ISSN 1635-3064

INSTITUT PAUL RICARD OCÉANOGRAPHIQUE

THE NEWSLETTER

COP 21
UNITED NATIONS CLIMATE CHANGE CONFERENCE

THE MEDITERRANEAN SEA IS GETTING WARMER

THE OCEAN

Master of the climate

N°14 - 2015

Keeping the ocean alive: our best chance for reducing the impact of climate change

The ocean is essential for life, it is the source of the air we breathe and the water we drink.

We must have a clear vision of our Earth as an island in the middle of the world ocean. We are embarked on a vessel called Earth.

Among the shifting paradigms that we are living through today, there is one that is essential: the inversion of our relation with the living world and a renewed acceptance of our inter-related destinies. Like all species on the planet, we depend on the climate, the water and the air for our survival. We all depend on the ocean, Master of the climate.

Only a living and healthy ocean can continue to provide us with the ecosystem services we need and ways of coming to terms with and attenuating climate change. The study of the ocean and its preservation should be at the core of our road map to make our societies more sustainable.

I hope the ocean was not only the 'surprise' trump card but also the 'solutions' trump card that swept the board in this planet-scale challenge which was the 21st World Climate Conference in Paris.

The time has come for us to really *'know and protect the sea'*, in reference to the founding motto of the Paul Ricard Oceanography Institute, which celebrated its fiftieth anniversary in 2016.

Our thanks to Dr Françoise Gaill, Director of Research CNRS and member of the Board of Management of our Institute, for her contribution: *The Ocean – Master of the Climate*, which I invite you to read in this edition of the *Newsletter*.

Patricia Ricard
President of the Paul Ricard Oceanography Institute

// OCEANOGRAPHY

Climate / Report

NEWSLETTER OF THE PAUL RICARD OCEANOGRAPHY INSTITUTE
N°14 - 2015 - Offprint of the Institute's Newsletter

Institut océanographique Paul Ricard
île des Embiez
83140 Six-Fours-les-Plages
Phone: +33 494 34 02 49
E-mail: embiez@institut-paul-ricard.org
www.institut-paul-ricard.org

Cover photo - The interaction between ocean and atmosphere, the source of the evolution of the climate system (Photo Fotolia-G. Andrushko).

Managing Editor: Patricia Ricard - **Editor:** Christian Frasson-Botton - **Writers:** Jean-Luc Bonnefont, Karine Braneyre, Isabelle Croizeau, Christian Frasson-Botton, Patrick Lelong, Yvan Martin, Alain Riva, Nardo Vicente - **Page layout:** Ouvreboîte, Marseille - **Printed by:** Groupe Taurrus impression, Marseille. Printed on 100% recycled paper, label Imprim'vert 2009. **Publication registration:** October 2015. Reprint in September 2019.

INSTITUT PAUL RICARD OCÉANOGRAPHIQUE

www.institut-paul-ricard.org

The Ocean
Master of the climate

1 / Major role of the ocean in the mechanisms of climate

2 / Climate change, the impact on the ocean, its inhabitants and the littoral

3 / Solutions derived from the ocean to combat climate change

Photo: Fotolia-S. Vivens

INTERVIEW WITH Dr FRANÇOISE GAILL
Director of Research, CNRS
Scientific Coordinator for the Ocean & Climate Platform
Member of the Board of Management of the Paul Ricard Oceanographic Institute

Photo: C. F.-B

The climate of the planet is similar to a vast machine of a complexity that in many aspects still eludes us.

In space and time, its functioning is controlled by the operation of mechanisms that drive various components: the atmosphere; the lithosphere (earth's crust); the hydrosphere (seas, oceans, lakes, water courses); the cryosphere (ice) and the biosphere (living organisms).

The energy needed for the functioning of the system is for the most part provided by solar activity. And its geographical and seasonal patterns of diffusion depend on astronomical parameters such as the rotundity of the planet, the tilt of its axis of rotation and the angle of its orbit around our star, which themselves vary over cycles of a few decades to several millennia.

The different climatic zones result then from this variability of the quantity of solar energy reaching the Earth.
It is this that conditions the distribution of living organisms.

But that is not all: this natural phenomenon combines with other natural phenomena, namely the way the atmospheric and oceanic circulation redistributes this received energy. Added to that there is a greenhouse effect resulting from the absorption of the atmospheric re-emission of the infrared radiation from the surface of the Earth towards the sky.

So much for the explanations of climate differences as they have existed naturally since the dawn of time.

But everything started to change gradually from the beginning of the 19th century Industrial Revolution.

>>

CAREER

FRANÇOISE GAILL

AFTER UNDERGRADUATE STUDIES AT PIERRE ET MARIE CURIE UNIVERSITY AND A POSTGRADUATE RESEARCH DEGREE (DEA) IN EXPERIMENTAL ZOOLOGY (1971), FRANÇOISE GAILL STARTED HER CAREER AS A RESEARCHER AT THE BIOLOGY OF MARINE INVERTEBRATES LABORATORY AT THE MUSÉUM NATIONAL D'HISTOIRE NATURELLE (NATIONAL NATURAL HISTORY MUSEUM, PARIS): *"A FIELD WHICH WILL ALWAYS BE A GREAT PASSION FOR ME"*, SHE NOTED.

This young scientist's career took on a new dimension when she joined the CNRS (1973) and was awarded her PhD (1981).

Françoise Gaill then worked in various laboratories, including the Roscoff marine biology centre (1993 - 1998).

She set up an inter-university electronic microscopy centre at Jussieu (1999), in the joint research unit (UMR), Developmental Biology.

In 2003, she took part in the founding of a new joint research unit at the CNRS, Systematics, Adaptation, Evolution, of which she was co-director from 2003 to 2008. The work of this laboratory is focused on marine biodiversity.

As Director of Research CNRS, she was appointed head of the Environment and Sustainable Development department in 2008. She was responsible for setting up the new CNRS National Institute of Ecology and Environment (INEE), which she headed until 2013.

In parallel, from 2006, Françoise Gaill was appointed to the Management of the CNRS as scientific delegate in the Life Sciences department, in charge of International Relations.

In the course of her career, Dr Gaill has taken part in around thirty international oceanographic surveys and has carried out thirty or more deep sea dives.

"I thought in the mid-1970s that we had nothing left to discover in the deep sea environment. But the new technologies and the submersibles have proved the contrary. Extreme environments have always fascinated me".

Dr Françoise Gaill has provided evidence of one of the molecular mechanisms enabling organisms to adapt to the high temperatures of hydrothermal fluids of mid-ocean ridges; she has discovered numerous modes of development and symbiotic associations.

After being President of the Research and Innovation operational committee of the *Grenelle de la Mer* project, launched in 2009, Dr Gaill took part in the *Alliance Nationale pour les Sciences de l'Environnement* (Allenvi – national alliance for environmental sciences), of which she was appointed Vice-President for research planning in 2011. She is a member of the *Conseil National de la Mer et des Littoraux* (national council for the sea and the littoral). Françoise Gaill is Scientific Counsellor to the management of the CNRS (INEE). She has taken part in various international organizations such as the European Science Foundation (ESF).

She has been a member of several scientific councils of universities and research organizations or agencies.

Dr Gaill is counsellor or member of the board of management of various corporate research organizations and foundations:
Total, Veolia, Paul Ricard Oceanography Institute, Tara.

She is a member of the ethics committee of INRA and of CIRAD, and chairs the *Conseil d'Orientation Stratégique et Scientifique* (COSS – strategic and scientific planning council) of the French oceanographic fleet. She has taken part in the work of the United Nations first World Ocean Assessment.

Dr Gaill's work has been the subject of more than 130 publications and has given rise to several patents, one of which, Alvinellicine, is an antibiotic.

>>

The great machine then began to run out of control, became deregulated at least, with the yearly emission of several tens of million tons of carbon into the atmosphere. And even if the world ocean absorbs about half of it, the conclusions of the 5th Climate Assessment Report (IPCC / GIEC) (1) are clear: the implication of human activities in the current climate warming is unarguably possible, with consequences that are severe, dangerous, even irreversible for the living world if rapid and global solutions are not found as a matter of urgency.

Françoise Gaill : *"Ocean and climate are intimately linked, and we are in the process of upsetting the major systems of balances: the ocean has become warmer down to depths of 3000 metres, it is becoming more acidic by absorbing more carbon dioxide; the sea level is rising by 1.7 millimetres a year, threatening the coasts and the islands."*

This is a new alert from the scientists to decisions makers and to the general public. With a few chapters devoted to it in this IPCC / GIEC report, it should also be a starting point for taking the ocean into account as one of the major actors in the climate mechanism. Today, advances in knowledge have enabled us to better assess the importance of its role and its vulnerability, but the scientific uncertainties are still considerable and far-ranging. A special IPCC / GIEC report on the ocean would thus be a great added value.

Interview with Dr Françoise Gaill, an oceanographer who has completed 34 deep dives down to 4000 metres on board various types of submersible. An expert and committed militant working with the *Ocean & Climate Platform*, the aim of which is to make the voice of the ocean heard at international level, including COPs (2).

(1) This Report, published on 2 November 2014, was based on more than 30 000 scientific documents.

(2) The 21st Conference of Parties (COP) of the United Nations Framework Convention on Climate Change was held in Paris from 30 November to 11 December 2015.

THE OCEAN, MASTER OF THE CLIMATE

1/ The major role of the ocean in climate mechanisms

"Ocean and climate are intimately linked, and we are in the process of upsetting the major systems of balances"

Photo: Fotolia-T. Launois

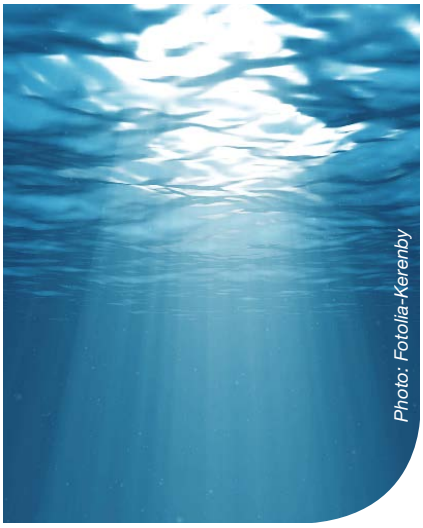


Photo: Fotolia-Kerenby

➔ FRANÇOISE GAILL, YOUR EXPERTISE HAS RESULTED IN YOUR PARTICIPATION IN THE UNITED NATIONS FIRST WORLD OCEAN ASSESSMENT. YOU ARE ALSO RESPONSIBLE FOR THE SCIENTIFIC COORDINATION OF A PLATFORM THAT HIGHLIGHTS THE ROLE OF THE OCEAN IN CLIMATE MECHANISMS. WHAT IS BEHIND THIS COMMITMENT?

In 2015, the United Nations published the first assessment of the state of the oceans. This is a 'bible', a zero state for our knowledge of the oceans, and a vast source of data.

But there is no investigation of the impact of the transformations in progress in the oceans in relation to the climate, as it was decided not to deal with what is being taken care of by the IPCC / GIEC.

However, if the temperature of the water in the oceans rises, as a matter of physics, the water will expand, (3) and its volume will increase. The sea level will therefore rise, with repercussions for the biodiversity and for human societies.

I think today the climate is a field which concerns all of us because it is global, and because climate change has to date been seen as the result of human activities and affecting mainly the inhabitants of the continents. And we still neglect the importance of the oceans in this field.

➔ THEN WHAT IS THE ROLE OF THE OCEAN AS DRIVER OF CLIMATE CHANGE?

At a very simple level, if we think that climate change is based solely on the emission of elements influencing the greenhouse effect, we forget that everything comes from the sun, the provider of energy, that all living creatures – including we humans – use and exploit in a certain way.

But what we emit and produce (4) blocks this solar energy radiated towards the Earth. So we lose certain things, a certain intensity of radiation, but what is passed through this filter is recycled or stored in the ocean (see p. 7 : The Ocean – The Planet's Thermostat – Ed.).

This aspect is not generally known to the general public.

(3) To find out more about the expansion of water (in French):
http://education.meteofrance.fr/college/activites-experimentales/l-eau/la-dilation-de-l-eau

(4) Fine particles, water vapour, various gases, etc.

>>

The forest canopy is exposed to the light of the sun to uptake a maximum of the energy necessary for photosynthesis.

>>

➜ MORE SPECIFICALLY, WHAT ARE THE FACTORS INVOLVED IN THIS UPTAKE OF CARBON DIOXIDE IN THE ATMOSPHERE ?

This is a subject that is very much on the agenda today, as there are various principles regarding what we call pumps or sinks, which accumulate the carbon. They are capable of recycling it, of using it in other ways, integrated within a system of natural balances, which we are beginning to get some idea of, but which is still a vast new area to be explored.

In this vision of things, the living world is a determinant factor, and even if the physical phenomena are still preponderant, the biodiversity is the determinant factor.

Though considered as indispensible carbon sinks, the forests are mere pinpricks compared with the oceans.

For now, we only know part of the action of the marine plankton and associated microbes, but one thing is certain, this oceanic biological carbon pump plays a significant role in the absorption of carbon dioxide.

With regard to this schema, it remains to determine the full range of the interactions with other species, other environments and to understand how it all fits together to finally result in stability over time, since Planet Earth has been relatively 'calm' for twenty centuries.

> ***"Though considered as indispensible carbon sinks, the forests are mere pinpricks compared with the oceans"***

➜ BY PARTLY ABSORBING THE CARBON DIOXIDE, THE OCEAN IS A NATURAL REGULATOR OF THE CLIMATE. BUT WITH THE INCREASE IN THE CONCENTRATIONS OF THIS GAS, WHAT IS GOING TO HAPPEN ? WHAT ARE THE SCENARIOS FOR THE CLIMATE OF THE FUTURE ?

Of course, the scenarios are at the scale of several decades, since the models we dispose of today are those that have an impact in the medium term, as we do not know how to deal with short-term scenarios, that is to say the level of uncertainty is very high.

But for the first part of your question, we can say with certainty that we have been observing an increase in the temperature of the ocean for some time now (see p. 7 : The Ocean – The Planet's Thermostat – Ed.).

Without the ocean, this increase would be much greater than the two degrees announced and targeted for 2100. But we cannot really estimate it, since current knowledge does not provide a basis for defining with precision how the ocean, which is a heat reservoir, acts upon the overall thermal regulation.

Furthermore, if the ocean can uptake about 25 % of the CO_2 that we emit today, we are certainly going to see an acidification of the water with immediate consequences for the populations of coastal areas.

This acidification would appear to be unavoidable. Since the beginning of the industrial era (1850), we have recorded an increase in acidification of more than 30 %, corresponding to a drop close to 0.1 pH unit, and I think that we should take that into account (see p. 10 : The Ocean - Acidification in progress – Ed.).

The infinitely small elements constituting most of the plankton become visible at night because of their ability to produce bioluminescence. The bioluminescent phytoplankton is mainly composed of photosynthetic dinoflagellates, which are found near the surface.

Interview continued p. 13 >>

Photo: Fotolia - I. Chalkovskiy

THE OCEAN THE PLANET'S THERMOSTAT

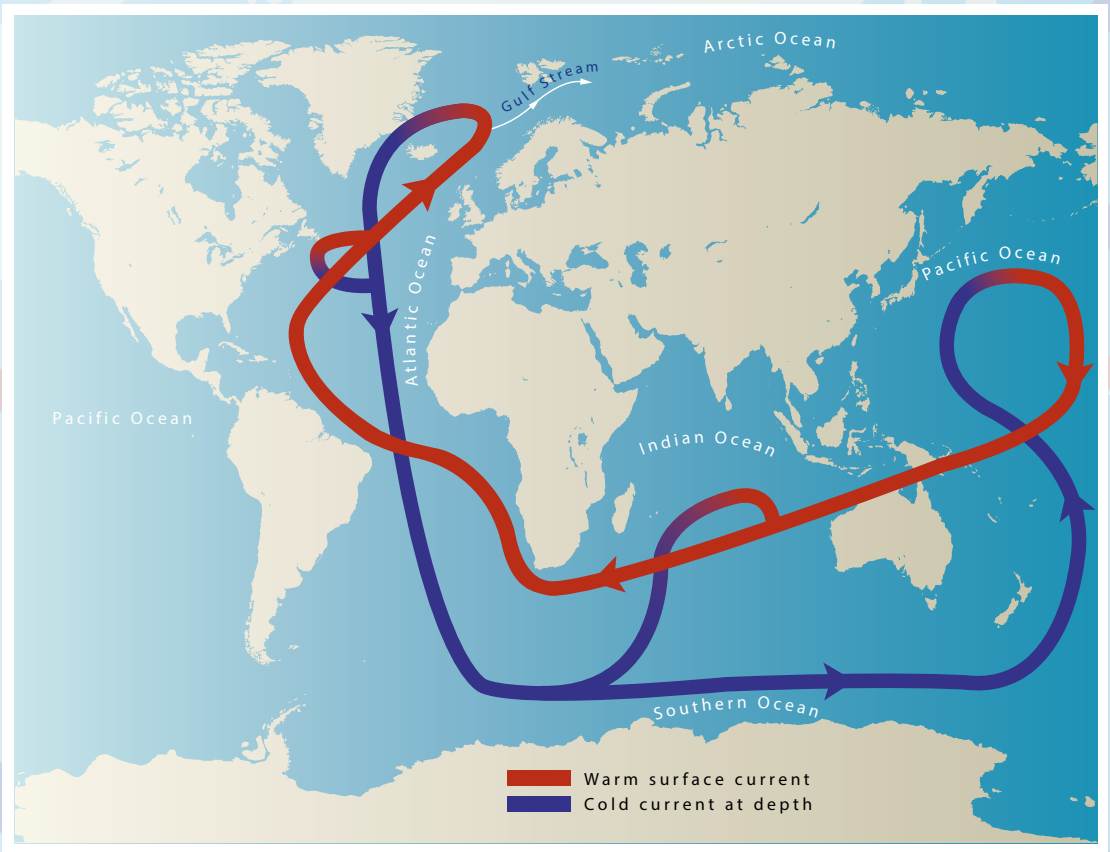
THE WORLD OCEAN [1] IS A DETERMINANT FACTOR FOR THE CLIMATE OF THE PLANET. BUT ITS FUNCTION AS THERMOSTATIC REGULATOR HAS BEEN DISTURBED BY GLOBAL WARMING RESULTING FROM THE GREENHOUSE EFFECT.

The ocean is a vast thermal machine which heats up and cools down very slowly. Thus, it can store a quantity of heat around a thousand times greater than that in the atmosphere, which it restores over periods of greater or lesser duration.

The marine currents redistribute the absorbed thermal energy, by means of the oceanic circulation engendered by the surface winds, the rotation of the Earth and certain properties of the ocean, such as the temperature and the salinity.

At the surface, the masses of warm water transport the heat accumulated under the tropics towards the poles. This is the case with the Gulf Stream. But we also observe at depth cold currents that go in the opposite direction.

Like a conveyor belt, this global pattern of circulation contributes to the redistribution of heat at the scale of the planet, while maintaining permanent exchanges with the atmosphere.



Focus

A HEAT RESERVOIR

The capacity of the ocean to store heat is far more efficient than that of the continents and the atmosphere.

The excess heat resulting from the increase in the atmospheric concentration of greenhouse gases (2) is 93 % absorbed by the ocean. This attenuates the increase of temperature in the atmosphere.

But the absorption of this excess heat inevitably induces a slight warming of the seawater, which is detectable at least down to 700m depth. It now affects the polar regions and is propagated towards all the ocean basins, which has an impact on the properties and the dynamic of the ocean, on the exchanges with the atmosphere and the marine ecosystems.

And even if the greenhouse gas emissions (2) were halted today, the effects linked to the heating of the ocean would still persist for decades.

(1) Formed by the five inter-communicating oceans of the planet: Atlantic, Pacific, Indian Ocean, Arctic Ocean and Southern Ocean.

(2) The main gases are carbon dioxide or CO_2 (fossil fuels, deforestation), which is the most important in terms of quantity; methane (livestock farming, marshes, etc.); nitrous oxide (fertilizer, agriculture, etc.); industrial halogen hydrocarbons (refrigerating gases, aerosols) and water vapour, responsible for three quarters of the total greenhouse effect. http://www.fnh.org/francais/faq/effet_serre/gaz.htm

GREENHOUSE EFFECT AND ALBEDO

What we call the greenhouse effect is a natural phenomenon and is important for the regulation of the climate on Earth. Without it, the average temperature would be –18°C instead of +15°C, and life would perhaps not exist.

The gases which are responsible for it, mainly water vapour, carbon dioxide and methane, are not very abundant naturally in the atmosphere.

But because of the development of human activities since the 19th century, the concentration of these greenhouse gases has considerably increased in the atmosphere: that of carbon dioxide by 40%, that of methane by more than 150%.

The principle of the greenhouse effect is simple. All environments do not reflect the light in the same way: snowfields reflect 80% of the solar energy; the Sahara, 35%; temperate forests, 12%; 'dark' forests (resinous), 5% and the oceans, between 5 and 10%.

This quantity of solar radiation reflected by the earth's surface is called albedo, or reflection factor. This reflected energy serves as a gaseous shield which re-emits energy towards the Earth, resulting in an increase in temperature, living species being, as it were, placed inside a greenhouse.

If we wish to predict the future progression of the greenhouse effect and of its impact, the use of models is indispensible. However, the level of the retroactions (positive or negative), the physics of the clouds and numerous other parameters make the modelling of climate-related phenomena difficult.

Sources: Website Ocean & Climate Platform - *ocean-climate.org, and website of the French ministry of ecology, sustainable development and energy: http://www.developpement-durable.gouv.fr/-Comprendre-le-changement-.html*

"Unless practical and effective measures are urgently deployed to combat climate change, it will be impossible to attain the objective of ensuring that the temperatures do not increase by more than 2°C at worldwide scale."

Ban Ki-moon, former Secretary General of the United Nations


Photo: Fotolia-corbis_fancy

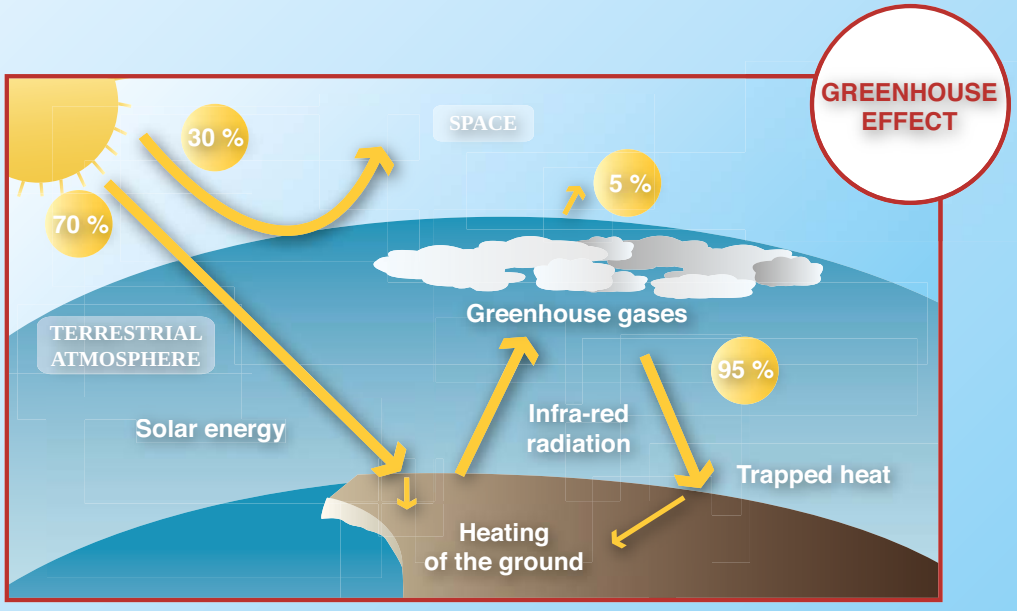

Photo: Fotolia-INFINITY


Photo: Fotolia-rob245

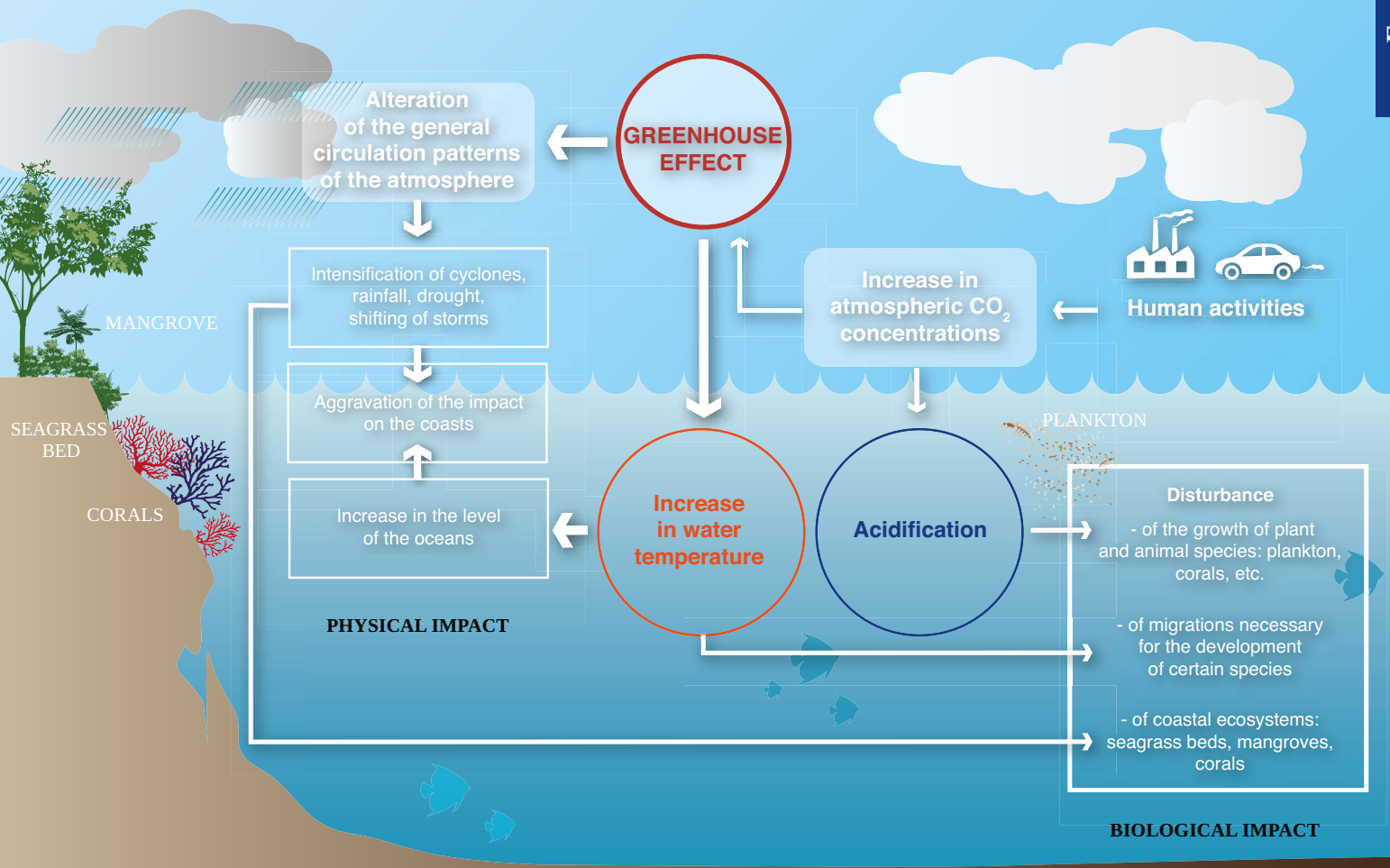
The quantity of carbon dioxide continues to increase and cannot be compensated by the carbon pumps that are the ocean and the forest. Without some reaction at worldwide scale, the imbalance will get worse under the impact of increasing deforestation (some 13 million hectares a year) and the soaring consumption of fossil fuels because of human activity: industry, transport, etc.

Impact of the increase

OF THE GREENHOUSE EFFECT AND OF ATMOSPHERIC CARBON DIOXIDE



It is estimated that only 70 % of the solar energy reaches the Earth's surface. It is partly reflected in the form of infra-red radiation. But instead of mainly dispersing into space, this radiation comes up against a kind of shield formed of the greenhouse gases emitted by man [2]. This trapped heat is re-emitted towards the Earth, thus increasing the temperature at ground level.



Based on the Ocean & Climate Platform *fact sheets - ocean-climate.org*

THE OCEAN ACIDIFICATION IN PROGRESS

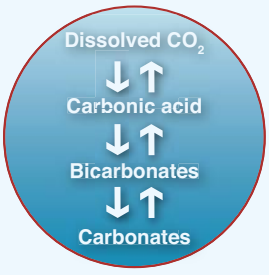
CARBON DIOXIDE (CO_2) – NATURALLY PRESENT IN THE ATMOSPHERE (0.035 %) - IS PRODUCED BY VOLCANIC ERUPTIONS, THE RESPIRATION OF PLANTS, ANIMALS AND MAN, BY FIRES, ETC. THEN THERE ARE THE HUMAN ACTIVITIES USING FOSSIL FUELS: TRANSPORT, HEATING, INDUSTRY, AGRICULTURE, ETC., WHICH ARE RESPONSIBLE FOR A CONSTANT INCREASE IN CARBON DIOXIDE CONCENTRATIONS.

Since 1750, the concentrations of carbon dioxide (CO_2) have been constantly on the increase in the atmosphere, from 280 ppmv (parts per million in volume) before the industrial era to 363.71 ppmv in 1997, at the time of Kyoto Protocol on the reduction of greenhouse gas emissions, to reach 400 ppmv in 2013. This increase in CO_2 has continued to speed up since the mid-1960s. Between 2006 and 2013, it reached on average a value of 2.26 ppmv per year. About one third of the carbon dioxide produced by human activity is absorbed by the ocean. When its concentration increases in the air, it also increases in the water, in function of the temperature and the atmospheric pressure. This phenomenon of dissolution spontaneously forms carbonic acid and results in a tendency towards the acidification of the oceans.

Source: *Ocean & Climate Platform* - ocean-climate.org
To know more: http://www.planetoscope.com/co2/261-emissions-mondiales-de-co2-dans-l-atmosphere.html
http://i2i.stanford.edu/AcidOcean/AcidOcean_Fr.htm
http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate2616.html

A CONSTRUCTION OF THE LIVING WORLD

An increase in carbonic acid is the cause of changes in the chemical balance of the seawater.
It results in an increase in hydrogen ions (H+), responsible for the acidification [1], which alters the direction of the chemical reaction leading to the carbonates [2], essential elements necessary for marine plants and animals to enable them to develop their skeleton or their shell: corals, mussels, oysters [3], etc.



Carbon dioxide combines with water to give carbonic acid, which is transformed into bicarbonates and carbonates, resulting in a chemical balance between these three constituents. The carbonates are associated with calcium to form limestone which drifts down towards the ocean floor, where it ends up forming sedimentary rock (physical carbon pump).

This process of acidification of the ocean is a major change that is in progress: the pH [1] has declined by 0.1 pH unit in some 200 years, and certain statistical models predict a more severe drop: 0.3 unit by 2100, if the CO_2 emissions in the atmosphere are not reduced.

We do not yet know very well the effects of the acidification of the ocean, and especially on calcareous shell components: coccolithophores *(see photo)*, pteropods, Foraminifera, algae, Corallines, corals, shellfish, etc. Its interaction with other environmental changes also remains poorly known. All the biodiversity and the food webs are likely to be disturbed.

(1) The acidification is the decrease in the pH, which is the unit of measurement of the acidity of a liquid on a scale of 1 to 14, neutrality corresponding to 7. An environment becomes acid below this value and alkaline above it. The pH of seawater is slightly alkaline and ranges from 7.5 to 8.3, depending on the area. Currently, it is considered that the mean pH of the oceans is 8.2. This might progressively drop if the concentration of CO_2 continues to increase. Acidification is a process in progress, but the ocean will not become an acidified medium.

(2) www.us-ocb.org / www.epoca-project.eu - FAQ on the acidification of the oceans. Ocean Carbon & Biogeochemistry (March 2010).

(3) The skeletons of living organisms are a biological pump that sequesters carbon in the form of calcium carbonate. These skeletons end up forming sediment on the bottom.

Photo: Fotolia-S. Chayko

The coral reefs of the Maldives (Indian Ocean) are exposed to the impact of climate change. The bleaching of the coral is a threat to tourism and fisheries.

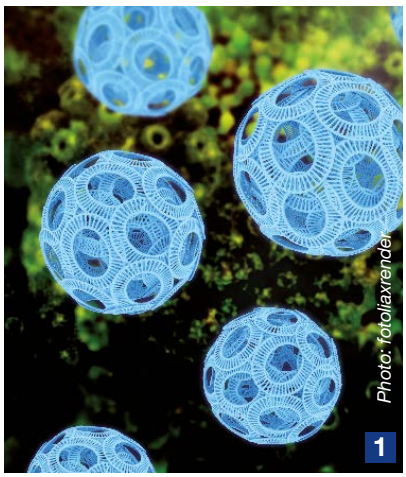


Photo: totoliaxrender

1

Photo: akitos7

2

Photo: j_beyrard

3

Photo: Jeremy Jonas

4

VICTIMS AND WITNESSES

The acidification of the oceans has deleterious effects on organisms with calcareous skeletons or shells.

1 The coccolithophores are calcareous microalgae (3D imaging). A study has shown that the secretion of the calcareous skeleton diminishes when the seawater becomes more 'acidified'. It has also enabled observation in waters off the coast of Chile, in the most 'acidified' waters of the ocean today (pH from 7.6 to 7.9), of highly calcified coccoliths, in contrast to the general trend. The capacity for adaptation of this group remains unknown (source: insu.cnrs.fr).

2 The calcification of the edible mussel, *Mytilus edulis*, and the oyster, *Crassostrea gigas*, decreases in linear fashion with the increase in CO_2 and the diminution of the pH (source: insu.cnrs.fr).

3 The giant clam lives in a reef environment. The study of the chemical composition and the patterns of growth of its shell provides information on variations in the environment over several years (source: monoil.ird.fr)

4 The bleaching of the coral is a phenomenon of stress caused by an increase in oceanic temperatures above 30°C, which may cause the death of the animal (source: cnrs.fr). With the acidification of the oceans, the corals will also have increasing difficulty in constructing their calcareous skeletons.

© CNRS photo library-DOLAN John (Laboratoire d'océanographie de Villefranche-sur-Mer)

THE OCEAN CARBON PUMP AND OXYGEN PRODUCER

Marine diatoms harvested in the Amundsen Sea (Southern Ocean), off the coast of Antarctica. The diatoms are unicellular photosynthetic algae, with a silica skeleton. They are part of the phytoplankton and play a role in carbon pumping.

Focus

THE OCEAN PLAYS A MAJOR ROLE IN THE REGULATION OF THE CLIMATE AND IN MAINTAINING LIFE. THE VEGETAL PLANKTON USES THE CARBON DIOXIDE IN THE ATMOSPHERE TO PRODUCE MORE THAN HALF OF THE OXYGEN IN THE AIR THAT WE BREATHE.

A world invisible to the naked eye proliferates beneath the surface: the plankton. Composed of thousands of species of more or less microscopic algae and animals in suspension in the water, drifting with the current, it represents more than 95 % of the marine biomass. Its diversity is remarkable: viruses, bacteria, microalgae, invertebrate larvae (sea urchins, crustaceans, molluscs), small pelagic crustaceans, jellyfish, larvae of fishes.

The phytoplankton is a key element in the carbon cycle. It is omnipresent in the well-lit surface layer of the ocean and includes all the green plants, that is it uses the energy of the sun to achieve photosynthesis.

This biological process is destined to store up energy in the form of carbohydrates (sugar). It is characterised by the absorption of carbon dioxide and the release of oxygen. The ultimate result is to constitute organic matter, what we call the primary production. This is the first link in the marine food chain, which enables other organisms that are not subject to photosynthesis to feed.

The planktonic biodiversity is vital for the fishing industry. It also constitutes one of the major factors for the regulation of the world climate.

Photo: Fotolia-R. Carey

Photo: Fotolia-H. Dohnke

Marine plants, such as the Posidonia in the Mediterranean (left) and the Laminaria (right), live in shallow waters where the sunlight can penetrate. Like the phytoplankton, they use this energy to achieve photosynthesis which favours the absorption of CO_2.

THE OCEAN, MASTER OF THE CLIMATE

2/ Climate change, the impact on the ocean, its inhabitants and the littoral

“Currently, the rise in sea level is on average a little more than 1.7 millimetres a year!”

Photo: Fotolia-J. Will

The melting of the icecap has an impact on the survival of the polar bear, in search of food.

➜ THE SPECIALISTS TALK TODAY OF CLIMATE CHANGE, IN WHAT WAY IS THAT DIFFERENT FROM GLOBAL CHANGE?

Climate change is one aspect of global change.

Global change is in my view much more general. It is a subject of study that affects the whole world. It encompasses from the scientific point of view all the disciplines and at the political level all the consequences that may result from it at planetary scale, be they economic, social or environmental.
We are only talking here about climate change. Nevertheless, we must not forget that, when all’s said and done, it is global change that is the cause.

➜ WHAT WILL BE THE CONSEQUENCES OF CLIMATE CHANGE, IN PARTICULAR THE WARMING OF THE OCEAN, ON ITS INHABITANTS AND ON THE LITTORAL?

With the increase in the temperature of the ocean, the melting of the polar ice will speed up, in particular in the Arctic and in Greenland [3]. This massive input of freshwater will amplify the rise in sea level, which is already happening with the expansion of the oceans owing to the increase in temperature.

More generally, we might say that the human species, and the living world in general, have already lived through similar variations in sea level.

In France, we have observed this phenomenon during the past twenty centuries. Certain coastal areas near the sea have moved away from it. In other cases, such as Xynthia [4], irreparable damage was caused following a greater rise in the sea level under the impact of that storm.

South-eastern France, with the Camargue, for instance, and all the *Départements d’Outre Mer* (French overseas territories), will be affected.

The question is to know how we are going to manage the zones which are potentially exposed to this impact.

The responsibility of the human species is central to this issue: we have concreted over the coastal areas and because of this, the wetlands, that act as natural buffer zones, now practically no longer exist. In this way, we have introduced artificial elements, resulting in the disappearance of the know-how we have accumulated for managing the environment. And we are still incapable of modelling the future in this respect.

>>

Photo: Fotolia-natureimmortal

Photo: Fotolia-P. Devanne

The Camargue in southern France presents a topography that makes it highly vulnerable to flooding of the Rhône, since this area is very close to the sea level of the Mediterranean, with a high point at an altitude of about three metres. Despite a great deal of defensive construction work (here, the dyke at Salins-de-Giraud), it is threatened with disappearance with the rise in the water level due to climate warming.

Photo: Fotolia-dvalkyne

Forest ravaged by a violent storm. Is this the visible sign of climate warming? We should not jump to conclusions...

Photo: Fotolia-Qz Comunicación

The built-up coastline of the Costa del Sol (Spain).

>>

➔ SO WE USED TO LIVE IN HARMONY WITH THE LITTORAL, AND WE HAVE LOST THIS GOOD RELATIONSHIP, THIS NATURAL UNDERSTANDING…

Quite so, since we were living in a territory that we occupied in a way that was compatible with the system of natural balances, even if I don't particularly like that expression as it is always unstable as far as the living world is concerned…

➔ WHAT IS YOUR FEELING WITH REGARD TO CLIMATE REFUGEES SUCH AS THOSE FROM THE ATOLL OF TUVALU IN THE PACIFIC OCEAN?

Of course, it goes without saying that the islands will be seriously impacted by the rise in sea level.

I think we must take this problem into account and try to think ahead regarding the possible scenarios of what might happen.

A group of countries, islanders, are very concerned by this issue, and are lobbying at the United Nations for specific programmes to deal with this problem *(see* Tuvalu : the New Climate Refugees – *Ed.)*

➔ A REAL MOVEMENT OF SOLIDARITY AT PLANETARY SCALE ?

Yes, exactly.

>>

(3) According to the major scientific organizations, via the World Meteorological Organization (WMO), the arctic regions are undergoing a period of warming that is twice as rapid as the worldwide average.

(4) This episode of violent gales hit the west of France during the night of 27 to 28 February 2010, causing around fifty deaths, 29 of them at Faute-sur-Mer (Vendée), following the submersion of a dyke.

TUVALU
THE NEW CLIMATE REFUGEES

Tuvalu is an archipelago that has been independent since 1978, situated in the south-west of the Pacific Ocean, a thousand kilometres north of the islands of Fiji. It is particularly impacted by the rise in sea level.

Photo: Alofa Tuvalu

Composed of nine atolls, Tuvalu has an area of 26 km^2 and 11 636 inhabitants ; its warm maritime climate is characterized by a constant temperature ranging from 26 to 32° C, high humidity and abundant rainfall.

The rise in the level of the ocean has had a very serious impact on the archipelago, where the altitude is rarely higher than three metres: the floods caused by high tides, storms and typhoons are more severe and more frequent, the soil is impregnated with salt, resulting in the destruction of the vegetation (coconut palms, mangroves) and impeding any agricultural activity.

During 2007, the sea level rose by 5.6 mm on the atoll of Funafuti, or twice the average figure communicated by the Inter-governmental Panel on Climate Change [(1)].

The same phenomenon occurred on other small Pacific islands.

This irremediable situation induced by climate change has had an economic and nutritional impact. Already, a thousand inhabitants have decided to leave their native land to migrate to the islands of Fiji, New Zealand or French Polynesia. Most of them put off the decision, out of fear of losing their strong sense of identity.

(1) According to the 5th Report of the IPCC / GIEC, the mean rise in sea level was 1.7 mm/year from 1901 to 2010. But the phenomenon is speeding up.

Since the year 2000, the Tuvalu archipelago has been submerged during episodes of high tides. The Franco-Tuvalu Association Alofa Tuvalu ('Love Tuvalu') was launched in 2004 on the basis of the will to preserve the first nation threatened by submersion caused by climate change. The association has organized a range of actions to raise public awareness, in particular by showing the film: Clouds in Paradise *(Nuages au Paradis)*, which shows the increasingly difficult situation faced by the islanders. http://alofatuvalu.tv

Photo: Davidarfonjones/Wikipedia

The island of Fongafale is situated to the east of the atoll of Funafuti, Tuvalu. It measures twelve kilometres in length and only 10 to 40 metres in width.

A LOSS OF MARINE BIODIVERSITY

THE CLIMATIC DEREGULATION HAS A DIRECT IMPACT ON MARINE SPECIES BY ALTERING THEIR HABITAT, THEIR BIOLOGY AND THE COMMUNITIES TO WHICH THEY BELONG. THIS ULTIMATELY RESULTS IN THE FRAGILISATION OF THE OCEAN ECOSYSTEM.

The rise in temperature of the seawater induces different behaviour patterns, according to the species: some adapt to the variations; others migrate towards the poles or towards regions that are more favourable for their development; others disappear, such as certain corals that have already been affected by acidification, pollution, and fishing.

The acidification of the ocean has a direct impact on marine organisms which have a calcareous skeleton or shell: phytoplankton, crustaceans, molluscs, corals, etc.

Exceptional climatic events (storms, typhoons, etc.) deplete the natural environment, for example through erosion and flooding. They alter the conditions of marine life in the littoral zone: mangroves, seagrass beds, and so on.

The combined impact of these factors linked to climate change causes a loss of biodiversity, since:

- they deplete the food resources of human populations, mainly those of developing countries, given that fish is the basic source of protein for tens of millions of inhabitants of the planet;
- they deplete the resources in genes and, in consequence, in molecules that are of high potential value for medical research and for industry.

The accumulation of these multiple changes in marine ecosystems aggravates the vulnerability of the ocean in the face of climate change, and they are not sufficiently taken into account.

Photo: Fotolia-Rawpixel

Stilt fishing, a tradition in Sri Lanka. The fishers swim out twice a day to fish on two-metre stilts 20 metres from the shore.

Photo: Fotolia-gerrod

The United Nations Food and Agriculture Organization (FAO) prediction is that climate change will have a profound impact on fishing and aquaculture, with far-reaching consequences for food safety for certain populations.

THE OCEAN, MASTER OF THE CLIMATE

3/ Solutions derived from the ocean to combat climate change


Photo: A. Riva


Photo: A. Riva

Partial view of Zakynthos National Park (Greece). Founded in 1999, the park includes breeding grounds of the Loggerhead sea turtle, Caretta caretta. *This system of protection covers terrestrial and marine components of the coastal zone for the purposes of sustainable management.*

➜ CAN THE OCEAN PROVIDE THE MEANS TO COMBAT CLIMATE CHANGE OR EVEN PROVIDE SOLUTIONS BASED ON MODES OF DEVELOPMENT AND WAYS OF LIFE THAT ARE MORE SUSTAINABLE FOR THE PLANET?

Apart from problems that have still to be identified regarding carbon or the best way to manage the coastal areas, I think the ocean can contribute to the maintenance of optimal biodiversity in order to conserve the capacity of ecosystems to regulate climate change. This will require the setting up of Marine Protected Areas (MPA) and developing them in the high seas [5] within a suitable legal framework.

The intelligent management of marine food resources, in particular fishing, is another necessity.

The exploitation of renewable marine energy systems (offshore wind turbines, underwater marine current turbines, swell or wave energy systems, etc.) could result in the reduction of emissions into the atmosphere of the polluting gases that are directly linked to climatic deregulation.

I think too that with regard to the future, that is at the scale of half a century, we have become aware of the finite nature of the territorial space occupied by our societies.

If there is still something to be done, something to take into account in rethinking another kind of society for the future, it is the ocean. This is a new space that we have not yet occupied as societies.

I'm not saying that that's what we must do, but in any case that is one direction in which we could imagine a new kind of society.

>>

(5) The six High Seas Marine Protected Areas cover a total area of 285 000 km², along and on either side of the mid-Atlantic ridge. It is a real ecological network set up in 2010 by the OSPAR Commission (source / find out more: aires-marines.fr).

> *"If there is still something to be done, something to take into account in rethinking another kind of society for the future, it is the ocean."*

>>

➜ WE HAVEN'T GOT A SECOND PLANET, BUT THE OCEAN MIGHT SOMEHOW OFFER US A SECOND CHANCE...

Absolutely.

➜ ...AND IT'S PRECISELY TO HIGHLIGHT THE INDISSOLUBLE LINK BETWEEN OCEAN AND CLIMATE THAT THERE IS NOW A PLATFORM ORGANIZED BY UNESCO... WHAT DO YOU THINK MIGHT BE ACHIEVED BY THIS ACTION, AND MORE BROADLY, BY THE WORLD CLIMATE CONFERENCE?

The *Ocean & Climate Platform* is focused on three very important fields of action:

- the first is to get it generally accepted that the ocean is a dimension that must be taken into account by all the human beings on the planet;

- the second is to see what knowledge can achieve in this regard in order to better understand the relation between climate and ocean, which to date are observable, I would say, from the point of view of the statistics rather than the mechanics;

- finally, it is a matter of mobilising among the political leaders a general raising of awareness, in such a way that we will have the right discourse to negotiate and achieve recognition for the ocean at international level by the United Nations.

➜ TO CONCLUDE THIS INTERVIEW, WHAT WOULD YOU DO FOR THE FOLLOW-UP TO THE COP21 ADVENTURE?

What I'm going to say is rather ambitious. It was a long road to set up the Intergovernmental Panel on Climate Change (IPCC), otherwise known as the Intergovernmental Group of Experts on Climate Change (GIEC).

It was another long road to achieve the foundation of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

I think we should endow the ocean with the equivalent of these international organizations, which would offer it a platform at international and planetary level. ■

Report written and edited by
Christian Frasson-Botton and Alain Riva

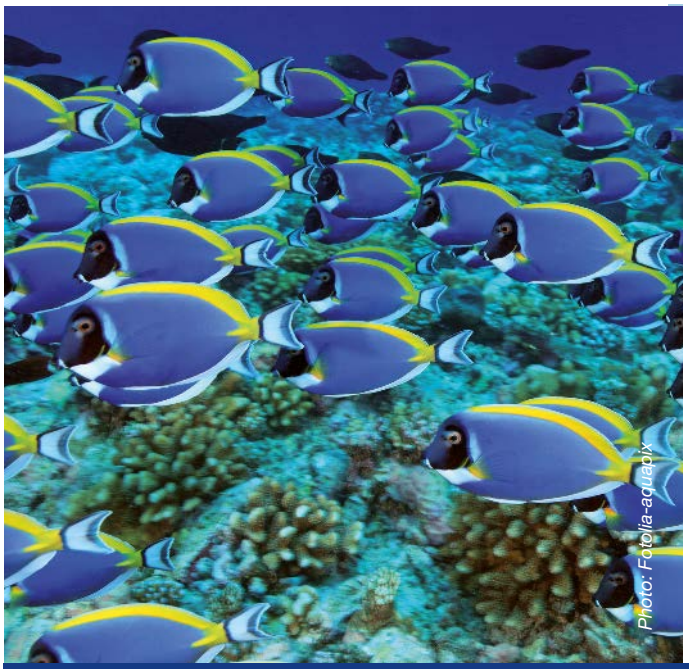


Photo: Fotolia-aquapix


Photo: Fotolia-A. de tomas

To combat the impact of climate change is to preserve the biodiversity (here, a shoal of surgeon fish Acanthurus leucosternon*), to combat the over-exploitation of living resources, to develop renewable energies.*

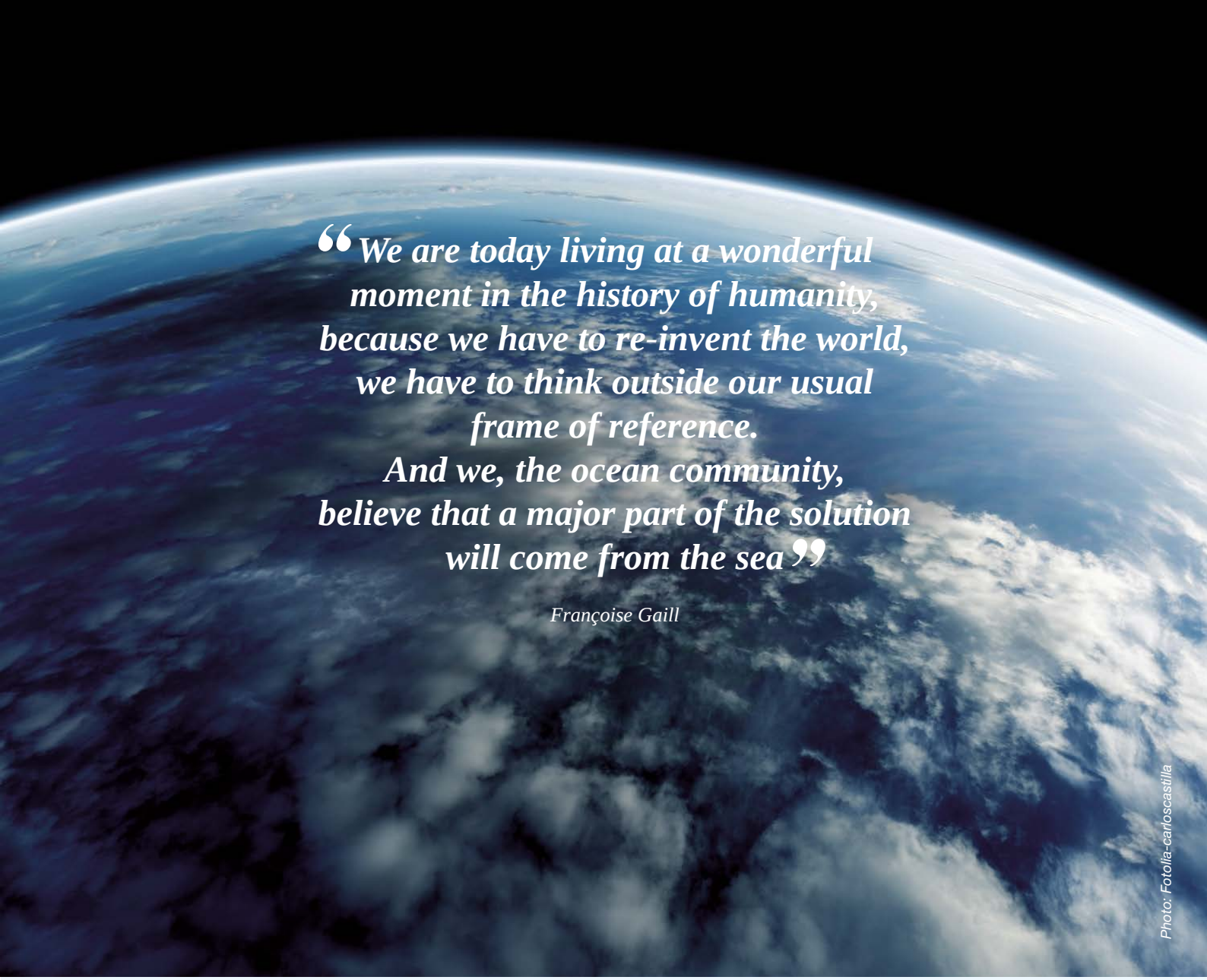


Photo: Fotolia-carloscastilla

MAKING THE VOICE OF THE OCEAN HEARD

The initial goal of the *Ocean & Climate Platform* was to integrate the ocean within the climate negotiations at the World Climate Conference (COP 21) [1]. The Platform includes major NGOs, research, protection of nature and awareness-raising organizations, including the Paul Ricard Oceanography Institute.
In 2015, Catherine Chabaud was the Platform's ambassador and Dr Françoise Gaill the scientific coordinator.

(1) Paris, 30 November to 11 December 2015.

FOUNDER MEMBERS

Agence Française des Aires Marines Protégées (MPA French agency); *Association Innovations Bleues*; CNRS; French Committee of the International Union for the Conservation of Nature; Green Cross France and Overseas Territories; *Fondation Prince Albert II de Monaco*; *Institut Océanographique - Fondation Albert Ier Prince de Monaco*; *Institut du Développement Durable et Relations Internationales*; *Institut de l'Ecologie et Environnement*; Paul Ricard Oceanography Institute; NASF; *Nausicaá-Centre national de la Mer*; The Pew Charitable Trusts; MEDPAN ; World Ocean Network; Surfrider Foundation Europe; Tara Expeditions; COI-UNESCO.

Photo: C.F.-B

Dr Françoise Gaill, Coordinator of the Scientific Committee of the Ocean & Climate Platform *(left) and Patricia Ricard, President of the Paul Ricard Oceanography Institute, present the Ocean & Climate fact sheets published to raise awareness and inform the general public.*

www.ocean-climate.org

THE
NEWSLETTER
N°14 - 2015


Photo: Fotolia-Artketype

The Mediterranean, the 'sea in the midst of the land', is often referred to as a hotspot of climate change.

The Mediterranean is getting warmer

"FOR FIFTEEN YEARS OR SO, THE HYPOTHESIS THAT THE WATERS OF THE MEDITERRANEAN MAY BE IN THE PROCESS OF WARMING UP HAS BEEN BACKED BY A SERIES OF PHYSICAL AND ECOLOGICAL OBSERVATIONS...

OVERALL, THE AVAILABLE RESULTS CONFIRM THE HYPOTHESIS OF THE WARMING OF THE COASTAL WATERS OF THE WESTERN MEDITERRANEAN AT A RATE THAT IS PROBABLY FASTER THAN IT WAS A FEW DECADES AGO".

This observation by Professor Lucien Laubier [(1)] in 2003 is supported by the opinion of the CIESM [(2)], in 2008, but there remains considerable uncertainty regarding the patterns of change in the marine populations under the impact of increases in carbon dioxide (CO_2), in the acidification of the waters and in the temperature.

The contribution of the Paul Ricard Oceanography Institute

The Paul Ricard Oceanography Institute has for half a century been located on the island of Les Embiez (near Toulon, SE France), in the French western Mediterranean.

Since 1990, the research programmes undertaken have shown the Institute's strong commitment to the issues of climate change. What conclusions can we draw from these observations and investigations regarding certain disturbances of the marine environment ?

• Confirmation regarding the impact of a rise in temperature:
- this has a negative effect on certain organisms such as the red gorgonians (see photo), sea squirts and sponges;
- it results in the proliferation of microorganisms. For example, for fifteen years or so, we have observed the occurrence of tropical microscopic algae of the genus Ostreopsis, near Marseille and Toulon, which is strongly linked to the high summer temperatures; and which cause irritation of the respiratory tract.
- it favours the northerly extension of the range of distribution or breeding grounds of certain fish species: ornate wrasse, barracuda, zebra seabream. The breeding of the dusky grouper now takes place in the north of the western Mediterranean basin.

• More knowledge concerning the response of the phytoplankton to a two-fold increase in atmospheric carbon dioxide:
- from the qualitative and quantitative points of view; regarding its effectiveness in fixing CO_2 and the stability of the pH. These findings have resulted in the development of a simulation model of the dynamic of communities, providing a basis for testing various situations.

• Questions regarding the possible appearance of emergent pathogenic agents, partly related to the rise in temperature, which have a potential impact on the animal populations, organisms of economic interest (shellfish, fishes), or even human populations.

Dr Yvan Martin
Director of Research, Paul Ricard Oceanography Institute, 1995 - 2012

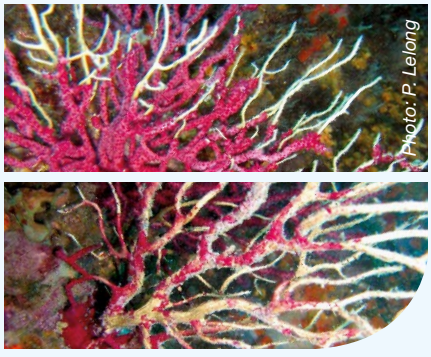


Photo: P. Lelong

In the red gorgonian, necroses may appear above a certain water temperature. If the parts affected are very extensive, the colony may die.

(1) Laubier et al, 2003, Mar. Life, vol.13.
(2) Workshop n°35, 2008 : "Climate warming and related changes in Mediterranean marine biota."

Printed on 100 % recycled paper. IMPRIM'VERT

INSTITUT PAUL RICARD OCÉANOGRAPHIQUE
www.institut-paul-ricard.org