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Tipping elements in the ocean

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The current situation

- Ocean = heat and net carbon reservoir due to global large-scale mixing of ocean layers (Fig.1) and ocean currents
- Climate change enforces frequency of extraordinary abrupt singular events (i.e., ocean heat waves)
- Unavoidable changes → profound impact on marine environment, goods & services, and hence on society

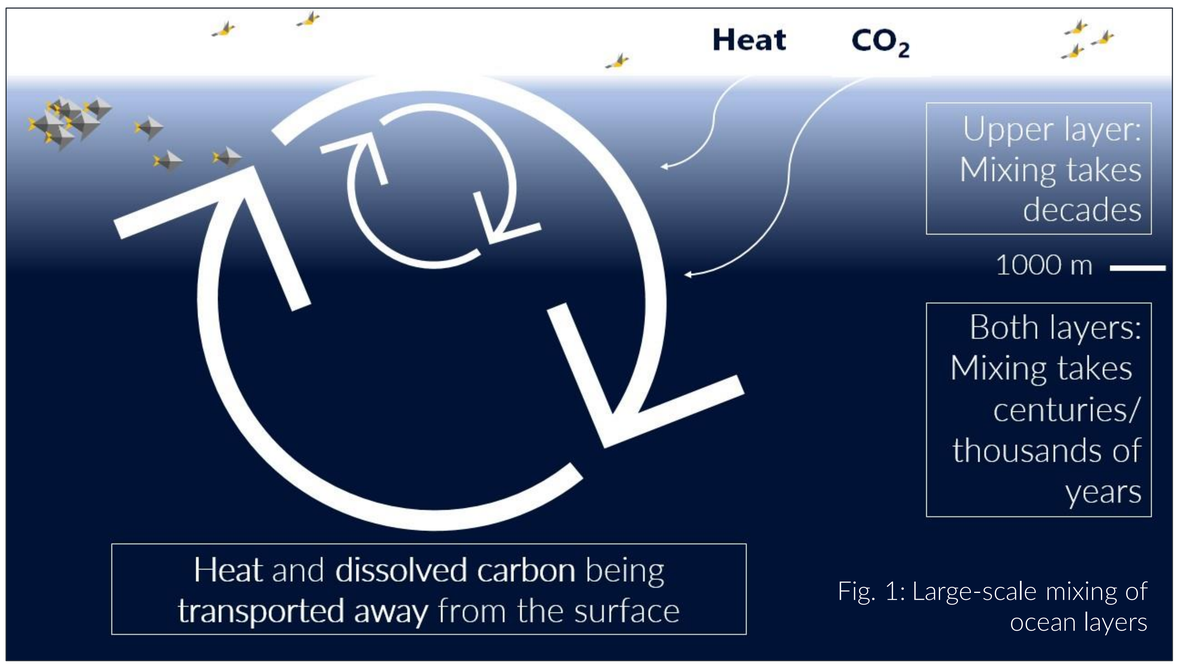
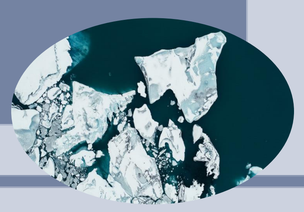


Fig. 1: Large-scale mixing of ocean layers

Enforcing tipping elements may lead to severe changes in marine ecosystems that result in a regime shift.
A regime shift will not only affect marine life but also the human society.

DRIVING FORCES

Physical drivers
- Radiative forcing
- Changes in albedo



Biogeochemical drivers
- CO_2/pH forcing
- Nutrient input
- O_2 solubility

Ecosystem drivers
- Environmental stressors
- Confounding stressors, like overfishing

BOUNDARY CONDITIONS

TIPPING ELEMENTS

Warming
- ⚠ Threat to species that are vulnerable towards warming
- ⚠ Changes in the ocean circulation pattern
- ⚠ Decrease in solubility of O_2

Acidification
- Threat to organisms with shells/ skeletal structures made of calcium carbonate
- Will prevail long after reduction of carbon emissions to net zero

Deoxygenation
- ⚠ Less oxygen in the water
- ⚠ Formation of “dead zones” for higher animals
- ⚠ May persist for millennia

REGIME SHIFT of marine ecosystems

Fig. 2: How driving forces induce regime shift of marine ecosystems based on Heinze et al. (2021), fig. 1

References
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Figure „Claas tractor on meadow delivering manure”: Photo by Mirko Fabian on Unsplash, date of access 25.06.2022 (https://unsplash.com/)
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