Radiocarbon dated common mussels *Mytilus edulis* from eastern Svalbard and the Holocene marine climatic optimum

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The common mussel *Mytilus edulis* is an indicator of milder marine conditions in the Arctic, with stronger Atlantic Water influx, during the Holocene and earlier interglacials. Twelve Holocene radiocarbon dates of *Mytilus* from eastern Svalbard fall between ca 8800 and 5000 BP and roughly delimit the marine climatic optimum period there. The beginning of this period in the east coincides with the immigration of boreal extralimital molluscs to western Svalbard, indicating the culmination of Holocene Atlantic influence.

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Introduction

The common mussel *Mytilus edulis* L. is mainly an intertidal to shallow sub-tidal bivalve, which spreads with pelagic larvae and byssus drifting. It does not live on Svalbard today, but living specimens attached to seaweed, boxes and other items, presumed to have drifted from the south, have been encountered several times during the last hundred years (Knipowitsch 1903a; Heintz 1926; Peacock 1983; Mangerud & Bolstad unpubl.).

However, during the warmer parts of the Holocene, *Mytilus* was common on Svalbard, especially on the western coast (summary in Salvigsen et al. 1992; see Fig. 1). Reports from the colder northern and eastern parts of the archipelago are fewer. In the east, scattered finds had been made earlier on Edgeøya (Knipowitsch 1903b) and on Svenskøya in the Kong Karls Land archipelago (Nathorst 1901; Hägg 1950). Nansen (1902) even found it as far east as Franz Josef Land.

The PONAM expedition

During the PONAM (Polar North Atlantic Margins, Late Cenozoic Evolution, see Acknowledgements) expedition to eastern Svalbard in 1991, most major sections in Quaternary sediments on Edgeøya and Barentsøya were studied, with extensive work being done also on western Kongsøya in Kong Karls Land. *Mytilus* was found in raised marine sediments at several localities, but only on Edgeøya (Hjort et al. 1992), where it occurs from ca 45 m a.s.l. to a few metres above the present shore. In some places it was very common, for example at Habenichtbukta on southwestern Edgeøya, close to Kraussbavn where it was found during the Russian expedition in 1899 (Knipowitsch 1903b).

The dated *Mytilus* samples from Edgeøya and the earlier Svenskøya find are listed in Table 1. Most of the localities and finds were described by Hjort et al. (1992) and also listed by Gulliksen et al. (1992), but four new dated samples, also collected during the PONAM expedition, have now been added. All known occurrences on Edgeøya are indicated on Fig. 2.

Radiocarbon dates

Eleven radiocarbon dates were made on *Mytilus* shells collected on Edgeøya during the PONAM expedition 1991 (Table 1). Eight of these were conventional datings made in Trondheim and Lund and three were AMS-datings made in Aarhus or Uppsala. The fragments found on

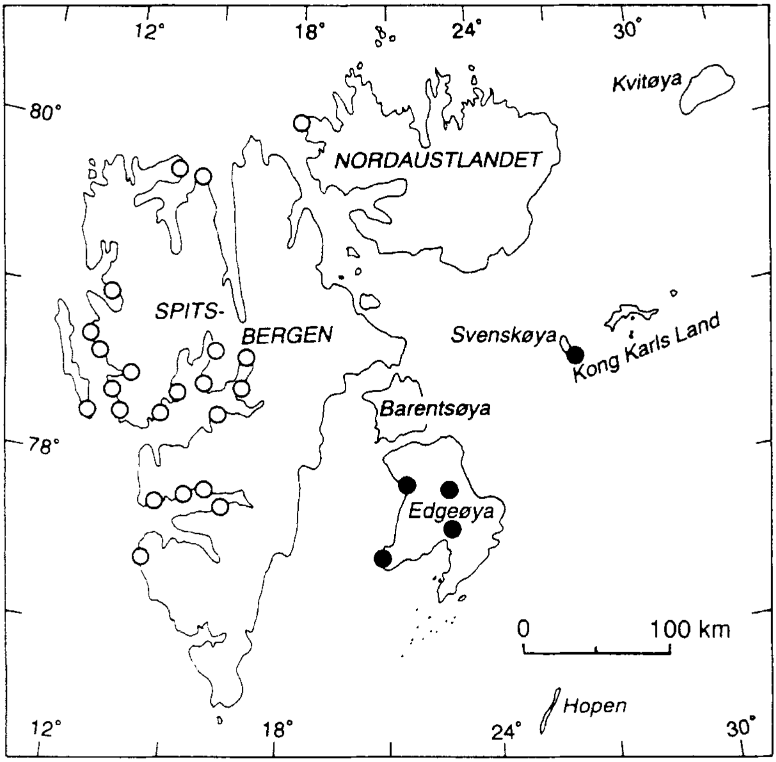

Fig. 1. Svalbard, with dated *Mytilus edulis* finds according to Salvigsen et al. (1992, open circles) and as added through this study (filled circles, details in Fig. 2).

Table 1. Radiocarbon dated *Mytilus edulis* samples from eastern Svalbard. Except for no. 4, which is from Kong Karls Land and was collected in 1898 (Nathorst 1901; Hägg 1950), all samples are from Edgeøya (Fig. 2) and were collected during the PONAM expedition in 1991 (Hjort et al. 1992; Gulliksen et al. 1992). The ages are corrected for a reservoir effect of −440 years (Mangerud & Gulliksen 1975). $\delta^{13}C$ is expressed as ‰ on the PDB scale.

	Locality	Sample no.	m a.s.l.	Age BP	^{14}C lab. no.	$\delta^{13}C$	Collector
1	Smelledalen	86-707D	40	8755 ± 125	T-9919	−0.2	J. Mangerud & S. Bondevik
2	Blafjorddalen	88-456	39	8510 ± 120	T-9909	-	J. Y. Landvik
3	Raddedalen	86-307	36	8210 ± 150	AAR-837	0.1	O. Stubdrup & S. Bondevik
4	Svenskøya	88-739	25	7260 ± 100	AAR-853	−0.3	G. Andersson
5	Seidbreen	88-735	in till	7205 ± 115	Ua-3279	-	C. Hjort
6	Smelledalen	86-703A	35	7175 ± 110	T-9922	0.5	J. Mangerud & S. Bondevik
7	Smelledalen	87-653	37	7095 ± 55	Tua-473	1.0	J. Mangerud
8	Smelledalen	86-702A	34	7095 ± 135	T-10144	0.3	J. Mangerud & S. Bondevik
9	Smelledalen	87-655	15	7050 ± 140	T-9921	0.3	J. Mangerud
10	Smelledalen	87-654C	28	6885 ± 85	T-10145	−0.3	J. Mangerud
11	Smelledalen	86-701A	27	5835 ± 125	T-9920	0.5	J. Mangerud & S. Bondevik
12	Habenichtbukta	88-711	4	4960 ± 80	Lu-3373	−0.6	C. Hjort & L. Adrielsson

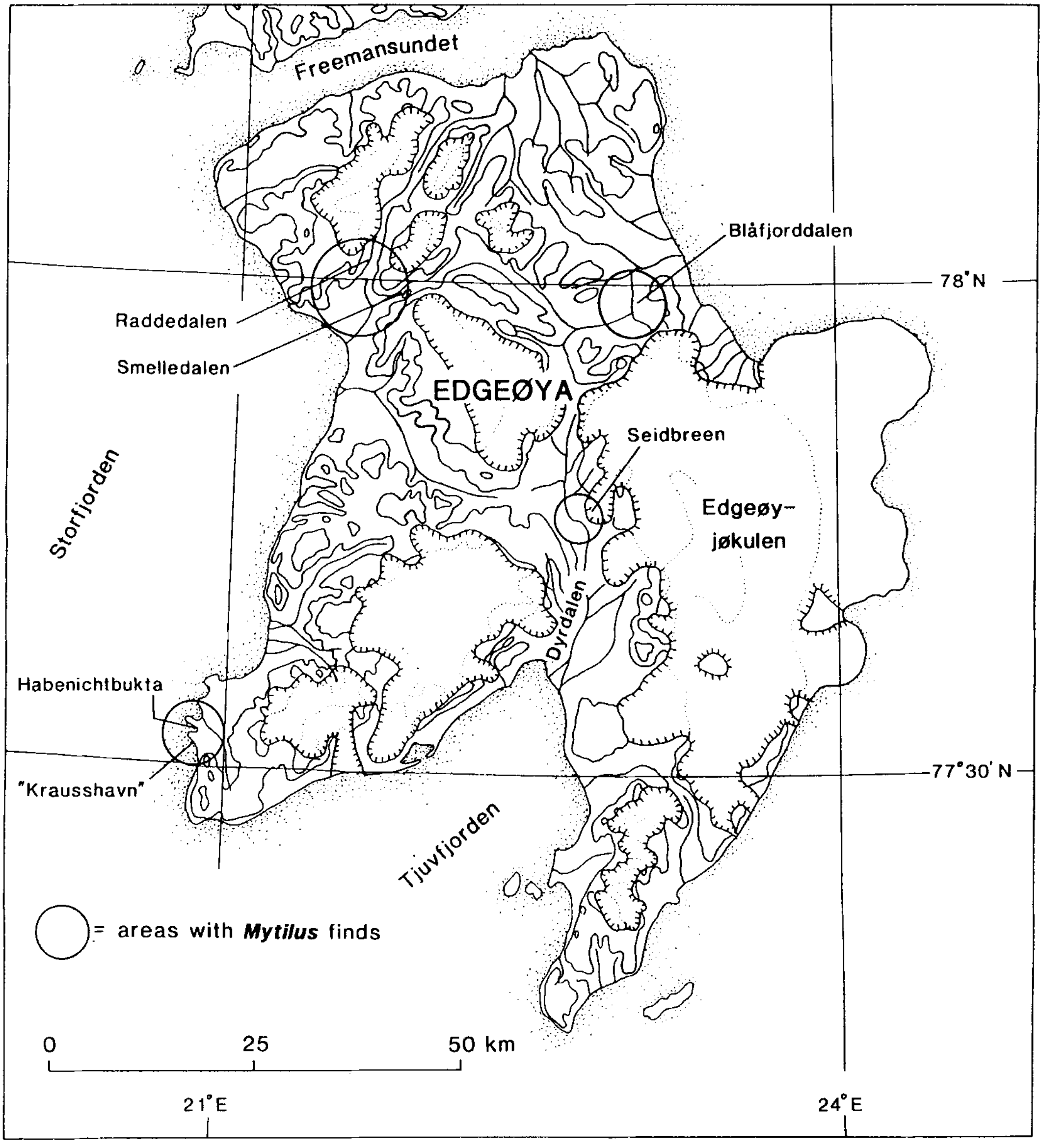

Fig. 2. Edgeøya with known occurrences of *Mytilus edulis*.

Svenskøya in 1898 were AMS-dated in Aarhus. All samples have been corrected for a reservoir effect of −440 years, according to Mangerud & Gulliksen (1975).

The oldest shells date from 8755 ± 125 yrs BP and belong to those collected at the highest altitudes. The youngest dated shells, from 4960 ± 80 BP at Habenichtbukta, were those encountered at the lowest altitude, 4 m a.s.l. Our datings thus show that *Mytilus* immigrated to eastern Svalbard not later than ca 8800 BP and was still living there around 5000 BP.

Discussion

Present distribution

Although *Mytilus* is not found living on Svalbard today, it penetrates far into southeastern Barents

Sea (Peacock 1989) and up along the western coast of Greenland (Funder & Weidick 1991). It even maintains populations on the southeastern coast of Greenland, within waters affected by the cold East Greenland Current (Hjort & Funder 1974; Funder & Weidick 1991). It also occurs at scattered localities along the eastern coast of Baffin Island, where Arctic Water flows southward in the Baffin-Labrador Current (Andrews 1972). *Mytilus* may thus live under conditions where summer sea-surface temperatures (SST's) approach 0°C. The presence of marginal populations which live today in fjord areas inside cold-water currents (e.g. in the Ammassalik district in southeastern Greenland), indicates an ability to colonise rather local areas with higher than average SST's. This may occur during years with stronger than average Atlantic Water penetration (cf. discussion in Peacock 1989, p. 189).

Hypsithermal distribution

Mytilus had a much larger northward distribution during earlier parts of the Holocene and has become the classical exponent for warmer-than-present conditions in the Arctic. Svalbard was the area where this first became evident (e.g. Blomstrand 1864; Nathorst 1884; Högbom 1913; Feyling-Hanssen 1955).

According to the review by Salvigsen et al. (1992), it immigrated to the western coast of Svalbard before 9500 BP and lived there until around 3500 BP. Thereafter it briefly reimmigrated during the warm period around 1000 BP. Thus it seems to have appeared on eastern Svalbard some 500–900 years later than on the western coast. The western and northern coasts are today the areas most affected by Atlantic Water, and that this general pattern prevailed also earlier during the Holocene is, for example, indicated by the mid-Holocene occurrence only on the central western coast of the boreal molluscs *Zirphea crispata*, *Modiolus modiolus*, *Arctica islandica* and *Littorina littorea* (Feyling-Hanssen 1955; Salvigsen et al. 1992; Mangerud & Svendsen 1992). According to our radiocarbon dates, the immigration of *Mytilus* to eastern Svalbard roughly coincided with the first appearance of boreal molluscs on the west coast, which took place around 8700 BP (Salvigsen et al. 1992). Thus it seems that it managed to colonise these eastern parts as an effect of a maximum Atlantic Water influx to the region. But *Mytilus* lived on along the shores of Edgeøya well after the boreal period on the western coast had come to an end, as it did around 7700 BP. Nor was our youngest *Mytilus* date, from ca 5000 BP, from a population on the verge of extinction. It then still lived in profusion in a local shallow lagoon environment in Habenichtbukta (Adrielsson et al. 1992).

Today the waters around Edgeøya and Kong Karls Land are dominated by the southwesterly flow of Arctic Water in the East Spitsbergen Current (e.g. Loeng 1991). It seems that a precondition for the immigration of *Mytilus* into this area, and for its persistence there during ca 4000 years, must have been a weakening of this cold current and a much stronger influx of Atlantic Water than today. The foraminiferal record in marine sediment cores from western Franz Josef Land, northeast of our study area and much further away from the Atlantic source supports this. It indicates that the most favourable marine conditions there, with the strongest Atlantic influence, were between 7000–5000 BP (Polyak & Solheim 1994). How quickly the balance between warmer Atlantic and colder Arctic waters may indeed shift, over a few decades or less, has recently been documented from the northern coast of Svalbard by Eggertsson (1994), with the help of driftwood studies.

The same pattern of early to mid-Holocene weakening of cold water outflows from the Polar Basin, with a markedly stronger Atlantic influence, has been suggested for both the East Greenland Current and the Baffin-Labrador Current, using *Mytilus* dates (Andrews 1972; Hjort & Funder 1974; Funder & Weidick 1991). A study by Koc & Jansen (1994), based on oxygen isotope and diatom stratigraphy in deep sea cores from the Greenland Sea, confirms that this enhanced Atlantic influence began to affect the coast of central East Greenland ca 8500 BP, which is roughly when *Mytilus* immigrated (Hjort & Funder 1974). The Atlantic influence diminished from ca 5000 BP, coinciding with the disappearance of *Mytilus*. This further illustrates the close relationship between oceanographic climatic conditions and the geographic distribution of this pelagically spreading indicator bivalve!

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