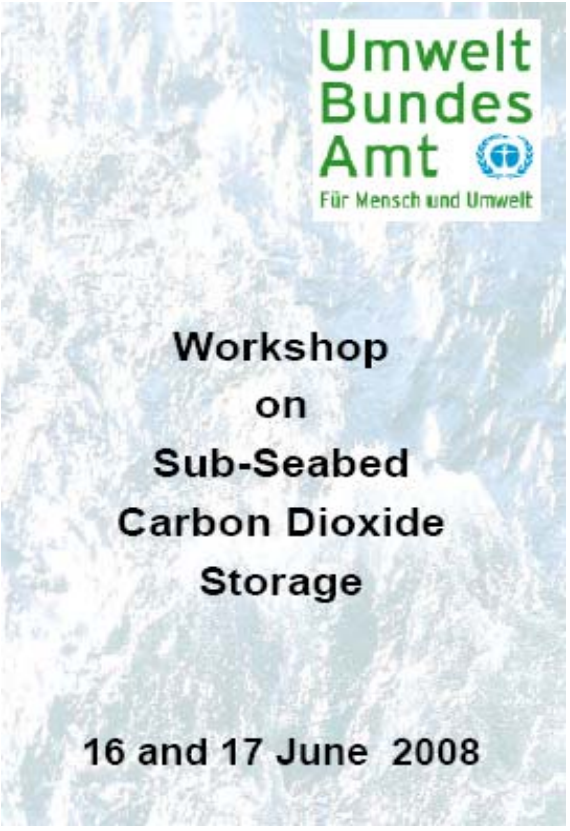
Scientific and technical aspects

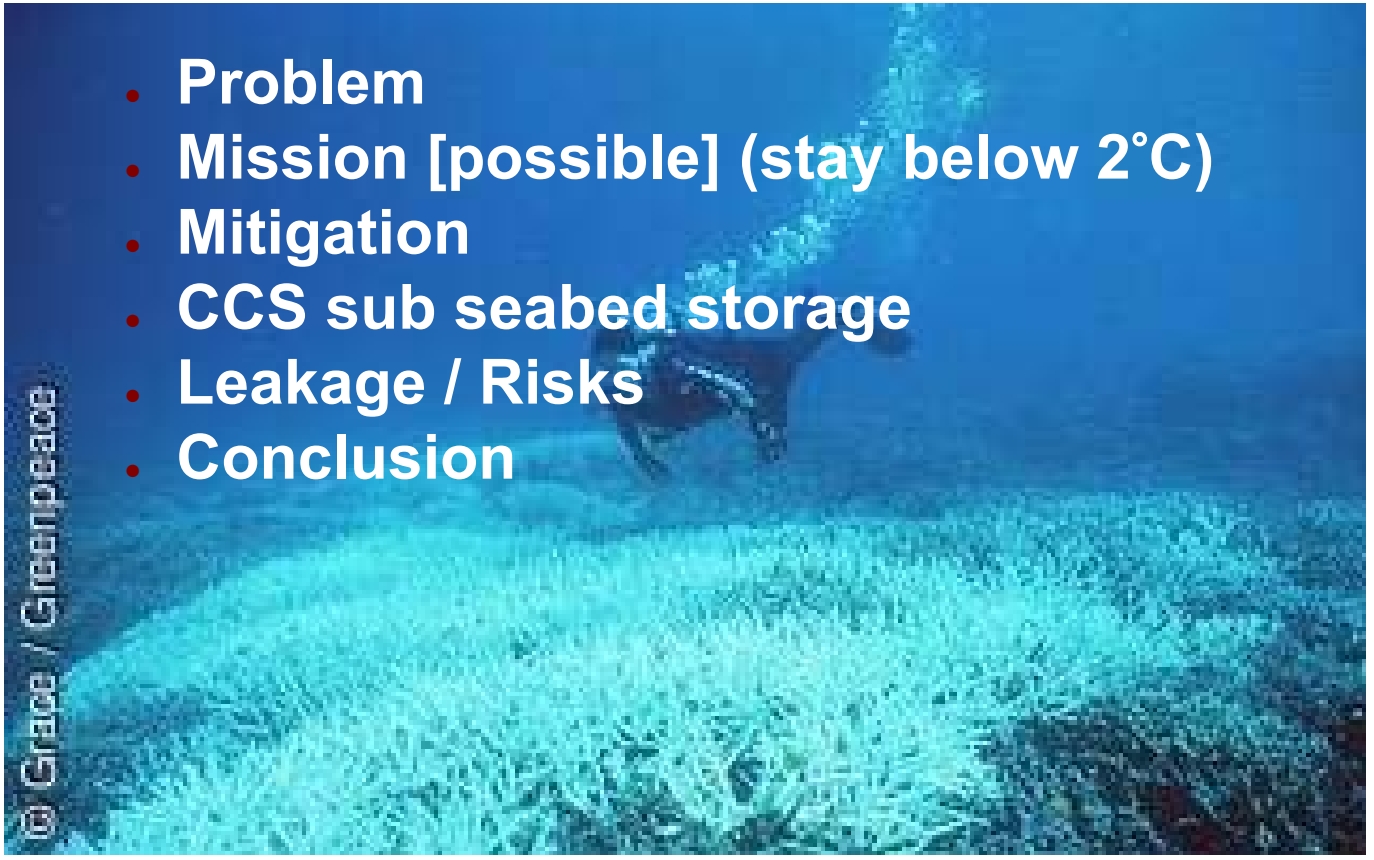
1. Describing the risks

What to expect:

temporal and spatial scales



Content



- Problem
- Mission [possible] (stay below 2˚C)
- Mitigation
- CCS sub seabed storage
- Leakage / Risks
- Conclusion

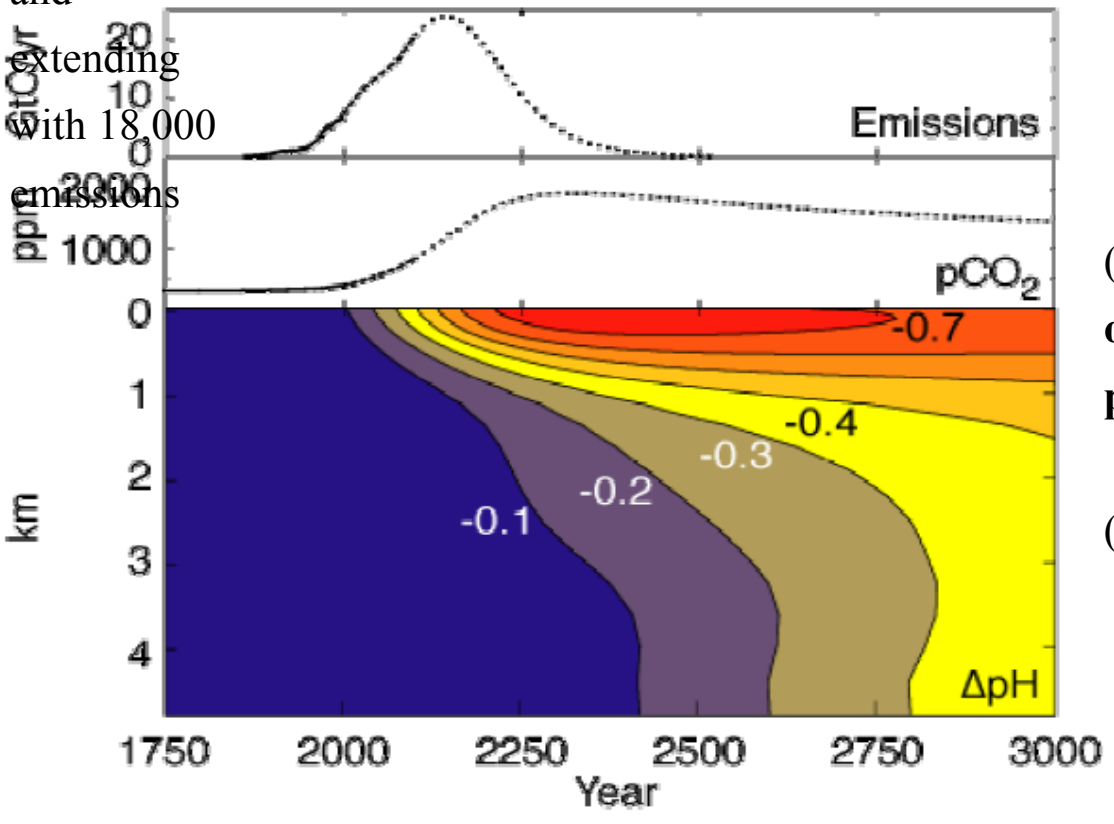
The problem

Warming → OCEAN ← Acidification

- Global atmospheric temperature increase so far ca. 0.74˚C since pre-ind. level, **ocean warming with delay**, from surface into deeper regions over centuries
- The increase in atmospheric CO_2 due to anthropogenic emissions has resulted in the **oceans taking up CO_2** at a rate of about 7 $GtCO_2\ yr^{-1}$.
- Over the past 200 years the oceans have taken up 500 $GtCO_2$ from the atmosphere out of 1300 $GtCO_2$ total anthropogenic emissions.
- CO_2 resides primarily in the upper ocean and has thus far resulted in a **decrease of *p*H of about 0.1** at the ocean surface.

Long-term effect on the ocean

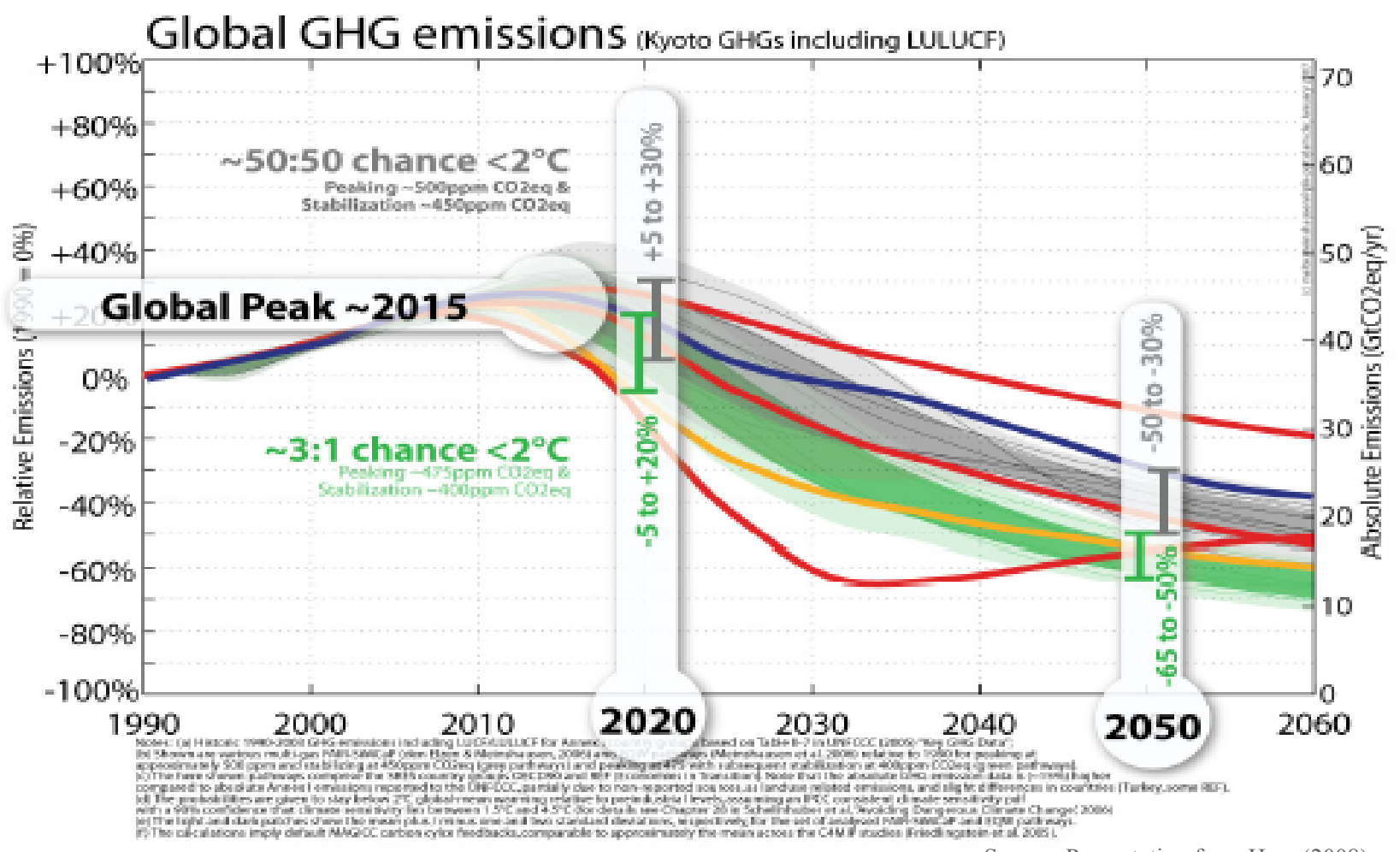
Extreme example: Simulated ocean pH changes from CO_2 release to the atmosphere. Modelled atmospheric CO_2 change and horizontally averaged ΔpH driven by a CO_2 emissions scenario: historic atmospheric CO_2 up to 2000, IS92a from 2000 to 2100, and logistic curve extending beyond 2100 with 18,000 $GtCO_2$ cumulative emissions from 2000 onward (**comparable to estimates of fossil fuel resources - predominantly coal**)



(Caldeira and Wickett, 2003)

IPCC, SRCCS 2005

What do to: Stay below 2˚C



Source: Presentation from Hare (2008)

Mitigation

GHG emssions must peak around 2015 if we we want to stay below 2˚C!

Any delay in action increases the propability to overshoot the 2˚C target.

If we want to prevent catastrophic climate change, we must change our energy system and our consumption behaviour now.

What about CCS?

Not available in time to get over the peak.

Under deployment, available possibly around 2020 at costs similar to those of most renewable energies.

CCS is not sustainable: loss of fossil resources, **huge amounts of CO_2 and storage sites** future generations need to take care off, environmental **impacts** due to mining and **storage (leakage)**

Huge dimension

Example*:
1000MW coal-fired power plant producing
8.6 million tons of CO_2 per year
could generate an underground

CO_2 plume of 18 km² in the first year of injection alone.

Furthermore, the plume would be expected to grow further still after closure of injection ended, extending to 200 to 360 km², depending on the lifetime of the storage project (here 30 ys), the amount of CO_2 stored, the thickness of the storage formation.

... and this is just one power plant.

*Benson S., Hoversten M., Gasperikova E., Haines M. (2005): Monitoring protocols and life-cycle costs for geologic storage of carbon dioxide.

Leakage

... has implications on

the environment / ecosystems
the climate
public acceptance
accounting / GHG inventories / ETS
cost / insurance / liability

"accaptable leakage"
is an accounting, insurance issue
but not an environmental one: here any leakage is a problem
precautionary: leakage is not acceptable
guidance, prerequisite for CO_2 storage

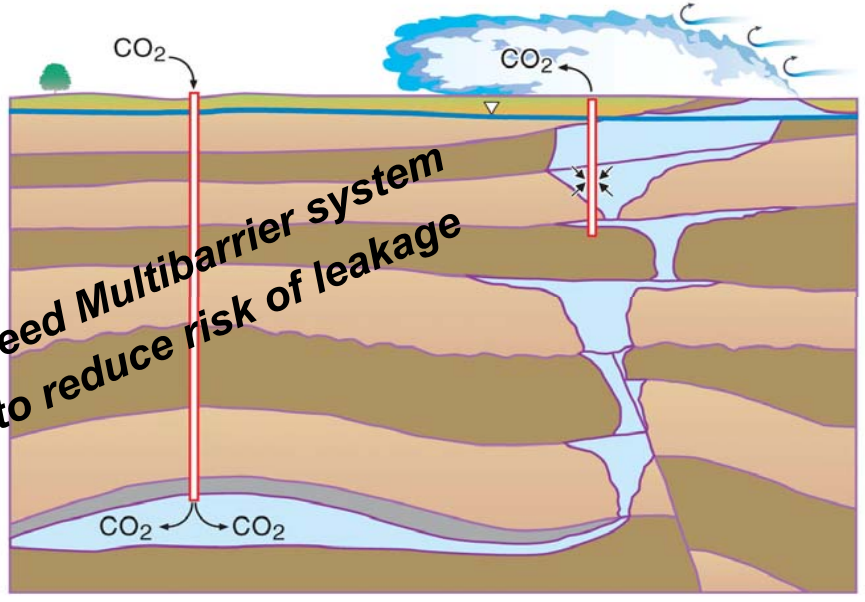
If leakage were to become a siginificant source of emissions, emissions of human activities would have to be restricted to even lower levels to reach a set stabilization target.

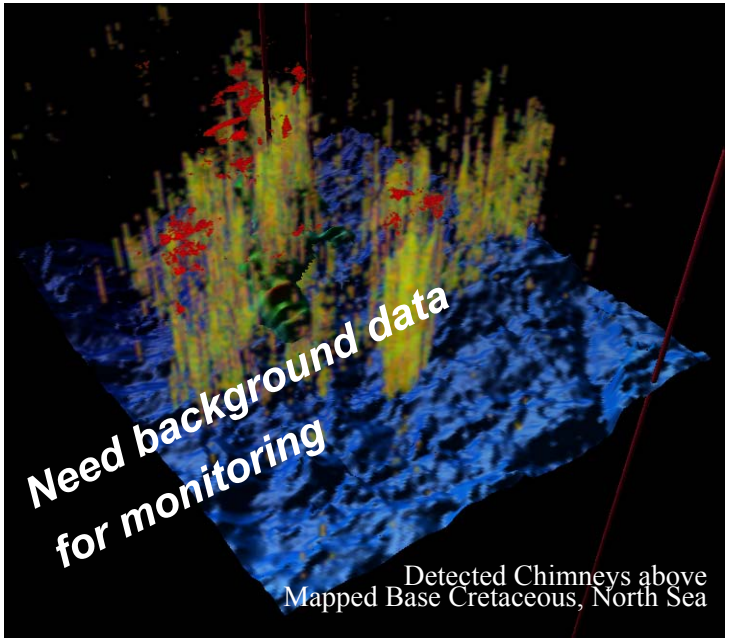
IPCC: Up to 600 Gt C storage over the next 100 ys possible - If 0.1% would leak that year, this would amount to as much as **0.6 GtC**, which is roughly a tenth of current total global CO_2 emissions from fossil fuels.

Leakage

["easy" to detect and remediate on land, but offshore?]

- leaky bore holes
- unknown (unsealed) bore holes
- reactive (CO_2-H_2O) acidic solutions – reactions (cap rock integrity)
- migration of fluids
- over pressurization of reservoir - fracturing of caprock
- Onshore issue: displaced brine or CO_2 reaches groundwater table

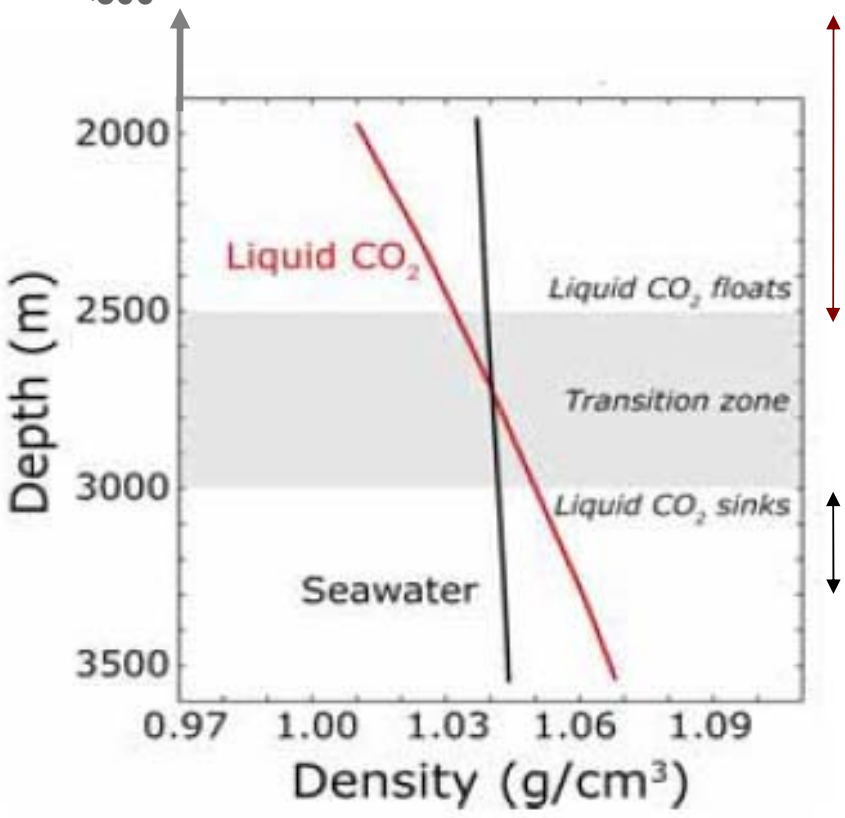




Leakage sub-seabed:

Water column as barrier

Gaseous CO_2 less dense than seawater, rise, below 9˚C and 400 m hydrate froms



less dense than seawater, rise,
T well below 9˚C = hydrate forms

CO2 denser than water, sinks,
T well below 9˚C = hydrate forms

No barrier: Time-delayed release

CO_2 released onto the sea floor deeper than 3 km is denser than surrounding water and is expected to accumulating as a lake of CO_2 over which a thin hydrate layer would form.

This hydrate layer would retard dissolution, but it would not insulate the lake from the overlying water. The hydrate would dissolve into the overlying water, but the hydrate layer would be continuously renewed through the formation of new crystals.

It has been estimated that, at a depth of >3000m,

ining 58.4 Mt would dissolve

over approximately 240 years.

Over several centuries, CO_2 released

ean would be transported

urface and interact with

e.

Source: IPCC SRCCS 2005 and Johnston/Santillo

Conclusions - Protecting the oceans

Better not produce CO_2 at all. Reduce GHG emissions NOW
(clean technologies are at hand!)

No CO_2 ocean storage

Leave oceans undisturbed

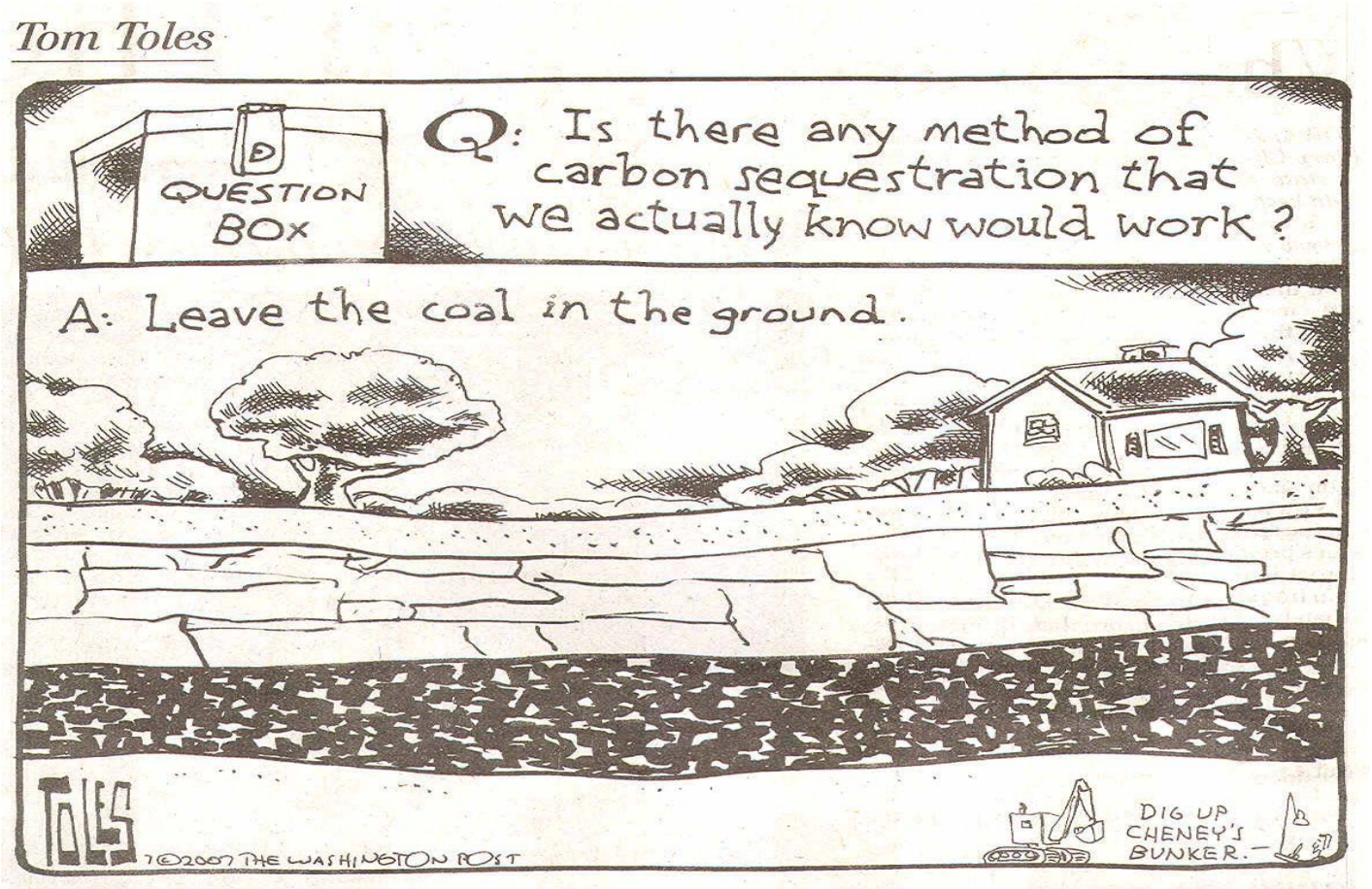
- no CO_2 sub seabed storage
- don't touch methan hydrates (risk of destabilisation)

Pay attention to pipeline systems that could cross sensitive areas.

Need more marine protection areas for recovery

If CO_2 storage at all, than better onshore (better for remediation in case of leakage)
or in geological formations offshore at greater water depth

Thanks



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