RAW

GLACIERS RETREAT AND FIORDS WITHER

funded by

Norway grants

NATIONAL SCIENCE CENTRE
POLAND

Institute of Geophysics
Polish Academy of Sciences

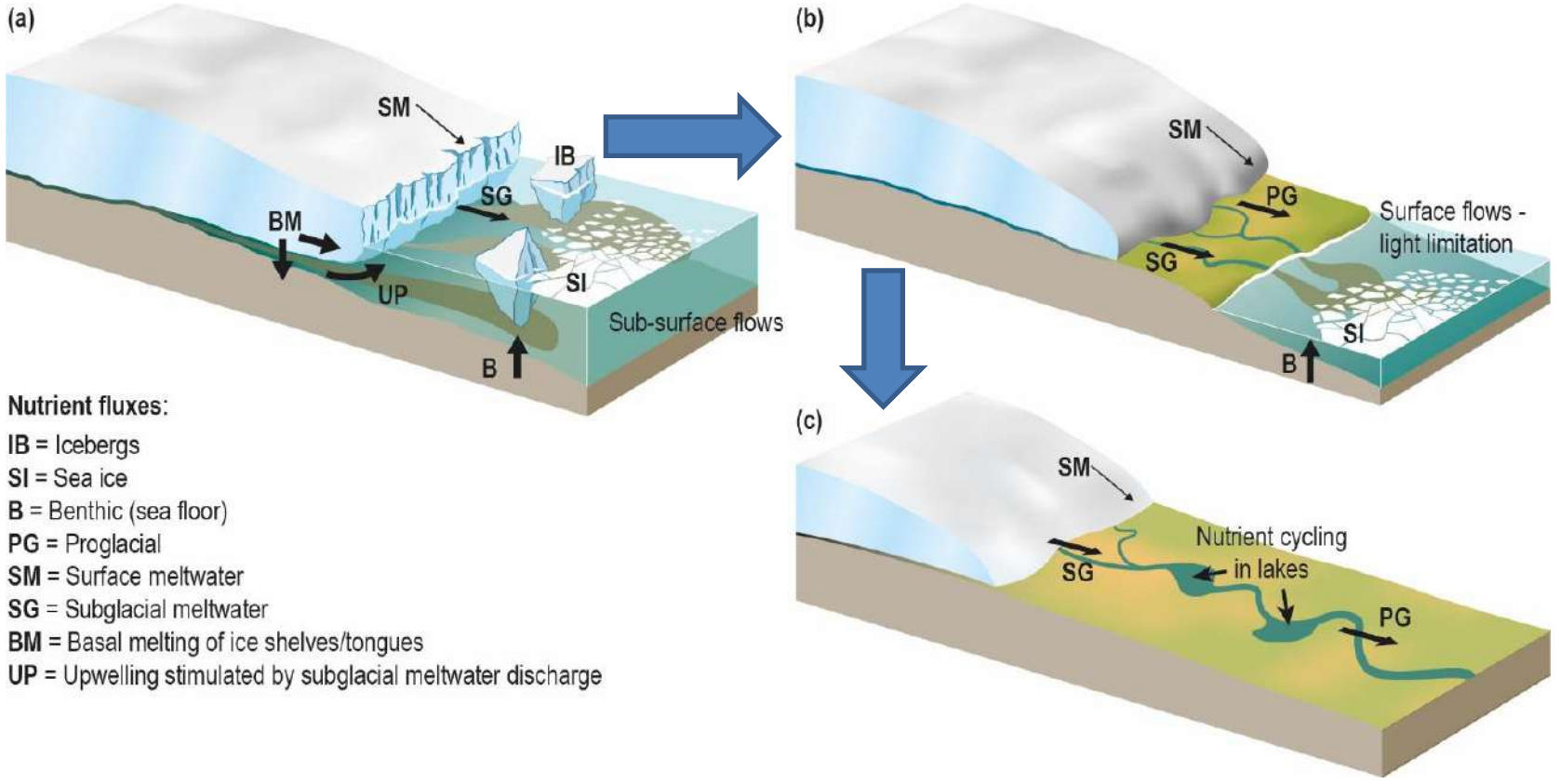
Western Norway
University of
Applied Sciences

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

Mateusz Moskalik

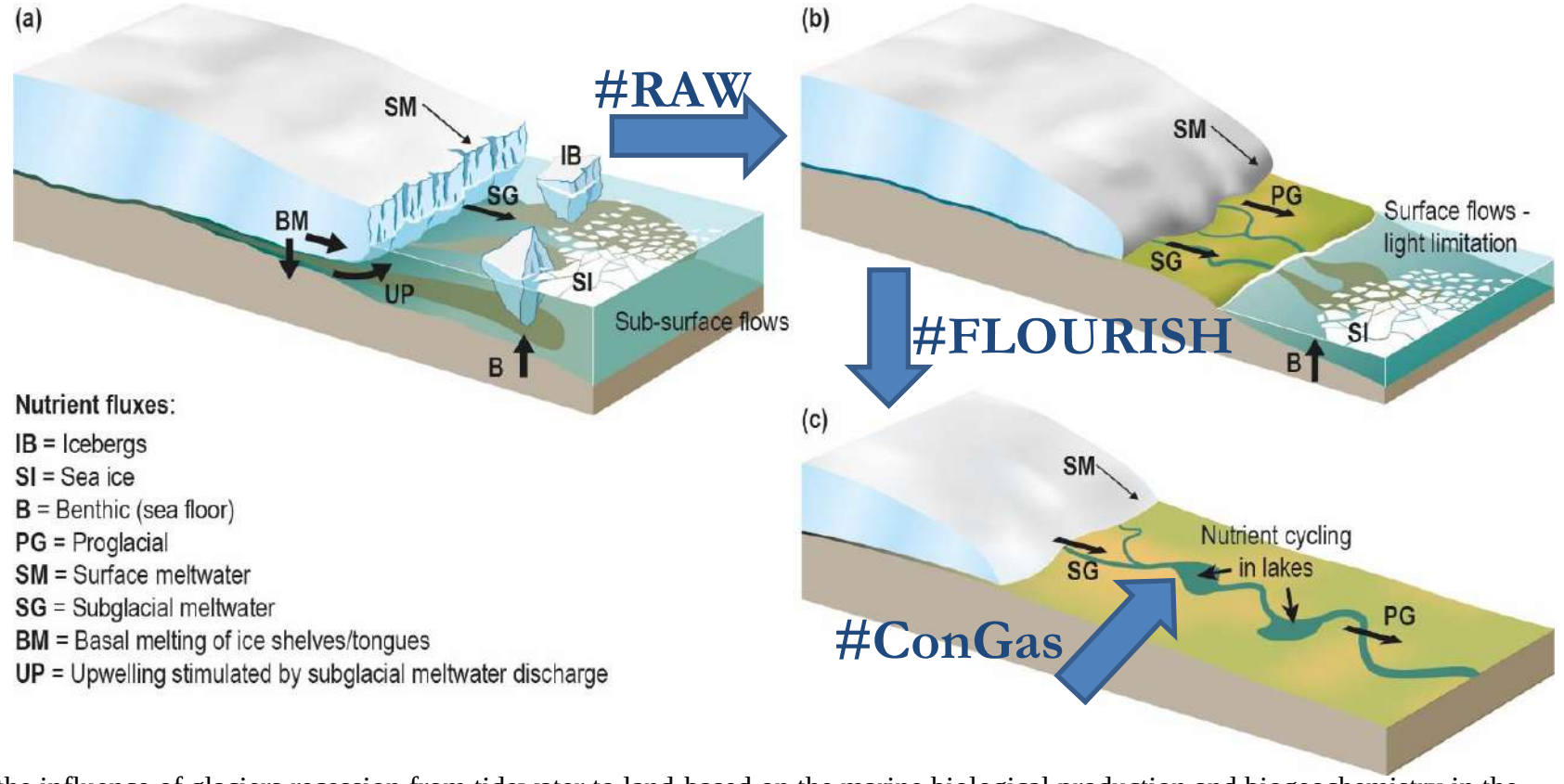
Institute of Geophysics PAS

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



Glacier recession causes changes in fiord hydrography, sedimentology, and biogeochemical cycles in sea and on land occurring at: 1) transition of tidewater to land-based glacier, 2) long-term recession of land-based glaciers (IPCC, 2019, Chapter 3)

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

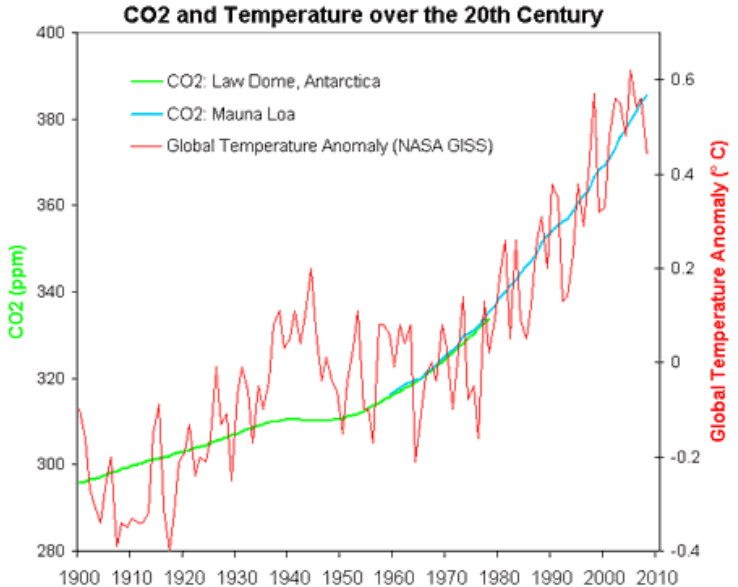


2021 – 2024 „**RAW** – What is the influence of glaciers recession from tidewater to land-based on the marine biological production and biogeochemistry in the Arctic" (NCN GRIEG) (IGF PAN, IO PAN, HVL)

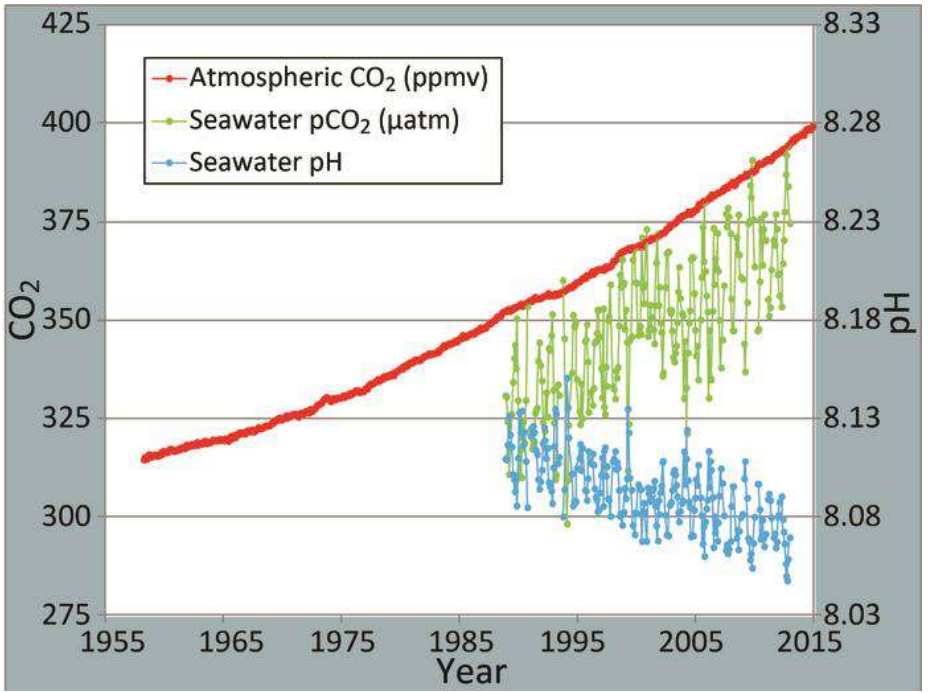
2022 – 2025 „**FLOURISH** – Consequences of glacier changes on downstream nutrient supply and carbon metabolism" (NCN SONATA) (SONATA 17) (UWr, IGF PAN)

2021 – 2025 „**ConGas –** Ecosystem connectivity effects on the metabolism and greenhouse gas flux in warming Arctic and Alpine lakes" (NCN, OPUS LAP) (IGF PAN, UB)

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



https://skepticalscience.com//co2-temperature-correlation-intermediate.htm

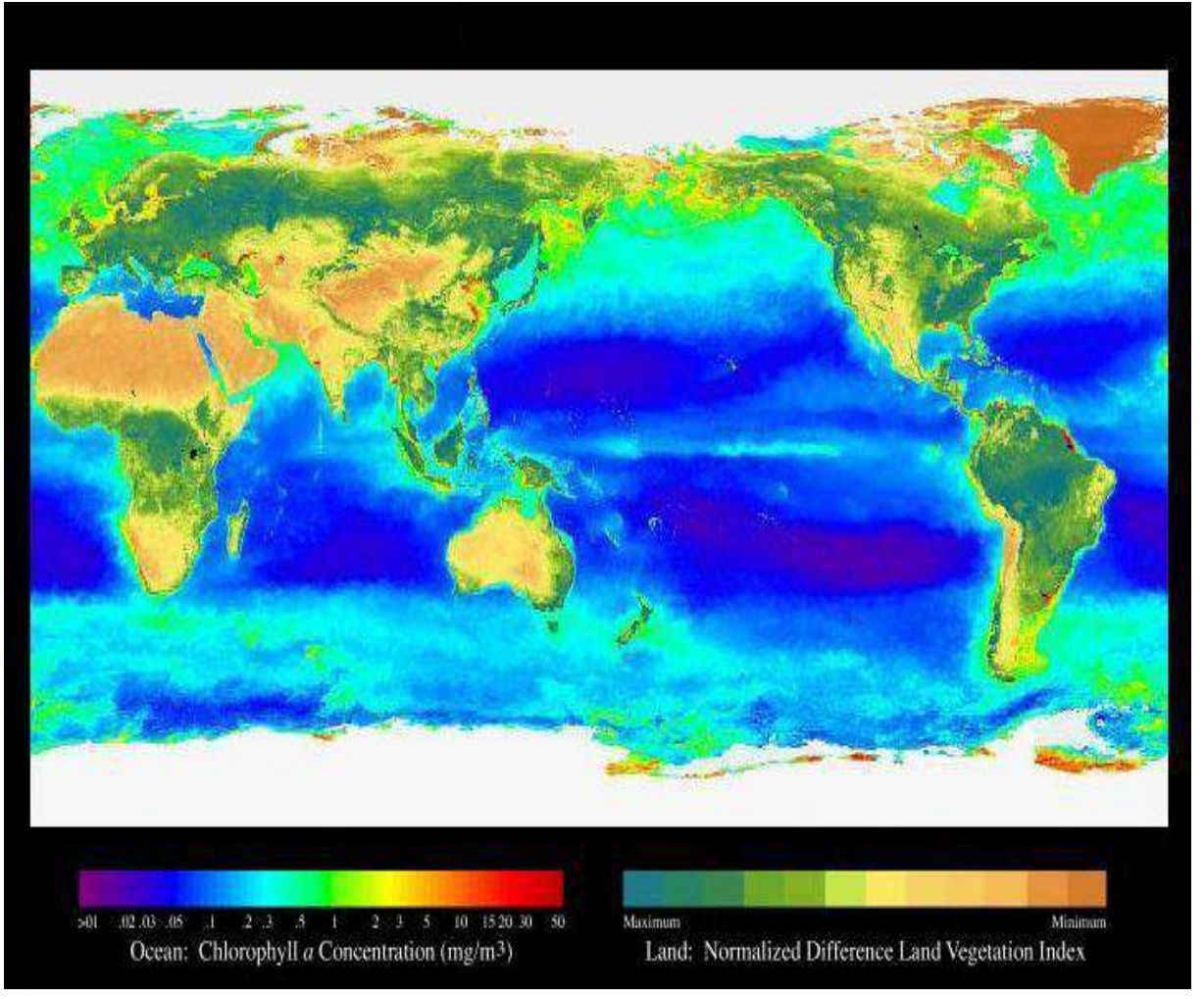


http://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/

- CO_2 is a major greenhouse gas responsible for global Warming
- Increase of atmospheric CO_2 causes increase in seawater CO_2
- The inverse processes can be also observed – lower CO_2 concentration in seawater causes decrease in atmospheric CO_2

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

Marine productivity conditions drive to a large degree the air-sea CO_2 exchange. The Arctic Ocean, due to its relatively high primary productivity and low water temperatures is responsible for as much as 14% of the global CO_2 uptake by marine regions (Bates and Mathis, 2009). It makes the Arctic marine ecosystems an important component in the global carbon cycle. The recent findings (Ericson et al. 2018, 2019; Smith et al. 2015) showed that Arctic fjords are especially effective in absorbing atmospheric CO_2 and burial of organic matter in the sediments.



https://commons.wikimedia.org/w/index.php?curid=164378

Norway grants

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

Example of international ocean studies examined the fertilization phenomenon:

- Ironex, 1995;
- SOIREE (Southern Ocean Iron Release Experiment), 1999;
- EisenEx (Iron Experiment), 2000;
- SEEDS (Subarctic Pacific Iron Experiment for Ecosystem Dynamics Study), 2001;
- SOFeX (Southern Ocean Iron Experiments - North & South), 2002;
- SERIES (Subarctic Ecosystem Response to Iron Enrichment Study), 2002;
- SEEDS-II, 2004;
- EIFEX (European Iron Fertilization Experiment), 2004;
- CROZEX (CROZet natural iron bloom and Export experiment), 2005;
- LOHAFEX (Indian and German Iron Fertilization Experiment), 2009;
- Haida Salmon Restoration Corporation (HSRC), 2012;

' It is based on the reasoning that adding trace amounts of iron to iron-limited phytoplankton of the Southern Ocean will lead to blooms, mass sinking of organic matter and ultimately sequestration of significant amounts of atmospheric carbon dioxide (CO2) in the deep sea and sediments. This iron hypothesis, proposed by John Martin in 1990 (Martin 1990 Paleoceanography5, 1–13), has been tested by five mesoscale experiments'

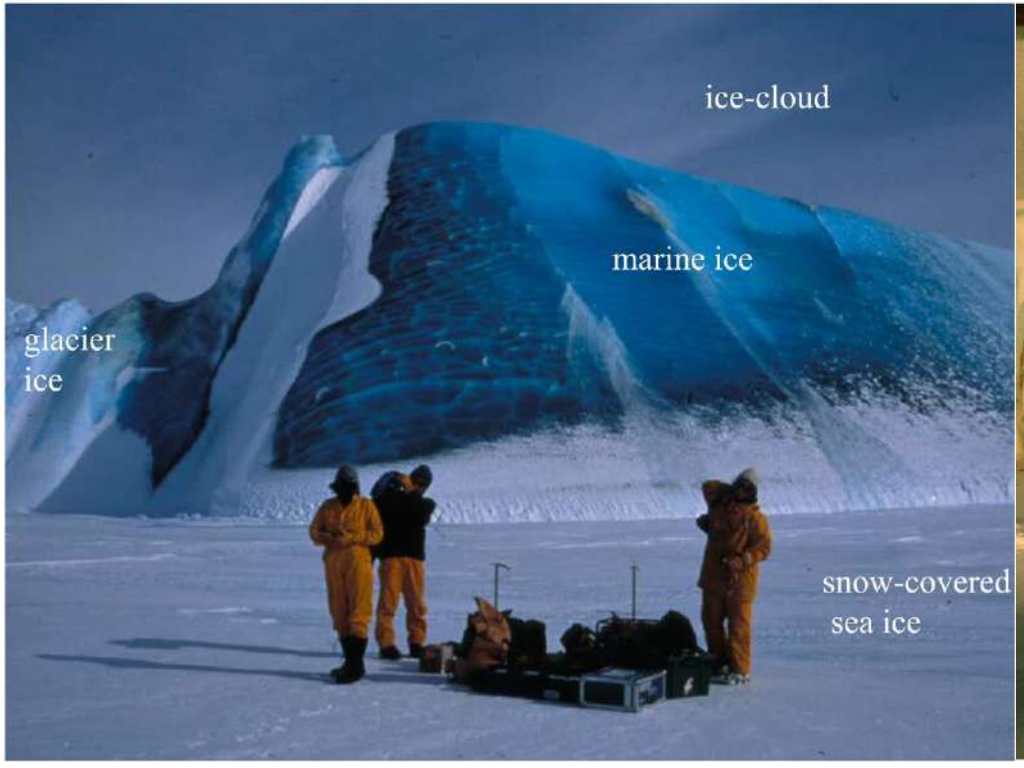
Smetacek V. i in. 2008. The next generation of iron fertilization experiments in the Southern Ocean. Phil. Trans. R. Soc. A 10.1098/rsta.2008.0144

'Fertilization of the ocean by adding iron compounds has induced diatom-dominated phytoplankton blooms accompanied by considerable carbon dioxide drawdown in the ocean surface layer.'

Smetacek V. i in. 2012. Deep carbon export from a Southern Ocean iron-fertilized diatom bloom. Nature 487, 313-319

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

The mystery of the Emerald Ice



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

The mystery of the Emerald Ice

The typical color of icebergs is white, blue. From the beginning of polar regions exploration, explorers inform about „green icebergs”.

‘Analysis of the samples by fluorescence spectroscopy indicates that the blue absorption, and hence the inherent green color, is due to the presence of marine-derived organic matter in the green iceberg, basal ice, and seawater. Thick accumulations of green ice, in icebergs and at the base of ice shelves, indicate that high concentrations of organic matter exist in seawater for centuries at the depth of basal freezing.’

Warren S.G. i in. 1993.Green icebergs formed by freezing of organic-rich seawater to the base of Antarctic ice shelves. JGR Oceans 98, 6921-6928

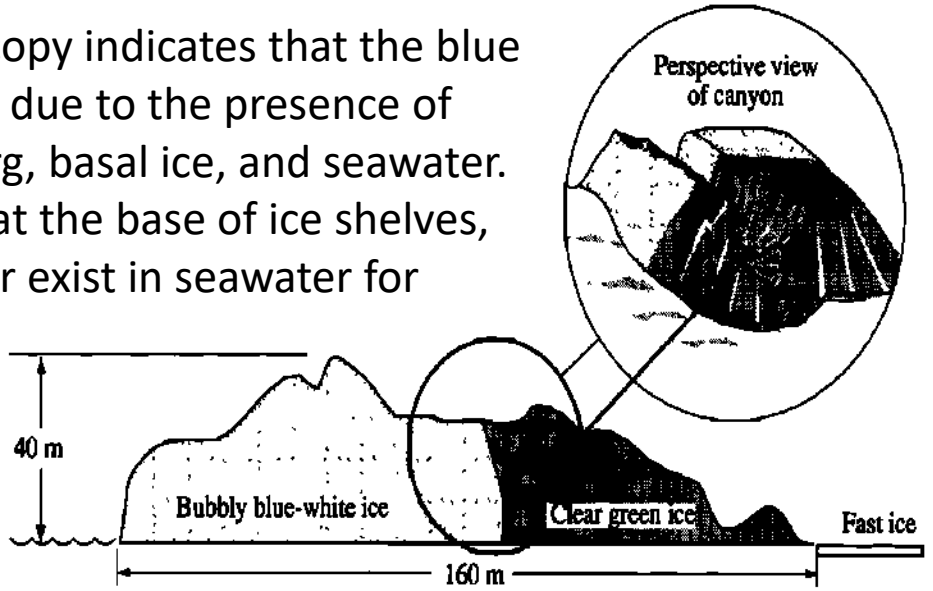


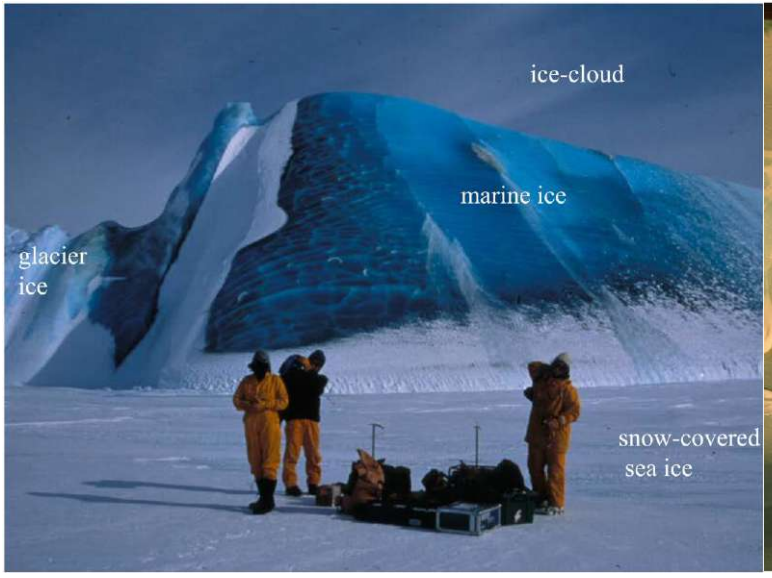
Fig. 1 Diagram of the iceberg sampled on November 19, 1988, at 67°S, 62°E (viewed toward east). Spectral measurements and core sample were taken at the location marked as a black dot in the canyon. We argue that the iceberg broke off from an ice shelf in which the boundary plane separating blue ice from green ice was originally horizontal.

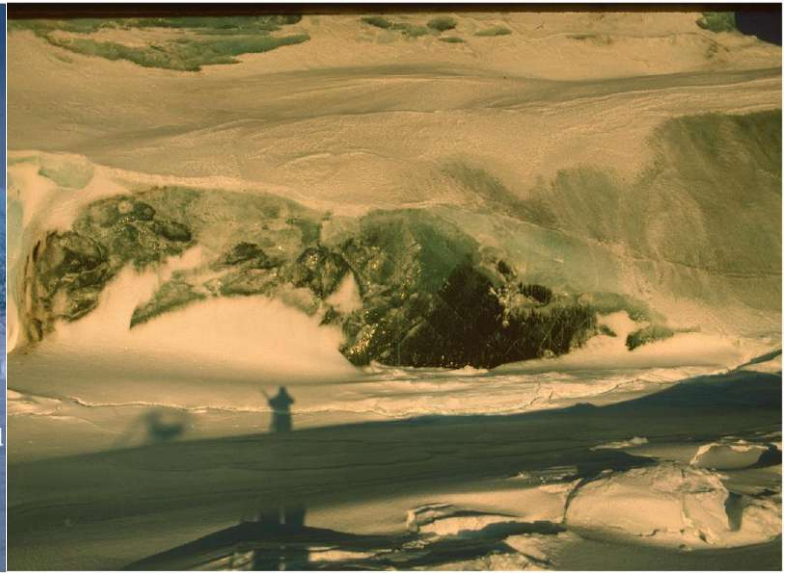
Project funded by the Norwegian Financial Mechanism 2014-2021 Grant agreement no. UMO-2019/34/H/ST10/00504

The mystery of the Emerald Ice

‘Previously, dissolved organic carbon (DOC) had been proposed to be responsible for the green color. Subsequent measurements of low DOC values in green icebergs, together with the recent finding of large concentrations of iron in ice from the Amery Ice Shelf, suggest that the color of green icebergs is caused more by iron-oxide minerals than by DOC.’

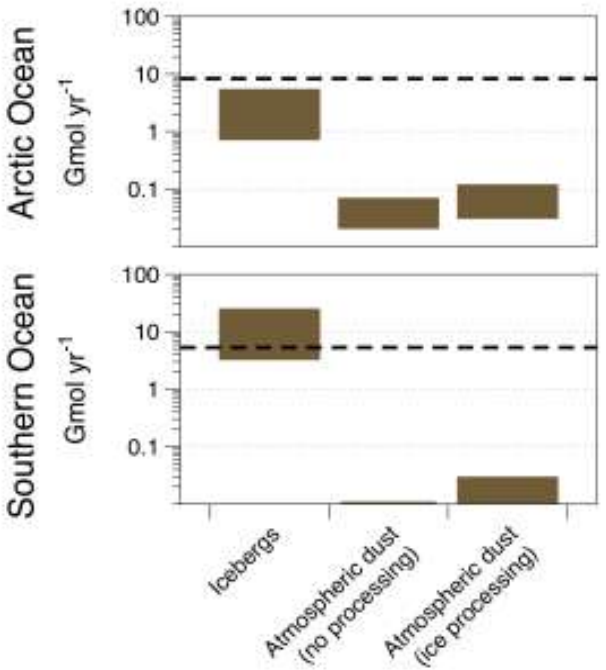
Warren S.G. i in. 2019. Green icebergs revisited. JGR Oceans 10.1029/JC014479



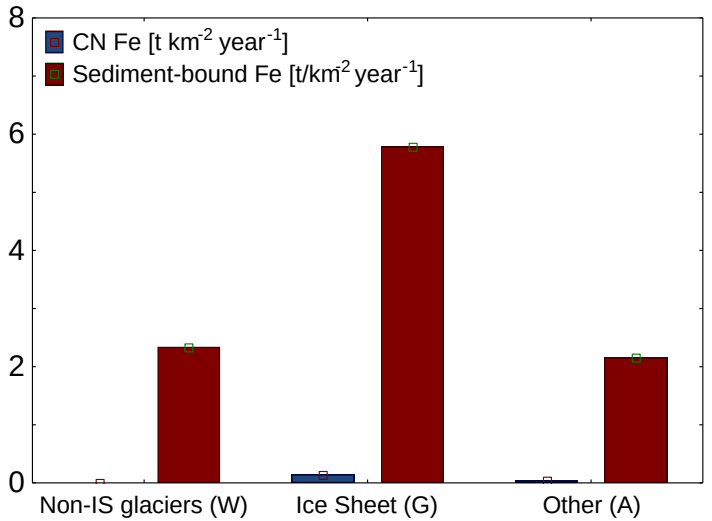


Project funded by the Norwegian Financial Mechanism 2014-2021 Grant agreement no. UMO-2019/34/H/ST10/00504

„Glacier erosion driven sediment-bound micronutrient supply”



(Raiswell et al., 2016)



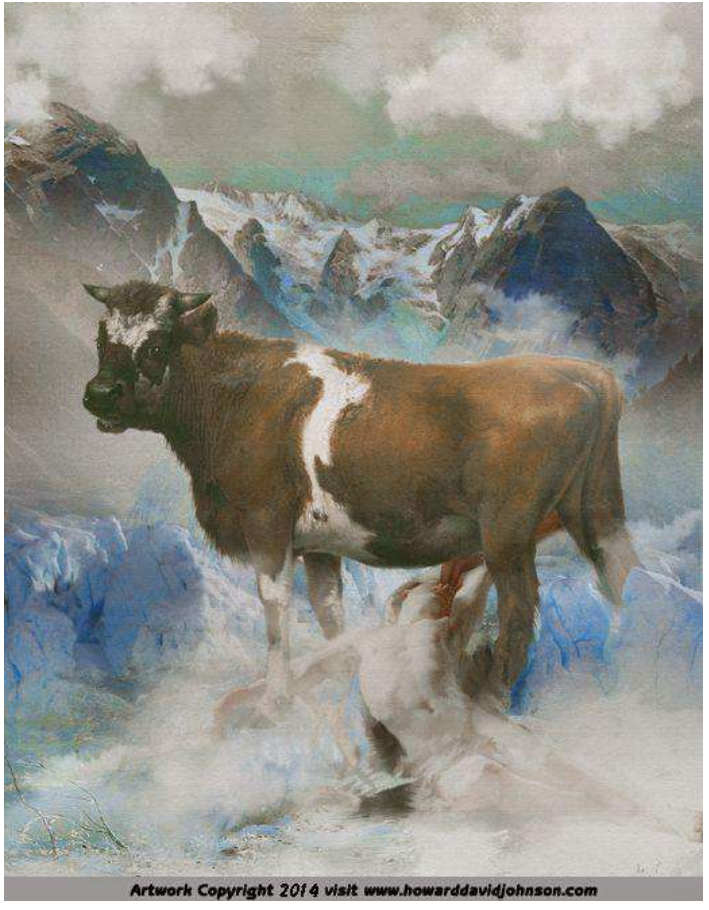
W – Werenskioldbreen (Ł.S. unpublished)
G – Leverett, Grenlandia (Hawkings et al., 2014)
A – Antarktyka (Hodson et al., 2017)

Release of iron from icebergs is greater than from atmospheric dust

Amount of iron adsorbed on the sediment is at least two orders of magnitude higher than disolved

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

Holy cows

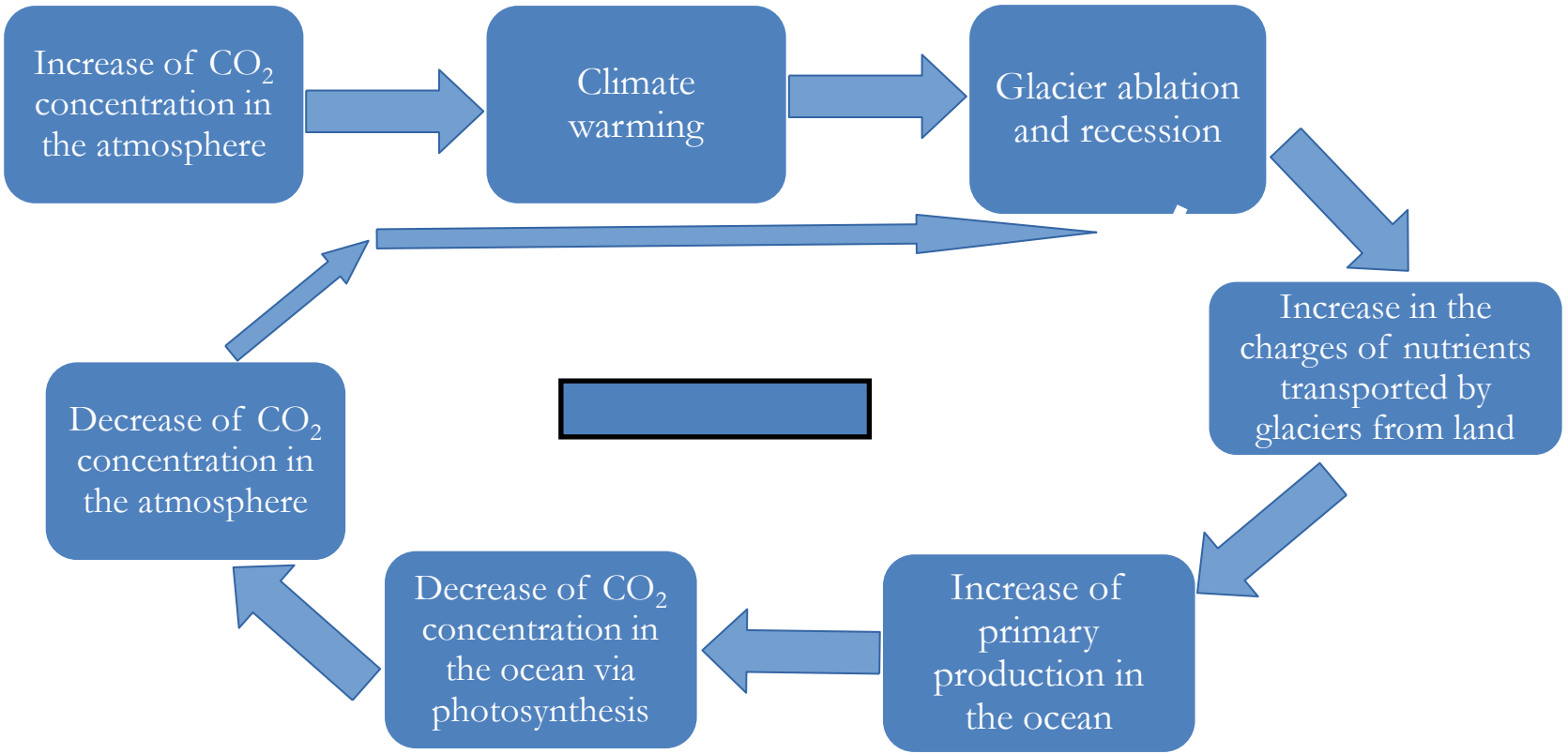


Auđumbla (Norse myhology) is a primeval cow. The Ymir fed on her milk, and over the course of three days, she licked away the salty rime rocks and revealed Búri, grandfather of the gods Odin, Vili, and Vé. The cow's name Auđumbla (Auđhumla, and Auđumla) is generally accepted as meaning **'hornless cow rich in milk'** (from Old Norse auđr 'riches' and humala 'hornless'). However, auđr can also mean **'fate'** and **'desolate desert'** and so Auđhum(b)la may also have been understood as the **'destroyer of the desert'**.

Kamadhenu (Hinduism), the mother of all cows. Himalaya are her legs. On Kajas mount (in Buddhism this mount is the center of the world) there is Gomukh glacier (means 'Cow Mouth'). Water from this and other glaciers on this mount are part of four main Asia rivers: Indusu, Gangesu, Brahmaputry and Satledźu. She's name means **'cow of plenty'**.

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

Negative feedback effect with CO_2 concentration via photosynthesis (De Baar et al. 2008; Gerringa et al. 2012)



Norway grants

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

But .....

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

Norway grants

Meire et al. 2016 Highe export of dissolved silica from the Greenland Ice Sheet. *GRL*

Meire et al.,2017 Marine-terminating glaciers sustain high productivity in Greenland fjords. *Global Change Biology*

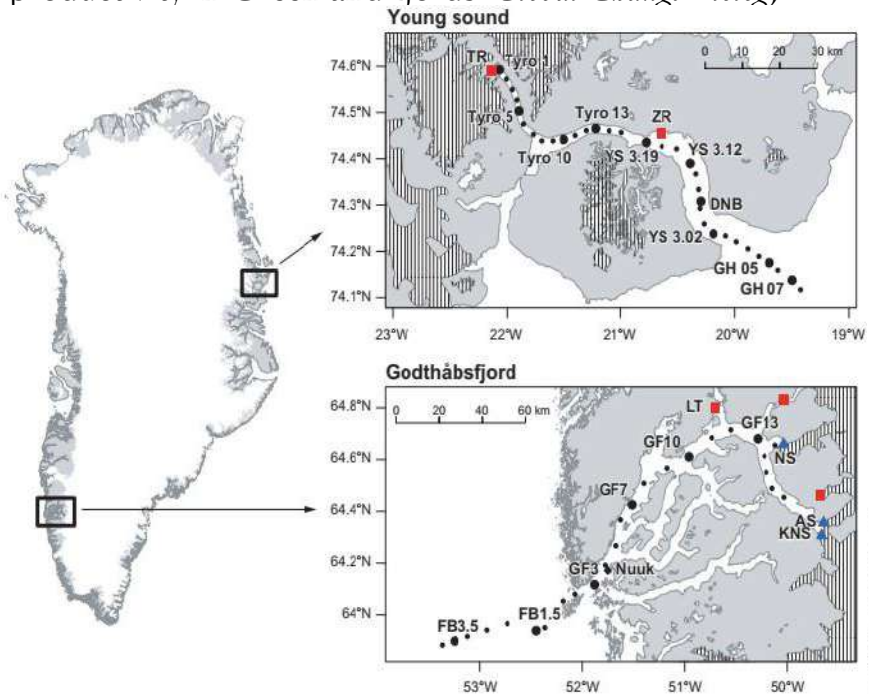


FIGURE 1 Map of Young Sound and Godthåbsfjord indicating the stations (solid dots) along a transect from the Greenland Ice Sheet (shaded area) towards the mouth of fjord region. Marine-terminating glaciers in Godthåbsfjord are indicated by blue triangles (NS, KNS and AS), major meltwater rivers in Godthåbsfjord and Young Sound by red squares (Lake Tasersuaq LT; Zackenberg river ZR; Tyroler river TR)

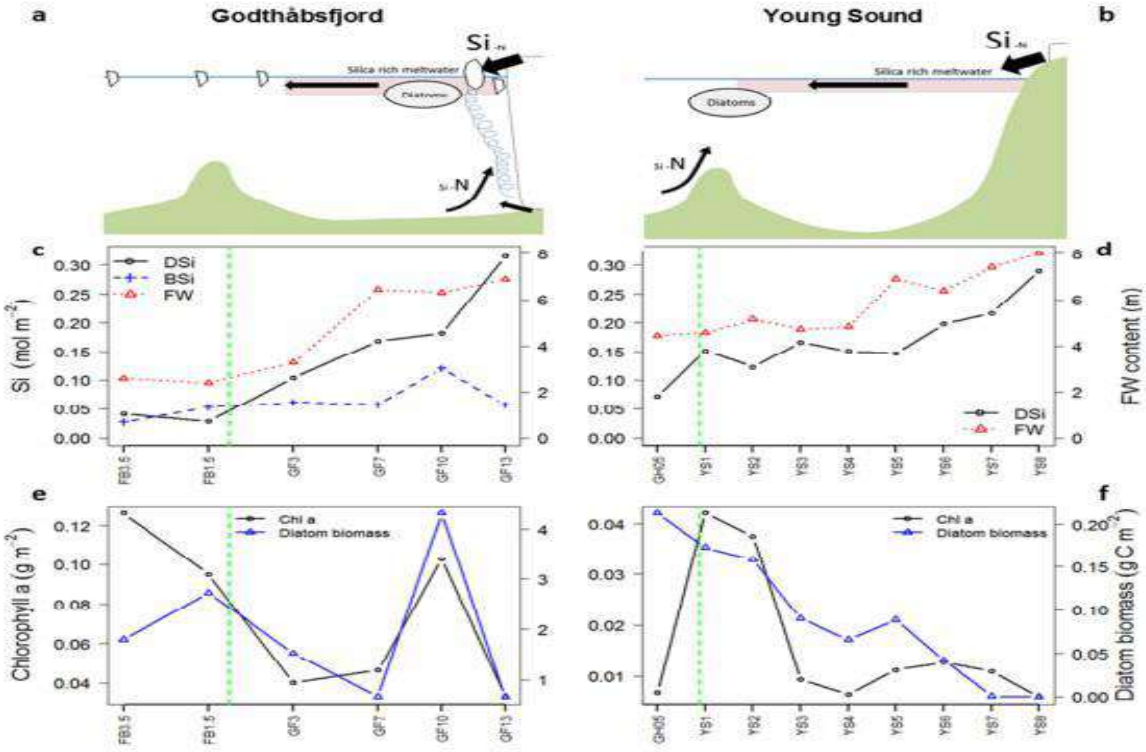
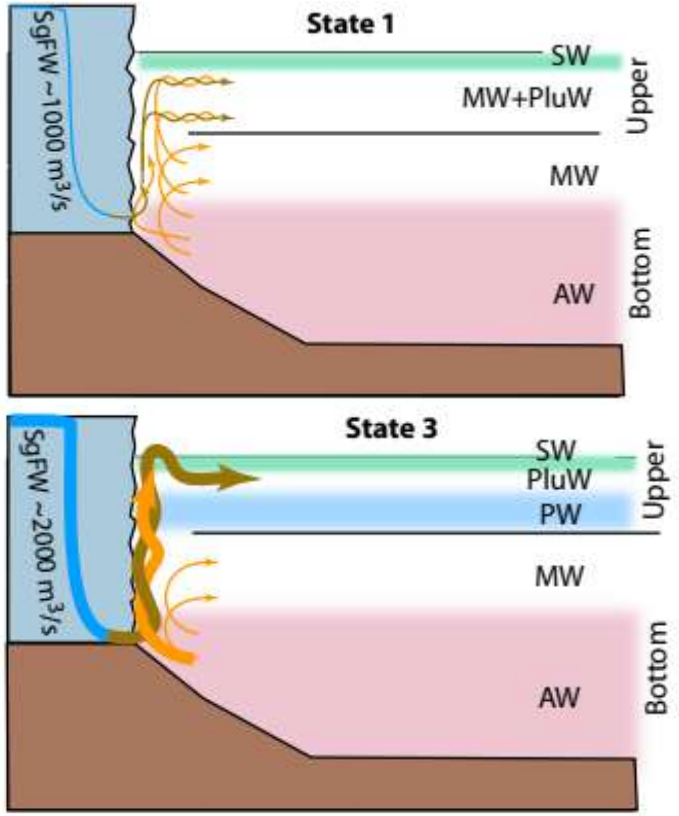


Figure 2. Conceptual model on the link between meltwater runoff rich in silicate and diatom blooms in a fjord system impacted by marine and land terminating glaciers (a,b). Integrated concentrations in the upper 40 m along a length transect in August from the inner fjord (right) to the open shelf area (left) in Godthåbsfjord (c) and Young Sound (d). For Godthåbsfjord both dissolved silica (DSi, black) and biogenic silica (BSi, blue) are shown alongside the freshwater content (FW, red). The green dashed line indicates the mouth of the fjord. Panel e and f show the integrated chlorophyll *a* concentration (g m^{-2}) and diatom biomass (in g C m^{-2}) in the upper 40 m for Godthåbsfjord (e) and Young Sound (f). Note the different scaling for chlorophyll and diatoms biomass between Young Sound and Godthåbsfjord.

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

„Glacier meltwater driven marine macronutrient upwelling”



(Chauche et al., 2014)

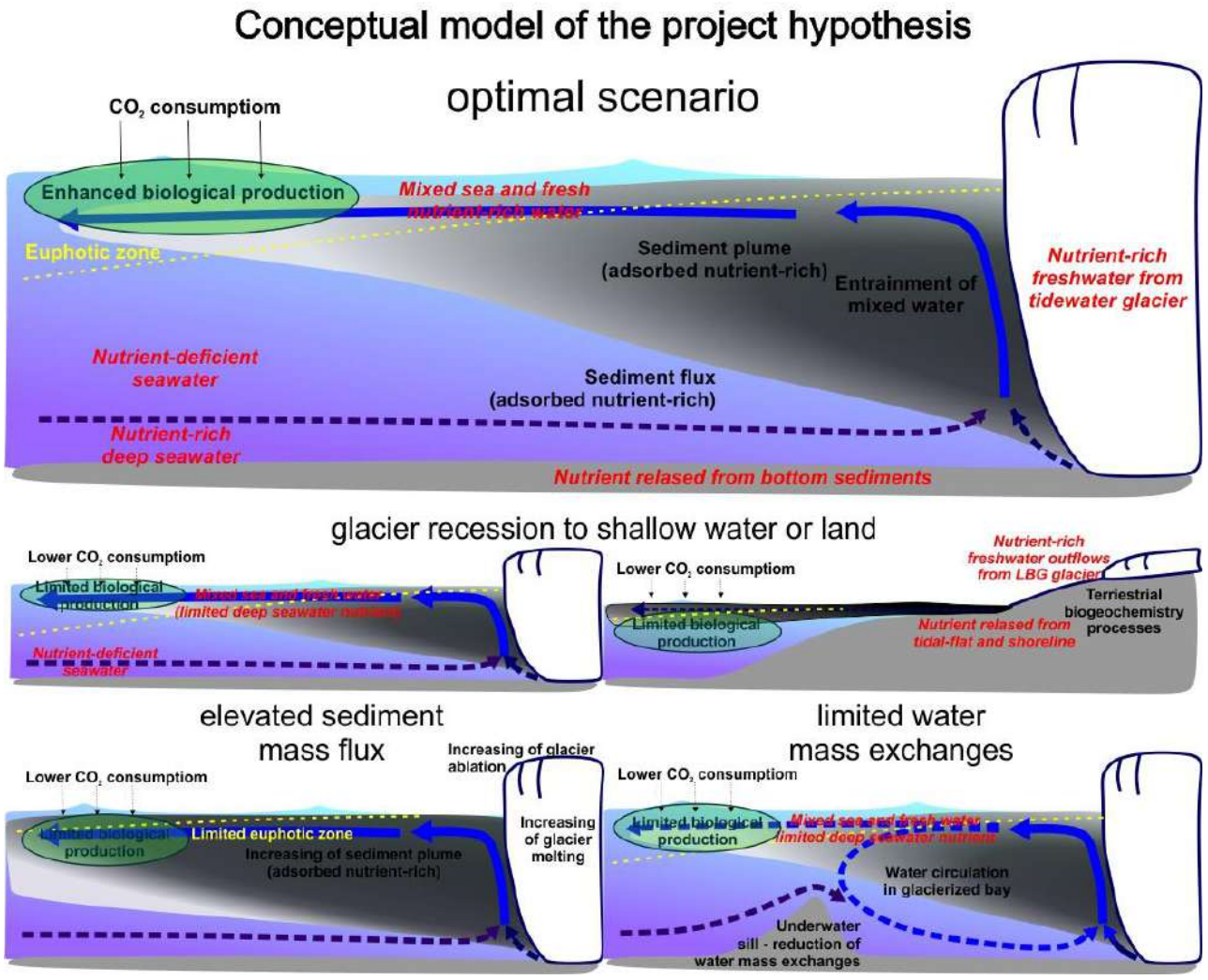
- Higher subglacial runoff in tidewater glacier causes upwelling of deep waters
- Upwelling waters should get to photic zone to cause an increase in primary production

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

RAW Project hypothesis

The warming-driven glacier recession causes a reduction in marine biological production in polar coastal regions and seas due to:

- unfavorable nutrient balance caused by a reduction in nutrient-rich deep water upwelling from buoyant meltwaters plumes;
- shallowing the euphotic zone caused by increased surface suspended sediments concentration
- reduction of water mass exchanges and sediment-bound nutrients transfer between the fjord/open sea and newly formed bay due to hydrography and formation of natural sediment traps.



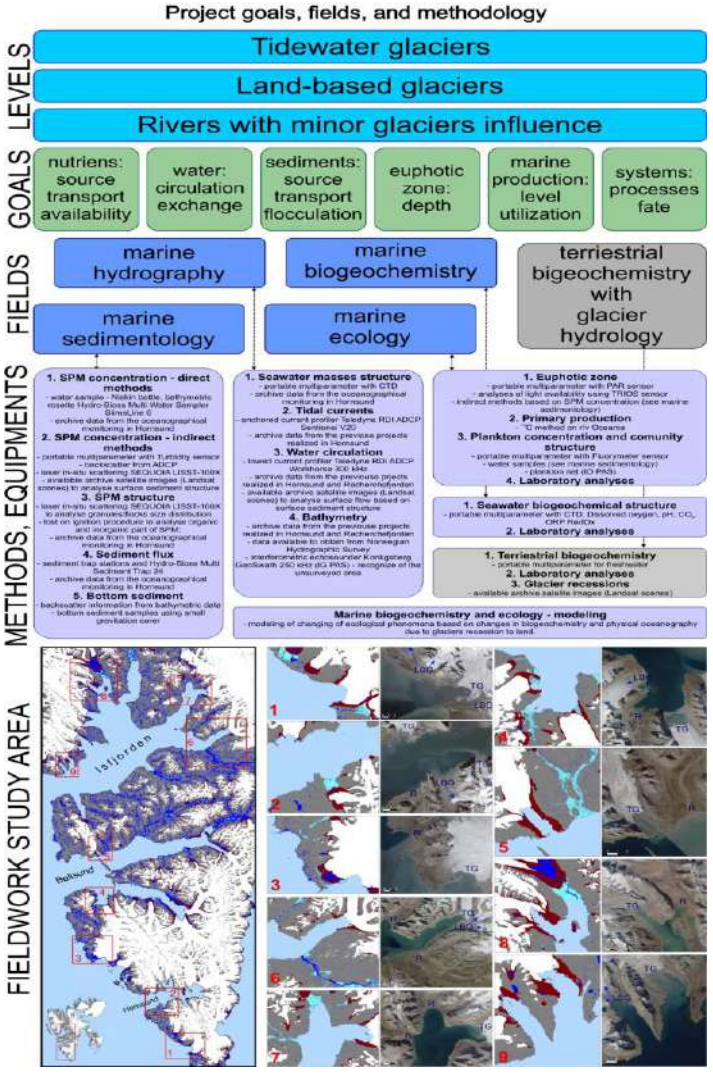
Project funded by the Norwegian Financial Mechanism 2014-2021 Grant agreement no. UMO-2019/34/H/ST10/00504

Working group:
Bożek Dagmara (IG PAS), Dąbrowska Anna (IO PAS), Dragańska-Deja Katarzyna (IO PAS), Gackowska Natalia (UG), Giżejewski Jerzy (IG PAS), Gjerde Marthe (HVL), Głowacki Oskar (IG PAS), Hodson Andrew (HVL), Jain Vineet (IG PAS), Kitowska Małgorzata (IO PAS), Korhonen Meri (IG PAS), Koziorowska-Makuch Katarzyna (IO PAS), Kuliński Karol (IO PAS), Luks Bartłomiej (IG PAS), Moskalik Mateusz (IG PAS), Rets Ekaterina (IG PAS), Stachnik Łukasz (UWr), Szymczycha Beata (IO PAS), Trudnowska Emilia (IO PAS), Yde Jacob (HVL) ..... and be more

IG PAS - Institute of Geophysics Polish Academy of Sciences
IO PAS - Institute of Oceanology Polish Academy of Sciences
UG - University of Gdańsk
HVL - Western Norway University of Applied Sciences
UWr - University of Wrocław

Project webpage:
https://raw-grieg.igf.edu.pl/

Project FB:
https://www.facebook.com/glacierretreatandfjordswither



Norway grants

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

Norway
grants

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

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

Norway
grants

Norway grants

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

National Science Centre Poland

Institute of Geophysics Polish Academy of Sciences

Western Norway University of Applied Sciences

RAW Glaciers Retreat And Fjords Wither