



Australian Government
Parks Australia



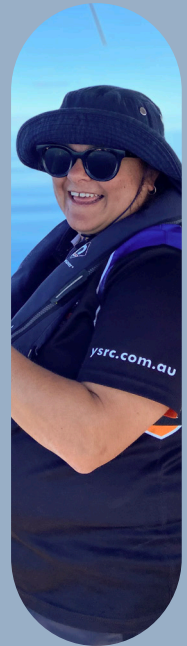
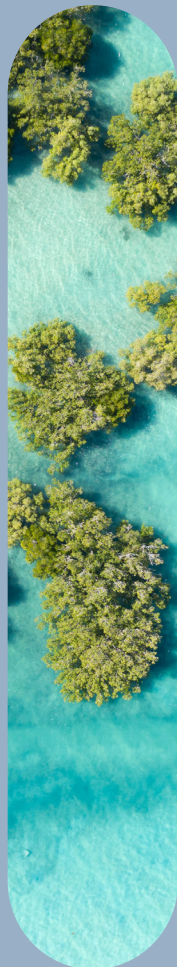
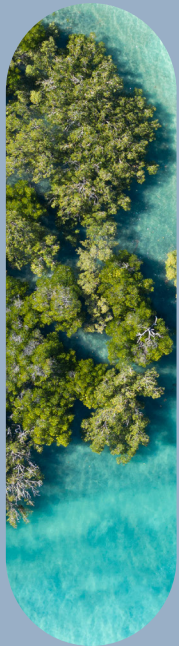
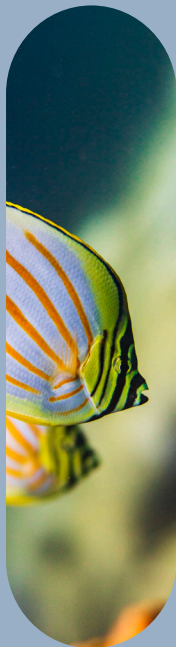
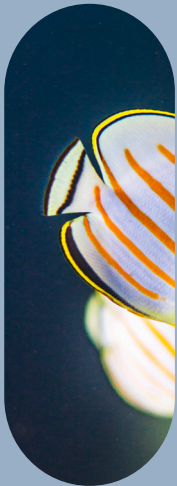
Australian
Marine Parks



Catalysing the uptake of environmental DNA (eDNA) into marine park management across Australia

Summary and overview

February 2026



The Ocean Discovery and Restoration Program

Recognising that strategic partnerships are essential to unlocking the full potential of marine science and conservation efforts, the Australian Government committed \$15 million over four years to the Ocean Discovery and Restoration (ODR) program. Administered by the Director of National Parks (DNP), the program supported projects that advance the understanding and sustainable management of Australian Marine Parks.

Through the ODR program, the DNP co-contributed to several genomics-based initiatives focused on increasing our knowledge of species and habitats, while demonstrating how innovative technologies and approaches can help address monitoring and management challenges in Australian Marine Parks.

Through the Ocean Discovery & Restoration program, Parks Australia and the Minderoo Foundation partnered to explore how eDNA-based, ecosystem-wide data can become a valuable and integrated component of a future national biodiversity monitoring framework.

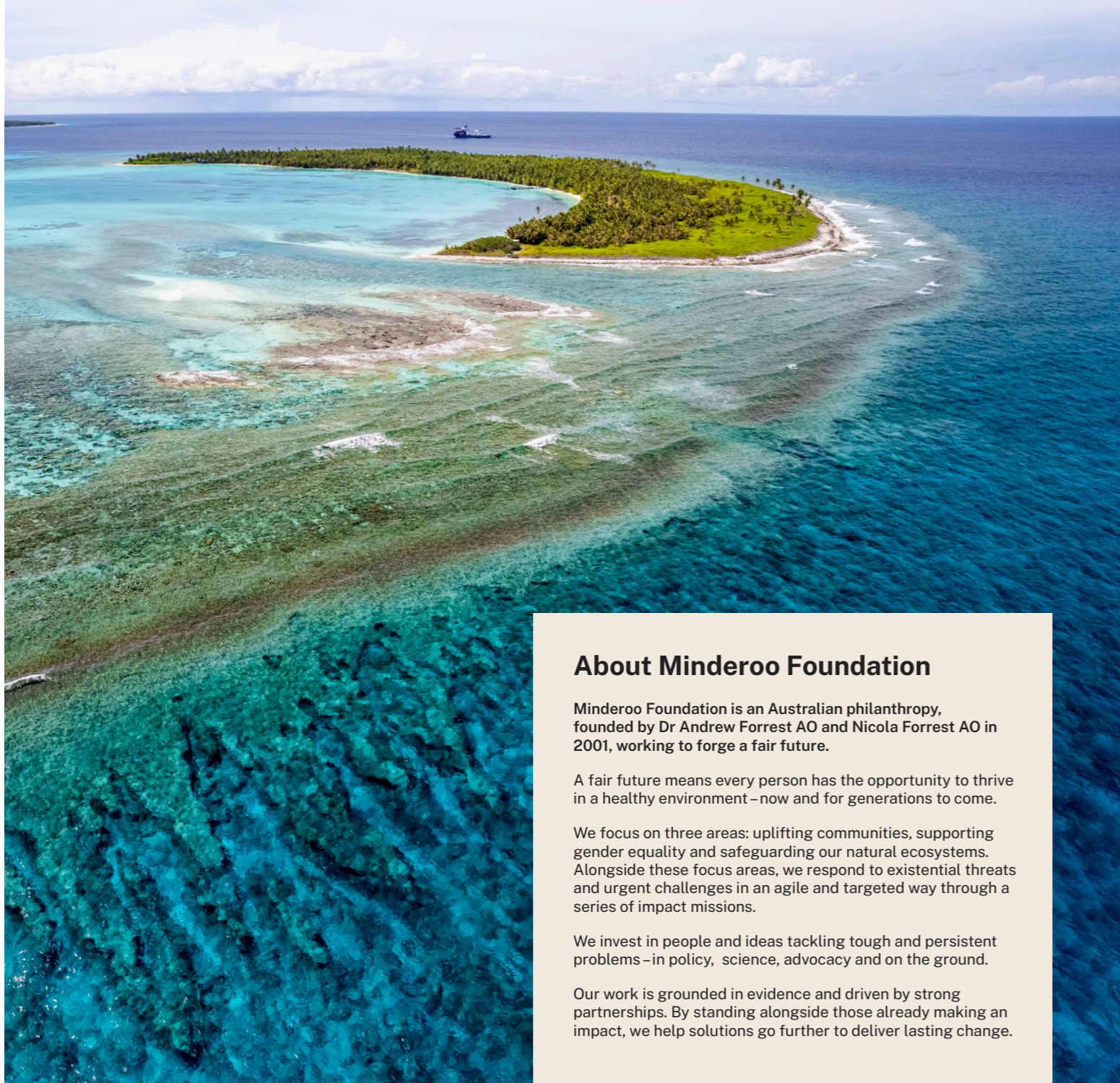
Here, we synthesise a key outcome of this partnership: a white paper which aims to help guide policy, foster stakeholder commitment, and advance molecular approaches as a trusted, efficient, effective, and scalable tool for marine conservation and ecosystem management. The paper outlines near- and long-term strategic opportunities and examines the benefits, barriers to uptake, and limitations associated with the use of eDNA to support marine park management.

Challenge: Measuring nature at scale

Accurately measuring ocean life and turning that information into effective management actions is a complex task. Making robust decisions requires identifying critical data gaps, while working more effectively with incomplete data and uncertainty. Effective management of Australia's Marine Parks depends on understanding the biological components of marine ecosystems and how they are changing over time. However, comprehensive, large-scale measurements of marine biodiversity are challenging. While traditional scientific tools have delivered important insights into ocean biota, their application at oceanic scales is often constrained by cost, logistics, and coverage, limiting the ability to fully characterise ecosystem structure and identify critical knowledge gaps.

Solution: A collaborative eDNA network

By integrating eDNA into a *predictive conservation* approach - where genomic data is combined with AI-driven ecosystem modelling, remote sensing, and socio-economic risk forecasts - managers can shift from a detect-and-respond model to a prevent-and-optimize strategy. This approach supports earlier interventions, targeted at where they are likely to have the greatest ecological payoff, and helps operationalise adaptive management.



About Minderoo Foundation

Minderoo Foundation is an Australian philanthropy, founded by Dr Andrew Forrest AO and Nicola Forrest AO in 2001, working to forge a fair future.

A fair future means every person has the opportunity to thrive in a healthy environment – now and for generations to come.

We focus on three areas: uplifting communities, supporting gender equality and safeguarding our natural ecosystems. Alongside these focus areas, we respond to existential threats and urgent challenges in an agile and targeted way through a series of impact missions.

We invest in people and ideas tackling tough and persistent problems – in policy, science, advocacy and on the ground.

Our work is grounded in evidence and driven by strong partnerships. By standing alongside those already making an impact, we help solutions go further to deliver lasting change.

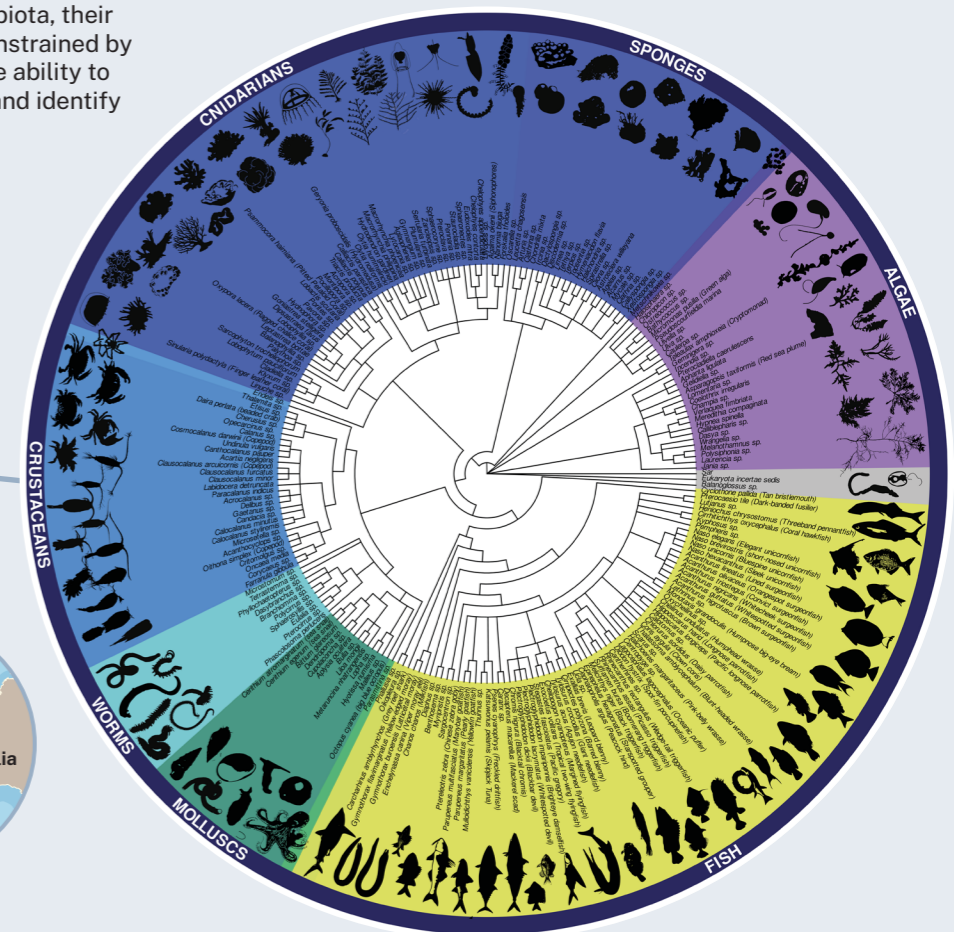
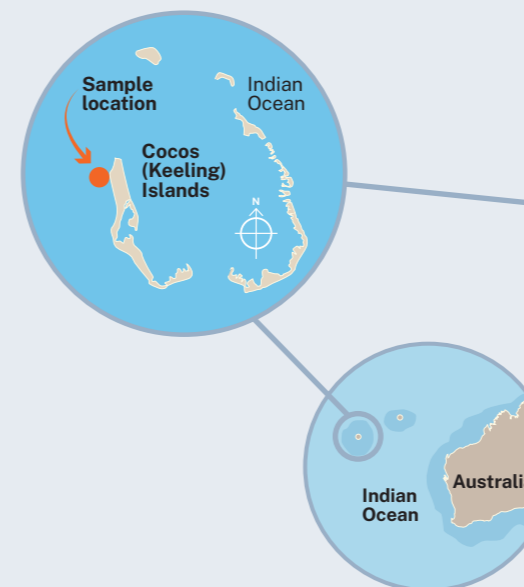


Figure 1: Tree of Life eDNA sample from Cocos (Keeling) Islands.

Current and Future Potential of eDNA

Strategic opportunities

Policy and management strategies	<p>Stakeholder involvement Facilitating marine park stewardship through collaborative monitoring programs, data sharing, and targeted funding to support responsive and adaptive management.</p>
	<p>A national monitoring framework A value proposition for integrating eDNA into a strategic, nationwide monitoring program to align efforts, standardise methods, optimise funding, and augment impact.</p>
	<p>Management strategies Embedding eDNA approaches and eDNA-derived data and metrics into management strategies to help inform conservation action, improve regulatory compliance, and track the effectiveness of practices and interventions.</p>
Empowerment	<p>Empowering communities Including local and Indigenous communities and their knowledge systems in the monitoring of our marine ecosystems, to enable scalable and inclusive biodiversity monitoring and stewardship.</p>
	<p>Ecosystem-wide surveillance Improving ecosystem monitoring and management by interweaving Tree Of Life data with other biodiversity monitoring approaches to support ecosystem based monitoring.</p>
	<p>A multi-modal, biosecurity and endangered species monitoring approach Simultaneously tracking and providing early detection of invasive and threatened species will reduce costs and enhance detection capabilities.</p>
eDNA innovation	<p>Monitoring change across space and time Unlocking qualitative and quantitative insights from eDNA data by tracking frequency of occurrence and rank abundance enables decision-making to move beyond presence-absence data, enabling more accurate monitoring of biodiversity shifts and functional diversity.</p>
	<p>Overcoming data sparsity through reference databases Improving reference libraries and open-access data infrastructure will enhance species-level identification and enrich qualitative and quantitative insights from eDNA.</p>
	<p>Discovery and mapping 'dark' biodiversity and silent extinction Deploying AI to identify unique genetic sequences from taxa yet to be discovered or fully characterised will reveal unknown biodiversity and generate the most complete inventory of life within marine parks.</p>
Scalability and cost-effectiveness	<p>Embedding eDNA into maritime operations Partnering with existing infrastructure and deploying autonomous eDNA samplers on vessels operating along routine shipping routes will enable national-scale, cost-efficient biodiversity monitoring across and around marine protected areas.</p>
	<p>AI, big data and predictive modelling Investing in data interoperability, decision frameworks, and AI-driven learning will support predictive modelling and help detect biodiversity trends, biosecurity threats, and shifts in species distributions. Combined with remote sensing and ecological models, this approach could enable real-time, ecosystem-wide predictive biodiversity assessments.</p>
	<p>Scalability through industry and service providers Involving service providers and specialised laboratories can support cost-effective standardisation, scalability and timely production of high-resolution data.</p>

The focus of this document is to explore both the opportunities and key barriers to the uptake of eDNA technologies in marine parks, while identifying scalable approaches for their deployment to strengthen the capacity of scientists and managers to monitor, understand, and predict ecosystem health.

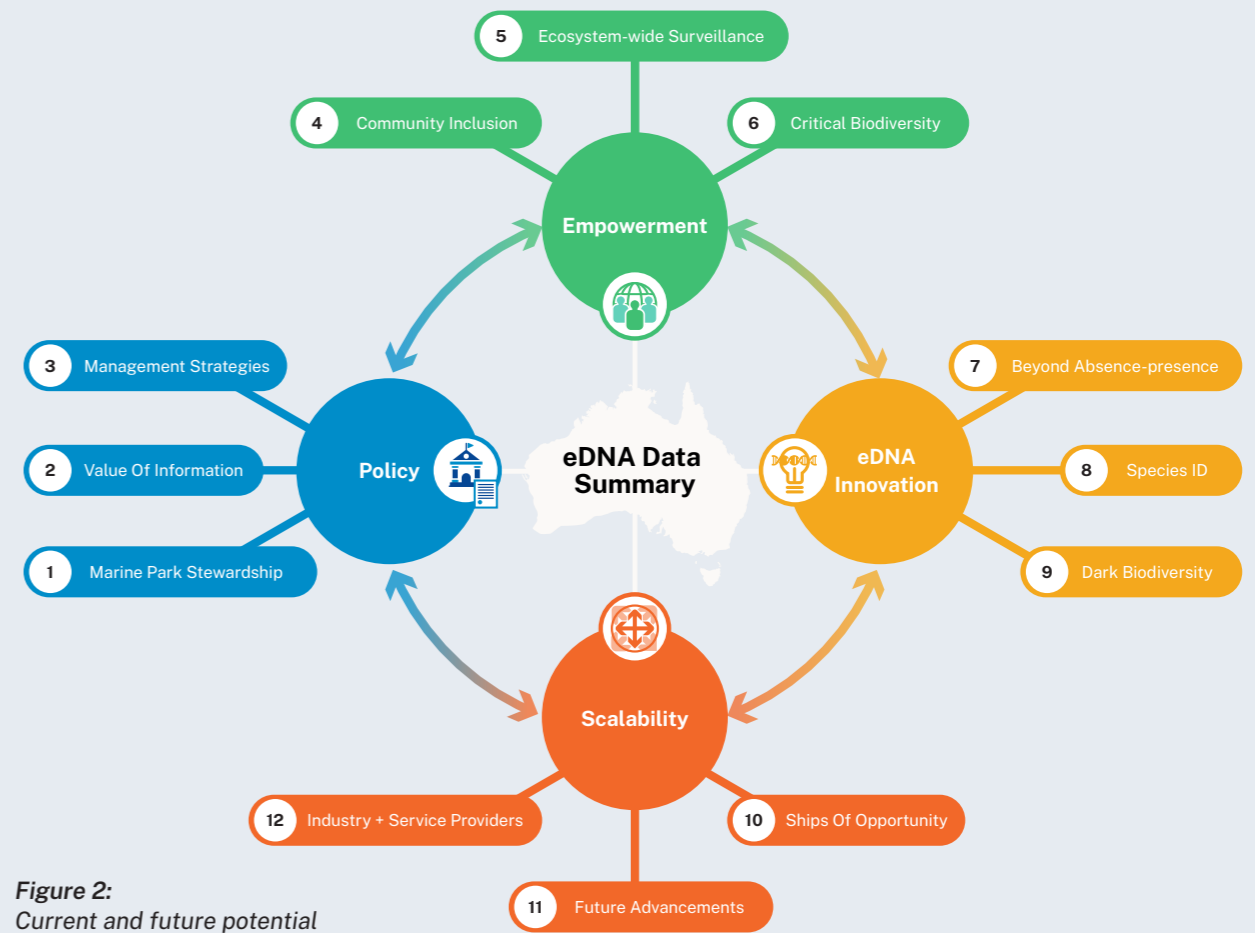


Figure 2: Current and future potential of eDNA: Vision mindmap.

To operationalize eDNA at scale there is a clear need for:

- Fostering multidisciplinary collaborations:**
Bridging expertise across genomics, ecology, policy, and management.
- Investment in capacity building and skills sharing:**
Increased resourcing to expand training, knowledge exchange, and opportunities.
- Addressing barriers to adoption:**
Strategies to address barriers and resistance to uptake to overcome scepticism and institutional inertia.
- Translating data into actionable insights:**
Clear translation of sequencing outputs into actionable insights that inform practical management decisions.

The insights from this partnership are informed by the collection of more than 6,000 eDNA samples from within and around Australian Marine Parks, alongside multi-institutional national and international workshops and expert discussions involving stakeholders from industry to community leaders.

Together, these analyses and R&D activities provide a value proposition for operationalising and integrating eDNA monitoring at scale across space and time.

The value of biodiversity data - and especially eDNA - extends well beyond biodiversity monitoring. eDNA is a tangible and powerful tool for ocean advocacy, strengthening marine ecosystem conservation, integrating Indigenous knowledge, and promoting sustainable stewardship for future generations.

Today, technological innovations in genetics, AI, acoustics, cameras, remotely operated vehicles (ROVs) and remote sensing are collectively transforming the way scientists and managers observe, understand and manage ocean environments

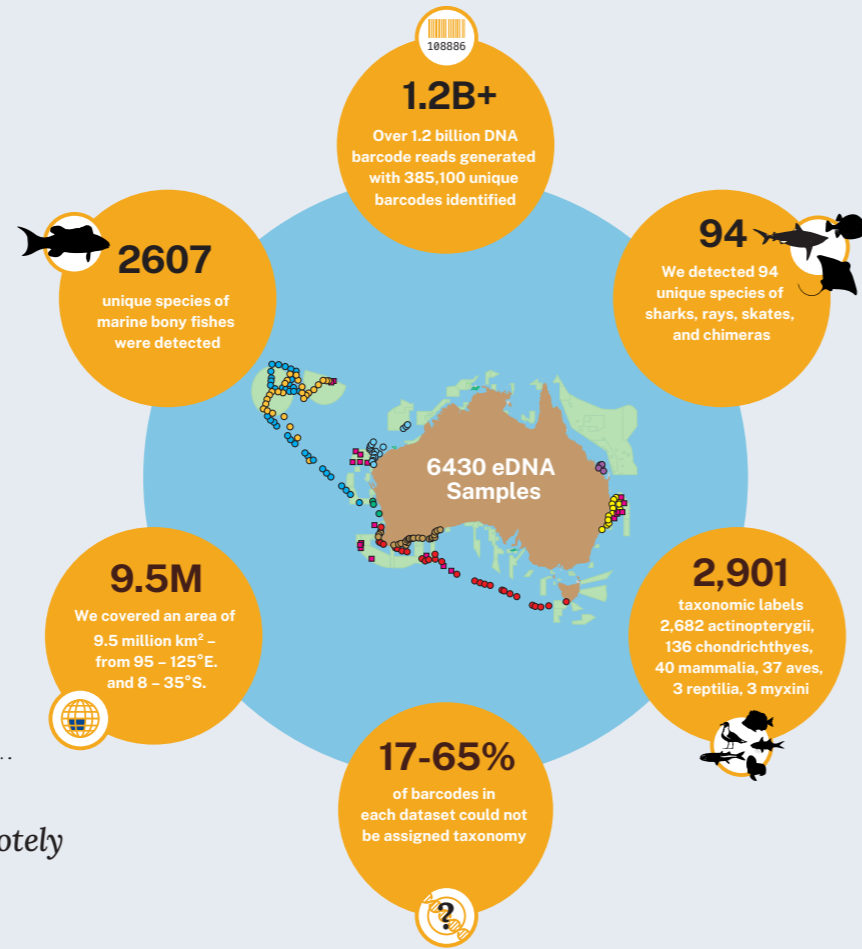


Figure 3: Four years of large-scale eDNA expeditions in Australian waters

eDNA Dashboard: listen to the ocean

The OceanOmics eDNA Dashboard enables you to explore data collected from temperate ecosystem to tropical reefs and deep-sea canyons. Use the Dashboard to see what has been in your own blue backyard, explore locations of endangered animals, and identify previously unknown species.

The Dashboard is a game-changing way to visualise data using online graphics, artificial intelligence and collected eDNA samples.

There are four ways to swim with the data: by park, by species, using AI, or exploring the unknown.

→ Explore by park

→ Explore by species

→ Chat with the data

→ Explore the unknown

DIVE IN!

marine-parks.minderoo.org/

Case Study 1: eDNA gets better with time

Robust reference sequences enable high-identity matches that reduce taxonomic ambiguity, often refining identifications from broad genus- or family-level assignments to precise species-level resolution.

A real-world example is shown below (Fig 4), where classification accuracy in detecting unique species across four mitochondrial marine vertebrate markers improved by 18.5–51.5% across the region, demonstrating how enriched reference libraries unlock deeper biodiversity insights (data from two Southwest Expeditions; 2022-2023).

To illustrate the value of these improved reference datasets, we highlight three examples: a coastal pelagic shark (*Sphyrna zygaena*; smooth hammerhead shark), a charismatic cryptic species (*Hippocampus breviceps*; knobby seahorse), and an endemic demersal fish of conservation importance (*Epinephelides armatus*; Breaksea Cod). Occurrence data for these taxa in the Ocean Biodiversity Information System (OBIS) were previously low and spatially sparse across our survey area spanning the Albany–Israelite Bay transect in Western Australia (Fig. 5). This work demonstrates how eDNA can improve species detection through updated genomic reference libraries and fill knowledge gaps in the open ocean.

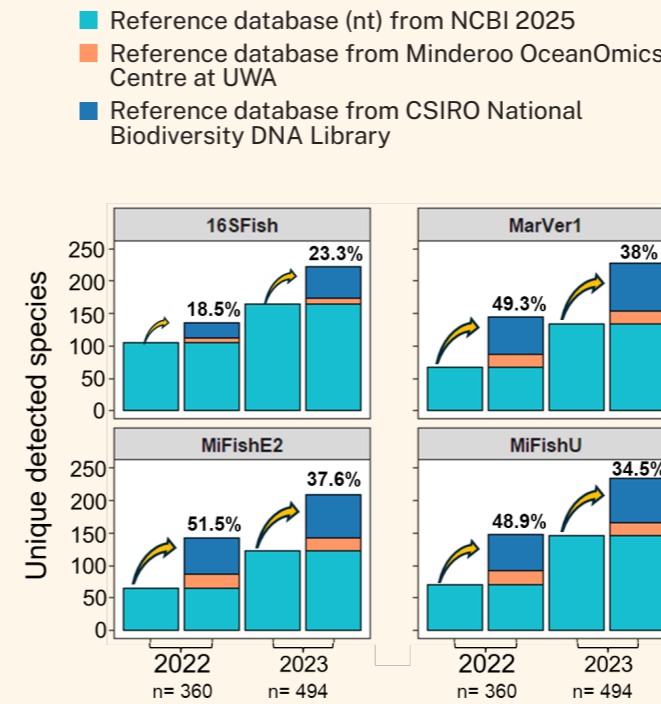


Figure 4: Increase in taxonomic coverage across three databases (see legend). The four panels show the percentage increase in uniquely detected species with the addition of the CSIRO National Biodiversity DNA Library and the Minderoo OceanOmics Centre' reference database for four mitochondrial vertebrate markers. Samples for each eDNA survey are noted on the x-axis.

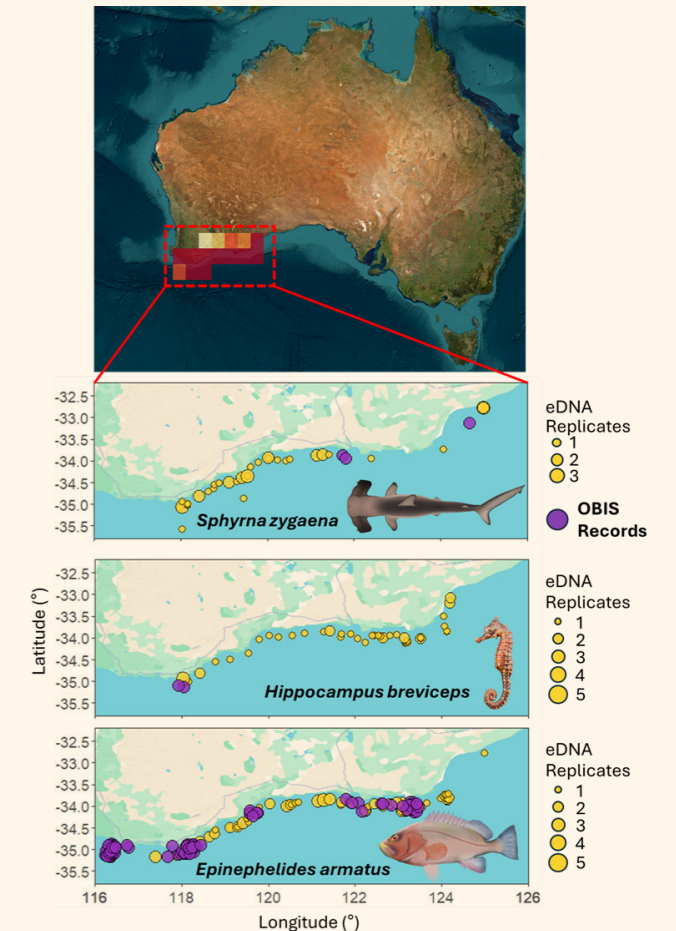


Figure 5: OBIS occurrences (purple dots) and eDNA detections (yellow dots) for a *Sphyrna zygaena* (smooth hammerhead shark), *Hippocampus breviceps* (knobby seahorse), and *Epinephelides armatus* (Breaksea Cod). Larger circles indicate higher replicate detection frequency. Images by [Marinewise.com.au](https://www.marinewise.com.au).

Removing barrier to entry

The adoption of eDNA-based monitoring has been limited by a range of technical, logistical, and institutional barriers, including incomplete reference genomic databases, uncertainty about how eDNA complements existing monitoring approaches, perceived costs, and limited access to specialised genomic and bioinformatic expertise. Significant progress is now being made to address these challenges through sustained national investment and multi-institutional collaboration, including the expansion of reference libraries and the development of taxon-independent analytical approaches that reduce reliance on complete genomic databases.

Combined with increased community-led sampling, engagement with Traditional Knowledge systems, and molecular training modules, these efforts are enabling broader participation in biodiversity monitoring and supporting the routine integration of eDNA into large-scale, evidence-based ecosystem assessment and management frameworks.

At the same time, advances in autonomous and scalable eDNA sampling technologies are reducing logistical and cost constraints by enabling integration into routine maritime operations.

Finally, the development of AI, large language models, interactive visualisation platforms, and service-based workflows are lowering technical barriers by translating complex genomic outputs into decision-ready information for non-specialists.

Case study 2: eDNA helps with IUCN Red List assessments

CRITICAL BIODIVERSITY

The IUCN Red List of Threatened Species is a critical global indicator of biodiversity health and a key tool for guiding conservation action and policy.

eDNA-derived data has strong potential to strengthen Red List assessments by providing accurate, frequent, and spatially extensive biodiversity information to refine species evaluations.

By improving detection and occurrence records for species that are difficult to survey using conventional methods, including cryptic, rare, and deep-sea taxa, eDNA can enhance species distribution models, support the reassessment of Data Deficient species, and improve extinction risk evaluations. Its scalability across large spatial areas and repeated time points, combined with relatively simple field deployment, enables biodiversity data to be collected more consistently and comprehensively than many traditional marine survey approaches.

For the IUCN Red List, eDNA can complement existing data sources, address critical data gaps, and strengthen the evidentiary basis of species assessments. As biodiversity datasets increase in volume and complexity, interpreting eDNA and other genomic data can present barriers for non-specialists. Developing accessible analytical and decision-support tools is therefore essential to enable broader uptake within conservation assessment frameworks.

User-friendly platforms that integrate eDNA with environmental, spatial, and risk-based information can translate complex genomic outputs into actionable insights, supporting more consistent and informed use of eDNA-derived evidence in IUCN Red List assessments.

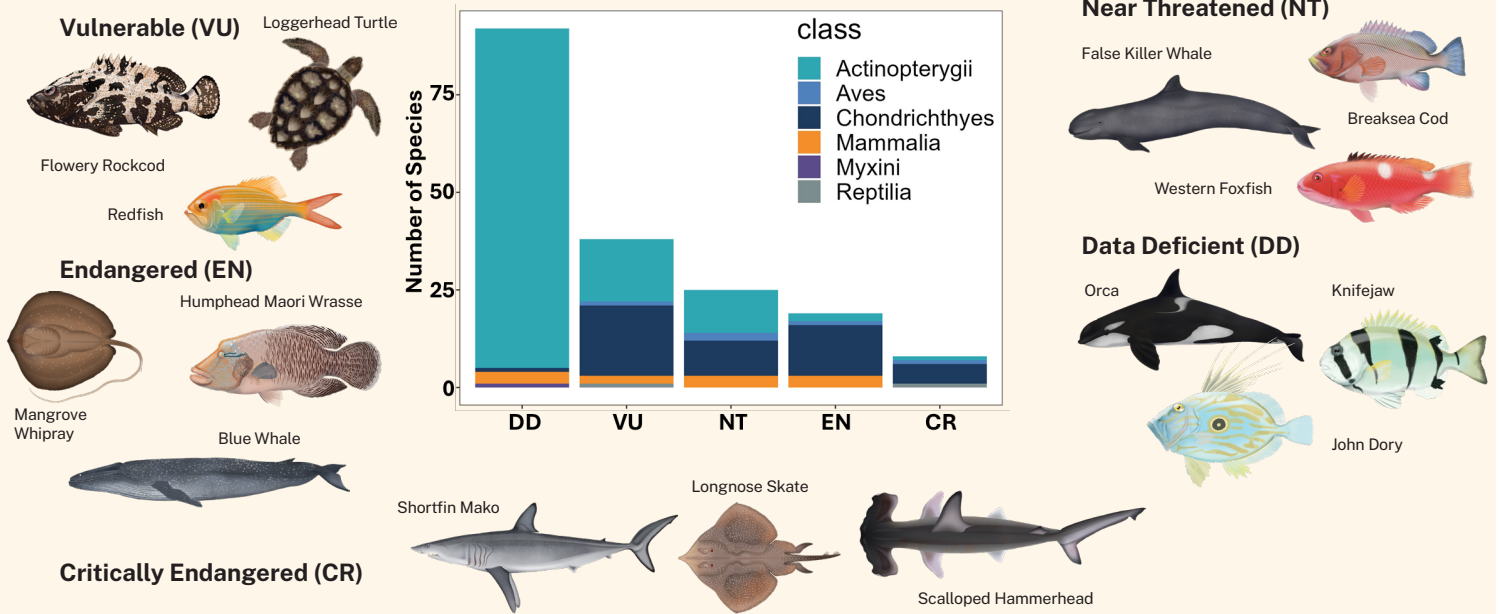


Figure 6: Species detected in the 4,499 eDNA samples collected in collaboration between Parks Australia and Minderoo, that are listed on the IUCN Red List of Threatened Species. Images by Marinewise.com.au.

eDNA data generated through the ODR project was actively integrated into a recent assessment of 542 Australasian fish species, conducted in collaboration with the IUCN, Minderoo Foundation, and specialist ichthyology assessors. An interactive dashboard was also trialed, enabling assessors without genomic expertise to explore and interpret eDNA-derived evidence alongside conventional data sources.

Red Velvetfish (*Gnathanacanthus goetzeei*) is an Australian endemic associated with rocky reefs and kelp habitats. The species is listed as Endangered following an estimated population decline of more than 70%, driven by kelp loss and ocean warming. eDNA detections informed the western extent of the species' known range and were incorporated into distribution mapping used to support conservation planning. Image by Marinewise.com.au.

