Sensitivity of the Eastern Tropical South Pacific Oxygen Minimum Zone to Climate Change

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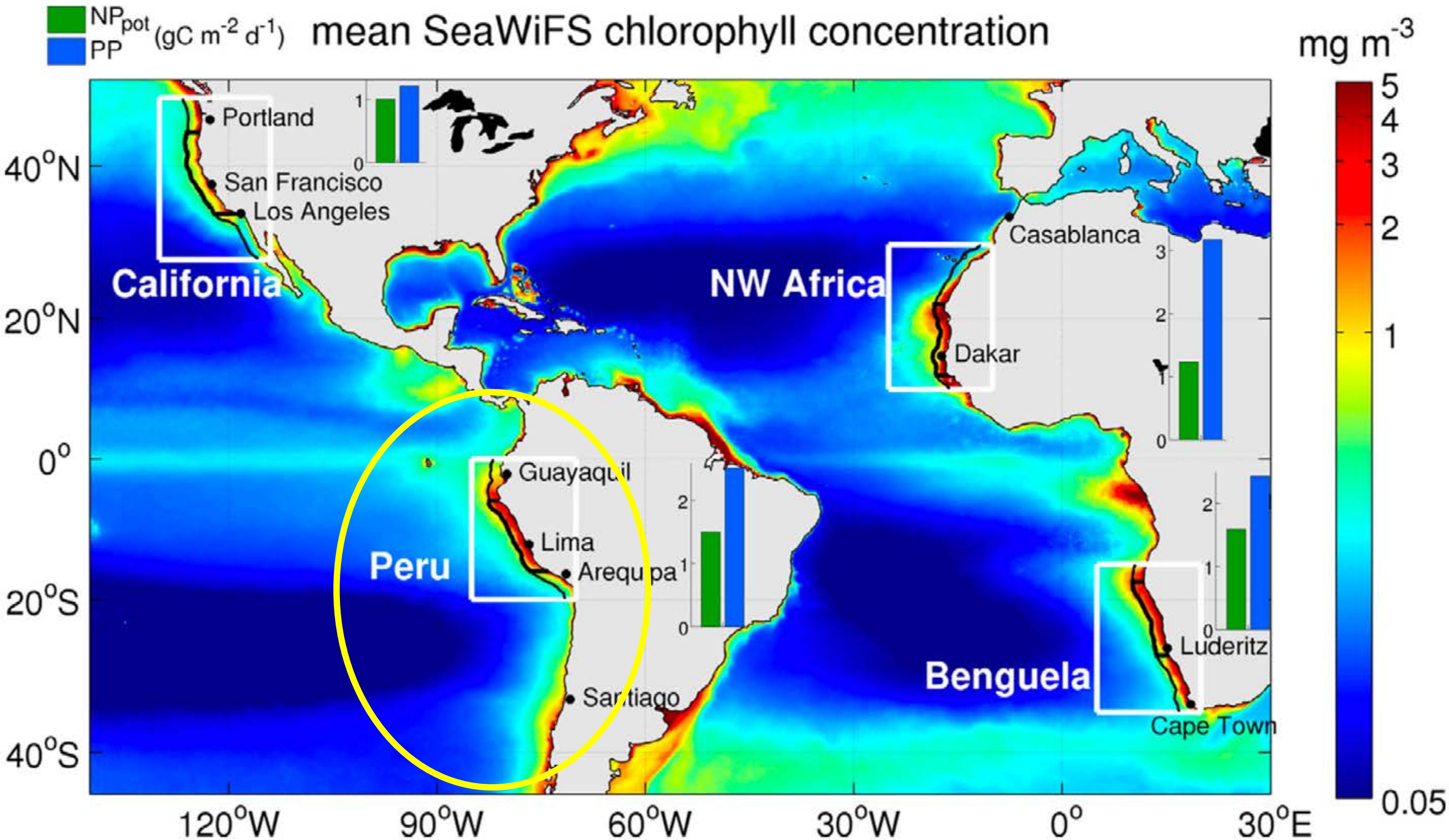
SFB 754

GO_2NE
Global Ocean Oxygen NEtwork

GEOMAR

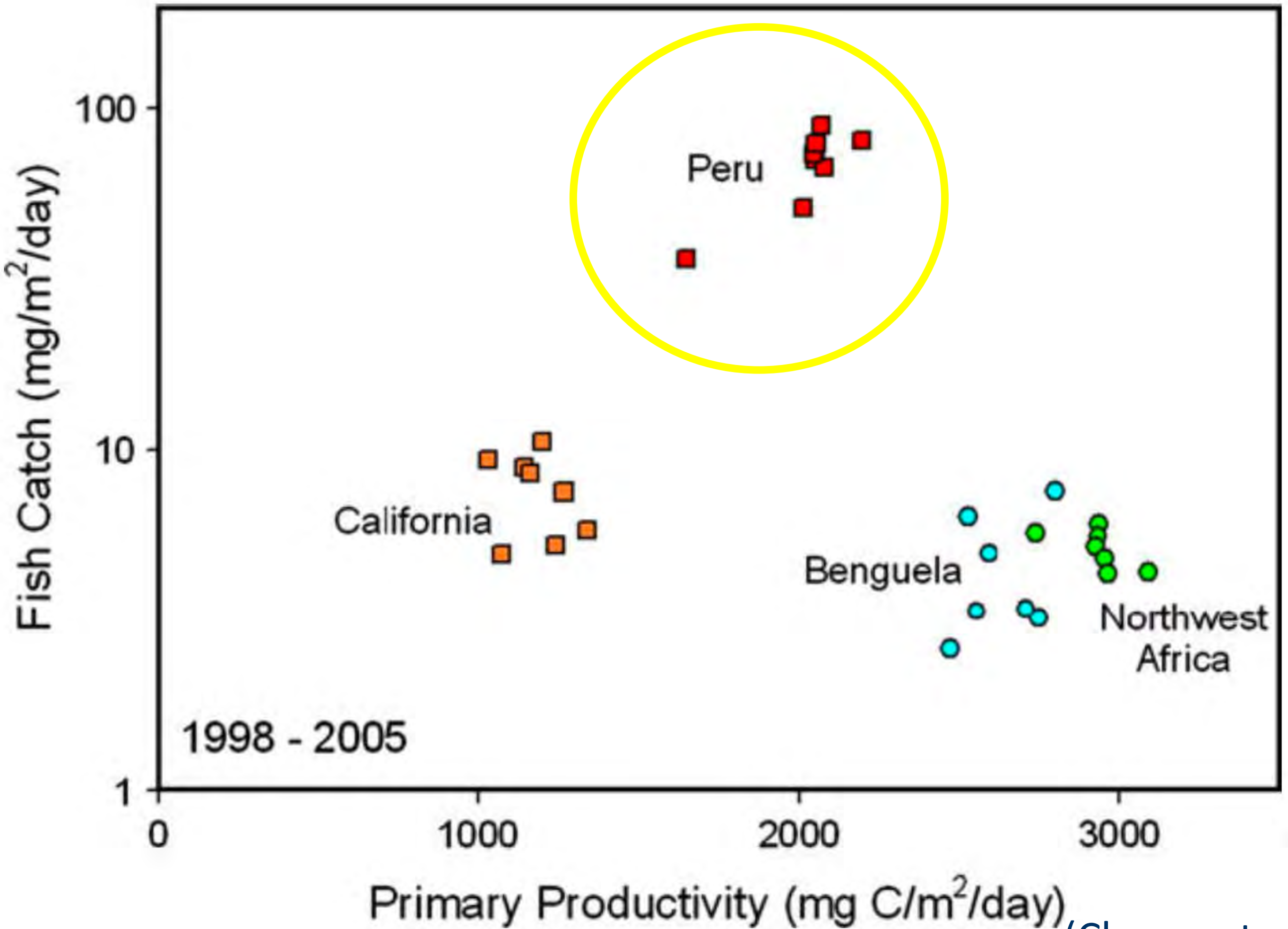
Eastern Boundary Upwelling Systems



(Messié & Chavez, Prog.Oc. 2015)

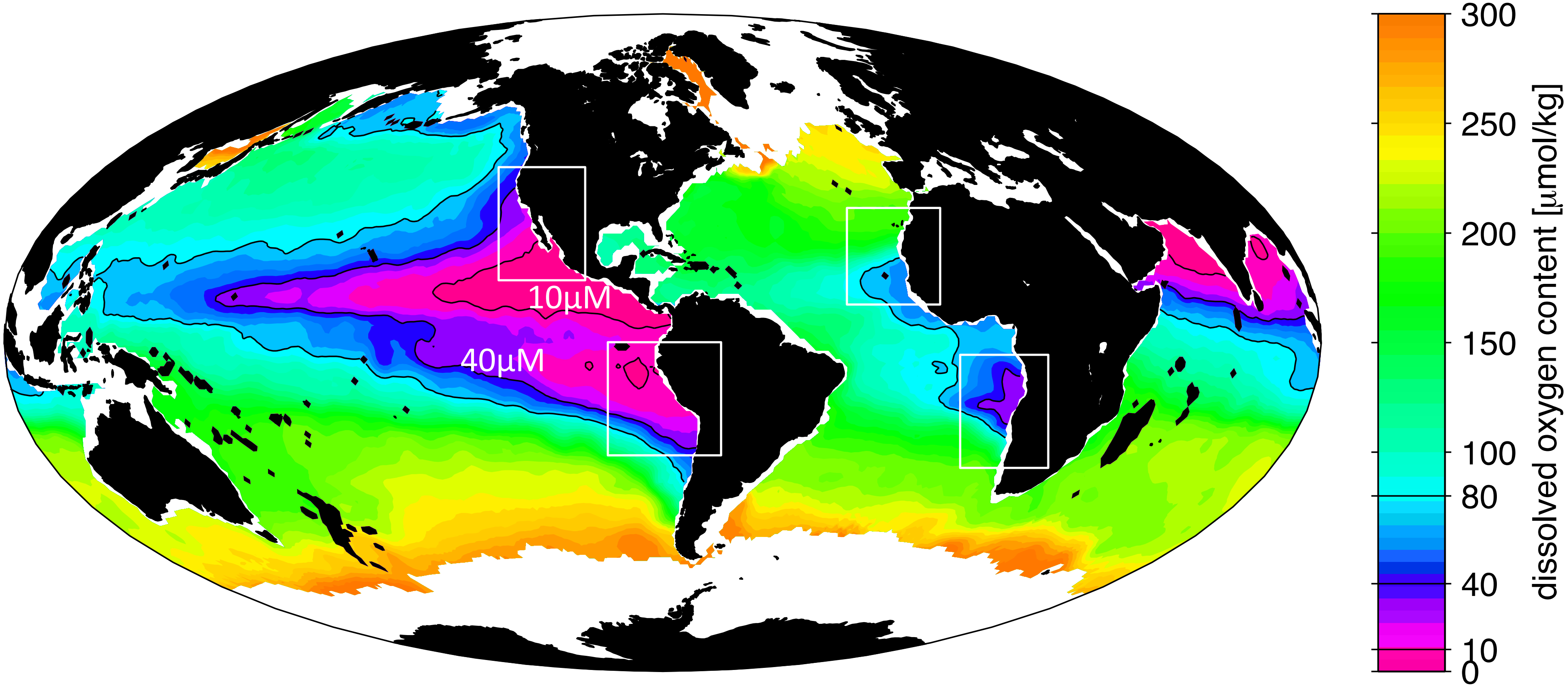
Peruvian upwelling is special

- Highest fish catch in Peruvian Upwelling



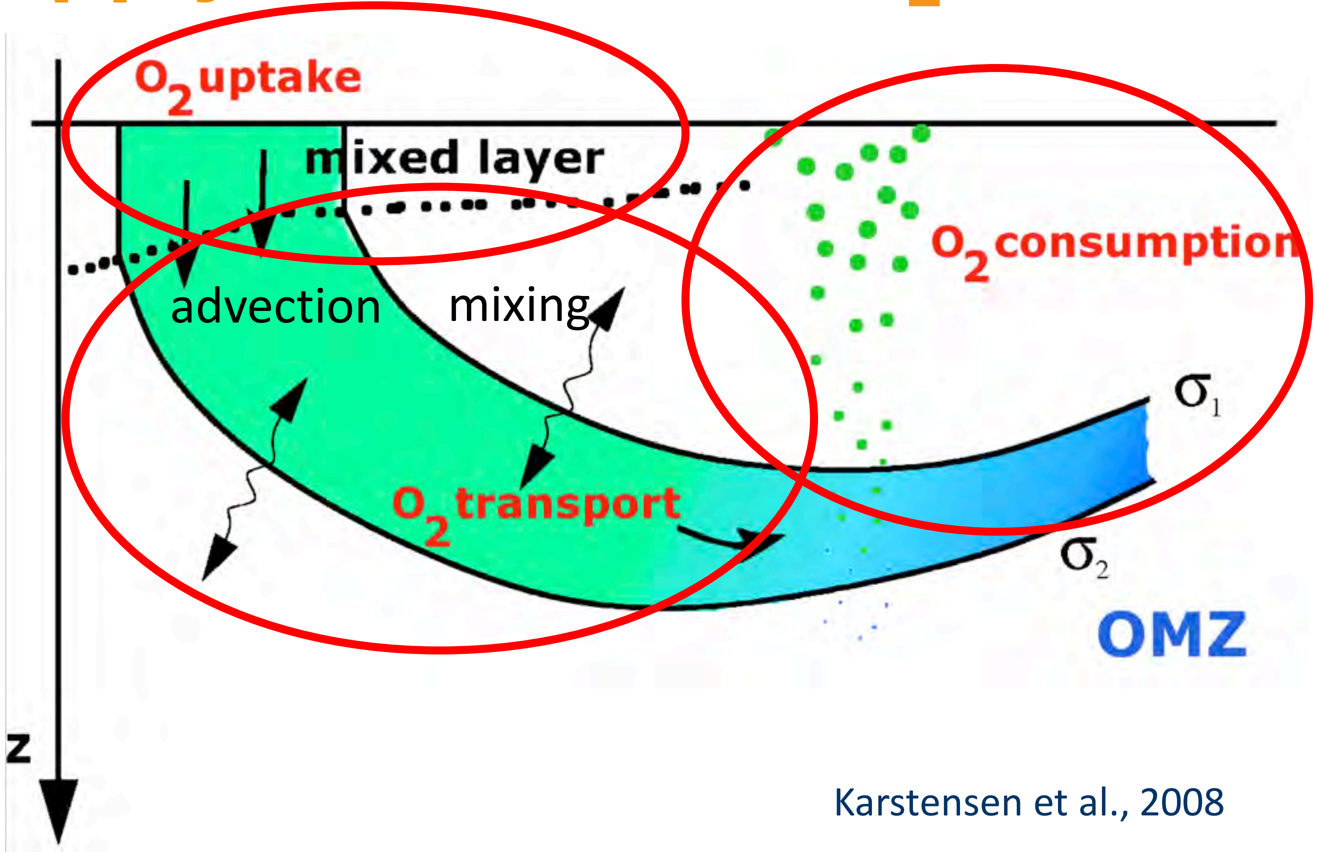
(Chavez et al., Prog.Oc. 2008)

Oxygen Minimum Zones in the tropical oceans



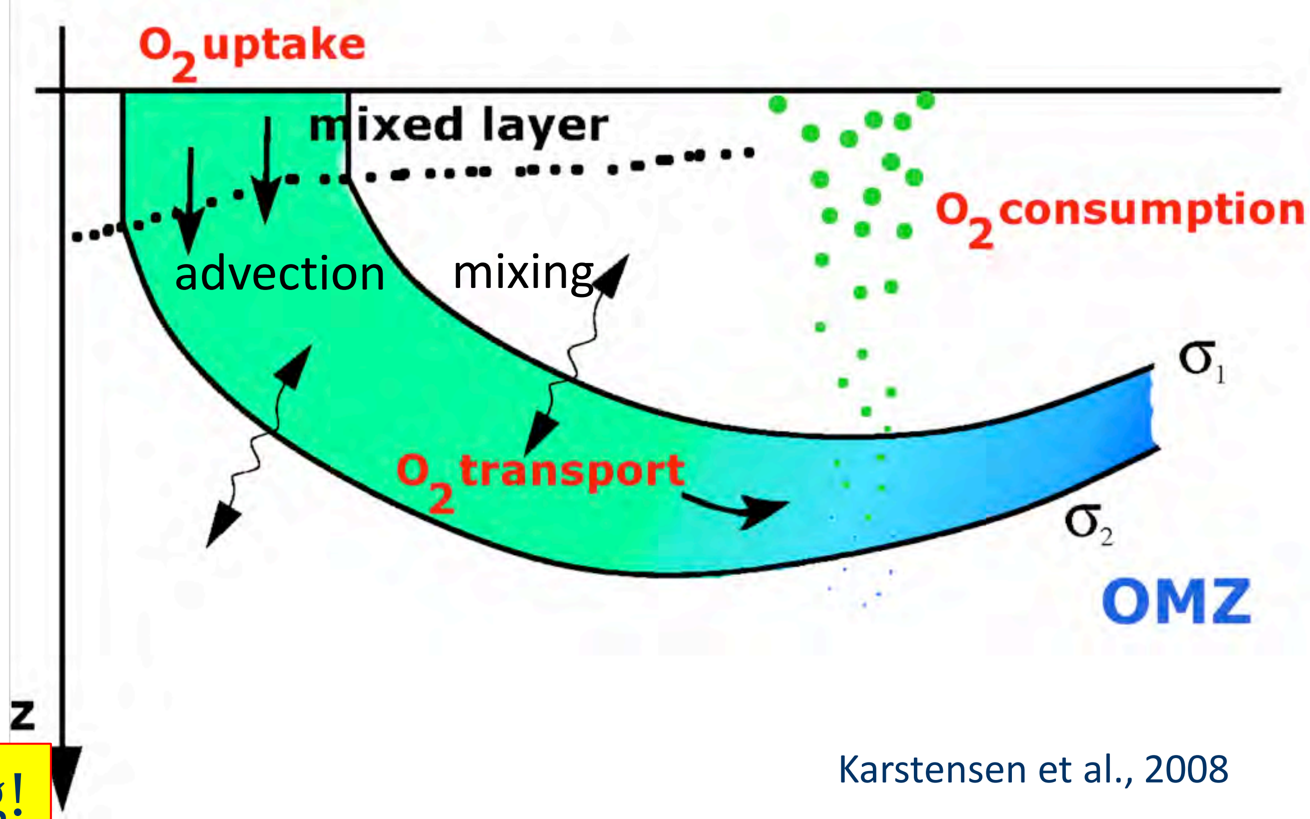
O_2 on σ=26.9 isopycnal

OMZs: Close interplay between sluggish O_2 supply and intense O_2 consumption



- **O_2 uptake**: Gas exchange with atmosphere
- **O_2 transport**: supply via vertical mixing & circulation
- **O_2 consumption** via respiration of organic matter

OMZs: Close interplay between sluggish O_2 supply and intense O_2 consumption



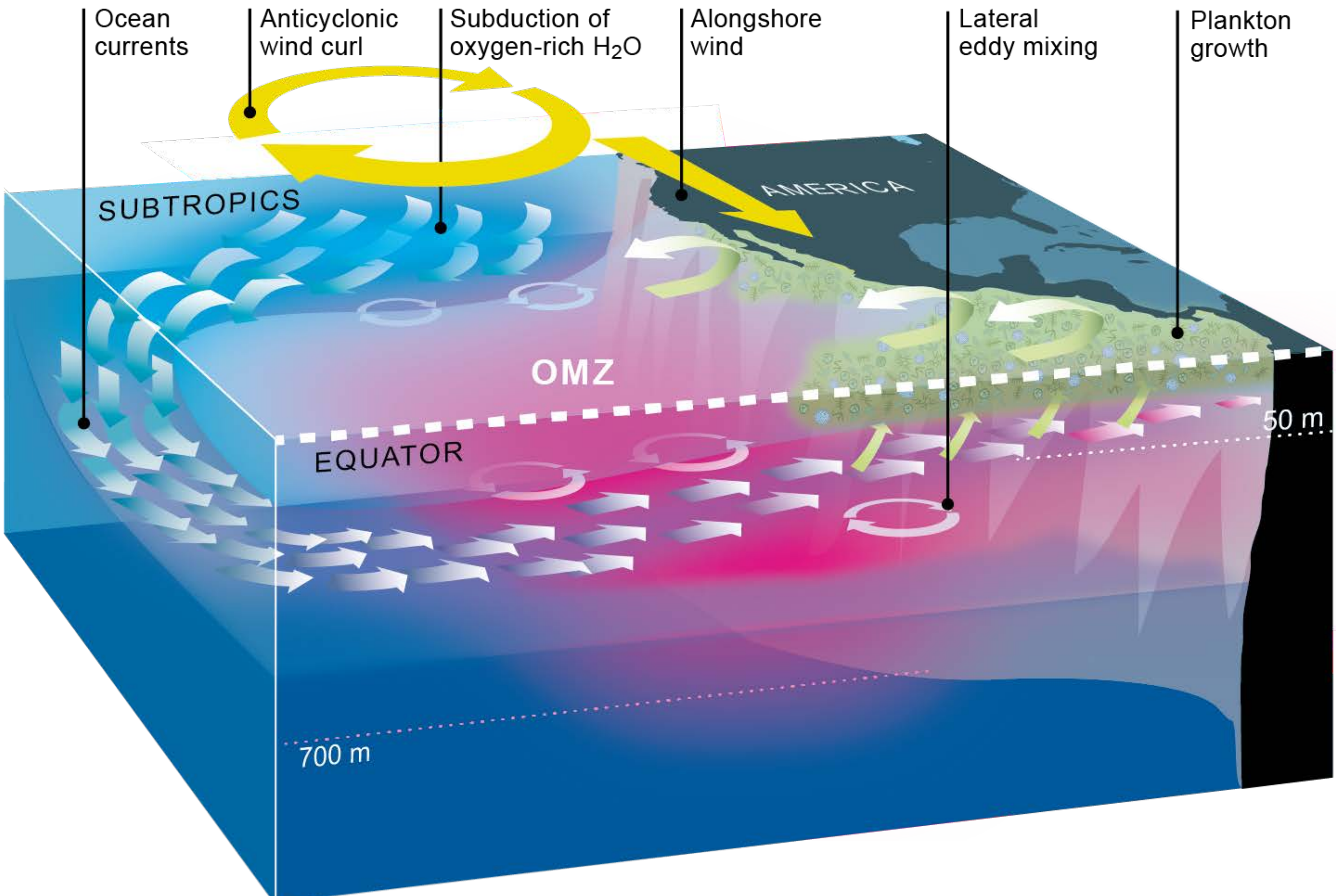
Karstensen et al., 2008

Warming!

- **O_2 uptake**: Gas exchange with atmosphere
- ? **O_2 transport**: supply via vertical mixing & circulation
- ? **O_2 consumption** via respiration of organic matter

More dimensions…

- Remote processes may matter.
- Supply of oxygen and nutrients closely interlinked.

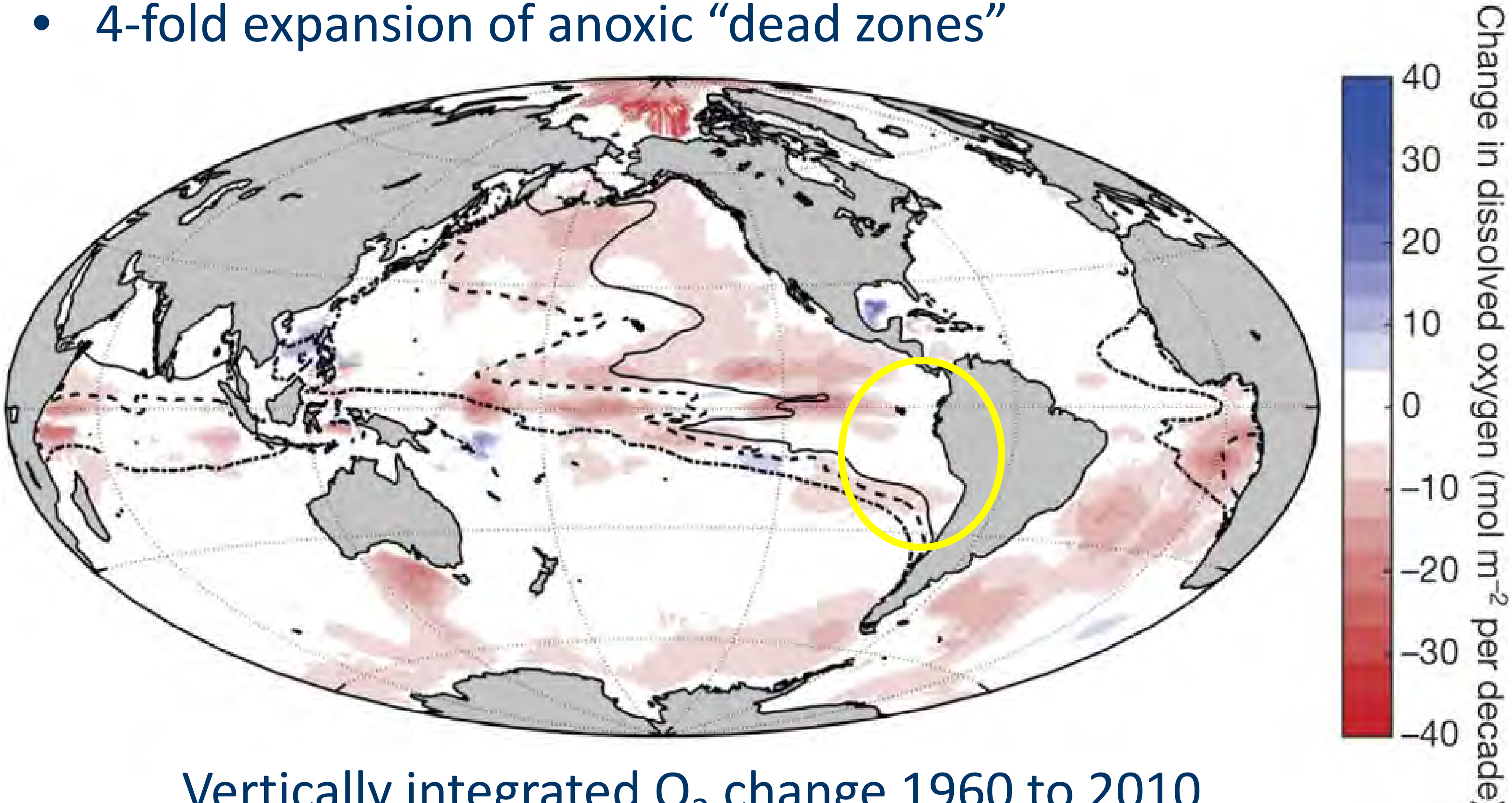


(Oschlies et al., Nat.Geo. in press)

Major climate impact: Ocean deoxygenation

Observational estimate:

- 2% of oceanic inventory lost since 1960
- 4-fold expansion of anoxic "dead zones"

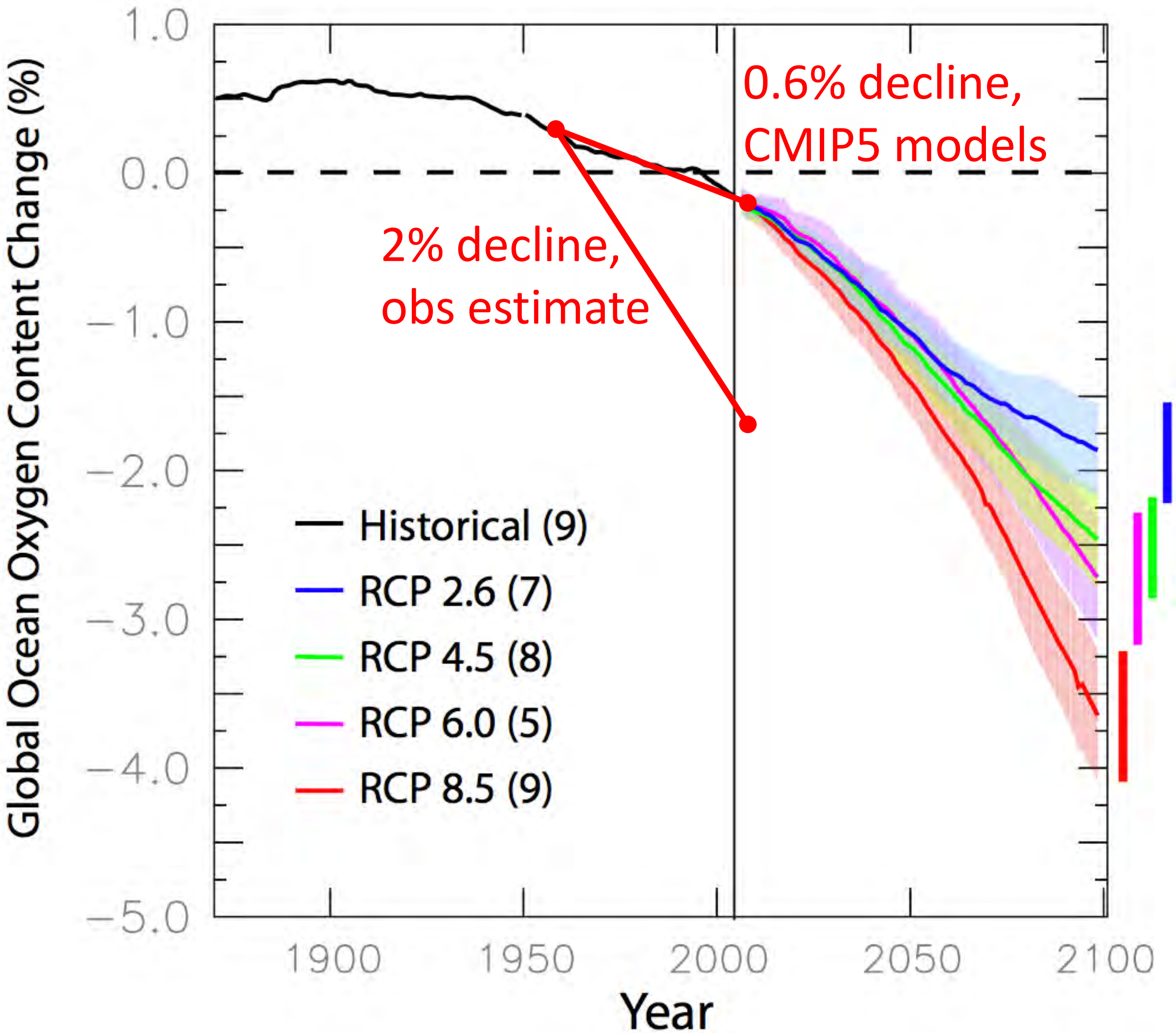


Vertically integrated O_2 change 1960 to 2010

(Schmidtko et al., Nature 2017)

Ocean deoxygenation

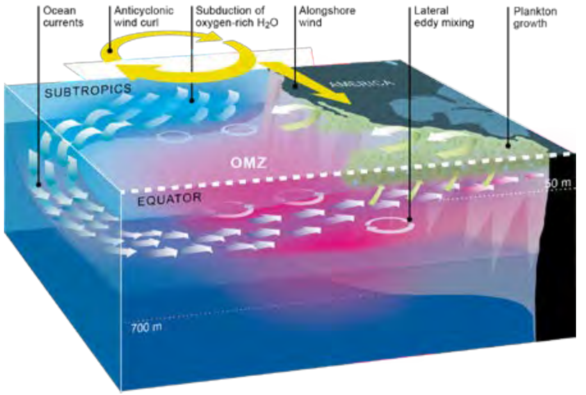
Models predict further O_2 decline under global warming



more warming,
less oxygen

(Bopp et al., BG 2013)

Agenda

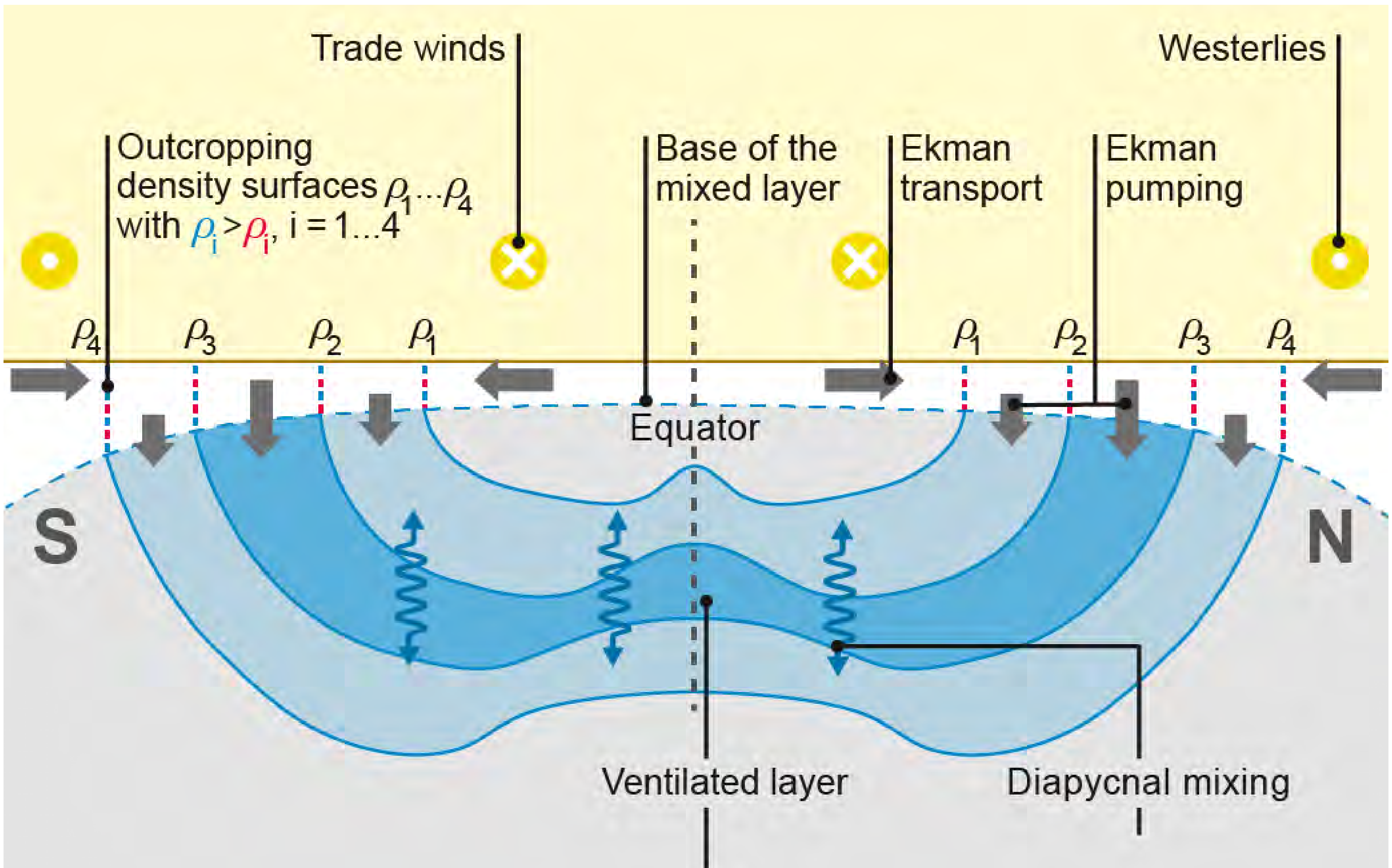


Aspects of climate change

- Warming, enhanced stratification
- Regional winds
- Southern Ocean winds
- The ”complete” picture

Effects of warming

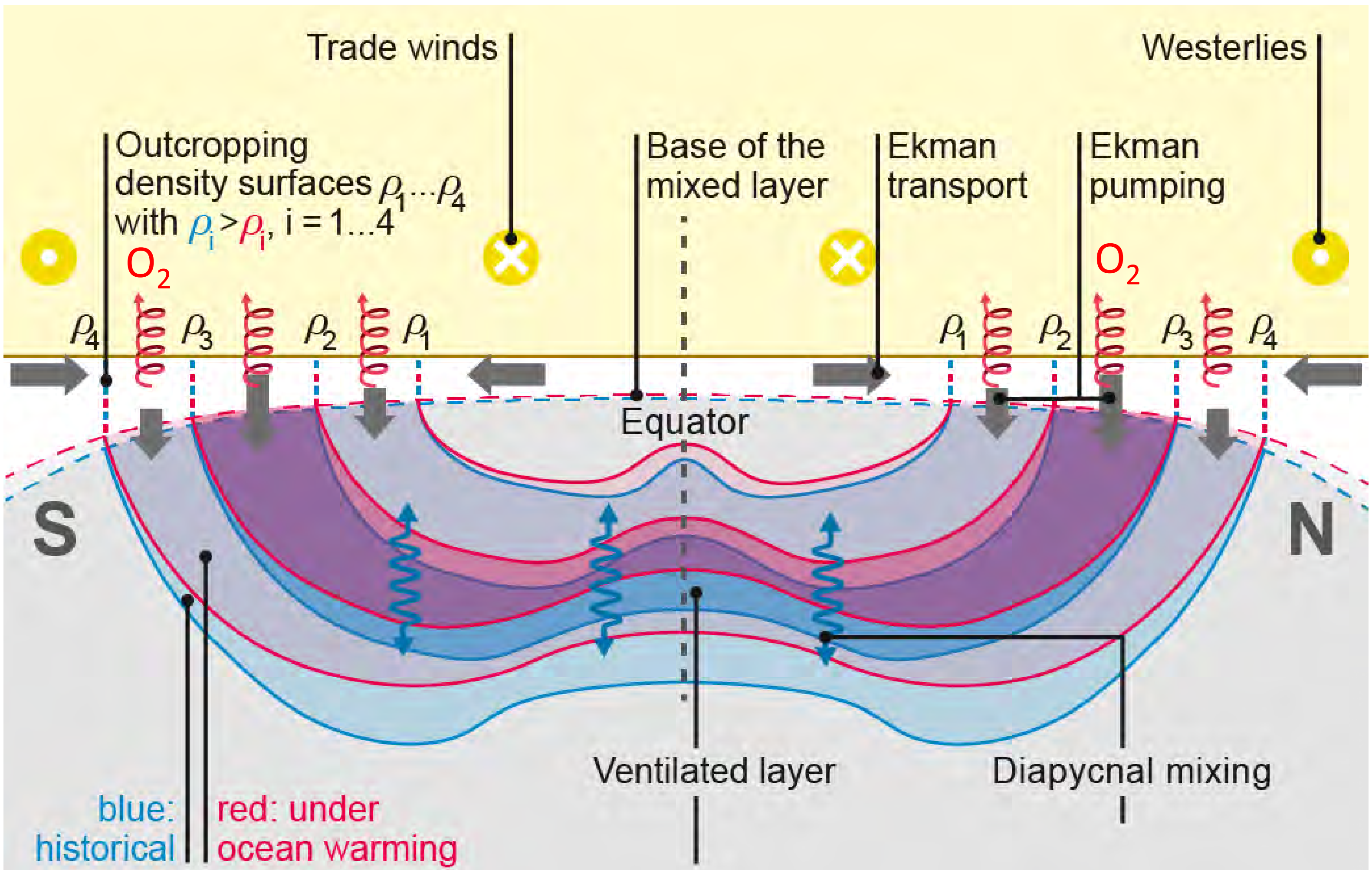
zonally averaged view of the upper ocean



(Oschlies et al., Nat.Geosci., in press)

Effects of warming

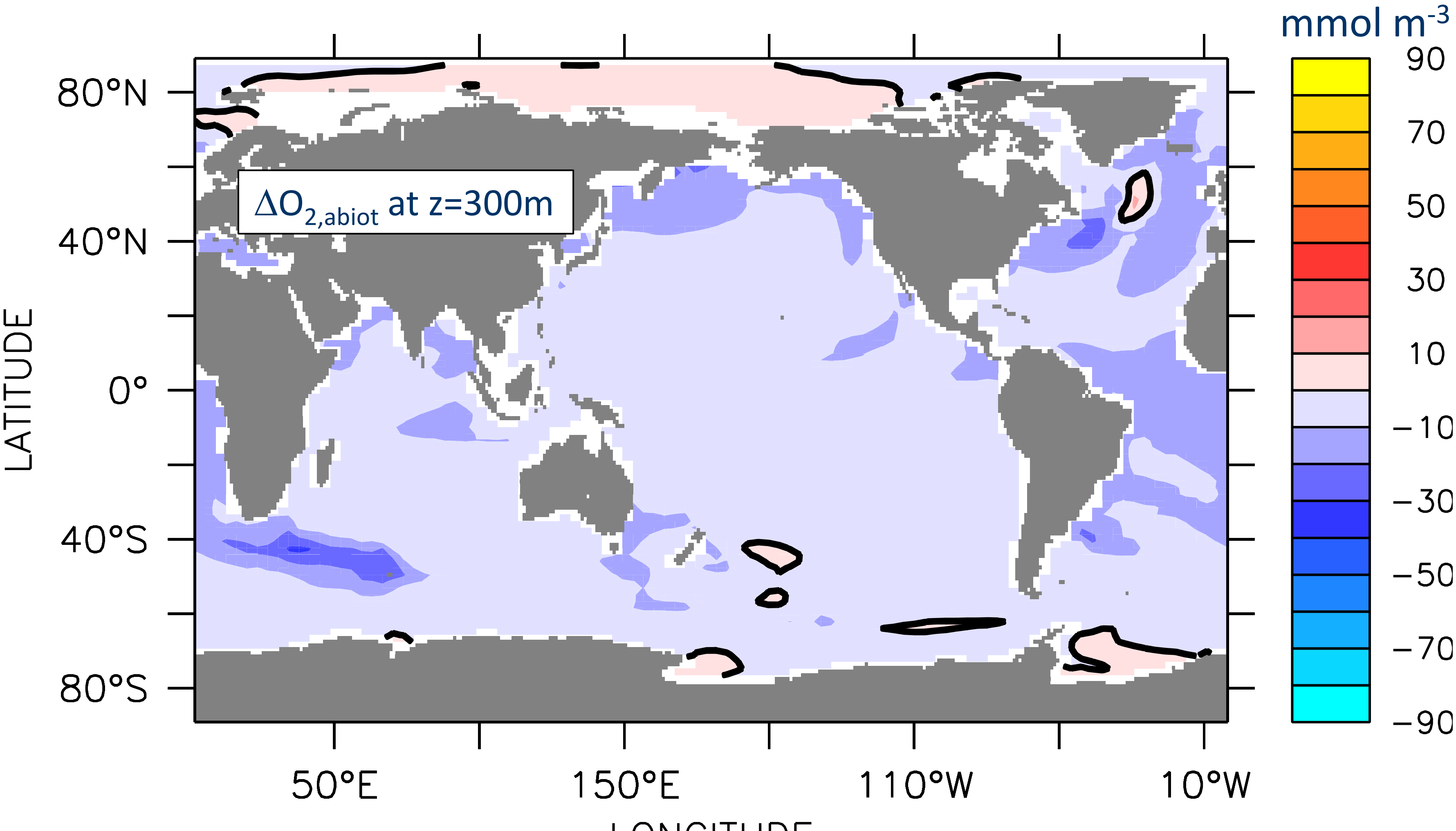
Drop in solubility, enhanced stratification



(Oschlies et al., Nat.Geosci., in press)

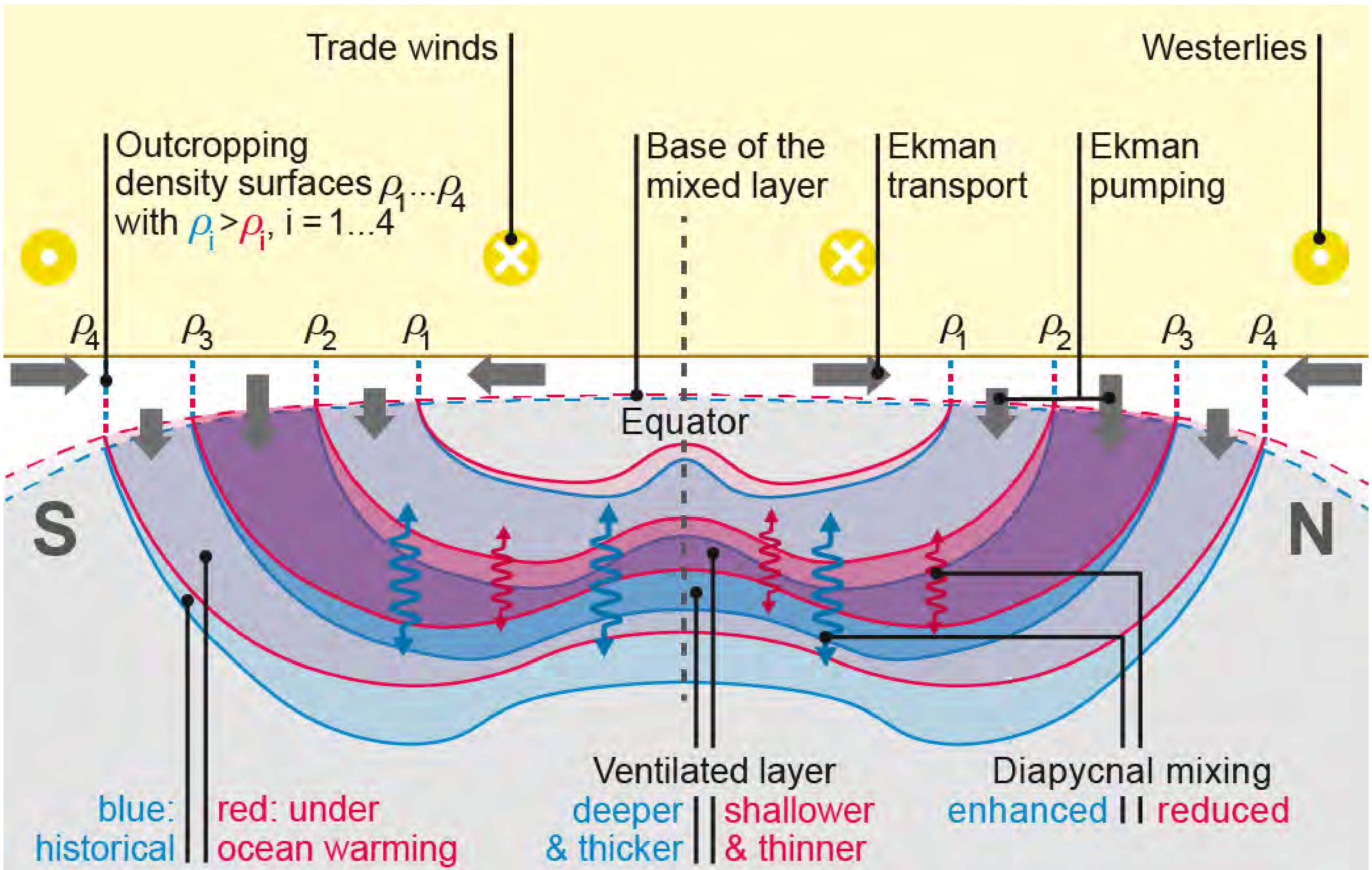
Effects of warming

Change in "abiotic O_2" (z=300m, yr 2100 – 1990)



Effects of warming

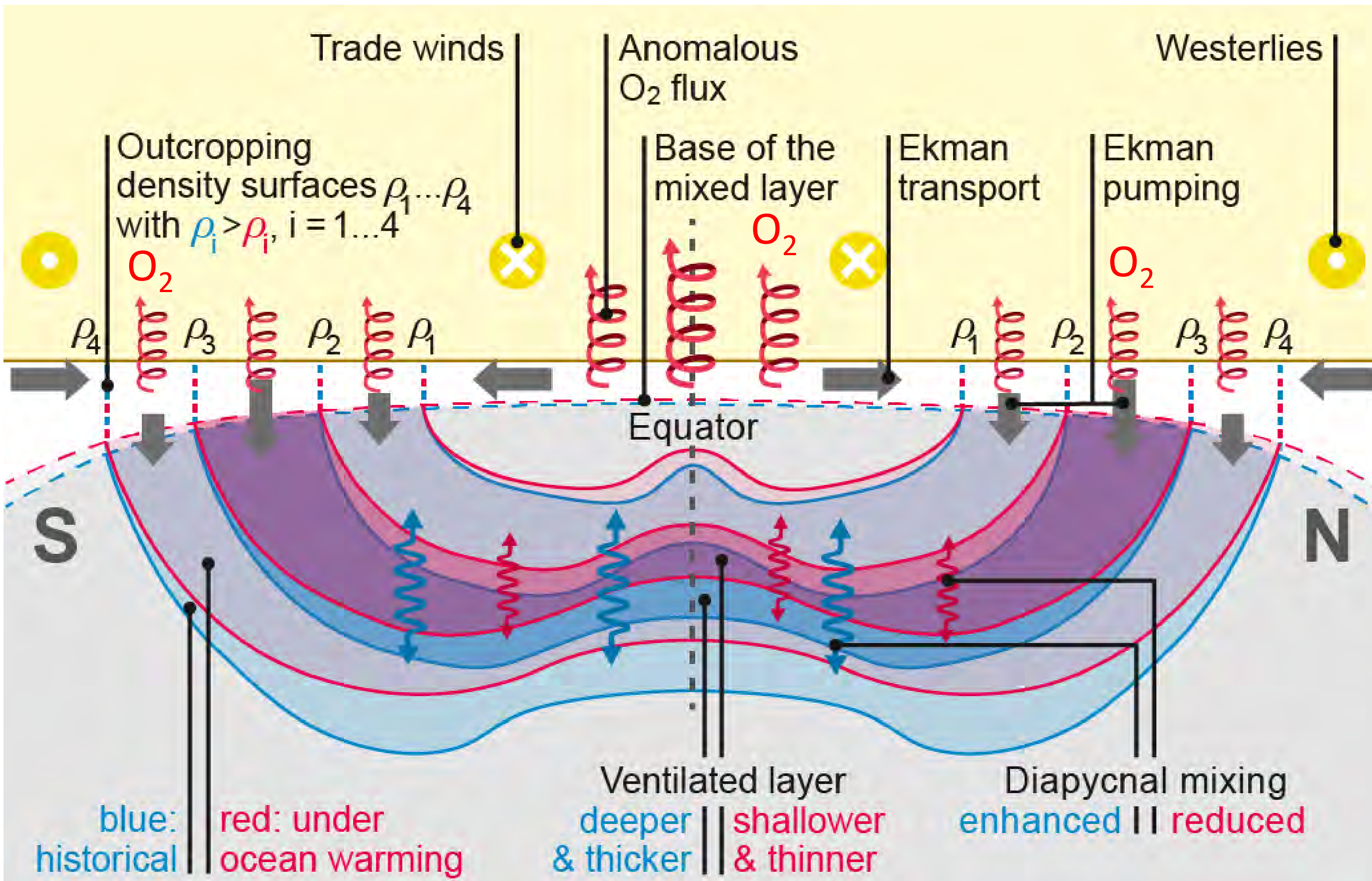
enhanced stratification, reduced mixing



(Oschlies et al., Nat.Geosci., in press)

Effects of warming

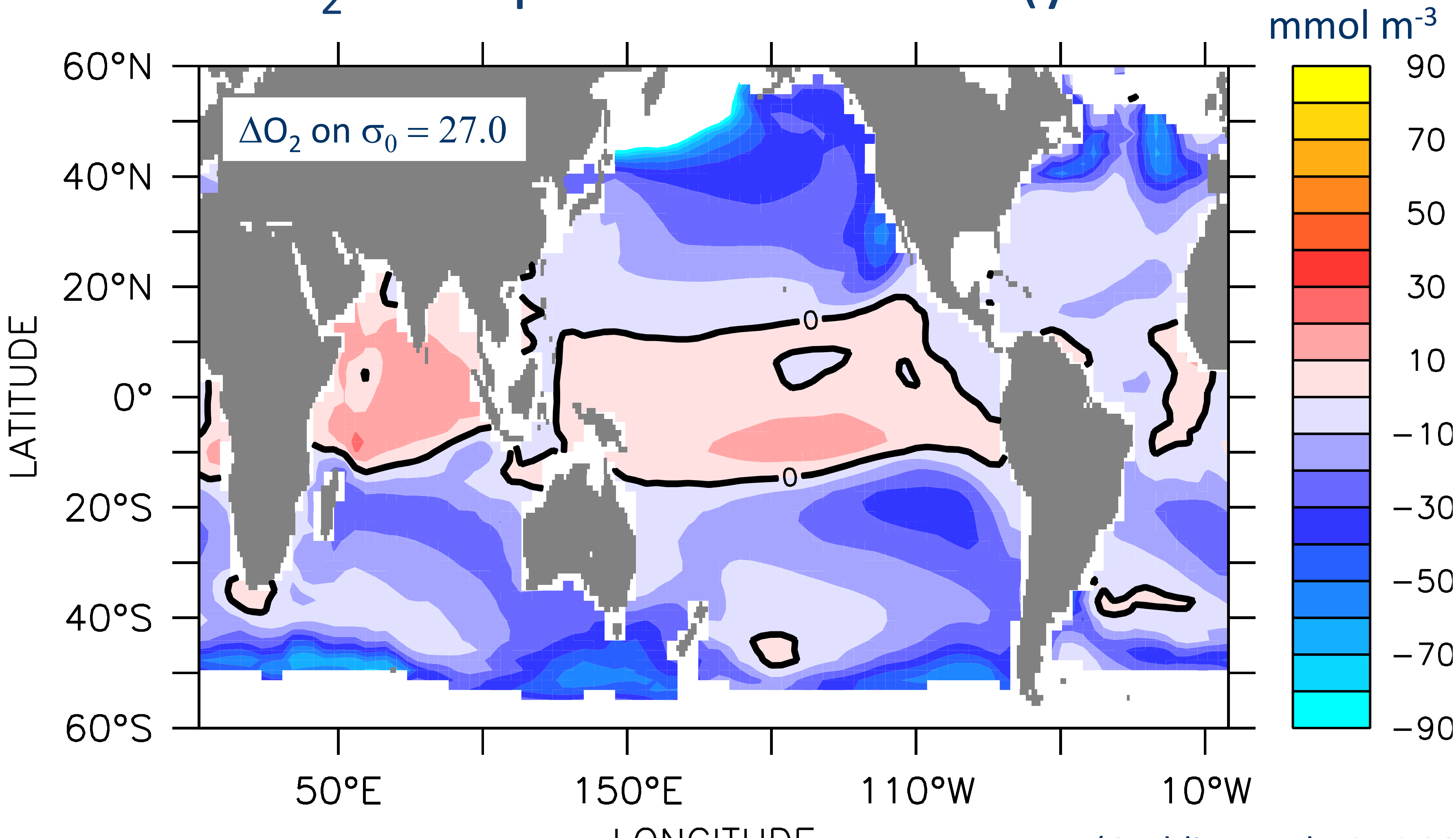
shallower thermocline → faster ventilation, less mixing, more oxygenated waters



(Oschlies et al., Nat.Geosci., in press)

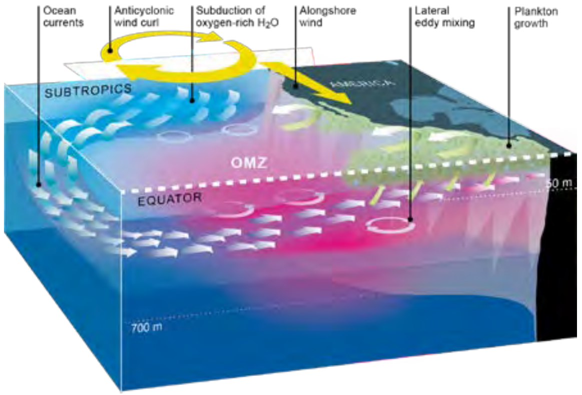
Effects of warming
(no change in winds)

Elevated O_2 in tropical thermocline (yr 2100 – 1990)



(Oschlies et al., GBC 2008)

Conclusions (i)



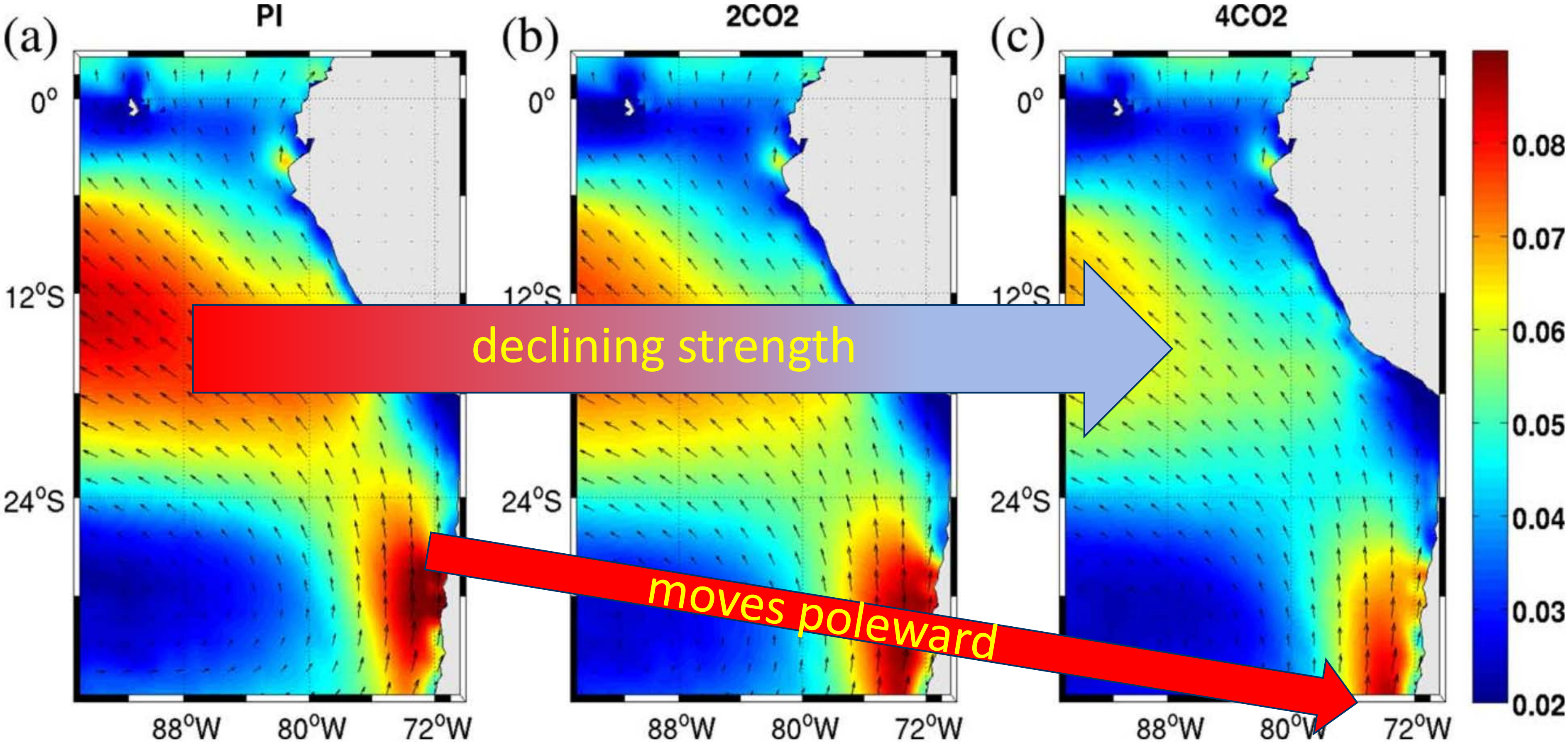
<u>Aspects of climate change</u>

- Warming & enhanced stratification → O_2 ↑

Expected regional wind changes

Weakening of Walker circulation

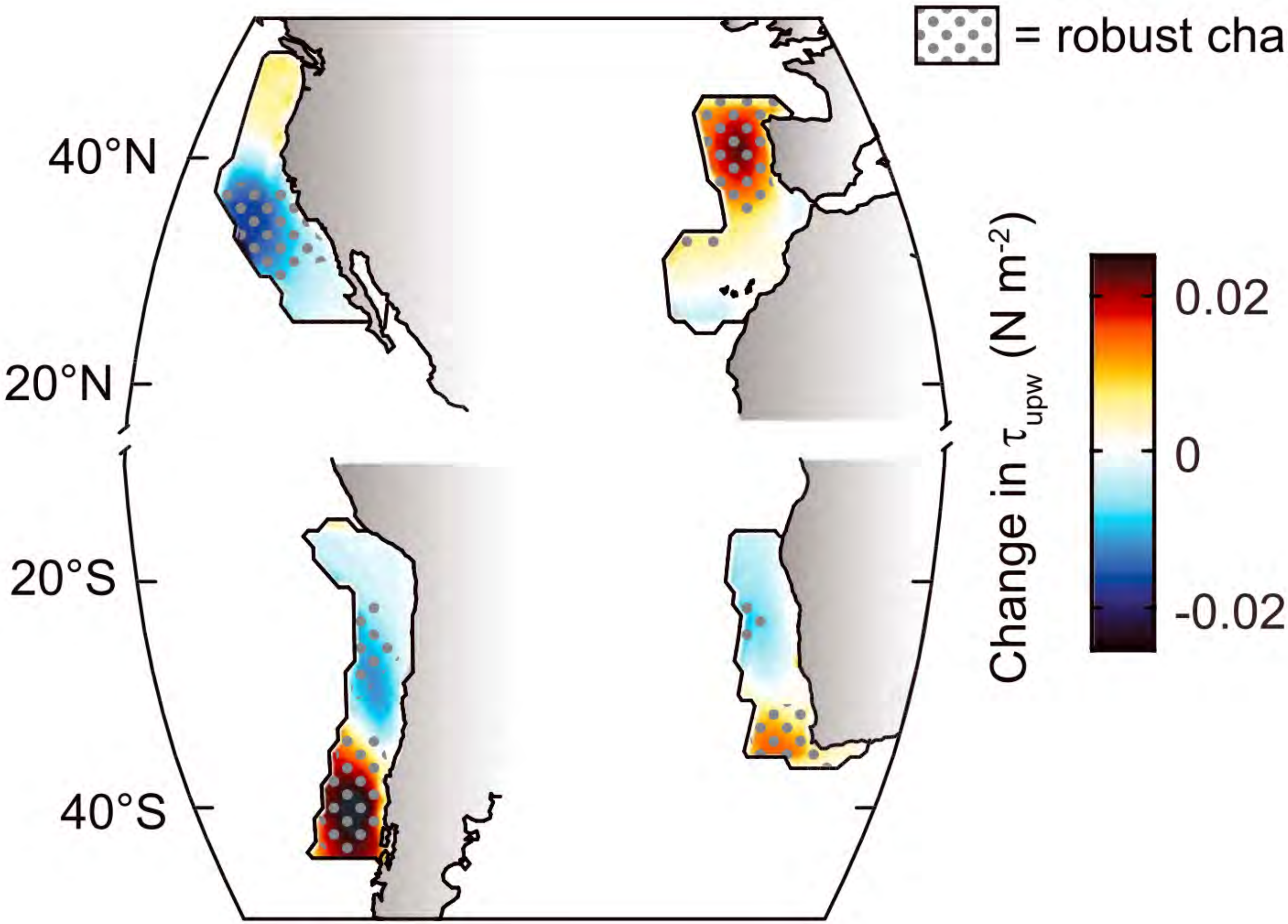
Poleward extension of upwelling-favorable winds



(Oerder et al., JGR 2015)

Effects of regional wind changes

CMIP5 mean change (2071-2100 minus 1861-1890)



increase in equatorward along-shore winds

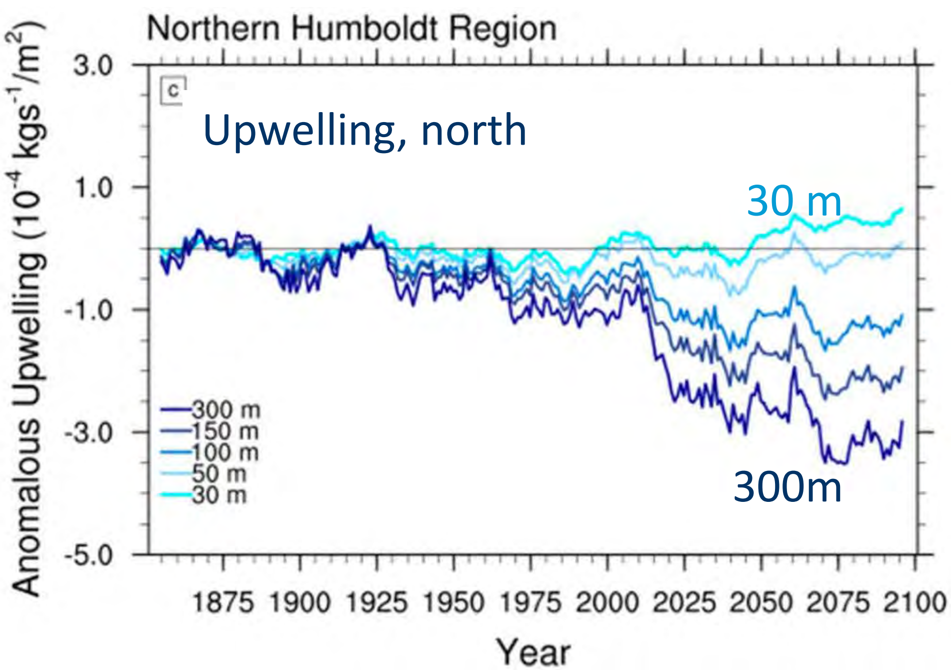
decrease in equatorward along-shore winds

(Rykaczewski et al., GRL 2015)

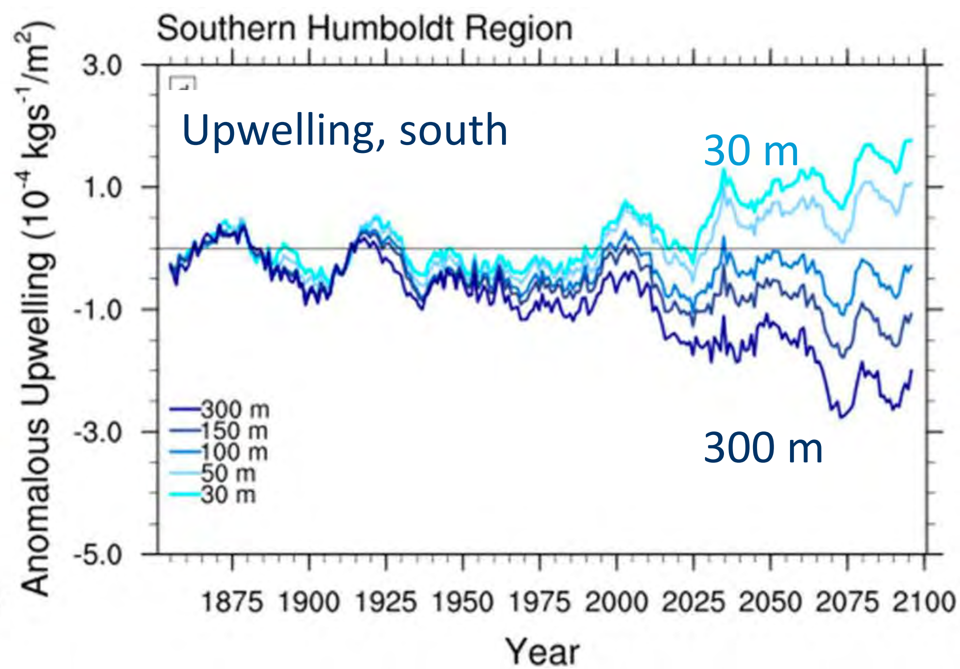
Effects of winds & warming on upwelling

CMIP5 ensemble mean

Upwelling, north (16ºS - 28ºS)



Upwelling, south (29ºS – 40ºS)



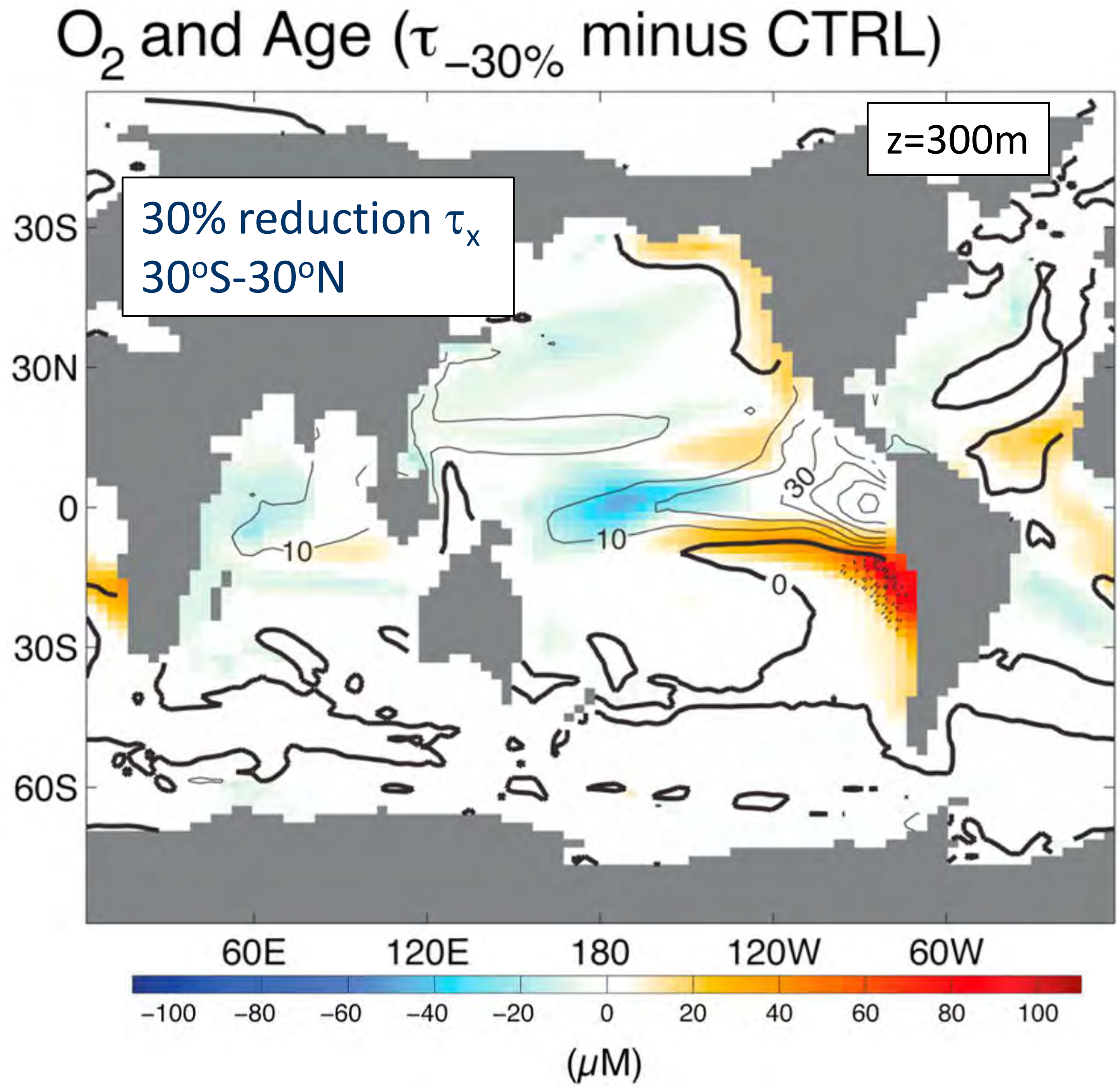
(Oyarzun & Brierley, Clim.Dyn. 2018)

Effects of tropical wind changes

Possible slow-down of Walker circulation

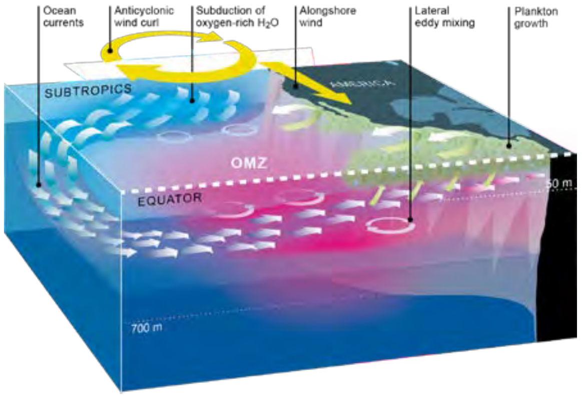
→ weaker trade winds, weaker EUC, weaker poleward undercurrent

→ more O_2-rich waters supplied from south



(Ridder & England, GBC 2014)

Conclusions (ii)

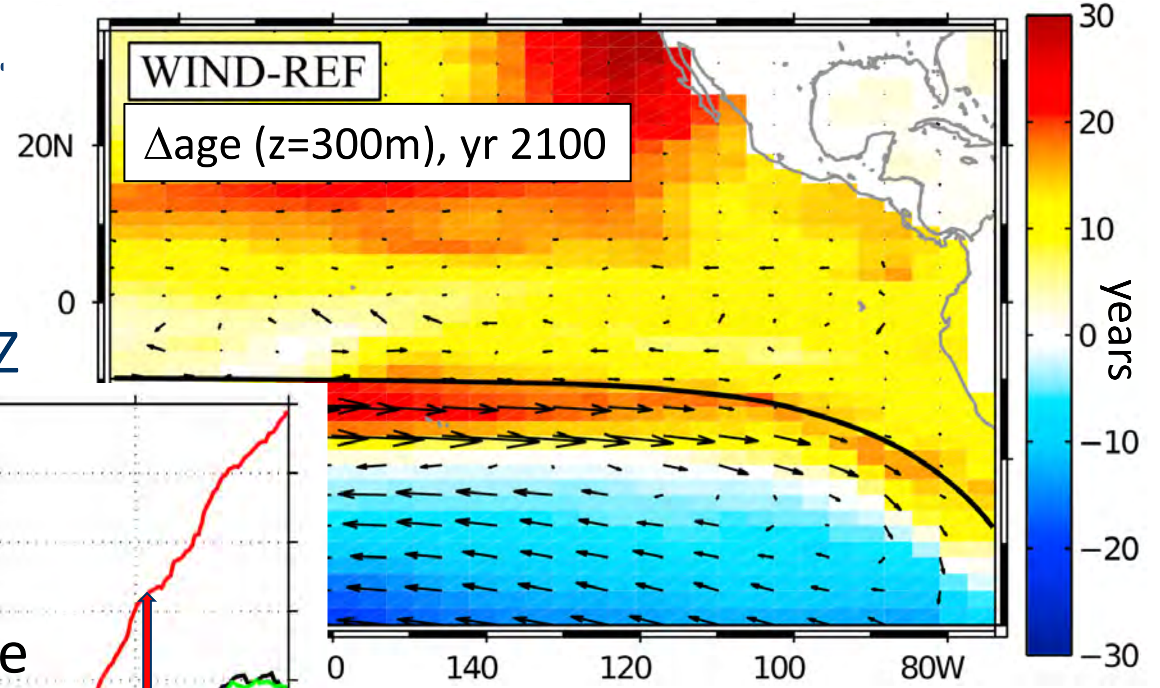


Aspects of climate change

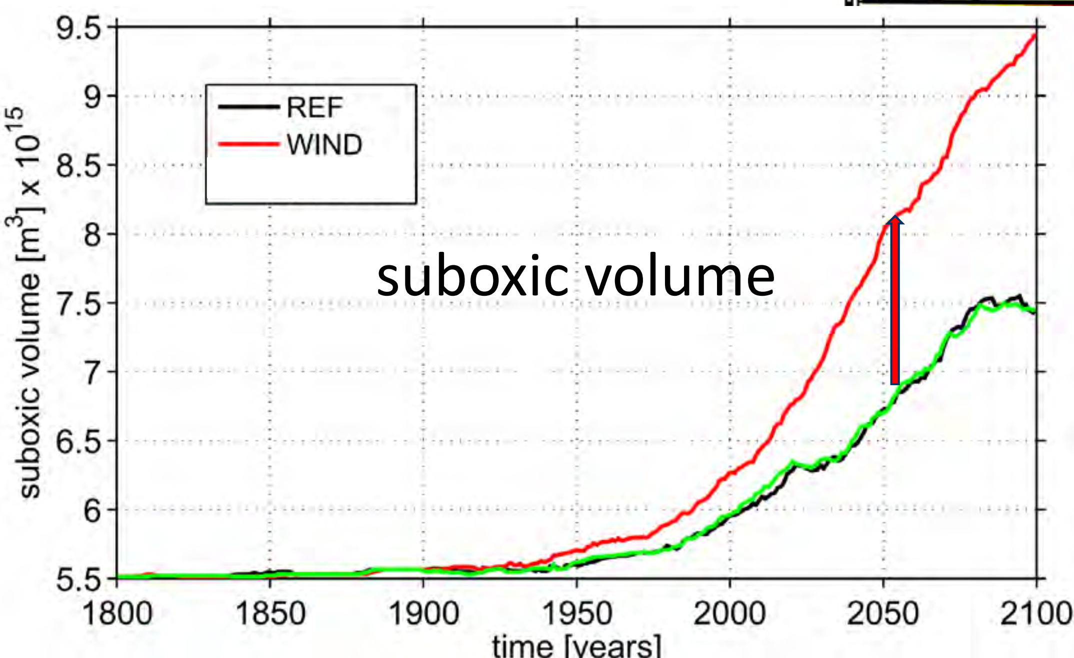
- Warming, enhanced stratification → O_2 ↑
- Regional winds → O_2 ↑

Effects of Southern Ocean wind changes

- Observed intensification and poleward shift of westerlies
- Faster ventilation from the south, but southward shift of S.H. subtropical gyre.

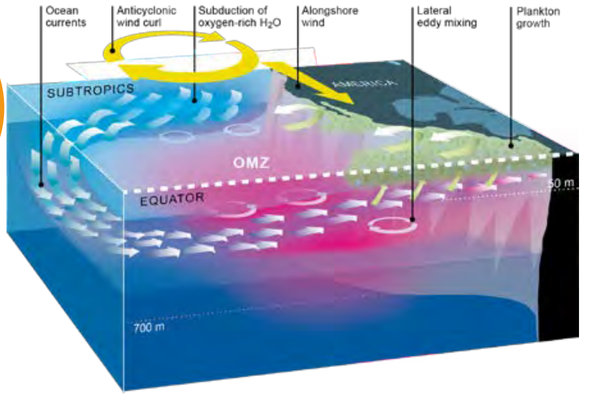


Intensification of ETSP OMZ



(Getzlaff et al., GRL 2016)

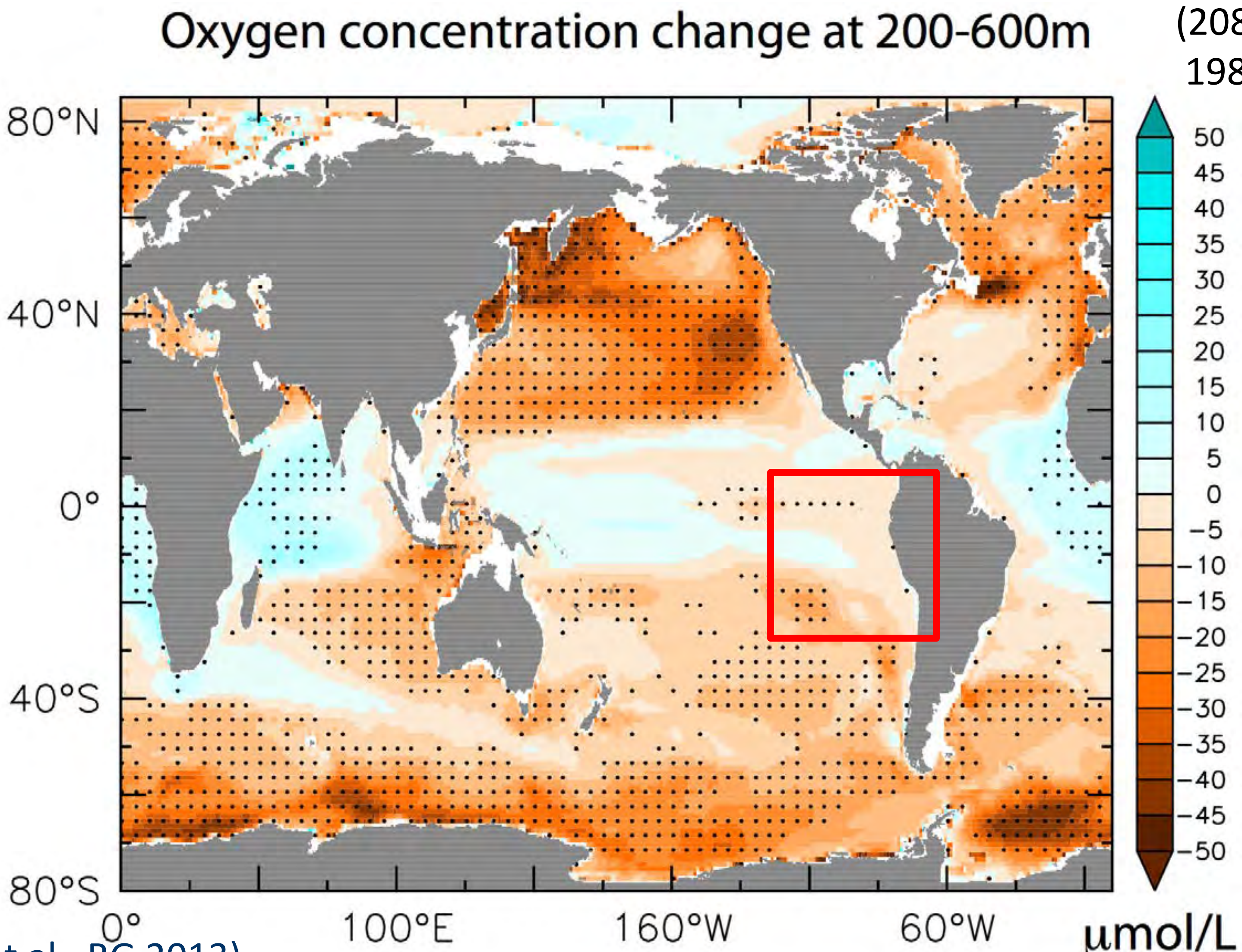
Conclusions (iii)



<u>Aspects of climate change</u>

- Warming, enhanced stratification → O_2 ↑
- Local winds → O_2 ↑
- Southern Ocean winds → O_2 ↓

The complete picture – according to the models…

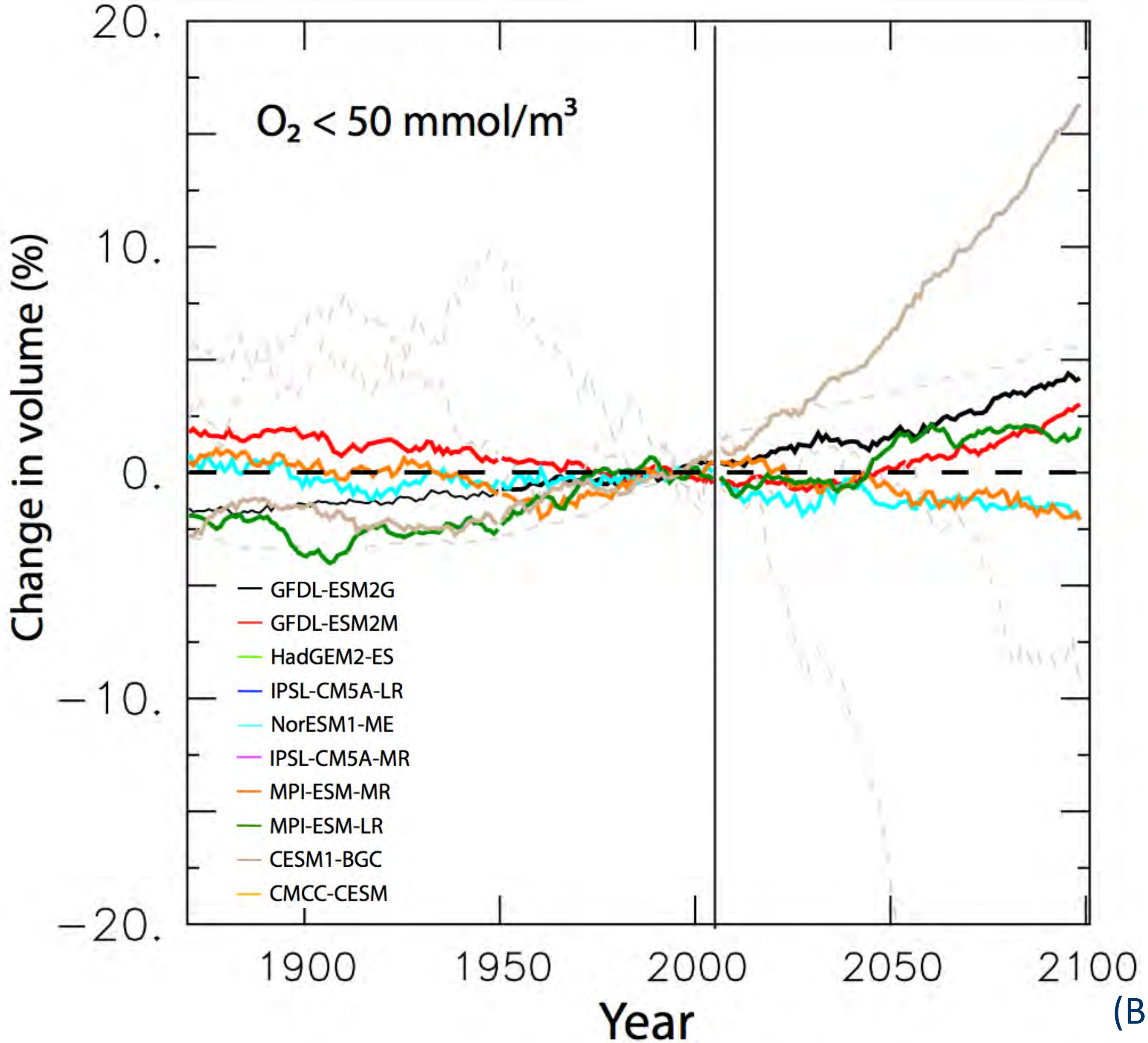


(2089-99 minus 1989-99)

O_2

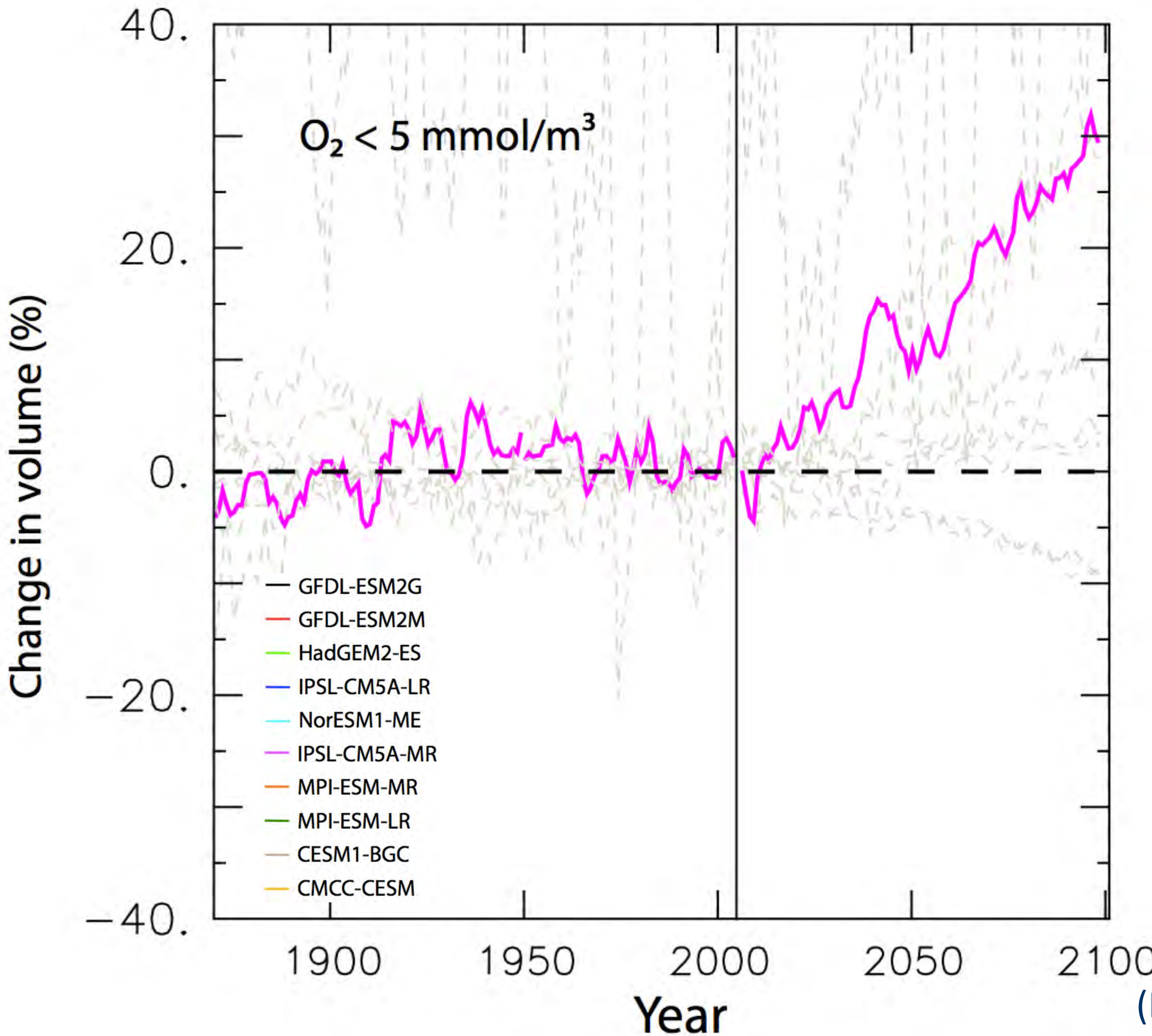
(Bopp et al., BG 2013)

CMIP5 models, V_{hypox}



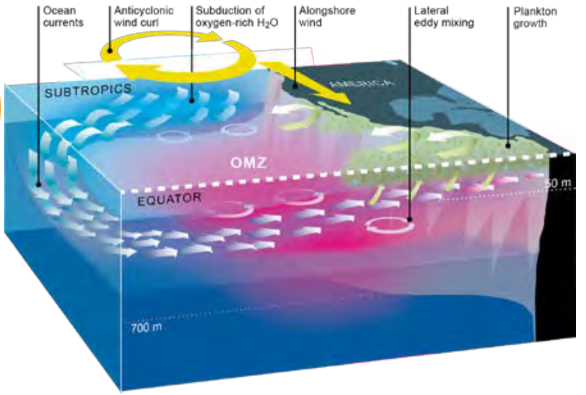
(Bopp et al., BG 2013)

CMIP5 models, V_{subox}



(Bopp et al., BG 2013)

Conclusions (iv)

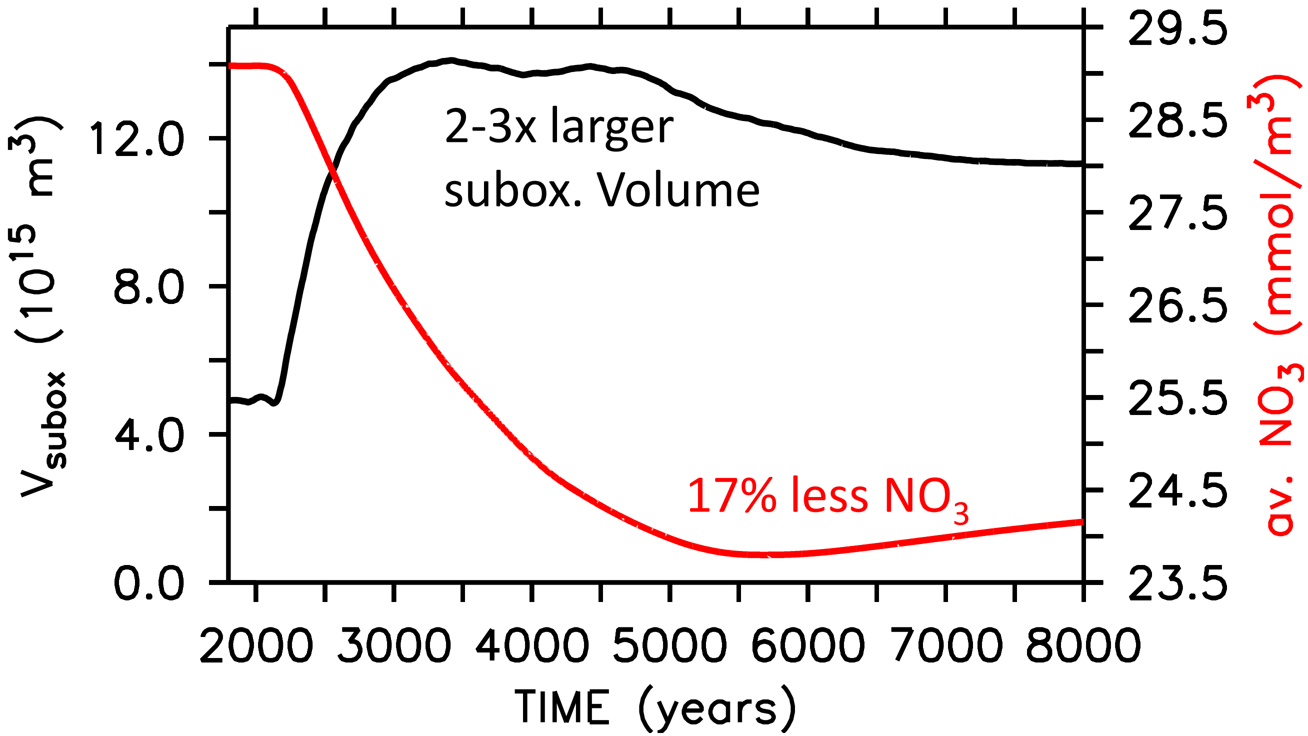


<u>Aspects of climate change</u>

- Warming, enhanced stratification → O_2 ↑
- Local winds → O_2 ↑
- Southern Ocean winds → O_2 ↓

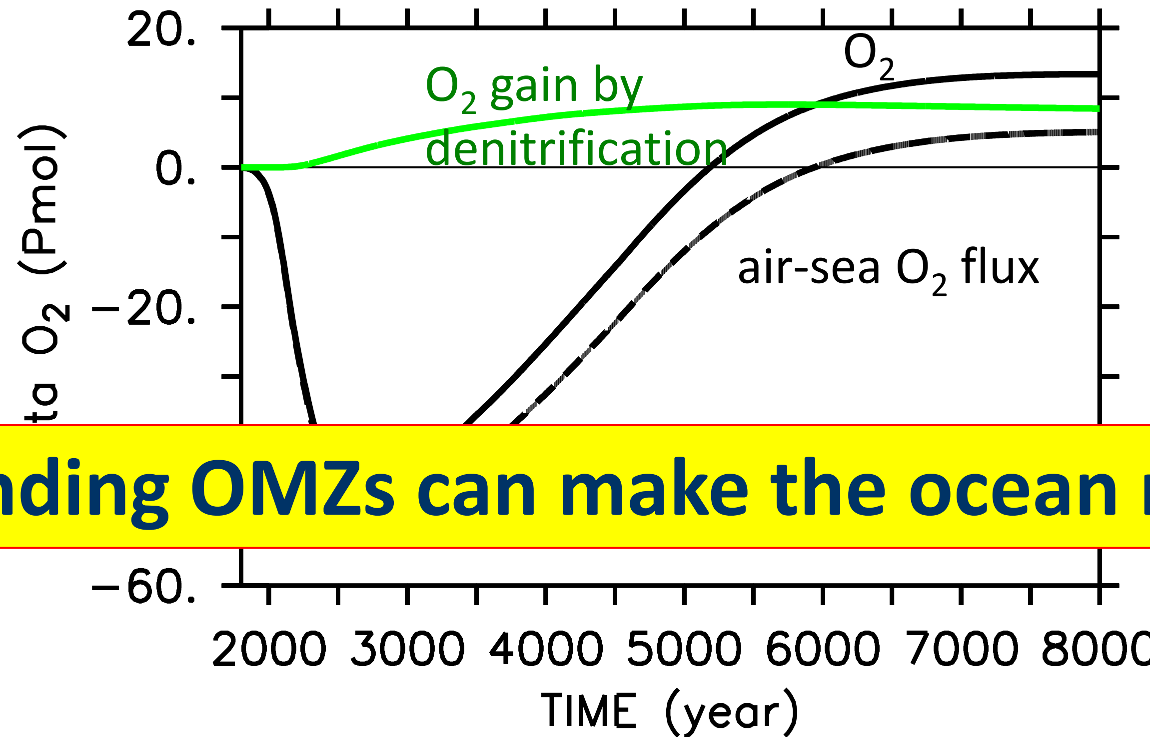
- The “complete” picture → O_2 ↓

Long-term legacy?



- 2-3-fold expansion of suboxic volume, ETSP, ETNP → denitrification and N_2 fixation more than double
- Net loss of fixed N

Long-term legacy?



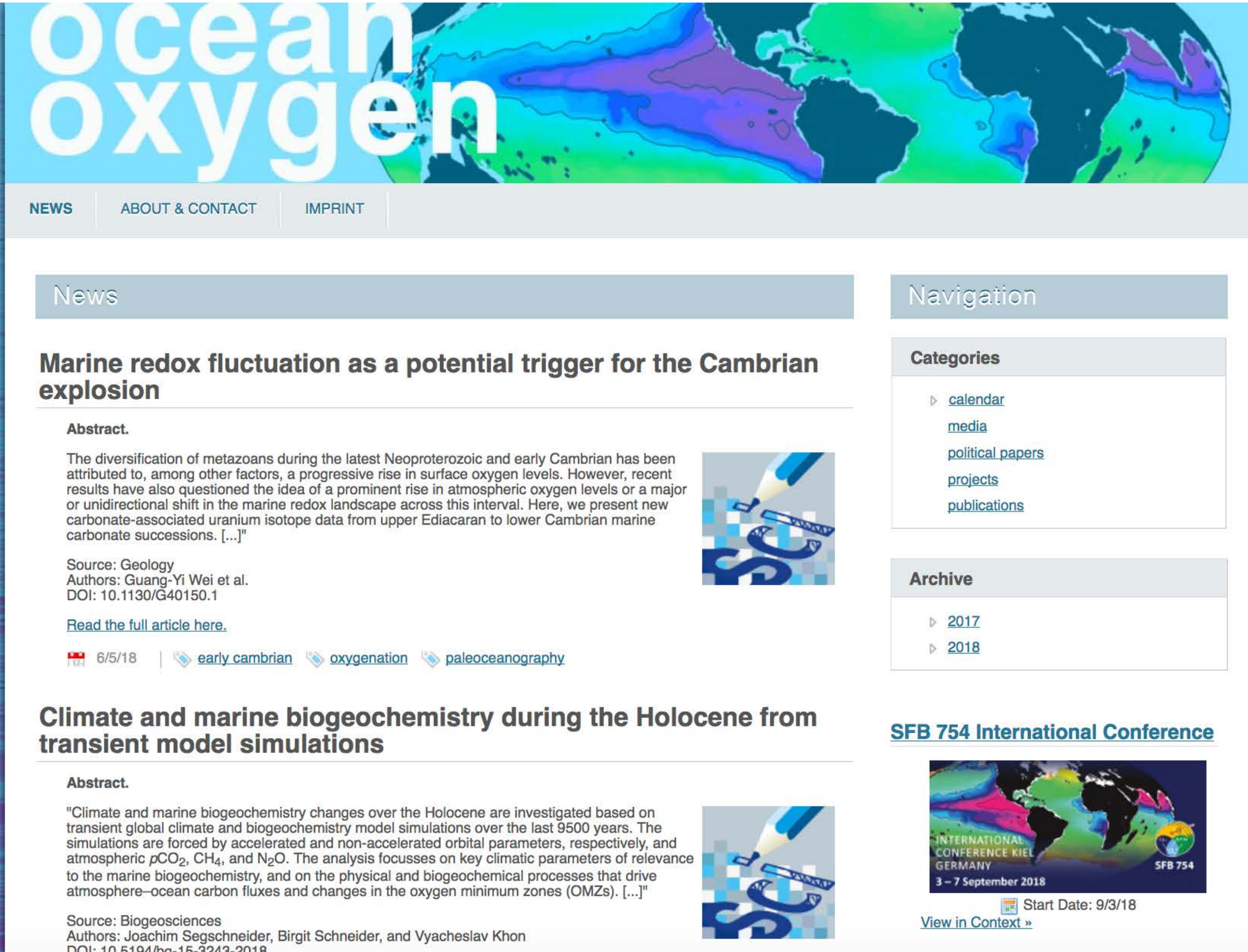
Expanding OMZs can make the ocean more oxic!

- Loss of fixed N is net O_2 source!
  → warmer future ocean may hold more oxygen!
  → possible negative feedback on expansion of OMZs

- It all depends on the response of N_2 fixation…

Let‘s collaborate☺

www.ocean-oxygen.org



ocean oxygen

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News

Marine redox fluctuation as a potential trigger for the Cambrian explosion

Abstract.

The diversification of metazoans during the latest Neoproterozoic and early Cambrian has been attributed to, among other factors, a progressive rise in surface oxygen levels. However, recent results have also questioned the idea of a prominent rise in atmospheric oxygen levels or a major or unidirectional shift in the marine redox landscape across this interval. Here, we present new carbonate-associated uranium isotope data from upper Ediacaran to lower Cambrian marine carbonate successions. [...]"

Source: Geology
Authors: Guang-Yi Wei et al.
DOI: 10.1130/G40150.1

Read the full article here.

6/5/18 | early cambrian | oxygenation | paleoceanography

Climate and marine biogeochemistry during the Holocene from transient model simulations

Abstract.

"Climate and marine biogeochemistry changes over the Holocene are investigated based on transient global climate and biogeochemistry model simulations over the last 9500 years. The simulations are forced by accelerated and non-accelerated orbital parameters, respectively, and atmospheric pCO_2, CH_4, and N_2O. The analysis focusses on key climatic parameters of relevance to the marine biogeochemistry, and on the physical and biogeochemical processes that drive atmosphere–ocean carbon fluxes and changes in the oxygen minimum zones (OMZs). [...]"

Source: Biogeosciences
Authors: Joachim Segschneider, Birgit Schneider, and Vyacheslav Khon
DOI: 10.5194/bg-15-3243-2018

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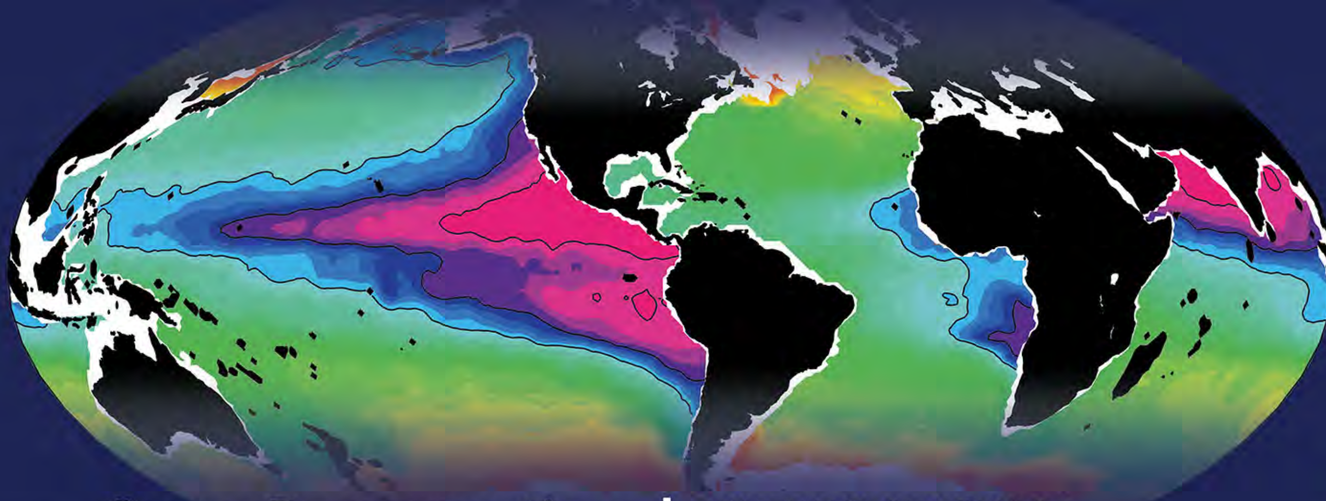
SFB 754 International Conference

Start Date: 9/3/18
View in Context »



Ocean Deoxygenation: Drivers and Consequences · Past · Present · Future ·

INTERNATIONAL CONFERENCE KIEL GERMANY

SFB 754

3 – 7 September 2018

The distribution of oxygen in the ocean is controlled by physical, biogeochemical and biological processes. Both the supply and consumption of oxygen are sensitive to climate change in ways that are not fully understood.

Recent observations suggest that the oxygen content of the ocean is declining (**ocean deoxygenation**) and that oxygen minimum zones and coastal hypoxia sites are expanding with tremendous effects on the ocean's ecosystems and living organisms.

The call for submission opens December 2017.

This conference will:

- focus on the past, present and future state of oxygen in the ocean on global, regional and local scales
- analyse mechanisms and feedbacks critical to identify natural and anthropogenic causes of oxygen variability
- determine impacts on biogeochemical cycles and ecosystems

More information:
www.sfb754.de/o2conference2018

GO2NE Global Ocean Oxygen NEtwork

GEOMAR

CAU Kiel University Christian-Albrechts-Universität zu Kiel

future ocean KIEL MARINE SCIENCES

DFG

UNESCO United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

Thank you!