Beach litter in West Greenland: a source analysis

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WAGENINGEN UNIVERSITY & RESEARCH

AARHUS UNIVERSITY
DEPARTMENT OF BIOSCIENCE

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Kalaallit Nunaata Kitaani sissani eqqakkat: eqqakkat suminngaanneernerinik misissuineq
Strandaffald fra Vest Grønland: en kildeanalyse

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In dit rapport staan de resultaten van een gedetailleerde bronanalyse van zwerfafval dat in september en oktober 2019 op drie locaties in West-Groenland verzameld is: Sisimiut, Qaqortoq en Maniitsoq. Deze analyse vond plaats tijdens een interactieve Litter-ID sessie met lokale stakeholders en experts. Uit de resultaten blijkt, dat vrijwel al het afval van lokale oorsprong is en gerelateerd is aan outdoor activiteiten zoals vissen en jagen en aan zwerfafval dat afkomstig is van lokale dorpen en nederzettingennederzettingen. Litter-ID sessies hebben tot doel om een gezamenlijk inzicht te creëren in de bronnen, herkomst, oorzaken, interactie met het ecosysteem en waar mogelijk de oplossingen van lokaal strandafval in kaart te brengen. Deze kennis kan vervolgens gebruikt worden als basis voor het nemen van verdere actie gericht op preventie.

This report presents the results and findings of a detailed source analysis on beach litter that was collected from three locations in West Greenland in September and October 2019: Sisimiut, Qaqortoq and Maniitsoq. The results show that most of the litter is of local origin and can be traced back to outdoor activities such as commercial and recreational fishing and hunting and municipal waste from local communities and settlements. The analysis took place during an interactive Litter-ID session with local stakeholders and experts. Such sessions are intended to create a common understanding of the sources and pathways of beach litter as well as insights into the interaction of such litter with the local environment. This detailed knowledge can then be used as input for further action to prevent future marine littering.

Keywords: Greenland, marine litter, beach litter, beach litter monitoring, plastic soup, ALDFG, fisheries, Litter-ID.

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Cover photo: W.J. Strietman/Wageningen University & Research

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Preface

Plastic marine pollution is a worldwide phenomenon, even in the remote and sparsely populated Arctic. This causes a variety of risks and challenges for marine species, coastal communities and sea-based activities in the region. To mitigate plastic pollution and to find solutions to reduce its harmful effects, a better understanding of its sources and pathways is needed.

At Wageningen University & Research, we believe that a better understanding of the root causes of marine litter and a stronger feeling of ownership paves the way for taking more effective action on local, national and international scales. To achieve this goal, we developed several marine and riverine litter analysis tools. One of these is the interactive 'Litter-ID session'.

In November 2019 such a session was organised in Sisimiut, Greenland. During the session, 315 kg of beach litter that had previously been collected at three locations in West Greenland was thoroughly analysed in collaboration with local and national stakeholders. This session provided in-depth knowledge of the sources and pathways of beach litter in West Greenland as well as recommendations to prevent future marine littering in the region.

We are thankful for the collaboration and support of all the people and organisations involved in this research effort (see also Section 1.4, Acknowledgements). We hope that the findings and recommendations in this report can be used as input to refine and further strengthen ongoing initiatives and policies in Greenland and beyond.

Ir. O. (Olaf) Hietbrink
Business Unit Manager Wageningen Economic Research
Wageningen University & Research

Summary

S.1 Key findings

An in-depth Litter-ID analysis of beach litter collected near three communities in West Greenland (Sisimiut, Maniitsoq and Qaqortoq) showed that almost all litter was of local origin and consisted of everyday use products used in local communities and settlements and of products used during outdoor activities such as fishing and hunting. Examples of such products are not only sanitary toilet bags, longlines, fishing nets, gloves, shotgun shells and outboard engine oil but also the type of everyday products that people would bring along on day trips, such as soft drinks, crisps and biscuits.

The results of the Litter-ID analysis provide additional weight to the findings of the SUMAG project (DCE – Danish Centre for Environment and Energy, Aarhus University), where it was assessed that local sources and not long-range transport of litter items from places much further away, are the main contributors to beach litter in West Greenland.

A few litter items carried animals and plants ('marine fouling organisms') such as moss animals (bryozoans), calcifying tube worms or barnacles. As floating litter may carry such organisms for long distances, there may be a risk to introduce new (non-indigenous) species to these locations. Due to the low numbers of such attached organisms, this risk was considered to be low.

Based on the results of this research, it is recommended to engage with local community and industry representatives and to start a dialogue to better understand a) the local causes of marine littering and b) which solutions could work in the local context. By engaging local community in this dialogue, locally supported solutions can be developed and implemented. Next to this, setting up and/or enhancing educational programmes at the schools could further raise an intrinsic awareness on the benefits of a clean environment and the need for waste collection.

S.2 Methodology

This report presents the results of the Litter-ID session that took place from 11-14 November 2019 in Sisimiut, Greenland. The session was part of the Arctic Marine Litter Project, which is coordinated by Wageningen Economic Research (part of Wageningen University & Research). Activities in the project, including the Litter-ID sessions, are financed by donations and carried out in collaboration with WWF Denmark and local partners.

Litter-ID sessions are designed to support stakeholders by creating a common understanding of the sources and pathways of beach litter and the interaction of such litter with the local environment. This knowledge can be used as input for further preventive action. The method applied combines new and existing beach litter monitoring and environmental impact analysis methods.

During the Litter-ID session in Sisimiut, a source analysis was carried out on 315 kg of beach litter that had been collected in three areas in West Greenland: around Sisimiut (266 kg), Maniitsoq (45 kg) and Qaqortoq (4kg).

- On the first and second days of the session, all items from the three locations were sorted and categorised separately into the 112 OSPAR beach litter item categories.
- On the third day, the stakeholder session took place, to further determine and discuss the sources, pathways and potential solutions.
- On the last day, all items were counted, weighed and photographed.

- The research team also checked each litter item for traces or clues of the interaction of litter items with the local ecosystem. Litter washed ashore can interact with the local ecosystem in various ways. For example, animals can become entangled in debris, swallow the debris, or introduce new species through biological fouling (the accumulation of animals or plants) on floating material. For the purpose of identifying biological fouling species and assessing the presence of fouling species and/or bitemarks, visual observations of litter items were carried out; close-up photos were taken of all items where this occurred.
- After the session took place, the results were entered in datasheets (Excel) for further statistical analyses.

Resumé

S.1 Resultater

En dybdegående analyse af strandaffald fra tre områder i Vestgrønland (Sisimiut, Maniitsoq og Qaqortoq) viste, at næsten al affald kan føres tilbage til lokale kilder. Det analyserede affald bestod af emballage fra dagligvarer, som man kan købe i grønlandske byer og bygder, men også genstande, der ofte bruges ved udendørsaktiviteter så som fiskeri og jagt. Eksempler fra det indsamlede affald er ikke blot sanitære toiletposer, langliner, fiskenet, handsker, patronhylstre og dunke med olie til påhængsmotorer, men også emballage fra læskedrikke, chips og småkager som man gerne tager med på ture i naturen.

Resultaterne fra denne affaldsanalyse er i overensstemmelse med resultaterne i SUMAG-projektet (DCE – Dansk Center for Miljø og Energi, Aarhus Universitet), der peger på, at størstedelen af det strandaffald man finder i Vestgrønland, er fra lokale kilder og ikke er ført hertil med havstrømmene.

Enkelte affaldsprøver var tilgroet med dyr og planter såsom mosdyr, kalkrørsorme eller rurer. Flydende affald kan transportere sådanne organismer over lange afstande, og der kan være en risiko for at introducere nye arter til disse områder. I de indsamlede prøver fandt vi få affaldsfragmenter med tilgroning og vi vurderede på dette grundlag, at risikoen for introduktion af arter med affald ført hertil er lav.

Baseret på resultaterne af dette studie, anbefales det at engagere lokalsamfundene og lokale virksomheder i en dialog for at forstå a) de lokale årsager til at affald ender i havet og b) hvilke løsninger der kan fungere lokalt. Dialogen skal have fokus på at sikre forslag til løsninger, der kan implementeres, fordi de er tilpasset forholdene lokalt, og fordi de allerede nyder opbakning blandt centrale aktører. Sideløbende anbefales det, at der udvikles målrettede undervisningsmaterialer til skolerne for at øge elevernes viden om vigtigheden af et rent miljø og behovet for indsamling af affald.

S.2 Metode

I denne rapport præsenteres resultaterne af den affaldsanalyse (engelsk: Litter ID), der blev gennemført i dagene 11.-14. november 2019 i Sisimiut, Grønland. Affaldsanalysen var en del af "the Arctic Marine Litter Project", der ledes af Wageningen Economic Research (en del af Wageningen University & Research). Aktiviteterne i projektet, herunder affaldsanalysen, finansieres af donationer og gennemføres i samarbejde med WWF Verdensnaturfonden og en række lokale partnere.

Affaldsanalysen har til formål at engagere lokale aktører og skabe en fælles forståelse for de vigtigste kilder til affald i naturen, de bagvedliggende årsager og mulige løsninger. Det er viden, der kan anvendes til at planlægge indsatser, der forebygger affald i naturen. Den anvendte metode kombinerer nye og eksisterende overvågninger af affald på strande og analysemetoder af miljøpåvirkninger.

Som en del af affaldsanalysen blev der foretaget en kildeanalyse af i alt 315 kg strandaffald indsamlet fra tre lokaliteter i det vestlige Grønland: Sisimiut (266 kg), Maniitsoq (45 kg) og Qaqortoq (4 kg).

- De første to dage blev brugt til at sortere og kategorisere det indsamlede affald fra alle tre lokaliteter. Kategoriseringen blev udført i henhold til de 112 OSPAR-kategorier for marint affald.
- På tredjedagen blev lokale aktører inviteret til at deltage i en gennemgang af det sorterede affald med henblik på at diskutere kilder, årsager og mulige løsninger.

- Herefter blev alle genstande optalt, vejet og fotograferet.
- Forskerteamet gennemgik alle affaldsprøver for spor af interaktion med det lokale miljø. Affald, der driver i land, kan interagere med det lokale miljø på forskellig vis. Dyr kan blive viklet ind i affald, de kan indtage mindre stykker af affald og nye arter kan blive introduceret hvis de hæfter sig fast på flydende fragmenter. En visuel gennemgang af affaldet blev gennemført for at identificere biologisk tilvækst og vurdere tilstedeværelsen af nye arter såvel som for at identificere bidemærker. Genstande, der bar spor af interaktion med det lokale miljø, blev dokumenteret med fotos.
- Efter sessionen blev al affaldet registreret i en database (Excel) for videre statistiske analyser.

Eqikkaaneq

S.1 Angusat

Kalaallit Nunaata kitaani sumiiffinni pingasuni (Sisimiut, Maniitsoq aamma Qaqortoq) eqqakkanik sissamiittunik itinerusumik misissueqqissaarinerup takutippaa eqqakkat tamarluinnangajammik najukkaminnganneersuusut. Eqqakkat misissoqqissaarneqartut tassaapput nioqqutit Kalaallit Nunaanni illoqarfinni nunaqarfinnilu pisiarineqarsinnaasut poortuutaat, aammali atortussanik silami sulianut atorneqartartunik, soorlu aalisarnermi aallaaniarnermilu atorneqakkajuttunik ilaqarput. Eqqakkanut katersorneqartunut assersuutissat tassaaginnanngillat anartarfiit puussiartaat, ningittagarsuutit, aalisakkanut qassutit, aaqqatit, imassat puui aquuteralaallu uuliassaannut dunkit, aammali imeruersaatit, naatsiiat panertut kaageeqqallu asimut taquarineqartartut puukui pineqarput.

Eqqakkanik misissueqqissaarinermi matumani angusat suliniutip SUMAG-ip (DCE – Dansk Center for Miljø og Energi, Aarhus Universitet) angusaanut naapertuupput, taakkunani Kalaallit Nunaata kitaani sissami eqqakkat amerlanersaasa najukkameersuunerat imaatalu sarfaanit tamaanga ingerlatitaasimannginnerat tikkuarneqarmat.

Eqqakkat misissugassatut katersorneqartut ataasiakkaat uumasunik naasunillu naggussimasortaqarput, soorlu uumasunik issuatsiarmiunik, qullugissanik kalkrørsorminik kaattungianillu. Eqqakkat tissukartut uumassusilinnik taama ittunik ungasissorsuarmut ingerlaartitsisinnaapput, uumassusillillu nutaat sumiiffinnut pineqartunut anngunneqarnissaannut aarlerinaateqarpoq. Misissugassatut katersorneqartuni eqqakkat ilamerngi naggussimasut ikittuinnaat nassaarivagut, tamannalu tunngavigalugu naliliivugut uumassusilinnik nutaanik imaatigut tamaanga anngussisinnaanerup aarlerinaateqarnera annikitsuaraasoq.

Misissuinermi matumani angusat tunngavigalugit inassutigineqassaaq najukkani inuiaqatigiit najukkanilu suliffeqarfiit oqaloqatigiinnermut akuutinneqassasut makku paasissutissiissutiginiarlugit a) eqqakkat imaanut pisarnerinut pissutaasut najukkaniittut aamma b) aaqqiissutissat suut najukkani atorneqarsinnaanersut. Aaqqissuutissatut siunnersuutit piviusunngortinneqarsinnaasut oqaloqatigiinnermi aallaavigineqassapput, taakku najukkani pissutsinut naleqqussagaammata ingerlatsisullu qitiusut akornanni tapersersorneqareermata. Tamatuma peqatigisaanik inassutigineqarpoq atuarfinnut saaffiginnittunik ilinniartitsinermi atortussanik ineriartortitsisoqassasoq, avatangiisit saligaatsuunissaasa eqqakkanillu katersuisarnerup pingaaruteqassusia pillugit atuartut ilisimasaat annertusarumallugit.

S.2 Periaaseq

Eqqakkanik misissueqqissaarinermi (tuluttut: Litter-ID) Kalaallit Nunaanni, Sisimiuni, 2019-imi novembarip 11-anit 14-ianut ingerlanneqartumi angusat nalunaarusiami matumani saqqummiunneqarput. Eqqakkanik misissueqqissaarineq ”the Arctic Marine Litter Project”-ip ilagaa, Wageningen Economic Researchimit siuttuuffigineqartoq (Wageningen University & Researchip ilaa). Suliniummi matumani suliarineqartut, tassunga ilaalluni eqqakkanik misissueqqissaarineq, aningaasatigut tunissutinik aningaasalersugaavoq Nunarsuarlu tamakkerlugu pinngortitaq pillugu suliniaqatigiiffik WWF najukkamilu suleqatigisat arlallit suleqatigalugit ingerlanneqarluni.

Eqqakkanik misissueqqissaarinerup siunertaraa najukkami ingerlatsisut peqataatilissallugit pinngortitamilu eqqakkanut aallaaviusut pingaarnerit, pissutaasunut tunuliaqutaasut aaqqiissutaasinnaasullu pillugit paaseqatigiinnissaq. Ilisimasat suliniutinik pinngortitami eqqakkanut pinaveersaartitsisinnaasunik pilersaarusiornissamut atorneqarsinnaapput. Periaatsimi atorneqartumi

sissani eqqakkanik nakkutilliinerit nutaat pioreersullu aamma avatangiisinut sunniutaasinnaasunik misissueqqissaarinermut periaatsit ataqatigiissinneqarput.

Eqqakkanik misissueqqissaarinerup ilaatut sissami eqqakkat Kalaallit Nunaata kitaani sumiiffinni pingasuni katersat katillugit 315 kg-t aallaavigisaannik misissueqqissaarineq ingerlanneqarpoq: Sisimiut (266 kg), Maniitsoq (45 kg) aamma Qaqortoq (4 kg).

- Ullut siulliit marluk sumiiffinni pingasuni eqqakkanik katersat immikkoortiternissaannut kategoriserernissaannullu atorneqarput. Kategoriseriineq imaani eqqakkanut OSPAR-kategorit 112-iusut naapertorlugit ingerlanneqarpoq.
- Ullut pingajussaanni najukkani ingerlatsisut eqqakkat immikkoortitikkat misissornissaannut aggersarneqarput, aallaavigisaat, pissutaasut aaqqiissutaasinnaasullu oqaloqatigiissutiginissaat siunertaralugu.
- Tamatuma kingorna katersat tamaasa kisinneqarput, oqimaalutarneqarlutik assilineqarlutillu.
- Ilisimatusartut suleqatigiit eqqakkanik misissugassatut katersat tamaasa misissorpaat sumiiffimmi avatangiisinut sunniivigeqatigiittoqarsimasinnaaneranut takussutissaqarnersoq misissorlugu. Eqqakkat nunamut tipisut sumiiffimmi avatangiisinut assigiinngitsutigut sunniivigeqateqarsinnaapput. Uumasut eqqakkanut napissinnaapput, eqqakkat ilaannik mikisunik nerisaqarsinnaapput uumassusillillu nutaat eqqakkanut tissukartunut nippullutik sumiiffimmut aamma anngussinnaallutik. Eqqakkanik takuinnarlugit misissuineq ingerlanneqarpoq uumassusilinnik naaffigineqarsimasinnaanerat uumassusilinnillu nutaanik takussutissaqarnersut kiggeqarnersullu misissorneqarluni. Sumiiffimmi avatangiisinut sunniivigeqateqarsimanermut takussutissartallit assilillugit uppernarsaasersorneqarput.
- Misissuereernermi eqqakkat tamakkerlugit databasemut nalunaarsorneqarput (Excel) kisitsisitigut paasissutissat atorlugit misissueqqissaareqqittoqarnissaa siunertaralugu.

1 Introduction

1.1 Background

1.1.1 Marine litter and Greenland

Greenland is the world's largest island, located between the Arctic and Atlantic oceans. With a population of only 56,400 inhabitants (Statistics Greenland, 2020), it is one of the least densely populated regions in the world. Even though the population density is relatively low, human influence is visible along most of the shoreline: many beaches are covered in marine litter, which ended up there after having been brought by wind, waves and ocean currents.

1.1.2 Risks to the local environment

The presence of plastics in the Greenland environment poses a direct threat to wildlife. Animals of all sizes, ranging from the tiniest species of zooplankton to the largest species of whales, can be affected. Smaller pieces of plastic can be ingested, pieces of rope and netting can cause entanglement of bird and mammal species. Bio-accumulation and bio-magnification of toxics can occur, either being released from plastic items or adsorbed and accumulated on plastic particles. Fouling organisms which attach themselves to floating pieces of litter such as algae or barnacles that do not naturally occur in the area can be transported via ocean currents from faraway places and disrupt the local food web. Marine litter may also damage benthic habitats and communities (Werner et al., 2016; Vlachogianni et al., 2018; Thiel et al., 2018; Van den Heuvel-Greve et al., 2021; Ladewig et al., 2021).

Figure 1.1 *Arctic wildlife affected by marine litter*
Photos: Sysselmannen (left) & W.J. Strietman (right).

1.1.3 Threats to economic activities and human well-being

Lost or abandoned fishing nets may directly affect local fisheries. Ghost fishing by gillnets and longlines can affect commercial fish stocks, impacting the livelihoods of fishermen. Fishing gear can

also get stuck in old nets on the sea floor. In Greenlandic there is even a word for areas where fishers may risk getting their long lines stuck in old nets on the sea floor: 'nassinartut'.

Certain marine litter items, especially nets, ropes and strapping may also pose a serious safety risk to ships and their crews because such items can get caught up in ships' propellers. Such safety risks are even higher in the Arctic, an area with very limited means of communication or safety and rescue capacity. This not only poses a risk to human safety but also to wildlife: such an accident might result in a ship running aground and leaking oil. In addition to this, tourism may be affected by the off-putting sight of littered beaches in these otherwise pristine areas.

1.1.4 Taking action: preventing plastics from entering the Arctic marine ecosystem

Societies throughout the Arctic, including Greenland, are demanding solutions to stop and reverse the trend of increasing litter in their environment. Many citizen groups, governments, industries and NGOs are taking initiatives to address this challenge, for example by cleaning up beaches or addressing waste management practices.

At the international level, the Arctic Council is addressing the issue of marine litter in the Arctic by working on a Regional Action Plan to combat marine litter in the Arctic (PAME, 2019) and initiating the Protection of the Arctic Marine Environment (PAME) Working Group on Marine Litter. Marine litter has also become a focus of other international organisations such as OSPAR[1], the IMO[2], the EU[3] and the FAO[4].

In recent years, Greenland has also seen a steady increase in societal and political awareness on the issue of plastics in the environment. Local community-based efforts, scientific research, NGO-led projects, industry efforts and municipal and national government actions have so far all contributed to a higher awareness and more effective actions to tackle this issue. This culminated in the development of two new government action plans addressing the use of plastic and lost fishing gear in 2020 (Naalakkersuisut, 2020a; Naalakkersuisut, 2020b).

1.1.5 Setting the diagnosis: beach litter monitoring efforts in Greenland

As marine litter is a by-product of human behaviour – processes and actions taken either on land or at sea – an effective way to prevent plastics from ending up in the sea is to address the root causes. Such preventive action is only possible if it is known what and who to address. Beach litter monitoring can provide valuable data on the amount and composition of (floating) marine litter.

The internationally applied OSPAR Beach Litter Monitoring Guideline (OSPAR, 2010) is one of the most detailed beach litter monitoring protocols currently being applied throughout the North Atlantic Arctic. It provides insight into the amount and composition of beach litter, using a fixed set of 112 beach litter item categories. The OSPAR protocol does have its limitations though: registration of the weight, information on the origin, sources and pathways of litter ending up in the sea is not part of the protocol. Such in-depth information can be used to provide a better understanding of the sources and pathways of beach litter and in this way provide the building blocks to develop effective solutions.

In Greenland, a slightly adapted version of the OSPAR protocol that also includes subcategories for 'typical' Greenland items (e.g. melted pieces of plastic, detonation cords and sanitary toilet bags) has been applied as part of the Survey of Marine Litter in Greenland (SUMAG) project since 2016. The SUMAG project is coordinated by Aarhus University in collaboration with Pinngortitaleriffik/Greenland Institute for Natural Resources and individuals living in communities throughout Greenland.

[1] https://www.ospar.org/work-areas/eiha/marine-litter/regional-action-plan
[2] http://www.imo.org/en/MediaCentre/PressBriefings/Pages/20-marinelitteractionmecp73.aspx
[3] https://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/index_en.htm
[4] http://www.fao.org/3/i0620e/i0620e00.htm

The SUMAG monitoring activities include 1–2 yearly surveys at 10 shoreline locations in West Greenland, all chosen for being located facing the sea at some distance to (and potentially under less influence from) local communities and settlements. This also includes two outer shoreline locations in the Sisimiut region. Within the SUMAG project, a slightly extended version of the OSPAR list of category items is applied including for instance subcategories for 'typical' Greenland items (e.g. melted pieces of plastic, detonation cords and sanitary toilet bags). Especially in 2016, the first year with surveys, the origin of collected litter items was a special focus of the project, with the aim of assessing to which extent local sources contributed to the litter on the shorelines. After 2016, as part of the survey protocol, the origin has not routinely been recorded any more (Strand et al., 2018 & Strand, 2020 pers. comm.).

As a result of these monitoring efforts, the SUMAG project has gained important insights into the type, amount, composition and general sources of beach litter present around Greenland's coast and the general sources that contribute to this (Strand et al., 2018 & Strand, 2020 pers. comm.). However, more in-depth information on the specific origin of litter items is not systematically registered in the SUMAG project. Such information is highly relevant to assess the major sources of litter in Greenland.

1.1.6 The Arctic Marine Litter Project

A better understanding of the sources and pathways of beach litter can provide the building blocks to target the root causes. In order to develop such in-depth knowledge, the Arctic Marine Litter Project was initiated in 2017 by Wageningen University & Research in collaboration with Leeways Marine. The goal of the Arctic Marine Litter Project is to engage and support stakeholders in the Arctic by creating a better understanding of the sources, pathways and solutions to beach litter as well as insights into the interaction of such litter with the local environment. Such detailed knowledge is aimed to supplement ongoing beach litter monitoring efforts and could be used by stakeholders in the Arctic to refine ongoing actions or measures and/or develop new ones. In return, such actions and measures could benefit economic activities, human well-being and biodiversity in the region.

To achieve this goal, key elements in the Arctic Marine Litter Project are 1 – beach litter collection; 2 – Litter-ID sessions and 3 – sharing the results (Figure 1.2).

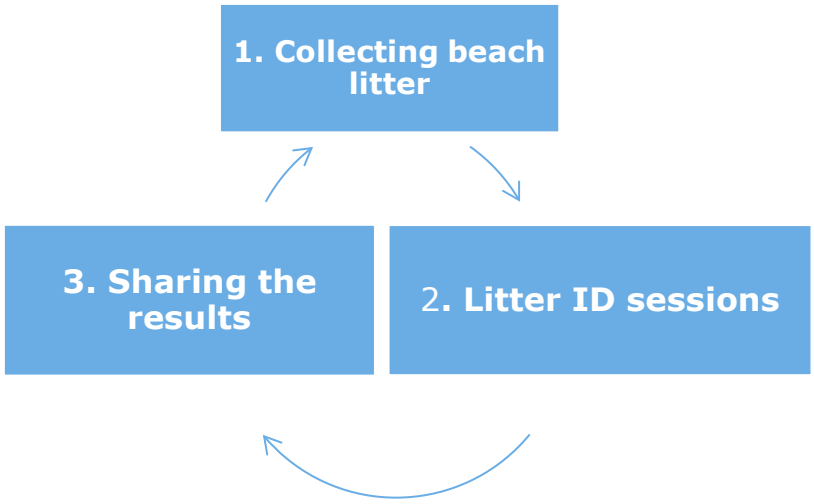


Figure 1.2 *The three-step approach of the WUR Litter-ID methodology*
Source: Wageningen Economic Research, 2020.

The heart of the methodology is formed by so-called Litter-ID sessions, in which new and existing beach litter monitoring and environmental impact analyses methods are combined (Strietman et al., 2020). It applies extensions to the standardised OSPAR beach litter characterisation method, in order to gain as much additional knowledge as feasibly possible on locally collected beach litter. During those sessions, local stakeholders are actively engaged in the analysis and discussion of such litter in

order to create a common and deeper understanding of its sources, pathways and solutions as well as insight into the interaction of such litter with the local environment. This knowledge can then be used as input for further preventive action on the local, national and international scales (e.g. the Arctic Council, the IMO and OSPAR).

The Arctic Marine Litter Project is carried out by a multidisciplinary team of researchers from different research institutes within Wageningen University & Research (WUR), that works together with researchers, industry representatives, policymakers and other stakeholders throughout the Arctic region. Since the start of the project in 2017, we have so far focused our efforts on Svalbard, Jan Mayen, Iceland and Greenland. Our ambition is to expand our activities to the Faroe Islands and the North Atlantic Arctic regions of Canada and Russia.

1.1.7 Feasibility trip to Nuuk, Greenland, May 2019

In May 2019, Wouter Jan Strietman (Wageningen Economic Research) was invited by WWF Denmark (Mette Frost, Kaare Winther Hansen) to travel to Nuuk, Greenland to assess whether local stakeholders would be interested in bringing the Arctic Marine Litter Project to Greenland. Together they engaged with government officials, industry and scientists to assess the interest into further collaboration on this topic. They also conducted a preliminary assessment of the type and sources of beach litter around the capital of Nuuk.

The team was met with an open approach to discussing national sources of marine litter and the potential reasons behind it: challenges with local waste management, lack of sewage treatment but also human behaviour in relation to waste and the producer's responsibility.

Based on the outcomes of that initial trip and additional conversations with local and national policymakers, scientists from Aarhus University, Pinngortitaleriffik / Greenland Institute of Natural Resources and potential funders afterwards, it was concluded that there was both an interest and sufficient financial support to carry out a Litter-ID session in November 2019. Such an in-depth analysis of beach litter was thought to provide valuable additional data to the ongoing beach litter monitoring efforts throughout Greenland carried out in the SUMAG project.

1.2 Aim

The aim of this report is to present the results of the Litter-ID session that took place from 11–14 November 2019 in Sisimiut, Greenland. The aim of the session was to provide local and national stakeholders with a better understanding of the sources and pathways of beach litter as input for further preventive action. The findings presented in this report will be shared with stakeholders in Greenland and will also feed into the work of the Arctic Council PAME Working Group.

1.3 Reading guide

In Chapter two we describe the method applied to collect and analyse the beach litter from three locations in West Greenland. In Chapters 3, 4 and 5 we present the results of these analyses. In Chapter 6 we reflect upon the results and put them into perspective. In Chapter 7 we summarise the main conclusions and provide recommendations.

1.4 Acknowledgements

There are several people without whose help and support the organisation of the session would not have been possible. Firstly, we would like to thank Mette Frost (WWF Denmark) for her help in reaching out to the stakeholders in Greenland, coordinating the logistics and co-organising the session in Sisimiut together with the research team. We are also very grateful to Katinka Skovgaard,

Christina Natalie Kompf and their colleagues from Qeqqata Municipality in the Technical and Environmental Department and Nikolaj Salomonsen and his team at Sisimiut Waste Management Facility for their participation and support. For the collection and shipment of beach litter from Qaqortoq we would like to thank Kathrin Grundmann and the students from Campus Kujalleq. For the collection and shipment of litter from Maniitsoq we would like to thank the anonymous beach litter collector. We would also like to express our gratitude for the participation of Andreas Haugaard of the Greenland Ministry of Science and Environment, Mette Noort Hansen from KTI Sisimiut and Lars Thomassen from Qalut Vónin and Anna Marie Plejdrup from Aarhus University in the Litter-ID session.

The activities in Greenland are part of the Arctic Marine Litter Project, which is part of the WUR Fundamental Change campaign. Fundamental Change is a campaign intended to raise funds for 15 research projects that stand out for their relevance to the United Nations' Sustainable Development Goals (SDGs). Projects that are part of the Fundamental Change Campaign are funded by donations through the University Fund Wageningen (UFW). The activities in Greenland have been made possible with donations by the World Wide Fund for Nature (WWF the Netherlands and WWF Sweden). the Circumpolar Conservation Union, the Dutch Ministry of Foreign Affairs, DANCEA (Denmark) and the Dolfinarium (the Netherlands), for which we are very grateful.

2 Methodology and approach

2.1 Introduction

In November 2019, Wageningen University & Research in collaboration with WWF Denmark organised a Litter-ID session in Sisimiut, Greenland. During the session, beach litter was analysed together with local and national stakeholders that had been collected at three different locations in West Greenland. In this chapter, we discuss the collection process and the method applied in the Litter-ID session to analyse this litter.

2.1.1 Beach litter collection and sample size

The basis of the Litter-ID session was formed by a substantial amount of beach litter that had been collected near Sisimiut, Maniitsoq and Qaqortoq, West Greenland, in the months leading up to the session (Figure 2.1).

Figure 2.1 *Locations of the beaches where litter was collected as input for the Litter-ID session Illustration: Wageningen University & Research; map: Google Maps.*

In the sections below, we describe where and how the litter was collected in each of the three locations and which parts of it were used for the Litter-ID analysis in Sisimiut.

2.1.2 Sisimiut (Amerloq Fjord)

During the summer of 2019 our collaboration partner, WWF Denmark, was informed of a large beach clean-up that was planned in Amerloq Fjord. The fjord is located just south of Sisimiut and stretches approximately 36 km inland, where the small settlement of Sarfannguit is located. Amerloq Fjord is part of the newly established UNESCO world heritage site 'Aasivissuit – Nipisat. Inuit Hunting Ground between Ice and Sea' (UNESCO, 2018). The clean-up was organised by Qeqqata Municipality with funding from the Government of Greenland Environmental Fund.

It was known that large amounts of litter were present in the fjord and a beach clean-up had never taken place in the area before. The purpose of the Qeqqata Municipality clean-up was to remove as much litter as possible from the fjord and get an initial understanding of the type and amount of litter present in the area (a beach litter analysis was not part of the original plan). During the two-week operation, 4,200 kg of beach litter was collected by Qeqqata Municipality, the Technical and Environmental Department and the team at Sisimiut Waste Management Facility. Not all beaches that were originally planned to be cleaned up could be visited simply because there was far more beach litter than had been anticipated or planned for. The clean-up effort provided Qeqqata Municipality with a general insight into the type and amount of litter that can be found along the shoreline of a fjord not previously cleaned, but also with experience in organising a clean-up under difficult conditions, e.g. clean-up on shorelines covered by rocks or no opportunity to bring a boat safely to shore.

In the run-up to the clean-up, WWF Denmark and the research team contacted Qeqqata Municipality and offered to conduct a Litter-ID analysis on the litter to determine the sources, origin and underlying reasons why this litter ended up in the fjord. Initially, the municipality did not plan to conduct an analysis of the collected litter, but by hearing about the offer, they became aware of the opportunity to gain more insight into the sources and origin of beach litter in the area.

Such information would be helpful in the light of the focus of the municipality's actions for a cleaner city and surroundings and to provide locals and tourists with a better experience when living and travelling in and around the municipality.

Qeqqata Municipality offered its help in transporting litter from the local waste management facility where all the collected litter was stored to the location of the Litter-ID session and also participated in the Litter-ID session.

Figure 2.2 *Photos taken during the beach clean-up of Amerloq Fjord, September 2019*
Photos: Qeqqata Municipality.

A total of 4,200 kg of litter was collected from the beaches of Amerloq Fjord. All the collected beach litter was then stored in bulk waste bags at the local waste management facility.

Due to the large amount of litter collected at Sisimiut and the limited time and space available during the Litter-ID session, the total amount that could be analysed had to be limited. For this purpose, we initially inspected the contents of each bulk waste bag that was stored at the local waste management facility. On site, we selected the bags that we would take to the location of the Litter-ID session for further analysis. The decision was made to select only those bags that contained a relatively large number of beach litter items and trawl nets (Figure 2.3).

Figure 2.3 *Selection of bulk waste bags and transportation from the waste management facility Photos: W.J. Strietman.*

During the selection process, bulk waste bags with only a few (mostly larger and often difficult or dangerous to handle items) items were avoided except for those with trawl nets. Quite a number of these bags contained tangled gillnets. After we heard from the team members involved in the clean-up that a few of those gillnets had most likely been left behind on shore by fishers, we realised that it would be hard to distinguish between gillnets that were intentionally left behind and those that were lost at sea and were washed ashore. Therefore, it was decided to leave gillnets out of the analysis. During the clean-up, a total of 160 fish boxes had also been collected. For practical reasons, these were also not taken to the location of the Litter-ID session but were counted at the waste management facility (Figure 2.4).

Figure 2.4 *Fish boxes stored at the waste management facility Photo: E. Leemans.*

Because of the choices that were made to select the sample bags, the total sample was not representative of all litter collected. We believe however, that the sample taken for analysis is representative for the smaller items due to the high number of items.

Figure 2.5 shows the proportions and total amount of litter collected during the clean-up and the sample size of items that were further analysed during the Litter-ID session.

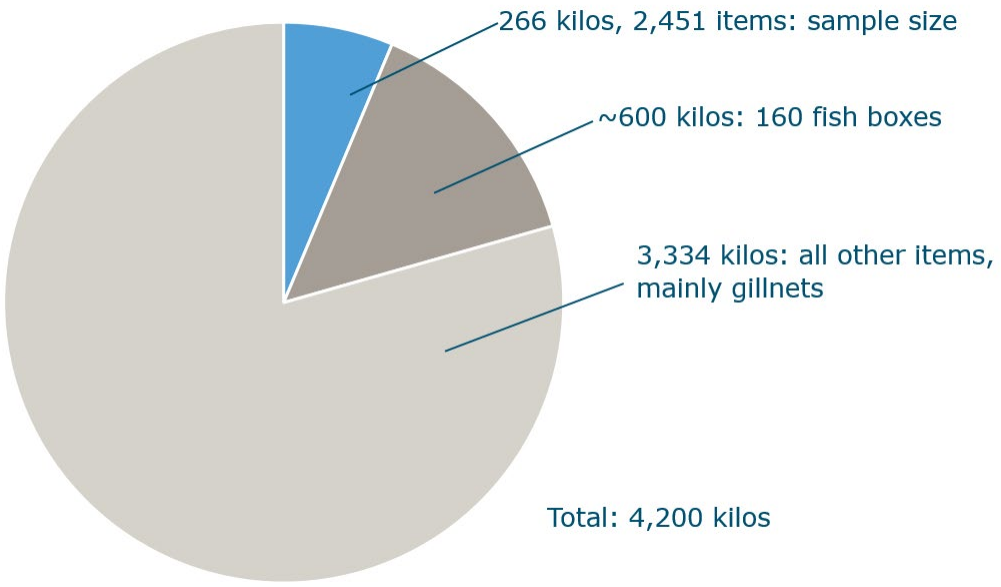


Figure 2.5 *Proportion and weight of collected litter types and the subsample size selected for analysis*
Source: Wageningen Economic Research, 2020.

2.1.3 Maniitsoq

The Maniitsoq beach litter was collected from four beaches facing the open water of the ocean, by a local fisherman who is also involved in the collection of beach litter for the SUMAG project. In total, 45 kg was collected from all four beaches. After the collection, the litter was shipped to Sisimiut and made part of the Litter-ID analysis.

Figure 2.6 *Photos taken during beach clean-ups of three locations southeast of Maniitsoq, October 2019 (lower and upper left, upper right), the beach litter collection locations (lower right) Photos: Reproduced with kind permission of the (anonymous) photographer.*

2.1.4 Qaqortoq (Igalikup Fjord)

To supplement beach litter data from Amerloq Fjord and Maniitsoq, students from Campus Kujalleq in Qaqortoq were involved with collecting litter on beaches in Igalikup Fjord, which is a sheltered inland fjord east of Qaqortoq on the southwestern tip of Greenland. In total, they collected 3 kg of beach litter at two different locations; a location within the UNESCO World Heritage Site of Kujataa and a location immediately south of here (UNESCO, 2021). The litter was then shipped to Sisimiut and made part of the analysis.

Figure 2.7 *Photos taken during beach clean-ups of three locations at Igalikup Fjord, September 2019 (upper left and right), the beach litter collection locations (lower left) and the litter being sorted by students at Campus Kujalleq (lower right)*
Photos: Campus Kujalleq.

2.2 Litter-ID session: in-depth analysis of beach litter

2.2.1 Introduction

From November 11–14 2019 a Litter-ID session was organised in Sisimiut. During those days, the litter that had previously been collected from beaches around Sisimiut, Qaqortoq and Maniitsoq was analysed. The aim of the session was to provide local stakeholders with a better understanding of the origin, sources and pathways of this litter into the marine environment as a basis for further action to prevent future marine littering in the region.

The method applied during a Litter-ID session combines new and existing beach litter source analysis and environmental impact analysis methods. It applies extensions to the standardised OSPAR beach litter characterisation method to gain as much additional knowledge as feasibly possible on the sources and pathways of beach litter as well as insight into the interaction of such litter with the local environment. During the session, stakeholders are actively engaged in the analysis process in order to create a common and deeper understanding of its sources, pathways and solutions.
In the sections below we discuss the method in further detail.

2.2.2 Stakeholder engagement

Litter-ID sessions are interactive sessions in which the research team of Wageningen University & Research (consisting of social and environmental scientists and biologists), together with experts and representatives from sector organisations, government, environmental organisations and other (local or national) stakeholder groups, collectively analyse a large amount of previously collected beach litter in detail on several aspects and discuss the results.

By actively involving local and national stakeholders in the analysis, the aim is to create a higher awareness and better understanding of the origin, sources and pathways of litter into the marine environment, as well as a stronger sense of common ownership and responsibility, paving the way for creating more effective and targeted measures.

The method to carry out an in-depth analysis of previously collected beach litter with local stakeholders is inspired by the 'deep dive' method developed by SALT (Norway), with whom the research team collaborated on Svalbard in 2017 and 2018 (Falk-Andersson & Strietman, 2019).

2.2.3 Participants of the Litter-ID session

The following people took part in the session (in alphabetical order):
- Lis Bach (Aarhus University – SUMAG Project)
- Anneke van den Brink (Wageningen Marine Research – Litter-ID research team)
- Mette Frost (WWF Denmark)
- Andreas Haugaard (Government of Greenland, Ministry of Science and Environment)
- Martine van den Heuvel-Greve (Wageningen Marine Research – Litter-ID research team)
- Eelco Leemans (Leeways Marine – Litter-ID research team)
- Mette Noort Hansen (KTI Sisimiut / local SUMAG coordinator)
- Anna Marie Plejdrup (Aarhus University – SUMAG project)
- Nikolaj Salomonsen (Qeqqata Municipality, Forbrændingen. Coordinator of the beach clean-up in Amerloq Fjord)
- Katinka Sif Skovgaard (Qeqqata Municipality, Teknik og Miljøforvaltningen)
- Wouter Jan Strietman (Wageningen Economic Research – Litter-ID research team)
- Lars Thomassen (Qalut Vónin Sisimiut)

As part of the planning process of the process, WWF Denmark had an important role in identifying and contacting key stakeholders and invite them to participate in the Litter-ID session.
Wouter Jan Strietman of Wageningen University & Research coordinated the session and the analysis of the results.

2.2.4 Sorting and categorising

On the first day of the session in Sisimiut, the research team together with several of the participants sorted the beach litter items into the litter categories used in the internationally recognised OSPAR Beach Litter Monitoring Guideline (OSPAR, 2010) (see Figure 2.8) for each of the three locations. By applying the OSPAR categorisation to sort and count the litter, the results of the analysis can later be compared with ongoing monitoring actions in the region.

OSPAR ID	Unep ID	Items	Total
29		Oyster trays (round from oyster cultures)	
30		Plastic sheeting from mussel culture (Tahitians)	
31		Rope (diameter more than 1 cm)	
32		String and cord (diameter less than 1 cm)	
115		Nets and pieces of net < 50 cm	
116		Nets and pieces of net > 50 cm	
33		Tangled nets/cord/rope and string	
34		Fish boxes	
35		Fishing line (angling)	

Figure 2.8 *A selection of litter item categories in the OSPAR Beach Litter Monitoring Guideline Source: OSPAR, 2010.*

During the sorting procedure, all items belonging to the same OSPAR category are placed together on the floor or on a table. By clustering items together, patterns emerge that would otherwise go unnoticed (Figures 2.9 and 2.10).

Figure 2.9 *Sorting of beach litter items into one of the 112 OSPAR litter item categories Photo: A. van den Brink.*

Figure 2.10 *All items sorted into OSPAR beach litter item categories*
Photo: A. van den Brink.

2.2.5 In-depth analysis of items within each OSPAR category

Litter-ID goes further where the OSPAR beach litter monitoring protocol stops: items within each OSPAR category are further analysed to obtain as much information as possible on the sources and the underlying causes (pathways) of why those items ended up in the sea and of the interaction of items with the marine and coastal environment (e.g. bite marks, fouling). The Litter-ID method therefore adds several analysis and registration steps:

1. Adding subcategories to several OSPAR categories, in order to provide more insight into the exact composition of these categories
2. Registration of the origin of each item or item subcategory
3. Registration of the source of each item or item subcategory
4. Registration of the weight of each category and subcategory
5. Specific analysis of fishing nets (see section below)
6. Registration of signs of interaction with the local environment
7. Taking samples of fouling (attachment of plants and animals) for eDNA analysis

The additional analysis steps are detective work and often a challenge because it is not always clear what the origin or source of the beach litter is. This is, however, why the involvement of local stakeholders is crucial to the process: they might recognise items and their (local) use based on external characteristics, label texts or other recognisable clues.

As a first step in the analysis process, the group of participants is divided into smaller groups, each of which is assigned one or more OSPAR categories to perform additional sorting of items based on the type of item and origin. Consider, for example, the subcategory ‘cola bottles’ within the ‘plastic bottles’ category or a subcategory based on where an item was most likely sold (based on inscriptions and/or other clues).

The second step in the analysis procedure is a group discussion about items in each OSPAR category (Figure 2.13). This step provides a bird’s eye view of all litter items combined and in relation to each

other. As such, it provides additional understanding on the sources and/or origin of clusters of items. This diagnosis helps in showing the way forward in terms of action or who to involve in this.

Figure 2.11 *Discussing the results*
Photo: A. van den Brink.

2.2.6 Using the Fishing Net Assessment Protocol to further analyse fishing nets

In order to obtain a better understanding of the (geographical) origin, sources (type of fisheries involved) and underlying causes (pathways) of why fishing nets end up on beaches, a specific protocol was used: the Fishing Net Assessment Protocol. This protocol was developed by Wageningen Economic Research and has been applied in the North Atlantic region since 2017 (Strietman, 2021).

The Fishing Net Assessment Protocol was designed with the purpose of obtaining as much information on beached fishing nets as feasibly possible. The combination of both quantitative and qualitative elements in the examination procedure is intended to provide a better understanding of the sources, origin and pathways of such nets. Using the protocol, each net is examined in a consistent and systematic way, which makes the results comparable.

This type of analysis helps in answering the question of whether the net was used in local fisheries or whether it arrived in the area from much further away through ocean currents. It also helps to answer the question of whether it is a current or historical issue (judging by the age of the net), the type of fisheries involved and its origin (e.g. mesh size) and determining whether the net had been accidentally torn off while fishing, or cut out of a replacement or an in-use net for repair (based on an examination of tearing and cutting marks).

Each examination is carried out by a researcher from Wageningen Economic Research together with a (local) fishing gear expert and/or expert with a background in fishing. For the interpretation part of the analysis, the involvement of such experts has shown to be of crucial importance.

As mentioned in Section 2.1.2, all gillnets were left out of the analysis due to representational issues. In that way, the results presented in this report may not be fully representative of all larger fishing nets that end up on beaches (other than having been intentionally left behind, such as some gillnets) in West Greenland, but are close to it. In terms of trawl nets, we feel that the results are as close to a representative sample as was feasibly possible given the low number of nets involved.

The analysis protocol for nets > 50 cm is divided into two analysis steps: a quantitative assessment and a qualitative assessment.

As a first step, each fishing net is untangled and stretched out on the floor. The untangling of each net is a crucial step, because only then it becomes possible to conduct an extensive analysis of the source, origin and pathway of each net. After untangling a net, the following quantitative aspects are measured and registered:

- The length and width (total size registered in one of six size classes);
- The weight;
- The mesh size;
- The number of pieces within the net (a net can consist of different pieces joined together sometimes consisting of different mesh sizes);
- The level of wear of the material including the number of tear holes in the net; and
- The presence and type of cut and/or tear marks on each side of the net including:
  - Cut marks made with a certain pattern along the side of the net that have been made to cut a net into the right shape before use;
  - Cut marks that are the result of having cut-out a piece of fishing net during repairs (replacing a torn or worn out piece); and
  - Tear marks that show an irregular pattern, typical of wear and tear.

Figure 2.12 *Assessing the sides of the net*
Photos: A. van den Brink.

For the second qualitative step, the results are interpreted with the help of a (local) fishing gear expert and/or expert with a background in fishing to determine:

- The most probable fishing sector involved (based on the type of fishing net and mesh size);
- The area where such fishing nets are being used (also based on the type of fishing net and mesh size);
- The age of the net: less or more than five years;
- The reason for the net sample to have ended up in the sea as follows::
  1. Accidental loss (after being entangled, for example on the seabed);
  2. Mismanaged net waste:
     a. Pieces of net that are damaged through regular wear and tear or by accident are cut from the rest of the net. Usually but not always (if the remaining damaged area is very small) the net is mended with new netting material. The net is mended by joining new pieces to the

net. If the net cutting is then not properly collected and stored, it may end up in the sea. Mismanaged net waste can therefore be caused by unintentional or intentional discarding (d'Arcy Metcalfe & Bentley, 2020).

b. Additionally, after replacement of a broken or worn piece of fishing net with new netting material, there could be 'leftovers' on the new roll of net. These leftovers may then not be collected and properly stored and end up in the sea, again due to unintentional or intentional discarding.

The results of the quantitative and qualitative assessments are registered in an excel database. A photo is taken of each untangled net for further reference.

2.2.7 Additional analysis of items that show signs of species interaction

Along with the source analysis together with the participants of the Litter-ID session, the research team also checks each litter item for traces or clues on the interaction with the local ecosystem. Litter washed ashore can interact with the local ecosystem in various ways. For example, animals can become entangled in debris, swallow the debris, or introduce new species through fouling on the floating material (e.g. Van den Heuvel-Greve et al., 2021) (see Figure 2.13).

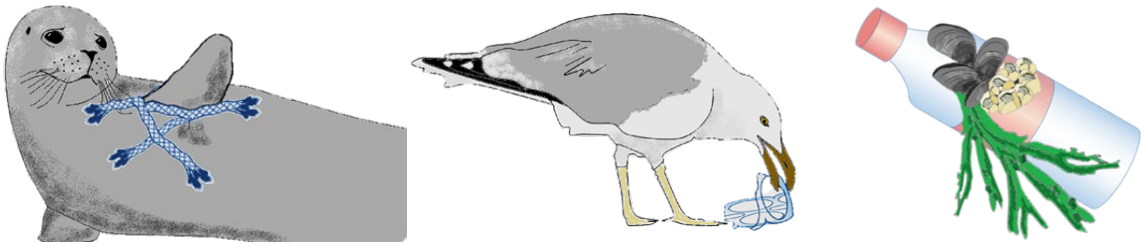


Figure 2.13 *Three ways in which marine litter can affect the ecosystem: entanglement (left), ingestion (centre) or the introduction of new species through fouling (right)*
Illustration: Anneke van den Brink – Wageningen Marine Research.

For the purpose of assessing the presence of fouling species and/or bite marks, visual observations of litter items are carried out; close-up photos are taken of all items where this occurs (Figure 2.14). As the beach litter was stored for two months prior to analysis, no further taxonomic identification of the species could be conducted as no fresh eDNA samples could be taken.

Figure 2.14 *Biological fouling (left) and bite marks (right) on plastic items collected during the beach clean-up*
Photo: A. van den Brink.

2.2.8 Counting, weighing and registration of the results

As the final step of the analysis, after the group discussion and species interaction analysis takes place, all items within OSPAR categories and additional Litter-ID subcategories are counted, weighed, registered and photographed.

Please note that in all major beach litter monitoring protocols (e.g. OSPAR, UNEP), items that belong to a certain category are counted as such, whether the item is still intact or not. This is also the way in which items are counted during a Litter-ID session, but it is good to keep this principle in mind when reading the results.

2.2.9 Sharing the results with (inter)national stakeholders and the public

The ultimate aim of the Arctic Marine Litter Project is to provide local and regional actors (e.g. local and national authorities, industry groups, citizen groups and NGOs) with management relevant data and information tailored in such a way that it can be used by stakeholders to take targeted action to address the issue of marine litter in the Arctic.

Along with direct stakeholder interaction and sharing the results during and after Litter-ID sessions, we intend to provide the results of the project as input to several ongoing policy, industry and research initiatives to combat marine litter in the region such as the Qeqqata Municipality, the Government of Greenland, WWF Denmark, the SUMAG project, the Arctic Council (PAME), the IMO, OSPAR and others.

3 Litter-ID results Sisimiut

3.1 Introduction

For Sisimiut, the sample size was 2,451 items in total, with a combined weight of 266 kg. Tables 3.1 and 3.2 provide an overview of the ten main litter item categories in terms of numbers and weight.

Table 3.1 *The ten litter categories with the largest number of items*

OSPAR category type	Number of items	Share (%)
1. Industrial packaging, plastic sheeting	753	31%
2. Crisp/sweets packets and lolly sticks	228	9%
3. Shotgun cartridges	189	8%
4. Bags (e.g. shopping)	144	6%
5. Food containers incl. fast food containers	112	5%
6. Gloves (industrial/professional gloves)	107	4%
7. Drinks (bottles, containers and drums)	105	4%
8. String and cord (diameter less than 1 cm)	99	4%
9. Engine oil containers and drums	57	2%
10. Caps/lids	54	2%
Other category items	603	25%
Total	**2451**	**100%**

Source: Wageningen University & Research, 2020.

Table 3.2 *The litter categories with the largest weight*

OSPAR category type	Weight (kg)	Share (%)
1. Nets and pieces of net > 50 cm	154.74	38%
2. Industrial packaging, plastic sheeting	34.97	13%
3. Bags (e.g. shopping)	20.97	8%
4. Floats/buoys	15.1	6%
5. Plastic/polystyrene pieces 2.5–50 cm	10.95	5%
6. Textiles	10.51	4%
7. Rope (diameter more than 1 cm)	10.06	4%
8. Jerry cans	9.39	4%
9. Engine oil containers and drums	7.23	3%
10. Buckets	6.59	2%
Other category items	6.17	13%
Total	266	100%

Source: Wageningen University & Research, 2020.

In the sections below, we provide more information on items in each of the major categories, based on the source analysis carried out during the Litter-ID session.

3.2 Consumer waste

One of the largest source categories of beach litter collected near Sisimiut was consumer waste. Many items within this type of litter contain inscriptions that make it relatively easy to determine where they were produced or where they came from. The main categories within this source category are plastic bags, plastic food packaging, bottles and sweets packaging. We discuss these categories one by one below. We then provide information about items that were found in smaller numbers but which, in conjunction with the other items, provide some insight into the major sources of beach litter that end up on beaches in the area south of Sisimiut.

3.2.1 Plastic bags

As part of the Litter-ID protocol, items within the OSPAR category 'plastic bags' were further divided into 'shopping bags' and 'sanitary toilet bags'. In total, these two subcatregories contained 144 items with a total weight of 21 kg. This is 6% of the total items and 8% of the total weight of the sample of collected beach litter.

The reason for adding the subcategory 'sanitary toilet bags' was the exceptionally large number of (parts of) such bags (63 in total) within the 'plastic bags' category (Figure 3.1).

Figure 3.1 *Sanitary toilet bags collected during the beach clean-up*
Photo: W.J. Strietman.

According to participants of the Litter-ID session, such bags likely originate from houses in the settlement of Sarfannguit and perhaps from smaller cabins around the fjord. All of these houses and cabins do not have plumbing, so people use plastic bags instead. Then it is the responsibility of the owners of such houses and cabins to take the filled bags back to Sisimiut or Sarfannguit to be handled at the local waste management facilities. Any sanitary toilet bags used in houses or cabins that have not been taken back or have been left at local waste dumps could be be blown into the sea by the wind or be dumped into the fjord. Sanitary toilet bags left outside by hunters or fishers may have been left where they were used and then also blown into the sea by the wind.

Of the 81 shopping bags, 35 contained logos or text that made it possible to determine the most probable origin. After careful analysis and consultation with local experts, all 35 bags were determined to be of local or perhaps regional origin (Figure 3.2); none were foreign.

Figure 3.2 *Plastic shopping bags*
Photo: M. van den Heuvel-Greve.

3.2.2 Plastic food packaging, crisps and sweets packages

In this section we discuss both the OSPAR categories 'food packaging' (112 items, 1.86 kg) and 'crisp/sweets packets and lollypop sticks' (228 items, 0.39 kg). According to the Litter-ID protocol, items in both categories were further divided into several subcategories based on whether larger clusters of items could be identified within these two OSPAR categories. As a result, the 'food container' category included six subcategories such as sauce bottles, meat containers and other types of food containers. The 'crisp/sweets packets and lollypop sticks' category was also subdivided into 'biscuits, cakes and nuts' packaging, crisps packaging, sweets packaging and miscellaneous packaging.

Text was printed on 41 items (36%) within the plastic food container category, which made it possible to determine in which country these products were produced and where it was likely to have been sold. Out of the 41 items, 40 (98%) had Danish texts and one a foreign text. All items within the 'crisp/sweets packets and lollypop sticks' category had Danish texts printed on them. After careful analysis and consultation with local experts, it was determined that all the items with Danish texts were of local or regional origin as these products are all sold in the local supermarkets and supply stores.

Miscellaneous food packaging

Crisps packaging

Biscuits, cakes and nuts packaging

Sweets packaging

Figure 3.3 *Plastic food packaging, crisps and sweets packages*
Photos: M. van den Heuvel-Greve.

3.2.3 Plastic bottles

In this section we discuss four related OSPAR categories related to plastic bottles:

- Drinks (bottles, containers and drums): 105 items, 5.9 kg
- Cleaner (bottles, containers and drums): 28 items, 2.19 kg
- Toiletries (bottles and containers e.g. sun lotion, shampoo, shower gel, deodorant): three items, 0.2 kg
- Caps/lids: 54 items, 0.47 kg

These items together make up 8% of the total number of items in the sample and 3% of the total weight.

According to the Litter-ID protocol, items in all four categories were further divided into several subcategories based on whether larger clusters of items could be identified. As a result, several subcategories were identified, such as locally used deposit scheme bottles (e.g. Faxe Kondi bottles) and juice bottles.

Water and soft drink bottles (selection)

Juice bottles

Cleaner bottles (selection)

Caps/lids (selection)

Figure 3.4 *Bottles and caps*
Photos: M. van den Heuvel-Greve.

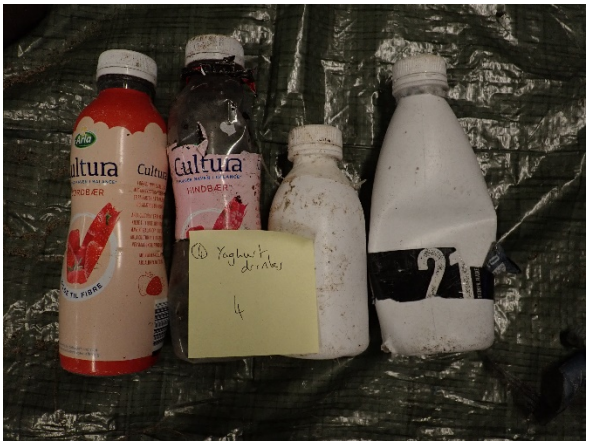
Almost all drink bottles still had their caps attached. This was also the reason why these bottles ended up on the beach. Usually, bottles without caps have a low buoyancy and tend to sink to the seabed, lowering the chance of them ending up on a beach.

Of the juice bottles, roughly half of them had been cut into two (see photo above). The reason for doing so is that such halves are often used to scoop out leaking water from boats. Perhaps these are discarded after use or are flushed overboard in rough weather. Because of the design of these type of bottles (shaped like jerrycans), they are also often used as floaters for fishing nets (gillnets); some of the bottles still had pieces of string attached to them.

Of all plastic drinking water and soft drink bottles (105), a large number (89) could be traced back to a likely origin. Of these 89 bottles, 88 had Danish text and according to the participants, were likely of local/regional origin due to these being available in local supermarkets (Figure 3.5). Only two bottles may have been potentially of foreign origin due to them not likely being sold in Greenland shops. The origin of the cleaner bottles and caps could not be determined because of a lack of text or other clues.

Faxe Kondi bottles collected at the beach

Faxe Kondi bottles in the supermarket



Cultura bottles collected at the beach

Cultura bottles in the supermarket

Figure 3.5 *Bottles collected at the beach and photographed in a Greenlandic supermarket Photos: M. van den Heuvel-Greve & K. Winther Hansen.*

3.2.4 Oil containers and jerrycans

In total, 67 oil containers and jerrycans were analysed. These make up 3% of the total number of items in the sample and 6% of the total weight. According to the Litter-ID protocol, items in these two categories were further divided into subcategories based on whether larger clusters of items could be identified. Based on this further categorisation, it became clear that most of the oil containers consisted of 1 L two-stroke Texaco engine oil containers and 4 or 5 L four-stroke engine oil containers.

1 L two-stroke Texaco engine oil containers

Miscellaneous two-stroke engine oil containers

Four-stroke engine oil containers

Jerrycans

Figure 3.6 *Engine oil containers and jerrycans Photos: M van den Heuvel-Greve.*

According to the local participants of the Litter-ID session, the two-stroke and four-stroke engine oil containers were likely of local/regional origin as they are often used for outboard engines on small,

open boats, used for fishing and hunting. Such containers can also be cut in half and used to scoop out water of a vessel or as buoys to mark the location of gillnets.

3.2.5 Other consumer waste

In addition to the larger categories of consumer waste, there are also a few smaller categories that provide insight into the sources and origin of the litter that washes up in Amerloq Fjord and near Sisimiut. In this section we describe some examples of such items: plastic toys, brushes and broom heads, clothing, ammunition holders and shotgun shells (Figure 3.7).

Ammunition holders and shotgun shells

Brushes and broom heads

Clothing

Children's toys

Figure 3.7 *Examples of items in other consumer waste categories*
Photos: M. van den Heuvel-Greve.

The origins for all four of these item categories are unknown, but as with the other categories, the most likely origin is local; especially the clothes, ammunition holders, toys and shotgun shells. The clothes could possibly have been collected near the settlement of Sarfannguit and may not be genuine marine litter.

The shotgun shells act as bullet casings to contain pellets called shot. These are typically used in bird hunting. The back of such casings has a metal cap, however, none of the shell casings analysed had this cap anymore. This is a phenomenon that we have encountered on other beaches in Northern Europe. We suspect that these bullet casings normally sink due to the presence of the metal. But as soon as the metal part rusts and comes off, the plastic part floats to the surface and is carried away by the current. This process probably takes several years, so the shotgun shells collected around the shoreline of Amerloq Fjord are at least several years old. Since bird hunting takes place in the area, this could be a source of these shells. The same goes for the bullet casings. Bullets are usually used to hunt larger mammals such as whales, seal and reindeer.

3.3 Fisheries waste

Besides consumer waste, fisheries waste is the largest source category. Items that fall into this category include parts of fishing nets, ropes, buoys and rubber gloves. The analysis of all fisheries waste was carried out together with a fishing gear expert from the local supply store of fishing and trawling gear.

3.3.1 Fishing nets > 50 cm

This category consisted of eight trawl nets (gillnets had been left out of the analysis), 101.5 kg in total. In numbers this is less than 1% of the total but 38% of the weight of the analysed sample.

Figure 3.8 *Analysis of the fishing nets*
Photos: A. van den Brink.

All eight trawl nets were analysed in accordance to the Fishing Net Assessment Protocol. Based on this, the following conclusions were reached:

- None of the trawl nets were complete nets; all were sections of nets.
- All nets are used in trawl fisheries that take place inside the fjord or close to it.
- Six of the eight nets (75%) were found to be mismanaged off-cuts from trawl nets, the result of mending work on fishing nets, while two sections (25%) were found to be accidentally lost during fishing operations due to wear and tear.

Table 3.3 *Results fishing net analysis (> 50 cm) Sisimiut*

Category type	
Total number of nets analysed	8
Total weight (kg)	101.5
Average size (m^2)	30
Source: cod fishery	37%
Source: northern prawn fishery	63%
Accidentally lost due to wear and tear	18%
Mismanaged net waste	82%

Source: Wageningen Economic Research, 2020.

3.3.2 Small net cut-offs

In addition to the larger pieces of netting, smaller cut-off pieces of netting were also analysed. In total, 32 of such items were counted (0.2 kg) which were less than 50 cm in length and 15 which were more than 50 cm in length. It was not possible to determine their exact source and origin but they could perhaps also be related to the trawl net fishery in the fjord.

Figure 3.9 *Short mesh ends and a few short lengths of twine for mending nets collected at Amerloq Fjord (left) and the process of cutting off loose mesh ends (right)*
Photos: M. van den Heuvel-Greve (left) and W.J. Strietman (right).

The smaller cut-offs are cuttings of loose ends of meshes and were probably washed overboard after mending the net. The longer single cords are parts of twine specifically used for mending nets. It is not clear what the most probable pathway is for such pieces to have ended up in the sea. These could be either cutting waste or have been accidentally lost due to wear and tear of the net.

Figure 3.10 *Longer loose lengths of twine for mending nets (left) and a new roll of such twine in the local supply store (right)*
Photos: W.J. Strietman.

3.3.3 Rope, string and cord

Within the OSPAR categorisation, two rope categories are distinguished: 'diameter < 1 cm' and 'diameter > 1 cm'. These two categories together consisted of 115 items (5% of the total sample size), with a total weight of 16.7 kg (6% of the total sample weight). As part of the Litter-ID protocol, all rope, string and cord is sorted into five subcategories which help in further identifying the source of these items, based on their diameter: 0–3 mm, 3–10 mm, 10–30 mm and 30–100 mm.

Figure 3.11 *Rope, string and cord sorted by diameter: 0–3 mm, 3–10 mm and 10–30 mm Photos: M. van den Heuvel-Greve.*

With the help of the local fishing gear manufacturer, an expert judgement was made for each subcategory as to what the estimated minimum share of fisheries was. The results are shown in Table 3.4.

Table 3.4 *Results: rope, string and cord analysis*

OSPAR category type and Litter-ID subcategory	Number	Weight (kg)	Estimated share fisheries (%)
31 Rope (diameter > 1 cm)			
31A 10-30 mm	16	10.5	Unknown
31B 30-100 mm	-	-	-
32 String and cord (diameter < 1 cm)			
32A 0-3 mm	37	1.2	100%
32B 3-10 mm	62	4.9	> 5%
Total	115	16.7	

Source: Wageningen Economic Research, 2020.

The analysis shows that not all rope, string and cord could be properly identified as to the source, especially the ropes of 10–30 mm in diameter. They are usually used to tie smaller vessels to the dock; these could potentially include smaller fishing vessels. Ropes of 0–0.3 cm in diameter are all longlines used in the (local/regional) halibut fishery.

3.3.4 Gloves and gloves packets

This category consisted of 107 items (a total of 1 kg). Of these items, 91 consisted of glove packets, 9 of rubber fishers' gloves and 7 gloves that are usually used for washing up. The glove packets are most certainly local since they can be bought at several local supply stores (Figure 3.12). According to participants of the workshop, these gloves are widely used by small-scale fishermen in small open boats; most of them have this kind of gloves in their boat to handle gillnets.

Figure 3.12 *Glove packets collected at Amerloq Fjord and offered at the local supply store Photos: M. van den Heuvel-Greve (left) and W.J. Strietman (right).*

Figure 3.13 shows both orange fishers' gloves and tight blue rubber gloves. The origin of the orange fishers' gloves could be local or regional, but this cannot be determined for certain, because these types of gloves are used throughout the North Atlantic region. According to the participants of the Litter-ID session, the blue rubber gloves are most likely used by local fishers.

Figure 3.13 *Rubber gloves collected at Amerloq Fjord Photo: M. van den Heuvel-Greve.*

3.3.5 Other types of fisheries waste

In addition to the larger categories of fishing waste, there are also a few smaller categories that provide insight into the type of fishing waste that washes up on the shores of Amerloq Fjord. In this section we describe some examples.

Large plastic buoys

Small floaters

Donut buoys

Strapping

Figure 3.14 *Examples of other types of fisheries waste*
Photos: M. van den Heuvel-Greve.

According to the local fishing gear expert, of the items shown above all are most likely not of local origin but may be used in trawl fisheries further offshore (cod and prawn). For example, strapping is used to secure cardboard boxes with frozen fish or prawns.

4 Litter-ID results Qaqortoq

4.1 Introduction

For Qaqortoq, the sample size was 181 items, with a combined weight of 4 kg. Tables 4.1 and 4.2 provide an overview of the ten main litter item categories in terms of numbers and weight.

Table 4.1 *The ten litter categories with the largest number of items*

OSPAR category type	Number of items	Share (%)
1. Industrial packaging, plastic sheeting	43	18%
2. Plastic/polystyrene pieces 0–2.5 cm	30	13%
3. Plastic/polystyrene pieces 2.5–50 cm	30	13%
4. Shotgun cartridges	28	12%
5. String and cord (diameter < 1 cm)	31	13%
6. Nets and pieces of net < 50 cm	12	5%
7. Caps/lids	11	5%
8. Strapping	7	3%
9. Styrofoam large (> 5 cm)	7	3%
10. Crisp/sweets packets and lolly sticks	5	2%
Other category items	31	13%
Total	235	100%

Source: Wageningen University & Research, 2020.

Table 4.2 *The ten litter categories with the largest weight*

OSPAR category type	Weight (kg)	Share (%)
1. Floats/buoys	1.43	36%
2. Engine oil containers and drums	0.81	20%
3. Balloons, including plastic valves, ribbons, strings etc.	0.41	10%
4. String and cord (diameter < 1 cm)	0.36	9%
5. Plastic/polystyrene pieces 2.5–50 cm	0.21	5%
6. Buckets	0.15	4%
7. Shotgun cartridges	0.12	3%
8. Bags (e.g. shopping)	0.12	3%
9. Nets and pieces of net > 50 cm	0.1	3%
10. Industrial packaging, plastic sheeting	0.09	2%
Other category items	0.2	5%
Total	**4**	**100%**

Source: Wageningen University & Research, 2020.

4.2 Main results

The main item categories in numbers are plastic sheeting, shotgun cartridges, string and cord (diameter < 1 cm), nets and pieces of net < 50 cm, caps/lids and strapping. Even though the sample size was low, the composition of this sample in terms of the type of items was similar to that of Amerloq Fjord (Sisimiut). Similar items were industrial packaging/sheeting, shotgun cartridges, string and cord and caps/lids. The Qaqortoq sample had a few smaller, unidentifiable items. In comparison to Amerloq Fjord, it had less consumer waste such as drinking bottles, engine oil containers and bags.

Figure 4.1 *Litter items collected at Qaqortoq*
Photo: Campus Kujalleq.

5 Litter-ID results Maniitsoq

5.1 Introduction

For Maniitsoq, the sample size was 181 items, with a combined weight of 45 kg. Tables 5.1 and 5.2 provide an overview of the ten main litter item categories in terms of numbers and weight.

Table 5.1 *The ten litter categories with the largest number of items*

OSPAR category type	Number of items	Share (%)
1. Plastic/polystyrene pieces 0–2.5 cm	45	25%
2. Engine oil containers and drums	21	12%
3. Drinks (bottles, containers and drums)	20	11%
4. Nets and pieces of net < 50 cm	20	11%
5. Cleaner (bottles, containers and drums)	10	6%
6. Food containers incl. fast food containers	7	4%
7. String and cord (diameter < 1 cm)	6	3%
8. Gloves (industrial/professional gloves)	5	3%
9. Nets and pieces of net > 50 cm	5	3%
10. Shotgun cartridges	5	3%
Other category items	37	20%
Total	**181**	**100%**

Source: Wageningen University & Research, 2020.

Table 5.2 *The ten litter categories with the largest weight*

OSPAR category type	Weight (kg)	Share (%)
1. Nets and pieces of net > 50 cm	17	38%
2. Engine oil containers and drums > 50 cm	7	15%
3. Floats/buoys	5	12%
4. Fish boxes	5	11%
5. Engine oil containers and drums	3	7%
6. Drinks (bottles, containers and drums)	1	3%
7. Crates	1	3%
8. Plastic/polystyrene pieces 2.5–50 cm	1	2%
9. Rope (diameter more than 1 cm)	1	1%
10. Cleaner (bottles, containers and drums)	1	1%
Other category items	3	7%
Total	**45**	**100%**

Source: Wageningen University & Research, 2020.

5.2 Main results

The main item categories in numbers are engine oil containers and drums, drinking bottles, fishing nets, cleaner bottles, food containers, string and cord, gloves and shotgun cartridges. In terms of numbers, the sample size was lower than that of Qaqortoq. Because of the low sample size, it was less useful for an in-depth analysis into the origin, sources and pathways of most of the items in the major item categories.

Despite this, in terms of the type of items major item categories were similar to that of Amerloq Fjord (Sisimiut). Examples of these were engine oil containers, drinking bottles, fishing nets, cleaner bottles, food containers, string and cord, gloves and shotgun cartridges. As such, the major categories were consumer waste and fisheries waste. Based on a further analysis of these items (inscriptions, brand names and other clues), it was likely that most of these items were of local origin (Figure 5.1).

Plastic drinking bottles

2-stroke and 4-stroke engine oil containers

Shotgun shells

Cleaner bottles

Figure 5.1 *Examples of consumer waste collected at beaches near Maniitsoq Photos: M. van den Heuvel-Greve.*

6 Beach litter – species interactions

6.1 Introduction

As part of the Litter-ID session, each litter item from all three sample locations was examined to determine whether they showed signs of fouling and/or bite marks. During such sessions, where possible, samples are also taken of fouling (attachment of plants and animals) for eDNA analysis. In this case, the litter items had been stored for two months prior to analysis and were therefore not fresh enough to take such samples for taxonomic identification. In the sections below we describe fouling species and bite mark signs on beach litter items from all three locations combined.

6.2 Fouling

During the Litter-ID session, fouling was found on nine items; seven on items found in Sisimiut, two on items found in Maniitsoq (Table 6.1). Fouling consisted mainly of bryozoans, whereas some items also had calcifying tube worms and/or barnacles attached to them. One item carried traces of seaweed. All items that contained fouling were rather worn down. As fouling is also a sign of being in the water for a longer period, this may perhaps suggest that the item has been transported from further away having its source of origin from outside Greenland, or it could have stayed in the fjord for a longer period of time (and be of local origin).

Table 6.1 *Biological fouling on marine litter, identified on beach litter from Sisimiut and Maniitsoq*

Location	Item description	Total # with fouling	# with Annelida (calcifying tube worms)	# with Arthropoda (barnacles)	# with Bryozoa (moss animals)	# with algae and/or seaweed
Sisimiut						
	Household cleaner bottle	1		1		
	Shotgun cartridges	6	2	1	5	
Maniitsoq	Watering can	1			1	1
	Marker pen	1			1	
TOTAL		**9**	**2**	**2**	**7**	**1**

Source: Wageningen Economic Research, 2020.

Figure 6.1 *A household cleaner bottle (category 5A) with barnacles, Sisimiut, 2019 Photo: M van den Heuvel-Greve.*

Figure 6.2 *Shotgun cartridges (category 43) with invertebrate fouling (bryozoans, calcifying tube worms, barnacles), Sisimiut, 2019*
Photo: M. van den Heuvel-Greve.

Figure 6.3 *Watering can (category 46/47) with algae/seaweed, Maniitsoq, 2019*
Photo: M. van den Heuvel-Greve.

Figure 6.4 *Marker pen (category 17) with bryozoans, Maniitsoq, 2019*
Photo: M. van den Heuvel-Greve.

6.3 Bite marks

During the Litter-ID session, bite marks were found on four items. Three items contained bite marks of either Arctic fox or raven. One item had teeth marks from reindeer.

Table 6.2 *Bite marks identified on beach litter from Sisimiut and Qaqortoq*

Location	Item #	Item description	Total # with bite marks	Additional information
Sisimiut	5A	Industrial paste tube	1	Arctic fox or raven
	6	Sauce bottles	2	Arctic fox or raven
Qaqortoq	43	Shotgun cartridges	1	Reindeer
TOTAL			**4**	

Source: Wageningen Economic Research, 2020.

Figure 6.5 *Industrial paste tube (category 5A) with canine bite marks, Sisimiut, 2019*
Photo: M. van den Heuvel-Greve.

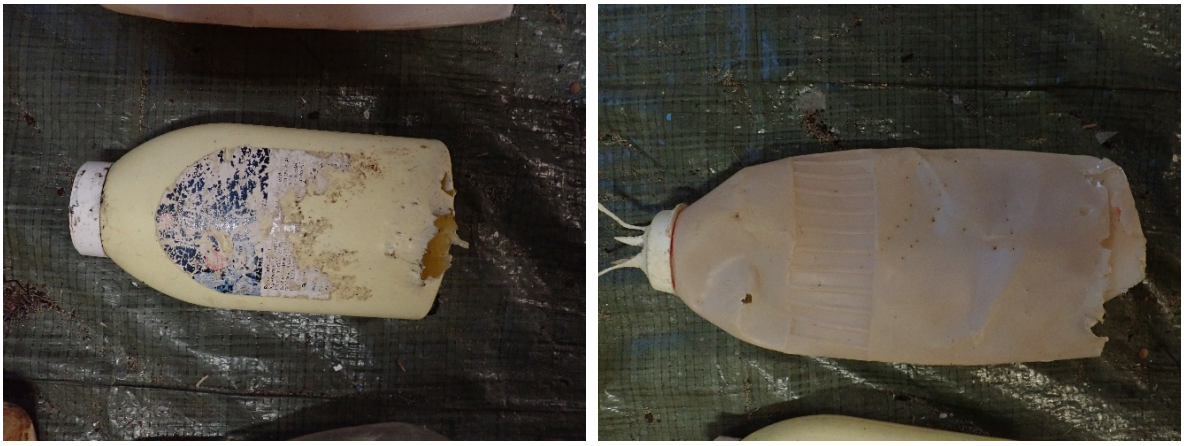


Figure 6.6 *Two types of sauce bottles (category 6) with bite marks, Sisimiut, 2019*
Photo: M. van den Heuvel-Greve.

Figure 6.7 *Shotgun cartridge (category 43) with reindeer bite marks, Qaqortoq, 2019*
Photo: M. van den Heuvel-Greve.

7 Discussion

7.1 Representativity

The research team was dependent on the amount of litter that had been collected locally in three locations and that was available for analysis. The amount of litter available for analysis was highest in the sample from Amerloq Fjord (Sisimiut). The amount of items in the samples from Maniitsoq and Qaqortoq were significantly smaller. Because there were fewer numbers of items within each category in these latter two locations, it was less feasible to gain as much in-depth knowledge on the items as was possible with the sample from Amerloq Fjord (the more items in each category, the more information can be obtained).

The sample from Amerloq Fjord was taken from a much bigger sized sample of beach litter collected from the area during a beach clean-up. Because of time restraints and logistical challenges related to the transportation of larger litter items from the municipal waste management location (where the litter was stored) to the location where the analysis took place, it was decided to only use a subsample for further analysis (see Chapter 2). During the selection process, bulk waste bags containing large amounts of small items were selected and those with only a few (mostly larger) items were avoided. Therefore, the subsample was not representative for all litter collected during the Amerloq Fjord beach clean-up. The selected subsample is however representative of the relatively smaller items that were collected during the beach clean-up.

A constraint in the identification of the material collected as marine litter in Amerloq Fjord is the fact that some of the litter was also collected at the coastline of the settlement Sarfannguit. It can be expected that some part of the litter analysed during the Litter-ID session might have been collected at the coastline directly in front of this settlement and might not be 'genuine' marine litter. As the bulk waste bags with collected litter could not be identified to their respective sample sites/beaches, it was impossible to determine the extent to which waste from specifically the shoreline of Sarfannguit was a major source of litter in the analysis.

At all three of the sampled locations, litter was collected by people other than the research team. Based on our experience with other beach clean-ups, there is a theoretic chance that the focus in the collection process might have been biased towards collecting as much litter items as feasibly possible given the restrictions of the time available, thereby focusing on relatively larger (> 1 cm), more easily visible litter items. It is also of relevance to note that the purpose of the clean-up in Amerloq Fjord was not to identify and analyse litter items, but to collect as much litter as practically possible. Thus, the collectors would assumedly not focus on the collection of smaller items. Even though there might have been a possible lack of smaller items in the samples used for this analysis, due to smaller items often being broken up pieces of larger items and thus not being recognisable anymore, making it impossible to assign such pieces to specific litter categories, this has no significant influence on the representativeness of the results with regard to the origin and sources. The only exception might theoretically be cigarette butts as these are recognisable but rather small and often in a colour that blends in with pebbles and sand, making these items potentially hard to distinguish.

7.2 Origin of beach litter

During the Litter-ID session, the geographic origin was determined as much as possible for each individual item. This was done based on inscriptions, labels and other external characteristics or indications that were found on the litter items, as well as input from local participants of the session. Each item was classified as likely to be local/regional or foreign. Where this could not be determined it was classified as being of unknown origin (Figures 7.1 and 7.2).

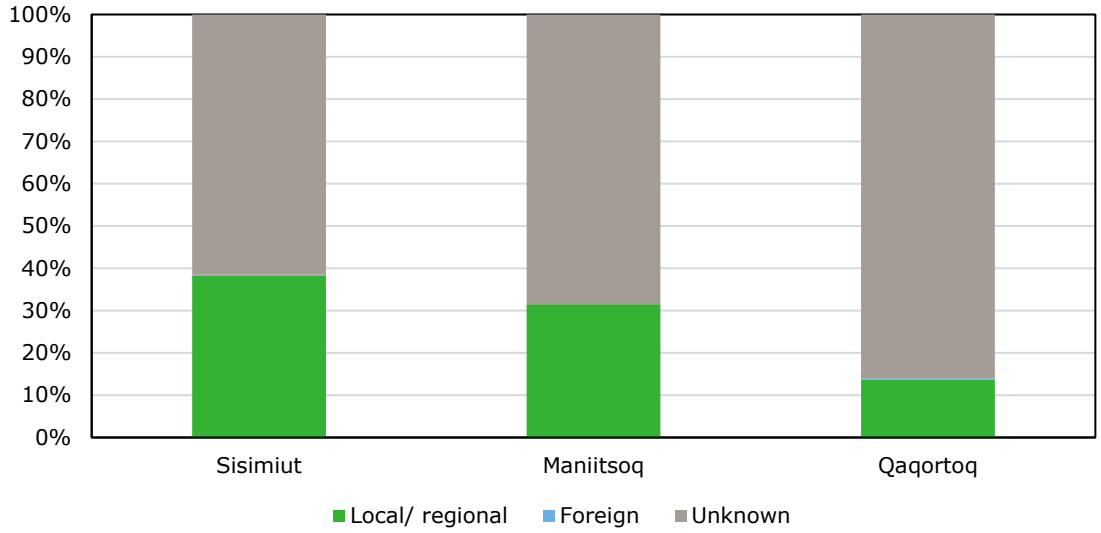


Figure 7.1 *Distribution of the share of litter that is of local, foreign, or unknown origin for each of the three locations, based on the number of items*
Source: Wageningen Economic Research, 2020.

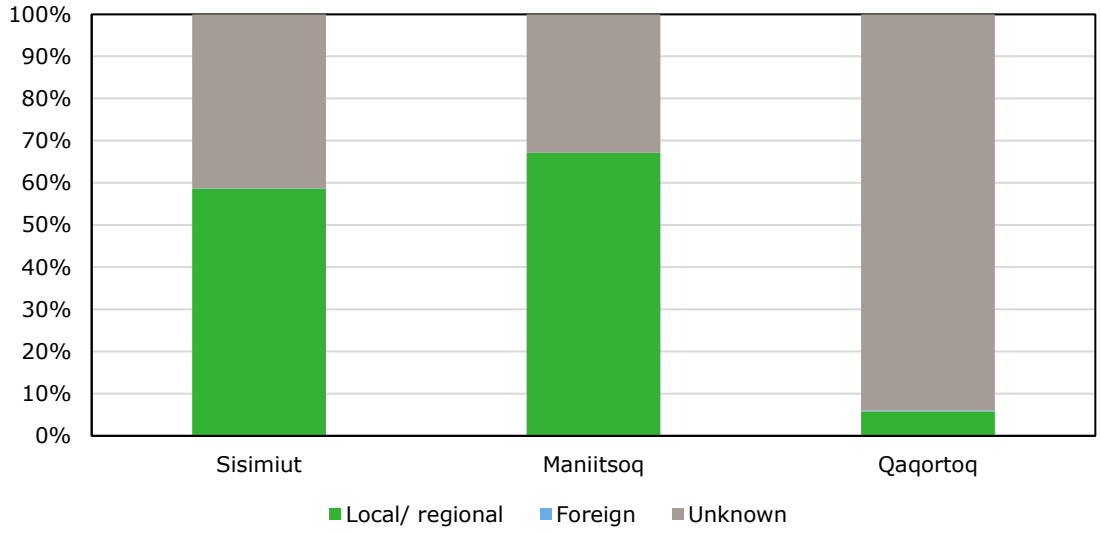


Figure 7.2 *Distribution of the share of litter that is of local, foreign or unknown origin for each of the three locations, based on the weight of items*
Source: Wageningen Economic Research, 2020.

Before the Litter-ID analysis took place, the hypothesis was that a substantial amount of the beach litter analysed would be from places further away, including locations outside Greenland. However, as it turned out, much (if not all) of it is local. In the figures above, the amount of foreign items is barely

visible because only a handful of items were found to be of likely foreign origin. The positive side to the situation is that this also means that the solutions can be found locally.

As such, the results also show that the solution is to target the issue of marine litter on the local scale in Greenland itself. This further underlines the need for the recently introduced Government of Greenland plan to create solutions for the handling of all forms of waste in Greenland. This plan includes the building of two new incineration plants and setting up a wrap, store and collect system where combustible waste can be shipped to Sisimiut and Nuuk, while other types of waste will be sent for processing to other locations in Greenland or abroad (ESANI, 2020).

7.3 Main sources of beach litter

To gain insight into the main sources of the collected beach litter in each of the three locations, all items have been classified as far as possible into one of the following five source categories: fisheries, consumers, shipping, agriculture, industrial and unknown. During the analysis, none of the items were classified as agriculture or industrial, so these categories were therefore excluded from Figure 7.1.

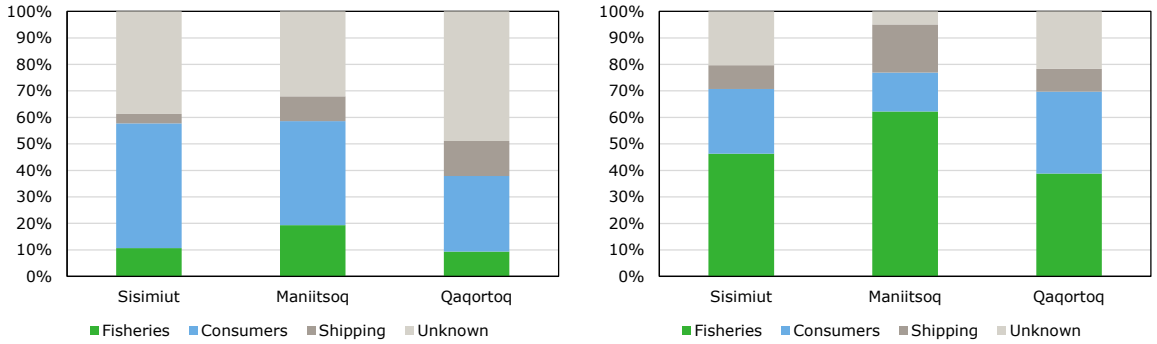


Figure 7.3 *Distribution of the different source categories based on numbers (left) and weight (right) at each of the three locations*
Source: Wageningen Economic Research, 2020.

In numbers, consumer waste is the dominant source of litter for all three locations. In terms of weight it is fisheries litter (Figure 6.1). Due to the fact that the sample of Sisimiut was not representative in terms of larger items (which consisted mainly of heavy gillnets and fish boxes), both the number and the weight of fisheries items in the subsample is thought to be an underestimation of the entire sample and is expected to increase the fraction of fisheries as source for both number and weight for the Sisimiut location.

7.3.1 A more detailed look into litter from Amerloq Fjord

Consumer waste
In terms of numbers, consumer-related waste made up the largest share of the sample of litter collected in Amerloq Fjord. Most of the items were of the type that were related to what people would take with them on a day trip, such as soft drinks, crisps, biscuits and oil for outboard engines. Small boats are used for those type of trips, whereas in other parts of the world, these would be cars. As such, the type of products taken on those trips is largely similar except for items such as engine oil. Typical household waste such as kitchen waste (e.g. meat or vegetable packaging) or bathroom waste (e.g. shampoo bottles) was found much less.

Fisheries
Fisheries-related waste made up the largest share of all the litter in terms of weight. Except for the gillnets that had not been analysed as part of the Litter-ID session, the results of the Litter-ID analysis

show that most of the fisheries-related litter was of local origin and originates from both small-scale line and gillnet fisheries and bottom trawl fisheries for northern prawn and cod. Small-scale fisheries-related litter mainly consisted of gillnets, longlines and possibly engine oil containers for small boats. Bottom trawl fisheries-related litter mainly consisted of larger sections of cut-out and mismanaged nets, accidentally lost sections of net due to wear and tear and smaller mismanaged off-cuts. In both types of fisheries, ropes were also a source of litter, but based on the analysis it could not be determined to what extent this was and to which type of fisheries these could be related.

Most of the pieces of trawl nets were off-cuts, the result of mending work on the nets. The share of such mismanaged trawl fishing nets collected in Amerloq Fjord (75%) may seem high but is by no means unique: this percentage is similar to those of other locations where we carried out similar analyses: Svalbard, Jan Mayen, Iceland, Norway and the Netherlands (Strietman, 2021).

Based on the analysis it is not possible to determine how often fisheries waste ends up in the sea and if this is a widespread phenomenon or only connected to a few individual fishers. Imagine, for example, that an individual discards one waste item when he/she is on the water every week that the vessel is out fishing (e.g. 40 weeks); that could amount to 40 items each year. The same would account for, for example, 40 individuals discarding only one item each year. Therefore, this aspect needs further examination (see Chapter 8, recommendations).

Shipping
During the analysis, we did not come across any items that we could say with 100% certainty were related to freight shipping.

For items such as 2-stroke and 4-stroke engine oil containers and certain ropes, we determined them to be most likely from small, local vessels (4 m–6 m in length). Whether these were mainly used for fishing, hunting or other type of outdoor activities could not be determined.

Sisimiut and Sarfannguit
Sisimiut is a large community at the north-western entrance to the fjord and Sarfannguit is a small village (population of approximately 100 in 2020) at the eastern end of the fjord. Amerloq Fjord is used by the inhabitants of both communities for fishing, hunting and other recreational activities and includes the use of cabins.

Based on the results of the Litter-ID, it is likely that most of the collected litter is related to outdoor activities such as fishing, hunting and recreation. In addition, it is possible that lightweight litter items from both Sisimiut and Sarfannguit may end up in the fjord if not properly disposed of and are then blown away by the wind. Also, as described earlier in Section 7.2, the amount and type of litter collected at the coastline of Sarfannguit is unknown. Thus, a part of the litter collected and included in the analysis could potentially originate from the shoreline of the settlement itself and may originally not have been in the water of the fjord at all.

Marine litter that originates from outside Greenland can travel with ocean currents into the fjord. However, only a handful of items were found that could have been of foreign origin.

Based on the Litter-ID analysis, it was concluded that almost all litter items that could be traced back to a specific origin were of local or possibly regional origin. Each of the most probable sources are shown in Figure 7.4.

Figure 7.4 *Most probable sources of litter around Amerloq Fjord*
Source: Wageningen Economic Research, 2020.

Comparison with results of the SUMAG project

The results of 59 surveys at West Greenland shorelines in 2016–2019 show similar types of items that were also encountered in the samples from Sisimiut, Qaqortoq and Maniitsoq, such as: shotgun cartridges, caps/lids, industrial plastic sheeting, crisps packets/sweets wrappers, plastic bags and food containers (Table 7.1).

Table 7.1 *The top 15 list of items (> 2.5 cm) recorded during beach litter surveys in West Greenland 2016–2019*

OSPAR category type	Number of items	Share (%)
1. Plastic fragments 2.5–50 cm	1849	22%
2. Processed/worked wood, other < 50 cm	1104	13%
3. String and cords, diameter < 1 cm	957	11%
4. Foamed polystyrene pieces 2.5 cm–50 cm	815	10%
5. Shotgun cartridges, plastic	728	9%
6. Processed/worked wood, other > 50 cm	298	3%
7. Caps/lids, plastic	244	3%
8. Foam sponges, plastic	201	2%
9. Industrial sheeting, plastic	199	2%
10. Strapping band	147	2%
11. Crisps packets/sweets wrappers, plastic	142	2%
12. Glass bottles incl. pieces	113	1%
13. Larger plastic bags	105	1%
14. Small plastic bags	103	1%
15. Food containers and wrapping, plastic	102	1%
Other category items	1435	17%
Total	**8542**	**100%**

Source: J. Strand – Aarhus University, 2020.

Based on an assessment of text or other characteristic elements on the analysed items that was part of the beach litter monitoring efforts carried out under the SUMAG project, it was also similarly concluded that most of the items are of Greenlandic origin. Also, local sources and not long-range transport of litter items, are therefore assessed to be the main contributor to litter at the surveyed

shorelines in West Greenland. For instance, the only items identified as of foreign origin in 2016 were one plastic bag for shrimp bait of Canadian origin, one plastic bag for frozen food items of Russian origin and one small engine oil container of plastic with the volume given in gallons indicating American origin or from ship-generated waste at sea (Strand et al., 2018 & Strand, 2020 pers. comm.).

7.4 Species interaction

Fouling organisms such as bryozoans, barnacles, calcifying tube worms and algae/seaweed were found attached to some items. As the beach litter was stored for two months prior to analysis no further taxonomic identification of the species could be conducted. Fouling species were brittle and often partly broken. In a future set-up it is recommended that the presence of fouling species is assessed during the beach clean-up activity. This way more detailed pictures of fouling organisms can be taken, which further enhances taxonomic identification. This will also enable the collection of samples to identify species based on their DNA.

As most of the marine litter items were not worn down and did not contain fouling organisms, it seems likely that litter items ending up in the fjord did not arrive there as a result of long-range transport by ocean currents. Therefore, the risk of beach litter serving as a vector of transport for non-indigenous species was considered low for these locations based on these data. This is likely the result of the sheltered water systems around the sampled locations, except for Maniitsoq. Such fouling organisms could potentially include non-indigenous species and become invasive.

Bite marks from Arctic foxes and reindeer were found on a few items. Ingestion of plastic by these animals can potentially lead to internal damage, blockage of the digestive system or a feeling of fullness which leads to the animal not eating and eventually starving. Also, in the case of bottles or tubes contain remnants of harmful liquids, chewing on these may expose the animal to these fluids potentially causing detrimental effects. The Arctic fox bite marks on plastic bottles may indicate that the fox was investigating the item as a potential food source. The fox would then be wasting energy it could be spending on finding real food, maintaining a den or other necessary activities. It is possible that the shotgun cartridge found with reindeer bite marks was covered by foliage on the beach and mistakenly chewed on by a reindeer before being discarded.

8 Conclusion and recommendations

8.1 Conclusion

An in-depth Litter-ID analysis of beach litter collected in three locations in West Greenland showed that almost all litter was of local origin and consisted of everyday use products used in local communities and settlements and of products used during outdoor activities such as fishing and hunting. Examples of such products are not only sanitary toilet bags, longlines, fishing nets, gloves, shotgun shells and outboard engine oil but also the type of everyday products that people would bring along on day trips, such as soft drinks, crisps and biscuits.

The results of the Litter-ID analysis provide additional weight to the findings of the SUMAG project (DCE – Danish Centre for Environment and Energy, Aarhus University), where it was assessed that local sources and not long-range transport of litter items from places much further away, are the main contributors to beach litter in West Greenland.

A few litter items carried animals and plants ('marine fouling organisms') such as moss animals (bryozoans), calcifying tube worms or barnacles. As floating litter may carry such organisms for long distances, there may be a risk to introduce new (non-indigenous) species to these locations. Due to the low numbers of such attached organisms, this risk was considered to be low.

8.2 Recommendations

Policy recommendations

- Engage with community groups, fishers and hunters to start a dialogue to better understand the causes of marine littering and which solutions could work for those stakeholder groups in the municipal and national context. Such causes could for instance be technical/operational such as lack of waste collection facilities, but behaviour and habits regarding waste and perceptions of the issue of local marine litter could perhaps also play a role. By engaging local community groups and fishers and hunters in this dialogue, solutions could be developed together (co-creation) to get the local support needed to tackle the issue in the most effective way.
- Examine which litter facilities or services can be offered in local harbours to provide an incentive for people engaged in outdoor activities, fishers and hunters to bring their litter to the harbour for proper disposal.
- Set up municipal and national awareness programmes on the issue of marine litter and littering in general, in particular for boat owners, cabin owners, fishermen and hunters.
- In order to create zero pollution in the future, set up or enhance educational programmes for children and youth and develop an intrinsic awareness on the benefits of a circular economy.
- Assess which of the items that often end up in nature could be replaced by reusable items or could be part of a deposit scheme.[5]

Scientific recommendations

- Develop a beach litter monitoring framework in Greenland for the purpose of securing data not only on the amounts and composition of litter but also on the sources, pathways and weight. This should also specifically focus on items that are directly related to implementation of Government action plans (i.e. an extension of the SUMAG project and/or organising additional Litter-ID sessions). The more specific the better (e.g. a certain brand of plastic bottles instead of 'a plastic bottle'). Such specific and detailed monitoring data can then be used to measure the effectiveness of municipal or national action plans to combat marine litter.

[5] e.g. the return scheme recently set up by KNI PolarOil for engine oil containers: https://www.kni.gl/kl/nyheder/fra-kni/utertitsisalernermiit-ukioq-ataasinngorpoq

- In order to create a better understanding of the sources, pathways and solutions to local beach litter in the South and East of Greenland, it would be recommended to organise additional Litter-ID sessions in those areas in collaboration with local stakeholders.
- In terms of continuing beach litter monitoring in Amerloq Fjord, a certain stretch of coastline could be designated as a sample area where all litter will be collected separately for a follow-up analysis. This would increase representativity of future beach litter analysis.
- To study fouling organisms (plants and animals attached to litter items) properly, the freshest possible material is needed. When a beach clean-up takes place, it is best to collect, photograph and preserve fouling material on the spot. Then, based on detailed photos and DNA samples, fouling species can be further identified at species level by experts. Such an approach can further assess the introduction of new and potential harmful species into the area through floating marine litter.

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