EUROPEAN GEOSCIENCES UNION – GENERAL ASSEMBLY
Geosciences Information for Teachers Workshop (GIFT) 2023
24-26 April 2023

The ocean and its ecosystems, climate change and SDG14

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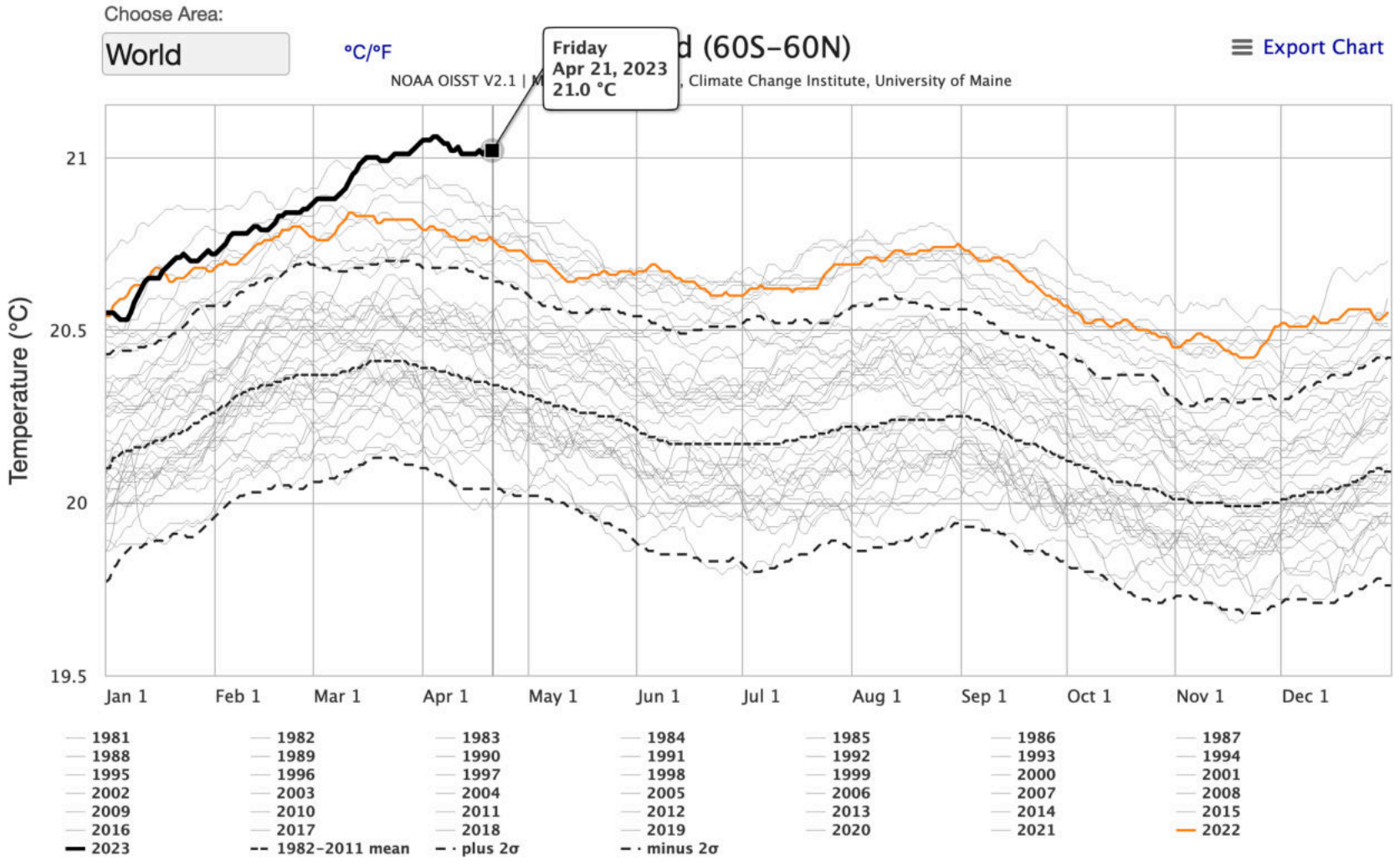
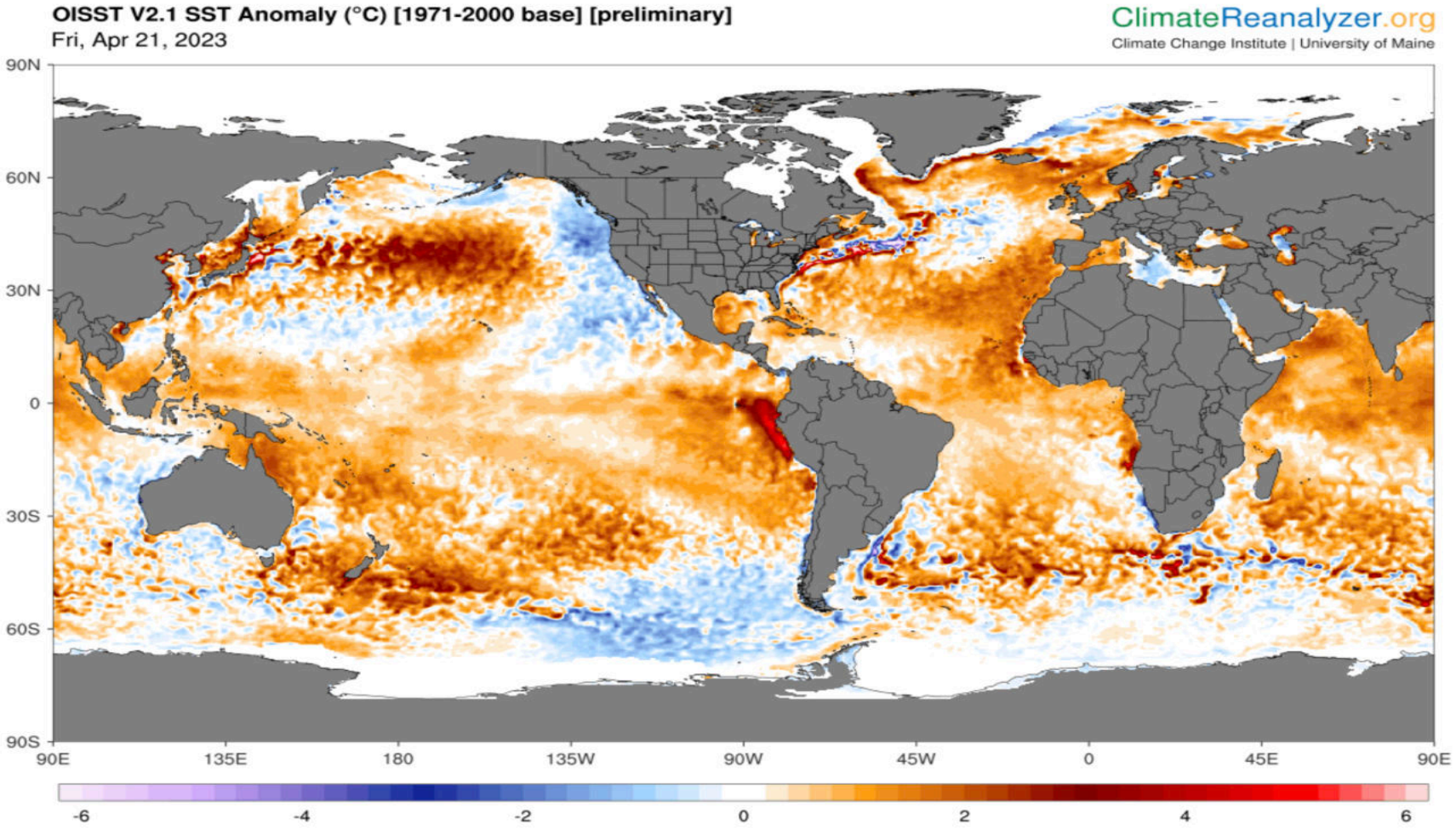
Ecole Normale Supérieure

Ocean temperatures highest ever recorded



(Source: Noaa, Maine Climate Office, Climate Change Institute, University of Maine)

Ocean temperatures highest ever recorded with multiple Marine Heat Waves



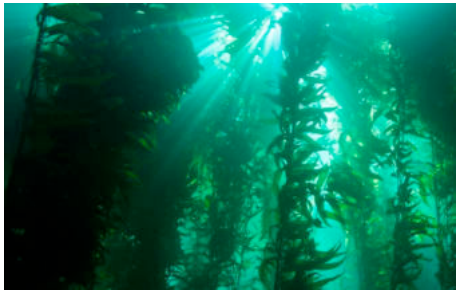
(Source: Noaa, Maine Climate Office, Climate Change Institute, University of Maine)

The ocean is home to a rich biodiversity

- Some iconic **species** & **ecosystems**





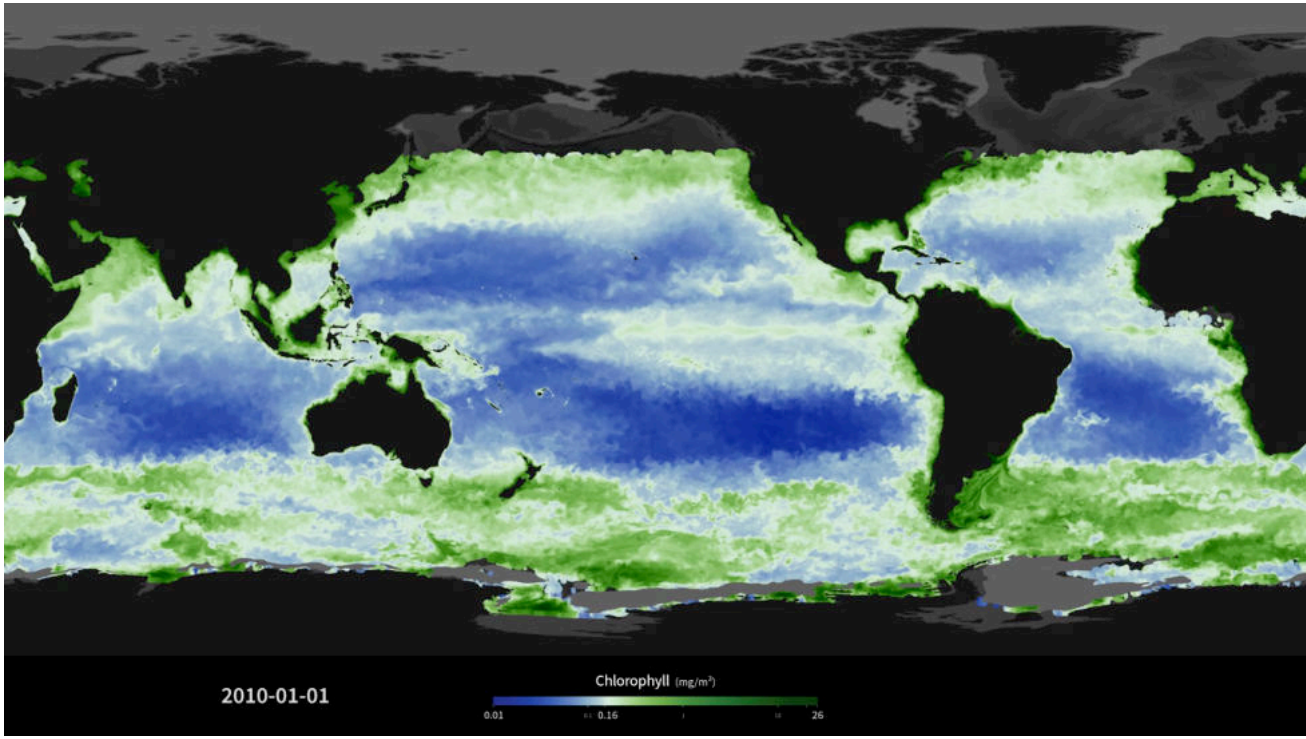


The ocean is home to a rich biodiversity

- Some iconic **species** & **ecosystems**
- Importance of small organisms - **plankton**!

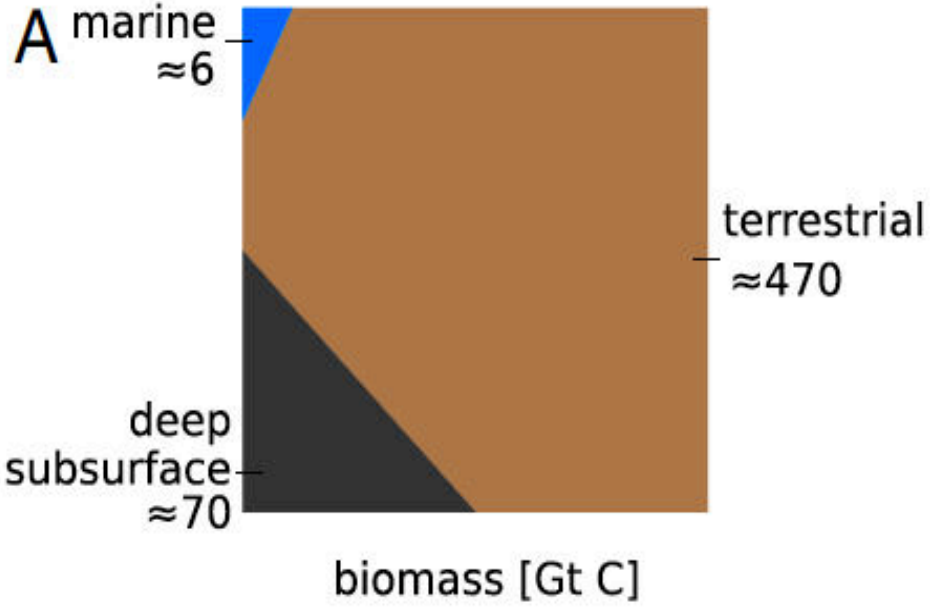
Planktonic Diversity

Phytoplankton from space (MODIS)



Ocean Ecosystems

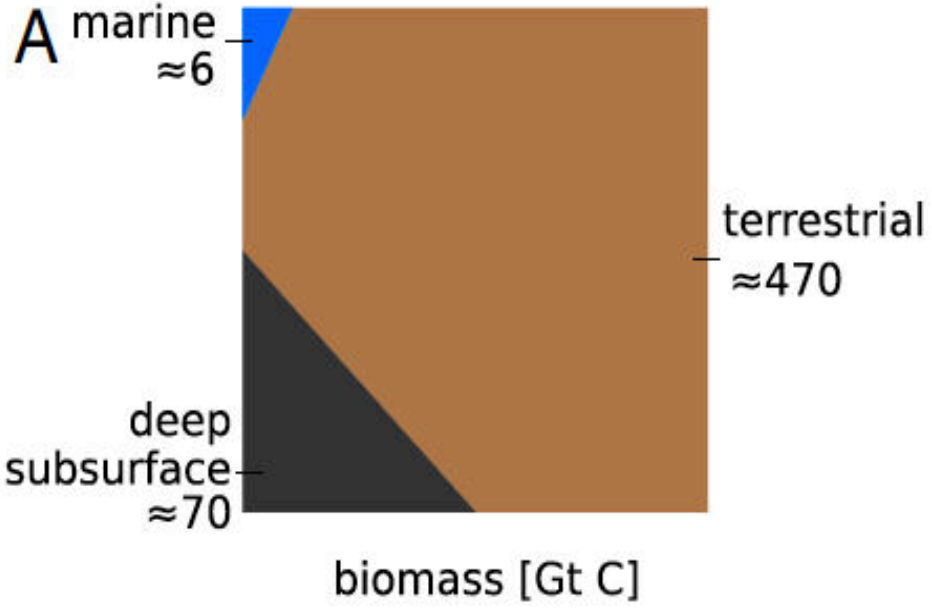
Biomass



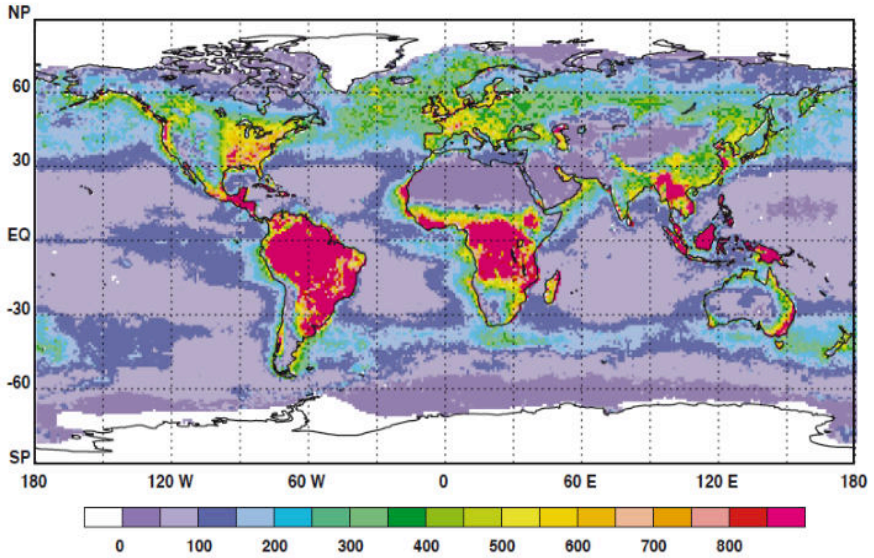
Bar-On et al. PNAS 2018

Ocean Ecosystems – half of global productivity

Biomass



Productivity !



(gC/m2/y)

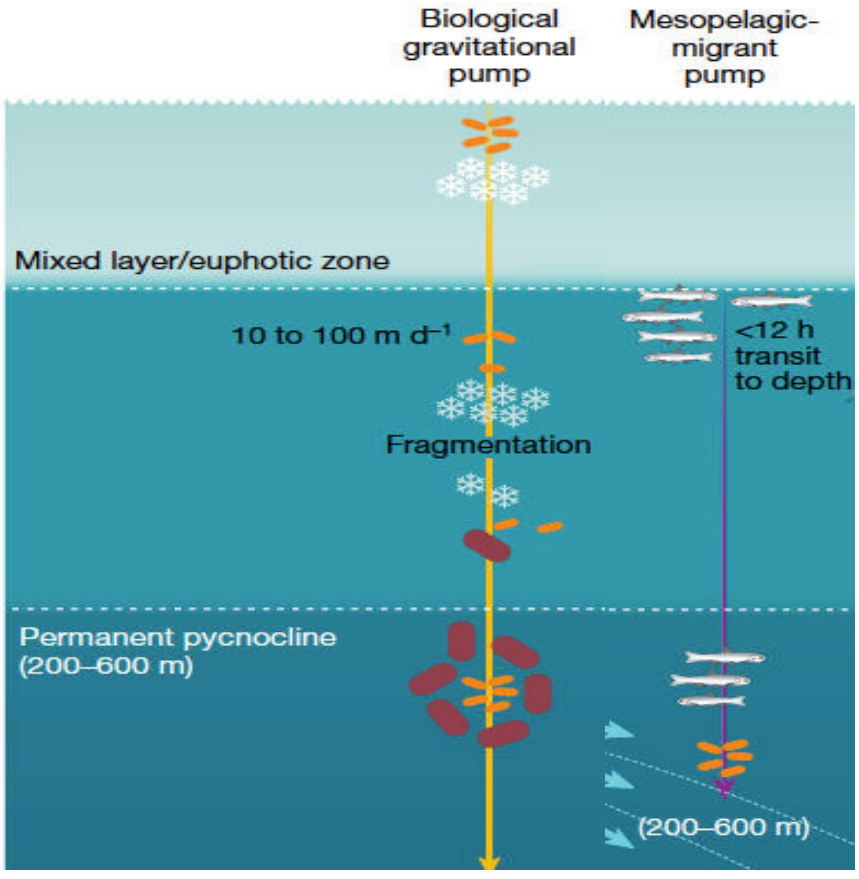
	Land	Ocean
NPP (GtC/y)	56.4	48.5

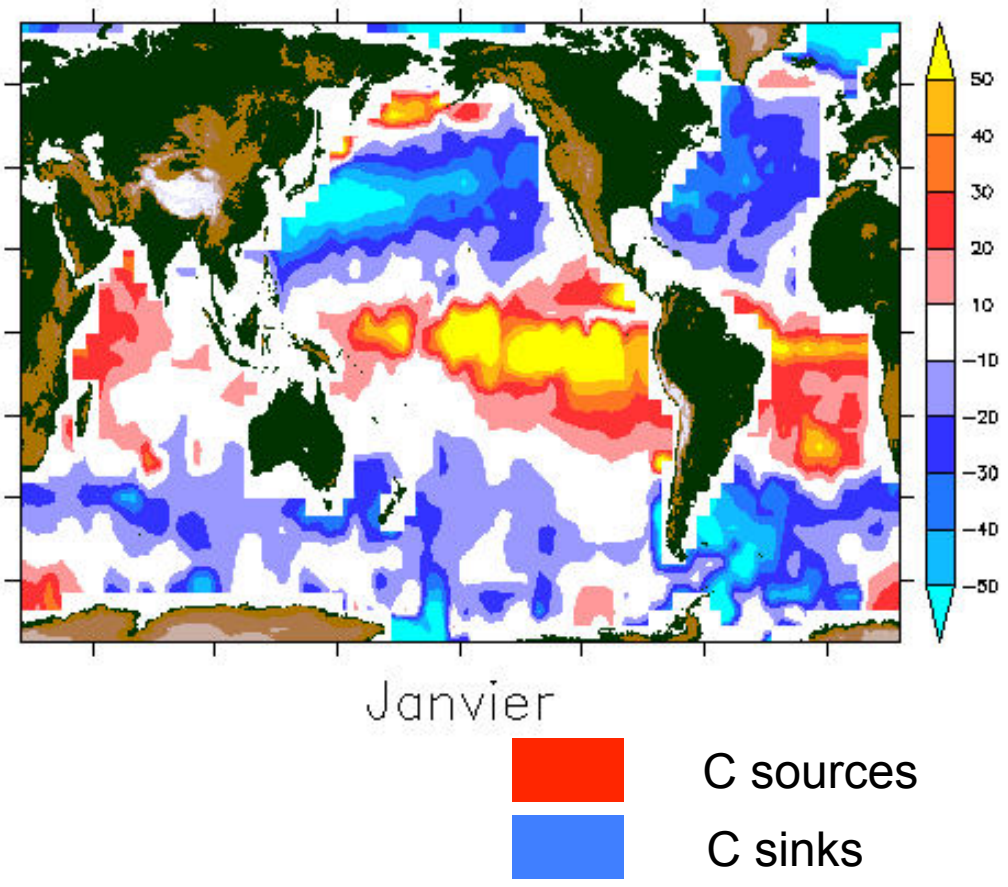
Bar-On et al. PNAS 2018

Field et al. Science 1998

Marine Ecosystems and the ocean carbon cycle

The ocean is a huge carbon reservoir (50x more than the atmosphere) - and absorbs 25% of anthropogenic CO2 emissions





Marine ecosystems play a key role in the transfer of carbon from the surface to the bottom

Marine Ecosystems & Man Kind

…. Fishing: 80 million tons per year
20% of animal proteins / world population
~400 billion dollars

(FAO 2020)

Bluefin
Tuna
Fishing

Marine Ecosystems & Man Kind

…. Fishing: 80 million tons per year
20% of animal proteins / world population
~400 billion dollars

(FAO 2020)

Bluefin
Tuna
Fishing

Great Barrier Reef
(Australia)

…. Tourism :

Coral Reefs

+ More than 100 countries benefit
from reef & reef-related services

e.g. Great Barrier Reef –

1.9 million visitors/year, 54,000 jobs,
A$ 5.4 billion/year

Marine Ecosystems & Man Kind

Goal 14: Conserve and sustainably use the oceans, seas and marine resources

The world's oceans – their temperature, chemistry, currents and life – drive global systems that make the Earth habitable for humankind.

Our rainwater, drinking water, weather, climate, coastlines, much of our food, and even the oxygen in the air we breathe, are all ultimately provided and regulated by the sea. Throughout history, oceans and seas have been vital conduits for trade and transportation.

Careful management of this essential global resource is a key feature of a sustainable future.

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

The United Nations has proclaimed **a Decade of Ocean Science for Sustainable Development (2021-2030)** to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in creating improved conditions for sustainable development of the Ocean

What are the impacts of climate change
on the ocean
and its ecosystems?

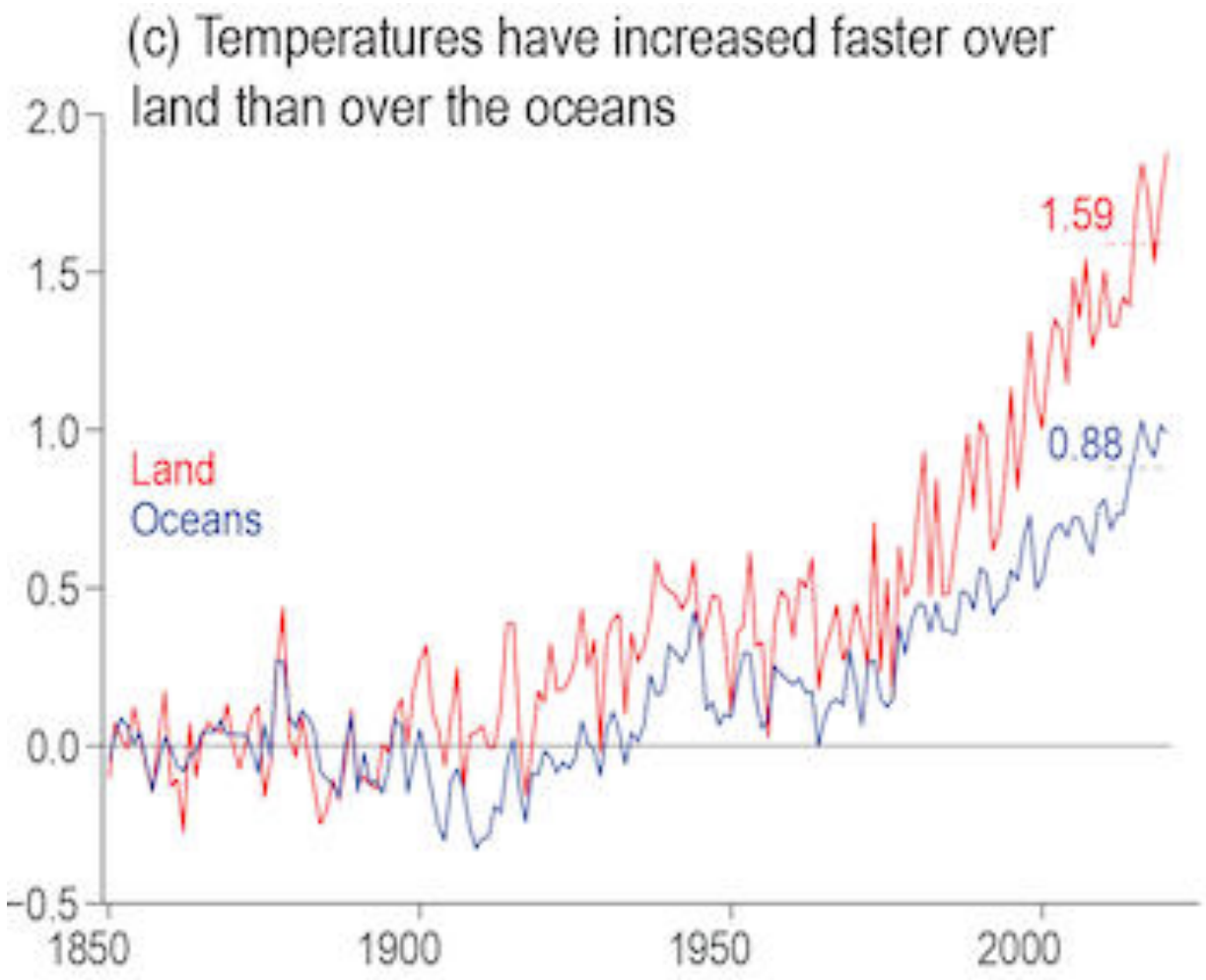
Other threats to marine ecosystems?

What are the impacts of climate change on the ocean and its ecosystems?

- Climate change is altering the physical, chemical properties of the ocean.
- Physical and chemical modifications affect the distribution of species and the functioning of ecosystems
- Depending on the different scenarios for the 21st century even more significant changes are expected.

Warming, rising sea level, Ocean Acidification and Ocean Deoxygenation

- The ocean surface has warmed by ~0.9°C since 1850.



IPCC, AR6, WG1, 2021

Warming, rising sea level, Ocean Acidification and Ocean Deoxygenation

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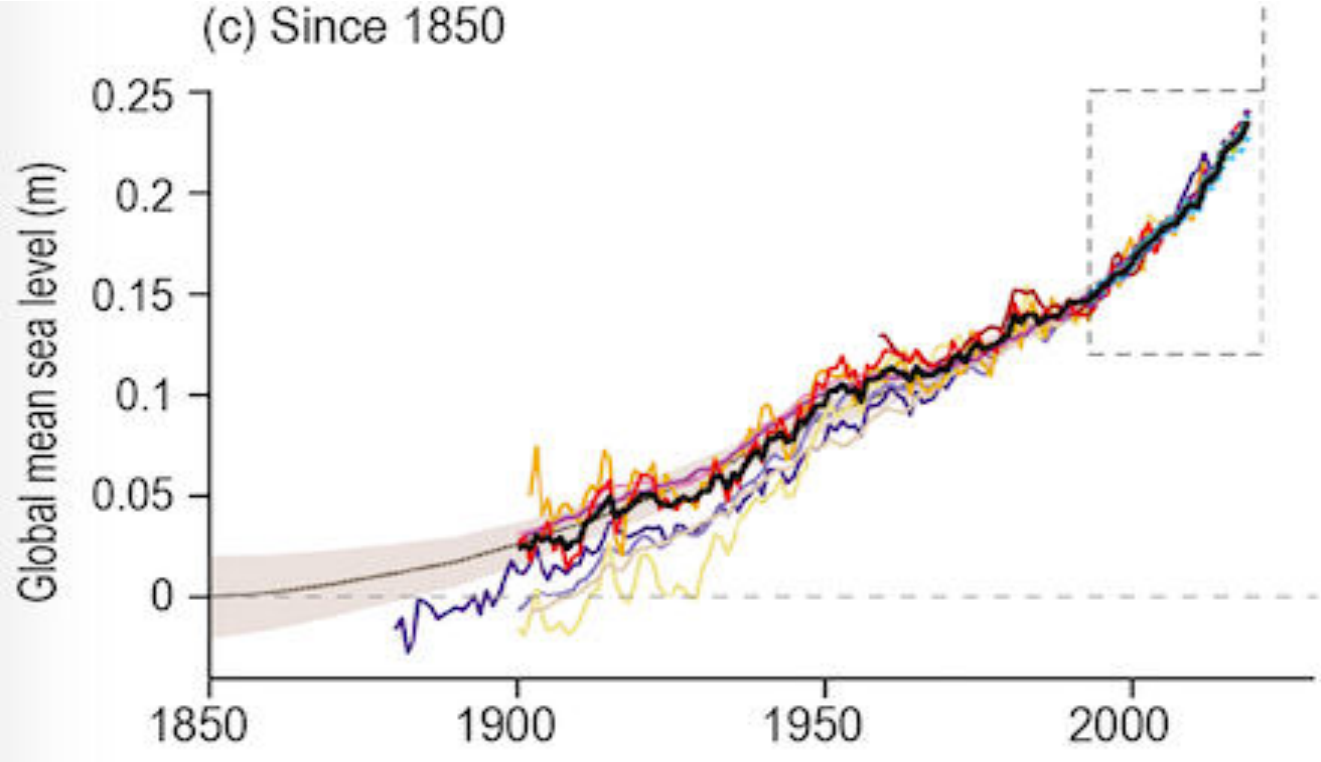
- The sea level rose by ~20 cm since 1900.



IPCC AR6 WG1 2021

Warming, rising sea level, Ocean Acidification and Ocean Deoxygenation

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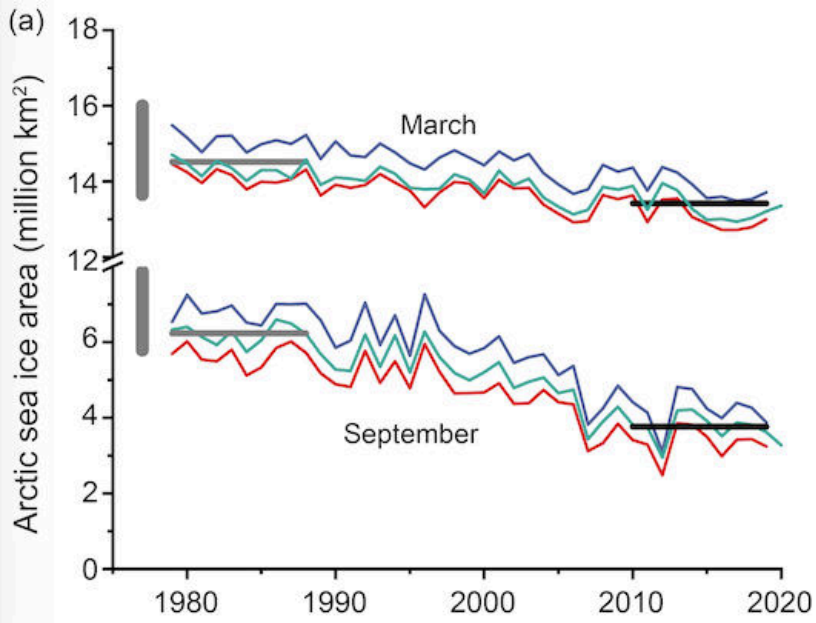
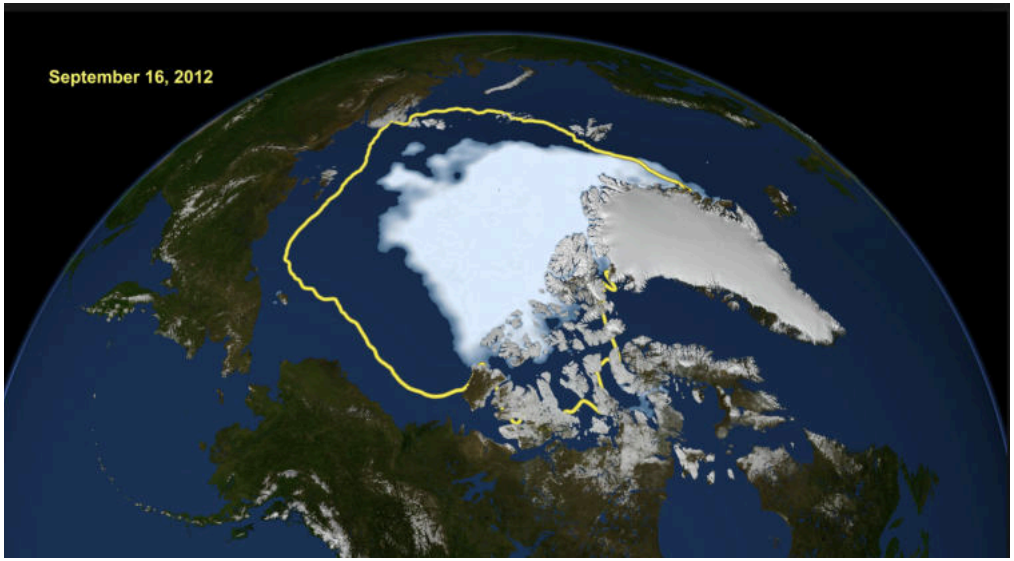


(IPCC AR6 WG1 2021)



(National Snow and Ice Data Center)

Warming, rising sea level, Ocean Acidification and Ocean Deoxygenation

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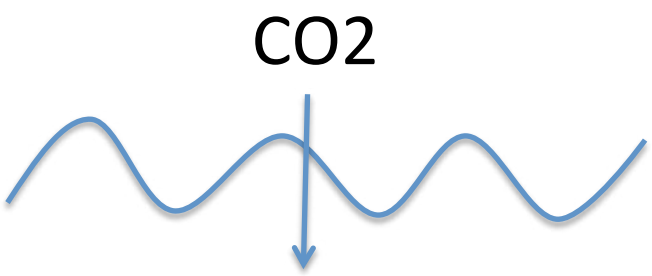
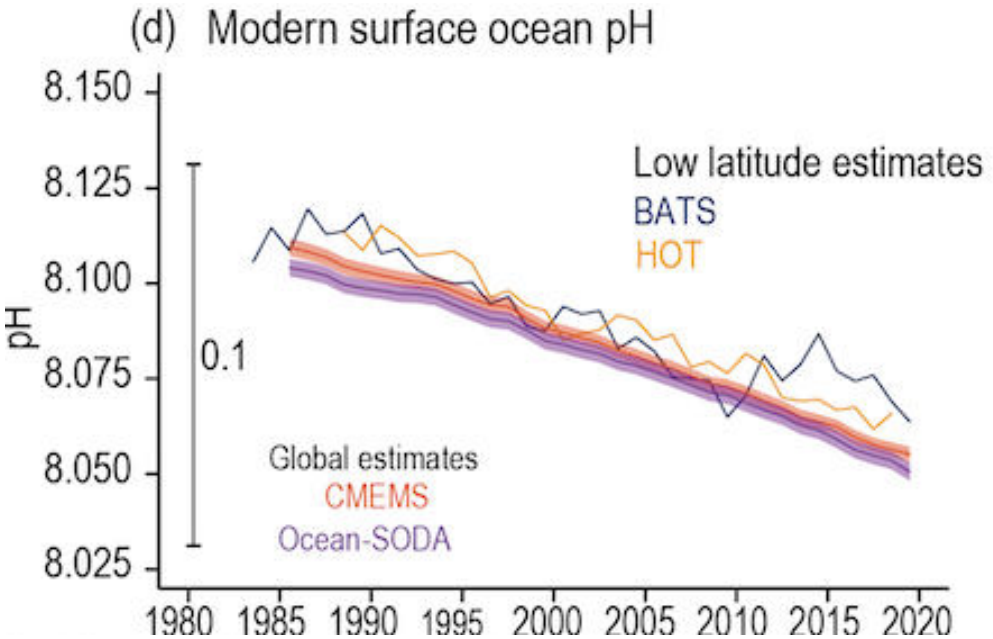
- Sea-ice in the Arctic has lost half its surface in summer
- The ocean's surface has become more acidic – pH has decreased by 0.1





Focus on Ocean Acidification !

- The ocean's surface has become more acidic (pH has decreased by 0.1 unit)

When CO_2 dissolves in Sea Water…

$$CO_{2\,(gas)} + H_2O \rightleftharpoons H_2CO_3^*$$

$$H_2CO_3^* \rightleftharpoons H^+ + HCO_3^-$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

Principle : CO2 is a weak acid – its dissolution in the ocean causes **acidification**
Ocean acidification is also accompanied by HCO_3^- ↗ and CO_3^{2-} ↘

A threat on marine ecosystems?

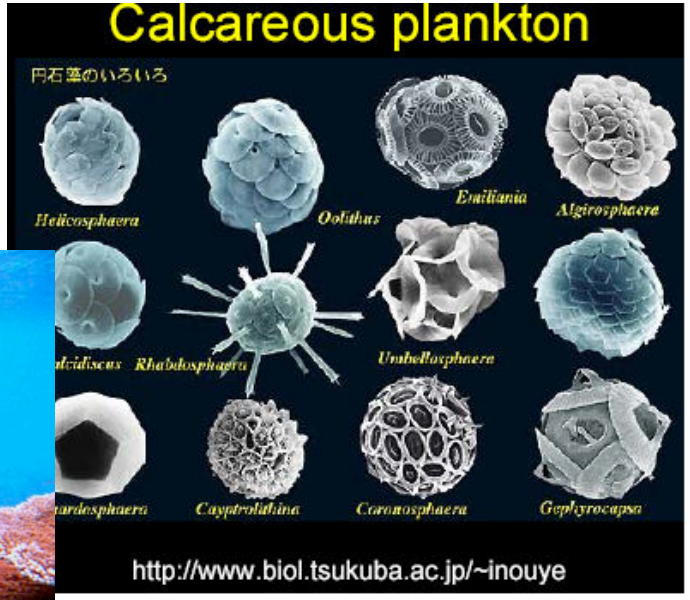
Mostly on calcifying organisms… (but not only)
Because they use CO_3^{2-} to produce shells, skeletons, tests, … in $CaCO_3$

Focus on Ocean Acidification – Calcifying Organisms

Bivalves

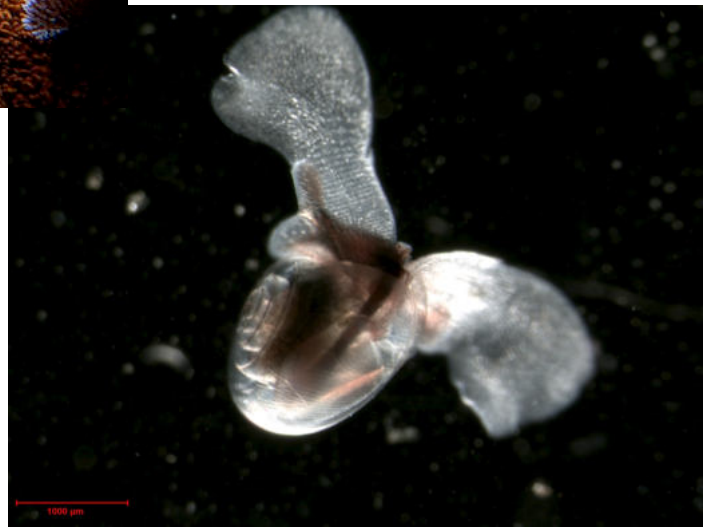
Phytoplankton
(Coccolithophorids)

Tropical Reefs



Zooplankton
(Pteropods)

Cold
Water
Corals



Warming, rising sea level, Ocean Acidification and Ocean Deoxygenation

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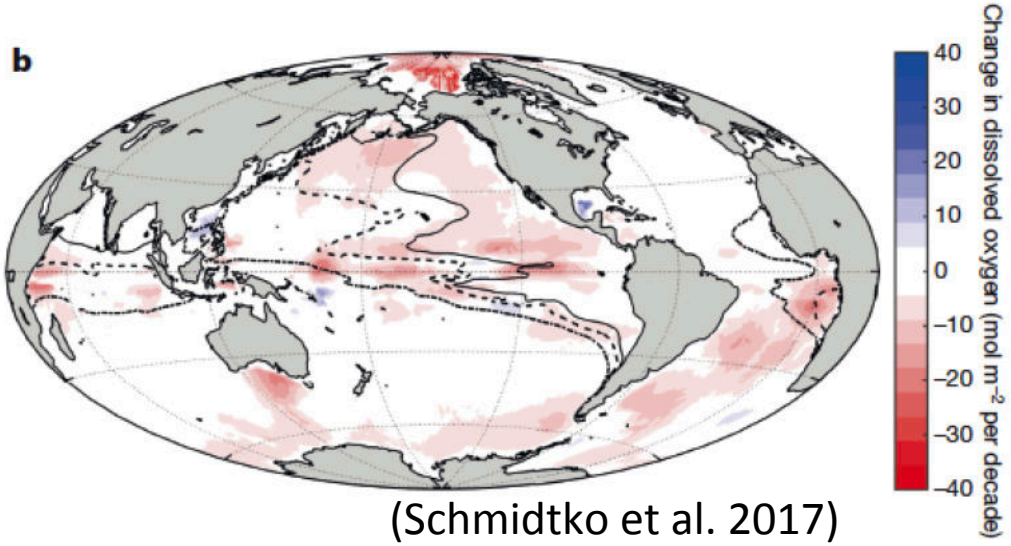
- The ocean's surface has become more acidic – pH has decreased by 0.1
- The ocean has lost ~ 2 % of its oxygen since the pre-industrial

Ocean Deoxygenation



(Schmidtko et al. 2017)

Focus on Ocean Deoxygenation !

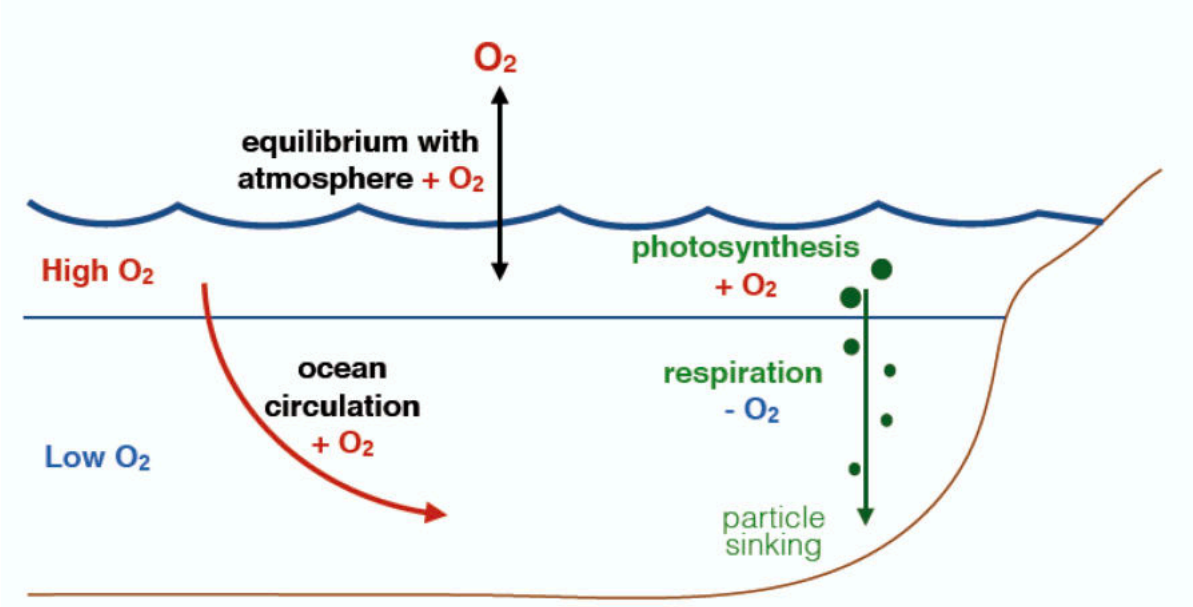
- The ocean has lost ~ 2 % of its oxygen since the pre-industrial

Principle :

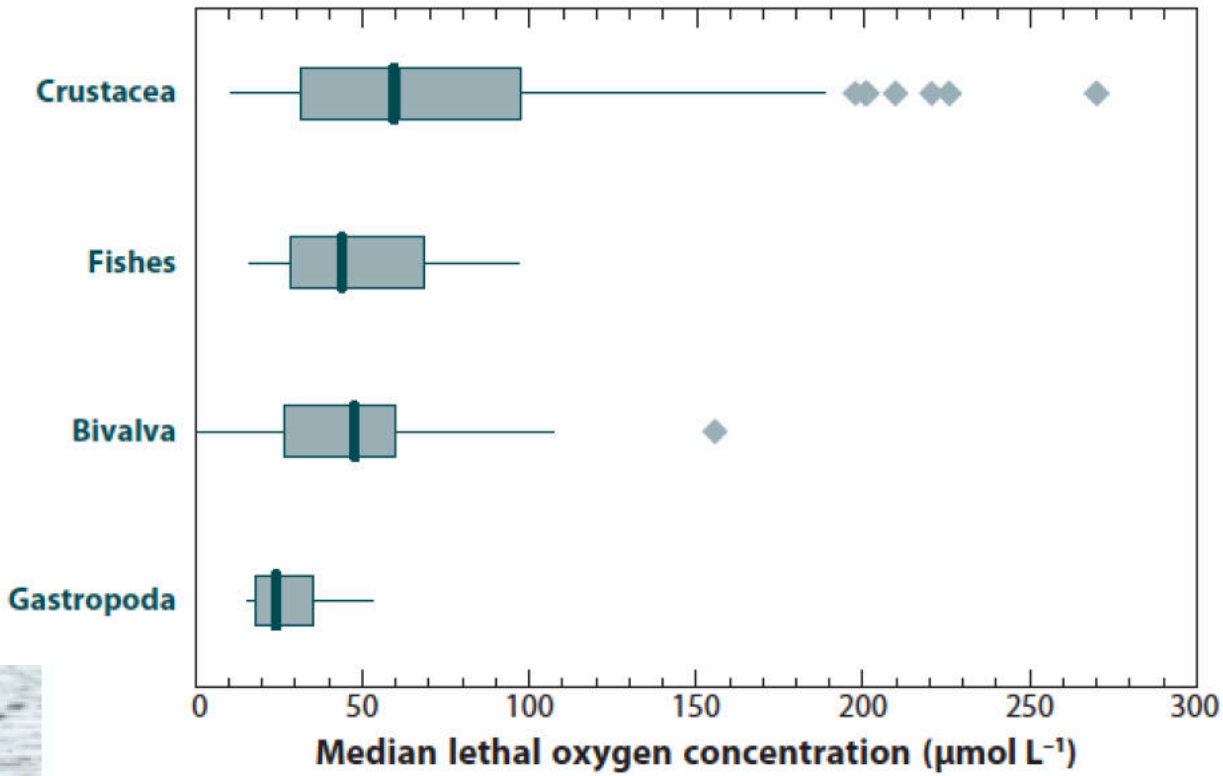
When Sea-water warms…

O_2 is much less soluble (less atmospheric O_2 dissolves at the surface)

And the ocean is more stratified so that less oxygen-rich waters are ventilated / mixed towards the deeper ocean



Focus on Ocean Deoxygenation – Potential Impacts ?



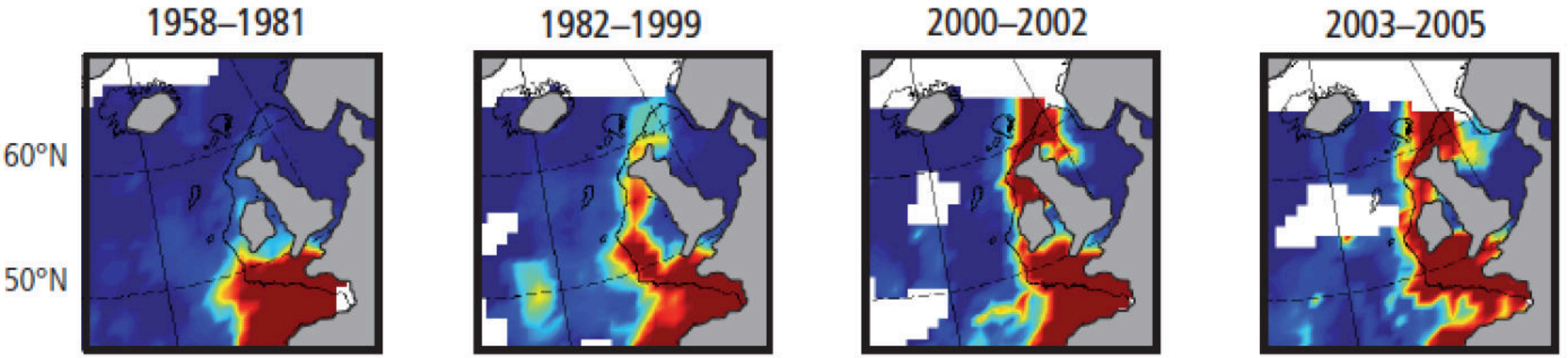
Anoxia and Some Mass mortality Events

Redrawn after Vaquer-Sunyer & Duarte (2008). Copyright (2008) National Academy of Sciences, U.S.A

Observed Impacts on Ecosystems ?

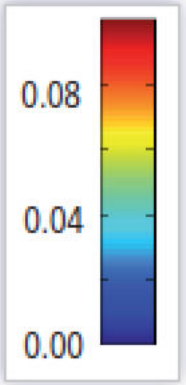
- Changes in abundances, spatial distributions, ...

Northward migration of warm-water temperate species



Copépodes

Number of species



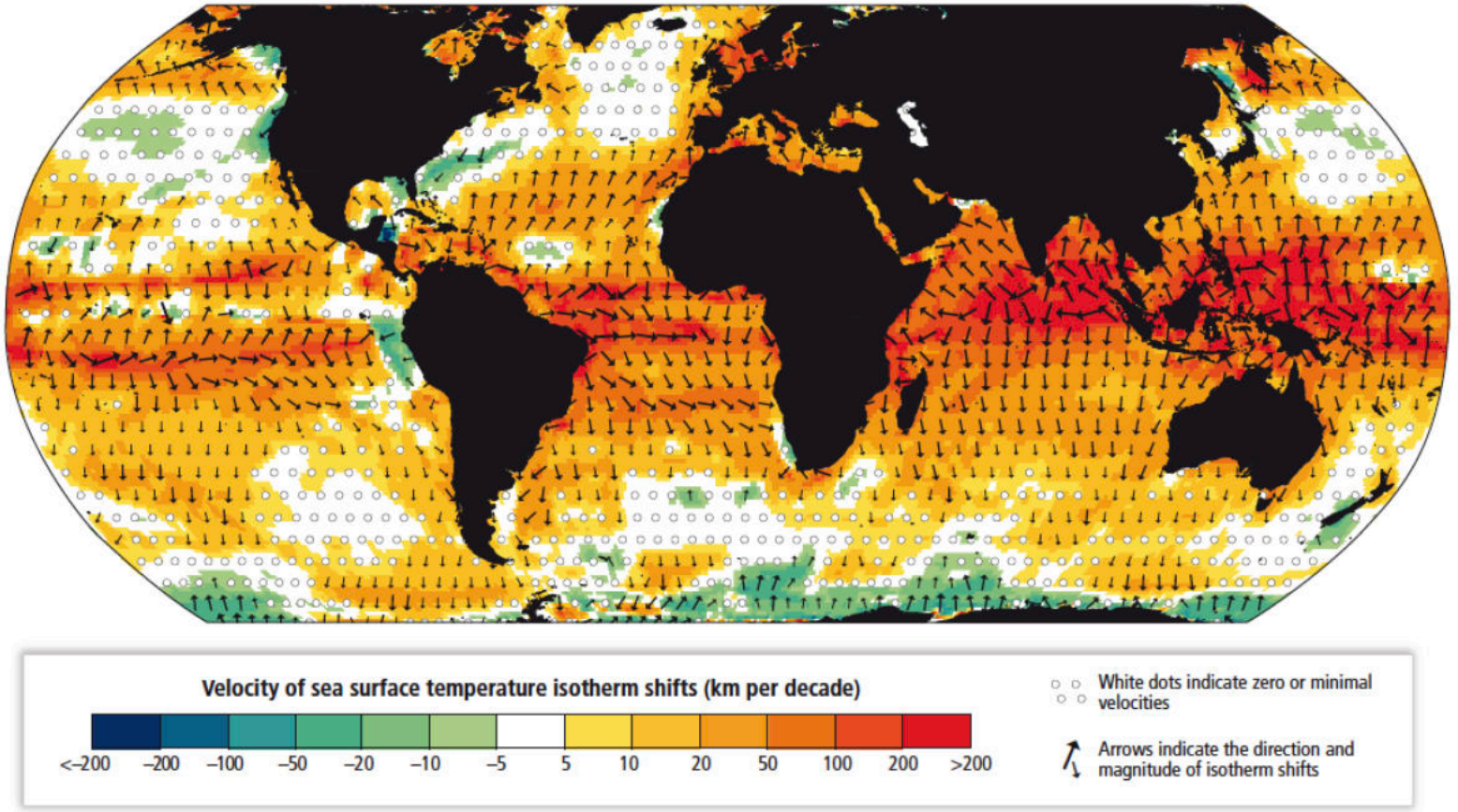
(Beaugrand et al. 2009)

Observed Impacts on Ecosystems ?

Changes in marine species ranges since the 1950s − Mostly **poleward shifts !**
>50 km per decade at the surface
~30 km per decade for benthic organisms

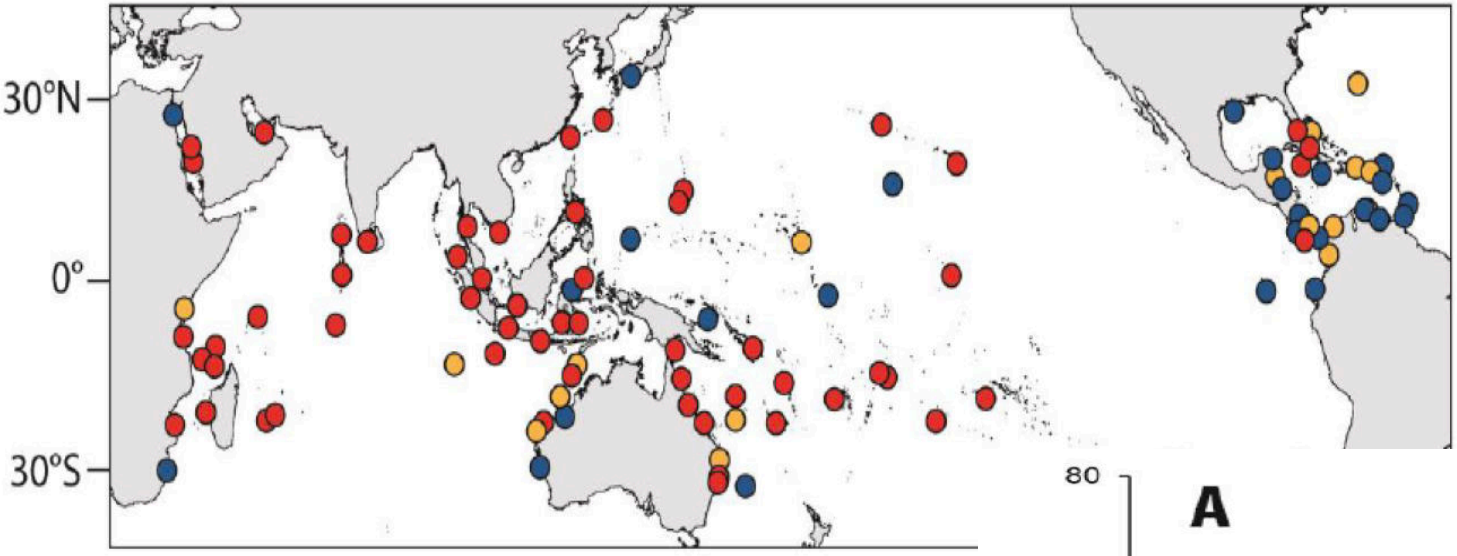
(IPCC AR5 2014)

Very well correlated with climate velocity (°C / km)



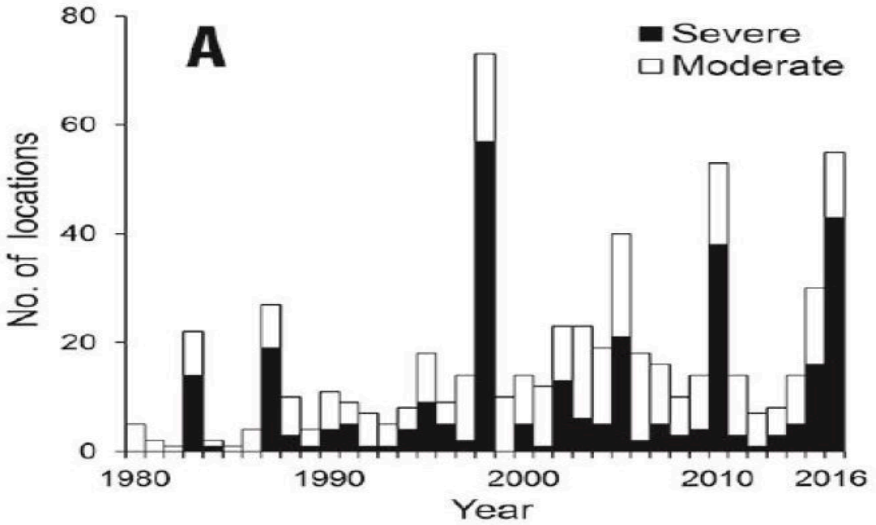
Impacts on Coral Reefs

Warming has increased the frequency of large-scale coral bleaching events, leading to reef degradation worldwide since 1997-1998 (IPCC SROCC, 2019)

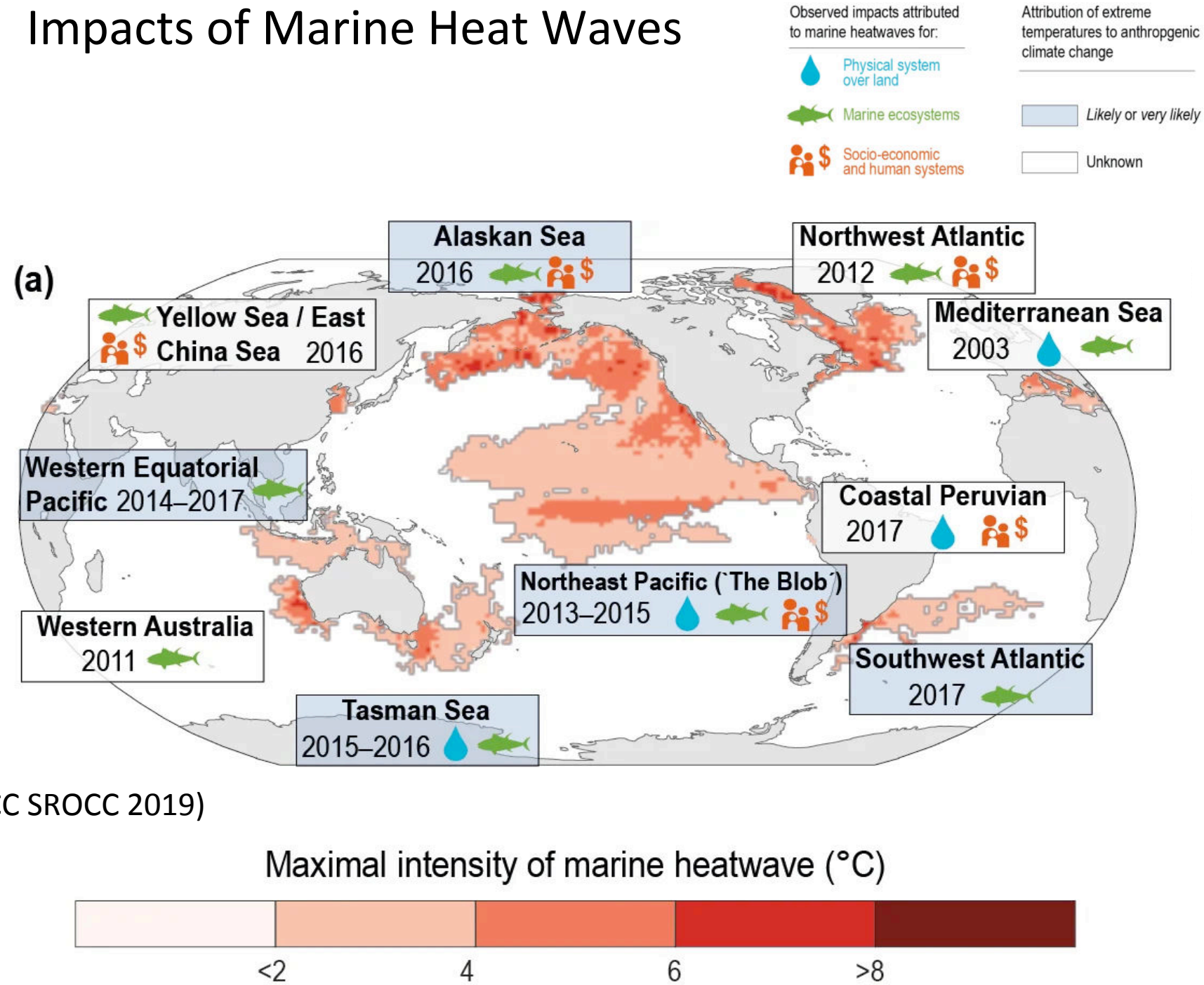


(Hughes et al. 2018)

The global extent of mass coral bleaching in 2015-2016.
(in red: severe bleaching, >30% of corals)

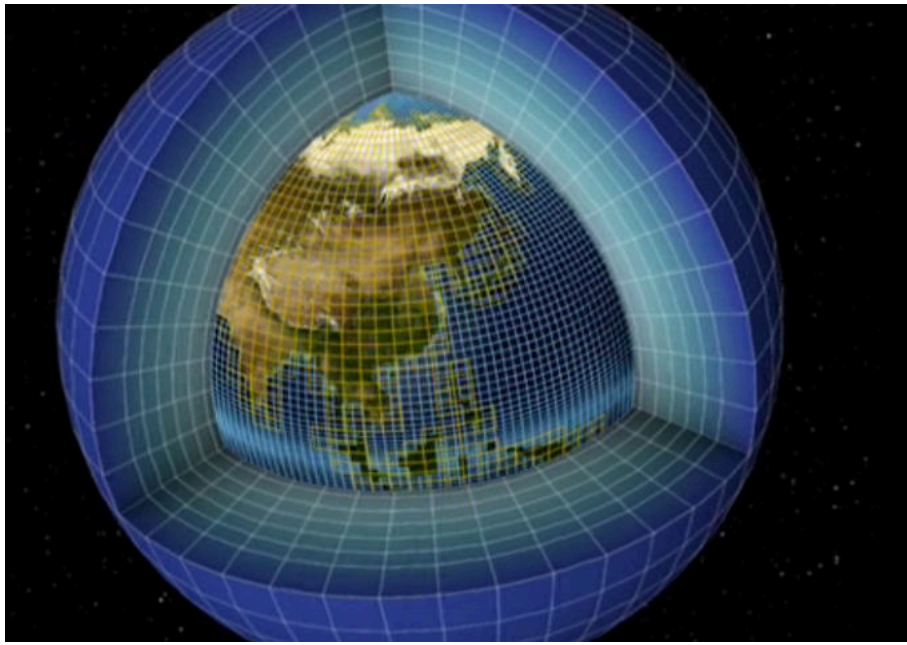


Impacts of Marine Heat Waves

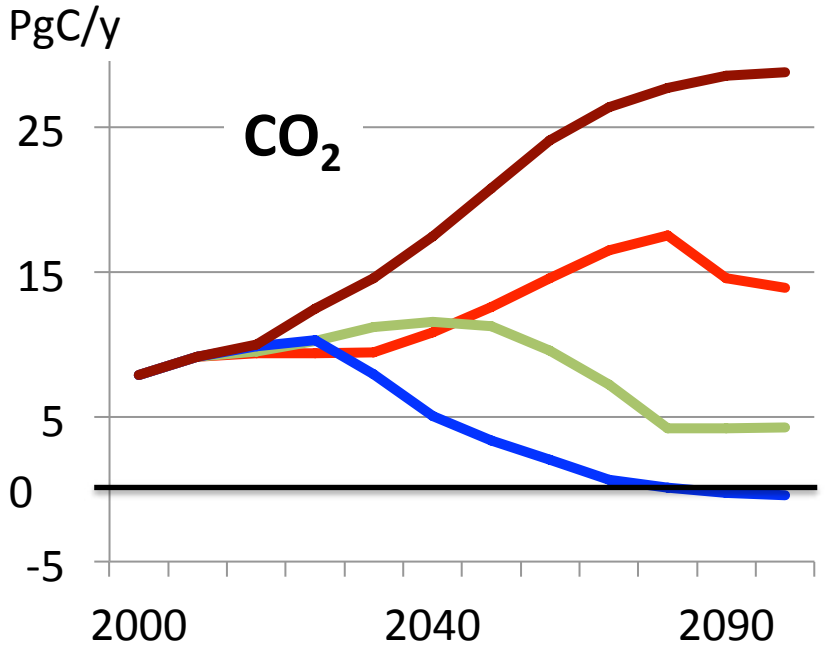


(IPCC SROCC 2019)

Climate Projections on Marine Ecosystems



CO_2 Emissions Scenarios



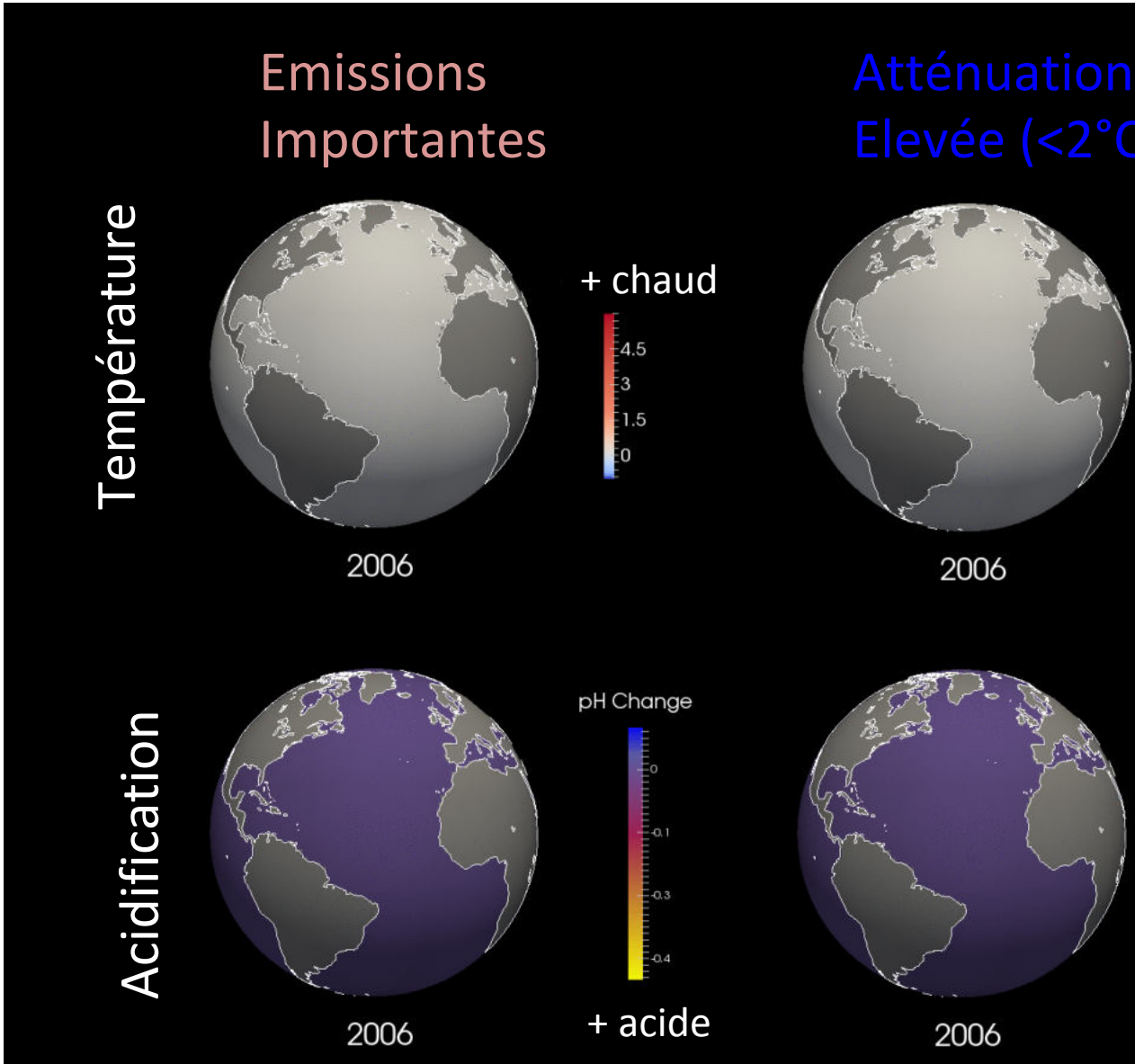
High Emissions

High Mitigation

Climate Models

Climate projections: significant differences between the different scenarios.

Depending on the scenario, the surface temperature of the oceans increases from 0.7 to 2.7°C and the pH decreases from -0.07 to -0.33 (in 2100 compared to 2000)



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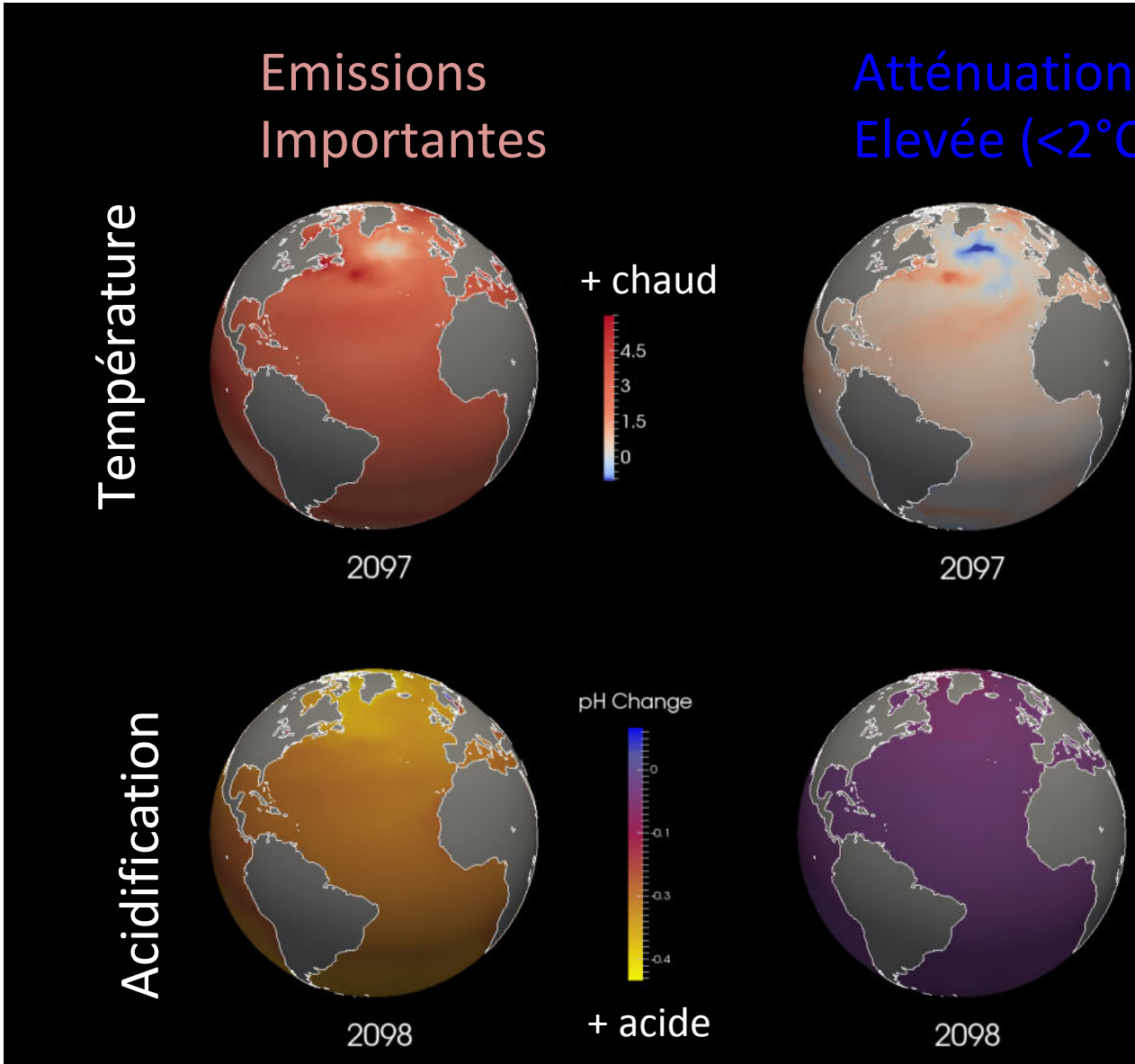

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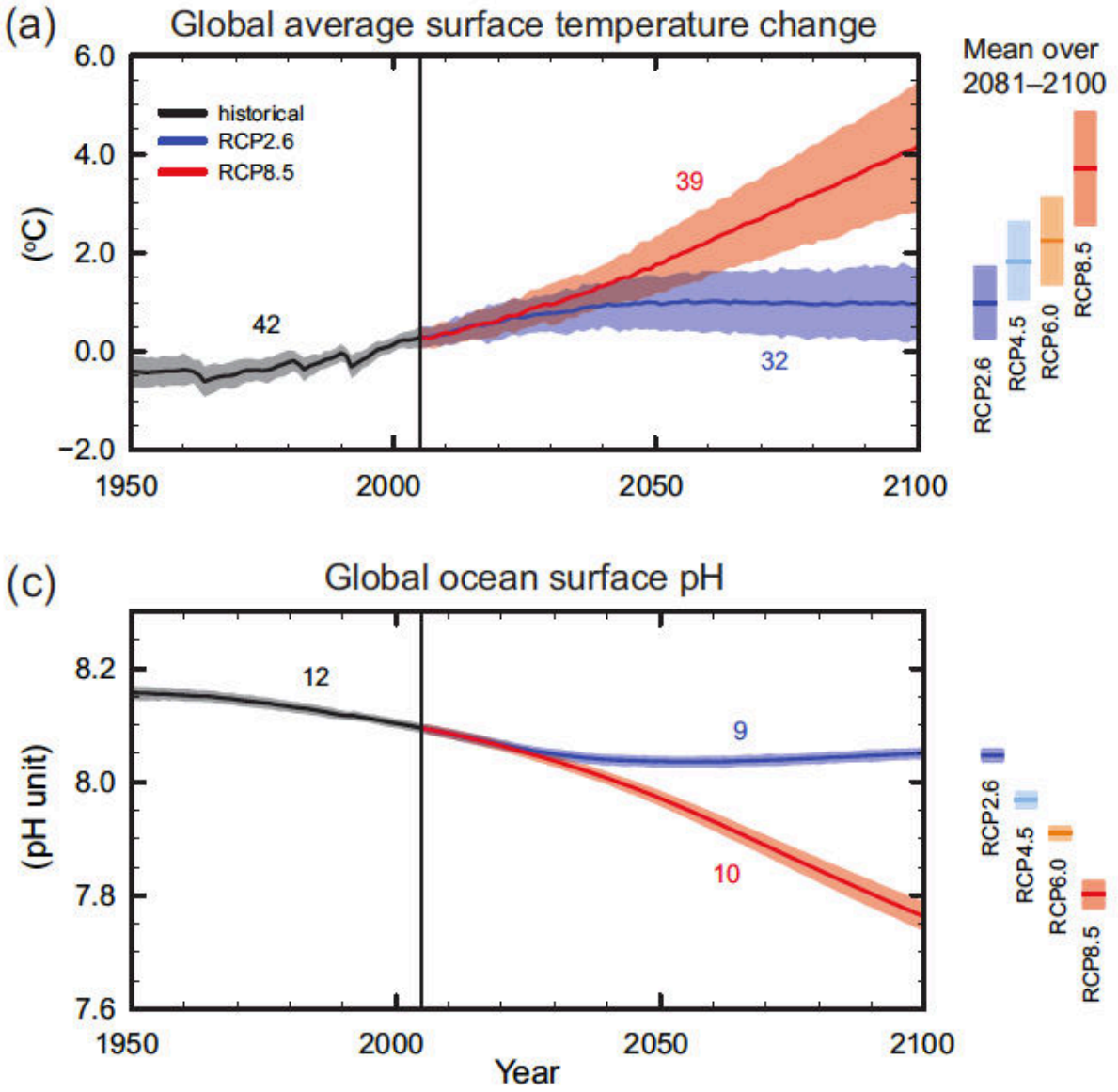
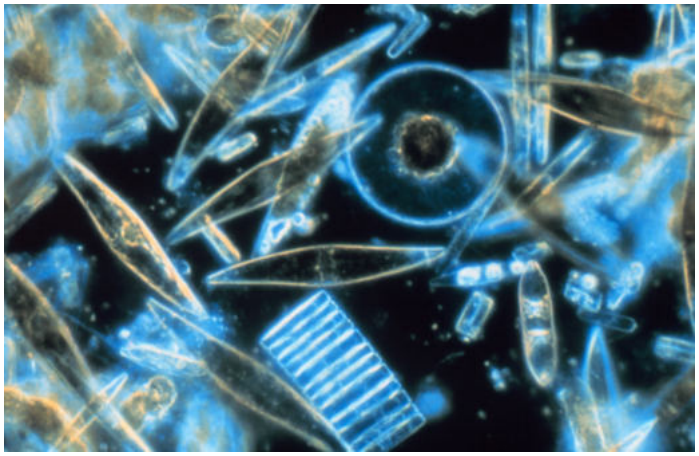
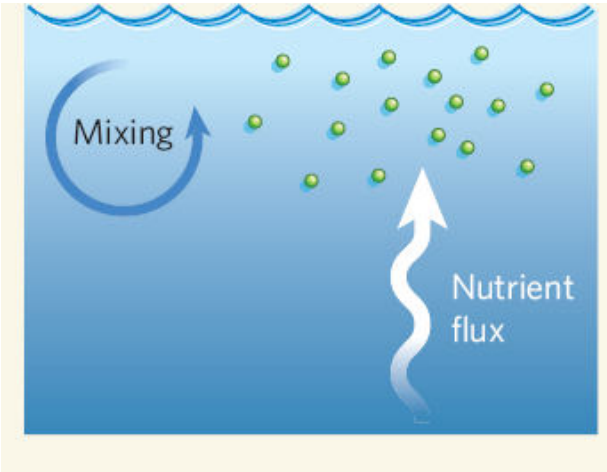


Climate Projections: What impact on fishing?

Impact of climate change
on phytoplankton production





Phytoplankton growth is controlled by nutrient abundance, light and temperature.....

Climate Projections: What impact on fishing?

Impact of climate change
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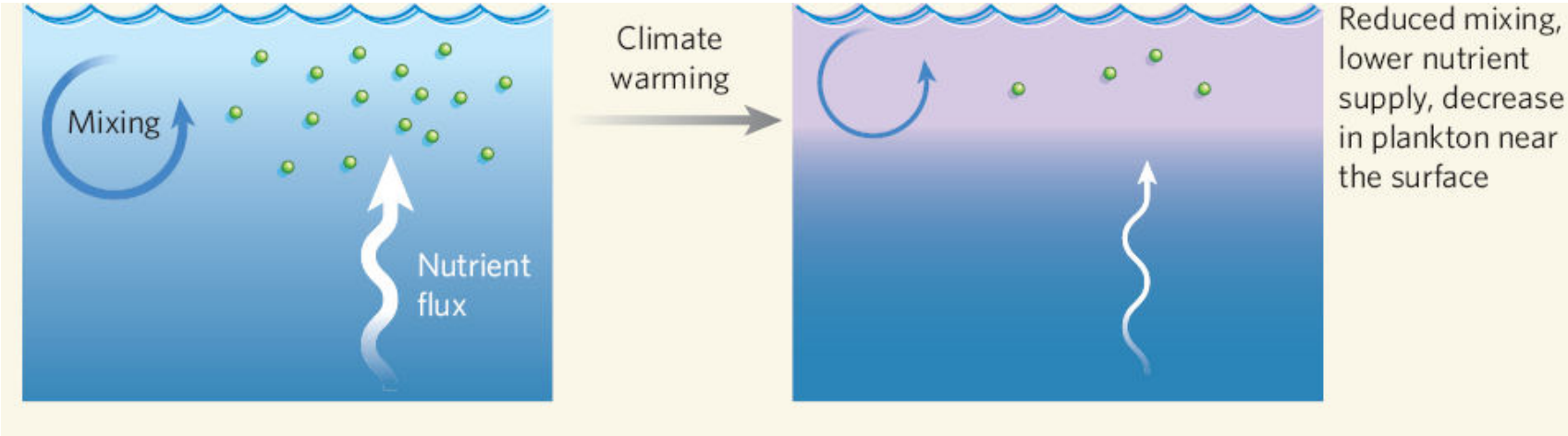
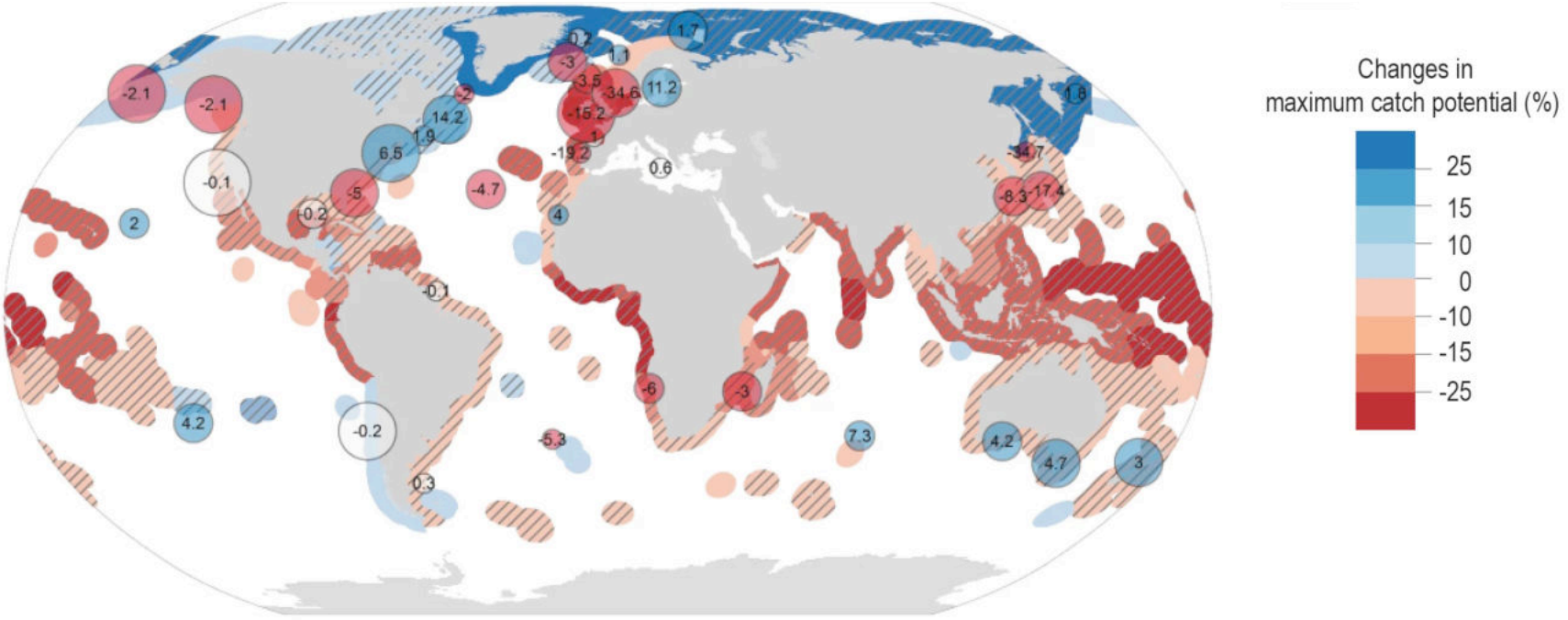


With climate change, a more "stratified" ocean leads to a decrease in nutrient abundance and phytoplankton productivity... and probably to a potential decrease in fish stocks

Climate Projections: What impact on fishing?

Projections of a significant reduction of the total biomass of marine animals (up to -15%) of the fish catch potential (up to -25%). With important contrasts between low and high latitudes...



Impact of climate change on fish catch potential
(RCP8.5, 2080-2099 vs. 1986-2005)

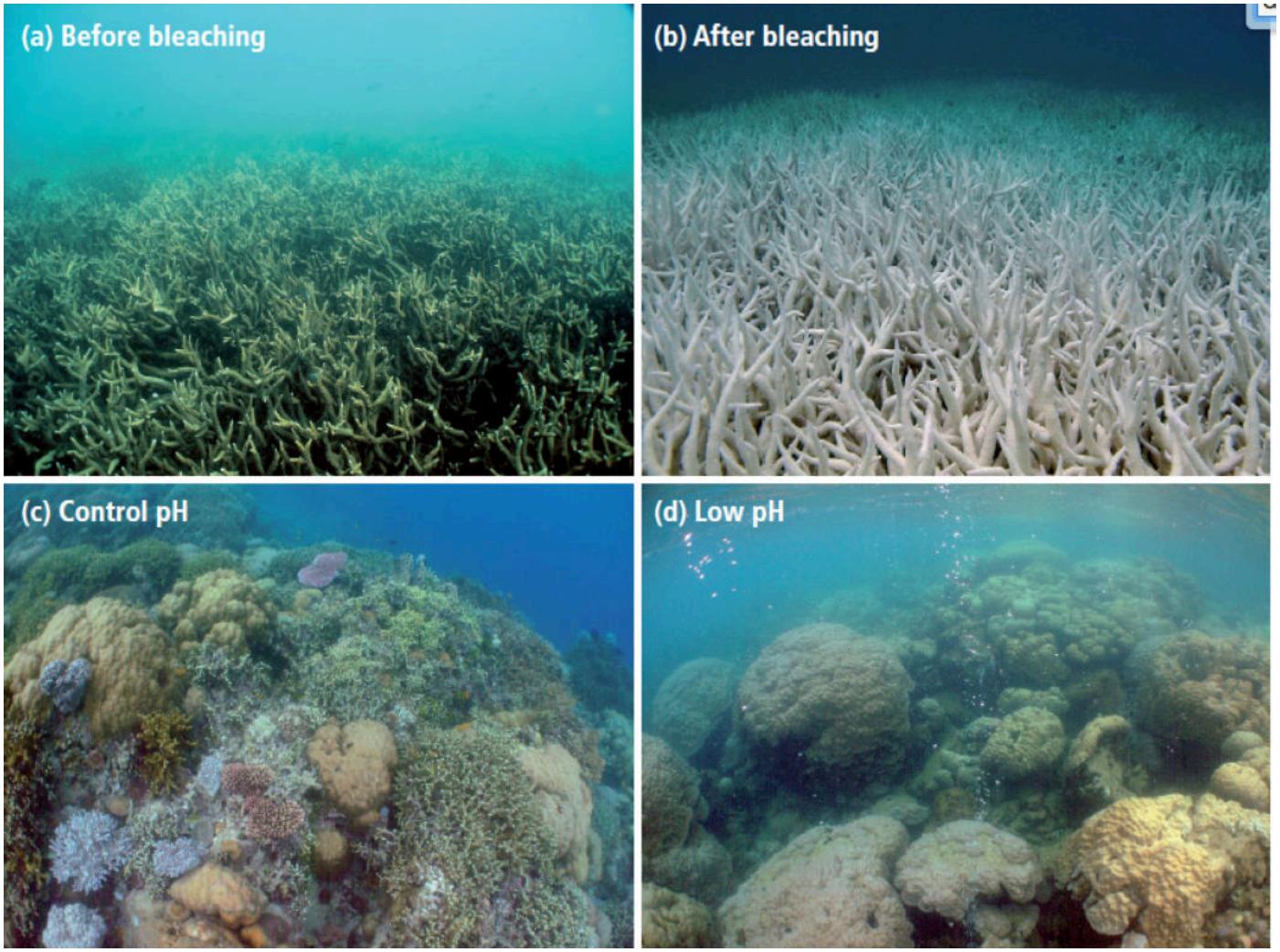
(IPCC SROCC 2019)

Climate Projections: What impact on reefs?

Impact of temperature increase and acidification and acidification on coral reefs

Temperature

pH



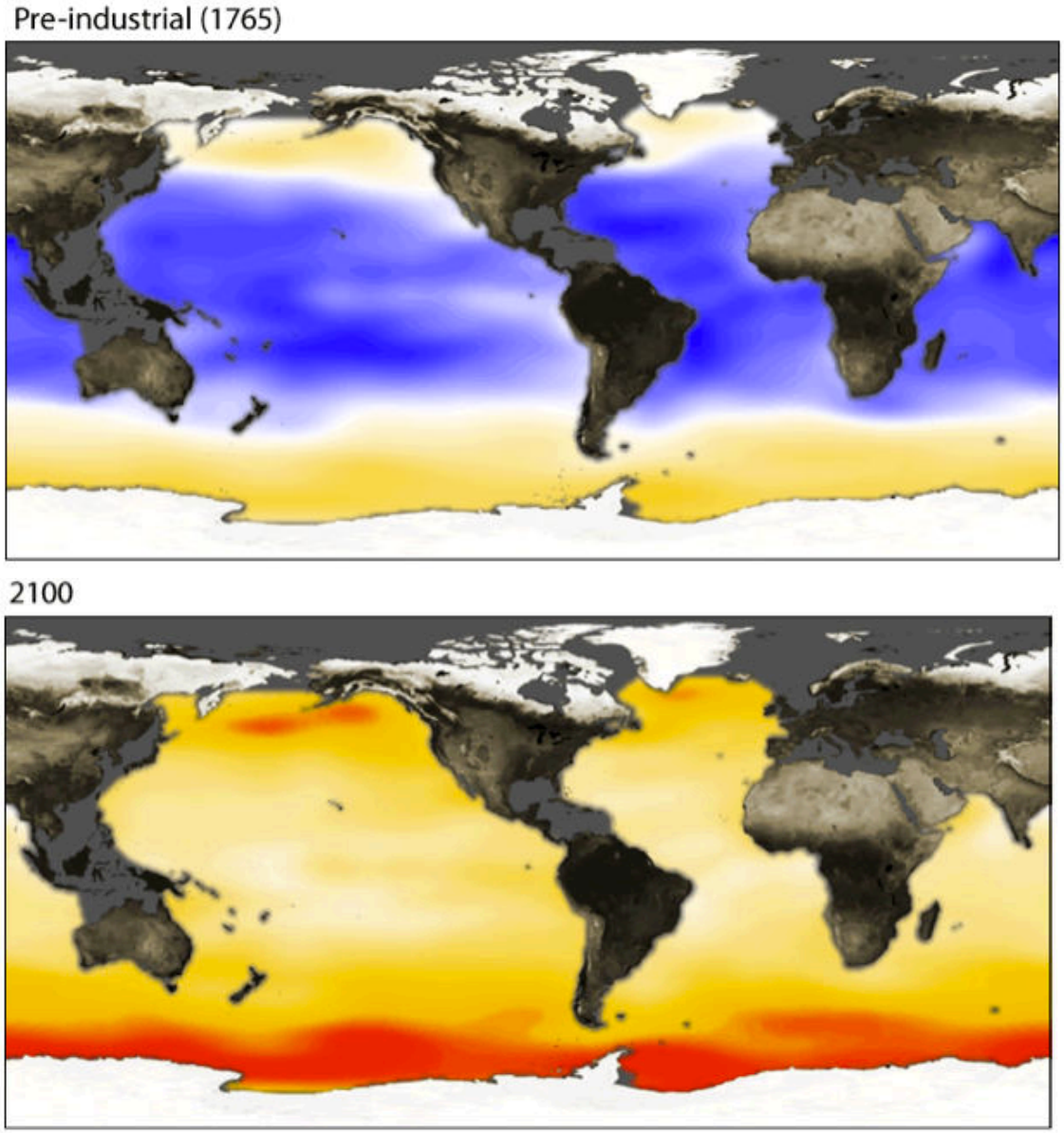
Climate Projections: What impact on reefs?

Evolution of the habitat of corals

Nearly all coral reefs will degrade from their current state, even if global warming remains below 2°C.

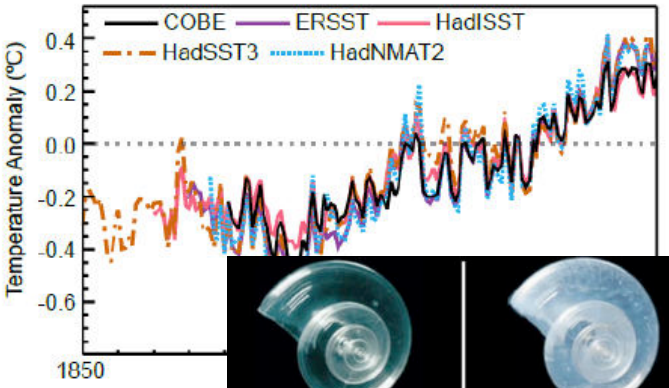
The remaining shallow coral reef communities will differ from current reefs in terms of species composition and diversity.

IPCC SROCC 2019

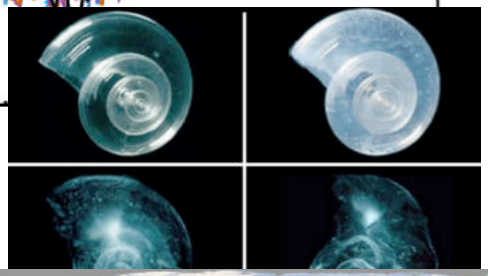


(Impact of acidification, Scénario RCP8.5)

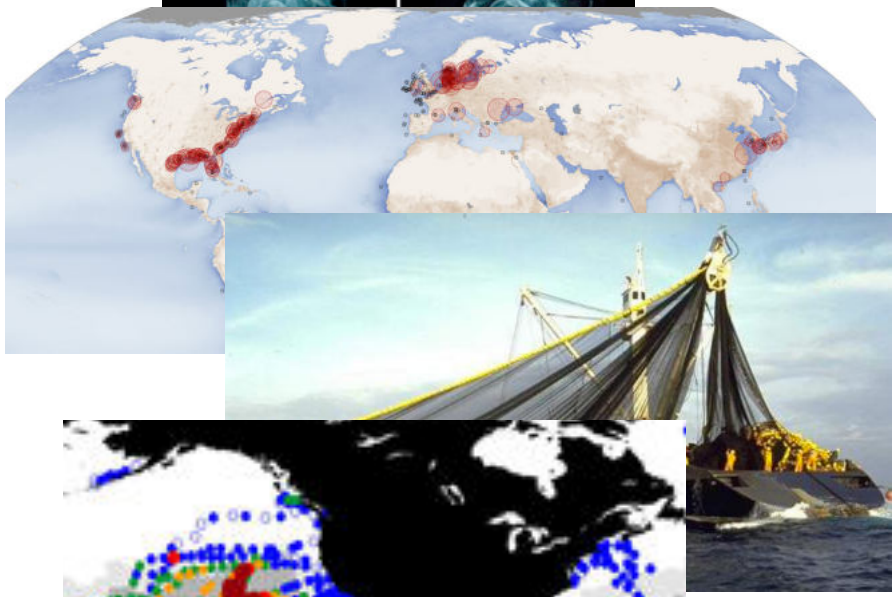
The ocean in the face of anthropogenic pressures



Climate change and
Ocean warming



Ocean Acidification



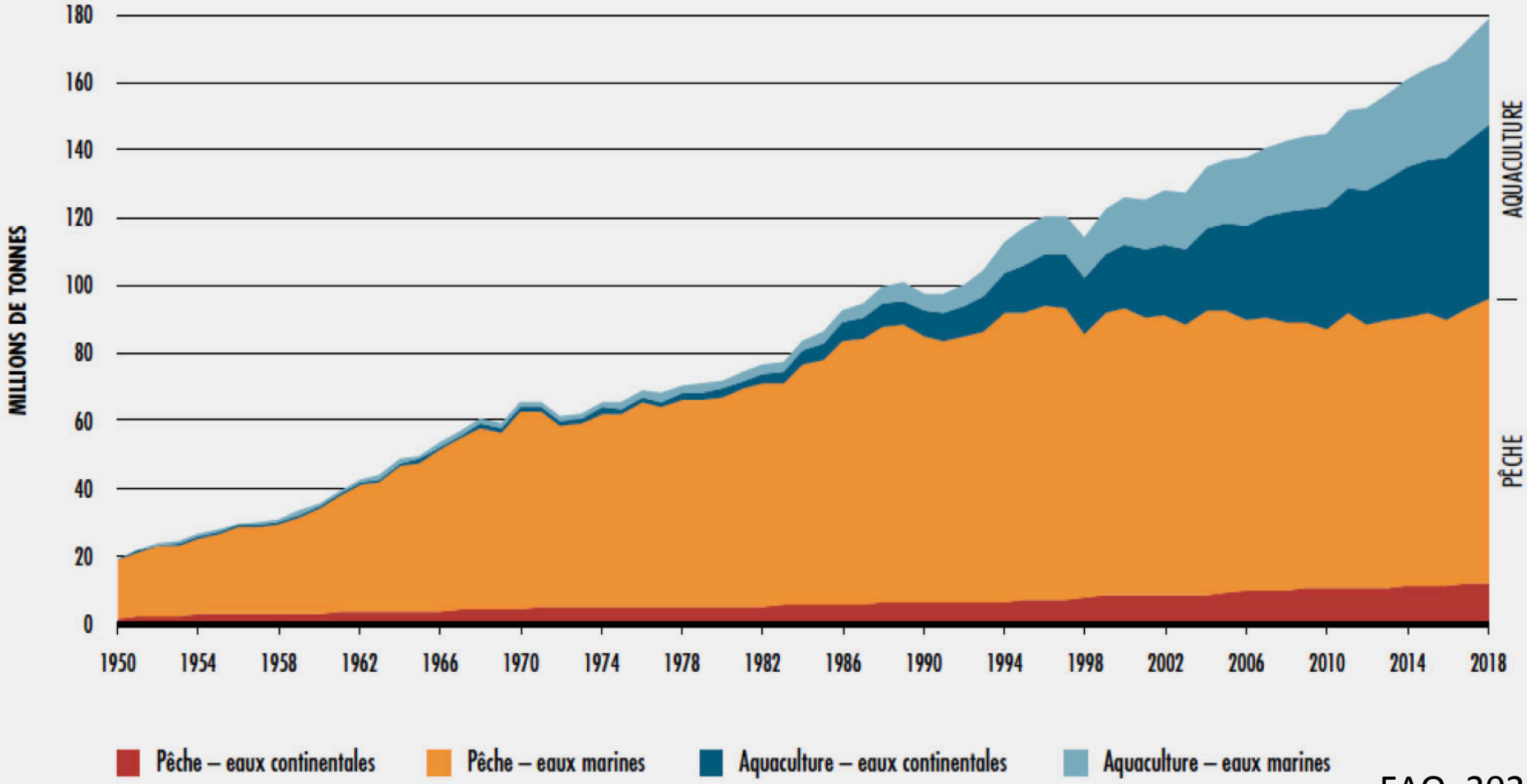
Eutrophication,
and hypoxic zones

Over-fishing

Pollution
(plastics, metals, ...)

Other threats to ecosystems: overfishing

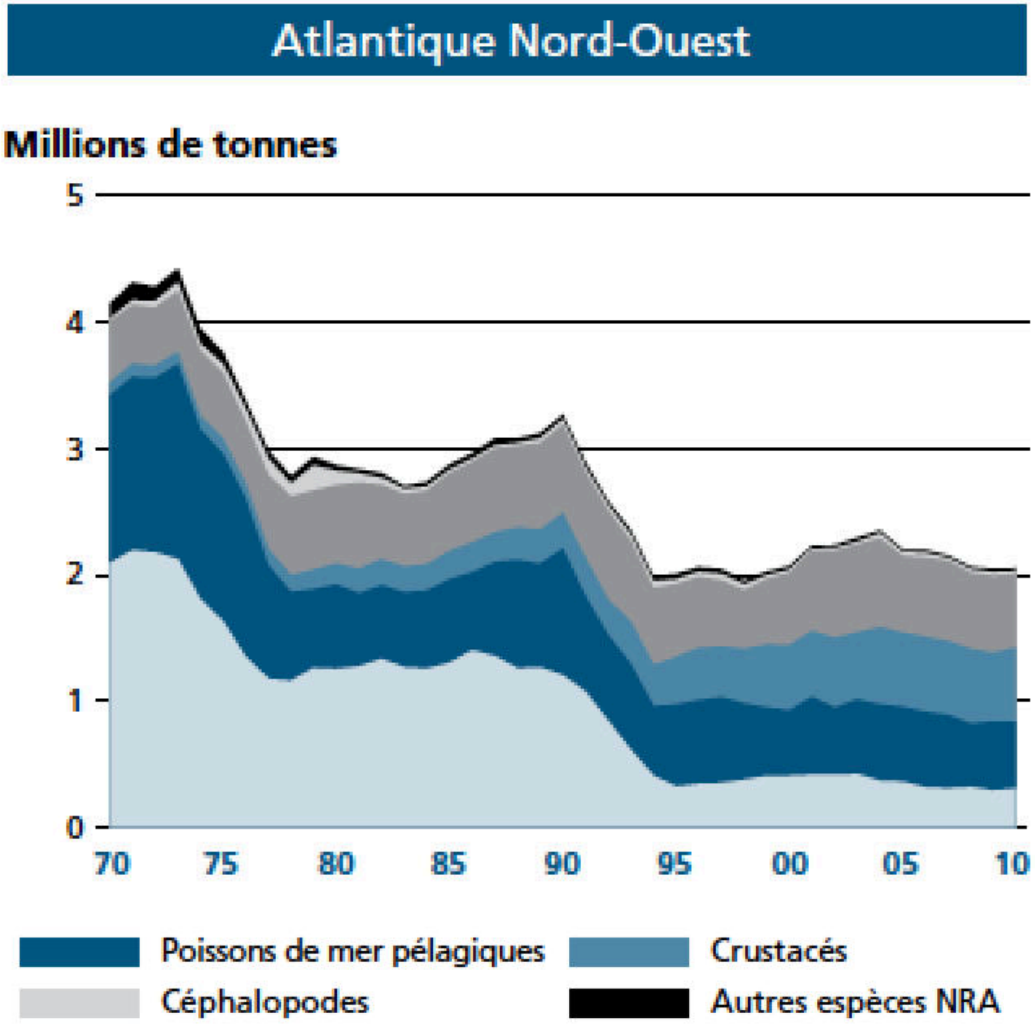
…. Fishing: Stagnation of catches since 1990
while fishing effort continues to increase



FAO, 2020

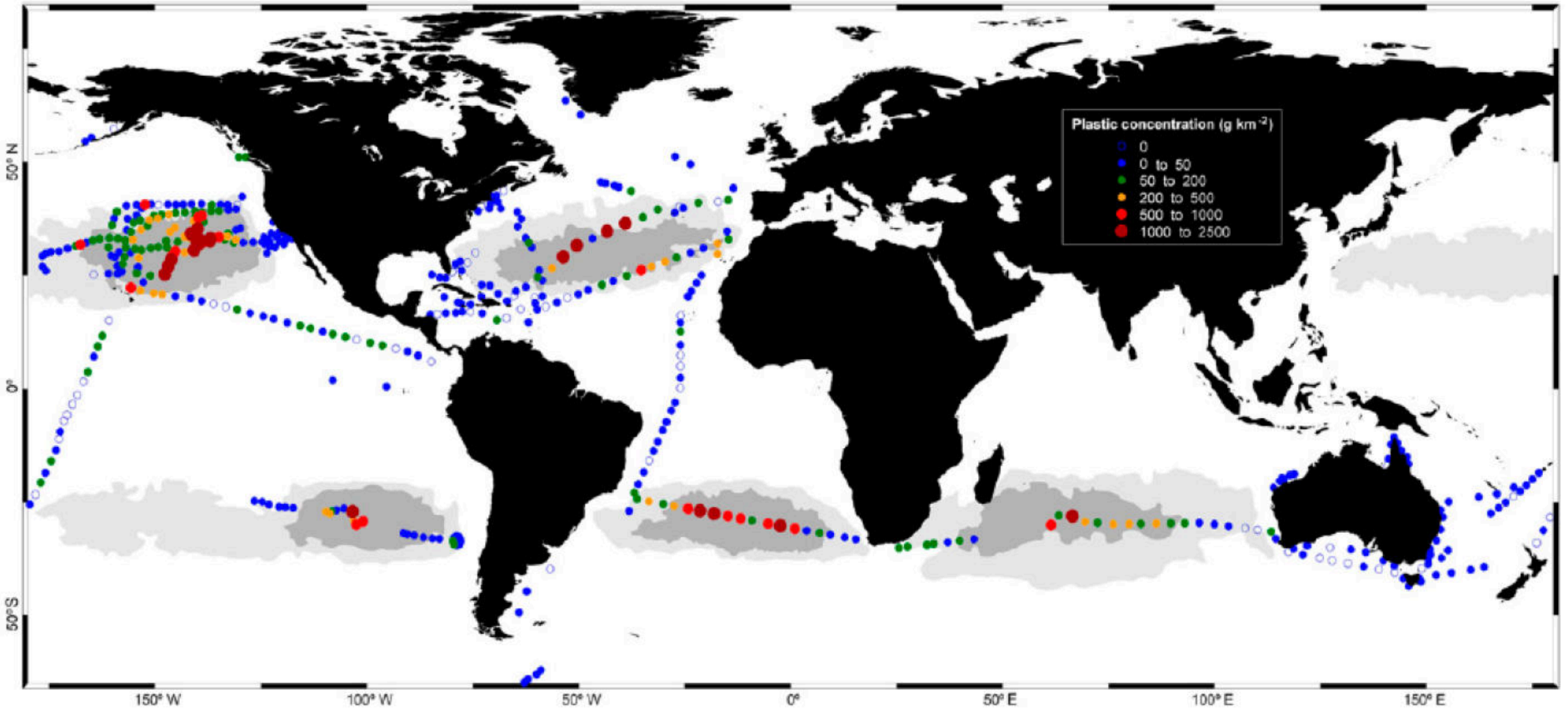
Other threats to ecosystems: overfishing

Some regions show a very clear decline in catches (collapse of stocks)
e.g. for cod
in the Northwest Atlantic



Other threats to ecosystems: pollution

…. A "plastic ocean":
High concentrations of plastic debris



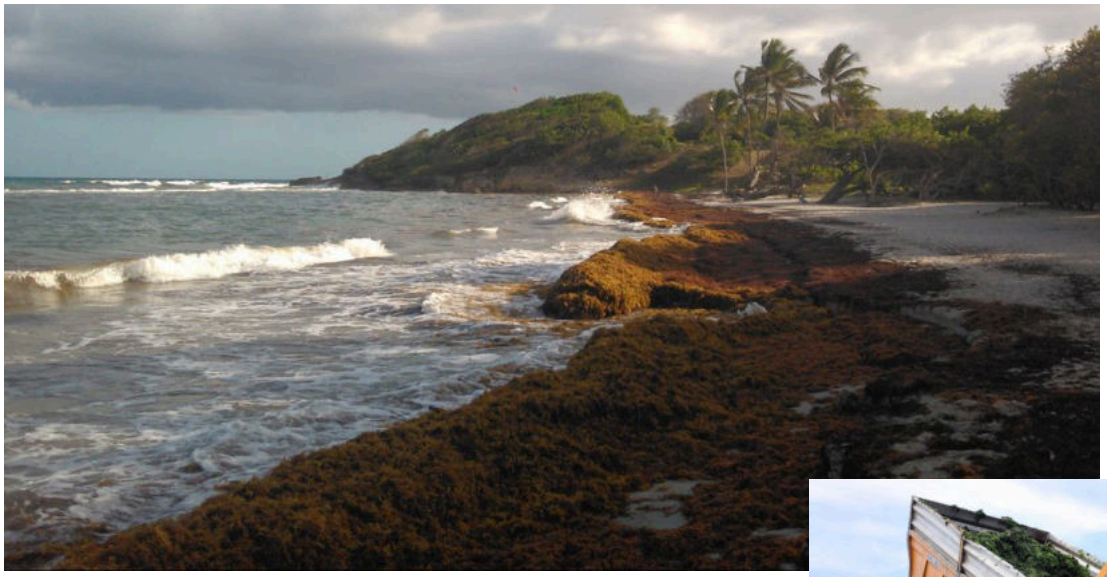
Other threats to ecosystems: pollution

…. A "plastic ocean":
With Consequences for Marine Organisms

Dead sperm whale
in the Mediterranean Sea

Inventory of plastic debris
in the stomach of the sperm whale ….

Other threats to ecosystems: eutrophication



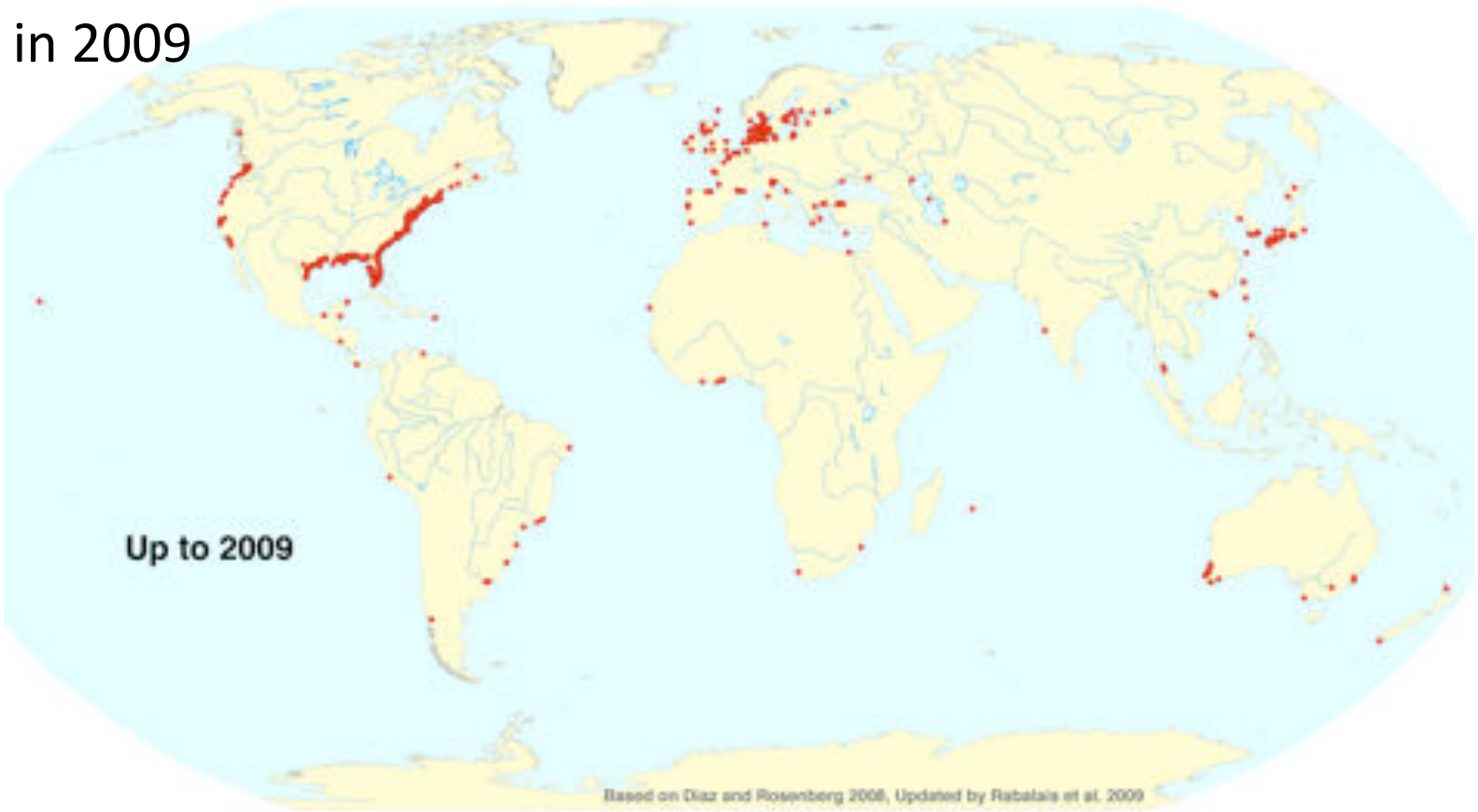
Radeaux d'algues brunes aux Antilles
((Le monde, Mai 2015, Guadeloupe)

« Marées vertes »
en Bretagne

Other threats to ecosystems: eutrophication

Nutrient inputs (nitrogen, phosphorus) in the coastal zone
Phytoplankton blooms
Oxygen consumption and anoxic or dead zones

Hypoxic zones
Identified in 2009



A rather dark panorama... but!

Climate Change and Acidification:

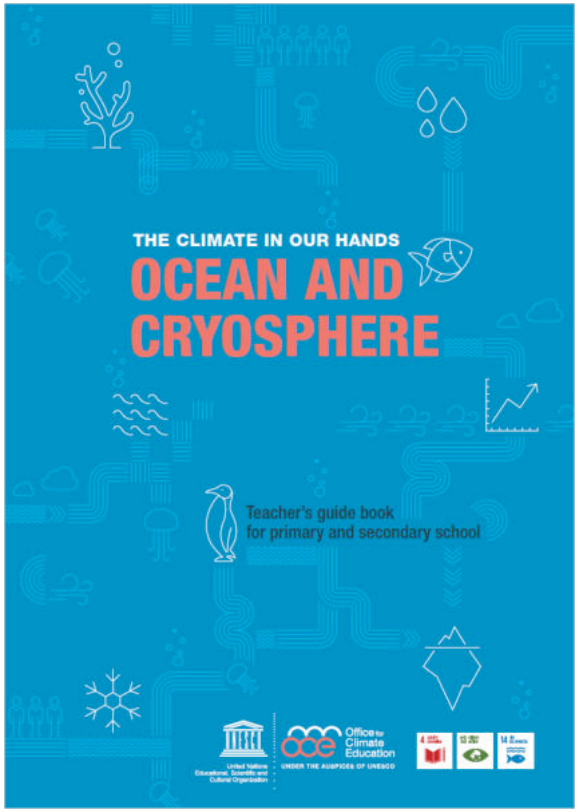
Paris Climate Conference (December 2015)
Keeping warming well below +2°C

Overfishing, pollution, ... :

Local solutions, regulations (fishing quotas), creation of marine protected areas, ...

Educational resources

Office for Climate Education



The climate in our hands - Ocean and Cryosphere

The climate in our hands - Ocean and Cryosphere The climate in our hands - Ocean and Cryosphere is the first teacher's guide book of the collection “The climate in our hands”, a series of volumes on...

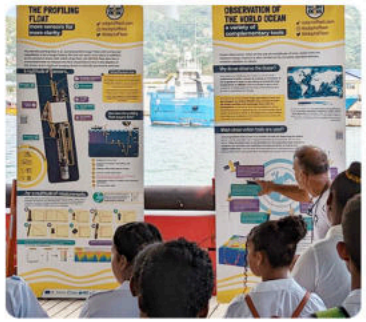
(https://www.oce.global/en/resources/class-activities/climate-our-hands-ocean-and-cryospher

Educational resources

https://adoptafloat.com/

The Program

ADOPT A FLOAT IS A MULTIDISCIPLINARY EDUCATIONAL PROGRAM



Our Objectives

Share Ocean Knowledge with Students ...

Our Value

Discovering, Sharing, Together & for All ...

The Profiling Float

Flagship Robot of Ocean Observation ...

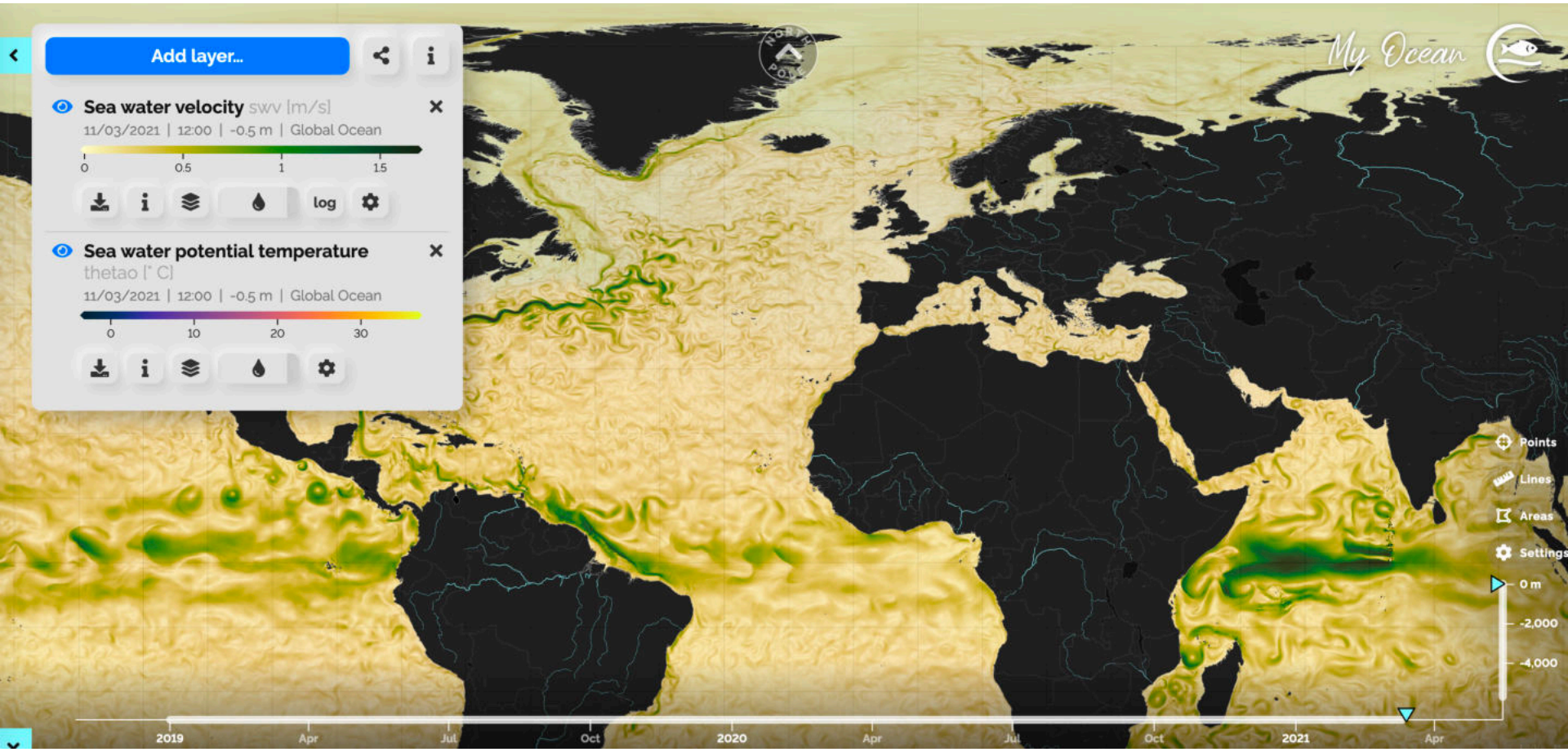
The school year

Events throughout the School Year ...

How to adopt?

Simple Procedure to Adopt ...

Educational resources



MERCATOR OCEAN INTERNATIONAL

https://myoceanlearn.marine.copernicus.eu/

Educational resources

Interactive IPCC atlas

https://interactive-atlas.ipcc.ch/