

Advancing Environmental DNA Applications for Marine Biodiversity Conservation and Ecosystem Management

An Emerging Area Advanced by the Sub-Commission

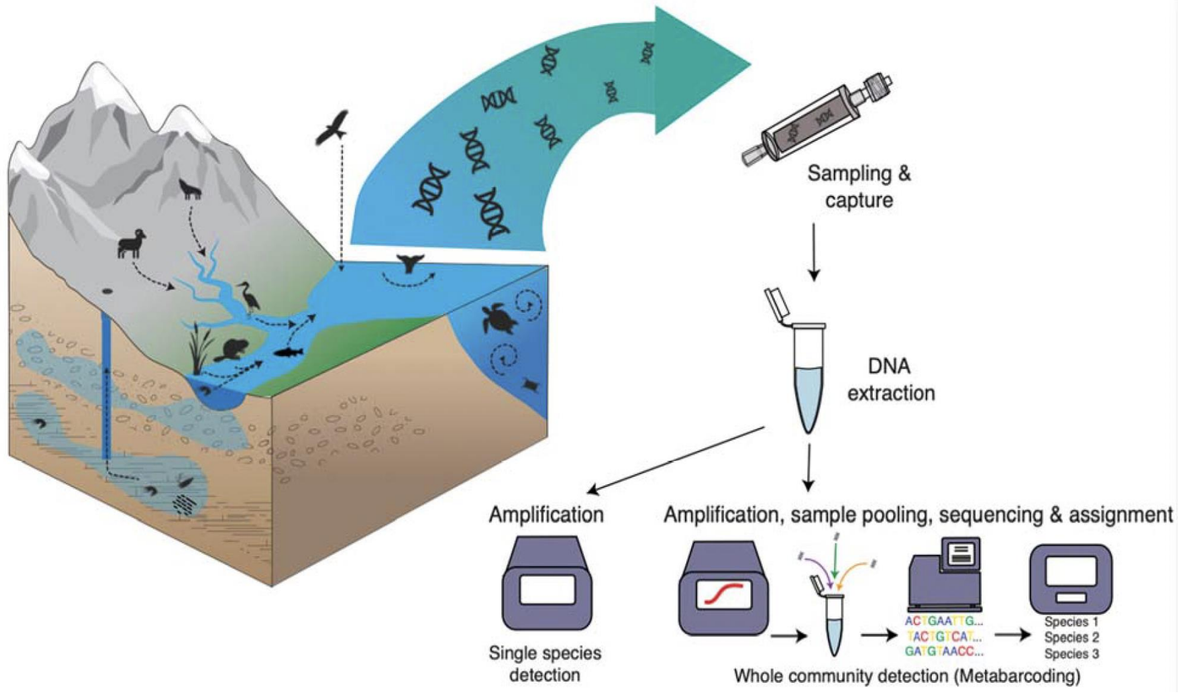
Wenxi Zhu, Xiaowei Zhang, and all partners and colleagues
IOC Sub-Commission for the Western Pacific, IOC/UNESCO

Sixteenth Intergovernmental Session of the
IOC Sub-Commission for the Western Pacific (WESTPAC-XVI)
Hangzhou, China, 10-12 November 2026

The Science of Environmental DNA

Environmental DNA (eDNA) refers to genetic material obtained directly from environmental samples (such as water, soil, sediment, air, or snow) without prior isolation of the target organisms.

eDNA metabarcoding approach ---Untargeted analysis



PCR based eDNA detection ---targeted analysis



USA: NATIONAL AQUATIC ENVIRONMENTAL DNA STRATEGY

The White House released the National Aquatic eDNA Strategy in June 2024, calling for the **development of eDNA infrastructure** and the advancement of **coordinated aquatic eDNA observations** across multiple stakeholders.

NATIONAL AQUATIC ENVIRONMENTAL DNA STRATEGY

A Report by the

eDNA TASK TEAM *of the*

INTERAGENCY WORKING GROUP ON BIODIVERSITY *of the*

SUBCOMMITTEE ON OCEAN SCIENCE AND TECHNOLOGY

COMMITTEE ON ENVIRONMENT

of the

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

June 2024

BOX 1: What is eDNA?

Environmental DNA (eDNA) is genetic material found in the environment. Biodiversity can be examined through traces of eDNA found in environmental samples. For example, marine and freshwater samples contain eDNA from many types of organisms – ranging from the smallest microbes to the largest mammals.

Aquatic applications are many, including:

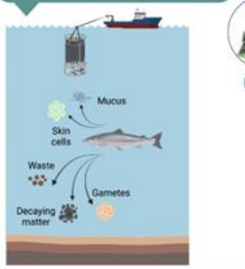
- Detection of invasive or endangered species;
- Surveillance of harmful algae and other microbes;
- Evaluation of environmental impacts and restoration efficacy;
- Fisheries assessments;
- Biodiversity monitoring;
- Ocean exploration.

Strengths of aquatic eDNA biomonitoring:

- Ease of sampling with minimal environmental impact and ability to collect samples remotely.
- Detection of broad diversity of species from a single environmental sample - "microbes to mammals" approach.
- Improved detection of rare and hard-to-identify (cryptic) species.
- Standardized taxonomic analyses minimize bias and increase data comparability.
- Cost-effective way to execute large scale observations for an increasing number of applications.

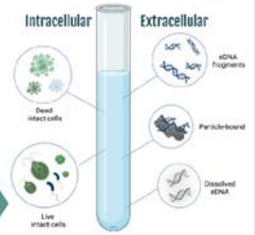
Image Credits: Susanna Theroux. Images created with biorender.com; https://www.sccwrp.org/about/research-areas/bioassessment/dna-barcoding/edna-101/

Genetic material (DNA) from aquatic life can be found in all environments, including fresh and saltwater.



Typical eDNA workflows involve sample collection, filtration and preservation, DNA extraction, and analysis for species identification or quantification.





eDNA can persist for hours to weeks, depending on environmental processes and its state.

- 4 -

BOX 5: Commercial Fisheries Applications

Challenge:

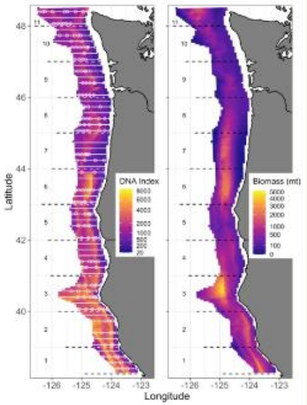
The Magnuson-Stevens Act requires information about fish and fisheries on a vast spatial scale. However, survey vessels are expensive to operate, and current methods struggle to capture broad biodiversity and are often invasive. These limitations hinder routine stock assessments and the ability to respond to emergent events within the more than 4.3 million square miles of the U.S. exclusive economic zone.

Solution:

Water samples contain eDNA, including genetic traces of fish, mammals, invertebrates, and other species. For some applications, analyzing eDNA can add to high-confidence indices of abundance for fish species, and add value by mapping other species of interest, such as marine birds and mammals, harmful algae, or invasive species.



Graphic Credit: NOAA



A comparison of hake abundance from a NOAA fisheries survey based on eDNA (left) and acoustic profiles (right).

Graphic Credit: Shelton et al. 2022, https://doi.org/10.1098/rspb.2021.2613

The Royal Society: eDNA policy explainer



Current and Emerging Application of eDNA

FIGURE 1

A summary of the current and emerging policy-relevant applications of eDNA

CURRENT AND EMERGING eDNA APPLICATIONS

Biodiversity	Crime and forensic science	Health and disease	Ancient eDNA	Pollution	Bioterror and defence
Identify the presence or absence of a range of species in an environment. Understand the relative abundance of different species. Detect changes in species and community composition over time. Provide insights into species functions and trophic interactions.	Provide forensic evidence. Link suspects to crime scenes. Trace the provenance of illegal goods, including the illegal wildlife trade.	Detect and monitor pathogens in wastewater. Act as an early warning signal to allow rapid response to outbreaks. Understand disease transmission. Provide food safety and provenance information.	Reconstruct past ecological communities. Investigate the impact of past environmental change on ecosystems – to inform future predictions. Understand trends in species distribution and biodiversity over time.	Assess microbial communities as a proxy for levels of pollution in the environment. Study the link between pollutant exposure and ecological responses. Assess biological allergens such as pollen.	Act as an early warning signal for bioterror threats. Act as early warning signal for crop pests and diseases. Detect invasive species.

Portable Technologies

FIGURE 9

Examples of portable eDNA technologies

Oxford Nanopore MinION
All Oxford Nanopore sequencing devices use flow cells which contain an array of tiny holes – nanopores – embedded in an electro-resistant membrane. Each nanopore corresponds to its own electrode connected to a channel and sensor chip, which measures the electric current that flows through the nanopore. When a molecule passes through a nanopore, the current is disrupted to produce a characteristic 'squiggle'. The squiggle is then decoded using basecalling algorithms to determine the DNA or RNA sequence in real time.





Image: © Oxford Nanopore Technologies, 2025.

Smith-Root eDNA sampler
A Smith-Root eDNA sampler is a portable, backpack-mounted system designed to collect eDNA from water. Using a computer-controlled pump to draw water through a specialized filter cartridge, this captures trace amounts of DNA shed by organisms present in the water, allowing for analysis of species composition in a given area without directly capturing the organisms themselves. It features onboard data logging, GPS geotagging, and customizable settings for sample volume and flow rate, ensuring consistent and accurate eDNA collection in field settings.

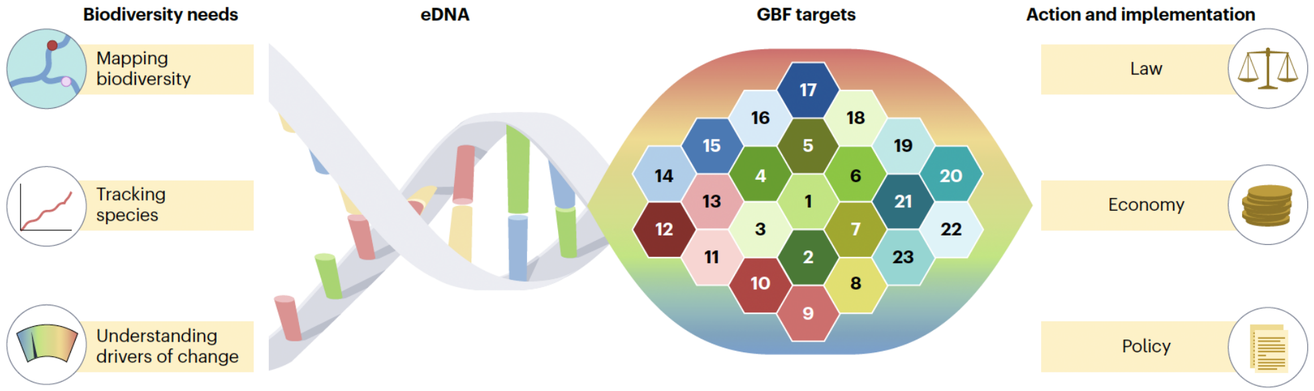




Image: © Smith-Root.

Utilizing aquatic eDNA to address global biodiversity targets

a **eDNA can inform and support progress towards GBF targets**

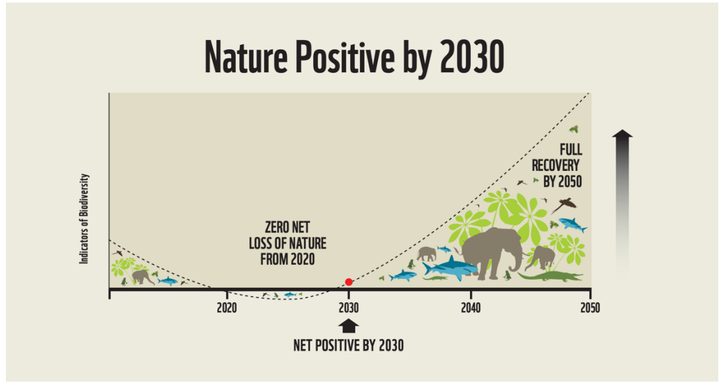


b **Example contributions of eDNA to GBF targets**

GBF target		eDNA contributions
1	Plan and manage all areas to reduce biodiversity loss	Monitor and assess species richness to identify biodiversity hotspots and target species occurrences
2	Restore 30% of all degraded ecosystems	Evaluate pre and post restoration effectively
3	Conserve 30% of land, waters and seas	Effective single species gene flow assessment; effective population size estimates; eDNA derived beta-diversity and community dynamics

GBF target		eDNA contributions
6	Reduce the introduction of invasive alien species by 50% and minimize their impact	Single species assays for early detection to prevent invasive species spread
7	Reduce pollution to levels that are not harmful to biodiversity	Nuanced pollution indicators derived from eDNA data
14	Integrate biodiversity in decision-making at every level	Informed decision making from effective biomonitoring with highly resolved spatial and temporal eDNA





Nature Reviews Biodiversity Altermatt F, Zhang X et Al., 2025

From DNA Barcoding to Environmental DNA

Evolution of the Sub-Commission's regional efforts in marine biodiversity research and monitoring



DRMREEF-I inception
Bangkok, 5-6, August 2013



DRMREEF-II inception
Qingdao, 1-2 Dec 2016



DRMREEF-II wrap-up
Seoul, 20-21 Jan 2018



DRMREEF-III Reception
Nha Trang, 24-25 Oct 2019





Second regional eDNA training workshop
in Chonburi, 22-24 June 2026



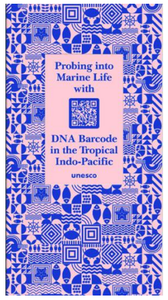
Training Course on DNA barcoding
Nha Trang, 20-21 April 2014



Molecular Taxonomy training
RTRC-MarBEST, Jakarta, 25 Sep- 5 Oct 2017







DNA barcode publications, 2021- 2022



First regional eDNA training workshop
in Phuket, 27-29 Nov 2023

2013

DRMREEF launched

WESTPAC project on DNA taxonomy and coral reef recruitment monitoring

2013–2018

DNA barcoding capacity

Successive project phases: scientific networks, species identification and reference information

2019-2022

Outputs and Transition toward eDNA

2023

Advancing eDNA applications

Strategic direction: From molecular species identification → biodiversity monitoring → evidence-based conservation and ecosystem management

First eDNA Workshop and Polit study

First Training Workshop on Monitoring Marine Fish Communities with Environmental DNA Method, 27-29 November 2023, Phuket Marine Biological Center, in partnership with the Institute for Marine and Coastal Resources Research and Development (Thailand), and Nanjing University (China)

Schedule

11.27 **Day 1**

eDNA training

- Principle of technology
- Progress
- Case study

11.28 **Day 2**

field eDNA sampling

- Capsule eDNA sampling
- Underwater sampling
- Coral reef sampling

11.29 **Day 3**

eDNA presentation

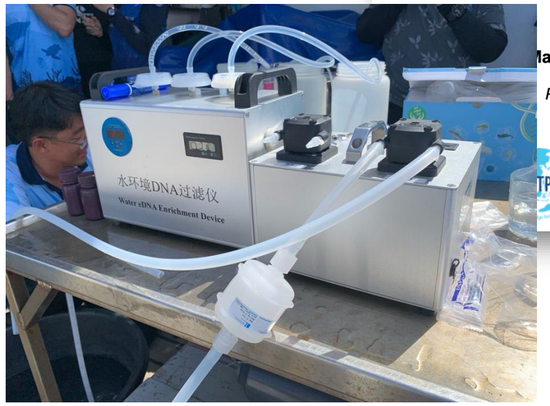
- Bangladesh
- Malaysia
- Vietnam
- Thailand
- China

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
COMMISSION OCÉANOGRAPHIQUE INTERGOUVERNEMENTALE
COMISIÓN OCEANOGRÁFICA INTERGUBERNAMENTAL
МЕЖПРАВИТЕЛЬСТВЕННАЯ ОКЕАНОГРАФИЧЕСКАЯ КОМИССИЯ
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政府间海洋学委员会

UNESCO

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Demonstration of eDNA Capacity

- Three methods: Standardized eDNA supply, capsule eDNA sampler, professional underwater sampling instrument

① Standard eDNA sampler



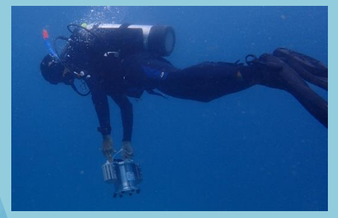
Surface water
3-10 L
15 min

② Large volume sampler (capsule)



Surface water
50-100 L
150 min

③ Underwater sampler



Coral reef water
3-10 L
5-15 min

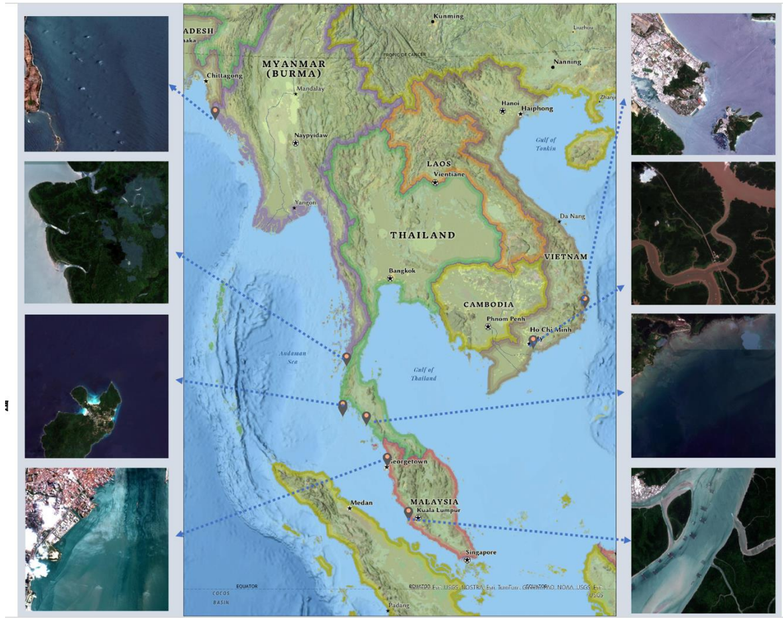
Capsule eDNA sampler

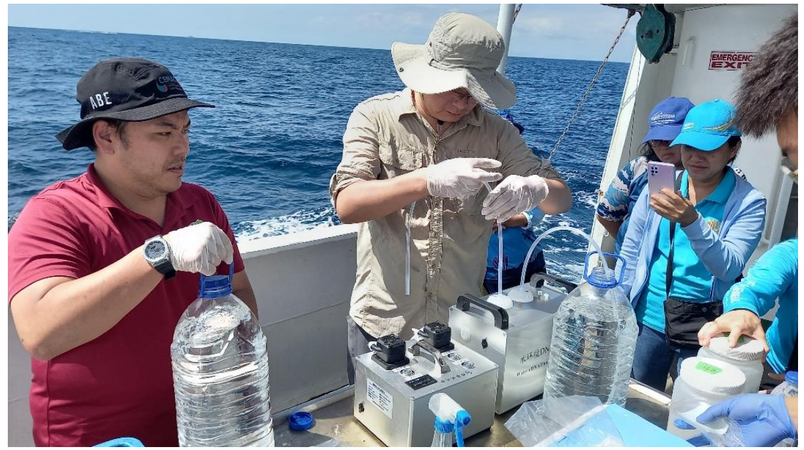


③ Underwater instrument



Bottom water
50-100 L
8-12 hours





Second eDNA Workshop and Polit study

Second Training Workshop on Environmental DNA (eDNA) Applications in Marine Biodiversity Monitoring and Assessment, 22-24 June 2026, Chonburi Thailand, in partnership with the Department of Marine and Coastal Resources (Thailand), Mahidol University (Thailand), Kasetsart University (Thailand), Yunnan University (China), and Nanjing University (China)

















4. Anticipated activities and outputs in 2027

IOC WESTPAC 2027
MANILA, PHILIPPINES

HOME | ABOUT | PARTICIPATION | ABSTRACT SUBMISSION | PROGRAMME | LOGISTIC INFORMATION

12th WESTPAC International Marine Science Conference & 3rd UN Ocean Decade Regional Conference

From Knowledge to Action: Connecting Science, Policy, and Society for a Resilient Western Pacific

Manila, Philippines 20–23 April 2027

B7 **ADVANCING ENVIRONMENTAL DNA (EDNA) TECHNOLOGY FOR AQUATIC BIODIVERSITY MONITORING AND CONSERVATION** SUB-THEME B

Xiaowei Zhang, Yan Zhang, Itchika Sivaipram, Imane Sioud, Youn-Ho Lee

HIDE DETAILS

CONVENERS

Xiaowei Zhang
Yunnan University, China

Yan Zhang
Nanjing University, China

Itchika Sivaipram
Chulalongkorn University, Thailand

Imane Sioud
Tohoku University, Japan

Youn-Ho Lee
Korea Institute of Ocean Science and Technology

SESSION DESCRIPTION

Aquatic ecosystems support biodiversity, livelihoods, and economies, yet face growing pressures from human activities and climate change. Effective conservation requires robust biodiversity information, but conventional monitoring methods are often difficult to implement at large scales. Environmental DNA (eDNA) metabarcoding is emerging as a powerful, cost-effective, and low-impact tool for monitoring biodiversity across marine, coastal, and freshwater ecosystems.

This session aims to share advances, applications, and future perspectives on eDNA-based biodiversity observation. Discussions will explore scientific and technological developments, include autonomous sampling platforms, AI-based noise reduction, and portable sequencing, as well as practical challenges related to standardization, data comparability, and long-term monitoring. The session will also examine opportunities for international collaboration in the region, and highlight how eDNA- approaches can strengthen biodiversity knowledge and support evidence-based conservation and ecosystem management, including fisheries management, invasive species detection, and MPA evaluation.





WESTPAC-XVI, 10-12 November 2026, Hangzhou, China

5. Biennial Workplan for 2028-2029

- Detailed outline of planned activities, and deliverables for the next intersessional period

No.	Activity / Output Description	Expected Result / Output	Y1-1st H	Y1-2nd H	Y2-1st H	Y2-2nd H	IOC RP Budget (USD)	XB Required (USD)	Lead Responsibility
HLO 1 — HEALTHY OCEAN AND SUSTAINED OCEAN ECOSYSTEM SERVICES									
Expected Result 1.1 (Sub-obj. 1.1): Regional ocean biodiversity and ecosystem observations and FAIR data strengthened									
1.1.1	Develop and enhance technical capacity of Member States for eDNA based marine biodiversity monitoring and assessment	Strengthened regional technical capacity and expertise	□ Y	Y	Y	Y	20000	40000	
1.1.2									
Expected Result 1.2 (Sub-obj. 1.2 + 1.3): Scientific knowledge for ecosystem management developed and ecosystem-based management applied									
1.2.1	Advance eDNA applications in marine biodiversity conservation and ecosystem management	Pilot applications demonstrating the value of eDNA for biodiversity assessment.	y	Y	Y	Y	20000	40000	
1.2.2									

5. Biennial Workplan for 2028-2029

- Detailed outline of planned activities, and deliverables for the next intersessional period

No.	Activity / Output Description	Expected Result / Output	Y1-1st H	Y1-2nd H	Y2-1st H	Y2-2nd H	IOC RP Budget (USD)	XB Required (USD)	Lead Responsibility
HLO 5 — FORESIGHT ON EMERGING OCEAN SCIENCE ISSUES									
Expected Result 5.1 (Sub-obj. 5.1+5.2): Regional foresight capacity on emerging ocean science issues strengthened and communicated									
5.1.1									
5.1.2									
Expected Result 5.2 (Sub-obj. 5.2+5.3): Emerging ocean science issues integrated into regional governance and decision-making									
5.2.1									
5.2.2									