

# Biodiversity in the Marine Environment



**Photo 1.** Shrimp fisheries in French Guiana. (© Ifremer, Chaloupe Project, Fabian Blanchard)

Philippe Gouletquer • Philippe Gros  
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# Biodiversity in the Marine Environment

Translated by Janet Heard-Carnot



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# Foreword

Oceans and seas cover more than 70% of the Earth and hold extraordinarily rich biodiversity, right down to great depths where abundant life forms thrive near ocean ridges. But marine biodiversity remains poorly known and faces numerous threats. Endangered by ever-increasing pressures from human activities, it is also sensitive to climate-based disturbances, in particular their consequences on ocean acidification.

Therefore, we must learn more about marine biodiversity and protect it. It is truly essential in ecosystem function and provides people with a vast number of resources and services. Maintaining marine biodiversity has now become a global priority clearly identified in several international treaties and agreements, like the Convention on Biological Diversity, and is correlatively part of European policies and national strategies (e.g. the national strategy for biodiversity and the *Grenelle* environmental and marine stakeholder consultation and legislative processes in France).

Indeed, France has special responsibility in this domain. With nearly 11 million km<sup>2</sup>, the French exclusive economic zone (EEZ) is the second largest in the world, sheltering a great part of global biodiversity, especially in its overseas maritime area, with coral reefs, mangroves, etc.

Ifremer is one of the marine research bodies with the broadest range of expertise, spanning fisheries and aquaculture, coastal environment, biotechnologies, geosciences, mineral and energy resources, operational oceanography, underwater technologies and operation of offshore and inshore research fleets. Thanks to this extensive multidisciplinary and the integrated approach it enables, our Institute is a natural partner in numerous projects and actions related to biodiversity. Indeed, one of the ten key objectives set out in the Ifremer strategic plan is “*learn about and characterise marine biodiversity to better protect it*”.

As a true scientific challenge, an appropriate research strategy must be defined for this biodiversity. That is why I wanted a collective expert review to be conducted by a group of recognised French and foreign specialists and researchers, to answer the following question: what should Ifremer’s priorities be for marine biodiversity research?

Chaired by Gilles Boeuf, who is a professor at Pierre & Marie Curie University and president of the MNHN national museum of natural history, the group of fourteen intentional experts formed for this purpose analysed existing literature and compared the results of their analysis with Ifremer's specificities. This detailed report examining the state of knowledge for marine biodiversity, drawn up during the first half of 2010, is the direct outcome of this expert review. It defines five high-priority orientations for marine biodiversity research and proposes that a partnership-based research programme be implemented. Its recommendations will enable a coherent programme to be developed, offering a framework for Ifremer, working with our partners, to further strengthen our ability to provide advice and expert assessments, in contact with the decision and policy makers in charge of managing and protecting biodiversity.

This expert panel review was supported by the Ministry of Ecology, Sustainable development, Transport and Housing (MEDDTL). Of course, it also falls under the scientific foresight work on French research on biodiversity, drawn up upon request from the Ministry of higher education and research on behalf of the national strategy for research and innovation (SNRI), by the scientific council of the Foundation for research on biodiversity, of which Ifremer is a founding member.

**Jean-Yves Perrot**  
Chief Executive Officer of Ifremer

# Introduction

The term “biodiversity” was first used in 1985 by the American ecologist W.G. Rosen and then broadly disseminated by the American entomologist E.O. Wilson. What is meant by biodiversity? Entire chapters have been devoted to presenting and explaining the concept. *Simply put, biodiversity designates the variety, amount and distribution of life on earth. It is the living part of Nature.* Much more than a simple inventory of species inhabiting ecosystems, it highlights the relationships established between these species and their environment. It is the outcome of ecological and evolutionary processes modified by human and environmental impacts. Biodiversity is intricately linked to ecosystem functions and the provision of ecosystem services (i.e. the products and processes supplied by the environment) that people benefit from. Efforts to ensure the sustainable use and conservation of biodiversity are driven by social, economic and ethical concerns and informed by scientific expertise. Numerous international commitments exist for the sustainable use of biodiversity, recognising its fundamental importance to human well-being and setting targets to halt the loss of biodiversity (MA 2005; Barbault 2006; CSPNB 2007, 2008).

The scientific requirements for knowledge needed to describe the variety of life and provide a rational basis for its management can be put into five categories:

- Cataloguing biodiversity where it is found (the variety, quantity and distribution of genes, individuals, populations, communities and ecosystems) and developing the tools and metrics needed to describe it.
- Understanding the ecological and evolutionary processes that account for the variety, quantity and distribution of genes, individuals, populations, communities and ecosystems over space and time, (i.e. how has Nature engendered more than 1.5 billion species in less than 4 billion years?) and assessing how biodiversity responds to environmental and human drivers based on analysis of the past and present, and scenarios for the future.
- Appraising how patterns of biodiversity influence the functioning of populations, communities and ecosystems in providing ecosystem services, including large-scale biogeochemical cycles and all relationships with the non-living world, as well as assessing the resulting social and economic benefits.



**Fig. 1** Tuamotu (French Polynesia) land and seascape, an atoll. (© Ifremer, Olivier Dugornay)

- Understanding the factors of change in human use of marine biodiversity at various scales, including economic, social, cultural, institutional and political dimensions, as well as the ability of individuals and societies to adapt to changes in the state of marine biodiversity.
- Implementing management systems to meet objectives for biodiversity conservation, based on designing innovative approaches and tools to aid decision-makers. This involves models and indicators of changes in biodiversity and management tool performance assessments. They are informed by the first four points above, and backed up by understanding, on various scales, of the social-economic consequences of management approaches.

Future trends in human and environmental impacts on biodiversity remain uncertain and yet, it is essential that current planning and management take account of changes that may occur. Scenarios are widely used, an approach which is probabilistic by nature and takes account of the range of uncertainties related to current scientific knowledge. A key avenue for progress in this field lies in finding better ways to integrate scientific knowledge in decision-making processes, including innovation and development of adaptive learning in processes to regulate activities impacting marine biodiversity.

This document aims to explain why marine biodiversity research holds highly strategic interest for society and the scientific community.



**Fig. 2** Illustrations of bivalve molluscs. (Taken from Tryon 1879, *Manual of conchology, structural systematics*, Vol. III, plate 131)

For society, research on marine biodiversity will offer new insights into marine life and could provide the necessary evidence to justify conservation priorities, while helping to prepare alternate management actions for the future. For scientists, strategic refocusing on biodiversity research will lead to shared vision and, by spotlighting the subject, help attract scientists from a range of fields and stimulate new knowledge being brought to the fore. Such a strategy will foster an interdisciplinary approach and better coordination between scientists, especially by bringing together various strands of research, as the ecosystem-based approach becomes the standard choice in marine resource management. This shift in perspective will meet the vital need to grow our capacity to provide scientific advice to policy makers in charge of managing and protecting biodiversity, as shown by the development of the IPBES Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.<sup>1</sup>

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<sup>1</sup> <http://www.ipbes.net/>.

# Acknowledgements

It is with great pleasure that the authors extend their thanks to Jean-Yves Perrot, the President-Managing Director of Ifremer, who was the initiator of this expert panel review on research needs in the social and environmental sciences in the field of marine biodiversity. He supported this work and made it materialise in Ifremer's scientific strategy, working jointly with Ifremer's Scientific Director Marie-Hélène Tusseau-Vuillemin and Associate Managing Director Patrick Vincent.

This review is the result of rich and fruitful exchanges between scientists at various French and international research institutes and the Foundation for scientific cooperation for Research on Biodiversity (FRB). Several experts have compared and cross-checked the issues raised in their respective fields of study (exact and natural sciences, human and social sciences) to identify the priorities for marine biodiversity research. Our warmest thanks go to them, and most particularly to Christophe Béné, Gary Carvalho, Philippe Cury, Bruno David, Daniel Desbruyères, Luc Doyen, Susan Hanna, Simon Jennings, Harold Levrel and Olivier Thébaud.

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# Abbreviations and Acronyms

## International agreements and organisations

EEA	European Environment Agency ( <a href="http://www.eea.europa.eu/">http://www.eea.europa.eu/</a> ).
CBD	Convention on Biological Diversity ( <a href="http://www.cbd.int/">http://www.cbd.int/</a> ).
ICES	International Council for the Exploration of the Sea ( <a href="http://www.ices.dk">www.ices.dk</a> ).
RAMSAR	Convention on Wetlands ( <a href="http://www.ramsar.org/">http://www.ramsar.org/</a> ).
COP	United Nations Convention ( <a href="http://www.un.org/Depts/los/index.htm">http://www.un.org/Depts/los/index.htm</a> ).
DIVERSITAS	Conference of Parties (Convention on Biodiversity Diversity). International Programme of Biodiversity Science, under the institutional auspices of international organisations such as UNESCO, SCOPE, IUBS, ICSU and IUMS ( <a href="http://www.diversitas-international.org/">http://www.diversitas-international.org/</a> ).
EC	European Commission ( <a href="http://ec.europa.eu/index_en.htm">http://ec.europa.eu/index_en.htm</a> ).
FAO	Food and Agriculture Organization of the United Nations ( <a href="http://www.fao.org">www.fao.org</a> ).
IPCC	Intergovernmental Panel on Climate Change ( <a href="http://www.ipcc.ch/">http://www.ipcc.ch/</a> ).
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services ( <a href="http://ipbes.net">http://ipbes.net</a> ).
OECD	Organisation for Economic Co-operation and Development ( <a href="http://www.oecd.org/">http://www.oecd.org/</a> ).
IMO	International Maritime Organization ( <a href="http://www.imo.org/">www.imo.org/</a> ).
OSPAR	Oslo-Paris Convention ( <a href="http://www.ospar.org/">http://www.ospar.org/</a> ).
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice ( <a href="http://www.cbd.int/sbstta/">http://www.cbd.int/sbstta/</a> ).
IUCN	International Union for the Conservation of Nature ( <a href="http://www.iucn.org/">http://www.iucn.org/</a> ).
UNCED	United Nations Conference on Environment and Development ( <a href="http://www.un.org/esa/sustdev/documents/agenda21/english/Agenda21.pdf">http://www.un.org/esa/sustdev/documents/agenda21/english/Agenda21.pdf</a> ).

UNCLOS	United Nations Convention on the Law of the Sea ( <a href="http://en.wikipedia.org/wiki/United_Nations_Convention_on_the_Law_of_the_Sea">http://en.wikipedia.org/wiki/United_Nations_Convention_on_the_Law_of_the_Sea</a> ).
WorldFish Center	( <a href="http://www.worldfishcenter.org">http://www.worldfishcenter.org</a> ).

## International policies

MFSD	Marine Framework Strategy Directive ( <a href="http://ec.europa.eu/environment/marine/index_en.htm">http://ec.europa.eu/environment/marine/index_en.htm</a> ).
WFD	Water Framework Directive ( <a href="http://ec.europa.eu/environment/water/water-framework/index_en.html">http://ec.europa.eu/environment/water/water-framework/index_en.html</a> ).
EUNIS	European Nature Information System ( <a href="http://eunis.eea.europa.eu/">http://eunis.eea.europa.eu/</a> ).
CFP	Common Fisheries Policy ( <a href="http://ec.europa.eu/fisheries/cfp_en.htm">http://ec.europa.eu/fisheries/cfp_en.htm</a> ).
EEZ	European Union's Exclusive Economic Zone ( <a href="http://en.wikipedia.org/wiki/Exclusive_Economic_Zone">http://en.wikipedia.org/wiki/Exclusive_Economic_Zone</a> ).

## Agencies, research institutes and foundations

AAMP	French Agency for marine protected areas ( <a href="http://www.aire-marines.fr/">http://www.aire-marines.fr/</a> ).
CSIRO	Commonwealth Scientific & Industrial Research Organisation, Australia ( <a href="http://www.csiro.au/">http://www.csiro.au/</a> ).
DEFRA	Department for Environment, Food & Rural Affairs, United Kingdom ( <a href="http://www.defra.gov.uk/">http://www.defra.gov.uk/</a> ).
EPA	Environmental Protection Agency, United States ( <a href="http://www.epa.gov/">http://www.epa.gov/</a> ).
FWS	U.S. Fish and Wildlife Service ( <a href="http://www.fws.gov/">http://www.fws.gov/</a> ).
Ifremer	French Research Institute for Exploitation of the Sea ( <a href="http://www.ifremer.fr/">http://www.ifremer.fr/</a> ).
MacArthur Foundation	( <a href="http://www.macfound.org/">http://www.macfound.org/</a> ).
MEDDTL	The French Ministry of Ecology, sustainable development, transport and housing, which became the Ministry of Ecology, sustainable development and energy (MEDDE) in May 2012 ( <a href="http://www.developpement-durable.gouv.fr/">http://www.developpement-durable.gouv.fr/</a> ).
MMS	Minerals Management Service ( <a href="http://www.mms.gov/">http://www.mms.gov/</a> ).
MNHN	National museum of natural history ( <a href="http://www.mnhn.fr/museum/office/transverse/transverse/accueil.xsp">http://www.mnhn.fr/museum/office/transverse/transverse/accueil.xsp</a> ).

NCBI	National Center for Biotechnology Information ( <a href="http://www.ncbi.nlm.nih.gov/">http://www.ncbi.nlm.nih.gov/</a> ).
NOAA	National Oceanic and Atmospheric Administration ( <a href="http://www.noaa.gov/">http://www.noaa.gov/</a> ).
Sloan Foundation	( <a href="http://www.sloan.org/">http://www.sloan.org/</a> ).
VLIZ	Flanders Marine Institute ( <a href="http://www.vliz.be/EN/INTRO">http://www.vliz.be/EN/INTRO</a> ).
World Resources Institute	Earth trends ( <a href="http://www.earthtrends.wri.org/">http://www.earthtrends.wri.org/</a> ).
WWF	World Wildlife Fund ( <a href="http://www.wwf.fr/">http://www.wwf.fr/</a> ).

## National (France) and international Programmes

CHALOUPE	ANR project <a href="http://www.univ-brest.fr/gdr-amure/projet-chaloupe/">http://www.univ-brest.fr/gdr-amure/projet-chaloupe/</a> .
COML	Census of Marine Life ( <a href="http://www.coml.org">www.coml.org</a> ).
CBOL	Consortium for the Barcode of Life ( <a href="http://www.barcoding.si.edu/">http://www.barcoding.si.edu/</a> ).
CORONA Project	Coordinated Research on North Atlantic NSF-DEB-0130275/ Biogeographic Study on North Atlantic.
CPR	Continuous Plankton Recorder Project ( <a href="http://www.sahfos.ac.uk/">http://www.sahfos.ac.uk/</a> ).
EDMONET	European Marine Observation and Data Network <a href="http://208.254.39.65/coastmapnews/e_article001208695.cfm">http://208.254.39.65/coastmapnews/e_article001208695.cfm</a> .
EUR-OCEANS	Climate Change & Marine Ecosystems ( <a href="http://www.eur-oceans.info/EN/home/index.php">http://www.eur-oceans.info/EN/home/index.php</a> ).
FISH-BOL	( <a href="http://www.fishbol.org">www.fishbol.org</a> ).
GEOBON	( <a href="http://www.earthobservations.org/geobon.shtml">http://www.earthobservations.org/geobon.shtml</a> ).
GISP	Global Invasive Species Program ( <a href="http://www.gisp.org/">http://www.gisp.org/</a> ).
GOOS	Global Ocean Observation System ( <a href="http://www.ioc-goos.org/">http://www.ioc-goos.org/</a> ).
HMAP	History of Marine Animal Populations ( <a href="http://www.hmap-coml.org/">http://www.hmap-coml.org/</a> ).
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research ( <a href="http://www.imber.info/">http://www.imber.info/</a> ).
INSDC	International Nucleotide Sequence Database Collaboration ( <a href="http://www.ebi.ac.uk/embl/Contact/collaboration.html">http://www.ebi.ac.uk/embl/Contact/collaboration.html</a> ).
IUBS/DIVERSITAS	( <a href="http://www.diversitas-international.org/">http://www.diversitas-international.org/</a> ).
MarBEF	Marine Biodiversity and Ecosystem Functioning ( <a href="http://www.marbef.org/">http://www.marbef.org/</a> ).
MA	Millennium Ecosystem Assessment ( <a href="http://www.millennium-massessment.org">http://www.millennium-massessment.org</a> ).

MESH European MOREST	( <a href="http://www.searchmesh.net/Default.aspx?page=578">http://www.searchmesh.net/Default.aspx?page=578</a> ). Summer mortality of Pacific oysters project <a href="http://www.ifremer.fr/morest-gigas/">http://www.ifremer.fr/morest-gigas/</a> .
NOEP	National Ocean Economics Program ( <a href="http://www.oceanoeconomics.org/">http://www.oceanoeconomics.org/</a> ).
REPER	Environmental research observatory (ORE)-Pertuis Charentais region observatory.
RSL	Lagoon monitoring network ( <a href="http://rsl.cepralmar.com/">http://rsl.cepralmar.com/</a> ).
SAUP	Sea Around Us Project-Fisheries Ecosystem & Biodiversity ( <a href="http://www.seaaroundus.org/">http://www.seaaroundus.org/</a> ).
SEBI	Streamlining European Biodiversity Indicators <a href="http://biodiversity.europa.eu/topics/sebi-indicators">http://biodiversity.europa.eu/topics/sebi-indicators</a> .

## Technical acronyms and abbreviations

AM	Adaptive Management ( <a href="http://en.wikipedia.org/wiki/Adaptive_management">http://en.wikipedia.org/wiki/Adaptive_management</a> ).
DPSIR	Drivers, Pressure, State, Impact, Response ( <a href="http://www.springerlink.com/content/v447r90jl1wh0430">http://www.springerlink.com/content/v447r90jl1wh0430</a> ).
EAF	Ecosystem-based Approach for Fisheries Management ( <a href="http://www.jncc.gov.uk/">http://www.jncc.gov.uk/</a> ).
EBFM	Ecosystem-based Fisheries Management Approach.
ENSO	El Niño and Southern Oscillation Climate Pattern.
HABs	Harmful Algal Blooms ( <a href="http://en.wikipedia.org/wiki/Algal_bloom">http://en.wikipedia.org/wiki/Algal_bloom</a> ).
IAS	Invasive Alien Species ( <a href="http://www.cbd.int/invasive/">http://www.cbd.int/invasive/</a> ).
ITQ	Individual Transferable Quota (Fishery Management).
IUU	Illegal, Unreported, Unregulated Fishing.
MEY	Maximum Economic Yield ( <a href="http://stats.oecd.org/glossary/detail.asp?ID=6504">http://stats.oecd.org/glossary/detail.asp?ID=6504</a> ).
MPA	Marine Protected Area.
MSVPA	Multi-Species Virtual Population Analysis.
MSY	Maximum Sustainable Yield ( <a href="http://en.wikipedia.org/wiki/Maximum_sustainable_yield">http://en.wikipedia.org/wiki/Maximum_sustainable_yield</a> ).
NIS	Non-Indigenous Species ( <a href="http://fl.biology.usgs.gov/Nonindigenous_Species/nonindigenous_species.html">http://fl.biology.usgs.gov/Nonindigenous_Species/nonindigenous_species.html</a> ).
PSR	Pressure-State-Response ( <a href="http://www.ens.gu.edu.au/AES1161/Topic1/Topic1R1.htm">http://www.ens.gu.edu.au/AES1161/Topic1/Topic1R1.htm</a> ).
PVA	Population Viability Analysis ( <a href="http://en.wikipedia.org/wiki/Population_viability_analysis">http://en.wikipedia.org/wiki/Population_viability_analysis</a> ).

SST	Sea Surface Temperature ( <a href="http://en.wikipedia.org/wiki/Sea_surface_temperature">http://en.wikipedia.org/wiki/Sea_surface_temperature</a> ).
TEV	Total Economic Value ( <a href="http://en.wikipedia.org/wiki/Total_Economic_Value">http://en.wikipedia.org/wiki/Total_Economic_Value</a> )

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