

The variability of upwellings

Upwelling systems are areas where cold, nutrient-rich water rises, which contains high numbers of fish and is important for fisheries. But their productivity varies from year to year. Where do these fluctuations come from?



Fishing off the coast of Peru.

© IRD/A. Bertrand

PARTNERS

Marine Institute of Peru

Cheikh Anta Diop University, Dakar, Senegal

Assane Seck University, Ziguinchor, Senegal

Of all the upwellings, the one off the coast of Peru is the most productive by far - it alone accounts for 5-6% of the world's fishing. However, this cornucopia sometimes dries up completely, as in 1972, causing the sudden collapse of an entire economic sector.

Such abrupt changes have led research teams to question the upwelling's local and global mechanics. It appears that the driving force is not located in the depths of the ocean - rather, the winds and Coriolis force push surface waters out to sea like a conveyor belt, causing the nutrient-rich waters beneath to rise... very slowly.

... Scientists have sought to gain a better understanding of the complex mechanics of upwellings in order to anticipate fluctuations in fishing productivity ...

This is the key to the zone's extreme productivity. Because in these calm, nutrient-rich, well-lit waters, phytoplankton flourish and, with them, so does the entire food chain. However, in some years during the El Niño phenomenon, the machine breaks down and the deep waters no longer rise. A layer of water from the Equatorial Zone, warm and low in nutrients and plankton, then accumulates on the surface, stopping photosynthesis and driving away the fish.

Conversely, when the upwelling is in full swing, so much organic matter is produced that some of it (dead organisms, faecal pellets, etc.) sinks and is consumed by ocean bacteria, which breathe and consume the ambient oxygen. This creates a deep layer of water with very low oxygen content which, in certain cases, due to an ocean wave from the north, can rise and destroy the entire ecosystem in one go.



© IRD/Ifrémer/O. Dugornay

Collecting oceanographic data during the intense upwelling season, Senegal.

The way in which upwelling zones are stirred up by winds and waves therefore influences their productivity. This complex mechanism could be at work in other parts of the world, such as in West Africa, along the coast of Senegal, and in South Africa. What will happen to it in the context of climate change? In the 1990s, measurements suggested that wind speeds would increase, speeding up the engine and therefore the productivity of upwellings. But more recent research shows that this trend is only true for high latitudes. In regions close to the tropics, this would not be the case, which could ultimately lead to a drop in the productivity of upwellings in Peru and Senegal.

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

This open-access publication is available to the public under the terms of the Creative Commons CC BY-NC-ND 4.0 license, which can be viewed at <https://creativecommons.org/licenses/by-nc-nd/4.0/deed.fr>. It authorizes any dissemination of the original work in its entirety, provided that the authors and publishers are mentioned and that a link to the CC By-NC-ND 4.0 license is included. No modification or commercial use is allowed.



© IRD, 2025

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 Lanço, 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 Beekensteiner, 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