Assessment Box SPM.2 Table 1 (continued)

Continued next page →

Central and South America

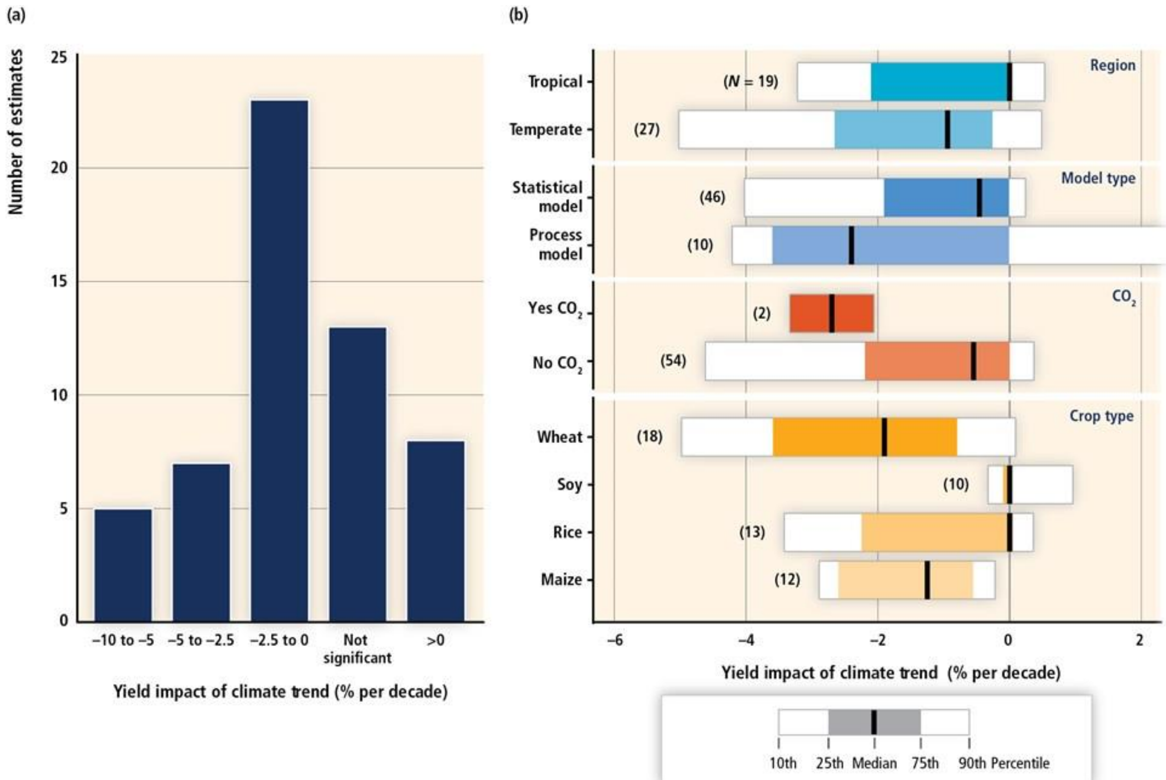
Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Water availability in semi-arid and glacier-melt-dependent regions and Central America; flooding and landslides in urban and rural areas due to extreme precipitation (*high confidence*) [27.3]	• Integrated water resource management • Urban and rural flood management (including infrastructure), early warning systems, better weather and runoff forecasts, and infectious disease control		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low / Medium / Very high
Decreased food production and food quality (*medium confidence*) [27.3]	• Development of new crop varieties more adapted to climate change (temperature and drought) • Offsetting of human and animal health impacts of reduced food quality • Offsetting of economic impacts of land-use change • Strengthening traditional indigenous knowledge systems and practices		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low / Medium / Very high
Spread of vector-borne diseases in altitude and latitude (*high confidence*) [27.3]	• Development of early warning systems for disease control and mitigation based on climatic and other relevant inputs. Many factors augment vulnerability. • Establishing programs to extend basic public health services		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low / Medium / Very high Long term 2°C: not available Long term 4°C: not available

Polar Regions

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Risks for freshwater and terrestrial ecosystems (*high confidence*) and marine ecosystems (*medium confidence*), due to changes in ice, snow cover, permafrost, and freshwater/ocean conditions, affecting species' habitat quality, ranges, phenology, and productivity, as well as dependent economies [28.2-4]	• Improved understanding through scientific and indigenous knowledge, producing more effective solutions and/or technological innovations • Enhanced monitoring, regulation, and warning systems that achieve safe and sustainable use of ecosystem resources • Hunting or fishing for different species, if possible, and diversifying income sources		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low / Medium / Very high
Risks for the health and well-being of Arctic residents, resulting from injuries and illness from the changing physical environment, food insecurity, lack of reliable and safe drinking water, and damage to infrastructure, including infrastructure in permafrost regions (*high confidence*) [28.2-4]	• Co-production of more robust solutions that combine science and technology with indigenous knowledge • Enhanced observation, monitoring, and warning systems • Improved communications, education, and training • Shifting resource bases, land use, and/or settlement areas		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low / Medium / Very high
Unprecedented challenges for northern communities due to complex inter-linkages between climate-related hazards and societal factors, particularly if rate of change is faster than social systems can adapt (*high confidence*) [28.2-4]	• Co-production of more robust solutions that combine science and technology with indigenous knowledge • Enhanced observation, monitoring, and warning systems • Improved communications, education, and training • Adaptive co-management responses developed through the settlement of land claims		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low / Medium / Very high

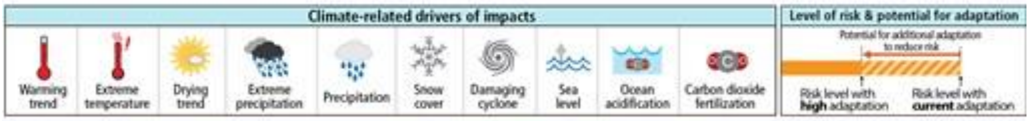
Small Islands

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Loss of livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (*high confidence*) [29.6, 29.8, Figure 29-4]	• Significant potential exists for adaptation in islands, but additional external resources and technologies will enhance response. • Maintenance and enhancement of ecosystem functions and services and of water and food security • Efficacy of traditional community coping strategies is expected to be substantially reduced in the future.		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low / Medium / Very high
The interaction of rising global mean sea level in the 21st century with high-water-level events will threaten low-lying coastal areas (*high confidence*) [29.4, Table 29-1; WGI AR5 13.5, Table 13.5]	• High ratio of coastal area to land mass will make adaptation a significant financial and resource challenge for islands. • Adaptation options include maintenance and restoration of coastal landforms and ecosystems, improved management of soils and freshwater resources, and appropriate building codes and settlement patterns.		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low / Medium / Very high



(a)
Number of estimates
25
20
15
10
5
0
−10 to −5
−5 to −2.5
−2.5 to 0
Not significant
>0
Yield impact of climate trend (% per decade)
(b)
Region
Tropical
(N = 19)
Temperate
(27)
Model type
Statistical model
(46)
Process model
(10)
CO2
Yes CO2
(2)
No CO2
(54)
Crop type
Wheat
(18)
Soy
(10)
Rice
(13)
Maize
(12)
−6
−4
−2
0
2
Yield impact of climate trend (% per decade)
10th
25th
Median
75th
90th Percentile

Assessment Box SPM.2 Table 1 | Key regional risks from climate change and the potential for reducing risks through adaptation and mitigation. Each key risk is characterized as very low to very high for three timeframes: the present, near term (here, assessed over 2030–2040), and longer term (here, assessed over 2080–2100). In the near term, projected levels of global mean temperature increase do not diverge substantially for different emission scenarios. For the longer term, risk levels are presented for two scenarios of global mean temperature increase (2°C and 4°C above preindustrial levels). These scenarios illustrate the potential for mitigation and adaptation to reduce the risks related to climate change. Climate-related drivers of impacts are indicated by icons.

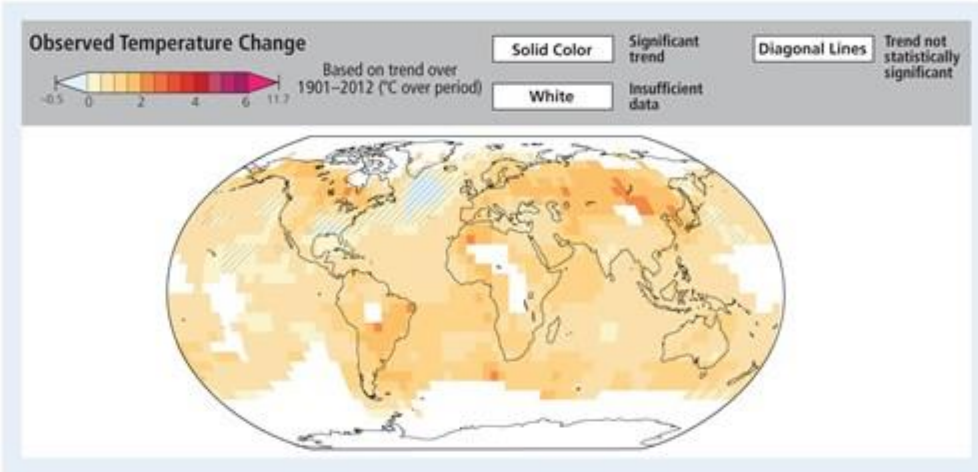


Africa

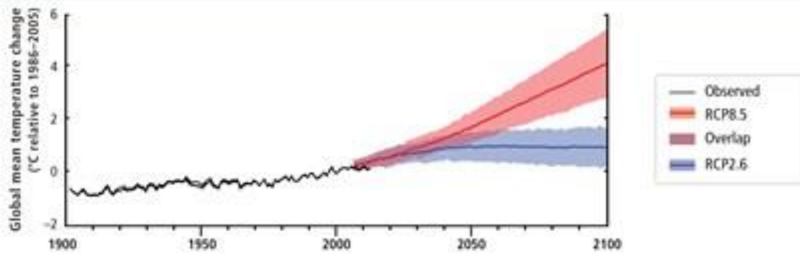
Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Compounded stress on water resources facing significant strain from overexploitation and degradation at present and increased demand in the future, with drought stress exacerbated in drought-prone regions of Africa (*high confidence*) [22.3-4]	• Reducing non-climate stressors on water resources • Strengthening institutional capacities for demand management, groundwater assessment, integrated water-wastewater planning, and integrated land and water governance • Sustainable urban development		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	
Reduced crop productivity associated with heat and drought stress, with strong adverse effects on regional, national, and household livelihood and food security, also given increased pest and disease damage and flood impacts on food system infrastructure (*high confidence*) [22.3-4]	• Technological adaptation responses (e.g., stress-tolerant crop varieties, irrigation, enhanced observation systems) • Enhancing smallholder access to credit and other critical production resources; Diversifying livelihoods • Strengthening institutions at local, national, and regional levels to support agriculture (including early warning systems) and gender-oriented policy • Agronomic adaptation responses (e.g., agroforestry, conservation agriculture)		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	
Changes in the incidence and geographic range of vector- and water-borne diseases due to changes in the mean and variability of temperature and precipitation, particularly along the edges of their distribution (*medium confidence*) [22.3]	• Achieving development goals, particularly improved access to safe water and improved sanitation, and enhancement of public health functions such as surveillance • Vulnerability mapping and early warning systems • Coordination across sectors • Sustainable urban development		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	

Continued next page →

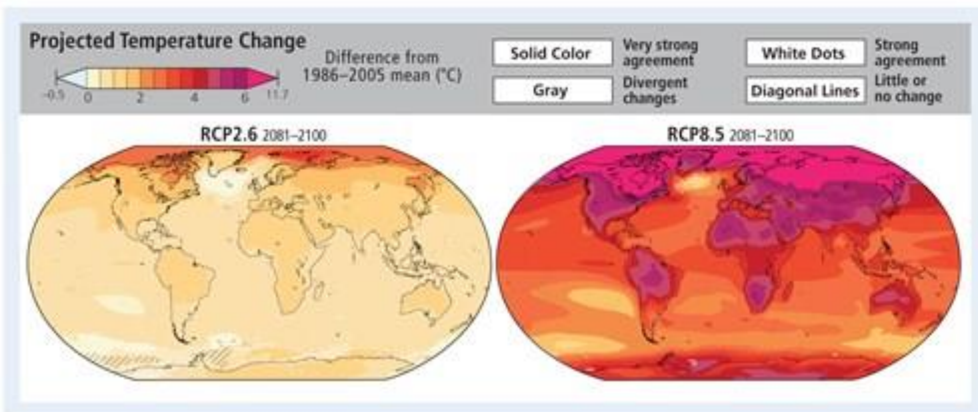
(A)

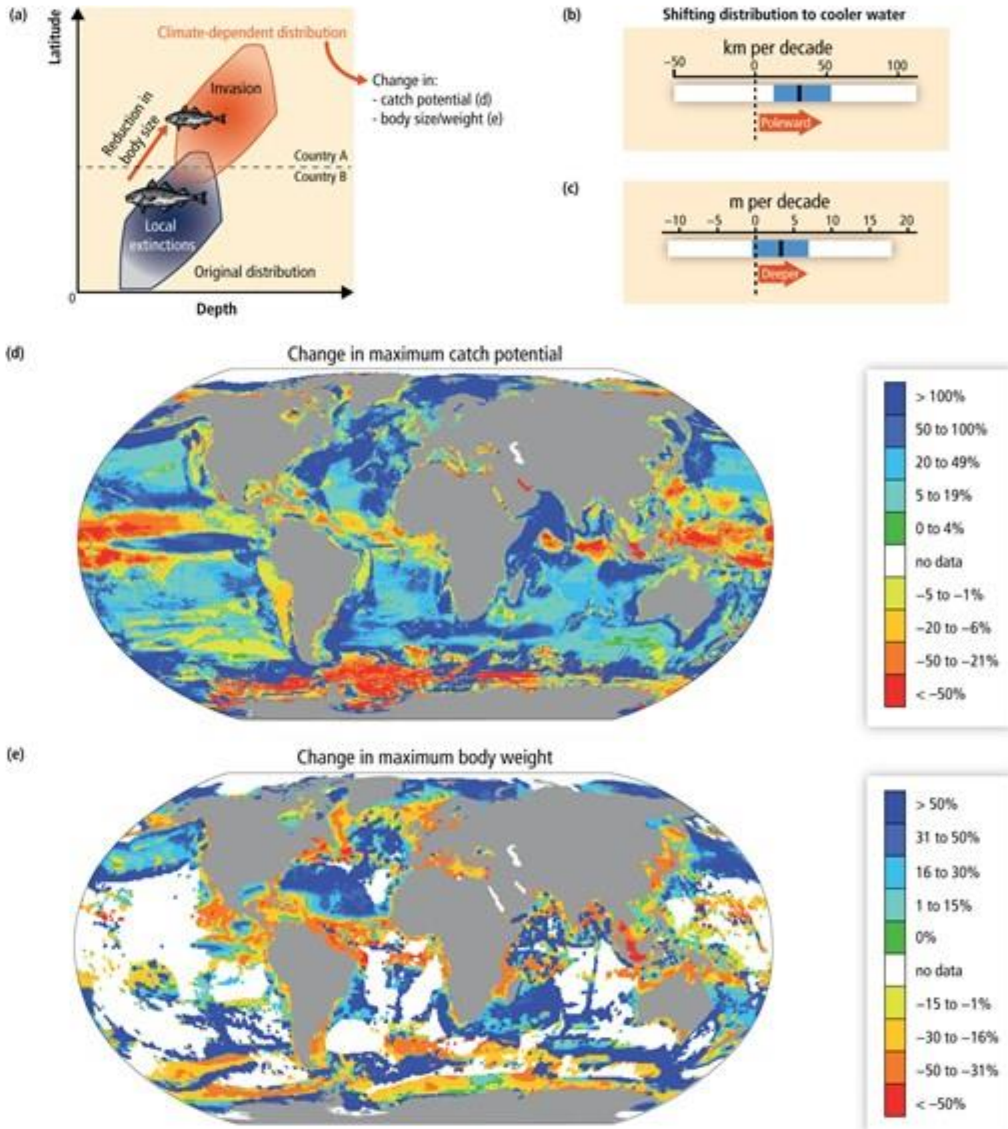

Observed Temperature Change
Based on trend over 1901–2012 (°C over period)
-0.5 0 2 4 6 11.7
Solid Color
Significant trend
White
Insufficient data
Diagonal Lines
Trend not statistically significant

(B)


Global mean temperature change (°C relative to 1986–2005)
6
4
2
0
−2
1900
1950
2000
2050
2100
Observed
RCP8.5
Overlap
RCP2.6

(C)


Projected Temperature Change
Difference from 1986–2005 mean (°C)
-0.5 0 2 4 6 11.7
Solid Color
Very strong agreement
Gray
Divergent changes
White Dots
Strong agreement
Diagonal Lines
Little or no change
RCP2.6 2081–2100
RCP8.5 2081–2100


(a)
Latitude
Climate-dependent distribution
Invasion
Reduction in body size
Country A
Country B
Local extinctions
Original distribution
0
Depth
Change in:
- catch potential (d)
- body size/weight (e)
(b)
Shifting distribution to cooler water
km per decade
−50 0 50 100
Poleward
(c)
m per decade
−10 −5 0 5 10 15 20
Deeper
(d)
Change in maximum catch potential
> 100%
50 to 100%
20 to 49%
5 to 19%
0 to 4%
no data
−5 to −1%
−20 to −6%
−50 to −21%
< −50%
(e)
Change in maximum body weight
> 50%
31 to 50%
16 to 30%
1 to 15%
0%
no data
−15 to −1%
−30 to −16%
−50 to −31%
< −50%

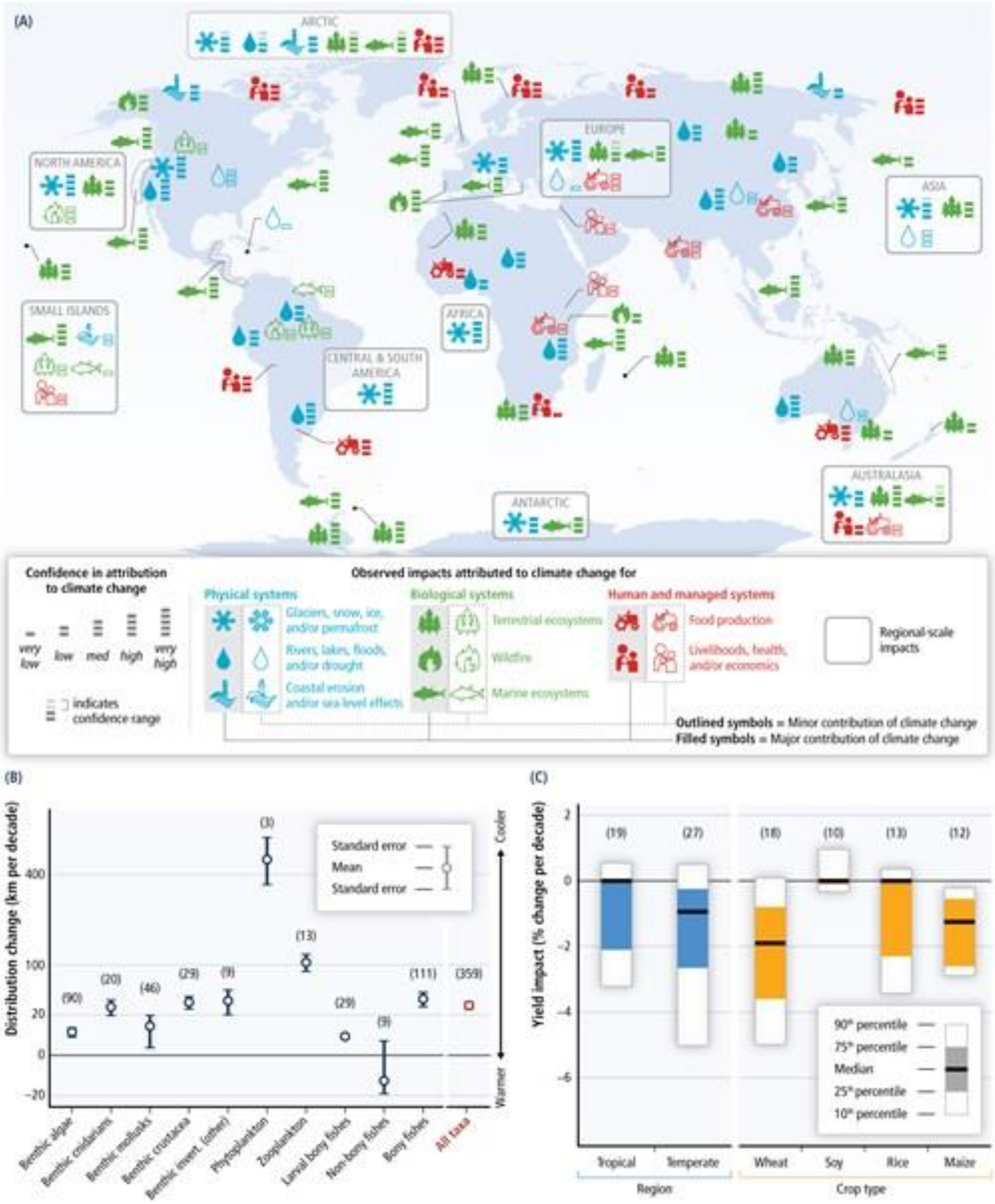

(A)
ARCTIC
NORTH AMERICA
EUROPE
ASIA
SMALL ISLANDS
AFRICA
CENTRAL & SOUTH AMERICA
ANTARCTIC
AUSTRALASIA
Confidence in attribution to climate change
very low
low
med
high
very high
indicates confidence range
Observed impacts attributed to climate change for
Physical systems
Glaciers, snow, ice, and/or permafrost
Rivers, lakes, floods, and/or drought
Coastal erosion and/or sea level effects
Biological systems
Terrestrial ecosystems
Wildfire
Marine ecosystems
Human and managed systems
Food production
Livelihoods, health, and/or economics
Regional-scale impacts
Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change
(B)
Distribution change (km per decade)
Standard error
Mean
Standard error
Cooler
Warmer
Benthic algae
Benthic cnidarians
Benthic mollusks
Benthic crustacea
Benthic invert. (other)
Phytoplankton
Zooplankton
Larval bony fishes
Non-bony fishes
Bony fishes
All taxa
(C)
Yield impact (% change per decade)
90th percentile
75th percentile
Median
25th percentile
10th percentile
Tropical
Temperate
Region
Wheat
Soy
Rice
Maize
Crop type

Table 6-2 | Selected examples of species responses and underlying mechanisms to changing temperature, oxygen level and ocean acidification (OA). References are indicated by superscript numbers and in the footnote.

	Phenomenon	Key drivers	Mechanism/Sensitivity
Biogeography	Northward shift in the distribution of North Sea cod (*Gadus morhua*) stocks between 1977 and 2001. [1,2]	Temperature	Bottlenecks of high sensitivity during early life stages as well as adult spawning stage in winter/early spring.
	Shift from sardines (*Sardinops melanostictus*) to anchovies (*Engraulis japonicus*) in the western North Pacific observed between 1993 and 2003. [3,4]	Temperature	Thermal windows of growth and reproductive output are found at higher temperatures for anchovies than sardines, food preferences of the competing species being similar.
	Variable sensitivity of Pacific tuna species to the availability of dissolved O_2. Bigeye tuna routinely reach depths where ambient O_2 content is below 1.5 ml L^{-1} (≈ 60 µmoles kg^{-1}). [5,6]	Oxygen	Oxygen transport via hemoglobin is adapted to be highly efficient supporting high metabolic rates as needed during feeding in the OMZ.
	Northward movement of species and the conversion of polar into more temperate and temperate into more subtropical system characteristics in the European Large Marine Ecosystems between 1958–2005. [7,8]	Warming and current advection	Effects are attributed to climate change but may be influenced by nutrient enrichment and overfishing.
Abundance	Increase in abundance of arctic boreal plankton species, notably the copepods *Calanus hyperboreus*, *Calanus glacialis* and the dinoflagellate *Ceratium arcticum* between 1960 and 2000 in the Newfoundland Shelf, Northwest Atlantic. [9,10]	Temperature	Temperature sensitivity of phyto- and zooplankter resulting from cooling due to increased influx of Arctic water.
	A benthic fish species, the eelpout (*Zoarces viviparus*) at its southern distribution limit, the German Wadden Sea, displayed abundance losses during warming periods and rising summer extreme temperatures between 1993 and 2005, with early disappearance of the largest individuals. [11]	Temperature	Temperature extremes exceed organism's thermal windows, with largest individuals being relatively less tolerant to high temperature than smaller individuals.
	Variable sensitivities to OA within and across animal phyla (Figure 6-10b). [12–21]	Anthropogenic OA, sea water acidification by elevated pCO_2 in OMZs, upwelling areas, involving anthropogenic ocean acidification.	Lowered extracellular (blood plasma) pH causing a lowering of the rates of ion exchange and metabolism in muscle or liver (hepatocytes) of vertebrates and invertebrates. High sensitivity at reduced energy turnover in tissues and/or whole organism by reduced ion exchange, use of more energy efficient transport mechanisms, reduced protein synthesis, enhanced nitrogen release from amino acid catabolism and protein degradation, slower growth.
Phenology	Migration time of pink salmon (*Oncorhynchus gorbuscha*) in Alaska is almost two weeks earlier in 2010s relative to 40 years ago. [22]	Warming	Rapid microevolution for earlier migration timing.
	In the waters around the UK, during a period of warming between 1976 and 2005, the seasonal timing of biological events of all major marine taxonomic groups (plant/phytoplankton, invertebrate and vertebrates) advanced, on average, by 0.31 to 0.43 days $year^{-1}$. [23]	Warming	Sensitivity to seasonal temperature changes as a result of specific thermal windows of different organisms.
Body size and growth	Asymptotic body sizes of different populations of Atlantic cod (*Gadus morhua*) and Atlantic Herring (*Clupea harengus*) are negatively related to temperature. [24,25]	Warming	At large body size, oxygen supply limitations are exacerbated and the organism reaches its long-term heat tolerance limits at lower temperatures, thus limiting the maximum body size that can be reached.

1. Perry et al. (2005); 2. Pörtner et al. (2008); 3. Takasuka et al. (2007); 4. Takasuka et al. (2008); 5. Lehodey et al. (2011); 6. Seibel (2011); 7. Beaugrand et al. (2009); 8. Philippart et al. (2011); 9. Johns et al. (2001);10. Greene and Pershing (2003); 11. Pörtner and Knust (2007); 12. Reipschläger and Pörtner (1996); 13. Pörtner et al. (2000); 14. Vezzoli et al. (2004); 15. Langenbuch and Pörtner (2003); 16. Fernández-Reiriz et al. (2011); 17. Langenbuch and Pörtner (2002);18. Langenbuch et al. (2006); 19. Michaelidis et al. (2005); 20. Pörtner et al. (1998); 21. Stumpp et al. (2012); 22. Kovach et al. (2012); 23. Thackeray et al. (2010); 24. Taylor (1958); 25. Brunel and Dickey-Collas (2010).

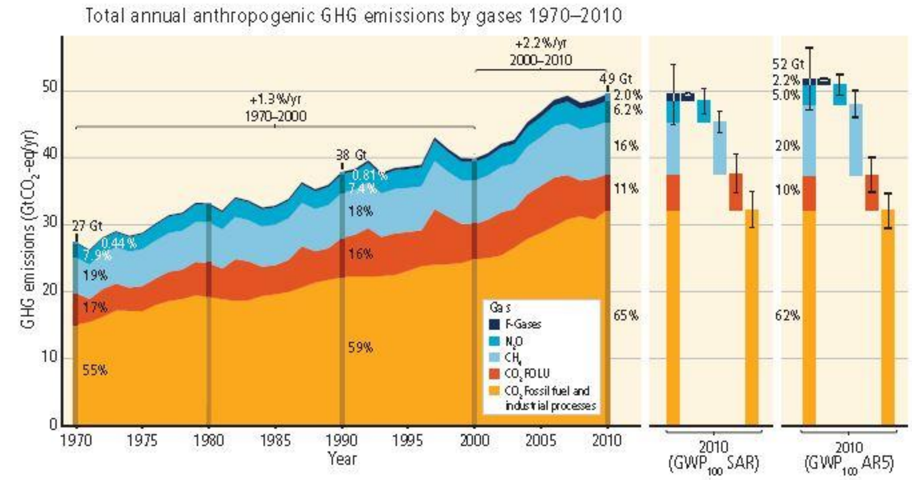


Figure SPM.2 | Total annual anthropogenic greenhouse gas (GHG) emissions (gigatonne of CO_2-equivalent per year, $GtCO_2$-eq/yr) for the period 1970 to 2010 by gases: CO_2 from fossil fuel combustion and industrial processes; CO_2 from Forestry and Other Land Use (FOLU); methane (CH_4); nitrous oxide (N_2O); fluorinated gases covered under the Kyoto Protocol (F-gases). Right hand side shows 2010 emissions, using alternatively CO_2-equivalent emission weightings based on IPCC Second Assessment Report (SAR) and AR5 values. Unless otherwise stated, CO_2-equivalent emissions in this report include the basket of Kyoto gases (CO_2, CH_4, N_2O as well as F-gases) calculated based on 100-year Global Warming Potential (GWP_{100}) values from the SAR (see Glossary). Using the most recent GWP_{100} values from the AR5 (right-hand bars) would result in higher total annual GHG emissions (52 $GtCO_2$-eq/yr) from an increased contribution of methane, but does not change the long-term trend significantly. *{Figure 1.6, Box 3.2}*

Assessment Box SPM.2 Table 1 (continued)

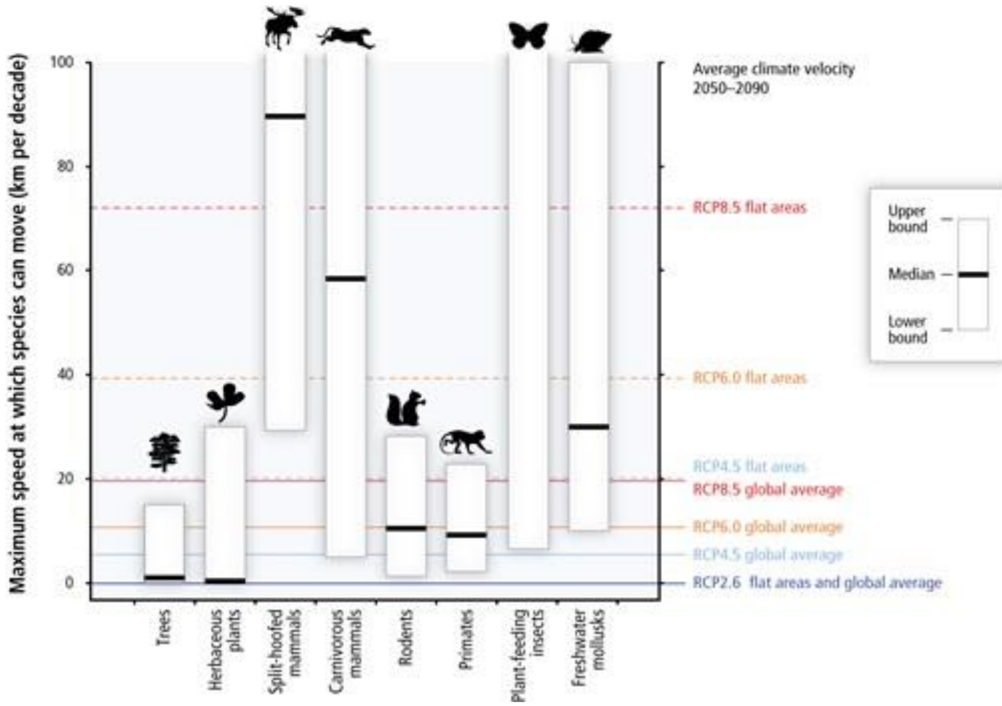
Continued next page →

Australasia

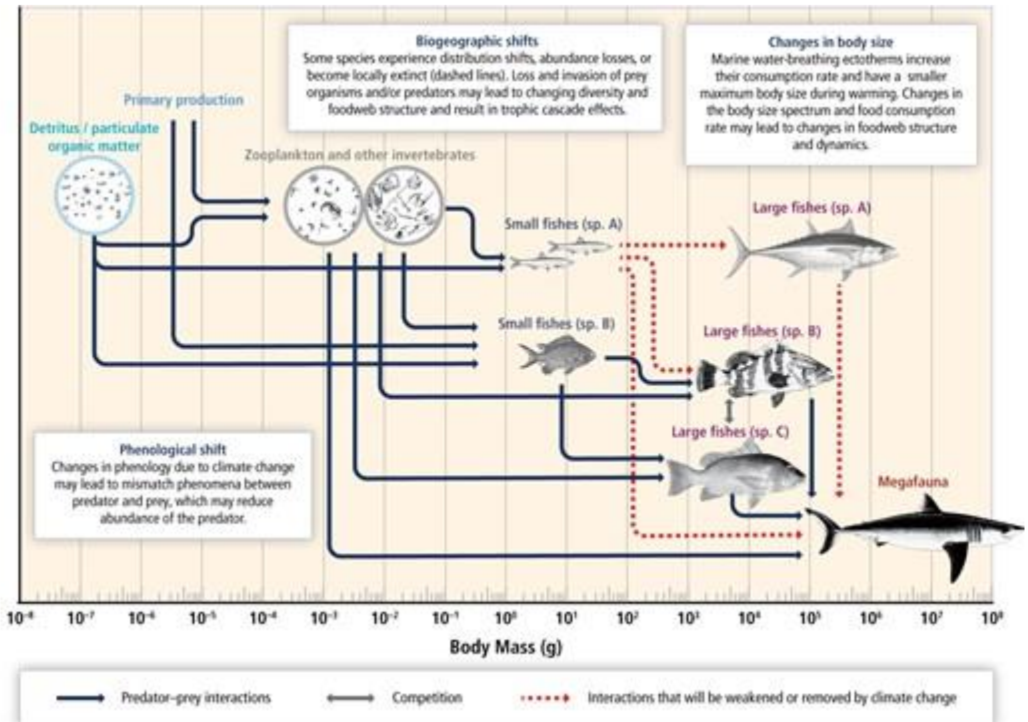
Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Significant change in community composition and structure of coral reef systems in Australia (*high confidence*) [25.6, 30.5, Boxes CC-CR and CC-OA]	• Ability of corals to adapt naturally appears limited and insufficient to offset the detrimental effects of rising temperatures and acidification. • Other options are mostly limited to reducing other stresses (water quality, tourism, fishing) and early warning systems; direct interventions such as assisted colonization and shading have been proposed but remain untested at scale.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low – Medium – Very high
Increased frequency and intensity of flood damage to infrastructure and settlements in Australia and New Zealand (*high confidence*) [Table 25-1, Boxes 25-8 and 25-9]	• Significant adaptation deficit in some regions to current flood risk. • Effective adaptation includes land-use controls and relocation as well as protection and accommodation of increased risk to ensure flexibility.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low – Medium – Very high
Increasing risks to coastal infrastructure and low-lying ecosystems in Australia and New Zealand, with widespread damage towards the upper end of projected sea-level-rise ranges (*high confidence*) [25.6, 25.10, Box 25-1]	• Adaptation deficit in some locations to current coastal erosion and flood risk. Successive building and protection cycles constrain flexible responses. • Effective adaptation includes land-use controls and ultimately relocation as well as protection and accommodation.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low – Medium – Very high

North America

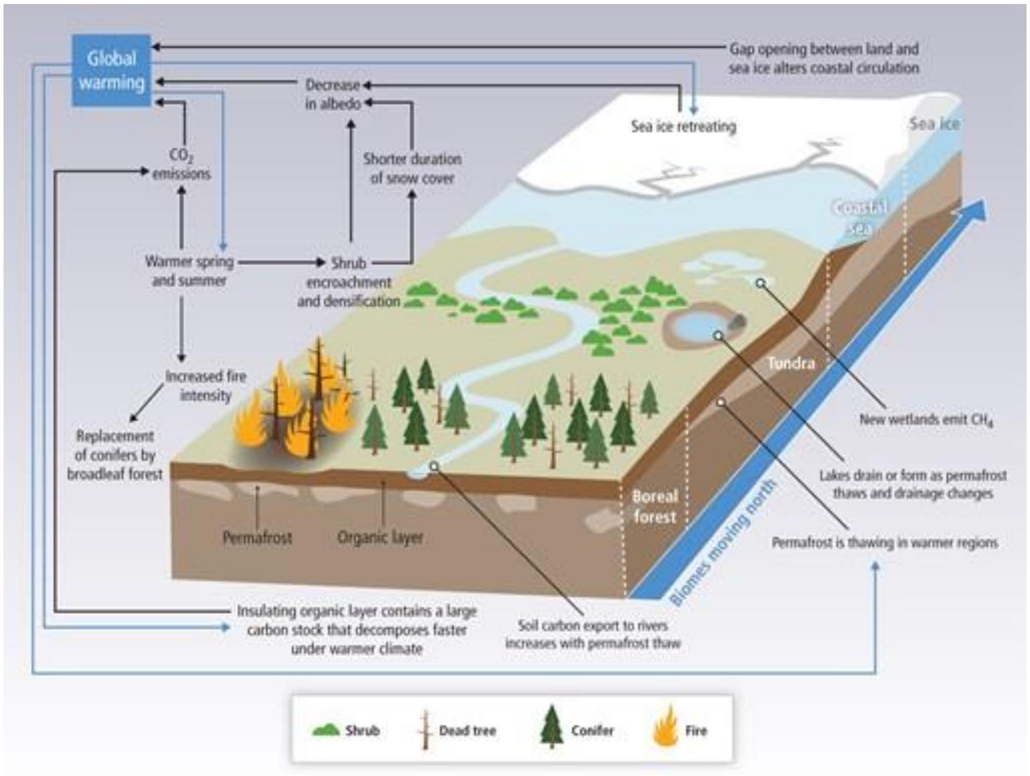
Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Wildfire-induced loss of ecosystem integrity, property loss, human morbidity, and mortality as a result of increased drying trend and temperature trend (*high confidence*) [26.4, 26.8, Box 26-2]	• Some ecosystems are more fire-adapted than others. Forest managers and municipal planners are increasingly incorporating fire protection measures (e.g., prescribed burning, introduction of resilient vegetation). Institutional capacity to support ecosystem adaptation is limited. • Adaptation of human settlements is constrained by rapid private property development in high-risk areas and by limited household-level adaptive capacity. • Agroforestry can be an effective strategy for reduction of slash and burn practices in Mexico.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low – Medium – Very high
Heat-related human mortality (*high confidence*) [26.6, 26.8]	• Residential air conditioning (A/C) can effectively reduce risk. However, availability and usage of A/C is highly variable and is subject to complete loss during power failures. Vulnerable populations include athletes and outdoor workers for whom A/C is not available. • Community- and household-scale adaptations have the potential to reduce exposure to heat extremes via family support, early heat warning systems, cooling centers, greening, and high-albedo surfaces.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low – Medium – Very high
Urban floods in riverine and coastal areas, inducing property and infrastructure damage; supply chain, ecosystem, and social system disruption; public health impacts; and water quality impairment, due to sea level rise, extreme precipitation, and cyclones (*high confidence*) [26.2-4, 26.8]	• Implementing management of urban drainage is expensive and disruptive to urban areas. • Low-regret strategies with co-benefits include less impervious surfaces leading to more groundwater recharge, green infrastructure, and rooftop gardens. • Sea level rise increases water elevations in coastal outfalls, which impedes drainage. In many cases, older rainfall design standards are being used that need to be updated to reflect current climate conditions. • Conservation of wetlands, including mangroves, and land-use planning strategies can reduce the intensity of flood events.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low – Medium – Very high



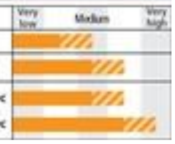
Maximum speed at which species can move (km per decade)
100
80
60
40
20
0
Average climate velocity 2050–2090
RCP8.5 flat areas
RCP6.0 flat areas
RCP4.5 flat areas
RCP8.5 global average
RCP6.0 global average
RCP4.5 global average
RCP2.6 flat areas and global average
Upper bound
Median
Lower bound
Trees
Herbaceous plants
Split-hoofed mammals
Carnivorous mammals
Rodents
Primates
Plant-feeding insects
Freshwater mollusks

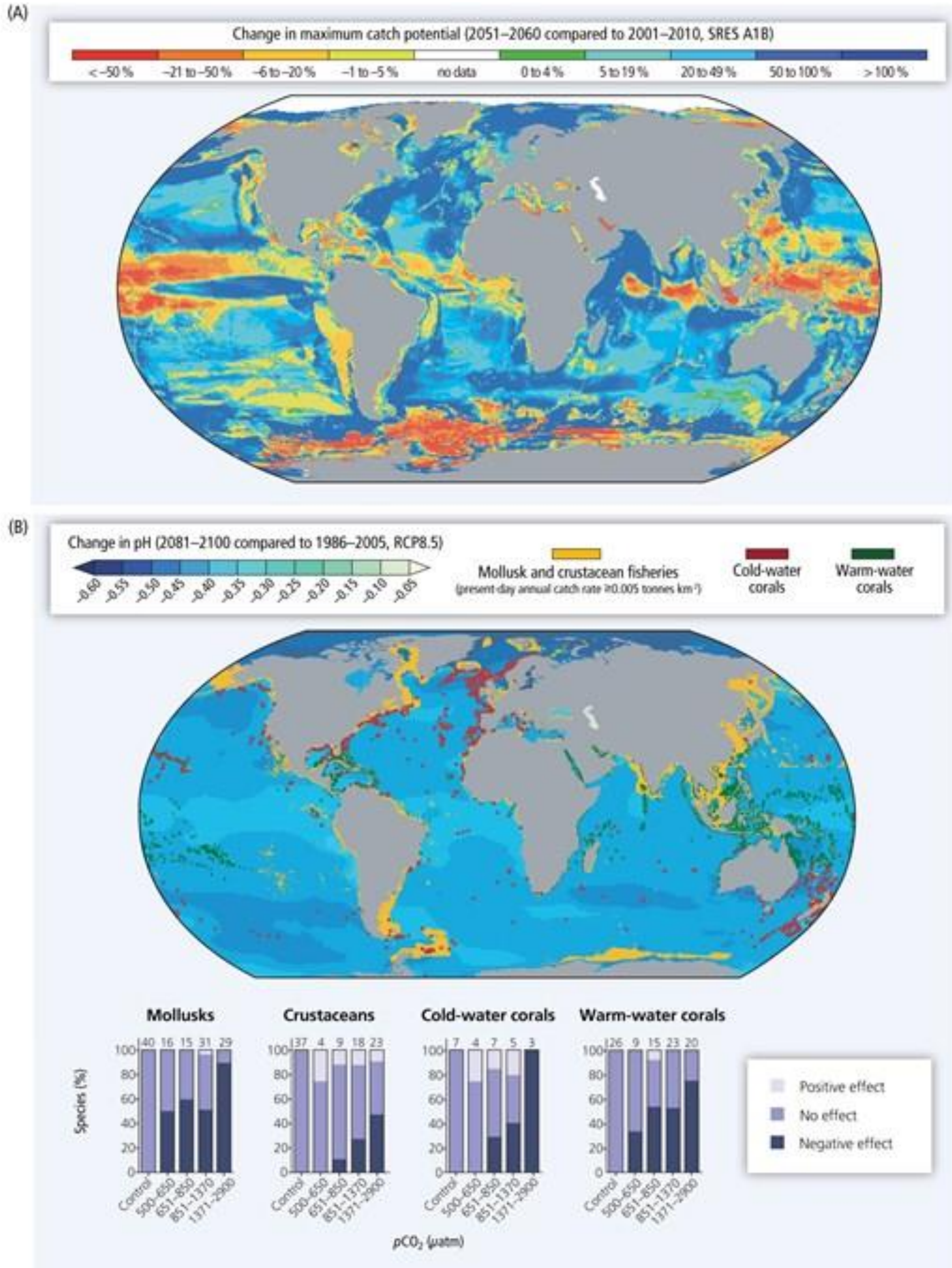


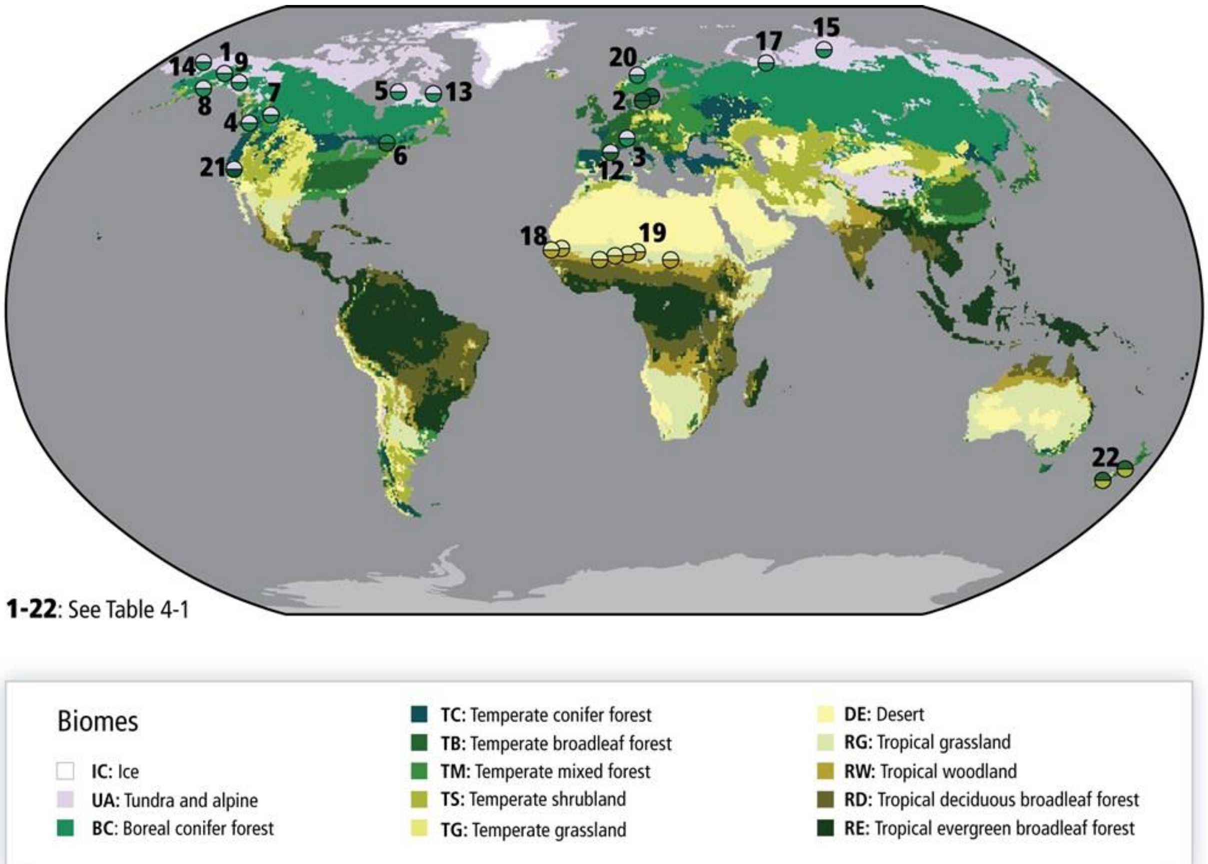
Biogeographic shifts
Some species experience distribution shifts, abundance losses, or become locally extinct (dashed lines). Loss and invasion of prey organisms and/or predators may lead to changing diversity and foodweb structure and result in trophic cascade effects.
Changes in body size
Marine water-breathing ectotherms increase their consumption rate and have a smaller maximum body size during warming. Changes in the body size spectrum and food consumption rate may lead to changes in foodweb structure and dynamics.
Primary production
Detritus / particulate organic matter
Zooplankton and other invertebrates
Small fishes (sp. A)
Large fishes (sp. A)
Small fishes (sp. B)
Large fishes (sp. B)
Large fishes (sp. C)
Megafauna
Phenological shift
Changes in phenology due to climate change may lead to mismatch phenomena between predator and prey, which may reduce abundance of the predator.
10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6} 10^{7} 10^{8}
Body Mass (g)
Predator–prey interactions
Competition
Interactions that will be weakened or removed by climate change


Global warming
Gap opening between land and sea ice alters coastal circulation
Decrease in albedo
Sea ice retreating
Sea ice
CO_2 emissions
Shorter duration of snow cover
Coastal sea
Warmer spring and summer
Shrub encroachment and densification
Increased fire intensity
Tundra
New wetlands emit CH_4
Replacement of conifers by broadleaf forest
Lakes drain or form as permafrost thaws and drainage changes
Boreal forest
Permafrost
Organic layer
Biomes moving north
Permafrost is thawing in warmer regions
Insulating organic layer contains a large carbon stock that decomposes faster under warmer climate
Soil carbon export to rivers increases with permafrost thaw
Shrub
Dead tree
Conifer
Fire

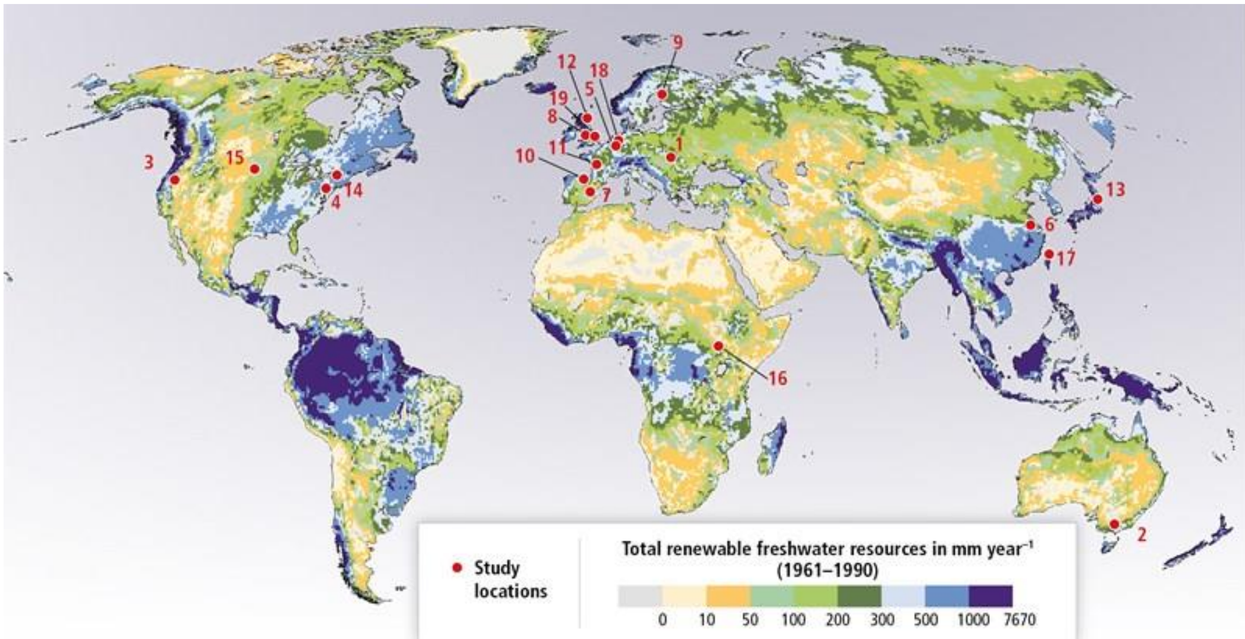
Assessment Box SPM.2 Table 1 (continued)

The Ocean				
Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Distributional shift in fish and invertebrate species, and decrease in fisheries catch potential at low latitudes, e.g., in equatorial upwelling and coastal boundary systems and sub-tropical gyres (*high confidence*) [6.3, 30.5-6, Tables 6-6 and 30-3, Box CC-MB]	• Evolutionary adaptation potential of fish and invertebrate species to warming is limited as indicated by their changes in distribution to maintain temperatures. • Human adaptation options: Large-scale translocation of industrial fishing activities following the regional decreases (low latitude) vs. possibly transient increases (high latitude) in catch potential; Flexible management that can react to variability and change; Improvement of fish resilience to thermal stress by reducing other stressors such as pollution and eutrophication; Expansion of sustainable aquaculture and the development of alternative livelihoods in some regions.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	
Reduced biodiversity, fisheries abundance, and coastal protection by coral reefs due to heat-induced mass coral bleaching and mortality increases, exacerbated by ocean acidification, e.g., in coastal boundary systems and sub-tropical gyres (*high confidence*) [5.4, 6.4, 30.3, 30.5-6, Tables 6-6 and 30-3, Box CC-CR]	• Evidence of rapid evolution by corals is very limited. Some corals may migrate to higher latitudes, but entire reef systems are not expected to be able to track the high rates of temperature shifts. • Human adaptation options are limited to reducing other stresses, mainly by enhancing water quality, and limiting pressures from tourism and fishing. These options will delay human impacts of climate change by a few decades, but their efficacy will be severely reduced as thermal stress increases.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	
Coastal inundation and habitat loss due to sea level rise, extreme events, changes in precipitation, and reduced ecological resilience, e.g., in coastal boundary systems and sub-tropical gyres (*medium* to *high confidence*) [5.5, 30.5-6, Tables 6-6 and 30-3, Box CC-CR]	• Human adaptation options are limited to reducing other stresses, mainly by reducing pollution and limiting pressures from tourism, fishing, physical destruction, and unsustainable aquaculture. • Reducing deforestation and increasing reforestation of river catchments and coastal areas to retain sediments and nutrients • Increased mangrove, coral reef, and seagrass protection, and restoration to protect numerous ecosystem goods and services such as coastal protection, tourist value, and fish habitat		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	


(A)
Change in maximum catch potential (2051–2060 compared to 2001–2010, SRES A1B)
< –50 %
–21 to –50 %
–6 to –20 %
–1 to –5 %
no data
0 to 4 %
5 to 19 %
20 to 49 %
50 to 100 %
> 100 %
(B)
Change in pH (2081–2100 compared to 1986–2005, RCP8.5)
-0.60 -0.55 -0.50 -0.45 -0.40 -0.35 -0.30 -0.25 -0.20 -0.15 -0.10 -0.05
Mollusk and crustacean fisheries
(present-day annual catch rate ≥0.005 tonnes km⁻²)
Cold-water corals
Warm-water corals
Mollusks
Crustaceans
Cold-water corals
Warm-water corals
Species (%)
Control
500–650
651–850
851–1370
1371–2900
Positive effect
No effect
Negative effect
pCO₂ (µatm)

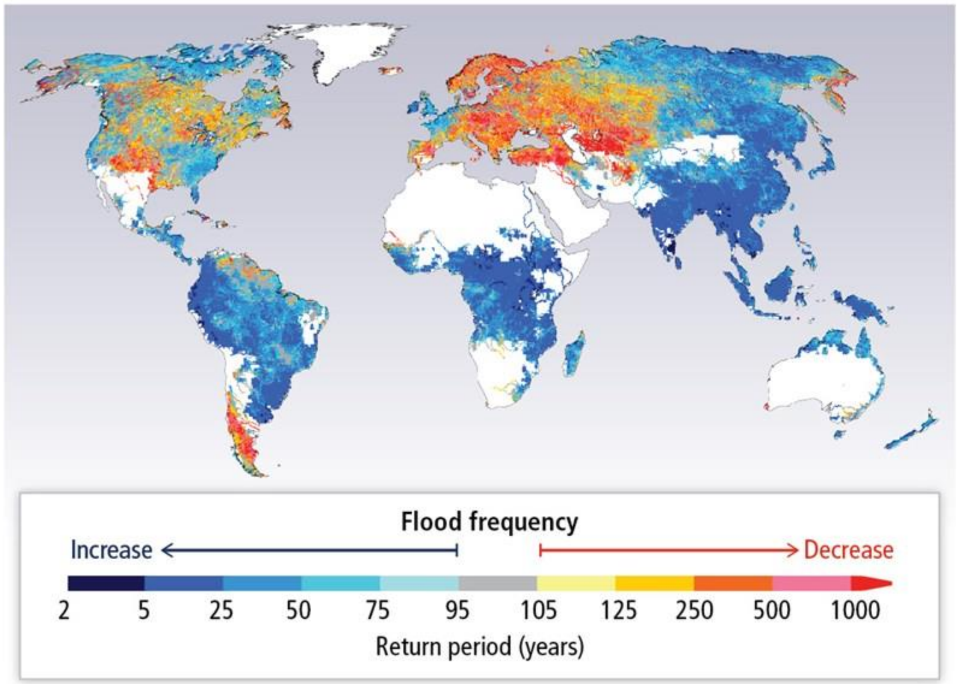


14
1
9
8
7
4
5
13
6
21
20
2
3
12
17
15
18
19
22
1-22: See Table 4-1
Biomes
IC: Ice
UA: Tundra and alpine
BC: Boreal conifer forest
TC: Temperate conifer forest
TB: Temperate broadleaf forest
TM: Temperate mixed forest
TS: Temperate shrubland
TG: Temperate grassland
DE: Desert
RG: Tropical grassland
RW: Tropical woodland
RD: Tropical deciduous broadleaf forest
RE: Tropical evergreen broadleaf forest

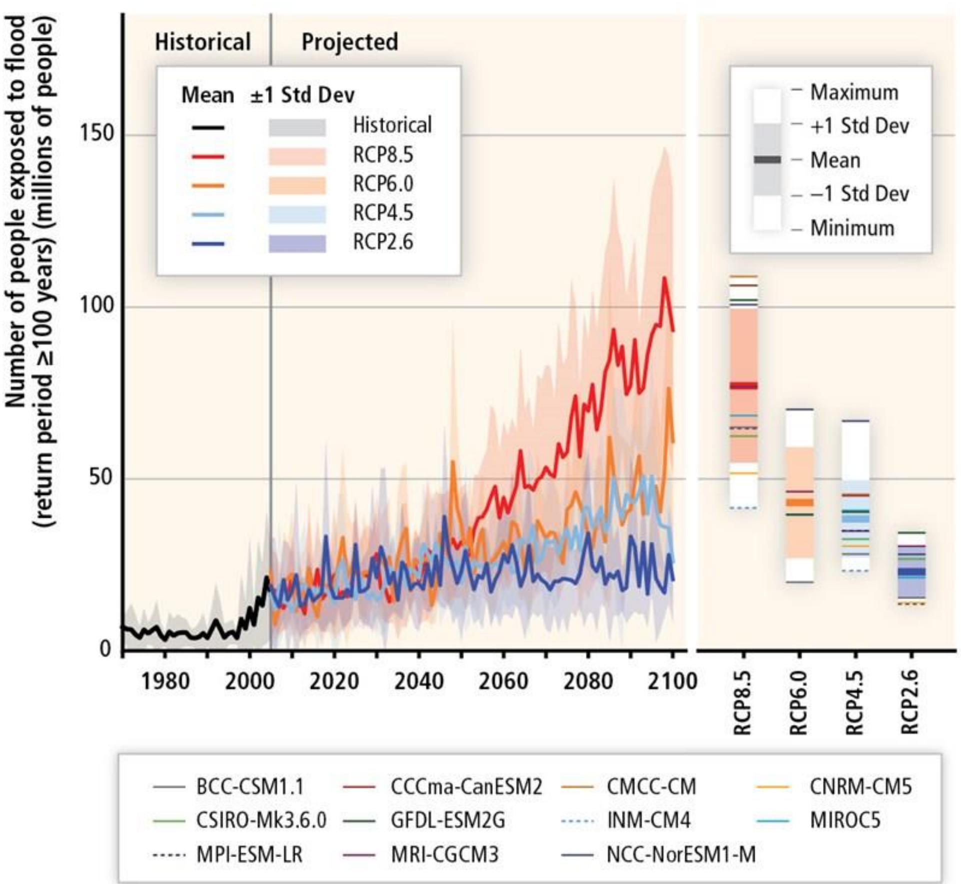


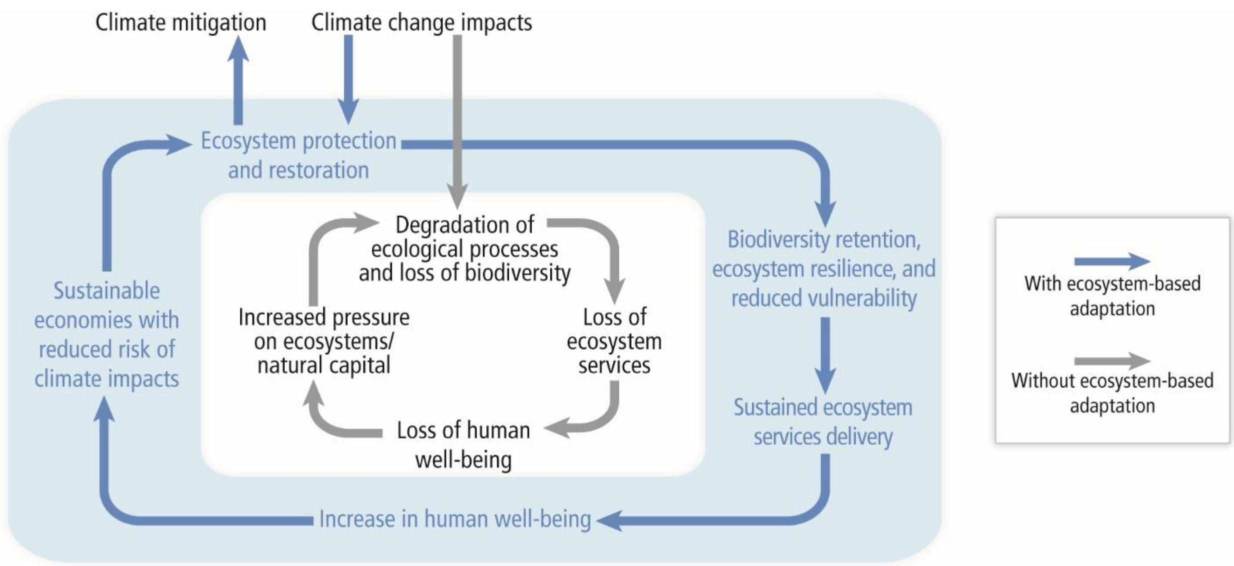
	Location	Study period	Observation on water quality	Reference
1	Danube River, Bratislava, Slovakia	1926–2005	The water temperature is rising but the trend of the weighted long-term average temperature values resulted close to zero because of the interannual distribution of the mean monthly discharge.	Pekarova et al. (2008)
2	Purrumbete, Colac and Bullen Merri Lakes, Victoria, Australia	1984–2000	The increases in salinity and nutrient content were associated with the air temperature increase; salinity in addition was associated with variations in the effective precipitation.	Tibby and Tiller (2007)
3	Lake Tahoe, California and Nevada States, USA	1970–2007	Thermal stability resulting from a higher ambient temperature decreased the dissolved oxygen content.	Sahoo et al. (2010)
4	Neuse River Estuary, North Carolina, USA	1979–2003	Intense storms and hurricanes flushed nutrients from the estuary, reducing eutrophic conditions and the risk of algal blooms.	Paerl et al., (2006); Paerl and Huisman (2008)
5	River Meuse, western Europe	1976–2003	Increase of water temperature and the content of major elements and some heavy metals were associated with droughts. Algal blooms resulted from a higher nutrient content due to higher water temperature and longer residence time.	van Vliet and Zwolsman (2008)
6	Lake Taihu, Wuxi, Jiangsu, China	2007	The lake, already suffering from periodic cyanobacterial blooms, was affected by a very intensive bloom in May 2007 attributed to an unusually warm spring and leading to the presence of *Microcystis* toxins in the water. This forced two million people to drink bottled water for at least one week.	Qin et al. (2010)
7	Sau Reservoir, Spain	1964–2007	Stream flow variations were of greater significance than temperature increases in the depletion of dissolved oxygen.	Marcé et al. (2010)
8	22 upland waters in UK	1988–2002	Dissolved organic matter increased due to temperature increase but also due to rainfall variations, acid deposition, land use, and CO_2 enrichment.	Evans et al. (2005)
9	Coastal rivers from western Finland	1913–2007	Low pH values are associated with higher rainfall and river discharge in an acid sulfate soil basin.	Saarinen et al. (2010)
		1961–2007	Critical values of dissolved organic carbon is associated with higher rainfall and river discharge.	
10	15 pristine mountain rivers, northern Spain	1973–2005	For a semiarid area, there is a clear relationship between increases in air temperature and a higher nutrient and dissolved organic carbon content.	Benítez-Gilabert et al. (2010)
11	30 coastal rivers and groundwater of western France	1973–2007 (2–6 years)	Interannual variations in the nutrient content associated with air temperature, rainfall, and management practices changes. These effects were not observed in groundwater because of the delay in response time and the depuration of soil on water.	Gascuel-Odoux et al. (2010)
12	Girnock, Scotland	14 months	Higher risks of fecal pollution are clearly related to rainfall during the wet period.	Tetzlaff et al. (2010)
13	27 rivers in Japan	1987–1995	Increases in organic matter and sediment and decreases in the dissolved oxygen content are associated with increases in ambient temperature. Precipitation increases and variations are associated with an increase in the organic matter, sediments, and chemical oxygen demand content in water.	Ozaki et al. (2003)
14	Conestoga River Basin, Pennsylvania, USA	1977–1997	There is a close association between annual loads of total nitrogen and annual precipitation increases.	Chang (2004)
15	USA	1948–1994	Increased rainfall and runoff are associated with site-specific outbreaks of waterborne disease.	Curriero et al. (2001)
16	Northern and eastern Uganda	1999–2001, 2004, 2007	Elevated concentrations of fecal coliforms are observed in groundwater-fed water supplies during the rainy season.	Tumwine et al. (2002, 2003); Taylor et al. (2009)
17	Taiwan, China	1998	The probability of detecting cases of enterovirus infection was greater than 50%, with rainfall rates >31 mm h^{-1}. The higher the rainfall rate, the higher the probability of an enterovirus epidemic.	Jean et al. (2006)
18	Rhine Basin	1980–2001	Nutrient content in rivers followed seasonal variations in precipitation which were also linked to erosion within the basin.	Loos et al. (2009)
19	River Thames, England	1868–2008	Higher nutrient contents were associated to changes in river runoff and land use.	Howden et al. (2010)

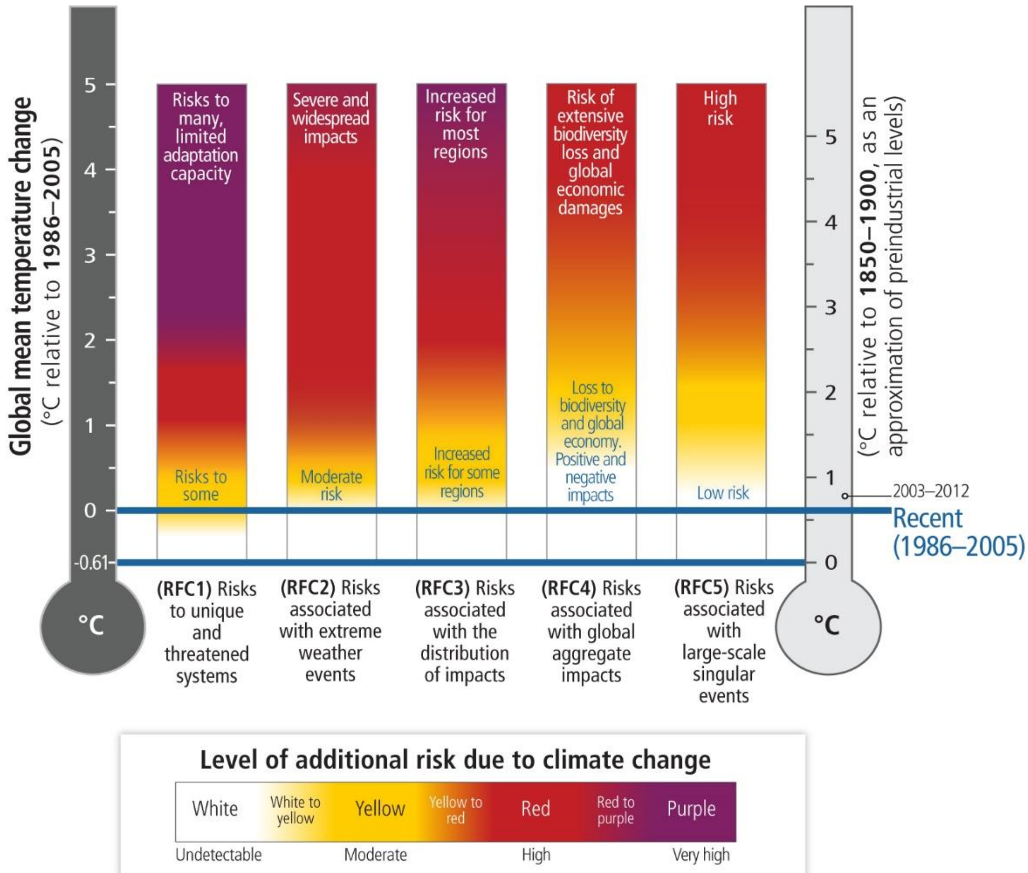
(a)

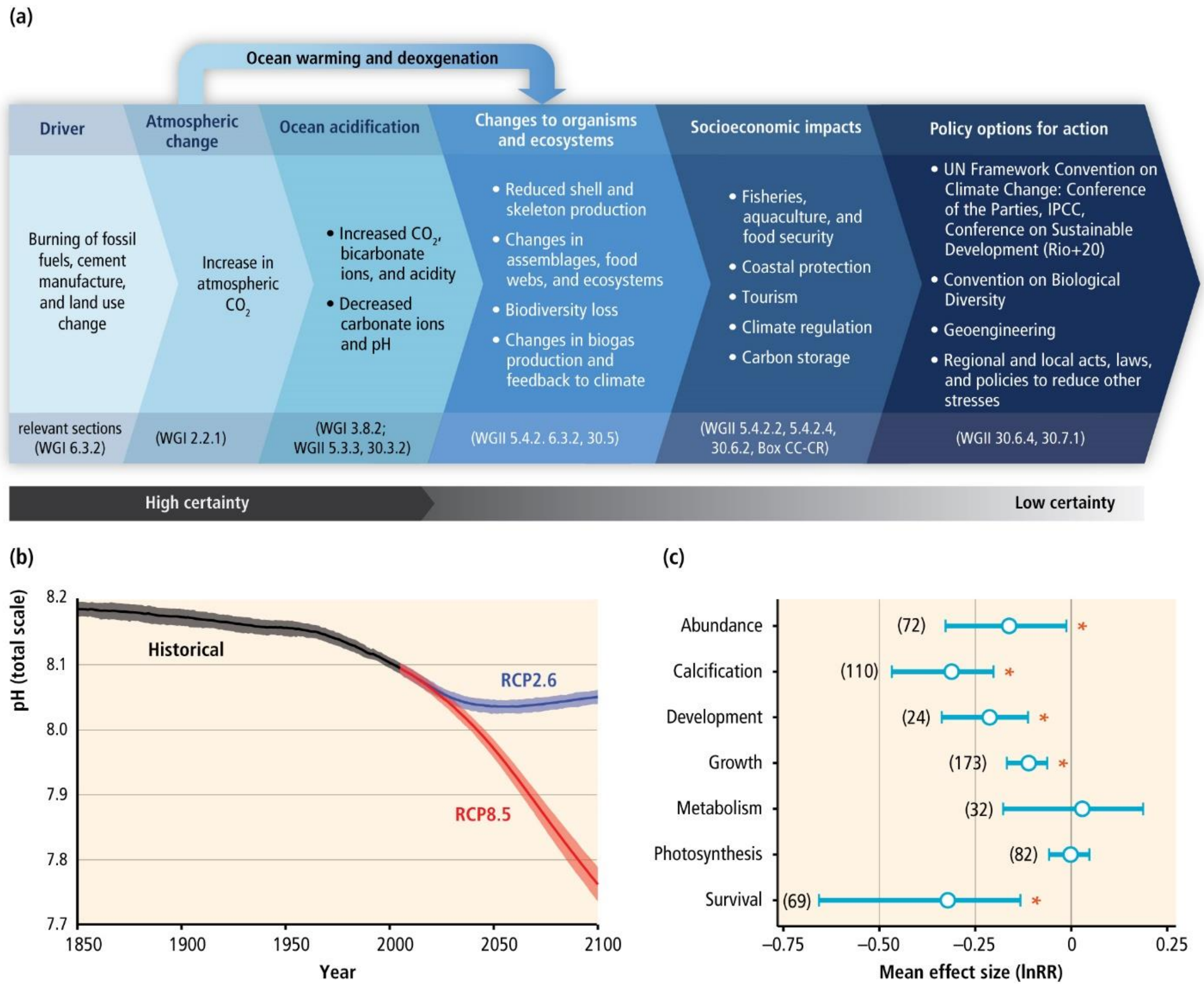

Flood frequency
Increase
Decrease
2 5 25 50 75 95 105 125 250 500 1000
Return period (years)

(b)

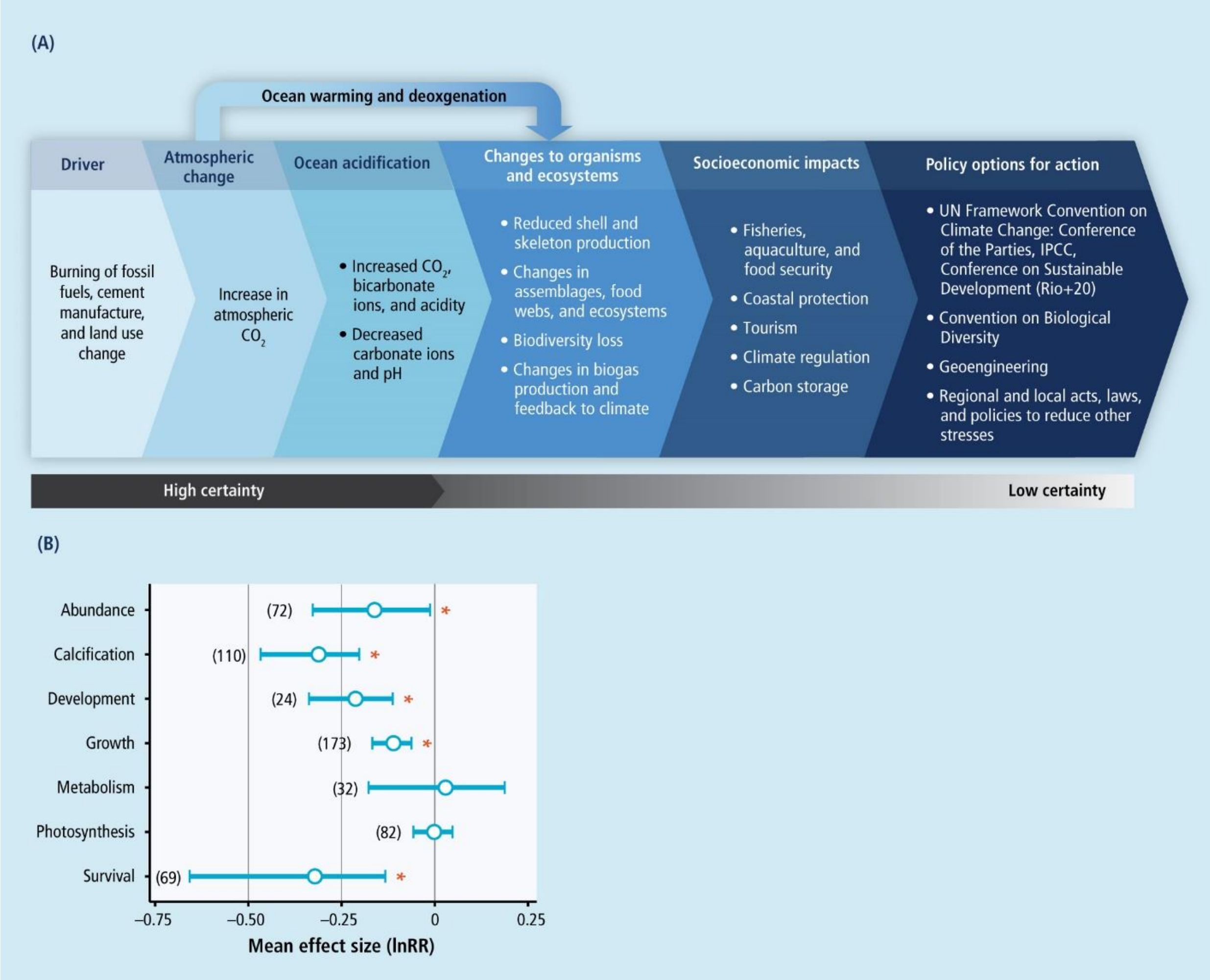

Number of people exposed to flood (return period ≥100 years) (millions of people)
Historical
Projected
Mean ±1 Std Dev
Historical
RCP8.5
RCP6.0
RCP4.5
RCP2.6
Maximum
+1 Std Dev
Mean
−1 Std Dev
Minimum
150
100
50
0
1980 2000 2020 2040 2060 2080 2100
RCP8.5
RCP6.0
RCP4.5
RCP2.6
BCC-CSM1.1
CCCma-CanESM2
CMCC-CM
CNRM-CM5
CSIRO-Mk3.6.0
GFDL-ESM2G
INM-CM4
MIROC5
MPI-ESM-LR
MRI-CGCM3
NCC-NorESM1-M

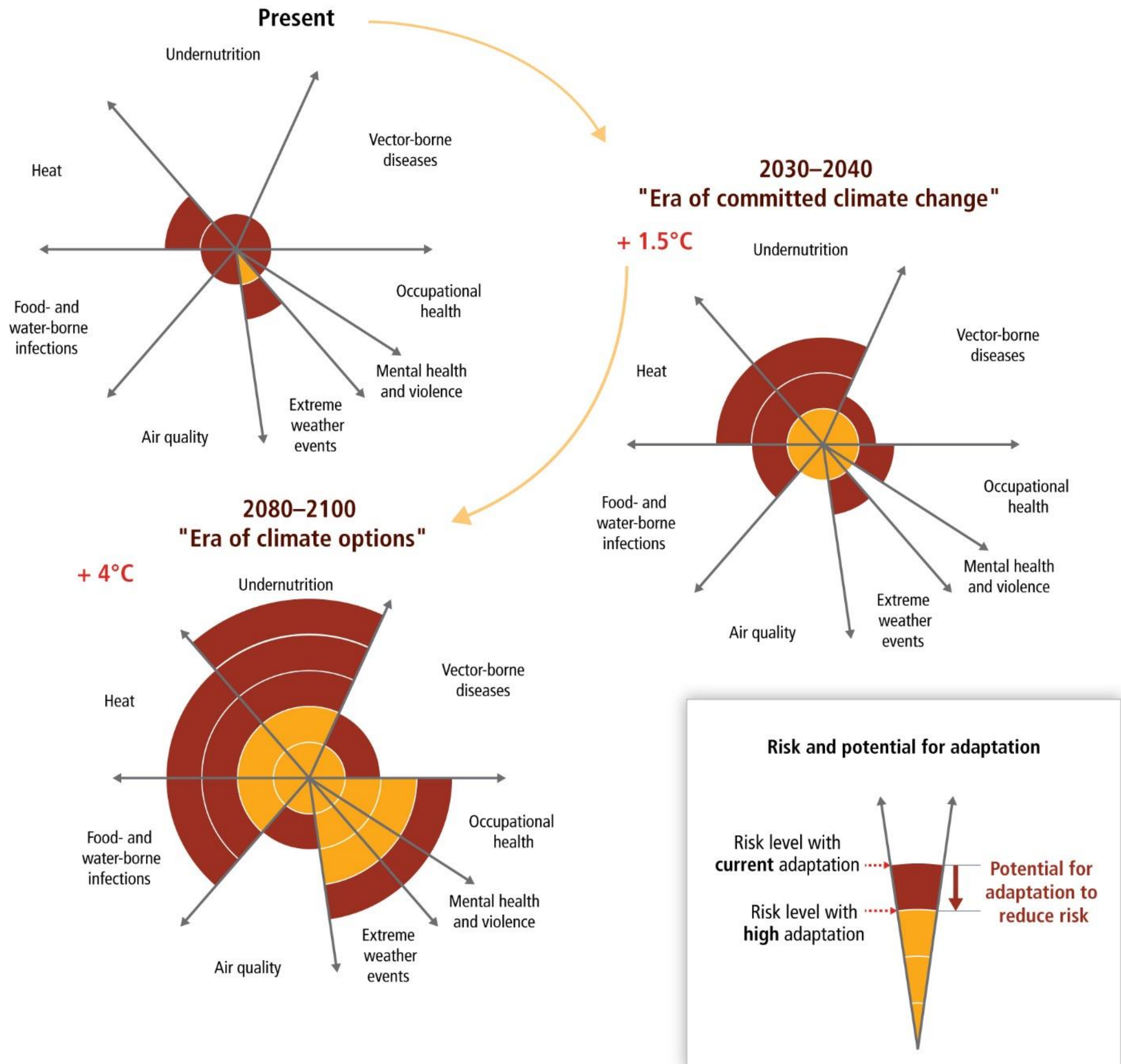

Climate mitigation
Climate change impacts
Ecosystem protection and restoration
Biodiversity retention, ecosystem resilience, and reduced vulnerability
Sustained ecosystem services delivery
Increase in human well-being
Sustainable economies with reduced risk of climate impacts
Degradation of ecological processes and loss of biodiversity
Loss of ecosystem services
Loss of human well-being
Increased pressure on ecosystems/ natural capital
With ecosystem-based adaptation
Without ecosystem-based adaptation


Global mean temperature change
(°C relative to 1986–2005)
(°C relative to 1850–1900, as an approximation of preindustrial levels)
5
4
3
2
1
0
-0.61
°C
Risks to many, limited adaptation capacity
Risks to some
Severe and widespread impacts
Moderate risk
Increased risk for most regions
Increased risk for some regions
Risk of extensive biodiversity loss and global economic damages
Loss to biodiversity and global economy. Positive and negative impacts
High risk
Low risk
2003–2012
Recent (1986–2005)
(RFC1) Risks to unique and threatened systems
(RFC2) Risks associated with extreme weather events
(RFC3) Risks associated with the distribution of impacts
(RFC4) Risks associated with global aggregate impacts
(RFC5) Risks associated with large-scale singular events
Level of additional risk due to climate change
White
White to yellow
Yellow
Yellow to red
Red
Red to purple
Purple
Undetectable
Moderate
High
Very high



(a)
Ocean warming and deoxgenation
Driver
Atmospheric change
Ocean acidification
Changes to organisms and ecosystems
Socioeconomic impacts
Policy options for action
Burning of fossil fuels, cement manufacture, and land use change
Increase in atmospheric CO_2
• Increased CO_2, bicarbonate ions, and acidity
• Decreased carbonate ions and pH
• Reduced shell and skeleton production
• Changes in assemblages, food webs, and ecosystems
• Biodiversity loss
• Changes in biogas production and feedback to climate
• Fisheries, aquaculture, and food security
• Coastal protection
• Tourism
• Climate regulation
• Carbon storage
• UN Framework Convention on Climate Change: Conference of the Parties, IPCC, Conference on Sustainable Development (Rio+20)
• Convention on Biological Diversity
• Geoengineering
• Regional and local acts, laws, and policies to reduce other stresses
relevant sections (WGI 6.3.2)
(WGI 2.2.1)
(WGI 3.8.2; WGII 5.3.3, 30.3.2)
(WGII 5.4.2. 6.3.2, 30.5)
(WGII 5.4.2.2, 5.4.2.4, 30.6.2, Box CC-CR)
(WGII 30.6.4, 30.7.1)
High certainty
Low certainty
(b)
pH (total scale)
8.2
8.1
8.0
7.9
7.8
7.7
Historical
RCP2.6
RCP8.5
1850
1900
1950
2000
2050
2100
Year
(c)
Abundance
Calcification
Development
Growth
Metabolism
Photosynthesis
Survival
(72)
(110)
(24)
(173)
(32)
(82)
(69)
*
–0.75
–0.50
–0.25
0
0.25
Mean effect size (lnRR)


(A)
Ocean warming and deoxgenation
Driver
Atmospheric change
Ocean acidification
Changes to organisms and ecosystems
Socioeconomic impacts
Policy options for action
Burning of fossil fuels, cement manufacture, and land use change
Increase in atmospheric CO_2
• Increased CO_2, bicarbonate ions, and acidity
• Decreased carbonate ions and pH
• Reduced shell and skeleton production
• Changes in assemblages, food webs, and ecosystems
• Biodiversity loss
• Changes in biogas production and feedback to climate
• Fisheries, aquaculture, and food security
• Coastal protection
• Tourism
• Climate regulation
• Carbon storage
• UN Framework Convention on Climate Change: Conference of the Parties, IPCC, Conference on Sustainable Development (Rio+20)
• Convention on Biological Diversity
• Geoengineering
• Regional and local acts, laws, and policies to reduce other stresses
High certainty
Low certainty
(B)
Abundance
Calcification
Development
Growth
Metabolism
Photosynthesis
Survival
(72)
(110)
(24)
(173)
(32)
(82)
(69)
–0.75
–0.50
–0.25
0
0.25
Mean effect size (lnRR)


Present
Undernutrition
Vector-borne diseases
Heat
Occupational health
Food- and water-borne infections
Mental health and violence
Extreme weather events
Air quality
2030–2040
"Era of committed climate change"
+ 1.5°C
Undernutrition
Vector-borne diseases
Heat
Occupational health
Food- and water-borne infections
Mental health and violence
Extreme weather events
Air quality
2080–2100
"Era of climate options"
+ 4°C
Undernutrition
Vector-borne diseases
Heat
Occupational health
Food- and water-borne infections
Mental health and violence
Extreme weather events
Air quality
Risk and potential for adaptation
Risk level with current adaptation
Risk level with high adaptation
Potential for adaptation to reduce risk