Newly ice-free coastal zones as emerging carbon sinks in the warming Arctic fjords (Svalbard, West Spitsbergen)

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Norway grants

RAW
GLACIERS RETREAT AND FIORDS WITHER

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Gains and losses in the productivity of the polar fjords

euphotic zone ↓

Fig. 1 Brown zones in front of Tunabreen (14th Aug 2021)

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Gains and losses in the productivity of the polar fjords

euphotic zone ↓

new area ↑

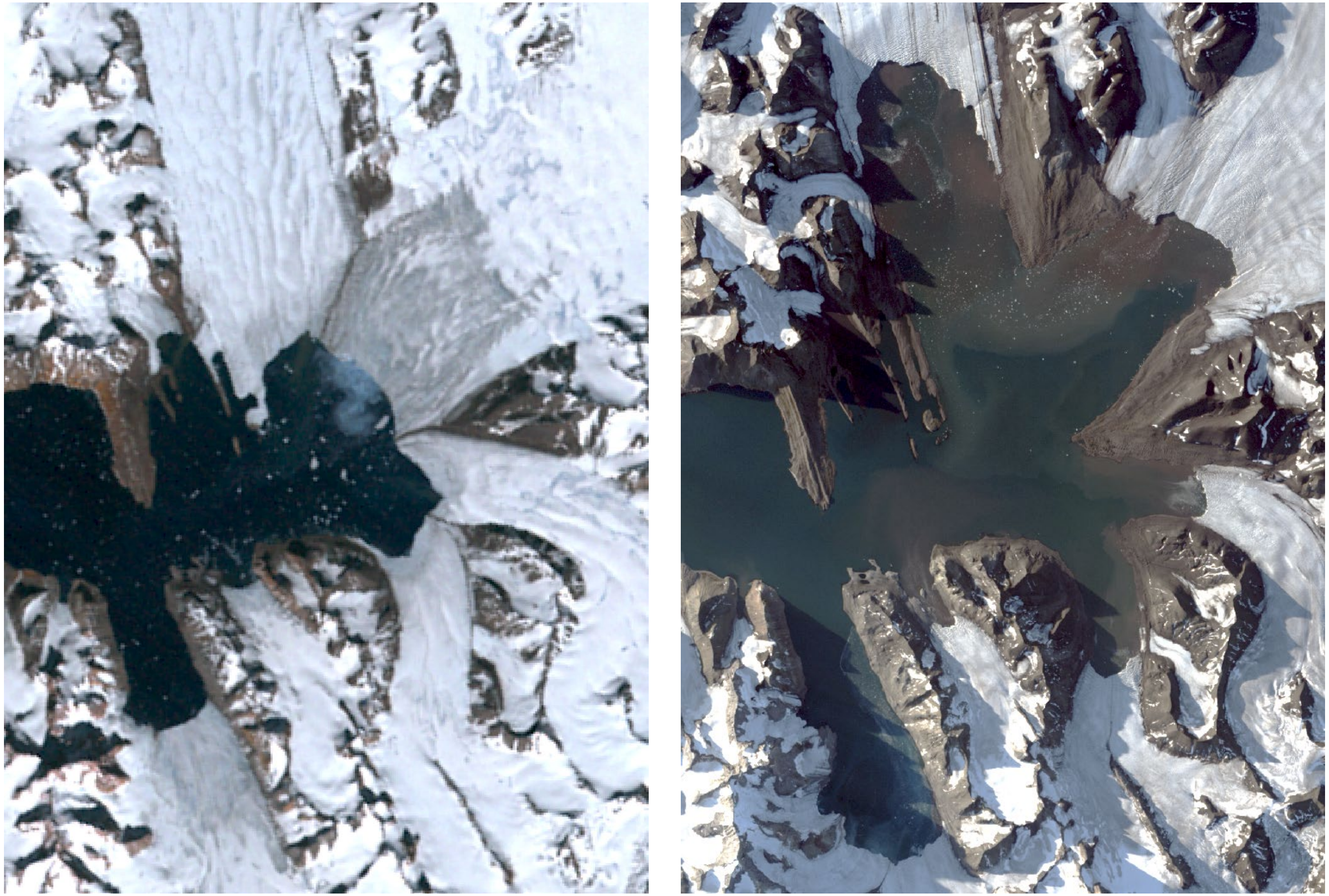

Fig. 2 Landsat RGB composites of Brepollen from 23rd July 1978 and 4th August 2022.

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Gains and losses in the productivity of the polar fjords

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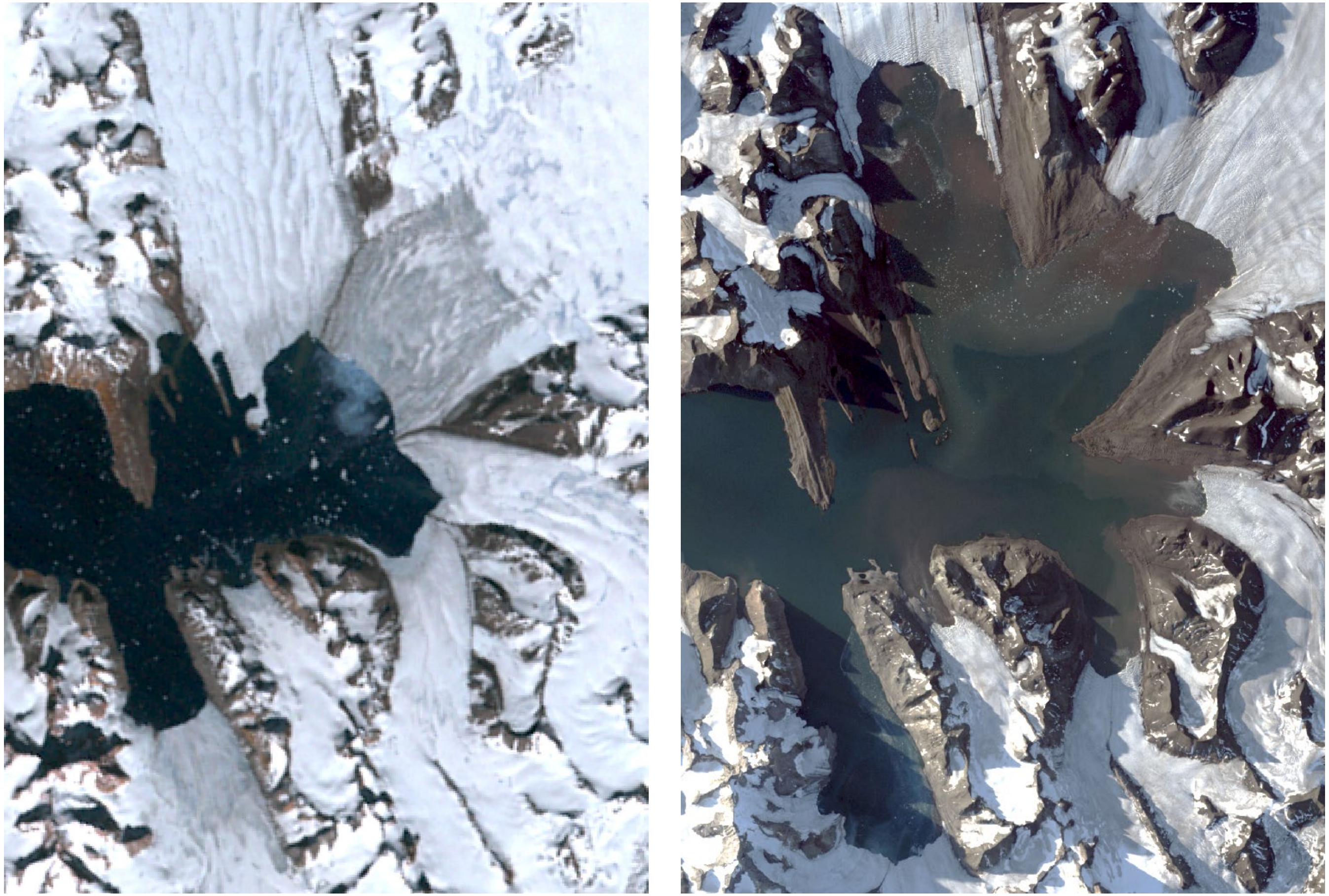
new area ↑

water mass exchange ↓



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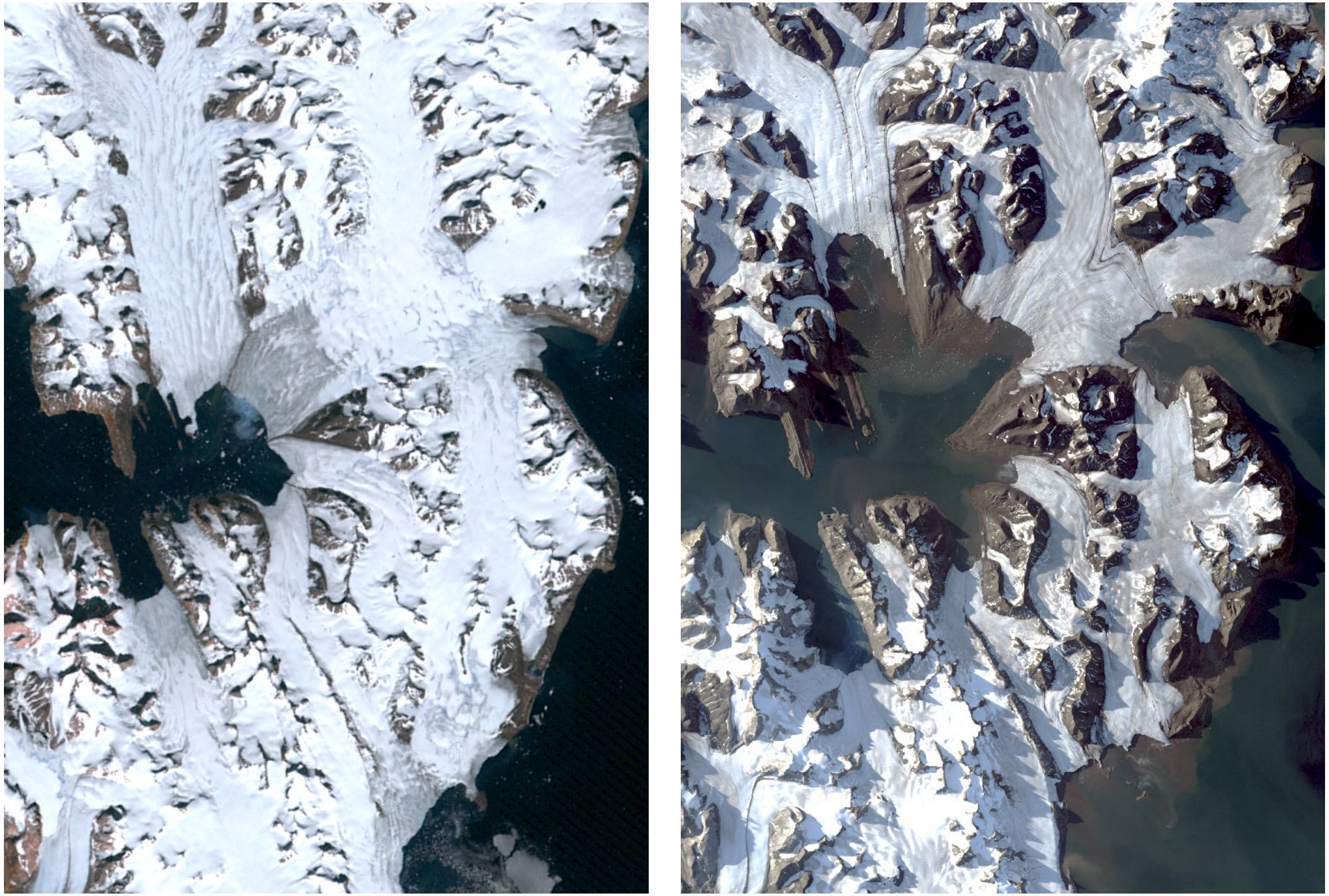

Fig. 3 Landsat RGB composites of Brepollen from 23rd July 1978 and 4th August 2022.

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Gains and losses in the productivity of the polar fjords

euphotic zone ↓

new area ↑

water mass exchange ↓ ?

stratification ↓

Fig. 4 The brown water caused by sediment being dredged up from the base of the glacier by meltwater plumes. Credit: NASA/JPL-Caltech

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nutrient balance ↓ ?

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Gains and losses in the productivity of the polar fjords

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new area ↑

water mass exchange ↓ ?

stratification ↓

nutrient balance ↓ ?

longer productive season ↑

Fig. 5 Arctic animals such as polar bears rely on sea ice that is shrinking as global temperatures rise. Credit: Ekaterina Anismova/AFP via Getty

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Gains and losses in the productivity of the polar fjords

euphotic zone ↓

new area ↑

water mass exchange ↓ ?

stratification ↓

nutrient balance ↓ ?

longer productive season ↑

advection ↑

Fig. 5 Arctic animals such as polar bears rely on sea ice that is shrinking as global temperatures rise. Credit: Ekaterina Anismova/AFP via Getty

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Objective

Estimate the primary and zoobenthic production and carbon burial in the West Spitsbergen coastal waters and the newly ice-free area's contribution

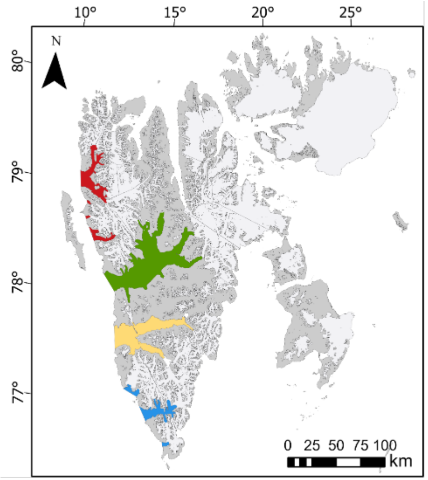

Fig. 6 Map of the Svalbard archipelago with the investigated coastal zones.

Tab. 1 Primary production, zoobenthos and carbon burial in the West Spitsbergen fjords.

Variable	KGF outer	KGF inner	HOR outer	HOR inner	BIL	Reference
Summer pelagic primary production [mgCm^{-2}day^{-1}]	108	59	336 - 1333	173		Piwosz et al., 2009
		80 - 155				Iversen and Seuthe, 2011
Spring pelagic primary production [mgCm^{-2}day^{-1}]		405 - 445	320 - 2770			Iversen and Seuthe, 2011
		30 - 1850				Hodal et al., 2012
					42.6	Vonnahme et al., 2021
Zoobenthos production [gCm^{-2} year^{-1}]	9.4		19.2			Włodarska-Kowalczuk et al., 2019
Burial rate of OC [gCm^{-2}year^{-1}]	28 ± 6		28 ± 1			Włodarska-Kowalczuk et al., 2019
	13	9				Kuliński et al., 2014
	10.0	5.7	19.3	30.3		Koziorowska et al., 2018
		15		38		Zaborska et al., 2018

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Marine-terminating glaciers (1976-2022)

Data: **Landsat satellite images**

Time: **summer 1976-2022**

Resolution: **15 – 60 m**

KKS – 15 glaciers
ISF – 8 glaciers

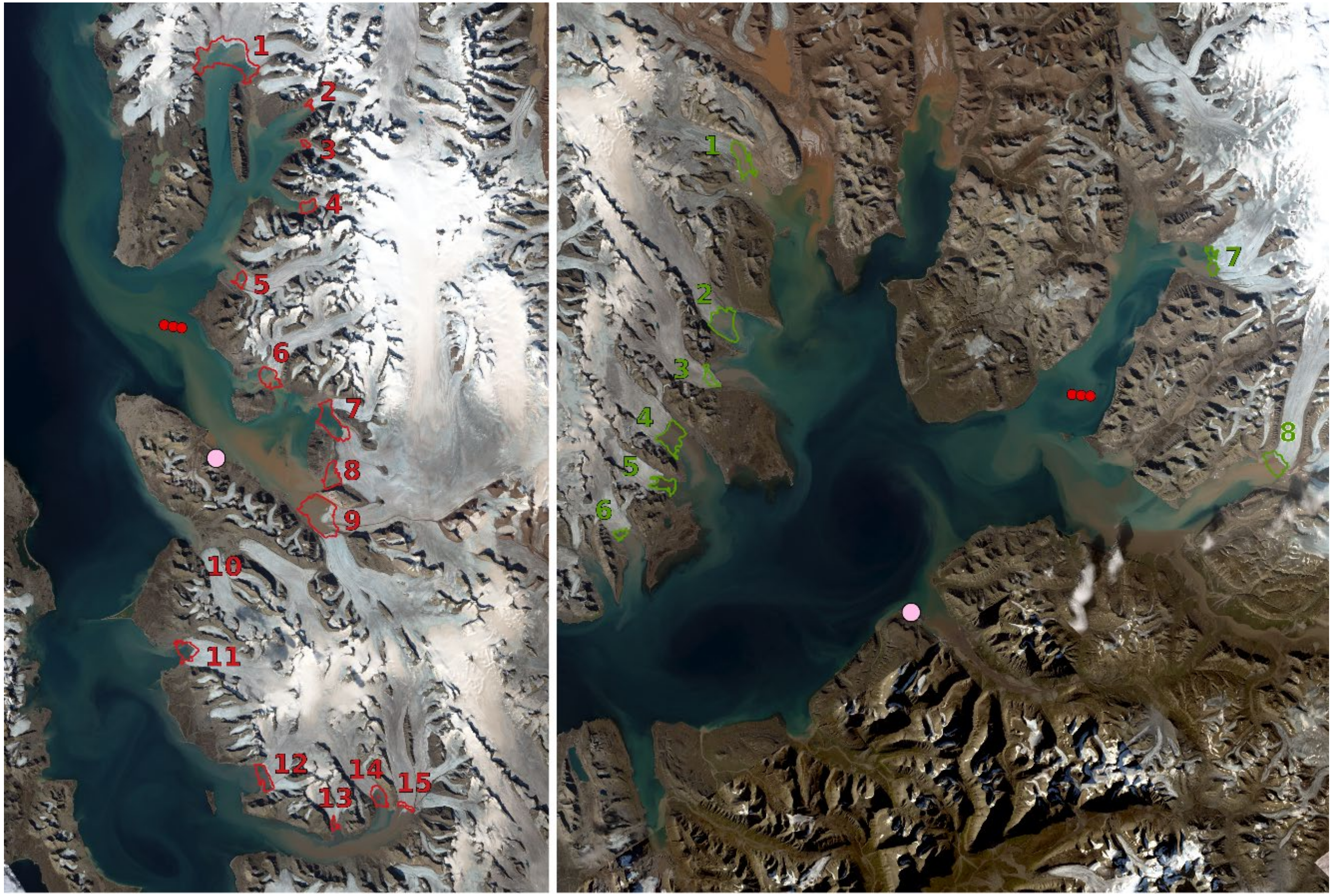

Fig. 7 Glacial bays with glaciers or glacial systems connected to the sea at least at one point in 1976 – 2022. Red dots represent SST data points. Pink dots represent the location of the meteorological stations. Background: Landsat8 satellite images from 27th July 2020

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Marine-terminating glaciers (1976-2022)

Data: **Landsat satellite images**

Time: **summer 1976-2022**

Resolution: **15 – 60 m**

VMK – 4 glaciers

HST – 15 glaciers

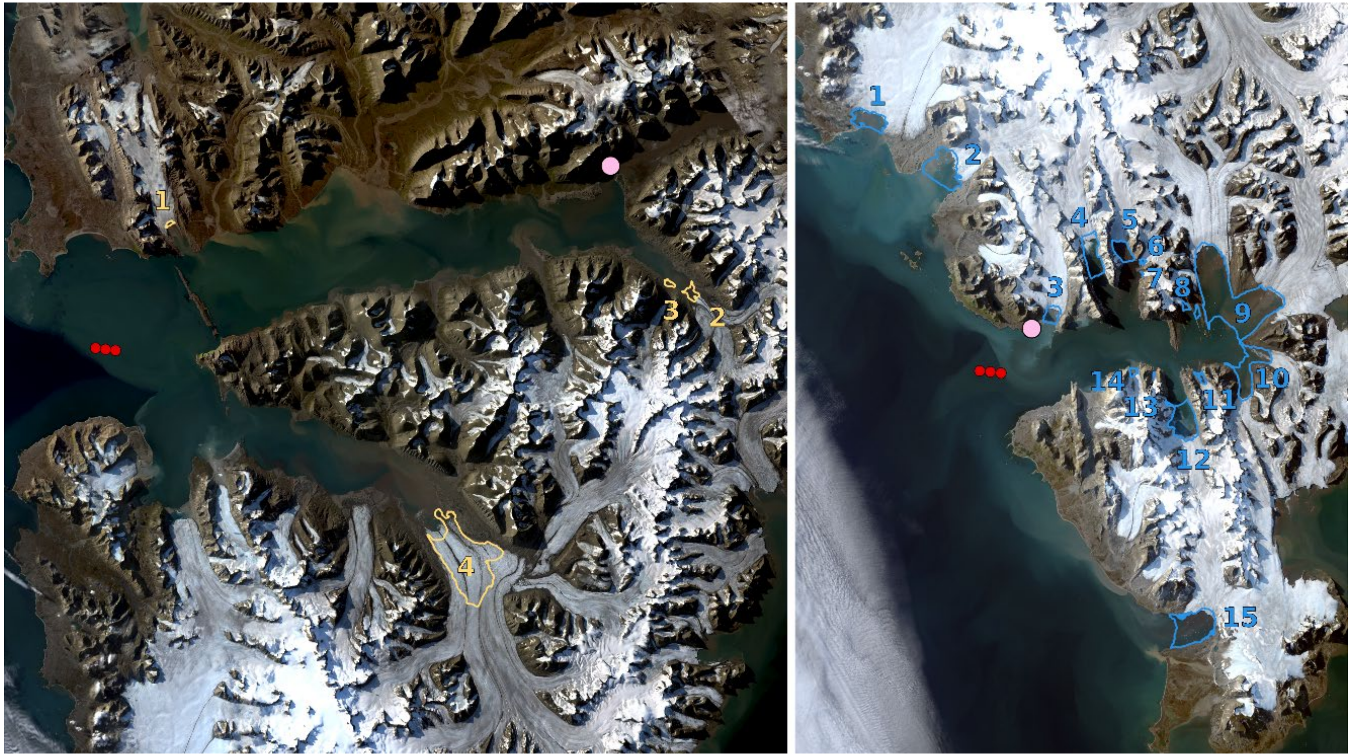

Fig. 8 Glacial bays with glaciers or glacial systems connected to the sea at least at one point in 1976 – 2022. Red dots represent SST data points. Pink dots represent the location of the meteorological stations. Background: Landsat8 satellite images from 4th August 2020

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Sea ice

Data: **Landsat satellite images**

Time: **May 2022**

Resolution: **15 m**

KKS
ISF

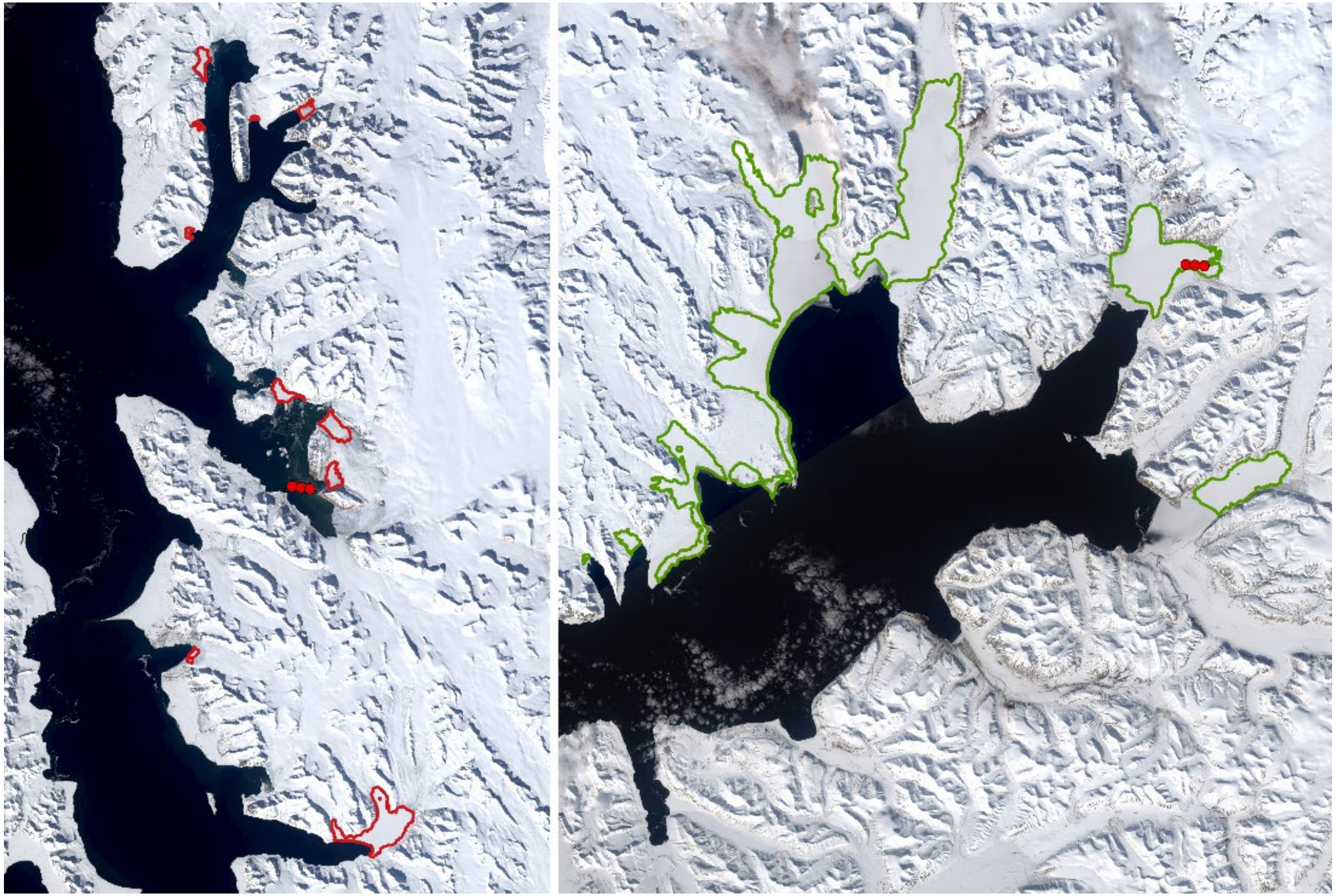

Fig. 9 Sea ice in the West Spitsbergen fjords. Red dots represent SIC data points. Background: Landsat8 satellite images from May 2022

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Sea ice

Data: **Landsat satellite images**

Time: **May 2022**

Resolution: **15 m**

VMK
HST

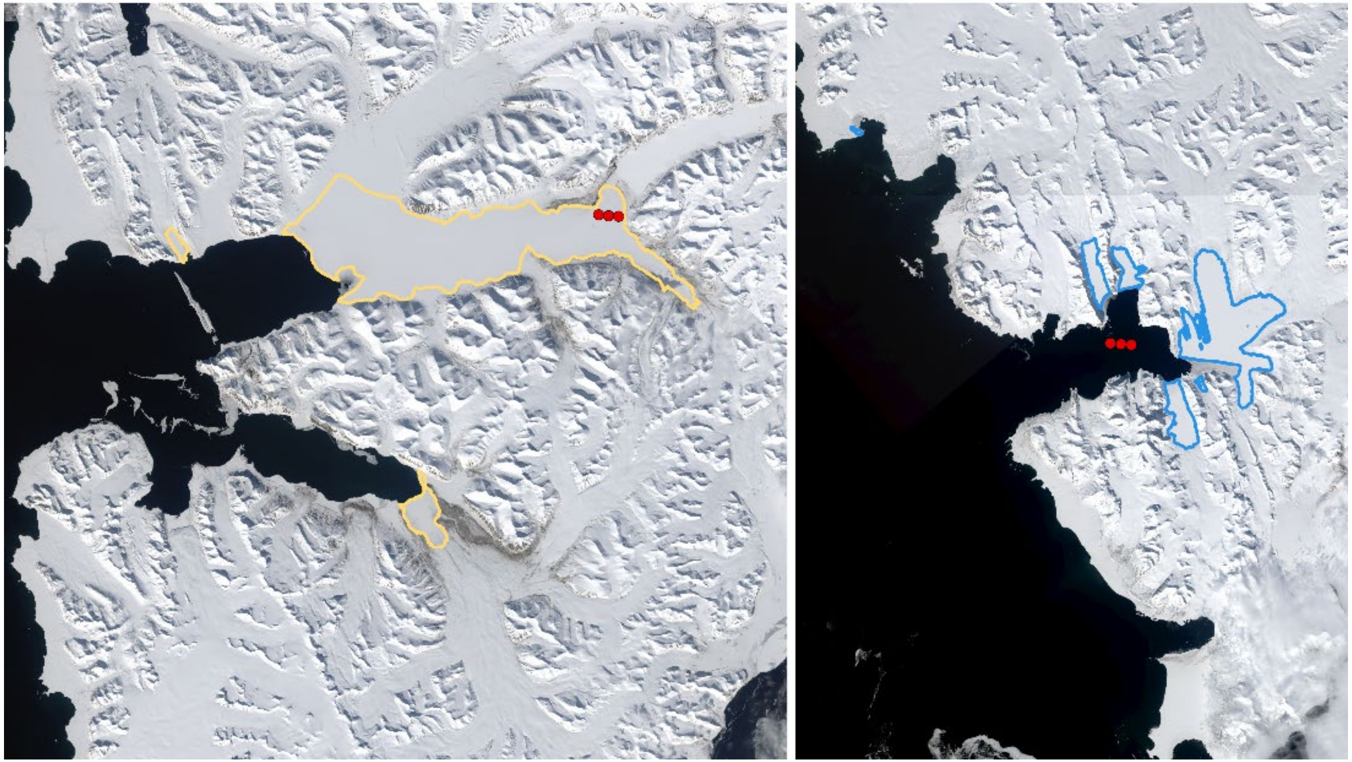

Fig. 10 Sea ice in the West Spitsbergen fjords. Red dots represent SIC data points. Background: Landsat8 satellite images from May 2022

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Changes in the coastal zones area related to marine-terminating glaciers dynamics (1976-2022)

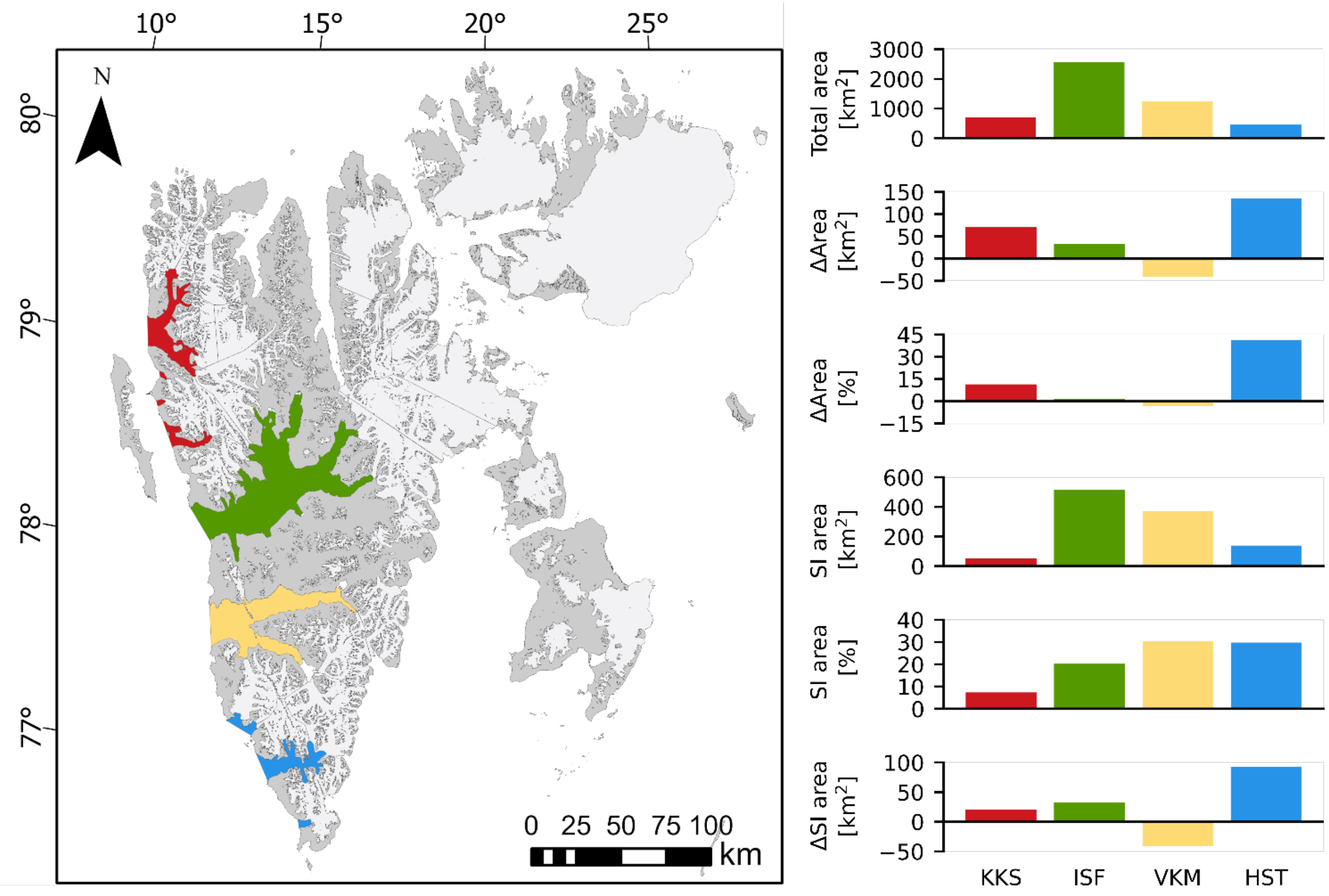

Fig. 11 Map of the Svalbard archipelago with the investigated coastal zones (left). The total area of the coastal zones, changes in the area in 1976-2022, and sea-ice cover in 2022 (right). Land and glaciers extent downloaded from https://geodata.npolar.no/.

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Primary production, zoobenthic production and carbon burial

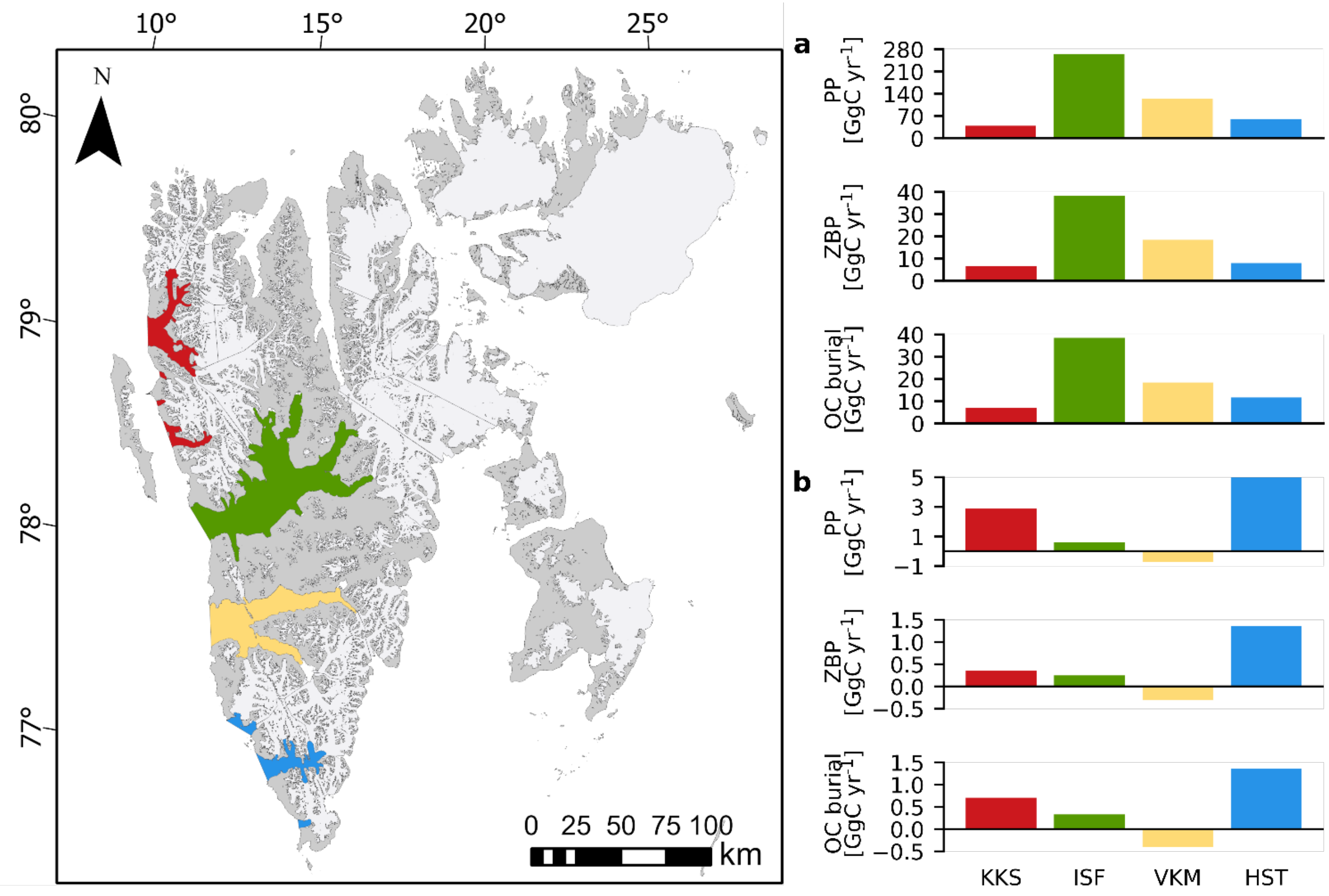

Fig. 12 Map of the Svalbard archipelago with the investigated coastal zones (left). Primary production (PP), zoobenthic production (ZBP), and organic carbon (OC) burial in the total area of the coastal zones (a) and newly ice-free areas (b).

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Long-term trends in the coastal zones area, sea ice cover and melt potential

Data: **Arctic Sea and Ice Surface Temperature, L4, 5km daily (DMI-ARC-SEAIC_TEMP-L4-NRT-OBS)**
Time: **1976-2022**
Resolution: **1 km, daily**

Data: **Meteorological stations (01003, 01007, 01008, Sveagruva)**
Time: **1975-2022**
Resolution: **daily**

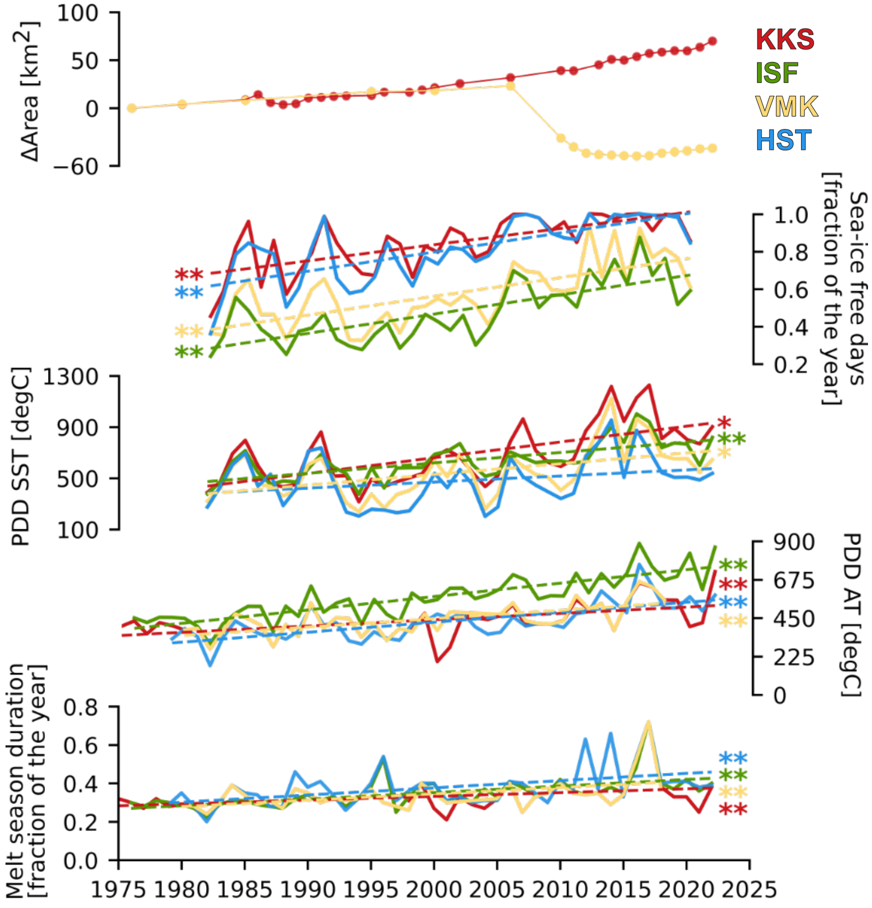

Fig. 13 Long-term trends in the West Spitsbergen coastal waters: changes in the area related to marine-terminating glaciers dynamics, sea-ice duration, PDD SST and AT, melt season duration (- p<0.05, ** - p<0.001 for modified Mann Kendall test).*

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Conclusions

more data needed

OC burial in the newly ice-free areas in the West Spitsbergen – only a small fraction of the global C burial in marine sediments

scale of marine ice loss worldwide

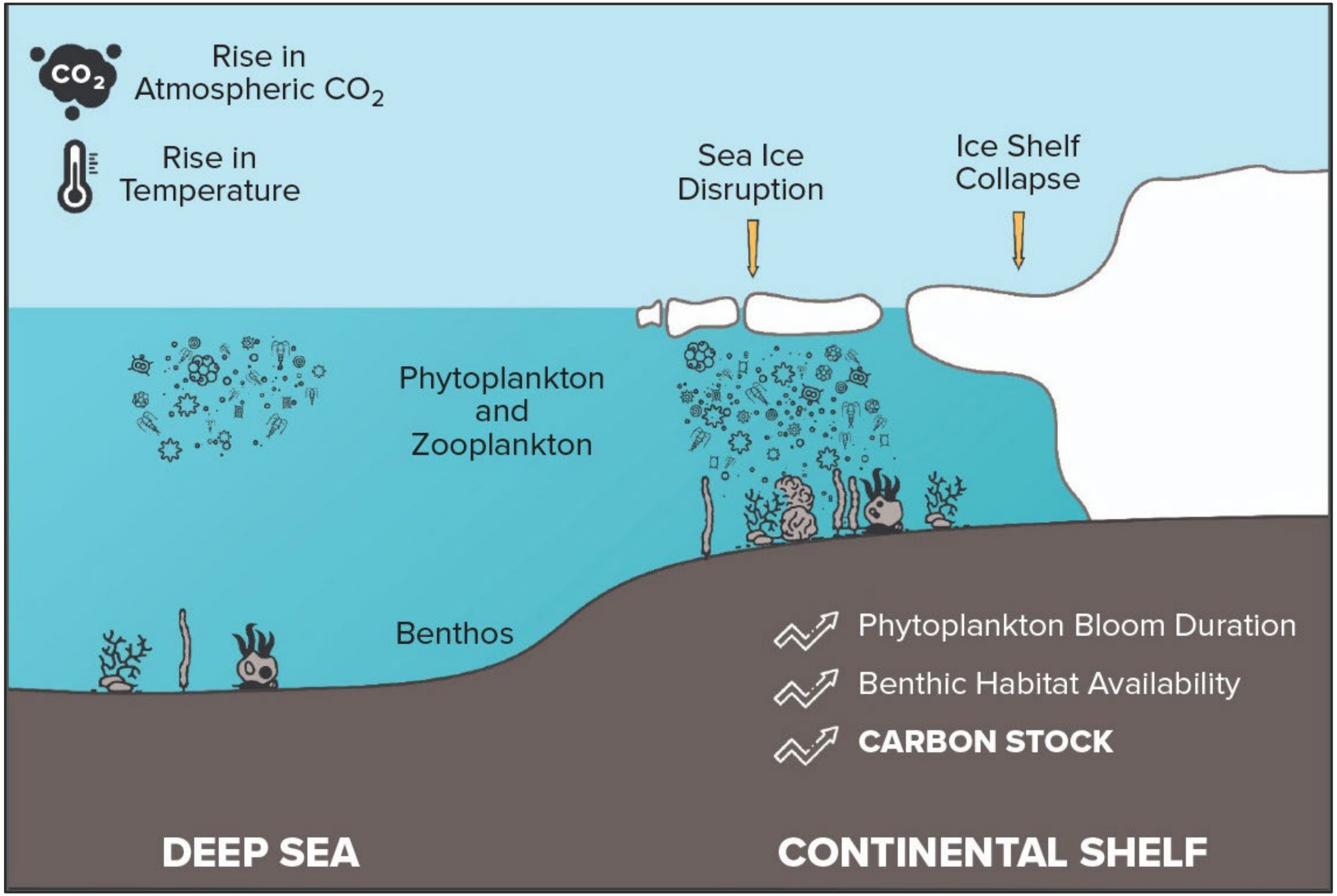

Fig. 14 The growing potential of Antarctic blue carbon (Sands et al., 2023)