



IPCC WGII findings on the polar regions: **Ecosystem impacts of ocean warming and acidification**

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Observed Temperature



Trend over 1901-2012
(°C over period)

Solid Color

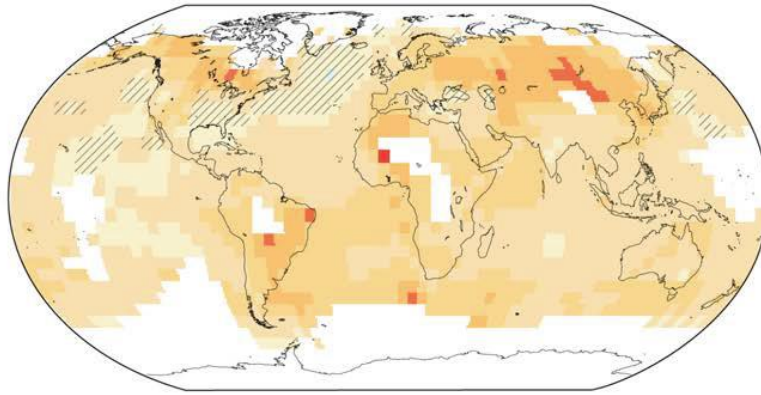
Significant
trend

Diagonal Lines

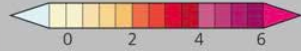
Trend not
statistically
significant

White

Insufficient
data



Projected Temperature



Difference from
1986-2005 mean (°C)

Solid Color

Very strong
agreement

White Dots

Strong
agreement

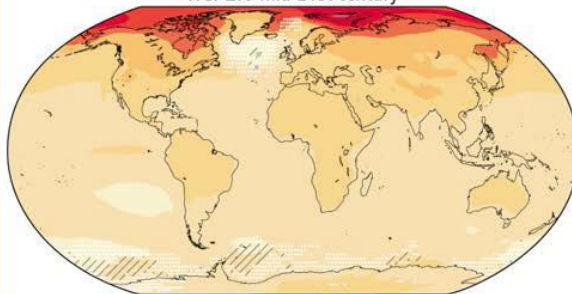
Gray

Divergent
changes

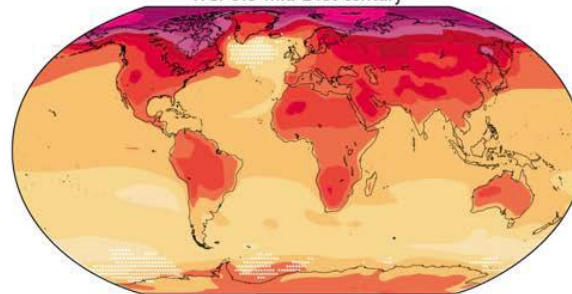
Diagonal Lines

Little or
no change

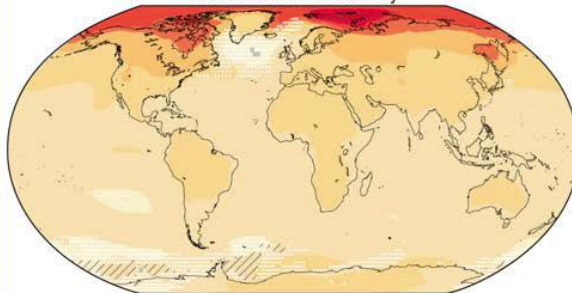
RCP2.6 mid-21st century



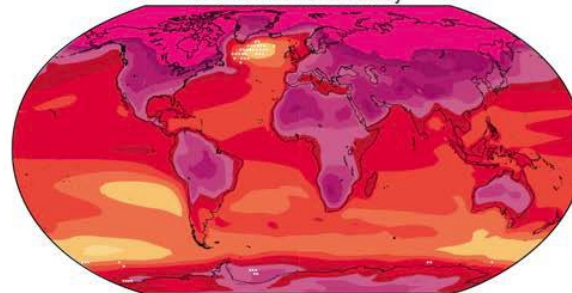
RCP8.5 mid-21st century



RCP2.6 late-21st century



RCP8.5 late-21st century



Warming

Observations
(1901-2012)

Projections

mid 21st century

late 21st century

.....warming affecting cold-specialized marine fauna: stenothermy in high polar areas

(a) Competition, predator/prey, phenologies of organisms in different climate zones

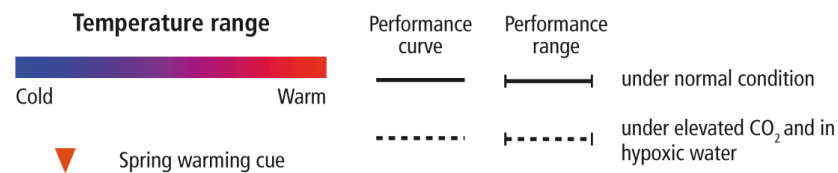
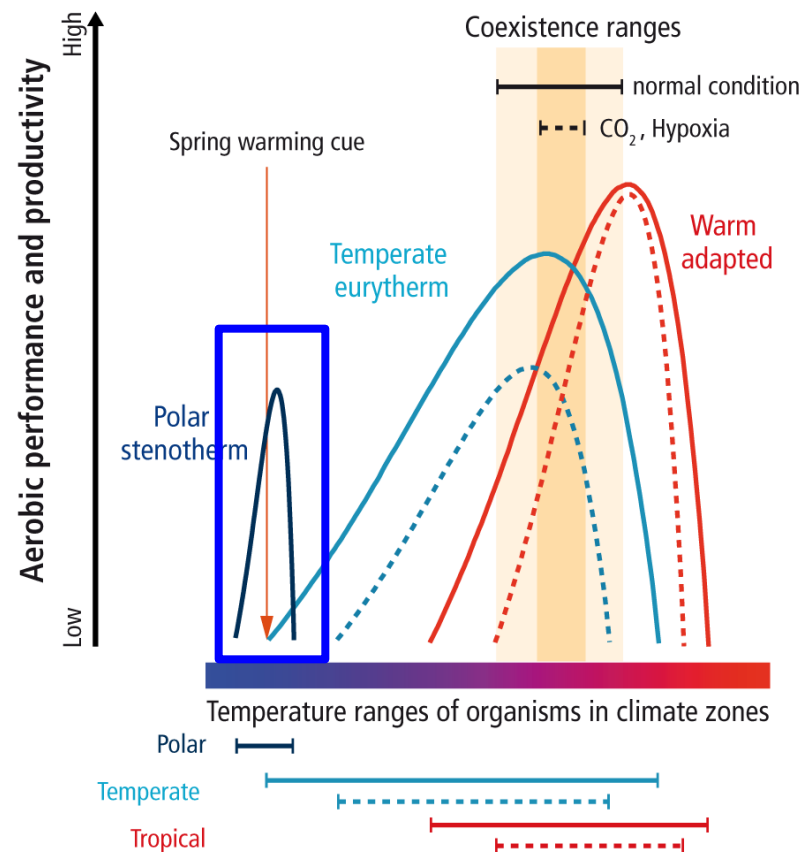
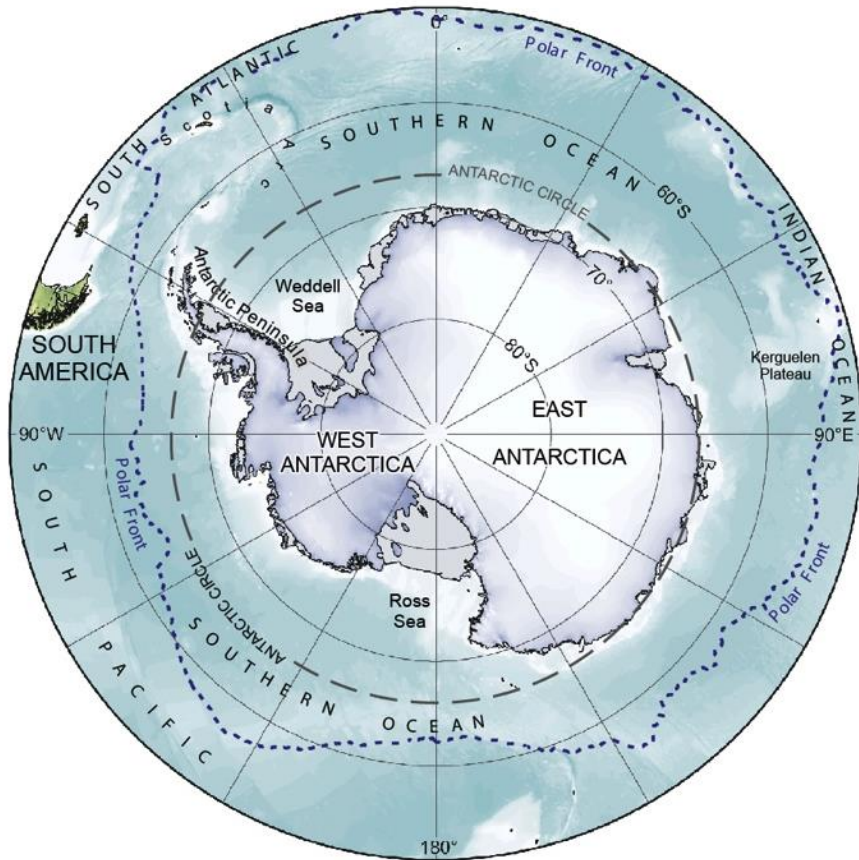


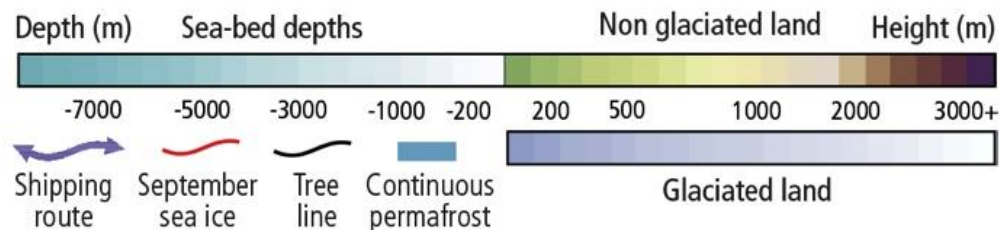
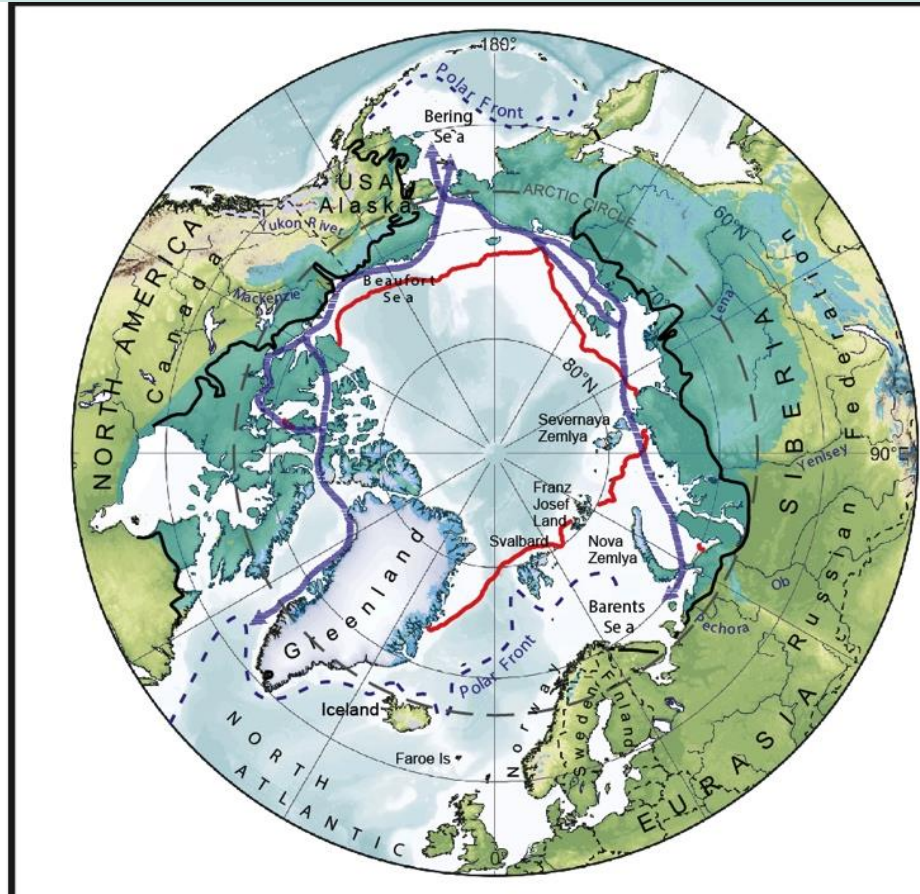
Figure 6-7

Different characteristics and specific vulnerabilities of polar areas

Antarctic (“closed system”)



Arctic (“open system”)



Differences between hemispheres: Arctic versus Antarctic

similarly low ocean temperatures reached

temperature variability

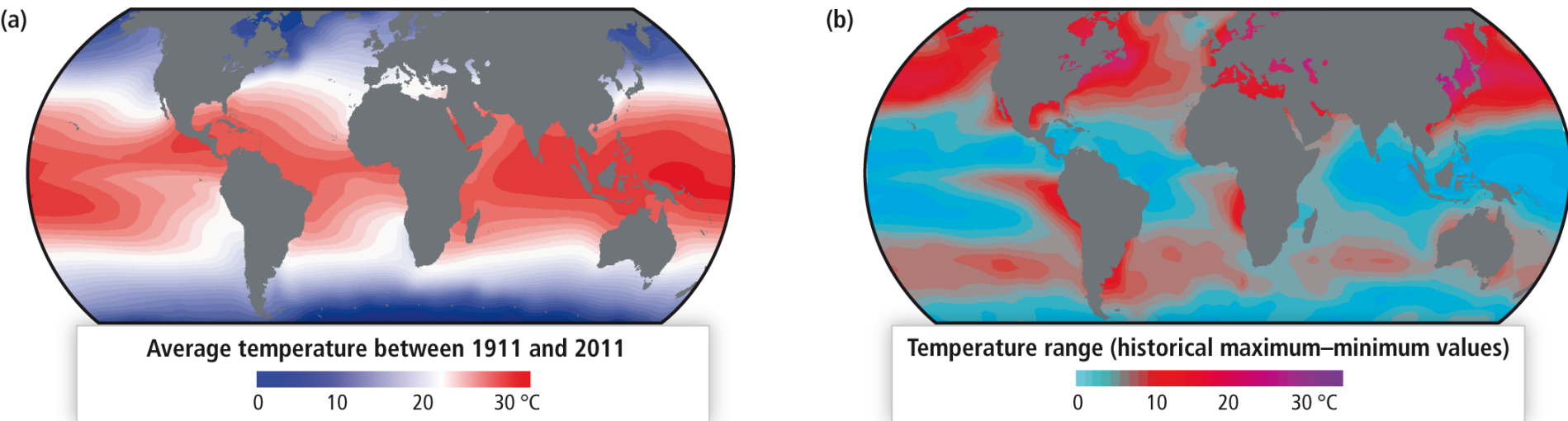


Figure 6-1

Functional tradeoffs in high polar (esp. Antarctic) stenotherms (narrow thermal windows):

- slow growth, low metabolism
- long development times
- long generation times
- low reproductive output
- low modes of activity in many species
- „no high polar tuna“

versus sub-polar (Arctic) eurytherms

(wide thermal windows):

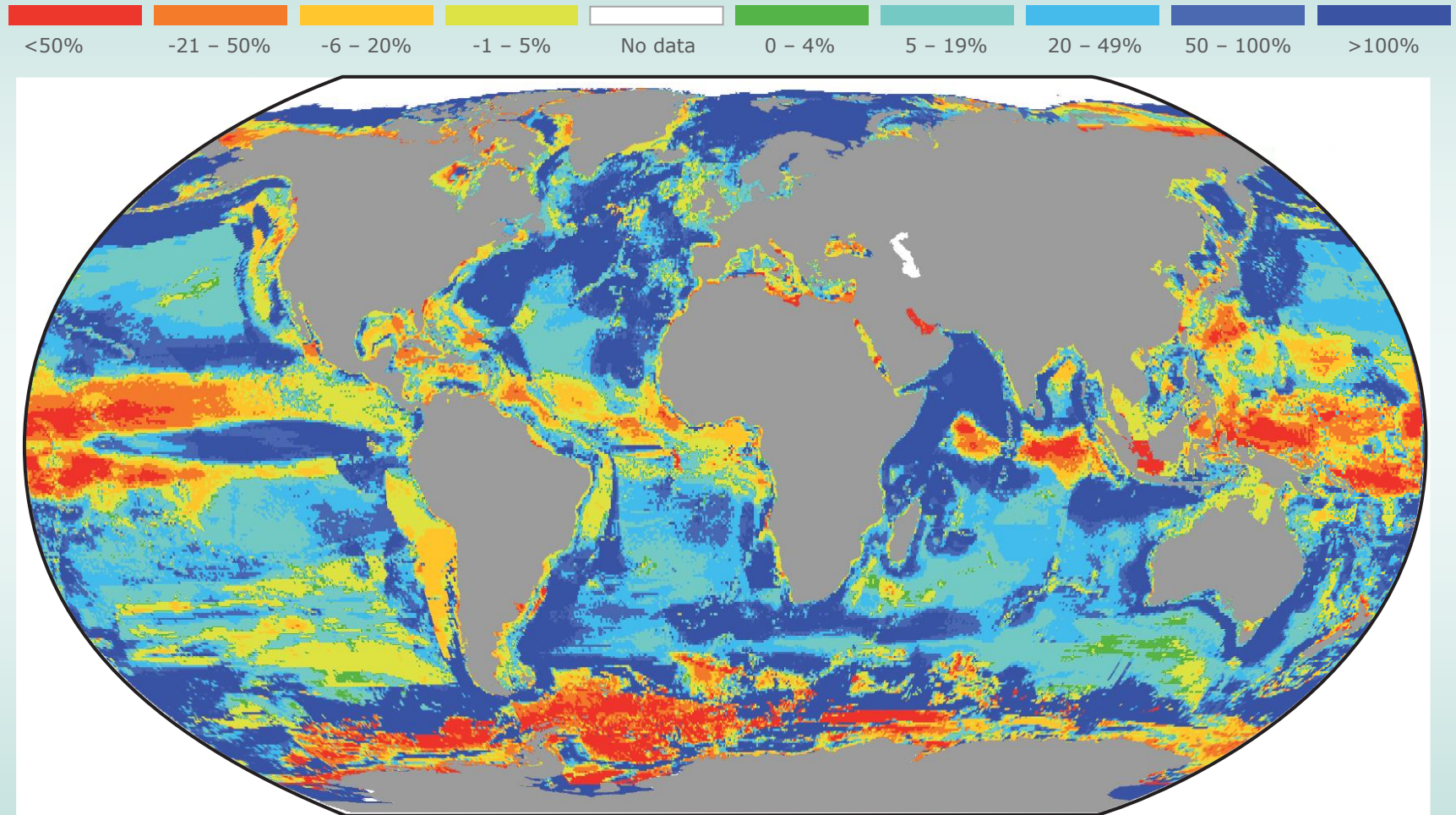
- elevated metabolism in spring and summer,
- growth and reproduction suspended in winter
- tolerant to sustain warmer summers

... resilience often has an energy cost ...
higher sensitivity of high polar than subpolar
species to warming (!) and acidification (?)

PROJECTIONS

Ocean warming 2051-60: Poleward displacement of fish and invertebrate stocks

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



High latitude warming: higher productivity and biodiversity

contributing to improved fisheries productivity
(reduced stocks at lower latitudes)

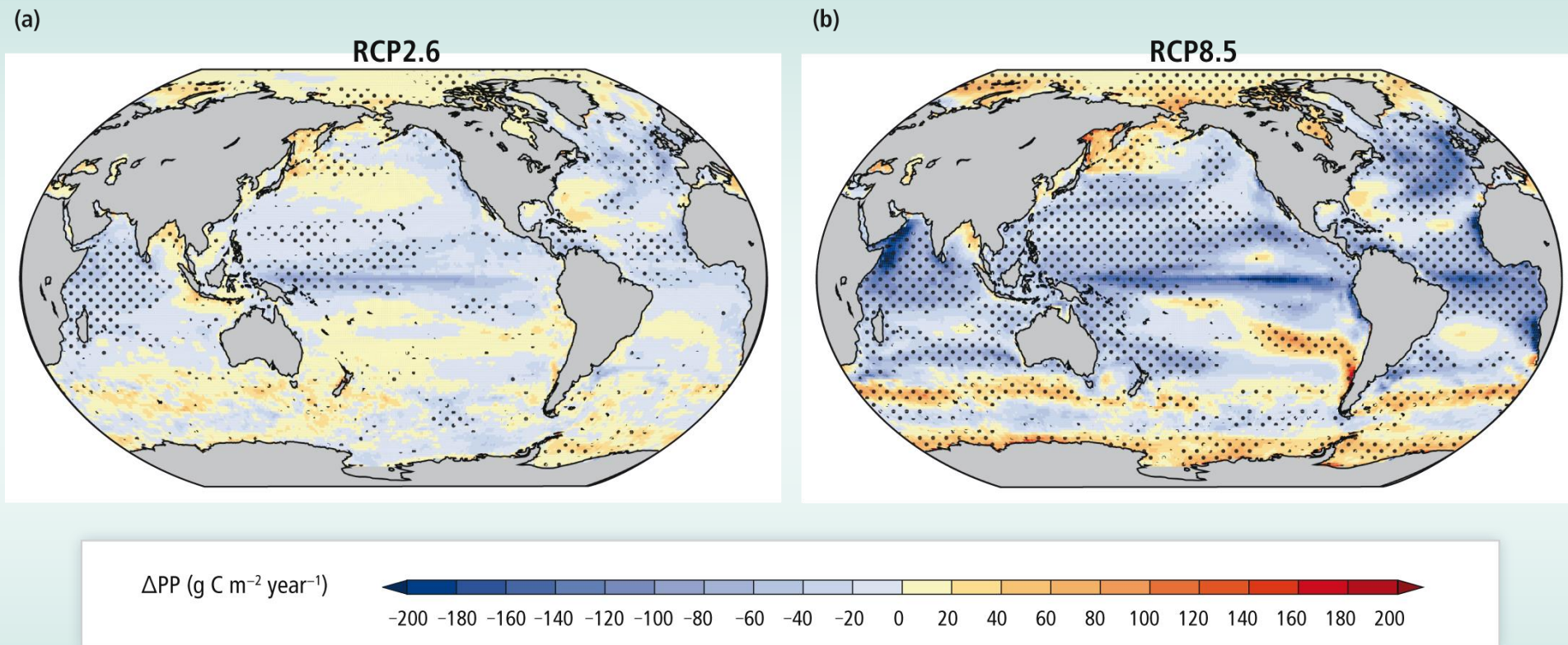
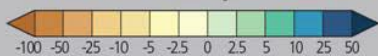


Figure 6-13

Observed Precipitation



Trend over 1951-2012
(mm/year/decade)

Solid Color

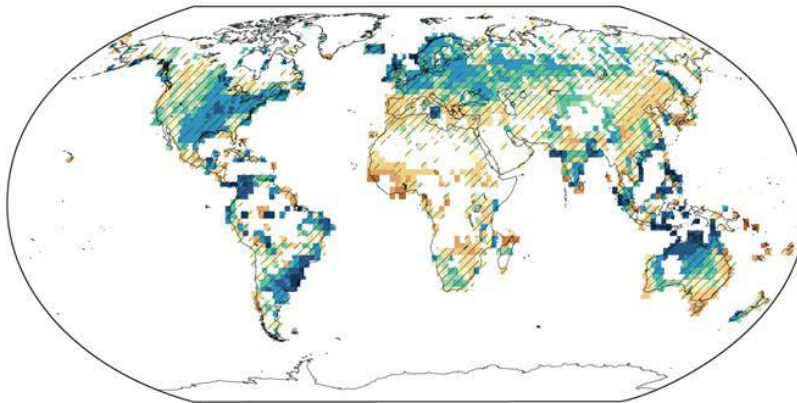
Significant
trend

Diagonal Lines

Trend not
statistically
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White

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data



Projected Precipitation



Difference from
1986-2005 mean (%)

Solid Color

Very strong
agreement

White Dots

Strong
agreement

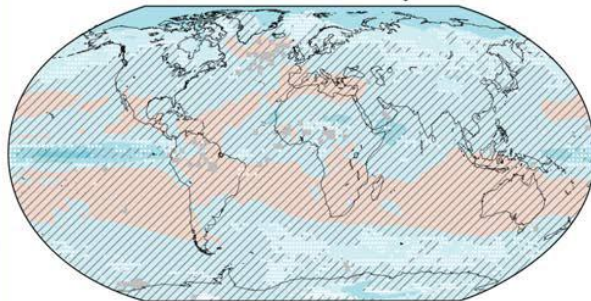
Gray

Divergent
changes

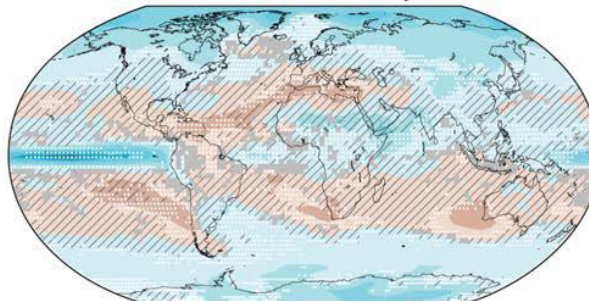
Diagonal Lines

Little or
no change

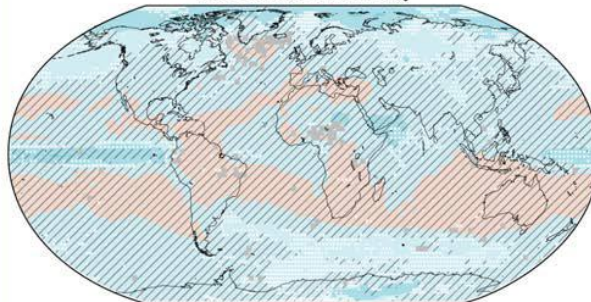
RCP2.6 mid-21st century



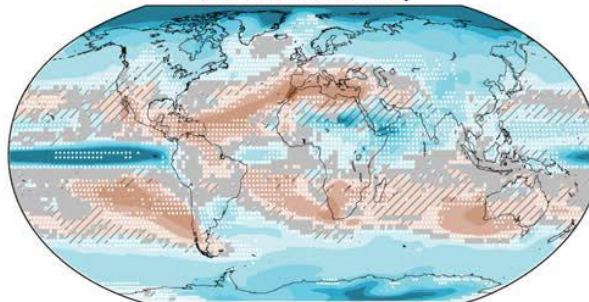
RCP8.5 mid-21st century



RCP2.6 late-21st century



RCP8.5 late-21st century



Precipitation

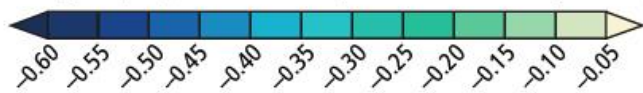
Observed

Projected

Enhanced
precipitation in the
Arctic exacerbating
ocean acidification

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

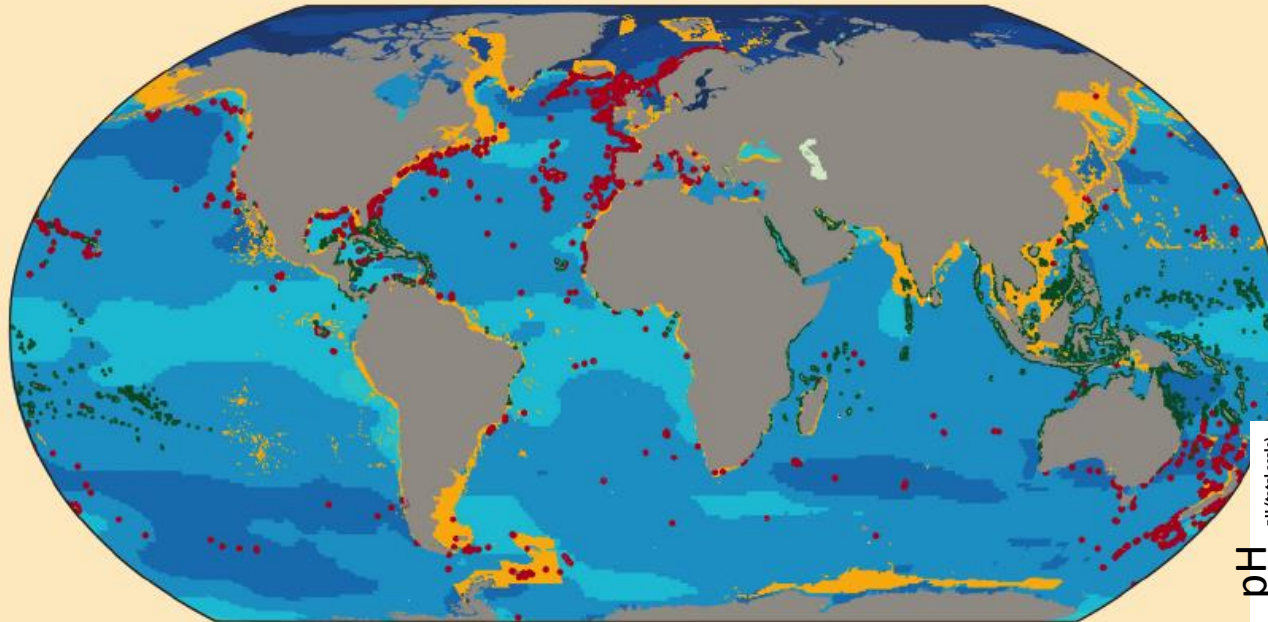
Change in pH (2081-2100 compared to 1986-2005, RCP8.5)



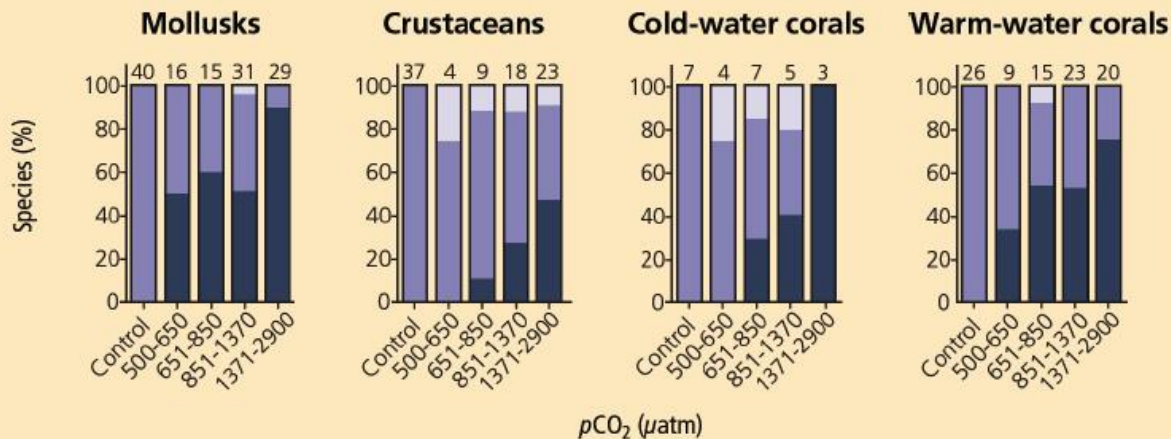
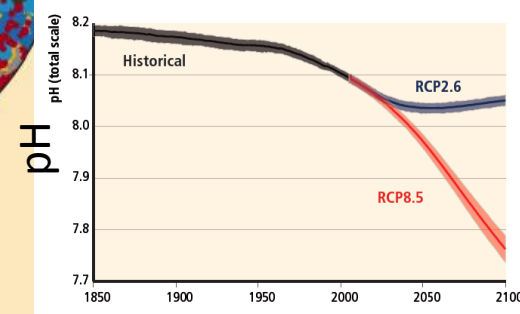
Mollusk and crustacean fisheries
(present-day annual catch rate ≥ 0.005 tonnes km^{-2})

Cold-water corals

Warm-water corals

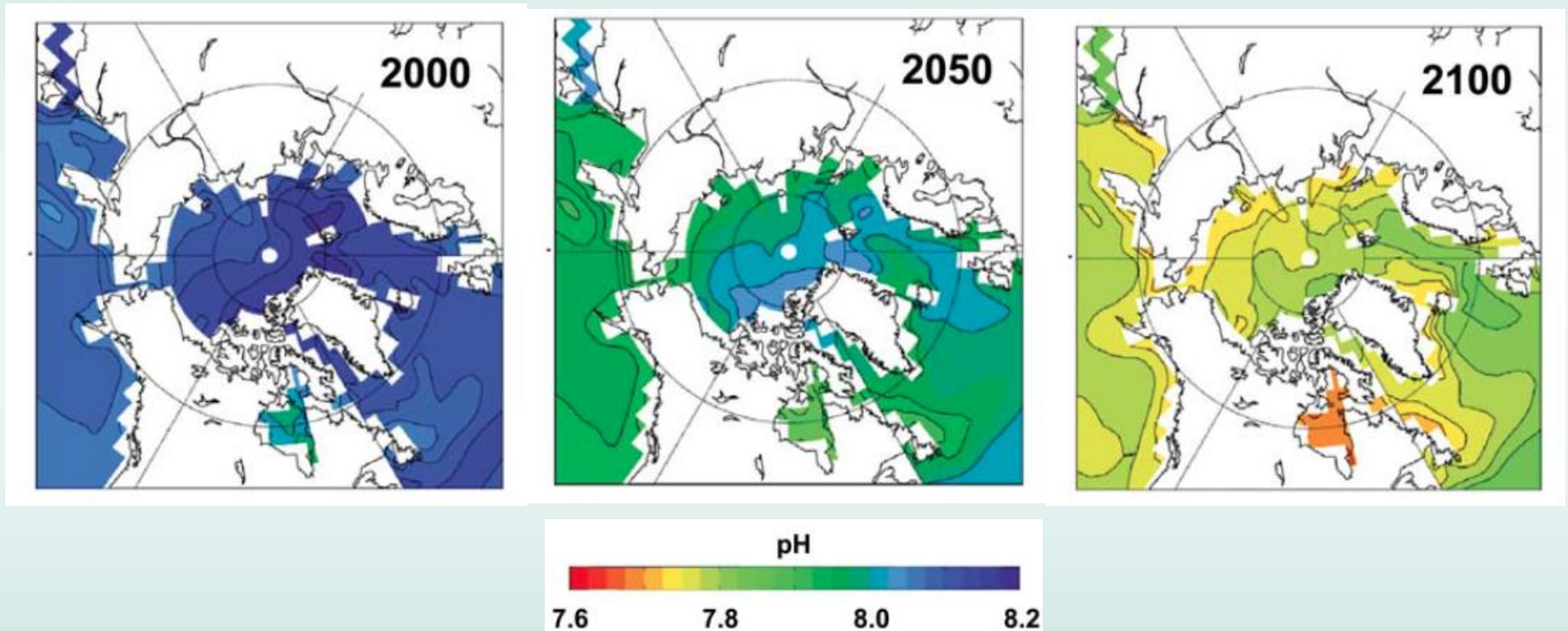


observed projected



until 2100

Arctic marine waters will experience widespread and rapid ocean acidification
(some regional variability)



Does a high degree of acidification meet high sensitivity of polar fauna?

A polar bear is walking across a vast, flat expanse of sea ice. The ice is a pale, milky blue color and is marked by several long, dark, jagged cracks that run across the surface. The bear is positioned in the lower center of the frame, facing right. The overall scene is desolate and cold, representing the Arctic sea ice ecosystem.

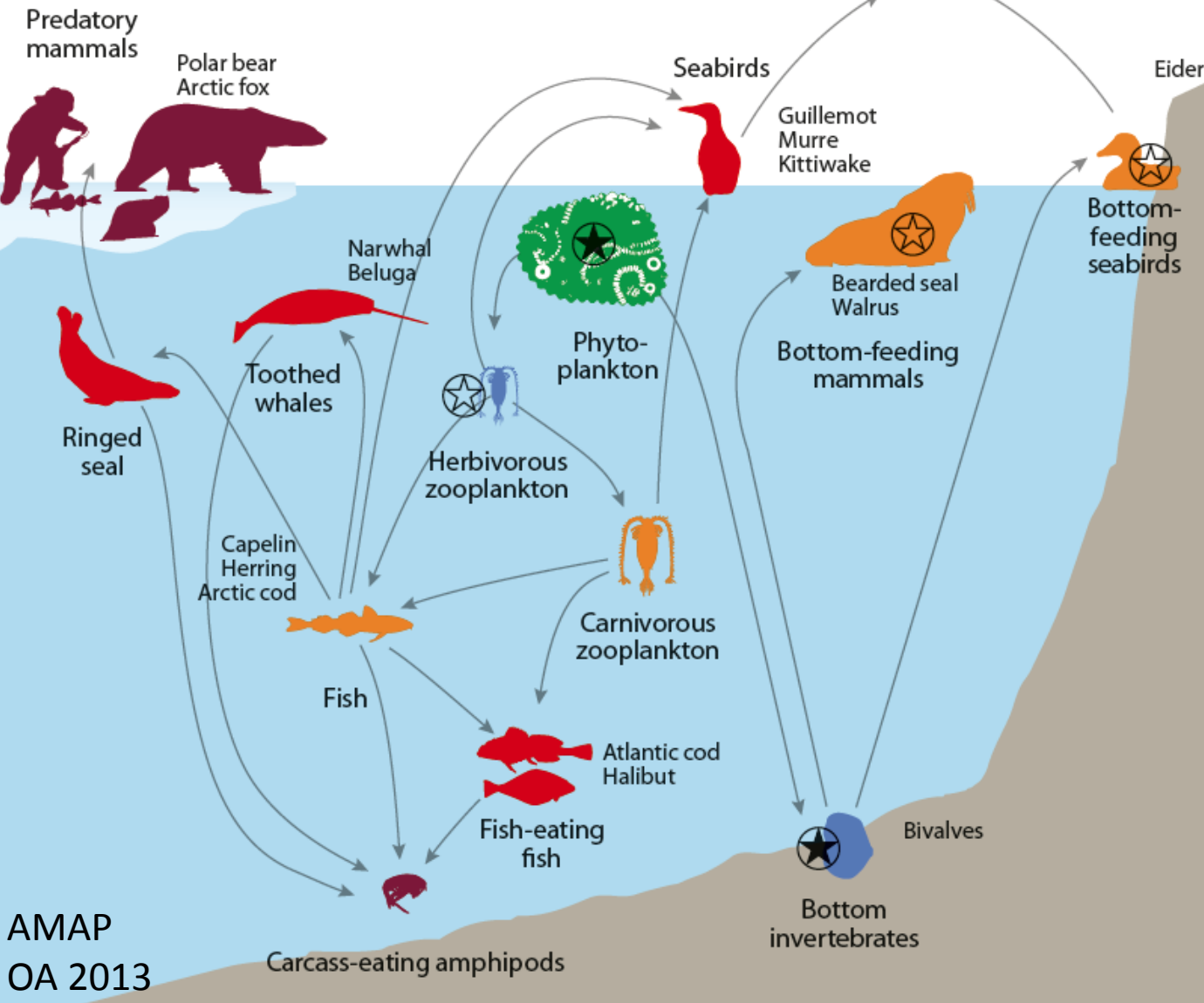
Vulnerable ecosystems

Arctic sea ice ecosystem

Warming and acidification affect a special ecosystem in the Arctic

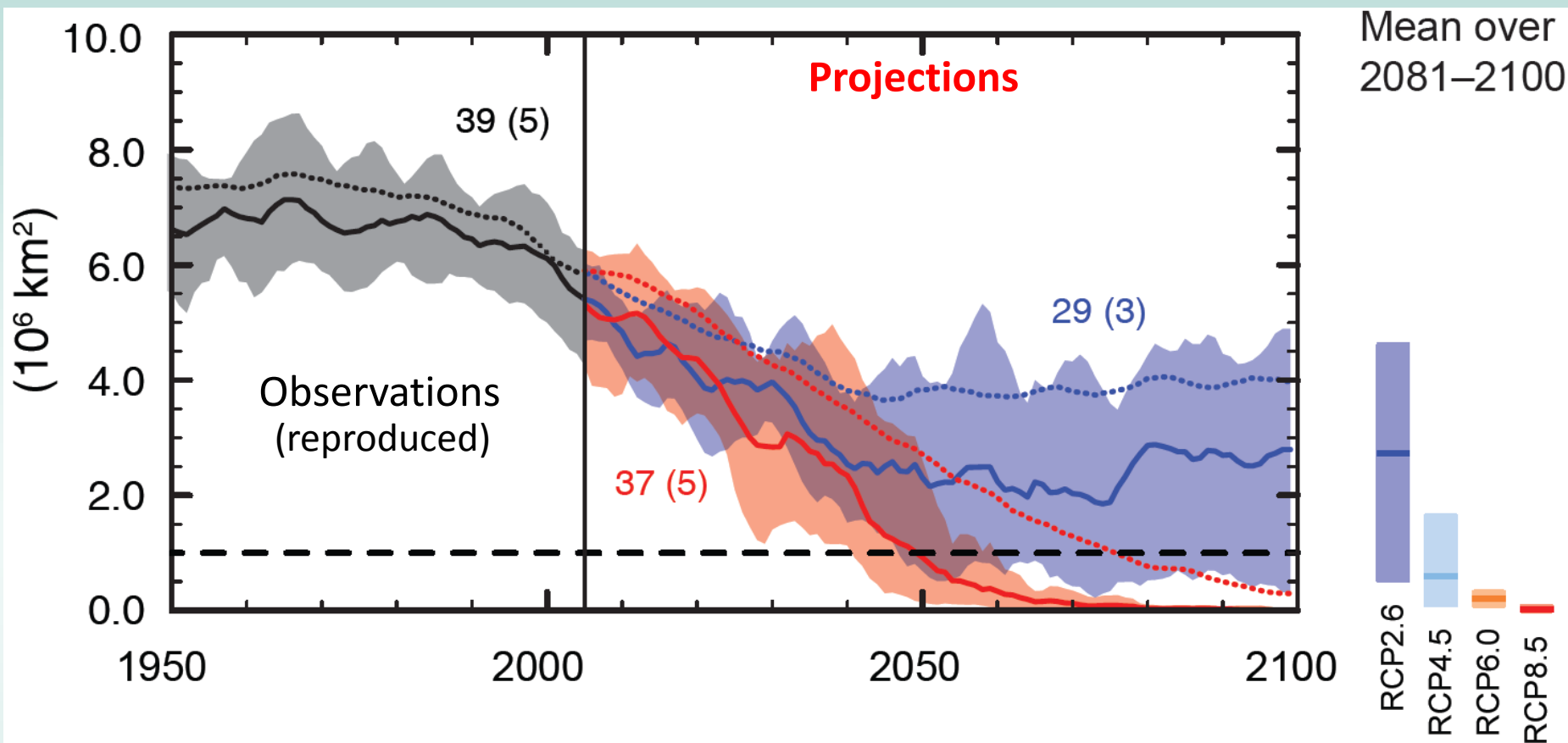
Figure 4.5. Generalized Arctic food web, with trophic levels very likely to be directly affected by ocean acidification noted with a filled star, and species likely to be indirectly affected (such as via a predator-prey relationship with a directly affected species) noted with an open star. Source: adapted from Murray et al, 1998.

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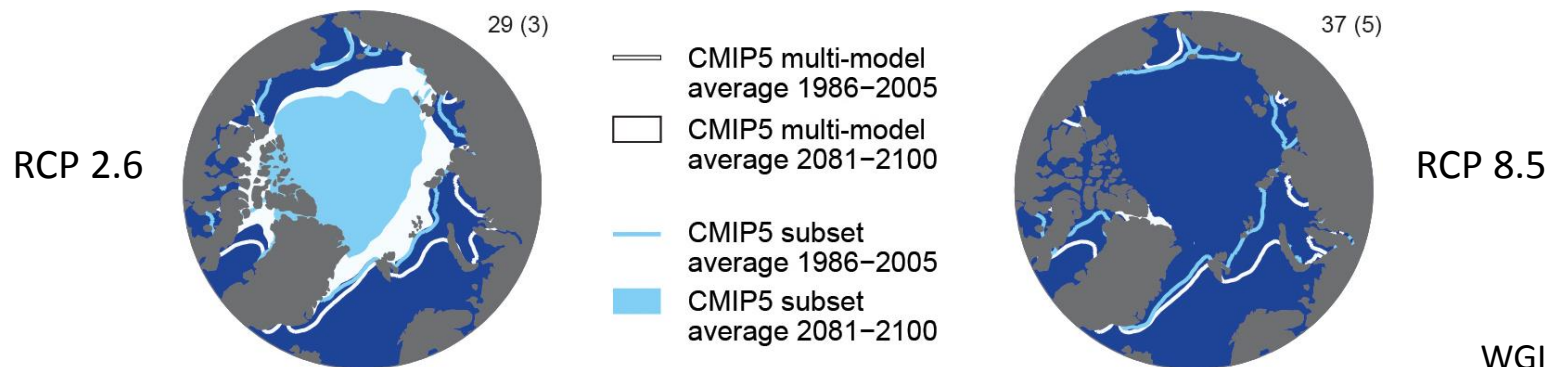


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OA 2013

Northern Hemisphere September sea ice extent: Marginalization with continued warming



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



...retreat of ice associated ecosystems also along the Antarctic peninsula and in the Antarctic sea ice zone (incl. krill and some penguins species affected)

...marginalization of high polar systems due to warming (!), exacerbated by acidification (!?)

A polar bear is walking across a vast, flat expanse of sea ice. The ice is a pale, textured blue-grey color, with several dark, jagged cracks running across it. The bear is in the lower-middle ground, facing right. The background is a uniform, light blue-grey, suggesting a distant horizon or a very large body of water under a pale sky.

Vulnerable ecosystems
Arctic sea ice ecosystem

Thank you