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Methods for determining the geographical origin and age of beach litter: challenges and opportunities

Abstract

Beach litter analysis is a cost-effective tool to identify litter sources and subsequent management actions. However, standard beach litter protocols are not generally developed to identify litter's origins and age. Data from Svalbard (North Atlantic/ Arctic Ocean) were therefore used to explore reliable methods to fill this knowledge gap. Written text and country specific brands, as well as printed production or expiry dates proved the most efficient and reliable identifiers. The use of product design and logos considerably increased the proportion of items that could be sourced (by 19%) and dated (by 22%). The successful use of these is defined by the expertise of the analysing team and may introduce bias. The bias can be reduced by developing picture guides and involving stakeholders. The analyses showed that littering is on-going and that the area's major fishing nations, Norway and Russia, dominated the identified litter (38% and 14%, respectively).

Introduction

Anthropogenic litter, particularly plastics, is ubiquitous in the marine environment, even in the remote reaches of the Arctic (Cózar *et al.*, 2017; Halsband and Herzke, 2019; Vesman *et al.*, 2020). Curbing the flow of plastic pollution depends on our ability to accurately determine its sources, both in space and time (Tudor and Williams, 2004; Cau *et al.*, 2019). Such knowledge enables the design of effective preventative and mitigative measures, as well as the monitoring of their efficiency. However, sourcing litter presents multiple challenges. While some items can be sourced relatively easily, many items may have multiple potential sources (*e.g.,* food packaging may stem from both land- and sea-based activities) (Tudor and Williams, 2004; Veiga *et al.*, 2016). Consequently, standardised item-to-source categories may not be appropriate. Region-specific protocols (Veiga *et al.*, 2016; Vlachogianni *et al.*, 2018) linking the function of items to the likelihood of them originating from regional fishing and shipping (Earll *et al.*, 2000) have been developed. Such regional standards, however, may have limited global relevance due to local differences in the usage of items.

Determining the country or region of origin and age of litter can be globally relevant tools in sourcing and identification of recent discards (Earll *et al.*, 1996; Veiga *et al.*, 2016; Smith *et al.*, 2018; Cau *et al.*, 2019; Ryan *et al.*, 2019; Falk-Andersson, 2021). There are some limitations to identifying the likely geographic origin of a litter item. The globalisation of markets has increased the distribution of products (Veiga *et al.*, 2016), which weakens the link between litter identification and its source. However, when a clear signal is observed repeatedly, hypotheses regarding likely sources can be made. The age of litter will also give an indication of ongoing pollution *versus* "old sins", and thus be useful in the development of targeted measures. Age in conjunction with geographical origin can also strengthen assumptions about sources as recently discarded litter is less likely to stem from long-range transport (Ryan *et al.*, 2019).

Several studies have identified the age and geographical origin of litter items (Duhec *et al.*, 2015; Smith *et al.*, 2018; Cau *et al.*, 2019; Ryan *et al.*, 2019; Ryan, 2020). However, descriptions of the underlying methodology and the application of different identifiers are insufficient. The objective of this study was to explore methods for identification of the geographical origin and age of litter types. Analyses were carried out on beach litter collected from the Svalbard archipelago in the European Arctic.

Methods

Beach litter was obtained through local clean-up initiatives at four locations on the west coast of the Svalbard archipelago, Arctic Norway (Fig. S1) in summer 2019. No specific protocol was followed during litter collection; only the site location was recorded. The litter was analysed over four days by a team of five persons. Food packaging, beverage containers (plastic and glass bottles, cans), jerry cans, cleaning bottles (household cleaning bottles, laundry detergent), and personal hygiene products (deodorant, shampoo, toothpaste, etc.) were photographed and carefully assessed to determine geographical origin, approximate age and level of degradation. Litter from all locations were pooled during statistical analysis. Items were inspected for text, logo/brand, design and production/expiry date which could be used to identify the country or region of origin and age (Table 1, Fig. 1), using a hierarchy of preferred identifiers. Text in the form of a brand name, was registered under "logo/brand". Online tools such as Google search, Google-Translate, Logopedia and digitaltmuseum.no (Norwegian) were employed. Some items were identified based on photos after the field work through more extensive online searches or contact with producers.

For origin, text stating the country of origin (i.e., "made in..") or language(s) linking to a country/region was preferred, followed by logos/brands that could connect items to producers/firms/companies from specific countries/regions, and finally design. Although many brands are multinational (*e.g*., Coca-Cola, Unilever), certain brands are nation-specific (*e.g*., Norwegian brands such as Mack, Solo). Geographical origin was recorded to the highest resolution possible. Packaging with text in multiple languages are distributed in many countries; these were classified as "unknown" or allocated to a region. For example, in Scandinavia product information is written in Norwegian, Swedish, Danish, and Finnish, while CIS (Commonwealth of Independent States) was an identity given to products with labels containing text in 3 or more languages mostly in the Cyrillic alphabet, a general practice for products of some post-Soviet republics. "Non-Norwegian" was used for items the team did not recognize as Norwegian.

For dating analysis, printed dates were preferred, but there was no preference with respect to the use of text, logo/brand or design when printed date was unavailable. Manufacture date was preferred over expiry date as the former is a better indicator of the maximum time an item could have been out in the environment (Ryan *et al.*, 2019). Certain types of mould stamps on packaging represent manufacture date of the plastic container (Ryan, 2020); these were used in line with other identifiers for dating analysis. In cases when it was not clear whether a printed date is production or expiry, it can still be used to estimate the age of containers as food and beverage typically have a shelf life of 2-12 months post-production (Ryan *et al.*, 2019). Approximate age may be estimated from text (*e.g.,* "Made in West-Germany", "USSR"), a logo used during a specific time period, or a product that entered the market at a specific time. For items with a printed date the exact year was recorded; items dated based on other identifiers were classified by maximum and minimum age and the intervals <5, >5 or >10 years old assigned during processing.

Items were assigned one of three levels of degradation: (1) no discernible degradation or limited photodegradation (i.e., sun-bleaching) only, (2) some mechanical abrasion (e.g., rounded or chipped edges) or moderate to high photodegradation, and (3) obvious loss of structural integrity (e.g., extensive cracking, deformities; brittle) and significant loss of tensile strength. These were classified as “low”, “moderate” and “high”, respectively.

Results and discussion

1156 items (147 kg) were analysed: 311 items of food packaging, 350 beverage containers, 152 jerry cans (oil/chemical containers), 201 cleaning bottles, and 142 personal hygiene products. Geographical origin and approximate age could be determined for 43% and 35% of items, respectively. The proportion of items successfully assigned geographical origin differed significantly among litter categories (χ^2_4 = 67.00, p <.0001) (Fig. 2a), as did the proportion successfully dated (χ^2_4 = 30.79, p<.0001) (Fig. 2b). Determining geographical origin was most successful for beverage containers (56%), followed by food packaging (46%), and least successful for jerry cans (18%) (Fig. 2a). Dating was the most successful for jerry cans (41%), food packaging (41%) and beverage containers (37%), and least successful for hygiene products and cleaning bottles and (26% and 21%, respectively) (Fig. 2b).

Geographical origin

Text was the most successful method to allocate geographical origin (56% of items allocated). However, the most successful identifier varied among litter categories (χ^2_8 = 194.46, p <.00001) (Fig. 2a), which is in line with the findings of Duhec et al (2015). Text was used almost exclusively to allocate geographical origin to jerry cans, personal hygiene products and food packaging (>80% of allocated items, Fig. 2a). Text was present on 33% of items overall. When present it was used to identify origin in 73% of cases overall, and especially for food packaging and personal hygiene products when text was used 92% of the time when present. Text was present particularly often on jerry cans (51%), but only used to identify origin in 30% of the cases (see Table S1 for details regarding other item categories). Text is a particularly suitable identifier for food packaging, as labels are generally written in the language of the country in which they are sold and often printed directly on the container (as opposed to labels which may be lost). Food items are also frequently nation-specific due to supply from local producers. However, some caution is necessary as language may be misleading (e.g., English is a highly prevalent language). In some cases, nationality may be further identified in combination with other factors, such as currency (*e.g.,* price in £/ $) or measurement units (gallon, pint).

Increasing the proportion of items that can be sourced is important to reduce bias towards easily identifiable items (Ryan, 2020). Only 11% of beverage containers could be allocated geographical origin based on text, while logo/brand (17%) and product design (28%) increased the number to 56% (Fig. 2a). Glued-on labels are more common than direct printing on the bottle but are readily lost, making other factors such as design and symbols on the bottle/lid more important identifiers (Smith *et al.*, 2018). Logo/brand was present on 32% of beverage containers and used to identify origin 54% of the time when present. However, logo/brand was rarely present on cleaning bottles and jerry cans (13% and 12%, respectively) and its use did not drastically increase allocability of these items. Overall, logo/brand was present on 29% of the items, but only used to identify origin 24% of the time when present. Of the beverage containers identified to geographical origin based on design, 57% were allocated based on the design of bottles used in the Norwegian and Danish deposit return-system. Nearly all food packaging and cleaning bottles for which geographical origin was identified based on design (87% and 88%, respectively), were Norwegian (*e.g.,* Norwegian cleaning products Zalo, Salmi and Klorin). This demonstrates how the use of design is dependent on the knowledge of those analysing the litter, which introduces bias. It is also assumed that the design is truly unique for a country/region. As illustrated in Ryan (2020) identification of the geographical origin of containers require in-depth knowledge on design from likely sources.

Overall Norwegian litter was the most common (33%), with litter of Scandinavian and Russian/CIS origin also prevalent (Fig. 2c). The Russian (48 items), USSR (3) and CIS (19) items were pooled as "Russia/CIS". The combined proportion of Norwegian and Russian/CIS litter identified (47%) is similar to that reported by Bergmann *et al*. (PAME, 2019) (41%), although the proportion observed in this study is higher when including all Scandinavian items (62%). Given the high Norwegian maritime activity in the area, it can be assumed that many of these Scandinavian items are Norwegian.

Dating

Relatively similar proportions of dateable litter were classified as <5, >5 and >10 years old (Fig. 2d). 43% of items <5 years had printed dates. The majority of recent (<5 years) litter was comprised of food packaging (47%) and beverage containers (31%). This could suggest a systematic issue of on-going discharges despite the implementation of MARPOL annex V in 1988 (MARPOL, 1988). Given the limited land-based local litter sources and intense maritime activity around Svalbard, recent discards likely suggest leakages from ships in the area. However, bottles may travel far within a 5-year period, and according to drift models even reach Svalbard from the European shelves within a single year (Strand *et al.*, 2021). Non-bottle food packaging, on the other hand, is generally more susceptible to rapid biofouling and degradation and thus sink before long-range transport is possible (Ryan, 2015). The relative proportions of floating bags and food wrappers have been shown to decrease while bottles and floats increase from coastal to oceanic waters, suggesting the drift potential is considerably reduced for the former (Ryan, 2015). Thus, while the beverage containers in our sample could have travelled from the mainland, this scenario is less likely for non-bottle food packaging, making this category particularly useful in identifying local litter sources.

Food packaging was less common among older litter (17% and 29% of litter >5 and >10 years old, respectively). Beverage bottles were the most common item aged >5 years (64%) but was rarely aged to >10 years (5%). Jerry cans were the most common item aged >10 years (37%). Of the litter items dated based on printed dates, beverage containers dominated the most recent items, followed by food packaging (Fig. 2e). These were typically marked with expiry date, while manufacture date was commonly used for personal hygiene products and jerry cans, the latter which could be dated up to 43 years back in time as they typically had the date stamped directly into the plastic. The changing composition of litter among the age classes could be due to a change in the type of litter discarded over time. More likely, however, this is a result of differences in rates of weathering of different types of litter, and/or differences in rates of degradation of identifying characteristics of litter. For recently dated items, manufacture date could be a better indication of recent discards compared to expiry date as the shelf life of products may differ. Food and drinks generally have relatively short shelf lives of around 1 year (Ryan *et al.*, 2019), while non-food products could be used for a long time before discarded. Thus, for documenting on-going discarding practices, food and drinks-related items and items marked with manufacture date may be the most relevant.

The method(s) most successfully used to determine age of items varied among litter categories (χ^2_{16} = 277.47, p <.00001). Expiry and manufacture date are the most time efficient and accurate identifiers, and particularly successful for dating beverage containers and food packaging. 83% of the litter dated by expiry date was <5 years old, making it a good identifier of recent discards. Design was commonly used to date beverage containers and personal hygiene products (59%-68% of dated items), but rarely jerry cans (14% of dated items) (Fig. 2b). For beverage containers this relates to the bottle design used in the Norwegian and Danish deposit return-system, which lasted until 2012 (R. Haavik, Infinitum, pers.com.); hence bottles >5 years were dated by design in 96% of cases. Contrastingly, beverage bottles <5 years were mostly dated using expiry date (73%). Design was also useful for dating hygiene products through retro designs or recognizable current designs of common brands. Jerry cans were predominantly dated using manufacture date (75% of dated items) (Fig. 2b) as these often had a plastic injection mould stamp identifying production month and year (Fig. 1e). Chemicals may have a longer "life cycle" compared to food products, making it more difficult to determine when an older jerry can was discarded. Mould stamps were rarely present on food packaging, hygiene products and beverage containers, and other identifiers fade or rub off with time.

Age determination was not independent of degradation ($\chi^2_6 = 83.96$, p <.00001). Items showing little degradation were more likely to be successfully dated (Fig. 2f). Items of low degradation were more often <5 years compared to moderately or highly degraded items, and items >10 years old were increasingly prevalent as degradation increased (Fig. 2f). Thus, degradation reduces the ability to identify the age of litter. Additionally, as all combinations of age and degradation categories were observed, degradation level cannot be used as a proxy for age. Degradation also reduces the success of determining geographical origin ($\chi^2_2 = 12.28$, p = 0.002) (Fig. 2g).

As degradation levels hinder dating it raises some concerns regarding the ability to identify older litter. The loss of date stamps over time is likely to affect the documentation of age (Ryan *et al.*, 2019). Thus, reliably extending dating to >5 years back in time may not be feasible using date stamps/prints (the maximum time may be greater for *e.g.,* jerry cans with mold stamps), which is the method requiring the least prior knowledge. This limitation does not negate dating of litter, however, as documentation of relatively new releases is most relevant from a management perspective to identify emission points. Nevertheless, it is useful to know the age-composition of litter in a region to determine if clean-up actions or preventive measures are likely to be more effective in reducing the stock of litter.

Implications and limitations

Knowledge of the geographical origin and age of marine litter could aid in discerning the relative importance of local maritime sources *versus* long-distance transport. The dominance of Norwegian and Russian litter items suggest that the largest fisheries nations in the area, Norway and Russia (Sakshaug *et al.*, 2009; Grønnevet, 2016; Bergmann *et al.*, 2017) are key contributors to marine litter in the studied area. This also supports previous analyses of fishing nets found on Svalbard beaches, where most were found to be cut-offs after repairs and traceable to the type of fishing gear used by the Norwegian and Russian fishing fleet operating in the surrounding waters (Falk-Andersson and Strietman, 2019). An international fleet of cruise ships (62 000 cruise passengers in 2018, Statistics Norway, ssb.no) could also be a local sea-based source, while the North Atlantic Current could transport litter from further away (Cózar *et al.*, 2017). Given the low population density of around 3000 inhabitants (Statistics Norway, ssb.no), availability of waste management systems in the settlements, and that the vessels operating in the area generally get their supplies at the mainland, local land-based sources are few.

A combination of geographical origin and the age of litter items as identified through production/ expiry date, can be used in combination with oceanographic models to determine the likelihood of the litter originating from local maritime sources or being transported long distance (Duhec *et al.*, 2015; Ryan *et al.*, 2019; Ryan, 2020). This requires a higher resolution on dating than the age categories reported here. Given that only 73 of the items analysed could be identified to both geographical origin and age, there was insufficient information to draw any such conclusions from this study (See Fig. S2). A further limitation of this study is the lack of information and characteristics of the sampling sites, and if/when the area was cleaned before, meaning it is unknown whether the litter represented long-term accumulation or recent influx. This made it impossible to ascertain whether older items are still in circulation or if these have been beached for a long time. Although a number of factors determines beach litter dynamics (e.g. Brennan et al. (2018)), regular monitoring would give better insight into the time between release and stranding, and thereby the time between manufacture and arrival on the beach.

Other studies have recorded a range of additional factors to evaluate the likely geographical origin of litter, such as material (including plastic polymer), density, windage (the degree to which wind would influence dispersal of floating litter items), the presence of lids on bottles, and the presence of macro-epibionts and bite barks (Duhec *et al.*, 2015; Smith *et al.*, 2018; Ryan, 2020). Identification of brand has been conducted in order to document the need for increased producer responsibility (BFFP, 2019). The content of containers may also indicate source. For example, in Duhec et al (2015) Asian energy drinks were assumed to be from Asian fishing boats, while bottled water was associated with cruise ships and yachts. The number of factors to record is a trade-off between effort to collect data and the usefulness of this for the research question(s) asked. Ryan (2020) recorded the different types of polymers of bottles, but could not conclude a link between this and origin. Material and polymer type, however, influence the potential for dispersal, as well degradation rate. The latter would affect both identifiability and dating using degradation rate as a proxy.

Considerations of method application

The expertise of the team conducting the analysis, including knowledge of languages, local consumer cultures and products used during different time periods, determines the ability to identify the geographical origin and age of products. This team was represented by three nationalities (Norway, Denmark and USA) with international backgrounds and able to read/recognise Scandinavian languages, Russian, English, Latin languages (Italian, French, Portuguese, Spanish) and CIS languages. The age of participants ranged from 21 to 39. Our research team therefore enabled easier recognition of Norwegian, Scandinavian, Russian and CIS products, hence possibly biasing the results towards these geographical areas. The identification of Scandinavian bottles is an example where the team's expertise influenced the likelihood of recognising outdated designs of nation-specific products. The use of digital tools can reduce the bias. Still, the team's expertise can bias which products are further investigated and successfully identified. For example, Norwegian ketchup and mustard bottles from the manufacturer Idun were readily recognised as Norwegian and assigned an approximate age based on online searches on design changes.

Involving experts or stakeholders could improve the ability to identify the correct age and geographical origin of items, and has been recommended to successfully source beach litter (Earll *et al.*, 2000; Tudor and Williams, 2004; Volckaert *et al.*, 2012; Veiga *et al.*, 2016; Falk-Andersson, 2021). While it can be assumed that sea-based sources are dominating at Svalbard also for non-fishery related items, it may be more difficult to differentiate sea-based and land-based sources in other regions of the world. Development of protocols adapted to the specificities of a region, analytical methods exploring the relationship between distribution and environmental factors, as well as the overall litter composition indicating likely source of items, are all methods that have been explored (see Falk-Andersson (2021)).

Visual aids have also been developed to help correct identification of beach litter (e.g. Earll et al. (2000) and OSPAR (2010)). Photo guides should be developed to help to correctly identify the geographical origin and age of litter items, reducing the bias introduced by the research team. Communication with beach cleaners in the region suggest that many of the items are found repeatedly. Thus, the most relevant items to be included in a photo guide could be identified with their help. Online tools can also be used to get input from the public and experts from different regions. Specialized Facebook© group pages have been used to identify litter items originating from the Norwegian aquaculture industry (Vangelsten *et al.*, 2019) and identify bottles to geographical origin (Smith *et al.*, 2018). This and previous studies have developed data bases with photos to aid identification (Smith *et al.*, 2018; Ryan, 2020). Making a global inventory would aid future studies on litter identification.

The dominance of certain types of litter is a strong indicator that a single source systematically discharges litter into the system (Veiga *et al.*, 2016). It is therefore important to be aware of, report, and reduce potential biases in analyses to avoid reaching false conclusions. While our finding that Norwegian/Scandinavian and Russian/CIS products dominate beach litter on Svalbard is supported by other studies (Bergmann *et al.*, 2017; Falk-Andersson and Strietman, 2019), there is a potential bias related to the research team's expertise. Generally, text, expiry- and manufacture dates are the most robust identifiers of geographical origin and age as these do not require knowledge of design or logos/brands used in the past and present for products from different geographical areas. Logos/brands in the form of text (e.g. "Solo") can be robust identifiers as these can be readily identified using on-line sources, but the use of text vs. graphics in identifying logos/brands was not specified in the data. Utilising identifiers other than text for geographical origin and expiry/manufacture date for dating did introduce a certain bias towards nationalities/regions best known to the research team (χ^2_{29} = 2011.58, p <.00001) and towards newer items that were more familiar (χ^2_3 = 1599.35, p < .00001). However, the magnitude of this bias was small and did not change the overall results or conclusions (*i.e.,* patterns of dominant origins and age classes were comparable). Furthermore, the addition of these identifiers allowed the allocation of origin and age class to an additional 19% and 22% of items, respectively, effectively doubling the sample size for classified items in each case.

Conclusion

In conclusion, the presented results demonstrate a potential to identify the geographical origin and age of certain litter items. This information can be used to support source identification. Older items and items with identifiers that are less robust, will likely be underestimated. Thus, these types of analyses may not give strong data on the relative age distribution of litter, but they can provide useful information for management. Written text and date stamps are the most robust methods for determining geographical origin and age, respectively, as these are less dependent on the expertise of the research team. To enable widespread use of logo/brand and design without introducing a bias in the results, it is recommended that detailed picture guides are developed.

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Table 1: An overview of identifiers used to determine origin and age of litter items .

Identifier	Example	Used to determine
Text	Language(s) on product; currency, countries that no longer exist (e.g. USSR)	Country/ region of origin, approximate age
Logo/brand	"Coca-Cola" (international brand, i.e. unknown nationality), "Solo" (Norwegian soft drink), logo used/ introduced in specific time period	Country/ region of origin, approximate age
Design	Shape or colour of the container	Country/ region of origin, approximate age
Production/expiry date	"Best before (…)", mold stamp on chemical containers (production date)	Age

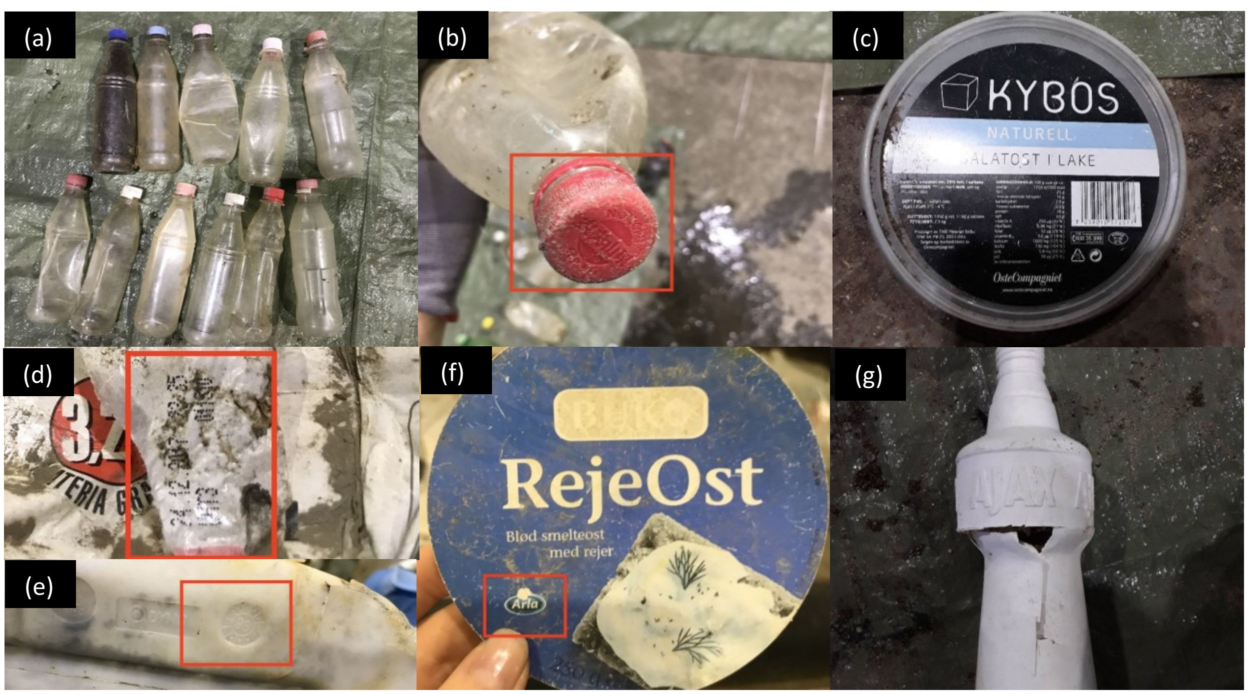


***Figure 1:** Examples of geographical origin, age identifiers and degradation rates. (a) Drinking bottles used in Denmark's and Norway's deposit-return system (design). (b) A drinking bottle with the logo "Nongfu Spring", which according to Google search is a Chinese bottled water and beverage company (logo/brand), moderate degradation. (c) A food container with the text written in Norwegian indicating geographical origin (text), low degradation. (d) A food container with the expiry date 24.12.2017 printed on (expiry date). (e) An oil- or chemical container with a mold stamp where 6 of 12 months are marked and 98 is stamped in the middle of the circle referring to the container being produced in June 1998 (production date). (f) A cream cheese lid with the "Arla" logo, which according to https://logos.fandom.com/wiki/Logopedia was adopted by the company in 2008, dating the product to be maximum 11 years old (logo/brand). (g) Ajax bottle, internationally distributed thus unknown geographical origin, highly degraded.*

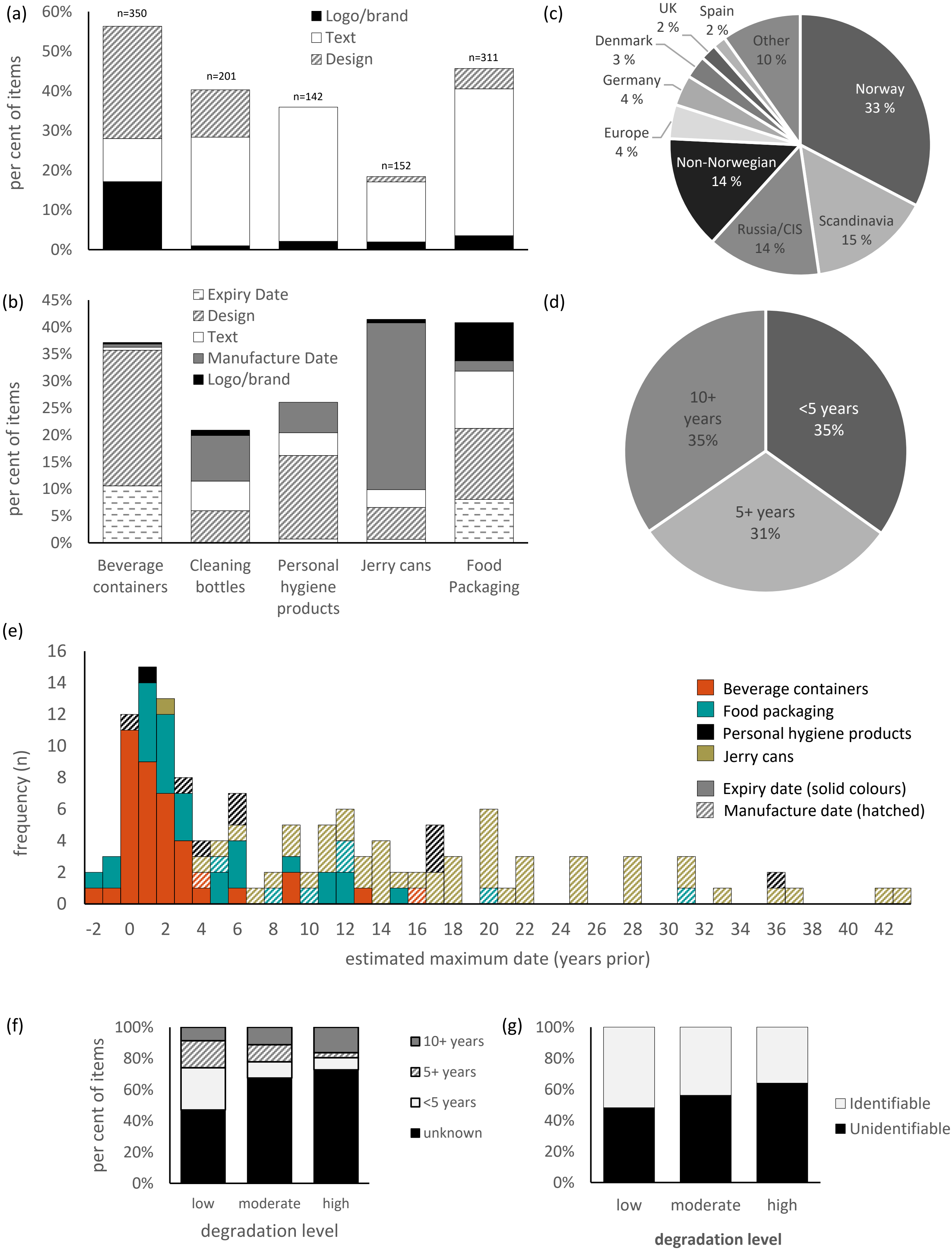


Figure 2: *Panels (a) and (b) show the percentage of items for which origin and date were determined, respectively, as well as the frequency with which each method was used; n above the columns show total number of items analysed. Pie charts indicate the percentage of allocated items identified to different (c) origins and (d) date classes. (e) Frequency distribution of years difference from 2019 (sampling year) for items dated by expiry or manufacture date. Negative values indicate the presence of expiry dates beyond 2019 while positive values indicate expiry/manufacture dates prior to 2019. Readers are referred to the online version of the article for a colour rendition of this panel. (f) Stacked bar graph showing the percentage of items assigned different age categories in relation to degradation level. (g) Stacked bar graph showing the percentage of items able to be assigned to a geographical origin in relation to degradation level.*

Supplementary material

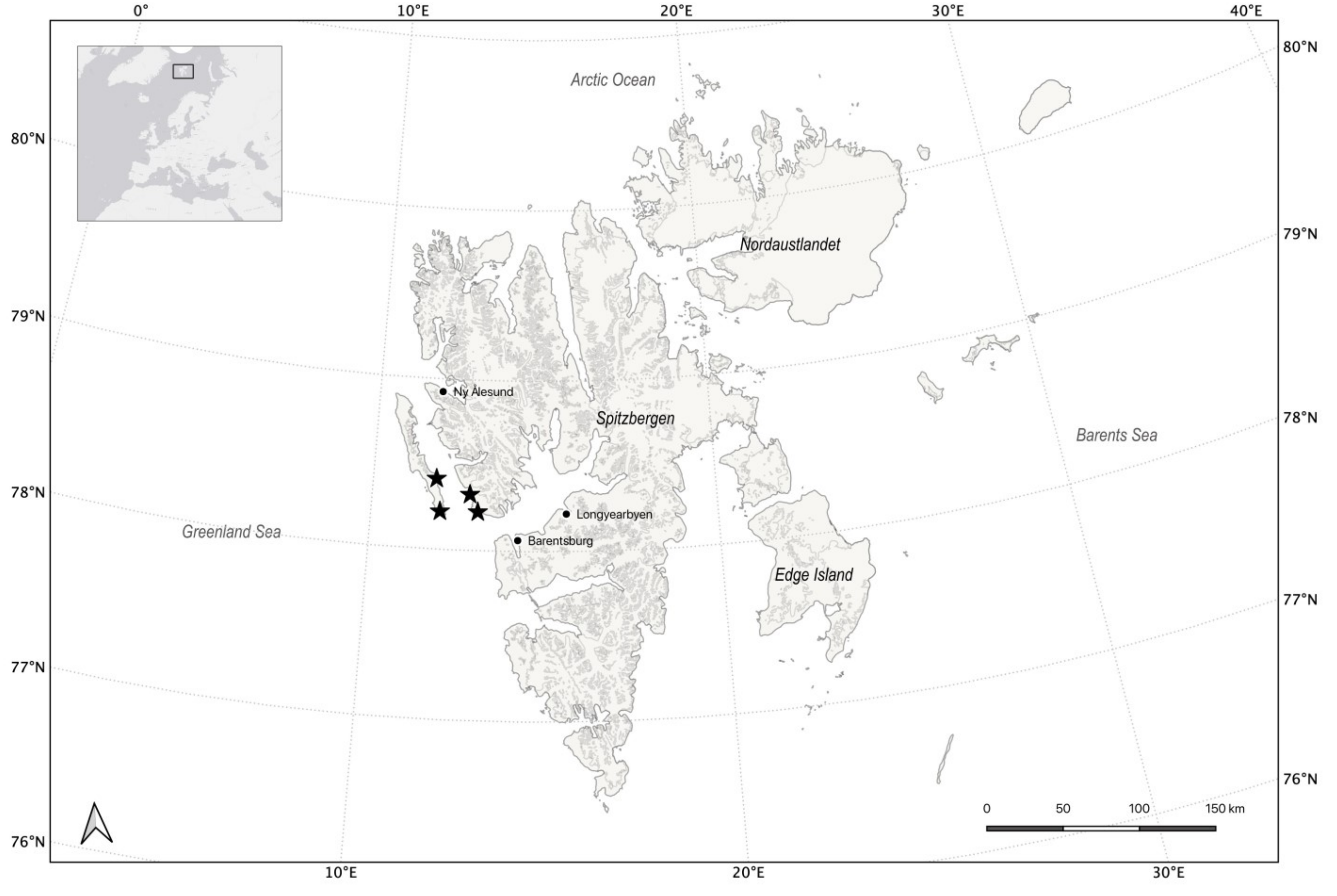


Figure S1: *Location of the beach from which litter was obtained (indicated by stars).*

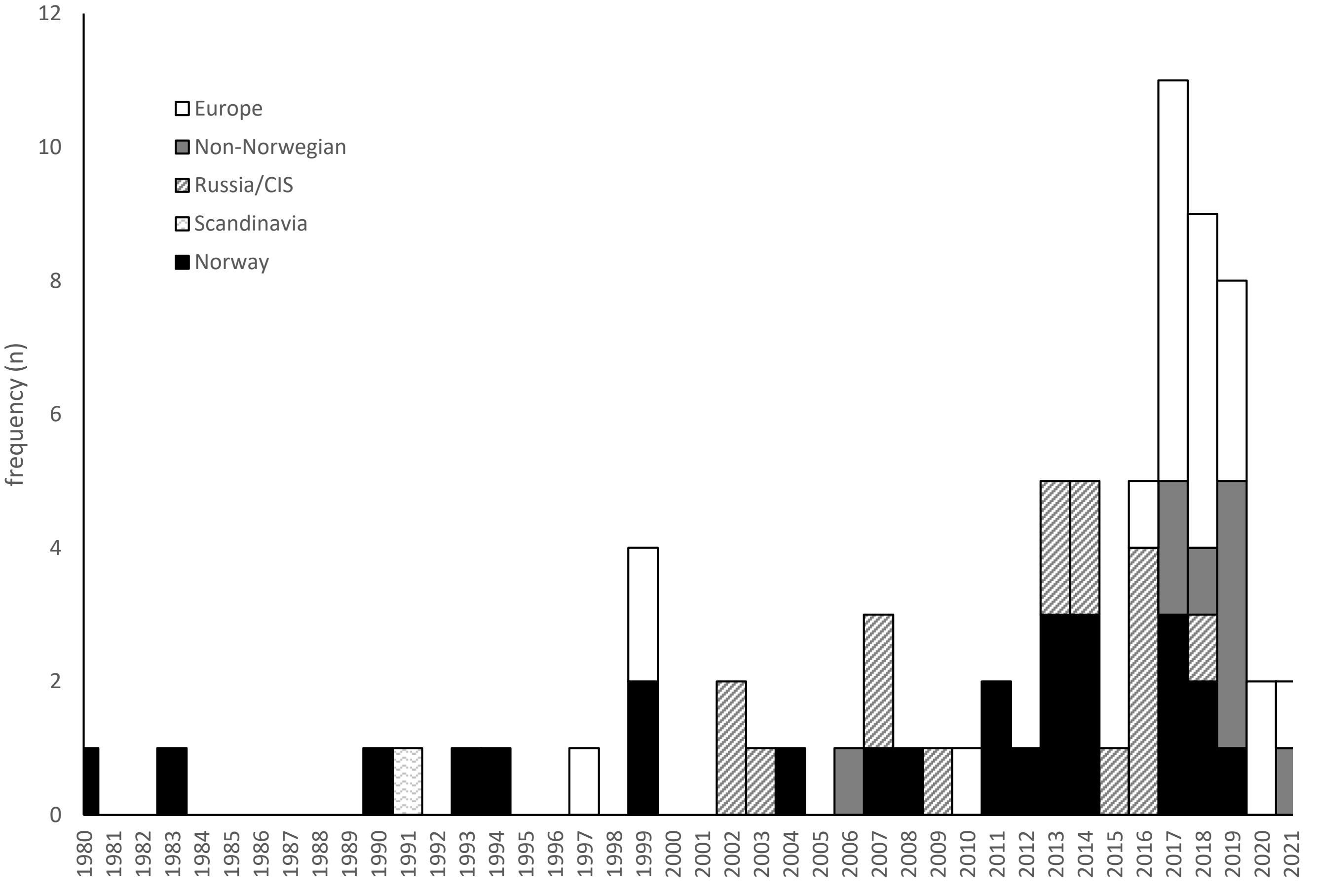
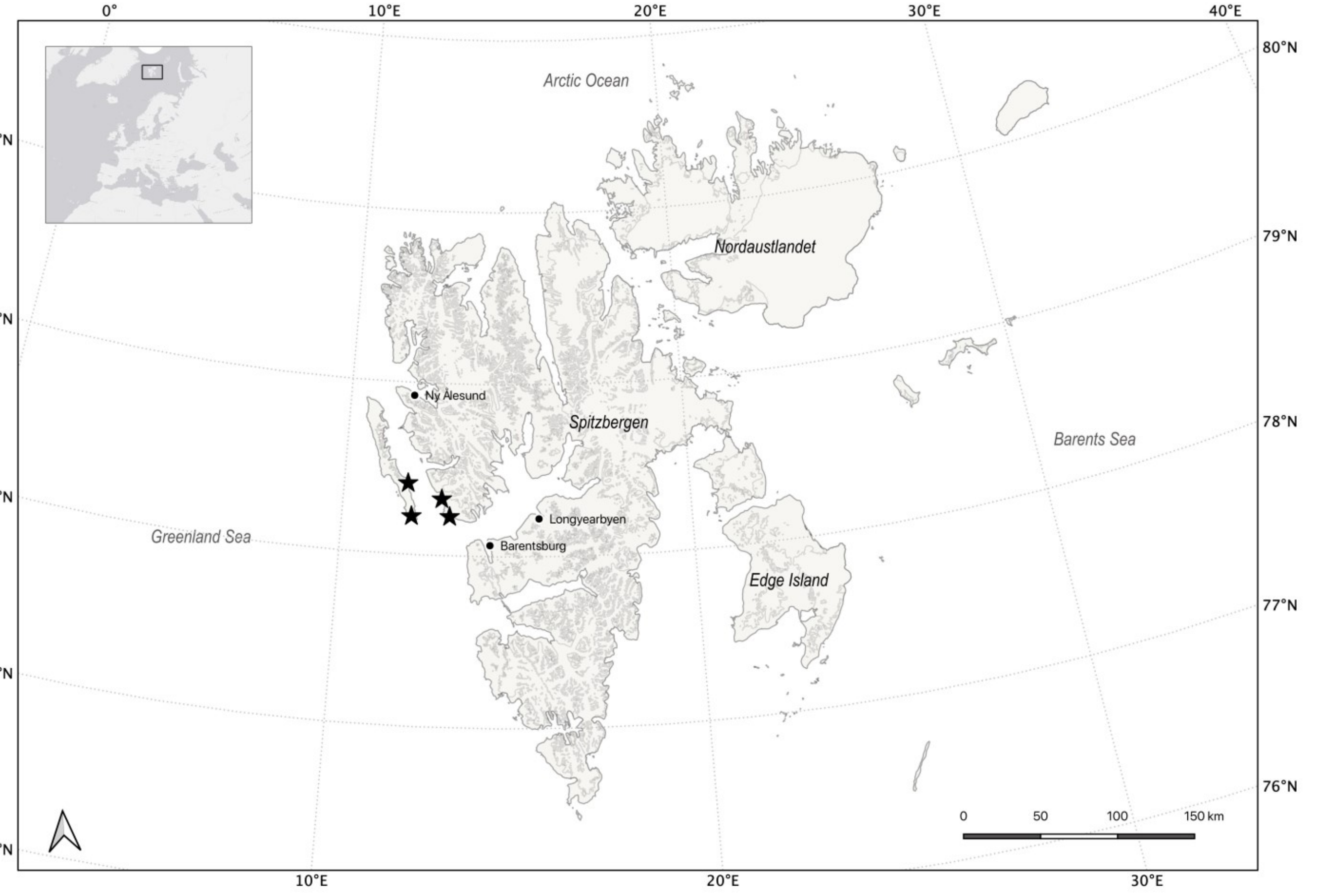


Figure S2: *Frequency distribution of dated items (production or expiry date) by nationality. European items were German (12 items), Denmark (11), Europe (6), France, Estonia, Latvia, Poland, Spain (3), Scotland, Finland (2) Italy, UK, Turkey, Lithuania and Denmark/Faroe Island/ Greenland (1).*

Table S1: *Overview of the prevalence of text and logo/brand on different types of litter items, and the degree to which this information was used for dating and origin determination.*

Item category	***Present***	***Absent***	***Used for origin determination***	***Used for dating***	***Used when present (origin)***	***Used when present (date)***
Text						
Beverage containers	13%	87%	11%	1%	83%	4%
Cleaning bottles	41%	59%	27%	5%	66%	13%
Personal hygiene products	37%	63%	34%	4%	92%	12%
Industrial Oil/Chemical Containers	51%	49%	15%	3%	30%	6%
Food Packaging	40%	60%	37%	11%	92%	26%
Total	33%	67%	24%	5%	73%	15%
Logo/brand						
Beverage containers	32%	68%	17%	0%	54%	1%
Cleaning bottles	13%	87%	1%	1%	8%	8%
Personal hygiene products	27%	73%	2%	0%	8%	0%
Industrial Oil/Chemical Containers	12%	88%	2%	1%	17%	6%
Food Packaging	44%	56%	4%	7%	8%	16%
Total	29%	71%	7%	2%	24%	8%

Supplementary material



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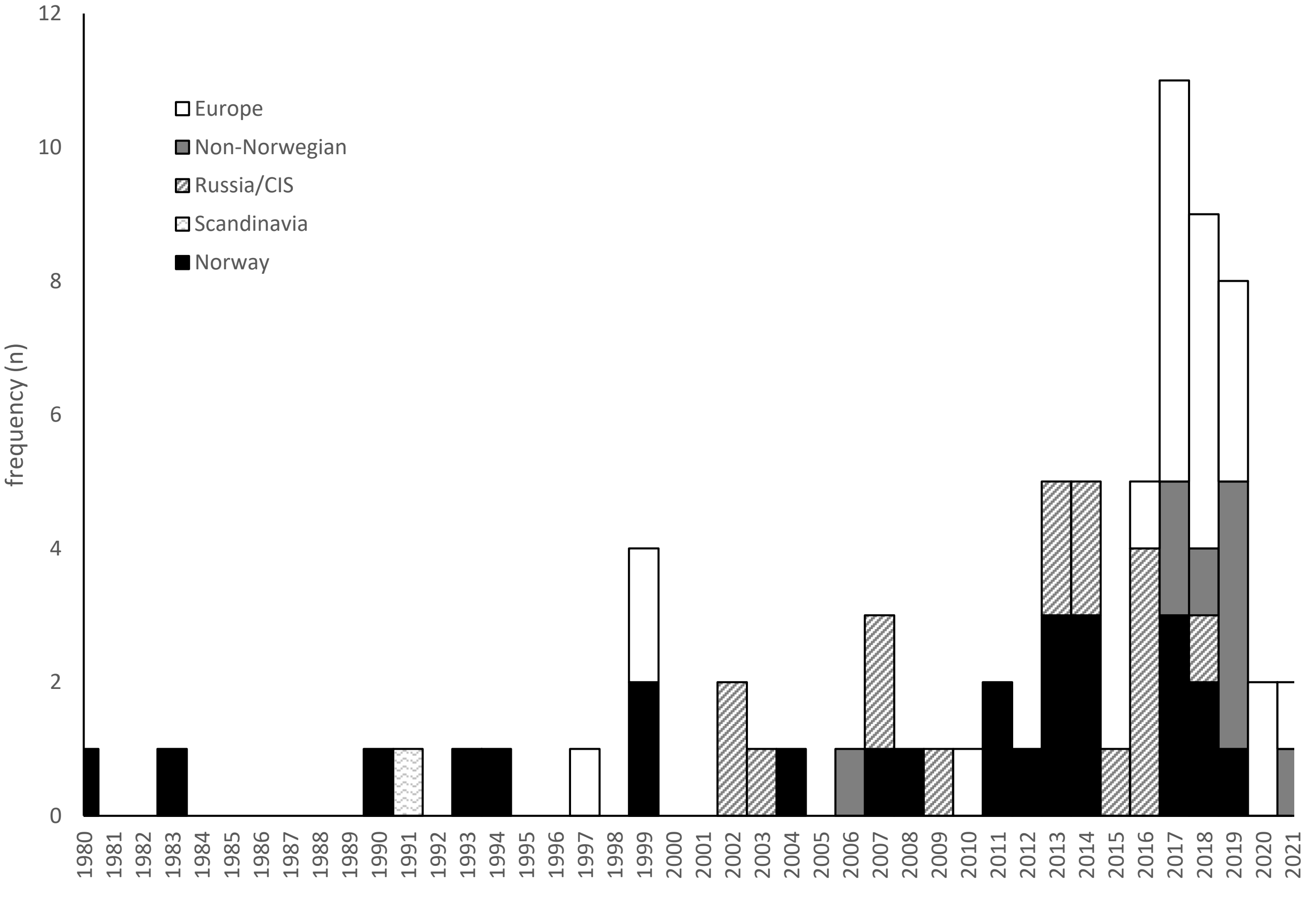

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