STORAGE OF ATMOSPHERIC CO_2

1. COASTAL BLUE CARBON ECOSYSTEMS

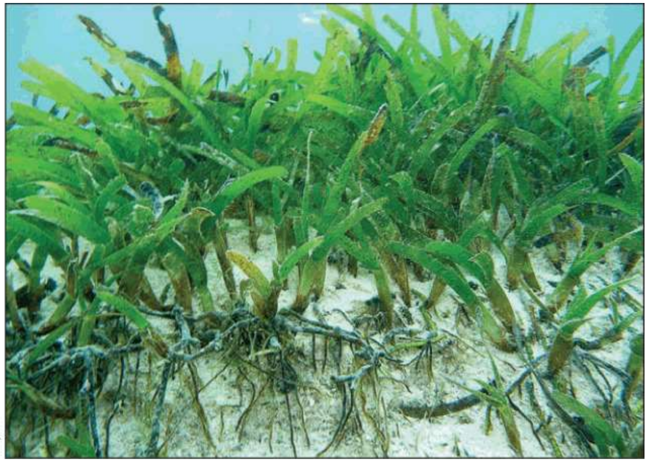
2. ROCK WEATHERING

GUILLAUME SOULET, IFREMER, 05/09/2023

ANCRE WORKSHEET 3: CARBON STORAGE IN THE AQUATIC ENVIRONMENTS AND FROM ROCK WEATHERING

Salt marshes

Seagrass meadows



Mangroves

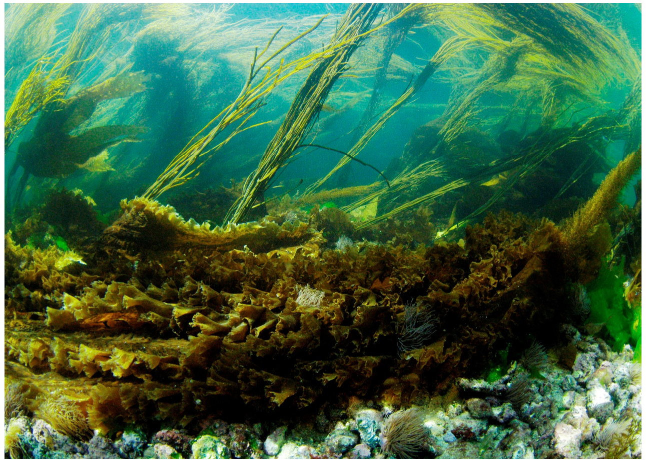
Pics from McLeod et al. (2011)

Blue carbon is all biologically-driven carbon fluxes and storage in marine systems that are amenable to management (Pörtner et al., IPCC, 2019)

Much of our understanding focuses on Coastal Blue Carbon Ecosystems

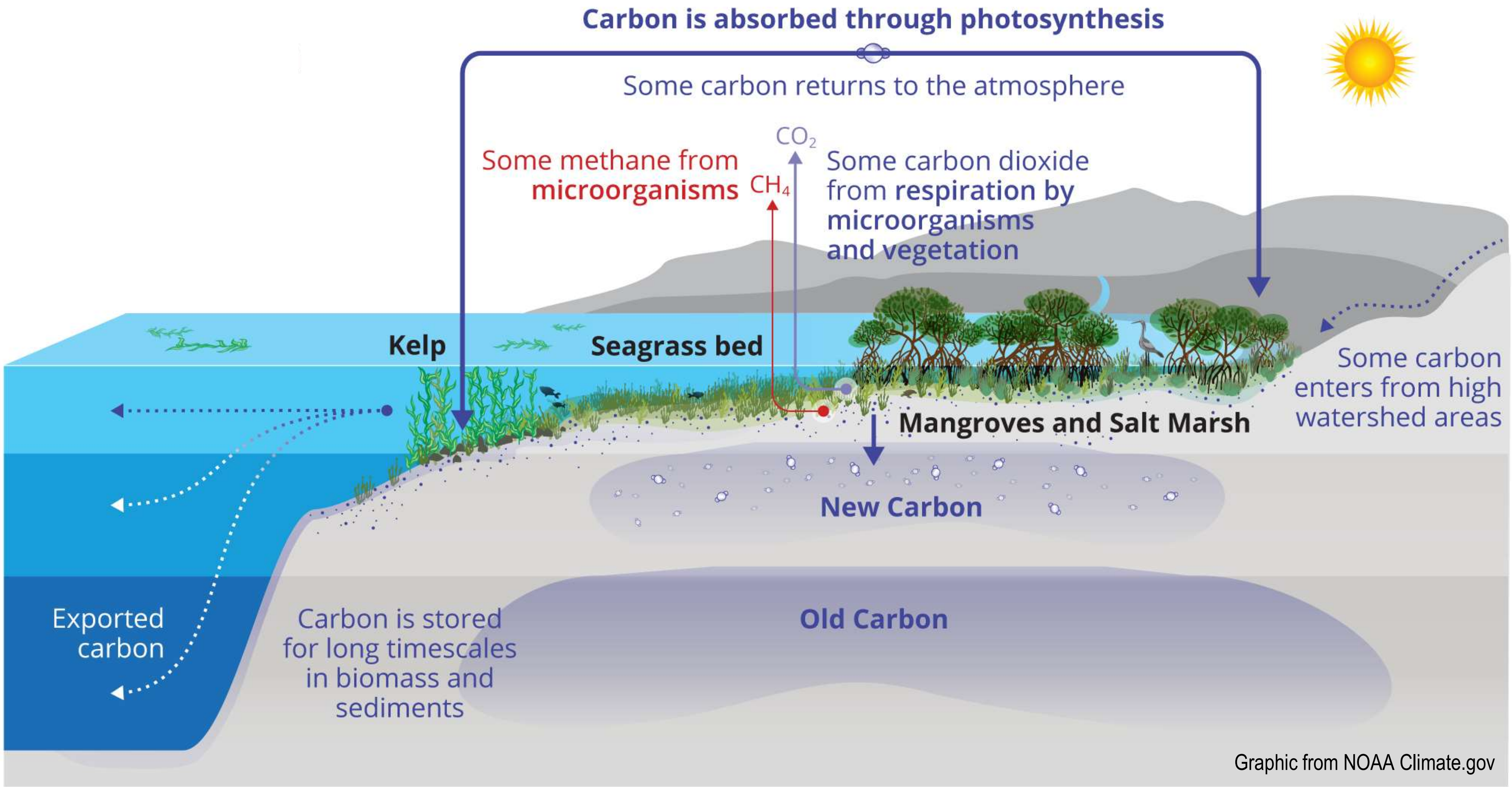
They could offset up to 1-3% of the annual CO_2 emissions (Macreadie et al., 2021). But they are vulnerable, with a loss of surface area of ~1.5-2% each year (Regnier et al. 2022)

Kelp forests



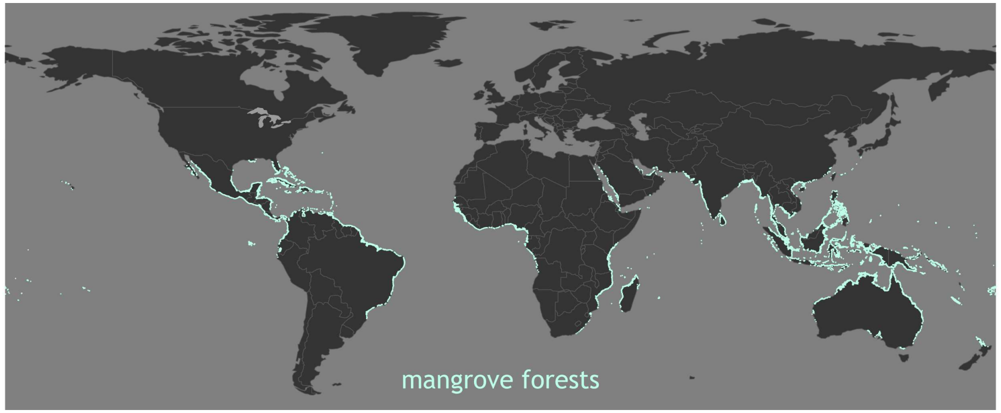
Pic from X. Caisey, used under CC by 4.0

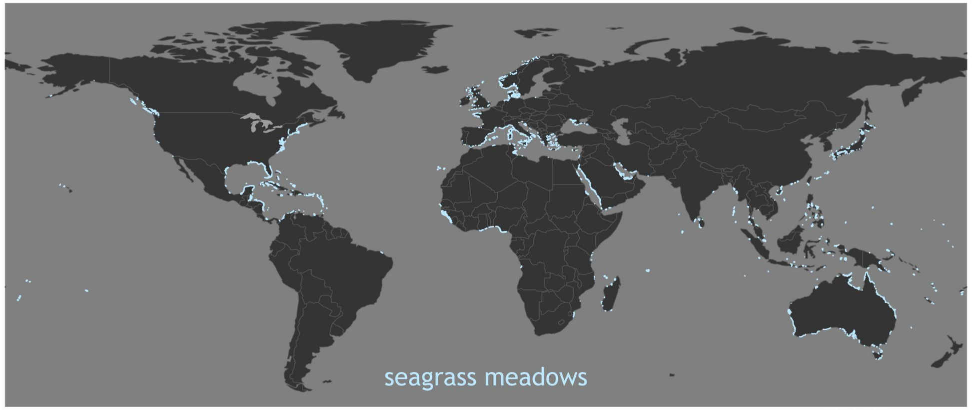
Coastal Blue Carbon cycling



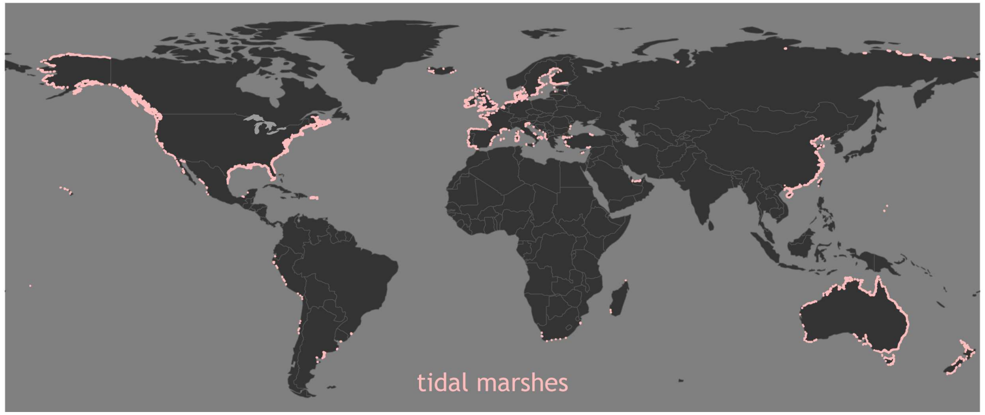
Graphic from NOAA Climate.gov

Global locations of key Blue Carbon ecosystems





NOAA Climate.gov
Data: UNEP WCMC

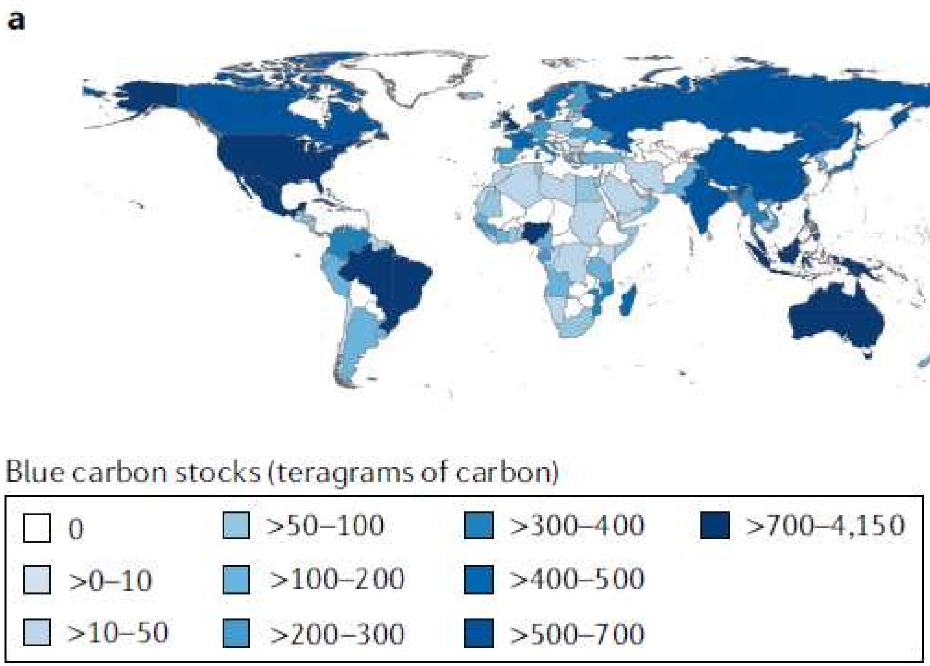


Potential for Europe: salt marshes (Atlantic coast, North Sea) and seagrass meadows (Mediterranean coast).

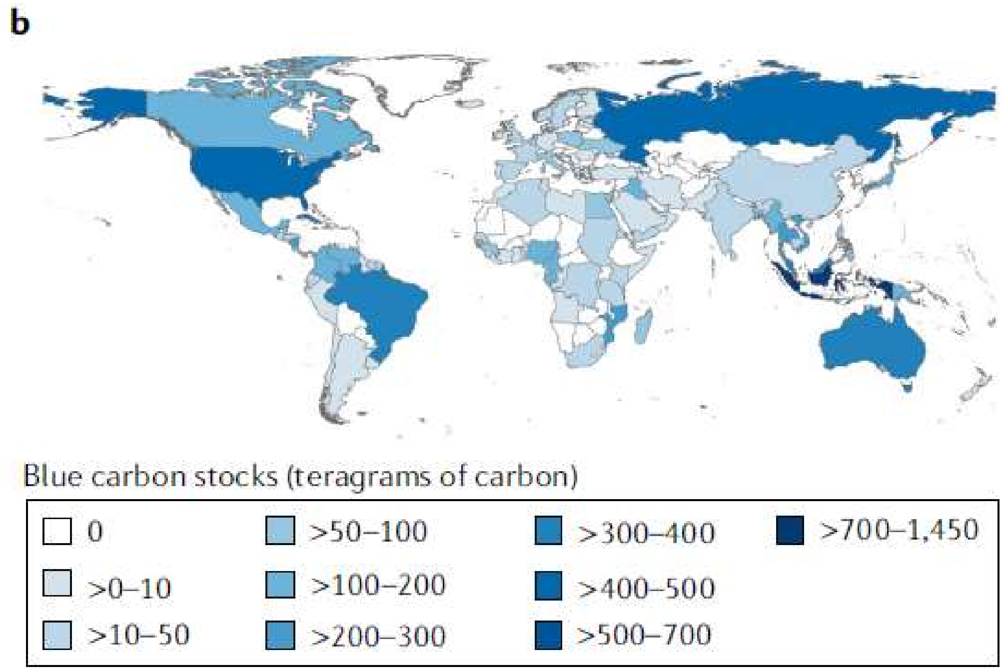
France (1 MtC/yr) realizes 66% of its annual sequestration potential within overseas territories

National stocks estimates

From Macreadie et al. (2021)



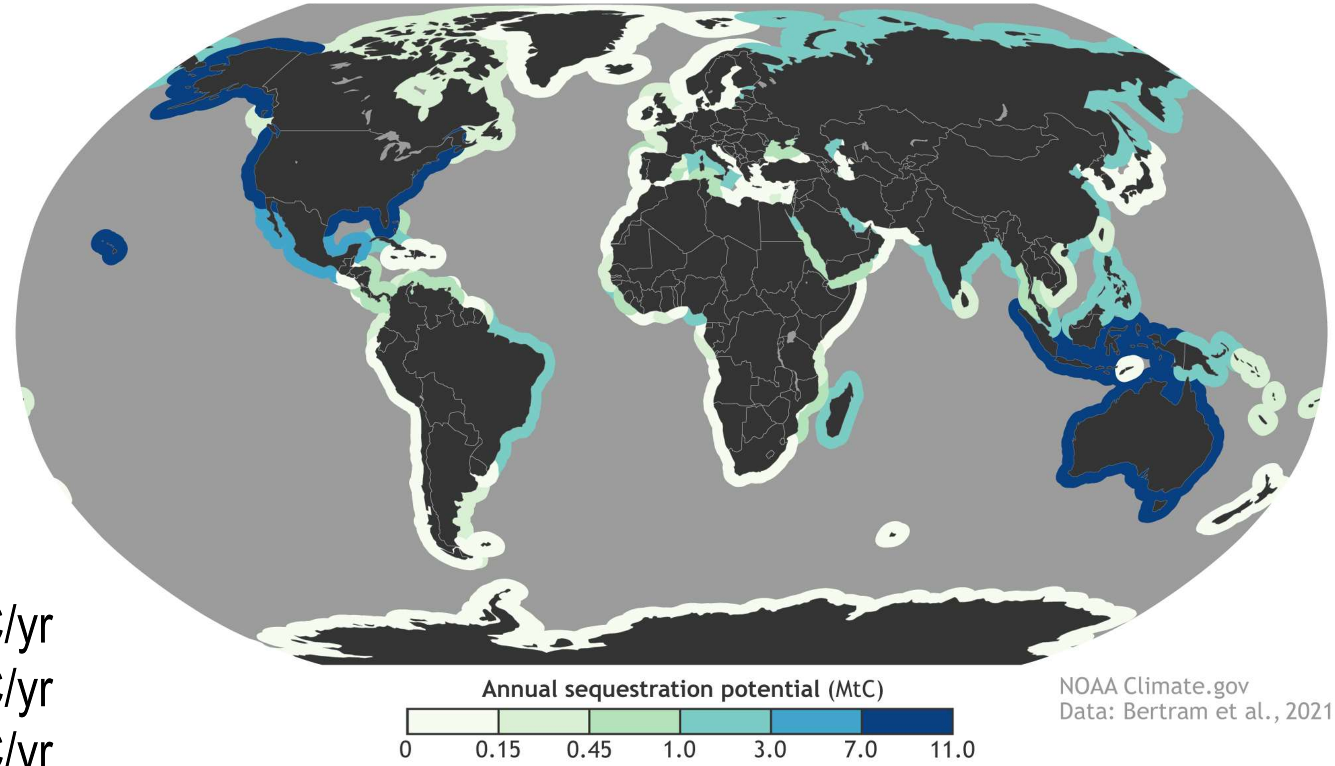
Higher bound



Lower bound

CBCEs hold potentially 9000 to 33000 MtC globally in soils and biomass… quite large range

Global carbon storage potential of coastal ecosystems



Bertram et al. (2021)

Seagrass meadows	44 ± 12 MtC/yr
Mangroves	24 ± 3 MtC/yr
Saltmarshes	13 ± 1 MtC/yr

Total Blue Carbon Ecosystems

81 ± 13 MtC/yr → offsets less than 1% annual anthropogenic CO_2 emissions

This global flux is estimated to have decreased by 25 to 50% compared to preindustrial era (150 ± 50 MtC/yr) (Regnier et al., 2022).

Benefits

- Climate change mitigation as long-term carbon sink
- Wealth of biodiversity
- Nursery grounds for fish
- Coastal protection from storms
- Country-specific wealth of blue carbon
- Socioeconomics (fisheries, tourism, carbon crediting…)

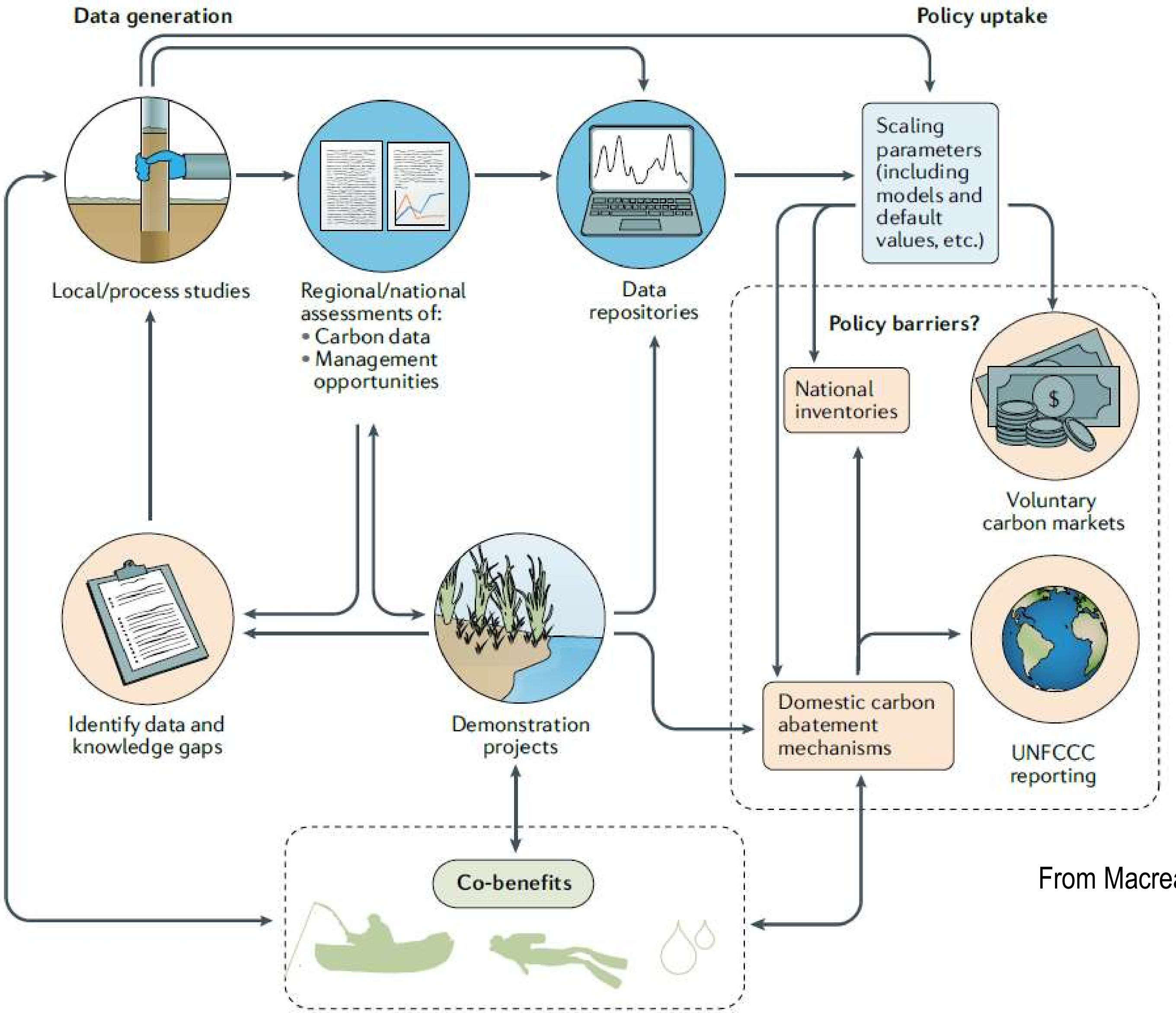
Knowledge gaps

- Extent of CBCEs
  - Detailed mapping
  - Loss or gain in the surface area?
- Blue carbon flux estimates and Methodology (interlaboratory comparisons – reproducibility, standardization)
- Reservoir size (carbon stocks) and resilience (carbon fate)
- CBCEs – actually a sink or a source?
  - Off-site reservoirs through the export of blue carbon offshore
  - CO_2 emissions
    - Respiration of the blue carbon
    - Fate of the released Dissolved Organic Carbon
    - Carbonate precipitation
  - Other Greenhouse Gas emissions (Methane, nitrous oxyde)
- Kelp forests to be included in the CBCEs?

Challenges

- Vulnerability due to anthropic factors – climate change, sea level rise, pollution, overexploitation
- Actions to forster and encourage scientific efforts to fill the blue carbon kwowledge gaps
- Encourage emerging field of research about socioeconomic impact of blue carbon from local, regional, national to global scales
    - Blue carbon crediting and fair redistribution
    - Change adaptation, social resilience, food security…
- Policy actions to recognize CBCEs as key ecosystems for mitigation strategies
- Involve decision makers in the protection and restoration in their local CBCEs

Link between science – policy – co-benefits



From Macreadie et al. (2021)

Fig. 6 | **Road map for incorporating data into carbon accounting frameworks and conservation strategies.** There are

Pic by G. Soulet; view of the Laval catchment, Draix, France.

Geological carbon cycle

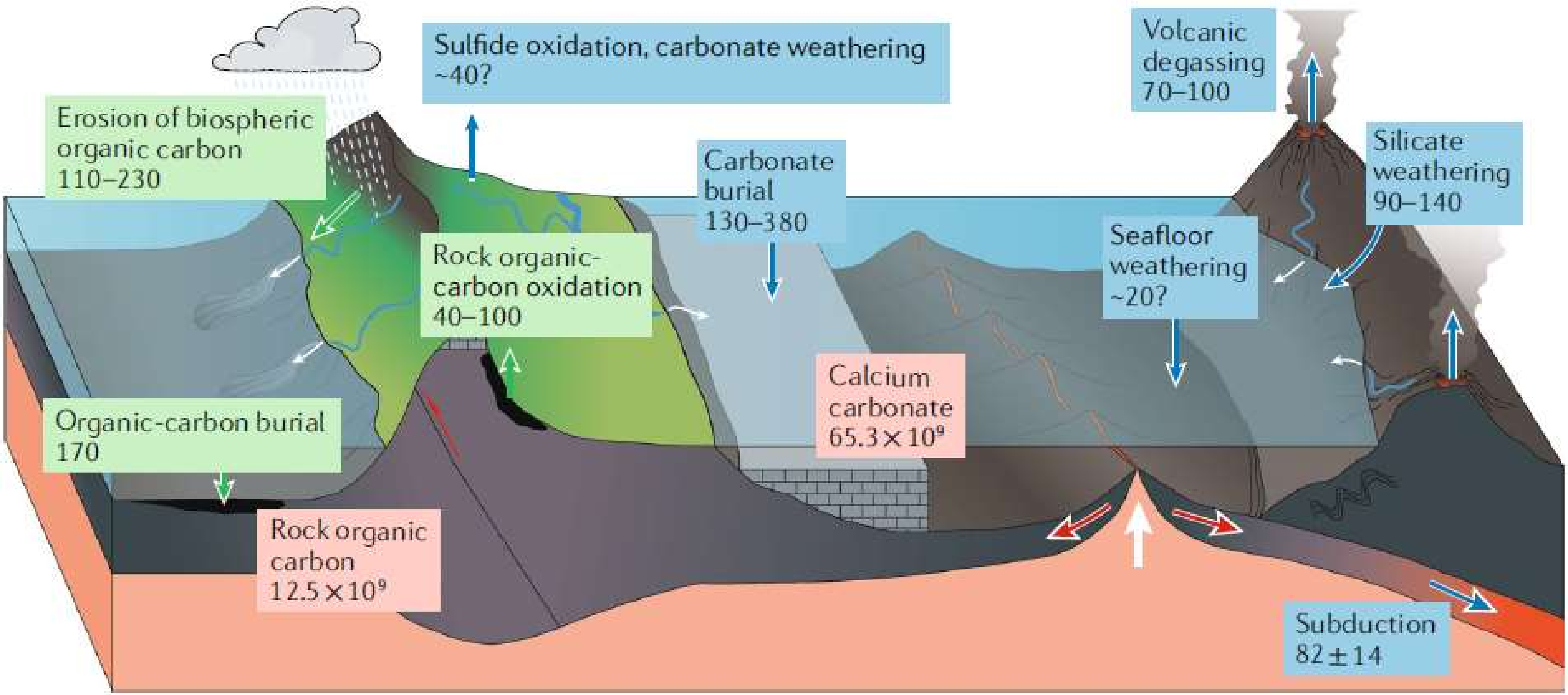


Fig. 1 | **The geological carbon cycle and transfers of carbon between the atmosphere and rocks.**

From Hilton and West, 2020.

Rock weathering by carbonic acid

Silicate weathering

$2CO_2$ + silicate + $3H_2O \rightarrow Ca^{2+} + 2HCO_3^-$ + clay

$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + CO_2 + H_2O$

Timescale ~10^4 years
→ CO_2 sink over geological timescales
→ CO_2 sink over the timescale of climate change mitigation

Carbonate weathering

$CaCO_3 + CO_2 + H_2O \rightarrow Ca^{2+} + 2HCO_3^-$

$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + CO_2 + H_2O$

Timescale ~10^4 years
→ CO_2 neutral over geological timescales
→ CO_2 sink over the timescale of climate change mitigation

Benefits

- Climate change mitigation through atmospheric CO_2 removal
- Reduce ocean acidification

Knowledge gaps and challenges

- Refining carbon flux estimates globally and regionally
- Better understanding of the biogeochemical processes involved and their sensitivity to climate/environment changes (temperature, rainfall/hydrology, vegetation)
- Observatories: Monitoring, reporting, and verifying the amount of carbon removed as a result of natural/enhanced weathering reactions
- Agricultural enhanced carbonate and silicate weathering in croplands: large-scale deployment feasibility, CO_2 cost, environmental and health and societal impacts?