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INSTITUT PAUL RICARD OCÉANOGRAPHIQUE

THE NEWSLETTER

DOSSIER

THE CLIMATE'S ALLY

BLUE CARBON

The breath of the Ocean...

N°17 - 2019


Ph. DR

OCEAN, CLIMATE, BIODIVERSITY

A vital triangle for the future

We know today that 50 % of the oxygen available on the planet comes from the Ocean; the international climate experts of the IPCC have written a special report on the ocean and the cryosphere.

The Ocean and the climate are now at the core of negotiations in the major international conferences, and the importance of their interactions is unequivocal … But to achieve our vital goal of reducing CO_2 emissions, combating the climate disruption for which we are responsible, we will have to speed up the changes in our practices and place sustainable innovation at the core of our actions.

It is essential that the living world should be at the centre of our concerns, since it is marine and terrestrial biodiversity which will enable us, to cite the fine expression of Emmanuel Delannoy, to reconcile the technosphere and the biosphere upon which we are dependent.

What is more, we must bear in mind the functions of the ecosystems that are vital for the survival of human societies, such as the production of the oxygen in the air, the natural filtering of the water and the capability to store atmospheric carbon. This is what we call the blue carbon absorbed by the marine ecosystems, and more particularly those of the shallow coastal waters, such as the *Posidonia oceanica* seagrass meadows, the coral reefs, the mangroves and the tidal salt marshes. There are studies in progress to also assess the action of the plankton.

We must change our perception of biodiversity and no longer think of it as a negative issue but as a source of positive solutions.

With the emergence of solutions based on nature, the Ocean has pride of place as the fundamental ally in the adaptation to climate change and the mitigation of its impact. This is what leading scientists explain in our dossier. They share their expertise and their vision regarding blue carbon to unveil its mechanisms, and also to analyse its strategic and financial importance.

To preserve and to protect the Ocean means to enable it to continue to fulfil its essential function as the breath of life of the planet. It also means conserving the marine biodiversity, which is the source of... blue carbon.

More than ever, our future is embedded in the fragile triangle of the interactions between Ocean, climate and biodiversity, upon which the natural equilibrium of the planet, and therefore our societies, are dependent.

To conclude, I would like to express my gratitude to all the personalities and experts, and in particular those of the Ocean and Climate Platform, who have taken the time to share their knowledge in the hope of awakening our consciences.

Patricia Ricard
President of the Institut Océanographique Paul Ricard

INSTITUT OCÉANOGRAPHIQUE PAUL RICARD
The Newsletter
N°17 - 2019

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Cover - Posidonia oceanica *meadow: the long leaves are strongly exposed to the sunlight. (Photo: Adobe Stock/R. Carey).*

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Blue carbon, the breath of the Ocean…

INTERVIEW WITH LAURENT BOPP
Director of Research CNRS (French National Scientific Research Centre) at the Laboratoire de Météorologie Dynamique (LMD, Laboratory of Dynamic Meteorology), Institut Pierre-Simon Laplace (IPSL), Paris

Interview at the *École Normale Supérieure de Paris*, in the *Quartier Latin*. All the expertise and the teaching skills of a senior academic to make a complex subject more accessible: the carbon cycle and the Ocean-Climate interactions.

> *"We have really messed up the climate and Ocean system"*

INTERVIEW WITH DOROTHÉE HERR
Manager, Oceans and Climate Change, Global Marine and Polar Programme, International Union for the Conservation of Nature (IUCN)

In Paris, a meeting with a scientist from Germany who is pursuing her planetary pathway in support of the battle against climate change, in particular through blue carbon. A discourse that is convincing, sometimes militant, in the best sense of the word.

> *"To encourage better management of coastal ecosystems by an array of policies concerning climate change and financial incentives"*

INTERVIEW WITH CHLOË WEBSTER
Scientific consultant for the marine environment

Interview at the island of *Les Embiez* (south-eastern France) with a Mediterranean specialist, an experienced actor in the Marine Protected Areas managers network *MedPAN*. A point of view that is well-researched and committed, a focus on blue carbon and its importance in a mini-ocean.

> *"In the Mediterranean, the Marine Protected Areas are key management tools for the preservation of biodiversity and one of our responses to climate change"*

Ph. DR

"WINNING THE BATTLE FOR THE CLIMATE"

This is the appeal launched (*) by the Secretary General of the United Nations, Antonio Gutterres, in support of the anger of students and school children in a hundred countries. They were all out in the street demonstrating on 15th March 2019 to demand urgent action against climate change.

"Despite the years of discussions […]," says Antonio Gutteres regretfully, *"the sea level is rising, the coral reefs are dying, and we are beginning to see the deadly impact on human health whether from air pollution, heatwaves or the risks for food safety".*

A Climate Action Summit
23 September 2019, New York

"Fortunately", he goes on, *"we have the Paris Agreement, a trailblazing framework that is effective and focused on the future, which spells out exactly what must be done to put an end to climate disruption and to reverse its impact".*

The Secretary General of the UN visited the South Pacific, including Tuvalu (photo), to highlight the destructive impact of climate change in certain regions: the rise in sea level and extreme meteorological phenomena contributing to the flooding of low-lying areas. This visit was undertaken in preparation for the Climate Action Summit.

Ph. AdobeStock/Dmitry

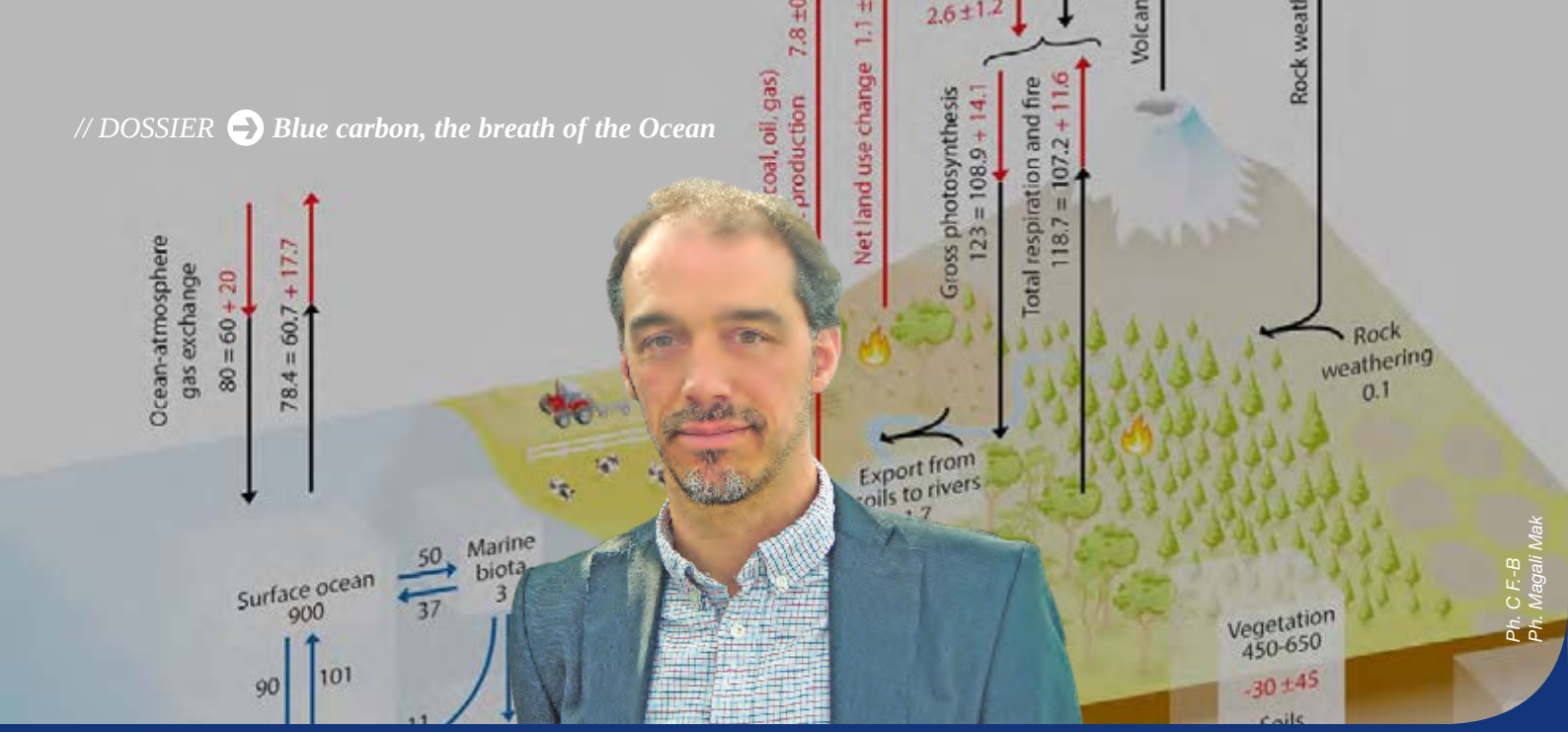
But according to Antonio Gutterres, we must *"imperatively"* go faster and go further, to give a new breath of life to this universal agreement from 2015 so as to beef up our strategies to achieve the goals that were fixed, and be more ambitious in our actions for the climate.

So the Secretary General of the UN has invited heads of state, leaders from the world of business and civil society to take part in a Climate Action Summit on 23 September 2019 in New York.

Ambitious solutions already exist: the reduction of greenhouse gas emissions, the development of renewable energies, ways of mitigating the impact of climate change, in particular through nature-based solutions. All these issues will be on the table in the discussions at the UN, and most of them are topics that are dealt with in the Blue Carbon dossier of this *Newsletter.*

"I know that the young can change the world, and that they're already doing it" […], concluded Antonio Gutterres. *"The more I see you taking a stand and defending your convictions, the more convinced I am that we shall end up winning the battle."*

(*) In a column in the French paper Le Monde *(20 March 2019).*



Ph. C.F-B
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INTERVIEW WITH

LAURENT BOPP

Director of Research CNRS at the Laboratoire de Météorologie Dynamique (LMD) (Laboratory of Dynamic Meteorology), Institut Pierre-Simon Laplace (IPSL), Paris.

> *"We've really messed up the climate system and the Ocean"*

ALL ABOUT CARBON…

1 /
CARBON EXCHANGES ON OUR PLANET: A COMPLEX CYCLE IN UNSTABLE EQUILIBRIUM

2 /
UNBRIDLED HUMAN ACTIVITY AND DEEP DISRUPTION OF THE OCEAN SYSTEM: ACIDIFICATION, CLIMATE CHANGE

3 /
SOLUTIONS TO MITIGATE CLIMATE CHANGE AND TO ADAPT TO IT

CAREER
LAURENT BOPP

Laurent Bopp defines himself as a climatologist and oceanographer. "*I am interested in the role of the Ocean in the climate system, climate change and in particular, the carbon cycle.*"

In 1990, this young man from Strasbourg was 16, and one event was to shape his destiny: the publication of the first Report by the Intergovernmental Panel on Climate Change (IPCC)[1]. "*I had this document in my hands, and I said to myself that this was the topic I wanted to work on.*"

In 1994, Laurent Bopp was admitted to the prestigious *École Normale Supérieure de Paris*, where he graduated in geosciences and geophysics four years later. "*From internship to internship, I specialised in oceanography and I worked for a PhD on the interactions between Ocean and climate.*"

After a PhD in Sciences of the Environment, defended in 2001 at the *Laboratoire des Sciences du Climat et de l'Environnement* (Laboratory of Climate and Environmental Sciences), Paris 6 University, Laurent Bopp opted to go abroad for his post-doctoral studies: in Germany *(Max-Planck-Institut für Biogeochemie, Jena)*,

in the United Kingdom (University of East Anglia, Norwich), "*And then, in 2003, I managed to get a post as Researcher in the laboratory where I'd done my PhD, in the Paris area.*"

In 2016, Laurent Bopp went back to the *École Normale Supérieure de Paris*, but this time to set up a research group on Ocean and Climate and to take up a post as Associate Professor.

Laurent Bopp is currently Director of Research CNRS at the *Laboratoire de Météorologie Dynamique* (LMD) (Laboratory of Dynamic Meteorology) at the *Institut Pierre-Simon Laplace* (IPSL), Paris. He is a member of several French and international committees, and has participated in the drafting of the latest report by the Intergovernmental Panel on Climate Change (IPCC).

His work is focused on the study of the carbon cycle in the Ocean. His main speciality is the modelling of the interactions between marine biochemistry and the climate system, studying in particular the fate of atmospheric gases such as carbon dioxide and oxygen.

Laurent Bopp's research findings have been used in all the recent estimates of carbon sinks and are of major importance for understanding and predicting patterns of change in greenhouse gases, and the processes of acidification of the seawater.

"*I think*", he pointed out, "*that today, we are more aware of the complexity of the ocean system. To understand the carbon cycle in the Ocean, for example, we have to try to understand the oceanic patterns of circulation, the chemical reactions which involve the carbon molecules... and the influence of living organisms.*

The biological system is absolutely fabulous: from the really very small to the large organisms at the very top of the food chain.

We had the impression that the volume of the Ocean was so great that human action couldn't really disturb it. But that isn't the case. The Ocean is impacted by Mankind at the surface, at depth, near the coasts. The physics, the chemistry, the biology are changing.

I think we have learned a great deal about the Ocean, but there is still a lot to learn."

Laurent Bopp is the author and co-author of more than 180 scientific publications in international journals. He has also written several scientific books for the general public [2].

(1) This first IPCC Assessment Report (1990) led the United Nations General Assembly to draw up the Framework Convention recognising the existence of climate change linked to human activities. Laurent Bopp is one of the contributors to the chapter: 'Carbon and Other Biogeochemical Cycles', in the 5th IPCC Report.

(2) Les poissons vont-ils mourir de faim (et nous avec) ? – Paris, Le Pommier, 2010 –, and *Les dessous de l'océan* – Paris, Le Pommier, 2012..

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Ph. Adobe Stock/tsuneomp

No doubt about it, seen from a satellite, the Earth fully deserves its name 'Blue Planet'. Protected by a gaseous envelope, life has developed there in a myriad of forms, thanks in particular to the omnipresence of an abundant element, carbon.

1/ Carbon exchanges on our planet: a complex cycle in unstable equilibrium

➔ WHAT WAS THE ORIGINAL ROLE OF CARBON ON EARTH? WHAT FORM DID IT TAKE?

Carbon is found more or less everywhere on our planet:

- in the bodies of living organisms: it is one of the atoms that compose most of the organic matter which we are made of;

- in the atmosphere, in the Ocean, on the surface of the Earth, within it – soils and sub-soils – , and extensive exchanges of gases occur between all these components of System Earth [see page 10: *Carbon cycle – Main fluxes and sinks at the scale of the Planet*].

We have taken a particular interest in carbon for the last few years because carbon dioxide (CO_2) – the main form of carbon in the atmosphere – is a greenhouse gas which has a strong impact on the climate.

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> *“ The variations in the emissions and storing of carbon have a determining effect on the overall patterns of change in the climate ”*

Ph. Adobe Stock/willyam

Curiously, in one image, the continental and oceanic biospheres meet. But it is just an artifice of Nature. The elephants of the Andaman Islands in the Indian Ocean can swim. Using their trunks as a snorkel, they can cover a distance of three kilometres to reach the forestry logging sites. This activity was banned 15 years ago to protect the archipelago, and the elephants are no longer used.

Ph. Adobe Stock/valerie

The cryosphere designates the parts of the Earth's surface where water appears in its solid state: the sea ice, mountain glaciers, continental snow and polar ice cap: here, in the Antarctic. These tens of millions of square kilometres play a role in the climate and bear witness to current and past patterns of change.

Measuring the depth of the snow in Nunavik, an Arctic region of Quebec. The snow cover has a direct impact on the temperature of the permafrost, the soil that has been frozen for thousands of years. As it thaws under the effect of climate warming, the permafrost (photo above) releases into the atmosphere carbon dioxide and methane, two powerful greenhouse gases. *(Ph. L. Cailloce/Takuvik/CNRS Photothèque / Ph. Erwan AMICE / LEMAR / CNRS Photothèque)*

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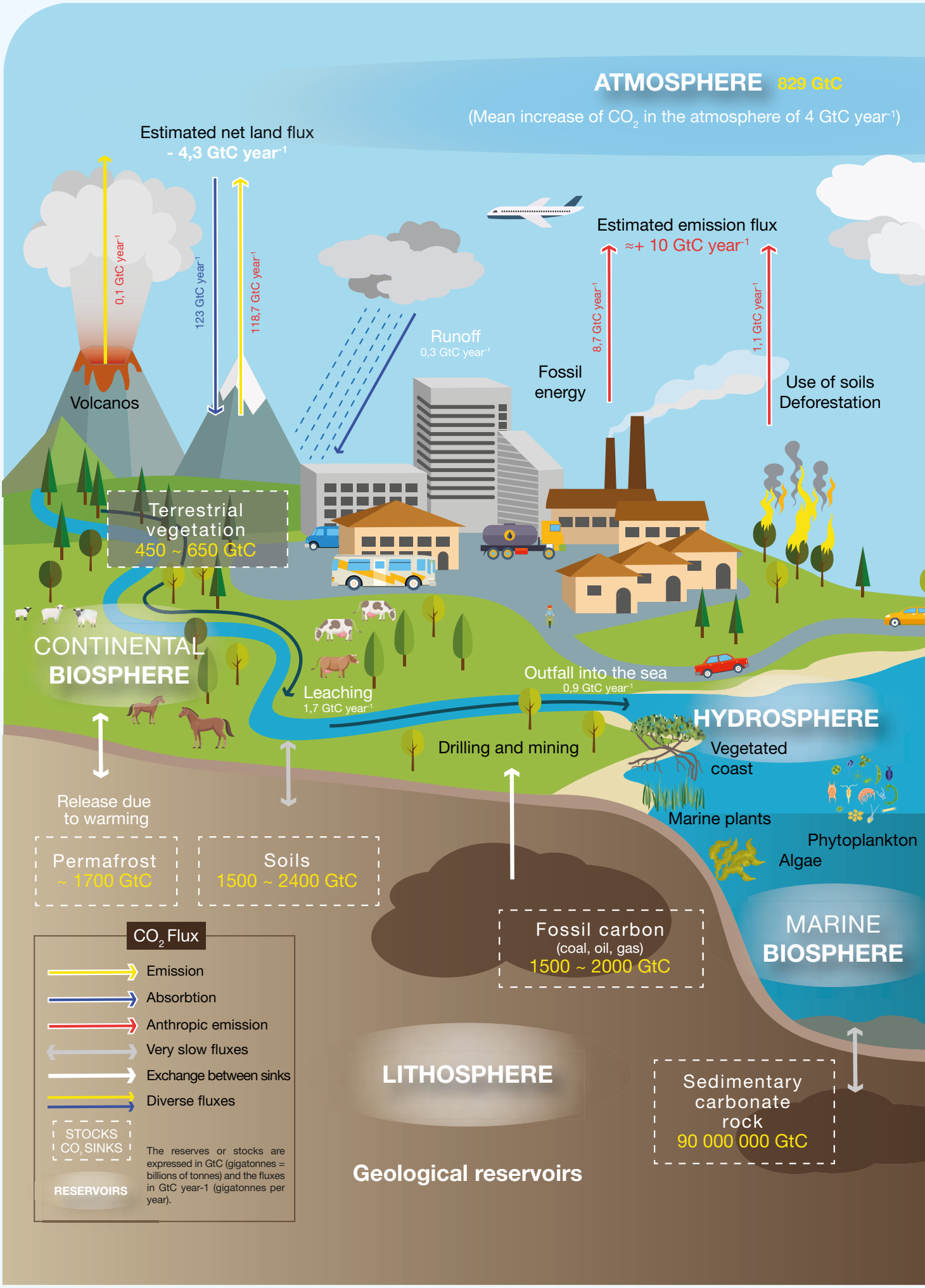
The sedimentary rocks can contain marine fossils (here, trilobites). They reveal organisms that inhabited the environment at the time when the rocks were formed.

Ph. Adobe Stock/lead72

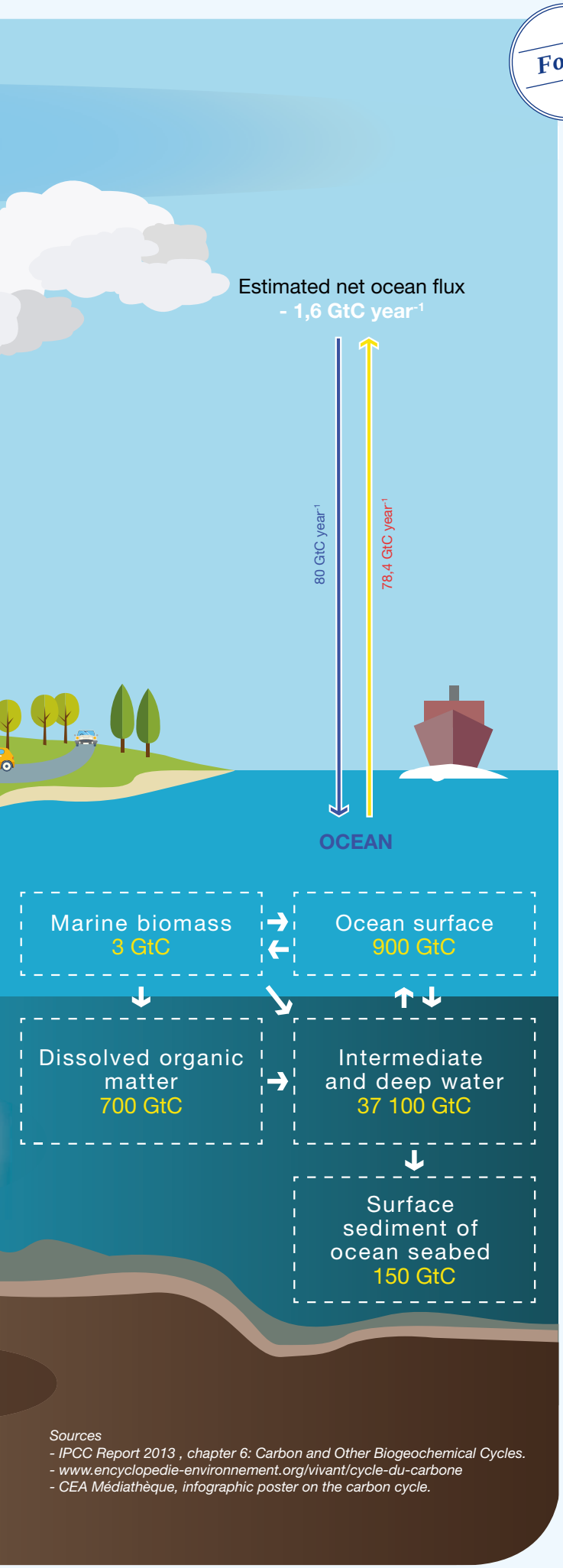
The oceanic biosphere plays a major role in the production of atmospheric carbon dioxide.


ATMOSPHERE 829 GtC
(Mean increase of CO_2 in the atmosphere of 4 GtC year^{-1})
Estimated net land flux
- 4,3 GtC year^{-1}
0,1 GtC year^{-1}
123 GtC year^{-1}
118,7 GtC year^{-1}
Volcanos
Runoff
0,3 GtC year^{-1}
Estimated emission flux
≈+ 10 GtC year^{-1}
8,7 GtC year^{-1}
1,1 GtC year^{-1}
Fossil energy
Use of soils Deforestation
Terrestrial vegetation
450 ~ 650 GtC
CONTINENTAL BIOSPHERE
Leaching
1,7 GtC year^{-1}
Outfall into the sea
0,9 GtC year^{-1}
HYDROSPHERE
Drilling and mining
Vegetated coast
Marine plants
Phytoplankton
Algae
Release due to warming
Permafrost
~ 1700 GtC
Soils
1500 ~ 2400 GtC
Fossil carbon
(coal, oil, gas)
1500 ~ 2000 GtC
MARINE BIOSPHERE
CO_2 Flux
Emission
Absorbtion
Anthropic emission
Very slow fluxes
Exchange between sinks
Diverse fluxes
STOCKS
CO_2 SINKS
RESERVOIRS
The reserves or stocks are expressed in GtC (gigatonnes = billions of tonnes) and the fluxes in GtC year-1 (gigatonnes per year).
LITHOSPHERE
Sedimentary carbonate rock
90 000 000 GtC
Geological reservoirs

Focus

CARBON CYCLE

MAIN FLUXES AND SINKS AT THE SCALE OF THE PLANET



Sources
- IPCC Report 2013 , chapter 6: Carbon and Other Biogeochemical Cycles.
- www.encyclopedie-environnement.org/vivant/cycle-du-carbone
- CEA Médiathèque, infographic poster on the carbon cycle.

On Earth, carbon takes various forms in external envelopes known as reservoirs: the lithosphere, the hydrosphere, the biosphere and the atmosphere. Carbon fluxes occur between these reservoirs and the carbon 'travels', so it is in perpetual movement and circulates from one reservoir to another. This is what we refer to as the carbon cycle.

FOUR RESERVOIRS

• **The lithosphere** – soils and sub-soils – is the main carbon reservoir in terms of quantity. It appears mainly in mineral form in the sedimentary rocks, but also in organic form in the fossil carbonaceous rocks: oil, gas and coal.

• **In the hydrosphere** – seas, oceans, lakes and rivers – carbon is mainly present in the form of molecules dissolved in the water, often in the form of ions (carbonate or bicarbonate ions).

• **The biosphere** – continental or oceanic – includes the plants, the animals and other living organisms, as well as decomposing organic matter.

• **The atmosphere** is a layer of gas enveloping the terrestrial globe which, in the part closest to the surface of the Earth, constitutes the air which living beings breathe. Composed essentially of oxygen and nitrogen, it also contains carbon in the form of carbon dioxide.

The carbon dioxide content only represents 0.04% of the total volume, with a very strong increase over the past decades because of human activity.

Carbon fluxes circulate from one reservoir to another according to biological, physical and chemical processes.

SOURCES AND SINKS

When they release carbon, these reservoirs are sources: for example, factories using fossil fuels emit into the atmosphere smoke composed among other things of carbon dioxide. In contrast, the plants, which, in the presence of light, absorb carbon from the atmosphere, are considered as sinks.

Most of the carbon cycle occurs between the atmosphere, the surface layers of the Earth and its interior, the Ocean and the biosphere.

Living beings play an active role in exchanges of carbon between the reservoirs, by means of complex mechanisms such as respiration, photosynthesis and also the decomposition and fermentation (*) of organic matter. All these mechanisms produce carbon dioxide, which is concentrated in the atmosphere and the hydrosphere.
By breathing, the French emit into the atmosphere every second more than 600 kilos or carbon dioxide, or about 20 million tonnes a year. (**)

The processes of concentration of carbon act together at various time scales: from a decade for the recycling of carbon dioxide by plants to hundreds of years for the formation of sedimentary rocks (limestone) or reserves of fossil fuels.

(*) *The decomposition of organic matter is a reaction of oxidation by microorganisms, which produces carbon dioxide and energy. Fermentation tends toward the same result but occurs in an oxygen-free medium.*

(**) *From* planetoscope.com

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➜ WHAT ARE THE MAIN MECHANISMS IN EXCHANGES OF CARBON WITH THE ATMOSPHERE?

At the short timescales which interest us, it is above all the continental biosphere and the Ocean which exchange carbon with the atmosphere [see page 10: *Carbon cycle – Main fluxes and sinks at the scale of the Planet*].

The exchanges of gases with the living organisms on the various continents are linked to biological processes. They correspond to respiratory phenomena: respiration and photosynthesis for plants and respiration in animals (3) [see opposite: *Photosynthesis – A highly sophisticated natural mechanism*].

Terrestrial and marine plants, the artisans of photosynthesis. Seen here in the Brusc lagoon (Var, south-eastern France).

Between the atmosphere and the continental biosphere, there develops a process of continuous and very intensive exchanges of carbon dioxide and oxygen.

In the Ocean, it’s a little more complicated.

Photosynthetic marine organisms, such as algae and phytoplankton, photosynthesize and breathe – marine animals also breathe. There are thus similar exchanges to those of the terrestrial biosphere. But in addition, important physical exchanges - continuous and fairly rapid - occur at the atmosphere - Ocean interface.

The carbon dioxide in the atmosphere is dissolved in the surface waters. And then, depending on its concentration, the atmospheric pressure, the temperature and the water turbulence, part of this gas goes back into the atmosphere.

At global scale, scientists are beginning to have a fairly accurate idea of this pattern of distribution of the carbon in the system composed of the atmosphere, the Ocean and the continental biosphere [see page 10: *Carbon cycle – Main fluxes and sinks at the scale of the Planet*].

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(3) This physiological process enables animals to develop their metabolism, that is to say all the mechanisms of nutrition and cellular development.

Focus

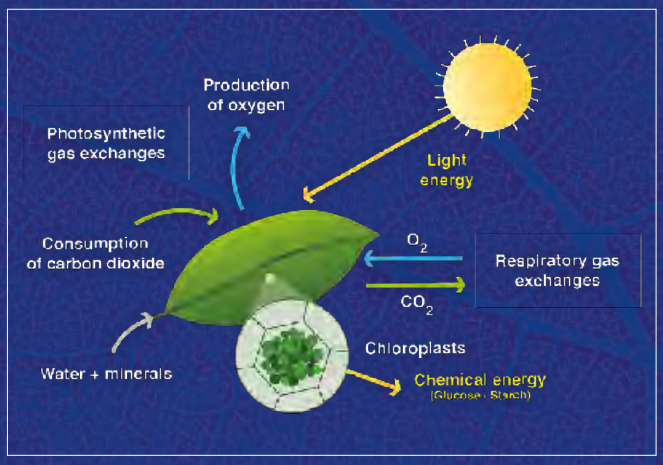
PHOTOSYNTHESIS
A HIGHLY COMPLEX NATURAL MECHANISM

The leaves of green plants are the site of a biological process that is essential to the development of life on our planet: photosynthesis (from the Greek *phos*, light, and *synthesis*, putting together).

In the cells of leaves are found the chloroplasts, which contain a green pigment - chlorophyll. This is able to uptake the light energy from the sun to transfer it into chemical energy.

The chloroplasts then combine the carbon dioxide absorbed in the atmosphere with water and minerals derived from the soil to produce sugars, themselves stored in the plant in the form of starch.

Thus, photosynthesis is a complex biochemical reaction enabling chlorophyll-containing plants to uptake the light energy, to transform the atmospheric carbon dioxide into organic carbon which is vital for them (*) and to restore oxygen to the atmosphere (*see schema*).



Green plants take up - mainly via their leaves (**) – the carbon and the oxygen necessary for the cellular metabolism and for the production of organic molecules such as carbohydrates. Like all living organisms, they breathe, that is to say they uptake oxygen (O_2) and emit carbon dioxide (CO_2) into the medium in which they live.

In the presence of light, chlorophyll-containing plants continue to breathe, but this phenomenon is counterbalanced by another more important process – photosynthesis – where the exchanges of gas are reversed: absorption of carbon dioxide and emission of oxygen.

Quantitatively, photosynthesis predominates over the normal respiration of plants, which thus sequester carbon.

THE EARTH "BREATHES" THANKS TO PLANTS

Plant life on Earth is not static, it varies over the seasons.

Monitoring the monthly mean of carbon dioxide concentrations in the atmosphere shows a sinusoid curve with an increasing trend.

This annual variation reflects the absorbtion and emission of carbon dioxide in the atmosphere. In the spring and summer, during the period of maximum plant growth, the dominant flux is the absorption of carbon dioxide by the vegetation, whereas in autumn and winter the dominant flux is that of the decomposition of dead plants, the respiration of plants and of microorganisms.

Since 1997, NASA has been continuously scrutinising by satellite the plant life on land and sea, showing the effect of the seasons on our planet.

Thanks to a fascinating animation, we can follow in a few minutes the seasonal variations in the photosynthesis performed by the plants and the phytoplankton. (***)

"It is the Earth which 'breathes' each day, alters with the seasons, responds to the solar exposure, the changing wind patterns, the ocean currents and the variations in temperature", notes Gene Carl Feldman, an oceanographer at NASA's Goddard Space Flight Center, Maryland, USA.

Breathing experimental chamber of a Zostera noltii *seagrass meadow in the gulf of Banc d'Arguin (Mauritania). The aim? To measure the oxygen production and the carbon dioxide flux. More broadly, the aim of the PACOBA project is to enhance our knowledge of the biocenoses - the plant and animal populations - of this coastal region.*

(*) The plants and chlorophyll-containing organisms, like the cyanobacteria, are referred to as autotrophs, since they are able to generate their own organic matter from mineral elements. For that, they use light energy by photosynthesis or, in rare cases, by chemosynthesis. By contrast, heterotrophic organisms – bacteria, animals, including humans – can only make their own organic matter from that generated by other organisms: autotrophic plants for the herbivores; animals for the carnivores, insectivores, piscivores, necrophagous species.

(**) Apart from a few arid zone plants such as cactuses and Euphorbiaceae in which exchanges of gases occur via the stem.

(***) To view the animated film: www.nasa.gov/feature/goddard/2017/the-changing-colors-of-our-living-planet.

2/ Unbridled human activity and deep disruption of the Ocean system: acidification, climate change

➜ IN THE NATURAL STATE, IS THE CARBON CYCLE IN EQUILIBRIUM? IF SO, THROUGH WHAT PROCESSES?

This is a complicated question, which depends a lot on the timescales considered.

When they are very long – for example, the history of Planet Earth over the past several billion years – we know that the concentration of carbon dioxide in the atmosphere has progressed continuously.

We may also observe phases during which the concentrations were very high – at the time of the brutal extinction of the dinosaurs [4], for example – and periods when they were much lower. So there is no equilibrium at those timescales.

We hypothesise nonetheless that before human-generated disruptions, the concentrations of carbon dioxide in the atmosphere were more or less in equilibrium [5], with continuous exchanges between the Ocean and the continental biosphere.

Ph. Adobe Stock/Zacarias da Mata

> *"Ten billion tonnes of carbon, in the form of carbon dioxide, is emitted every year into the atmosphere"*

➜ WHAT DO YOU MEAN BY "HUMAN-GENERATED DISRUPTIONS"? HOW DID THE CARBON CYCLE BECOME DISRUPTED?

The carbon cycle became disrupted because we - the human race - use oil, coal and gas, and when we exploit these fossil fuels, a combustion reaction emits carbon dioxide into the atmosphere. Which has been done since the Industrial Revolution in the period 1750 – 1800 [6], and at an ever-increasing rate. Today, up to 10 billion tonnes of carbon, in the form of carbon dioxide, is emitted every year into the atmosphere.

These human-generated emissions have increased constantly over the past years, despite the alarmist discourse of the climatologists, the recommendations of the Paris Agreement on the climate [7] and a certain number of decisions.

Since the Industrial Revolution, human-caused emissions of greenhouse gases have been constantly on the increase.

Ph. Adobe Stock/Erica Guilane-Nachez

Focus

CONCENTRATIONS OF CARBON DIOXIDE IN THE ATMOSPHERE
AN EXPONENTIAL INCREASE

The increase in the concentrations of carbon dioxide in the atmosphere is estimated at about 40% since the years 1750 - 1800, which mark the beginning of the Industrial Revolution.

The concentration was then 280 ppm [8] (see figure). It has accelerated over the past sixty years, under the impact of human activity, progressing from 315 ppm in 1958 to almost 400 ppm in 2019.

Ph. Adobe Stock/De kaktuzoid
Ph. Adobe Stock/ssguy

Progression of the concentration of carbon dioxide in the terrestrial atmosphere.

• Before 1958, the data come from the analysis of cores in the ice in Greenland and the Antarctic. The composition of the atmosphere is provided by small bubbles of air imprisoned over time.

• After 1958, the data come from the Mauna Loa Observatory (Hawaii), under the control of Charles David Keeling in the earliest years. The concentration of carbon dioxide was 414.50 ppm on 8th May 2019 (source: NOAA Earth System Research Laboratory – Scripps Institution of Oceanography*).*

➔ WHAT ARE THE CONSEQUENCES OF THE OVER-PRODUCTION OF GREENHOUSE GASES, IN PARTICULAR CARBON DIOXIDE?

The consequences of these carbon emissions - first of all it's an increase in the concentrations of carbon dioxide in the atmosphere. The climatologists and the astrophysicists measure it very precisely.

According to continuous temporal series on the patterns of change in CO_2 concentrations [9], we can see that the carbon dioxide continues to increase in the atmosphere.

This increase is mainly responsible for the climate change that we are currently observing and experiencing [above: *Concentrations of carbon dioxide in the atmosphere – an exponential increase*].

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(4) During this period, known as the Mesozoic Era, 65 million years ago, atmospheric concentrations of carbon dioxide were, according to the scientists, up to 12 times higher than those recorded today. According to the study (2017) published in the Proceedings of the National Academy of Sciences (PNAS), these high concentrations were due to volcanic eruptions caused by an enormous meteorite which smashed into the Earth. Smoke and dust then masked the sun, so that the light needed for the photosynthesis of plants could no longer pass through, gradually destroying the dinosaurs' food.

(5) For 800 000 years, the concentration of atmospheric carbon dioxide did not exceed 300 ppm, whereas in 100 years, it has reached more than 400 ppm (source: France, Climat, réveillez-vous ! Les solutions sont là. By Anne Hessel, Jean Jouzel, Pierre Larrouturou, Indigène éditions, 2018).

(6) This period of rapid growth, characterised by profound social and economic repercussions, began in Great Britain during the second half of the 18th century. It continued in Europe, then in other countries, including the United States of America. It marked the beginning of a sharp increase in the use of fossil fuels.

(7) The Paris Agreement on the climate, signed during COP 21 (2015), provided evidence of the essential interaction between the climate and the Ocean. The aim of the Agreement was to limit the warming of the planet to +2°C, or even +1.5°C, in comparison with the pre-industrial era.

(8) The ppm (parts-per-million) is a unit of measurement which expresses a fraction in volume of the atmospheric air. It corresponds to a ratio of 10-6, which represents one cubic centimetre of gas per cubic metre of air. Or one molecule of the gas in question for 1 000 000 molecules of all the other gases present.

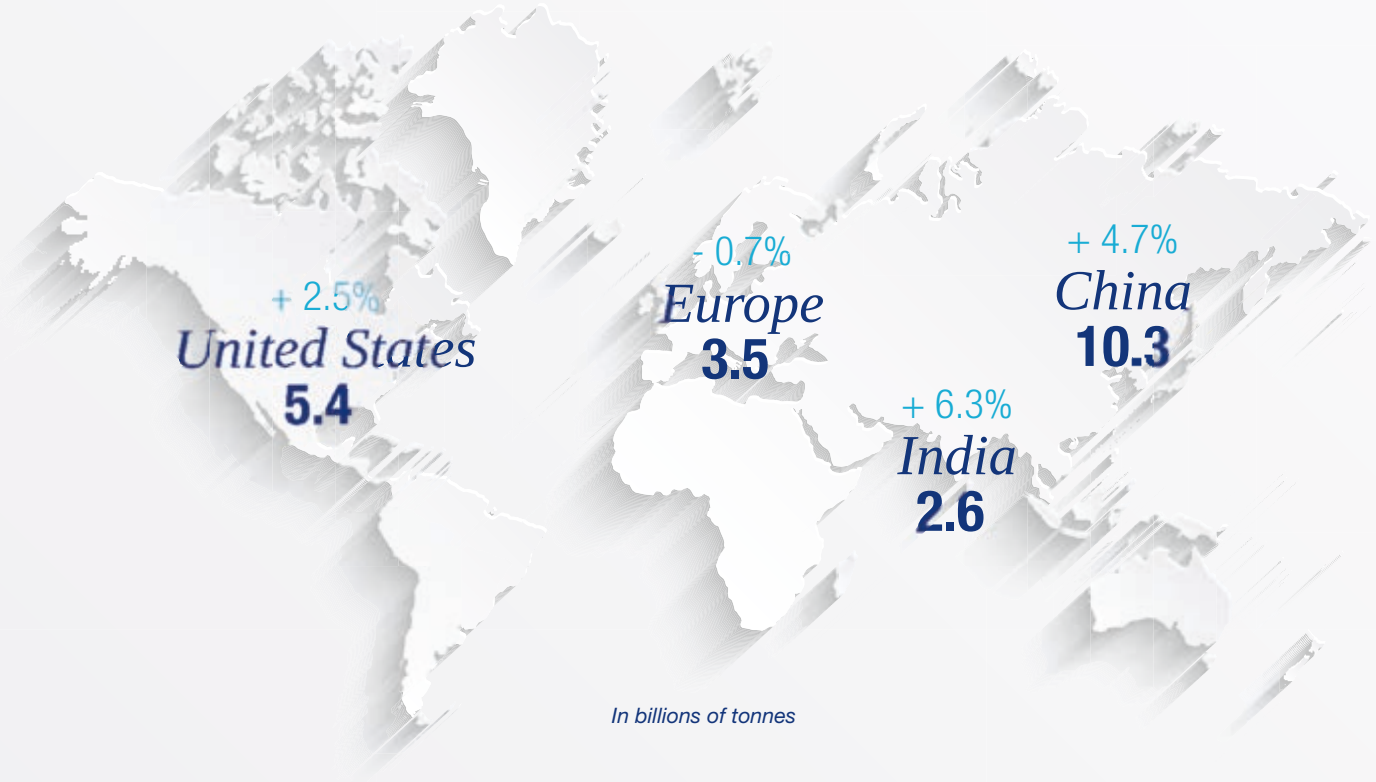
(9) These continuous measurements of the CO_2 in the air began in 1958, when Charles David Keeling founded, with the help of the American army, the Mauna Loa Observatory (Hawaii). Gradually other stations – a hundred or so today in all the regions of the world – have added their scientific contribution.

Focus

WORLD CARBON DIOXIDE EMISSIONS
AN ALL-TIME RECORD IN 2018

World carbon dioxide emissions linked to fossil fuels and human activities were again on the increase in 2018 with 37.1 billion tonnes. A new all-time record after three years of quasi-stability (2014 - 2016).

The main polluters remain China and the United States. Next is Europe, which is nonetheless relatively well-behaved with a decrease of 0.7 % of emissions, and India. For France, emissions declined between 2000 and 2007, but increased by 2 % between 2016 and 2017 (source: *Global carbon project (2018)* – Data CDIAC/GCP/UNFCCC/BP/USGS).



➜ WHAT IS THE FATE OF THE CARBON DIOXIDE EMISSIONS CAUSED BY HUMAN ACTIVITIES?

I explained it briefly while talking earlier of the carbon cycle. The carbon dioxide which is emitted by man accumulates in the atmosphere, and much of it – about half – is sequestered by what we call natural carbon sinks: the Ocean, on one hand, and the terrestrial biosphere on the other hand [see page 10: *Carbon cycle – Main fluxes and sinks at the scale of the Planet*].

In fact, thanks to these natural carbon sinks, the carbon dioxide concentration in the atmosphere increases twice as slowly.

The Ocean has absorbed in the order of 150 billion tonnes of carbon since 1870. Each year, it sequesters 2.5 billion tonnes.

The Ocean thus contributes to the mitigation of climate change caused by the increase in human-generated emissions of this greenhouse gas.

>>

“ Thanks to natural carbon sinks, the concentration of carbon dioxide in the atmosphere increases twice as slowly ”

Focus

GREENHOUSE EFFECT

A NATURAL PHENOMENON THAT HAS BEEN STRONGLY DISTURBED

The atmosphere is composed of 78 % nitrogen, 21 % oxygen. Other gases such as water vapour, methane, nitrous oxide, ozone and carbon dioxide are said to be greenhouse gases (GHG) and form a layer of gas in the lower atmosphere.

Two thirds of the energy produced by the rays of the sun is absorbed by the atmosphere, the soil and the Ocean. The remaining third is directly reflected towards space by the clouds, the aerosols, the atmosphere and the surface of the earth.

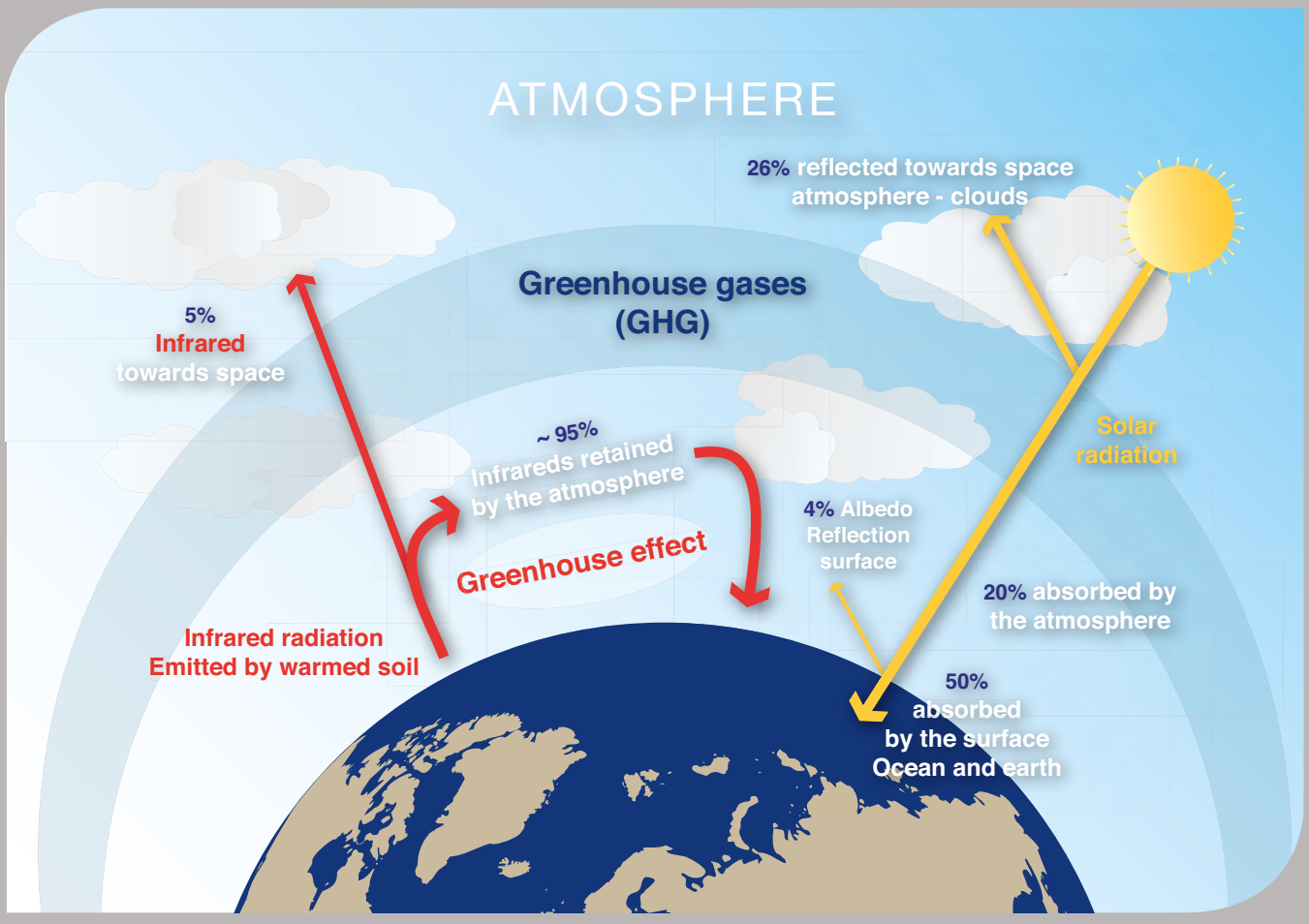
The atmosphere and the surface of the earth emit in return infrared radiation which the clouds and the greenhouse gases store. They act like the windows of a greenhouse, and the heat they have received is in large part returned to the Earth. Which contributes to the warming of our planet.

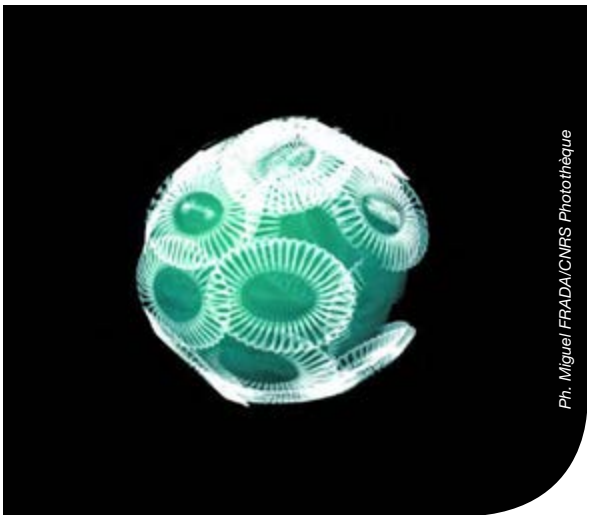
Without this natural phenomenon known as the greenhouse effect, life on Earth would be impossible, since the temperature would be around -18°C.

But since the beginning of the industrial age, human activity has upset everything by releasing enormous masses of greenhouse gas into the atmosphere. Which has generated an additional greenhouse effect, which is today out of control, and perhaps uncontrollable.

The phenomenon will continue to be exacerbated, and the experts forecast a strong increase in temperature on our planet: 10°C, on average, by 2150, if nothing is done to reduce the emissions of greenhouse gases.

For more information (in French):
jancovici.com - Quest-ce-que-l'effet-de-serre





Ph. Miguel FRADA/CNRS Photothèque

The alga Emiliania huxleyi *(5 thousandths of millimetres), with its shell of plates of calcite. This coccolithophore is numerically the most abundant and the most widespread on the planet. It plays a major role in climate equilibrium.*

Ph. T. Chevalier/CNRS Photothèque

Partial mortality of a colony of coral Pocillopora meandrina *in the archipelago of Tuamotu (French Polynesia). The phenomenon of the dying off of the corals is reflected in the discoloration of the animal following the disappearance of the symbiotic algae which supply the energy necessary for the synthesis of the calcareous skeleton.*

>>

➜ IS THE OCEAN DISTURBED BY THIS MASSIVE INPUT OF CARBON DIOXIDE?

There are two major consequences: the first is what we refer to as the acidification of the Ocean. The other is climate change.

Carbon dioxide is dissolved in the sea in proportion to the increase in its concentration in the atmosphere. In other words, the more this gas is present in the air, the more a large quantity of it is transferred into the water that is in contact with it.

But this capacity of the Ocean to absorb the carbon dioxide produces a negative effect, since its dissolution causes acidity and thus creates a disequilibrium of the water chemistry [10].

➜ COULD YOU BE MORE SPECIFIC?

The more the Ocean traps carbon dioxide, the more its pH is diminished, and the more the waters become acid [11]. This will have consequences for a number of marine organisms.

➜ SO, IN TANGIBLE TERMS, WHAT IMPACT DOES THE ACIDIFICATION OF THE WATER HAVE ON MARINE LIFE?

Experiments have been performed in the laboratory to try to understand how organisms respond to the acidification of the water.

The most threatened are those that calcify, that is that produce calcareous shells or skeletons, in calcite or aragonite.

Do you remember those very revealing experiments at secondary school, which consisted in pouring a drop of hydrochloric acid on a calcareous rock to trigger its dissolution?

We haven't got to that stage in the Ocean, but in water that has become more acid, it is biologically more complicated to develop shells or skeletons [12].

Many organisms are exposed to the acidification of the oceans [13]: bivalves such as the oysters and the mussels, which live along our coasts. We might also mention the corals which have a skeleton in aragonite, a mineral composed of fairly soluble calcium carbonate; microscopic organisms, which live in the water masses of the open Ocean: phytoplankton, coccolithophores [14], zooplankton.

Ph. Adobe Stock/ALF photo

➜ IS THE BLEACHING OF THE CORALS ALSO LINKED TO ACIDIFICATION?

Acidification is an alteration of the chemistry of the seawater with an impact on mainly calcifying organisms.

With the bleaching of the corals, we move on to the second impact undergone by the Ocean, which is related to the emissions of greenhouse gases in the atmosphere. It is a matter of climate change. Because there is more carbon dioxide in the atmosphere, the system heats up: the atmosphere first, then the Ocean.

Initially, the Ocean constitutes an enormous reservoir of heat with very high thermal inertia, that is, it stocks heat with a high capacity to retain it, and to release it very slowly.

When the climate system heats up, the Ocean stocks about 90 % of the extra heat [15] due to the greenhouse effect. This increases the warming of the water at the surface and at depth.

> *“The Ocean constitutes an enormous reservoir of heat”*

➜ HAS THIS WARMING OF THE WATER BEEN MEASURED?

Yes, the temperature of the surface of the Ocean has risen by almost one degree since the beginning of the 1900s. And at depth, certain areas have warmed up by several tenths of a degree over the past hundred years or so.

➜ WHAT ARE THE EFFECTS ON THE ECOSYSTEMS, THE MARINE ORGANISMS?

In warmer water, certain organisms of the phytoplankton and the zooplankton, which live freely in the water mass, are able to move away to find more suitable thermal conditions.

Others, such as certain algae or plants like the Posidonia seagrasses and the corals are fixed and directly suffer the effects of a rise in temperature.

This is also the case for the whole functioning of the Ocean system. The major currents, for example, are disrupted by alterations in the temperature or the force of the winds, with an impact on the ecological niches of certain organisms.

The alteration of the ocean currents also disrupts the distribution of chemical species [16] in the water mass and in particular nutritive elements. Remember that they are essential for the development of the algae and the phytoplankton, upon which depend virtually all living beings in the oceans.

> *“We are experiencing a gigantic disruption of the ocean system”*

The models show that with climate change, the waters are warmer at the surface, and being less dense, they mix more easily with the waters lying below.

Our models also show that the surface waters are less well supplied by the deep waters, which bring to the surface the nutritive elements. So we must expect a drop in the productivity of the oceanic ecosystems.

Thus, in the Ocean, all the food chains might be disrupted by climate change: from the phytoplankton to the zooplankton, from small fish to large ones, and the coastal ecosystems.

We are experiencing a gigantic disruption of the ocean system.

>>

(10) For more information: The Ocean, Master of the Climate - Interview with Dr Françoise Gaill, Director of Research, CNRS, Scientific Coordinator of the Ocean & Climate Platform, Institut Océanographique Paul Ricard Newsletter n° 14, *2015.*

(11) The pH is an indicator of the acidity of the water. The acidity of the oceans has increased by 30 % in 250 years. Simulations have shown that at the current rate of emissions, the acidity of the surface waters might triple by the end of the century (source: Acidification des océans, *by Jean-Pierre Gattuso and Lina Hansson*, in L'Océan à découvert, *CNRS Éditions, 2017, pp. 66-67).*

(12) The dissolution of the CO_2 in the seawater entails the diminution of certain molecules – carbonate ions– which are necessary for numerous organisms to build their calcareous skeletons and shells. They are themselves exposed to dissolution, since above a certain level of acidity the seawater becomes corrosive for the calcium (source: Acidification des océans, *by Jean-Pierre Gattuso and Lina Hansson*, in L'Océan à découvert, *CNRS Éditions, 2017, pp. 66-67).*

(13) For more information: The Ocean, Master of the Climate - Interview with Dr Françoise Gaill, Director of Research, CNRS, Scientific Coordinator of the Ocean & Climate Platform, Institut Océanographique Paul Ricard Newsletter n° 14, *2015.*

(14) Group of species of unicellular algae, possessing a calcareous skeleton.

(15) Only 1 % of the additional heat goes into the atmosphere, 3 % into the ice and 3 % into the continental surface (source: IPCC).

(16) According to the definition, any ensemble of identical chemical characters (atoms or groups of atoms). Thus, most foods and everyday objects are constituted of numerous chemical species. For example: an apple contains water, sugars, colouring agents.

>>

➜ MORE BROADLY, ON THIS TOPIC, WHAT ARE THE LINKS BETWEEN THE CLIMATE AND THE OCEANIC CARBON CYCLE?

We have talked about acidification, which is simply the fact that the Ocean absorbs the excess carbon in the atmosphere. And then we mentioned climate change, which leads to the warming of the Ocean, an alteration of the currents.

To answer your question, we will discuss rather more complex notions to show that there is a link between the two, that is between the carbon cycle and the climate system.

➜ CAN WE TALK OF A DOMINO EFFECT?

Yes, the scientists talk rather of positive feedback [See below: *Positive feedback – Chain reactions between the climate system and the carbon cycle*].

➜ IN FACT, WE'VE REALLY MESSED THINGS UP…

Yes, we've made a big mess of the climate system and the Ocean.

Focus

POSITIVE FEEDBACK

CHAIN REACTIONS BETWEEN THE CLIMATE SYSTEM AND THE CARBON CYCLE

According to the definition (*), when one component of the climate system is altered by climate change and this alteration in turn acts on the climate, we speak of feedback.

This coupling between the climate and the carbon cycle induces chain reactions, which we call 'positive feedback'. The term 'positive' is not strictly appropriate because this phenomenon has a negative effect on the changes in the climate system. In this case, it amplifies the warming. The feedback would be called 'negative' if it diminished the warming.

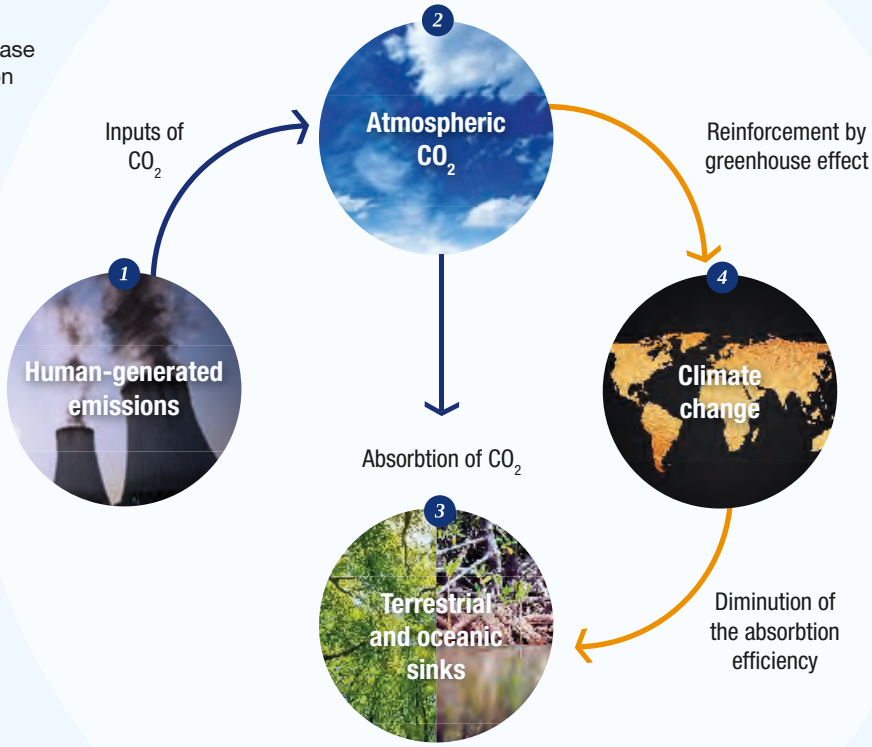
So what is really happening ?

When the carbon dioxide emissions 1 increase in the atmosphere 2 , then natural carbon sinks - terrestrial and oceanic 3 - are less efficient in absorbing the carbon, since a warmer Ocean uptakes less carbon dioxide (**).

So the rate of carbon dioxide concentration in the atmosphere speeds up, so the climate system warms up even more, climate 4 change is amplified and the natural carbon sinks diminish again… And so on, for a new loop. *(Source : Laurent Bopp and Pierre Friedlingstein (2015) - Rétroactions entre le climat et le cycle du carbone. Conference with seminars organised by the chair in Évolution du climat et de l'Océan, Collège de France.)*

(*) *Le changement climatique : les rétroactions*, insu.cnrs.fr

(**) For more information : jancovici.com - *Les puits de carbone ne vont-ils pas absorber le surplus de CO_2 ?*



Focus

WHAT WILL BE THE FUTURE PATTERNS OF CHANGE IN THE CLIMATE?

In its 5th assessment report (2013-2014), the Intergovernmental Panel on Climate Change (IPCC) defined four trajectories of emissions and concentrations of greenhouse gases (GHG), referred to as *Representative Concentration Pathways*. (*)

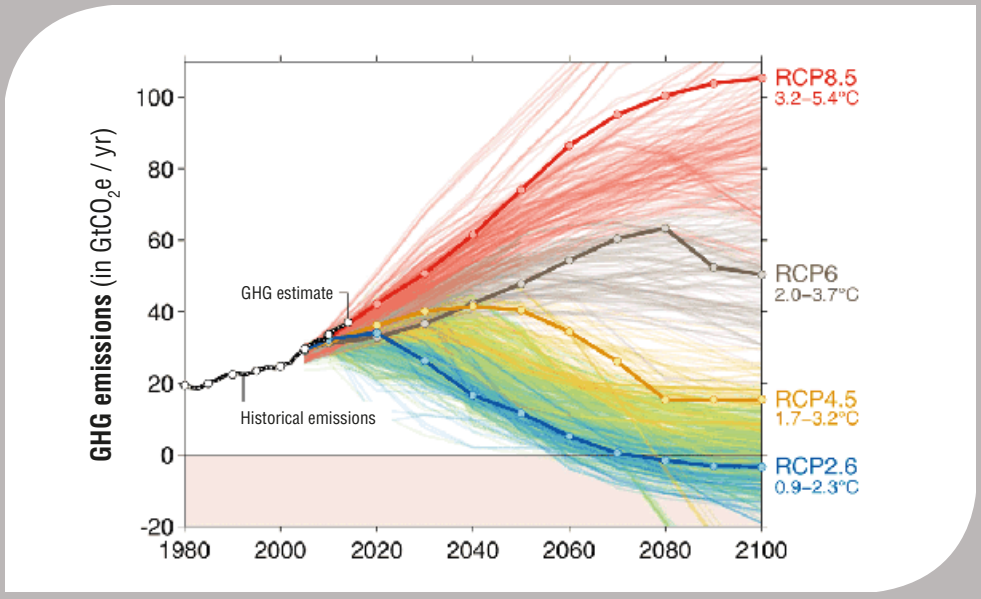
• **SCENARIO RCP 2.6** integrates for the first time the effects of policies for reducing, or likely to limit, planetary warming to 2°C in 2100.

• **SCENARIO RCP 8.5** is the most pessimistic scenario, but the most probable, since it corresponds to the prolongation of the current rate of GHG emissions.

• **SCENARIO RCP 6.0** and **SCENARIO RCP 4.5** are intermediate. They clearly correspond to the stabilisation of CO_2 emissions *(source: IPCC climate scenarios – Global Carbon Project)*.

(*) A special IPCC report, Ocean and Cryosphere in a Changing Climate, will be published at the end of 2019.

CLIMATE SCENARIOS ESTABLISHED BY THE IPCC
FROM THE MOST PESSIMISTIC TO THE MOST OPTIMISTIC



➜ IS THIS OUT OF CONTROL?

No, reducing the carbon dioxide emissions would suffice to stop this rush towards a warmer world and a more acid Ocean.

➜ IS THERE A POINT OF NO RETURN?

That's a difficult question.

We have emitted a lot of carbon, and this carbon is today in the atmosphere.

The system is disrupted, and it will be for a long time. The atmosphere and the Ocean have become warmer, the snow cover and the ice have diminished, and the sea level has risen.

At the scale of the human life span, we have slid towards a point of no return. And it will take many future generations to get back to the initial pre-industrial state. Which doesn't mean that all is lost.

Depending on the actions we undertake today, and the way in which we will in the future be able to reduce our greenhouse gas emissions, the forecasts may be very different: from a profoundly disrupted world to a world which is less disrupted.

➜ *"LIKE SLEEP WALKERS, WE ARE MARCHING TOWARDS THE ABYSS"* WROTE EDGAR MORIN. DO YOU SHARE THIS FEELING?

Yes, I have the impression that we continue to walk towards the abyss despite being warned of it long ago, despite the scientific research and certain political decisions. It is, after all, difficult to be optimistic.

>>

3/ Solutions to mitigate climate change and to adapt to it

Ph. Magali Mak Photos

➔ LET'S DISCUSS THE SOLUTIONS FOR COMBATING CLIMATE CHANGE. WHAT ARE THE MAIN GUIDELINES?

For the solutions, there are two major lines of approach: mitigation and adaptation.

Regarding mitigation, I explained that the Ocean is an enormous reservoir, which already plays an important role on our planet in the absorbtion of carbon dioxide.

Of course, this approach is the one to develop in priority, since the final objective is to limit the impact of climate change. But it is already there, it's rather a matter of thinking how to adapt to it.

A range of solutions are on the table. Certain scientists have even thought of artificially increasing the capacity of the Ocean as a blue carbon sink, but we must remember that the best solution consists in reducing the emissions of greenhouse gases.

➔ ARE WE ALREADY DOING IT?

No, but let's be optimistic, certain signs are positive.

A certain number of countries have succeeded – in certain cases, still too locally, to be sure – in decoupling economic growth and carbon dioxide emissions. How? By changing our systems of production of energy in favour of others which are renewable [17]; by reducing the carbon footprint of transport, industry, agriculture, for example.

These solutions should be extended more rapidly to the whole planet. It is important to work on technologies which would enable us to emit less carbon [18] while conserving sustained economic and social development.

➔ WHICH IMPLIES CHANGES IN GOVERNANCE AND SOCIAL CHANGES...

… in governance, in individual and collective behaviour, of course.

When we talk of adaptation to climate change, we often refer to fairly local measures. Countries work for their own benefit, for their territories, whereas climate change is a global problem. When I emit carbon dioxide in Beijing, at the Cape or in Melbourne, the atmosphere is mixed fairly rapidly throughout the planet.

Thus the Ocean enables us to reflect on the world governance of the oceans [19], because we are in international waters, an environment that is shared by all.

Furthermore, the fact that climate change is a global problem makes it a good indicator panel, but also something that awakens our conscience.

>>

(17) Energy from currents, tides, waves, wind power at sea, thermal energy from the sea.

(18) The European Commission plans to invest more than 10 billion euros, over the period 2020-2030, in low-carbon technologies.

(19) For more information: What governance for the Ocean? - *Interview with Serge Segura,* French Ambassador for the Oceans, *Institut Océanographique Paul Ricard Newsletter n° 16, 2018, p. 14.*

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1

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2

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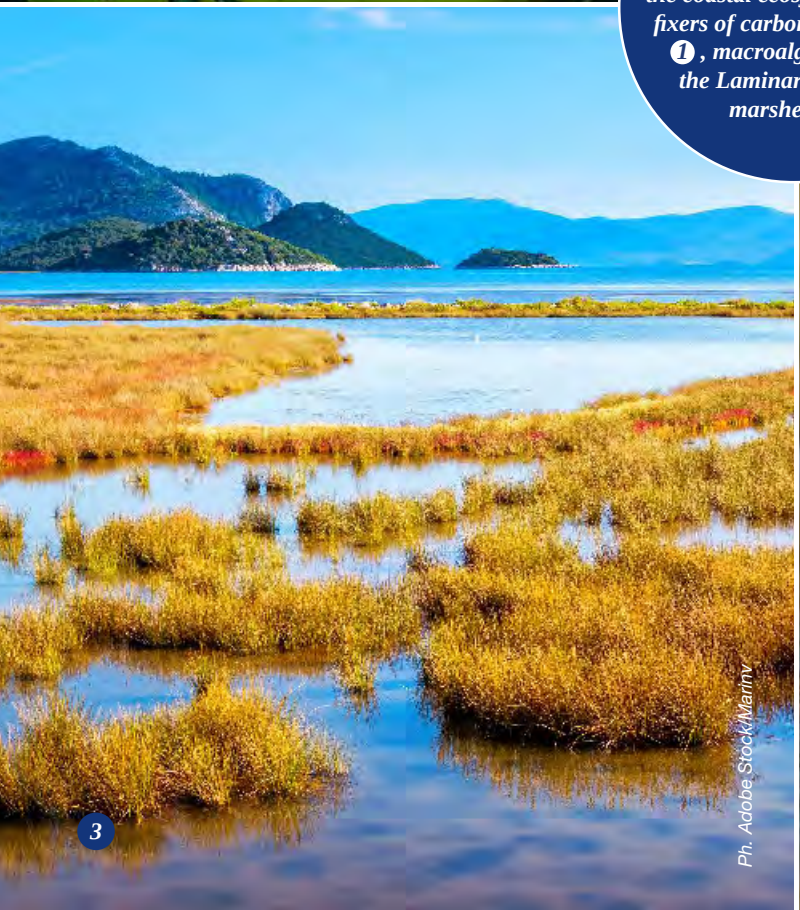
Blue carbon… The scientists use this term specifically to refer to the coastal ecosystems, major fixers of carbon: mangroves 1, macroalgae such as the Laminaria 2, salt marshes 3.



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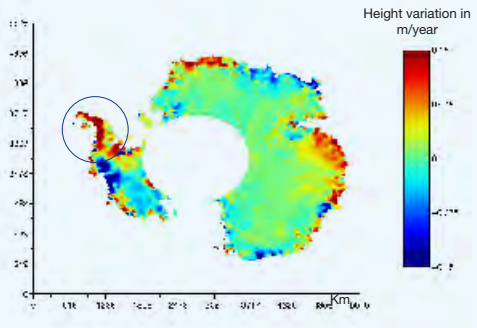
Focus

MODELLING, CARBON AND IRON CYCLES…
MAIN RESEARCH CENTRES

There are two major groups which are dedicated to climate modelling in France: *the Institut Pierre Simon Laplace*, near Paris, and the *Centre National de Recherches Météorologiques* (CNRM - National Meteorological Research Centre), in Toulouse, which work on the modelling of the carbon cycle in the Ocean at global scale, in relation with the climate system.

Certain oceanography research centres also focus on these issues: in Brest, for example, research teams at the *Institut Universitaire Européen de la Mer* (European University Institute of the Sea) are trying to understand the link between the iron cycle and the production of phytoplankton; in Marseille, the *Institut Méditerranéen d'Océanographie* (MIO - Mediterranean Institute of Oceanography) is working on carbon in the Mediterranean.



Ph. Benoit LEGRESY/CNRS Photothèque

Changes in the topography of the Antarctic between 1992 and 2002 based on data from the European Remote Sensing *(ERS) satellite system. This model shows that for the time being, the loss of the Antarctic ice cap is not much affected by climate warming, except on the peninsula where the production of icebergs is on the increase.*

> *"The Ocean is the giant which is heating up in a very constant way, the real evidence of climate change"*

>>

➜ WHAT IS THE ROLE OF NATURE-BASED SOLUTIONS?

I want to talk about *blue carbon*, which is a term that has taken on a certain importance in recent years. But there is still some confusion.

One might imagine that *blue carbon* means all the blue carbon that is to be found in the Ocean. In fact, scientists use this term specifically to refer to the coastal ecosystems: mangroves, sea marshes, *Posidonia oceanica* seagrass meadows, macroalgae such as the Laminaria, on certain coasts.

These highly productive coastal ecosystems are able to fix a large quantity of carbon. The idea is that their conservation and their restoration might help to mitigate climate change [see page 28: Blue carbon - Interview with Dorothée Herr, and page 40, Interview with Chloë Webster].

➜ TODAY, DO WE HAVE ALL THE TOOLS NECESSARY TO UNDERSTAND MORE CLEARLY THE FUNCTIONING OF THE OCEAN AND ITS ROLE IN THE CLIMATE SYSTEM? WHAT ARE THE MAIN RESEARCH THEMES THAT HAVE BEEN DEVELOPED?

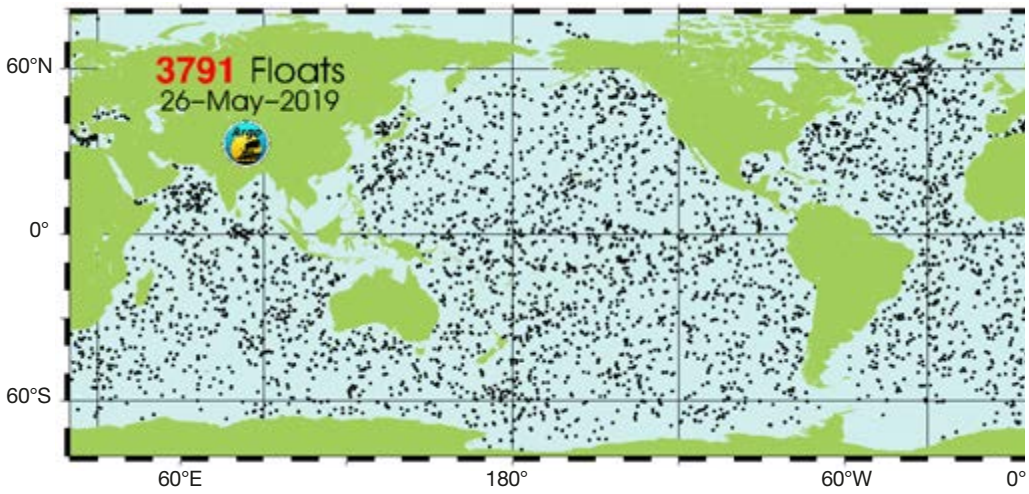
The Ocean plays a key role in the climate system, it absorbs carbon, a lot of heat. It is the giant that is heating up in a very constant way, the real evidence of climate change.

Finally, by measuring the quantity of heat in the Ocean, or even the quantity of carbon, we can monitor the slow progression of climate change, in response to human activity. This is why we really must document and measure what is happening in the Ocean - temperature, currents, carbon - and observe the behaviour of the marine ecosystems in reaction to these different parameters. That, I feel, is essential.

➜ COULD WE LIST SOME OF THE MAJOR THEMES ON WHICH WE NEED TO PROGRESS FURTHER?

With regard to the quantity of heat in the Ocean, today we have the Argo international network, which is permanently relaying information collected from floats [see map, right].

We absolutely must continue to equip these floats so that they can inform us even more fully on the complex relations between the Ocean and the climate. Which is why it is necessary to measure other dimensions such as the quantity of oxygen – the Ocean is losing oxygen, it is a major problem – or to evaluate the nutritive elements and the chlorophyll, which are indicators of the vitality of the ecosystem.



Map showing the position of 3791 operational Argo floats deployed by 25 countries (May 2019). For fifteen years, these autonomous underwater instruments have scoured the Ocean. They are left adrift and regularly dive down to depths of 2 000 metres before rising to the surface to deliver their data via satellites.
Source : www.jcommops.org/board/wa/Archives?t=Argo and www.argo.ucsd.edu

Launch of a float developed by IFREMER (French Research Institute for the Exploitation of the Sea - Institut Français de Recherche pour l'Exploitation de la Mer*).*

We also need to probe the zones that have been little or not at all explored, the deep sea areas. I have explained that they are also warming up, but what is the impact on these deep ecosystems?

We also need to better understand the natural variations in the climate without disruption. To get the answers, we need to turn to paleoceanography, paleoclimatology – the study of ancient climates – since it is necessary to reconstitute the variations of the past. To do that, cores are taken in the Ocean seabed.

We also need to determine how the ecosystems have adapted to ancient phenomena in order to better predict future patterns of change.

Better forecasts call for more powerful computer tools, calculators, and the development in parallel of research on a three-fold axis: observation, the reconstitution of the past and the prediction of the future.

➜ TO CONCLUDE OUR INTERVIEW, HAVE YOU GOT A MESSAGE TO PASS ON REGARDING CLIMATE CHANGE AND THE FUTURE OF OUR PLANET?

Above all, don't give up!
We are in the process of upsetting the climate system – that is perfectly clear – but we mustn't see it all in catastrophic terms.

The planet is not in danger. The system has already been subjected to concentrations of carbon dioxide much higher than those we should see at the end of the 21st century.

The climate has already been much warmer. When all's said and done, the planet has already seen it all!

The problem is that human society developed in a relatively stable climate until the pre-industrial age, and we are now heading towards a different climate and a different world.

But what world? I believe we still have some leverage, we have our hands on the controls to choose which world we wish to go to.

> ***"The planet has already seen it all"***

The technologies exist to reduce greenhouse gas emissions, to help certain ecosystems to adapt to climate change. But first we need a strong political will, a general awareness that it is by acting now, within 10 to 20 years, that we will have to decide on the trajectory to follow over the coming decades and probably the coming centuries.

There is still time to act, but we have to do it now! ■

Interview with Christian Frasson-Botton
March 2019

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Underwater forest of Kelp, large brown Laminaria.

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Ph. DR / Ph. Adobe StockTOMO

INTERVIEW WITH

DOROTHÉE HERR

Manager, Oceans and Climate Change, Global Marine and Polar Programme
International Union for the Conservation of Nature (IUCN)

> *"To encourage better management of coastal ecosystems using an array of policies concerning climate change and financial incentives"*

1 / THE VEGETATED COASTAL HABITATS, THE MAIN SOURCES OF BLUE CARBON

2 / BLUE CARBON AS A VALUE FOR ECONOMIC INCENTIVES AND A SOURCE OF REVENUE

CAREER
DOROTHÉE HERR

Dorothée Herr began her university career with a course in geography at the University of Heidelberg, in Germany. After which she opted for a year doing voluntary work. "*I wanted to do something with a focus on the oceans. I had the opportunity to spend three and a half months on the ship Esperanza, belonging to the international NGO Greenpeace, and I could see for myself the impact that we humans were having on the Ocean.*"

After that Dorothée Herr wanted "to do more environmental work", and she "*had the good fortune*", she said, "*to be admitted to the University of Oxford*", where she was awarded a master's degree in environmental change and management.
"*While the overarching topic of my studies at Oxford was climate change, I already focused my attention on the oceans. This led me in 2009, to join the International Union for the Conservation of Nature (IUCN). It was my first job after university, and I still work for this intergovernmental organisation today.*"

The young graduate began by working with the deputy director of the Global Marine Programme at the IUCN office in Washington, where she was concerned with the issues of the polar regions and climate change.

"*I progressed in this field and tried to apply my climate change expertise to the marine environment*", Dorothée Herr added. "*From the outset of my career, I have dealt with the issues of blue carbon, the use of ecosystem-based adaptation and the acidification of the oceans.*"

Today, Dorothée Herr manages various types of project as Manager for Oceans and Climate at IUCN. In particular, she is following the negotiations in progress under the United Nations Framework Convention on Climate Changes (UNFCCC) and is working to ensure that marine and coastal issues are better integrated in the international political debate.

1/ The vegetated coastal habitats, the main source of blue carbon

➔ THE QUESTION OF THE COMPLEX LINK BETWEEN THE OCEAN AND THE CLIMATE IS RECENT. BECAUSE OF THIS, PEOPLE ARE NOT YET REALLY AWARE OF WHAT IS MEANT BY THE CARBON CYCLE IN THE OCEAN, MUCH LESS BLUE CARBON. COULD YOU GIVE US SOME INSIGHT?

In fact, we are already clearly experiencing the impact of climate change, and we are looking for solutions to mitigate the effects. Among them there are the natural carbon sinks, such as the soils, the forests and the Ocean.

Clearly, the Ocean as a whole is the largest natural carbon sink on Earth, yet that comes with negative side effects like ocean acidification. Yet, there are particular coastal ecosystems such as the mangrove forests, the seagrass meadows and the salt marshes that absorb and store carbon long-term. That's what we call blue carbon.

The plants uptake the carbon dioxide from the atmosphere by photosynthesis and trap the carbon in the sediments via their complex root systems, thus sequestering the carbon for a long time *[see page 13: Photosynthesis – A highly sophisticated natural mechanism]*.

The mangroves are highly efficient blue carbon sinks: compared to their terrestrial counterparts, they store three to five times more carbon for the same surface area. And these mangrove forests are all the more interesting in that the carbon can remain for several years, or even several decades, in the biomass (leaves, branches, etc.), but several millennia in the sediment.

On the other hand, non-sustainable aquaculture and other human practices, which degrade or destroy the mangroves, induce the release into the atmosphere the carbon stored for centuries [(1)]. From natural blue carbon sinks they then become sources of greenhouse gases.

> *"The mangrove forests are highly efficient blue carbon sinks"*

The restoration of degraded areas also has a positive impact in terms of taking carbon out of the atmosphere, but with less efficiency, since in that case, the capacity of the mangroves to serve as a blue carbon sink is diminished and requires several years before being regenerated.

Maintaining coastal ecosystems in a good state of health is therefore the most effective way of keeping carbon in the ground.

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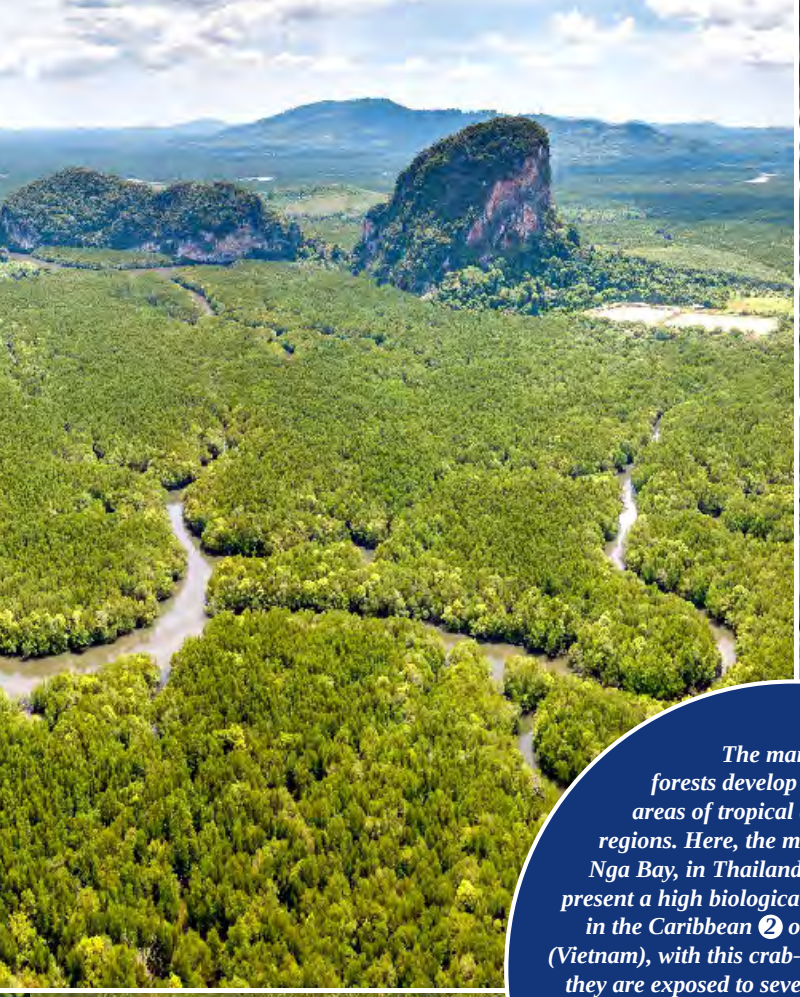
Ph. Christophe PROISY/IRD/AMAP/CNRS Photothèque

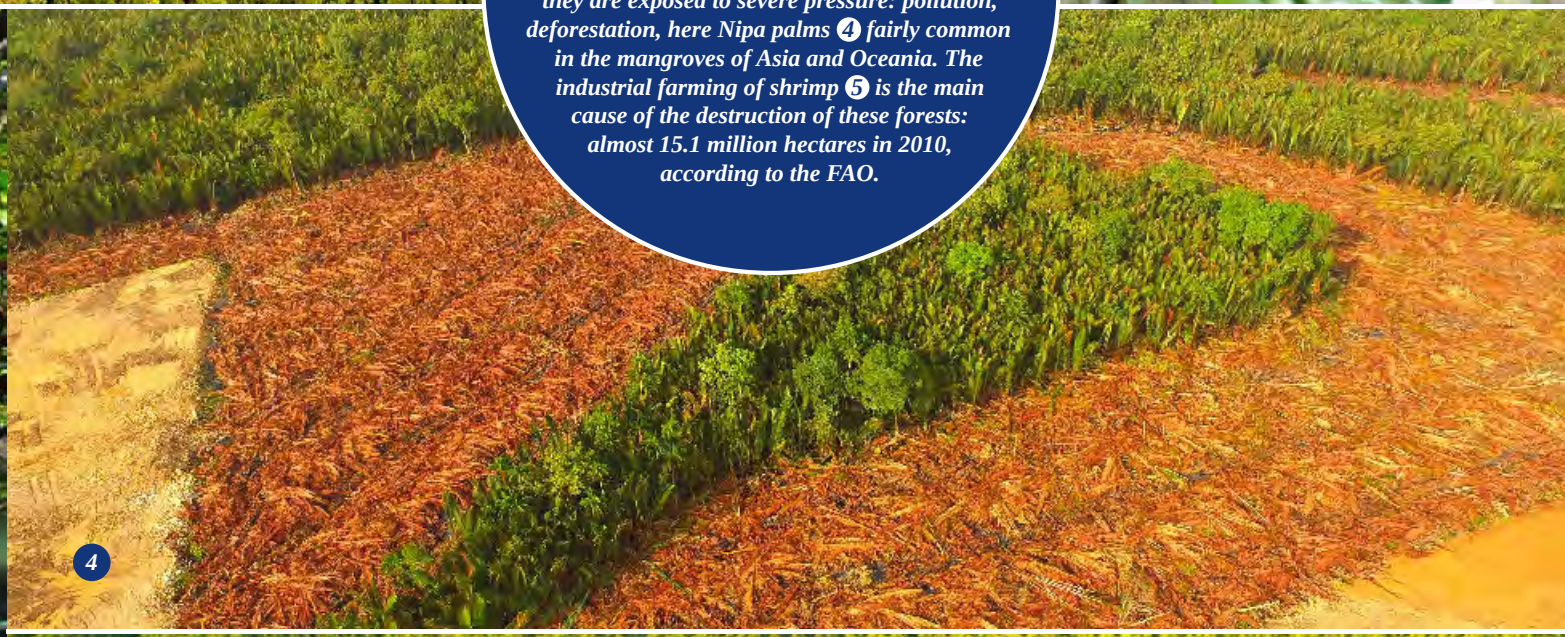
Planted and natural mangroves in the delta of the River Mahakam (Indonesia).

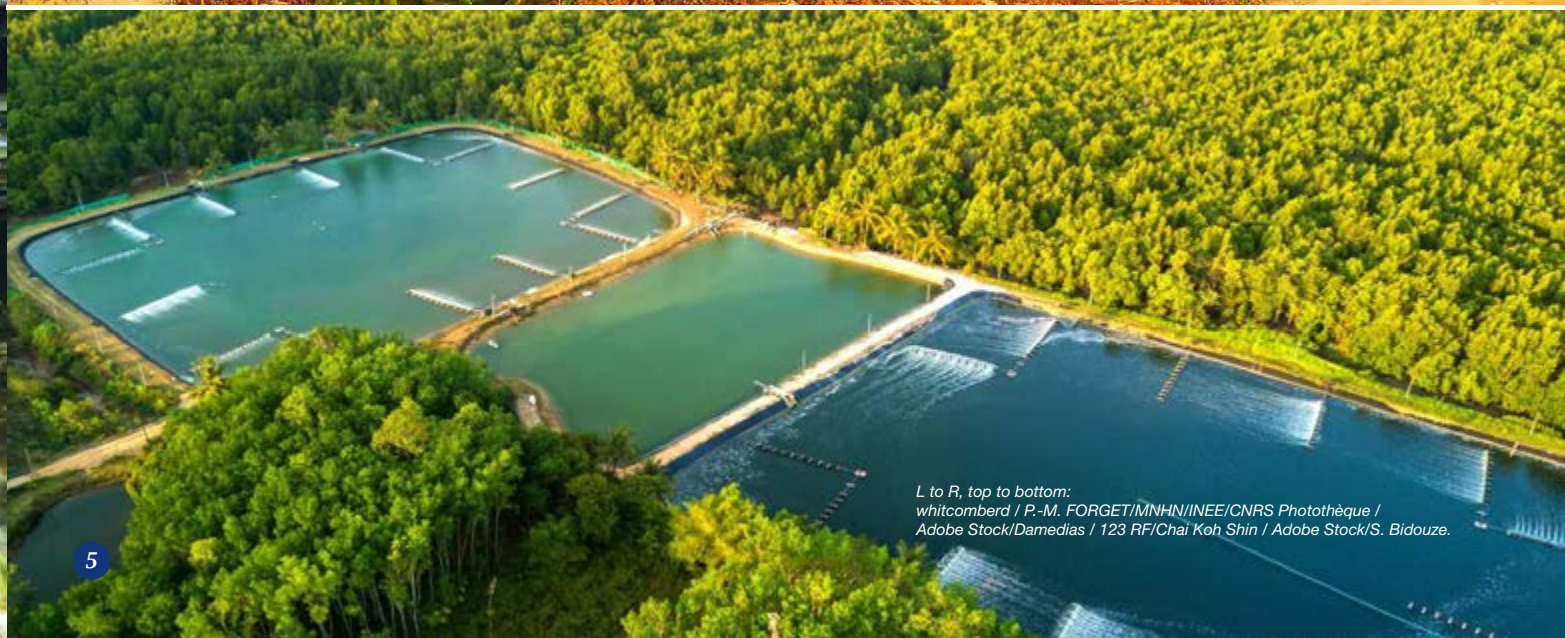
1

2



The mangrove forests develop in the coastal areas of tropical and subtropical regions. Here, the mangroves of Phang Nga Bay, in Thailand ❶. The mangroves present a high biological diversity, for example in the Caribbean ❷ or near Ho Chi Minh (Vietnam), with this crab-eating macaque ❸. But they are exposed to severe pressure: pollution, deforestation, here Nipa palms ❹ fairly common in the mangroves of Asia and Oceania. The industrial farming of shrimp ❺ is the main cause of the destruction of these forests: almost 15.1 million hectares in 2010, according to the FAO.





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➜ DOES THAT MEAN THAT THE SURFACE AREA OF MANGROVES SHOULD BE EXTENDED?

Yes, as far as possible. Efforts have already been made along those lines by many actors, also as part of the work of the *Global Mangrove Alliance* [(2)].

➜ WHAT CAN YOU TELL US ABOUT BLUE CARBON AND THE *POSIDONIA OCEANICA* SEAGRASS MEADOWS IN THE MEDITERRANEAN. DO THEY PLAY THE SAME ROLE AS THE MANGROVES?

Yes indeed, it is one of the most efficient seagrass meadows.

Increasing attention is now being paid to them, and scientists are working to develop tools for evaluating their carbon stores and to seek ways of including this ecosystem in a coastal carbon projects. This can be another tool using nature conservation and management contributing to the mitigation of climate change [see page 40: Interview with Chloë Webster].

But is blue carbon measureable? Can it be combined with certain measures for the management of the coastal areas? Could a country account for blue carbon sinks and sources within its jurisdiction?

By all accounts, since it is a matter of the Ocean, the further you go from the coast, the more complex certain of these issues become. Talking of blue carbon, the most tangible measures and strategies for mitigating climate change remain for the moment within the coastal areas.

The debate about what stores, absorbs or releases carbon in the ocean is not only scientific. There are policy and finance related matters that need to be discussed, in terms of how blue carbon will be considered in international climate strategies.

➜ WHAT ABOUT THE COUNTRIES WITHOUT COASTS? WOULD YOU INCLUDE RIVERS AND LAKES IN THE PROCESS, OR DOES BLUE CARBON ONLY CONCERN THE SEAS?

No, the inland areas come under the category of wetlands, and in particular the peatlands. Other stakeholders have been working on this particular area for some time. But whether inland or coastal, States need to consider the various options available to mitigate climate change.

Peatlands and lakes in Val Studer, Kerguelen, an archipelago in the French Southern and Antarctic Lands (Terres Australes et Antarctiques Françaises)*. The '4 ILES' programme (Crozet, Saint-Paul, Amsterdam and Kerguelen) on the effects of climate change was partly carried out in this subantarctic region (2003-2004).*

➜ GIVEN THAT THE ISSUE HAS APPEARED QUITE RECENTLY, DO YOU THINK THAT WE DISPOSE OF ENOUGH TOOLS TO MEASURE THE BLUE CARBON?

At the present time, the techniques and the tools are already there. For instance, to standardise the sampling methods, measurements in the laboratory and the analysis of blue carbon stocks, the Blue Carbon Initiative, which IUCN is part of, has produced a dedicated manual [(3)]. In fact, it's a practical tool available for scientists and coastal managers in the field.

> *"The techniques and the tools for measuring the blue carbon already exist"*

Then, it all depends of course on availability of technologies and capacity, primarily in the developing countries. There are research partnerships that enable certain States, if they wish, to work with specialist laboratories, in particular in Europe and the United States.

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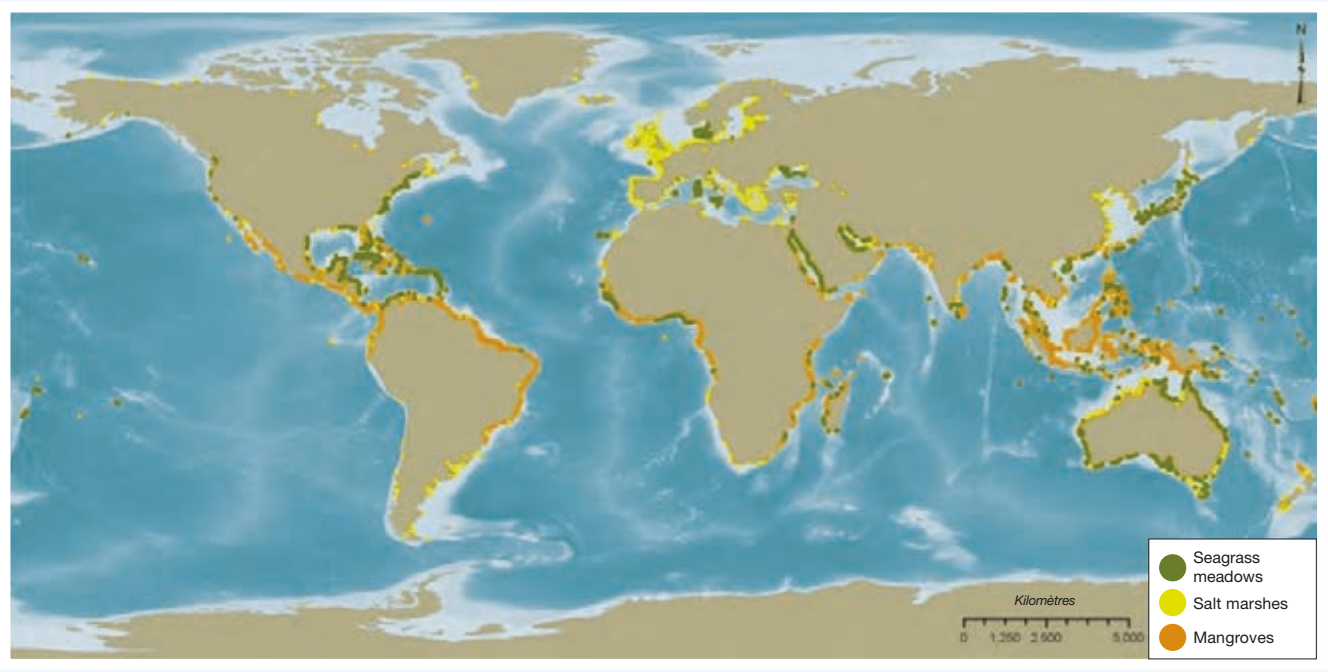
(1) According to the experts, almost 1.02 billion tons of carbon dioxide is released each year by degraded coastal ecosystems (source: thebluecarboninitiative.org).

(2) The aim of this programme, launched in 2017, is to increase by 20% the worldwide cover of mangroves by 2030. To meet this challenge, the WWF is associated with the International Union for the Conservation of Nature (IUCN) and The Nature Conservancy.

(3) This work is entitled: Coastal blue carbon: methods for assessing carbon stocks and emissions factors in mangroves, salt marshes and seagrass meadows. *It was produced by the Blue Carbon Scientific Working Group. Formed in 2011, this group constitutes the scientific foundation of the Blue Carbon Initiative.*

WORLDWIDE DISTRIBUTION OF MANGROVES, SEAGRASS MEADOWS AND SALT MARSHES



Sources of data: for the seagrass meadows and salt marshes, World Conservation Monitoring Centre of the United Nations Environment Programme (UNEP-WCMC); for the mangroves, UNEP-WCMC, in collaboration with the International Society for Mangrove Ecosystems (ISME).

Ph. Erwan AMICE / LEMAR / CNRS Photothèque

Observation dive among the roots of Rhizophora in a mangrove in the lagoon of Xel-Ha, Mexico. The scientific aim is to better understand and predict how the global changes – eutrophisation, climate change, invasive species – disturb the coastal ecosystems.

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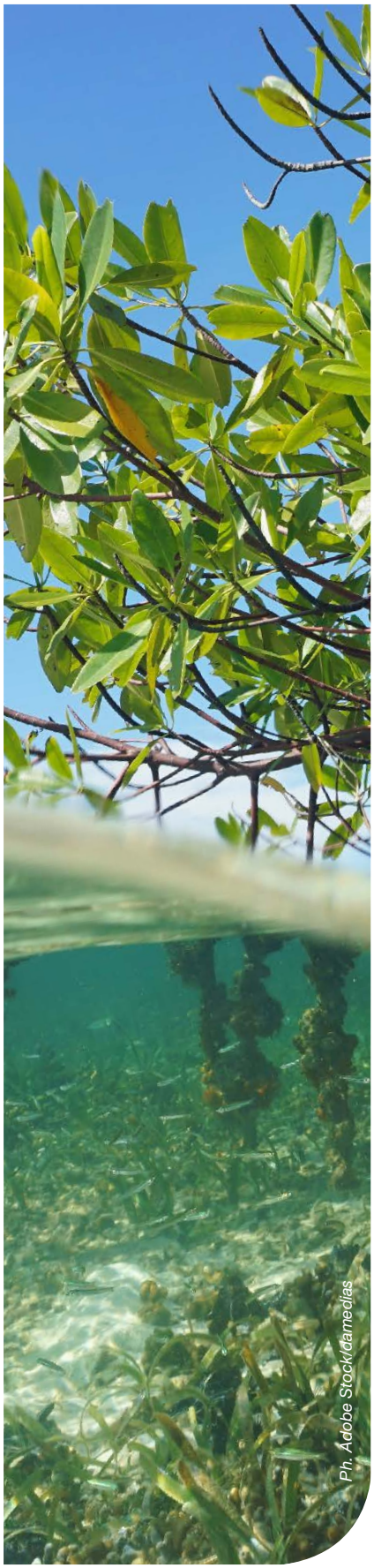
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➜ ARE THERE ANY CENTRES THAT COLLECT THE DATA SO THAT IT MIGHT GIVE US AN OVERALL VIEW OF THE TRUE SITUATION WITH REGARD TO BLUE CARBON?

Yes, efforts have been made, but more particularly in favour of the large natural carbon sinks such as the soil, the forest and the Ocean.
The international Blue Carbon Scientific Working Group has set up a portal where various scientific and academic institutions can come and share their data. It is certain that this issue has become the focus of increasing development and growing interest.

➜ IN YOUR VIEW, WHAT ARE THE MOST INTERESTING INNOVATIONS IN THE SCIENTIFIC PROGRAMMES THAT YOU SUPERVISE? ARE THERE ANY NEW TRENDS CONCERNING BLUE CARBON?

I think in fact that it is above all a matter of collecting experiences and results covering the whole planet.

In the early days of our work, we only had sketchy information provided by the actors of a few fieldwork projects, some figures were extrapolated… Today, we have more specific data concerning all the continents, yet some gaps remain.

A mangrove in Costa Rica does not necessarily absorb or stock the same quantity of carbon as a mangrove in Indonesia, and I think that the fact of having more details and characteristic elements helps the countries to achieve more accurate inventories of their blue carbon [see opposite page: Blue Carbon Initiative].

In my view, it is along this route that more research organisations should engage in order to collect still more data.

➜ WE WILL SOON EMBARK ON THE UNITED NATIONS DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT (2021-2030). DO YOU THINK THAT BLUE CARBON WILL BE AT THE CORE OF CERTAIN PROGRAMMES?

I think that science has been essential to bring the issue of blue carbon into the front line. Ten years ago, when I joined the International Union for the Conservation of Nature (IUCN), some of my colleagues in the World Commission on Protected Areas did some bibliographical research on coastal blue carbon, and then said: *"Careful, we are missing out part of the equation: it's good that the forest gets so much attention, but there's another element in the solution that must be taken into account."*

It was from this moment that the issue of blue carbon really took off, with a sharp increase in the number of academic institutions worldwide - in Costa Rica, the Philippines, Kenya - and the launch of new master's courses integrating this subject.

Meanwhile, the Blue Carbon Scientific Working Group grows in numbers; it organises an annual meeting in a different part of the world to build a global overview of the state of coastal ecosystems and carbon sinks.

It's amazing to see how active the scientific community has been in seeking to provide a scientific basis for blue carbon so as to enable others to find the best political solutions.

Focus

THE BLUE CARBON INITIATIVE A GLOBAL ENDEAVOUR

This programme (*) is focused on the mitigation of climate changes by the conservation and the restoration of coastal and marine ecosystems worldwide. It currently targets mangroves, salt marshes and seagrass meadows.

The Blue Carbon Initiative has brought together governments, research organisations and non-governmental organisations. Its main aims are:
- to develop management approaches, financial incentives and political mechanisms to ensure the conservation, restoration and sustainable use of blue carbon coastal ecosystems;
- to promote policies which are based on the conservation, management and funding of coastal blue carbon;
- to develop methods for evaluating blue carbon stocks and emissions;
- to implement, worldwide, projects to show the feasibility of the quantification, the management and incentive agreements regarding blue carbon;
- to support scientific research on the role of blue carbon coastal ecosystems in the mitigation of climate change.

To fulfil these missions, the Initiative coordinates the Blue Carbon Scientific Working Group and the Blue Carbon Policy Working Group, which provide the orientation for the research and the implementation of projects. Certain are in the course of development in various continents with the aim of protecting and restoring the coastal ecosystems for their blue carbon value *(sources : thebluecarboninitiative.org and MedPan).*

(*) Founded in 2009 and coordinated by the International Union for the Conservation of Nature (IUCN), Conservation International (CI) and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO).

*Turtle above a meadow of eel grass (*Zostera marina*) - a marine aquatic plant - seeking food.*

➜ HOW WOULD YOU RELATE BLUE CARBON TO NATURE-BASED SOLUTIONS?

Basically, I see nature-based solutions as the use of the conservation, the restoration and the sustainable management of ecosystems – terrestrial, marine and coastal – to respond to the needs of humanity: food security, the battle against climate change, and so on.

An example of a conflict of uses: a fisher on his boat between the mangroves destroyed by shrimp farming and a petroleum industry plant in the Mahakam delta (Indonesia).

The interest of these natural solutions is that it is not limited to solely a matter of the absorbtion of atmospheric carbon.

The mangroves and the seagrass meadows also play many other roles which we refer to as ecosystem services (4).

But in terms of climate change, I think that we must also be fully aware of the fact that nature-based solutions are integrated, and part of a vast box of tools that countries can delve into to tackle climate change. Because we know that to combat the impact of current and future climate change, we should, and we will have to, make use of all the possible, yet sustainable, solutions in the sectors of industry, transport and renewable energy.

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(4) The coastal zones represent 7 % of the total area of the oceans, but they supply 50 % of world fish farming production; they host a rich biodiversity, perform the filtering of the water, mitigate the impact of coastal pollution, encourage sedimentation, the protection of the coasts against erosion. (source: notre-planète.info).

2/ Blue carbon as a value for economic incentives and a source of revenue

➜ THE COASTAL AREAS ARE OFTEN ECONOMIC DEVELOPMENT ZONES. HOW CAN HUMAN ECONOMIC ACTIVITY BE COMBINED WITH PROGRAMMES FOR THE CONSERVATION AND RESTORATION OF THE PRECIOUS BLUE CARBON ECOSYSTEMS?

It is certain that unsustainable economic development - aquaculture, agriculture - is the main cause of the degradation and destruction of the ecosystems of the coastal zone worldwide. But we are currently seeing opportunities to also generate revenue through the valorisation of coastal habitats in various sectors: eco-tourism, the sale of what are called carbon offset credits [see opposite page: *Carbon offset*].

Lagoon with turquoise waters and mangroves at the island of Koh Hong (Thailand).

Currently, efforts are being made, including by the IUCN, to try to attract the private sector while enjoying the support of the public in what we refer to as blended funding systems. It is a matter of showing that the restoration of mangrove forests or seagrass meadows might have an economic value if, for example, we associate it with sustainable fishing practices, and if we integrate this action within a framework of coastal management.

It is true that we are much more aware of the fact that coastal and marine ecosystems are the core underpinning of what we now call the sustainable blue economy [(5)].

Invasion by plastic waste, a vast environmental problem at worldwide scale.

➜ MORE SPECIFICALLY, WHAT DOES THIS AMOUNT TO?

The IUCN, for example, disposes of a new technical assistance scheme called the Blue Natural Capital Financing Facility (BNCFF).

With the Blue Natural Capital Financing Facility, we provide support to the project proponents who take into account the ecosystemic and social impact of climate change projects, while seeking to attract private sector capital.

To this end, we put them into contact with potential investors, by studying not only the part relative to the sustainable management of coastal and marine ecosystems, but also by thinking about ways to combine it with the development of renewable energies or solutions for water pollution control.

> *“A sincere and growing interest in getting together and trying to speak the same language”*

(5) The sustainable blue economy should ensure that investments generate social and economic benefits in the long term while protecting and restoring the diversity, the productivity and the resilience of marine ecosystems. It concerns five sectors: fisheries and aquaculture, tourism, maritime transport, offshore energy, prospection of the seabed.

Plastic is clearly an important issue. For example, we can see how revenue can be generated by collecting ghost fishing nets, the lost fishing gear of all kinds which has an impact on species, on habitats and on underwater landscapes.

There are indeed innovative areas to explore, and we can see, from both the conservation and the financial points of view, a potential and an interest for getting together and trying to speak the same language.

➜ DOES BLUE CARBON HAVE AN ECONOMIC VALUE EQUIVALENT TO THE CARBON TAX, WHICH APPLIES TO CARS? WHAT DO YOU RECOMMEND?

We are seeing new projects which sell credits, what is known as carbon offsets. That means that a value is attributed to carbon which remains locked away or which is extracted from that atmosphere through measures of restoration of the coastal habitats [see below : *Carbon offset*].

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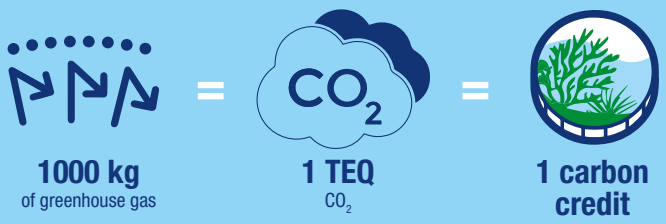
Focus

CARBON OFFSET
THE EXCHANGE OF CARBON CREDITS AGAINST A PROJECT FOR THE REDUCTION OF GREENHOUSE GAS EMISSIONS

The Kyoto Protocol (1997) was the first international agreement aimed at reducing greenhouse gases. It introduced the principle of carbon offset, based on the fact that a given quantity of carbon dioxide emitted at a given place may be compensated by the reduction or sequestration of an equivalent quantity of CO_2 in another place elsewhere on the planet.

This principle enables signatory States and their companies to finance projects for the reduction of greenhouse gases abroad in exchange for carbon credits, that is to say, 'the right to pollute' (*).



In other words, if a country emits more carbon dioxide than authorised by its quotas, it can buy the quotas of countries that emit less. The resale of excess quotas enables it to finance its own projects.

Each tonne of CO_2 not emitted in the atmosphere corresponds to a credit on the carbon market.

The offset projects are extremely varied. Those that have most benefited from carbon credits concern forestation and reforestation, the restoration of the biodiversity, the development of renewable energies - solar, wind power, hydroelectricity - to replace fossil fuels, waste management to reduce methane emissions in waste dumps.

RESTORATION OF MANGROVES

Some 4 700 hectares of mangroves restored in the River Casamance delta and the Saloum estuary, Senegal; 16 million mangrove trees planted in the Sundarbans forest, India, which covers the deltas of the Ganges, the Brahmaputra and the Meghna. These two cases of the restoration of degraded ecosystems (**) illustrate the principle of carbon offset, namely the dynamisation of local economies and a combat against climate change in exchange for carbon credits: useable by the investors to 'offset' their own greenhouse gas emissions, or for resale on the carbon market *(source: Blue Carbon and Blue REDD: Transforming coastal ecosystems into merchandise, World Rainforest Movement,* 2014*).*

(*) *Called Emission Reduction Units or Certified Emission Reductions, depending on whether they are issued under the Joint Implementation Project or the Clean Development Mechanism (CDM). These certificates are underwritten by the UN.*

(**) *Through the Danone Fund for nature, in 2009, with IUCN and RAMSAR. In 2011, it became the carbon fund Livelihoods 1 then 2 (2017), which continues its investment in the restoration of mangroves.*

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One might be critical with regard to the current use of carbon offsets to reduce greenhouse gases and to deal with the impact of climate change. It is nonetheless a means which enables the communities of coastal zones to generate revenue through improved management and improved restoration practices.

Of course, implementing a good system for sharing the carbon revenue can be complex. But the projects on the ground – at small and medium scale – constitute a springboard for better understanding what context, what means and what potential there might be at national and regional level to develop larger-scale financial incentive programmes.

The next High Level United Nations Conference to support the implementation of Sustainable Development Goal n°14: Conserve and sustainably use the oceans, seas and marine resources*, will be held in Lisbon, from 2nd to 6th June 2020.*

➔ WOULD YOU SAY THAT AT PRESENT, THERE IS A WORLDWIDE CONSENSUS ON BLUE CARBON? AT THE UN, ARE ALL THE STATES IN AGREEMENT?

Ten years ago, there were still a lot of questions on the lines of: *"What's it all about ?"*. But thanks to the ongoing work of communication and raising awareness, and the work of scientific experts in a political context, we have achieved a certain level of understanding and trust.

The most important thing, in this respect, was the *2013 Supplement to the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands.*

This document [6] offers help and guidance on the way to include greenhouse gas emissions and carbon sinks corresponding to the management of coastal wetlands in the greenhouse gas inventories of the countries concerned.

➔ DO YOU THINK BLUE CARBON COULD BE INTEGRATED IN THE PROCESS OF NATIONALLY DETERMINED CONTRIBUTIONS (NDC), WHICH MARKS THE COMMITMENT OF COUNTRIES FOLLOWING THE PARIS AGREEMENT ON THE CLIMATE TO REDUCE THEIR GREENHOUSE GAS EMISSIONS AND TO ADAPT TO THE IMPACT OF CLIMATE CHANGE?

It is an opportunity to encourage countries to take an interest in blue carbon.

At international level, with the United Nations Framework Convention on Climate Change, all the incentives are there to encourage countries to include blue carbon GHG accounting.

I think that the general and global framework already exists. Blue carbon already plays a role with regard to the management of coastal areas and planning processes, among other things. Nevertheless, the carbon element could still feature more prominently in the development of national strategies and in the incentive mechanisms for their implementation in certain countries.

The management of the coastal environment should be part of a far broader context involving a much wider range of issues where the States should be more ambitious with regard to the climate in order to contribute to the reduction of emissions of greenhouse gases worldwide.

Furthermore, a lot of research has been done to collect more robust and more reliable data for the areas beyond the coasts, to see whether or not the carbon stocks occurs in the long term. For example, one question I find intriguing is to what extent trawling contributes to a form of release of the carbon present in or on the seabed. This question is important because it might then come under national jurisdiction and thus be relevant to the States.

➔ SOME SAY THAT COP 25 WILL BE THE 'BLUE COP'. DO YOU THINK THAT MUCH IMPORTANCE WILL BE ATTRIBUTED TO THE OCEAN DURING THIS INTERNATIONAL CONFERENCE ON THE CLIMATE?

I hope that during this climate conference [7], the attention paid to the Ocean will be given a fresh impetus.

We have gone far beyond the stage of general discussions. The difficulty is to find tangible and practical solutions to climate change.

Even if detailed elements feature in the UNFCCC, and if certain mechanisms may and should still be improved, I think that at a broader political level, it would be fantastic if certain countries took the initiative to get together and undertake, for example, a joint effort to help countries reduce greenhouse gas emissions from coastal management.

The ocean community often claims that they do not have sufficient financial means – which is true, to some extent. But nonetheless, we also already dispose of other schemes, such as the Green Climate Fund [8] which already cover the adaptation of coastal zones to climate changes, but are under-utilized for ocean issues. But, we are seeing the gradual integration of aspects relative to blue carbon.

In comparison with the terrestrial domain, we still have to make an effort. There are means we could use which have not yet been fully exploited.

➜ ALL THE MORE SO IN THAT IT'S A QUITE NEW ISSUE INVOLVING A COMPLEX APPROACH. IN MARCH 2019, AT THE *ONE PLANET SUMMIT* IN NAIROBI, IT WAS SAID THAT THE NATIONALLY DETERMINED CONTRIBUTIONS SHOULD BE SUPPORTED BY THE WORLD BANK INVESTMENT PLANS.

DO YOU THINK THAT THE CAUSE OF BLUE CARBON MIGHT BE A GOOD APPROACH TO HELP COMMUNITIES TO RESTORE THEIR COASTAL AREAS AND TO INCLUDE THEM IN THEIR NATIONALLY DETERMINED CONTRIBUTIONS?

Yes, I think that it's an interesting way to go, and we come back to the work we're doing with the Blue Natural Capital Financing Facility [9], in particular to make projects more attractive, to bring in other financial partners.

This Blue Natural Capital Financing Facility is an important project that we're running at present and which, in my view, might potentially become a more innovative tool. Countries must work less in isolation, in matters of energy, transport, nature-based solutions.

There is no silver bullet to use in specific circumstances, but the fact of thinking more of the blue natural capital as an instrument capable of driving the mitigation of the impact of climate change, adaptation and development would help to refocus the debate on broader discussions on coastal management issues. This is very important.

> ***"This is no longer a battle, but rather a debate, a search for solutions"***

Ph. C. F-B

➜ WHAT IS IT THAT GIVES YOU HOPE AND ENTHUSIASM IN ALL THE WORK YOU DO?

Since 2010, I have been working on the link between the Ocean and the climate, and I am still optimistic.

The battle has been long and difficult; today, it has rather become a search for solutions, and I think that that is in itself a source of strength.

We should also stress the work done by the IUCN and its partners and members on the different aspects of the conservation of the coastal areas, the adaptation to climate change and its mitigation.

Yes, things are complex, but we must keep them moving. I would like to be able to say to my children that I've done everything I could to help them to enjoy a beautiful future. ■

Interview with Patricia Ricard
April 2019

(6) Adopted under the United Nations Framework Convention on Climate Change (UNFCCC).

(7) From 11 to 22 November 2019, in Santiago, Chile.

(8) A UN financial instrument, linked to the United Nations Framework Convention on Climate Change (UNFCCC).

(9) The Blue Natural Capital Financing Facility is a financial instrument set up by the IUCN with support from the Government of Luxembourg. www.bluenaturalcapital.org.

Ph. C. F-B / Ph. Adobe Stock/Damedias

INTERVIEW WITH

CHLOË WEBSTER

Marine Environment Scientific Consultant

> *"In the Mediterranean, the Marine Protected Areas are key management tools for the preservation of biodiversity and one of our responses to climate change"*

1 / IN THE MEDITERRANEAN, THE SEAGRASS *POSIDONIA OCEANICA*, AN EMBLEMATIC SPECIES FOR BLUE CARBON

2 / THE MARINE PROTECTED AREAS, TOOLS FOR STORING BLUE CARBON

CAREER
CHLOË WEBSTER

"I studied environmental sciences in England, in general, and since my childhood, I have always felt a strong passion for the marine environment."

Chloë Webster long hesitated between the infinitely small and the infinitely large, and gradually she began to focus on the cetaceans, especially the large whales, in Canada. *"And then, I turned towards the environmental NGOs working on the protection of the sea, in England and in other countries, such as Madagascar, where I ran a marine environment research station".*

Chloë Webster has worked on a variety of subjects, ranging from mangroves and coral reefs to marine mammals and sea turtles.

Her experience related to the understanding and conservation of the marine environment laid the foundations for her future role with MedPAN, the network of managers of Marine Protected Areas in the Mediterranean, which she joined in 2011 as Scientific Officer. *"Recently, I left MedPAN to get started as freelance consultant, still focused on the marine environment, but with the aim of also extending the scope of my activities beyond our beautiful Mediterranean".*

Photo above - The Posidonia oceanica *seagrass forms vast underwater meadows which perform a range of functions of major ecological importance. Among other things, these seagrass beds are an essential source of oxygen for the marine environment.*

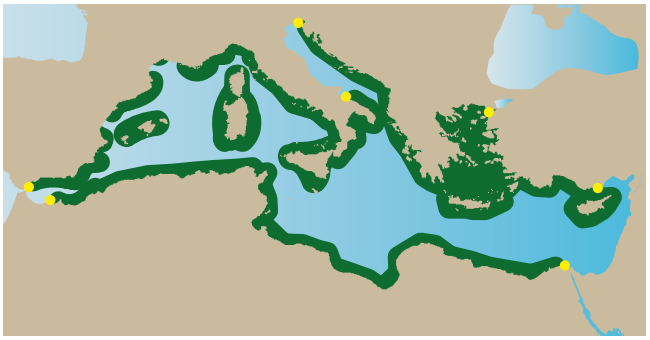
1/ In the Mediterranean, the seagrass Posidonia oceanica, an emblematic species for blue carbon

➜ YOU WERE SCIENTIFIC OFFICER AT MedPAN, AND IN THIS ROLE YOUR RESEARCH WAS FOCUSED ON THE MEDITERRANEAN. HOW WOULD YOU DESCRIBE THE MEDITERRANEAN IN TERMS OF BIODIVERSITY?

The Mediterranean is a very special sea: it's semi-enclosed, it has its own circulation system, a bit like a mini-ocean.

Recognised as a hotspot of biodiversity, the Mediterranean is very rich: it covers only 0.7 % of the surface of the oceans and seas worldwide, but it is home to 7.5 % of the marine fauna and as much as 18 % of the marine flora of the planet, with a certain number of highly endangered organisms and a high rate of endemic species [1], such as the seagrass *Posidonia oceanica*. This flowering plant is very widespread, it occupies 20 to 50 % of the seabed between the surface and 50 metres depth [2].

It is found throughout the Mediterranean, forming meadows ranked among the most productive coastal natural habitats on the planet, along with the mangroves and the tidal salt marshes.



Distribution of meadows of the seagrass Posidonia oceanica *in the Mediterranean. The green dots correspond to the limits of the range of distribution of the species (source: Mediterranean Seagrass Meadows – Resilience and contribution to Climate Change Mitigation, 2012 - published by IUCN).*

All provide precious ecosystem services, and in particular play a role as especially efficient carbon sinks [See opposite: *Marine and coastal ecosystems – Services rendered*].

The carbon sequestered and stored over an indefinite period of time by the coastal marine ecosystems is called blue carbon [3].

The mangroves, salt marshes and kelp forests are very efficient at storing carbon; the seagrass meadows [4] – and not only those constituted by *Posidonia oceanica* - also play a major role.

This blue carbon reduces the concentration of carbon dioxide in the atmosphere, which means that it can contribute to combating climate change, and can mitigate its impact.

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Focus

MARINE AND COASTAL ECOSYSTEMS
Services rendered

The *Millennium Ecosystem Assessment* (MEA) – launched by the UN (2000) – defines four categories of 'ecosystem services'.

• **Supporting** – services necessary for the production of other ecosystem services, that is providing living space for plants and animals, enabling the diversity of species and the preservation of genetic diversity.

• **Provisioning** – material advantages derived from ecosystems, for example supplying food, drinking water, wood fibre; fuel and biochemical and pharmaceutical products.

• **Regulating** – services which moderate or regulate natural phenomena: air quality, soil fertility, combating climate change, floods and disease, the pollination of crops.

• **Cultural** – non-material benefits: tourism, leisure activities.

In 2014, the total value of ecosystem services was assessed as 125 000 billion dollars. But their quality depends on the resilience and the protection of the ecosystems. If it is degraded, an ecosystem provides fewer services.

Should this natural capital disappear, all the ecosystems would be compromised along with the world economy, which is fully dependent on their existence.

In 2009, France adapted this programme to the scale of its own territory, with a report: *Étude exploratoire pour une évaluation des services rendus par les écosystèmes en France – Application du* Millenium Ecosystem Assessment *à la France (*Exploratory study for an assessment of services rendered by ecosystems in France - Application of the Millennium Assessment to France).

Source: ocean-climate.org and United Nations Food and Agriculture Organisation (FAO).

Ph. Adobe Stock/R. Carey

The Posidonia oceanica *seagrass meadow offers shelter to numerous animal species, including at least 20% of Mediterranean fishes which are regularly present there. They come to feed and to shelter from predators.*

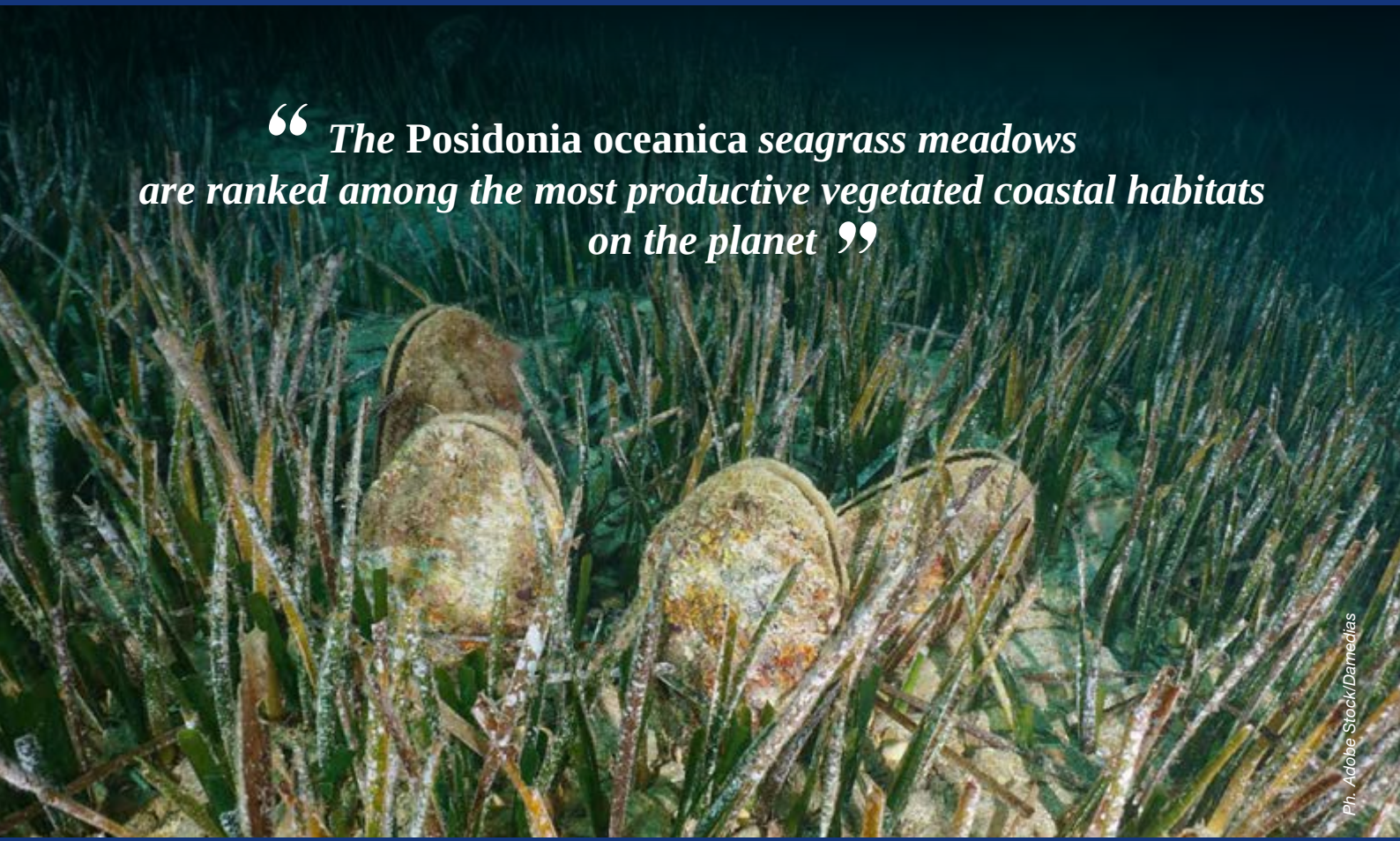
Ph. Adobe Stock/PIXATERRA

Rather unusually, a Posidonia oceanica *seagrass bed on a rocky ledge, with its rhizomes clearly visible.*

Ph. Adobe Stock/PIXATERRA

The seahorse, Hippocampus guttulatus*, hiding among the leaves to gobble up small shrimp passing within reach.*

> *“The* **Posidonia oceanica** *seagrass meadows are ranked among the most productive vegetated coastal habitats on the planet”*



Ph. Adobe Stock/Damedias

A clump of fan mussels, Pinna nobilis*, in a seagrass bed in winter, at Cap de Creus, on the Costa Brava (Spain).*

>>

➔ WHAT ARE THE PROCESSES OF CARBON UPTAKE BY THE MARINE PLANTS, IN PARTICULAR THE *POSIDONIA OCEANICA* SEAGRASS BEDS?

The marine plants absorb the carbon dioxide present in their immediate environment and fix the carbon in its organic form through photosynthesis. The efficiency of this process is greater in the case of the *Posidonia oceanica* beds because after its integration within the plant biomass, part of this carbon is sequestered in the underlying matte [5], and is thus trapped long-term, for several decades, centuries or even millennia [see page 13: *Photosynthesis – A highly complex natural mechanism.* Interview with Laurent Bopp].

The production of organic carbon enables plants to develop more energetically and thus enhances the ecosystem services they provide. *Posidonia oceanica* can extend its surface of exchange with the environment and uptake more carbon dioxide, but also release more oxygen into the atmosphere [6].

In the opposite case, the degradation of the seagrass meadows would give rise to a new source of emissions by releasing back into circulation in the environment a considerable quantity of the already stored carbon.

➔ IN THE MEDITERRANEAN, ARE ANY OTHER COASTAL ECOSYSTEMS BLUE CARBON SINKS?

Yes, and in the end the process is similar.
We might mention the coralligenous beds [7], the maerl [8], the rodoliths which are calcified red algae.

Colleagues at the *Université de Corse*, at Corte, have done an interesting experiment involving taking cores in certain of these ecosystems. They found that in comparison with the *Posidonia oceanica* seagrass, the coralligenous and the maerl may have carbon sequestration rates that are just as high and become efficient blue carbon sinks, on condition that they are preserved from any degradation caused by human activities: fishing with trawling gear, dredging, extraction and so on.

➔ DO CERTAIN MEDITERRANEAN PLANTS SEQUESTER CARBON DURING THE CONSTRUCTION OF THEIR SKELETON? HAS THE EFFICIENCY OF THESE CALCIFICATION PROCESSES IN THE SEQUESTRATION OF CARBON BEEN ASSESSED?

We have just mentioned the particular ecosystems constituted for the most part of calcareous red algae - coralline and others - which store carbon both through photosynthesis and by the


Ph. Adobe Stock/bolga2b


Ph. Adobe Stock/Noble Nature

Deposits of dead *Posidonia oceanica* leaves washed up during storms. They form large *banquettes* on the shore containing sea balls of woody fibre of various sizes. These *banquettes* offer protection for the shores.

process of calcification of their skeleton (thallus). Which finally results in the production of carbonated sediments, in particular in temperate and cold seas.

Nonetheless, the role of these ecosystems such as the rhodolith beds or the Mediterranean coralligenous assemblages in the sequestration of carbon is not altogether clear.

In fact, the process of calcification does not necessarily involve the trapping of carbon. The opposite tendency might occur in certain cases. If we take the example of the rhodoliths, it seems that their calcification process may put carbon back into circulation in the environment.

We already know that these calcareous algae are vulnerable to the warming and acidification of the seawater. This may be reflected in a visible diminution of their calcification, affect their growth or their reproduction [9].

Experiments are under way precisely to try to understand this phenomenon in this type of algae. It is important to quantify the carbon to see whether it is indeed stored or, finally, is partly released back into the atmosphere.

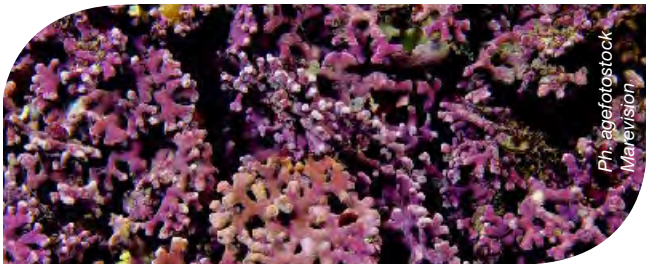
This is what we try to evaluate to determine the net carbon sequestration corresponding to the balance between the quantity of carbon dioxide sequestered and the quantity released back into circulation in the environment.
This process may occur over a variable period of time and may be measured at species, habitat or ecosystem level.

In fact, the net sequestration of carbon by these algae is what will remain in the end. It corresponds to what is really stored and constitutes the blue carbon sink.

➔ CAN WE SAY THAT BLUE CARBON IS AN EXAMPLE OF A NATURE-BASED SOLUTION [10] TO MITIGATE CLIMATE CHANGE BY THE STORING OF THE CARBON OF OUR ATMOSPHERE?

I'm not altogether convinced that blue carbon is a nature-based solution. It is an already existing process that the pressures generated by human activity tend to destroy, which therefore contributes to climate change.

My feeling is rather that a nature-based solution is grounded in protection measures such as the creation of the Marine Protected Areas and the introduction of other regulatory measures aimed at reducing human-generated pressures. The aim is to secure and to maintain the blue carbon sinks in a good state, notably by protecting them from potential destruction.



Maerl – Calcified red algae living freely on the surface of the sediment.

The gorgonians of the Mediterranean coralligenous beds are very fragile and vulnerable to warming of the water.

>>

(1) An endemic species only occurs within a given territory. Its disappearance from a territory thus entails its disappearance on the planet.

(2) Préservation et conservation des herbiers à Posidonia oceanica – *Boudouresque C.F., Bernard G., Bonhomme P., Charbonnel E., Diviacco G., Meinesz A., Pergent G., Pergent-Martini C., Ruitton S., Tunesi L., 2006 RAMOGE pub. : 1-202.*

(3) In contrast, green carbon is terrestrial. It is fixed and stored within the plant biomass, the soils of forests, grasslands and farmland.

(4) Marine seagrass meadows are constituted of marine magnoliophytes. These flowering plants – sixty or so species on the planet, including Posidonia oceanica *– colonise the shallow coastal waters. These formations occupy only 1 % of the oceans, but are estimated to be responsible for 40 % of the carbon fixed each year by the coastal vegetation, with variations linked to the species and the environmental conditions (source: Laffoley and Grimsditch, 2009).*

(5) The matte is a structure buried beneath the plant and constituted of a lattice of rhizomes, roots, dead leaves and sediment that fills in the interstices of this construction of poorly putrescible matter. It can reach several metres in height and may last for millennia.

(6) A study by the Institut Méditerranéen de Recherche Avancée *(IMéRA - Mediterranean Advanced Research Institute) and the BBVA Foundation indicates that the Mediterranean Posidonia oceanica ecosystems produce 14 to 20 litres of oxygen per square metre per day.*

(7) An underwater ecosystem characterised by an abundance of calcareous algae which construct by superimposition of crusts or by accumulation of deposits massifs comparable to coral reefs. Animal species with calcareous skeletons – sponges, gorgonians – may also be associated with these constructions.

(8) Accumulations of red calcareous algae over a thickness varying from a few centimetres to several metres. The maerl is widespread in the North Atlantic and in the Mediterranean: Algeria; Spain, Balearics; France, on the Hyères islands, near Marseille, Corsica.

(9) Basso D., 2012 – Carbonate production by calcareous red algae and global change. Geodiversitas 34 (1): 13-33.

(10) Nature-based solutions are defined by the IUCN as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".

THE 2016 FORUM of Marine Protected Areas in the Mediterranean

Forum organised by:

Financial and technical partners:

The system of **Mediterranean M**

7.14%

Surface under protection status
179,798 km² / 1,231 MPAs and Other Effective Area-based Conservation Measures (OECM) including*:

- 186 MPAs of national status: 1.60%
- 898 marine Natura 2000 sites: 2.37%
- 3 GFCM Fisheries Restricted Areas: 0.62%
- Pelagos Sanctuary for marine mammals: 3.47%

* The above percentages cannot be added because there are overlaps between sites and not all sites are mentioned

0.04%

Surface under stronger protection (no-go, no-take or no-fishing zones)

+ 1.8%

of surface under designation compared to the last status of Mediterranean MPAs in 2012, including:

- 6 national status MPAs (21,827 km² added)
- 391 marine Natura 2000 sites (34,458 km² added)

* The MAPAMED database lists in 2016 a greater variety of sites than in 2012 including sites designated before 2012

>100

Potential sites identified t
MPAs or be subjected to
spatial conservation mea
12 countries

LEGEND

- MPAs of national status
- Marine Natura 2000 sites
- Pelagos Sanctuary for marine mammals
- Particularly Sensitive Sea Area
- Parc International Marin des Bouches de Bonifacio SPAMI
- Fisheries Restricted Areas (GFCM)
- UNESCO Biosphere reserves
- UNESCO world heritage sites
- Ramsar Sites
- Depth >1,000m

SLOVENIA
Under designati
National status:
Marine Natura
Stronger protect

ITALY
Under designation: 9.07% (48,890 km²)
National status: 0.56% (3,012 km²)
Marine Natura 2000: 1.2% (6,468 km²)
Stronger protection: 27 sites (155 km²)
Potential sites identified: 22 (0,25 km²)

FRANCE
Under designation: 60.17% (53,282 km²)
National status: 15.37% (13,616 km²)
Marine Natura 2000: 11.13% (9,859 km²)
Stronger protection: 8 sites (74 km²)

MONACO
Under designation: 100% (283 km²)
National status: 0.08% (0.24 km²)
Stronger protection: 2 sites (0.25 km²)

SPAIN
Under designation: 11.66% (30,459 km²)
National status: 0.86% (2,242 km²)
Marine Natura 2000: 11.64% (30,411 km²)
Stronger protection: 16 sites (116 km²)

MOROCCO
Under designation: 2% (376 km²)
National status: 1.14% (214 km²)
Potential sites identified: 9

ALGERIA
Under designation: 0.03% (44 km²)
National status: 0.02% (26 km²)
Stronger protection: 1 site (5 km²)
Potential sites identified: 8

TUNISIA
Under designation: 1.01% (1,020 km²)
National status: 0.15% (150 km²)
Stronger protection: 2 sites (161 km²)
Potential sites identified: 7

MALTA
Under de
National

The Mediterranean : a sea under pressure

- **1/3 of the global maritime traffic**
  + 4% per year planned by 2025
- **1st world tourist destination**
  343 million of annual arrivals in 2014,
  + 40% planned by 2025
- **Booming exploitation of hydrocarbons at sea**
- **Overexploited**
  85%* of fish stocks ove
  * FAO, 2016. The state of Mediterr
  Fisheries Commission for the Medi

Source : Projet MedTrends, (WWF France), Plan Bleu

MARINE PROTECTED AREAS
Everyone's Business.

Marine Protected Areas in 2016

90.05%

Share of the total Mediterranean surface under designation located in European waters

Perspectives

Aichi objective 11 is not limited to reaching 10%. Having "effectively and equitably managed" MPAs and OECMs by 2020 implies that numerous qualitative improvements be made, in link with:

- Legal frameworks and governance
- Availability of adequate funding
- Systematic management planning
- Appointment of sufficient permanent staff
- Regulations and surveillance
- Stakeholder engagement
- Integration with Marine Spatial Planning

In 2016, MedPAN and the SPA/RAC undertook an assessment survey of the state of the Marine Protected Areas (MPA) and other effective area-based conservation measures in the Mediterranean. The figures relative to the MPAs presented in this document come from the October 2016 version of MAPAMED, the database of sites of interest for the conservation of the marine environment in the Mediterranean, developed by MedPAN and UNEP/MAP-RAC/SPA (now UN-Environment and SPA/RAC, www.unenvironment.org).

MONTENEGRO
Under designation: 0.35% (26 km²)
National status: 0.34% (26 km²)
Potential sites identified: 4

GREECE
Under designation: 1.55% (7,666 km²)
National status: 0.72% (3,544 km²)
Marine Natura 2000: 1.45% (7,168 km²)
Stronger protection: 2 sites (2 km²)
Potential sites identified: 3

ALBANIA
Under designation: 1.63% (181 km²)
National status: 1.63% (181 km²)
Stronger protection: 2 sites (106 km²)
Potential sites identified: 3

TURKEY
Under designation: 12.58% (9,111 km²)
National status: 12.35% (8,944 km²)
Stronger protection: 3 sites (30 km²)

SYRIA
Under designation: 0.04% (4 km²)
National status: 0.04% (4 km²)
Potential sites identified: 3

CYPRUS
Under designation: 10.26% (10,069 km²)
National status: 0.01% (8 km²)
Marine Natura 2000: 0.13% (131 km²)

LEBANON
Under designation: 0.21% (43 km²)
National status: 0.21% (43 km²)
Potential sites identified: 14

LIBYA
Under designation: 0.03% (313 km²)
National status: 0.03% (313 km²)
Potential sites identified: 20

EGYPT
Under designation: 2.03% (3,542 km²)
National status: 0.3% (518 km²)

ISRAEL
Under designation: 4.68% (1,270 km²)
National status: 0.1% (28 km²)
Stronger protection: 6 sites (17 km²)
Potential sites identified: 14

CROATIA
Under designation: 9.51% (5,314 km²)
National status: 1.11% (622 km²)
Marine Natura 2000: 9.43% (5,268 km²)
Stronger protection: 4 sites (158 km²)

Disclaimer:
The designations used in this document, the presentation of the data and the demarcation of the MPAs, OECMs and other sites of conservation interest presented do not imply the expression of any opinion whatsoever on the part of MedPAN, UN Environment/MAP SPA/RAC and their partners neither concerning the legal status of any state, territory, city, zone or of their authorities, nor concerning the delimitation of their territorial and marine borders or limits.

Since the Exclusive Economic Zones (EEZ) in Mediterranean countries are not yet all established, the theoretical EEZ (Source: Flanders Marine Institute, World 'all EEZ) was used as an indication for the calculation of these percentages. They may vary from the surfaces declared by the States and are not binding for the authors and partners of this document.

Content:
MPAs: *MAPAMED, the database on Sites of interest for the conservation of marine environment in the Mediterranean Sea, MedPAN, UN Environment/MAP SPA/RAC. October 2016 release.*
COUNTRIES: *Natural Earth. Admin 0 - Countries. 2016*

- **Land-based pollutions** profound effects on biodiversity
- **Drastic impacts linked to climate change**
- **Over 900 non-native marine species including at least 40 invasives**

2/ The Marine Protected Areas, tools for storing blue carbon

➜ WHAT ROLE CAN THE MARINE PROTECTED AREAS (MPA) PLAY IN A PROCESS OF PROTECTION OF THE BLUE CARBON SINKS?

Their role is in my view very important. For example, a study was carried out in Indonesia to assess their role in the protection of the mangroves. Experts calculated that the creation of Marine Protected Areas between 2000 and 2010 had prevented the destruction of 14 000 hectares of mangroves, thus avoiding the release of 13 million tonnes of carbon dioxide back into the natural environment [11].

About 7 % of the surface area of the Mediterranean sea has been placed under a protection status [See map, page 46-47].

If properly managed, these areas can effectively protect the blue carbon sinks within the vegetal coastal habitats and sediments. They can also aid certain ecosystems to restore themselves and to breathe.

When a site is properly protected, various studies have shown that the predators return and settle there.

Furthermore, the large carnivorous fishes help to protect the carbon stocks in the blue carbon ecosystems by limiting the density of herbivorous populations. These reduce the vegetal production by eliminating part of the leaf surface area, which reduces even more the photosynthesis potential and thus the absorbtion of carbon dioxide.

In the Mediterranean, the MPAs are indeed key management tools for the preservation of biodiversity and one of the responses in the process of fighting to slow down climate change, in relation with the blue carbon coastal ecosystems.

Focus

MedPAN
A TOOL FOR SURVEILLANCE AND MANAGEMENT

MedPAN is the network of managers of Marine Protected Areas (MPA) in the Mediterranean. It brings together more than a hundred institutions and non-governmental organisations (NGOs) in 19 countries.

Their role is to manage the MPAs and to support their development.

The Marine Protected Areas are a strategic tool for the long-term conservation of the marine environment, in particular the species, the habitats, the ecosystems, and to guarantee the sustainable management and economic development of marine resources.

MedPAN has set up a small projects scheme to provide direct support for the MPA managers. The aim is to implement practical actions in order to enhance the efficiency of the MPA management, to set up pilot schemes which might be useful for other Marine Protected Areas.

Among the MedPAN partners are the UN Environment - Mediterranean Action Plan (MAP), the Specially Protected Areas Regional Activities Centre (SPA/RAC), World Wildlife Fund (WWF), the International Union for the Conservation of Nature (IUCN), the Agreement for the Conservation of Cetaceans of the Mediterranean Sea, Black Sea and Contiguous Atlantic Area (ACCOBAMS), the General Fisheries Commission for the Mediterranean (GFCM).

Source : medpan.org

For more information: ***http://www.aires-marines.com/Marine-Protected-Areas***

➜ ARE THERE ANY INTERNATIONAL PROGRAMMES FOCUSED ON THE ISSUE OF BLUE CARBON?

Yes, indeed, there are several international programmes working on this issue. We might mention the International Blue Carbon Initiative. This programme is focused on the mitigation of climate change through the conservation and the restoration of marine and coastal ecosystems [See too page 35: *The International Blue Carbon Initiative* – Interview with Dorothée Herr].

A considerable amount of research is being done in this area to better understand the processes, better analyse the carbon cycle and to adapt to climate change. Increasingly, this is contributing to our knowledge and to the development of actions focused on the protection of coastal habitats.

Ph. D. Loquet /CNRS Photothèque

Underwater glider used on the north-western Mediterranean. This device can travel in full autonomy between the surface and 500 metres depth. It takes measurements, notably to identify the zones with high photosynthesis revealing the consumption of carbon dioxide by phytoplankton.

>>

Ph. Y. et M. Tavernier

Parc National des Calanques *(Marseille - Calanques National Park) – In the foreground, the islands of Jarre and Jarron, then Maïre, in the Riou archipelago.*

Ph. Adobe Stock/anemone

Dilek Peninsula National Park, south of Kusadasi (Turkey).

1 231

This is the number of Marine Protected Areas (MPA) and other areas of conservation interest in the Mediterranean in 2016. They cover **179 798 km²**, which means that **7.14 %** of the Mediterranean is under legal protection status. Let us recall that the goal is to place **10 %** of waters under effectively-managed MPA status by 2020 (Aichi Targets of the Convention on Biological Diversity).
Source : medpan.org

>>

➔ CAN BLUE CARBON CONFER ECONOMIC BENEFITS FOR STATES, NOTABLY IN THE MEDITERRANEAN?

Recent research in the field of blue carbon has been focused, for example, on the evaluation of the amount of carbon stored in the *Posidonia ocanica* seagrass meadows.

It would indeed be economically very interesting to know this in order to be able to access the carbon markets [(12)] which are fairly dynamic. But for the *Posidonia oceanica* beds, we don't yet know how to determine their financial value in terms of blue carbon.

➔ ARE THE MPAs A WAY TO CONTRIBUTE TO MEETING NATIONAL AND GLOBAL GOALS WITH REGARD TO THE MITIGATION OF CLIMATE CHANGE?

Some countries are increasingly exploring the possibility of including vegetal coastal habitats in their national greenhouse gas budgets.

However, fewer than 20 % of the 151 countries which have blue carbon habitats mention these habitats as being part of their strategy for the mitigation of climate change.

On the other hand, from the economic point of view, I think that the States might get more solid support for the efforts of conservation and restoration they deploy in favour of marine habitats in general and blue carbon habitats in particular, by demonstrating the contribution of the Marine Protected Areas to national and global goals relative to climate change.

The MPAs come within the framework of economically viable policies for storing blue carbon. But while this is of major importance, we must not neglect the source of the problem, which is the emissions themselves.

We must stress the fact that a hundred or so companies are responsible for 70 % of the greenhouse gas emissions worldwide since 1988. Perhaps the time has come for political action to target the urgent reduction of the production and consumption of fossil fuels. ■

Interview with Christian Frasson-Botton
March 2019

(11) Consult a recent reference on the subject (in French): La protection de l'environnement marin en Indonésie - *www.tresor.economie.gouv.fr/Articles/2019/05/06/la-protection-de-l-environnement-marin-en-indonesie*

(12) Schemes for exchanging the right to emit carbon dioxide in a similar way to exchanges of financial stocks.

Focus

BLUE CARBON AND MPAs

These two topics are the focus of international scientific conferences which place them in the forefront of current issues of major concern associating the preservation of biodiversity and climate changes.

• ***"Blue carbon: an innovative method worth exploring to sustain our MPAs",*** was the title of a session on blue carbon at the 2016 Forum of Marine Protected Areas in the Mediterranean (Tangiers).

During this international conference, the importance of the MPAs in the protection of blue carbon ecosystems was discussed, highlighting that the effective management of existing MPAs or the creation of new MPAs might be supported financially by schemes for financing blue carbon. Several programmes in progress have been the focus of case studies such as *The Blue Carbon Initiative* and *Life Blue Natura*, a European blue carbon project aimed at quantifying the carbon deposits and the rate of sequestration of habitats.

• ***Advances and initiatives in research on blue carbon ecosystems*** were presented in 2017 during the Interdisciplinary Symposium on the Monitoring of Global Change held at the *Université de Corse* (Corte), from the *Blue Carbon Initiative to the conservation and restoration of blue carbon habitats.*

Source: Science for the management of Marine Protected Areas - Blue carbon: the importance of marine conservation for climate change, n° 8, September 2018, MedPAN.

For more information: ***thebluecarboninitiative.org*** and ***life-bluenatura.eu***

Ph. Adobe Stock/rochagneux

“The MPAs play a very important role in the carbon sink process”

Ph. Adobe Stock/Fourcade.N

Seagrass Posidonia oceanica *with a shoal of fish, Mediterranean sea, Cabo de Gata Nijar, Almeria, Andalusia, Spain.*

Ph. Adobe Stock/damedias

Focus

WHEN WE DIDN'T YET SPEAK OF BLUE CARBON...
INNOVATIVE WORK CARRIED OUT AT THE *INSTITUT OCÉANOGRAPHIQUE PAUL RICARD*

"*From the beginning of the 1990s*", explains Yvan Martin, former Director of Research at the Institute, "*we began to work on the response of the plankton network to the doubling of concentrations of atmospheric carbon dioxide*". An increase which, according to the forecasts in the first IPCC report, was expected to occur in 2100.

"*Even if we didn't yet use the term 'blue carbon'*", Dr Martin recalls, "*we knew that the Ocean was a regulatory element, even if we didn't understand all the mechanisms*".

The project, set up then in partnership with Elf-Aquitaine, consisted in dreaming up an experimental system to analyse the impact of the doubling of the partial pressure of atmospheric carbon dioxide on the microbial communities in the seawater, and their role in the biological pumping of this gas. "*And what was particularly innovative*", explains Yvan Martin, "*was the use of mesocosms, that is closed tanks measuring one to three metres, constantly supplied with seawater and air enriched or not in CO_2. No one had worked on such large volumes before*".

The measurements provided a means to demonstrate the importance of the physical and also biological processes in pumping atmospheric carbon dioxide.

The physical pump, which is the process of diffusion and dissolution of CO_2 in the seawater, plays a primordial role.

But the biological pump which is the process of absorbtion and uptake by the vegetal plankton maintains the phenomenon and enhances the effects. "*Our experiments*", adds Dr Martin, "*also enabled us to develop a mathematical model of the dynamic of these chemical and biological components*", an essential stage as a basis for prospective studies.

This pioneering project, run until 1995, was followed by a second programme, DOREMI, carried out with in partnership with other research organisations (INSU, CNRS, Elf Aquitaine) in 2000 and 2001. Twenty researchers carried out experiments on the same topic for one month at the island of Les Embiez.

Ph. V. Tollard

Experimental setup for the study of carbon dioxide absorbtion by the marine microbial communities: bacteria, microalgae, etc.

In the course of their research on experimental aquaculture and combating human-generated marine pollution, the scientists at the Institut océanographique Paul Ricard have also focused on the issue of climate change since the early 1990s. Seen here, a meeting with Prof. Nardo Vicente and Dr Yvan Martin.

“Even if we didn’t yet use the term ‘blue carbon’, we knew that the Ocean was a regulatory element”

Ph. AdobeStock/willyam

THE
NEWSLETTER
N°17 - 2019

"Civilisations have their young people, in the North countries and the South countries of the Mediterranean; and it is up to these young people, with us, to invent a new page (...), a new mythology."
Emmanuel Macron

With President Emmanuel Macron (left to right): Ouided Bouchamaoui, President of the Steering Committee of the Two Shores Summit, and Nobel Peace Prize laureate 2015; Assia Bensalah Alaoui, Ambassador-at-large and leader of the Moroccan delegation; Patricia Ricard, leader of the French delegation.

SUMMIT OF THE TWO SHORES

Commitments for a new ambition for the Mediterranean

ON 23RD AND 24TH JUNE 2019, THE SUMMIT OF THE TWO SHORES IN MARSEILLE BROUGHT TOGETHER REPRESENTATIVES OF THE CIVIL SOCIETY OF THE MEDITERRANEAN COUNTRIES, AND THE MINISTERS OF FOREIGN AFFAIRS OF THE 5+5 COUNTRIES (FRANCE, PORTUGAL, SPAIN, ITALY, MALTA, MAURITANIA, MOROCCO, ALGERIA, TUNISIA, LIBYA), IN THE PRESENCE OF PRESIDENT EMMANUEL MACRON. AT THE CONCLUSION OF THE SUMMIT, COMMITMENTS WERE SIGNED.

Patricia Ricard, leader of the French delegation*: "We have always said that the Mediterranean is a model ocean and the cradle of civilisations, and here I think we can give birth to a fine new civilisation of reconciliation and resilience. This Summit will be a way to create a Mediterranean generation that will stand shoulder to shoulder in the face of common challenges".*

"We have really taken it to heart that we must engage in the fight against climate change, must be in phase with the aims of sustainable development, and we do this in full awareness, with constancy and goodwill."

Closing session of the Summit in Marseille, with President Emmanuel Macron.

8 COMMITMENTS FOR THE FUTURE

1. Commitments for a Mediterranean of knowledge and mobility

2. Commitments for a sustainable Mediterranean

3. Commitments for a multicultural Mediterranean

4. Commitments for an innovative, digital and entrepreneurial Mediterranean

5. Commitments for a Mediterranean of cities, rooted in its territories

6. We are convinced that the actions that we are proposing to undertake will enhance peace and development in our region.

7. A political commitment in favour of the Union for the Mediterranean and the Anna Lindh Foundation, which remain key platforms for strengthening the partnership between the European Union and all the Mediterranean countries.

8. We are finally convinced that a Mediterranean community based on solidarity, conviviality and mutual benefit is possible. It will favour reciprocal exchanges. It will nourish the contributions the Mediterranean can make to the world.

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

Photo credits : France diplomatie