Shining a light on invisible biodiversity

Based on technology that has been in use for over twenty years, the study of DNA fragments left behind by organisms in the environment is undergoing unprecedented development thanks to a revolution on two fronts - microelectronic and digital.

Damselfish and coral, New Caledonia.

Anyone who has ever seen a detective show knows: we leave traces of DNA behind us. Not only is it useful for cracking cases, but it can also help when studying marine ecology. Because, just like criminals, aquatic organisms release fragments of DNA into the environment. This genetic material, known as environmental DNA (eDNA), can be recovered from the water and analysed by scientists to get an idea of marine biodiversity - at least in theory.

In reality, this "soup" contains mainly the eDNA of the most abundant species, such as microscopic plankton. Finding rarer species, such as fish, dugongs or sharks, is like looking for needles in a haystack. But advances in microelectronics (miniature sensors built into sequencers) paired with developments in digital technology (bioinformatics and artificial intelligence) have changed the game.

It is now possible to very quickly detect species that were previously difficult to observe using traditional approaches (diving, video), either because they are rare or because they cannot be distinguished from other species with the naked eye. While much remains to be done, including identifying the DNA of thousands of marine species, this genetic revolution opens up a whole range of applications, particularly for ecosystem managers.

"In an area with one of the greatest degrees of biodiversity on the planet, environmental DNA technology represents a way forward for the study, conservation and management of our maritime space. This work by IRD is essential both for the management of our reefs, which are listed as a World Heritage Site by the United Nations Educational, Scientific and Cultural Organisation (UNESCO), and for the development of tools to rapidly detect species of interest such as sharks."

Emmanuel Coutures, Sustainable Territorial Development, Southern Province of New Caledonia, France

••• Studying environmental DNA is now making it possible to detect previously invisible species and get a better idea of an ecosystem's biodiversity •••

© IRD/K. Bussone

Taking marine surface samples for analysis, New Caledonia.

Studies carried out in New Caledonia have shown that this approach can detect 44% more shark species than traditional methods. Continuous analysis of eDNA in the lagoon's water could be used to create a brand new surveillance system capable of detecting the presence of sharks in a matter of hours. Clearly, this would reduce the risk of attacks.

eDNA analysis has also made it possible to compare the ecological diversity of seamounts, depending on their depth. Scientists have shown that the shallowest of these (50-100 m) are home to a high number of large predatory fish species, which are threatened by human activity everywhere else. It is therefore vital to protect these refuge ecosystems.

PARTNERS

Government of New Caledonia, France

Southern, Loyalty Islands and Northern Provinces, New Caledonia, France

New Caledonian Biodiversity Agency, France

Ginger-SOPRONER, New Caledonia, France

Bluecham, New Caledonia, France

OUR SHARED OCEAN

Science in the Global South for a Sustainable World

IRD Éditions
Collection Grands enjeux
Marseille, 2025

Editorial management
Marie-Lise Sabrié

Editorial coordination
Corinne Lavagne
Jasmine Portal-Cabanel

Iconographic research
Daina Rechner

Written by
Viviane Thivent
Marie-Lise Sabrié

Design and page layout
Charlotte Devanz

Traduction
Fluent Planet

Proofreading
Anne Causse

Distribution coordination
Christel Bec

Cover photo
Children fishing on a reef flat in Reao, French Polynesia. © IRD/S. Andréfouët

ISBN Papier: 978-2-7099-3070-3
ISBN PDF: 978-2-7099-3071-0
ISBN Open/epub: 978-2-7099-3072-7

LIST OF SCIENTIFIC CONTRIBUTORS

Evolving environments

El Niño in the spotlight
Jérôme Vialard, physical oceanographer and climatologist, UMR LOCEAN

PIRATA, the observatory in the Tropical Atlantic
Bernard Bourlès, physical oceanographer, UAR IMAGO

Extreme waves and tropical cyclones
Christophe Menkes, climatologist, UMR ENTROPIE
Jérôme Lefèvre, ecologist, UMR ENTROPIE

The variability of upwellings
Vincent Échevin, physical oceanographer, UMR LOCEAN

Mapping the tsunami hazard
Mansour Ioualalen, physicist, UMR Géoazur

Understanding the complexity of Southeast Asia's climate
Marine Herrmann, physical oceanographer, UMR LEGOS

The unsuspected variability of lagoons
Thomas Stieglitz, coastal ecohydrologist, UMR CEREGE

Resilient Mexican mangroves
Johanna Jupin, Geochemist, UMR LOCEAN

An oasis in an ocean desert
Sophie Bonnet, oceanographer and biogeochemist, UMR MIO
Cécile Guieu, biogeochemist, UMR LOV

Resilient coral in New Caledonia
Riccardo Rodolfo-Metalpa, ecophysiologist, UMR ENTROPIE

Sargassum taking over
Julien Jouanno, physical oceanographer, UMR LEGOS

Soot in the water
Xavier Mari, oceanographer and biogeochemist, UMR MIO
Marc Tedetti, oceanographer and biogeochemist, UMR MIO

Plastics: from the rivers to the ocean
Lisa Weiss, physical oceanographer, UMR LEGOS, UMR LOPS

The fate of river water in the ocean
Nadia Ayoub, physical oceanographer, UMR LEGOS

On the trail of ocean plastic
Christophe Maes, physical oceanographer, UMR LOPS

Our friends from the deep
Leandro Nole-Eduardo, ecologist, UMR MARBEC

From micronekton to tuna

Christophe Menkès, climatologist, UMR ENTROPIE
Anne Lebourges-Dhaussy, ecosystem acoustician, UMR LEMAR

The end of the reign of the anchovy?

Arnaud Bertrand, ecologist, UMR MARBEC

Societies facing the ocean

Senegal: the emergence of a resilient fishing industry

Ndickou Gaye, geographer, Cheikh Anta Diop University, Dakar and UMI SOURCE

The future of the Vezo

Francis Veriza, geographer, University of Toliara and UMR Passages

Alexandria, how not to adapt?

Sylvie Fanchette, geographer, UMR CESSMA

Is the sinking of the Mekong Delta inevitable?

Nicolas Gratiot, geophysicist, UMR IGE

Reducing vulnerability in the city of Douala

Raphaël Onguene, physical oceanographer, University of Douala

Food security in Polynesia

Marianna Cavallo, ecologist, UMR LEMAR

The role of women in fishing

Ariadna Burgos, ethnoecologist, UMR PALOC

Nokoué, a lagoon under pressure

Alexis Chaigneau, physical oceanographer, UMR LEGOS
Yves Morel, physical oceanographer, UMR LEGOS
Victor Okpeitcha, physical oceanographer, Prodata SARL
Zacharie Sohou, oceanographer, fisherman and biologist, IRHOB and UAC
Thomas Stieglitz, coastal ecohydrologist, UMR CEREGE

Towards sustainable resources

A plankton model

Olivier Maury, oceanologist, UMR MARBEC

Tropical tuna under surveillance

Daniel Gaertner, biologist, UMR MARBEC

Towards more sustainable baits

Pascal Bach, ecologist, UMR MARBEC

The birds' share
Philippe Cury, oceanographer and biologist, UMR MARBEC

Artisanal fishing on an industrial level
Arnaud Bertrand, ecologist, UMR MARBEC

Food biodiversity
Fany Sardenne, ecologist, UMR LEMAR

Aquaculture for better nutrition
Maria Darias, biologist, UMR MARBEC

Gathering data by sailboat
Éric Machu, biogeochemist, UMR LEGOS

Swimming over underwater habitats
Rodolphe Devillers, geographer, UMR Espace-Dev
Priscilla Dupont, biologist, UMR Espace-Dev

Shining a light on invisible biodiversity
Laurent Vigliola, ecologist, UMR ENTROPIE

Using artificial intelligence to measure biodiversity
Laurent Vigliola, ecologist, UMR ENTROPIE

The AI that thought it was a seabird
Sophie Lanco, ecologist, UMR MARBEC

Bacteria on the back of plastic
Thierry Bouvier, ecologist, UMR MARBEC

Towards home-made electricity?
Pierre-Pol Liebgott, biochemist and ecologist, UMR MIO

The Comoros in need of sand
Gilbert David, geographer, UMR Espace-Dev
Nourddine Mirhani, geographer, University of Comoros

Let the mangroves grow back on their own
Marie-Christine Cormier-Salem, geographer, UMR PALOC

Shared knowledge

The sound of silence
Timothée Brochier, ocean modeller, UMI UMMISCO
Nicolas Puig, anthropologist, UMR Urmis

Changing our approach to corals
Pascale Chabanet, ecologist, UMR ENTROPIE
Lola Massé, biologist, UMR ENTROPIE

Changing estuary water flows
Stéphanie Duvail, geographer, UMR PALOC

Draw me the sea
Élodie Fache, anthropologist, UMR SENS
Stéphanie Carrière, ethnoecologist, UMR SENS,
Catherine Sabinot, anthropologist, UMR Espace-Dev

Towards a sustainable mangrove crab industry in Madagascar
Jennifer Beckensteiner, fisheries expert, UMR AMURE
Marc Léopold, economist, UMR AMURE, UMR ENTROPIE

Managing milky waters
François Colas, physical oceanographer, UMR LOPS
Jonathan Flye-Sainte-Marie, ecologist, UMR LEMAR
Alice Pietri, physical oceanographer, UMR LOCEAN

Marine heatwave alert
Sophie Cravatte, physical oceanographer, UMR LEGOS

A little-known but coveted deep-sea
Valelia Muni Toke, anthropologist, UMR SeDyl
Puerre-Yves Le Meur, anthropologist, UMR Sens

Towards a new ocean governance

The Seychelles: towards a truly sustainable blue economy?
Patrice Guillotreau, economist, UMR MARBEC

Regulations based on local realities
Catherine Sabinot, anthropologist, UMR Espace-Dev
Marc Léopold, economist, UMR AMURE, UMR ENTROPIE

The Mediterranean Sea as a legal entity
Victor David, environmental lawyer, UMR IMBE

Gabon proactive in protecting biodiversity
François Le Loc'h, ecologist, UMR LEMAR

Making assessments for more effective steering
Adrien Comte, economist, UMR LEMAR

AI at the service of marine environmental law
Marie Bonnin, environmental lawyer, UMR LEMAR

Protecting marine areas more effectively
Tarik Dahou, socioanthropologist, UMR PALOC

When science emancipates people
Latifa Pelage, ecologist, UMR MARBEC