REPORT

Svalbard Beach Litter Deep Dive

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Svalbard Beach Litter Deep Dive

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Sammendrag / Summary

«Beach litter deep dive» is a new method developed by SALT in cooperation with a broad range of experts. The method aims at providing knowledge on the sources of marine litter and the reasons behind littering, including whether litter originates from local-, regional- or global activities. It has proven a promising tool to cost-effectively provide knowledge that can be used to implement measures that can prevent waste from entering our oceans. This report summarises findings from a deep dive into beach litter collected through Clean-up Svalbard. The aim of the project was both to refine the methodology and to identify items that should be given particular attention in future monitoring of beach litter in the region. The analysis shows that the fishing activity in the region, rather than long-range transport, is likely the most significant source of beach litter in the region. Analysis of nets identified that the large majority of these were of a type used by the Norwegian and Russian trawl fleet in the Barents Sea, and that these were sections of nets cut out to repair the trawl. Ropes, including rope cut-offs, could also largely be traced back to fishing activities. Further analyses are needed to identify the likely sources of other items, such as food- and cleaning containers, sanitary products and oil- and chemical containers, but preliminary analysis suggests that there is a link between the nationality of these containers and the nationality of vessels operating in the area.

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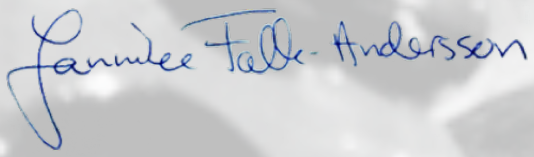
PREFACE

This work to identify the sources of- and reasons behind marine litter found on the shores of Svalbard has brought together a number of stakeholders in collection of data, analysis and discussions on preventive measures. On behalf of SALT, Wageningen Economic Research, UiT The Arctic University of Norway, the Norwegian Polar Institute and Leemans Maritime Consultancy. I am grateful for the funding from the Svalbard Environmental Protection Fund, for the opportunity to develop the beach litter deep dive methodology further and provide new knowledge on the sources of marine litter at Svalbard. I would also like to acknowledge the co-funding from the MARP project (project number 257584/E10, POLARPROG), Wageningen Research, the Dutch Ministry of Foreign Affairs and the Dolfinarium (see attachment 6 for details). This reports also includes results from net analysis carried out as part of the 2017 Arctic Marine Litter project coordinated by Wageningen Economic Research.

A special thanks is also extended to volunteers contributing to the Clean-up Svalbard project and all the stakeholders and experts contributing to the project. In addition to the project team, these were: Ben Wensink, Ymuiden Stores/ Wireco, Sarah Auffret, Association of Arctic Expedition Cruise Operators, Silje Hagen, Aktiv i Friluft, Dagfinn Lilleng, the Norwegian Directorate of Fisheries, Marloes Schravesande, University of Utrecht, Margrethe Keyser, Prosjekt Isfjorden, and Elisabeth Thomas, Plymouth Marine Laboratory.

We would like to dedicate this report to Sarah Auffret whose knowledge about and passion for the issue of plastic pollution in the Arctic and reducing the use of single-use plastic products on Arctic expedition cruise vessels will be deeply missed. We believe this report will contribute to achieving her goals of a cleaner Arctic and more responsible human behaviour in the region.

Tromsø, 30.03.19



Jannike Falk-Andersson

Project leader, SALT

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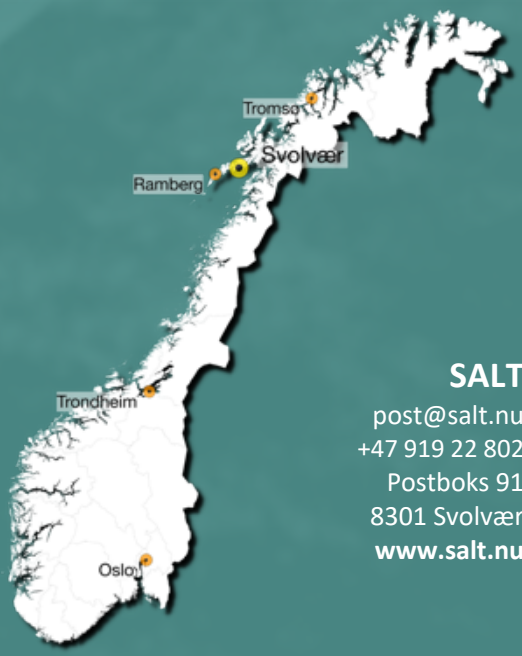

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Summary and recommendations

Beach litter deep dive is a method for registering and analysing marine litter to give more management relevant knowledge on the sources of and reasons behind littering. This report summarizes the knowledge gained from implementing a deep dive on beach litter collected at Svalbard as well as an extensive net protocol where experts in fishing gear helped identifying the type of nets found, their likely origin and why they ended up at sea.

The analysis shows that Barents Sea fishing vessels are likely the most important source of marine litter in the region. Furthermore, the net analysis documented a practice of discarding sections of nets that have been cut out as part of repairing the trawl. The nets were of a type used by Norwegian and Russian trawlers in the Barents Sea. There also seems to be a dominance of household litter from Norway and Russia, although a small sample size made the conclusions less robust.

Further studies are needed, particularly on household items and oil- and chemical containers, in order to determine the degree to which discarding of litter is taking place from different nationality vessels operating in the area. This would also provide new knowledge on the significance of long-range transport of litter into the region.

Key terminology

Marine litter: *«any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores»* (UNEP 2005).

Marine debris: has been used as a synonym to marine litter but could also include detached natural fragments as well as pieces of litter.

Marine plastic debris/marine plastic litter/marine plastic pollution/marine plastics: refers to the plastic fraction of marine litter.

Waste: *«any substance or object which the holder discards or intends or is required to discard»* (EU 2008).

There are many definitions describing the size fractions of plastic. **Generally, particles < 5 mm are defined as microplastics and macroplastics are > 5 mm**. The definitions used in this report are generally as follows:

- **Nanoplastic**: < 100 µm (Koelmans, Besseling, and Shim 2015)
- **Small microplastics**: 0.33-1.00 mm (Eriksen et al. 2014)
- **Large microplastics**: 1.01-4.75 mm (Eriksen et al. 2014)
- **Mesoplastic**: 4.76-200 mm (Eriksen et al. 2014)
- **Macroplastic**: > 200 mm (Eriksen et al. 2014)

1 BACKGROUND AND AIM OF THE STUDY

1.1 Introduction

Marine plastic pollution is an ever-growing problem of global proportions due to increasing plastic production, improper waste management and extreme durability (UNEP 2011). All around the world, people are starting to realise the enormity of the impact and the challenge ahead to deal with this. In one of Europe's most uninhabited and unspoilt regions, Svalbard, marine litter is also building up in large quantities. Although uninhabited and laying at the outer edge of Europe, the region is not isolated. High levels of plastics have been found in the Svalbard and Barents Sea area at the sea floor (M. Bergmann Klages, M. 2012), in the water column (Lusher et al. 2015), in ice cores from the Arctic basin (Obbard et al. 2014), in Fulmar stomachs (Trevail et al. 2015) and along the shores (MOSJ 2015; M. Bergmann et al. 2017). A conservative estimate suggests that there are around 101 million litter items on the Barents Sea seafloor south of Svalbard, corresponding to 79 million tons (Buhl-Mortensen and Buhl-Mortensen 2017). As it takes hundreds or even thousands of years for this (mostly plastic) waste to degrade, the amount of plastic in the region is accumulating rapidly.

The presence of plastics in the Arctic could pose a serious threat to wildlife and local communities. Animals of all sizes, from zooplankton to polar bears, could ingest plastics and associated chemicals. The effect of this could be damages of respiratory and digestive systems, causing suffering, reduced survival and potentially death. Animals may also get entangled in the litter, such as in trawl nets and ropes, which may also lead to suffering and death. Litter also pose a safety risk to shipping in the area due, for example, to the risk of propeller entanglement (UNEP 2005, 2011). Finally, the presence of plastics on beaches also negatively affects recreational experiences (Wyles et al. 2015), which has a direct impact on both locals and visitors, including the tourist industry in this area (Hallanger and Gabrielsen 2018). Reducing the amount of litter in the region, is therefore vital to secure the health of the ecosystems and the well-being of humans.

Prevention is the most cost-effective measure against marine litter, and an important first step in this process is to identify the actors that need to be targeted to reduce littering. A key to identifying actors contributing to marine litter at Svalbard, is to get a better understanding of the why so much litter ends up in this relatively remote location. Through ocean currents, the region is potentially influenced by pollution coming from other parts of the world (Van Sebille, England, and Froyland 2012). A by-product of this connection could be that large amounts of plastic litter arrive in the region every day (Hallanger and Gabrielsen 2018). However, there are also activities in the vicinity of the Islands that could represent a more regional source of litter. Large fisheries take place in the Barents Sea, many of these close to the Svalbard islands, others further south where ocean currents could transport litter northwards. There are also large shipping activities, as well as tourism, research and recreational activities taking place in the region. Previous beach litter registrations suggest that fisheries is the dominating source of the litter at Svalbard beaches (MOSJ 2015; M. Bergmann et al. 2017; Nashoug 2017). Involvement of fisheries experts is therefore important in order to understand the sources of litter at Svalbard.

Beach litter analysis recording the number of items found of key litter categories has been established as a key indicator of the sources of marine litter (Nelms et al. 2016). Current beach litter protocols, however, have some limitations with respect to collecting information that can be used to understand the sources of litter and identify appropriate management measures. An example is the category "nets", that does not differentiate between the types of fishing nets found, nor whether these are lost or discarded. A qualitative beach litter analysis with fisheries experts at Svalbard found that many of the nets were from cod and shrimp trawls and that some of these had clean cuts,

indicating they were discarded (Nashoug 2017). Nationality of containers can also say something about the origin of the litter. Beach litter deep dives in Northern Norway, suggest a link between the nationality of food containers and the nationality of vessels operating along the coast (Falk-Andersson, Olaussen, and Macintyre 2018). Additionally, the analysis also records the relative contribution of different sources in weight, thereby identifying which sources to target to reduce the quantity of litter (Falk-Andersson, Olaussen, and Macintyre 2018). Finally, involving stakeholders through beach litter deep dive workshops, also increases their awareness and thereby the likelihood of them taking ownership of the problems and solutions to prevent marine littering (Falk-Andersson 2018).

The beach litter deep dive concept (Falk-Andersson, Olaussen, and Macintyre 2018) was developed as a supplement to existing beach litter protocols, providing additional knowledge that is useful for identifying and implementing preventive measures. The method has proven a promising and cost-effective supplementary tool to regular beach litter analysis to provide knowledge and awareness needed to combat littering. While a qualitative analysis on beach litter at Svalbard has been conducted (Nashoug 2017) and beach litter protocols have been implemented (MOSJ 2015; M. Bergmann et al. 2017), there have been no previous studies doing a detailed analysis of the litter with the aim of identifying management measures that would give a reduction in marine litter in the region.

To get a better understanding of the sources, the potential for reducing the amount of litter ending up in the region and which stakeholders should be approached to achieve this, a beach litter deep dive study was conducted on litter collected along the shores of Svalbard by volunteers in the summer of 2018. The aim of the study was to refine the methodology of "beach litter deep dives" and identify items that should be given particular attention in future monitoring. This will give better insight into the reasons why items have ended up in the sea and what can be done to prevent this.

2 KNOWLEDGE STATUS OF THE SOURCES OF MARINE LITTER AT SVALBARD

A global analysis of the sources of marine litter, shows that fisheries and shipping are believed to be the main sources of plastic input into the ocean in the Svalbard region (Figure 1). This is because the number of people living in the region is low, while there are large fishing and shipping activities. This has been confirmed by beach litter analysis in the region (MOSJ 2015; M. Bergmann et al. 2017; Nashoug 2017). Norway and Russia are the largest fisheries nations in the region, and these are also the two countries that are bordering the waters around Svalbard and have the largest presence on the Svalbard Island. Norway and Russia produce similar amounts of plastic waste, despite the large difference in size and population of the two nations (Figure 2). Norway, however, has a lower rate of mismanagement of waste compared to Russia (Figure 3).

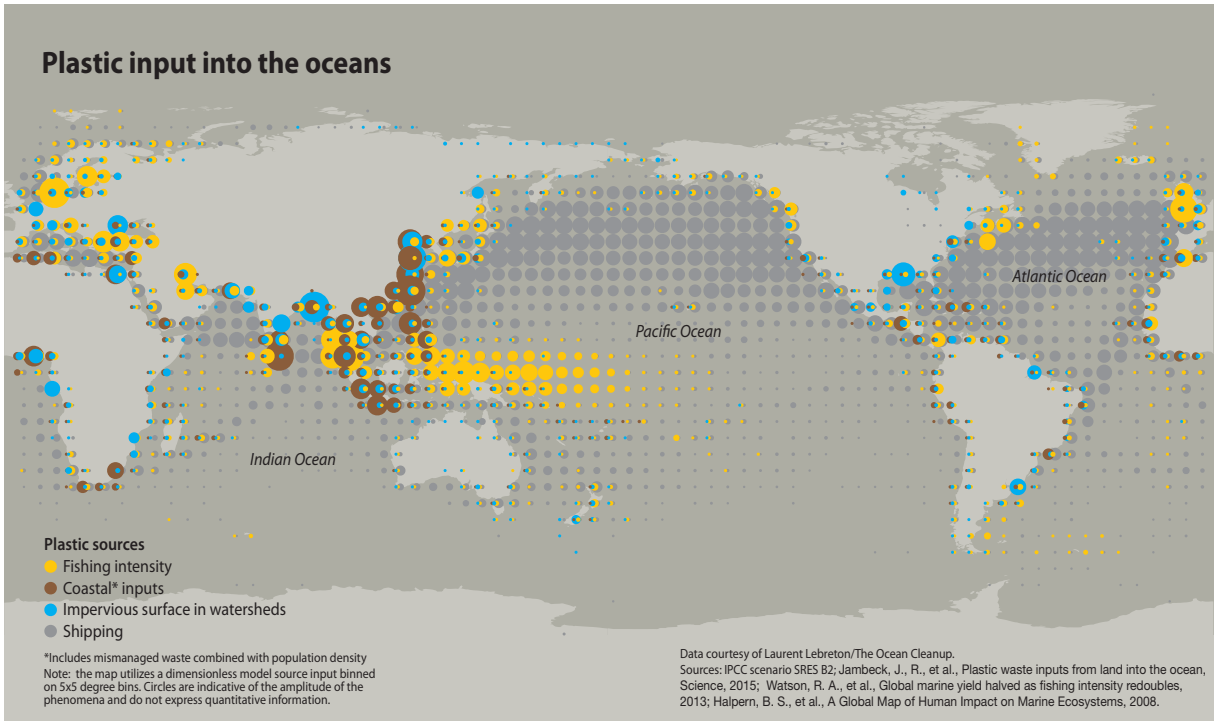

Figure 1 Plastic input into the oceans by different type of sources (Illustration: UNEP and GRID-Arendal (2016)).

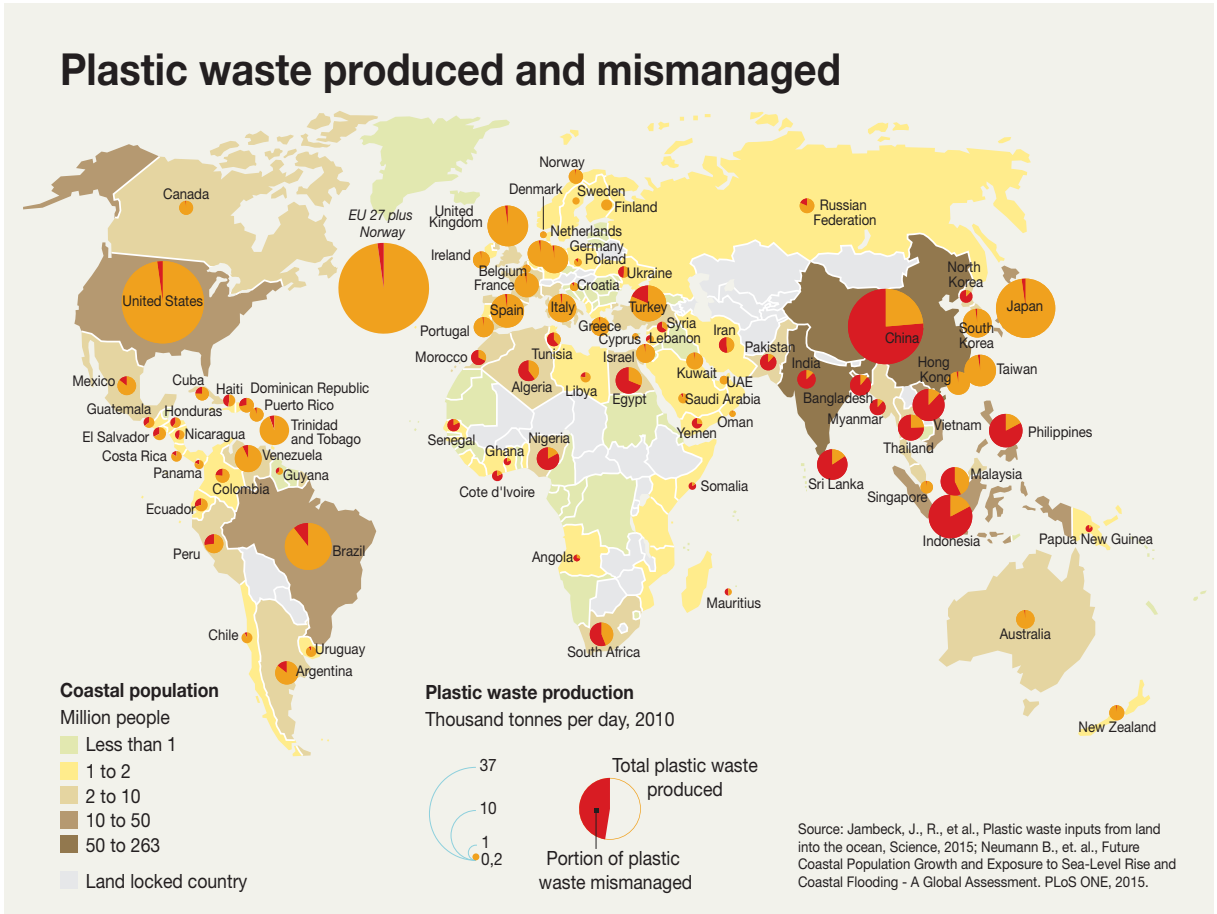

Figure 2 Regional variations in total amount of plastic waste produced compared to the proportion of plastic waste mismanaged (Illustration: UNEP and GRID-Arendal (2016)).

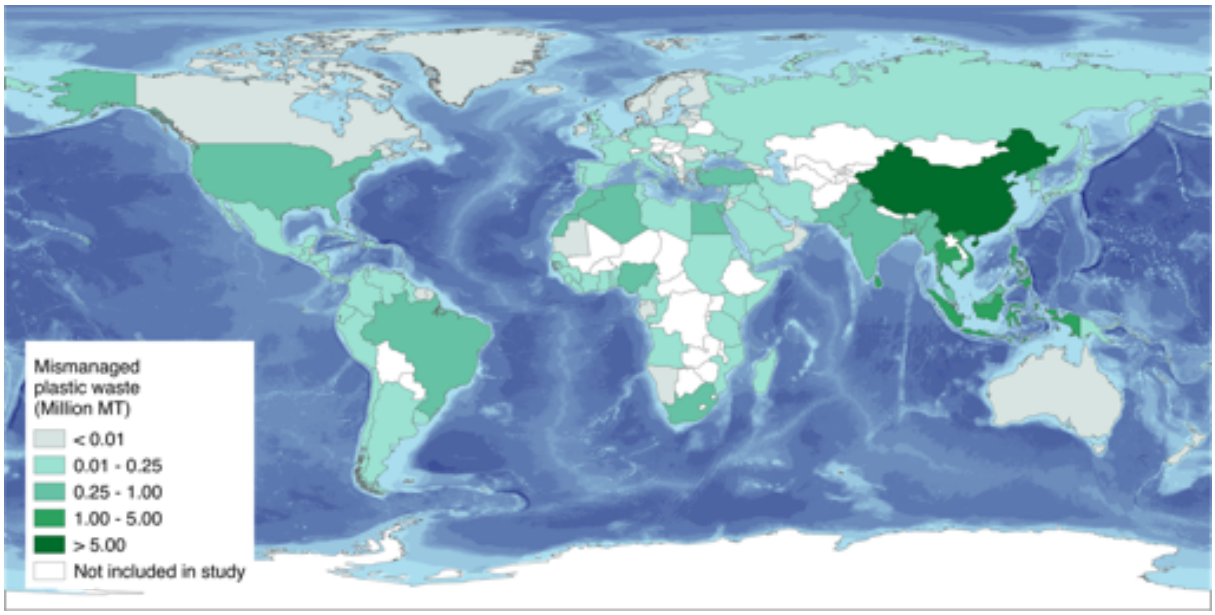

Figure 3 A global map illustrating the estimated mass of mismanaged plastic waste (millions of tons) generated in 2010 by populations living within 50km of the coast (Adapted from Jambeck et al (2015)).

2.1 Studies of beach litter at Svalbard

While the number of studies on micro-litter has increased significantly the past 10 years, there are few scientifically published studies on macro litter. Reports have been given out based on analysis of beach litter, the majority of these being based on citizen science data collection, indicating the main sources of litter in different parts of the world. Ocean Conservancy is an example of a global NGO that encourage registration of beach litter and produces annual reports based on such data[1]. There are no citizen science data collected at Svalbard using protocols based on Ocean Conservancy, but OSPAR registrations have been taken place since 2011 (Falk-Andersson, Berkhout, and Abate 2019). This section summarises the main findings from analysis of beach litter at Svalbard.

2.1.1 OSPAR Beach litter monitoring data

The OSPAR protocol (OSPAR 2010) has been applied at Været, Brucebukta and Luftskipodden at Svalbard. The number of items in different source categories is recorded for a 100m stretch of beach. Data collected in the period 2011-2016, was sorted according to source categories described in Falk-Andersson et al. (2019) to illustrate the identifiable sources of litter[2] at Svalbard (Figure 4). The figure shows that pieces of rope made up the largest fraction of the litter, followed by litter “on the fly”. The latter includes plastic bags, food containers and smoking wares and is classified as litter related to outdoor activities, although such activities are expected to be of minor importance at Svalbard. The next largest source is fisheries, followed by litter of domestic origin, such as cleaning agents, sanitary items and wearables, and nets. Industry related items make up the smallest portion of the number of identifiable items (Figure 4). The OSPAR data does not provide any information on the weight of the source fractions. The report provided by the Governor of Svalbard, however, notes that the majority of the litter consists of plastic originating from fishing vessels (MOSJ 2015). This indicates that the number of items is not representative of the mass of the litter in terms of

[1] https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/

[2] The unidentifiable pieces of litter made up 49 % of the number of litter items found.

identifying the main sources of litter. Furthermore, they point to fishing vessels in the Norwegian and the Barents Sea as the likely sources of the bulk of the litter at Svalbard, but also recognise that some of the litter may originate from cruise ships and other vessels. Apart from that, they find it difficult to specify the sources further (MOSJ 2015).

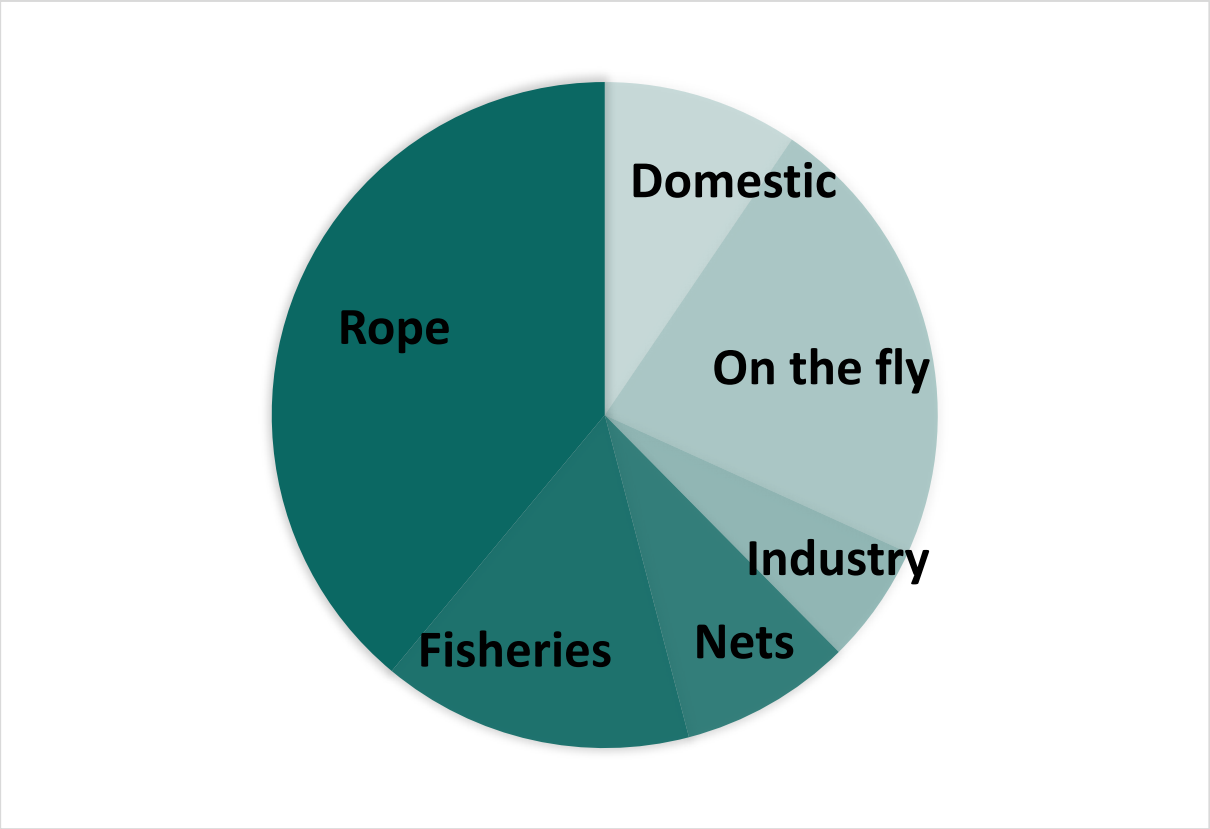

Figure 4 Identifiable sources of litter at Svalbard according to 2011-2016 OSPAR beach litter registrations of number of litter items.

According to MOSJ (2015), no obvious tendency can be read out of the statistics based on the limited number of beaches monitored today. Thus, based on the current monitoring data it is not possible to say if the quantity of litter in the area is changing.

2.1.2 The Arctic Marine Litter Project beach litter analysis

The Arctic Marine Litter project[3] was initiated in order to provide management relevant knowledge on the origin, sources, causes and solutions for marine litter in the North Atlantic Arctic. As a part of the project, monitoring of litter took place on 14 beaches at Svalbard[4] applying the OSPAR (2010) protocol for the 100 m stretch of beach analysis. Many of the locations analysed had likely been cleaned by cruise passengers prior to the analysis of the Arctic Marine Litter Project. Thus, the analysis may not be representative of the type of litter items that most often end up on the beaches of Svalbard.

Excluding wood items[5], in total, approximately 4.820 litter items were collected and analysed. The breakdown of the number of items for each major category is shown in Table 1. (Wouter Jan Strietman, Wageningen Economic Research, pers. com.).

Table 1 Top 10 items in numbers from 14 Svalbard Beaches.

#	Top 10 (based on the number of items)	Share	Share without unidentifiable pieces of plastic
1	Unidentifiable pieces of plastic	63%	
2	Nets and pieces of nets	7%	19%
3	Caps/lids	5%	14%
4	Strapping band	5%	14%
5	String and ropes	3%	8%
6	Industrial packaging/sheeting	3%	8%
7	Floats/buoys	2%	5%
8	Plastic bottles and containers	2%	5%
9	Plastic bags	2%	5%
10	Cotton bud sticks	1%	3%
	Other items	7%	19%

As is shown in the table above, more than half of all litter items analysed were unidentifiable. These were usually smaller than 10 cm in length. The number of unidentifiable pieces of plastic may have been inflated as the litter sometimes broke into smaller pieces when picked up and transported to

[3] The project was initiated in 2017 by Wageningen Economic Research and Leemans Maritime Consultancy.

[4] Poolepynten, Sarstangen, Bay de la Recherche (5 locations), Hornsund, Worsleyhamn, Kapp Lee Stasjonen, Hiorthamn, Anservika, Gipshuksletta, Phantomodden.

[5] Wood items may be of cultural heritage and cannot be collected

the vessel where it was analysed (Figure 5). The dominating identifiable items were nets/ pieces of

Figure 5 Unidentifiable pieces of plastic, broken apart at the beach. (Photo: WJ Strietman).

nets, caps/lids, strapping bands, string/ ropes and industrial packaging/ sheeting. Many of these items can be related to the fisheries (Wouter Jan Strietman, Wageningen Economic Research, pers. com.).

2.1.3 Citizen science study involving cruise tourists

Expedition staff and cruise tourists onboard the vessels of two tourist cruse operators were involved in a citizen science study where they applied a simple protocol for categorising and quantifying beach litter in the north-western part of the Svalbard Archipelago. Transects between 90-120 m length at six beaches were surveyed in 2016 and assigned to six categories (see Table 2). There were large differences in the quantity of litter sampled at the different beaches, ranging from 9 to 534 g m^{-2}. At the most polluted beach, there were 525 g litter m^{-2} that was almost exclusively fisheries related plastics, including a heavy net (M. Bergmann et al. 2017). Fisheries related plastic, including ropes, buoys, floaters and nets, accounted for 44-100% of the total mass of litter found. Non-fisheries items were mainly packaging material, bottles, cups, daily use articles (e.g. tooth brushes and lighters) and toys (M. Bergmann et al. 2017). The study did not record the number of items.

Table 2 Results from beach surveys. Litter quantities given in g m-2. P: pebble, S: sand, M: mud, G: gravel, +: present. Table from Bergmann et al (2017).

	Brucebukta	Reinstrandodden	Sørvika	Isflakbukta	Crozierpynten	Alpiniøya	Total	Mean	± SEM
Date	31/05/16	08/06/16	20/06/16	28/07/16	18/08/16	22/08/16			
Longitude (°N)	78.449936	79.73336	79.95949	80.69094	79.91858	80.35131			
Latitude (°E)	11.71226	13.85031	18.64714	20.91088	16.83768	24.75289			
Distance to water (m)	20	0.2	0.5	0.5	0.5–2	5.7–7			
Sediment characteristics	P, S	P, S	P, S, M	P	P, S	S, G			
Survey length × width (m)	90 × 20	120 × 14	n.a.	90 × 20	90 × 20.5	100 × 52			
Area sampled (m^2)	1800	1680	2048*	1800	1845	2559	11,732	1955	130
Plastics	6.78	0.91	6.23	6.53	3.94	4.38	28.77	4.80	0.91
Plastics (fisheries)	11.11	522.77	13.13	6.08	4.89	21.65	579.63	96.61	85.27
Clothing	1.11		0.61	0.32	0.21		2.26	0.38	0.17
Metal	0.06			0.26			0.32	0.05	0.04
Glass	2.67			0.52		0.31	3.49	0.58	0.43
Biotic						0.002	0.002	0.00	0.00
Total	21.72	523.67	19.98	13.71	9.04	26.35	614.48	102.41	84.29

3 SVALBARD BEACH LITTER DEEP DIVE

Litter from volunteers cleaning beach litter at Svalbard is delivered in Clean-up Svalbard containers. These are divided into three compartments: metal, ropes and nets, and burnable (the latter will be referred to as "rest"). The Deep Dive analysis took place at the waste management facility at Longyearbyen that were very helpful in facilitating the work. One container of ropes and nets were analysed, with a focus on the nets, as well as two containers of "rest".

The first day of the workshop one container of "rest", mostly plastic litter collected by the coast guard at Franzøya in Hinlopen was analysed using the deep dive protocol (See Attachment 1 and 2 for instructions and protocol). About 4.2 km of beach was cleaned, and it was assumed that $4m^3$ litter was collected in 5 hours. The cleaners noted that the majority of the litter that was found is assumed to come from the fishing fleet as the findings included trawls, ropes, floats from trawls and fish boxes (for maps and pictures, see Attachment 3). The rope fraction in this sample which is reported in the result section is likely to be underrepresented in the deep dive analysis. This would in particular be true for the larger ropes, in addition to nets and metal items. This is because the majority of these items would have been separated from the "rest" compartment of the Clean-up Svalbard container.

The second day of the workshop another container from clean-up Svalbard was analysed. This container turned out to consist mostly of nets and ropes. Experts that had been involved in Clean-up Svalbard said that litter in this container likely was the from the "ropes and nets" compartment, and the few other items were likely due to someone sorting the litter wrong when emptying beach litter in the Clean-up Svalbard container. Since this analysis did not provide new data, the results from Day 2 analysis of the "rest" compartment is not reported on. There were no other containers that could be used for analysis as the litter had been shipped to the mainland for disposal.

3.1 Methodology

3.1.1 Development of the Svalbard Deep Dive Protocol

The deep dive protocol was developed during the summer of 2018 in a deep dive project analysing beach litter in Northern Norway. A detailed description of the development of the protocol can be found in Falk-Andersson et al (2018). A short summary is given here in English.

The analysis can be done on different types of litter and for different environments, for example cities (Fråne et al. 2012), but beach litter has been the focus of these analysis and the protocol is therefore most suitable for this type of litter. The OSPAR (2010), Keep Norway Beautiful and Lofoten Waste management protocols (See Falk-Andersson et al (2019) for a description of the protocols) were used as a basis for the deep dive protocol. Input from experts, either industry representatives or experienced beach cleaners, beach litter analysis at Svalbard with fishers and other experts (Nashoug 2017), as well as SALTs own experience from beach litter analysis, was used to determine which categories should be expanded and which ones should be excluded. Items of particular concern, such as batteries and bundles of strapping bands, were included in the protocol. The presence of single use plastic grocery bags was also recorded separately as these are a particular focus item both at the EU level and in Norway (EU 2015; Vestli 2015). Documenting if this item represents a large pollution problem is therefore of importance. Plastic shopping nets were therefore recorded separately from other types of plastic bags.

The nationality of the litter could indicate whether the litter found is of local origin, transported long distances, or if marine activities in the area can explain their sources. For cleaning bottles, food packaging, drinking bottles and sanitary products, the nationality of the items was therefore

recorded where possible. The Norwegian deposit scheme makes the Norwegian drink bottles easily identifiable from foreign bottles. Particular items that have been regularly observed when beach cleaning were also recorded. These were *Zalo* (a Norwegian dishwashing liquid also used to clean the deck of fishing vessels (Hartviksen 2016)), *Idun* tomato sauce and *Idun* mustard, and instant coffee (nestle). All are Norwegian products. There were in some cases not sufficient space to note the number of containers of different nationalities. A separate table with the relevant categories for noting nationality would therefore be an advantage (Falk-Andersson, Olaussen, and Macintyre 2018).

While the Svalbard deep dive protocol differentiates between caps and lids of different types, it has been concluded that compared to the effort put into analysis this doesn't give particularly valuable insight into their origin and why they end up at sea. Additionally, they make up a small fraction of the litter in terms of weight and could therefore be counted as "caps and lids" but go into the "other" category in terms of source. Schravensande, who took part in the deep dive, has studied caps to link it to source, but there is no information available on the results of the study to evaluate if this type of analysis can be used to link caps to likely source.

Fisheries related items that had been identified in Nashoug (2017) and Falk-Andersson et al (2018) as likely discarded, were recorded separately in terms of numbers. This included tubes for plastic foil, parts of conveyor belts and strapping bands (differentiating between single strapping bands and bundles). The types of fish boat items found were also noted. Different colours of plastic sheeting were differentiated between, since for example blue plastic sheeting can be linked specifically to onboard processing of fish (Falk-Andersson, Olaussen, and Macintyre 2018). Transparent plastic is also used for this purpose, but transparent plastic could also have other origins, such as construction work. While the Svalbard beach litter deep dive protocol differentiated between different types of plastic sheeting, the fact that these may have many different uses and origins, the knowledge gained from the differentiation may not be justified. A qualitative note including pictures, could be sufficient to identify if the origin is likely from industry or from household packaging that has degraded. As for any category of litter found in a deep dive, further studies and descriptions can be justified if it makes up a significant part of the litter (Falk-Andersson, Olaussen, and Macintyre 2018).

Apart from likely being of industrial origin, unidentified pieces of plastic did not give any significant information to the deep dive analysis in Northern Norway (Falk-Andersson, Olaussen, and Macintyre 2018). This fraction was therefore not given particular attention during the Svalbard beach litter deep dives and may be underrepresented in the sample.

A deep dive is a supplement to existing beach litter protocols, and the main aim is not to give a representative representation of the litter, but to give supplementary knowledge that is useful for implementing preventive measures. However, it is possible to get representative information if it is applied on litter from known locations where explanatory variables (such as for example size of area cleaned, substrate, prevailing wind directions) have been recorded. The information required regarding the litter used for analysis depend on the aim of the study.

The final deep dive protocol applied can be found in Attachment 1 and 2. The nets were analysed using a more detailed protocol (see section "Development of the net protocol") and were therefore excluded from the analysis of the "rest" fraction. However, it was concluded in Falk-Andersson et al (2018) that differentiation between cut or torn nets gives more information than the OSPAR differentiation between nets under or over 50 cm.

3.1.2 Development of the Net Protocol

A more detailed insight into fishing nets was needed to be able to match the type of net and type of fisheries with the area where such fisheries take place, along with the underlying behaviour and processes that have most likely contributed to the litter having ended up in the sea. Experts on fisheries technology were involved in the evaluation procedure. The main experts for the analysis at

the Svalbard Beach Litter Deep Dive were Roger Larsen, fisheries technologist, and Dagfinn Lilleng at the Norwegian Directorate of Fisheries.

A total of 62 (sections of) fishing net were analysed during the workshop. The protocol (Attachment 4) was developed in collaboration with a former fisherman, Klaas-Jelle Koffeman, when 42 nets from the Clean-up Svalbard containers were analysed in September of 2017. The scientific rigour of the protocol was confirmed by the experts involved in the Svalbard beach litter deep dive workshop.

For the net analysis, the following characteristics are examined: 1) Size of the net, 2) Full nets or sections of nets (and if so, which section) 3) Age of the net, 4) Type of fisheries involved, 5) Probable fishing areas, 6) Accidentally lost or discarded, 7) Other relevant information

The procedure of examination is as follows: first, a piece of net is disentangled and spread out on the floor for further investigation (Figure 6).

Figure 6 Fish net analysis at the Longyearbyen waste management facility (Photos: WJ. Strietman).

After that, the dimensions, mesh size and probable age of the net are registered, and photos taken. The net is then thoroughly checked to determine whether there are any signs of being torn or cut. If the net shows signs of cuts, it is determined whether they have been cut as part of the process of cutting the net into the right shape before use or cut as part of the procedure to replace a piece of broken net. Also, the type of fisheries involved is registered, and the likely reason why it had ended up in the sea (lost or discarded), along with any other additional comments.

The net analysis is carried out with the help of fisheries experts. Measurements can be done by non-fishing experts, but it is recommended that the conclusions as to the likely cause of why these nets have ended up in the sea should be done by fisheries experts and/or (ex-)fishermen with knowledge of net preparation and net repair procedures on board fishing vessels.

3.1.3 Rope analysis

Time did not allow for an analysis quantifying ropes according to type, nor cut-offs vs non cut-offs. An evaluation of the age of the ropes (< or > 5 years) would also have given useful information about current practices. A visual inspection where some of the ropes were laid out on the floor and commented upon by the experts was conducted.

The ropes and nets that were analysed during the workshop, made up in total 1880 kg. They were compressed and transported to the mainland for disposal (Hans Petter Lauritsen, Reno-Vest, pers.com).

3.1.4 Deep litter deep dive workshop

The deep dive analysis was organised as a workshop at the Longyearbyen Waste Management Facility where experts were involved in the analysis on day 1 and 2, and in discussions of preventive measures on day 3 (see workshop program, Attachment 5). The participants were divided into groups and given responsibility of different weight categories. Each group had one leader from the project team. The protocol and instructions were sent out prior to the workshop (Attachment 1 and 2). Instructions were also given prior to starting the analysis. After sorting the different weight categories, the whole team went around to the different tarps and discussed the findings. Notes were taken during the discussions.

4 RESULTS

4.1 Day 1 Deep dive of the "rest" fraction collected at Franzøya

3011 items weighing around 577 kg were analysed on day 1. Figure 7 shows the pile of litter that was analysed. A large number of the non-fisheries items were quite worn, indicating that this was a beach with a lot of old litter. This also made it difficult to identify many of the items to nationality and brand. Data on bags had to be removed due to errors during registrations. Zero-value findings are not reported in the figure (tobacco products, agriculture and nets). The "rest" fraction largely excluded ropes and nets; thus, these categories will be underreported in the data from Franzøya. Larger ropes, that are easy to separate out, are expected to be more or less absent from the sample, while smaller ropes are expected to be underrepresented.

Figure 7 The basis for the deep dive analysis on Day 1

The relative abundance of the main litter categories in the “rest” fraction collected by KV Nordkapp at Franzøya in Hinlopen in terms of numbers and weight is shown in Figure 8. It illustrates that the relative contribution of fisheries related items is over 40% higher in terms of weight compared to number of items. There were relatively few items in the categories food-, sanitary- and cleaner-products, which were the main items where nationality of products could be recorded. Presence of burned plastics indicates a practice of burning litter, but it was not possible to say something about the age of these plastic items and thereby not whether this is an on-going practice.

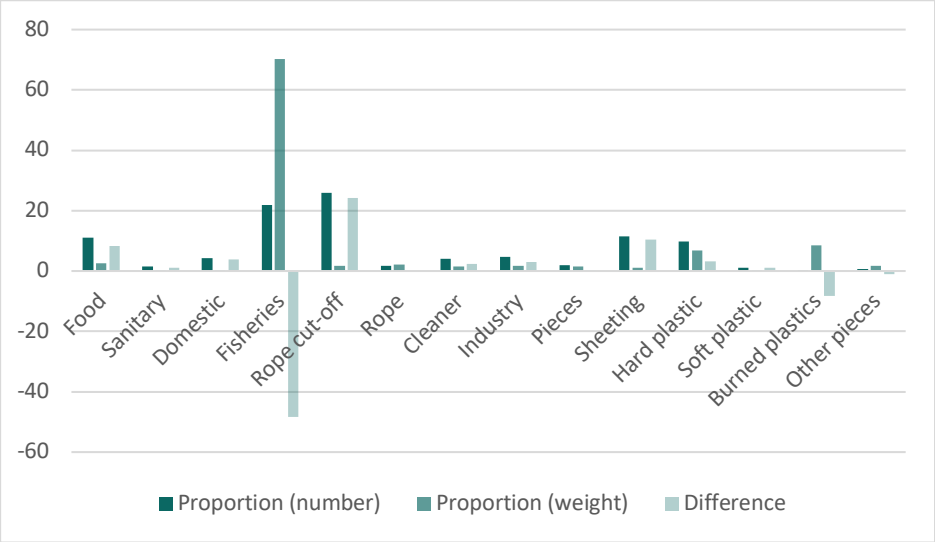

Figure 8 The proportion of different litter categories in terms of number and weight, as well as the difference between these, for the "rest" fraction collected at Franzøya.

Rope-cut-offs dominated in terms of number of items, but in terms of weight the fisheries category made up around 70% of the litter. A large number of small cut-offs, resulted in the “rope cut-offs” making up a large proportion of the litter in terms of numbers, but a small proportion in terms of weight (Figure 8). With respect to the ropes analysed the majority were cut-offs (94%). 783 ropes being identified as cut off in both ends, and 53 pieces of ropes either being too old to identify whether they were cut-offs or having minimum one end not being clear-cut. Smaller cut-offs could to a large extend be traced back to ropes used on shrimp- and cod trawls (Figure 9). When the trawls are repaired, the end of the rope is cut off and may fall onto the deck and/or the trawl. If these are not picked up, they are likely to enter the ocean when the trawl is released into the water again (Roger Larsen, Norwegian College of Fishery Science, UiT, pers.com.).

Figure 9 Examples of rope finings, including rope cut-offs, and expert opinion on the origin of the ropes, as well as a piece of net cut-off and its origin (Photos by WJ Strietman and SALT).

A closer look at fisheries-related items (excluding ropes), shows that the majority of the weight is made up of trawl floats (Figure 10). “Other floats” were mainly made of light material, such as cork, resulting in their relatively low weight Figure 11. The “fisheries” category consisted of part of conveyor belts (4 pieces), tubes for plastic foil (13), 16 fish boat items of various types (fish baskets, crab bait containers and a part of a crab pot) and 266 single pieces of strapping bands were found. These were not weighed separately, but the 7 bundles of strapping bands were weighed separately (Bundle of strapping band illustrated in Figure 11). These bundles of strapping bands made up a relatively high proportion of the weight of the fisheries related litter. Items recorded as “fish boxes” were mainly pieces of fish boxes, but there were some whole fish boxes. The latter were marked with company names (Donegal co-op fishiries Killybegs, Kilhorn Bay Seafoods, Pers box (4), Stømbergs (3), Hanstholm, Alliance Fish, Myregruppen, Royallsland, Norsk, ABSA, F.K. Hirtshals, Caley Fisheries, P.C. Fisk, Prestfjord, Aarsæther, Iceland.)

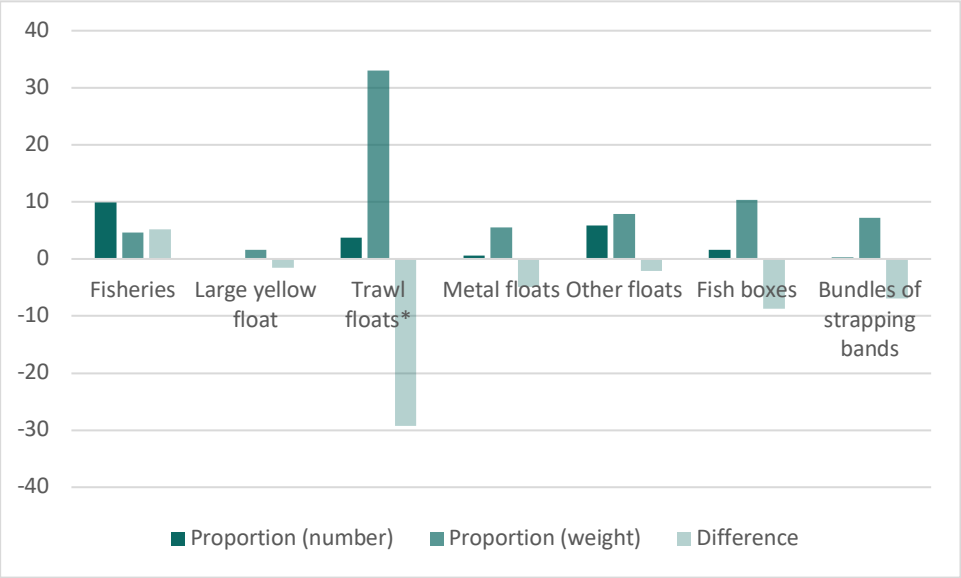

Figure 10 Relative proportion of fisheries related items in numbers and weight, as well as the difference between the two.

Figure 11 "Other floats" to the left and "bundle of strapping band" to the right (Phote: WJ Strietman).

Analysis of cleaning bottles, water bottles and drinking bottles showed that out of those that could be identified as being either foreign or Norwegian, most of them were foreign (Figure 12). However, a significant number of the items were also Norwegian. The latter included 10 Zalo bottles and 5 instant coffee glass bottles and/ or plastic lids, as well as 8 Idun bottles (the latter not included in the

analysis in Figure 12). The majority of the items could not be identified to nationality. The number of items per nationality were not recorded for all categories, just the countries represented. Thus, this data cannot be used to list the dominating nationalities found among the litter. The nationalities of the containers were: Norway, UK, Greenland, Denmark, Spain, Portugal, Germany, Russia, Italy, America, Estonia and China.

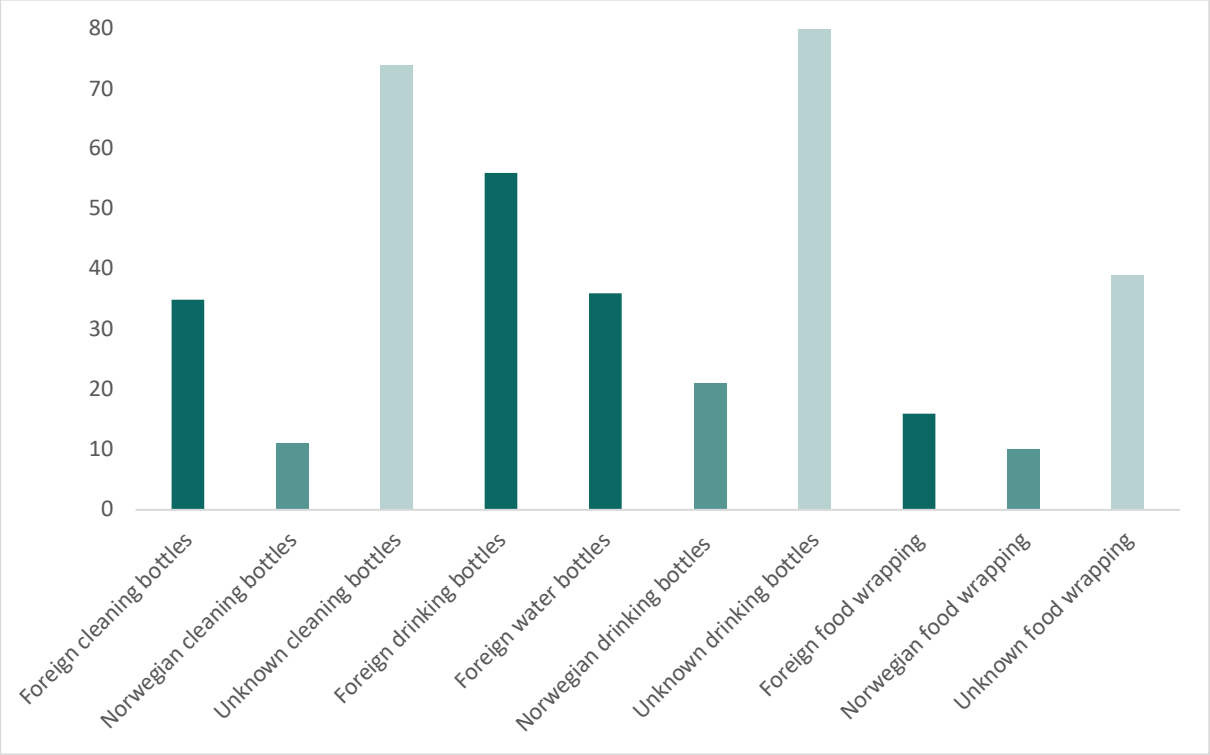

Figure 12 The number of domestic items of foreign, Norwegian and unknown origin

4.2 Analysis of nets

The net analysis showed that all the nets were sections of nets and that the average size of each section of net was 10-20m^2. Most of the sections of nets were square in shape, indicating that they had been cut out around damaged parts of a trawl net to be replaced by a new piece of net. The results of the net analysis show large variations in the number of net sections being younger versus older that 5 years old in the two analysis. Of the 42 nets analysed in 2017, 35 were < 5 years old, while only 13 out of 62 nets were assessed to be < 5 years old in the 2018 analysis (Figure 13). Combining the two analysis, over half the nets analysed were younger than 5 years.

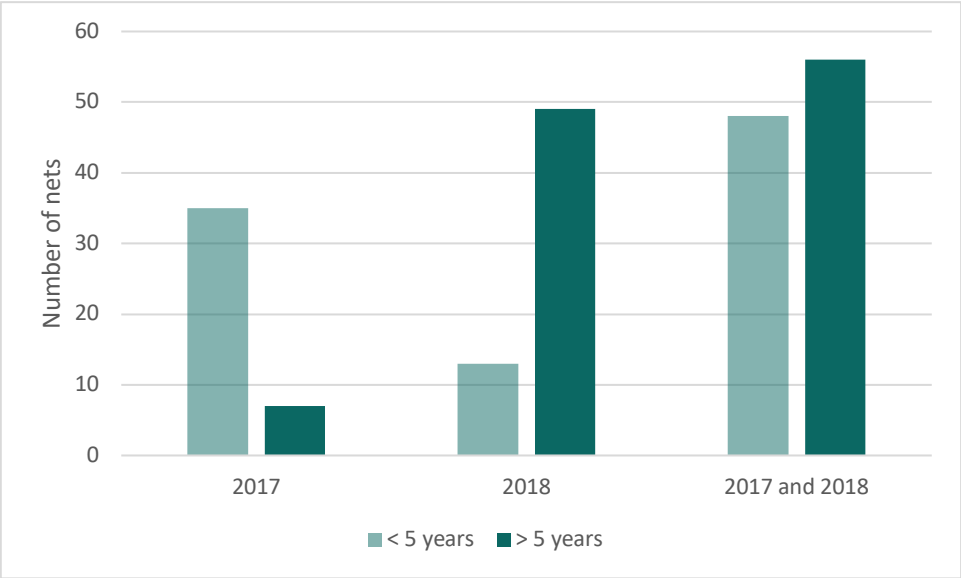

Figure 13 The number of nets being < 5-year-old and > 5 years old in 2017, 2018 and combined 2017 and 2018

The evaluation of whether the nets had been torn and likely lost after being stuck on the seabed (accidental loss) versus been cut out of the net after being damaged and thereby discarded were similar between the two years. 88% and 92% of the sections of nets were judged to be discarded in the 2017 and 2018 analysis respectively (Figure 14). The reasoning behind the "discarded" conclusion is that for each of these cut-out sections of nets, one or more sides were torn, and one or more sides cut. Like explained in the methodology, if the net shows signs of cuts, it is determined whether they have been cut as part of the process of cutting the net into the right shape before use or cut as part of the procedure to replace a piece of broken net. After replacing the damaged sections with new netting material, these damaged sections ended up in the sea. The most likely reason behind this, according to the fisheries experts, being deliberate discarding.

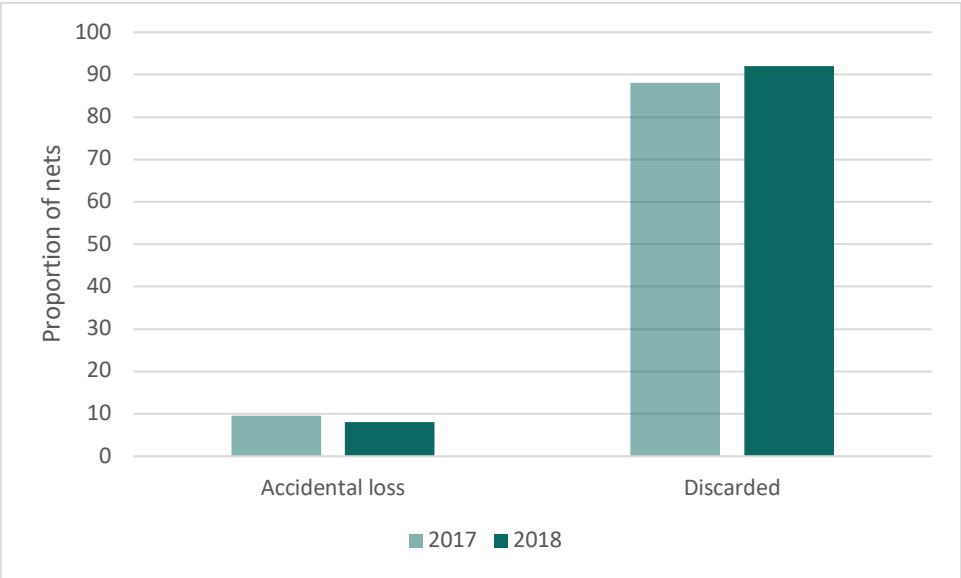

Figure 14 The proportion of nets being lost accidentally vs those discarded in the 2017 analysis vs the 2018 analysis. One net in the 2017 analysis was evaluated as "unknown".

The majority of nets analysed in both years were sections of nets from whitefish bottom trawl, followed by shrimp trawl. In total, these made up bout 90% of the nets analysed the two years (Figure 15).

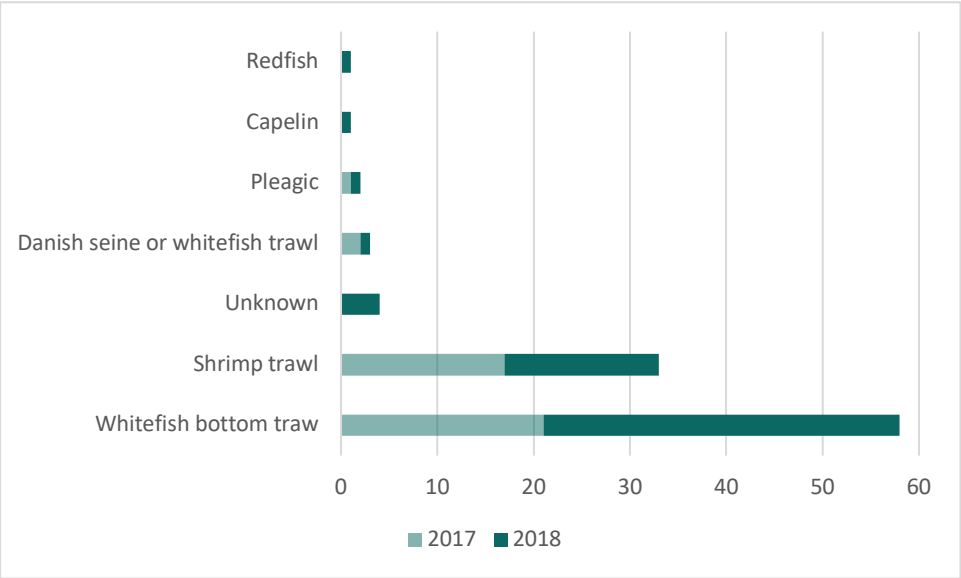

Figure 15 The number of nets of different types identified in the net analysis in 2017 and 2018.

Other information that came out of the analysis was that all of the nets analysed had been made from polyethylene, a material which floats. Furthermore, expert knowledge helps in identifying the type of fisheries involved. Shrimp trawls, for example, can use net of bigger mesh sizes in the front of the trawl. Thus, only using mesh size to identify the type of fishery, may not always be accurate.

4.3 Discussions on the different sources of litter

Once the litter had been sorted into different categories and put on display, the workshop participants evaluated the findings together. This was also followed up and discussed at the third day of the workshop, where also possible management actions were discussed. These are notes from the discussions on the different items. The pictures are not necessarily representative of all the litter recorded in the protocol but are used to illustrate the findings. Where comments are made about discards, this could either be deliberate or in some cases due to waste not being secured good enough on deck.

4.3.1 Floats

The fisheries experts believed that the aluminium floats were probably Russian (see in the middle of the picture in Figure 16). Ring floats were from gill nets, and many had branding. They used to be popular, but they have since been replaced with floating ropes. In the North East Atlantic they switched to ropes approximately ten years ago. It was noted that none of the rings had fouling. Gill nets are generally not used in the Barents Sea area, and they are not used by Russian fishers at all.

Trawl floats (see bottom right of the picture in Figure 16) could be from deep water trawlers. The ones with “bumps” were likely from shrimp trawlers, while the others could be from pelagic trawlers. These floats could be from anywhere in the Atlantic. There has been a practice of smashing damaged trawl floats open and discard them. They will therefore sink and won’t be found on beaches. It is not

a mystery that we find lots of floats, as they are made to float and are likely to be washed ashore. The floats are rarely dumped because they are valuable. The floats can be lost if gear breaks during operation, or when gear snaps during howling. As with the ring floats, none of the trawl floats had fouling on them.

Figure 16 Experts identifying the origin of floats (Picture: WJ Strietman).

4.3.2 Fishery related items

The type of fish boxes found on the shores of Svalbard are used a lot in the North Sea fishery and are likely also used elsewhere in the North Atlantic. Many of the fish boxes were Norwegian, but such boxes are not used very much any longer. Such crates are made from polyethylene and will therefore float after ending up in the sea. Most fish auctions where such boxes are used, use a deposit scheme, to make sure that most boxes get back to shore and to the place where they originate. It is a normal practise that these are exchanged between boats within the same nations, but not between different nationality vessels. They are used on all types of vessels to store fresh fish on ice. They are often stored on deck and can therefore be lost in bad weather if they are not properly secured. The boxes are usually made out of polyethylene, which floats. It is therefore likely that these are washed ashore on beaches.

Plastic tubes are used to hold rolls of thin plastic film/sheeting. The plastic film is used to wrap frozen fish on industrial freezing trawlers as part of fish processing on board these vessels. This process takes place below deck. Therefore, the pipes ending up in the sea point towards deliberate discarding. The black pipes in the middle of Figure 17 are examples of such plastic tubes. Conveyor belts are also likely discarded.

Figure 17 Analysis of various fisheries related items (Picture: Sarah Auffret).

Strapping bands are either encountered as shorter bits or large bundles. Larger bundles occur when the strapping machine gets stuck and the mechanic has to run a large spool through the machine to fix it. This is bulky to store and useless so is thrown overboard. If the rolls of strapping bands are stored for too long onboard, they can get humid and cause the problem of jamming in the machines. Sand in the machinery can have the same effect and could be a consequence of poor maintenance. Strapping bands are a pure attitude/ discarding problem, especially the large bundles. Small pieces of strapping band could be from activities conducted below deck (in processing) so they are unlikely to go overboard by accident. Strapping bands are used in a number of industries as part of packaging, including fish processing. The bands are strapped around boxes of frozen fish. It could be possible to identify the likely sources and ages of the strapping bands based on knowledge of when these were in use and the dimensions used onboard Norwegian vs Russian vessels.

4.3.3 Plastic sheeting

This category consisted mainly of thin white, blue and transparent sheets of plastic (Figure 18). It is not entirely clear where the main share of these kinds of items originate from, but it is known that (blue) transparent plastic film is used to wrap frozen fish on industrial freezing trawlers as part of fish processing on board these vessels. This process takes place below deck. Therefore, plastic items from this category ending up in the sea may point towards deliberate discarding. Blue sheeting is also used to separate fish in the bait boxes and there is a practice of tying these together as the fishers to the baiting. This can be found as bundle of tie-up plastic sheets. Black sheeting could either be sheeting or remains of a garbage bag. It can be difficult to differentiate between sheeting and bags. Large plastic pieces may also come from the building industry, but these are usually thicker. Sheeting often does not travel very far, as it is quickly torn into smaller pieces or sinks out. Thus, it can be argued that they have to originate from a local source.

Figure 18 Blue, white and transparent pieces of sheeting (Photo: WJ Strietman)

4.3.4 Food

Figure 19 illustrates different types of food related items found during the deep dive. The most common item found was drinking bottles with unknown origin. The reason this category is dominating might be because logos and prints are eroded by sunlight, wind and waves. The second most common item was drinking bottles from other nationalities. Most of the drinking bottles from other nationalities had Cyrillic text printed on them. Plastic bottles mainly are made out of heavy polymer and are therefore likely to sink if they end up at sea without the lid. The rather large number of lids and caps found in the analysis, might implicate a “dark number” of bottles at sea.

Out of all the food wrappings, oil- and sausage packages were the most common. The fourth most common item(s) was lids and caps. An evaluation of the caps and lids showed that they were mostly from brands sold in Russia and Norway. That is not a surprising result because most of the fishing vessels active in the Svalbard region are indeed from Russia and Norway. Another contributing factor might be the geographical proximity of both Norway and Russia.

While some of the food items could be identified with respect to brand and nationality, the origin cannot be assumed based on language only (e.g. Cyrillic alphabet), because where an item has been bought may not be same area as where it has been released into the sea.

Food items are used in the galley and should not be going overboard by accident. If there were imprints in the plastic that could identify the packaging, then it would be easier to identify the producer as other prints or labelling wears off more quickly. On the other hand, such an ID system would not identify the consumer or dumper. Another action that could be tested, is preorganized waste containers for different types of garbage at the ports.

Figure 19 Food related items (Photo: WJ Strietman)

4.3.5 Domestic

While some of the shoes were working boots most of them were “leisure shoes”. There were also a large number of plastic gloves, as well as hard hats (Figure 20). The latter were likely to be of industrial origin but are categorised as domestic. On reasons behind why we find these items on the shores, it was commented that most shoes were probably lost. Gloves and hard hats are from fishing or cargo and are also more likely to be lost.

A bundle of balloons with strings was found, and it was commented that this is an item that is of concern due to impact on marine life. Some suggested that single use items (lighters and balloons) could be regulated by the government. Balloons are mostly for big events so alternatives could be promoted.

Figure 20 Domestic litter (Photo: WJ Strietman)

4.3.6 Cleaner products

Many of the cleaning bottles could not be identified to nationality (Figure 21). The majority of the containers were from after the 90s. Many bottles had bite marks indicating that they had been chewed on by organisms.

Cleaning bottles are more likely to be dumped from all kinds of vessels. It was noted that there were a lot of Russian and Danish products (Danish products could come from Faroe Islands). One bottle was labelled 1979 and some of the Zalo bottles were also very old. This indicates that the clean-up event behind this litter is the first one taking place in that specific area.

Figure 21 Cleaner bottles (Photo: WJ Strietman)

4.3.7 Cosmetics

Items in this category mainly consisted of shaving foam, shampoo, deodorant and aftershave (Figure 22). Some containers were clearly cosmetic products, but the brand name was not clear. 7 of the items were Russian, while 5 were Norwegian. It was found that most of the sanitary products are associated to male consumption. During the workshop it was discussed if this finding could be linked to the fisheries, because of the abundance of male fishing crew.

These products are used below deck, are household litter and are therefore likely discarded. The majority of the sanitary items looked old, from the 80s-90s.

Figure 22 Cosmetics (Phote: WJ Strietman)

4.3.8 Plastic pieces

In general, the hard-plastic items looked like they were related to industry. The smaller pieces in this category mainly consist of items that cannot be identified to its original product. It is therefore difficult to say why these items have ended up at sea. The larger bits mainly consist of remains of crates and buckets and could be considered being defined as a category in the registration form.

4.3.9 Industry

In this category, 5 litre containers were the most abundant, mostly blue square containers with handles (presumably oil containers) and white containers. Some containers still contained sticky substances (oil etc) or even had bite marks on them (especially the white ones). These containers are likely discarded. Some of the jerrycans were crushed, but it is not known if this is from being in the environment, or if it is done by people. The majority of the containers were from after the 90s (see Figure 23 for example of industry related items). Since ships stock in different ports, the nationality of a bottle doesn't necessarily reflect the nationality of the boat it was discarded from.

A possible solution suggested to reduce the amount of oil and chemical containers being discarded is better incentives to return these to port. Now it costs money to properly dispose of oil, which is a disincentive to responsible disposal. It is also worth looking into if the Styrofoam insulation commonly used in Svalbard could be replaced by some other substance or material, to hinder wind transportation.

Figure 23 Industry related items (Picture: Sarah Auffret)

Another item in the industry category was Styrofoam. Findings of blue pieces of Styrofoam could be linked to insulation pipes used at Svalbard. They easily break up and become litter.

4.3.10 Fishing nets

The majority of the nets were trawl nets used in the fishery for whitefish and shrimp in the Barents Sea. According to the rope- and net manufacturer present at the analysis, Ben Wensink, the specific type of netting is used by both Russian and Norwegian fishing vessels. Both fleets use nets from the same manufacturers. Wensink could tell by the type of nets and mesh size that these types of nets were not from the North Sea region but were of a type used by the fleet that is active in the Barents Sea. To estimate the distances the ropes and nets have travelled, one might suggest that ropes and nets that have travelled far would contain a lot of fouling. It can be difficult to tell the nationality of the fishing nets. While some of the nets floats and can therefore float long distances, it is expected that most of the nets are from the northern part of the Norwegian Sea and the Barents Sea.

All of the nets we found is made out of polyethylene, which gives the net a floating characteristic. Other nets, like gillnets (which are made out of nylon) were not found. The absence of gillnets might be due to the fact that nylon sinks. Therefore, the beach litter cleanups do not represent a representative picture of the fishing gear used around the area of Svalbard. Put in another way; whitefish and shrimp fishing does not necessarily represent main sources of litter but do represent the most common sources of *beach* litter.

During the workshop, the representative from the Norwegian Directorate of Fisheries noted that using polyethylene as the main netting material in trawl nets is a quite new practice, implicating that most of the nets we found are fairly new (less than 10 years old). Further, the representative stated that there are a lot of shrimp- and cod fishing around Svalbard, both Norwegian and foreign.

Some of the workshop participants argued that the bottom trawls could be lost because they come into contact with the seabed and sometimes get stuck. On the other hand, two fisheries experts taking part in the workshop argued that the majority of the analyzed nets has been discarded.

4.3.11 Ropes

The experts present at the workshop agreed that more or less all ropes with a diameter < 1 cm were cut-offs. These could to a large degree be linked to maintenance of the nets (Figure 9). During this procedure small pieces of nets are cut off in order to create straight lines/sections. After repairs, these cut-offs end up in between the netting or loose on the deck. Additionally, rope is used for tying the new piece onto the fishing gear, and the ends of these are cut off and dropped on deck. The rope cut-offs are then either intentionally or unintentionally washed overboard. It takes quite an effort to collect all these individual cut-offs during maintenance procedures. It was recommended that it would be useful to have a designer's workshop with fishermen to try to find a solution and to understand why this behaviour is so hard to solve.

60-80% of all the larger ropes were related to the fisheries (Figure 24). Some of these were 'raising ropes' used to collect pots, others were slings and ropes used in trawling gear. Some larger ropes could be from freight ships or larger fishing trawlers. Many of the ropes were still useful and complete, making it unlikely that these would have been intentionally discarded. One of the experts said that around 20% of the ropes laid out for evaluation could have ended up at sea due to accidents. Thus, the majority of the ropes ending up overboard would therefore be due to intentional discards or bad waste management.

Figure 24 Rope analysis with experts (Photo: WJ Strietman)

4.4 Feedback on the protocol

For some of the weighing categories the workshop participants suggested modifications to improve the Deep Dive protocol. A general feedback was to evaluate whether the containers were from before or after the 90s, which is the time period when a general ban on discarding waste at sea became effective.

A separate category of research equipment, weather balloons being one example, could determine the degree to which research and monitoring activities at Svalbard contribute to marine littering. Registering the percentage of litter being likely discarded vs accidentally lost could identify the proportion of litter that can be reduced through improved wastes management.

4.4.1 Comments to source categories

Fishery related items: Bundles of strapping band: register the thickness and colour to be better able to link these to specific sources.

Food: It would be useful to add 'Norwegian water bottles' as a category in Svalbard.

Domestic: One could consider classifying gloves and hard hats as industry related plastic items, not textile under domestic sources.

Cleaner products: In the protocol, laundry bottles and cleaning bottles are recorded separately, but they can be hard to distinguish and should be recorded as "cleaning bottles".

Plastic pieces: Crates for food and bottles could be considered as a separate category as they belong to large households.

Industry: Oil and chemical containers could be identified further to evaluate if they originate from marine industries. Photo guides could be developed for differentiating the different types of containers found, and thereby better link these to source.

Fishing nets: The current version of the protocol provides enough categories for the data recorded to be useful for management purposes and does not need to be adjusted. Application of the protocol in cooperation with experts on fisheries technology is an advantage to secure correct evaluation of the different parameters in the protocol. It is difficult for a non-expert to conclude on which part of the net is found, or what type of net. Collecting and storing small (roughly A4) samples of nets during clean-ups for later evaluation by experts would identify the type of fisheries involved, but not give information on the size of the net and the probable cause for it having ended up in the sea. It is easy for lay people to differentiate between gill nets and other nets, and also after instructions record the mesh size and whether the net section investigated a single or a double twine netting. Including a sliding calliper as part of the equipment for analysis would make it easier to measure the mesh size of the nets. Photo documentation could also give enough information for experts to evaluate the nets.

Ropes: One could note the length of the ropes, in addition to thickness as already included in the current protocol and make cut-offs from nets a separate category. The current criteria is that the rope has to be cut in both ends to qualify as cut-off. One could be less strict and say that one end cut is enough because a snagged or damaged rope will be cut cleanly so the rest of the rope can be conserved

4.4.2 Further ideas and recommendations for data collection and cooperation

During the workshop, a number of additional ideas and recommendations were discussed. In order to provide estimates of how much litter is found at a beach, it would be useful to know the area of beached cleaned, as well as the degree to which the area was cleaned (e.g. all visible items or large items only). It would be interesting to check the hypothesis that there is a correlation between the presence of different types of fishing fleets in the fjords of Svalbard and litter on the nearby beaches. Satellite monitoring and aerial photography (plane/helicopter) could be explored as complementary tools for monitoring beach litter.

Developing a citizen science beach clean-up app was also discussed. This would have to include instructions on data collection, an interface for submitting pictures and the possibility to report areas where no litter is found.

The Clean-up Svalbard forum tries to have a dialog between the organizations working on litter. It was argued and explained during the workshop, that different organizations have different strengths regarding clean-ups and that there is great potential for cooperation on data collection. AECO has access to beaches within a long range, while Aktiv i Friluft has community engagement. It was discussed if it is possible to organize a more efficient division of labour between the organizations involved in beach clean-ups and analysis in order to cost-effectively collect data needed to provide management relevant knowledge. Table 3 illustrates the current actions taking place, as well as the potential for deep dive projects to be a supplement to data collection and clean-up actions going on today. It illustrates that today there is little overlap between the activities taking place, and that there is great potential for cooperation on data collection.

Table 3 Overview of actors involved in beach cleaning and analysis at Svalbard. "X" indicates current actions, "(X") indicates potential action.

	Location	Trend monitoring	Behaviour	Sources	Total weight
Aktiv i Friluft	X				
AECO	X				X
The governor of Svalbard (OSPAR)	X	X		X	X
Clean-up Svalbard					X
Deep dive projects		(X)	X	X	

5 DISCUSSION

5.1 Fisheries is the main source of litter at Svalbard

The Svalbard beach litter deep dive confirmed previous studies that fisheries related litter is the dominating source of litter at and around Svalbard both in number of items and their weight. Our study has also documented an on-going practice of discarding of sections of trawl nets, which can be linked to Norwegian and Russian fishing operations in the Barents Sea.

Fishing nets, which we have identified as largely consisting of cut-offs from repairs of cod and shrimp trawls, are a particular concern, as wildlife can get entangled in them. Such nets with skulls of reindeer entangled in them, has become a regular site on the beaches of Svalbard (M. Bergmann et al. 2017). Reindeer forage on macroalgae in the intertidal during winter, which increases the risk of being entangled in fishing nets. This may represent a resource to predators that come to feed on the decaying reindeer, but these scavengers also risk getting entangled (M. Bergmann et al. 2017). The potential high impact of fishing nets on wildlife in the area, in addition to the unknown impacts of microplastics as the nets degrade, makes nets a particular source of concern. In terms of weight, it is expected that this fraction of litter makes up a significant part of the beach litter at Svalbard.

Combined with the knowledge from the deep dive analysis, that discarding of nets is still taking place, suggests that this practice should be a particular focus for preventive management actions.

Other fisheries-related plastic litter also represents a threat in terms of entanglement. Ropes and dolly rope fibers have been documented to affect wildlife at Svalbard (M. Bergmann et al. 2017). Strapping bands, which according to this and previous analysis (Nashoug 2017) are likely discarded, represent the same risk. Additionally, the strapping bands contain chemicals, including UV stabilisers, that are of particular environmental concern (Geir Gabrielsen, Norwegian Polar Institute, pers. com.). The result of entanglement may be infection in resulting wounds or strangulation, but also that animals get more vulnerable to predation. The qualitative evaluation of the ropes by experts, suggested that the majority of the ropes found were related to fisheries. Furthermore, clear-cuts of a large fraction of the ropes and in particular the presence of large bundles of strapping bands, suggest a deliberative action. It is not known how easy it is to prevent all types of cut-offs, but preventive measures could significantly reduce the amount of litter on the shores of Svalbard since ropes represents a large fraction of the litter. Ropes and strapping bands should therefore also be a target for preventive actions.

5.2 Local versus global sources of marine litter

The low number of identifiable containers in the “rest” fraction and the fact that the litter was from one location on the west coast of Svalbard that had not been cleaned before, did not provide good enough data to make any strong conclusions with respect to the nationality of the litter at Svalbard in general. However, litter from the two largest fisheries nations, Norway and Russia, seem to dominate. This is also in line with a study of the nationality of litter from a beach on Kipertøya, north-west on the Svalbard Islands, where 28% of the items were Russian and 13% Norwegian. They also found a relatively large proportion of Danish litter (13%), followed by German (7%) and litter with imprints in English (8%) (M. Bergmann, Afred Wegner Institute, pers.com).

The litter analysed from Svalbard showed many similarities to litter analysed in Northern-Norway, where fisheries related items also dominate (Falk-Andersson, Olaussen, and Macintyre 2018). Both Norwegian and Russian vessels operate in these areas, with trawling activity being particularly high off the North-Norwegian coast and in the Barents Sea west of the south tip of Svalbard. There is also trawling activity along the west and north-west coast of Svalbard (Figure 25). Particular items that are found in both areas include floats, fish boxes, bundles of strapping bands, tubes for plastic foil, parts of conveyors, oil- and chemical containers, Idun bottles, instant coffee glasses/ lids and Zalo. Norwegian and Russian food packaging also seem to dominate in this region. Fishers in Finnmark reported that household litter from Eastern European countries arriving to the coast after fishing fleets from these countries got access to fishing rights through the EU (Falk-Andersson, Olaussen, and Macintyre 2018). Many of the oil- and chemical containers found at Svalbard are likely from vessels but is today categorised at industry-related. Deep dives from the Oslo fjord, showed a more diverse picture with respect to this category, with multiple sources, including private ones (Drægni and Falk-Andersson 2019).

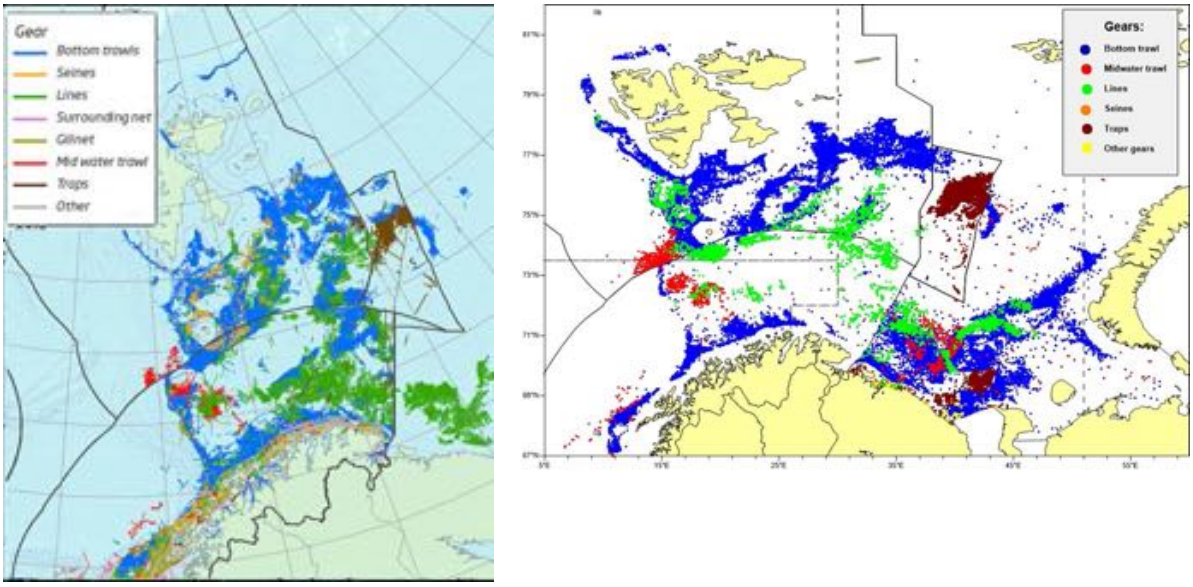

Figure 25 Norwegian and foreign fisheries activity in the Norwegian Economic Zone, as reported to Norwegian authorities based on VMS-data (left). Russian and non-Russian fisheries activities in the Russian Economic Zone in 2014 as reported to Russian authorities based on VMS data (right). (Figures from http://www.ices.dk/explore-us/Action%20Areas/ESD/Pages/Barents-Sea-Pressures-Abrasion.aspx).

While more data is needed on non-net items, the high number of fishing nets available for analysis allowed for clear conclusions with respect to their origin. The majority of the nets were sections of shrimp and whitefish bottom trawling nets of a type used by Norwegian and Russian fishing vessels in the Barents Sea region. Since they use the same manufacturers, it is not possible to determine which nationality contributes the most to the practice of discarding this waste. Some nets could originate from the northern part of the Norwegian Sea, but a lack of fouling and the high trawling activity in the area and the type of nets found, suggest the nets, and also the ropes analysed, are not due to long-range transport, but discarding of waste from vessels operating in the Barents Sea. Given that over half the nets analysed are less than 5 years old, this is a practice that is still on-going.

The deep dive findings are in line with other studies on the sources of marine litter at Svalbard that also concludes that the strong dominance of fisheries related litter is a clear sign that local sources contributes substantially to the litter in the region. Combined with a recent increase in fishing effort in the region and a lot of trawl marks on the seafloor in the area, there main source of the litter found seems to be quite clear (M. Bergmann et al. 2017). However, a number of factors have been listed as arguments for why much of the litter found at Svalbard could be due to long-range transport from the south. Svalbard is heavily influenced by the West Spitsbergen Current that carries water from the Atlantic northwards and along the western coast of Svalbard (Svendsen et al. 2002), which could bring litter from North Atlantic fisheries to the region (M. Bergmann et al. 2017). The presence of fish boxes and other items marked with suppliers of either fisheries equipment or beverages, suggest that parts of the litter has been carried far (M. Bergmann et al. 2017). An oceanographic model developed by Cózar et al (2017) predicted that large amount of floating litter in the Arctic originates from the south. However, the paper is based on surface trawls using a manta net and the upper size limit of the plastic items were limited to the mouth of the net. The largest size class was from 32 to 860 mm and made up a very small part of the sample. Also the OSPAR registrations point to fisheries as the main source of the litter in the region (MOSJ 2015). None of these studies, however, have collected data that can link the litter to specific sources and practices in or outside the region.

While recognizing that certain litter items have the potential to travel far, the deep dive analysis points to local sources rather than long-range transport from the south as the main origin of the litter. The analysis has also investigated the degree to which the nationality of items found can be used to link the litter to sources. Fish boxes, for example, are known to be used on different vessels independent of the name of the vessel printed on the fish boxes but are seldom exchanged between the different nationalities. Given that fish boxes are not used so much today, they are not a good indicator of current practices. Fisheries equipment is traded internationally, making it difficult to trace fisheries related litter back to the nationality of the fleet operating in an area (Nashoug 2017), but fishing nets can be traced to a practice of discarding of fishing gear used by the Norwegian and Russian trawl fleet. The absence of fouling of nets and ropes suggest that these have not travelled very far. Fouling could be used as an indicator of the likelihood of long-range dispersal. The identification of organisms attached to litter has been used to evaluate the potential for litter to act as rafts for alien species to the region (Weslawski and Kotwicki 2018). Such analysis could also be used to identify the likely origin of the litter, including how far it has travelled. For items that have been present in the region for a long time, ice, snow and other physical interactions may have "cleaned" the plastic products from fouling. Finally, an overlap between the nationality of household products and oil- and chemical containers, as well as the type of products found, can give a good indication of the likely origin of the litter. The limited data available today, also suggest a practice of discarding from Norwegian and Russian vessels, but we cannot say if this is an on-going practice. Evaluation of the age of the products found can give insights into this.

The eastern coast of the Svalbard Islands, receives Arctic water from the northeast (Misund et al. 2016), which could be expected to be more influenced by litter from the Barents Sea fisheries. There is no data available to analyse the difference in the litter footprint along the eastern and the western coast of Svalbard. In this study, the "rest" fraction of litter collected at Franzøya in Hinlopen situated on the north-eastern side of the islands was analysed. Analysis of samples of litter from the eastern and the western coast of Svalbard could give insights into whether there are differences in the type of litter found and if these could be linked to local activities or the different currents bringing items from the North Atlantic and the fishing areas east of Svalbard, respectively.

Deep dives have a high potential in identifying the likely sources of the beach litter. Information available on the locations of ships can be coupled to deep dive data to identify potential sea-based sources of the litter. This type of knowledge is important in informing models predicting the transportation and accumulation of marine litter as the release points of litter in the models is an important factor driving the results. Outputs from these types of models are used both to better understand the sources of litter and where clean-up efforts are the most efficient.

The deep dive analysis has illustrated that this is a valuable supplement to the beach litter protocols in used today. Beach litter at Svalbard is monitored according to the OSPAR protocol. However, while the protocol is extensive in terms of the number of items recorded, it does not identify important sources of- and behaviour behind littering that can be used to implement preventive measures. For example, it cannot be used to identify the types of fisheries contributing to littering as it only contains one category for nets which does not differentiate between types of nets and whether these are discarded or lost. Furthermore, the OSPAR data does not provide information that can link the litter to global or local sources of litter, nor to on-going discarding practices. There is a general need for developing marine litter indicators, and in particular indicators that can be used in implementation and monitoring of preventive efforts as these are the most cost-effective management measures against marine littering. A more systematic collection of beach litter data using deep dives identifying the nationality, type and age of household-, oil-, and chemical containers, could provide more solid documentation on the likely origin of litter in the region and the degree to which discarding is an on-going practice. A more detailed monitoring of nets, ropes and strapping bands is also recommended. Monitoring of items the deep dive have identified as

potentially important indicators, would require that the beaches sampled are known and that they are regularly cleaned for monitoring purposes. This would be an important step in developing a monitoring scheme that is better suited for assessing the impact of preventive measures over time.

5.3 How representative is beach litter with respect to the sources of marine litter at Svalbard?

A number of factors affects which litter items end up at Svalbard beaches. Different types of materials and items have different properties when it comes to persistence and the ability to float. Items with a lower density than sea water made of hard-plastic will have a higher likelihood of ending up on the shores where they are available for being picked up. Intact plastic bottles, polyethylene nets and trawl floats, for example, are more likely to end up as identifiable items om beaches compared to a trawl door made of metal or a gill net that will sink and plastic sheeting that disintegrates quickly. The beach litter items studied are therefore not representative of the population of waste ending up in the sea. Similarly, the net sections analysed in this deep dive, were of a material that floats. Other nets (nylon – used in pelagic; static nets – e.g. gill nets with weights) have not been analysed as they would sink and not end up on a beach to be collected during a clean-up. Based on this, we have an idea of the type of fishing gear that is lost or discarded in terms of floating nets. To say that whitefish and shrimp fishing are the main sources of litter in the Barents Sea region as a whole would be inaccurate.

In terms of how representative the litter analysed was, the “rest” fraction is likely not representative of the litter at Svalbard overall as it only consisted of litter from one location. Furthermore, larger items were more likely to be picked up given that this was the first time the area was cleaned, and it would be expected that the beaches contained a lot of litter. This is the general case with collection of beach litter data by volunteers, that they focus on larger items that are easy to detect as this is more time efficient compared to picking smaller pieces. Since the deep dive is focused on identifiable items, this may not represent a problem for this particular analysis, although some identifiable items such as Q-tips may be underrepresented.

Floating debris is transported by currents and wind at the sea surface and may eventually either sink to the seafloor or get washed up on shore (Galgani, Hanke, and Maes 2015). It is believed that the majority of marine plastic pollution has ended up at the sea floor (94%) with an estimated 70 kg of plastics per km^2 on the sea bed. About 1% is floating at or on the surface, with a global average estimate of less than 1 kg per km^2. The plastic found on beaches is believed to represent around 5% of the total amount of marine plastic (Figure 26). Thus, the litter on beaches is not necessarily representative for the input of litter to the ocean. However, it is the most cost-effective way to collect data on the sources of marine litter both due to the high concentration of litter on beaches (on average 2000 kg per km^2) and relatively low requirement to equipment and logistics compared to analysis at the sea floor or in the ocean surface. Thus, despite its limitations, beach litter is a relatively cheap method that gives valuable knowledge on the main sources of marine litter.

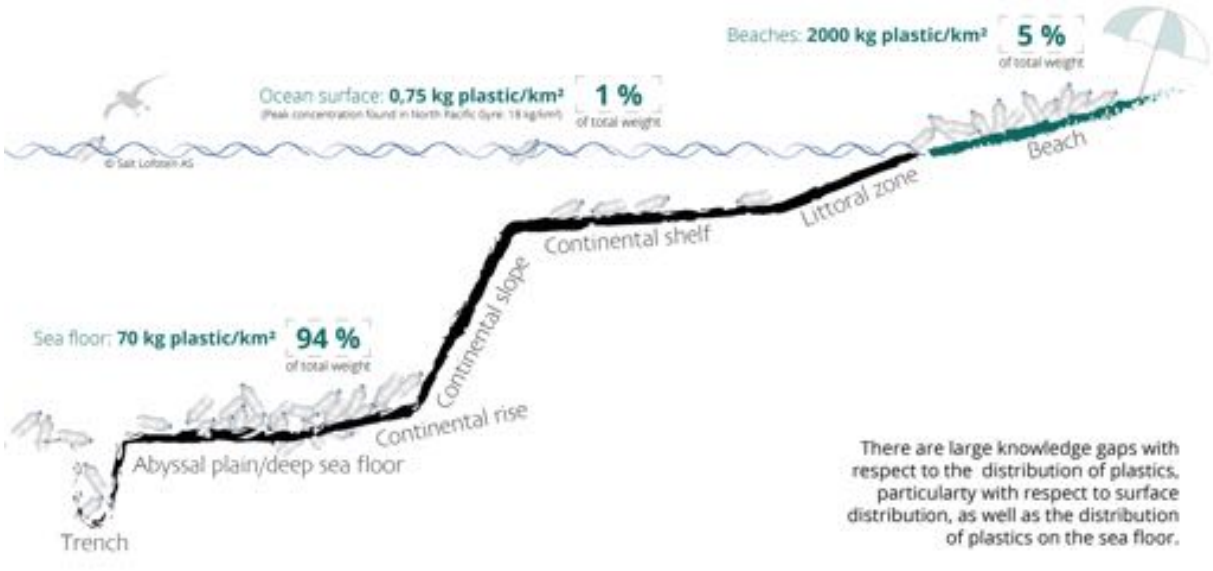

Figure 26 Plastic pollution in the ocean showing the relative distribution of marine plastic pollution and the average density on beaches, on and at the sea surface and at the sea floor (modified from Eunomia(2016)).

5.4 Implementation of the deep dive protocol

This project was a part of a number of pilot studies applying the beach litter deep dive protocol. The protocol can be implemented by a team of experts or, as in this case, as a deep dive workshop inviting in different litter experts and/ or stakeholders. The most important take home message from this deep dive workshop, is that there needs to be enough experts trained in the method taking part so that each of them can lead the different teams. In particular, the lack of enough trained people to lead the groups resulted in data not being recorded properly for some categories. This resulted in some data being discarded and that the number of items per nationality was not recorded. A separate table on nationality could secure that this information is recorded in the future. This would also give a better system for recording the nationality of the bottles, which was a specific feedback from this workshop. However, while a deep dive is a cost-effective method, it does require enough funding to allow for participation of more trained deep dive experts to secure the quality of the data collected at a deep dive workshop.

There were some inputs to the protocol that could be implemented in future deep dives at Svalbard. The large difference in the evaluation of the age of the nets in 2017 compared to 2018, could either be due to the sample of fishing nets being of different age, or that the experts evaluated the age differently. In 2017 there was one former fisherman doing the evaluation, while in 2018 two experts on fishing gear technology, both with a background as fishers, did the assessment. Thus, the 2018 evaluation may be more robust. Since the age of the nets is an important factor in evaluating the degree to which discarding is an on-going practice it is important to standardise this evaluation. Independent evaluation of at least two experts as well as clear evaluation criteria may secure the quality of the assessment. Knowing the cleaning history of the beaches where the nets are collected would also be an advantage as it is likely that beaches cleaned for the first time have a high number of old nets. This illustrates that deep dives on a sample of litter from a region can say if discarding of waste is taking place or not, but not quantify how big the problem is, nor the trend over time.

Evaluating the age of net cut-offs documented an on-going practice of poor waste management, which again identified improved waste management practices as an important step towards reducing marine litter in the region. A thorough analysis of the age of other litter items could provide further

knowledge regarding the degree to which other types of waste is discarded, while the nationality of these items could link them to likely source. Aging the litter items to before or after the 90s, as suggested by the workshop participants, will be quite difficult as labels are often washed off, but a pilot study could evaluate the feasibility of assessing if the items are older or younger than 5 years old. A separate table recording the nationality, type and relative age of household products as well as oil- and chemical containers, is recommended as it would give valuable information on the likely sources of litter in the region and document on-going discarding practices. Photo documentation could both be used to help in identification and to develop a manual as a tool for future analysis.

Given that strapping bands is an item of particular concern, further analysis of these may be able to better link them to source. Wearable items that are of an industrial nature, could be separated out. However, they did not make up a significant part of the litter and were regarded as likely lost. Laundry bottles and cleaning bottles could be one category as separating these items does not give any additional information. Crates for food and bottles could be a separate category given that it indicates waste from a large household. Recording the length of ropes, would not allow for further identification of the ropes to source. However, with the help of a photo guide, cut-offs from repairs of fishing gear could be identified. While some of the ropes that are only cut in one end may also be cut-offs, it is better to use the more conservative criteria (cut off in both ends) to make sure that the number of cut-offs is not overestimated.

The net protocol applied for this analysis is more extensive than the one suggested in the deep dive protocol. The net protocol was implemented with the help of experts on fishing gear, which is believed to have improved the robustness of the results. A lower difference between the evaluation of the proportion lost vs discarded and the type of nets analysed, compared to the aging of the nets, gives confidence that these parameters have been evaluated correctly. Availability of large amounts of nets for analysis is quite unique for Svalbard as these are delivered in a separate compartment of the Clean-up Svalbard container. This made it possible to analyse a large sample within a short time period using experts. It is more difficult for non- fisheries experts to implement such a protocol but taking samples and photos for later consultations by expert could compensate for this. Use of photos to guide the analysis of the net categories in the deep dive protocol could aid analysis of fishing nets but would have to be tested. Previous efforts to get citizens to identify the type of nets using photo guides have shown that this can be difficult (Hartviksen 2017), but this may be less of a problem for people trained in implementing the deep dive protocol.

Any additional information recording will increase the complexity of implementing the protocol. Thus, one must always consider the value of the information gained, compared to the effort of analysing the litter. In terms of achieving a reduction in marine litter in the region, we have enough knowledge to identify some of the key stakeholders to enter dialogue with, namely Norwegian and Russian fishers. Experience from analysing litter with stakeholders have shown that this is an efficient way of communication that can lead to the stakeholders taking ownership of the problem and the solutions (Falk-Andersson 2018). Collecting further data could be an advantage in order to identify other stakeholders that should be a part of such a process, as there are more actors in the region that could contribute to littering.

5.5 Cooperation on data collection and stakeholder communication

The overview on the activities taking place with respect to beach litter cleaning and monitoring, shows that the only activity documenting the sources of litter on a regular basis is the OSPAR monitoring effort. The most extensive data set on marine litter in Norway and internationally is the one collected by volunteers through Keep Norway Beautiful and Ocean Conservancy. One should

therefore encourage such data collection through citizen science also at Svalbard (Falk-Andersson, Berkhout, and Abate 2019).

None of the regular marine litter monitoring activities taking place at Svalbard today looks closer at the sources of litter at a level relevant for management actions, nor seeks to understand the behaviour behind the littering, why discarding takes place and how waste management can be improved. Through close cooperation between those involved in beach-cleaning and registration, and experts on beach litter deep dives, data on the sources of litter in the region can be collected and analysed relatively cost-efficiently. Today, a number of questions remains unanswered due to a lack of data on the sources of and behaviour behind the litter found in the region.

There is also a great potential for cooperation on outreach projects, where knowledge from deep dives can be used to inform both local, regional and international stakeholders. It is recommended that beach litter deep dives are conducted as a first step in identifying important stakeholders, and that this is followed up with a deep dive workshop with the relevant stakeholders identified. In dialogue with stakeholders, one can get insight into the underlying behaviour and processes resulting in waste being discarded, solutions to better waste management and which steps are needed to prevent litter ending up in the ocean. Monitoring of key litter items in focus for preventive actions can confirm if there is a change in the litter items found at beaches, both evaluating the effectiveness of management actions and the next items that need to be focused on to further reduce marine littering.

6 CONCLUSIONS

Application of the deep dive protocol on Svalbard beach litter has provided new insight into the sources of- and reasons behind these items ending up in the marine environment. The analysis of the nets showed that the majority of the nets are of a type used in the Barents Sea by Norwegian and Russian vessels, and that discarding of nets seems to be an on-going practice.

Data on the nationality of household products was scarce, but there seem to be an overlap between the nationality of the fishing vessels operating in the area and the nationality of household products found on beaches. The findings suggest that Norwegian and Russian fishing vessels operating in the Barents Sea are an important target for management efforts to reduce marine littering in the region. Given the environmental impact of discarded fishing nets, this should be a particular area of focus in preventive actions.

Further studies are needed, particularly on household items and oil- and chemical containers, in order to determine the degree to which discarding of litter is currently taking place from different nationality vessels operating in the area. This would also provide new knowledge on the significance of long-range transport of litter into the region.

The beach litter deep dive methodology is a promising tool that is relatively cost-effective in providing management relevant knowledge. It can be adjusted for different regions to document the main litter problems that should be the focus of preventive actions. Successful implementation, however, require a good understanding of the methodology and how to use experts to get a better understanding of the litter. Beach litter deep dive as implemented in this project is a complement, rather than a supplement, of beach litter protocols used for monitoring in the region today. There is great potential, however, for using beach litter deep dives to improve monitoring programs. Insight from this type of analysis can also be coupled with modelling to improve our understanding marine litter transport and accumulation spots. Finally, deep dives can also be used as a tool of

communication when involving stakeholders in identifying the solutions that can prevent waste ending up at sea.

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8 ATTACHMENTS

Attachment 1 Instructions beach litter deep dive workshop Svalbard

Aim of the deep dive workshop

The aim of a beach litter deep dive is to efficiently get more knowledge on the most abundant types of litter in order to be able to implement management actions to reduce input of litter to the environment. Secondly, the deep dive will identify items or litter types that are particularly worrying and/or items that can easily give important knowledge to managers and decision makers (such as their sources and/or underlying processes or behaviour that might have resulted in these items ending up in the sea), and therefore should be monitored through existing beach-litter protocols.

What is a deep dive?

To identify the sources and reasons behind waste ending up at sea, there is often a need for a higher resolution on the data than provided by current beach-registration protocols used in the region.

1. The OSPAR beach litter monitoring protocol, which is being applied at Svalbard
2. The Keep Norway Beautiful protocol, which is extensively used on the mainland of Norway and is adapted from the Ocean Conservancy protocol.

"Deep dive" is a method under development. The field work will therefore also give valuable input into how the method can be developed and applied in order to efficiently collect relevant data. Participants are therefore encouraged to extend the protocol during the workshop if relevant, and give feedback on how easy/hard it is to apply the method.

Equipment provided by the organizers

- Scale (hand held). Scale at waste management facility can be used for larger items.
- Ziplock bags for samples.
- Large bags/ tarpaulin for sorting into weight categories
- Pens/ marker pen and paper, registration forms
- "Hard plate" for writing the form
- Tape
- Knife
- First aid kit
- Camera
- Post it notes
- Snacks and soft drinks

Equipment to bring

- Gloves (for example thick garden gloves), warm clothes and shoes, water bottle. The temperature in Longyearbyen is currently around 5°C. We will be indoors, but in a locality that is not heated.

Outline of the deep dive workshop

This deep dive will take place at the Longyearbyen Waste Management Company and analyse litter that has been collected by volunteers at Svalbard. We do not know the specific locations of where

this litter has been collected, so the deep dive analysis will give insight in litter from the Svalbard region in general.

Deep dives can be time consuming and one has to have this in mind when deciding how much time should be used for counting and weighing unidentified pieces of plastics and items that are not abundant. Remember that we are interested in 1) identifying the most abundant items in weight and/or numbers and 2) a deeper understanding of the sources and reasons why these items may have ended up in the sea.

The first step during the workshop will be to divide all litter items into the different Weight Categories (e.g. industrial items, food items, fisheries items), and then further count the number of items within each Number Category. For this purpose, we will be using two types of protocols: **the deep dive protocol** and the **fishing net protocol.** The fishing net protocol makes it possible to do a deeper analysis of the item category fishing nets. Which category you will focus on is listed in the next section.

Organisation at the workshop

1) Table 1 shows who is responsible for registration of the different Weight Categories of litter.
2) Each group has one person responsible for taking notes (**in bold**) and one person responsible for taking photos, including organizing the photos afterwards.

The groups are responsible for counting, weighing and taking photos of the different categories, as well as taking notes when discussing findings. Bags/ tarpaulins marked with the different weighing categories are provided. You will also be provided with the protocol, pencils, hand scale etc. Larger items (over 40 kg) can be weighed using the scale at the waste management facility.

Table 1

Group	Weight category
Vilma, France, Margrete	Food
Marloes , Silje	Domestic, cleaner, industry
Eelco, Governor	Sanitary, smoke, agriculture, bags, sheeting, other
Jannike, Elisabeth. Dagfinn, Roger (Monday)	Fisheries, rope cut off, rope
Wouter Jan, Ben, Roger, Dagfinn (Tuesday)	Nets (fishing nets)
Amanda, Sarah, Dean	Pieces, hard/soft plastic, burned plastic

Application of the deep dive protocol

There will be one tarpaulin/ bag for each Weight Category (Table 2). Find items from the container for your weight categories (see protocol for details) and fill the respective tarpaulins with these items. Once the tarpaulin is covered, take a picture, count the number of items in each Number Category (see protocol) and weigh the tarpaulin with the items.

Take photos and use post-it notes if needed to refer to specific findings illustrating management relevant issues. Also take notes if relevant (for example to note that the ropes are generally too weathered to be assessed for cut-off).

Table 2: Weigh Categories

food: food and drink related items

bags: any type of plastic bag (non food)
sani: items related to sanitary or medical purposes*
smok: smoking related items*
dome: other items related to domestic/personal use
fish: fisheries related items
nett: any fisheries netting materials
Rope cut off
rope: any ropes
clea: cleaner packaging
agri: agricultural items
indu: other items related to industrial uses
Piec
Sheeting
Hard plastic
Soft plastic
Burned plastics
Other pieces

*The weight of these items may be small and may have to be weighed in a zip-lock bag. If so, make a note of it so we can correct for the weight of the zip-lock bag instead of the tarpaulin.

Count the number of items of each Number Category. Note the nationality and brand of identifiable items in the "note" section. Also note the number of items of each type (for example, Norwegian Maarud potato chips III, UK milk bottle IIII).

If you find many items and/or items of particular concern/ that give important information of a category that you believed should be specified further; count them separately and take pictures. You can also weigh them separately. For example; a large number of tubes used for plastic foil onboard fish processing vessels were found on the coast of Finnmark. They made up a large part of the fisheries related waste in weight and were therefore counted and weighed separately, and later included as a Number Category in the protocol.

The "Pieces hard/ pieces soft" categories: If there are large amounts of unidentifiable items, one can do a sample to get an idea of the ratio, alternatively only weigh this category. Thereafter the focus should be on identifiable items. The latter will be a priority in any case. Make a note on the approach followed and take pictures.

Table 3 shows different rope and string categories. We take a conservative approach to evaluating if a rope has been cut. Only if both ends are cut, do we categorize as cut-off. If there are large bundles of rope, fishing nets etc that are difficult to disentangle, don't spend too long on trying to separate these. Rather use the "Bundle of rope" category. Cut-offs should be put in a bag after registration as they may be used for an art project later.

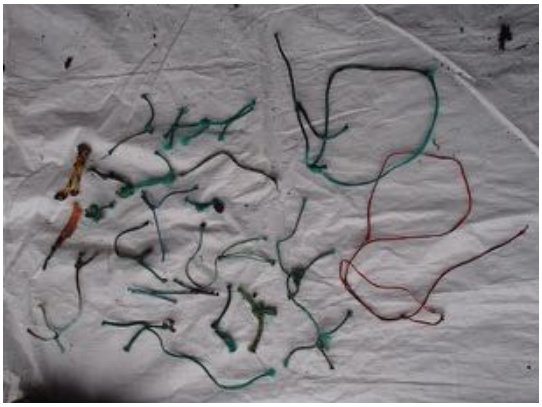
At the workshop the cut-offs should be displayed and evaluated by the fisheries experts to determine the source (are they cut-offs from repair of nets) and how should the rope category be categorised in order to best link to source and behaviour. Should we have a category called "cut-offs from nets"

instead of the current three cut-off categories? Or is it sufficient to document the likely source by approximate estimate of proportion and/or photos.

Table 3: Different rope categories, or rope-like items.

Total sample of “string and cord (diameter less than 1 cm)” from Rekvika

Plastic detonation cords



Rope (<1 cm) cut off with knot

Rope (<1 cm) cut off

Rope (<1 cm)

Dolly-rope

There will be one group working on fishing nets. It will therefore not be relevant to take samples of fishing nets unless there is a need for further analysis, or for communication purposes. Samples should be put in a zip-lock bag and marked with place and date.

Application of the fishing net protocol

Fishing nets will be analyses in further detail using the fishing net protocol. For this purpose, each net will be analysed separately, looking into characteristics such as the dimensions, colour and mesh size, but also into the potential reason why these nets may have ended up in the sea.

The first step is to lay a fishing net on the floor, disentangled:

Then, a photo or photos will be taken and the number of the filename noted. After that, the characteristics will be registered, after which the potential reason why these nets may have ended up in the sea will be noted, based on signs of snagging and cuttings of the net. Afterwards, the net will be taken to where it was stored and a new net will be put on the floor for further analysis. This process takes about 5-15m for each net.

Data

Data is typed into an Excel-file by the responsible for each group. A word file is made for general notes and a folder is made for pictures with identification tags.

Attachment 2 Deep dive protocol

Attachment 3 Report from beach clean-up by kv nordkapp

Kystvakten
KV Nordkapp

NOTAT

Side 2

Vår saksbehandler
[illegible]

Vår dato 2018-07-[illegible] **Vår referanse**

Tidligere dato **Tidligere referanse**

Til
Sysselmannen på Svalbard
V/ Miljøvernavdelingen

Kopi til
[illegible]

Rapport etter strandrydding på Fransøya i Hinlopen.

KV Nordkapp gjennomførte en strandryddeaksjon den 11.07.2018 på **Fransøya i Hinlopen**. Dette ble gjort på frivillig basis og i samråd med Miljøvernavdelingen ved Sysselmannen på Svalbard. Strekningen som ble ryddet var på ca 4.2 km, og vi antar at vi har plukket opp 4 m³ søppel på 5 timer. Majoriteten av søppelet som ble funnet og plukket opp antas å komme fra fiskeflåten. Bl.a trålutstyr, trålsekker/nett, tauverk, trålkuler, fiskekasser.

Se vedlegg: Kart over område som ble ryddet

Tore [illegible]
Orlogskaptein
Skipssjef
KV Nordkapp

1 garn og nett
1 [illegible] (den vi registrerte)

[illegible]

Vedlegg

Div bilder fra strandrydding på Fruholmen 31.07.2018

Attachment 4 The net protocol

Net analysis protocol, including examples of how the nets were aged, conclusion on discards, sides of net and conclusions.

Picture no.	Net dimensions	Surface area category	Surface area net	Net colour	Mesh size	No. of parts	Potential damage to the net due clean-up operation	Holes	Wear/ tear	Age of the net	Description sides of net	Other comments	Conclusion	Potentially discarded

Age	Potentially discarded	Description sides of net	Conclusion
< 5 years	Yes	All sides ripped	Potentially discarded after being cut out after replacement/repair of damaged/ripped net
> 5 years	No	All sides cut	Ripped off after being stuck on the seabed
	Unknown	1 side ripped, 3 sides cut	Potentially discarded for unknown reason
		2 sides ripped, 2 sides cut	Still usable pieces of net have been cut out, only rope itself discarded
		3 sides ripped, 1 side cut	Potentially discarded after being cut out of the net for unknown reasons
			Potentially discarded after being cut out of the net due to wear and tear
			Potentially discarded after being cut out of new net
			Unknown

Attachment 5 The workshop program

(edited: excludes details on practicalities)

Program beach waste analysis workshop 2-6 September

On September 3rd-5th, SALT and Wageningen Economic Research will be organising a “beach litter deep dive” workshop at the local waste management facility in Longyearbyen, Svalbard. During this workshop, marine litter collected during clean-ups in the summer of 2018 will be systematically sorted and analysed by researchers, fisheries experts and stakeholders from the region.

Aim

The aim of the workshop will be to identify specific sources, behaviour and processes that have resulted in litter items having ended up on the shores of Svalbard, with a specific focus on fisheries related litter as this is the main category of litter in this region. This information will be used to engage stakeholders in working on solutions to reducing marine littering and identify items that should be given particular attention in future monitoring and management actions.

Participants

Name	Institution
Jannike Falk-Andersson	SALT
Emil Røthe Johannessen	SALT
Wouter Jan Strietman	Wageningen Economic Research
Eelco Leemans	Leemans Maritime Consultancy
Roger Larsen	University of Tromsø
Geir Gabrielsen	Norwegian Polar institute
France Collard	Norwegian Polar institute
Ben Wensink	Ymuiden Stores / Wireco
Sarah Auffret	Association of Arctic Expedition Cruise Operators
Silje Hagen	Aktiv i friluft
Dagfinn Lilleng	Directorate of fisheries
Amanda Schadeberg	Wageningen Marine Research
Marloes Schravesande	University of Utrecht
	The Governor of Svalbard
Margrete Keyser	NFR/ Svalbard Science Forum
Elisabeth Thomas	Plymouth Marine Laboratory
Dean Cruickshanks	Plymouth Marine Laboratory

Arrival and departure times indicated in the table. Participation for lunch (L) and dinner (D)

Sunday 2nd September

14:05 Arrival flight SK 4414 TOS-LYR Transport to hotel and check in

15:30 Start-up at Longyearbyen Avfallsmottak (waste management facility) for Jannike, Vilma, Roger and France

Put up sorting stations and start analysing non-fish net items.

18:30 Wrap-up

Monday 3rd of September

08:30 Waste analysis at Longyearbyen Avfallsmottak for Jannike, Vilma, Roger and France

09.30 Start of workshop with everybody

Round of introductions and instructions

12:00 Lunch at UNIS

13:00 – 18:00 Waste analysis at Longyearbyen Avfallsmottak

Snack break at 15.30 with discussions/ reflections. A short round of introductions to the litter of the different groups.

Tuesday 4th of September

08:30 Waste analysis at Longyearbyen Avfallsmottak

12:00 Lunch at UNIS

13:00 – 18:00 Waste analysis at Longyearbyen Avfallsmottak

Snack break at 15.30 with discussions/ reflections.

Wednesday 5th of September

Workshop at red cross office, road 612-3 (Sjøgarasjen- the boat house of the Governor of Svalbard. Look for the LRKH logo at the entrance towards the sea)

09:00-10:00 Discussion of results within the different groups.

15.15-15.30 Silje from Aktiv i Friluft: Experiences from clean-ups, potential for cooperation on data collection, reflections on sources.

15.30-15.45 Sara Auffret from AECO: Experiences from clean-ups, potential for cooperation on data collection, reflections on sources. Can some of the litter be related to private/ organized cruise tourism/ boating?

15. 45-16.00 The Governor of Svalbard: Experiences from clean-ups, collection of data, reflections on sources and actions. How could data from clean-ups at Svalbard contribute to reducing plastic pollution at Svalbard. CANCELLED. Representatives from the Governor of Svalbard visited the deep dive workshop on day 2 and discussed results and potential collaboration.

16.00-16.30 Discussion: how can we cooperate on clean-ups, data collection and preventive measures?

16.30-16.45 Wrap-up and end of workshop

Thursday 6th of September

Core project group will meet to discuss findings and plan the next steps in the project.

Attachment 6 Specification of co-funding

The co-founders not only provided for additional outreach activities, but mainly provided funding for man-hours and travel/accommodation in the project itself. In this way, Wageningen Research paid for Amanda's and Marloes' hours and travel/accommodation at the Deep Dive but also Amanda's travel/accommodation during the Arctic Frontiers and for Wouter Jan's additional hours throughout the project. The Dutch Ministry of Foreign Affairs paid for both Wouter Jan's and Eelco's travel and accommodation at the Arctic Frontiers and for Ben Wensink's travel and accommodation of the Deep Dive in Svalbard, The Dolfinarium also paid for additional hours and the Deep Dive group dinner in Longyearbyen. The Norwegian Fisheries Directorate paid for Dagfinn's hours and travel/accommodation costs (Wouter Jan Strietman, pers.com).

SALT kunnskap – friske ideer

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