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Macro-plastic litter, a new vector for boreal species dispersal on Svalbard

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Abstract: The 100 km long west coast of Prins Karl Forlandet (westernmost island of Svalbard archipelago) was assessed for the density of macro-plastic litter. The most numerous were fragments of fishing gear (buoys, ropes, nets) followed by various containers, sheets of foil and plastic textiles. The total density was estimated at 14 400 items with a total weight of 18 tonnes of plastic debris on the inspected coastline. The largest objects (fishing boxes, containers) were colonised by barnacles (*Semibalanus* sp.), gooseneck barnacles (*Lepas* sp.), blue shells (*Mytilus* sp.), bryozoans and marine macro-algae. The rafting of groups of adult organisms favours their better biological dispersal compared to larval transport, and is regarded here as the main reason for reappearance of genus *Mytilus* on Svalbard.

Key words: Arctic, Svalbard, macro-plastic, beach litter, species dispersal.

Introduction

The problem of plastic debris in the Arctic Region has received fast growing attention over recent years. One of the reasons is that plastic has a long decomposition time in the environment, apparently longer in cold, saline waters (Gregory 2009) and there is a rapid increase of debris accumulated on the remote oceanic shores, 72% of which is estimated to consist of plastic (Litterbase 2017). Although the direct toxicity of plastic debris has not yet been proven (US EPA 2006; Rochman *et al*. 2013) the issue of microplastic ingestion in marine invertebrates is a threat for the pelagic food web (Reisser *et al*. 2014) and macro-plastic (especially fishing nets and foil) is reported to trap and wound birds, marine mammals, turtles and other organisms (Barnes *et al*. 2009; Kühn *et al*. 2015). Macro-plastic is now commonly recorded in nests of seabirds and is a component of their diet, especially in surface-feeding birds such as fulmars, albatrosses and gulls (Kühn *et al*. 2015; Trevail *et al*. 2015). The occurrence of plastic litter on the sea bed was reported first as a problem in the Skagerrak (Holmström 1975) but now it is frequently reported from great depths (Bergmann and Klages 2012; Tekman *et al*. 2017) and the sea surface (Bergmann *et al*. 2015). The review of various plastic debris in the Arctic is given in the report of Strand *et al*. (2015) and in the study of Bergman *et al*. (2017), which also includes an assessment of beach litter. Generally speaking, most of the plastic litter is found in semi-enclosed seas, large bays and near human settlements (Barnes and Milner 2005). The concentrations of plastic debris reported now worldwide ranges from 0 to 149 items per ha (Katsanevakis and Katsarou 2004; Barnes and Milner 2005), 46% of them is buoyant (US EPA 2006), and therefore floats at the sea surface form rafts available for colonisation (Engler 2012; Kiessling *et al*. 2015). The new reports state that the Arctic is a dead end of plastics exported from Europe by the thermohaline circulation (Cozar *et al*. 2017). The issue of plastic as a vector for species dispersal was highlighted by Barnes (2002) and Barnes and Milner (2005). In the present paper, we aim to estimate macro-plastic abundance on the 100 km long, ocean exposed coastline of a remote Arctic island – Prince Karl Forlandet (Svalbard archipelago) and signal the presence of encrusting boreal organisms found on several items.

Materials and methods

The coastal survey was completed between 4th and 11th of August 2017 in the framework of the Svalbard Intertidal Project (http://water.iopan.gda.pl/projects/SIP/SIP_2017/index.html). Prince Karl Forlandet (78°N), the westernmost isle of the Svalbard archipelago, is influenced by the West Spitsbergen Current (distant arm of the North Atlantic Current) (Walczowski and Piechura 2007) (Fig. 1). The survey of the coastline was performed during an 8-day continuous walk over 100 km distance. We focused on plastic debris, ignoring glass, metal and natural debris (wood and algae). The largest plastic debris (large fragments of fishing trawl over 100 kg) were all noted along the route. The plastic items were inspected for the presence of encrusting organisms along the entire 100-km route; eight of the fourteen objects contained encrusting organisms.

Easily visible (above 1 cm) plastic items were counted in the vicinity of each of six camp sites (Table 1, Fig. 1) on transects from the low water mark, 100 m long and wide strips. Such wide transects were chosen, as some debris was observed above the high water mark, wind-blown to the lower coastal plain. Additionally, visual observations along the daily route were conducted and the number of observed large plastic objects was recorded. Weight of individual plastic categories was taken arbitrarily from the similar items weighed in the laboratory.

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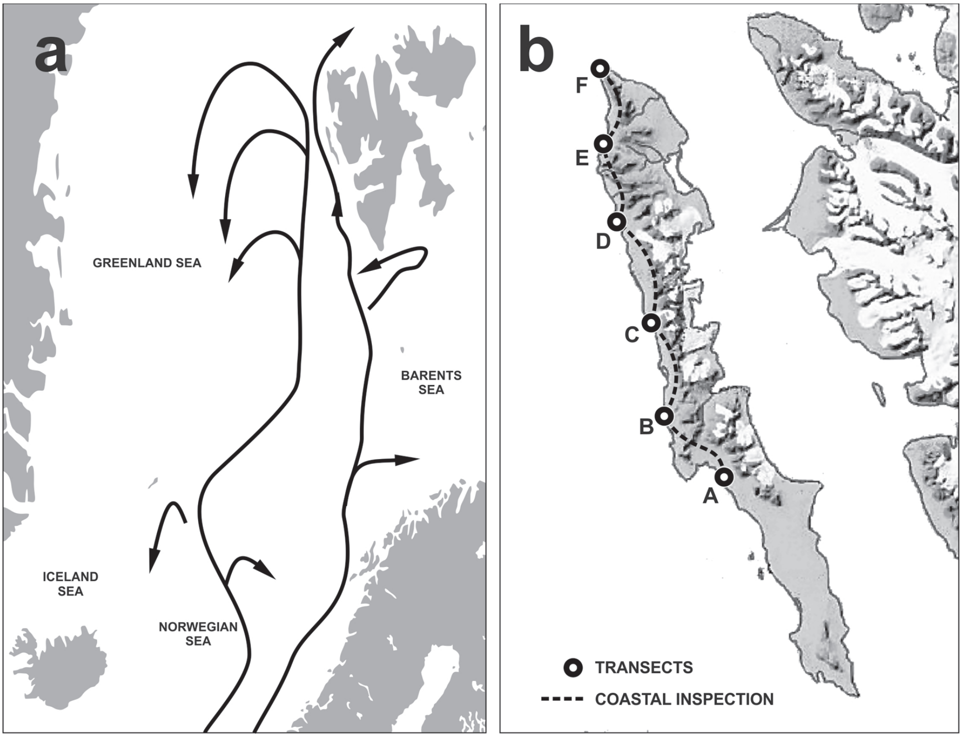

Fig. 1. Map of Svalbard archipelago; (a) main sea currents system and (b) location of sampling points on Prins Karl Forlandet.

Table 1

Location of the sampling stations.

Transect	Location	Date	Geographical position	
			Latitude	Longitude
A	Ravlodden	04 Aug 2017	78.26.024	11.21.921
B	Ossianbekken	05 Aug 2017	78.30.857	10.59.622
C	Skjernes	06 Aug 2017	78.36.941	10.51.570
D	Skurvodden	07 Aug 2017	78.43.906	10.37.241
E	Hornflya	08 Aug 2017	78.49.186	10.32.087
F	Fuglehuken	09 Aug 2017	78.53.687	10.27.854

In some cases where this seemed necessary, plastic objects (*e.g*. nets fragments) were collected for further analysis. The scale and number of observations was not sufficient to carry out any statistical analyses, so the present data are only pilot studies from an almost untouched region (Prins Karl Forlandet National Park, entrance by permit only). Still the comparison with other litter beach counts is possible. The presentation of the beach litter in the literature is expressed in different scales: from km of coastline, km^2 of the coast, to hectares and finally the number of items or weight per m^2. Typically, estimates are based on a limited number of short (a hundred meters) sections of coast that were inspected (see review in: Barnes and Milner 2005; Bergman *et al*. 2017).

Results and discussion

Litter quantities and composition. — Based on observations made on the surveyed transects, the amount of plastic litter ranged from 30 to 100 items per km of coastline with a width of 100 m, wide coastline with a mean of 60 items (Table 2). This gives an estimated total density of 14400 objects with a total weight of 18 tonnes of macro-plastic per 100 km of shoreline (approximately 1.8 g/m^2). As the six transects on which plastics were counted were deemed to be not necessarily representative for the whole inspected coastline, the number of observed large plastic objects along the daily route (about 12 km) was additionally recorded. There was an obvious difference between the mean number of items counted on transects and visual observation along the route. The estimated mean number of objects from visual continuous counting was usually larger; sometimes two or even three times higher (Table 2). The most common macro-plastic items were household articles such as PET bottles, light containers, plastic bags and textiles, which were often found high up on the shore, followed by fragments of fishing gear (buoys, ropes and fragments of nets; Table 2). Six large fragments of fishing trawls (almost whole sacs) were found high on the shore, filled with gravel and algal debris, constituted the largest mass (Table 2). The aggregation of plastics was usually associated with the driftwood accumulation – probably because it has similar buoyancy. Buhl-Mortensen and Buhl-Mortensen (2017) have recently reported that debris along the Norwegian coast and the southern Barents Sea associated with fishing as the predominant type. Citizens' scientific event organized for the collection of beached plastic from NW Spitsbergen (close to the present study area) showed 4.8 g/m^2 of non-fishery related items and 96 g/m^2 of fishing gear remains (Bergmann *et al*. 2017). Such a high value may result from the selective selection of the observed coastline. In our case, choosing a transect in which the fishing trawl (300 kg) has been stranded, would give a value of 30 g/m^2 (Table 2).

Table 2

Estimation of macro-plastic density and weight on the Prins Karl Forlandet west coast in August 2017.

	Number of plastic items						Mean number per transect 100×100 m (1 ha)	Single item weight [kg]	Estimated			
	TRANSECT								mean number of items per 100 km		macro-plastic weight	
	A	B	C	D	E	F			of transect coun-ting	of con-tinuous coun-ting	of transect coun-ting	of con-tinuous coun-ting
Fishing equipment remains									2166	4500	4165	10800
Plastic buoys	0	1	0	4	1	2	1.3	2.5	1333	3000	3332	7500
Nylon ropes and net fragments	2	1	0	1	0	1	0.8	1	833	1500	833	1500
Nets large fragments (trawls)								300		6		1800
Industrial plastic									1334	2400	5341	6615
Packing stripes	1	0	0	2	0	1	0.7	0.01	667	1500	7	15
Thick foil sheets	0	0	0	0	1	0	0.2	2	167	300	334	600
Large plastic boxes and containers	0	1	0	0	1	1	0.5	10	500	600	5000	6000
Household plastic									2500	7500	232	480
Small containers for liquids	3	0	1	2	0	1	1.2	0.01	1167	5000	12	50
PET bottles	1	0	1	0	0	0	0.3	0.06	333	500	20	30
Shoes	0	1	0	1	0	1	0.5	0.3	500	1000	150	300
Other (textiles, small items)	1	0	1	0	0	1	0.5	0.1	500	1000	50	100

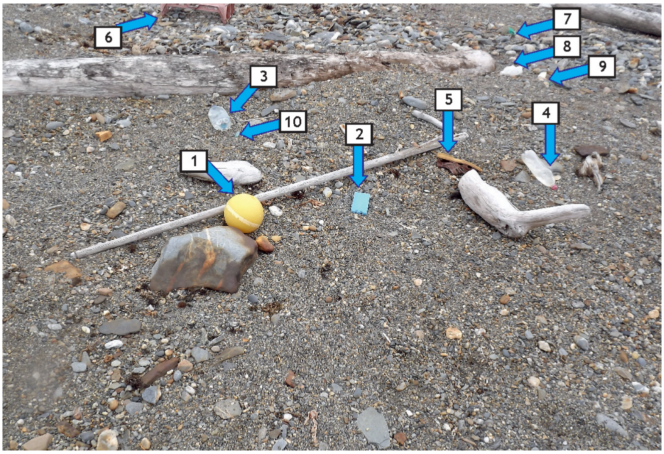

Fig. 2. Not arranged photo of beach between transect B and C, showing a plastic buoy (1), freezer package (2), two PET bottles (3, 4), sandal (5), plastic basket (6), nylon rope (7), two pieces of styrofoam (8, 9), plastic lighter (10) – visible area about 25 m^2.

Colonisation of litter objects. — Eight of the largest plastic items – fishing boxes, barrels, liquid containers – were encrusted by barnacles, bryozoans, molluscs, brown and red algae (Table 3). Observed encrusted taxa include both widely dispersed species found previously in the coastal waters of Svalbard (*Electra* spp, *Eucratea loricata*, *Semibalanus balanoides*) as well as widely distributed species, but never recorded in the Svalbard waters (*Lepas anatifera*). Unfortunately, the species identification of some encrusting biota cannot be determined in the field as the *Mytilus* sp. found here might be *M. edulis*, *M. galloprovincialis* or a hybrid of both species (Wenne personal communication). Taxonomic identification of *Ceramiales*, *Ectocarpales* and *Laminariales* requires laboratory inspection which was not undertaken in this study.

Fishing nets, ropes, buoys, foil, plastic bags were not overgrown, what might be linked with short times of drifting in water, as the intensively fished grounds and settlements are located in proximity of the inspected coast (Isfjorden – Barentsburg and Longyearbyen). On the other hand, a report by Duris and Wesławski (1995) shows an interesting observation of drifting fishing net NW of Bear Island (74°N) containing rafters – both boreal *Mytilus* sp. and the Arctic sympagic amphipod *Gammarus wilkitzkii* Birula, 1897. Barnes and Milner (2005) reported that 5% of the plastic items on Spitsbergen were colonized by encrusting fauna such as barnacles. Besides plastic objects colonized by fauna found in our survey, a large plastic barrel was found at the NW tip of Spitsbergen during a R/V *Helmer Hansen* cruise in 2013. It was encrusted by numerous individuals of *Mytilus* sp. and *Lepas* sp. (personal observation). The reappearance of *Mytilus* sp. on Svalbard after over 1000 years of absence was discovered by Berge *et al*. (2005) and presented as the effect of an increased warm water inflow,

Fig. 3. Fishing box with overgrowth (*Mytilus* sp., *Lepas anatifera*, *Eucratea loricata*, Gastropoda eggs, *Semibalanus balanoides* and Ectocarpales), beach between E and F transects.

Table 3

Presence of encrusting taxa on large plastic objects.

Transect	A	B	C	D	E	F
No of items	1	1	1	1	1	3
Electra spp. Bryozoa	x			x	x	x
Eucratea loricata (Linnaeus, 1758) Bryozoa						x
Ceramiales		x			x	x
Lepas (*Anatifa*) *anatifera* (Linnaeus, 1758) Cirripedia			x	x		x
Semibalanus balanoides (Linnaeus, 1767) Cirripedia	x		x	x	x	x
Ectocarpales	x					x
Gastropoda eggs						x
Laminariales	x	x	x		x	x
Mytilus sp. Mollusca			x	x	x	x

which allowed efficient drifting of larvae from the Norwegian mainland. Such a transport of larvae between Norway and Svalbard was considered unlikely (short-term survival of larvae and long, indirect flow of water) by Milejkovski (1968). This opinion has been supported by model simulations showing that most benthic larvae are retained in Norwegian coastal waters (Silberberger *et* *al*. 2016). Adult organisms rafting on plastic debris are more likely to survive long-distance travel (*e.g*. from the UK to Svalbard) and are regarded as a new phenomenon on an oceanic scale (Winston *et al*. 1997; Barnes *et al*. 2009). Model estimates by Van Sebille *et al*. (2016) suggest that the transportation of floating debris from the UK waters to the Arctic region takes 2 years.

Natural floats such as wood or algae may of course transport organisms as well (Thiel and Gutow 2005). In the case of Spitsbergen, common driftwood comes mainly from the Siberian coast, after passing through the Arctic. It is therefore unlikely to carry encrusting biota. Other common natural rafts are the communities of *Ascophyllum nodosum* from northern Europe, commonly observed on the West Spitsbergen coast (personal observation), yet no associated fauna was found.

The amount of plastic litter on the examined coastline is assessed in a very crude way. However, it still provides a scale of the phenomenon and allows comparison with previously published reports (Merell 1980; Convey *et al*. 2002; Barnes *et al*. 2009; Browne *et al*. 2010; Strand *et al*. 2015; Bergmann *et al*. 2017) in which 0.1 to 1 plastic items per ha were recorded. Our estimates range from 3 to 10 items per ha, what might be the effect of extreme exposure of the examined coast to the North Atlantic Current, as during our previous coastal transect-type surveys in more sheltered, inland waters of Svalbard we have not recorded such quantities of plastic litter (see web page of the Svalbard Intertidal Project http://water.iopan.gda.pl/projects/SIP/index.html and Węsławski *et al*. 1993).

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