>>> community without compromising commercially sensitive details. The partnership has contributed more than 65,000 square kilometres of high-resolution bathymetric data to the Seabed 2030 project.

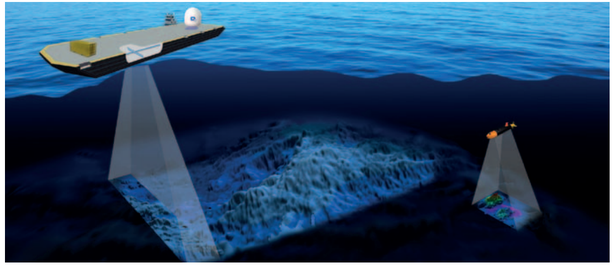
Texas-based surveying company Ocean Infinity also committed to donate 120,000 square kilometres of data collected during its search for the missing Malaysian airliner MH370. Ocean Infinity utilised a swarm of eight Autonomous Underwater Vehicles (AUVs), enabling data to be collected more quickly than traditional mapping missions using surface vessels with on-board echosounders.

In 2019, Seabed 2030 partnered with the pioneering Five Deeps Expedition, the world's first manned expedition to the deepest point in each of the five oceans. In order to dive safely at each location, the Five Deeps Expedition had to produce detailed bathymetric maps of each site, and it was agreed that these would be donated to Seabed 2030. Five Deeps' Creator, Sponsor and Chief Submersible Pilot, Victor Vescovo, also agreed to optimise their vessel's tracks between dive sites and collect transit data in previously unmapped areas, which will also be included in the GEBCO grid. Seabed 2030 has supported these efforts by providing mapping experts to operate the on-board sonar systems in transit.

A partnership has also been struck with the World Ocean Council, the global blue economy business organisation, for joint engagement with the ocean business community to promote the project's vision and the ways in which organisations in the maritime community can collect and contribute bathymetric data to Seabed 2030.

Crowdsourcing data

These partnerships epitomise the collaborative nature of the Seabed 2030 project, and highlight what can be achieved when the international community comes together with the aim of mapping the world's ocean floor. This is why the concept of crowdsourcing bathymetric data has become essential to achieving the mission of Seabed 2030. Around the world, hundreds of thousands of cargo vessels, fishing boats, cruise liners, private yachts and surveying ships are equipped with on-board echosounders to ensure the safety of their operations. By utilising assets already at sea, these craft can effectively become an international fleet of research vessels, collecting and donating bathymetric data to Seabed 2030 for inclusion in the global grid.



Implementing the latest technology for ocean mapping is one of the pillars of the Seabed 2030 project. The concept of an unmanned mapping barge, monitored by satellite communication and equipped with an ultra-narrow beam deep-water multibeam (left), is just one of many ways technology could be used to generate new data. Such a barge would be able to systematically map the deepest sections of the open ocean from the surface at a resolution in excess of 100x100 m. The sub-meter level of detail sometimes needed to investigate small scale processes at the seabed is today only possible to achieve in the deep ocean using AUVs equipped with high-resolution high frequency multibeam systems. These AUVs would serve as excellent complements to the mapping barge For further information: https://seabed2030.gebco.net/documents/seabed_2030_roadmap_v10_low.pdf

Building new technology and human capacity

In addition to utilising resources already available through Seabed 2030, The Nippon Foundation and GEBCO are heavily involved in the development and promotion of new technologies, as well as building human capacity by training the next generation of ocean mapping experts.

The Nippon Foundation-GEBCO Postgraduate Training Programme is a twelve-month course at the University of New Hampshire, leading to a Postgraduate Certificate in Ocean Bathymetry. Since the programme began in 2004, 90 students from 40 countries have graduated from UNH having learned new skills, going on to make significant contributions to the field of bathymetry around the world.

In May 2019, alumni from the postgraduate training programme won the $4m grand prize in the Shell Ocean Discovery XPRIZE, a global competition challenging teams to advance deep sea technologies for autonomous, fast, high-resolution ocean exploration. The GEBCO-Nippon Foundation Alumni Team was made up of more than 70 individuals, including 16 graduates of the postgraduate training programme representing the 13 countries of Russia, Egypt, South Africa, USA, Mauritius, Malaysia, Peru, Ireland, Japan, Philippines, Israel, Poland and Brazil.

The team's concept utilised a purpose-built Kongsberg Maritime Hugin AUV, rated to operate at depths up to 4,500 metres, which includes all of the company's most up-to-date technologies. The AUV was supported by a SEA-KIT™ unmanned surface vessel, USV Maxlimer. The SEA-KIT™ vessel has been designed and built by Hushcraft in the UK, and has the unique ability to autonomously launch and recover the AUV. The surface vessel acts as an active communication link during subsea survey operations.

It was also announced that Seabed 2030 would enter into a new agreement with XPRIZE to deepen cooperation in pursuit of mapping of the world's entire ocean floor.

Since being used in the GEBCO-NF Alumni Team's XPRIZE entry, SEA-KIT™ has completed the world's first international commercial uncrewed transit, successfully traversing the world's busiest shipping lane to deliver a box of oysters from the UK to Belgium on 7 May 2019.

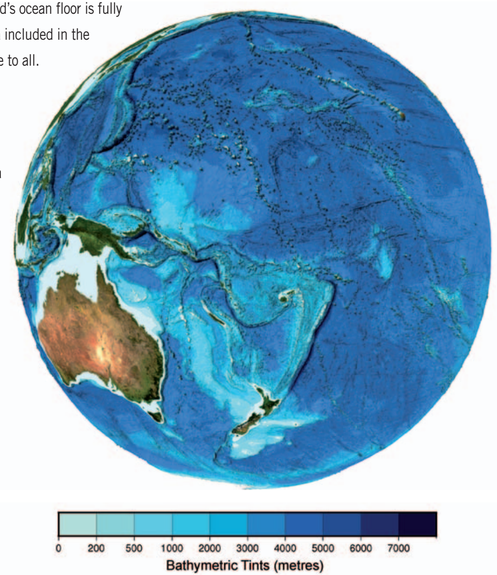
For more information, visit seabed2030.gebco.net or email director@seabed2030.org

DEEP AMBITION: HOW TO MAP THE WORLD
THIS INFORMATION IS BASED ON THE NIPPON FOUNDATION - GEBCO SEABED 2030 ROADMAP FOR FUTURE OCEAN FLOOR MAPPING

The Nippon Foundation-GEBCO Seabed 2030 Project: New Global Grid Published

Vision: By the year 2030, the world's ocean floor is fully mapped, with all bathymetric data included in the GEBCO global grid, freely available to all.

Mission: To compile all existing bathymetric data into the freely available GEBCO digital map, identifying areas for which no data exist to inform future mapping expeditions to 'map the gaps'. This detailed bathymetry will empower the world to use the oceans sustainably, to make informed policy decisions, to manage natural hazards and to pursue scientific research for the benefit of mankind.



The problem

Curiosity is a fundamental part of human nature. Our desire to explore has taken us to remote corners of the planet and beyond. Our probes have travelled further than the outermost reaches of the solar system. And yet, despite millennia of exploration, we do not know our own planet. The oceans cover more than 70% of Earth's surface, yet before the launch of The Nippon Foundation-GEBCO Seabed 2030 Project, only 6% of the seafloor was included to an adequate resolution in the world's most comprehensive digital bathymetric map: the GEBCO global grid of the ocean floor.

The United Nations' Sustainable Development Goal (SDG) 14, which has been officially adopted by all 193 Member States, commits us to "conserve and sustainably use the oceans, seas and marine resources for sustainable development". To succeed, we must develop a comprehensive understanding of our marine environments. With its aim to map the world's ocean floor by the year 2030, Seabed 2030 supports SDG 14 and is recognised as an important initiative in line with the UN Decade of Ocean Science.

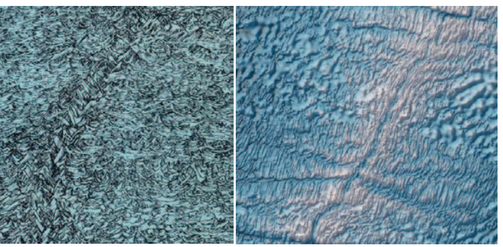
Why is mapping important?

A detailed scientific understanding of the seabed is important in its own right, but a global map showing the shape and depth of the world's ocean floor will deliver a host of tangible benefits. Bathymetric data from the deep ocean are essential to a variety of scientific disciplines, including oceanography, marine geology and geophysics. One such example is how data collected by Bruce Heezen and Marie Tharp during the 1950s and 60s led to our modern knowledge of plate tectonics, which in turn is the foundation for our understanding of earthquakes.

The shape of the seabed also influences a whole host of processes, and is critical to understanding ocean circulation patterns, our weather systems and climate, tides, wave action, sediment transport, tsunami wave propagation, and underwater geo-hazards. Seabed mapping is also vital for the security, safety and economic health of nation states. According to the Organization for Economic Cooperation and Development (OECD), the 'Blue Economy' is valued at $1.5 trillion a year and creates the equivalent of 31 million full-time jobs.

Humanity's duty of care to our marine environments has been brought into sharp relief in recent years, and it is vital that we are able to protect them for future generations. It is clear, however, that it is impossible to manage what we do not understand. A comprehensive map of the seafloor will lay the foundations for our sustainable management of the oceans.

A comparison of the Heezen and Tharp 1957 physiographic diagram of the Atlantic Ocean (left) with data from the GEBCO 2019 grid for the same area (right). What was once modeled from a few trans-Atlantic transects is now modeled based on the combination of measured and predicted bathymetry data. With measured bathymetry, important quantifiable details of seafloor morphology come into focus.



The solution

Seabed 2030 is a collaborative project between The Nippon Foundation, Japan's largest private philanthropic organisation, and the General Bathymetric Chart of the Oceans (GEBCO), to inspire the complete mapping of the world's ocean floor by 2030, and to compile all bathymetric data into the freely available GEBCO global grid.

Working under the auspices of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, GEBCO has more than a century of experience in ocean floor mapping.

Seabed 2030 was launched in 2017 at the United Nations Ocean Conference by Mr Yohei Sasakawa, Chairman of The Nippon Foundation, and operationalised in February 2018.

Yohei Sasakawa, Chairman of The Nippon Foundation, launches the operational phase of the project in Tokyo.

The project has three basic aims which, when taken together, will enable the production of the definitive map of the ocean floor by the year 2030:

1. To incorporate all existing data into the GEBCO global grid
2. To identify areas for which no data exist and encourage and facilitate data collection in these areas, so that we can 'map the gaps'
3. To identify technology gaps in bathymetric mapping and encourage innovation in these areas

How big is the challenge?

No one on Earth can say for sure what percentage of the seafloor has been mapped. It is impossible to know, for example, how much data that has already been collected is being held by private organisations, or stored in research labs inaccessible to the wider scientific community. Identifying how much data is out there, and which areas of the oceans are covered, is central to the mission of Seabed 2030. Once we have successfully identified all of the areas that have been mapped we can work to inform future mapping expeditions, ensuring efforts are not being duplicated.

We can, however, say how much is currently included in the GEBCO global grid. When the last GEBCO grid was published in 2014, it was considered to be 18% complete based on the resolution used at that time, which used a grid-cell size of ~1 km. Since then, the scientific community has agreed that a higher resolution would be more beneficial, so the target resolution for the Seabed 2030 project was adjusted accordingly.

At this new higher resolution, only 6.4% of the ocean was included in the 2014 GEBCO grid. This has now increased to 15% following the publication of the 2019 GEBCO grid, and the grid will be updated annually throughout the lifetime of the Seabed 2030 project.

What is the Seabed 2030 target resolution?

In an ideal world, by the end of Seabed 2030 we would be in possession of a complete map of the ocean floor at the same level of detail as our best land maps. Unfortunately, due to the limitations of optical imaging through water, we must instead rely on acoustic technologies, or sonar. As the overwhelming majority of bathymetric data is collected from surface vessels, the achievable resolution is inherently dependent on the depth of the ocean. This means that the best achievable resolution will vary.

The variable depth resolutions for Seabed 2030 have been based on what can be achieved using multibeam echosounders (MBES) with beam geometries of 2° × 2°. Given that high-quality MBES data can be acquired with a swath width of about four times the water depth, our target resolutions are determined by the footprint of data acquired from the outermost beams – at approximately 60° either side of the point directly beneath the MBES. Given this, target resolutions have been calculated to the following values:

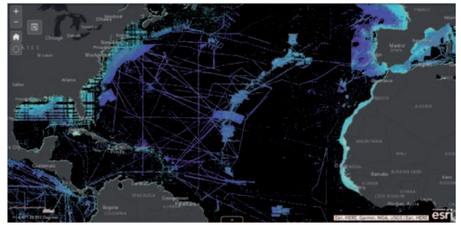
Ocean depth range	Grid-cell size	% of world ocean at this depth
0-1500 metres	100x100 metres	13.7
1500-3000 metres	200x200 metres	11
3000-5750 metres	400x400 metres	72.6
5750-11000 metres	800x800 metres	2.7

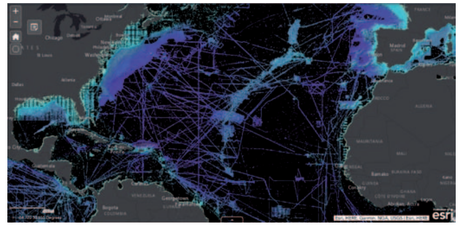
For a detailed explanation of the Seabed 2030 mission and the challenges ahead, read 'The Nippon Foundation-GEBCO Seabed 2030 Project: The Quest to See the World's Oceans Completely Mapped' (Mayer et al., 2018).

New global grid published

The 2019 GEBCO grid represents a major increase globally in the resolution at which GEBCO presents bathymetric data, doubling that of the 2014 grid. Contributions to the grid are equivalent to around 32,000,000 square kilometres of new bathymetric data, an area greater than the landmass of the entire African continent. Heeding the call from Seabed 2030, industry is now making significant contributions to the Seabed 2030 mission to map the entirety of the world's ocean floor. Around 570,000 square kilometres of data – roughly the size of Kenya – have been donated by industry partners for inclusion into the new map.

The latest edition of the grid is available to download now at www.gebco.net.





A comparison of data coverage in the Atlantic Ocean in the GEBCO 2014 global grid (top) vs the GEBCO 2019 global grid (bottom), revealing the tremendous progress that has been made. These images were generated by blacking out areas where predicted bathymetry support the GEBCO grid, and highlighting areas where measured observations support the grid. Blue colors in highlighted areas correspond to sea-floor depth.

How was the new grid produced?

The publication of the 2019 GEBCO grid is the product of a truly international effort, pulling together data from countless organisations and mapping initiatives around the world. For the purposes of Seabed 2030, the world has been divided into four regions, each overseen by a Regional Center. These Regional Centers are based at the Alfred Wegener Institute in Germany, covering the Southern Ocean; Stockholm University in Sweden, in partnership with the University of New Hampshire, US, for the Arctic and North Pacific Ocean; the Lamont Doherty Earth Observatory at Columbia University, US, covering the Atlantic and Indian Oceans; and the National Institute of Water and Atmospheric Research (NIWA) in Wellington, New Zealand, covering the South and West Pacific Ocean. Regional data products are fed into a Global Center hosted at the British Oceanographic Data Centre, National Oceanography Centre, in Southampton, UK.

Major partnerships

In addition to the results of dedicated mapping expeditions and research initiatives in each region, the new GEBCO grid contains valuable bathymetric data contributed by a number of private companies and other organisations that have chosen to partner with Seabed 2030.

In March 2018, just a month after the project was operationalised, Seabed 2030 teamed up with Fugro, one of the world's leading private sector off-shore survey companies. Fugro agreed to leave its on-board echosounders switched on while travelling between client projects in order to collect transit data, all of which has been donated to Seabed 2030 for inclusion in the global GEBCO grid. In addition to data collection, Fugro also committed to opening discussions with its clients to investigate how proprietary data can be shared with the scientific >>>

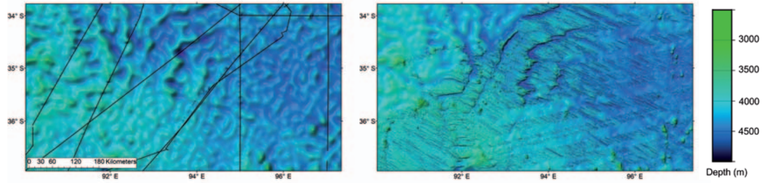


Fig. a Fig. b

A comparison between data from the GEBCO 2014 grid (Fig. a) and GEBCO 2019 grid (Fig. b) showing an area of the Indian Ocean covered by the search for flight MH370. The GEBCO 2019 global grid includes a number of new datasets contributed from a wide variety of different sources. As shown in the image above, data from the MH370 Phase One Data Release, collected during the search for flight MH370 and made available through Geoscience Australia, has helped to significantly improve the portrayal of the depth and shape of the seafloor where there was previously sparse ship-track data.