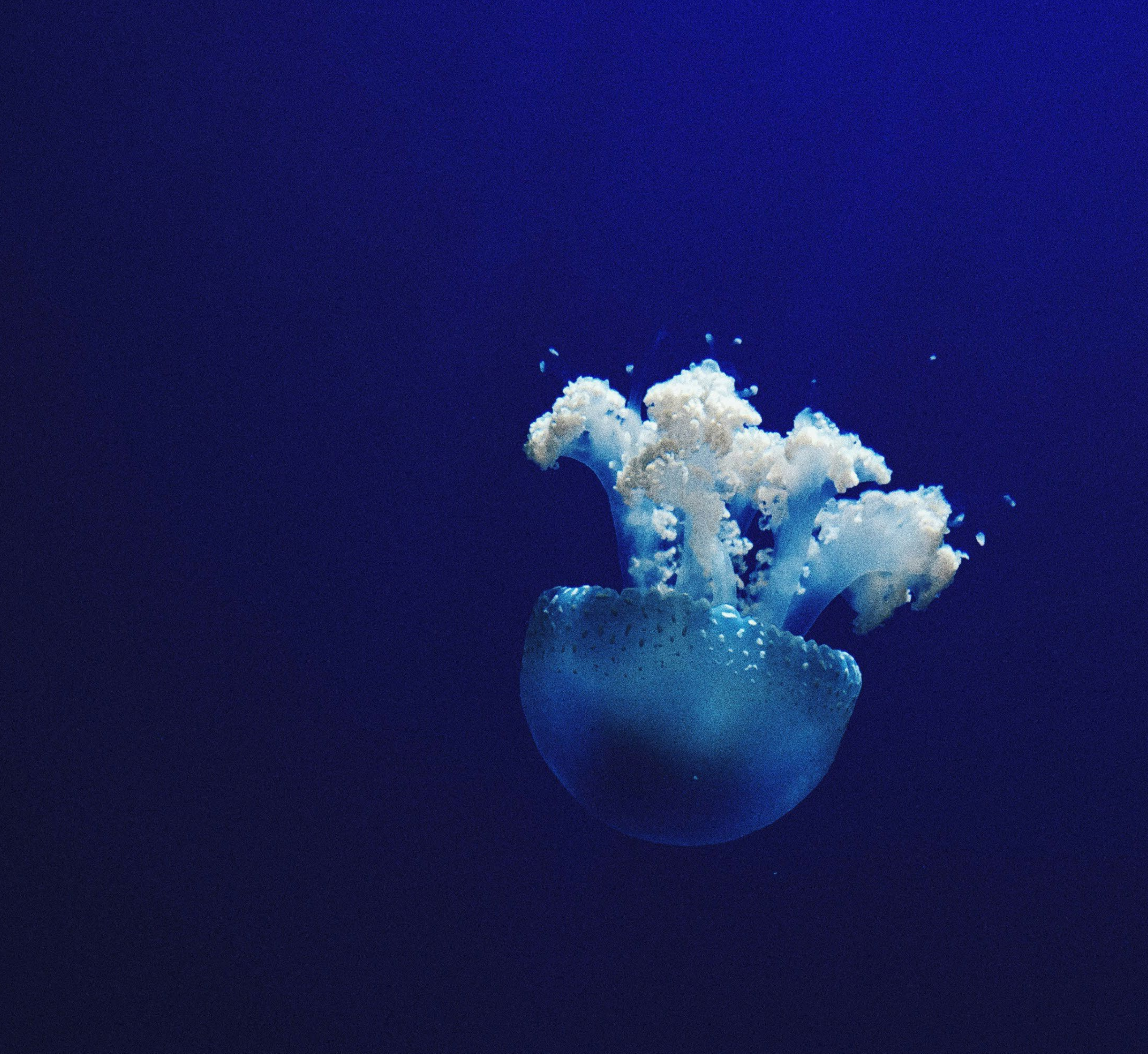


OBON
OCEAN BIOMOLECULAR OBSERVING NETWORK
STRATEGY

The story of life in the ocean is told by its biomolecular traces - the DNA, RNA and proteins that compose life on Earth. These hidden messages in the waves record the ebb and flow of life, and their analysis is transforming our ability to observe and understand species integral to ocean health and food security, upon which we all depend. Collection of these unifying signatures is simple, non-invasive, and can be cost-effectively scaled across our blue planet.

OBON VISION

Accelerate informed decision-making to restore the health of our ocean using the universal signatures of life on Earth: biomolecules.

Front cover photo: Unsplash, Erastus McCart
Photo: Unsplash, Cristian Palmer

Photo: Unsplash, Cristian Palmer

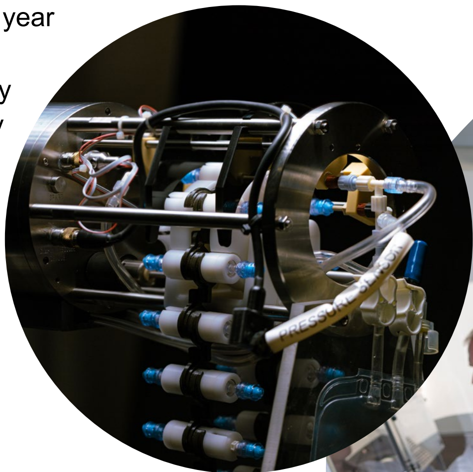
OBON MISSION

Create a hub for biomolecular measurement of marine life on Earth

The Ocean Biomolecular Observing Network (OBON) serves as the strategic hub for a global biomolecular observatory in support of the UN Decade of Ocean Science for Sustainable Development, generating knowledge based on biomolecules and strengthening capacity to advance and broaden their application to sustainable development, by supporting:

- the ocean observing community and marine conservation managers
- the progress of global initiatives, such as the Agenda 2030, the post-2020 Global Biodiversity Framework, the Convention on Migratory Species, the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES), and the World Ocean Assessment
- drivers of the blue economy valued at an estimated $2.5 trillion / year
- the 3 billion people globally reliant on fish as a primary source of protein.

The OBON hub will ensure that biomolecular observations of the ocean are globally coordinated, harmonised, adhere to the FAIR (Findable, Accessible, Interoperable, and Reusable) principles, and reliably flow into the global ocean observing system. This integration, as standard practice, is integral to sustainable ocean management and for deriving actionable knowledge from globally-distributed biomolecular observatories.



Photos: left- Daniel Bourne, National Oceanography Centre, right- Giacomo d’Orlando, OceanOmics

A healthy ocean relies on informed management

Biomolecular knowledge is currently applied to manage terrestrial ecosystems[1]. Due to its scalability, sensitivity and specificity, biomolecular information is key to a future of well-maintained, sustainably productive marine ecosystems.

OBON will use the power of environmental DNA (eDNA) and ‘omics (DNA, RNA or protein) technologies to inform diverse ocean stakeholders and ocean managers, using a scalable metric to measure and understand change, such as that in the 30% of protected ocean by 2030, and to predict and alert the population to ocean hazards, such as harmful algal blooms or oxygen depletion.

OBON will collect globally- and temporally-comprehensive datasets on ocean life and their environments, delivering solutions to ocean challenges. By understanding the impact of physical and chemical factors on marine communities, these biomolecular datasets will strengthen models predicting responses to increasingly common and catastrophic events such as heat waves, tropicalisation, and coral bleaching. Similarly, they will help evaluate the effects of expanding industries, such as aquaculture and offshore wind farms, on marine biodiversity.

OBON STRATEGY

A global biomolecular observatory supporting a sustainable ocean

OBON’s core pillars are to **INNOVATE** technology and methodologies, delivering frameworks to advance biomolecular observations from the coastal to the open ocean, thus enabling broad-scale interpretations and scientific discovery; to **DEVELOP** resources, networks and strengthen capacity globally, to advance observations and analyses while ensuring equitable access; and to **ENHANCE** the use and interpretation of these observations through agreed data practices and model integration, and the creation of ocean knowledge. Together, this work **INFORMS** ocean users and managers, ensuring sustainable interactions in support of a healthy ocean.

OBON will work directly with managers and regulators to integrate biomolecular data into existing monitoring programs, and measure their added value relative to current monitoring tools. OBON will simplify the integration of biomolecular tools into the Global Ocean Observing System (GOOS) specifications for Essential Ocean Variables, and report GOOS-relevant data as part of its data submissions.

1 https://www.mpi.govt.nz/biosecurity/exotic-pests-and-diseases-in-new-zealand/pests-and-diseases-under-response/freshwater-gold-clam

Photo: Ocean Image Bank; Dimitris Poursanidis

A sustained global observing programme for all marine life

OBON will leverage the many advantages of biomolecular ocean observing to elevate marine biology and ecology to the status of "core" oceanography, alongside salinity and temperature, concomitant with the rise of biogeochemical and nutrient measurements. In this way, any assessment of ocean state and change will be inseparable from that of the life that infuses it and upon which we all depend. OBON aims to upscale marine life observations in terms of time and space, innovating for higher-resolution autonomous sample collection. To enhance ongoing observatory activities and enable broader-scale knowledge of marine life, OBON develops and implements tools and networks to facilitate data sharing (Figure 1).

These activities enable the universal collection of comprehensive datasets measuring marine life, and a legacy of long-term observing ensured by training with marine managers and the value of biomolecular knowledge. Representing the first global marine biomolecular observing network, OBON aims to integrate harmonised biomolecular data into oceanographic models, intended to improve the prediction and forecasting of ecosystem dynamics.

Our programme will immerse the public in the captivating and mostly unseen world of marine life through education, outreach and citizen science initiatives. By unveiling the intricate fabric of ocean life with unparalleled clarity and scale, we seek to foster a deeper appreciation and understanding of the rich biodiversity beneath the waves.

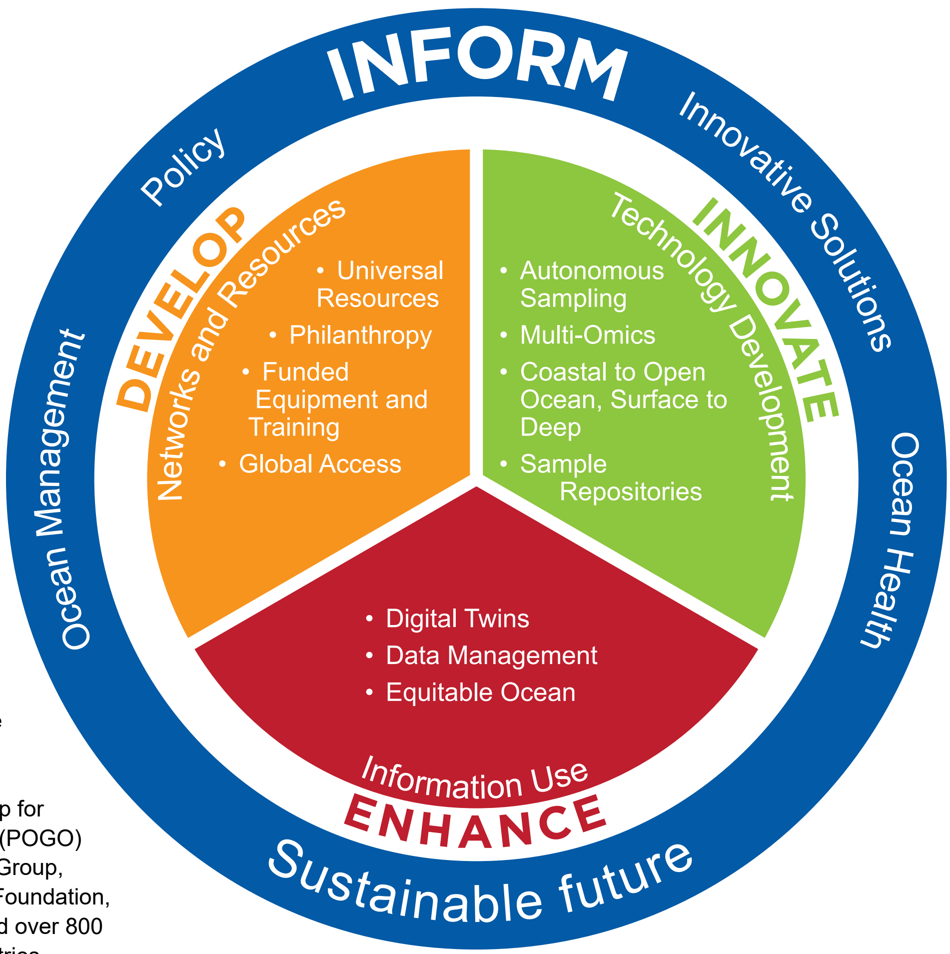


Figure 1. Framework of the OBON Ocean Decade programme. OBON was created from input gathered from the "International conference on the use of eDNA in marine environments: Opportunities and challenges," led by the Partnership for Observation of the Global Ocean (POGO) Biological Observations Working Group, with funding from the Lounsbery Foundation, in December 2020, which included over 800 participants representing 69 countries.

INNOVATE

OBON fosters the innovation of technological solutions and metrics to protect biodiversity even in remote regions, including the deep ocean and high seas. We develop strategic roadmaps towards the next generation of ocean observing, pioneering DNA and RNA tools for autonomous surveys of marine life.

READ THE CASE STUDY

DEVELOP

OBON develops global and regional networks, shares resources, and strengthens capacity, organising international workshops, training and networking events to share capabilities and accelerate innovation in biomolecular observing. We engage with funders, philanthropy and technologists with the ambition of developing and enabling broad access to tools and resources, towards a vision of equitable access to biomolecular knowledge pertaining to our ocean. The representative Projects play a crucial role in ensuring broad access to ocean observatories and resources through collaborations, effective communication of ocean knowledge, stakeholder interactions, dissemination of open data and co-designed science projects and data products.

READ THE CASE STUDY

ENHANCE

The strength of this partnership across OBON Projects lies in catalysing consensus on key issues, such as the CARE (Collective benefit, Authority to control, Responsibility and Ethics) and FAIR (Findable, Accessible, Interoperable and Reusable) principles, reporting and standards across biomolecular datasets. The requirement for discoverable and FAIR data across this global-scale network facilitates large-scale syntheses and biological model development. OBON governance mandates adherence to these data practices as a condition for project participation, promoting discoverability and the sharing of digital resources in alignment with the Ocean Decade's Data and Information Strategy. We support our partners in finding and implementing the necessary technologies, standards, and conventions to make their (meta)data, software, and digital services broadly discoverable. We also help partners share their digital capacities, data, information, and knowledge with new audiences in the ocean community, in coordination with other Programmes and Decade Coordination Centres/Offices This will enhance visibility and integration of biomolecular data in ocean assessments (e.g. via the defined Global Ocean Observing System Essential Ocean Variables), models, and digital twins of the ocean, contributing to a more inclusive understanding of ocean dynamics.

READ THE CASE STUDY

INFORM

OBON will ensure that biomolecular data is communicated over networks to broad user bases, informing knowledgeable use of the ocean in line with the Sustainable Development Goals and other relevant policy frameworks.

READ THE CASE STUDY

Figure 2. Map showing OBON project sampling locations as at 31 March 2024. An up-to-date map and more information on all OBON projects can be found at https://obon-ocean.org/endorsed-projects

A network of Projects working towards a global observatory in support of wise decision-making

At its core, OBON's impact is derived from the cumulative work of a strong network of Projects representing monitoring sites across the globe. OBON coordinates across these Projects to share knowledge, resources and capabilities and to provide recommendations and frameworks to advance biomolecular ocean observing internationally.

OBON Projects span a wide array of spatial, temporal, and taxonomic scales, delivering the Programme's comprehensive scope. They represent the breadth of science needed for marine biomolecular observations from microbes to whales, using tools and platforms like long-term observatories, coordination frameworks for data and protocols, and reference genome sequencing. They cover vast spatial scales: from surface waters to the deep sea and from coastal regions to open ocean. The projects maintain valuable local observatory sample archives and deploy networks of sensor and samplers for extensive multi-'omics sample collection and analysis. This approach marks a pioneering step towards global-scale biological observing in the ocean.

The ocean ecosystem is continuous with virtually all others on the planet, and the molecules of life are perhaps the most powerful way to show this interconnectedness. Each day, flows of material in and out of the ocean bear diverse biomolecules that connect its living systems to human life. Biomolecules are unifying signatures distinguishing all life on Earth, and their collection is simple, scalable, cost-effective and non-invasive.

Building OBON on the foundation of effective governance

OBON operates within the UN Ocean Decade framework, steered by a Scientific Advisory Committee and implemented by an Executive Committee, with the Programme Coordination Office facilitating communication and strategic coordination. The User Advisory Committee coordinates with the projects and working groups to align OBON's initiatives with the principles of sustainable ocean use, contributing to informed marine policy and conservation efforts globally.

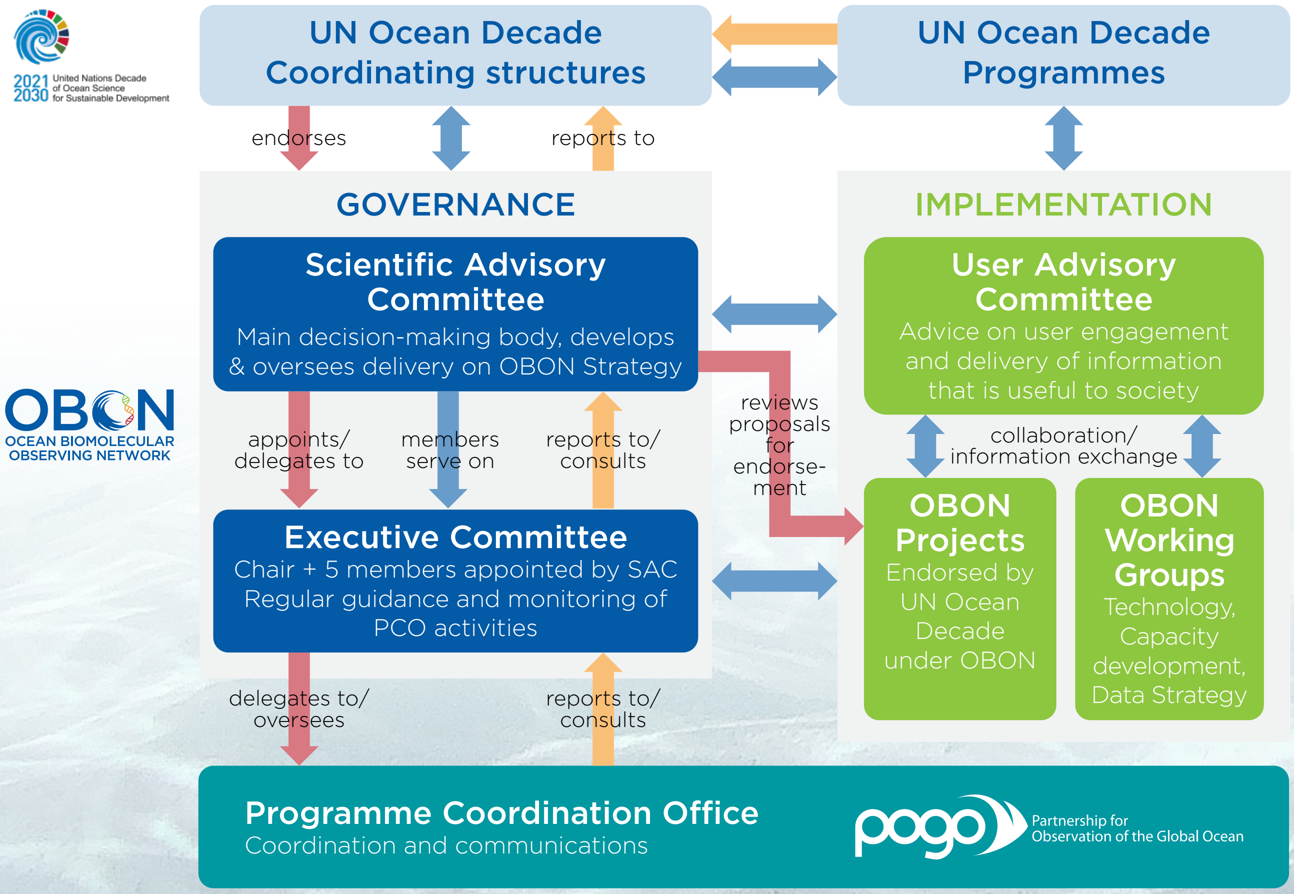


Figure 3. OBON's organisational structure.

Progress within each of the core pillars is achieved across OBON, with the Scientific Advisory Committee (SAC) and Projects enabling distinct and sometimes overlapping themes for implementation. In general, the SAC prioritises longer-timeframe, overarching and complex activities, while the Projects lead the actual implementation, providing tools, scientific data and knowledge from global marine biomes. OBON identifies strategic gaps and designs roadmaps, engages funders and identifies training and technology development opportunities to accelerate our shared vision, supporting the application of non-invasive biomolecular tools to scientific policy and management needs towards a sustainable future ocean.

Photo: Unsplash, Silas Baisch

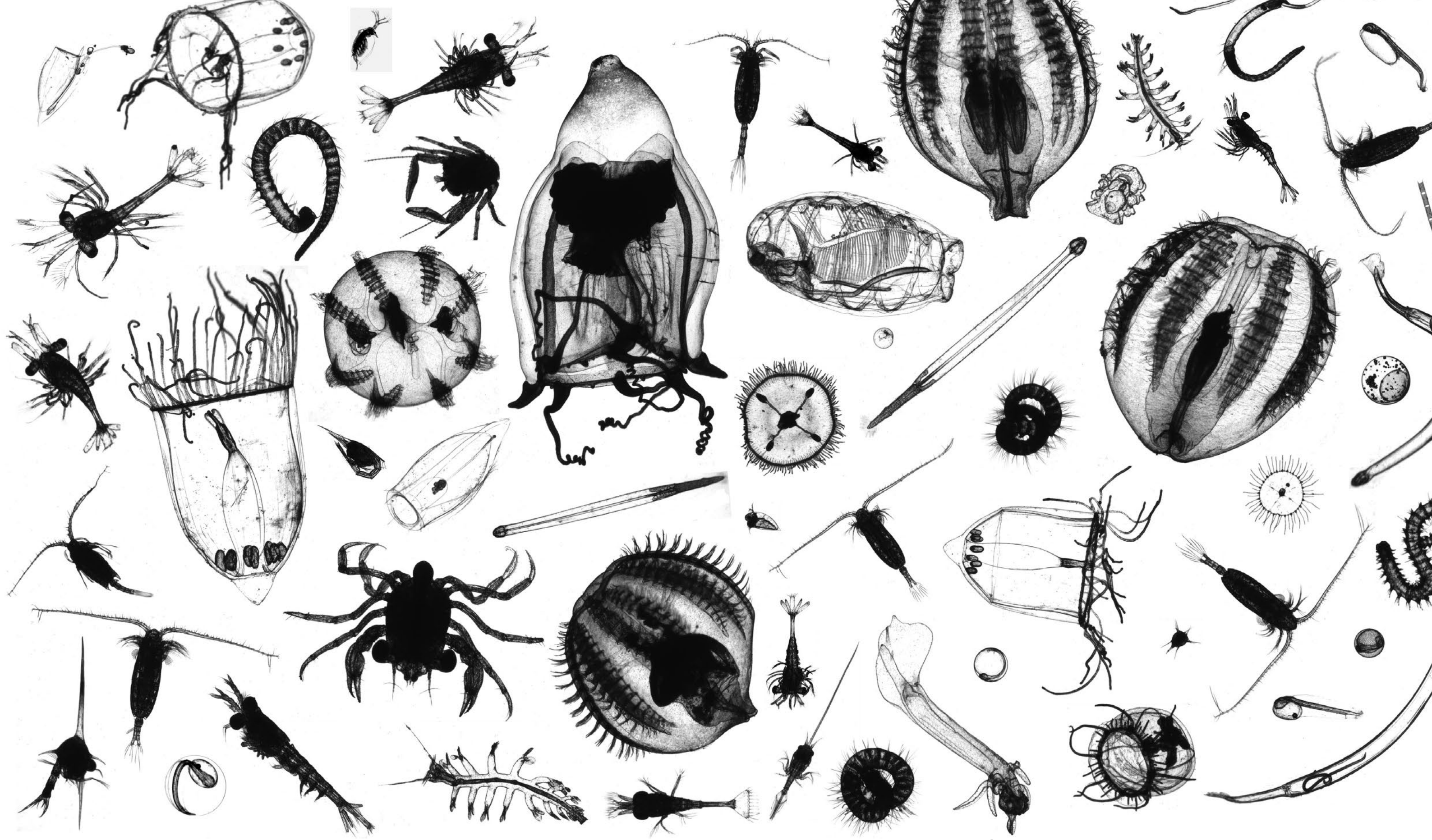


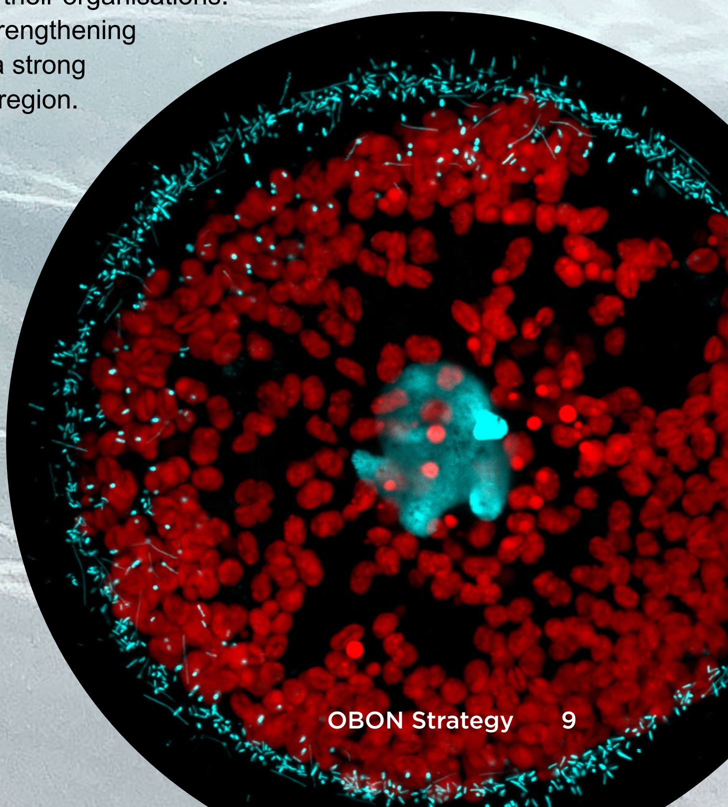
Photo: Rob Camp, Marine Biological Association

The User Advisory Committee will identify where and how OBON can best serve society and advise on linking the science/observations to user communities.

The Technology Working Group of the SAC coordinates innovation in collaboration with global experts. They conduct primary research and development to increase the technology readiness of deployable marine instrumentation, and they align science requirements with engineering needs, instrument specifications and funding opportunities to develop a technology roadmap for biomolecular observing.[2]

The Capacity Development Working Group discusses priorities for worldwide resource and network development and capacity strengthening, exchanging ideas and practices based on the experience of the WG members and their organisations. The group also plans future OBON capacity development/strengthening events, focussing on geographical locations where there is a strong engagement with OBON and a clear potential benefit to the region.

Photo: Davis Laundon, Marine Biological Association



2 The Marine 'Omics Technology Innovation workshop took place at the Monterey Bay Aquarium Research Institute (MBARI) in October 2023.

CASE STUDY

INNOVATE

Technological innovation for autonomous and non-invasive sampling

Biodiversity monitoring of the global ocean utilising autonomous biomolecular sampling instruments will revolutionise our understanding of ocean ecosystems. Autonomous biomolecular sampling, facilitated by uncrewed vehicles like autonomous surface vehicles (ASVs) and autonomous underwater vehicles (AUVs), allows access to previously understudied locations, such as deep-sea vents or polar regions, where traditional methods are impractical. These vehicles navigate remote areas, collecting genetic material from diverse marine habitats without disturbing fragile ecosystems. By deploying these instruments, researchers can significantly increase the spatio-temporal scale of measurements, enabling continuous monitoring across vast marine areas and over extended periods. This approach provides comprehensive data on species richness, abundance, and distribution patterns, essential for assessing ecosystem health and identifying conservation priorities. Moreover, autonomous sampling enhances the efficiency of biodiversity assessments, facilitating the detection of rare or elusive species and enabling timely responses to environmental changes. Combining autonomous sampling technology with biomolecular analysis, marine biodiversity monitoring can achieve unprecedented levels of precision, depth, and scope, contributing to more effective conservation and management strategies.

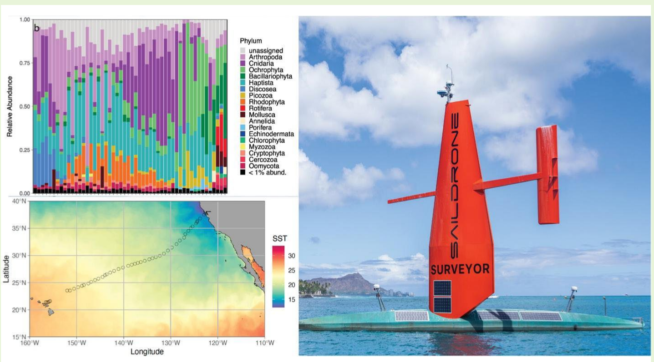


Figure 4. The Environmental Sample Processor (a biomolecular autosampler) aboard the Saildrone Autonomous Surface Vehicle measured eukaryotic biodiversity - 40 phyla - across a 4200km, 29-day transit in the North Pacific Ocean[3].

3 Preston C, Yamahara K, Pargett D, et al. (2024). Env DNA 6(1): p.e468, https://doi.org/10.1002/edn3.468.

CASE STUDY

DEVELOP

Ocean genomes: developing genome assemblies for all marine vertebrates

Reference genomes are foundational in modern biology, advancing various scientific fields like human health, agriculture, biodiversity, ecology, conservation, and evolution. Historically, they were limited to select model organisms due to economic, logistical, technical, and computational challenges. However, recent advances in sequencing technology and computational tools have enabled rapid and affordable production of reference genomes for non-model organisms globally[4].

Despite progress, vast swathes of regional, ecosystem, and taxonomic diversity remain unrepresented. For instance, only 3.5% of marine vertebrate species have reference genomes, with IUCN Red List threatened species being particularly underrepresented. Moreover, data production is biassed toward higher-resourced regions of the globe and the fauna that occur there[5].

Ocean Genomes, a partnership between Minderoo Foundation and the University of Western Australia (Perth, Australia), affiliated with the Earth BioGenome Project[4], aims to produce an openly accessible library of reference genome assemblies of marine vertebrates, prioritising species of high conservation value, and with a regional focus on Indo-Pacific and Australian fauna. This resource is intended to support genomics-enabled research to inform conservation management of marine vertebrates and facilitate the development of breakthrough eDNA-based biomonitoring applications.

4 Lewin HA, Robinson GE, Kress WJ, et al. (2018). Proc Natl Acad Sci USA115(17):4325–33, https://doi.org/10.1073/pnas.1720115115.

5 De Jong E, Parata L, Bayer PE, et al. (2024). GigaScience 13 giad119, https://doi.org/10.1093/gigascience/giad119.

CASE STUDY

ENHANCE

A database to enhance the use of biodiversity observations

ANEMONE is a biodiversity observation network utilising environmental DNA (eDNA[6]). By collaborating with universities, businesses, governments, and citizens, it started in Japan to cover the entire nation, acquiring and providing big data on ecosystems. The data acquisition uses “environmental DNA,” an innovative method anticipated to revolutionise the field. It enables the identification of species and their distribution from just a bucketful of water. The BIG Data obtained by ANEMONE is freely provided through the “ANEMONE DB”. Since 2020, in partnership with the non-profit Earthwatch Japan and universities, coastal surveys involving citizens have also been conducted.

The unique features of Biodiversity surveys using eDNA, allows us to realise extensive, multi-site, and high-frequency biodiversity observations, which were not easily achievable with traditional ecosystem monitoring. The goal of ANEMONE is to utilise the advanced ecosystem information obtained through eDNA observations to enhance the understanding and promotion of biodiversity, and to pave the way towards a Nature Positive society. We are expanding the ANEMONE platform to Asia and the rest of the world, striving for the internationalisation of the ANEMONE project under collaboration with other International research groups and organisations.

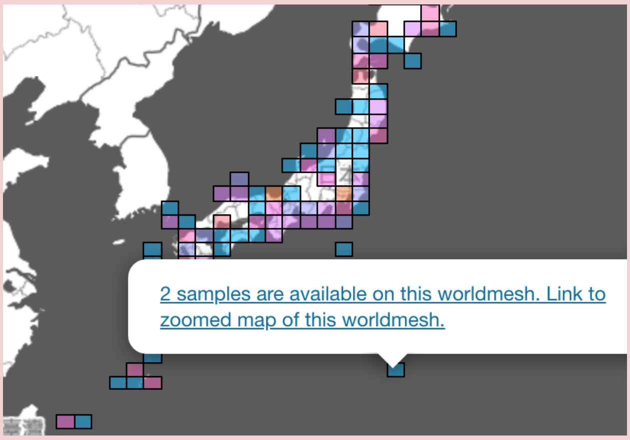


Figure 5. An example of ANEMONE DB. By clicking the observation site on the map, complete community composition data with MiFish sequences can be obtained. By October 2022, the number of survey locations reached 1,000, with the number of surveys conducted are in total 5,000, and fish species detected are more than 900.

6 https://anemone.bio/

CASE STUDY

INFORM

Digital PCR informing public health authorities in Southern California

In 2022, San Diego County became the first municipality in the United States to end its reliance on decades-old methods for monitoring faecal contamination in beach water in favour of a rapid, DNA-based method called droplet digital polymerase chain reaction (ddPCR[7]).

The ddPCR method enables public health officials to notify beachgoers about contaminated water on the same day that water samples are collected. It can measure faecal contamination levels in a beach water sample in as little as 3 hours from samples reaching the laboratory[8]. By contrast, results from traditional, culture-based methods typically become available 24-72 hours after samples reach the laboratory – a reporting delay that can put beachgoers at elevated risk of exposure to waterborne faecal pathogens.

The ddPCR method measures the genetic signature of a faecal bacterial indicator known as *Enterococcus*. Although traditional culture-based methods also measure *Enterococcus*, these culture-based methods require an overnight incubation period, allowing the sampled microbes to reach levels at which *Enterococcus* can be quantified.

ddPCR was approved by the Environmental Protection Agency’s Pacific Southwest Region and is now used at more than 50 County and State beach locations. This method was developed for beach use by the Southern California Coastal Water Research Project (SCCWRP) and implemented in collaboration with the California Department of Public Health (CDPH).

7 Cao Y, Raith MR and Griffith JF (2015). Water Res 70: 337-349.

8 Crain C, Kezer K, Steele S, et al. (2021). J. Microbiol. Meth. 184: 106206.

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