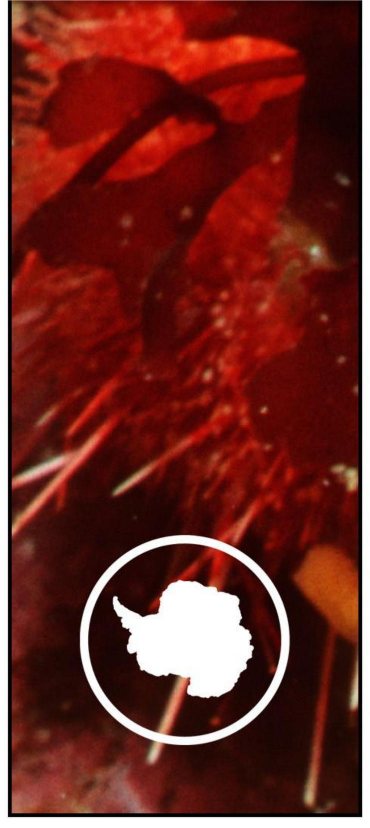

Zoobenthic blue carbon on cold shelf seabeds, how do Antarctic vs Arctic stocks compare?

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ABSTRACT

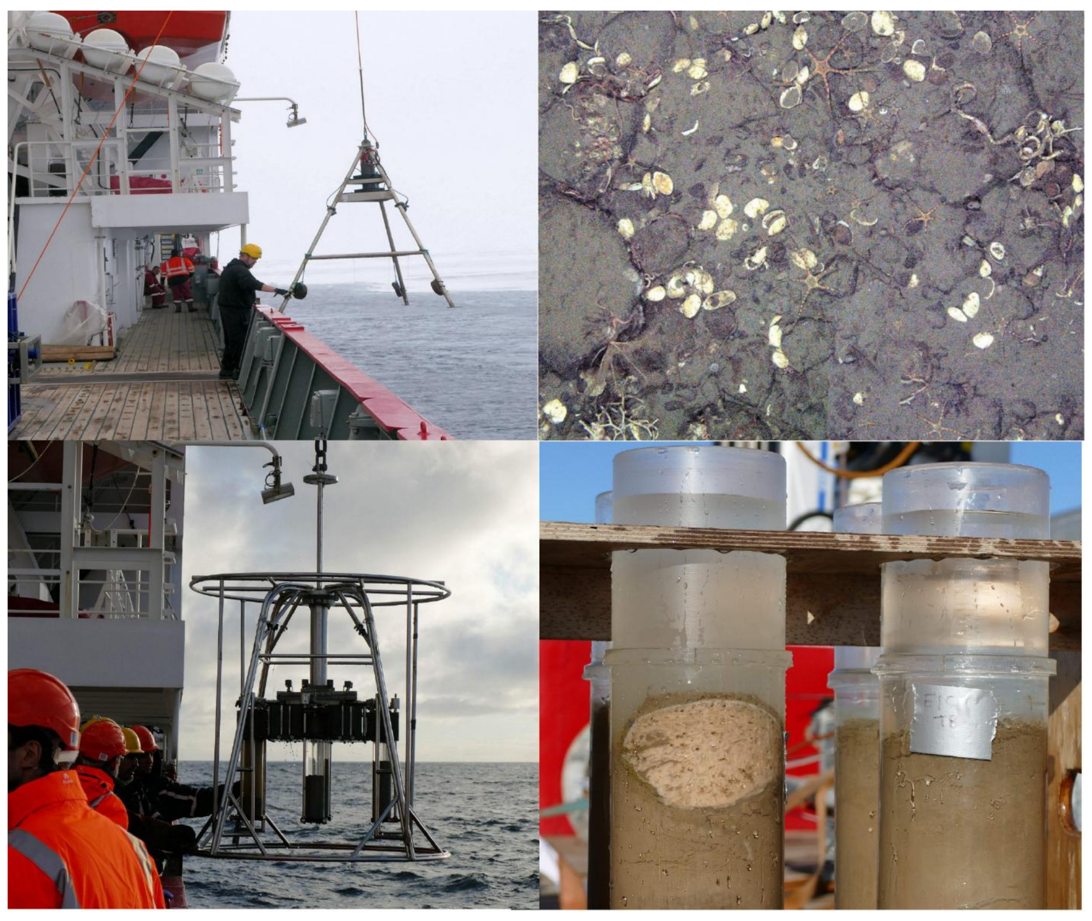
Sustained intense warming has led to Arctic seasonal sea ice losses. Around Antarctica warming and marine ice changes have been more complex, but West Antarctica has seen strong retreat of marine ice. This has caused new and longer phytoplankton algal blooms, and responsive growth increases of benthos, driving increases in zoobenthic blue carbon (carbon held within marine animals). This is important because it is a powerful regional negative feedback on climate change (warming decreases marine ice, which increases algal bloom duration, benthic growth, immobilization of seabed carbon and removal of carbon from cycling). West Antarctic marine ice losses drive benthos to store ~80 million tonnes zoobenthic carbon, but there are very considerable differences to Arctic continental shelves. In the Changing Arctic Ocean Seabed programme, we use comparable methods to those used in Antarctic estimates to calculate standing stock of zoobenthic carbon in the Barents Sea. Calibrated vertical camera deployments were made to get accurate 586 replicate seabed images across 15 sites to calculate densities of epi-benthic functional groups. Three replicate Agassiz trawls were towed to collect specimens of zoobenthos which were also identified before measuring morphometrics, drying, weighing and ashing and reweighing. Size spectra and carbon content of functional zoobenthic groups were calculated and analysed against physical factors measured at the time of collection).

Barents Sea's benthic carbon

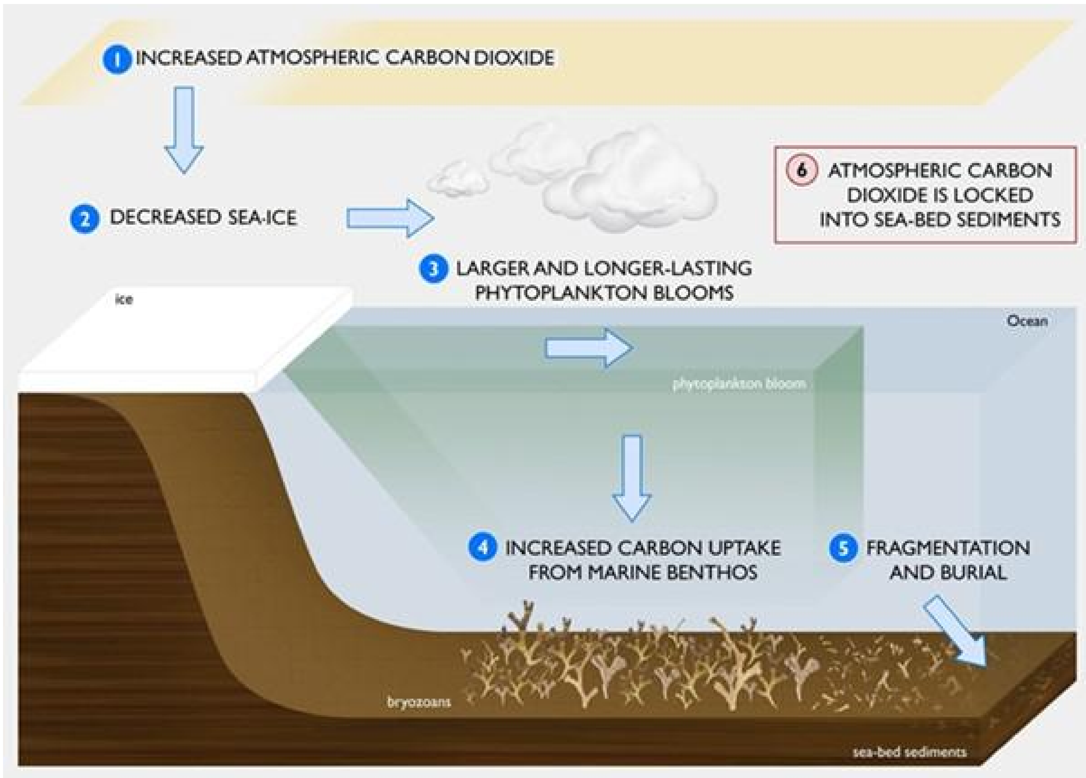
Background

Global climate change is driving massive ice and snow losses from high latitudes and altitudes. There have been large seasonal sea ice losses over continental shelves. The effect of ice losses on the carbon cycle, storage and sequestration in particular is a key issue because of potential for feedbacks on climate change. The Arctic carbon cycle is sensitive to aspects of climate change, and new multidisciplinary investigations, e.g. Changing Arctic Ocean programme (https://www.changing-arctic-ocean.ac.uk/) are underway to try to understand this.

In contrast to land, climate feedbacks on seabeds (from increased storage of carbon by marine life) are large, though complex. The big zoobenthic growth increases are inshore, but are wiped out by coincident increases in iceberg scouring. There are offshore gains in stored carbon, at least in West Antarctica. Arctic open water extent correlates with algal blooms, but sea ice also supports big under-ice algal blooms. Gains from open water blooms caused by shrinking Arctic sea ice have to be balanced against under-ice algal losses, and sequestration not capture drives climate feedbacks.



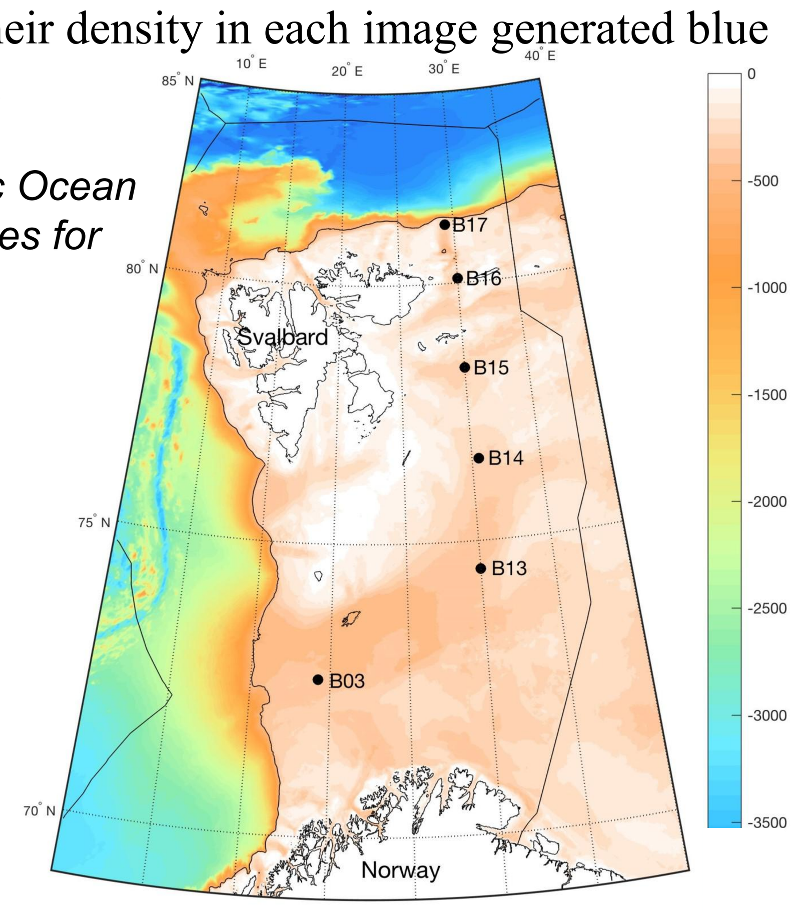
Imaging zoobenthos and collecting Barents Sea cores



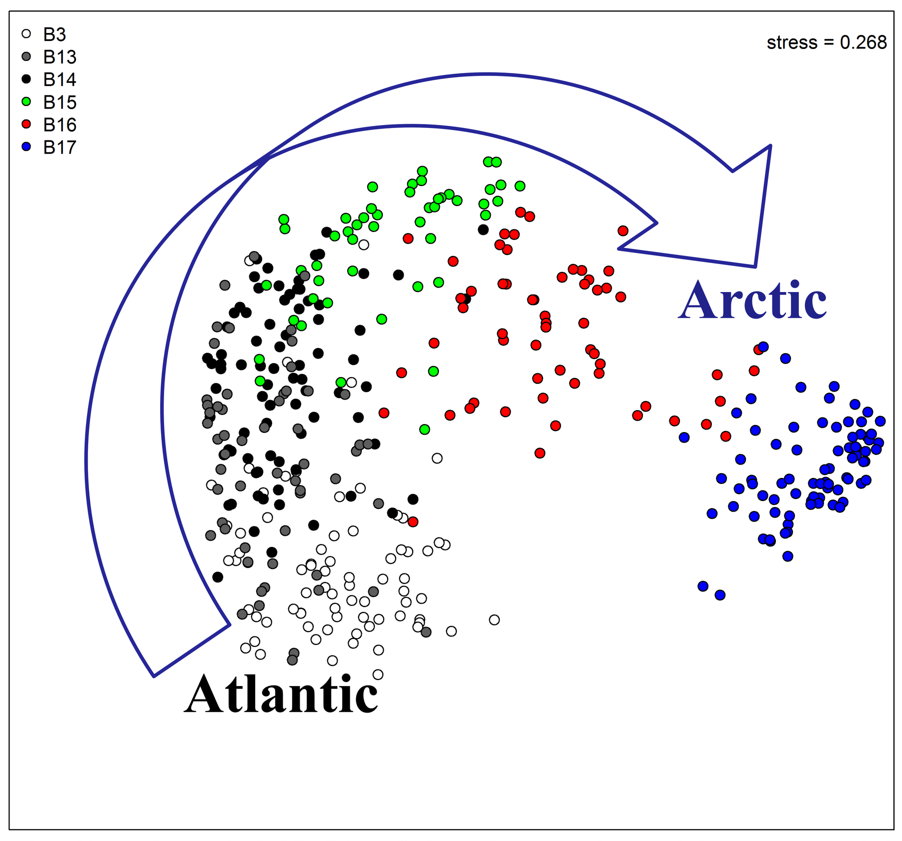
Blue carbon as a -ve feedback on climate change

Fieldwork

To estimate zoobenthic 'blue carbon' stock in the Barents Sea, we sampled benthos and measured environmental factors across six sites (see below). 20 images were taken at each of 3 locations within each site. Benthic groups were identified and the number of each was counted on each image. The suites of biota per image were ordinated using nMDS to compare similarity (above right). Carbon content was calculated for trawled specimens of all key faunal groups and plotted per size. Multiplying the mean carbon content per group by their density in each image generated blue carbon storage.



Changing Arctic Ocean Seabed field sites for 2017-2019



Ordination (nMDS) of Arctic zoobenthic assemblages

Results

Our key questions were how much zoobenthic carbon is held on a shelf north of the Atlantic and how does this compare with south of the Atlantic.

Assemblage composition changed gradually from Atlantic (at B3) to Arctic with distance/latitude along the shelf trough. This analysis was repeated for combined images to replot for 0.13, 0.25, 0.5 and 1 m^2 areas, for each of taxonomic and functional groups – but this pattern was little altered. Zoobenthic carbon storage showed high within and between sites. Maximum stock could be triple minimum within site, but sites varied more (see table below). Lowest levels were transition Atlantic-Arctic transition faunas. We found influences on blue carbon stock were complex.

Comparison with subAntarctic and West Antarctic shelf across four different habitats; coastal shallows, rock rubble, basin sediments and shelf edge sediments.

site	mean	SD	min	max
B3	11.3	4.15	7.8	13.6
B13	4.41	3.29	3.42	5.31
B14	3.23	3.17	2.71	4.23
B15	2.96	2.26	2.32	3.65
B16	20.4	15.8	10.2	29.1
B17	9.96	7.33	7.61	11.5

Zoobenthic blue carbon values in Arctic sites g/m^2 or t/km^2

Arctic vs Antarctic zoobenthic blue carbon stocks

The blue carbon standing stock (storage) values we found in Barents Sea samples were considerably higher than those at South Georgia (subAnt in Table right) and, apart from in the shallows higher than West Antarctic literature values. Much of the area of continental shelves are mud basins, so the fact that Arctic values were more than twice those in West Antarctic samples was important, especially given Arctic seabeds are bottom trawled. Arguably of more importance though is rates and directions of change, and feedback strengths on climate.

Habitat	Arctic	subAntarctic	Antarctic
Shallows	32	27	64
Rock	28	4	25
Basin	17	1	7
Shelf break	9	1	4

Mean zoobenthic blue carbon by habitat on polar shelves in g / m^2 or scaled up t / km^2

The Changing Arctic Ocean Seabed work described provides a testable baseline of blue carbon storage. Based on imaged burial rates and sediment cores we can also estimate sequestration potential of this zoobenthic storage. Preliminary investigation of this suggests values in the order of <1 to 6 t km^2. Generally this is highest at the interface of hard and soft substratum areas (the former increases storage, the latter increases burial). The final ChAOS science cruise will take place in July 2019 which will aid further investigation of spatial and temporal varaiablity in regional blue carbon and the biogeochemical detail at the sediment-water interface.

What next? A wider range of Barents Sea sites were sampled in 2017, which when analysed should better elucidate the multiple and complex influences on zoobenthic blue carbon in the region. This in turn should enable better prediction of magnitude of change in response to likely near future physical forcing.

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