CRUISE REPORT

TISA

Drivers of trophic interaction structures in Arctic environments

Le Commandant Charcot, Cruise No. CC150523 and CC080623
2023-05-15 – 2023-05-25, Reykjavik – Reykjavik (Iceland)
2023-06-08 – 2023-06-22, Reykjavik – Reykjavik (Iceland)

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Summary

The objective of the project is to quantify the structures of trophic networks in the Arctic, and evaluate how they are related to different environmental conditions along a latitude gradient. We will combine the data collected during the project with previously collected data on north Greenland and in northern Sweden. The project took part in two cruises, one to the area around the Sermilik and Ammassalik Fjords on south east Greenland and one to the area around the mouth of the Kangertittivaq Fjord and the northern stretches of the Blossomville coast. We visited a total of 9 land sites, which were accessed either by walking or driving a snow machine across the ice or by using a zodiac. We collected a total of 432 faces from arctic fox (*Vulpes lagopus*), ptarmigan (*Lagopus muta*), arctic hare (*Lepus arcticus*), muskoxen (*Ovibos muschatus*) and geese (*Anser* sp. and *Brenta* sp.), as well as 62 regurgitation pellets from raptors. Diet of herbivores will be quantified from their feces using microhistology at the Autonomous University of Barcelona, Spain, whereas predator diets will be quantified by identifying hair, feather and bode fragments at the Biodiversity Research Institute, Spain. Samples will also be subject to genetic analyses at Stockholm University, Sweden, analyzed for the stable isotopes of carbon and nitrogen at University of Pretoria, South Africa. During the expedition, we made some novel observations indicating the consumption of seaweed by arctic hares as well as notable observations regarding the distribution of the Greenland lemming (*Dicrostonyx groenlandicus*), as well as the presence of plastics in some fecal samples.

1. Research Programme/Objectives

The overall objective of this project is to quantify the structures of trophic networks in the Arctic, evaluate how they vary along latitude gradients, and evaluate how they are related to abiotic and biotic factors along latitude gradients. By combining data from these cruises with data previously collected on north Greenland, northern Ellesmere Island (Canada) and in northern Scandinavia (Fig 1), we will work with networks describing antagonistic trophic interactions between vertebrate herbivores and consumed plants and vertebrate predators and prey. Specifically, we will test if there is a shift from nested to modular network structures going from north to south in our latitude gradient are driven by abiotic and biotic conditions along the latitude gradient.

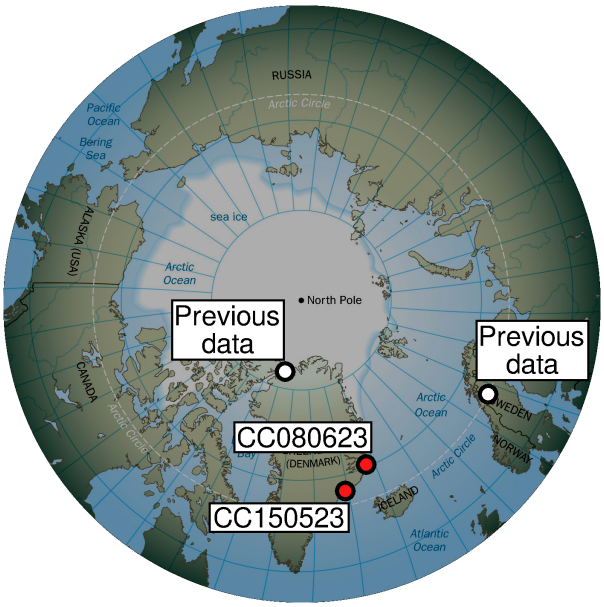

Fig. 1 Locations of the study areas covered by the two ARICE organised cruises with Ponant (CC150523 and CC080623) as well as location of study areas with previous data that the information collected during these cruises will be combined with.

2. Narrative of the Cruises

2.1 CC150523

The cruise started in Reykjavik on Monday May 15th, 2023. The ship left the harbour in the evening and headed west towards the Kulusuk coast to Sothestern of Greenland. The sailing mostly went over open water. We arrived to the mouth of the Ammassalik Fjord on May 16. The first field trip was on foot across the ice pack to the shoreline of one of the northern Kulusuk islands. We visited a snow-free ridge close to the coast line and we collected fecal samples from goose and ptarmigan. On Wednesday May 18, we used a snow machine to reach a snow-free ridge close to the coast line of the Ukîvejik Fjord. In the evening the same day, we also gave an introductory seminar about the research project to cruise participants. The day after, May 19, we did our third field excursion at the bottom of the same fiord. On this occasion, we reached the shore by zodiac. On May 20 we did our last field excursion around the town of Tasiilaq. Following the indications of a local guide, Jaakusaaq Søe, we sampled at the

base of several communication antennas. These structures are used as a watchtower by different birds of prey, so at their base we were able to collect samples of regurgitation pellets. The remaining days of the expedition were used to dry, label and store the samples. We also made microscopic slides from a few of samples to verify the presence of identifiable epidermal fragments. These preparations were observed under an optical microscope in the laboratory and photographic images of various types of plant epidermis were obtained. This allowed us to confirm the validity of the samples for the determination of the diet of both ptarmigans and geese. May 24 was spent in transit back to Iceland, during which we gave a final seminar outlining the activities and key findings of the research activities. We reached Reykjavik in the eraly morning May 25, and disemarked the same day.

Table 1 Gantt chart of the project activities and events during the CC0150523 cruise.

	May										
Activity/event	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Embark in Reykjavik											
Transit over Denmark strait											
Initial presentation of project											
Field visit site CC150523-1											
Field visit site CC150523-2											
Field visit site CC150523-3											
Field visit site CC150523-4											
Drying and packing of samples											
Cruise Blossomville coast											
Final presentation of project activities											
Disembark Reykjavik											

2.2 CC080623

The Cruise started in Reykjavik on Thursday June 8th, 2023. The ship left the harbour in the evening and headed north-northwest towards the Blossomville coast to Greenland. The sailing went over open water interspersed with some drift ice. This section of the cruise was spent on three tasks: (i) evaluating potential land sites, (ii) going through the field equipment, and (iii) going though the protocols, includig protocols for sample collection, data recordnig and preparation of samples for storage. On Saturday June 10, we also gave an introductory seminar about the research project to cruise participants. We arrived to the mouth of the Kangertittivaq Fjord on June 11. Using a snow machine for transport from the ship, we did your fierst field excursion. We visited a snow-free ridge close to the coast line approximately 8 km west of the Ittoqqortoomit village (CC080623-1). Despite the landscape being >80% covered in snow, this ridge was effectivly snow free. After 6 hours of sampling in the field we returned to the vessel at . The afternoon and evening was spent labelling samples and putting the in the drying oven overnight. Samples that did not fit in the over were stored at -20°C. On June 12, we again used a snow machine as transport from the ship. We first visited the mast stations of the Ittoqqortoomit village, which was largely unsuccesful, and later moved to a low-lying valley 3.5 km northwest of the village (CC080623-2). This valley had sufficiently large snow-free patches to allow for sampling. We spent 4.5 hours in this valley, and was back at the vessel at 16.05. The remaining afternoon and evening was spent labelling and packaging the dried samples from the night before as well as putting further samples in the oven for drying. On June 13, we had moved to the sourthern part of the mouth of the Kangertittivaq fiord. We again used the snow

machine to reach a very rocky and steep drainage (CC080623-3), which was largely snow free due to wind exposure. The snow machine was parked at a fishing camp, consisting of 2 cabins, one partly falled down but one well-maintained. We spent 3.5 hours sampling the lower parts of the drainage, and was back on board the vessel at 12.50. As wiht the previous two days, the afternoon was spent labelling, packaging and drying samples. June 13-18 was spent cruising the pack-ice outside the north Greenland National Park. Ice- and weather conditions did not allow for any field sampling these days. Instead, they were spent on data entry as well as drying, labelling, and packaging all the remaining samples. On June 19 we had returned to the northern part of the Blossomville coast, and managed to visit to separate land sites using a zodiac as transport from the vessel. The first of these was a steep rocky outcrop on the south end of the fjord (CC080623-4), and the second a rocky beack below a very steep bluff on the northern site of the fjord (CC080623-5). We spent approximately an hour on each site, and was back on the vessel at 16.00. The afternoon and evening was spent drying samples. On June 20 we had moved to a fiord system 55km further south. We attempted to visit the lower part of an broad valley by approaching using snow shoes, but had to cut the field sampling after only half an hour due to an approaching polar bear. Snow machine could not be used at this site due to snow and ice conditions. The remaining time of this day was spent drying, packaging and labelling samples, summarising data for the upcoming concluding seminar, and preparing for this semina. June 21 was spent in transit back to Iceland. This day was spent labelling and packaging the final samples, packing up all equipment and cleaning out the laboratory, as well as giving the final seminar outlining the activities and key findings of the research activities. We reached Reykjavik late in the evening of June 21, and disembarked in the morning of June 22. All samples were brought back to Sweden with the participants.

Table 2 Gantt chart of the project activities and events during the CC080623 cruise.

	June														
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Activity/event															
Embark in Reykjavik															
Transit over Denmark strait															
Initial presentation of project															
Field visit site CC080623-1															
Field visit site CC080623-2															
Field visit site CC080623-3															
Cruise Greenland pack ice															
Field visit sites CC080623-4 and CC080623-5															
Field visit site CC080623-6															
Drying and packing of samples															
Final presentation of project activities															
Disembark Reykjavik															

3. Land Sites Visited

We visited a total of 4 land sites during the cruise CC150523 and 5 during CC080623. The sites during CC150523 were visited between 17 and 20 of May and the sites during CC080623 between 11 and 20 of June (Table 3). One site during CC150523 was situated in the northern

Table 3 List of land sites visited, along with date and time of visit as well as the method used to approach each site from the vessel.

Cruise	Station	Date	Time	Latitude	Longitude	Access
CC150523	CC150523-1	20230517	15.30 - 17.30	65.6153	-37.1821	Walking
CC150523	CC150523-2	20230518	14.00 - 17.00	65.6411	-37.1701	Snow machine
CC150523	CC150523-3	20230519	10.20 - 12.10	66.1623	-37.5299	Zodiac
CC150523	CC150523-4	20230520	12.00 - 17.45	65.6034	-376363	Walking
CC080623	CC080623-1	20230611	09.00 - 16.10	70.4981	-22.1448	Snow machine
CC080623	CC080623-2	20230612	08.45 - 16.00	70.5151	-21.9932	Snow machine
CC080623	CC080623-3	20230613	08.30 - 13:00	70.1300	-22.2465	Snow machine
CC080623	CC080623-4	20230619	10.00 - 11.00	69.6222	-23.5489	Zodiac
CC080623	CC080623-5	20230619	11.30 - 12.30	69.6584	-23.4338	Zodiac
CC080623	CC080623-6	20230620	08.45 - 10.45	69.3151	-24.6003	Snow shoes

parts of the Sermilik Fjord (CC150525-3), whereas the other three sites were at the mouth of the Ammassilik Fjord (Fig. 2). Three sites during CC080623 were situated at the mouth of the Kangertittivaq Fjord (CC080623-1, CC080623-2, CC080623-3), and three sites along the northern stretches of the Blossomville coast (CC080623-4, CC080623-5, CC080623-6). The sites were accessed either by walking, with or without the aid of snow shoes, by snow machine, or using a zodiac (Table 3).

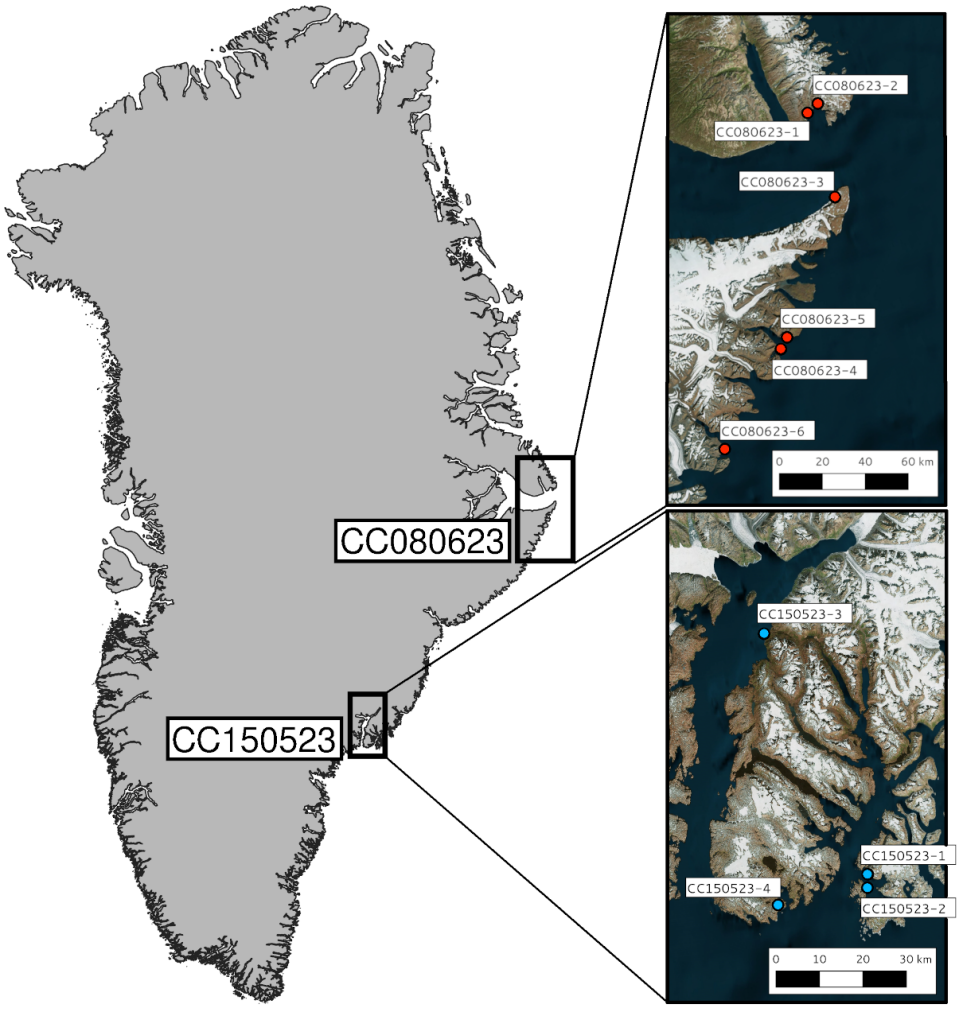

Fig. 2 Locations of the sites visited during each cruise.

4. Preliminary Results

4.1 Observed plants and animals

Due to extensive snow cover, no structured plant surveys were made, and time limitiations prevented us from doing structured observations of either birds or animals. However, we have listed our ad-hoc observations of plants, birds and animals for each cruise in Table 4. These observations are restricted to observations on or adjacent to the Greenland coast, and do not include observations made adjacent to Iceland or on the transit over the Denmark strait.

4.1 Collected samples

In total we collected 493 faecal samples or regurgitation pellets from vertebrate predators and herbivores, 176 during CC150523 and 317 during 080615 (Fig. 3). The most commonly sampled organisms were geese (either *Branta* sp. or *Anser* sp.), rock ptarmigan, and, on CC080623, Arctic hare. In addition, we collected 1 fur sample each from Arctic fox and Arctic hare, 35 feathers (mostly from geese or ptarmigan), and 23 bone samples from mammals and birds. We also collected plant tissue and root material from five different plants of the purple saxifrage (*Saxifraga oppositifolia*).

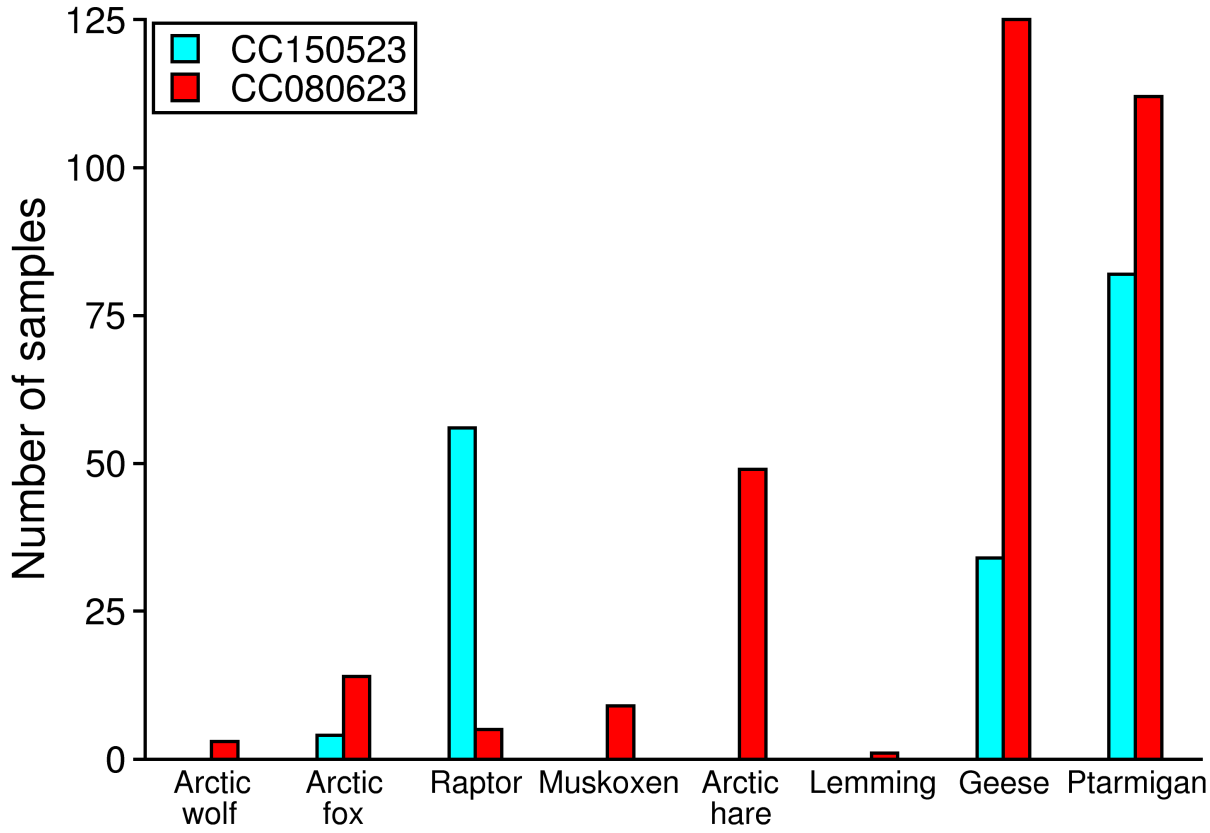

Fig. 3 Collected faeces and regurgitation pellets during each cruise.

Table 4 Ad-hoc observations of plants, birds and mammals on or along the Greenland coast.

Common name	Scientific name	Cruise	Notes
Plants			
Purpur saxifrage	*Saxifraga opositifolia*	CC150523, CC080623	
Arctic willow	*Salix arctica*	CC150523, CC080623	
Dwarf willow	*Salix herbacea*	CC150523	
Sedges	*Carex sp.*	CC150523, CC080623	
Crowberry	*Empetrum nigrum*	CC150523	
Bog bilberry	*Vaccinium uliginosum*	CC150523	
Northern wood rush	*Luzula confusa*	CC150523	
Club moss	*Lycopodium* sp.	CC150523	
Birds			
Snow bunting	*Plectrophenax nivalis*	CC150523, CC080623	
Common raven	*Corvus corax*	CC150523, CC080623	
Gyrfalcon	*Falco rusticulus*	CC150523, CC080623	regurgitation pellets
Parasitic skua	*Stercorarius parasiticus*	CC080623	
Long-tailed skua	*Stercorarius longicaudus*	CC080623	
Glaucus gull	*Larus hyperboreus*	CC150523, CC080623	
Iceland gull	*Larus glaucoides*	CC150523, CC080623	
Ivory gull	*Pagophila eburnea*	CC080623	
Kittiwake	*Rissa tridactyla*	CC150523	
Northern fulmar	*Fulmarus glacialis*	CC150523, CC080623	
Black guillemot	*Cepphus grylle*	CC080623	
Razorbill	*Alca torda*	CC080623	
Little auk	*Alle alle*	CC150523, CC080623	
Common eider	*Somateria mollissima*	CC080623	
King eider	*Somateria spectabilis*	CC080623	
Common scoter	*Melanitta nigra*	CC080623	
Pink-footed goose	*Anser brachyrhynchus*	CC080623	
Barnacle goose	*Branta leucopsis*	CC080623	
Dunlin	*Calidris alpina*	CC080623	
Purple sandpiper	Calidris maritima	CC080623	
Ringed plover	*Charadrius hiaticula*	CC080623	
Northern wheatear	*Oenanthe oenanthe*	CC150523	
Mammals			
Polar bear	*Ursus maritimus*	CC080623	
Walrus	*Odobenus rosmarus*	CC080623	
Harp seal	*Pagophilus groenlandicus*	CC080623	
Bearded seal	*Erignathus barbatus*	CC080623	
Ringed seal	*Pusa hispida*	CC080623	
Hooded seal	Cystophora cristata	CC150523	
Arctic wolf	*Canis lupus arctos*	CC080623	faeces
Arctic fox	*Vulpes lagopus*	CC150523, CC080623	tracks, faeces
Muskox	*Ovibus muschatus*	CC080623	faeces
Arctic hare	*Lepus arcticus*	CC080623	tracks, faeces
Greenland lemming	*Dicrostonyx groenlandicus*	CC080623	faeces

4.3 Notable natural history observations

We made two notable observations during these cruises. At site at site CC080623-5, which was a stony, narrow rock beach (Fig. 4a), we encountered numerous tracks and faeces of Arctic hares, all directly adjacent to washed up seaweed (Fig 4b). Since the rock beach was completely

without vegetation and lied under a very steep bluff, we interpret these observations as an indication that the hares had eaten the seaweed, and possibly also visited the beach with the direct intention of encountering this food source. Deliberate feeding on aquatic, and even marine, vegetation by mammalian terrestrial herbivores is a well known phenomenon (Lodge 1991; Ceacero et al. 2014), with either sodium deficiency in terrestrial plants or a higher nutritional value in aquatic and marine plants being potential reasons for the behaviour (Linn 1974; Jordan 1987). However, to our knowledge this behaviour has not been recorded for the Arctic hare previously. We will use a combination of microhistological, stable isotope and genetic methods to try to confirm the consumption of seaweed in collected hare faeces, to add another species to the list of herbivores that utilize aquatic or marine resources.

The other observation was made at site CC080623-6, the last site visited. Here, we found an Arctic fox faeces that contained a lemming jaw (Fig. 5a). The current distribution for the Greenland lemming described in the IUCN redlist of the species only lists it down to the north side of the Kangertittivaq Fjord (Fig 5b, Cassola 2016). The location where this sample was located is 135km from the closest area listed under the current distribution, which is larger that the likely daily movement of an Arctic fox (Poulin et al. 2021). Hence, our observation shows that this lemming species does occurr south of the Kangertittivaq Fjord as well. Gilg et al. (2004) made similar observations, which suggest that further observations are warranted to study the actual distribution of this species.

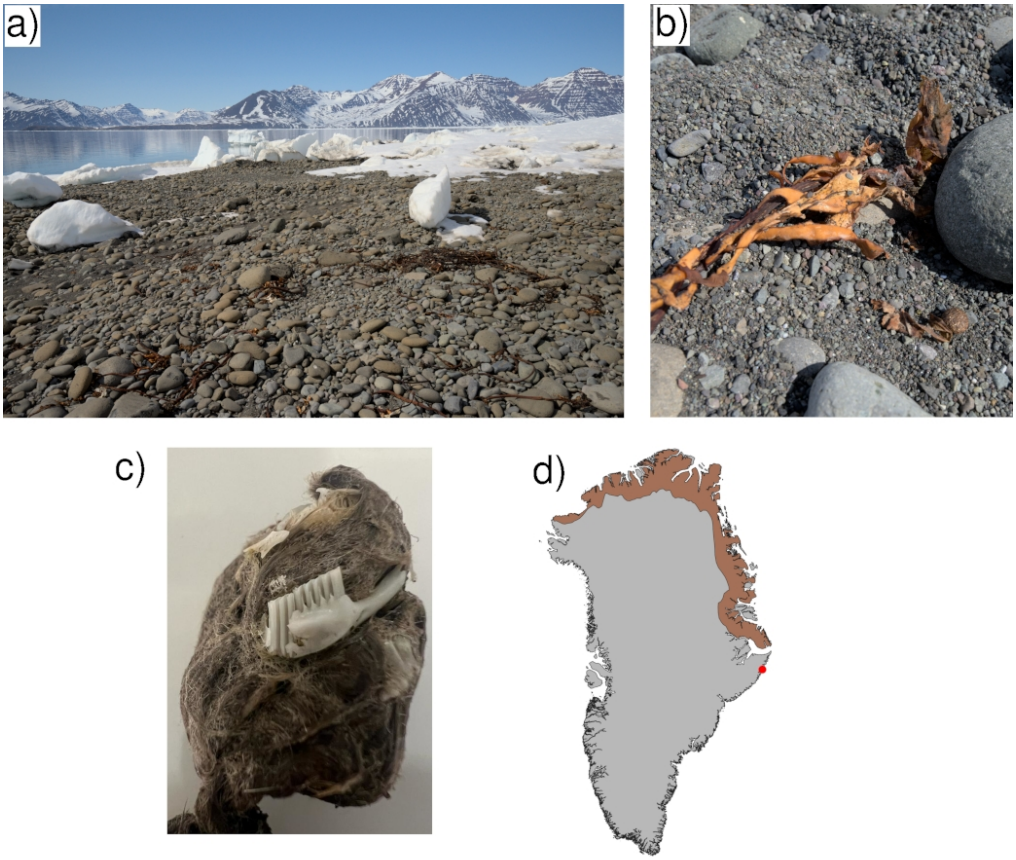

Fig. 4 The rocky beach at site CC080623-5 (a), a hare faeces observed close to washed up seaweed at this site (b), the Arctic fox faeces encountered at CC080623-6 which contained a jaw of the Greenland lemming (*Dictrostonyx groenlandicus*) (c), as well as the current distribution of this lemming species listed by the latest IUCN assessment (Cassola 2016) (d).

5. Data and Sample Storage / Availability

The samples are currently stored at Stockholm University, Sweden. Once quantified and published, the data will be deposited to figshare for full data access (http://www.figshare.com), including a reference DOI number for each data deposit.

6. Participants

Table 4 List of participants during the two cruise, their main tasks as well as their affiliations.

No.	Name	Early career	Gender	Affiliation	Cruise	On-board tasks
1	Jordi Bartolomé Filella	N	M	UAB	CC150523	Field data collection, data organisation, mammalian herbivore expert
2.	Rasmus Erlandsson	Y	M	SU	CC150523	Field data collection, data organisation
3.	Robert Björk	N	M	GU	CC080623	Field data collection, data organisation, botanical expert
4.	Fredrik Dalerum	N	M	IMIB, SU	CC080623	Field data collection, data organisation

UAB	Autonomous University of Barcelona, Barcelona, Spain
SU	Stockholm University, Stockholm, Sweden
GU	University of Gethenburg, Gothernburg, Sweden
IMIB	Biodiversity Research Institute, Mieres, Spain

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