Auswirkungen der Erderwärmung auf die Ozeane im Lichte der Pariser Klimaziele

Hans-O. Pörtner: Co-Chair WGII AR6
AR5: CLA WGII CH. 6, Ocean Systems,
Ocean products in TS and SPM, CC-Boxes, SYR, SED

BIOACID
Biological Impacts of Ocean ACIDification

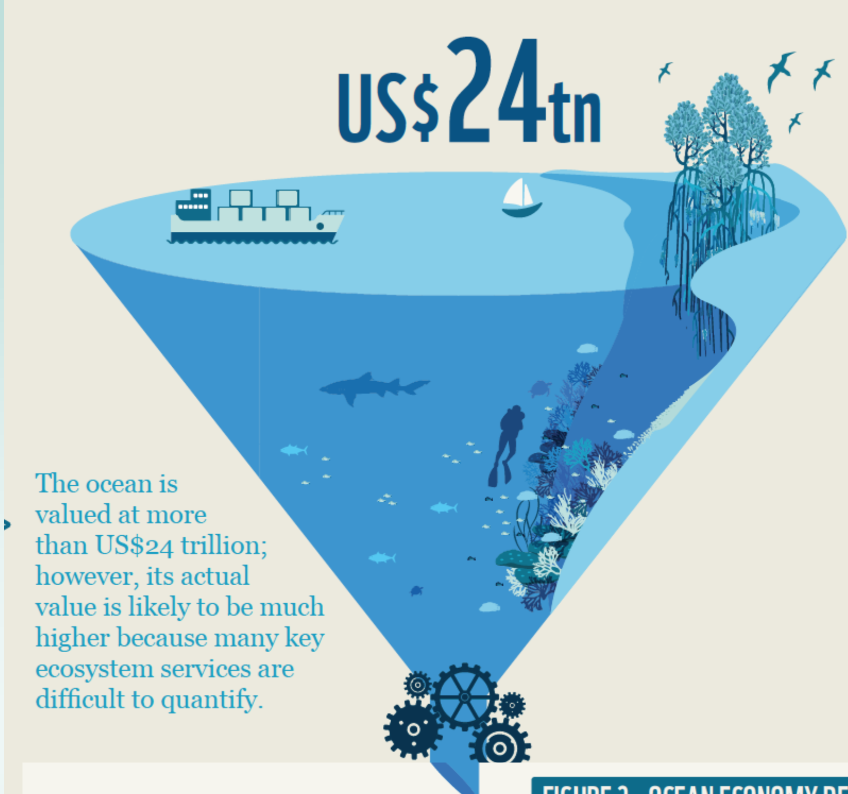
PRINCE ALBERT II OF MONACO FOUNDATION

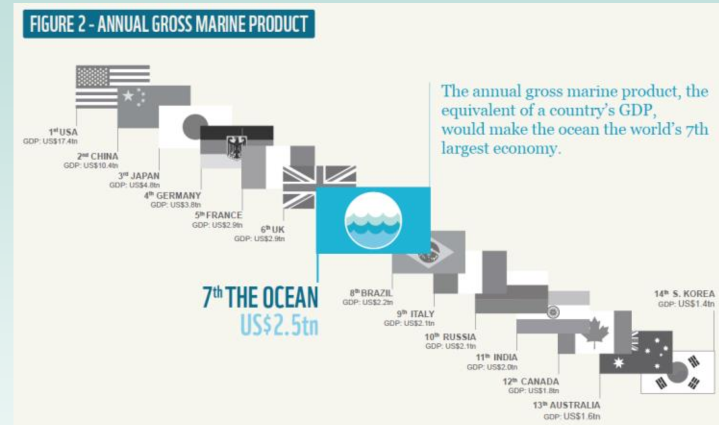
IAEA
Ocean Acidification International Coordination Centre
OA-ICC

OCEANS 2015 INITIATIVE

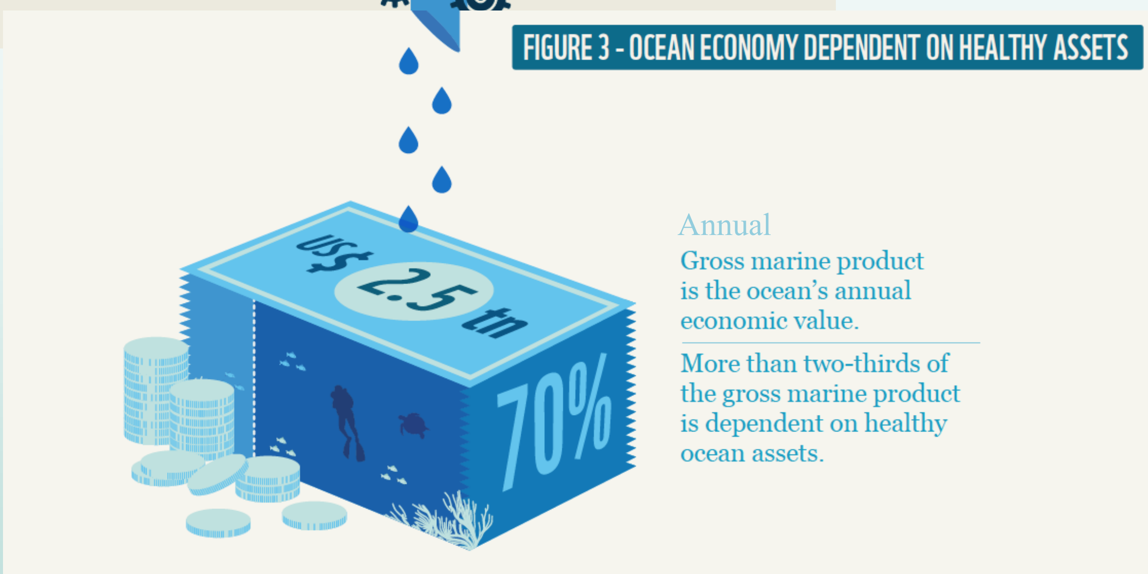
ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

Annual gross marine product





...no. 7 in the world...



......depending on healthy oceans

Analysis for this section is provided by: BCG The Boston Consulting Group

For more information on the BCG methodology, please visit: ocean.panda.org

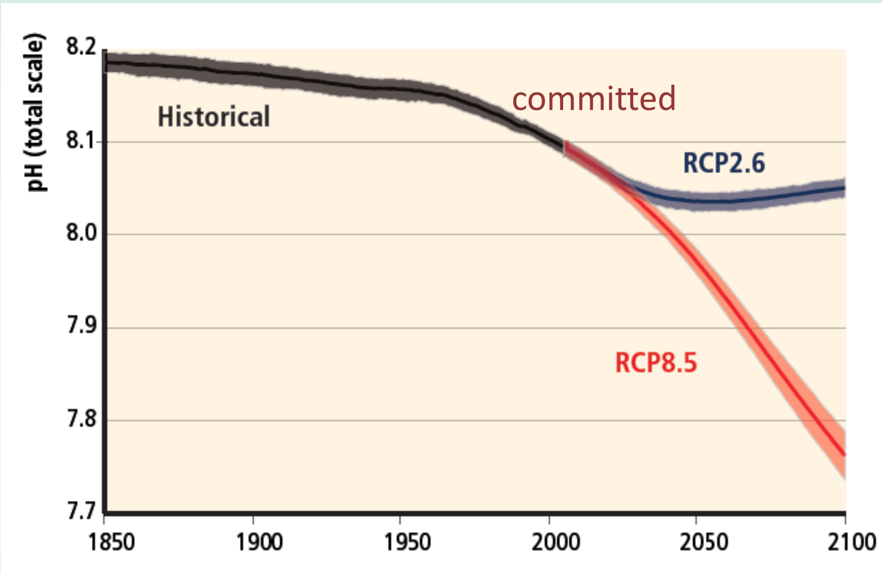
WWF 2015

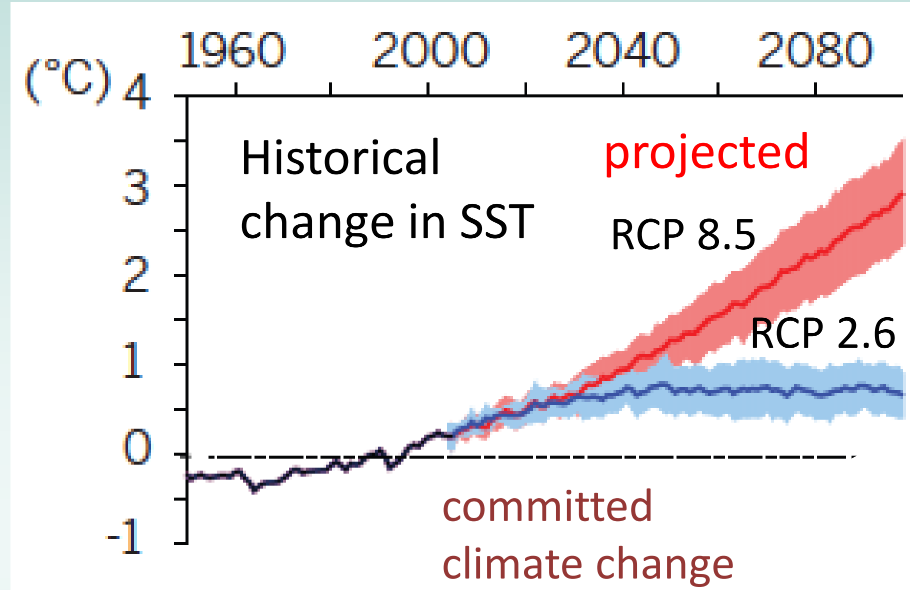
Challenges to ocean health:

According to emission scenarios oceans are: ... warming

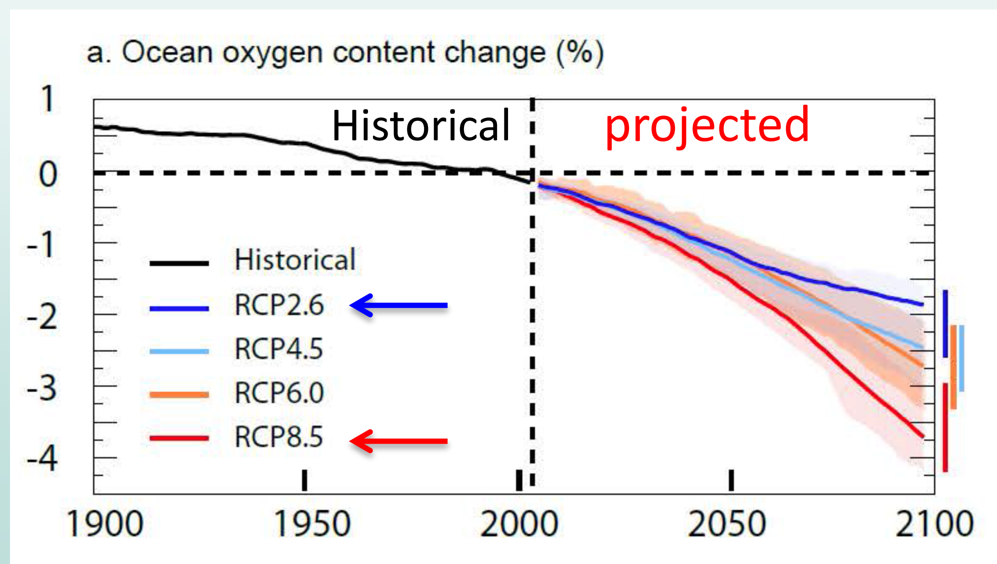
...acidifying

Historical → **Projections**





... losing oxygen

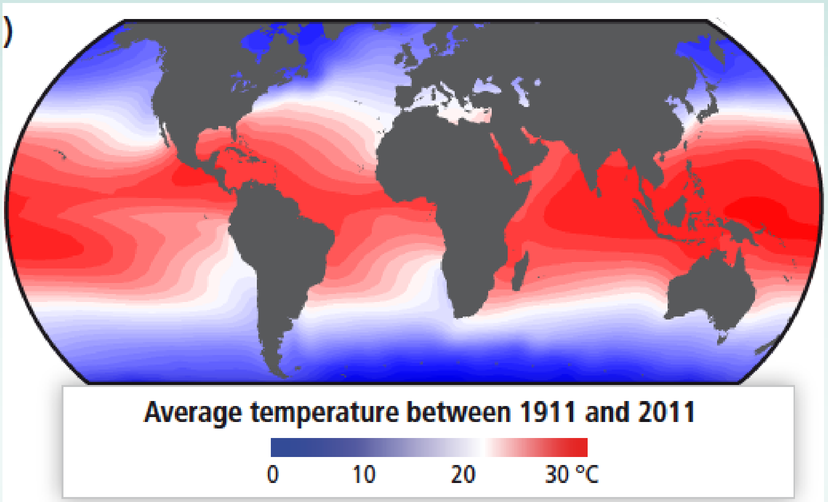


CMIP5 model runs

WGI Figure 6.30

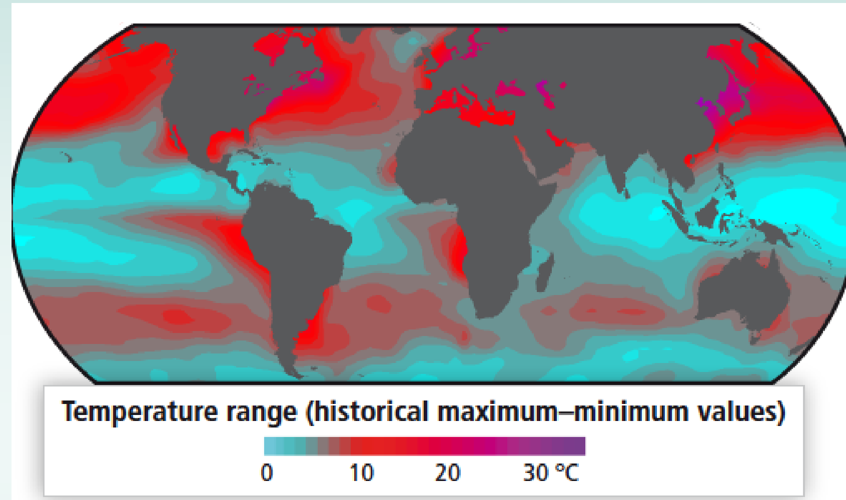
Gattuso et al., 2015

Warming, acidification, expanding hypoxia
occur on top of regional and natural variability:
➔ regional specificities: functional changes may depend on climate zone



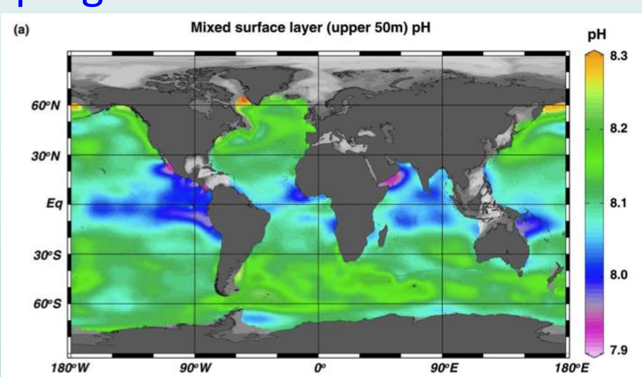
warming on top of means and variability

Pörtner et al. 2014



true also for: **light, nutrients, food**

progressive acidification

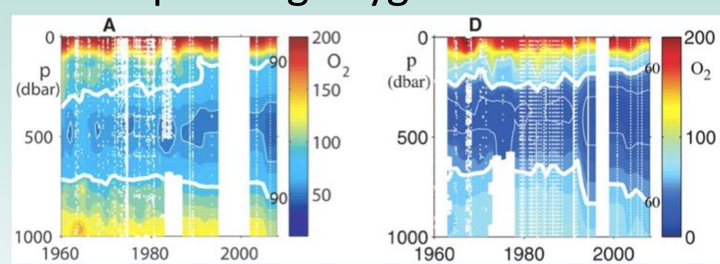


In ocean surface layers

(Pelejero et al., 2010)

expanding oxygen minimum zones

depth (m)



dissolved oxygen (μmol kg^{-1})

(A) Eastern tropical North Atlantic (10° to 14°N, 20° to 30°W)

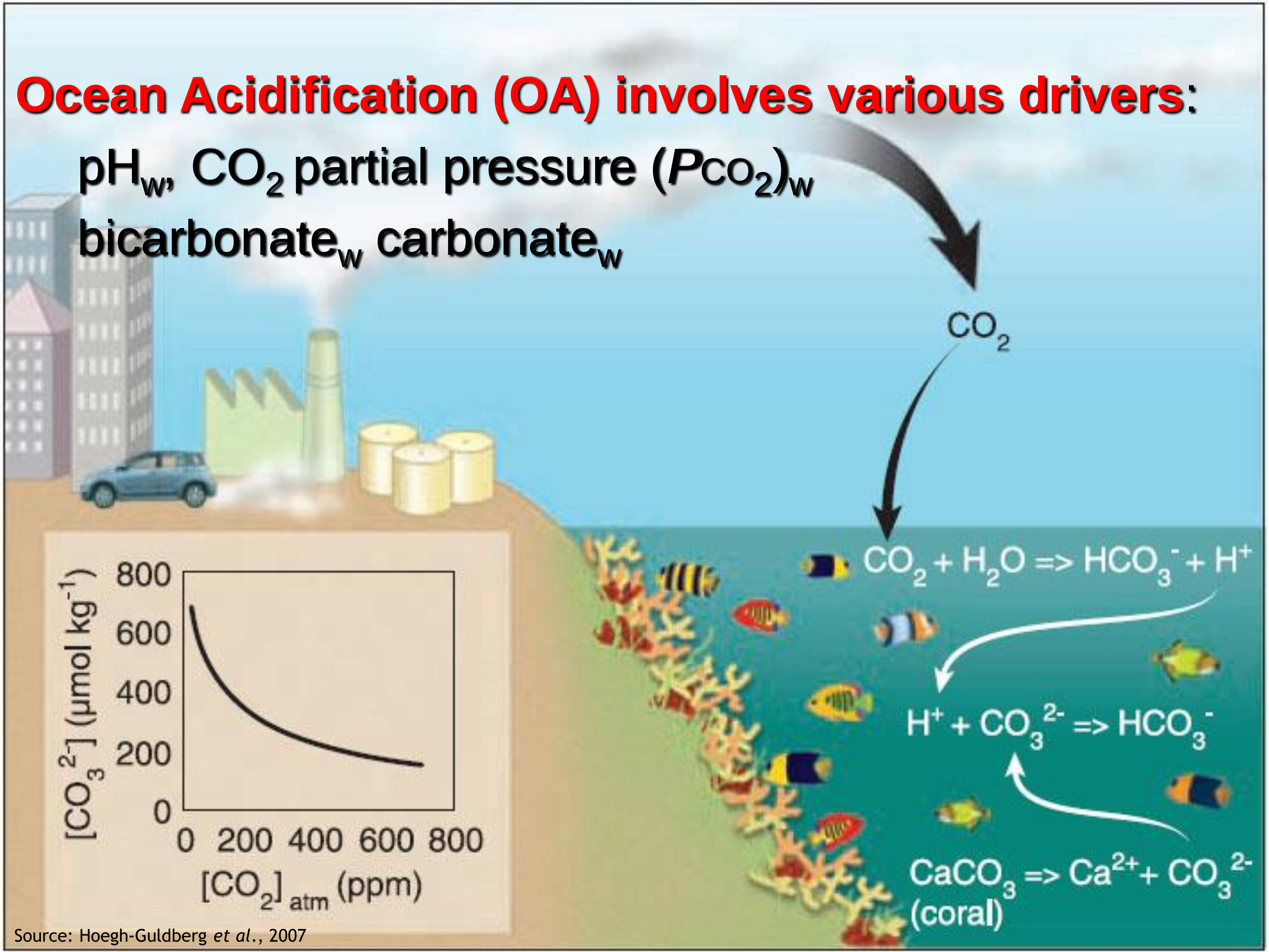
(D) Eastern equatorial Pacific Ocean (5°S to 5°N, 105° to 115°W)

(Stramma et al., 2008)

Ocean Acidification (OA) involves various drivers:

pH_w, CO_2 partial pressure $(P_{CO_2})_w$

$bicarbonate_w$, $carbonate_w$



Source: Hoegh-Guldberg *et al.*, 2007

These corrosive conditions dissolve shells of sea butterflies

Movie: Brad Seibel, University of Rhode Island

Sea butterfly shells ($CaCO_3$) exposed to corrosive conditions expected by 2100

Image: Victoria Fabry, California State University San Marcos

Orr et al. (2005)

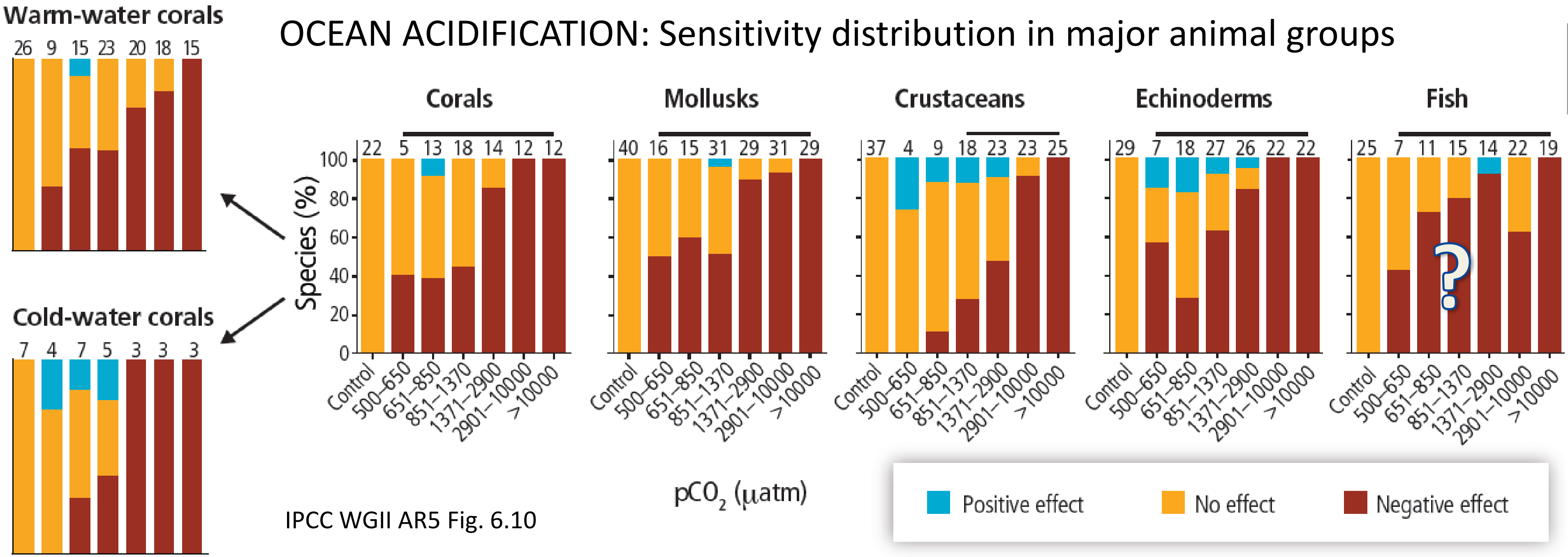
Fabry et al. (2008)

Comeau et al. (2009; 2011; 2012)

Lischka et al. (2011); Lischka & Riebesell (2012)

Bednarsek et al. (2012)

OCEAN ACIDIFICATION: Sensitivity distribution in major animal groups



IPCC WGII AR5 Fig. 6.10

.....effects exacerbated by warming extremes...

Biological Impacts of Ocean ACIDification

INTERGOVERNMENTAL PANEL ON climate change

Ocean areas naturally rich in CO_2 confirm expected future trends

- Less biodiversity
- Fewer calcifiers
- More fragile shells
- More invasive species
- More seagrasses, degraded corals

CO_2 bubbles rise from seafloor at Ischia, Bay of Naples, a natural lab to study acidification

Hall-Spencer et al. (2008)

Rodolfo-Metalpa et al. (2008)

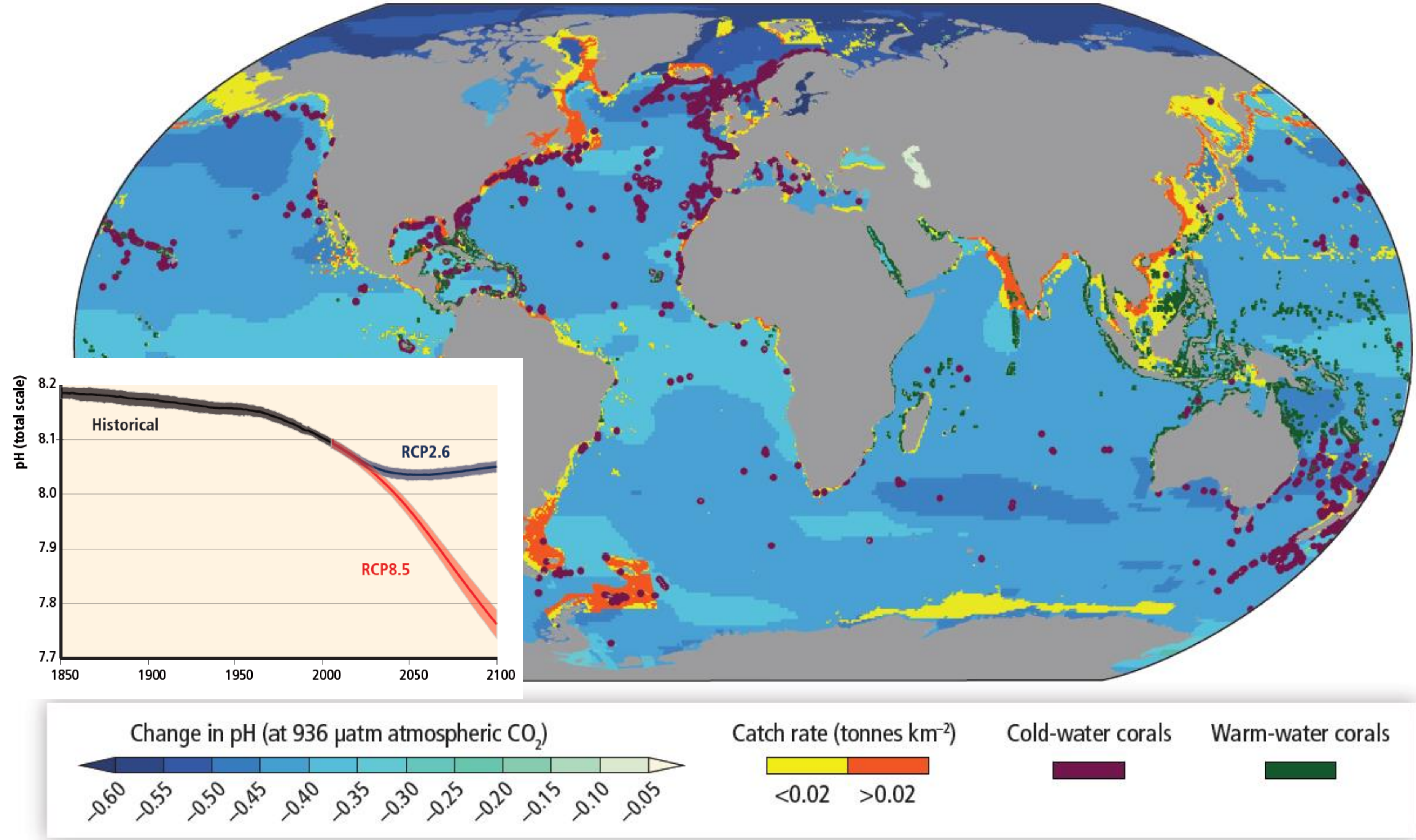
Photo: Jason Hall-Spencer, University of Plymouth

Photo: Steve Ringman, Seattle Times

Another natural CO_2 vent site in Papua, New Guinea, used to study effects of acidification on corals

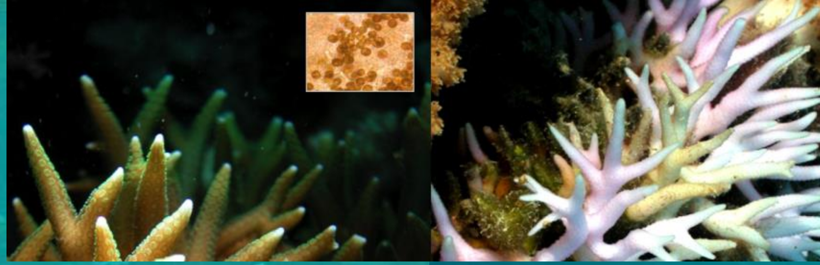
Projections: Ocean acidification affecting mollusk and crustacean fisheries, and coastal protection by coral reefs

>>2 °C



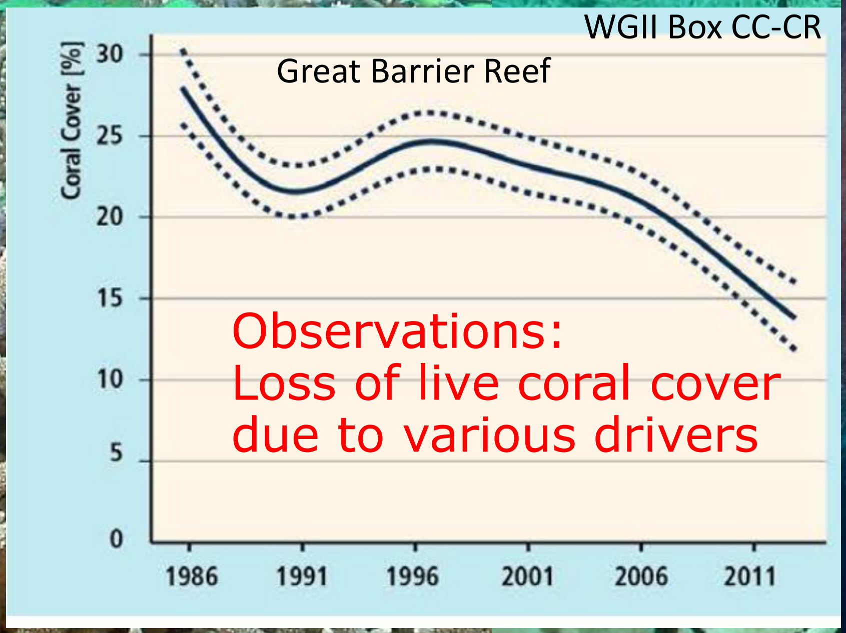
IPCC WGII AR5 Fig. 6.10

0.8°C



Vulnerable ecosystems

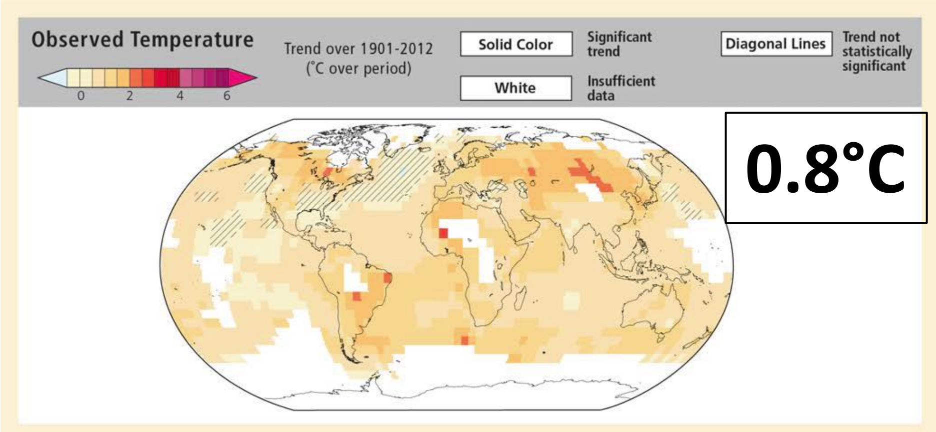
Warm water coral reefs under combined pressures at 0.8°C above pre-industrial:

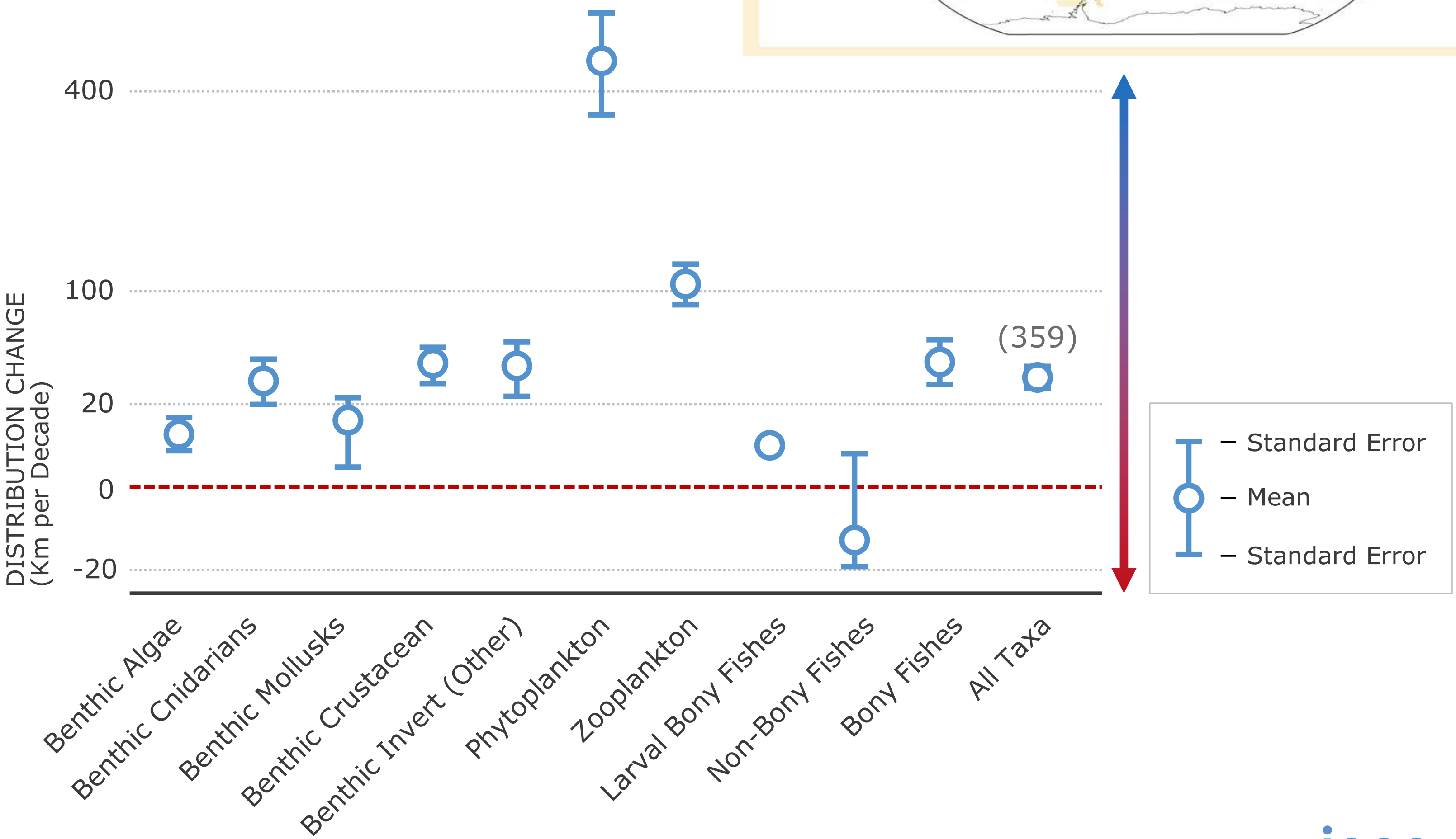


Verons 2009

OBSERVATIONS

World-wide marine species displacements due to climate change

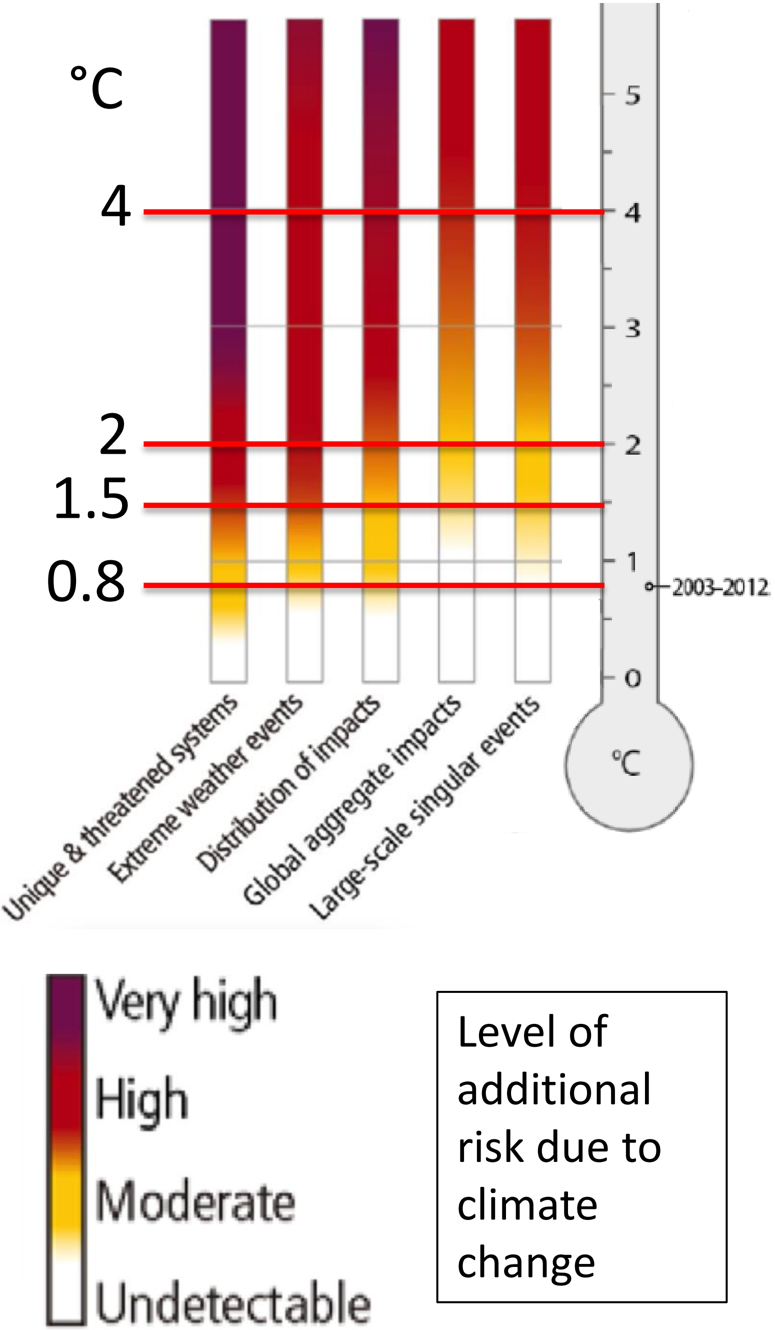




WGII, SPM.2

INTERGOVERNMENTAL PANEL ON climate change

Risk assessment: Reasons for concern



Level of additional risk due to climate change

How much change is acceptable?
A role for natural (and human) systems to guide the setting of **long-term global goals** (LTGG, relative to preindustrial), considering levels of **risk**

LTGG

4°C

2°C

1.5°C

0.8°C

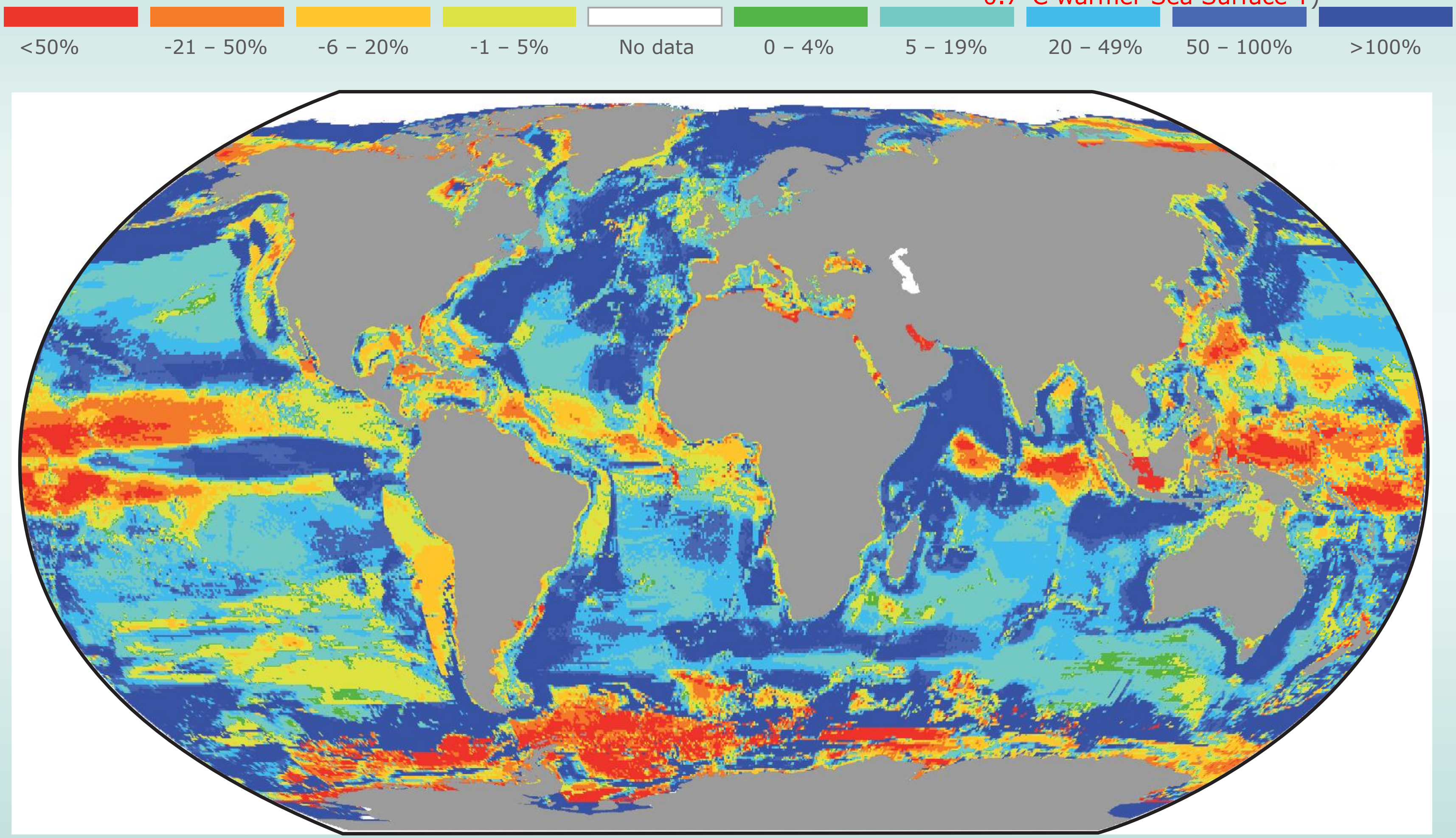
UNFCCC Structured Expert Dialogue, 2013 -2015:
...comparing 1.5 and 2°C,
identifying... Key risks of impacts
Avoided impacts

Food security constrained: ....Fisheries

2°C

2051-60: displaced and reduced fish and invertebrate biodiversity

CHANGE IN MAXIMUM CATCH POTENTIAL (2051-2060 COMPARED TO 2001-2010, SRES A1B, 2°C warming of global surface T 0.7°C warmer Sea Surface T)



WGII, 6-14, SPM.6, SYR 2.6

INTERGOVERNMENTAL PANEL ON climate change

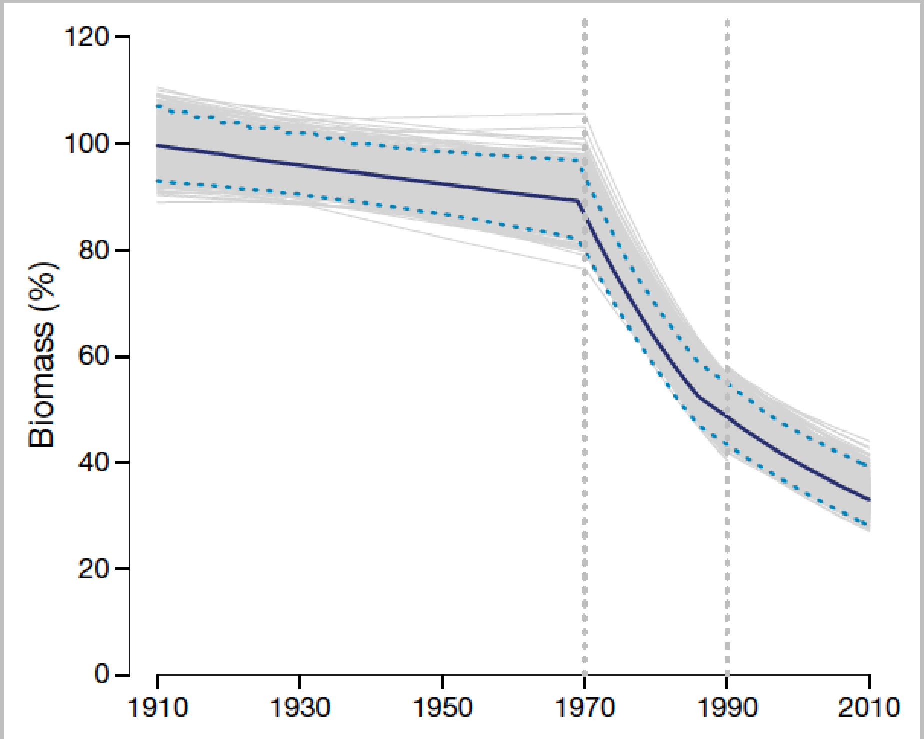
Food security constrained: ....Fisheries

2°C

2051-60: displaced and reduced fish and invertebrate biodiversity

..... 2°C:

Combined human pressures: oceans are warming, acidifying, losing oxygen, affecting presently overexploited stocks.

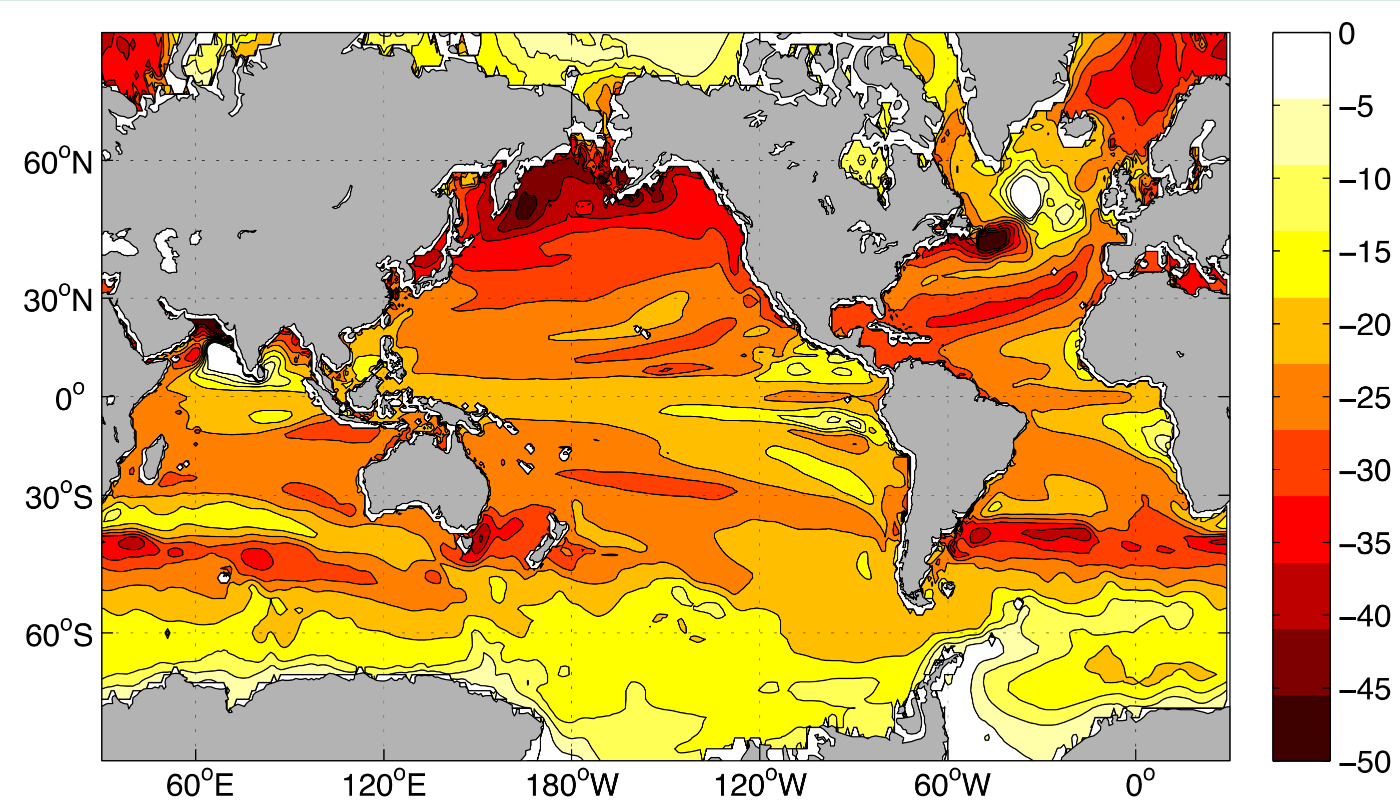


BACKGROUND:
OVERFISHING caused predatory fish biomass to decline
(by ≈ 70%!)

Christensen et al.
MEPS 512: 155–166, 2014

REDUCED HABITAT range of marine fishes and invertebrates due to thermal constraints combined with oxygen loss in the oceans…an additional role for CO_2?

>>2°C



% Decline in Metabolic Index Φ (= routine metabolic scope in marine animals)

by ~20% overall

Northern High Latitudes: by ~40%

2071-2100, 0-200m
IPCC Earth System Model mean, RCP8.5 scenario

Deutsch et al., *2015 Science*

BIOACID Biological Impacts of Ocean ACIDification

Vulnerable ecosystems identified in AR5: Arctic summer sea ice systems

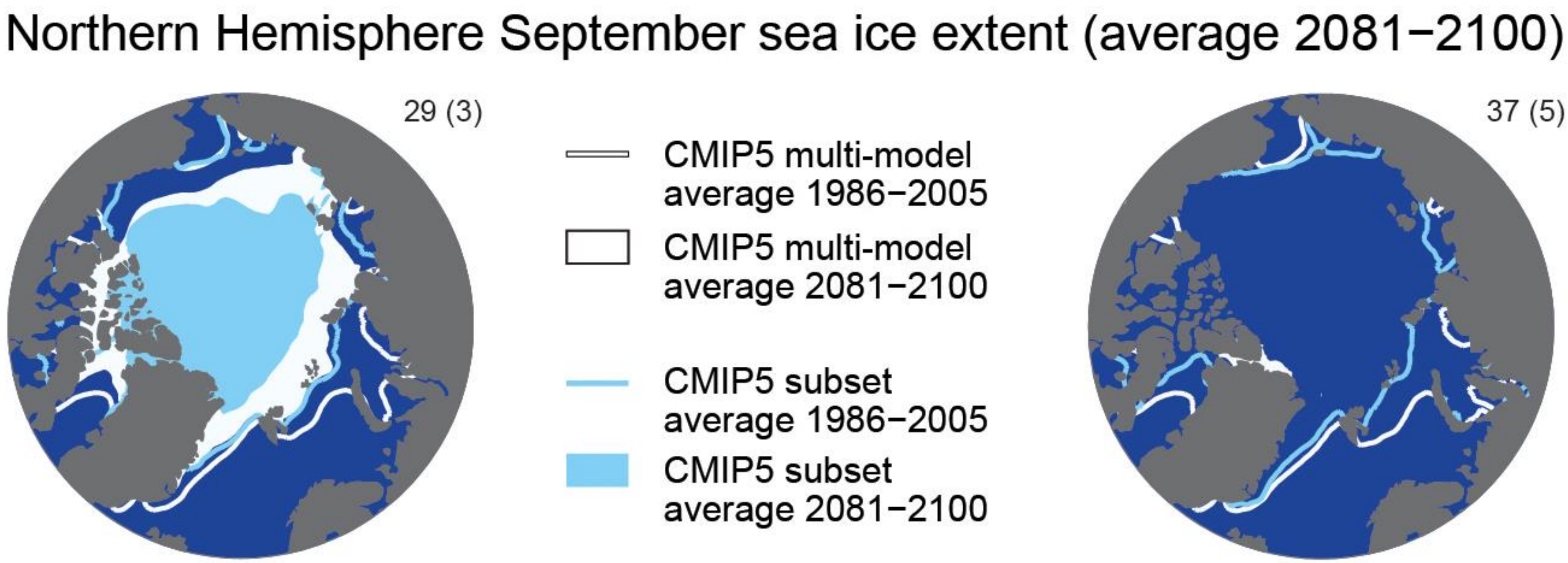
1.5°C

Important transitions between 1.5 and 2°C?

≥2°C

RCP 2.6
ambitious mitigation

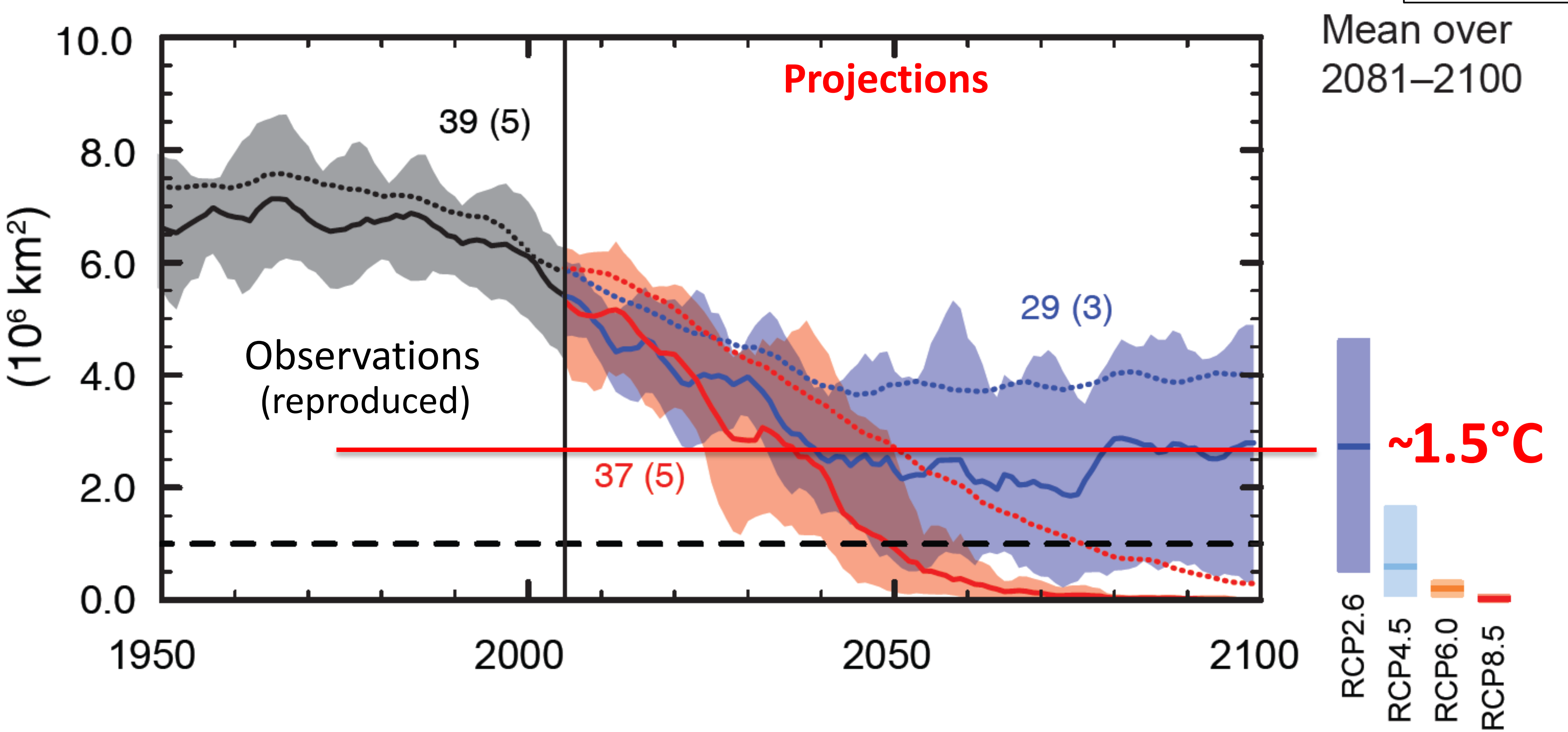
RCP 8.5
business as usual



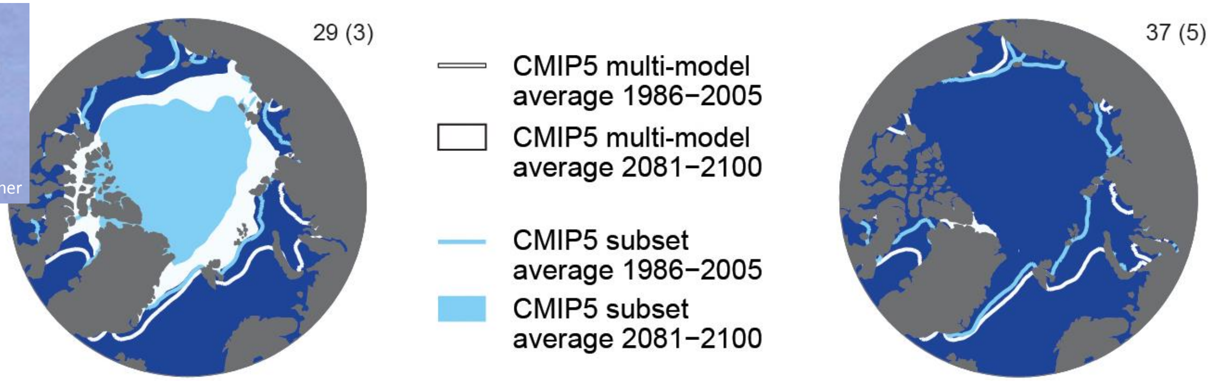
WGI SPM.7b, 8c

Some Arctic summer sea ice may be protected under RCP2.6

1.5°C



Northern Hemisphere September sea ice extent (average 2081−2100)



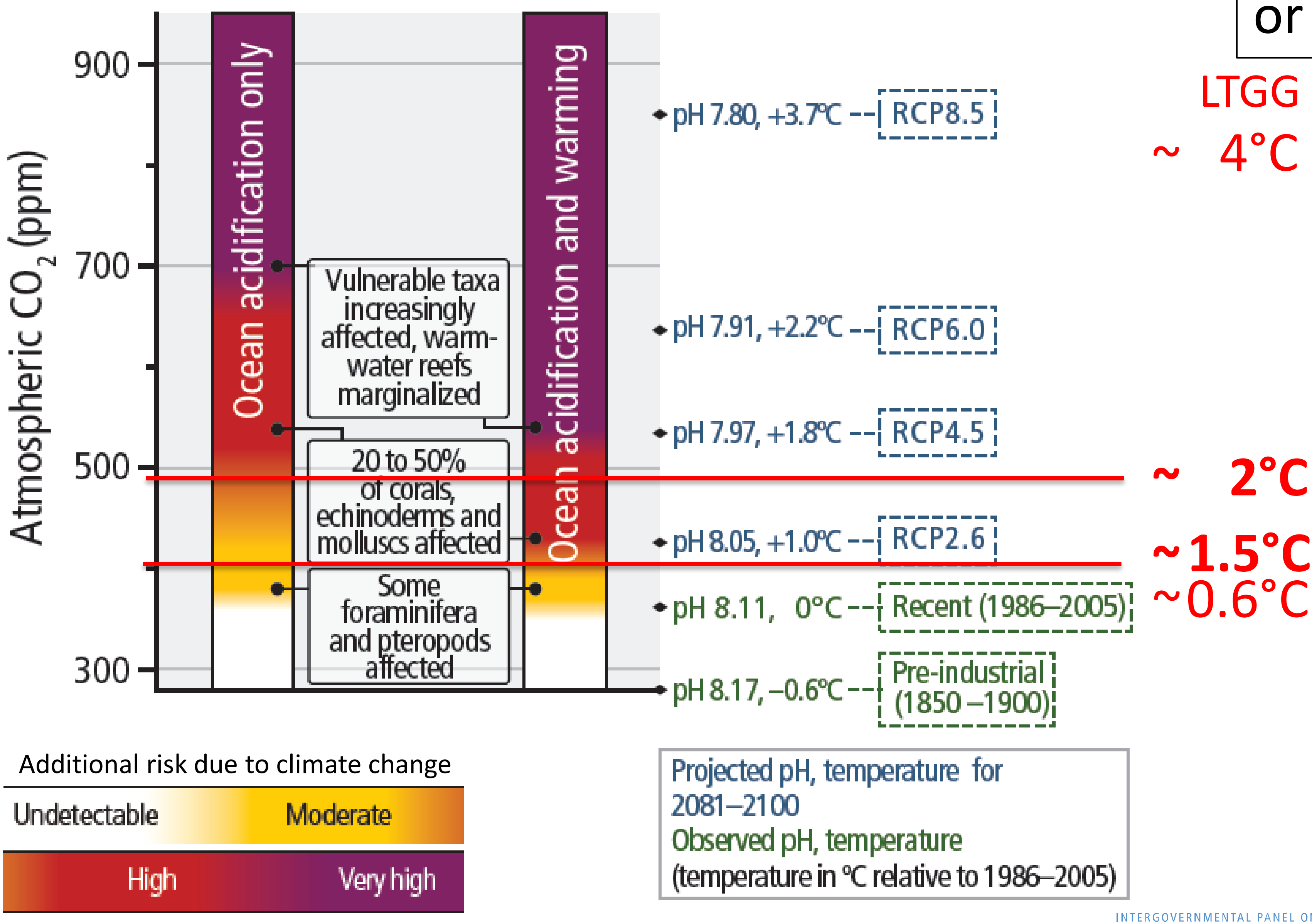
RCP 2.6

RCP 8.5

WGI SPM.7b, 8c

Risks due to combined impacts of **ocean warming** and **acidification** ... **Setting Long Term Global Goals (LTGG)**

1.5°C vs. 2°C or >>2°C



SYR 2.5

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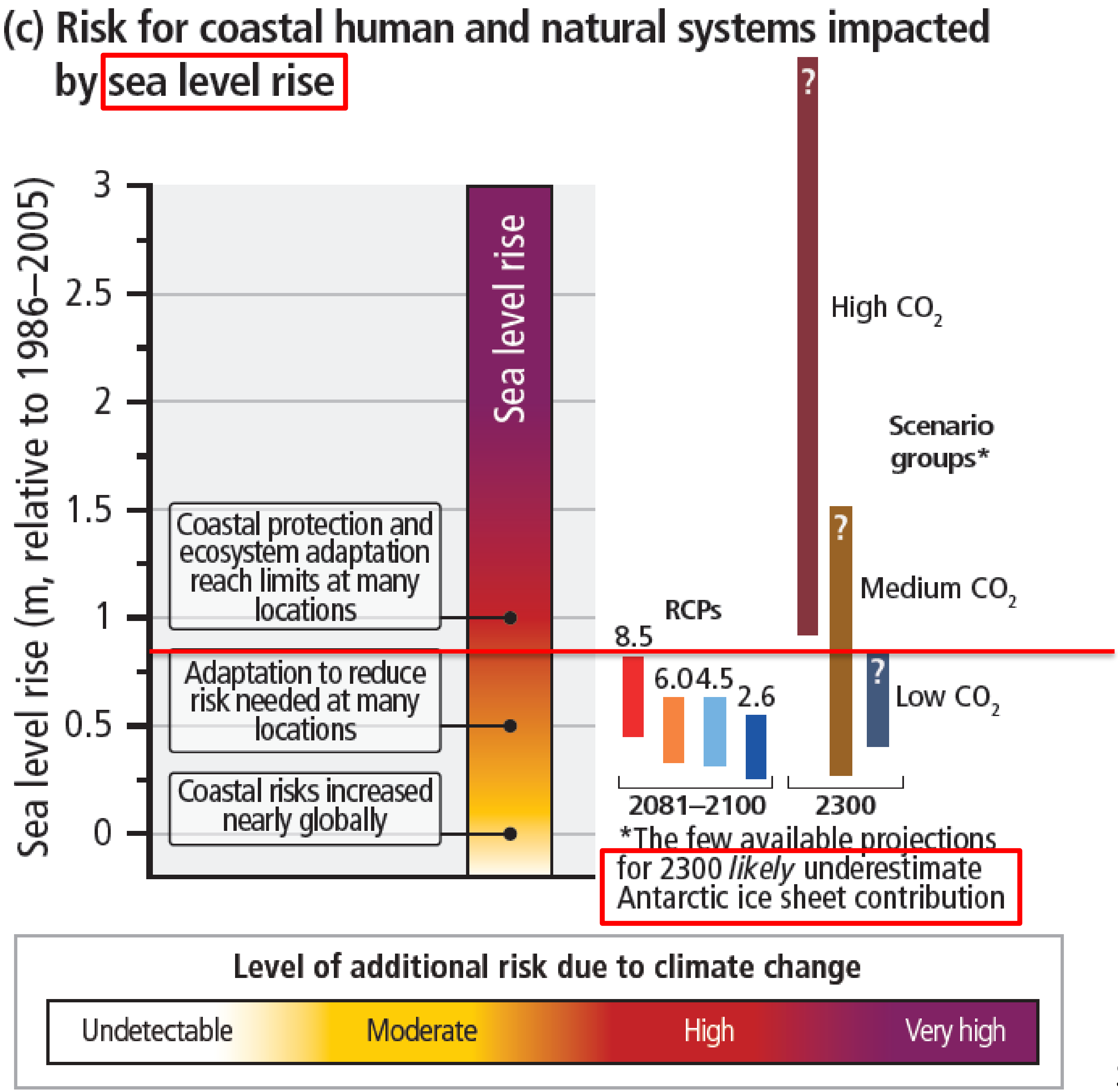
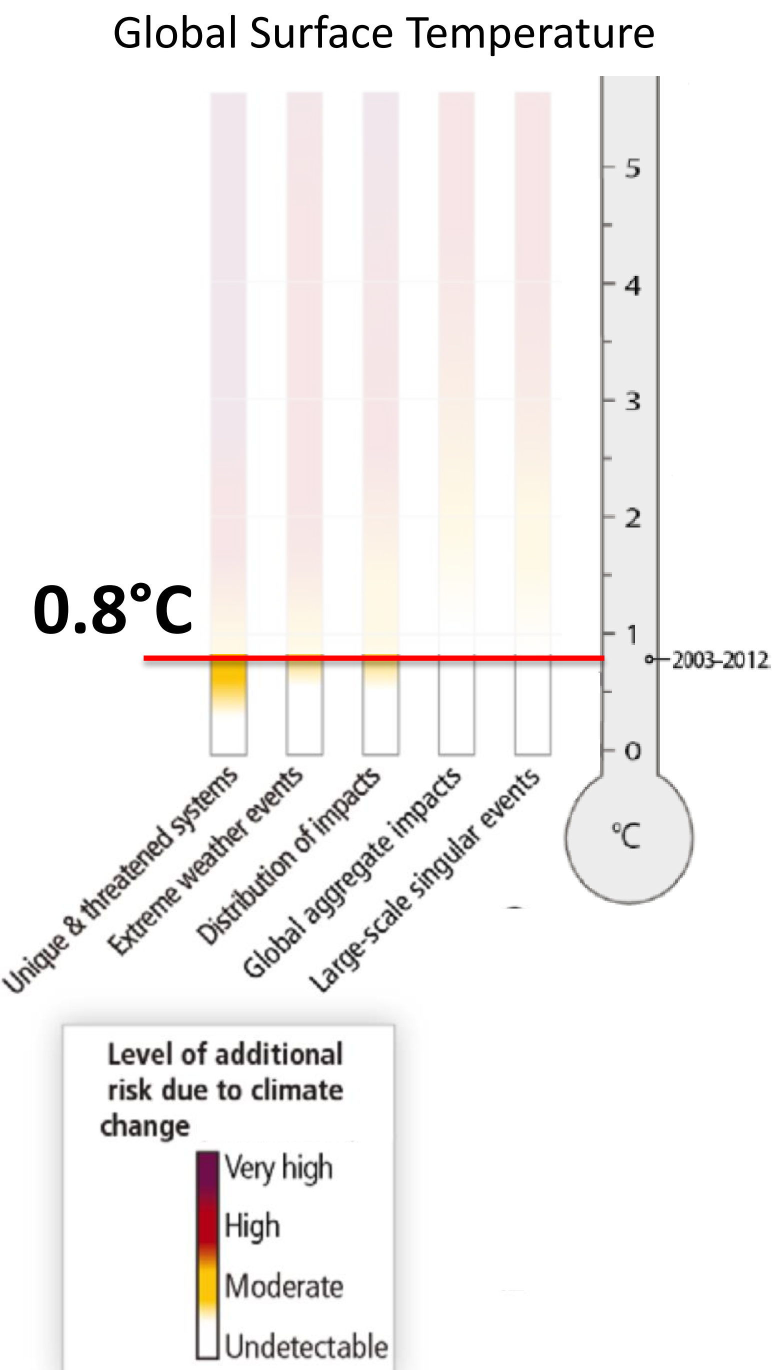
1.5°C



Increasing risk associated with high sea level beyond 2100 under RCPs > 2.6

However..... Contribution of Antarctic ice sheet likely underestimated

SYR 2.5

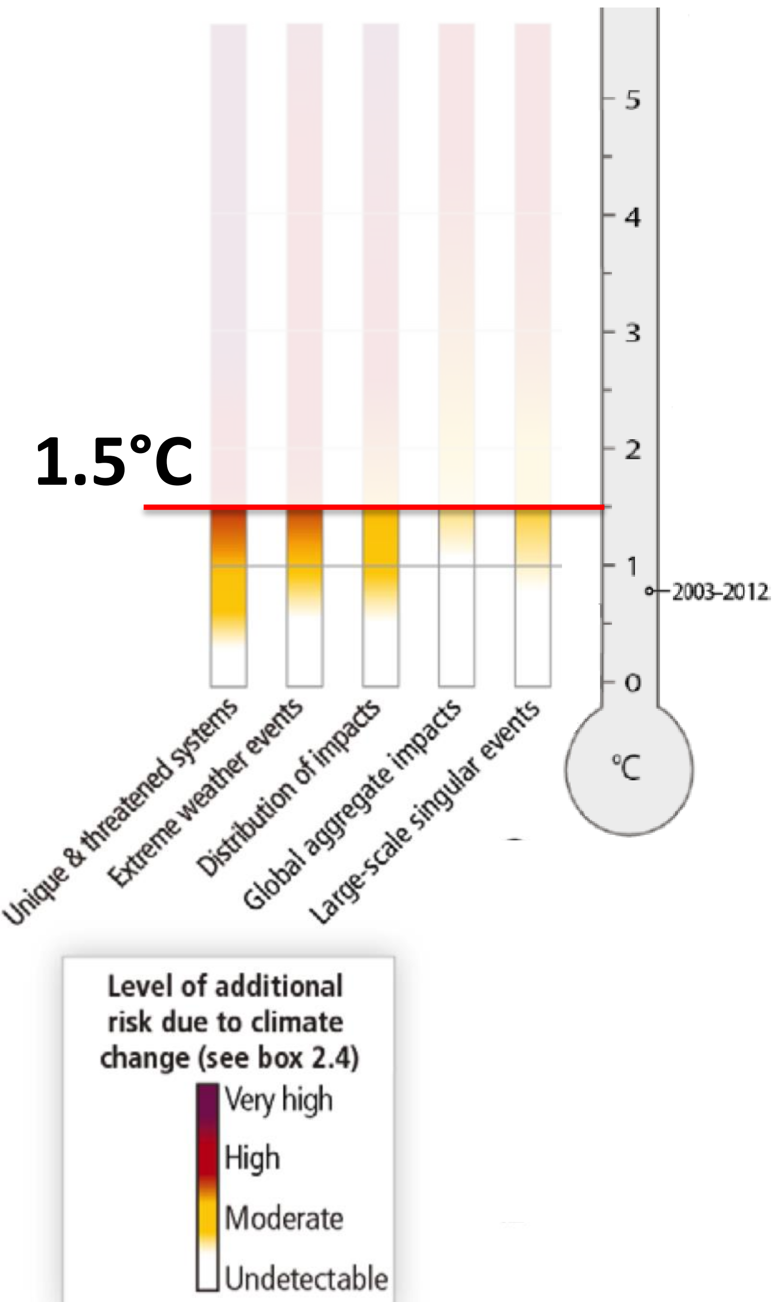


RECENT global surface T:

.... observed ecosystem impacts on all continents and in all oceans, e.g.

...in the oceans:

- **Species are displaced**
- Some **unique systems (coral reefs, summer sea ice systems) are losing resilience and spatial cover**
- **Pteropods, foraminifera and bivalve cultures show effects of ocean acidification**
- ...Risks are still moderate but **may rise** as climate change combines with other pressures

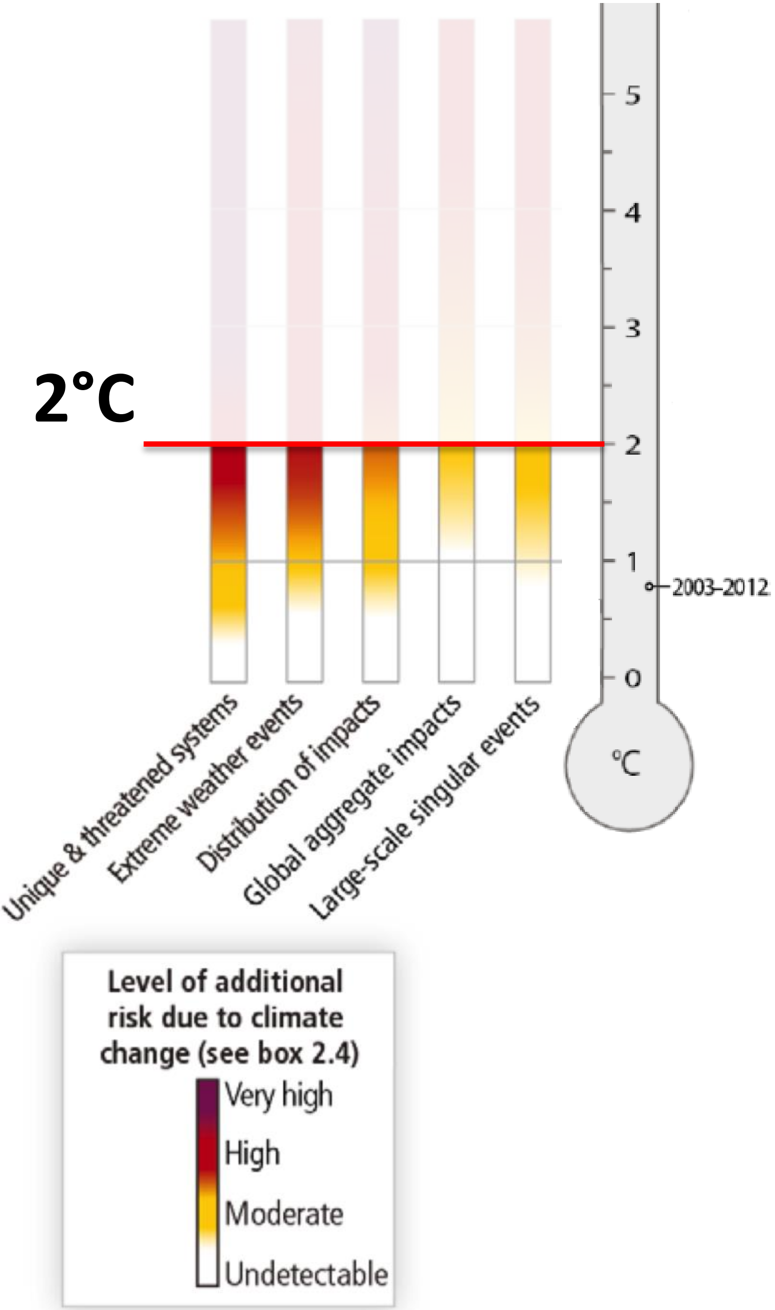


....climate change: ....avoided impacts
....projected impacts

- **climate change velocity slow enough** for most organisms to follow.
- up to **half of coral reefs may remain intact**.
- **sea level rise** may remain **below 1 m**.
- some Arctic **summer sea ice may remain**.
- **ocean acidification** impacts at **moderate** levels.

- **Capacity to increase food production reduced further** with some scope for adaptation.
- **some unique systems at high risk**.
- **more than half of coral reefs may be lost.**
- **risks of combined ocean acidification and warming become more prominent**.

....climate change: ....avoided impacts
....projected impacts



- **climate change velocity becomes too high for** some species to move sufficiently fast.
- **long-term sea level rise may exceed 1 m:** coastal habitat loss, flooding, seawater inundation.
- Arctic **summer sea ice may be lost.**
- some **unique systems at very high risk.**
  e.g. coral reefs and sea ice systems marginalized.
- **risks of combined ocean warming and acidification become high.**
- **food production at high risk** with some room for adaptation

ADAPTATION IS ALREADY OCCURRING

- **Ocean acidification:** Defending oyster cultures at the US Westcoast against inflow of acidified water.

- **Marine Protected Areas:** Enhancing the resilience of coral reefs and their fish stocks against warming and acidification.

- **Restoration** of Mangrove Forests

...but adaptation capacity is highest under moderate climate change,
$\leq 1.5°C$

Heads of delegations

Paris COP 21
November /
December 2015

Leading to the COP21 Agreement

UNFCCC inviting the IPCC
...to prepare a SR on "the impacts of global warming of 1.5°C above pre-industrial levels and related GHG emission pathways"

IPCC agreeing

31 proposals for Special Reports during AR6:
The co-chairs have allocated these to 9 clusters - 2 reports possible

Cluster A: Land use, food and agriculture (including desertification)	7 proposals
Cluster B: Cryosphere, oceans and mountains	8 proposals
Cluster C: Health and security	2 proposals
Cluster D: Integrating adaptation and mitigation	5 proposals
Cluster E: Carbon pricing	1 proposal
Cluster F: Scenarios and low-carbon development	4 proposals including **UNFCCC 1.5°**
Cluster G: Managing climate data and information	1 proposal
Cluster H: Updates policy relevant messages/extreme events	2 proposals
Cluster I: Cities	1 proposal

IPCC accepted the **invitation by UNFCCC** to prepare a SR on "the impacts of global warming of 1.5°C above pre-industrial levels and related GHG emission pathways" **led by WGI (co-led by II and III)**

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Further Nairobi decisions (going beyond present TSU capacities)

- SR on climate change and **oceans and the cryosphere (WGII?)**
- SR on climate change, **desertification, land degradation, sustainable land management, food security, and GHG fluxes in terrestrial ecosystems**. The scoping process **may** consider challenges and opportunities for both adaptation and mitigation **(WGIII?).**
- consider modalities for **addressing and enhancing the treatment of regional issues** in the scoping process for AR6 (**implementation unclear**).
- **AR7 cycle** will include an SR on climate change and **cities**
- to organize an **international scientific conference on climate change and cities** early in the AR6 cycle

ipcc
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Thank you!

IPCC WGII Ocean Reprint Collection:
http://ipcc-wg2.gov/publications/ocean/

AWI

GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

OCEANS 2015 INITIATIVE

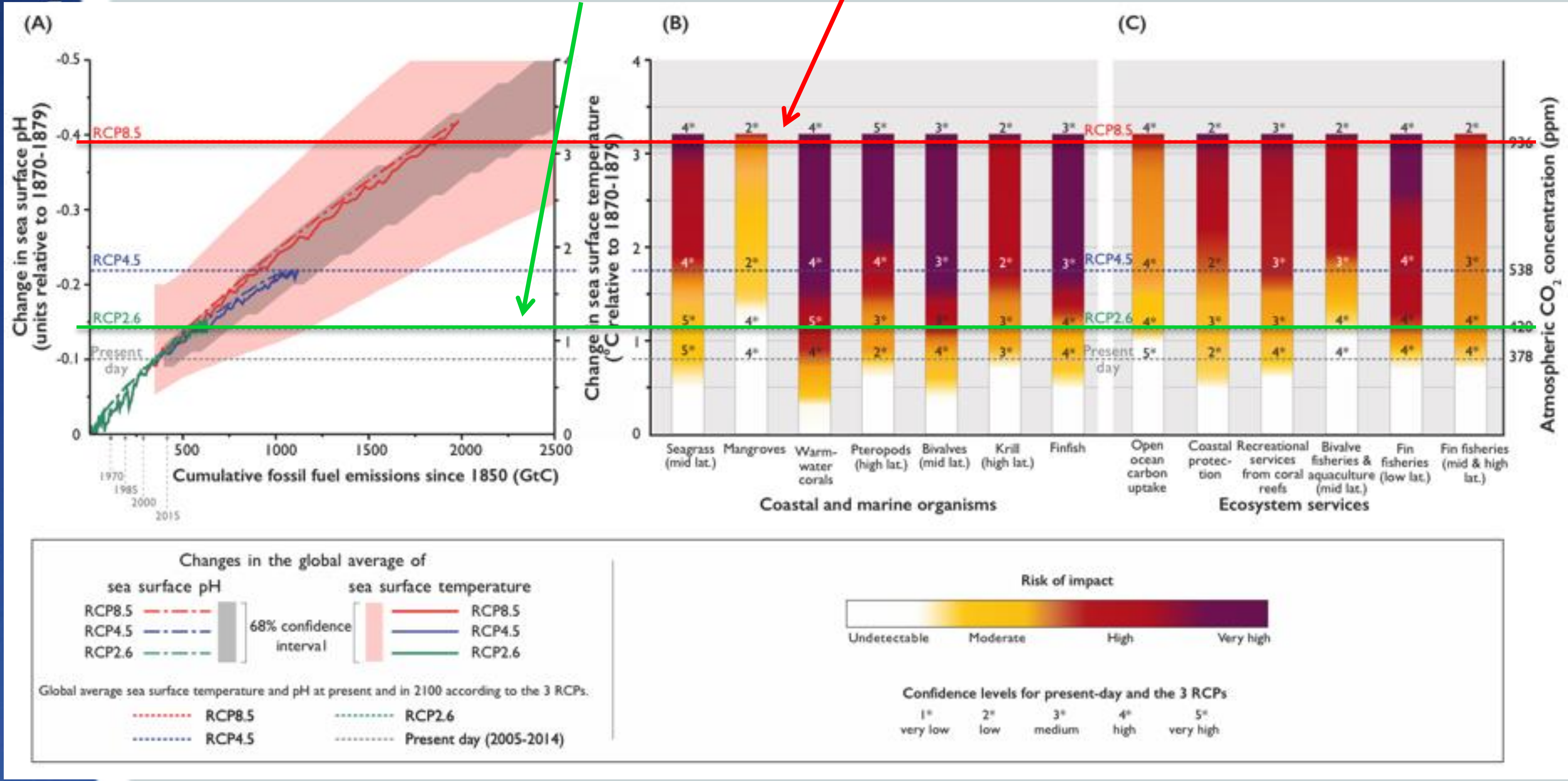
PRINCE ALBERT II OF MONACO FOUNDATION

IAEA
Ocean Acidification International Coordination Centre
OA-ICC

BIOACID
Biological Impacts of Ocean ACIDification

Bundesministerium für Bildung und Forschung

Impacts are already detectable + contrasting futures will depend on future GHG emissions (RCP2.6 vs. RCP 8.5)



Several organisms and ecosystems in the ocean will face a high risk of impact before 2100, even under the stringent mitigation scenario (i.e., RCP2.6)

Gattuso et al., 2015, Science

Possible timeline for first Special Report

- Scoping meeting : 09/16
- Nomination call : 03/17
- FOD end of 2017
- SOD spring 2018
- Approval <Nov 2018: before 1^{st} national stocktaking
- => *cited papers to be submitted in time for SOD*
  => *cited papers to be accepted in time for final draft*

Preliminary ideas on what a Special Report on 1.5°C may contain
WGI Perspective

- Climate sensitivity, cumulative emissions
  Propagation of uncertainties from climate modelling to impacts (with WGII)

- Non CO_2 GHG, aerosols and land use in deep decarbonisation pathways
  (with WGIII)

- Carbon cycle rebound effect *(with WGII-III)*

- Emergence : natural variability, response to human drivers (emissions / land use) in 1.5°C warmer climate (signal/noise in ensemble simulations)

- Response of the Earth system for different amplitudes of warming (1.5 vs 2, 2.5 or 3°C warming) : sea level, extreme events, water

!! CMIP6 simulations likely not available
=> new analyses of CMIP5 + sensitivity tests

INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Preliminary ideas on what a Special Report on 1.5°C may contain
WGII Perspective

...liaising to WGI and WGIII:

- **low emission impact** scenarios and statistical comparisons of scenarios and climate impacts
- **balancing adaptation and mitigation** strategies and trade-offs
- **socioeconomics of impacts and adaptation** under different emission scenarios
- **comparing „solution pathways“ with respect to impacts**, and the constraints, and tradeoffs in the capacity of adaptation and mitigation

What may be covered in a 1.5°C Special Report: **WG-III perspective**

- Integrated Assessment Modelling of 1.5˚C pathways

  (Energy, economy,

- Modelling “shocks” associated with a radical transition?
- Assessment of negative emission technologies
- Sustainability implications of 1.5˚C pathways, including those associated with mitigation options

Preliminary ideas on what a Special Report on 1.5°C may contain
Ethical aspects

- 1.5°C warming target vs committed warming and INDCs?
- 1.5°C warming impacts as baseline for loss and damage?
- Potentially dangerous mitigation (geoengineering, negative emissions)?

INDC: Intended Nationally Determined Contributions