UNESCO eDNA Expeditions: successfully transforming innovative eDNA sampling into actionable data with OBIS expertise

Decoding the Ocean: UNESCO eDNA Expeditions Unveil Ocean Biodiversity

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Spanning 21 marine World Heritage sites in 19 countries, the UNESCO eDNA Expeditions pilot program demonstrated the transformative potential of citizen science in enhancing ocean biodiversity monitoring and conservation. OBIS, in collaboration with the World Heritage Centre, implemented cutting-edge eDNA sampling techniques and developed an advanced data dashboard for the programme, paving the way for future large-scale biodiversity monitoring campaigns.

Environmental DNA (eDNA) is an affordable, non-invasive, reliable, and efficient biodiversity monitoring method that relies on collecting and analyzing genetic material shed by organisms in their surroundings. While the analysis of the samples involves complex molecular biology and bioinformatics techniques to identify DNA sequences, the collection of the samples is straightforward. It can be accomplished even by non-specialists, empowering citizens globally to participate in a crucial biodiversity monitoring process. Building on this potential, UNESCO launched the eDNA Expeditions programme. This 3-year initiative gave 250 schoolchildren worldwide the opportunity to participate in a unique biodiversity monitoring pilot programme at 21 marine World Heritage sites.

The UNESCO eDNA Expeditions' outcome was stunning. Through 396 samples taken at the 21 sites, the volunteers contributed to identifying more than 4400 marine species, including about 86 shark and ray species, 28 marine mammal species, and 3 turtle species. Among the findings were 120 species listed as vulnerable, endangered, or critically endangered on the IUCN Red List.

The programme also contributed to detecting rare species, such as the Commerson's dolphin or the Giant Guitarfish. Even more stunning was the realization that the UNESCO eDNA Expeditions programme detected 10 to 20% of the expected local fauna in sampling sites, an exceptional accomplishment for such a small campaign. Achieving the same result using traditional surveying methods could have taken years and cost several million dollars.

The highest number of species was recorded in New Caledonia, with 833 different species identified, including the greatest number of fish species (418 species). In contrast, the Ningaloo Coast in Australia had the highest diversity of sharks and rays (26 species) and also the greatest number of threatened species listed on the IUCN Red List (24 species, of which 4 are Critically Endangered, 6 are Endangered and 14 are classified as Vulnerable). “These numbers are truly mind-blowing, considering they were derived from filtering just a few litres of seawater”, said **Ward Appeltans**, head of UNESCO’s Ocean Biodiversity Information System (OBIS) and coordinator of this eDNA project together with Fanny Douvere, head of the UNESCO World Heritage marine programme. **Fanny Douvere** added that “these UNESCO sites are truly some of the planet's most precious marine treasures”.

Even more importantly, one of the programme's key findings was that ocean warming is pushing numerous species outside their known thermal ranges, shedding

an alarming light on the need for increased, drastic conservation action in the monitored areas.

The project estimated that already 16% of the detected species is currently experiencing heat stress in at least one site, and in the most likely climate scenario (SSP2) this number will double and increase to 33% and even to 52% in the worst case scenario (SSP5) by 2100. The biggest limitation of this method of estimating thermal risk is the uncertainty regarding the extent to which species can adapt to higher temperatures. This challenge is particularly acute in tropical regions, where extreme temperatures are expected, and we currently lack any analogues for meaningful comparison. “These numbers are very alarming”, says **Ward Appeltans** , coordinator of OBIS. “The impact of global warming in temperate areas might be less severe in terms of biodiversity, and some may even see an increase in the number of species by new warm water species coming in, but for tropical areas adding more than 2-3 degrees Celsius on the already warm water will be dramatic for marine life. For almost all coastal species it might simply become too hot if they have no coping mechanism”.

OBIS contribution, from data collection to actionable integration

A pioneering project, the UNESCO eDNA Expeditions covers the entire marine biodiversity observation data chain, from collection and analysis to integration into actionable, user-friendly dashboards. Bringing its unique, world-renowned eDNA expertise and its experience in integrating large quantities of data into usable interfaces, OBIS played a crucial role in the success of this adventure. If eDNA sampling is relatively simple, ensuring the collected samples' usability, durability, and quality is fundamental to the method's reliability. For the UNESCO eDNA Expeditions, OBIS eDNA experts selected an affordable sampling kit and a robust, age-adapted scientific protocol to make the technique accessible to schoolkids and adaptable anywhere worldwide, with instructions in Arabic, Danish, French, German, English and Spanish. The protocol consisted of measuring the sample's environment (temperature, salinity), collecting seawater from the shore or at sea using sterile equipment, passing the collected water through a syringe into an enclosed filter to capture DNA material, adding a neutral agent for preservation, labelling the sample using a unique identification tag, recording the tag into a database using a smartphone logged into a specifically developed sample portal and storing the sample until its transportation to a laboratory for analysis.

The UNESCO-provided sampling kit for the young collection teams was designed with usability in mind. It focused on avoiding cross-contamination, featuring easy-to-use, field- and fool-proof tools in sizes and materials adapted to the teams' ages. "With this kit, we wanted to be sure that the kids in sampling teams would have fun, would learn, and would provide usable DNA material," explains **Saara Suominen**, a leading OBIS eDNA expert and a co-author of *Engaging communities to safeguard ocean life,* a UNESCO publication about the eDNA Expeditions. "We were inspired by the quality of the results. We applied a standardized biodiversity surveying method that anyone can use. This can completely change how we monitor marine biodiversity in the future, as we can collect more data, more often and even in the most remote areas of the globe."

After DNA analysis of the samples in specialized laboratories, the collected data had to be treated, organized, and integrated. Sequencing of the 396 viable samples yielded over 600 million DNA sequences, and subsequent analysis using the OBIS developed PacMAN bioinformatics pipeline, identified 450,000 unique sequences. The OBIS data experts developed an in-house dedicated platform for the UNESCO eDNA Expeditions programme, with a strong focus on usability, user-friendliness, and accessibility of the data collected. The result is a series of connected, intuitive dashboards available at dashboard.ednaexpeditions.org

The UNESCO eDNA Expeditions Dashboard combines user-friendly design, accessible insights, and advanced DNA-derived scientific content. "We have designed the UNESCO eDNA Expeditions Dashboard with a diverse range of users in mind," explains **Pieter Provoost**, OBIS Data Manager and one of the architects behind the platform. "The Dashboard features multiple navigation interfaces tailored to better support users' needs. We prioritized a visual and fit-for-purpose interface to avoid overwhelming non-specialists with content that was too technical. The Dashboard is built on a layered, Open Science approach that maximizes inclusivity, offering educative content for teachers or curious citizens and actionable insights aimed at marine site managers or policymakers to support evidence-based decision-making."

"The UNESCO eDNA Expeditions programme is a real-life demonstration of the revolutionary efficiency of eDNA surveying techniques in marine environments," explains Mrs **Audrey Azoulay**, Director General of UNESCO. "It's a testimony of the fantastic potential of citizen engagement in biodiversity monitoring. This can serve as the blueprint for future scaled-up marine biodiversity monitoring campaigns, contributing to a better understanding of our Ocean and achieving the World's

objective set in 2022 by the Kunming-Montréal Global Biodiversity Framework: to protect a third of the ocean by 2030”.

“With the UNESCO eDNA Expeditions, data is just a click away from action”.

Acknowledgement

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