Arctic ocean acidification: Scientific updates on changes to carbonate chemistry

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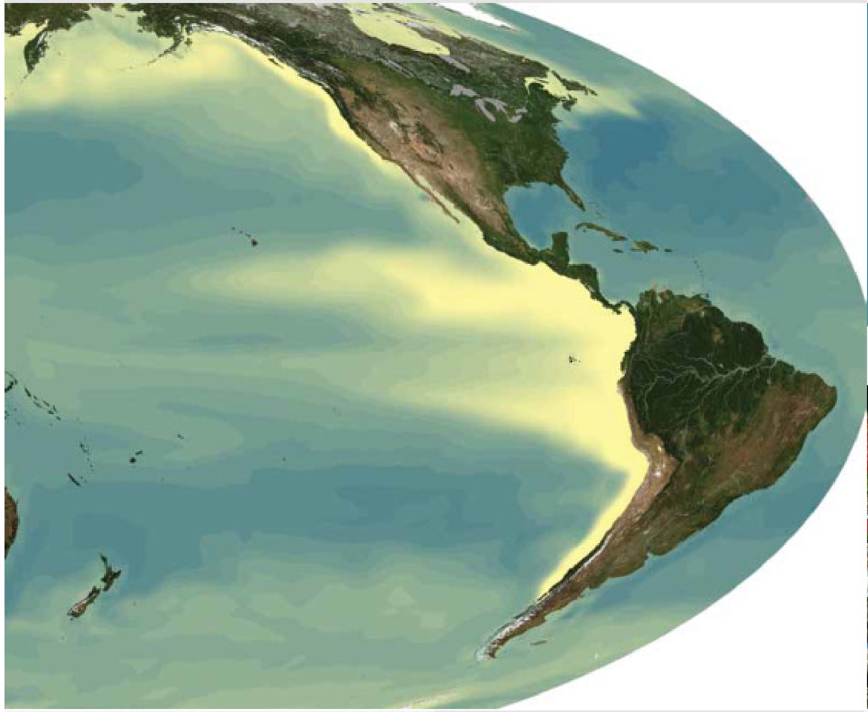
Ocean acidification in a nutshell

Ocean Acidification: What we know now



By the Numbers: 24 million

24 million

The number of tonnes of CO_2 the ocean absorbs every day.

Ocean Acidification Thresholds

Social consequences

By the Numbers: 10 times

10X

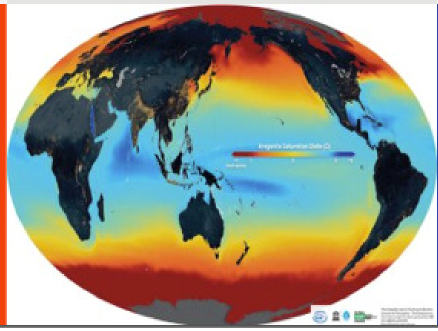
The current rate of acidification is over 10 times faster than any time in the last 55 million years.

By the Numbers: about 170%

170%

The projected increase in ocean acidity by 2100 compared with preindustrial levels if high CO2 emissions continue (business-as-usual scenario).

Visualising Ocean Acidification



By the Numbers: 26%

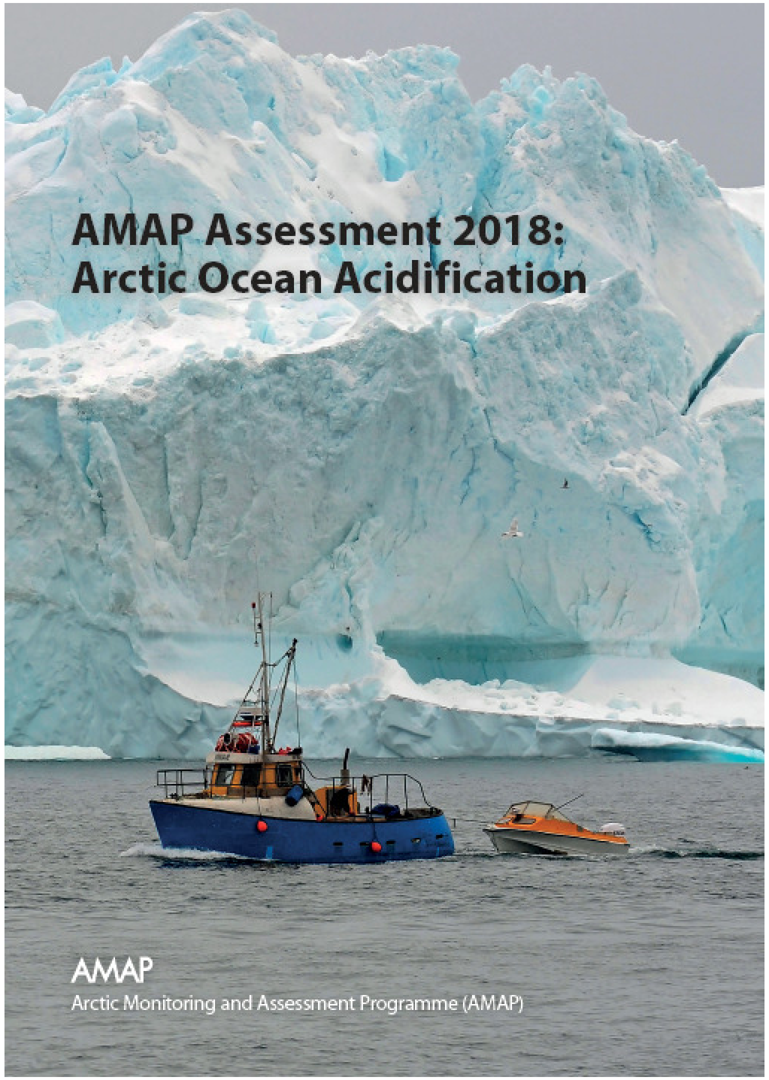
26%

The increase in ocean acidity from preindustrial levels to today.

Mitigation and Adaptation

www.ocean-acidification.net

AOA 2018 report is published



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Focus on socioecological response; following a request from the Arctic Council

A new basin scale study of ocean acidification has been delivered

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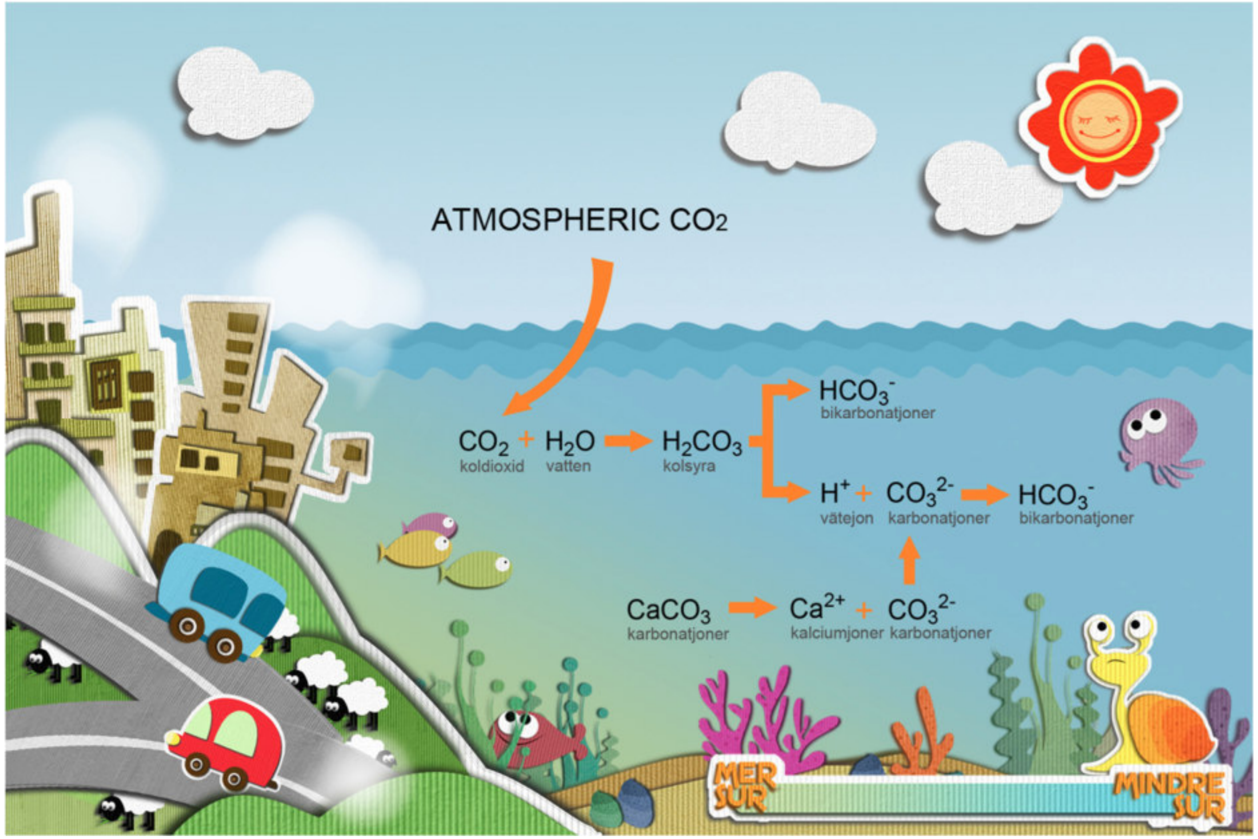
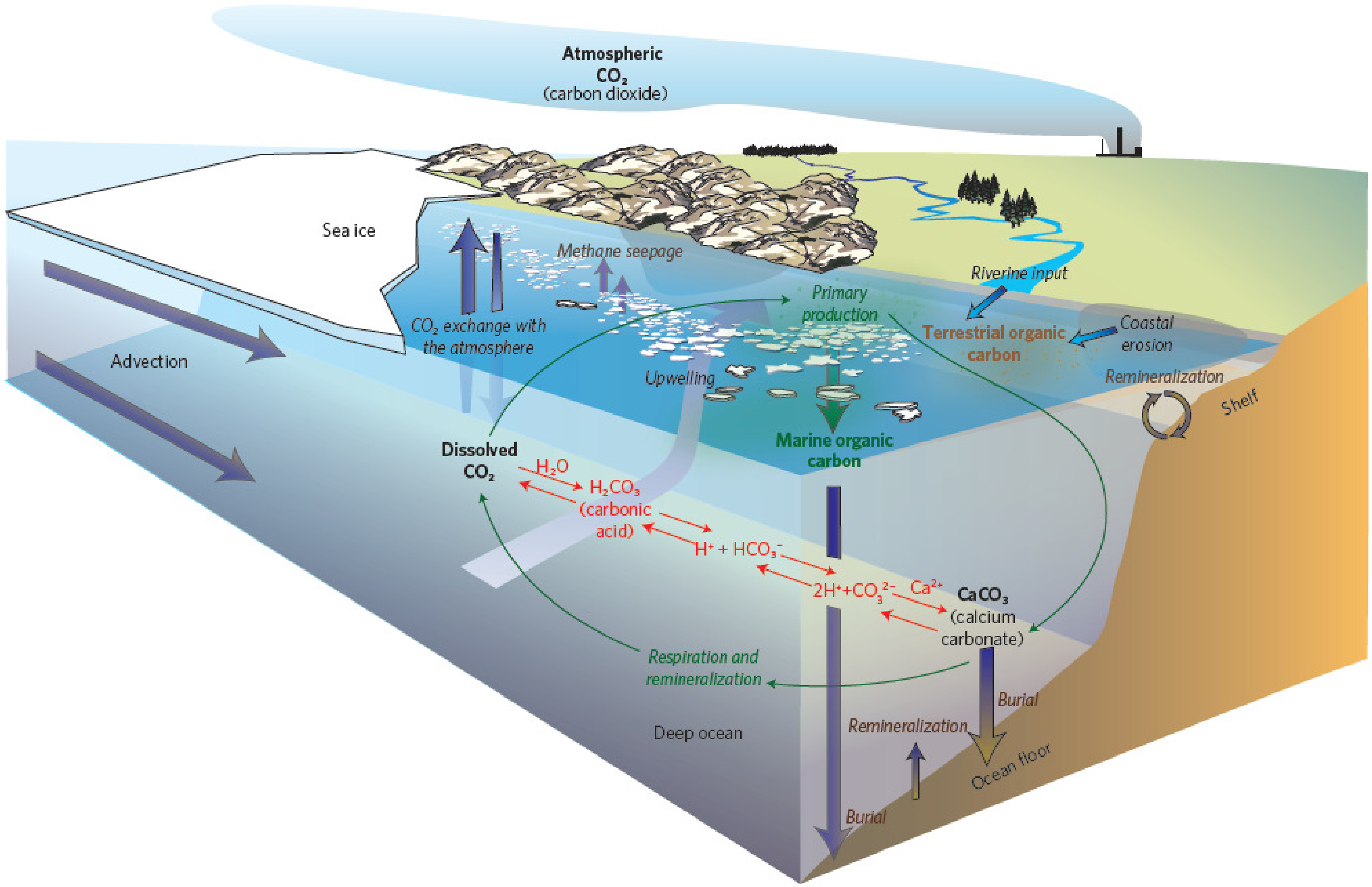
Ocean Carbon Chemistry and ocean acidification



CaCO$_3$ saturation

$$\Omega = \frac{[CO_3^{2-}].[Ca^{2+}]}{K'_{sp}}$$

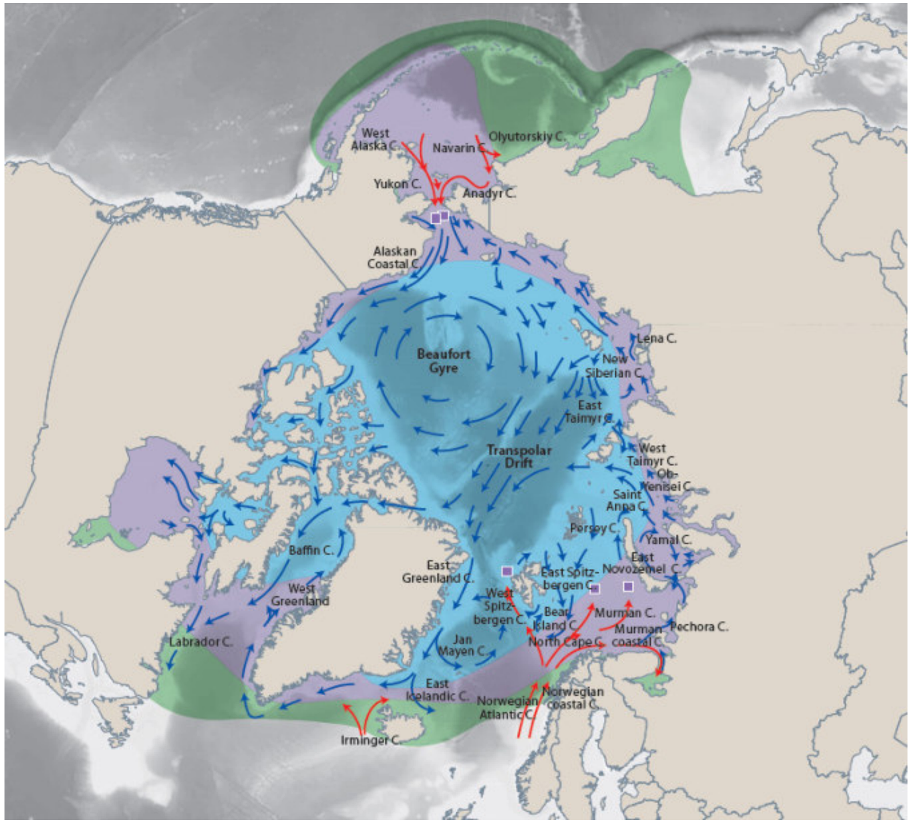
Processes controlling the carbonate system in the Arctic



Bellerby 2017. *Nature Climate Change*

Regional Seas studied In the report

Major currents in, around and out of the Arctic Ocean

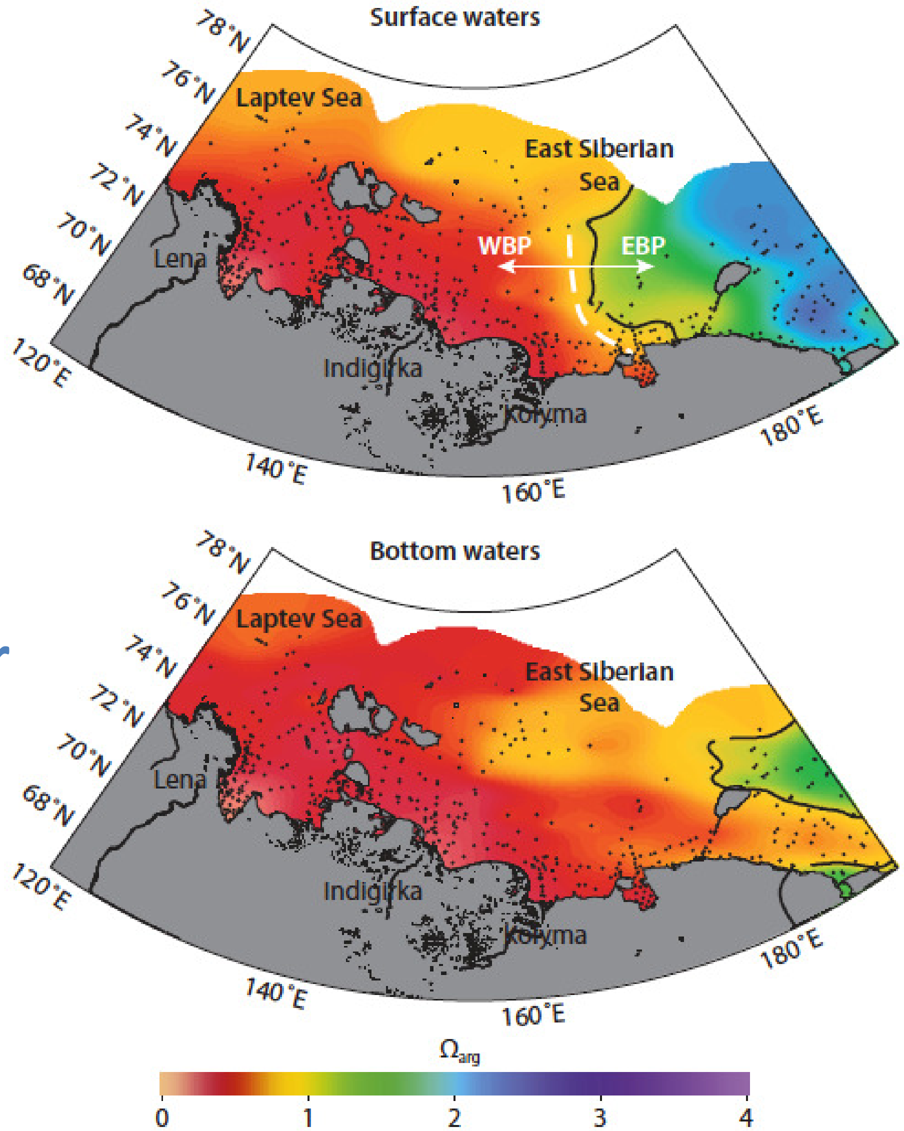


East Siberian Shelf exhibits large gradients of ocean acidification

Highly regulated by increasing organic carbon and freshwater

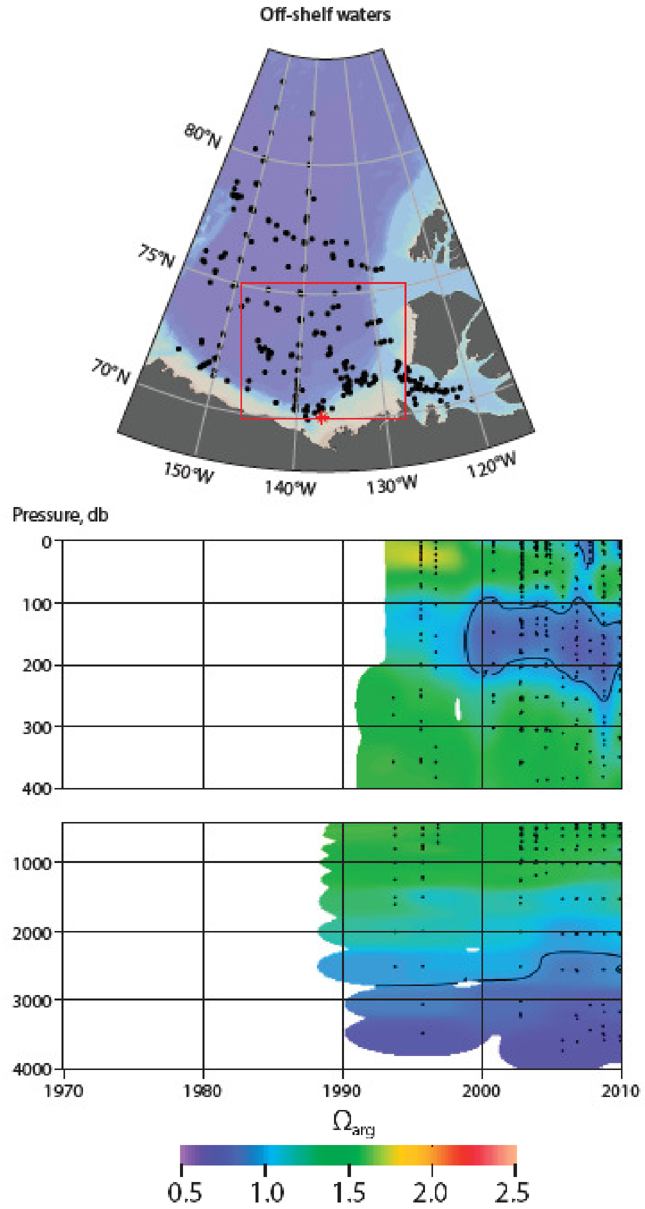
Western biogeochemical province (WBP) has lower pH and omega

Modified from Semilitov et al., 2016



Progressive acidification of the Canadian Basin

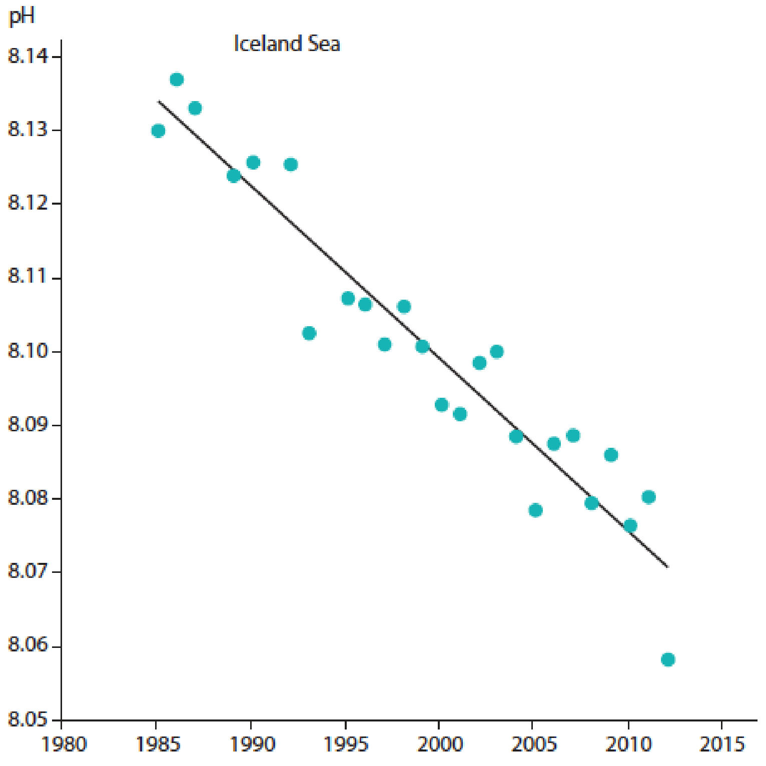
Shallowing of the deep water, and widening of the upper water column, omega saturation horizon



Update from Miller et al 2014

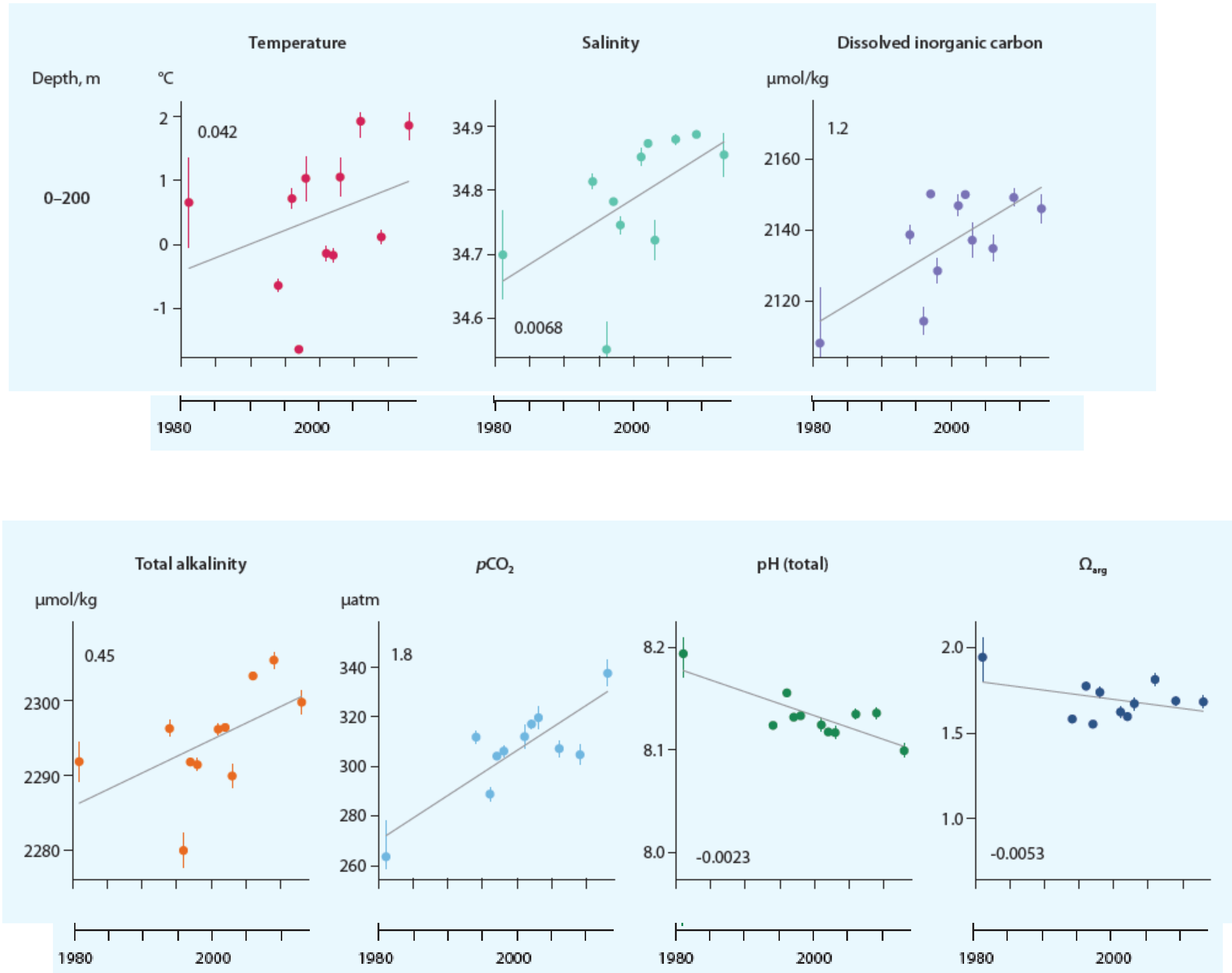
Iceland Sea long term ocean acidification

Reduction on seawater pH_T



Extended from Olafsson et al., 2009

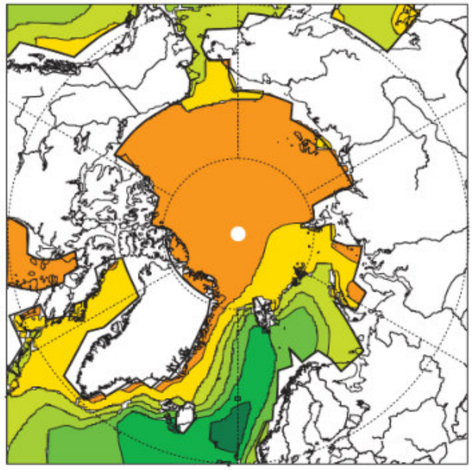
Large scale system changes in the Greenland Sea



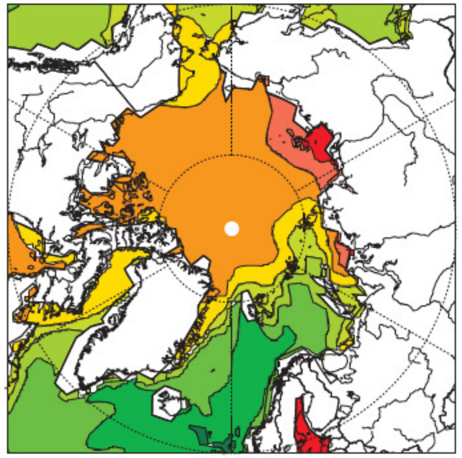
Based on Skjelvan et al., 2014

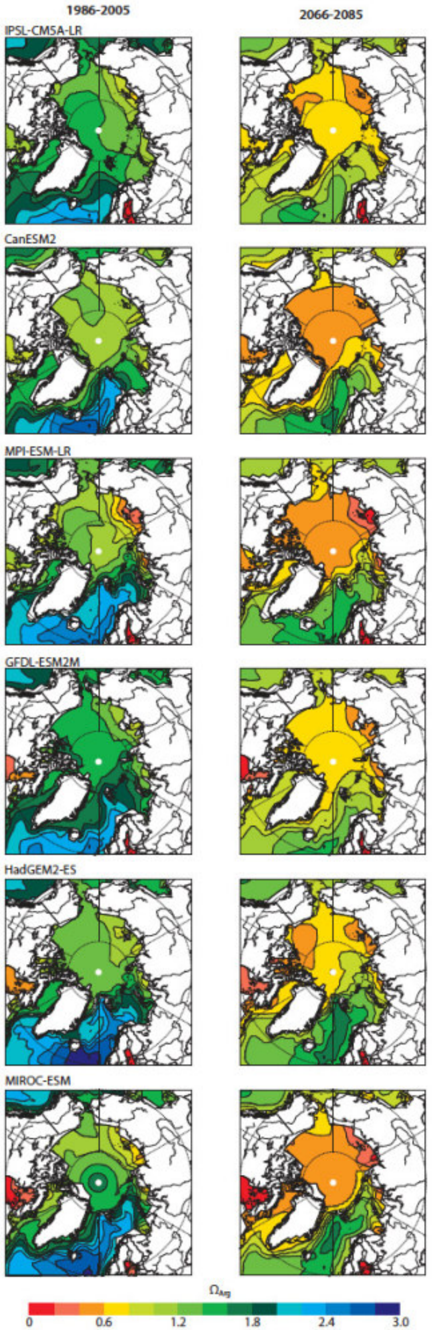
Earth System model projections of ocean-wide acidification (omega) under the RCP 8.5 scenario

CanESM2



MPI-ESM-LR

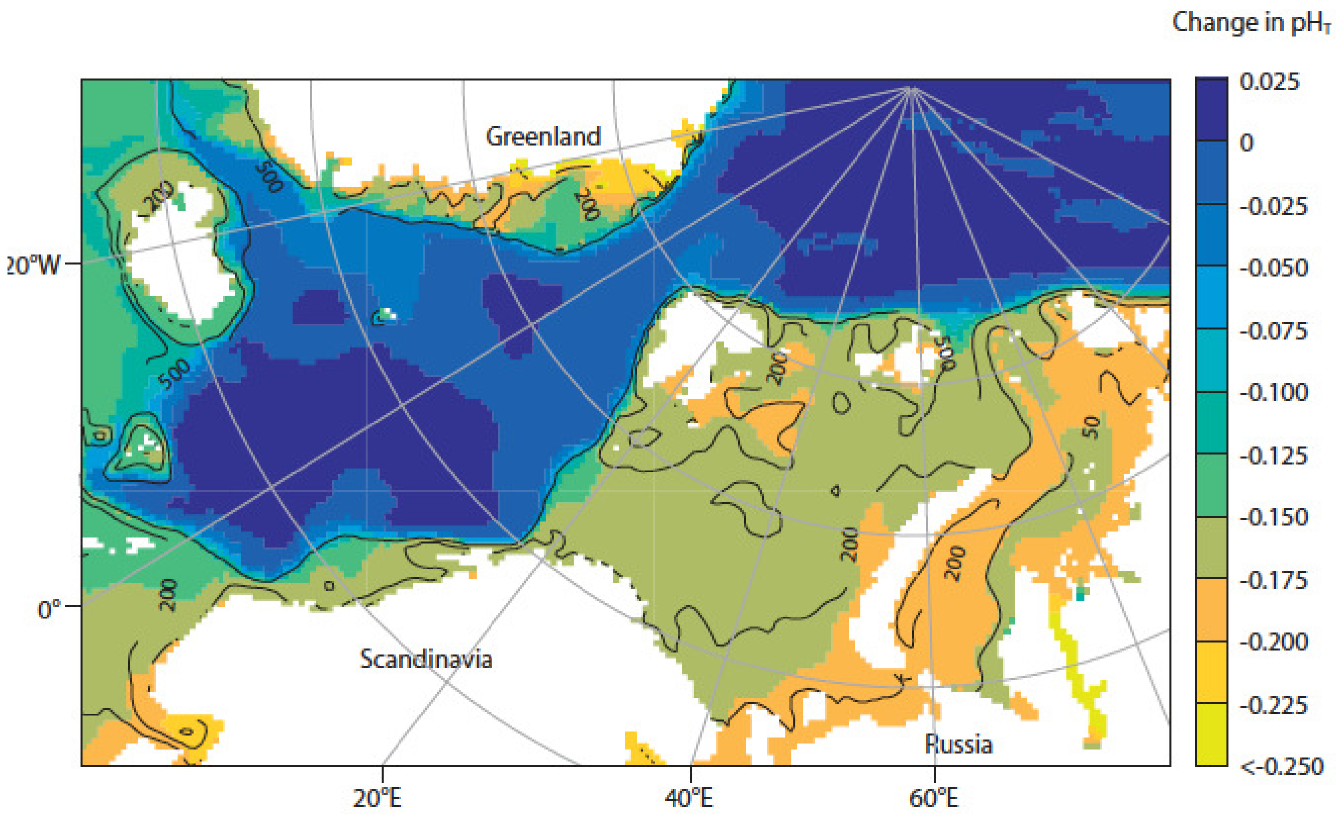




Steiner et al., 2014

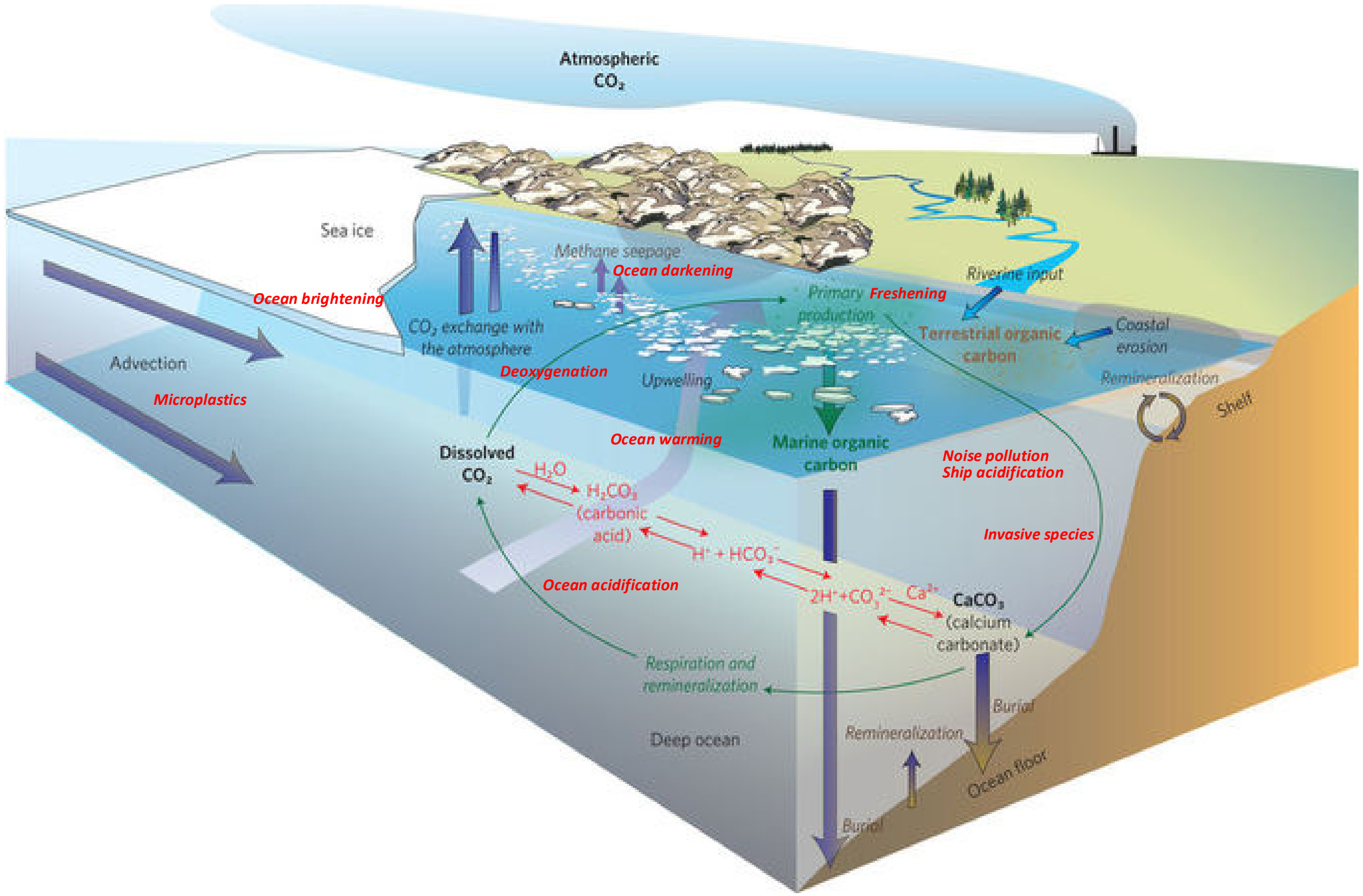
Regional ocean acidification projections with a focus on the Barents and Kara Seas

Reduction in bottom water pH_T between (bi-decadal averages around) 2010 and 2060



Wallhead et al., 2017

The Arctic Ocean ecosystem is coming under increasing pressure from multiple stressors



Adapted from Bellerby 2017. *Nature Climate Change*

Global Ocean Acidification – Observing Network

- **Goal 1:** Improve our understanding of **<u>global</u> ocean acidification** conditions.
  - Determine status of and spatial and temporal patterns in carbon chemistry, assessing the generality of response to ocean acidification;
  - Document and evaluate variation in carbon chemistry to infer mechanisms (including biological mechanisms) driving ocean acidification;
  - Quantify rates of change, trends, and identify areas of heightened vulnerability or resilience.
- **Goal 2:** Improve our understanding of **<u>ecosystem response to</u> ocean acidification**.
  - Track biological responses to OA, commensurate with physical and chemical measurements and in synergy with relevant experimental studies and theoretical frameworks;
  - Quantify rates of change and identify areas as well as species of heighted vulnerability or resilience.
- **Goal 3:** Acquire and exchange data and knowledge necessary to **<u>optimize modeling of</u> ocean acidification <u>and its impacts</u>**.
  - Provide spatially and temporally-resolved chemical and biological data to be used in developing models for societally-relevant analyses and projections;
  - Use improved knowledge gained through models to guide Goals 1 and 2 in an iterative fashion.

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Global Ocean Acidification Observing Network

A new international working group to compare and contrast ocean services in Chinese and Arctic marginal seas

Co-Chairs: **Prof. Richard Bellerby (SKLEC-NIVA, Shanghai/Bergen)**
Prof. Su Mei Liu (Ocean University of China, Qingdao)

- Identify key system services, stakeholders, regulatory institutions and process
- Identify recent historical and present variability in marginal seas services
- Couple environmental and ecological change to services
- Develop scenarios of future marginal seas services
- Optimise boundary conditions towards informed co-adaption to coastal change

IMBER

futurearth coasts
land-ocean interactions in the coastal zone

Conclusions

- Arctic Ocean is witnessing a rapidly changing carbonate system
- Large seasonal and regional variability
- «Traditional» OA is enhanced through changes to the hydrological cycle and land derived carbon
- There is a lack of international coordination of monitoring
- Ocean acidification is not yet studied in tandem with changes in other system stressors