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Climate-related changes in total alkalinity as a key to understanding ocean acidification in the coastal zone

Karol Kuliński

and:

Fernando Aguado Gonzalo, Laura Bromboszcz, Magdalena Diak, Katarzyna Koziorowska-Makuch, Przemysław Makuch, Izabela Palka, Piotr Prusiński, Seyed Reza Saghravani, Beata Szymczycha, and Aleksandra Winogradow

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RAW GLACIERS RETREAT AND FIORDS WITHER

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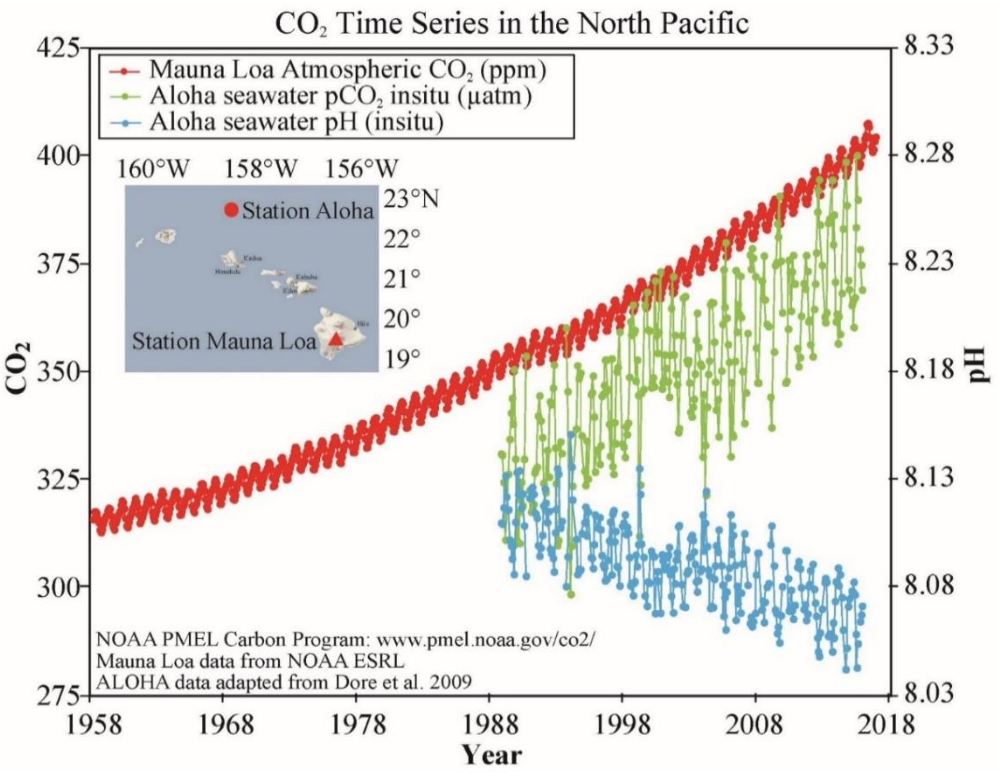
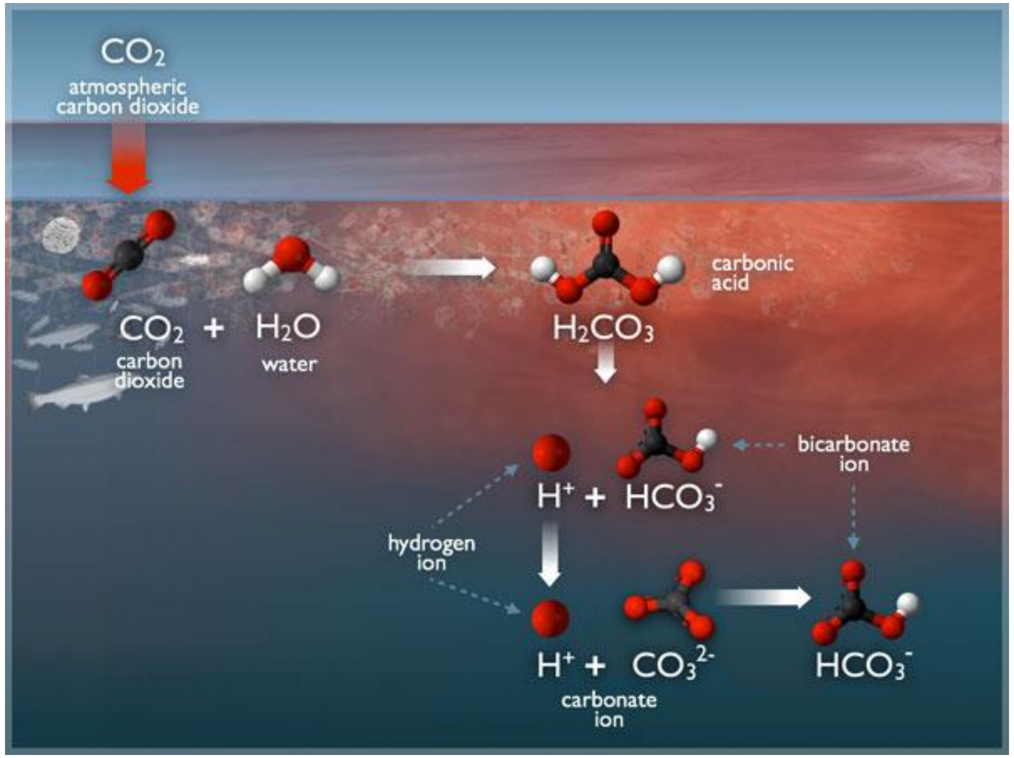
Ocean Acidification (OA)

- Due to rising atmospheric CO_2 there is more CO_2 in the surface ocean
- Dissolved CO_2 in water forms weak diprotic carbonic acid, its dissociation leads to H^+ release (pH decrease)



source: NOAA



source: www.whoi.edu

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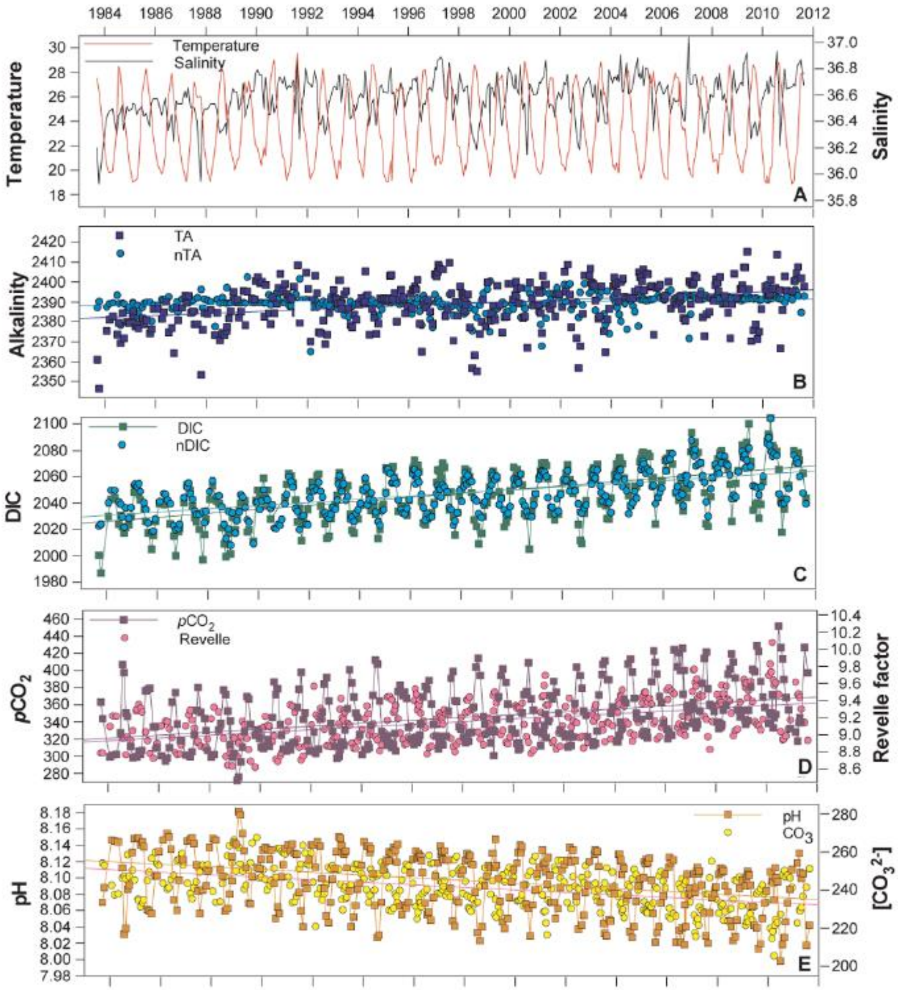
Ocean Acidification in the open ocean

BATS - Bermuda Atlantic Time-series Study



- The OA manifests in decrease of pH and CO_3^{2-} and increase of DIC

- As total alkalinity is relatively constant in the open ocean, OA can be understood from the atmospheric CO_2 levels and CO_2 exchange through the air/sea interface

Source: Bates et al., 2012

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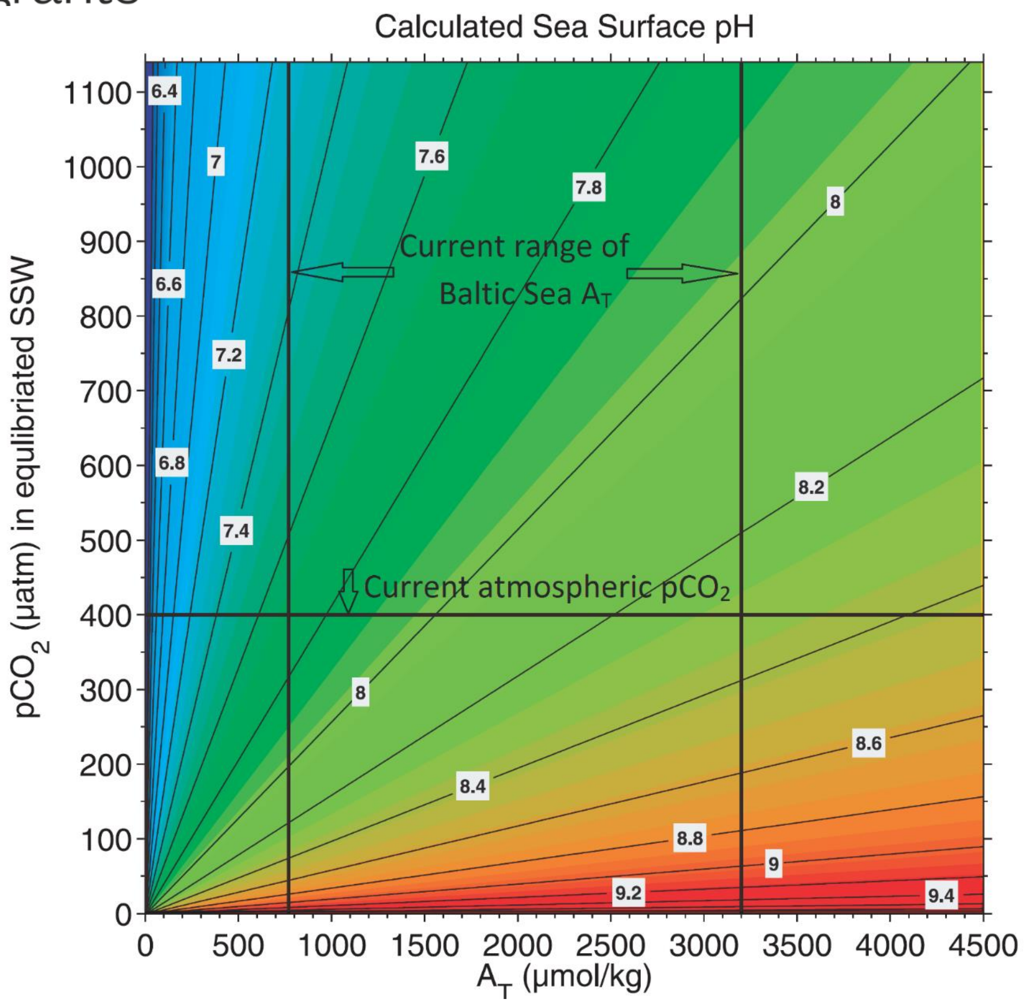
Ocean Acidification in the coastal zone – importance of alkalinity

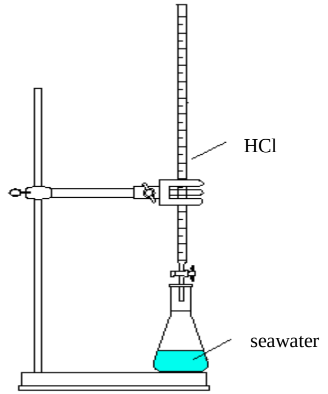


Source: Kuliński et al., 2017 modified after Omstedt et al., 2010

The total alkalinity of seawater is defined as the excess of proton acceptors (bases formed from weak acids with a dissociation constant $K \leq 10^{-4.5}$ at 25ºC) over proton donors (acids with $K > 10^{-4.5}$) and expressed as a hydrogen ion equivalent in one kilogram of sample (Dickson, 1981):

$$\mathbf{A_T} = [HCO_3^-] + 2[CO_3^{2-}] + [B(OH)_4^-] + [OH^-] + [HPO_4^{2-}] + 2[PO_4^{3-}] + [SiO(OH)_3^-] + [NH_3] + [HS^-] + \ldots + \text{minor bases}$$

$$- [H^+]_{wolny} - [HSO_4^-] - [HF] - [H_3PO_4] - \ldots - \text{minor acids}$$



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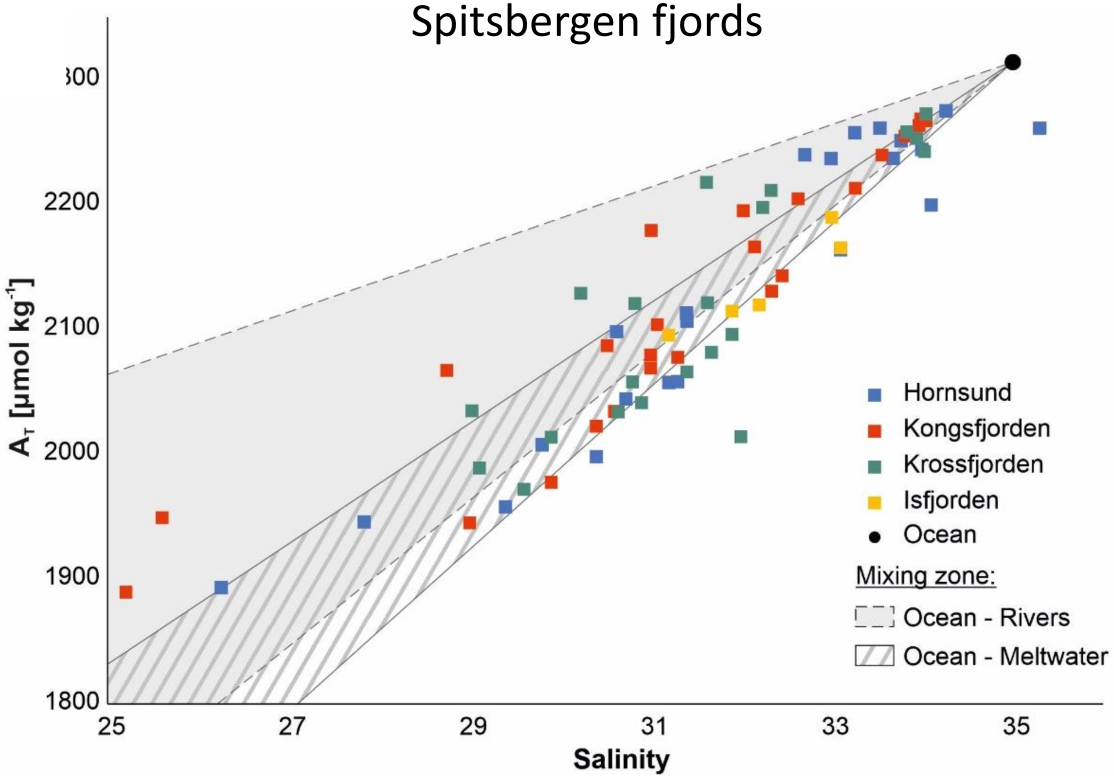
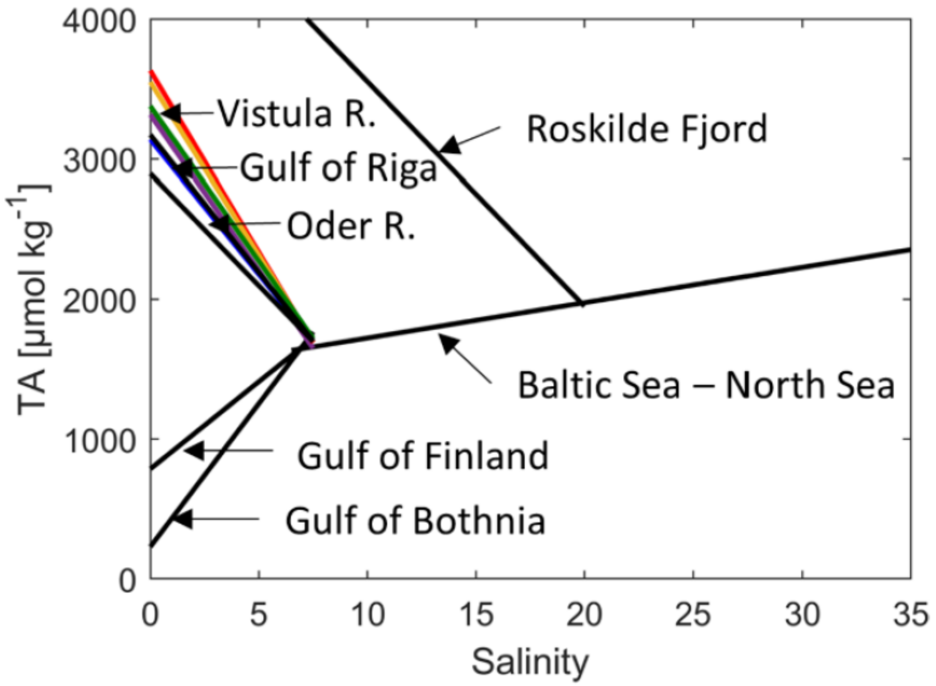
Ocean Acidification in the coastal zone
Examples from Spitsbergen fjords and the Baltic Sea

Spitsbergen fjords



Source: Koziorowska-Makuch et al., 2023

Baltic Sea



Source: Stokowski et al., 2021

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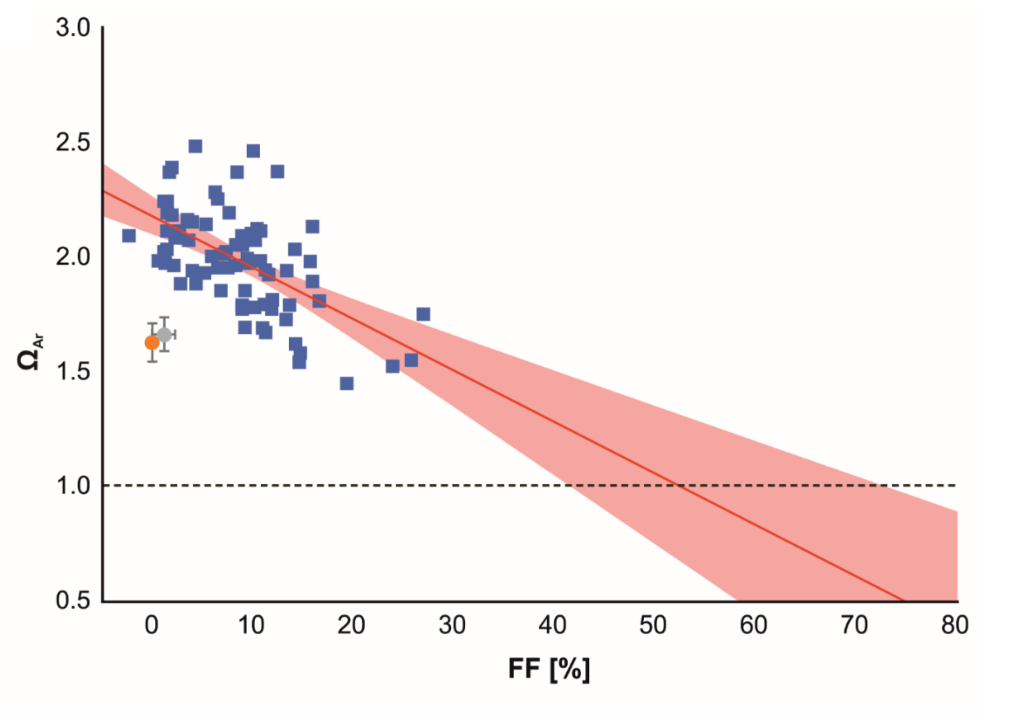
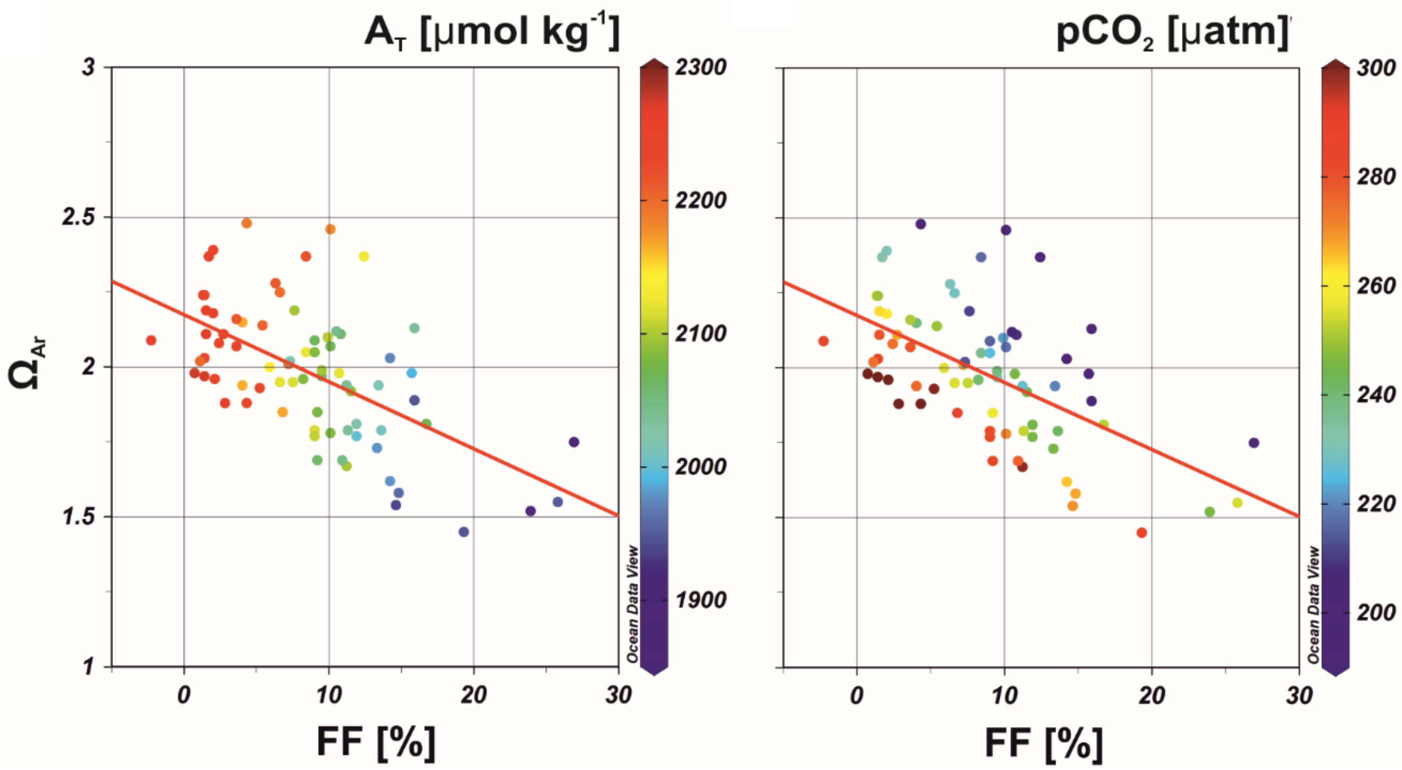
Seawater freshening in the Spitsbergen fjords due to glaciers retreat contributes to alkalinity and Ω decrease

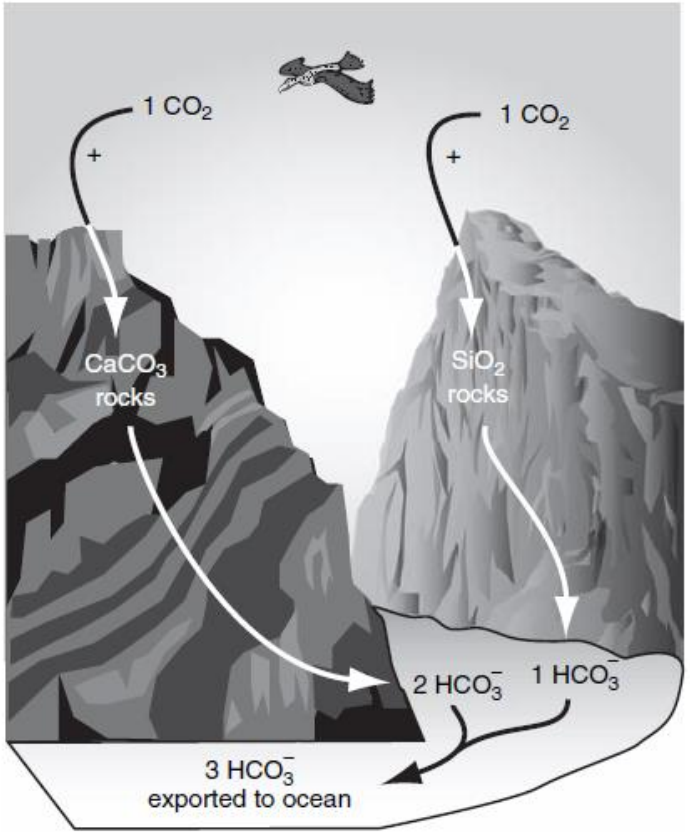




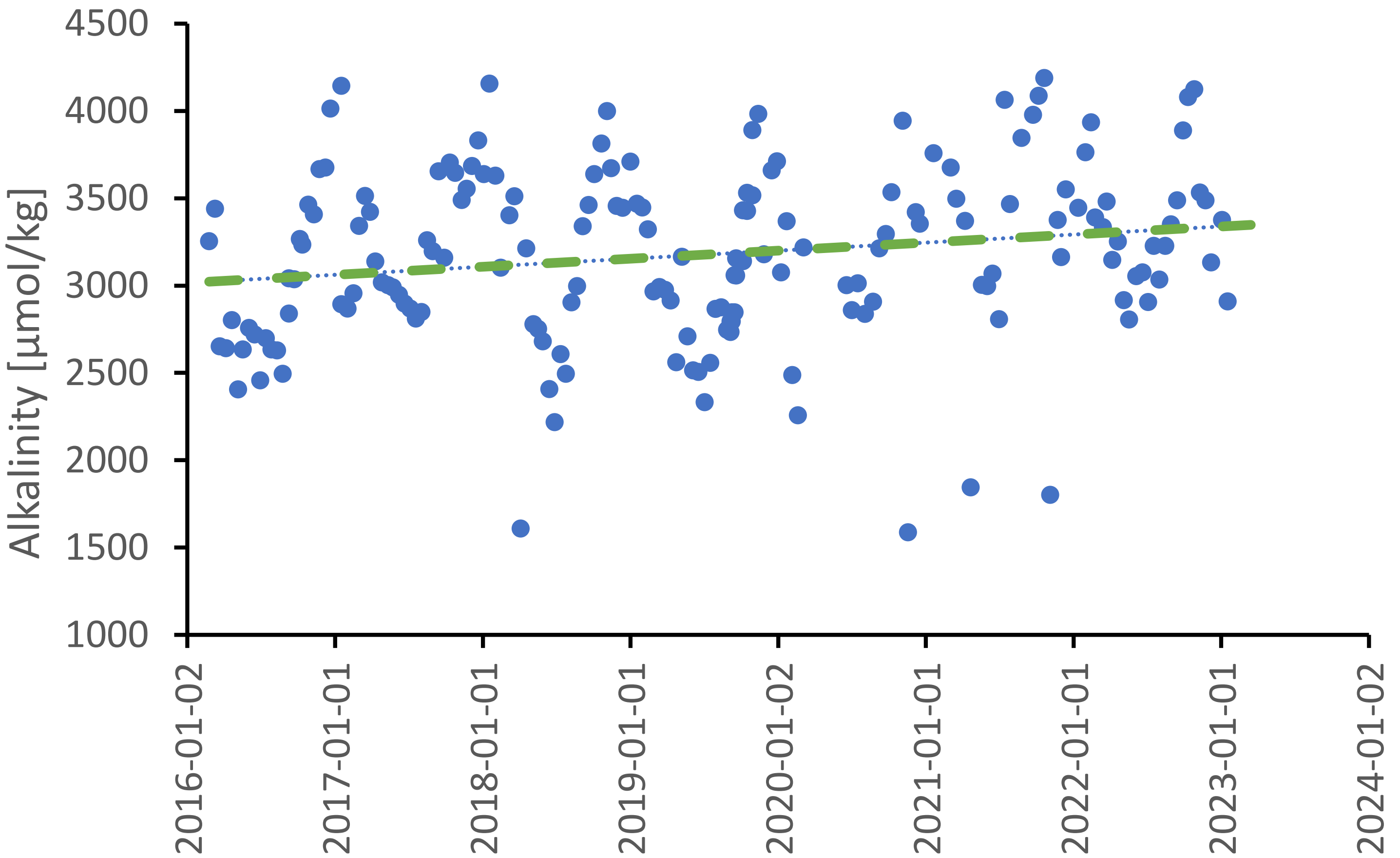
Source: Koziorowska-Makuch et al., 2023

Project funded by the Norwegian Financial Mechanism 2014-2021 Grant agreement no. UMO-2019/34/H/ST10/00504

Due to an increase in CO_2-induced catchment weathering, alkalinity in the Vistula River (southern Baltic Sea) is increasing by 46 µmol kg^{-1} yr^{-1}



Source: Emerson & Hedges, 2008



Source: own data, unpublished

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Conclusions:

- Total alkalinity is highly variable in space and time in the coastal zone
- Climate-driven processes, depending on the catchment structure, may differently influence the alkalinity pool in the coastal zone, from dilution (e.g. seawater freshening due to glaciers retreat) to alkalinity enrichment (enhanced weathering of limestone on land)
- Understanding the dynamics and future development of Ocean Acidification in the coastal zone requires quantification of alkalinity sinks and sources and knowledge about processes shaping them.

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PROSPECTOR
do permafrost-released organics amplify ocean acidification in the arctic?
IO PAN
Project financed by the Polish National Science Centre
Project No. 2019/34/E/ST10/00167

ArcticSGD
Project financed by the Norwegian Financial Mechanism 2014–2021 (85%) National Science Centre(15%) within GRIEG Programme
"Submarine Groundwater Discharge in a Changing Arctic Region: Scale and Biogeochemical impact"
Project No. 2019/34/H/ST10/00645

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RAW Glaciers Retreat And Fiords Wither