to balance ecological, economic, and social objectives, and (iii) aims for sustainable marine resource use and prosperous blue economies.

Marine Spatial Planning (MSP) is a process to spatially organize how people use the ocean to minimise user-conflict and maintain ecosystem health. This is especially important in Pacific Island countries where ~98% of these nations is ocean, and where livelihoods, food security, cultural wellbeing and economic dependencies are intertwined with the sea. MSP involves an inter-sector and participatory public process of identifying and achieving economic, social and ecological objectives in a transparent and organised way. *Source IUCN, Developing a Marine Spatial Plan: A toolkit for the Pacific, part of the IUCN Oceania Marine Programme.*

MSP is a practical way of spatially organising the human use of marine areas to balance the demands of human activities with the need to maintain the health of the ecosystems on which those activities depend. **Ocean Mapping is a foundational data for MSP**, cross cutting the MSP process providing geographic reference and



Source: Pacific Data Hub with GEBCO Basemap

context understanding on the ocean area, also a data layer upon which other ocean intelligence can be geographically referenced and/or presented. Further the data can be used as a visual aid for MSP stakeholder/ consultation engagement and communication. In reference to Kiribati MSP 'steps', Ocean Mapping is relevant to: Step 4: Gather and map baseline data and future conditions, Step 5: Identify special, unique marine areas, Step 6: Define desired ocean zones, Step 7: Prepare guidelines to assist zoning decisions, Step 9: Prepare a draft marine spatial plan, and Step 10: Prepare and implement the final marine spatial plan.

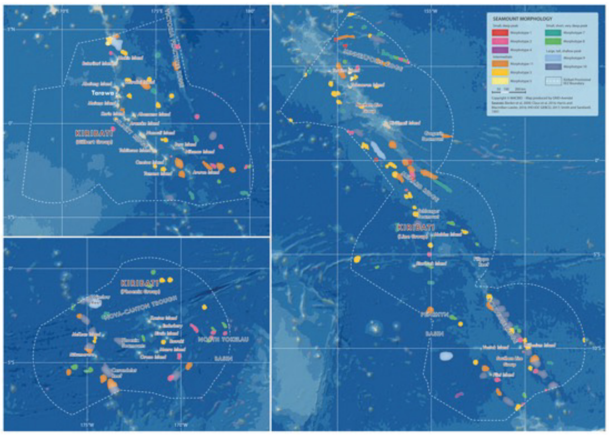
MSP Regional Dimension and Supporting Data Infrastructure. The Kiribati MSP approach adopted is aligned with neighbouring Pacific SIDS, including Fiji, Soloman Islands, Tonga and Vanuatu. These States have worked together with bodies such as IUCN to develop a common MSP toolkit approach. Further, and **to facilitate data dissemination and sharing**, the regional community ensure a single version of key data and information is available for re-use at local, regional and international levels, with key data being made available through the Pacific Data Hub (Regional) and The Kiribati Marine Atlas (National).

The Pacific Data Hub (PDH) aims to deliver the most comprehensive collection of data and information about the Pacific and for the Pacific, including key areas such as population statistics, fisheries science, climate change adaptation, disaster risk reduction and resilience, public health surveillance, conservation of plant genetic resources for food security, and human rights.

Note, GEBCO seabed map grid is used as a base map in both the Pacific Data Hub and Kiribati Marine Atlas. Further, the Kiribati Marine Atlas includes details on ocean depth, and a number of seabed spatial features, including basins, canyons, escarpments, guyots, seamounts, rift valleys, troughs, trenches slope, plateaus, abyssal, among others to aid and support decision-making.

The **Marine Atlas for Kiribati** compiles over a hundred datasets from countless data providers and makes marine and coastal information accessible and usable as data layers and as raw data.

Using the Atlas as a support tool, decision makers from all sectors can appreciate the value of marine ecosystems and the importance of spatial planning in managing these ecosystems. Practitioners can assist these planning processes using the accompanying data layers and raw data in their geographic information systems (GIS).



Source: Marine Atlas for Kiribati – Seamount Morphology. Copyright © MACBIO - Map produced by GRID-Arendal

Ocean/Blue Economy Areas and Ocean Mapping Support.

Tion Uriam, representing Republic of Kiribati Government and an Industry Expert, identified several Kiribati Ocean/Blue Economy areas where seabed mapping has supported. Some highlights of these include ocean mapping supporting:

- Kiribati SOLAS obligations for hydrographic services, with the provision of charting services (through PCA cooperation e.g., with UKHO).
- Port expansion, South Tarawa, enabling larger vessels and additional/more frequent journeys to be made, also boosting tourism.
- Safety of Inter-Island Navigation, improvement of ship safety navigation, enhancing the island access infrastructure and enhancing Lagoon crossings. Better maritime traffic safety and navigation between islands enables people and produce to move to/between the islands. Also, the channels survey work undertaken will support improved cargo ship access, and with this the ability to bring in larger construction machinery and equipment to support wider island infrastructure construction works.

Hydrographic Community Example PCA Support to SIDS, Source UKHO: Support to SOLAS obligations, charting, hydrographic surveying services, technical assistance and advice. E.g., on the governance and management of data, Advocate for support, and capacity building and training.

- Subsea cable support, e.g., the introduction of High-Speed Broadband to Kiritimati Island, Kiribati in 2022, providing connectivity with Australia, New Zealand, and Hawaii and delivering access to faster, more affordable internet.
- Survey data has clearly shown coral extents, supporting a range of environmental, marine biodiversity and habitat management activities.
- Support to fisheries, through understanding the seabed landscape and habitats, informing fisheries management e.g., the protection of fish nursery sites, among others.

Tion Uriam also emphasised the importance of capacity building in the use of hydrographic technologies, geospatial data and GIS, and guided that Kiribati Officers and Staff had participated in a range of training programmes, including IHO provided training in Cartography, a range of training and know how transfer provided through UKHO Primary Charting Authority cooperation and strong relation with LINZ in New Zealand and Seabed 2030 where both LINX and Seabed 2030 have been able to coordinate training support in recent years.

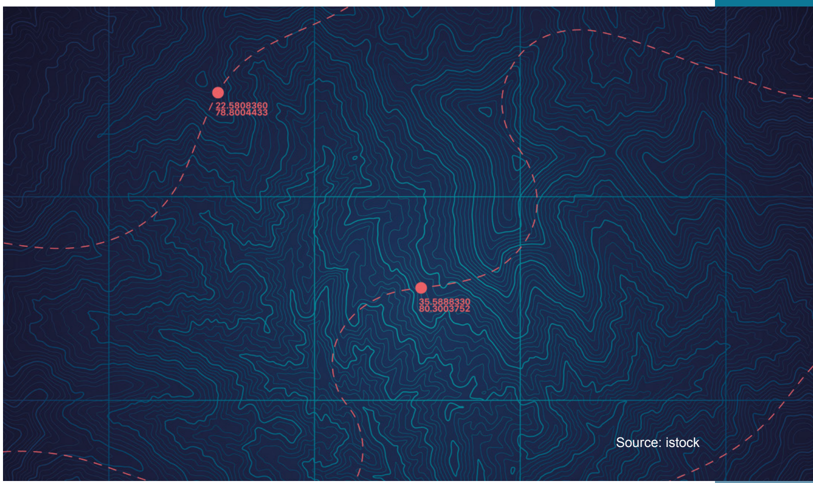
VALUE ADDED

Ocean mapping is a foundation data for and an enabler of SIDS marine and coastal development. As a foundation data Ocean Mapping supports Marine Spatial Planning, providing Ocean geographic context and insight, and a visualisation backdrop and context to aid MSP stakeholder engagement and communication.

Ocean Mapping is an enabler of key Marine and Coastal Infrastructure Development, underpinning major maritime/coastal infrastructure works such as the planning and design of Ports/Port expansion, and the opening up of Maritime transportation routes. The data is fundamental to delivery on international SOLAS commitments which in turn underpin the movement of trade and passengers by sea.

Further, the data informs decision-making and work in a number of Ocean/Blue Economy sector areas, ranging from fisheries through to natural resources management.

It is difficult to assign an economic value on the contribution Seabed Mapping makes to a SIDS economy, without dedicated investigation, but it can be said that without access to Ocean Mapping marine and coastal development can be impeded, delayed or not occur. Further, whilst addressed in a separate dedicated use study, it is important to note that ocean mapping also has a critical role in understanding, planning and a SIDS response to global marine/coastal challenges such as climate change, and sea level rise.



Source: istock

In Kiribati Ocean Mapping has enabled significant areas of socio-economic development, including the roll out of High Speed Broadband Internet through regional submarine cable networks, the opening up of inter-island maritime transport links to enable and sustain day to day life in Kiribati outer islands, supporting population expansion and relocation to the outer islands, and supporting the sustainable development and growth of key Ocean/Blue economy areas such as fisheries, tourism and in the future natural resources.

BENEFITS

- **Support marine and coastal development strategy and action, with foundational intelligence**, contributing to the delivery of SIDS priorities and interests, and the Nation response to major challenges such as climate change and sea level rise.
- **Supporting the development of nation ocean /blue economy,** including contributing to Maritime and Coastal Infrastructure development and expansion, and the growth of a variety of sectoral priorities and interests, maritime transportation, capture fisheries, tourism, among others.
- **Foundation data for marine and coastal environmental planning and management,** including supporting Nation response to major challenges such as biodiversity, conservation and informing the set up and management of MPAs and other special sites.
- **Capcity building** towards the tailored use of geospatial technologies and the adoption of a data-driven approaches to inform and monitor marine and coastal strategy, policy and delivery.

65 Million

Office of High Representatives for the Least Developed Countries, Landlocked Countries and Small Island States, (UN-OHRLLS)

The aggregated population of all the SIDS is 65 million persons, ~ 1% of the world's population. SIDS are located include: the Caribbean, the Pacific, the Atlantic, Indian Ocean and South China Sea (AIS).

80%

Our Market Research Shows:

A total of 80% of the Seabed 2030 Community identified strong levels of dependency on High Seas Seabed Mapping Grid Data, with 51.7% identified that Marine and Coastal Development sector has High Dependency on High Seas 'Seabed Mapping Grid Data'. [Meaning that Seabed 2030 high seas grid data is critical to the sector, a 'Must Have' position]. A further 28.3% identified that Marine and Coastal Development sector has Medium Dependency on High Seas 'Seabed Mapping Grid Data.' [Meaning that Seabed 2030 high seas grid data provides a level of enhanced value in the sector, a 'Good to Have' position].

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

Look to the Future

From a Seabed Mapping practitioner context, it is clear Ocean Mapping will continue be relevant to, support and enable SIDS Ocean/Blue economies. With Seabed 2030 achieving global ocean coverage of seabed mapping by 2030, all SIDS globally will be able to access and use a foundation level of Ocean Mapping for their marine and coastal development, while continuing to access higher resolution data and support through PCA cooperation.

THE NIPPON FOUNDATION-GEBCO SEABED 2030

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: MEDIUM

Author suggested qualitative view.

Source: istock

Tion Uriam Republic of Kiribati Representative and Industry Expert.

"Ocean mapping has supported the development of a number of Kiribati Ocean/Blue economy areas, including ports, maritime transport, maritime safety and navigation charts, submarine cables bringing high speed internet to Kiribati, tourism, fisheries, among others." Tion Uriam Republic of Kiribati Representative and Industry Expert.

Jamie McMichael-Phillips, Seabed 2030 Director.

"Small Island Developing States, particularly those with strong levels of need and requirements for Ocean Mapping are important users of GEBCO products. The Republic of Kiribati and neighbouring SIDS in the Pacific are making good use of Ocean Mapping to date and are good examples for SIDS elsewhere globally." Jamie McMichael-Phillips, Seabed 2030 Director.

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We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
CONTACT US:
enquiries@seabed2030.org

THE NIPPON FOUNDATION · GEBCO · IHO · unesco Intergovernmental Oceanographic Commission · 2021 2030 United Nations Decade of Ocean Science for Sustainable Development

THE NIPPON FOUNDATION-GEBCO
SEABED 2030

USE CASE: GOVERNMENT POLICY

Seabed mapping data informs key ocean policy areas and three global ocean challenge areas: climate change, marine biodiversity, and pollution.

Seabed mapping is foundation data supporting the development and implementation of ocean-related human activities and programmes/projects in key areas of ocean economy.

Source: istock

"Seabed mapping provides a 3-dimensional reference frame that supports key areas of ocean policy, such as Marine Spatial Planning and growing the New Blue Economy." Jamie McMichael-Phillips, Seabed 2030 Director.

The Challenge

Oceans are of global, regional, national, and local interest and concern.

Oceans are relevant to understanding and solving Global Challenges, such as climate change and biodiversity, among others.

Seabed mapping data needs to be accessible and useable globally, for use in public and private settings, for example for use by governments, industry, NGOs, academia, research, and by any individual with ocean interests or concerns.

Introduction

Oceans are of global importance. Oceans are fundamental to our global environment (Blue and Green), they are significant towards understanding and responding to three global challenges of our time, climate change, marine biodiversity and pollution. Oceans impact day to day life in both marine and terrestrial settings, through ocean related climate, biological, physical, chemical, and geological systems and processes. Oceans support human social, economic, cultural activities and way of life. The World Bank state, billions of people worldwide, especially the world's poorest, rely on oceans as a source of jobs and food.

Nominated International Institutions (UN Bodies, e.g., UNESCO, IOC, UNEP, IMO, among others), provide governance and coordinate areas of international ocean policies. Seabed mapping informs and support a range of international ocean policy areas including, international/national boundaries and sovereign rights, navigation and safety at sea, environment, among others as well policies addressing the three global challenges areas climate change, marine biodiversity, and pollution.

Seabed mapping is a foundation data. Regional and National institutions make seabed mapping data available through respective regional, national, and/or marine spatial data infrastructure, for use towards national / local ocean related policy and regulation development, and the implementation of ocean-related human activities and programmes/projects across example areas of ocean economy, such as capture fisheries, energy, minerals, telecommunications, among others.

Our Market Research Shows:
88% of the Seabed 2030 Community state: "It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

Source: istock

Source: istock

Seabed mapping enables the world to make policy decisions, use the ocean sustainably, and undertake scientific research that is informed by a detailed understanding of the global ocean floor.

Seabed mapping brings real world dimension, context, understanding and intelligence for policy development and implementation. This is applicable at global, regional, national, and local policy areas. We see seabed mapping supporting global policy and challenges.

United Nations SDG 14 Life Below Water – conserve and sustainably use the oceans, seas, and marine resources, for sustainable development. The United Nations (UNESCO) has proclaimed a **Decade of Ocean Science for Sustainable Development** (2021-2030) to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in creating improved conditions for sustainable development of the Ocean. UNESCO acknowledges and supports the role of seabed mapping and the work of GEBCO and Seabed 2030, and has pledged at the One Ocean Summit, Brest, France in February 2022, **announcing that at least 80% of the seabed will be mapped by 2030, in collaboration with other UN bodies and with the support of its Member States and the private sector.**

Seabed mapping has a significant role to play towards our understanding and response to **three global ocean challenges of our time: climate change, marine biodiversity, and pollution,** including: **Climate change:** as an input data for global ocean and sea level rise models. **Marine biodiversity**: as an input to aid habitat survey and mapping work, the monitoring and conservation of vulnerable marine habitats and ecosystems. **Marine pollution:** as an input to planning, design and environmental impact assessment associated with marine/maritime infrastructure work and energy resources in a marine environment context.

In a National and Local context seabed mapping has a significant role cross-cutting environmental, social, and economic domains. This includes: **International Marine, Sovereign Rights and National Policy Development and Obligations as well as Defence and National Security. Environment:** supporting a wide range of ocean and marine scientific research informing our understanding and policy, and **Socio-economic:** enabling socio-economic development and growth of the Ocean/Blue Economy and related human activity areas.

Ensuring Access to Global Coverage Seabed Mapping Data

Through the work of its committees and working groups, GEBCO produces and makes available a range of bathymetric data sets and products. These are publicly available, and anyone can access these data here: https://www.gebco.net/data_and_products/
In a Policy context and recognising the importance and relevance of seabed mapping data, key institutions include seabed mapping data in their respective Regional and National Data Infrastructure. For instance, the **World Bank Integrated Seascape Management approach for Marine Spatial Planning and Blue Economy**, identifies bathymetry as foundation 'physical category data'.
European Marine Observation and Data Network (EMODnet) is recognised as a best practice approach providing an effective pan-European marine data infrastructure. EMODnet provides access to European marine data across seven discipline-based themes: including Bathymetry, Biology, Chemistry, Geology, Human Activities, Physics and Seabed Habitats. Notably as a data infrastructure, EMODnet enables effective and efficient marine spatial planning and legislation for environment, fisheries, transport, border control, customs, and defence. EMODnet Bathymetry provides a service for viewing and downloading the best available harmonised Digital Terrain Model (DTM) for the European sea regions, together with a range of other bathymetric data, products, and services. Example EMODnet Bathymetry data include: coastlines, depth, DTM, and topography. GEBCO Bathymetry Products are also integral to and one of the main EMODnet Bathymetry data sources/products.

VALUE ADDED

NOAA state that "Seabed data is foundational for determining how the ocean works. Beyond navigation, the shape of the ocean floor plays a big role in the movement of ocean debris and pollution on its surfaces and currents. Knowledge about the depths can provide insights into sustainable fisheries management. Ocean acidification is also directly linked to depth; some areas may experience more chemical change and be less able to sustain healthy ecosystems than others." These all feed into the Seabed 2030 Value Proposition for Global Ocean Coverage.

In terms of economic value, in 2015, the WWF assessed the value of key Ocean assets at over US$24 trillion, with two-thirds of that based on assets that require healthy productive oceans. The total global value of the Blue Economy is currently around US$2.5 Trillion and is predicted to rise to US$3 Trillion by 2030 and employ 40 million people. [Source OECD, 2016. The Ocean Economy in 2030].

Engagement with two Sovereign Hydrographic Offices identified that Seabed Mapping Return On Investment (ROI) in territorial waters settings is providing 1:8 and 1:10 return on every $US spent on new bathymetric survey. Further, in Australia, recognising that Seabed mapping data is essential to the establishment and operation of many marine industries that significantly contribute to economic growth, Geoscience Australia commissioned Deloitte Access Economics to analyse the role of seabed mapping in the Australian economy, including its supply chain and employment effects. This key study identified that "Seabed mapping data enables economic activity in commercial fishing, tourism, national defence, water transport, oil exploration, search and rescue, and marine research and environmental protection by using the data for navigation, exploration, and research. The application of this data in these fields directly contributed $9 billion to the Australian economy and employed over 56,000 FTEs in 2018s" Further, the study identified "that uses of seabed mapping data also creates demand for upstream activities, contributing a further $7 billion in indirect value added to the economy in 2018-2019 and that there was $37 billion of unlocked economic activities in 2018-2019 that is attributable to the use of seabed mapping data during establishment".

Our Market Research Shows:
87.7% of the Seabed 2030 Community Strongly (67.7%) or Somewhat (20%) Agreed: "High Seas seabed mapping data is a useful foundation data supporting a wide range of ocean economy, marine and maritime activities/uses.

The EMODnet approach "collect once and use many times" philosophy benefits all pan-European marine data users, including policy makers, scientists, private industry, and the public. EMODnet state it has been estimated that such an integrated marine data policy saves at least one billion Euros per year, as well as opening new opportunities for innovation and growth.

BENEFITS

- **Map of Seafloor Benefits for Policy**
Seabed mapping provides topography detail of the ocean/seafloor, a map base reference, through which ocean policy can be considered, formulated, and presented geographically in 2 or 3 dimensions for public consumption.

- **Foundation Data Benefits**
Seabed mapping is a foundation data and provides geographic reference and context upon which other ocean information and intelligence can be geographically referenced and/or presented, e.g., administrative boundaries, policy delineations/boundaries, habitat mapping, among others.

- **Policy Benefits**
Seabed mapping provides support to policy implementation and monitoring and as an input to planning and implementation of ocean economy programmes and projects, including human activity areas of the ocean economy such as cable and pipelines planning and design, and renewable energy planning and design, through to the marine science programme design such as benthic habitat monitoring planning among others.

77%

Our Market Research Shows:

Seventy seven percent of the Seabed 2030 Community Strongly Agreed: "Seabed mapping data has an **important role to play in informing decisions and promoting the sustainable use of our ocean / marine resources."**

78%

Our Market Research Shows:

Seventy eight percent of the Seabed 2030 Community Strongly Agreed: "Seabed mapping data has an important role to play in **informing decisions and enabling economic value from ocean / marine resources."**

82%

Our Market Research Shows:

Eighty two percent of the Seabed 2030 Community Strongly Agreed: "Seabed mapping data has an important role to play as a **key input for marine science and research."**

GLOBAL SUPPORT TO SEABED 2030 MISSION

Everyone with a link to the ocean can play a powerful role in helping to map the entire seafloor by the end of the decade, Governments, Research, NGOs, Industry, Individuals and Philanthroipists.

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: HIGH

Author suggested qualitative view.

Source: istock

Kim Picard, a/g Director of the National Seabed Mapping Section, Geoscience Australia

”As reported by Deloitte Access Economics study, “in addition to economic activity, there are also significant social, cultural, and environmental benefits that are attributable to the production and use of seabed mapping. Seabed mapping data is also often used to understand vulnerability to human impacts, natural hazards such as storm surge, and the physical make-up (geomorphology) of our coastal environments and has been used widely for environmental management, monitoring, and research. Seabed mapping data also holds significant cultural value. It increases traditional owners’ understanding of Sea Country and can reveal culturally significant events, ranging from drowned landforms that may have been occupied by the ancestors of traditional owners, to historical shipwrecks. “Kim Picard, a/g Director of the National Seabed Mapping Section, Geoscience Australia

Jamie McMichael-Phillips, Seabed 2030 Director

“Seabed mapping provides a 3-dimensional reference frame that supports key areas of ocean policy, such as Marine Spatial Planning and growing the New Blue Economy.” Jamie McMichael-Phillips, Seabed 2030 Director.

SEABED 2030 MAPPING INITIATIVE

Our mission is to inspire ocean mapping and deliver a complete seabed map for the benefit of people and the planet. Formed by The Nippon Foundation & GEBCO, Seabed 2030 is a global initiative where industry, governments, researchers, and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

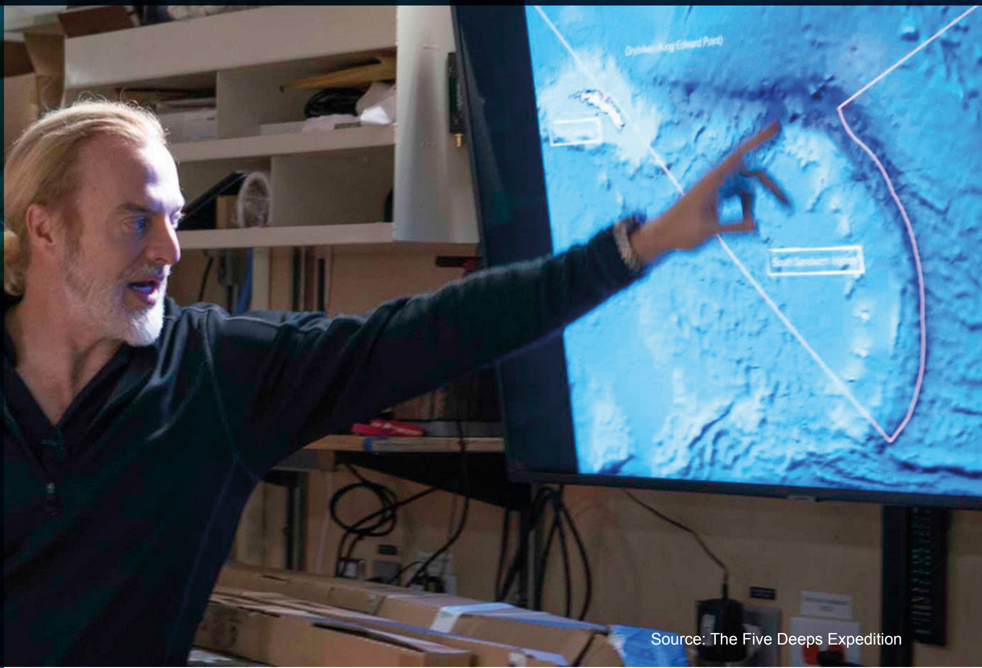
We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
CONTACT US:
enquiries@seabed2030.org

THE NIPPON FOUNDATION · GEBCO · IHO · unesco Intergovernmental Oceanographic Commission · 2021 2030 United Nations Decade of Ocean Science for Sustainable Development

USE CASE: OCEAN DISCOVERY & OCEAN EXPLORATION

Ocean Discovery includes the mapping, observation, and exploration of oceans. Ocean Exploration is about making discoveries, searching for things that are unusual and unexpected.



Source: The Five Deeps Expedition

"It's important for the world to map the entire seafloor, simply because this is our planet. And I think it's sad if we live on it and don't even know the nature of it or have a good map of our ocean floor." Victor Vescovo Explorer

The Challenge

Oceans constitute 70% of our planet, and of these oceans 80% are unexplored. Meaning, half of the world is completely unexplored and unmapped.

Seabed mapping is a foundation data providing ocean exploration intelligence, an aid to ocean exploration planning and decision-making. Should we achieve the Seabed 2030 mission and realise global ocean seabed mapping coverage, what new ocean discovery opportunities will present themselves?

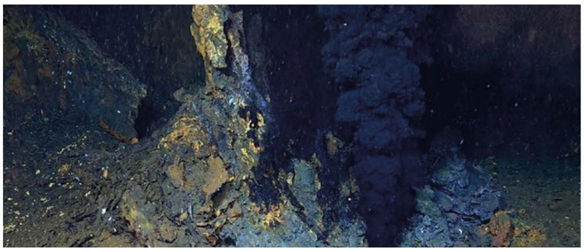
Seabed mapping is also a by-product of ocean exploration / discovery expeditions, providing an invaluable contribution to the global coverage seabed mapping. One of our challenges is to encourage more ocean exploration.

Introduction

Ocean discovery and ocean exploration are an innate part of being human, the desire to explore and discover the unknown. Exploration inspires. Ocean exploration goes hand in hand with, terrestrial, polar and space exploration, in terms of endeavour, the discovery of the unknown, yet brings its own specific set of challenges: operating in complex settings, extreme depths and levels of pressure, and an ability to remain at depth for periods of time to aid and optimise meaningful discoveries.

In interview, Victor Vescovo, Explorer emphasised: "Oceans constitute ~70% of our planet, and of these oceans ~80% are unexplored. Meaning half of the world is completely unexplored. With global concerns like climate change which need an understanding of how does the world work. Further today, we don't have an understanding of many of the global mechanisms of our world and these will only be understood by undertaking more marine research. It is important for the world to map the entire seafloor, simply because this is our planet. And I think it's sad if we live on it and don't even know the nature of it or have a good map of our ocean floor. I think it's also very important geologically, I think we can find out details that will help us with earthquake prediction, understanding plate tectonics, and even looking at biological interactions across the oceans that can affect climate models as well as life on land".

Seabed mapping, where available, serves as a foundation data providing ocean exploration intelligence, an aid to ocean exploration planning and decision-making. Seabed mapping is also a by-product of exploration expeditions, with explorers adding to our global ocean seabed mapping coverage often in difficult to survey areas, and areas that may not be scheduled for acquisition for some time.



Source: Eva Ramirez-Llodra et al. Aurora Vent Field black smokers, the Enceladus black smoker

Ocean exploration is highly dependent on seabed mapping data

Seabed mapping is a key component of ocean and earth exploration. Seabed mapping informs and supports exploration planning, expedition operations, and provides a map base upon which observations can be spatially referenced and presented in both 2 and 3 dimensions.

Seabed mapping where available, is a critical input to mission planning, supporting route planning, informing target mobilisation/demobilisation, and optimising vessel time in exploration areas of interest. It is important to map and be aware of major seafloor features and anomalies. The data may be the only data available to provide geographic insight on an area of interest exploration location, providing key detail on site context, it's geomorphology and ultimately aiding explorer decision-making.

The Ocean Exploration Trust states: "Explorers want to gather as much information as they can to make an informed decision about where to dive with the ROVs, to increase the opportunities to make discoveries. Whether exploring seamounts, canyons, or even a shipwreck, having or making a map of the seafloor is helpful so the ROVs don't spend all of their time crawling over the mud before encountering a target. In order to locate interesting terrain, scientists carefully examine the preliminary mapping data for features, such as rock cliffs or ridges, which are preferred habitat for many organisms".

Ocean Exploration seabed mapping is **cross-cutting and useful for different Marine Science specialisms:**

Geology: Plate tectonics, earthquake risk and potential to inform tsunami propagation models, geomorphology, presence of terrain features - Seamounts, Abyssal Plains, Cliffs, Ridges, among others.

NOAA state globally, it is estimated that there may be as many as 100,000 seamounts higher than 1,000 metres under our Oceans.

Chemistry / Physics: Identify hydrothermal vents, presence of marine minerals, and in the instance of multibeam sonar bathymetry useful towards the detection of phenomena in the water column, e.g., gas seeps.

Eva Ramira-Lodhra et al. in discussion on the topic of the scientific mission in the Gakkel Ridge (The Aurora Vent Field), referenced that since the discovery of deep-sea hydrothermal vents in 1977, just over 30% of the global mid-ocean ridge system has been investigated *Beaulieu et al., 2015. To date exploration has yielded an inventory of 722 confirmed high-temperature vent sites, with a further 720 high-temperature vents inferred from water column data, as reported in the InterRidge Vents database in September 2022 (Beaulieu and Szafranski, 2020

Biology: Connection between seafloor shape and type, habitats, and biological communities, such as vent species (Chemosynthetic bacteria, giant tube worms, crustaceans, molluscs, and other species considered endemic to vent sites, and hydrothermal vent habitats), holding intrinsic scientific value. An aid to locating, quantifying, and protecting valuable habitats and natural resources.

As Ocean Explorers go about their work, they also **extend the global ocean seabed mapping coverage often acquiring bathymetry data in difficult to survey areas, and for areas that may not be acquired for some time.** Seabed 2030 has benefited significantly from Explorer led, philanthropic and marine research led data donation including Victor Vescovo 'Five Deeps', and The Ocean Exploration Trust exploration missions, among others.

The Five Deeps Expedition successfully conducted the first detailed, sonar mapping and sample-collection mission at the deepest part of the Diamantina Fracture Zone of the Indian Ocean – an area known as the Dordrecht Deep. Using advanced multi-beam sonar and an ultra-deep-sea lander, the team found it to be 7,019 meters deep, slightly shallower than previously thought when historically measured by other, less precise, methods.

The data is important contribution to the Nippon Foundation – GEBCO – Seabed 2030 Project.

Looking forward to 2030, when complete ocean seabed mapping coverage **will be available, will provide significant ocean exploration future opportunities,** including:

- Identify **more candidate area options for exploration.**
- Ability to interpret seabed mapping data to **focus on global area selections to target ideal sea floor landscape features of interest, tailored to a specific target discovery or field of research.**
- Generally, **be more informed on seabed geomorphology** for any given field of interest, **reducing risk or the worry of wasting time and money, both enhancing expedition safety, and resulting in expedition cost efficiencies.**
- **A global ocean 3d map base** will be available upon which discoveries can be collated and presented to inform and educate the public.

SEABED MAPPING VALUE ADDED

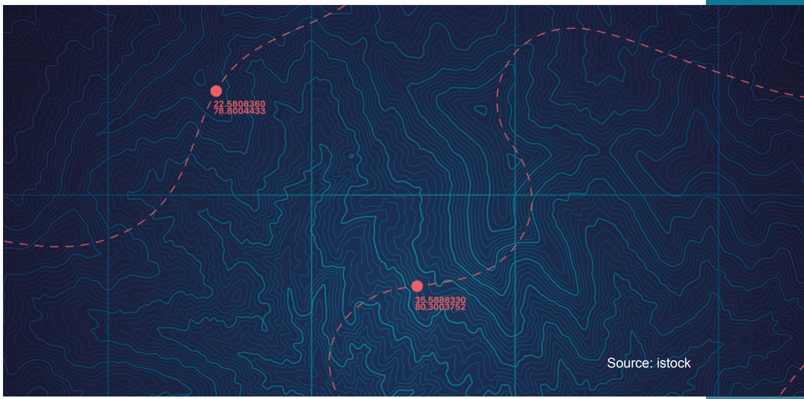
Ocean exploration includes the mapping, observation, and making of ocean discoveries, typically for scientific, economic or cultural purposes.

Ocean exploration is highly dependent on seabed mapping data, technologies, and processes. Seabed mapping informs and supports exploration planning, expedition operations, and provides a map base upon which observations can be spatially referenced and presented in both 2 and 3 dimensions.

Ocean exploration missions typically have a seabed mapper on the team both to source and make use of existing seabed mapping and support the acquisition and processing of newly acquired data.

Downstream value and resulting benefits can be significant, including in the marine sciences, enhancing our understanding and making discoveries including in geology, physics, chemistry, and biology fields. Marine archaeology brings a human dimension providing cultural and heritage downstream value.

Overall, Ocean Exploration, supported by seabed mapping aids the marine community to more effectively maintain ocean health, sustainably manage marine resources, accelerate areas of the ocean economy and build knowledge and understanding of the value and importance of the ocean.



Source: istock

Explorers and Marine Researchers also have identified spillover value where Ocean Exploration, for instance in Ice-covered Arctic has been a bridge and informed space science and space exploration and the search for life in space.

As the Seabed 2030 mission expands the Global Ocean seabed mapping coverage, more and more exploration/discovery missions are anticipated, likely leading to further discoveries and enhanced understanding in marine sciences, notably in geology, chemistry, physics, and biology domains.

Further providing discovery spill over benefits as a bridge to the search for life in space, for instance understanding complex environments such as hydrothermal vents beneath ice-covered oceans, among others.

BENEFITS

- **Human Knowledge Benefits**

Human knowledge and understanding of our ocean's, seas, and coastal areas.

- **Marine Sciences Research and Understanding Benefits**

Data input to understand marine processes and mechanisms, including for geology and wider marine science domains; biology, chemistry, among others.

- **Economic Benefits**

Direct Economic Benefits, through employment of seabed mappers and equipment aiding exploration/discovery.

Indirect Economic Benefits, supporting a range of Blue Economy opportunities, including bio-pharmacy, biotechnology, marine tourism and spillover for example through technology cross-over to key areas such as space exploration, biosensors, materials science [material behaviour at extreme pressures, etc.], and towards exploration and mapping complex sub-terranean environments, inland waters, and polar mapping.

50%

Fifty percent of the world is completely unexplored and unmapped.
Oceans constitute 70% of our planet, and of these oceans 80% are unexplored. Meaning, half of the world is completely unexplored and unmapped.

Five Deeps

After travelling 47,000 miles and completing 39 dives, the Five Deeps Expedition reached its successful conclusion: the first manned descent to the bottom of each of the world's five oceans. Numerous other firsts were made, including the world's deepest manned dive in history, to a new record 10,925 meters at the Mariana Trench's Challenger Deep, as well as the first submersible and pilots to repeatedly dive to the bottom of the ocean. See: https://fivedeeps.com/

20 minutes to ~4 hours

Example time durations at sea floor / study area as guided by Explorers and Marine Researchers. Seabed mapping allows the optimisation of explorer time at sea floor as an aid to expedition planning. **Every minute counts in ocean exploration…..**

Through Ocean Exploration and Extending Seabed Mapping Ocean coverage, we expand and inform man's vision of the future…
"Among the map makers of each generation are the risk takers, those who see the opportunities, seize the moment and expand man's vision of the future". Ralph Waldo Emerson, 19th Century Philosopher.

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: MEDIUM

ENVIRONMENTAL VALUE IMPACT: POTENTIALLY HIGH

Author suggested qualitative view.

Source: istock

EXPLORER/MARINE RESEARCHER VIEWS, VICTOR VESCOVO AND LARRY MAYERS

"It's important for the world to map the entire seafloor, simply because this is our planet. And I think it's sad if we live on it and don't even know the nature of it or have a good map of our ocean floor." Victor Vescovo Explorer."
We don't know what we will find but in mapping the complete seafloor we will find and discover. "Larry Mayer, Professor and Director, Center for Coastal and Ocean Mapping/NOAA-UNH Joint Hydrographic Center University of New Hampshire"

Jamie McMichael-Phillips, Seabed 2030 Director

"Ocean Exploration is all about discovering the unknown. Ocean Explorers, through their Expeditions are a tremendously important source of seabed mapping data, often for areas that would otherwise not be acquired for some time under our programme. Further, through their discoveries, the Ocean Explorer Community are a huge inspiration and motivator to the Seabed 2030 programme to progress our mission to achieve ocean coverage, which in itself will inevitably lead to significant discoveries and opportunities" Jamie McMichael-Phillips, Seabed 2030 Director.

SEABED 2030 MAPPING INITIATIVE

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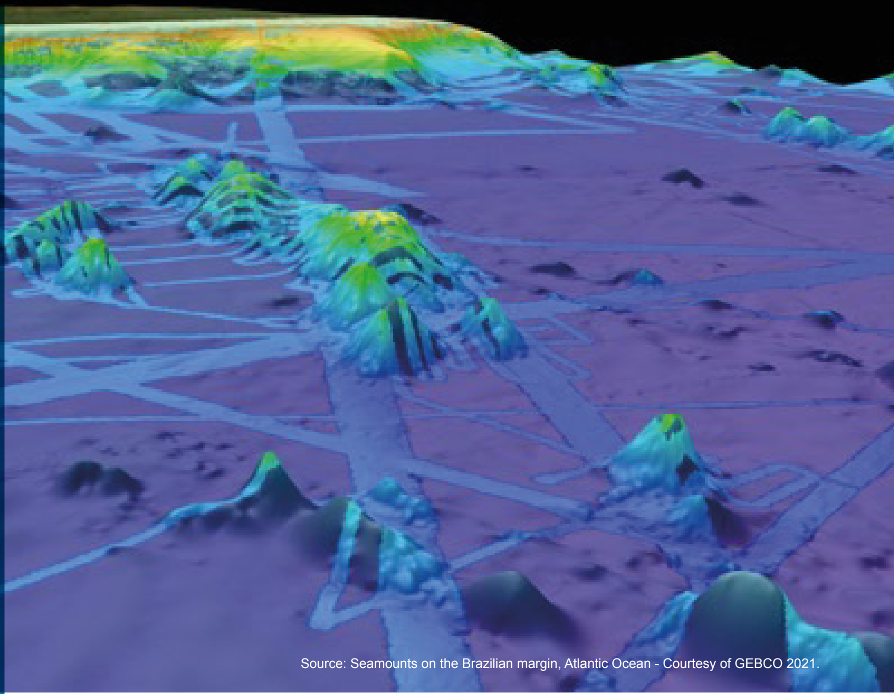
We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
CONTACT US:
enquiries@seabed2030.org

USE CASE: SEABED 2030 DRIVING HYDROGRAPHIC INDUSTRY EXPANSION AND HUMAN CAPITAL BENEFITS • USE CASE REF ID: UC012

USE CASE: SEABED 2030 DRIVING HYDROGRAPHIC INDUSTRY EXPANSION AND HUMAN CAPITAL BENEFITS

Seabed 2030 mission represents a tremendous opportunity for seabed mapping industrial development and growth, while driving human capital outcomes.



Source: Seamounts on the Brazilian margin, Atlantic Ocean - Courtesy of GEBCO 2021.

"Delivery of Seabed 2030 mission presents a tremendous opportunity to stimulate and accelerate seabed mapping industrial development and growth. It also provides a golden opportunity to focus attention and enhance human capacity concerns such as the build up of developing nation capacities, and enhance other human capital interests such as inclusivity and gender." Jamie McMichael-Phillips, Seabed 2030 Director.

The Challenge

The world's oceans cover 70% of the Earth. This is about 362 million square kilometres of the total surface area. (Eakins and Sharman, 2010)

Seabed 2030 is a Global commitment to gather and share seabed mapping data, the sheer scale of this endeavour is a challenge.

Putting the financial business case to one side, and focussing on technology, process, and people elements. To achieve the Seabed 2030 mission in the most effective and sustainable way while realising the considerable value add opportunities associated with the Seabed 2030 mission, requires industrial ramp up, the leveraging of emerging technologies and innovation, hand in hand with capacity building across the global seabed mapping community. How this is realised is a community and Seabed 2030 challenge to solve.

Introduction

Seabed 2030 mission to map global ocean seabed by 2030 represents a step change opportunity for the hydrographic survey industry and seabed mapping community. Seabed 2030 mission is also an enabler for innovation-led change. It is a tremendous opportunity to research, develop, test, and implement new technology and innovation approaches, accelerate technology and innovation adoption, and enhance operating models in the hydrographic survey industry and seabed mapping community for common benefit while achieving Seabed 2030 global ocean coverage mission.

Human capital opportunities are significant, with the Seabed 2030 mission providing a once in a generation opportunity to build capacity, enhance skills and competencies across the global hydrographic survey industry and seabed mapping community, to champion key human capital ambitions such as gender and remote working, whilst fundamentally building interest in the mission across a much wider community globally through outreach and public awareness campaigns.

This use case presents Industry Expert opinion on how the hydrographic survey community is already supporting Seabed 2030 and identifies example areas of opportunity for further hydrographic survey industrial development and growth. We highlight human capital potential opportunities and showcase some government/industry capacity building activities underway and resulting from Seabed 2030 achieving its mission and ambition to complete global ocean coverage of seabed mapping by 2030.

Seabed 2030 – a Global Initiative delivered through Partnership

Seabed 2030 is a joint initiative between The Nippon Foundation and the General Bathymetric Chart of the Oceans (GEBCO), itself a joint programme of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC).

The Nippon Foundation-GEBCO Seabed 2030 Project is formally endorsed as a flagship programme of the UN Decade of Ocean Science for Sustainable Development. The Call for Decade Actions [No. 04/2022], invited governments, organizations, and individuals to contribute data and resources to Seabed 2030; support this vital global effort; and help with the exploration of the planet's final frontier.

By 2023, today, the Seabed 2030 initiative is bolstered by over 200 partners, data contributors, and supporters from across 50 countries and increasing. Partners, contributors, and supporters include Governments, Industry, NGOs, Research, Philanthropists, and Individuals, demonstrating the community breadth involved in mission success. Fugro, a partner of Seabed 2030, since the programme early days in 2017 is a good example industrial partnership. Fugro supports three areas of Seabed 2030 mission (1) provision of their own data [in-transit bathymetry, (2) working with Fugro clients to investigate data sharing from client data back catalogue, and (3) a member of the Ocean Decade Corporate Data Group and is seeking to further develop **private sector** data provision opportunities, arrangements, and efforts.

Example Partner Co-operation and Industry Support to Seabed 2030 – Fugro three key areas of partnership and action. [Fugro Vessels Contribute 2,360,000 Km² on in-transit bathymetric data to Seabed 2030].
Recognising the importance of a wholly mapped ocean to climate change mitigation, ocean and coastal resilience and a sustainable blue economy, Fugro has been a leading private-sector supporter for The Nippon Foundation-GEBCO Seabed 2030 Project since its early planning stages. Fugro's support for the Seabed 2030 is largely focused on private-sector [data] contributions, including:
(1) **Fugro owned data.** In 2017, Fugro devised a method for collecting high-resolution bathymetry datasets from their survey vessels as they transit between survey projects. This 'in-transit' approach leveraged two of Fugro's earliest remote technologies, Fugro OARS® and Fugro Back2Base®, allowing Fugro to acquire and transmit valuable seafloor mapping information without dedicated survey crew onboard the vessels. **This approach has allowed Fugro survey vessels to collect more than 2 million Km² of bathymetry for Seabed 2030 with minimal cost and impact to our normal operations.**
(2) Fugro have been working with their **clients to investigate how their existing or planned datasets can be incorporated into the Seabed 2030 programme,** including datasets with sensitive information. Reducing the data resolution to a suitable degree and/or delaying the release of datasets until an acceptable amount of time has passed can mitigate these sensitivities and ensure the integrity of client-owned data.
(3) In a third area of partnership Fugro [February 2023] is helping to lead an **Ocean Decade Corporate Data Group under their partnership agreement with the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organisation (IOC-UNESCO).** This work also fully supports and benefits Seabed 2030 in terms of bathymetric contributions from the private sector.

Source: Fugro Venturer – a Fugro state-of-the-art survey vessel

Seabed 2030 continues to develop new partnerships towards collating existing data asset from across the global seabed map community, delivering mission outreach and awareness building, and coordinating the mission business case.

Current Year [2023], Seabed 2030 'New Partner' onboarding, includes a range of entities from Government, NGO's and Industry global players: planblue, SEABER, Memorial University of Newfoundland's Fisheries and Marine Institute, Marine Biodiversity Observation Network (MBON) and Marine Life 2030, Ocean Census, Society of Maritime Industries (SMI), NORBIT Oceans, Nigerian Navy, SEA-KIT International, ACUA Ocean, Saildrone, Orange Force Marine Ltd, ecoSUB Robotics – a subdivision of Planet Ocean, and Ministry of Information, Communications and Transport (MICT) for the Republic of Kiribati.

Seabed 2030 Enabling Hydrographic Survey Industrial Development and Growth

The global hydrographic industry and seabed mapping community are strongly supportive of the Seabed 2030 mission. The Wind in the Sails (WITS) community engagement in 2022 on seabed mapping needs and requirements received excellent support with a global coverage community response, with some 900-questionnaire survey returns. This was followed by a further targeted engagement in 2023 with IHO and IOC representatives 2023 on the topic of national and regional seabed mapping planning, benefits and priorities which received a further 200 survey returns.

All survey returns were analysed and reviewed and supplemented with targeted one to one Industry Expert interviews. **A common view prevails that Seabed 2030 mission represents a tremendous opportunity for industrial development and growth.**

The study has engaged on and proposed a value chain based on (i) upstream data production (Producers) activities, and (ii) downstream Data Use (or Users) activities that together generate value. There are industrial development and growth opportunities across all stages of the value chain.

Contributors to Data Production and the enablement of Value Generated through Data Production activities include:

- #National Government agencies with Hydrographic responsibilities & interests.
- #Industry. E.g., Hydrographic Survey and Marine/Mari time Infrastructure & Operations.
- #Service Providers. Enabling vessel and technologies (equipment, hardware & software) OEMs.
- #Scientific Programmes (direct and indirect).
- #Philanthrophic exploration programmes (direct and indirect).
- #Crowd Sourcing/Citizen Science.

For example, we see key industrial development and growth opportunities associated with new data acquisition, data processing and production, not least in the adoption of emerging technologies notably in 2 megatrend domains autonomy and AI/Machine Learning, among others (and as detailed in the Seabed Mapping Innovation Use Case document).

'Users' include any user of seabed mapping grid data (direct use (e.g., of published seabed mapping data in its readily available format)/indirect use (value add data processing) and economic spillover value generation, comprising:
#Direct use of product, including use of seabed mapping product in its unaltered form [the Published GEBCO Grid and associated products].
#Value add production of product by third parties,

Source: SEA-KIT International and SEABED 2030, Seakit remote control of survey operations.

an indirect use of the seabed mapping data product, centred on the use of seabed mapping product use in an altered form [Published Grid+ processed/modified].
#Economic spillover, including non-market benefits, where the use or existence of seabed mapping results in value benefit being generated in other areas of the economy, areas of the economy away from the intended purpose or original use of seabed mapping.

Users also include Public, Private, NGO/INGO, Research & Academic Institutions, and Citizens, and can be grouped by sector. The study investigated sectoral dependency on seabed mapping both to identify a set of priority sectors where promotional attention for seabed mapping uptake can be channelled, to identify sectors for use case production, and to inform future economic value assessment in support of Seabed 2030 mission business case. The Seabed 2030 Value Proposition presents the results in detail, but for the purposes of this use case we highlight example sectors applications that are both 'high dependency ['Must Have'] need for seabed mapping and at the same time represent strong industrial 'economic' growth opportunities.

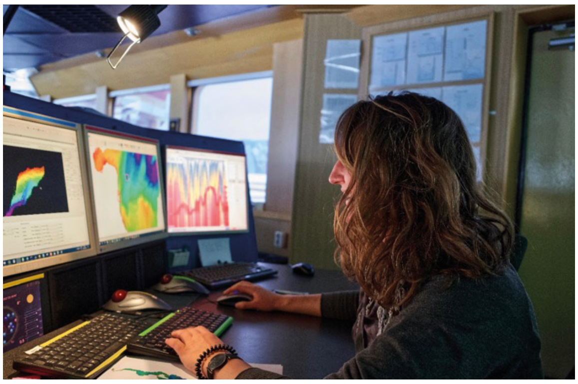
Example Seabed Mapping 'Must Have' Application areas and also representing key industrial 'economic' growth opportunities:

- Coastal development, ports, navigation and infrastructure planning, SOLAS, foundation enabling economic growth through increased trade and tourism, among others.
- Subsea cable planning [telecommunications and power].
- Subsea pipelines [oil, gas, and water].
- Energy resources exploration and offshore infrastructure planning and design [including Oil and gas, renewable energy offshore wind energy, tidal and wave].
- Tsunami modelling & Storm surge modelling [disaster management planning and response].
- Sea-level rise and coastal inundation [climate change mitigation and adaptation planning and design].
- Continental Shelf Nation Claims [Nation/Sovereign interests as per UNLCOS], and
- Hydrographic / Oceanographic surveys, which also includes Seabed 2030 mission global ocean coverage data acquisition and production itself.

Seabed 2030, the Human Capital Dimension

Industry Experts emphasised human capital factors are fundamental to successful delivery of Seabed 2030 mission and robust exploitation of the resulting product. An Industry Expert, exemplified details on the data acquisition, where traditional research vessel approach to data acquisition costs are ~ $50-60,000 per day, of which crew accounts for 30%, shore support for 6% and maintenance for 13% – all labour-intensive activities, and together totalling ~49% of the total cost]. Where autonomous vessel such as a **Saildrone** can be used, these costs drop to ~$25,000 per day, with increase in shore support and reduction on crew. From a human capital perspective crew, sensor engineers, hydrographers, geospatial/data analysts, cartographers, and survey managers, are all key profiles associated with traditional survey approach and continue to be relevant. Additionally, and with the adoption of new technologies and innovation we are witnessing modification of operating models and updated job profiles emerging. Example new skills/competencies needed include Cloud Engineer, Full Stack development, on the system side, and AI/ML, automation (RPA), and further sensor exploitation expertise needed to support data processing, analysis, and mapping. Also, a remote onshore support function may include the need to operate both platform and sensor, and then undertake acquisition data review, QA, and potentially initial data processing.

Seabed mapping community can draw on global capacity building support initiatives, examples include Primary Charting Authority (PCA), IHO and GEBCO – Nippon Foundation. As we move through the seabed mapping value chain there is a need for hydrographers to be able to champion the value and application of data for multiple and different uses. Industry Experts identified for example that in a SIDS setting, there may be no hydrographic expert with this coming through initially by PCA support. A key part of a PCA mission is to build capacity and provide tailored onboarding training. This includes both hydrography and geospatial data training to ensure the data can be stored, managed, distributed, accessed, used, and then applied. Further capacity building includes know how sharing and engagement support across target user communities where it is key to build knowledge on why bathymetric surveys are important, reinforce SOLAS responsibilities/accountabilities, and train on how the data can support key application areas of interests tailored and applicable to the specific SIDS context. These application areas may be diverse and include port development, coastal development, capture fisheries, marine protected areas, tourism, climate change and adaptation, among others. Finally, PCA missions have signposted individual officers for wider training in fields such as cartography (one areas of specialist training promoted by the IHO).



Source: A researcher monitors the incoming bathymetric data from Oden's multi-beam sonar array. Photograph taken by Bjorn Eriksson on the 2019 expedition to the Ryder Glacier, Greenland.

IHO maintains a **capacity building fund (called the CB fund),** based on contributions by member states and from which IHO provides a range of Capacity Building and Technical Cooperation Support. Including **'Capacity Building Assessment' through 'Technical visits'** aimed at assessing the status of hydrographic surveying, nautical charting, and maritime safety information (MSI) and the needs for future development, and High-level visits by the IHO Directing Committee, RHC Chairs or National Hydrographers to coastal States' high-level authorities to raise awareness of the importance of hydrography and to help further development of the national hydrographic services. **Technical Cooperation and Training activities** are aligned to the IHO Capacity Building Strategy, and includes **workshops and seminars, short and long courses** [Short courses being one to two-week trainings on Maritime Safety Information (MSI) and on hydrographic and cartographic related topics. Long courses are longer than one month and are related to specific agreements with donors], and **on the job and onboard training** [Activities performed in a working environment].

The Republic of Korea, through an MOU with IHO contributes to the IHO to help developing countries improve their ability to comply with international standards on hydrographic surveying, nautical cartography, and ocean observation. This initiative supports several Capacity Building activities of the IHO Capacity Building Work Programme, including those of the Regional Hydrographic Commissions and their longer term professional training [courses in hydrographic science, hydrographic survey and nautical hydrography] as well as 10-day training course which focusses on 'training the trainer', with the aim being for the trainer then delivering specific training programmes in their own countries, in their mother tongue and using their expertise. This training currently focuses on hydrographic surveying and has been successfully run within the East Asia Hydrographic Commission (EAHC) and is now expanded to the global IHO community.

Through the **GEBCO-Nippon Foundation Training Programme,** GEBCO has been funded by the Nippon Foundation, to train a new generation of scientists and hydrographers in ocean bathymetry. This twelve-month course, leading to a **Postgraduate Certificate in Ocean Bathymetry (PCOB)**, is held at the University of New Hampshire, USA and has been run since 2004. This course was launched to broaden the GEBCO community and to encourage more younger scientists and hydrographers to become involved in mapping the ocean floor. Students who have completed the course have returned to their home organisations where they apply the skills and knowledge, they acquired on the course to build capacity within their own country.

The Postgraduate Certificate in Ocean Bathymetry (PCOB) provides an excellent blend of academic, practical hands-on training for students, including (Modules): Integrated Seabed Mapping Systems,
Applied Tools for Ocean Mapping (core), Mathematics for Geodesy (core), Applied Physical Oceanography for Ocean Mappers, Advanced Topics in Ocean Mapping (core), Geodesy and Positioning for Ocean Mapping (core), Bathymetric Spatial Analysis (core), Marine Geology & Geophysics for Ocean Mappers (core), Seamanship and Marine Weather for Ocean Engineers and Scientists (assessed on individual background by instructor).

Additionally, and **practical hands-on training,** throughout the year, visiting specialists provide lectures on Ocean Mapping topics particularly pertinent to GEBCO practitioners. Short training courses in the use of common hydrographic processing packages (CARIS, Fledermaus, etc.) and other software and Seamanship are conducted. In the summer, students receive field course training (the Hydrographic Field Course module) and may take part in a research cruise and/or undertake a working visit(s) to another research lab(s), typically arranged over the late summer.

GEBCO and the Nippon Foundation jointly select typically six students each year out of many applicants. **Since its launch in 2004, 113 scholars have graduated drawn from 55 different countries including developing states. A further 7 scholars are currently in training [cohort year 2023/24].**

Industry experts acknowledge that given the global dimension of the Seabed 2030 mission, the mission itself presents a tremendous, once in a generation opportunity to improve industry human capital elements. Two example areas include: The use of remote working **enabling further** inclusion of persons who may otherwise not wish or are unable to work away from home, (at sea or in/close to specialist facilities) for long periods of time. Remote working strategies are already being adapted through programmes such as Fugro case studied above. Importantly also the global dimension enables the opportunity to **enhance gender balance.** Progress is being made in this area too but with more to do. For instance, of the 120 scholars across a twenty-year period referenced above, 86 are male and 34 are female [72% male/28% female proportion], which while a reasonable outcome, suggests there is more to do from a gender lens perspective.

Source: Seabed 2030 - Professor Martin Jakobsson, Co-Head of the Arctic and North Pacific Ocean Regional Centre, pointing at details of data collected on the 2019 expedition to the Ryder Glacier, Greenland, at the Nippon Foundation-GEBCO Seabed 2030 "From Vision to Action" Event at the Royal Society in London. 22nd October, 2019.

There are human capital challenges that need consideration, for example in UK the Association of Geographic Industry 2023 education and skills survey confirms that some areas of specialist skills including database administration skills, AI/machine learning, data modelling, and software engineering are difficult to recruit and retain into the geospatial industry given demand on these skills in wider sectors/industries and pay levels on offer elsewhere.

Industry Experts shared a common view that **whilst Seabed 2030 mission is a challenging mission, there is the community capability and willingness to deliver this ambition. Further, as a community there are the technologies, people, processes, and know-how available to both ramp up and deliver, and that it is more that adequate political support is needed to be secured and funding made available and directed towards mission delivery.**

SEABED MAPPING VALUE ADDED

There is an emerging body of evidence confirming strong industrial development and growth, and human capital opportunities. Wider direct and indirect economic value details are referenced in the Seabed 2030 Value Proposition document, but for the purposes of this use case and our focus on industrial development, three key sources are usefully signposted by Industry Experts, including:

(1) Market intelligence by IMARC Group confirms the Global Hydrographic Survey Equipment Market is exhibiting strong levels of growth (5.78% CAGR) and is forecast to reach US$ 4.1 Billion by 2028.

(2) The Seabed Mapping community estimate the cost of Seabed 2030 Mission delivery as between US$ 3 and 5 billion, with the lower number integrating autonomy approaches where sensible, and the higher number based on a traditional survey approach.

(3) The value of Australian seabed mapping data to the blue economy, [Deloitte Access Economics Study commissioned by Geoscience Australia], provides a useful Nation focus study. This study estimated (for a single year 2018-19), that the activities directly involved in producing seabed mapping data directly contributed $51 million to the Australian economy and created 500 jobs. Further, that the use of seabed mapping data also directly contributed over 56,000 jobs (FTEs) to the Australian economy in 2018-19, and the direct economic contribution of seabed mapping data use being $9 billion in the same year. This clearly demonstrates social benefit in a Nation context, and provides a useful reference model for other coastal nations.

Future view - Imagine a future in 2030, where we have global ocean coverage of seabed mapping collected, available, and in use.

While delivering new technologies and innovation have been accelerated and embedded industrially. The seabed mapping industry has an expanded FTE footprint, and new skills and competencies are routinely used. There are officers in post in every nation able to guide on the use of seabed mapping for nation use and benefit. And globally across priority economic sectors, seabed mapping is extensively used for strategic planning and decision-making, operations, and a range of project delivery, while in the scientific community global, regional, and national models are enhanced towards key marine community challenge areas such as climate change and marine biodiversity while informing and used for ongoing and new research.

Users recognise the inherent value of the seabed mapping baseline, and thereon readily support the ongoing sharing of newly acquired survey data leading to the ongoing seabed mapping baseline maintenance and updating.

BENEFITS

• Global Data Production Capacity Building Ramp Up, Industrial Development and Growth

A global delivery effort and outcome, driving and enable the global ramp up of seabed mapping delivery capacity across all areas of the data production value chain: from data prioritisation and planning through, data collection, data processing and production to data holding and dissemination.

• Global Multi-Sector Use and Value

Global ocean coverage leading to significant expansion of sector uses globally, in both established sectors and scientific and emerging sector areas/[Policy, coastal development, subsea cables and pipelines, energy sources including transition to renewables, among many others].

• One off Set of Human Capital Opportunities

Build capacity globally, accelerate capacity and competency building in new skills, accelerate operating model enhancements such as remote working with inclusion benefits, and focus attention on gender elements, among others.

92%

Our Market Research Shows:

Ninety two percent of the Seabed 2030 Community state: “Seabed mapping has an important role to play in informing decisions and enabling economic value from ocean/marine resources”.

90%

Our Market Research Shows:

Ninety percent of the Seabed 2030 Community state: “Seabed mapping data has an important role to play in informing decisions and promoting the sustainable use of our ocean/marine resources”.

88%

Our Market Research Shows:

Eighty eight percent of the Seabed 2030 Community state: “It is very important that global ocean seabed mapping coverage is acquired and available in this decade (by 2030).

To achieve the Seabed 2030 mission, a level of industrial expansion, innovation and associated investment is inevitably needed. Seabed 2030 is working to understand these needs and requirements, and how most effectively to realise and ensure mission. Seabed 2030 is interested to pursue industrial cooperation towards ensuring mission delivery and success.

THE NIPPON FOUNDATION-GEBCO SEABED 2030

SEABED MAPPING VALUE IMPACT

ECONOMIC VALUE IMPACT: HIGH

SOCIAL VALUE IMPACT: HIGH

ENVIRONMENTAL VALUE IMPACT: MEDIUM

Author suggested qualitative view.


Source: istock

INDUSTRY EXPERTS COMMON VIEW

"Whilst Seabed 2030 mission is a challenging mission, there is the community capability and willingness to deliver this ambition. Further, as a community there are the technologies, people, processes, and know-how available to both ramp up and deliver, and that it is more that adequate political support is needed to be secured and funding made available and directed towards mission delivery." Industry experts common view.

Jamie McMichael-Phillips, Seabed 2030 Director

"Delivery of Seabed 2030 mission presents a tremendous opportunity to stimulate and accelerate seabed mapping industrial development and growth. It also provides a golden opportunity to focus attention and enhance human capacity concerns such as the build up of developing nation capacities and enhance other human capital interests such as inclusivity and gender." Jamie McMichael-Phillips, Seabed 2030 Director

SEABED 2030 MAPPING INITIATIVE

Our mission is to inspire ocean mapping and deliver a complete seabed map for the benefit of people and the planet. Formed by The Nippon Foundation & GEBCO, Seabed 2030 is a global initiative where industry, governments, researchers, and everyday explorers come together to help us achieve our mission of mapping the entire ocean floor by 2030.

We are a global collective dedicated and relentless in our pursuit of achieving a complete map of the ocean floor by 2030. What unites us is a belief that in discovering the unknown, we can enable greater understanding, empower sustainable living and ensure everlasting protection of our ocean.

FOR MORE INFORMATION
CONTACT US:
enquiries@seabed2030.org

THE NIPPON FOUNDATION · GEBCO · IHO · unesco Intergovernmental Oceanographic Commission · 2021 2030 United Nations Decade of Ocean Science for Sustainable Development

SECTION: SEABED MAPPING USE CASE ACKNOWLEDGEMENTS, REFERENCES, AND IMAGE CREDITS

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Use Case 1: Seabed Mapping Innovation: Gary Hesling, Jamie McMichael-Phillips, Larry Mayer, David Millar

Use Case 2: EEZ Seabed Mapping in the Absence of a National Hydrographic Office: Gary Hesling Jamie McMichael-Phillips, Ian Davies, Kevin Mackay

Use Case 3: Subsea Cable Planning and Design: David Millar, Larry Mayer, René d'Avezac de Moran, Marzia Rovere

Use Case 4: Tsunami Propagation and Storm Surge Modeling: Martin Verlann, George Spoelstra, Kevin Mackay, Tion Uriam

Use Case 5: Renewable Energy - Offshore Wind Energy: Marzia Rovere, Steve Hall, David Millar, Larry Mayer

Use Case 6: Climate Change Ocean Models: Martin Jakobsson, Evert Flier, Larry Mayer

Use Case 7: Small Island Developing States (SIDS) Sea Level Rise and Coastal Inundation: Tion Uriam, David Millar

Use Case 8: Marine Biodiversity: Martin Jakobsson, Evert Flier, Eva Ramirez-Llodra

Use Case 9: Small Island Developing States (SIDS) Marine and Coastal Development, and the Use of Seabed Mapping as a Foundation Data for Marine Spatial Planning: Evert Flier, Ian Davies, Tion Uriam

Use Case 10: Government Policy: Jamie McMichael-Phillips, Evert Flier, Kim Picard

Use Case 11: Ocean Discovery and Ocean Exploration: Eva Ramirez-Llodra, Victor Vescovo, Larry Mayer

Use Case 12: Seabed 2030 Driving Hydrographic Industry Expansion and Human Capital Benefits: Gary Hesling, Jamie McMichael-Phillips, David Millar, Kim Picard, Kevin Mackay

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Use Case 10: Government Policy [4 images]
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Use Case 11: Ocean Discovery and Ocean Exploration [4 images]
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Use Case 12: Seabed 2030 Driving Hydrographic Industry Expansion and Human Capital Benefits [6 images]

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