



Recent distribution of Echinodermata species in Spitsbergen coastal waters

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Abstract: Thirty-two species of echinoderms from epibenthic sledges, dredges, scuba diving, and other samples (in total: 467 samples and c. 20 000 specimens) from fjords and coastal waters off Spitsbergen were analysed between 1996 and 2014. The most numerous group of echinoderms in the coastal waters off Spitsbergen is brittle stars (78% of the total individuals). The echinoderms do not form any clear assemblages according to depth or distance from glacial sedimentation and substrate. Some species prefer hard bottom (*Strongylocentrotus droebachiensis*) or water free from glacial suspensions (*Ophiopholis aculeata*). In contrast to the species listed above, we also found opportunistic species such as the starfish *Urasterias lincki* and the brittle star *Ophiocten sericeum*. These two species are distributed quite uniformly, regardless of the environmental factors. The majority of the species prefer a soft bottom below 200 m.

Key words: Arctic, fjords, Echinodermata, climate change, species distribution, megabenthos.

Introduction

Most echinoderms are megafauna, which are animals larger than a few centimeters that live as epifauna and are visible in underwater images. These large, long-living animals form an important element of the macroscopic food web and often serve as indicators of environmental change (*e.g.* Blacker 1957; Hoey *et al.* 2010). Because the European Arctic is considered the area most

impacted by ongoing climate change (ACIA 2005), identifying the distribution patterns of key species is also of great interest for general environmental knowledge and fisheries; this knowledge is expressed in large-scale mapping initiatives (Anisimova *et al.* 2010). Echinoderms in the Northern Atlantic belong to well-known taxa; *i.e.*, no major problems exist with species identification, and the expected number of unknown taxa is very low (Piepenburg and Schmidt 1996; Piepenburg 2000; Appeltans *et al.* 2011).

Due to its accessibility, the Svalbard archipelago was an area of early faunistic studies during the Arctic expeditions at the end of the 19th century, which collected data on Decapoda, Echinodermata, Amphipoda, Gastropoda, fish and macroalgae (see the review in Palerud *et al.* 2004). Recently, some of the old sampling stations were revisited and revealed a surprising stability of some animal taxa such as Decapoda (Berge *et al.* 2009) and the benthos in general (Renaud *et al.* 2007; Kędra *et al.* 2011). Large-scale fishery research in the Barents and Norwegian seas led to the use of by-catch animals that may serve as indicators of hydrological and climatic variability (Blacker 1957; Dyer *et al.* 1984). These animals may follow major environmental driving forces in the area: fluctuations in Atlantic water inflow to the Svalbard shelf and the Fram Strait (Walczowski and Piechura 2006) and instability in pack ice and fast ice cover (ACIA 2005). Coastal water fauna have received much less attention in this respect (bioindicators) than have the shelf and offshore benthos (Piepenburg *et al.* 1996; Berge *et al.* 2005; Renaud *et al.* 2011; Włodarska-Kowalczyk *et al.* 2012). Nevertheless, in view of the massive change in the distribution of tidal glaciers (melting, discharge of sediment-laden freshwater, and the uncovering of new areas of the seabed), the fjords are interesting sites for studying the occurrence patterns of megafauna. Our study aims to document the recent (1996–2014) occurrence of echinoderm species in the coastal and fjord waters of Svalbard with special reference to Hornsund, Isfjorden and Kongsfjorden, which are the most visited and studied Arctic fjords (Hop *et al.* 2002; Svendsen *et al.* 2002; Kędra *et al.* 2010). We wanted to determine whether cold water species (based on the literature) had retreated to give space to the thermophilic newcomers. Coastal Echinodermata distribution analysis can be an indicator of the presence of a water mass and an increase in temperature.

Study area

The Svalbard archipelago is situated in the northern Atlantic Ocean on the zoogeographical border between the Subarctic and Arctic provinces (Bakus 1986). The division runs along the west coast of Spitsbergen Island and is usually reported as a border between the Barents Sea and the Norwegian Sea marine

fauna (Blacker 1957). The west coast is washed with the recently increasing inflow of Atlantic waters from the West Spitsbergen Current (Loeng 1991; Walczowski and Piechura 2006), whereas the eastern part of the archipelago is under the influence of the colder Barents Sea shelf waters and transformed local coastal waters of Atlantic origin. The difference between the particular water masses is not very sharp: salinity ranges from the lowest value of 33.5 in the Arctic waters to the highest value of 34.7 in the core Atlantic waters (Beszczyńska-Møller *et al.* 1997). Seasonal differences are important because the inner fjord basins and most of the eastern parts of the archipelago are covered with fast ice and ice pack between December and June (Pavlov *et al.* 2010). In the winter, the water column cools to an isothermic -1.5°C in the fjords and coastal waters (Węśławski *et al.* 1994). In the summer, the maximum temperatures did not exceed 8°C at the surface and 5°C in the near-bottom waters (Swerpel 1985; Drewnik *et al.* 2016a). Most of the sediments in fjordic and coastal waters are glaciomarine and occur from numerous tidal glaciers that discharge turbid freshwaters and cause heavy mineral sedimentation in the fjords (Elverhoi *et al.* 1983; Lydersen *et al.* 2014). Stony and rocky outcrops are common, both as ice-rafted debris (dropstones) and as bedrock washed by the near-bottom currents (Elverhoi and Solheim 1983; Hop *et al.* 2002). Productivity in the Svalbard fjords and coastal waters is high, up to $120\text{ g C/m}^2/\text{year}$ (Eilertsen *et al.* 1989). The entire Svalbard is within an area of intensive warming (ACIA 2005), and numerous studies were recently undertaken on its hydrography and related interannual changes (*e.g.*, Walczowski and Piechura 2006; Cotier *et al.* 2010).

Materials and methods

The present material was collected between 1996 and 2014 during summer cruises of the *r/v Oceania* and *r/v Helmer Hansen*, including a number of scuba diving trips and underwater photography sessions (Lander, drop camera) within the framework of various projects run by the Institute of Oceanology PAS (Polish Academy of Sciences) in cooperation with Norsk Polarinstitutt, the University Centre in Svalbard and AkvaplanNiva. The various gear and the numbers of samples obtained are listed in Table 1. All of the samples were georeferenced and labelled with the depth, date and basic environmental parameters (temperature, salinity, and sediment/bottom type) and are stored at the Institute of Oceanology of Polish Academy of Sciences in the data repository (<http://www.iopan.gda.pl/projects/Game/Data>). The taxonomy was adopted from WoRMS (<http://www.marinespecies.org/>). The organisms were preserved on board/in the field in a 4% buffered formaldehyde solution or industrial alcohol and were identified

Table 1

Set of the samples collected and examined in this study during the summer seasons from 1996–2014.

Type of gear	Number of samples	Depth range [m]	Remarks
Van Veen grab	8	0–30	mainly small organisms and sampling only the soft bottom
Van Veen grab	61	31–100	
Van Veen grab	44	101–200	
Van Veen grab	43	201–400	
Epibenthic sledge	7	0–30	small and large organisms and different types of bottom
Epibenthic sledge	31	31–100	
Epibenthic sledge	14	101–200	
Epibenthic sledge	57	201–400	
Triangle dredge	4	0–30	small and large organisms and different types of bottom
Triangle dredge	1	31–100	
Triangle dredge	1	201–400	
Drop camera, Landers	3	31–100	mostly larger organisms and different types of bottom
Drop camera, Landers	9	101–200	
Scuba diver	181	0–30	mostly larger organisms and mainly hard bottom
Scuba diver	3	31–100	
Total	467		

under a stereomicroscope in the lab either as dry or wet samples, depending on the specific group. Identification was attempted to the lowest taxonomic level possible using the keys by: Clark (1970) Anisimova (1989), Hayward and Ryland (1990) and Anisimova (1992) *et al.*, and the dedicated web page (<http://www.iopan.gda.pl/ekologia/borszcz-echino/bor77.htm>.) The number of species in the sample was used to create arrays as the basis for the multivariate analysis. The data were transformed by presence/absence with dominant and rare species considered equally important (0 = absent in a sample, 1 = present) (Clarke and Green 1988). The similarities between the pairs of samples were calculated using the Bray-Curtis index (Bray and Curtis 1957). This formula is recommended in these types of analyses due to its insensitivity to the effect of “common absent” species in the samples (Clarke and Warwick 1994). Bray-Curtis similarities between the samples are shown by the nMDS (non-metric multidimensional scaling) method. Dendrogram of similarities between the species was created

based on transformed presence/absence data and used clustering algorithm “group average”. The Chao2 estimator is based on the principle that rare and uncommon species carry information about the number of species that are missing in samples (Chao 2004). $Chao2 = S_{obs} + Q_1^2/2Q^2$, where Q_1 is number of species that occurred only in one sample (uniques) and Q^2 is the number of species that have occurred exactly in two samples (duplicates). The Michaelis-Menten (MM) estimator is one of the most commonly used methods to generate a curve for the accumulation of species (Magurran 2004). The MM asymptote estimation is used to estimate the total species richness. The data were computed using the STATISTICA and PRIMER (multivariate statistics for ecologist) software.

Results

We registered over 460 positive findings (samples containing Echinodermata) from over 1000 seabed samples (Fig. 1). The analysed material contained 19.830 individual echinoderms. The material was determined to represent 32 species, including 14 starfish, 10 brittle stars, 5 sea cucumbers, 2 crinoids, and one species of sea urchin (Table 2 and 3). The species accumulation curve increased along its entire length and approached a level asymptote. Chao2 provided an estimate of 38 species and 30 species after using the Michaelis-Menten estimator (MM) (Fig. 2). The most common species were the sea urchin *Strongylocentrotus droebachiensis* and the brittle stars *Ophiura robusta*, *Ophiocten sericeum*, *Ophiopholis aculeata*, and *Ophiura sarsii* (over 10% of the frequency in samples containing echinoderms). Three species were most abundant: *O. sericeum*, *O. robusta* and *S. droebachiensis* (6972, 4772 and 3672 individuals, respectively, Table 3). Singletons, which were single individuals in the whole collection, included two sea cucumbers (*Acanthotrochus mirabilis* and *Cucumaria frondosa*), one brittle star (*Gorgonocephalus eucnemis*) and four starfish (*Hippasteria phrygiana*, *Hymenaster pellucidus*, *Poraniomorpha tumida*, and *Pteraster obscurus*, Table 2). The majority of the species found have wide boreal-arctic distributions (75%), with only six species described as true Arctic cold water species (*Acanthotrochus mirabilis*, *A. sundevalli*, *Hymenaster pellucidus*, *Ophiopleura borealis*, *Poliometra proluxa* and *Poraniomorpha tumida*; Table 3), (Brattegard and Holthe 2001; Sirienko 2001; Fetzer and Arntz 2008). The dominant functional groups were deposit feeders (10 species) and carnivores (12 species, Table 3). Species found in the collected samples were analysed for their co-occurrence to reveal species assemblages; however, there is no well-defined grouping (associations among the species analysed are on the very low level of similarity) below 40% (Fig. 3). The depth is not a factor that separates the collected species; *i.e.*, among the samples collected in the four depth strata, very

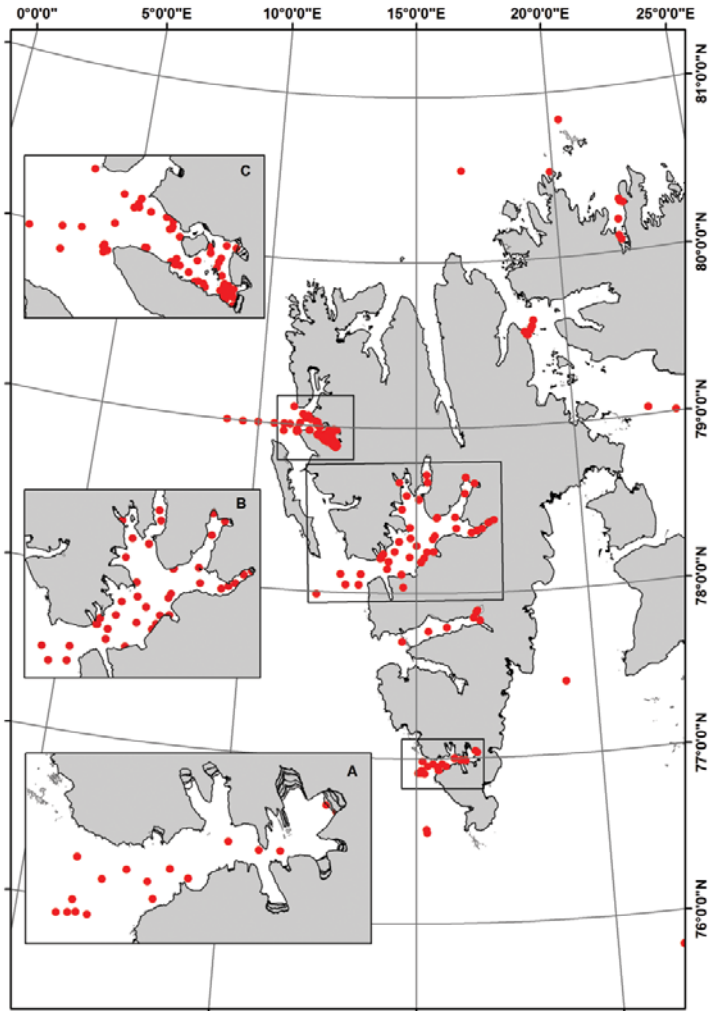


Fig. 1. Distribution of sampling stations in the Svalbard archipelago, with a focus on Hornsund (A), Isfjorden (B) and Kongsfjorden (C).

little difference in species composition was found (Fig. 4). The stations analysed for the spatial distribution pattern are spread nearly evenly on the nMDS plot (Fig. 4). Analysing the nMDS related to different sub-areas/fjords did not show any significant patterns. Depth, temperature, and other environmental variables were checked as the occurrence predictors, and the main relationship was between the shallow samples and the presence of *S. droebachiensis* (reportedly a sole herbivorous species feeding on kelp). Individual species distribution maps are available at the following web page: (www.iopan.gda.pl/projects/).

Table 2
 Dominance-relative contribution (D%) and frequency of occurrence (F%) of species
 in three studied fjords combined with the entire research area (all data).

Fjord	Isfjord		Kongsfjord		Hornsund		All data	
	D%	F%	D%	F%	D%	F%	D%	F%
<i>Acanthoerochus mirabilis</i> Danielssen et Koren, 1881	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
<i>Amphiura sundevalli</i> (Müller et Troschel, 1842)	1.8	11.6	0.4	4.4	4.1	28.1	0.9	12.4
<i>Asterias rubens</i> Linnaeus, 1758	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.6
<i>Crossaster papposus</i> (Linnaeus, 1767)	0.2	3.3	0.3	2.6	0.0	0.0	0.2	3.9
<i>Ctenodiscus crispatus</i> (Retzius, 1805)	0.7	6.6	0.0	0.0	0.4	3.1	0.7	4.5
<i>Cucumaria frondosa</i> (Gunnerus, 1767)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
<i>Diplopteraster multipes</i> (M. Sars, 1866)	0.1	0.8	0.0	0.0	0.0	0.0	0.0	1.3
<i>Eupyrgus scaber</i> Lütken, 1857	0.4	2.9	1.9	8.8	0.2	4.7	0.3	4.7
<i>Gorgonocephalus eucnemis</i> (Müller et Troschel, 1842)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
<i>Heliometra glacialis</i> (Owen, 1833 ex Leach MS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
<i>Henricia sanguinolenta</i> (O.F. Müller, 1776)	0.6	7.1	0.1	0.9	0.1	3.1	0.2	5.4
<i>Hippasteria phrygiana</i> (Parelius, 1768)	0.0	0.0	0.0	0.0	0.1	1.6	0.0	0.2
<i>Hymenaster pellucidus</i> Thomson, 1873	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
<i>Marthasterias glacialis</i> (Linnaeus, 1758)	0.0	0.0	0.0	0.0	1.3	3.1	0.1	0.4
<i>Myriostrochus rinkii</i> Steenstrup, 1851	0.1	1.2	0.4	4.4	0.0	0.0	0.0	1.7
<i>Ophiacantha bidentata</i> (Bruzelius, 1805)	0.5	1.7	1.6	10.5	4.1	14.1	1.1	8.6
<i>Ophiocten sericeum</i> (Forbes, 1852)	9.8	10.8	22.5	22.8	45.7	40.6	35.2	20.2
<i>Ophiopholis aculeata</i> (Linnaeus, 1767)	2.0	15.4	9.6	12.3	14.4	10.9	3.9	16.5
<i>Ophiopleura borealis</i> Danielssen et Koren, 1877	0.1	0.4	0.0	0.0	0.0	0.0	0.1	0.4
<i>Ophioscolex glacialis</i> Müller et Troschel, 1842	0.0	0.4	0.1	0.9	0.0	0.0	0.0	0.6
<i>Ophiura robusta</i> (Ayres, 1854)	11.9	18.3	19.3	23.7	6.9	23.4	24.1	22.5
<i>Ophiura sarsii</i> Lütken, 1855	1.9	10.4	12.2	18.4	3.7	12.5	2.6	15.2
Ophiuroidea juv. non determined	4.6	13.7	6.9	15.8	1.0	7.8	8.9	13.3
<i>Poliometra proluxa</i> (Sladen, 1881)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
<i>Pontaster tenuispinus</i> (Düben et Koren, 1846)	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9
<i>Poraniomorpha tumida</i> (Stuxberg, 1878)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
<i>Psolus squamatus</i> (O.F. Müller, 1776)	0.4	2.1	0.1	0.9	0.0	0.0	0.1	1.3
<i>Pteraster militaris</i> (O.F. Müller, 1776)	0.1	1.2	0.0	0.0	0.0	0.0	0.0	0.6
<i>Pteraster obscurus</i> (Perrier, 1891)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
<i>Solaster endeca</i> (Linnaeus, 1771)	0.2	1.7	0.1	0.9	0.0	0.0	0.1	1.1
<i>Stegophiura nodosa</i> (Lütken, 1855)	4.3	10.0	0.0	0.0	0.0	0.0	1.2	5.4
<i>Strongylocentrotus droebachiensis</i> (O.F. Müller, 1776)	60.3	60.6	13.4	22.8	5.8	4.7	18.5	41.6
<i>Urasterias lincki</i> (Müller et Troschel, 1842)	0.1	1.2	11.0	11.4	12.0	20.3	1.7	7.5

Table 3

Species composition and basic characteristics including food guilds (sus – suspension feeders, df – deposit feeders, car – carnivores, omni – omnivorous, sca – scavengers, and herb – herbivorous), habitat (m – mud bottom, mg – muddy gravel, r – rocky bottom, s – sand, ms – mixed sediments, si/ssi – silt, sandy silt, sb – soft bottom, and vs – variety of substrates) and zoogeographic rank (A – arctic, B – boreal, BA – boreal-arctic, and C – circumboreal). The data were compiled from Connor *et al.* (1997), Piepenburg (2000), Fetzer and Arntz (2008), and web sources <http://www.marinespecies.org/>, <http://www.habitas.org.uk/marinelife/>, and <http://www.iopan.pl>.

N	Species	n	depth [m]	Food guild	Habitat	Zoogeography
1	<i>Acanthotrochus mirabilis</i>	1	201	df?	m/mg	A
2	<i>Amphiura sundevalli</i>	187	6–355	sus	m	A
3	<i>Asterias rubens</i>	3	19–67	car	r/s/m	B
4	<i>Crossaster papposus</i>	31	15–207	car/omni/sca	r	BA
5	<i>Ctenodiscus crispatus</i>	133	74–323	df	m/ms	BA
6	<i>Diplopteraster multipes</i>	7	18–178	car?	vs?	BA. C
7	<i>Eupyrgus scaber</i>	53	54–305	df?	m/ms/mg	BA
8	<i>Gorgonocephalus eucnemis</i>	2	80	car/sus	r	BA
9	<i>Heliogetra glacialis</i>	3	56–207	sus	si/ssi	BA
10	<i>Henricia sanguinolenta</i>	44	10–120	sus	r	BA
11	<i>Hippasteria phrygiana</i>	2	147	car	ms	BA
12	<i>Hymenaster pellucidus</i>	1	207	df?	m	A
13	<i>Marthasterias glacialis</i>	19	50–100	car/omni/sca	hs	BA
14	<i>Myriotrochus rinkii</i>	9	10–308	df	mg/ms	BA
15	<i>Ophiacantha bidentata</i>	212	50–355	sus	ms	BA
16	<i>Ophiocten sericeum</i>	6972	10–323	df	sb	BA
17	<i>Ophiopholis aculeata</i>	782	6–390	sus	h	BA
18	<i>Ophiopleura borealis</i>	15	113–323	car/omni	sb/m	A
19	<i>Ophioscolex glacialis</i>	4	10–288	car	sb/m	BA
20	<i>Ophiura robusta</i>	4772	6–390	sus/car/omni/sca	vs	BA
21	<i>Ophiura sarsii</i>	509	2–288	car/omni/sca	sf	BA
22	Ophiuroidea juv	1768	4–300			
23	<i>Poliometra prolixa</i>	5	178–207	sus	si/ssi	A
24	<i>Pontaster tenuispinus</i>	11	178–323	df	sb/ms	BA
25	<i>Poraniomorpha (Poraniomorpha) tumida</i>	2	323			A
26	<i>Psolus squamatus</i>	22	120–240	df	mg/ms	BA
27	<i>Pteraster militaris</i>	4	15–20	df?	mg/ms	BA
28	<i>Pteraster obscurus</i>	1	60	df?	mg/ms	BA

N	Species	n	depth [m]	Food guild	Habitat	Zoogeography
29	<i>Solaster endeca</i>	12	12–100	car/omni	mg	BA
30	<i>Stegophiura nodosa</i>	231	6–240	car	s/mg	BA
31	<i>Strongylocentrotus droebachiensis</i>	3672	6–260	herb	r	BA
32	<i>Urasterias lincki</i>	340	15–323	car/omni/sca	ms	BA
33	<i>Cucumaria frondosa</i>	1	45	sus	mg/r	BA

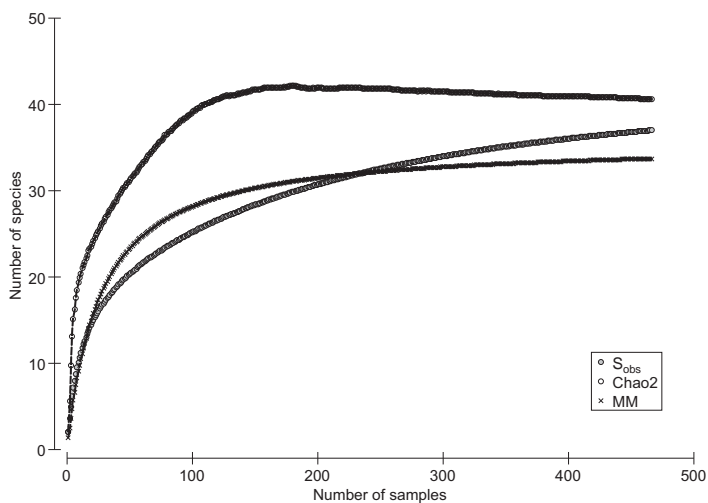


Fig. 2. Species accumulation curve representing the number of species (S_{obs}) and the number of species estimated by the Chao2 and Michaelis - Menten (MM) equations.

Discussion

The representativeness of the collected material was limited to the qualitative information regarding species presence/absence. The number of sampling points was high, although the samples were not distributed on a regular grid, as is recommended for species distribution modelling (Drewnik *et al.* 2016b). However, the set of species collected in the present study seems to be very complete, considering the obtained species accumulation curve (a similar result was obtained for other taxa collected in our projects; *e.g.*, Kędra *et al.* 2013). We found four new species for the area, including a single specimen of *Acantotrochus mirabilis*, which is a deep-water holothurian that has also been reported from Norwegian and Greenland seas below depths of 1000 m (Gebruk *et al.* 2014), but our record is a distinctly shallow one (250 m). Three other species (*Asterias rubens*, *Diplopteraster multipes*, and *Marthasterias glacialis*),

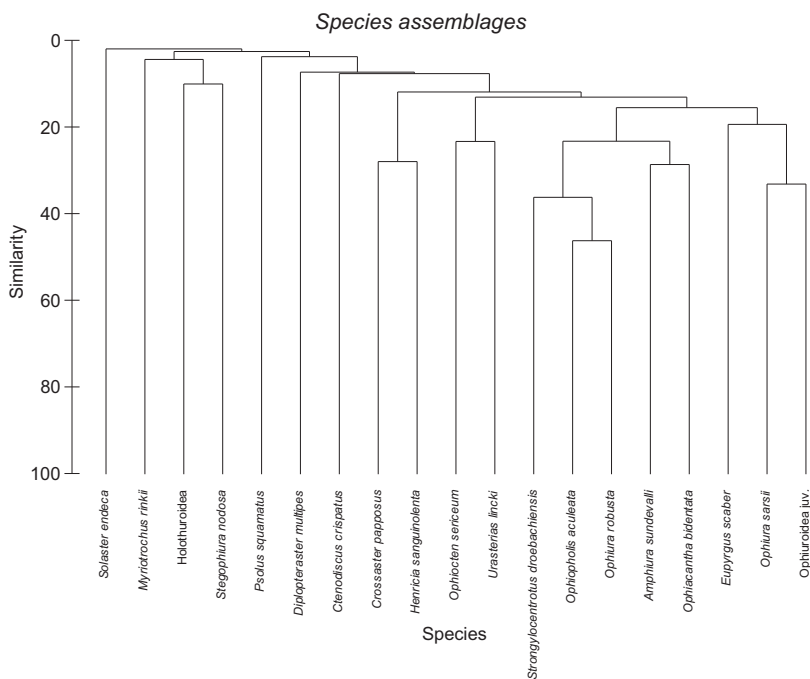


Fig. 3. Echinodermata species co-occurrence; data from the entire collection to reveal the species associations. Based on transformed presence/absence data; only species observed at five or more stations are included.

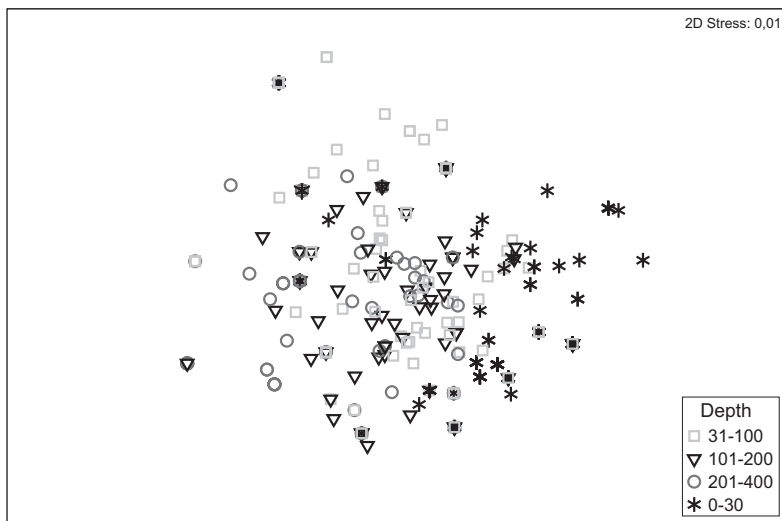


Fig. 4. Echinodermata species depth occurrence; the level of species similarity among the four depth intervals on the nMDS chart. The data were transformed as presence/absence.

all of wide boreal or circumpolar distributions, are known from Norway but had not been recorded so far north. We did not find the 30 species that had previously been recorded from Svalbard (Palerud *et al.* 2004), but some of these were rare echinoderms reported from deep water and the open shelf. The only exception was *Strongylocentrotus pallidus* (Voronkov *et al.* 2013), which might have been missed in our collection because it is very rare and almost indistinguishable from *Strongylocentrotus droebachiensis*. The set of echinoderm species observed at Svalbard might be treated as a subsample of the Norwegian Sea continental fauna, with the exception of only three species (*Stegophiura nodosa*, *Hymenaster pellucidus*, and *Ophiopleura borealis*); all three have been recorded from the Barents and Greenland Seas but have not been reported from coastal Norway (Piepenburg *et al.* 1996; Brattegard and Holthe 2001). All of the other echinoderm taxa collected on Svalbard have also been recorded in Norway, and the species number drops evenly from over 150 in western Norway to fewer than 60 in eastern Svalbard, along with the diminishing influence of Atlantic waters away from the Norwegian Sea (Fig. 5). This pattern of diminishing species number from the source (Atlantic) towards the Siberian shelf was presented for a number of taxa by Sirienko (2001).

The marine ecosystem of Svalbard is highly productive on the shelf (Wassmann *et al.* 2010) and in the fjords and coastal waters and in terms of habitats is no less diversified than that of continental Norway. The habitat heterogeneity is commonly considered a good predictor of species richness in the marine benthos (*e.g.*, Ellingsen and Gray 2002). Therefore, the reason

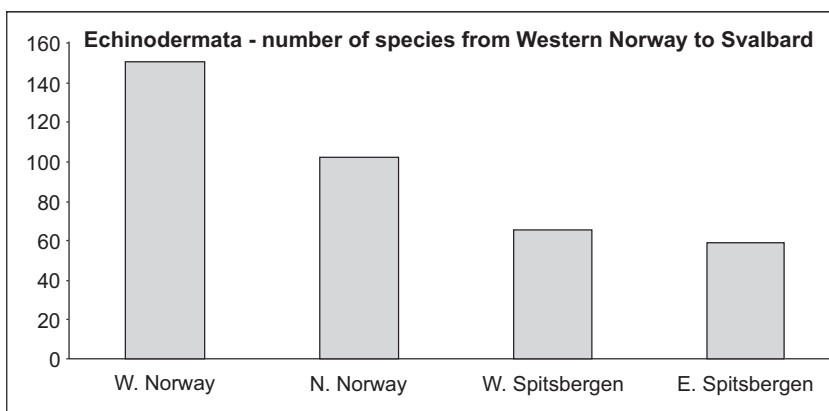


Fig. 5. Compilation of the distribution data from Norway (Brattegard & Holthe 2001) and Svalbard (Gulliksen *et al.* 1999). The number of valid species of Echinodermata recorded in the given regions including offshore shelf waters (Western Norway, Northern Norway, West Spitsbergen, and East Spitsbergen).

for the deficit in species richness in the Svalbard fjords is unclear. It might be evolutionary history following the deglaciations because the area is still recovering from the ice sheet (Ellingsen and Gray 2002); for the neritic, shallow water species, it could simply be the island effect (the distance from the mainland versus the size of the inhabited island; McArthur and Wilson 1964), which has been found as a strong predictor in European benthos distribution (Arvanitidis *et al.* 2009).

The wide occurrence of all of the observed species and the lack of clear distributional patterns in the study area confirms the observations of Dyer *et al.* (1985), who concluded that compared to the Blacker (1957) data, species are more widespread with fewer clear links to temperature-salinity patterns. This also follows a general observation by Thrush *et al.* (2006) regarding the homogenisation of habitats that follows global warming. Stability refers to the taxa presence in the fjords (Renaud *et al.* 2007; Berge *et al.* 2009), whereas homogeneity was recorded on the shelf (Dyer *et al.* 1984). Species having pelagic larvae, as is the case for most of our echinoderms, are expected to expand their occurrence ranges with the ongoing borealisation of the Svalbard area (Berge *et al.* 2005). West Spitsbergen fjords and coastal waters that were previously exposed to regular freezing and maintained local cold water pools are now often washed by Atlantic waters from the shelf and represent an ecotone type of area with mixed subarctic/boreal conditions (Drewnik *et al.* 2016a). This may explain the lack of zonation among the Echinodermata species found in this study.

Conclusions

The fjords of Spitsbergen, despite their diversity in physical factors such as water temperature, salinity and sedimentation, do not differ significantly from each other with respect to their Echinodermata fauna (Table 2). There was no depth zonation or other factor (water mass or sediment) that would clearly separate observed coastal and neritic species of echinoderms. Compared to historical records collected between 1900 and 1970 (Hofsten 1915; Clark 1970; Anisimova 1989; Gulliksen *et al.* 1999), the new thermophilic elements are sparse (three new records: *Acanthotrochus mirabilis*, *Diplopteraster multipes*, *Marthasterias glacialis* and eight species that were identified in older records were not present in our collection), and local cold water species are still in the same places in which they have been reported over the last 100 years. It is probable that the echinoderm fauna of Spitsbergen coastal waters is homogenous in terms of distribution and species associations. Reasons for the unexpected homogeneity could be the dominance of subpolar (Atlantic) species with a high physiological and ecological plasticity.

Acknowledgements. — We are grateful to Ania Iglirkowska for the supplementary material for this study and Jorgen Berge with Paul Renaud, who helped to collect the *Helmer Hansen* UNIS cruise data of 2013. Fieldwork was supported by the GAME NCN project and by the Polish-Norwegian Research Programme operated by the National Centre for Research and Development under the Norwegian Financial Mechanism 2009–2014 in the frame of Project Contract No POL-NOR/199377/91/2014 (GLAERE), No. POL-NOR/196260/81/2013 (POLNOR) and Leading National Research Centre (KNOW) received by the Centre for Polar Studies from 2014–2018.

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Received 14 April 2016

Accepted 23 September 2016