CLIMATE CHANGE

Impacts in the World’s Oceans

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Climate-related ocean isssues

Oceans play a major role in climate regulation globally:

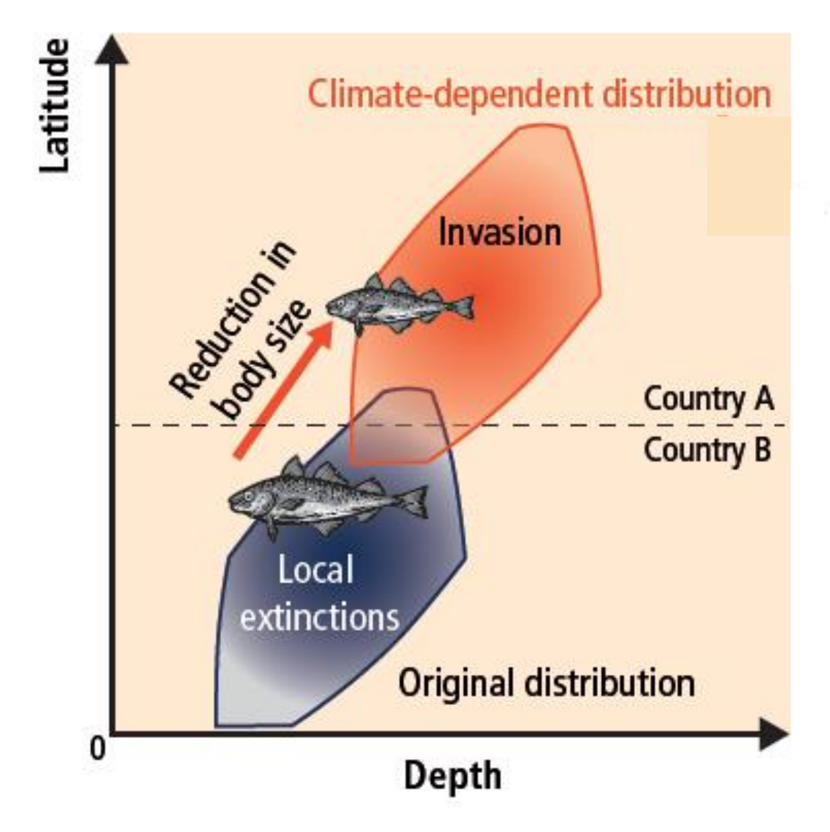
- absorb >90% of the heat accumulating in the atmosphere
  → ocean warming, hypoxia
- absorb 25% of man-made CO_2 → ocean acidification
- accumulate excess water from melting ice sheets → sea level rise

Human activities also influence ocean conditions locally:

- overfishing,
- pollution, and nutrient runoff via rivers that causes eutrophication,
- generating large coastal areas of water with low oxygen levels ("dead zones")
- harmful algal blooms
- redistribution of pathogens (cholera).

…with temperature presently being the predominant driver of ongoing global changes

Shifting biogeographical distributions are observed and will continue, shifting stocks across fishing zones



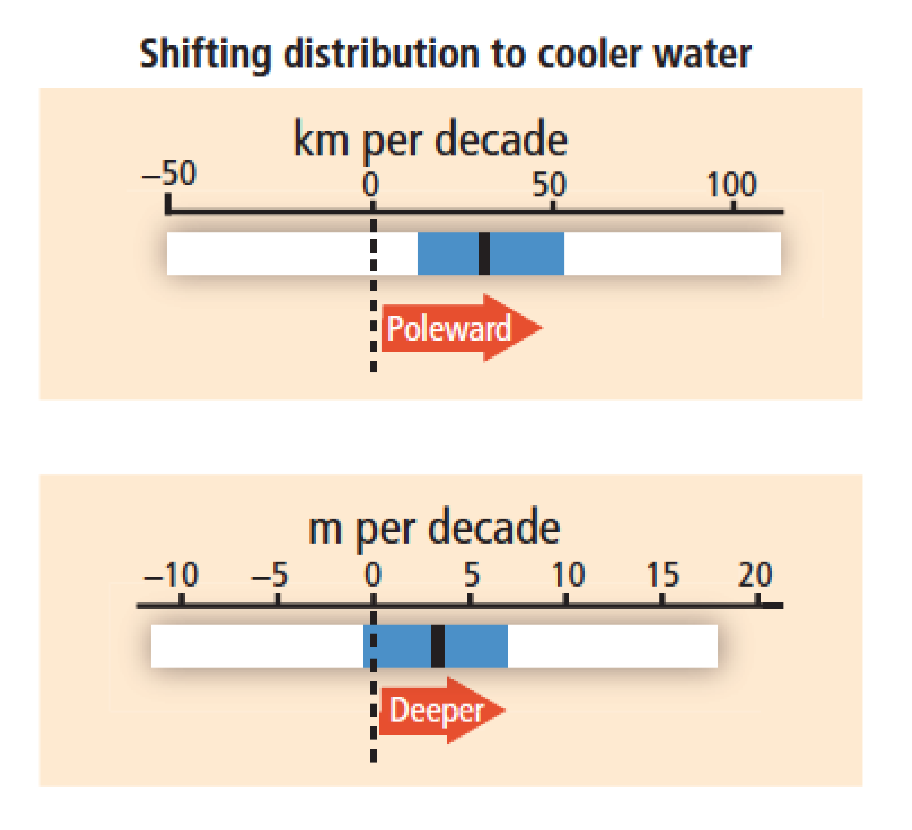


Figure 6-14

On the warm side: Maximum tolerance limits of higher marine life indicate vulnerability and lead to loss of warmest water habitats (e.g. seagrass meadows) no replacement by warm adapted plants and animals

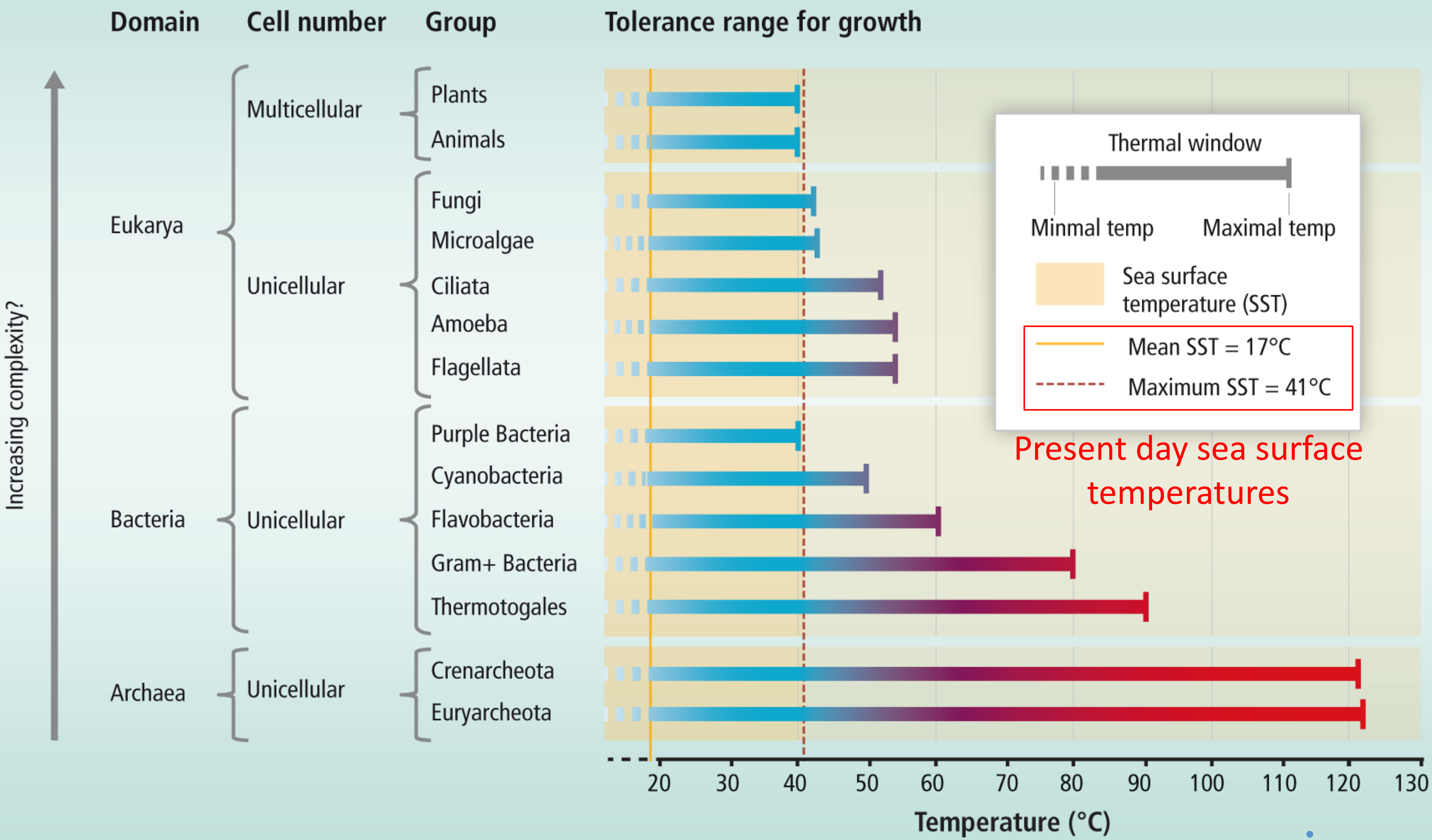


Figure 6-6

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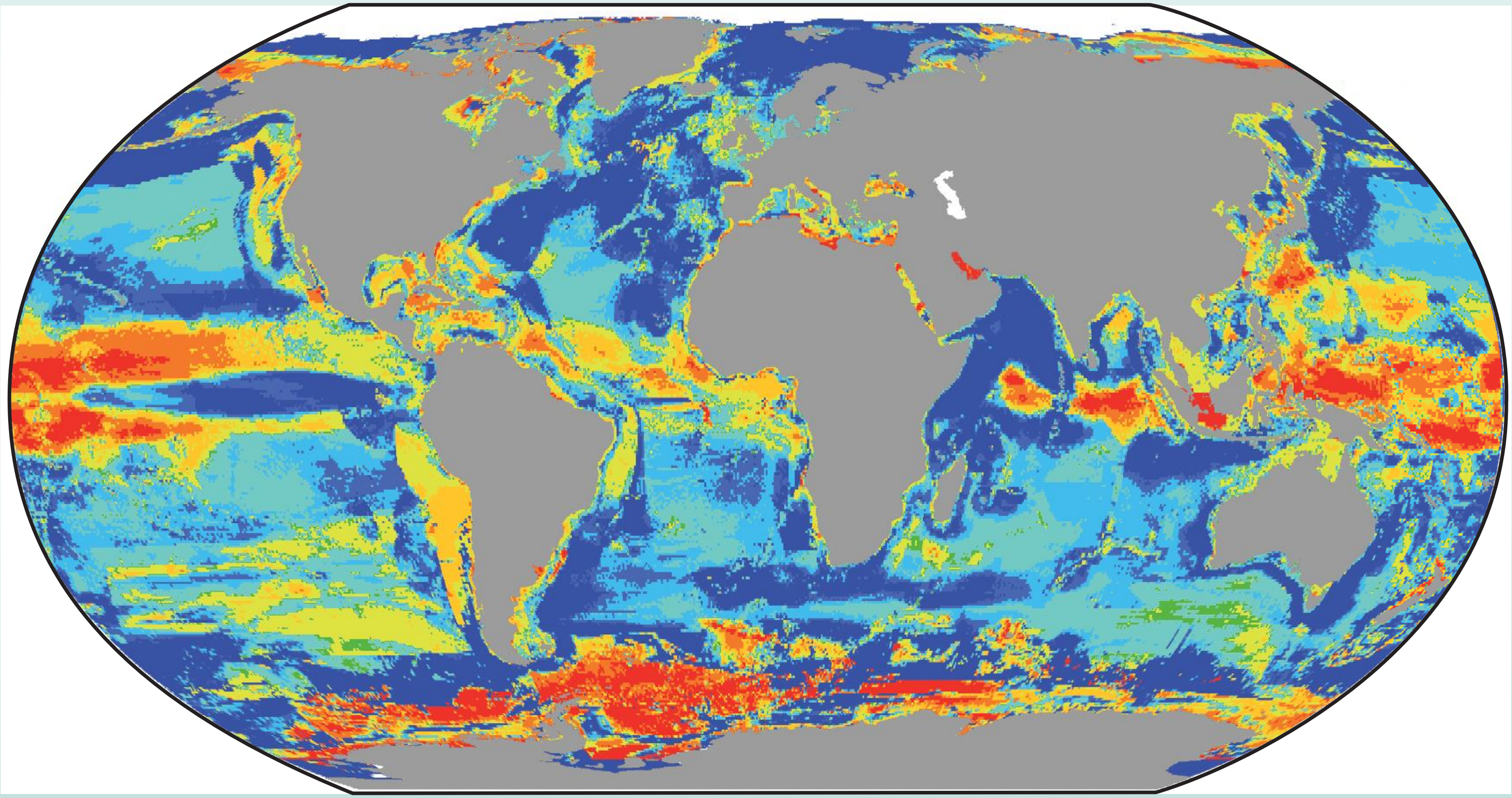
PROJECTIONS

Ocean warming, 2°C by 2051-60: displaced and reduced fish and invertebrate stocks, impoverished diversity at low latitudes

CHANGE IN MAXIMUM CATCH POTENTIAL (2051-2060 COMPARED TO 2001-2010, SRES A1B, 2°C warming)

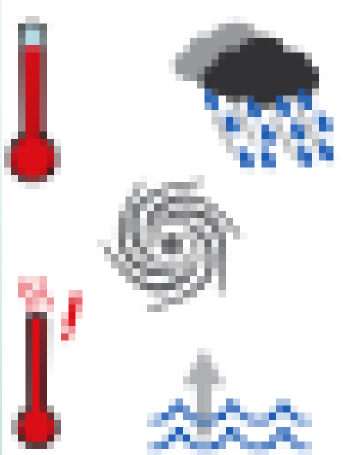
<50%	-21 – 50%	-6 – 20%	-1 – 5%	No data	0 – 4%	5 – 19%	20 – 49%	50 – 100%	>100%



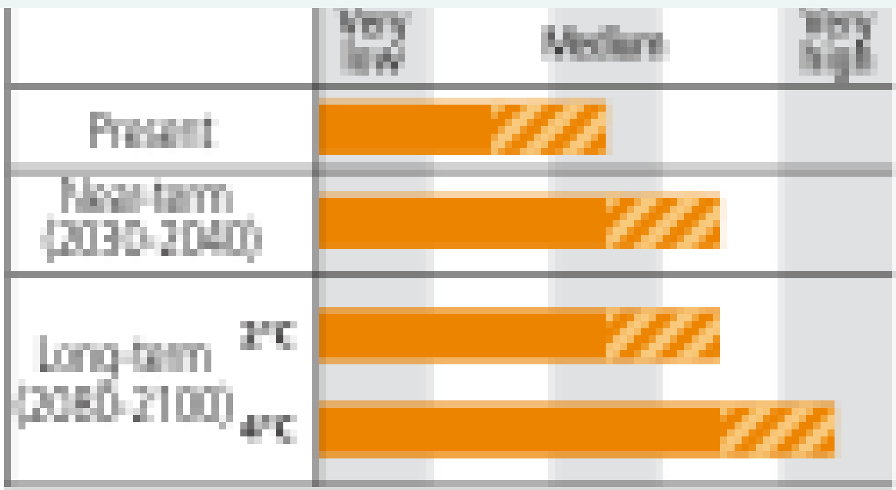
WGII, 6-14, SPM.6

Key risk	Adaptation issues and prospects
Risks to fisheries	
Reduced livelihoods and increased poverty (*medium confidence*)	Human adaptation options involve the large scale relocation of industrial fishing activities following the regional decreases (low latitude) versus increases (high latitude) in catch potential and shifts in biodiversity. Artisanal local fisheries are extremely limited in their adaptation options by available financial resources and technical capacities, except for their potential shift to other target species.

Temperature driven stock displacement



6.4.1-2, 30.6.2, 30.6.5, Table 30-3



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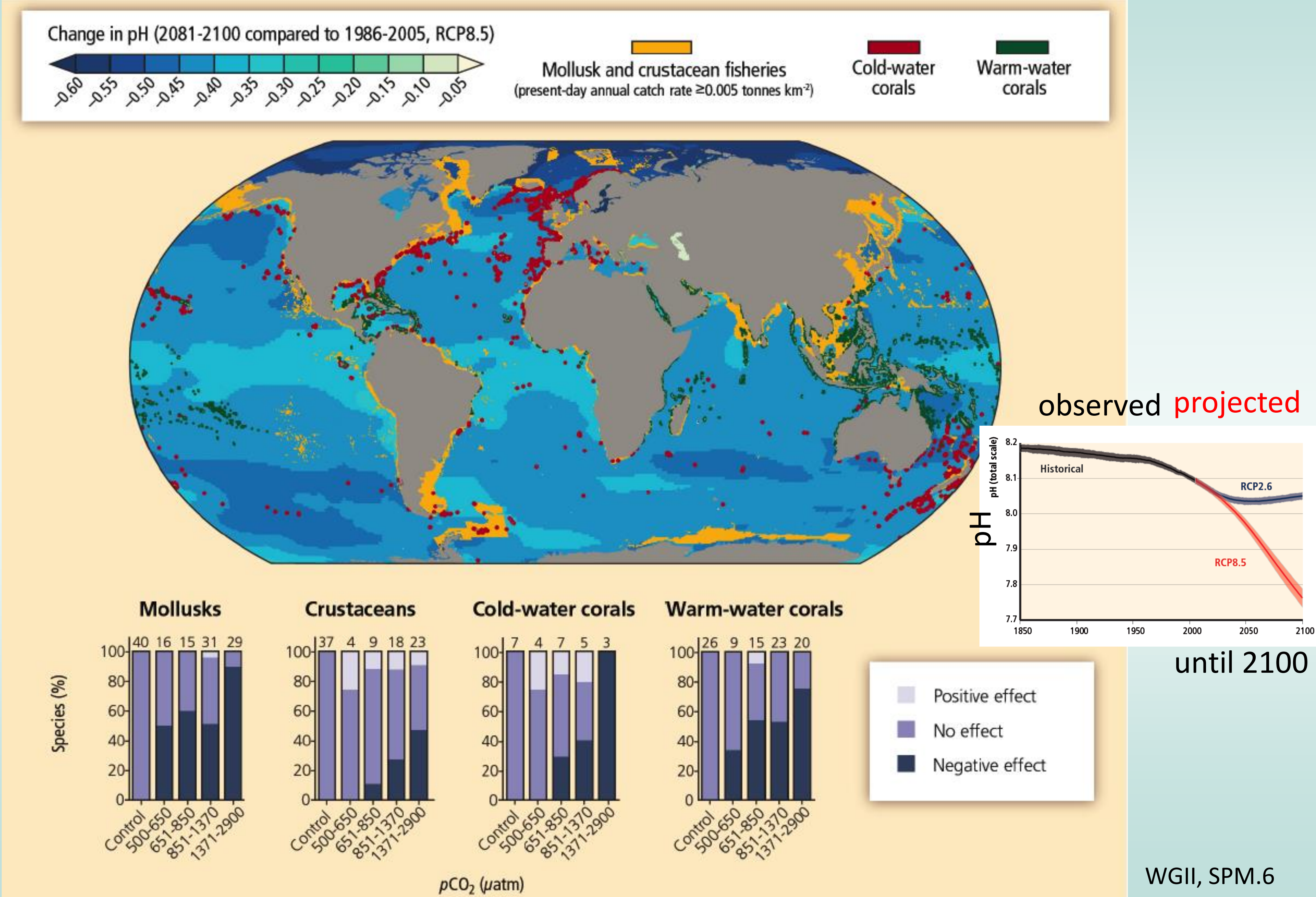
Projections: Ocean acidification, risks for mollusk and crustacean fisheries and coastal protection by coral reefs

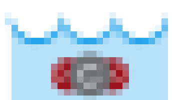


WGII, SPM.6

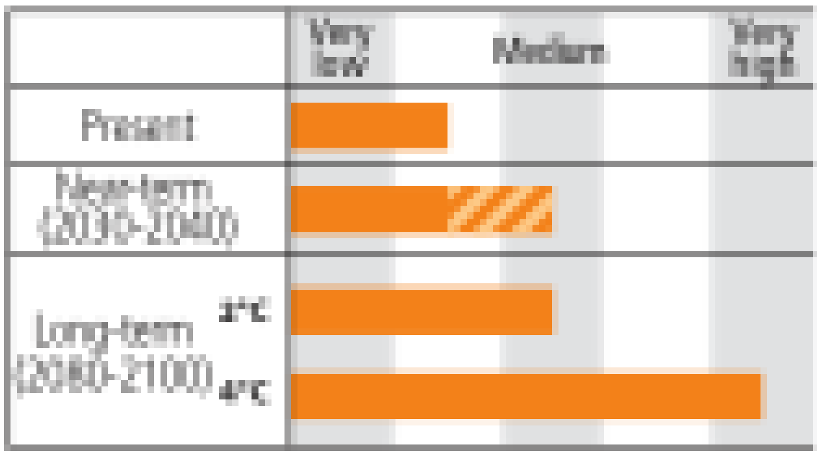
Key risk	Adaptation issues and prospects
Risks to fisheries	

Ocean acidification

Ocean acidification: Reduced growth and survival of commercially valuable shellfish and other calcifiers, e.g., reef building corals, calcareous red algae (*high confidence*)	Evidence for differential resistance and evolutionary adaptation of some species exists but is likely to be limited at higher CO_2 concentrations and temperatures reached; adaptation options include the shift to exploiting more resilient species or the protection of habitats with low natural CO_2 levels, as well as the reduction of other stresses, mainly pollution and limiting pressures from tourism and fishing.



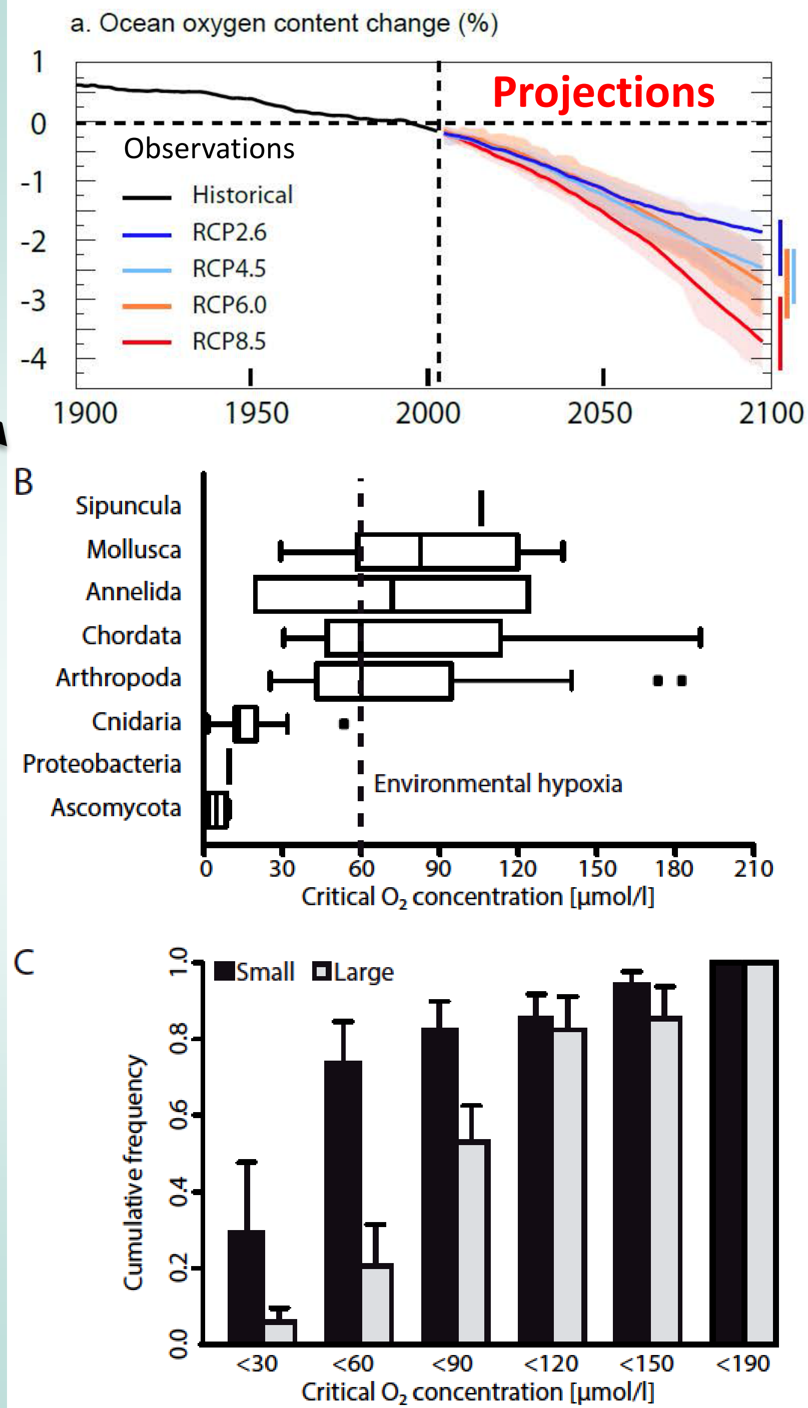
5.3.3.5, 6.1.1, 6.3.2, 6.4.1.1, 30.3.2.2, Box CC-OA



Oceans are losing oxygen

Different tolerances to low oxygen levels
explain the shift to tolerant communities
(unicells and small animals)

below 60 µmol l^{-1}
....in cool midwater Oxygen Minimum Zones



WGI

WGII

Dependence on body size in animals

WGI, 6-30, WGII, 6-11
D. Storch et al., 2014

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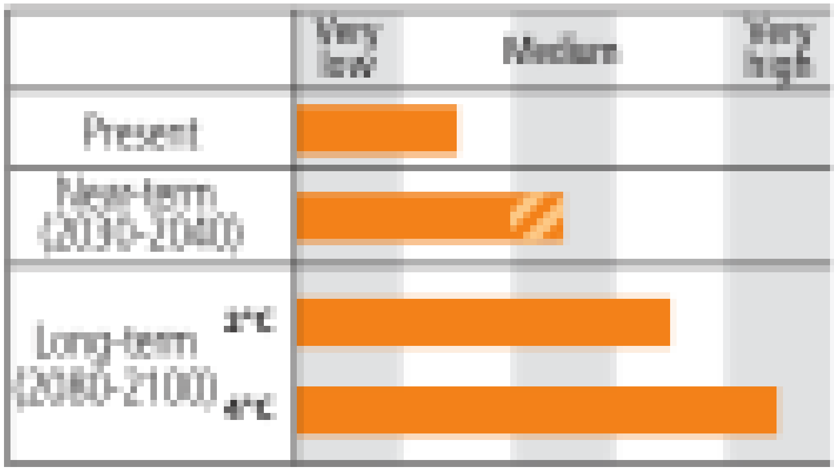
Key risk	Adaptation issues and prospects
Risks to fisheries	

Oxygen deficiency

High mortalities and loss of habitat to larger fauna including commercial species due to hypoxia expansion and effects, particularly in EBUE, some SES and CBS regions (*high confidence*)	Human adaptation options involve the large scale relocation of fishing activities as a consequence of the hypoxia induced decreases in biodiversity and fisheries catch of pelagic fish and squid. Specific fisheries may benefit (Humboldt squid). Reducing the amount of organic carbon running of coastlines by controlling nutrients and pollution running off agricultural areas can reduce microbial activity and consequently limit the extent of the oxygen drawdown and the formation of coastal dead zones.

6.1.1, 6.3.3, 30.5.3-5



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Interaction of THE three drivers

CO_2, hypoxia narrow thermal ranges ..... constraining T dependent biogeography

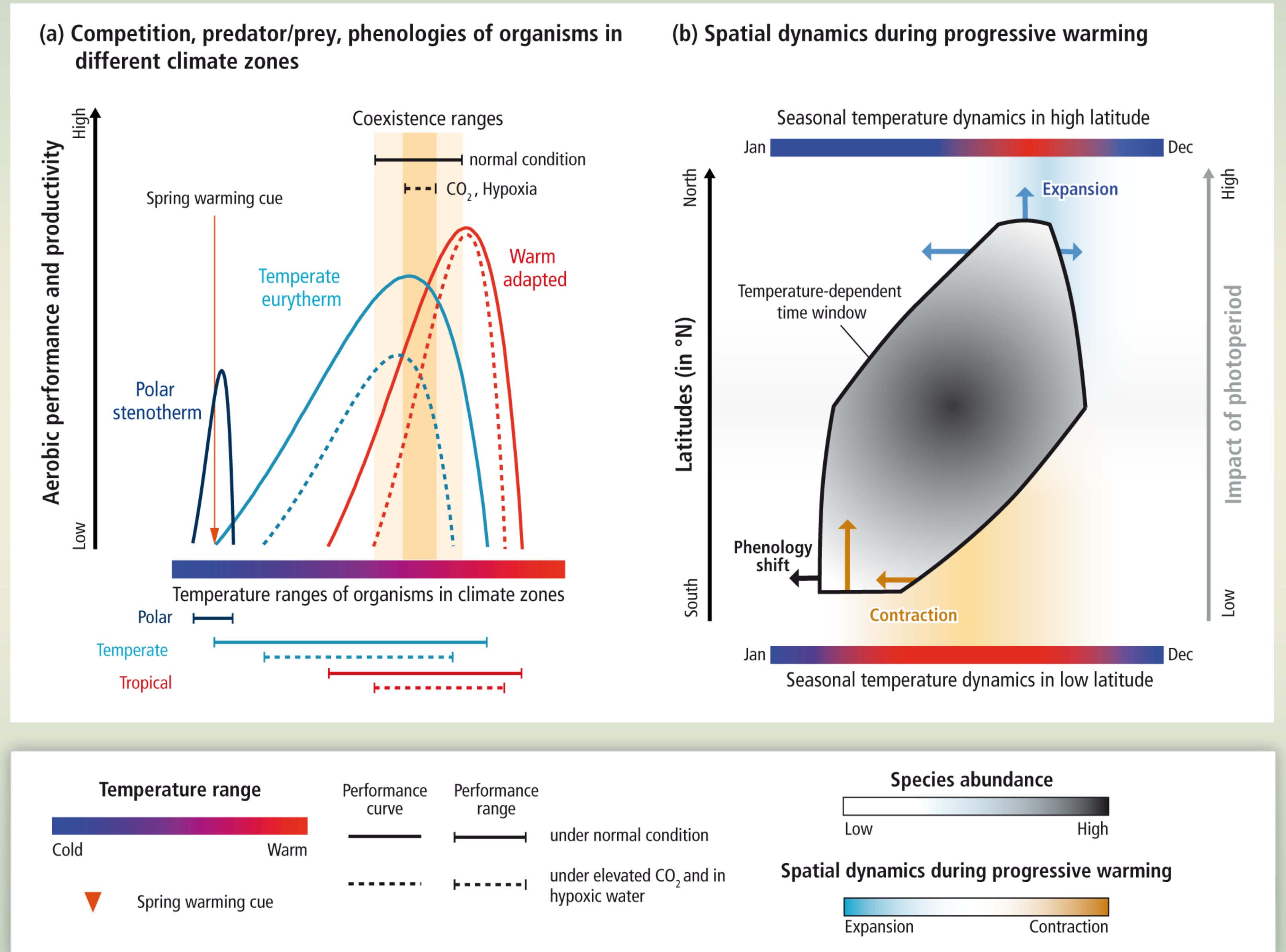


Figure 6-7

Interaction of THE three drivers

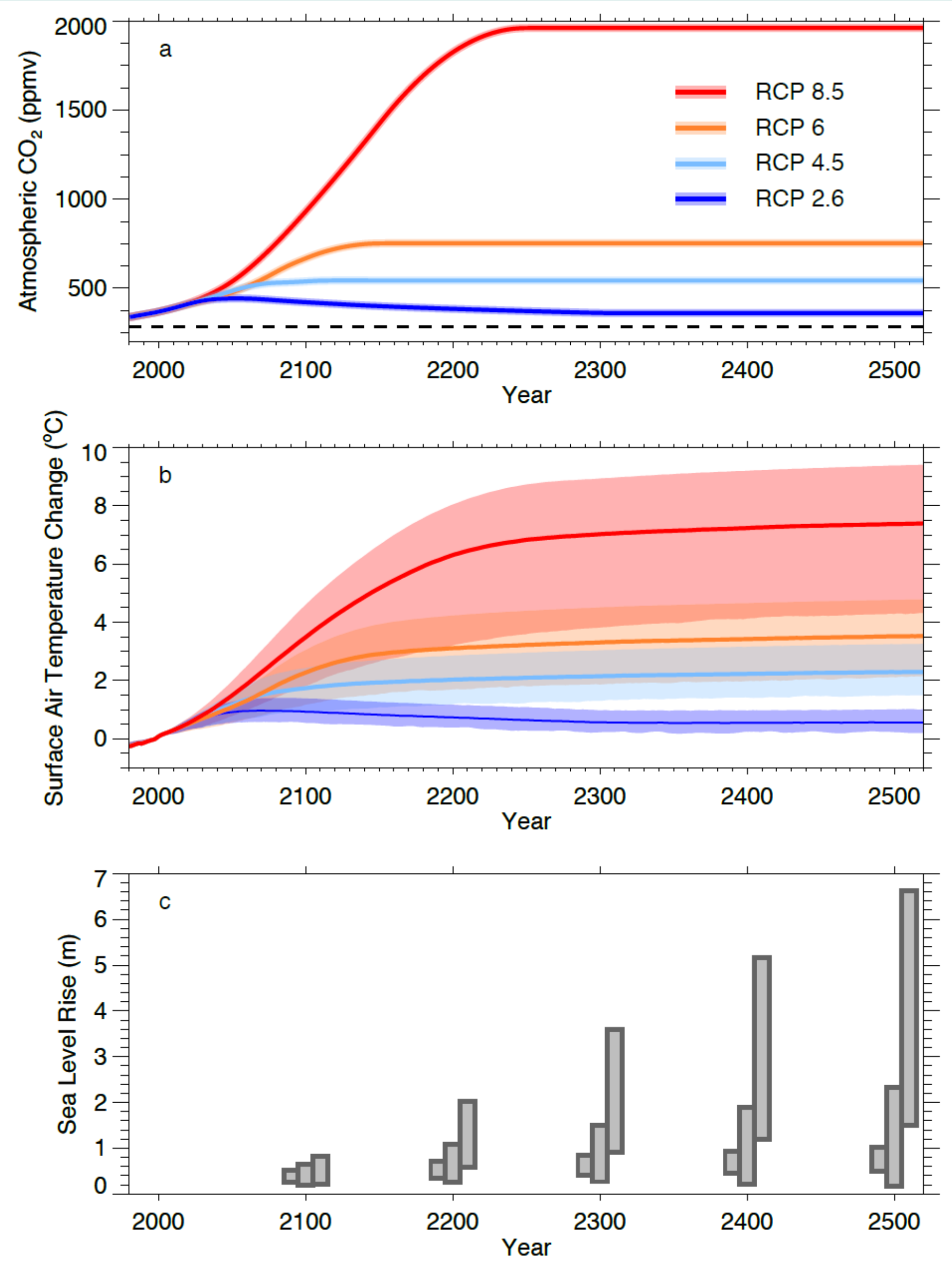
CO_2, hypoxia narrow thermal ranges ..... constraining T dependent biogeography

… in animals strongest impacts are expected where warming, acidification and hypoxia come together,

...indicating that assessments based on individual drivers are conservative.

Figure 6-7

Sea level rise: Projections beyond 2100, challenging natural and human systems



Paleo-observations

5-9 m : ...during the last interglacial (Eemian, 125.000 ya, at 0.7-2°C above pre-industrial)

>7m : ...last time when the atmosphere had 400 ppm CO_2 (in Pliocene, 3-5 Mya)

RCP6.0, 8.5

RCP4.5
RCP2.6

WGI Figure 12.43 and Table 13.8

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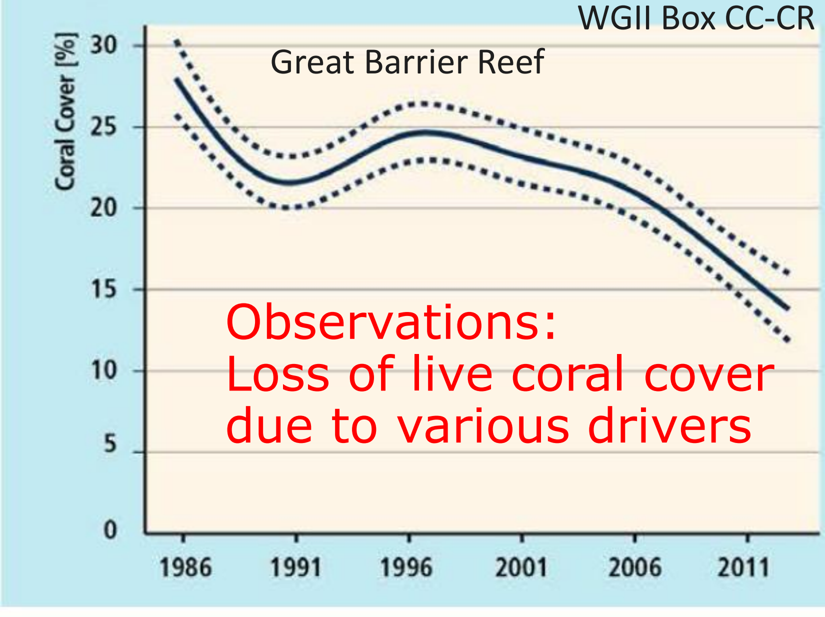
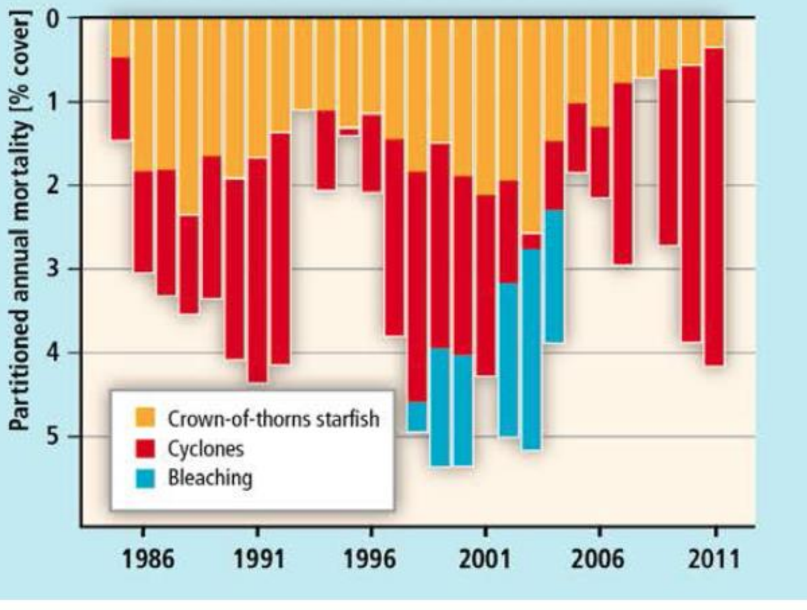
Vulnerable ecosystems

Warm water coral reefs



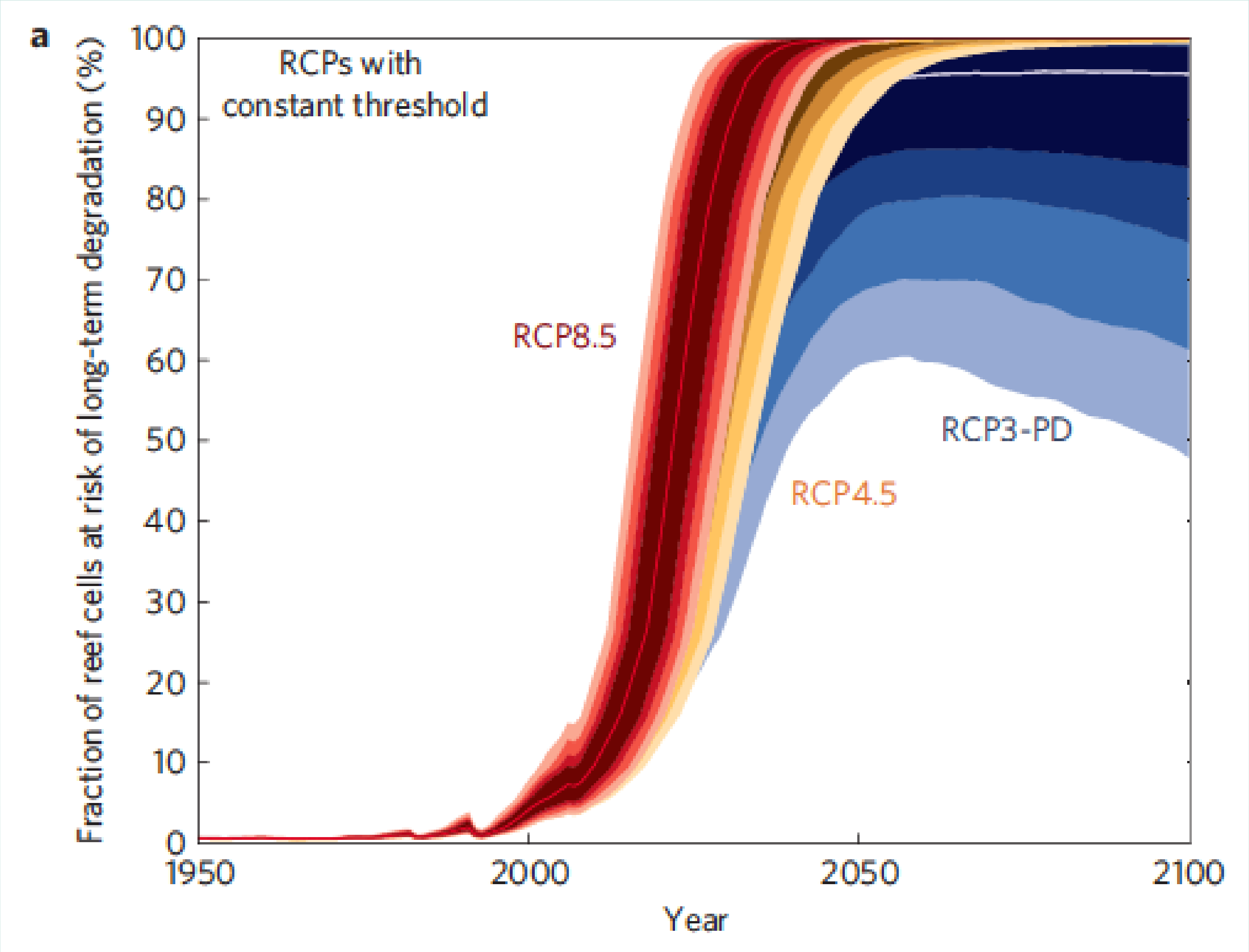


Verons 2009

Projections

Displacement of reefs constrained by ocean acidification

Mitigation ...needed to minimize the marginalization of coral reefs.



Frieler et al., 2013:

„To protect at least 50% of the coral reef cells, global mean temperature change would have to be limited to 1.2° C (1.1 – 1.4° C), especially given the lack of evidence that corals can evolve significantly on decadal timescales and under continually escalating thermal stress.“

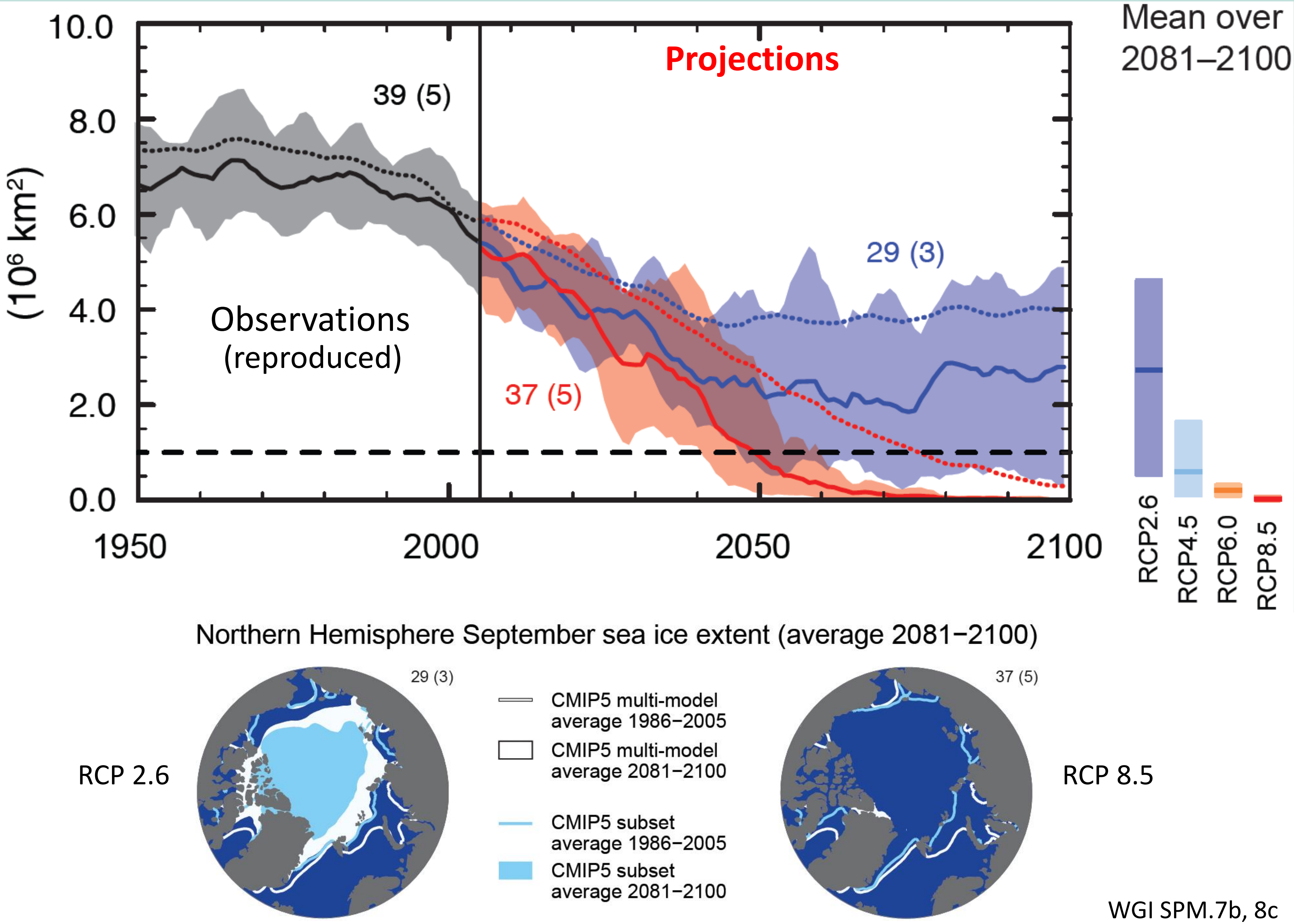
(....not yet taking ocean acidification effects into account)

WGII CC Box coral reefs

Vulnerable ecosystems

Arctic sea ice ecosystem

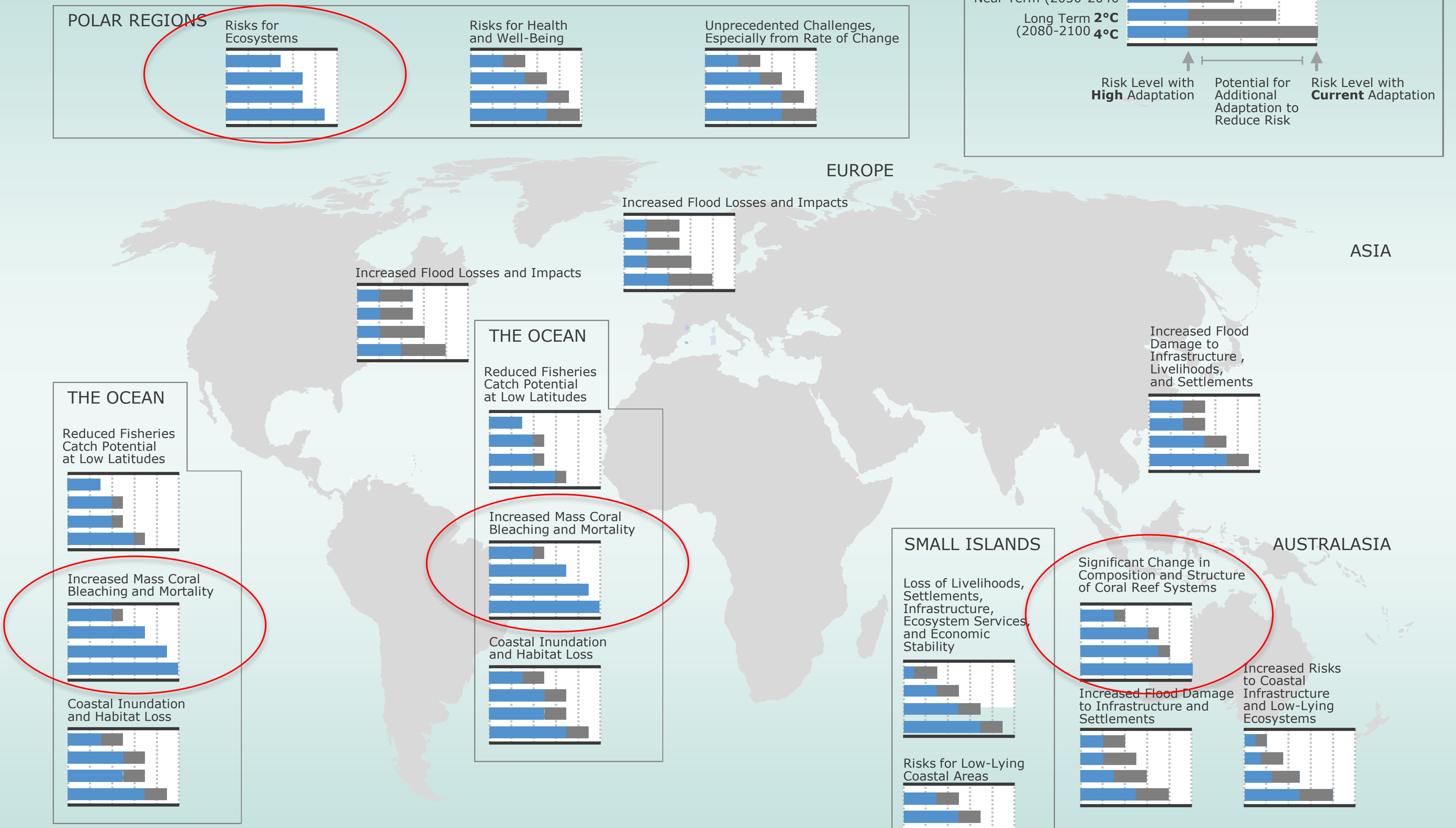
Northern Hemisphere September sea ice extent: Marginalization with continued warming



WGI SPM.7b, 8c

Risks involving the oceans, adaptation buys time but....

....is very limited for some systems



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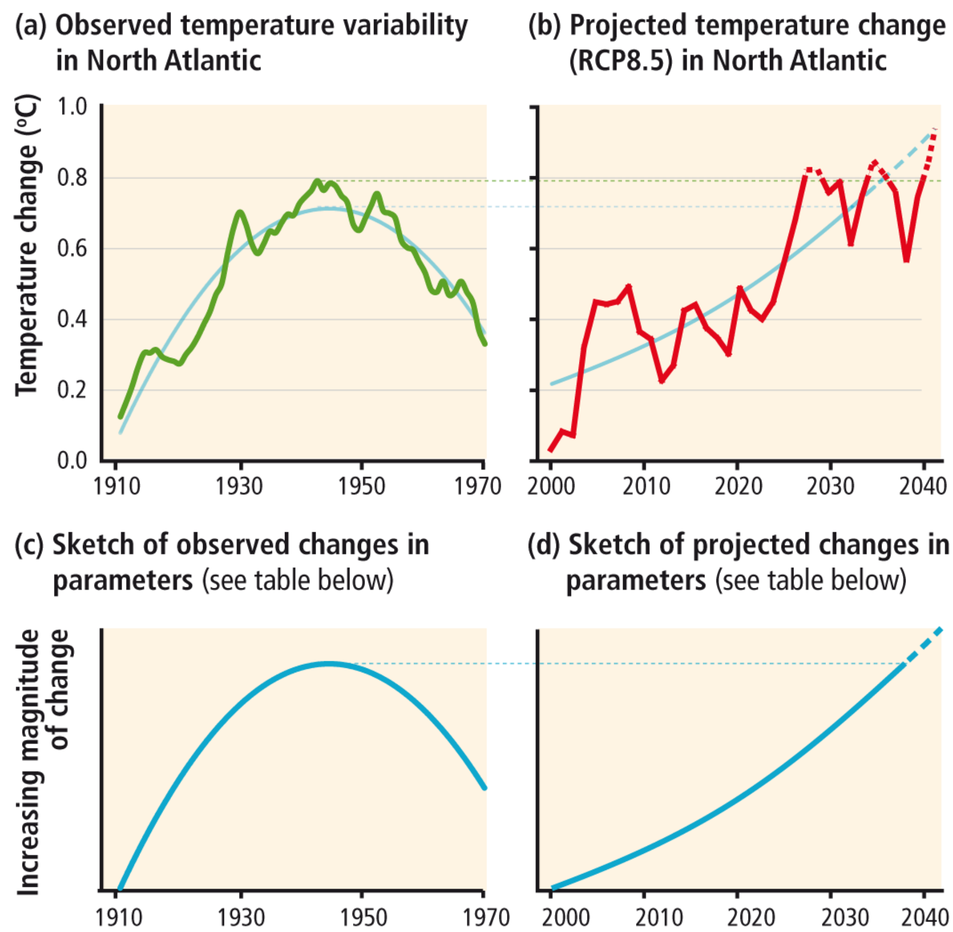
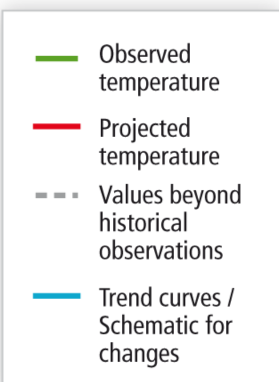
Thank you!

From observations of natural variability to **projections of long-term trends**

Climate variability provides evidence for close links between climate change and biological phenomena





Parameter sketched by curves (c) and (d)	How parameter changes
Biogeography	Poleward expansion and shift
Phenology	Timing variability
Community composition	Species turnover
NPP (mg C m^{-2} day^{-1})	Net primary productivity
Zooplankton (t km^{-2})	Biomass and latitudinal shift
Fish stocks (t km^{-2})	Biomass and latitudinal shift

Figure 6-9

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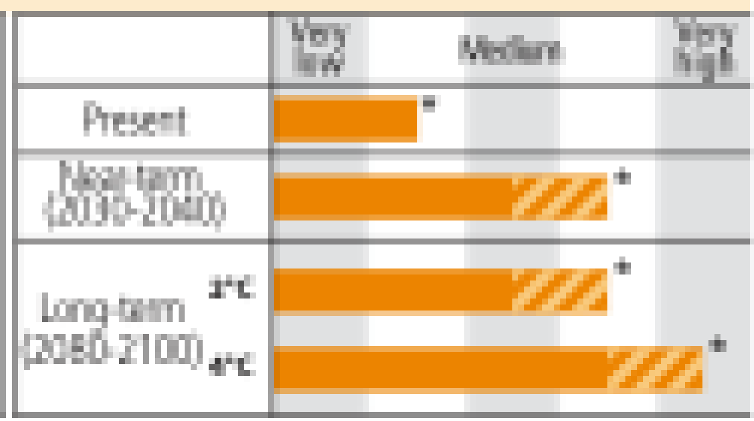
Risks to humans and infrastructure

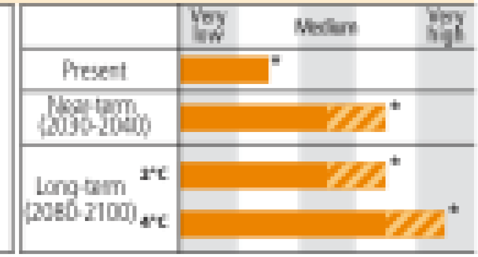
Coastal socio-economic security from changing habitat and ecosystem structure, as well as sea level rise (*high confidence*)	Human adaptation options involve (1) Protection using coastal defences (e.g. seawalls) and soft measures (e.g. mangrove replanting and enhancing coral growth), (2) Accommodation to allow continued occupation of coastal areas by making changes to human activities and infrastructure, and (3) Managed retreat may represent only option in some areas. Vary from large-scale engineering works to smaller scale community projects. Options are available under the more traditional CZM (coastal zone management) framework but increasingly under DRR (disaster risk reduction) and CCA (climate change adaptation) frameworks.

	5.5.2, 5.5.4, 30.6.5, 30.7.1, Table 30-3, Table 30-4



*high confidence in existence of adaptation measures, low confidence in magnitude of risk reduction

Risks to humans and infrastructure

Key risk	Adaptation issues & prospects	Climatic drivers	Supporting ch. sections	Risk & potential for adaptation
Coastal socio-economic security from changing habitat and ecosystem structure, as well as sea level rise (*high confidence*)	Human adaptation options involve (1) Protection using coastal defences (e.g. seawalls) and soft measures (e.g. mangrove replanting and enhancing coral growth), (2) Accommodation to allow continued occupation of coastal areas by making changes to human activities and infrastructure, and (3) Managed retreat may represent only option in some areas. Vary from large-scale engineering works to smaller scale community projects. Options are available under the more traditional CZM (coastal zone management) framework but increasingly under DRR (disaster risk reduction) and CCA (climate change adaptation) frameworks.	Damaging cyclone, Sea level	5.5.2, 5.5.4, 30.6.5, 30.7.1, Table 30-3, Table 30-4	

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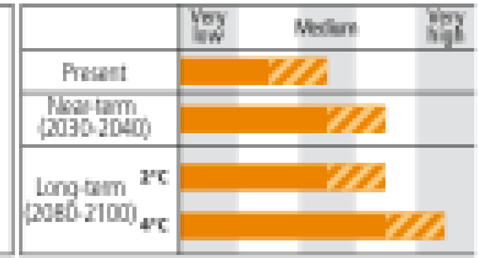
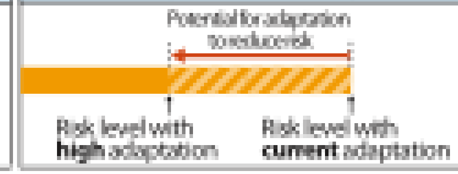
Reduced livelihoods and increased poverty (*medium confidence*)	Human adaptation options involve the large scale relocation of industrial fishing activities following the regional decreases (low latitude) versus increases (high latitude) in catch potential and shifts in biodiversity. Artisanal local fisheries are extremely limited in their adaptation options by available financial resources and technical capacities, except for their potential shift to other target species.	Warming trend, Extreme precipitation, Damaging cyclone, Extreme temperature, Sea level	6.4.1-2, 30.6.2, 30.6.5, Table 30-3	

Climatic drivers of impacts

Warming trend	Extreme temperature	Precipitation	Extreme precipitation	Damaging cyclone	Sea level	Hypoxia	Ocean acidification

Risk & potential for adaptation



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