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Development of a Norwegian monitoring program for Macroplastic and Litter

Photo: Jannike Falk-Andersson/NIVA

Norwegian Institute for Water Research

REPORT

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Summary

The Norwegian Environment Agency (NEA) aims to strengthen environmental monitoring of macroplastic and litter pollution in Norway. Macroplastic and litter are items above 25 mm. Monitoring of litter in the Northern Fulmar is included (1-25 mm) as this is an established indicator representing biota. The other environmental compartments covered in this report are coastal waters, oceans, lakes, rivers, and terrestrial environments. This report identifies international obligations and national needs for knowledge on litter, reviews international harmonisation efforts for monitoring of litter and evaluates their technological readiness levels for implementation in monitoring programs. Data availability, on-going monitoring activities and initiatives that could contribute to collecting data on litter in Norway is mapped, and the cost of expanding existing monitoring is evaluated. Based on this mapping recommendations are given on how monitoring of macroplastic and litter could be strengthened in the future in Norway.

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2. Monitoring	2. Overvåking
3. Norway	3. Norge
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Development of a Norwegian monitoring program for Macroplastic and Litter

Preface

This report presents the outcome from the project *Utvikling av et overvåkningsprogram for plastforurensning i Norge* (Development of a monitoring programme for plastic pollution in Norway). This project has been run in agreement between the Norwegian Environment Agency (Miljødirektoratet) as client and NIVA as project manager. The client's contact has been Kristine Von Hanno. Project leader at NIVA has been Jannike Falk-Andersson. The project from inception to reporting was carried out by Jannike Falk-Andersson and Amy Lusher (NIVA). The report was written with support from Marthe Larsen Haarr (SALT), Idun Rognerud, Rachel Hurley. Sverre Hjelset and Saskia Trubbach (NIVA) were responsible for literature collection and review. Chief Scientist Bert van Bavel carried out QA of the report. Marianne Olsen (NIVA) and Kathinka Furst are thanked for fruitful discussions. A special thanks to our international experts that reviewed and gave input to the report. NIVA appreciates the opportunity to complete this project and acknowledges everyone involved for good cooperation.

Tromsø, December 2022

Jannike Falk-Andersson
Project Manager

Table of contents

Summary

The environmental challenge posed by plastic pollution is recognised as a major problem in Norway as well as globally. Knowledge on the amounts and composition of litter in the environment is key to assess the state of the environment, identify measures, and monitor the effect of measures. A national monitoring program on microplastic was established in 2021, but there is currently no holistic monitoring program on other plastic pollution, including litter. The Norwegian Environment Agency (NEA) aims to strengthen environmental monitoring of macroplastic and litter pollution in Norway.

This report focuses on macroplastic and litter above 25 mm. The environmental compartments covered are coastal waters, oceans, lakes, rivers, and terrestrial environments. The Northern Fulmar is included representing biota, as their stomach content is already an OSPAR indicator for impact on biota from plastic particles 1-25 mm and stomach content sometimes reveals larger plastic fragments.

International obligations were mapped from the global to regional levels, with the United Nation's Sustainable Development Goals (SDGs) setting out a global framework including commitments to reduce plastic pollution. Whilst Norway has not implemented the EU Marine Strategy Framework Directive it is still a contracting party under the OSPAR Convention which has approved indicators for monitoring plastic pollution. Further regional initiatives of relevance include the Arctic Monitoring and Assessment Programmes (AMAP) and ICES. A stakeholder workshop and national policy documents identified national needs. Across all these international obligations and national needs identified, four indicators hold precedence: assessments of litter and macroplastics (1) on beaches and shorelines, (2) at the water surface, (3) on the seafloor, and (4) ingestion by biota. Knowledge on the amounts of litter, as well as their sources is requested both to identify mitigation actions and assess the impact of policies. Furthermore, knowledge across environmental compartments on the composition, spatial distribution, and sources of litter, as well as a better understanding of their transportation pathways, is requested.

Inconsistencies in sampling designs and classification systems has been identified as a major limitation to manage the marine litter crisis. These inconsistencies limit our abilities to compare levels and sources across regions, and thereby also the identification and development of global mitigations strategies. Harmonisation of monitoring guidelines has therefore been at the forefront of international efforts to secure that data generated is comparable on a national, regional, and international level. Outcomes of international synthesis and harmonisation efforts were reviewed and key, established monitoring guidelines summarised. These were evaluated for Technological Readiness Level (1-9, where 9 is the most mature), which is a systematic measurement approach to assess the maturity of a technology.

There are many different approaches and methods available to assess litter and macroplastics in the environment. A common element across all is the importance of sufficient metadata describing the location sampled and a classification system for documenting the amount (normally numbers, but weight, area or volume is required by some guidelines and compartments) and composition (material and/or source items) of the litter. The Joint List of Litter Categories compiled by the JFC combines the litter types from different marine litter monitoring lists (OSPAR, ICES, UNEP, etc.) into one.

Documentation of litter on shorelines and beaches can be addressed using robust methods (TRL 7- 8). These include accumulation surveys and standing stock surveys. Norway already applies the OSPAR

beach litter protocol on seven beaches. The citizen science initiative, Rydde, also generates beach litter data. However, the complexity and robustness of data generation has been called into question, since the heterogeneity of litter on shorelines and the number of beaches/sampling periods needs further investigation.

There are two main approaches to monitor floating marine litter. Net (trawl) surveys are the most common form of collection-based monitoring, and visual surveys are performed from vessels for monitoring purposes, with new technology such as airplanes and drones in combination with machine learning being investigated. Both visual and trawl approaches are recommended, with a combination being important to ground-truth visual observation methods (TRL 8-9). Litter and macroplastics presence in the water column is not currently included as a primary monitoring tool but can be useful to obtain data on litter transiting the water column (TRL 5).

Methods available for monitoring the seafloor are visual surveys using towed camera surveys, ROVs and submersibles and trawl surveys (TRL 7-8). For complex seafloor features, it is recommended that priority is given to visual surveys in areas where accumulation is known to occur, such as canyons and areas inaccessible by trawls. It is recommended that monitoring of floating and benthic litter is incorporated with surveys which are already in place, such as benthic fish or biodiversity surveys. The Norwegian Institute of Marine Research is combining such monitoring in the Barents Sea for the ocean surface, mid-water, and seafloor litter, and takes part in the International Bottom Trawl Surveys (IBTS) in the North Sea where benthic litter is documented. Additionally, litter is documented throughout the MAREANO program which maps the ocean floor. These programs could be extended and data collection harmonised with international guidelines.

Biota are included as indicators for the surface waters, as well as investigations of impacts on biota. For this reason, monitoring using stranded/beached seabirds are already well established with methods that can be transferable to other seabird species (TRL 8-9). For example, Norway already implemented OSPAR monitoring using stomach content of Fulmars, and this programme could be extended to more beaches (where birds are stranded), or additional species.

Monitoring in freshwater systems is still in its infancy (TRL 2-6) and not yet implemented in ongoing international monitoring programs, with comparative approaches recently emerging in monitoring recommendations. Rivers can be monitored for floating litter using observation-based sampling or physical inception-based monitoring. Currently none of these approaches are routinely applied in Norway but international approaches could be considered. For riverbanks, similar methods for shorelines could be applied and published studies are beginning to emerge internationally demonstrating their application and adding necessary optimisation. However, they may need to be further adapted based on catchment characteristics of a chosen site, including application of these methods in Norway. Riverbeds and banks will require further research and development before recommending them as an indicator for litter and macroplastics. No monitoring protocols are currently available for lakes, although surface and benthic sampling akin to the marine environment could be recommended for further research and development. Lake shorelines have received limited attention, drawing parallels from coastal shoreline methods with some adaptations necessary.

Terrestrial environments have been comparatively under-researched. Preliminary methods for quantifying plastic pollution in agricultural soils have emerged in recent years and citizen science initiatives have begun to quantify litter across both urban and rural environments (TRL 5 for the two methods identified) However, further research and development is needed to progress this work towards representative methods with established guidelines before incorporating terrestrial environments within a monitoring programme.

Beach litter data is the most abundant in Norway, followed by data from offshore monitoring programs that are combined with stock assessments or seabed mapping. There is little or no data available for other environmental compartments. Monitoring data on macroplastics and litter in Norway is available through open access platforms; OSPAR and EMODnet for OSPAR beach litter data and litter in Fulmars, Norsk Marint Datasenter for the Barents Sea survey and MAREANO documentations, and Rydde for citizen science beach litter data. Information on recovered fishing gear is reported in Yggdrasil. However, many data collection initiatives have not stored the data open access. Many of these are one-off initiatives without any long-term funding. There is currently no centralised location where all data on plastic pollution in the Norwegian environment is collected. Harmonisation is also lacking to secure that data can be compared across data collection initiatives and thereby also across compartments.

An evaluation of existing activities and inclusion of other actors identified several initiatives that has the potential to provide additional data on littering. The Rydd Norge program collects litter along the outer coasts and could collect samples for analysis, thus reducing the cost of data collection. Analysis of litter recovered through Fishing for Litter and the clean-up actions of the Directorate of Fisheries can also provide important insight on benthic litter. Citizen science initiatives are already providing data on littering and the value of these initiatives could be increased through harmonisation and close cooperation with experts holding competence on monitoring of litter. There is also a potential in collecting data from initiatives implementing clean-up technologies and involvement of producers in general, and the aquaculture, fisheries, agriculture, and construction industry specifically.

Key recommendations following this mapping is that Norway should extend its current monitoring efforts of shorelines, the ocean surface, the seafloor, and ingestion of litter by the Northern Fulmar. Norway should also strengthen the on-going citizen science effort Rydde and involve experts to increase the monitoring value of these initiatives. Internationally harmonised monitoring protocols should be applied, with prioritisation to those applied in Europe. For litter categorisation it is recommended that the Joint List of Litter Categories by the JRC is used where practically feasible. Adjustments should be made to document litter items that are important in a Norwegian context, particularly to follow up national policies related to producer responsibility. Norway should contribute to research to establish monitoring guidelines for non-marine environmental compartments and strengthen cooperation between citizen science initiatives, experts, and managers/decision makers. Apart from winter conditions, which may limit seasonal replications to comply with international monitoring guidelines, the main adaptation needed to implement a monitoring program is related to Norway's complex topography and the heterogeneity of litter documented along the shorelines. It is important that the variability in data is reduced. For each compartment, there is a need to consult experts to identify the appropriate sampling strategy given the magnitude of change different obligations and local needs require, and realistic resource use on monitoring.

Sammendrag

Tittel: Development of a Norwegian monitoring program for Macroplastic and Litter
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Miljøutfordringen som plastforurensning representerer, er anerkjent som et stort problem i Norge så vel som globalt. Overvåkning av forsøpling, inkludert makroplast, er en viktig del av arbeidet med å vurdere miljøtilstand i forhold til mengde søppel, identifisere tiltak og overvåke effekten av tiltak. Et nasjonalt overvåkningsprogram for mikroplast ble etablert i 2021, men det er i dag ikke noe helhetlig overvåkningsprogram for annen plastforurensing, inkludert forsøpling. Miljødirektoratet ønsker å styrke miljøovervåkning på makroplast og forsøpling i Norge.

Denne rapporten omhandler makroplast og søppel over 25 mm. Miljøene rapporten omfavner er kyst, hav, ferskvann og elver. Havhest er inkludert som representant for biota ettersom plast i magen til havhest allerede er en OSPAR indikator for påvirkning på biota fra partikler mellom 1 og 25 mm, selv om også større plastfragmenter har blitt observert

Internasjonale forpliktelser har blitt kartlagt fra globalt til regionalt nivå. FNs bærekraftsmål representerer et globalt rammeverk som også inkluderer forpliktelser til å redusere plastforurensingen. Norge har ikke implementert EUs havstrategidirektiv, men er likevel forpliktet under OSPAR konvensjonen som har vedtatt indikatorer for overvåkning av plastforurensing. Andre regionale initiativ av relevans er AMAP og ICES. En workshop med interessenter og studie av nasjonale utredninger identifiserte nasjonale behov for kunnskap. På tvers av alle disse forpliktelsene og behovene skilte fire indikatorer seg ut: evaluering av makroplast og søppel på (1) strender og strandlinjer, (2) på havoverflaten, (3) på havbunnen, og (4) biotas inntak av plast. Kunnskap om mengde søppel og deres kilder er etterspurt både for å identifisere forebyggende tiltak og evaluere effekten av tiltak. I tillegg etterspørres kunnskap på tvers av ulike miljøer angående sammensetning, fordeling og kilder, samt en bedre forståelse av hvordan søppel transporteres mellom og innad i miljøer.

Ulike prøvetakingsstrategier og klassifiseringssystemer har blitt identifisert som en stor hindring for å håndtere den marine forsøplingskrisen. Dette har begrenset muligheten til å sammenligne nivåer og kilder av forsøpling på tvers av regioner, og dermed også identifisering og utvikling av forebyggende strategier. Harmonisering av retningslinjer for overvåkning har derfor vært et sterkt fokus i internasjonale initiativer for å sikre at data er sammenlignbare på nasjonalt, regionalt, og internasjonalt nivå. Resultatene fra syntese og harmoniseringsarbeid ble gjennomgått og etablerte retningslinjer for overvåkning oppsummert. Disse ble vurdert for Teknologisk Modenhetsnivå (TRL 1-9 hvor 9 er mest modent), som er en systematisk måletilnærming for å vurdere modenhet til en teknologi.

Der er mange tilnærminger og metoder tilgjengelig for å hente inn kunnskap om makroplast og forsøpling i miljøet. Elementer som går igjen er viktigheten av tilstrekkelig metadata som beskriver prøvelokasjonen og et klassifiseringssystem for å dokumentere mengde (vanligvis i antall, men vekt, areal eller volum kreves ifølge noen retningslinjer og miljøer) og sammensetning (material og/eller kildekategorier) av søpla. "The Joint List of Litter Categories" kombinerer søppeltyper fra ulike protokoller for overvåkning av marin forsøpling (OSPAR, ICES, UNEP, etc) i en.

Dokumentasjon av søppel i strandsonen og på strender kan adresseres ved hjelp av robuste metoder (TRL 7-8). Dette inkluderer akkumuleringsundersøkelser, som gir kunnskap om avsetningsrate og endring i sammensetning over tid, og undersøkelse av mengden søppel som samler seg i et område over tid. Norge overvåker søppel på 7 strender i henhold til OSPAR metoden. Folkeforskningsdata genereres også for strender gjennom Rydde. Men kompleksiteten og robustheten til dataen som genereres har det blitt satt spørsmålstegn ved på grunn av stor variasjon av søppel langs strendene. Det er derfor behov for å få en større forståelse for hvor mange strender man bør samle data for og viktigheten av replikasjoner gjennom året.

Det er hovedsakelig to metoder for overvåkning av flytende søppel. Kartlegging ved bruk av trål er den vanligste formen for overvåkning der søppel blir samlet inn, mens visuell kartlegging gjennomføres fra båter. Ny teknologi, som kartlegging ved hjelp av fly og droner i kombinasjon med maskinlæring, utvikles og kan bli viktig i fremtiden. Både kartlegging ved hjelp av trål og visuelle metoder er anbefalt (TRL 8-9). Det er viktig å kombinere de to metodene for å bekrefte visuelle metoder. Overvåkning av makroplast og søppel i vannsøylen er ikke inkludert som en anbefalt overvåkningsmetode, men det kan være nyttig for å få data om søppeltransport i vannsøylen (TRL 5).

Metoder tilgjengelig for overvåkning av havbunnen er: visuelle metoder ved hjelp av kamera, ROV og undervannsfarkoster, samt trålmetoder (TRL 7-8). For komplekse bunnforhold er visuelle metoder anbefalt. Det er anbefalt at kjente akkumuleringsområder, som undervannscanyons, kartlegges ved hjelp av visuelle metoder. Overvåking av plast i havoverflaten og på havbunnen bør skje i sammenheng med pågående overvåkning, som bunnfisk- og biodiversitetsundersøkelser. Norsk Havforskningsinstitutt kombinerer slik overvåkning i Barentshavet for havoverflaten, vannsøylen og havbunnen, og deltar i de internasjonale bunntrålingstoktene i Nordsjøen hvor søppel dokumenteres. Gjennom MAREANO-programmet, som kartlegger havbunnen, dokumenteres også søppel. Disse programmene burde utvides og datainnhenting harmoniseres med internasjonale retningslinjer.

Biota er inkludert i overvåkning som indikator for både havoverflaten og påvirkning på biota. Overvåkning av strandede sjøfugl er en godt etablert metode som kan bli overført til andre sjøfuglarter (TRL 8-9). Norge har allerede iverksatt overvåkning av plast i magen til havhest i henhold til OSPAR. Dette kan utvides til å inkludere flere strender (hvor fugler er strandet) og arter.

Overvåkning av ferskvannssystemer er fremdeles i forskningsfasen (TRL 2-6) og er ikke implementert i pågående internasjonale overvåkningsprogrammer, men noen internasjonale anbefalinger har nylig blitt publisert. Elver kan overvåkes ved hjelp av visuelle og fysiske (oppsamlings-) metoder. Ingen av disse er i bruk rutinemessig i Norge i dag, men internasjonale anbefalinger kan vurderes. For elvebredder kan man ta i bruk lignende metoder som for strandlinjer og nyere internasjonale studier har demonstrert at disse kan ha overføringsverdi gitt at metodene optimaliseres. Men det kan være behov for ytterligere tilpasninger basert på karakteristikken til nedbørsfeltsområdet for det valgte området, inkludert tilpasninger av disse metodene til norske forhold. For elvebredder og -banker vil det kreves mer forskning og utvikling før metoder for overvåkning kan anbefales. Ingen retningslinjer er tilgjengelig for overvåkning av innsjøer, men metoder brukt for overvåking av havoverflaten og havbunnen kan ha overføringsverdi og bør utforskes videre. Strandlinjen til ferskvann har fått begrenset oppmerksomhet, men metoder brukt for strender i kystmiljø er forventet og ha høy overføringsverdi gitt noen tilpasninger.

Det er lite forskning på forsøpling i terrestriske miljøer. Metoder for kvantifisering av plastforurensing i matjord har blitt utviklet de senere år, og folkeforskningsinitiativer har begynt å kvantifisere forsøpling i urbane or rurale miljøer (TRL 5 for de to metodene identifisert). Det er behov for forskning og utvikling for at disse initiativene skal utvikles i retning representative metoder med etablerte retningslinjer før terrestriske miljøer kan inkluderes i et overvåkningsprogram.

Det er mest data på strandsøppel i Norge, etterfulgt av data fra overvåkningsprogrammer til havs som kombineres med bestandsvurderinger og kartlegging av havbunnen. Det er lite eller ingen data tilgjengelig for andre miljøer. Overvåkningsdata på makroplast og forsøpling er tilgjengelig via åpne plattformer for datautveksling; OSPAR og EMODnet for OSPAR data på strandsøppel og havhest, Norsk Marint Datasenter for Barentshavtoktet og MAREANO dokumentasjon, og Rydde for folkeforskningsdata fra strender. Informasjon fra oppfisking av tapte redskaper er rapportert i Yggdrasil. Men mange datainnsamlingsinitiativer har ikke lagret data åpent tilgjengelig. Mange av disse er engangsinitiativer uten langsiktig finansiering. I dag er det ikke noe sentralisert datalagringssystem for plastforurensing i Norge. Harmonisering mangler også for å sikre at data kan bli sammenlignet på tvers av datainnsamlingsinitiativer og dermed også på tvers av miljø.

En evaluering av pågående aktiviteter og inkludering av andre aktører identifiserte flere initiativer som har potensial til å gi ekstra data på forsøpling. «Rydd Norge»-programmet rydder søppel langs ytre kyst og kunne hentet inn prøver for analyser, noe som ville redusert kostnadene forbundet med datainnsamling. Analyse av søppel samlet inn gjennom Fishing for Litter og Fiskeridirektoratets oppfisking av tapte redskaper kan gi viktig innsikt i havbunnsforsøpling. Folkeforskningsinitiativer bidrar allerede med data på forsøpling og verdien av disse kan økes gjennom harmonisering og tett samarbeid med eksperter som har kompetanse på overvåkning av søppel og makroplast. Det er også et potensial for å samle data fra initiativer som benytter seg av ulik ryddeteknologi, samt involvering av produsenter generelt, og akvakultur, fiskeri, jordbruk og byggenæringen spesielt.

Sentrale anbefalinger basert på denne gjennomganger er at Norge utvider pågående overvåkningsaktivitet av søppel og makroplast på strender, på havoverflaten, på havbunnen og i magen til havhest. Norge bør også styrke pågående folkeforskningsaktivitet (Rydde) og eksperter involveres for å styrke verdien av disse initiativene i overvåkning. Man bør bruke internasjonalt harmoniserte overvåkningsprotokoller og prioritere de som blir brukt i Europa. For identifisering av søppelgjenstander anbefales det at protokollen «the Joint List of Litter Categories by the JRC" tas i bruk der dette er praktisk mulig. Tilpasninger bør gjøres for å dokumentere søppelgjenstander som er viktig i en norsk sammenheng, spesielt når det gjelder å følge opp produsentansvarsordningen. Norge bør bidra til forskning for å etablere retningslinjer for overvåkning i andre ikke-marine miljøer og styrke samarbeid mellom folkeforskningsinitiativer, eksperter og forvaltning/beslutningstagere. Internasjonale retningslinjer for overvåkning anbefaler at data samles inn gjennom hele året, noe som kan være utfordrende på grunn av vinterforholdene i Norge. Foruten dette, er behovet for tilpasning av retningslinjer for overvåkning hovedsakelig relatert til Norges komplekse topografi og heterogenitet i forsøpling som dokumentert langs strender. Man bør konsultere eksperter for å identifisere den rette prøvetakingsstrategien i de ulike miljøene i forhold til hvor stor sensitivitet som kreves for å måle endringer gitt de ulike internasjonale og lokale behovene, samt realistisk ressursbruk til overvåkning.

0 Glossary

Abbreviation	Definition
AMAP	Arctic Monitoring and Assessment Programme
AMAP LMEG	AMAP Litter and Microplastic Expert Group
ASEAN	Association of Southeast Asian Nations
CBD	Convention on Biological Diversity
CLT	Clean-up Technology
COBSEA	Coordinating Body on the Seas of East Asia
EC	European Commission
EcoQO	Ecological Quality Objective
EEA	European Economic Area
EMODnet	European Marine Observation and Data Network
EPR	Extended Producer Responsibility
EU	European Union
FFL	Fishing for Litter
GES	Good Environmental Status
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GPML	Global Partnership on Marine Litter
HMF	Norwegian Retailer's Environment Fund (Handelensmiljofond)
IBTS	International Bottom Trawl Survey
ICES WGML	International Council for Exploration for the Seas Working Groups on Marine Litter
IMR	The Norwegian Institute of Marine Research
IOC	Intergovernmental Oceanographic Commission
ISO	International Standardisation Organisation
Joint List	The Joint List of Litter Categories by JRC
JRC	Joint Research Council
KNB	Keep Norway Beautiful
LAS	Lofoten Avfallsselskap
MARFO	Norwegian Centre against Marine Litter
ML-RAP	Marine Litter Regional Action Plan
MSFD	Marine Strategy Framework Directive
MSFD TGML	MSFG Technical Group on Marine Litter
NDF	The Norwegian Directorate of Fisheries
NEA	Norwegian Environment Agency (Miljødirektoratet)
NFR	The Norwegian Research Council
NOAA	National Oceanic and Atmospheric Administration (USA)
NOWPAP	Northwest Pacific Action Plan
NRF	Norwegian Retailers' Environmental Fund
ODIMS	OSPAR Commission Data and Information Management System
OSPAR	Oslo-Paris Convention
RSCs	Regional Seas Conventions
SUP	Single Use Plastics- referring to the items being by the EU SUP Directive
TGML	Technical Group on Marine Litter
ToR	Terms of References
TRL(s)	Technological Readiness Level(s)

UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UN SDGs	United Nationals Sustainable Development Goals
UNEP WCMC	The UN Environment Programme World Conservation Monitoring Centre

1 Introduction

1.1 Background, aim and scope

The environmental challenge posed by plastic pollution is recognised as a major problem in Norway as well as globally. There have been huge international efforts focused towards developing methods and establishing monitoring frameworks, mostly directed towards the marine environment. This is mirrored in Norway's national plastics strategy and marine management plans (e.g. KLD (2021); NMCE (2017)). The Norwegian Environment Agency (NEA) aims to strengthen environmental monitoring of plastic pollution in Norway. A monitoring program on microplastic was established in 2021, but there is currently no holistic monitoring program on other plastic pollution, including marine litter. Knowledge on amounts and composition of litter in the environment is **key to assess the state of the environment, identify measures, and monitor the effect of measures**.

To plan and implement relevant monitoring that meets both international requirements and national needs, NEA would like to get a better overview of these requirements and needs, obtain an overview of existing methods and data available for monitoring macroplastic and litter in Norway, identify activities that could provide additional data relevant for monitoring, and estimate costs of different alternatives for monitoring. Finally, NEA would like to get advice on a future monitoring program on macroplastic and litter in Norway.

This report includes a mapping of international obligations and key findings from a stakeholder workshop on national needs for knowledge on litter, an overview of recommended monitoring methods of litter and macroplastics, as well as data available on plastic pollution in Norway including the method applied and environmental compartments covered. Potential needs for adjusting the methods to a Norwegian context are identified and the general logistics of macroplastic monitoring described. Current environmental monitoring programs in Norway have been mapped and the potential for collecting litter and macroplastic samples in coordination with these has been evaluated. Further, the potential for collecting data in connection with on-going activities has been described and estimates are provided for costs. This report does not consider microplastics, but focuses on macroplastic and litter above 25 mm. The environmental compartments covered are coast, ocean, lakes, rivers, and the Northern Fulmar. The latter is targeting plastic particles 1-25 mm.

With the recent recommendations for monitoring as the primary background (AMAP (2021a); COBSEA (2022); GESAMP (2019); (UNEP, 2021a); Vighi (2022)), supported by the international status of methods (Aliani et al., 2022; Browne et al., 2015; Cheshire et al., 2009; M. L. Haarr et al., 2022), this report provides recommendations for the establishment of a future monitoring programme for in macroplastic pollution and litter Norway that ensures measures implemented to reduce plastic pollution are knowledge-based and that changes in amounts and/or composition of litter can be detected over time. It focuses on available international literature (peer-reviewed and grey literature/reports) as well as central management-related documents on marine litter, and the outcomes of a stakeholder workshop, supported by review and input from national and international experts. The stakeholder workshop was held to discuss the challenges and opportunities associated with developing a monitoring program for plastics in Norway and mapped stakeholder's knowledge needs. Hence, this approach targets both national needs, as identified by stakeholders, and international obligations, whilst presenting modifications tailored for the complexity of environmental compartments and ecosystems in Norway.

1.2 Definitions and size

The definitions used throughout this report conform to the definitions harmonised through the EUROqCHARM project[1]. Plastic littering and littering are often referred to without clear definitions. The former includes litter made of the material plastics, while the latter includes litter of all types of materials. Considering the different definitions used for plastics (**Table 1**)[2], and that most established clean-up activities and monitoring focus on litter, in this report, **litter of all types of material will be included in the mapping of data and methods available, but for assessments, there will be a focus on the plastic fraction litter.**

Monitoring of macroplastic and litter mainly includes particles over 25 mm and will therefore be the focus in this report. This report will use the ISO definition, but also include some identifiable items such as nurdles, plastic biofilters, and cigarette butts since these items are identified in established clean-up protocols. This report will also include the mesoplastic fraction with respect to monitoring of plastics in the Fulmar stomachs, as the method applied is better suited for the fraction from 1 to 25 mm (AMAP, 2021a, 2021b). **Table 2** includes examples of the diversity of size categories used by the international community, including the ISO and international expert advisory groups.

Table 1. Definitions of plastics used by the international community

	Definition	Reference
Litter:	Any persistent, manufactured or processed solid material discarded, disposed of, or abandoned in the environment	(UNEP, 1995)
Plastic:	Materials consisting of a polymer to which additives or other substances may have been added, and which can function as a main structural component of final products, with the exception of natural polymers that have not been chemically modified.	DIRECTIVE 2019/904 (EU, 2019)
Plastic:	Material which contains as an essential ingredient a high molecular weight polymer and which, at some stage in its processing into finished products, can be shaped by flow.	**ISO 472:2013:**
Plastic:	A synthetic polymer with thermo-plastic or thermo-set properties (synthesized from hydrocarbon or biomass raw materials) and elastomers (e.g., butyl rubber). Many plastics are produced as a mixture of different polymers and various plasticizers, colourants, stabilisers, and other additives. Product types can include material fibres, monofilament lines, coatings, and ropes.	GESAMP (2019)

Note: “**Litter**” is the European terminology for solid materials of anthropogenic origin, whereas “**Debris**” is used in primarily in North America. Debris can also include natural organic material and will therefore not be used in this report to describe solid materials of anthropogenic origin to avoid confusion.

[1] The EU Horizon 2020 project EUROqCHARM (Grant Number: 101003805) aims to develop optimised, validated and harmonised methods for monitoring and assessment of plastics in the environment. www.EUROqCHARM.no. EUROqCHARM project brings together experts in plastics pollution from across Europe to establish harmonised methodologies for monitoring of plastic pollution. The project has reviewed analytical methods for plastic monitoring, conducting a systematic review of methods reported in the literature. The analysis included all steps, from sampling to data management, as well as assessment of the Technological Readiness Level (TRL) evaluating the maturity of the method with respect to being incorporated into plastic monitoring programmes.

[2] Inconsistencies between these definitions: (1) EU Directive excludes coatings, paints, inks and adhesives; (2) ISO 472:2013 excludes some elastomers (e.g., rubbers). For further discussion of definitions readers are referred to Hartmann et al. (2019).

Table 2. Size categories used in definitions of plastics[3]

	ISO (ISO/TR 21960:2020) / EUROqCHARM	GESAMP (2019) and AMAP (2021a)
Megaplastic:	Not included	> 1 m
Macroplastic:	> 25 mm	25-1000 mm
Mesoplastic:	5-25 mm	5-25 mm
Microplastic:	0.001- 5 mm*	0.001- 5 mm*
Nanoplastic:	0.001 mm – 0.000001 mm	<0.001 mm

** divided into large microplastics and small microplastics using 1 mm as the distinction*

1.3 Environmental compartments

This report maps data and methods available for macroplastic and litter monitoring in the following environments**: coast, ocean, lakes, rivers** (**Figure 1**). **The Northern Fulmar** are also included because of their prominence as an indicator under OSPAR**.**

Urban environments (e.g., cities, parks, roads) are not specifically included. However, one can expect a high density of citizen science data in areas of high population density and in areas that are easily accessible for clean-ups. Where this data is relevant for monitoring it has been included.

Assessment of plastics in the stomach of Fulmars is mostly suitable for particles 1-25 mm, although larger items are sometimes observed. The Northern Fulmar are included to represent biota in this report. Monitoring of plastics in Fulmar's stomachs is the only established indicator on plastic pollution under OSPAR for biota relevant to Norway (OSPAR, 2022a).

Environmental compartments not included in this report are: atmospheric samples, other biota, sediments and soil, and snow and ice. These compartments are however areas of interest for microplastic assessments, as highlighted in the recent AMAP monitoring plan and recommendations (AMAP, 2021a, 2021b). Given the strong focus of research and monitoring on plastic pollution in marine environments (e.g., GESAMP (2019), AMAP (2021a)), monitoring in coastal and ocean areas will also dominate in this report.

The geographical focus of this report is Norway and Norwegian waters, this includes Svalbard when ongoing monitoring activities are considered.

[3] Many technical reports and guidelines have introduced subcategories for size, usually to accommodate operational (sampling) or analytical (detection) limits. For example, the most recent AMAP guidelines use the size categories of >1 mm, 1 mm-0.3 mm, 0.3 -0.1 mm and <0.1 mm for water sampling; 5-1 mm, 1 mm- 0.3 mm, <0.3 mm for sediment and soil sampling (AMAP 2021).

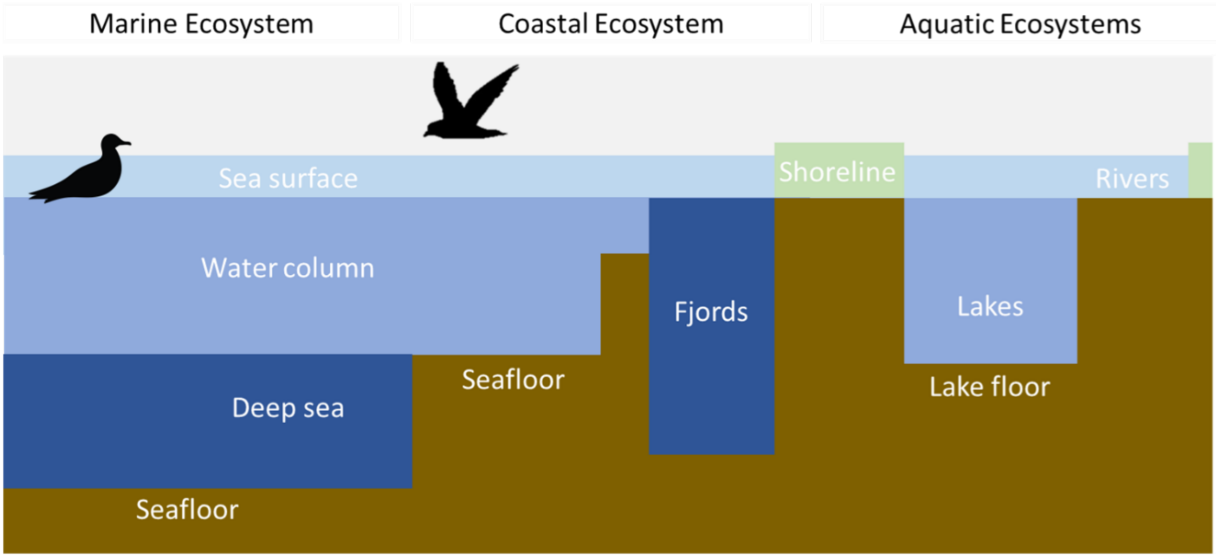


Figure 1. Conceptual diagram showing complexity of environments in Norway where monitoring could be considered on a national scale.

2 Methods

2.1 Overview of the review process

This study comprises a multi-factored approach to identifying the methods suitable for developing a monitoring programme. The tailored approach consisted of data collection to identify aims under international obligations and national needs, using a literature review and stakeholder workshop, respectively. Next, indicators and methods recommended for motoring were reviewed and put in context for use in Norway. Data available and current monitoring of macroplastic and litter, as well as activities that could contribute to sampling or data collection were mapped. The data gathered from were assessed for their Technological Readiness Level (TRL), cost, suitability for national and international requirements, any missing elements were highlighted, and used to formulate recommendations after an expert review. Through this process, this report has addressed the key questions asked by the NEA (**Table 3**).

Table 3. Overview of questions asked by NEA and which sections addresses these questions

	Questions asked	Sections where this is addressed
1	What type of methods are used for monitoring plastic pollution in Norway/Europe/globally?	3.4
2	To what degree are the methods reliable/ harmonised/ standardised?	3.4
3	What are the advantages and limitations of these methods, what type of ecosystems/ compartments can they monitor, and what type of information can they give (for example sources, weight, age)?	3.4
4	Is there data on macroplastic and litter in Norway that provides relevant information required to monitor of plastic pollution?	3.6, 3.7
5	Where, what type and how are data on plastic pollution registered today in Norway?	3.6
6	Can existing data be used more systematically to provide monitoring data on marine litter in Norway?	3.8
7	What type of adaptations are needed (if any) for Norwegian conditions?	4
8	Is it possible to include marine littering as part of existing, national monitoring programs of the Norwegian Environment Agency, or alternatively by including other sectors?	3.8
9	What is the cost and feasibility of implementing different types of monitoring?	3.8
10	How can existing monitoring be expanded or dedicated monitoring of plastic pollution in the environment in Norway be established?	3.8
11	What should be prioritised to design a monitoring program for marine litter in Norway?	4

2.2 Data collection

2.2.1 Mapping international obligations and local needs

A literature study was conducted to identify international obligations and reporting requirements on macroplastic and litter identified under the UN Sustainability Indicator 14.11b, the process towards a Global Plastics Agreement, the Global Partnership on Marine Litter (GPML), G7 and G20 Action Plan to combat Marine Litter, the EU Marine Strategy Framework Directive (MSFD), the OSPAR convention, the Arctic Monitoring and Assessment Programme (AMAP), and the International Council for Exploration for the Seas (ICES) Working Groups on Marine Litter (ICES-WGML).

To identify the local needs, a workshop was held as part of the NORqCHARM project 12th of October 2022 in Oslo at NEA. The workshop was arranged by NIVA, SALT and MARFO inviting a broad range of stakeholders (See Appendix 1 for list of participants) to map their needs for knowledge on littering and macroplastics, discussing the ability of implemented and potential monitoring methods to fill these knowledge needs, and how different type of actors can be motivated to contribute to data collection. This report summarises the identified stakeholder knowledge needs. Additional national needs were identified through the Norwegian Plastics Strategy (KLD, 2021) and an investigation of the implication of further development of producer responsibility in Norway (NEA, 2022).

2.2.2 Methods available for monitoring macroplastic pollution

International synthesis and harmonisation efforts were reviewed and key, established monitoring guidelines (AMAP (2021a); Cheshire et al. (2009); COBSEA (2022); GESAMP (2019); (UNEP, 2021a); Vighi (2022)), summarised for the relevant environmental compartments. These key guidelines give an overview of methods applied in current monitoring programs and the degree to which different indicators on marine litter and plastic has been implemented. Review studies on monitoring of macroplastics in freshwater environments (floating in rivers, riverbeds, riverbanks) were summarised (Hurley, 2021) and a search was made to identify monitoring methods applied in lakes. The EUROqCHARM meta-database was accessed to extract methods used in litter and plastic pollution research reported in scientific journals (until 2021). The meta database was the culmination of a systematic literature review carried out from 1960 – 2021 specifically designed to extract information on methods covering survey design, sample collection, sample preparation, analytical detection, quantification, and data reporting (Aliani et al., 2022)[4]. The search in the EUROqCHARM meta-database did not find any published studies reporting methods established in monitoring programs that was not covered by the synthesis reports.

2.3 Assessment

2.3.1 TRL assessment of established monitoring methods

Methods identified in section 2.2.2 (or absence of methods) were evaluated according to their Technological Readiness Level (TRL) in the different types of environments targeted for this report.

Technological Readiness Levels (TRLs) are used in many different settings as a systematic measurement approach to assess the maturity of a technology. TRLs are based on a scale from 1 to 9 with 9 being the most mature technology (**Figure 2**). The European Commission adopted the TRL approach (Commission Decision C(2014)4995, part 19) and the TRL scale became, through various modifications,

[4] The database will be made open access by the project on Zenodo following publication of results.

an innovation policy tool of the European Union (EU) (Héder, 2017). TRLs were incorporated into the EUROqCHARM project as a systematic approach to understand each element of the analytical chain in relation to monitoring. To do this, TRLs are used to assess the single steps of the analytical pipeline used when addressing plastic pollution. The analytical pipeline was divided into repeatable elements as a common pattern to approach the study of plastic pollution (including monitoring). The analytical chain was referred to as a reproducible analytical pipeline (RAP, (Aliani, under review), applicable to every size of plastics or environmental matrix. For the purpose of EUROqCHARM activities, these have been defined as:

- ***Survey design***: This defines the purpose of the monitoring programme including the choice of sites, statistical approach, replication, the used of a standardised protocol (e.g., OSPAR) or a method of their own design. **TRL for choosing representative sites for monitoring is low (1-2), it is only the use of a standardised protocol that is evaluated**.
- ***Sample collection:*** This defines the methods used to collect samples from different matrices in the environment and sub-compartments, also including location, how samples were obtained (equipment and tools), sample size (e.g., volume), the repeatability of the method, the use of recommended and validated guidelines, and size of target plastics (or litter).
- ***Sample preparation:*** The process by which samples are sorted, cleaned, stored for analysis (if relevant to the sample type). This step is not relevant if items are not removed from the environment (e.g., visual surveys from vessels, or ROVs).
- ***Analytical detection:*** This defines the approaches or tools used in the detection of target plastics. It includes the use of instruments (e.g., imaging technologies), or the naked eye to detect plastics. This also includes the upper and lower detection limits. This is more relevant for microplastic particles, so this is excluded from the TRL assessments.
- ***Plastic quantification:*** This defines the process by which plastics are described and confirmed as plastics, as well as quantified. This includes descriptions of particle characteristics (size, shape, colour, polymer), use of litter categories, how the mass/weight of items are calculated, confirmation of plastic units and metrics used for reporting.
- ***QA/QC:*** include the elements of methods validation, replicability, and data quality.
- ***Data reporting:*** This defines how data is handled once it is produced, this includes data reporting protocols, treatment, storage (international databases) and data availability.

Note: Due to the absence of experimental or modelling data regarding TRLs applied to monitoring environmental plastics, the EUROqCHARM assessment presented here is based on expert opinion following discussions with partners, stakeholders, and the wider research community. The TRL of each method element was evaluated according to the criteria of the plastic pollution TRLs (Aliani, under review). The TRL evaluation included an assessment of the degree to which these methods are reliable, harmonised, and standardised.

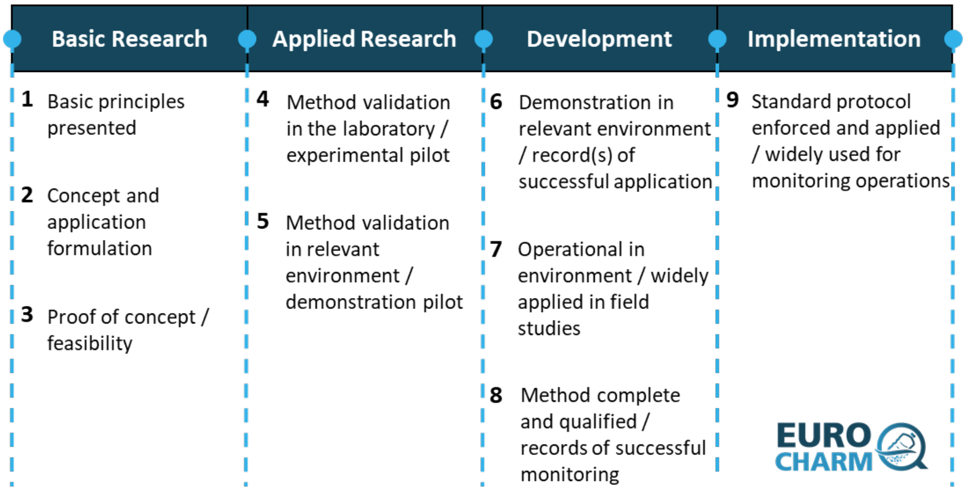


Figure 2. Overview of the nine Technological Readiness Levels (TRLs). TRLs 1-3 represent fundamental R&D (basic research), TRLs 4-5 include scaling and integration (applied research), and TRLs 6-9 include demonstration and full exploitation (development and implementation). Figure adapted from the EUROqCHARM project (Aliani et. al., under review).

2.3.2 Mapping of data available on plastic pollution in Norway

Data available on plastic pollution in Norway was mapped through searching in the following; 1) Public databases and Apps (data identified through search in litterbase.awi.de are referenced directly), 2) Projects and associated report databases of both the Norwegian Retailer's Fund (HMF) and Norwegian Research Council (NFR), 3) voluntary clean-up initiatives, and 4) data collection initiatives identified in the annual clean-up reports from Keep Norway Beautiful (KNB) as they aim at summarising all clean-up activities in Norway.

Information on the type of environment, year(s) of study, number of entries (spread in time and space), protocol used, and data availability (open access databases versus closed/ inaccessible data storage) were recorded. See Appendix 2 "Macro data available in Norway" for a full overview of databases searched and date accessed.

Given that citizen science data registered Rydde[5] is sent to Ocean Conservancy by KNB for inclusion in their data portal, data availability from the Ocean Conservancy platform is not reported here as we cannot identify which entries are registered directly by single users and which ones are included through Rydde. Similarly, data from Lofoten Avfallsselskap is included in Rydde. In both cases, the data is cleaned to fit the protocol of Ocean Conservancy and Rydde, respectively before being entered in the data bases.

2.3.3 Coordination with existing activities and inclusion of other affected sectors

The existing national monitoring activities of the Norwegian Environmental Agency was reviewed to evaluate the possibility to coordinate these with collection of data on macroplastic. Two experts at NIVA were asked to evaluate the possibility for using the existing monitoring activities to collect samples macroplastic (thus the first steps of the logistics of microplastic monitoring, **Section 3.4.1**).

[5] Rydde (ryddenorge.no)

The experts were Dr Marianne Olsen and Dr Morten Jartun. Dr Marianne Olsen is Research Director at NIVA with the overall responsibility for several of NIVA's running programs on environmental monitoring. In her former role as Research Manager she was responsible for the quality control of reports from several of the monitoring programs. In addition, she has been heavily involved in the development of monitoring methods and programs for riverine micro- and macro plastics in Asia through NIVA's aid-funded capacity building programs in India and ASEAN (Association of Southeast Asian Nations). Dr. Morten Jartun is the Research Manager for Environmental Contaminants in NIVA with responsibility for monitoring programs for contaminants and microplastics in the Norwegian environment. He is the project manager for monitoring of contaminants in freshwater ecosystems.

Sampling could be physical (collection of plastics) or visual in the form of videos or pictures. These samples would have to be transported/transferred, processed, and analysed after collection to generate data. The experts were asked to rank the relevance of the monitoring program for collecting samples of macroplastics (low, medium, high, unknown/irrelevant) and indicate if the samples would be physical or in the form of videos/pictures.

Other relevant initiatives that were evaluated with respect to the potential to collect relevant data were Fishing for Litter, the Norwegian Directorate of Fisheries' annual clean-up mission to look for lost fishing equipment, the Rydd Norge initiative financed by the Norwegian Retailer's fund, initiatives to implement clean-up technologies, and other citizen science activities, with a particular focus on those initiated by Keep Norway Beautiful. The potential role of key industry actors was also discussed.

Institute of Marine Research and the Norwegian Polar Institute were asked for input on opportunities to collect data on macroplastic and litter in connection with their on-going activities.

2.3.4 Cost of expanding existing monitoring activities

The possibility of extending existing monitoring activities on macroplastic and litter, as well as expand data collection through coordination with ongoing activities and key actors was discussed and the relative cost evaluated.

Given that the costs of monitoring are highly dependent on the questions that the data collected should answer, the cost estimates are given as relative values modified from AMAP (2021a). The experts (See appendix 3 for information on the experts) were asked specifically to give input on these assessments. The definitions of the four levels of costs are presented in **Table 4**.

Table 4. Relative cost of monitoring ranging from none (0) to high ($$$)

Cost	Explanation for relative cost.
0 -	litter and plastic pollution monitoring already in place with regular funding
$ -	relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution
$$ -	either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter and macroplastic pollution
$$$-	development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed.

2.4 Recommendations

Based on the mapping of international obligations and local needs, state-of-the art monitoring guidelines and their technological readiness levels, as well on-going monitoring and activities that could be expanded to collect data on macroplastic and litter, recommendations were given for a Norwegian monitoring program of macroplastic and litter. The recommendations included prioritisations and advice for how monitoring could be strengthened in the future.

3 Results

3.1 Key findings - International Obligations

This sub-chapter presents the results from the mapping of international obligations. The analysis runs from the global to the regional level. It starts by introducing the United Nation's Sustainable Development Goals (SDGs) as a global framework which includes commitments to reduce marine pollution. As such, the SDGs also need to have coherent indicator and monitoring frameworks to track progress. Next, the sub-chapter on the EU Marine Strategy Framework Directive which introduces the regional framework of the EU and the relevant criteria, indicators, and monitoring activities required by Member States. Following these broad frameworks, more specific initiatives of relevance to monitoring macroplastics in Norway are introduced: the OSPAR Convention, the Arctic Monitoring and Assessment Programmes (AMAP) initiative and ICES. The sub-chapter ends by taking a step back and elaborating on the ongoing negotiations on a Global Agreement to End Plastic Pollution, and how monitoring may be addressed under this Treaty.

3.1.1 Sustainable Development Goal 14.1.1b on Marine Plastic Debris

UNEP (2021b) points to significant knowledge gaps in quantifying the input and sources of plastics into the ocean, the accumulated amounts of plastics in the marine environment, and important source and sink locations of plastics. The report highlighted the need to use existing data from remote sensing, citizen science data and *in situ* monitoring. In most regions, beach litter data is the only source of data readily available for comparative assessments.

Proposed national indicators under SDG 14.1.1b include measurements to assess plastics in the marine environment, specifically in: beaches and shorelines, litter floating on or in the water column, and deposition on the seafloor. Ingestion by biota and river litter are listed as supplementary/ recommended indicators, along with several other indicators (**Table 5**). However, they also note the importance of monitoring information on waste management and the sources of plastics.

Proposed global indicators are plastic patches greater than 10 meters for areas beyond national jurisdiction or total ocean area (such as accumulation areas in oceanic gyres), and beach litter originating from national land-based sources. These indicators would be assessed using satellite images and global ocean circulation models of the movement of litter (UNEP, 2021b).

Table 5. SDG 14.1.1b national indicators of marine plastic debris and supplementary indicators relevant for macroplastic monitoring, as well as methods for monitoring relevant for macroplastics (adapted from (UNEP, 2021b).

Proposed national indicators	Proposed monitoring methods
Beach litter – average count of items per km^2 of coastline (surveys and citizen science data)	UNEP/IOC-UNESCO operational guidelines (Appendix 4 in UNEP (2021b))
Floating plastic debris density – average count of items per km^2	Net tows, visual observations from ship, photographic and aerial surveys (GESAMP, 2019)
Water column plastic density- average count per km^3 (demersal trawls)	Record marine litter caught as by-catch when using pelagic fishing gear (GESAMP, 2019)
Seafloor litter density- average count per km^2 (benthic trawls)	Trawling, divers/ snorkelers, video/camera tows, submersibles, remotely operated vehicles (GESAMP, 2019)

Beach litter is the indicator identified by UNEP that all countries should monitor and report on. Implementation of beach litter indicators, involves 1) identification of the national authority responsible for data gathering and reporting, and the organisation responsible for implementation of the surveys, 2) exploration of the use of existing data, and 3) conducting beach litter surveys applying the UNEP/IOC-UNESCO operational guidelines (UNEP, 2021b). National data collection efforts can be supported by citizen science initiatives, such as the Coastal Clean-up initiative of Ocean Conservancy, and NOAA's citizen science project. Instructions on how to conduct such citizen science surveys are included in GESAMP (2019) that provide guidance to secure sound data collection. The GESAMP guidelines differentiate between rapid assessment surveys and routine shoreline monitoring. The appropriate approach should be determined by the national needs.

Monitoring of floating plastics and plastics on the seafloor is recommended where there exists in-country capacity or opportunities. Implementation of indicators on floating plastics, plastics in the water column and on the seafloor involves 1) identification of the national authority responsible for data gathering and reporting, and the organisation responsible for monitoring, 2) work with the planning authority to understand local needs and determine the best approach to monitoring. UNEP (2021b) recommends the GESAMP guidelines for monitoring of plastics in these environments.

3.1.2 EU Marine Strategy Framework Directive

The EU Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) was adopted in June 2008 to protect the marine environment across Europe and achieve Good Environmental Status (GES) in the EU's waters (EC, 2022). The MSFD is a policy framework for the 23 coastal Member States of the EU with borders to the four European seas: the Mediterranean Sea, Black Sea, Baltic Sea and North-East Atlantic region. The MSFD mandates that Member States shall develop marine strategies in order to protect the marine environment and restore marine ecosystems and prevent and reduce pollution to the marine environment to ensure no significant negative impacts to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea (Article 1).

Norway does not implement the MSFD as it does not fall under the scope of the European Economic Area (EEA) agreement. While Norway does not implement the Directive, activities under the Directive are relevant as they relate to plastic indicators and monitoring under Regional Seas Conventions (RCS) (Sander et al., 2022). Harmonisation of efforts between the different initiatives will support robust and comparable data collection towards a global understanding of plastic pollution.

To measure progress towards achieving GES, trends in environmental status and effectiveness of mitigation measures, MSFD Article 5 requires Member States to establish and implement coordinated monitoring programmes (**Figure 3**). Article 11 further stipulates that methods are consistent across marine regions and subregions (which aligns with the corresponding RSCs). In Annex I, eleven qualitative descriptors are defined for determining GES. Commission Decision (EU) 2017/848 (the GES Decision) spells out the criteria and methodological standards for assessing the status of marine waters and determine GES in accordance with these eleven descriptors.

Descriptor 10 relates to marine litter: "*Properties and quantities of marine litter do not cause harm to the coastal and marine environment*". The criteria include two primary criteria: Litter in the environment (D10C1) and microlitter in the environment (D10C2), and two secondary criteria: litter in biota (D10C3) and adverse impacts on species (D10C4).

The MSFD is currently undergoing revisions as required under Article 23, with the aim to finalise the review and propose amendments by 2023. In 2024, the Member States will have to provide assessments for 2016-2021. There are also several knowledge gaps and outstanding issues relating to monitoring and assessments under the MSFD, such as: the need for developing standardised monitoring methods for monitoring of pellets; set baselines and thresholds for litter in the surface level and seabed (D10C1), ingestion in biota (D10C3) and adverse impacts in species (D10C4) (EC, 2022).

The following section presents the relevant descriptors for macrolitter, the monitoring standards and threshold values:

D10C1: Litter in the environment (macrolitter)
The criteria to achieve GES for D10C1 is that "*The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment*."

D10C1 refers to litter across three compartments: coastline, surface layer of the water column and the seabed. However, only monitoring of litter on the coastline is required under the current iteration of the Directive. Where possible, information on the source and pathway of the litter should be collected. Member States may choose to additionally monitor litter in the surface layer of the water column and on the seabed, however, the threshold values have not been determined for these compartments (EC, 2022). All threshold values for D10C1 will be established at the Union level. A threshold level of 20 macrolitter items per 100 m beach length has been defined (**Table 6**), which is estimated by experts to reduce the harm from beach litter to a precautionary level. Data should be collected following Galgani, Hanke, Werner and De Vrees (2013), of 100 m beach length preferably surveyed four times a year (seasonally) applying the Joint list. The median assessment value is suitable for the assessment, as is robust against extreme values, which is often found in beach litter monitoring, and there is a good correlation between median and mean beach litter abundance (Commission et al., 2020)

The GES Decision sets of the different categories to be assessed across different marine compartments: artificial polymer materials; rubber; cloth/textile; paper/cardboard; processed/worked wood; metal; glass/ceramics; chemicals; food waste; undefined. A deeper elaboration on the different items under each category is provided in the 'Joint List' to allow harmonisation in monitoring records (Fleet *et al.*, 2021). The Joint List provides a multi-tier system for categorisation, starting with level 1 (materials), level 2 (use) and subsequent levels with increasing specificity. Following the implementation of the EU Single Use Plastics Directive (Directive (EU) 2019/904), the sub-categorisation (level 2) of 'artificial polymer materials' is expanded to include 'single use plastics' and 'fishing gear' in accordance with the definitions of the SUP Directive (Fleet et al., 2021).

The reporting on D10C1 is aggregated across all categories to allow for assessing the status and progress towards achieving GES. However, the EU Assessment Guidance (EC, 2022) recommends trend assessments for three litter categories: artificial polymer materials, single use plastics and fishing gear.

Table 6. Units of measurement and threshold values for Descriptor 10 Category 1: Litter in the environment (macrolitter)

Compartment	Units of measurement	Threshold
Coastline	Per 100 metres (m) on the coastline	20 macrolitter items for 100 m beach length. This applies to the aggregated macrolitter reporting and cannot be defined per litter category.
Water column and seabed	Per square kilometre (km^2) for surface layer of the water column and for seabed	Threshold values are still being defined. In the absence of baselines, assessment should be based on trends analysis over six years to monitor and detect trends over time.

D10C3 and D10C4: Litter in biota and adverse impacts on species
D10C3 and D10C4 are both secondary criteria, with the threshold values and agreement on species for assessment to be agreed at the regional level. Reporting on ingestion in biota requires agreement on the regional level on what species to use as indicator species. The different RSC are currently working on regionally agreed indicator species for assessment of D10C3, with the North-East Atlantic having settled on species for some regions, and the Mediterranean Sea having settled on the Loggerhead Turtle (EC, 2022). Adverse impacts on species relates to the negative impacts on birds, mammals, reptiles, fish or invertebrates from marine litter. These adverse impacts may be from entanglement, injury, mortality or health effects (ibid). For assessing D10C4 (adverse impacts on species), no regionally agreed indicator species were settled by February 2022 (ibid.)

The criteria:
- D10C3: The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.
- D10C4: The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.

For reporting on ingestion, Member States are advised to report on litter and micro-litter ingested according to whether these are ‘artificial polymer materials’ or ‘other’. Following the implementation of the SUP Directive, Member States are also advised to consider reporting on the additional elements: ‘Single use plastic’ and potentially ‘pellets’ moving forwards (Fleet et al., 2021).

The threshold values for these two indicators are under development at the (sub)regional level. Some regions have started to determine thresholds for litter in biota, notably for fulmars in the North-East Atlantic drawing on OSPAR’s fulmar monitoring approach (van Franeker et al., 2021) (**Table 7**). Values are being developed for loggerhead turtles in the Mediterranean and sea turtles in some regions of the North-East Atlantic (EC, 2022). For adverse effects, no threshold values have been determined, and assessment methods are also still being developed.

Monitoring activities for D10C3 can entail collecting data on the amount of litter ingested and the number of individuals sampled over temporal and spatial scales. D10C4 may be monitoring by recording the number of individuals negatively impacted (e.g., by entanglement in breeding colonies, the number of strandings of dead animals), per survey.

Table 7. Units of measurement and threshold values for Descriptor 10 Category 3: Ingested litter, and Descriptor 10 Category 4: Adverse impacts on species.

Criteria	Units of measurement	Threshold
Litter in biota (D10C3)	1) Amount of litter/micro-litter in grams (g) 2) Number of items per individual for each species in relation to size (weight or length, as appropriate) of the individual sampled.	North-East Atlantic Region: Over a period of at least five consecutive years, no more than 10 % of northern fulmar (*Fulmarus glacialis)* in samples of at least 100 birds may exceed the level of 0.1 g plastic particles in the stomach. Other thresholds are being developed for species in different regions.
Adverse impacts on species (D10C4)	Number of individuals affected (lethal; sub-lethal) per species	Under Development

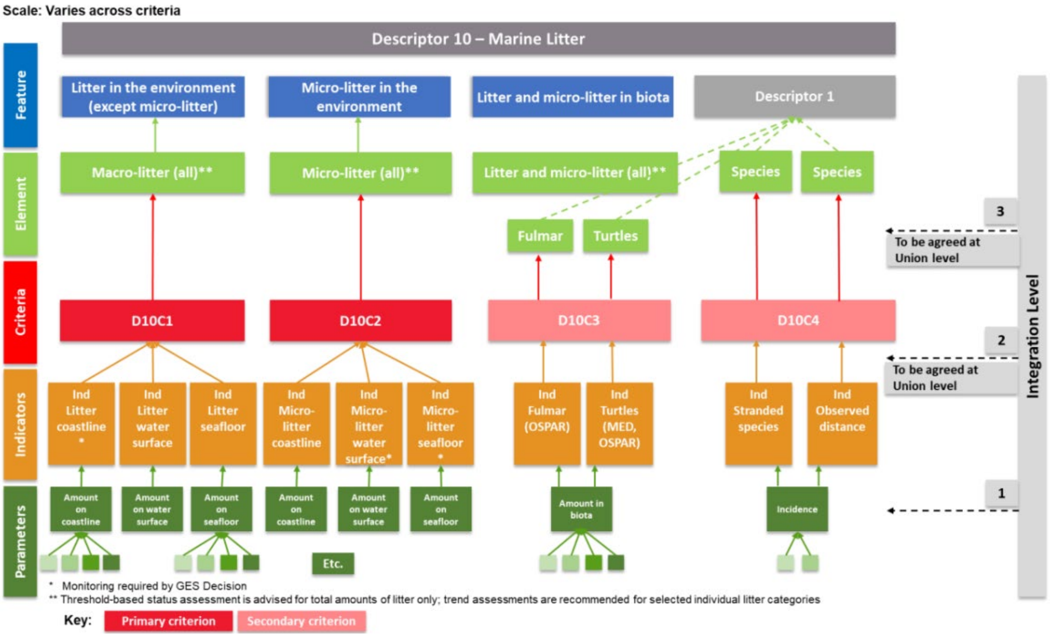


Figure 3. Overview of Descriptors, indicators and monitoring guidance under the MSFD (Figure from EC (2022).

3.1.3 OSPAR Convention

OSPAR is a Regional Seas Convention to which Norway is a signatory. Contracting Parties to OSPAR are obliged to "*undertake and publish at regular intervals joint assessments of the quality status of the marine environments and of its developments*". Norway is obliged to monitor macroplastic through the OSPAR-convention. This involves monitoring of litter on beaches, on the seabed and in the stomachs of Fulmars. A fourth indicator, marine litter ingested by sea turtles, is not relevant to Norway. Table xx

Beach litter: OSPAR has adopted the beach litter similar to the EU MSFD Criterion 10.1.1. The objectives for monitoring marine litter on beaches are: "*The collection of data on marine beach litter provides information on amounts, trends, and sources of marine litter. This information can be used to focus on effective mitigating measures and to test the effectiveness of existing legislation and regulations. The ultimate aim is that the amount of litter entering the marine environment is minimised*".

Seafloor litter: OSPAR has adopted an indicator on seafloor litter based on the EU MSFD Criterion 10.1.2. *Trends in the amount of litter in the water column (including floating at the surface) and deposited on the seafloor, including analysis of its composition, spatial distribution and, where possible, source*. This indicator is based on litter caught during existing fisheries trawl surveys and follow the Guidance on Monitoring of Marine Litter in European Seas (Galgani, Hanke, Werner, Oosterbaan, et al., 2013).

Plastic particles in fulmars: areas used as an indicator on quantities of floating litter and also indicate the impact marine litter has on biota. Fulmars (*Fulmarus glacialis*) are seabirds that feed exclusively at sea, and only rarely close to the shore. Since it is a poor diver, it feeds on what is available within the few top few metres of the sea surface. They do not regurgitate indigestible items, but grind these into sizes small enough to pass the intestines. Their stomach contents are therefore representative of their feeding over a period of days to weeks (OSPAR, 2022a).

OSPAR's Second Regional Action Plan (RAP) was launched in 2022. The RAP will support implementation of EU's Marine Strategy Framework Directive (MSFD) and other EU processes that are relevant to marine litter. It will contribute to harmonised monitoring for marine litter that also contribute to and reflect international processes. Furthermore, it will cooperate with and contribute to regional to global initiatives to reduce marine litter. Included in the 12 strategic objectives for achieving GES in the marine environments, are preventive efforts to significantly reduce marine litter. The aim of the Strategic Objective 4 is to reach levels that do not cause adverse effects to the marine and coastal environment, with the ultimate aim of eliminating all inputs of litter (OSPAR, 2022b). The supporting operational objectives (**Table 8**) makes reference to the EU Single Use Plastics Directive (EU, 2019) in reducing the single-use plastic items most commonly found on beaches, as well as reducing maritime-related plastic items on beaches. Quantitative reduction targets for marine litter on beaches and other relevant environmental compartments are to be developed by 2023. In addition, there is an aim to reduce impacts of items causing the most harm, which also includes improving the evidence base on harm of marine litter (OSPAR, 2022b).

While the beach litter indicator has provided the foundation for setting reduction targets (S4.03, **Table 8**), OSPAR (2022b) point to knowledge gaps in understanding the problem and establishing the knowledge base needed for setting further targets and baselines. Contracting Parties will continue to support research and development to address these knowledge gaps and identify effective solutions, as well as understanding the impacts of marine litter and develop new indicators in response to emerging priorities. Monitoring and assessment should therefor also identify new sources or types of marine litter, in addition to assessing the effectiveness of individual actions (OSPAR, 2022b).

Table 8. OSPAR Supporting operational objectives to Strategic Objective 4 (Adapted from OSPAR (2022b).

S4.01	By 2022 agree on an updated RAP on marine litter including a set of prioritised SMART objective to address new and emerging issues and to reduce the impacts of those items causing most harm to the environment.
S4.02	By 2023 improve the evidence base on harm of marine litter with the aim of developing and agreeing and actions to measures to reduce harm by 2025.
S4.03	By 2023 reduce by at least 50%, and by 2030 at least 75%, the prevalence of the most commonly found single-use plastic items and of maritime-related plastic items on beaches in order to contribute to the achievement of relevant regional and EU threshold values building on the EU Single Use Plastic Directive
S4.04	By 2023 develop additional regionally coordinated quantitative reduction targets for all marine litter on beaches, and as soon as possible for other relevant environmental compartments, taking account of relevant regional and EU threshold values.
S4.05	By 2025 adopt programmes and measures to control and, where appropriate, phase out plastic from materials placed at sea for the purposes of marine infrastructure development.
S4.06	By 2027 develop measures to control, and where possible, phase out discharges of plastic substances, including microplastics, contained in chemicals from offshore sources.
S4.07	By 2025 develop approaches to prevent and reduce riverine marine litter inputs in cooperation with the relevant international river or river basin commissions, and other appropriate authorities and organisations.
S4.08	By 2025 develop and implement measures to substantially reduce marine litter from fishing and aquaculture gear, in collaboration with those sectors, as appropriate, and by 2027 determine the need for, and where appropriate adopt, targets or other actions for the separate collection of end-of-life fishing and aquaculture gear coherent with relevant EU directives and the update of the OSPAR RAP on Marine litter.

3.1.4 Arctic Monitoring and Assessment Programme

The Arctic Monitoring and Assessment Programme (AMAP) is a Working Group of the Arctic Council. This AMAP Litter and Microplastics Monitoring Plan (AMAP LMMP) was prepared by the AMAP Litter and Microplastics Expert Group (LMEG) to provide recommendations for developing coordinated pan-Arctic monitoring activities. When the AMAP LMMP was developed, the data available in the Arctic was sporadic and unevenly distributed, with cost identified as one of the biggest limitations. ***Therefore, recommendations were that sampling should be carried out through existing national monitoring efforts***. Monitoring in the Arctic should be aligned to facilitate regional and global comparisons. The Monitoring Plan recommends a series of environmental compartments for monitoring, for consideration by national and regional institutions when implementing their respective plastics monitoring initiatives, recognizing that it is these institutions' decision, if specific recommendations are implemented (AMAP, 2021a, 2021b).

The main purpose is to identify key elements and considerations for a coordinated environmental monitoring program for litter and microplastics across the Arctic, including recommendations on environmental matrices and indicators, locations as well as times, and frequency of sampling. The specific objectives are to:

1. Promote a standardized approach for baseline mapping of litter and microplastics across a wide range of environmental compartments in the Arctic that will enable more robust spatial and temporal comparisons in the coming years;
2. Initiate trend monitoring that will generate data to assess temporal and spatial trends for litter and microplastics in the Arctic;
3. Provide guidance to Arctic nations, Permanent Participants, and the Arctic Council Observers to consider in the development and implementation of litter and microplastics monitoring and research via national initiatives, community-based programs, and other mechanisms in the context of a pan-Arctic program;
4. Identify key datasets that can be used in association with the Marine Litter Regional Action Plan (ML-RAP);
5. Act as a catalyst for future work in the field of litter and microplastics in the Arctic, for example, effects on biota, including determining environmentally relevant concentrations, with a view to cumulative effect assessments;
6. Enhance the ability of the Arctic Council to assess the state of the Arctic region with respect to plastic pollution and to contribute Arctic regional data and information to future assessments of litter and microplastics in the environment on a broader international scale.

AMAP recommends baseline mapping, trend monitoring, and source and surveillance monitoring to meet these objectives. In the future, when target values are further defined (e.g., as thresholds under the EU MSFD and OSPAR assessments), it is expected that monitoring can be expanded to compliance monitoring, effects monitoring and risk-based monitoring.

Recommendations from AMAP were divided by size cut offs 1 mm, therefore those environmental compartments relevant to macroplastic monitoring are: beaches/shorelines, water, sediments (benthic) and the seafloor, mammals, seabirds. These compartments span different ecosystems in the Arctic (lakes, rivers, coastlines, subtidal, fjords). For each of the environmental compartments, primary and secondary indicators were proposed in relation to the current state of methodologies, and the feasibility of the use across the Arctic. AMAP recommend that the primary indicators could be implemented immediately, whereas secondary indicators needed further research and development.

Given this, the **Priority 1** recommendations included the monitoring indicators of **water (marine and freshwater), sediments (freshwater and marine), beaches/shorelines and seabirds.**

3.1.5 ICES

Specifically, the ICES Working Groups on Marine Litter (WGML) addresses scientific questions relating to marine litter and microplastic monitoring, assessment and research. Currently, ICES WGML functions as a knowledge base for marine litter (and microplastics) and is developing guidance on monitoring and assessment to support data needs of member countries. A proposal on a seafloor litter (and microplastics) research and monitoring strategy for ICES, is under preparation in conjunction with member countries, a range of regional organisations and the ICES Data Centre (ICES, 2021). **There are no specific obligations under ICES, although ICES is the main focal point for seafloor litter supporting development of indicators across conventions.**

The Terms of References (ToR) for the ICES WGML are:

- **ToR a:** Internal and external cooperation and response to any advice requests (from e.g. EU, Regional Seas Conventions, ICES Data Centre/Secretariat, ICES expert groups).

- **ToR b:** Review and propose guidance for ongoing and future monitoring of marine litter and microplastic to support ICES data collection and assessment
- **ToR c:** Report new developments in quality assurance in marine litter and microplastic monitoring in Europe, and provide information on other proficiency testing schemes with relevance to WGML.
- **ToR d:** Align WGML with key international expert groups by collaborating with the European Marine Observation and Data Network (EMODNET) regarding marine litter and microplastic data assessment and quality assurance.
- **ToR e:** Towards an assessment of the distribution of abandoned, lost or otherwise discarded fishing gear.

3.1.6 A Global Agreement to End Plastic Pollution

UNEA Resolution 5/14 set in motion the negotiations towards an international legally binding instrument to end plastic pollution (UNEP, 2022). The Intergovernmental Negotiating Committee, which had its first meeting in November 2022, aims to develop a new instrument by the end of 2024. As the negotiating process is in its infancy, it is difficult to ascertain what monitoring obligations may be included under the agreement. However, taking heed from other multilateral environmental agreements, it is natural to assume that the instrument will include a monitoring framework for micro- and macrolitter across environmental compartments (including both terrestrial and aquatic) to track the progress towards the treaty objectives.

One example is the post-2020 Global Biodiversity Framework under the Convention on Biological Diversity (CBD), for which a monitoring framework is being developed with specific indicators for each goal and target under the convention (CBD, 2020). The proposed indicators relate both to environmental monitoring (red list index; species habitat index) as well as monitoring the implementation of the convention (e.g., coverage of spatial plans that integrate biodiversity, indicator of measures in place to prevent, manage and control potential adverse impacts of biotechnology on biodiversity). Notably, the proposals for the updated CBD also include Indicator 7.0.2. *Plastic Debris*

Density by location (beach, floating, sea column, sea floor) based on beach litter monitoring data (WCMC, 2020). In the Report from the Expert Workshop on the Monitoring Framework prior to the next CBD Conference of the Parties in December 2022, the indicators are proposed to shift to: *Floating plastic debris density* [by micro and macro plastics] and *Trends in the amount of litter in the water column including microplastics and on the seafloor* (CBD, 2022). While the proposed indicators for the CBD are predominantly related to marine litter, it can be anticipated that monitoring under the Plastics Treaty will have a broader scope, including monitoring of micro- and macrolitter in air/atmosphere, biota, soils, rivers and riverine environments and the marine environment, reflecting the emphasis in UNEA Resolution 5/14 that the plastics treaty will address plastic pollution in all environments.

Norway, together with many other countries, believe that the global agreement to end plastic pollution should involve a common agreement on indicators, including reporting on these. Development in the environmental state, influx, and leakage into the environment should be monitored to evaluate if the measures implemented are sufficient to reduce plastic pollution and or must be adjusted (KLD, 2021).

Box 1. Other international mechanisms

Global Partnership on Marine Litter
The Global Partnership on Marine Litter (GPML) is a multi-stakeholder partnership which brings together all actors working to prevent marine litter and plastic pollution. It was launched at the UN Conference on Sustainable Development in June 2012 in response to the Manila Declaration. GPML is a global platform to share knowledge and experience. It fosters cooperation and coordination, sharing ideas, knowledge and experiences, identifying gaps and issues, by harnessing expertise and resources of all partners to working together towards solutions to plastic pollution.

The Group of Seven (G7) is in an intergovernmental political forum. In 2015, it put forward the G7 Action Plan to combat Marine Litter. In short, the action plan outlines how the G7 countries commit to support improvements and developments towards combatting marine litter. This includes supporting international development through investments, implementation of regional action plans, support for monitoring through Regional Sea Conventions (RSC), sharing best practises – including in monitoring, ensuring the use of existing platforms and tools for cooperation, promote individual and corporate behavioural change, and supporting policy tools kits and instruments.

The Group of Twenty (G20) Action Plan on Marine Litter was put forward in 2017. The action plan highlights that the tools to reduce marine litter have to be as diverse as the challenge of marine litter itself. There is no 'one size fits all' solution. It highlights that some of issues to be addressed include pollution from land-based and sea-based sources, financial resources for cost-effective analysis and measures of prevention or reduction, the need for effective actions, as well as education and outreach, and research. One outcome so far from the G20 Action Plan was the launch global guidelines for microplastic monitoring in surface waters (Michida et al., 2019; UNEP, 2021a) and the upscaling initiative to compile global data using the technical guidelines.

Although Norway is not a member of G7 or G20, the action plans put forward have implications for international cooperation towards marine litter.

3.2 Key findings - National Needs

3.2.1 Stakeholder workshop

The main knowledge needs identified at the stakeholder workshop[6] was a better understanding of the amount and deposition rate of litter and macroplastics of different environments, monitoring methods and data, sources of litter, impact on the environment and human health, identify measures and track the success of these, and the impact and consequences of clean-ups. Knowledge on the plastic composition of litter was also asked for, which is connected to the potential for recycling.

With respect to the amount and input of litter, knowledge gaps were related to a better understanding of this in time and space, understanding mechanisms behind transportation of litter to the ocean, knowledge on differences in the amount of litter in different types of environments, including identification of accumulation areas, and knowledge on the total amount of litter in the environment. There was a need for knowledge on monitoring methods and data; specifically, to (1) identify which methods are most suitable for seeing changes over time and spatial differences, (2) document if international obligations are met, and (3) compare Norwegian data on litter to global data. Knowledge on the age of litter items, the difference between using weights and counts for litter items, urban littering, and knowledge to guide prioritisation of areas for monitoring (e.g. ecologically important areas and accumulation areas), were also sought after. Furthermore, there was a wish for increasing the availability and utilisation of existing data and data collection initiatives.

There was a general request of more knowledge on the environmental and human health impact of plastic pollution. Additionally, stakeholders wanted knowledge on the role of litter in transportation of environmental contaminants and alien species, and identification of litter items of high concern (thus establish criteria for and monitor particularly hazardous items). Many stakeholders emphasized the need for using monitoring data to identify measures to reduce the amount of plastic and litter in the environment. Thus, knowledge that could identify key actors and sources is needed to implement the polluter-pays principle for clean-ups, follow up producer responsibility, and develop targeted campaigns and ban specific products. The impact and potential negative consequences of clean-ups was also mentioned as a basis for evaluating the cost-benefit of clean-ups in different types of environments. For example, if plastic infiltrated in vegetation and buried in sediments should be removed, or if this would cause too much harm due to destruction of vegetation and remobilisation of plastic and chemicals. Knowledge on the optimal frequency of clean-ups, as well as when, where and what should be cleaned was also sought after.

3.2.2 Key national strategy documents

Knowledge needs relevant for litter identified in the Norwegian Plastic Strategy included a better understanding of the sources of litter, transportation pathways and consequences of plastic in the environment. The strategy document refers to SDG 14 and their recommendation to register marine litter on beaches, on the ocean surface and in the water column, as well as marine litter on the ocean floor**. Norway must evaluate how these indicators can be used and adapted to Norwegian conditions.** The indicators chosen must also satisfy both national needs for monitoring, as well as regional monitoring under OSPAR, as well as a future global agreement to end plastic pollution (KLD, 2021).

The Norwegian Environment Agency has evaluated the producer's responsibility in Norway and suggested the following changes of relevance for monitoring (NEA, 2022). The cost of waste

[6] A report from this workshop will be published in 2023.

management should be included in the price of the product to make the economy more circular end reduce littering. Introduction of extended producer responsibility is recommended for plastic waste specific to fisheries, aquaculture, and recreational fishing. In addition, an arrangement where producers must cover the cost of cleaning up litter from single use products (with reference to EU's single-use plastic directive) in public spaces is recommended. The three main categories of waste that are targeted are packaging (take away and fast-food containers, drink packaging under 3 l, beverage containers including lids, plastic bags), wet wipes and balloons, tobacco products with filters and filters used in connection with tobacco products. The producers should pay for the municipalities' cost of cleaning up the litter for all three categories, as well as data collection and reporting for the two latter. Identification of the relative proportion of different items littered, through representative analysis of the litter, is needed as part of determining the distribution of costs between different sectors.

3.3 Summary of international obligations and national needs

The data collection requirements identified for meeting the international requirements and national needs for different environmental compartments are summarised in **Table 9** (for extensive overview see Appendix 4). It shows that there are some specific requirements regarding classification of litter items according to material and source categories defined in established protocols, as well as a need for higher resolutions on some items to follow up policies and identify specific sources and actors. Implementation of the Norwegian Plastic Strategy would require monitoring data on sources of litter, with specific focus on single-use plastic items and items from fisheries, aquaculture, and recreational fisheries, as well as knowledge on transportation pathways. The only additional knowledge need identified at the stakeholder workshop was identification of items of high concern. The international obligations require monitoring of marine compartments to measure the amount of litter in number of items per area (floating and seafloor) or volume (water column), while OSPAR/MSFD for beaches require counts per 100 m. Plastic ingestion by Fulmars is an established indicator in OSPAR/MSFD, while extensions to other impacts and biota is suggested by SDG and MSFD. The MSFD, being a marine directive, only refer to monitoring across marine compartments of composition, amounts, and spatial distribution of litter, while international obligations and national needs requires data collection across all environmental compartments, including an increased understanding of transportation mechanisms.

Data collection aims at documenting trends in space and time, but it does not necessarily define the resolution required. However, OSPAR aims at by 2023 reduce by at least 50%, and by 2030 at least 75% prevalence of the most commonly found single-use plastic items and maritime-related plastic items on beaches (OSPAR 2022b). The MSFD set an environmental quality of objective of less than 20 items over 2.5 cm per 100 m beach (EC, 2022), while introduction of producer's responsibility in Norway will require documentation of the proportion of the litter that is made up of key single-use plastic items at a level that can be used to calculate what the producers must pay to cover clean-up costs. The ability of a monitoring program to capture such requirements, will depend both on the number of samples in time and space and the resolution of the protocol used for registration of data.

Table 9. Overview of data collection requirements to meet international obligations and national needs for different environmental compartments

Compartment/ type	Data required	References
Litter classification	Specific protocols according to material and source categories: UNRP/IOC- guidelines, OSPAR beach litter survey guidelines, Joint-list	SDG 14.1.1b, OSPAR, MSFG
	SUP items	OSPAR, MSFG, NEA 2022
	Items specific to the Arctic: melted plastic pieces, detonating cords for explosives, aquaculture/animal feed bags, plastic sanitary bags, trawl nets, gill nets, shotgun cartridges, riffle cartridges.	AMAP
	Items from commercial fisheries, recreational fishing and aquaculture	MSFG, NEA 2022
	Litter items of high concern	Stakeholder workshop
	Identification of polluters and producers	Stakeholder workshop, NEA 2022
Beach/Shoreline	Amounts (items) per km^2, amounts (items) per 100 m	SDG 14.1.1b, MSFG/OSPAR
Floating ocean surface	Number of items per $km^{2.}$ Trawl surveys: amounts including composition and source where possible	SDG 14.1.1b, OSPAR, MSFG, CBD
Water column ocean	Trawl surveys: amounts (items per km^3) including composition and source where possible	SDG 14.1.1b, OSPAR, CBD
Seafloor	Trawl surveys: amounts (items per $km^{2.}$) including composition and source where possible	SDG 14.1.1b, OSPAR, MSFG, CBD
Biota	Ingestion, litter in nests, entanglement	SDG 14.1.1b supl., MSFG
	Plastic ingestion by Fulmars	OSPAR, MSFG
River	River litter	SDG 14.1.1b supl.
Across marine compartments	Composition, amount, spatial distribution	MSFG
Across compartments	Composition, amount, spatial distribution, transportation pathways	Plastic treaty, NEA 2022, stakeholder workshop, AMAP

3.4 Methods available for monitoring macroplastic pollution

Our inability to manage the marine litter crisis stems from both a lack of clearly identified objectives and inconsistencies in sampling design and classification systems among litter surveys. Inconsistent sampling designs hampers our ability to compare litter levels among different areas and regions, which makes it challenging to develop and evaluate global strategies to mitigate the plastic tide (Aliani et al., 2022; Browne et al., 2015; Cheshire et al., 2009; M. L. Haarr et al., 2022). Even when the methods used to process and classify litter are similar, variations in the quality of meta-data collected, and sampling design, results in an inability to account for different sources of variability to truly discern regional patters (Cheshire et al., 2009; M. L. Haarr et al., 2022). Consequently, there is a considerable need to develop and adopt standardised and harmonised survey methods to allow for global analyses, comparisons among regions and nations, and the detection of temporal changes and effectiveness of mitigative and preventative measures (Aliani et al., 2022; Cheshire et al., 2009).

There are several survey design aspects which need to be considered, both for the optimisation of the monitoring scheme in question and with respects to harmonisation and comparability to other monitoring efforts. These include, but are not limited to, site selection criteria and procedures, sampling units (e.g., plot size and shape, potential sub-sampling and nesting of units), measurement units (e.g., item counts, weight or volume, standardised per unit area or per unit area per unit time) and litter classification systems (i.e., the categories of litter types recorded). The harmonisation efforts described in Box 2 have made suggestions and recommendations for best practices in terms of meeting management goals and for harmonisation to ensure comparability of data across regions based on practices in the individual monitoring programmes reviewed.

As these international efforts have already summarised and evaluated available monitoring methods in use today, this exercise is not repeated here. Instead, we have reviewed the methods recommended in these documents, which are described in subsequent sections.

Box 2. Harmonisation efforts

International harmonisation processes to secure coherent data collection and reporting of plastics, including comparability across compartments and regions is an important part of this process. To attempt to meet this need, considerable efforts have been made to harmonise methods for the quantification of litter, particularly in the marine environment. An early effort was made by United Nations Environment Programme (UNEP) and the Intergovernmental Oceanographic Commission (IOC), resulting in the "UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter" published over a decade ago (Cheshire et al., 2009). The Technical Working Group evaluated 13 monitoring schemes used worldwide at the time, and the recommendations in this report still stand today (Cheshire et al., 2009; UNEP, 2021a). Additional more recent harmonisation efforts include the GESAMP guidelines for the monitoring and assessment of plastic litter in the ocean (GESAMP, 2019), COBSEA (2022), the JRC Technical report on Monitoring of Floating Marine Macro Litter (Vighi, 2022), and AMAP (2021a) for recommendations specifically for Arctic environments. Within Europe, harmonisation efforts have and are taking place due to the Marine Strategy Framework Directive (MSFD) and the inclusion of litter as an indicator under OSPAR. The MSFD TGML (Technical Group on Marine Litter) has produced a comprehensive list of litter types, the Joint List of Litter Categories, to enable comparisons of sources of litter across compartments (Fleet et al., 2021). EUROqCHARM is an important European initiative that aims to develop optimised, validated, and harmonised methods for monitoring and assessment of plastics in the environment (www.EUROqCHARM.eu).

The following sections firstly describe the logistics of macroplastics monitoring, before describing recommended methods for monitoring, evaluation of their TRLs and adjustments for a Norwegian context. Method recommendations include logistical steps that macroplastic monitoring may require.

3.4.1 The logistics of macroplastics monitoring

There are six key steps to litter and macroplastic monitoring. Firstly, **planning** is a fundamental preparatory step, which may also require infrastructure, for example in the form of technical tools (e.g. GIS-based), or a good network of knowledge holders that can identify where litter may or may not accumulate. Next, the litter must be **sampled**, which can involve either visual or physical sampling. Then samples need to be **processed**, which can involve cleaning or drying, before being analysed. **Analysis** may also require a certain level of analytical **expertise**. Finally, data needs to be **reported**. Different types of equipment could be needed throughout the entire data collection process. For example, specific equipment may be needed in connection with sampling, litter removal, or quantifying/identifying the plastic composition of litter.

Sampling: The density and distribution of litter is dependent on several factors, such as variability in inputs, transportation, and degradation processes. Thus, a monitoring program should be designed so that spatial and temporal variations are detected, and a representative sample is obtained (JRC 2022). Selection of the appropriate scale and frequency of sampling depends on the question that should be answered. Sampling should be stratified according to the distribution of litter to cope with spatial heterogeneity. Sampling can involve either ***visual*** (e.g. photos, remote sensing) or ***physical*** sampling (e.g. hand collection or trawl haul). The sampling phase also involves recording of metadata[7]. This includes information such as the survey identifier, location, equipment used, and general environmental variables (GESAMP, 2019).

Processing: Also referred to as sample preparation, this step can involve cleaning (e.g. removal of sand and organic matter) and/or drying of litter items before analysis is performed.

Analysis: Analysis – the process by which items are quantified, divided into categories, counted, weighted etc. can take place in the field, or the litter can be moved to an appropriate location for analysis. Some analysis does not require removal of the litter from the environments, but removal can be needed to answer specific questions (accumulation versus standing-stock surveys). By removing items, this also reduces the environmental impact of the litter. The logistics related litter removal from the field can be challenging and costly for some environments and locations. Furthermore, if analysis is going to take place indoors - which is recommended to secure a safe and comfortable working environment and reduce the risk of loss of litter to the environment - there is a need for access to an appropriate location for analysis. This can be challenging as some are reluctant to rent out premises to litter analysis, and suitable premises may not be available at the local waste management facility.

Expertise: Analysis will require a minimum of training to secure data quality. Training can be in the form of instructions and photo guides, as provided by for example OSPAR (2010) or the Joint List (Fleet et al., 2021). For citizen science data collection, the protocol should be self-explanatory and not require specific training. Some methods may require more expertise and training. The Deep Dive method, for example, require insights into how to correctly record information on geographical origin and age of packaging, identify cut-off ropes from fisheries, and fisheries technology expertise in determining the origin of net cut-offs (Falk-Andersson, 2021). Visual techniques to identify floating litter, requires competent and dedicated observers (Vighi, 2022).

Reporting: This step includes how data is treated, stored, and made available. It is important that the data is reported clearly and accurately, with any manipulations or corrected datasets clearly accessible, and the raw data also made available. For example, if a monitoring programme is only interested in one type of plastics items, yet generates a full data set, the full dataset should be made available and accessible to others. Most monitoring guidelines include methods for data handling and treatment, although the storage of data can pose a challenge. This relies on databases begin accessible and interlinked. This is an important step as it determines if the data is easily available for downloading and use by others, including for research and monitoring. Major action is ongoing to ensure harmonisation between database. OSPAR data is being handled to a large extend by EMODnet and the integration of this database is being supported internationally by efforts of GPML.

3.4.2 Approaches and methods for monitoring litter and macroplastics

There are several methodological aspects of a monitoring programme. Some of these aspects, such as for example litter classification systems, are applied after the litter has been collected for analysis and are irrespective of compartments. These are also the methodological aspects that are generally best developed and tested. Survey design aspects of monitoring methodologies (i.e., how to obtain the litter samples for analysis) are often less developed and much more variable among compartments,

[7] Metadata for the monitoring protocols reviewed is not reported here, but requirements can be found in the original reports, as well as in the data sheet for the citizen science data.

although there are some common elements here also, such as considerations related to site selection procedures. Below follows an overview of relevant recommendations from key international harmonisation efforts, as well as relevant locally adapted research protocols. Methodological aspects which affect all compartments equally are discussed in general terms, while compartment-specific methodological aspects are discussed for each individual compartment.

3.4.2.1 Litter classification systems (common across compartments)

One key element for harmonisation of monitoring methods, which is common across all compartments, is the classification of the macrolitter once a sample has been identified. The resolution of such a classification system can vary widely, from low (<6 litter categories) to moderate (30-60 litter categories) to high (>90 litter categories) (Cheshire et al., 2009)[8]. A moderate resolution classification system is the most common, but the OSPAR protocol classifies litter at a very high resolution (112 categories) (Cheshire et al., 2009; Schulz et al., 2013). Identification of specific items aim to identify the sources of litter, which is particularly important for implementation of suitable preventive measures. It is important that monitoring programs are linked to policy interventions to be able to determine if implemented policies have been effective (Falk-Andersson, 2021). A common feature of all protocols is a need to carefully define the smallest size of litter to be surveyed. The smaller items tend to be more common as plastic fragments (e.g., Cózar et al. (2017)). Variable minimum detectable sizes among surveys are therefore a serious hindrance to the harmonisation of results, especially with respects to comparing densities.

The optimal resolution will depend on monitoring goals, and a higher resolution requires more resources and expertise (Cheshire et al., 2009; Falk-Andersson, 2021; M.L. Haarr et al., 2022). Higher resolution surveys provide more data and opportunities for analyses, but lower resolution surveys are simpler to carry out and may contain fewer errors (Cheshire et al., 2009). It is therefore necessary to weigh the relative importance of data resolution *versus* replication given the monitoring objectives, and if multiple objectives are incompatible, it may require multiple approaches to achieve both. A Norwegian study tested out both a low-resolution, high-replication survey to map density, and a high-resolution, low-replication survey to identify litter sources (M.L. Haarr et al., 2022). **The main conclusion was that there is no "one-size fits all" option and multiple strategies are needed to answer all relevant questions**.

There are three types of protocols specifically referred to as being recommended or required for beach litter monitoring. The OSPAR beach litter protocol, the UNEP/IOC-UNESCO monitoring protocol, and the MSFD Joint List. All of the protocols have a structure that allows for regional and local adaptations, but also ensures harmonised data as higher-resolution data can always be reduced to the original moderate resolution to larger scale inter-regional comparisons (Cheshire et al., 2009). The general structure is that they are divided in two tiers, first by material type and then by individual items (e.g., in the UNEP/IOC- monitoring protocol a single-use water bottle would be classified first as "plastic" and then as "bottles < 2 L"). Each individual item classification has a unique code (e.g., PL02 for plastic bottles <2 L), which can be further divided by the addition of a period and further numbering if it is necessary to increase the resolution of certain item categories to achieve a monitoring goal (e.g., PL02.1 and PL02.2 to distinguish water *versus* soft drinks).

The OSPAR guidelines has 112 item categories divided into 9 material categories, while the **UNEP/IOC guidelines** has a classification system of 77 litter categories. The **Joint List of Litter Categories** for Macrolitter Monitoring was prepared by the MSFD Technical Group on Marine Litter (MSFD TG ML), in

[8] For a comparison of litter characterisation categories across beach litter sampling guidelines see Appendix B, pg 106 in Cheshire et al 2009.

close collaboration with EU Member States and the Regional Sea Conventions. The Master List combines the litter types from different marine litter monitoring lists (OSPAR, ICES, UNEP, etc.) into one. A conversion table is being developed to align the data from current and future monitoring to existing data sets obtained through for example OSPAR. The Joint List was adopted by the MSFD Coordination Group (November 2019) and has 9 material categories and 252 item categories. It provides a comprehensive list of litter types, which occur in the coastal and marine environment, enabling comparable monitoring between regions and across different compartments of the marine environment (Fleet et al., 2021). The Joint List is compatible with the Commission Decision (EU) 2017/848 (EU 2017), laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment. The Joint List was expanded to monitor the impact of implementing the EU Single Use Plastics (SUP) Directive (Directive (EU) 2019/904), including the category 'single use plastics' and 'fishing gear' in accordance with the SUP Directive (Fleet et al., 2021). The 10 items being addresses by the SUP Directive are cotton bud sticks, cutlery/plates/straws/stirrers, balloons/sticks for balloons, food containers, cups for beverages, beverage containers, cigarette butts, plastic bags, packets/wrappers, wet wipes/sanitary items (hereby referred to as the SUP items).

Citizen science initiatives is seen as an important complementary activity to national data collection efforts (UNEP, 2021a). The main citizen science protocol applied in Norway is "**Rydde**", which is adapted to a Norwegian context from the **Ocean Conservation**[9] (OC) citizen science protocol. The protocols have changed somewhat over time, but the majority of the categories remain the same with individual items being registered for the source categories "personal use", "fisheries and aquaculture", "industry and construction", "hygiene and sanitary" and "other". Personal protective equipment has been added as a response to items that have been frequently observed as litter after Covid (see Appendix 5 for old and current version of their protocols). A key difference between the OC and Rydde protocols is the resolution of fisheries and construction related items. The OC protocol has over time reduced the resolution on fishing gear from 4 categories, to one category of fishing related items and one category on foam dock pieces. There is no documentation of the OC and Rydde protocols regarding decisions on item categories, including their changes over time[10]. Of specific importance for Norway is rope waste, as it is among the most commonly found items in the Norwegian coastal and marine environment (M.L. Haarr et al., 2022). The Rydde protocol has a more extensive list of identifiable fisheries and aquaculture related items compared to OC, even specifying two rope categories. Similarly, Rydde specifies 16 industry related items, while OC only has one "construction related" category. The OC protocol allows for registration of plastic and foam items less than 2.5 cm, while Rydde registers unidentified plastic pieces under and over 50 cm.

GESAMP (2019) recommends the UNEP/IOC-UNESCO guidelines (described in Cheshire et al. (2009)), but in addition they recommend extra information for more specific source tracking. This includes recording the label (brand name, barcode, address and production country) to infer origin, recording functional characteristics of fishing nets to infer the origin of fishing industry, and other physical characteristics to provide more detailed information. There are a few categories in the UNEP/IOC-UNESCO guidelines that are not included in the OSPAR protocol[11], however within some categories the

[9] Trash Free Seas - Ocean Conservancy

[10] This is not unique to citizen science protocols. Also, the recommended guidelines for national monitoring lack documentation on the reason behind identifying individual items beyond being items that are observed on beaches. The protocols may reflect the litter items in the areas where data collection has been most intensive, as reflected in a review on global marine litter research (Haarr et al 2022a), hence the need for local adaptations.

[11] backpacks and bags, cups and food packs material foam, foam buys, tableware material glass/ ceramics and metal, glass buoys, batteries (torch type), tubes for fireworks, inner-tubes and rubber sheet, rubber bands, matches and fireworks material wood

OSPAR protocol is more extensive. Some of the difference is because the OSPAR protocol does not differentiate between plastic and polystyrene/ foamed plastic and because they do not include all source categories in the different material categories. The differences are not regarded sufficiently large for recommending including the items to be recorded in addition to applying the OSPAR protocol. Apart from wet wipes, the OSPAR beach litter protocol includes all the SUP items. The Rydde protocol includes all the SUP items. AMAP (2021a) also list some marine litter items that should be identified specifically due to their Arctic relevance, and that are not currently in the Joint List, including: melted plastic pieces, detonating cords for explosives, aquaculture/animal feed bags, plastic sanitary bags, trawl nets, gill nets, riffle cartridges. Snuff bags and boxes is another litter item commonly found in Norway, that is included in the "Rydde" protocol, but not the Joint List.

Given that the MSFD Joint List combines other beach litter protocols, this is the most extensive established monitoring protocol that could be applied in its full version. However, experience from identification of beach litter originating from marine activities in Norway (Falk-Andersson, 2021; Johnsen, Falk-Andersson, et al., 2019) has found that a higher resolution is needed to identify the type of fisheries and to separate aquaculture related items (see Box 3 on Deep Dive analysis). While the Joint List identifies several fisheries related items[12], the information recorded on fishing nets is not sufficient to identify the type of fisheries as different fishing vessels use different type of fishing nets. In addition, the Joint List does not identify rope cut-offs from repairs of trawls, which has been found to dominate the rope category in many beach litter analysis in Norway (Falk-Andersson et al., 2018). Thus, a higher resolution of this category could potentially document a fisheries-related item that is found in high abundance, and that is subject to EPR (NEA, 2022) – something which is a focus within the industry. The aquaculture items in the Joint List (oyster trays, mussels/oyster mesh bags/net sack/ socks, plastic sheeting from mussel culture, plastic from aquaculture, plastic equipment for holding or protecting shellfish), are not specified for Norwegian aquaculture (dominated by salmon farming).

The MSFD recommends application of the Joint List across the marine environmental compartments, but it is most relevant for beach litter and litter recovered through sampling. For visual assessments of litter on the ocean surface, for example, achieving such a high level of identification may not be feasible. For remote observations of benthic and floating litter the UNEP/IOC guidelines recommends identification of 29 litter types, alternatively categorise litter according to seven general litter classes (containers, fishing/boating, food/beverage, packaging, sanitary, smoking, other) (Cheshire et al., 2009). The International Bottom Trawl Survey, where Norway also takes part, categorises litter according to the ICES Manual (ICES, 2022). Given that data collection on litter can be subject to time constraints and poor weather conditions, the categories are simpler compared to more comprehensive schemes, such as the Joint List. Seafloor litter is recorded into 6 material categories, and for each material there are source categories, including "other"[13]. In the Barents Sea, a protocol has been developed for collection of by-catch of litter in trawl surveys and visual observations during the Norwegian-Russian ecosystem survey. Only a few identifiable items (rope/line, nets, buoys/bobbins) is registered in these assessments (Grøsvik et al., 2018). Harmonisation efforts with ICES, the North Atlantic and North Pacific Marine Science Organisation (PICES), OSPAR and the MSFD has been recommended for monitoring of seafloor litter, including data collection that can reflect the impact of the SUP Directive (Directive (EU) 2019/904) on SUP and fisheries items. Documentation of litter interaction with epibenthic fauna, including the characteristics of this interaction (strangulation, injury,

[12] octopus pots, metal lobster/crab pots, fisheries related weights/sinkers/lures, fish boxes, bait containers/ packaging, fishing light/glow sticks, plastic flows for fishing nets, fishing line, nets and pieces of net (made of twine/cord), dolly rope strings, other plastic string and filaments exclusively from fishery, other plastic fisheries items

[13] Plastic: 16 item categories, Metal: 8, Rubber: 6, Glass and ceramics:4, Natural products: 5, and Miscellaneous: 3

coverage, species colonisation of litter) has also been recommended to document impact on biodiversity (Grøsvik et al., accepted manuscript).

Box 3. The Deep Dive methodology

Most litter item classification schemes were developed in other regions of the world where the dominant sources and types of marine litter may differ from those in Norway. Therefore, there has been a desire to augment them with additional data gathering and increased resolution for certain litter categories, such as fisheries-related items, to improve our understanding of sources. Efforts to date and determine the nationality of items have also been undertaken for the same reason. To complement standardised item-to-source protocols, Deep Dives have been suggested as an adaptive method determined by the context and aim of the analysis (Falk-Andersson, 2021). The concept has been used to identify sources and reasons behind litter found for a number of cases (e.g. Drægni et al. (2020); Falk-Andersson and Strietman (2019), Deep Dive studies summarised in Appendix 7), and a specific protocol has been developed for beach litter in the Arctic. Items included in this protocol, includes bundles of strapping bands, parts of conveyor belts, packaging tube rolls and clear-cut sections of trawl nets that fisheries experts have identified as being discarded from trawlers. This highly flexible, high-resolution protocol that can be applied as broadly or narrowly as desired depending on monitoring goals. In its full expert elicitation workshop format it can be used to inform management actions and set monitoring goals to measure their effects. Simultaneously, it is possible to simply adapt pieces of the protocol, such as the separation of cut-offs from net mending from other rope or the recording of language printed on packaging (an indicator of nationality) and its production or expiry date (an indicator of age), into other less comprehensive and harmonised monitoring protocols. An online registration platform for beach litter Deep Dives in the Arctic has been developed and is undergoing further development (see https://deepdive.grida.no). While the method has primarily been tested on beach litter there is no reason it could not be applied to macrolitter from other compartments also.

Box 4. Weights vs numbers

A major limitation of litter monitoring protocols is that they in general only record the number of items, not weight, to reflect the amount of litter. Thus, a small cotton bud and a large trawl net are both recorded as one item. If the weight was recorded, this would give a very different picture of the abundance of litter in different areas. This is particularly true for fisheries related litter, which is often quite large (Falk-Andersson et al., 2018; M.L. Haarr et al., 2022). Weight could, however, be affected by contamination of sediments and water (Schulz et al., 2013). The IBTS guidelines require both counts and weight data, preferably at the level of individual items. The items should not be left to dry, and be weighted with any fouling or sand (ICES, 2022). This practice is different to for example deep dive analysis, where the litter is left to dry and sand is removed (e.g. Jacob et al. (2021)).

Volume may also affect the apparent dominance of different items and material type. Polystyrene, for example, could have a high volume, but low weight, while if it is represented by number of items it would depend on the degree of deterioration (Hong et al., 2014). Sizing litter items is mandatory for the IBT surveys, which defines size 6 classes from <5*5 cm, to ≥ 100*100 cm, as well as 6 area classes for myofilaments (<25cm2, to ≥ 10000 cm2 = ≥ 1 m^2 (ICES, 2022)).

The total weigh of litter would not be affected much by the precision related to cleaning up the smallest items, while the total number will be drastically changed. Thus, the relative contribution of different litter items would be sensitive to the clean-up precision. Recording both numbers and weigh for all items, sub-categories or the total amount of litter cleaned, would therefore give a more complete picture of the amount of litter, as well as the relative contribution of different sources (Falk-Andersson et al., 2018; Hong et al., 2014). While recording the total amount of litter is relatively easy, obtaining weights for sub-categories or all items would be more time-consuming.

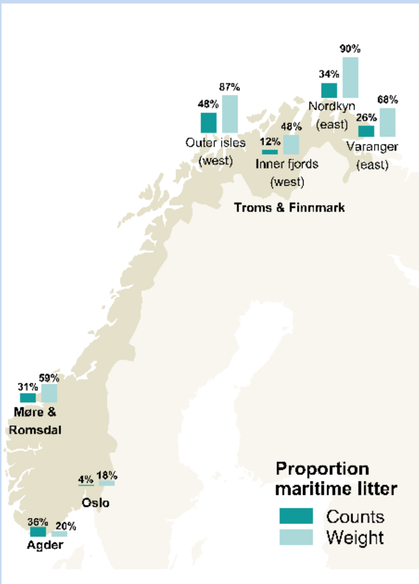


Figure 4. Counts and weight data from beach litter analysis on the coast of Norway, illustrates how the proportion of maritime litter changes depending on the metric used (Haarr et al., 2022).

3.4.2.2 Monitoring of plastics on shorelines, including beaches

There are two overarching types of shoreline surveys: accumulation and standing-stock surveys (Cheshire et al., 2009; Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019). **Accumulation surveys** reflect the rate of deposition (flux) of debris onto the shorelines (i.e., density per unit area per unit time) and require repeated measures of the same locations. These studies are labour-intensive and require litter removal but can give information about both composition and weight of litter in addition to counts. **Standing stock surveys** provide a snapshot of the litter present on the shore at a certain point in time only (density per unit area). Large-scale standing stock surveys are used to map variability and identify potential high accumulation zones to inform the development of further monitoring, whilst accumulation surveys are the preferred long-term monitoring strategy because they are likely more informative regarding the amounts and types of litter in the surrounding marine environment (Cheshire et al., 2009; Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019).

The UNEP/IOC guidelines were generated through an evaluation of several beach litter monitoring protocols and their strengths and weaknesses, including the OSPAR protocol currently applied in Norway (Cheshire et al., 2009). Its resulting key recommendations include: 1) **The main sampling unit is a beach, or a fixed length of coastline.** Length may vary among beaches, it only remains fixed for each individual beach during repeat surveys. The width of the beach is determined by the presence of vegetation, cliffs or other natural barriers or changes in substrate. 2) **Minimum 20 survey beaches per region**. Regions should be defined by management zones and there may be several regions within a larger country or several smaller countries within a larger region. Differences in spatial intensity of sampling between areas within a region should be avoided. 3) **Selected beaches should be minimum 100 m long** (100 m to 1 km ideal), **sand or gravel**, have a **slope of 15-45°**, **not obstructed or sheltered from the sea**, **not subject to other clean-up activities**, **not impacting endangered or protected species**, and be **stratified to include urban and rural locations**, as well as **locations in proximity of major rivers**. A beach can be linear, concave, convex or sinusoidal/tiered in shape. 4) **All litter >2.5 cm should be classified** according to the UNEP/IOC list of categories. Highly dense, smaller items may be subsampled in 10 m wide transects on either end of the beach. 5) The **minimum sampling frequency is annual**, although every three months is highly recommended to account for seasonal variation. 6) During data collection surveyors should form skirmish lines with 2 m distance between them. 7) Adequate meta-data need to be collected, including relating to the depositional environment of the beach and proximity to litter sources. 8) Data from replicates should be aggregated and standardized by total length of beach surveyed before any analysis that attempts to elucidate regional patterns.

The interval between surveys in accumulation monitoring will have an impact on the outcome. While the survey interval recommended by the UNEP/IOC guidelines is flexible, it should be noted that it is not equally flexible within the monitoring region and that widely different sampling intervals among regions will hamper comparisons among them (Cheshire et al., 2009). Beach litter accumulation is a function of both litter deposited on the beach and its residence time; in other words, litter deposited on the beach may also be removed from it through resuspension by waves and tides, alongshore transport by wind or removal through clean-ups (Cheshire et al., 2009; Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019; Solbakken et al., 2022). Consequently, estimates of daily accumulation rates will be higher the shorter the sampling interval (even if the actual amount of litter removed each sampling is lower) as shorter intervals are less influenced by litter removal (Eriksson et al., 2013; Ryan et al., 2014; Smith & Markic, 2013) . Which process dominates and whether a beach is mostly gaining or loosing litter, as well as the turnover rate of litter, can vary both among beaches and over time, such as among seasons (Solbakken et al., 2022). Annual surveys therefore measure the average equilibrium between deposition (influx) and removal over the course of a year, but the estimates will be coarse. The recommended quarterly surveys (e.g. OSPAR (2010)) will have some ability capture the seasonal variation in this equilibrium. However, if one of the monitoring goals is to measure purely deposition, then each such seasonal sampling rounds will need to be comprised of not one survey but bursts of several with short intervals between them (e.g., one week of daily surveys every four months) (GESAMP, 2019).

It is common for beach litter surveys to cover only the beach itself and cover the area between the waterline at low tide and the start of the backshore vegetation (or cliffs or other natural barrier or sharp substrate change), and this is a concrete recommendation by the UNEP/IOC guidelines (Cheshire et al., 2009). However, the backshore and vegetation beyond it has been identified as a possible major sink for marine litter (Olivelli et al., 2020) and including at least a portion of this zone to monitor the accumulation of litter here has since been recommended (GESAMP, 2019).

The beach selection criteria laid out in the UNEP/IOC guidelines are somewhat more flexible than those for OSPAR beaches, although they do not include recommendations for randomised site selection or other measures to ensure representativity of the sampling units. The majority of statistical analyses which would be done to test for trends in the monitoring data have an underlying assumption that any member of the population – in this case any beach within the monitoring region[14] – has an equal probability of being included. Violating this assumption means one cannot extrapolate the results to draw conclusions regarding the region as a whole (Galgani, Hanke, Werner, Oosterbaan, et al., 2013). This point is recognised in the more recent general guidelines by GESAMP and guidelines targeting the East Asia region by COBSEA/CSIRO and Europe through the MSFD where the need for representative site selection, ideally through a randomisation procedure, is highlighted (COBSEA, 2022; Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019). The MSFD TGML recommends a minimum of 40 surveys per country-sub region to secure a sufficiently robust median assessment value for beach litter (Commission et al., 2020).

There have been substantial investigations into understanding the complexity of survey design for beach monitoring (See case study in Box 5). The main take home messages are that **the variability in data should be reduced**. There are several ways in which this could be achieved. Firstly, accumulation surveys are less subject to some of the extreme variability of standing stock surveys as the time during which litter may have accumulated (or been removed) is standardised (Cheshire et al., 2009; Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019). There are also several geomorphological and other features of the coastline that impact litter deposition (Brennan et al., 2018; Cheshire et al., 2009; M.L. Haarr et al., 2022; Haarr et al., 2019). Standardising for some of these features will also inevitably reduce variability (Galgani, Hanke, Werner, Oosterbaan, et al., 2013). Hence why the UNEP/IOC guidelines and OSPAR, for example, have clear criteria for site selection. However, as already mentioned, if site selection is not probability-based, the results cannot be extrapolated beyond the individual beaches (Galgani, Hanke, Werner, Oosterbaan, et al., 2013). A potential compromise would be the use of GIS layers to eliminate coastline not meeting a chosen set of criteria (e.g., too steep) and then to randomly select locations from within the coastline which does meet the criteria. This would allow interpolation of results to all similar coastline types within regions, although note that extrapolation to the coastline in its entirety (i.e., including coastline types excluded from the site selection procedure) would still be inappropriate.

Recommendations for the statistical treatment of sampling units is somewhat variable. The UNEP/IOC guidelines recommend that all replicates within sampling areas be pooled to reduce variability in the data prior to statistical analyses of regional trends (Cheshire et al., 2009). This approach means that

[14] or, if using certain selection criteria, any beach meeting those criteria within the region

local variability is not given consideration and that replicates do not strictly lead to increased replication but rather to larger sampling units. This can be an appropriate solution to variable sample unit sizes as the size and shape of sampling units can impact density estimates and further increase noise in a dataset (M. L. Haarr et al., 2022; Krebs, 1999). However, it also eliminates one's ability to elucidate spatial autocorrelation patterns and relevant spatial scales in sampling as it results in the loss of considerable information. Spatial replication to assess variability in the system has been highlighted (GESAMP, 2019).

Box 5. Case study: beach litter standing stocks in Norway (Haarr et al., 2022b)

A relatively large-scale effort to map beach litter standing stocks along different regions of the Norwegian coastlines using a randomised survey design was undertaken between 2019-2021 (M.L. Haarr et al., 2022). The variability encountered in this dataset clearly illustrates some of the challenges connected with standing stock surveys and with representative site selection. Beach litter densities tend to follow a highly right-skewed distribution where the majority of locations are relatively clean or have a certain low to moderate "normal" pollution level, but where there are also a number of heavily polluted beaches which accumulate considerably more litter than the average location. When sampling such a distribution, the resulting mean values and variances will be highly sensitive to locations within this tail of the distribution. Consequently, extremely large sample sizes are necessary if one is to be reasonably accurate (close to the true mean density for the coastline as a whole) and precise (have a narrow confidence interval around this mean to allow for the detection of relatively small changes) (M.L. Haarr et al., 2022) **Figure 5**. This simulation was generated based on the distribution of data sub-sampled in transects, but the general shape of the distribution remains the same for both beach-aggregated randomised data and citizen science clean-up data from variable beach sizes, and its conclusions are therefore expected to hold also for these different data structures. The simulation illustrates that to conduct a fully representative standing stock survey along the Norwegian coast with sufficient precision to be able to detect small to moderate changes upon repeat surveys at a later point in time, thousands of survey locations are expected to be necessary (M.L. Haarr et al., 2022).

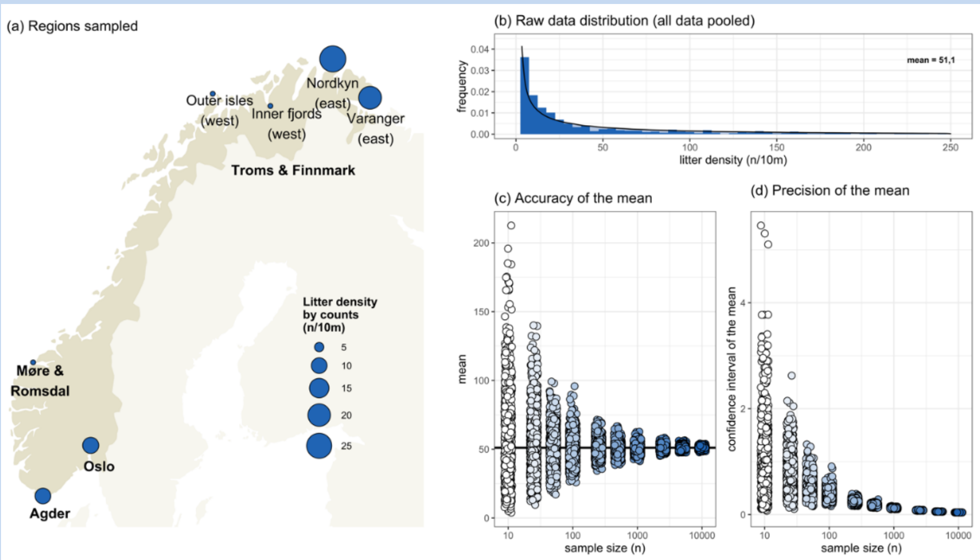


Figure 5. Overview of the simulated accuracy and precision of randomised standing stock surveys based on data collected from 266 beaches (three transects sub-sampled per beach) in four Norwegian counties. (a) The locations of the regions sampled and their median litter densities. (b) The heavily right-skewed distribution of the pooled raw data. (c-d) The result of randomised

subsampling of the distribution in panel b using different sample sizes. Each datapoint represents either the (c) mean or (d) confidence interval of the mean of one sub-sample. 1000 sub-sampled were generated per tested sample size. Sample size is plotted on the x-axis; note the logarithmic scale. The solid horizontal line in panel b shows the actual mean from the distribution hence the sub-samples were generated. Note the variability in mean values and large confidence intervals unless sample sizes are quite substantial. Adapted from M.L. Haarr et al. (2022).

3.4.2.3 Monitoring of plastics floating on the ocean surface

There are two fundamentally different approaches to monitoring plastics floating on (or near) the ocean surface: (1) **trawl surveys** or other collection-based methods, or (2) **visual surveys**, accomplished either through direct observation from vessels or airplanes or analyses of imagery obtained through aerial, drone or satellite-based remote sensing (Cheshire et al., 2009; Vighi, 2022).

During trawl surveys litter is collected and can be classified according to a high-resolution system, and measurement units may include both counts and weight either per surface area or by volume depending on the height of the trawl opening and the depth below the surface sampled. During visual surveys, however, the litter is only observed *in situ* and not collected, and thus can only be classified according to a lower resolution scheme and the only applicable measurement units are item counts per surface area (**Figure 6**) (Cheshire et al., 2009; Vighi, 2022). In the UNEP/IOC guidelines only direct visual observations in transects from ships or airplanes are included (Cheshire et al., 2009), but in the most recent assessment remote imaging-based methods are also considered (Vighi, 2022). Both fundamental approaches have different strengths and weaknesses.

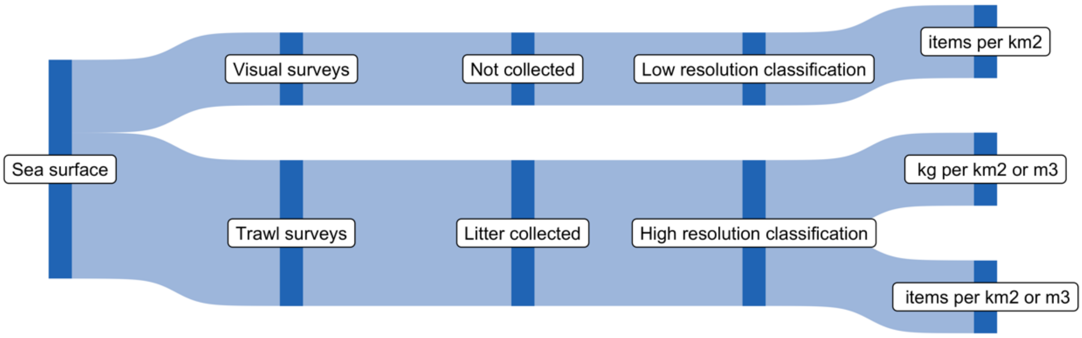


Figure 6. Illustration of the two fundamentally different choices in monitoring litter on the sea surface. Based on recommendations in the UNEP/IOC guidelines (Cheshire et al., 2009)(Cheshire et al., 2009).

The key benefit to trawl surveys is that litter is collected and sampled physically. This allows for much higher resolution of the litter classification system used and is a necessity for categorising items by material or identifying source-related characteristics such as age and nationality (Cheshire et al., 2009; Vighi, 2022).

The UNEP/IOC guidelines recommends a minimum of 20 sampling units per region for trawl surveys. Sampling units are defined as fixed 5 km × 5 km survey areas, which are in turn sub-divided into 25 blocks of 1 km × 1 km. Three of the smaller sub-blocks should be randomly selected for trawling. Within each selected sub-block five parallel trawl hauls up to 800 m long and separated by minimum 200 m should be conducted. For analyses data from all the trawl hauls within a 5x5 km survey block is to be aggregated (i.e., all litter summed and divided by the sum of the length of all the hauls) (Cheshire et al., 2009). Sites (location of sampling units) should be chosen to focus on known high-density areas stratified with proximity to urban coasts (i.e., mostly terrestrial inputs), rural coasts (i.e., mostly oceanic inputs), major riverine inputs, and in offshore areas (e.g., major current, shipping lanes, fishing grounds). Surveys should be conducted at least annually, although it is not immediately clear from the guidelines if sampling units should be identical among surveys as per the beach litter monitoring recommendations. The guidelines state that trawls used may typically have 2-4 cm mesh size and a 6 m wide opening, but there are no set recommendations (Cheshire et al., 2009).

These recommendations differ somewhat from the assessment in the most recent review of floating litter monitoring methods (Vighi, 2022). Here the challenges associated with the physical collection of macrolitter in a representative manner is discussed. Even in high-accumulation areas it is necessary to sample extensive surfaces of water as floating marine macrolitter is highly variable in space and time, including over very small scales (see e.g. Falk-Andersson et al. (2020), van Sebille (2020), M. L. Haarr et al. (2022). Consequently, physical sampling of macrolitter is rare to date and has only been employed on limited occasions (Vighi, 2022). However, a combination of visual observation and surface tow nets is still recommended as it could provide ground-truthing of observation methods, as well as provide data that could be used to estimate the mass of floating litter. Note also that the UNEP/IOC recommendation of targeted site selection is incompatible with need for representative survey designs expressed by the MSFD Technical Group on Marine Litter (Vighi, 2022). For an in-depth discussion of targeted *versus* randomised site selection see the relevant discussion for beach litter monitoring in section 3.4.2.2.

Visual observation methods have been more widely used for floating macrolitter surveys, although these also pose certain challenges (Vighi, 2022). Despite the use of competent and dedicated observers, direct observation is fraught with potential biases linked to the observation conditions and the type of platform used for observation. Depending on the size of the platform, the speed and observation height may differ, again affecting the ability for the observer to detect and identify litter items of different size classes or at different distances. While technological advances have been made with remote sensing techniques, these are still in development and often in an experimental stage. In the future, automatic recording may reduce the need for observers, as the item recognition is performed afterwards. The latter may also be facilitated by automated algorithms and machine learning techniques. However, remote sensing techniques are vulnerable to weather conditions affecting the detectability of litter (Vighi, 2022). Further information on the Technological Readiness Level of the use of remote sensing is presented in section 3.5.

As also recommended by the MSFD and regional programmes, the approach selected should consider the available equipment and expertise as well as opportunities for cost reduction in data collection (Vighi, 2022). JRC has developed The Floating Litter Monitoring (FLM) app to facilitate data acquisition during monitoring at sea and on rivers. The app allows categorisation of litter objects according to the Joint List, and record geographical coordinates, sampling date and time, litter type and size information. The monitoring of floating marine macrolitter is not yet established as an indicator under OSPAR, although new indicators are being considered; similarly, a monitoring plan for the Arctic is not yet operative, but floating marine litter is addressed in the AMAP draft plan (Vighi, 2022). Both regional conventions encompass Norway, and thus their eventual methodological choices will impact the harmonisation potential of future national monitoring in Norway.

3.4.2.4 Monitoring of plastics in the ocean water column

The water column is rarely sampled for litter, thus our knowledge about marine litter throughout the water column is very limited (COBSEA, 2022). While technically feasible, as for example in the Barents Sea ecosystem trawl survey (see section 3.7.2) it is not recommended in regular monitoring programs today (AMAP, 2021a). The monitoring guidelines and recommendations divide sampling between surface waters, and the sea floor. The extent of surface water mixing can vary greatly in the environment and therefore differentiating between the true water surface and the water column is not currently part of monitoring programmes. GESAMP (2019) did discuss potential methods for use in the water column, however the methods only include approaches to sample microplastics from the water column. Similarly, most available data focuses on microplastics sampled at different depths of the water column.

3.4.2.5 Monitoring of plastics on the seafloor

There are three fundamental approaches to monitoring macrolitter on the seafloor: (1) visual surveys carried out by SCUBA divers, (2) trawl surveys, and (3) remote sensing surveys using e.g., towed video cameras or ROVs (Cheshire et al., 2009; Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019). The three different methods are best suited for different seafloor environments, and all three may play a part in a holistic monitoring programme (**Figure 7**). SCUBA diving is best suited for shallow coastal waters (max. depth 20-30 m depending on the guideline). It is possible to collect items whilst diving, such as during clean-up actions by divers, although most monitoring guidelines focus on visual surveys only. Trawl surveys are well suited to large-scale monitoring on soft bottoms at moderate depths (20-800 m), and as litter is actually collected, higher-resolution classification schemes can be used to classify the litter. Remote sensing surveys are visual only but can provide access to very deep waters and substrates not suitable for trawling and have much less impact on benthic habitats than trawls (Cheshire et al., 2009; Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019).

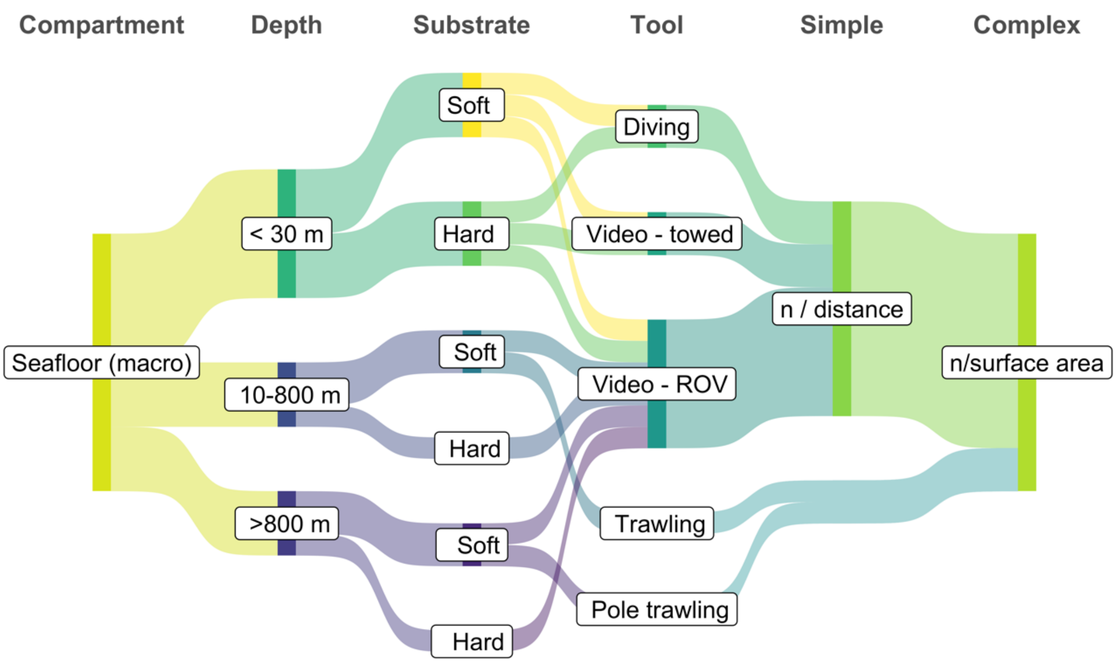


Figure 7. Options for seafloor macrolitter monitoring tools given different depths and bottom (substrate) types. Adapted from GESAMP (2019).

The UNEP/IOC guidelines for diver surveys recommend the use of belt transects 100 m long or more (Cheshire et al., 2009). Many diver-based seafloor surveys utilise small plots such as 10x10 m, but if the sampling units are too small they are unlikely to achieve representative coverage of the sampling area; when the sampling units are smaller than the scale of patchiness in the underlying spatial pattern under study the variability between them will be very high and larger-scale patterns difficult to detect (Cheshire et al., 2009; M. L. Haarr et al., 2022). Hence the recommendation of longer belt transects. The transects can be delineated by measuring tapes or weighted ropes along the bottom, and a pair of divers survey a 2 m wide strip on either side of the line (i.e., total plot size of 100 x 4 m). This approach has proven reliable for shallow water fish surveys and is assumed transferable to litter (Cheshire et al., 2009). Minimum 20 sampling units are recommended per region. It is possible to add replication within each site, in which case transects should be separated by at least 50 m and data aggregated before analyses. Sites should be shallower than 20 m, be known to accumulate litter, free of hazards to the divers, not impact endangered or protected species, and be readily accessible; sites should also be spread to cover both urban and rural coasts, as well as sites within proximity to major river outlets. Recommendations for temporal resolution of the sampling is the same as for beach litter surveys: minimum annual surveys, preferably every three months (Cheshire et al., 2009). Sites may also be paired with beach survey locations to provide matching data on both beach cast and sunk litter.

More recent recommendations from GESAMP and within the MSFD are relatively similar, both advising belt transects (Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019). Three-month sampling intervals are considered ideal within the MSFD (Galgani, Hanke, Werner, Oosterbaan, et al., 2013), although survey interval recommendations are not specified by GESAMP (2019). Common for both is the concrete recommendation of two transects per site, rather than optional site-level replication. GESAMP (2019) recommends slightly shorter transects of 50-100 m, while the MSFD recommends slightly more flexible transects of 20-200 m (Galgani, Hanke, Werner, Oosterbaan, et al., 2013). In other words, these protocols allow for somewhat smaller sampling units, although within the MSFD the overall plot size is increased by allowing wider transects of 4-8 m (rather than 2-4 m) long. In addition to simple item counts to estimate density, the MSFD guidelines also recommends abundance be adjusted based on detection probability, which is estimated according to the distance of each item from the central line of the transect (Galgani, Hanke, Werner, Oosterbaan, et al., 2013). Both guidelines stress the importance of appropriate site selection methods (i.e., an element of randomisation) given its importance for statistical inference.

For moderately deep water inaccessible to divers, trawl surveys are the most commonly recommended monitoring tool, at least for soft bottoms (Figure 1). The UNEP/IOC guidelines recommend minimum 20 sampling units per region to be surveyed at least annually, possibly every 3 months if sites are paired with beach monitoring sites (Cheshire et al., 2009). The suggested sampling units follow the same structure as for surface monitoring with a site comprising a 5x5 km square subdivided into a 1x1 km grid within which three sub-blocks are selected for trawling. The sites themselves are recommended to be selected to focus on known accumulation zones with consistent and uniform substrate and depth, and to be dispersed to cover urban and rural nearshore areas, areas close to major riverine outputs and offshore areas (e.g., shipping lanes, fishing grounds). The sub-blocks to be sampled within each site, however, should be randomly chosen once cells unsuitable for trawling have been eliminated. Within the selected sub-blocks five parallel trawl hauls up to 800 m long and separated by a minimum of 200 m are recommended (Cheshire et al., 2009). Data are recommended aggregated across all hauls and sub-blocks within each 5x5 km block. No specific recommendations are made with respect to the trawl equipment to be used, acknowledging that this may depend on the type of litter and seabed conditions. However, the type of trawl gear used will have considerable impact on the harmonisation potential of the data and ability to compare trends among regions and over time (if the gear is changed among years within a region) as differing sizes trawls will result in different plot sizes and variable mesh size in differing minimum detectable sizes of litter (e.g., Canals et al. (2021); M. L. Haarr et al. (2022)).

The recommendations from more recent guidelines are similar. The key difference is a clear recommendation to incorporate litter analyses with already ongoing benthic fish or biodiversity surveys, which has been employed successfully in several European countries (Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019). Such consolidation of monitoring efforts is considerably more cost-effective, thus allowing a programme with greater scope for the same resources. Bottom trawling also has considerable negative environmental impacts on benthic habitats and ecosystems, and consolidation of different monitoring efforts requiring the use of the benthic trawls reduces the cumulative negative impacts of multiple monitoring programmes. One consideration which must be made when consolidating litter monitoring with benthic fish or biodiversity surveys is the survey design, which may have different priorities than would be ideal for litter surveys. For example, utilising longer hauls when trawls are deployed in deeper water given the longer deployment time results in varying plot (sample unit) size with depth, which can impact abundance estimates, thus adding a potentially confounding variable; equivalent long hauls in shallower water would result in more harmonised data (M. L. Haarr et al., 2022).

Within Europe, benthic fish and biodiversity surveys using standardised trawl equipment and survey designs exits in different regions (i.e., the Atlantic, Baltic, Mediterranean and Black Seas) and provide excellent opportunities to generate harmonised data on seafloor litter (ICES, 2022). Galgani, Hanke, Werner, Oosterbaan, et al. (2013) reviewed the trawl surveys, which is what is reported here although there have been some changes in procedures as well as harmonisation efforts since then (see (ICES, 2017)). In the Atlantic and Baltic regions sampling is divided into a 30x30 nautical mile grid (1 x 0.5 degrees latitude), and minimum two trawl hauls conducted in each cell. Hauls are standardised to 30 minutes using the same 36/47 GOV-trawl with 20 mm mesh nets and vessel speeds of 3.5-4 up to 200 m depth. In the Mediterranean and Black Seas is derived from the MEDITS protocol. Sampling follows a stratified random design by depth from 10 to 800 m (Galgani, Hanke, Werner, Oosterbaan, et al., 2013). The replication within each depth strata is proportional to surface area of each strata within the region. The same locations are trawled each year (i.e., an accumulation survey). The trawl duration is fixed at 30 minutes at depths <200 m, and increased to 60 minutes at greater depths. Surveys take place between May and June using a GOC 73 trawl with 20 mm mesh nets. Given high stochastic variability in litter surveys, trend detection can be challenging. Power analyses of International Bottom Trawl Survey (IBTS) sampling (protocol used in the Atlantic and Baltic regions) suggest that the current design can detect a 50% change over a 5-10 year period. However, the ability to detect a 10% change over the same time period would require massive sample sizes (Galgani, Hanke, Werner, Oosterbaan, et al., 2013).

A limitation with trawl surveys is that they can only be employed over soft (sand/silt) and relatively flat substrates. This both reduces variability in the surveys somewhat by standardising the substrate surveys, but also limits the ability to interpolate results across a region in general terms. As seafloor topography is known to impact accumulation patterns of litter (see e.g., Buhl-Mortensen and Buhl-Mortensen (2017)), this limitation may result in underestimation of the average and overall litter densities (GESAMP 2019). Trawls can also only be deployed up to a certain depth (800-1000 m for most bottom trawls, although pole/beam trawling can be done up to 2500 m depth), and monitoring at greater depths or over rocky or otherwise heterogeneous or steeply sloped substrates requires the use of ROVs (GESAMP, 2019).

The UNEP/IOC guidelines do not encompass ROV surveys; the recommendations for trawl surveys are extended to all towed survey equipment, including towed cameras and submersibles, but no specific considerations were given to how ROVs may for example extend the survey area (Cheshire et al., 2009). The general premise of ROV-based surveys is similar to the distance/belt transects recommended for diver-based surveys; unlike trawl sampling weight cannot be recorded as litter is generally not collected (GESAMP 2019). Measures of the field of view and height above the seafloor are necessary to determine the area surveyed and videos recorded at low speeds (GESAMP, 2019). Minimum survey length should be 500 m (Hanke 2013). As the field of view is generally small (e.g., 0.5-3 m across), ROV surveys results in very long, narrow transects (M. L. Haarr et al., 2022). In general, ROV-based surveys report a greater proportion of clean transects than do trawl surveys. Direct comparisons with trawl surveys is of course challenging as they are generally not utilised in the same areas (substrates, depths), yet this could be a result of the narrow field of view meaning that even if the transect intersects a patch of high litter density it may not be detected depending on the distribution and density of litter within the patch (M. L. Haarr et al., 2022). ROV surveys are also costly and require highly trained expert personnel to conduct (GESAMP, 2019). When using ROVs for monitoring, it the therefore recommended that priority be given to marine canyons and other areas inaccessible to trawls but known to accumulate litter (Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019). A positive of ROV surveys is their low environmental impact (Canals et al., 2021).

3.4.2.6 Monitoring of plastic impacts on biota

Plastics and other litter items can impact biota in two primary ways: **entanglement** and **ingestion.** Biota can get entangled in larger litter items, this can lead to death via drowning if animals are unable to surface to breathe or are unable to access food. Similarly, if animals use litter as nesting material, they can become entangled, which may lead to mortality. Given that entanglement in litter and plastics can be challenging to differentiate from bycatch in active fishing gear, and that abandoned lost and otherwise discarded fishing gear prevents its own challenges they are not discussed further in this report.

Ingestion of plastic and other litter items can be a result of targeted or confusion during feeding. When non-prey items are ingested, they can potentially lead to blockages of, or damage to, the gastrointestinal tract, which can lead to malnutrition, increased station, reduced body condition, and ultimately death. Evidence of animals ingesting plastics dates to the 1980's for seabirds (AMAP 2021). The quantity of plastics ingested by marine wildlife mainly reflects the abundance of floating litter in their environment, although biota may also be affected on land for example through entanglement of beached nets. Seabirds are possibly the most studied biota group in terms of ingestion, this mostly stems from the accessibility of stranded or bycaught samples and the early adoption of using seabirds, specifically the Northern fulmar, as a biological indicate in the North Sea. However, while there are hundreds of studies investigating the negative effects of plastic ingestion at an individual level, there is no evidence that seabirds are negatively impacts at the population level (AMAP 2021).

OSPAR has used assessments of the stomach contents of Norther fulmars (stranded or accidentally killed) as an indicator for environmental quality for several years. They are an abundant and widespread species of seabird found to regularly ingest litter and plastic items. Fulmars feed in surface waters, exposing them to floating litter and plastics. They are pelagic species, feeding mostly in the open sea, rarely closely to shore, and never on land. Therefore, ingested items are a reflection of floating litter, rather than beached litter. Currently, OSPAR defines the Ecological Quality Objective (EcoQO) of marine plastics as "*There should be fewer than 10% of Northern Fulmars having 0.1 g or more plastic in the stomach in samples of 50-100 beached Fulmars from each of 5 different areas of the North Sea over a period of at least 5 years*."

The methods for sampling and analysis of Fulmar samples are now relatively standardised within Europe, with methods being applied in the North Sea, Arctic, Celtic Seas and the wider North Atlantic. The size of litter ingested tend to be in the micro- or meso size range (<25 mm in size), although larger items are recorded. Nurdles, or plastic pellets, are a commonly found item. Full details of methods have been provided in the OSPAR Guidelines for Monitoring of plastic particles in stomachs of fulmars in the North Sea area[15]. In short, dead (beached or accidently killed) specimens are collected (mostly by volunteer networks) and processed at experienced laboratories. Metadata including date of finding, location and geographical coordinates are reported. Birds are classified as adult, or non-adult, and by their sex. Stomachs are dissected out and their contents rinsed into a sieve with a 1 mm mesh, retained materials are sorted under a microscope. Industrial plastic granulates (pellets/nurdles) are separated from consumer litter, the number and mass is recorded. Data can be collected to calculate:

- the frequency of occurrence (%FO) the proportion of birds having plastic in the stomach (also referred to as ’incidence’ or ‘prevalence’)
- arithmetic average and standard error (avg±se) of the mean for number or mass of plastic
- EcoQO performance (EcoQO%), being the percentage of birds exceeding the level of 0.1g of ingested plastic as defined in the OSPAR EcoQO long term goal

The basic monitoring information required is the total mass of plastic in individual stomachs, and the percentage of stomachs exceeding the 0.1g level (referred to as ‘EcoQO performance’ or ‘EcoQO%’).

There are still limitations to using fulmars, as the species are not evenly distributed along all coastlines, so it is likely that there will be geographical gaps in monitoring programmes (AMAP, 2021a). Therefore, the use of similar seabird species should be explored.

Other biota that could be considered for understanding impacts on biota will be regionally specific, for example loggerhead sea turtles are being assessed as indicators for the Mediterranean (EC, 2022). For adverse effects, no threshold values have been determined, and assessment methods are also still being developed.

3.4.2.7 Monitoring of plastic flowing in rivers

This section is based on the global study by Hurley et al. (submitted) which reviewed methods for measuring riverine macroplastic. Their review included 39 studies published up until 01.12.2021. Most of the studies were conducted in Europe and South-East Asia. There were no Norwegian studies. While many guidelines for monitoring macroplastic in rivers exist, no single method has emerged representing the standard approach. This is due to the large variability in river systems on a global scale and that methods need to be adapted to the local environmental context and monitoring needs. Still, there is a need for harmonisation to secure comparability and utilisation of data by a diverse array of stakeholders.

Rivers are an important recipient and transportation pathway of plastics. Thus, to identify measures to reduce the amount of plastic in nature, knowledge on riverine plastic sources and transportation mechanisms is key. Several processes affect the fate of macroplastic in rivers (F, **Figure 7**) and a good understanding of the litter in rivers and the role of rivers in transporting litter to the ocean, requires a good understanding of all these processes. This section describes the state-of-the art with respect to monitoring of macroplastic flowing in the river, while the following two sections describe monitoring on the riverbed and on riverbanks.

[15] http://www.ospar.org/convention/agreements?q=fulmar

Macroplastic studies in rivers have mainly focused on methods to quantify, and often characterise, plastic waste that is being transported in the rivers. The two main methods applied are 1) **Observation-based sampling** surveys involving quantification or categorisation of items visible in the rivers without collecting these items (A and B **Figure 7**), and 2) **Physical inception-based sampling** which involves entrapment and collection before quantification and categorisation (C-E **Figure 8**).

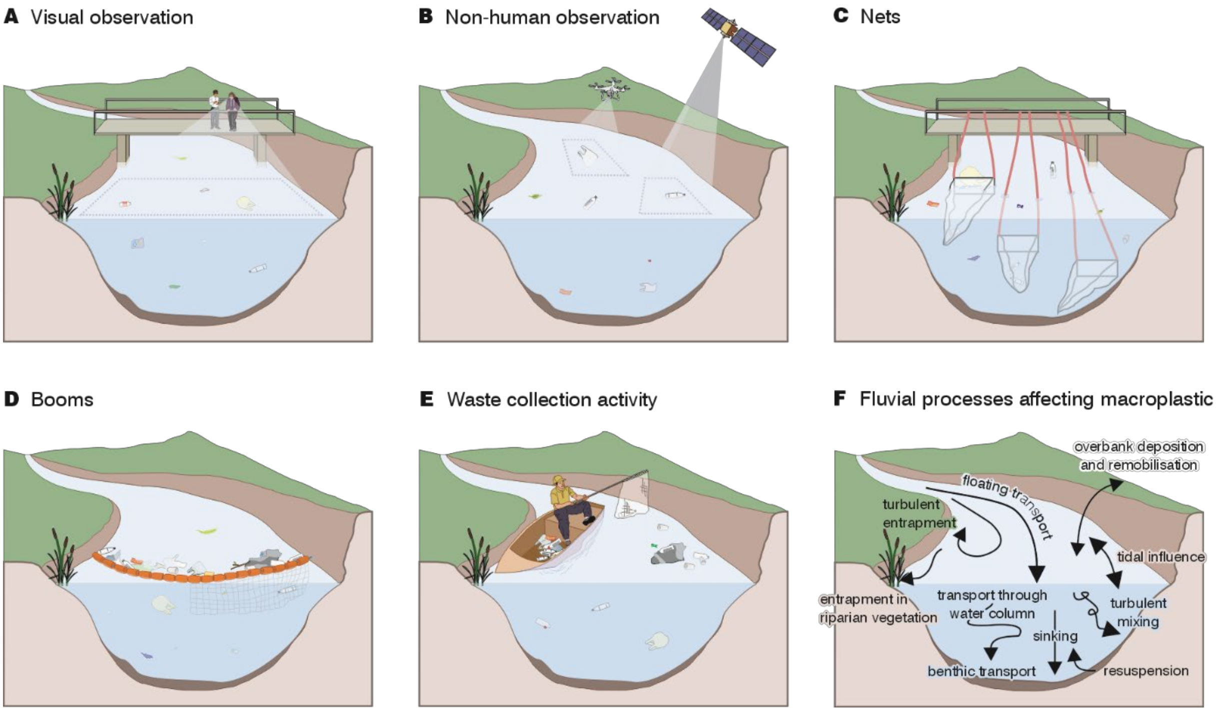


Figure 8. Depictions of the five main methodological approaches identified in the critical method review: A. visual observation using human analysts; B. non-human observation, such as the use of unmanned aerial vehicles (UAVs) or remote sensing; C. use of nets, such as trawl nets; D. use of booms, including an example of a boom with a net extending below the floating component; and E. waste collection activities that can be adapted for monitoring. Fluvial processes relevant for the fate and transport of macroplastic in rivers are described in panel F.

Observation-based sampling can involve visual observation by humans of a cross-section of a river (or a representative part of a cross-section), which requires a survey spot for observation (for example a bridge or, for narrow streams, the riverbank). Guidelines exists for securing representative observation points for larger rivers, which depends on several factors such as vantage point height, flow velocity, plastic load, and weather conditions (van Emmerik et al 2018, as in Hurley et al. (submitted)). Visual observation is a relatively inexpensive and efficient way of collecting data on plastic that is visible from the observation spot. It is not, however, representative of the plastic load in the river overall. Furthermore, if plastic loads become too high, it may not be possible to reliably record and categorise all the items flowing past (Geraeds et al 2019, van Emmerik et al 2018, as in Hurley et al. (submitted)). Turbulent flow can also affect the proportion of items that can be reliably observed. Thus, during times of likely high plastic loads, such as during flood conditions, visual observation methods may be less reliant or more difficult to undertake. Other factors affecting the reliability of observations is the width of the segments observed, whether selected observation points are representative of the full river width, the distance of the observer from the water surface, the difference between observers in likelihood of detecting smaller sized items (the lower size limit of observations applied by studies range from 0.5 to 5 cm), the visibility depth at the monitoring sites, and the concentration span of the observer (affected by e.g. observation time and plastic load). To establish good guidelines, there is still a need for method testing and validation, as well as clear guidelines for reporting metadata. Training of analysts is seen as essential to avoid under or over-reporting, especially with respect to smaller items.

Non-human observation using remote sensing approaches follows similar principles as for visual observation. Cameras and unmanned aerial vehicles (UAVs) have been applied to assess the visible macroplastic at the surface of the river. Sonar has also been applied to detect items below the water but cannot conclusively discriminate between plastics and other materials (Broere et al 2021 as in Hurley et al. (submitted)). Many of the same limitations as for human observations also apply to machine-assisted observations. Benefits of machine-assisted observations is that they can measure litter over longer durations with high levels of consistency, they can handle higher plastic loads and flow velocities, and if cameras are equipped with night vision capability, plastic flows can be measured also at night. UAVs are limited to specific conditions (e.g. low wind speeds, lack of precipitation). There are few studies using these type of techniques, and further testing and optimisation is needed before they can be used in routine monitoring.

Interception-based sampling can involve the use of nets, booms, or waste collection activities to retrieve litter before it is then analysed further. Nets can be used for measuring plastic that is floating or that which is transported sub-surface, as well as benthic transport of plastics. Nets are the most commonly used interception-based technique for measuring the flows of plastics, but there is very little harmonisation between monitoring programs using this method. Nets can be deployed from fixed points, e.g. a bridge or the riverbank, or from boats. The time the nets are deployed for can be predefined or, alternatively, the nets are retrieved when they become full. This time ranges from 30 seconds to 3 days in published studies. After retrieval, the content is counted, categorised and/or weighed. The proportion of the plastic load captured depends on the net opening, mesh size, location and deployment in the river cross-section. Similarly, a number of parameters will determine how long the net should be deployed for (e.g. selected mesh size, flow velocity of the river). Harmonisation between these factors require that methodological details are reported. Deployment of the nets with different configurations, e.g. net opening, mesh size, morphology, may affect their ability to capture plastics. For example, submerged nets may introduce drag, which adds turbulence to the water and affects the transport of plastics close to the net mouth, and thereby the likelihood of plastic capture. Testing is needed to optimise the use of nets in monitoring of plastic flows for different conditions and secure the safety of operators. Given the different operating conditions of rivers, it is unlikely that a single net configuration can be recommended for all rivers. However, development of a set of quality criteria would allow for calibration of methods where the operability window of a given net in a given environmental setting and plastic load is defined.

Booms are floating barriers that collect buoyant plastics as they accumulate upstream at the water surface. Typically, they are used as clean-up or pollution prevention measures, but can also be used to sample litter for data collection. Booms may also have a mesh or screen extending below the surface to collect near-surface litter. Depending on the nature of deployment, booms can measure surface macroplastic loads across the full river width, or a proportion of it, for the duration of deployment. A lack of reporting of metadata, e.g. dimensions of the boom or rate at which the boom was emptied, makes interpretation of data and harmonisation difficult. There is a need for method testing to use this approach to sample plastic as the design, plastic loads captured, and flow conditions could impact capture efficiency.

Interception-based sampling using nets and booms may also be problematic in terms of capturing of non-plastic items. Some studies have found that the majority of the debris collected was organic (e.g.

Gasperi et al 2014, as in Hurley (2021)), which adds needs in terms of requiring personnel and infrastructure for sorting the debris and removing it. **Figure 9** gives an overview of the potential coverage of different sampling approaches for plastic floating in rivers.

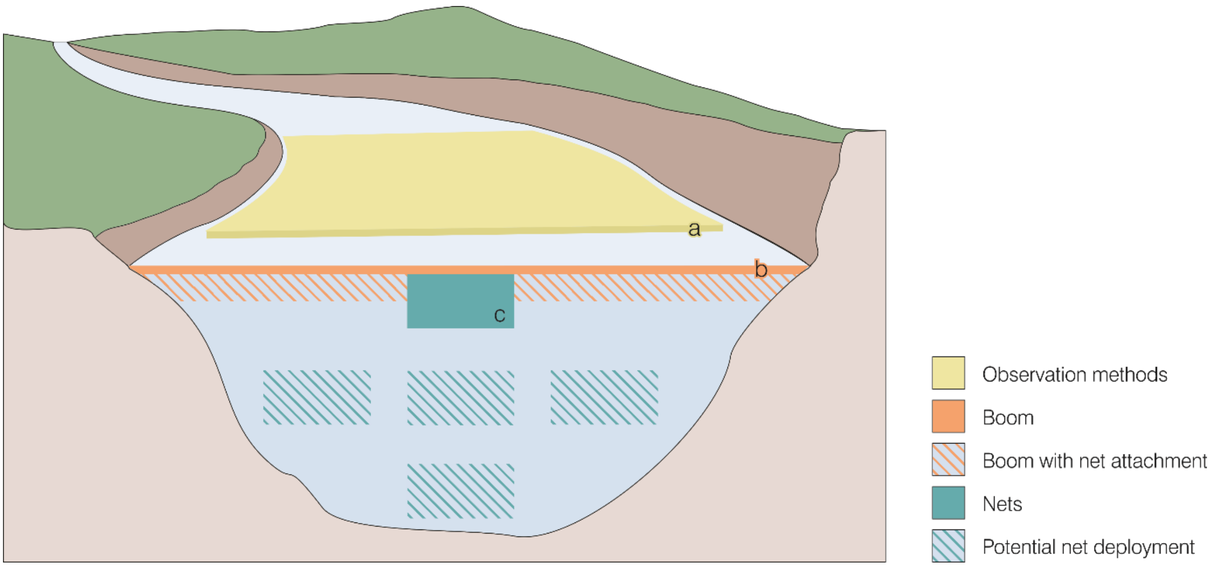


Figure 9. Coverage of different passive and active sampling approaches. Observation methods (human or technology-based) record surface and sub-surface – depending of the visibility (a) of macroplastic. Booms also capture the floating fraction, including near surface debris based on the height of the boom (b) and the inclusion of sub-surface nets (hatched orange section). The coverage associated with the deployment of nets depends on where they are deployed in the water column. This includes potential coverage of deep water or near- bottom flows based on the water depth and river discharge at a given site (hatched teal section).

Waste collection activities may also provide data on riverine macroplastic flows. Clean-up actions and operations linked to maintenance of dams, dredging activities or manual clean-ups of rivers and riverbanks, can give information on plastic pollution of rivers. The utilisation of data from such activities requires harmonisation of data collection and reporting, as well as proper training of those recording the data. The latter includes approaches for categorising macroplastic and separating plastic from other waste types, and how to report data. Important information to collect are the spatial coverage of the clean-up activity, estimated total capture rate of the activity, morphological and hydrological data enabling scaling for total flow assessment, and information on time elapsed since the last clean-up activity (Hurley et al., submitted). Information on by-catch of organic matter to assess the cost-benefit of mitigation actions using clean-up technologies has also been suggested as an important category to document (Falk-Andersson et al., in prep.)

Understanding how macroplastic flows in rivers is important when designing a monitoring program as plastic flows may reflect source dynamics, but also the net result of different hydrological processes. Litter typically follows a complicated journey as it moves through a river including being stranded or deposited in sediments, vegetation and eddies, and subsequent remobilisation. However, these processes are not well understood for the many different types of litter. Experiments have been only performed for plastic bottles, films, and sanitary products thus far. Understanding deposition and remobilisation dynamics, including in estuarine systems, is important to understand the role of rivers as transportation pathways to the ocean, including how representative litter found in or close to river mouths are in terms of understanding plastic sources and plastic loads in the environment. Recent research suggests that a substantial proportion of the litter ending up in rivers do not reach the ocean (van Emmerik et al 2022a, as in Hurley et al. (submitted)). This in turn increases the need for monitoring in river environments, to gain a better understanding of global plastic emissions and pollution as well as to protect river environments from the negative impacts of plastic pollution, as an important recipient of litter.

The objective of the monitoring activity will determine the appropriate method to be applied. The objective may be related to assessing inputs, flows, or accumulation areas. To assess the total macroplastic load, multiple methods may have to be applied. One may also need to include riverbeds, riverbanks, or floodplain environments, as well as riparian vegetation, to assess macroplastic in the entire river system. Only assessing floating litter may bias the results towards litter with certain characteristics (e.g. that make them more likely to float). The objective will also determine the spatial and temporal scales that methods should be applied in.

Harmonisation aims at achieving cross-comparability and interoperability in data outputs across surveys. Harmonisation will be easier if the methods chosen can be applied in a wide variety of settings. The studies reviewed did not only differ with respect to methods applied, but also how data was recorded to report macroplastic quantities. Harmonisation efforts would be facilitated by studies reporting in multiple units, which can be facilitated by many monitoring methods. Observation-based approaches generate count data, but interception-based sampling can also generate mass-based data, which may be preferred for establishing policy and regulations. Hurley et al. (submitted) produced a summary of data that are critical for interpreting and contextualising macroplastic data (APPENDIX 6). There is a need for a standardised approach for categorisation of the litter to get data on the scale of the problem, potential sources, and the effect of mitigation efforts.

3.4.2.8 Monitoring of plastic on the riverbed

Macroplastic and litter items may be deposited on the riverbed or transported in the lowermost parts of the water column. A better understanding of the role of transport along a benthic route and the role of riverbeds as temporary storage for plastics, is important to understand the total input of macroplastic to the ocean and flood-related flushing Hurley (2021). In the review of Hurley (2021), only three studies were identified that had assessed macroplastic flows along the riverbed. All these studies used nets placed close to the bed. Limitations of this approach includes expected thresholds linked to maximum flow velocities and river levels for safe operation and retrieval of nets, as well as limitations on how large a proportion of the river channel the nets will cover. Periodic sampling or sampling under a range of representative conditions can reduce the effort needed to routinely assess benthic litter transport. Sampling using automated, underwater cleaning devices could be another option; however, there is a need for methods testing and validation. Variability in the bed substrate of rivers could affect the possibility to use such devices and they should be assessed to better understand their limitations with regard to capturing different litter size or type. For rivers with periodic low water levels and good visibility, observation-based approaches could be used to establish the macroplastic loads temporarily stored during these times. However, this condition is only relevant for a small number of rivers globally.

3.4.2.9 Monitoring of plastic on riverbanks

Riverbanks include the river shoreline, beaches and floodplains or valley sides, and are influenced by the water flows or sediment erosion taking place under different hydrological conditions. These areas are expected to be an important and dynamic site for litter as they may represent release sites and because they can act as a sink or store of microplastic (**Figure 10**). Litter can accumulate in vegetation or sediments, or on the surface of riverbanks. Plastics have been found to be rapidly deposited or trapped in different parts of the river, including the riverbank, where they accumulate until they are remobilised. How often or fast this remobilisation occurs is not yet known and is likely to vary in different rivers globally. To understand the role of riverbanks as source or sinks for plastic, it is important to develop a more holistic understanding of the processes that determine the deposition, accumulation, storage, and remobilisation of litter in these areas.

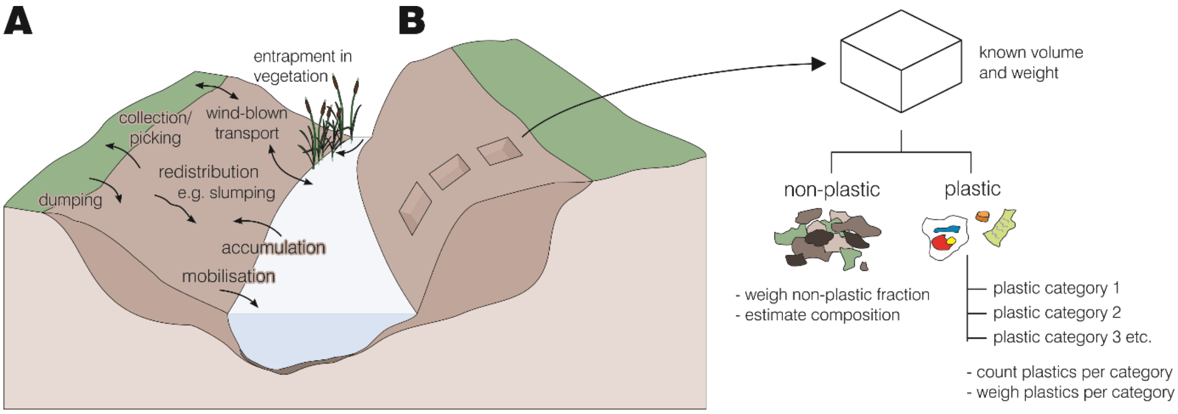


Figure 10. Processes affecting plastic contamination in the river bank zone (A), including releases, transport, accumulation and removal of plastic debris, and a potential approach to quantifying plastic storage in riverbank sediments (B).

Published studies assessing macroplastic on riverbanks mainly use data from riverbank clean-up activities or citizen science, such as the Plastic Pirates initiative (https://www.plastic-pirates.eu/en) (**Table 10**). Other surveys used transects or quadrats to assess accumulation of plastic at the sediment surface and provide either count or mass data. Categorising this litter into source categories is also possible. Harmonisation of data collection of litter on riverbanks requires harmonisation of data collection. A limitation of these studies is that they may miss buried plastic that has the potential to be remobilised (Hurley, 2021). In some types of river this may not be important, but for other river channel morphologies, accumulation and burial may occur rapidly in riverbank sediments. Monoliths can be used to extract a known volume of sediment, from which litter can be isolated, counted/weighed and categorised (e.g. **Figure 10**). However, further method testing is needed to establish monitoring guidelines that also considers requirements for accounting for spatial heterogeneity.

Methods used to document litter on riverbanks need to be adapted based on the catchment characteristics of the chosen site, area or region as different channel morphologies and the presence of vegetation will influence the sampling approach. For example, litter in rivers with a high density of riparian vegetation may become stranded more frequently and travel only short distances at a time. In some rivers, vegetation may be an important zone for trapping litter and specific methods could be developed to measure macroplastic accumulation in vegetation or to better understand the role of vegetation as a temporary store (e.g. duration of stranding, thresholds for remobilisation).

Table 10. Summary of methods reported in published macroplastic studies of riverbanks (From Hurley (2021)

Study	Location	Method	Details
Ivar do Sul et al., 2014[40]	Goiana River, Brazil	Release and track	- Bottles, bags, cups, blocks, and tubs (n=189) composed of different polymer types were marked with paint and released into different habitats associated with a mangrove forest - Items remaining in the forest where counted for the following 6 days. Nearby beaches were also checked.
Rech et al., 2015[41]	Elqui, Maipo, Maul & BioBio Rivers, Chile	Riverbank clean-up (citizen science)	- Surveyed areas split into river shore, mid bank, and upper bank. - Sampling protocol and standard data collection sheet used for clean-up activity
Kiessling et al., 2019[42]	German rivers	Transect survey (citizen science)	- Three transects at each site, perpendicular to the channel. Three points on each transect were selection, at different distances from the water level. - At each point on the transect, a 1.5 m radius was established and defined as the sampling zone. - All litter in the sampling zone was registered and categorised.
Tramoy et al., 2019[43]	Seine River, France	Quadrat survey	- All litter present within 1 m^2 quadrats was registered and collected for categorisation and weighing in the lab. - Plastic items were classified according to OSPAR and MSFD guidelines.
Blettler et al., 2019[44]	Paraná River, Argentina	Transect survey	- Two transects: 50 m long and 3 m wide, parallel to the riverbank and randomly selected, were analysed in each sampling location. - All visible macroplastic at the surface was collected. - Macroplastics were counted, categorised, and assessed for polymer type (ASTM Resin Identification code or FTIR analysis) in the lab.
Battulga et al., 2019[45]	Selenga River, Mongolia	Quadrat surveys	- Triplicate quadrats of 100 m^2 were defined at each sampling site. - All visible macroplastic were identified and categorised at the site.
Bernadini et al., 2020[46]	River Thames, UK	Transect survey (citizen science)	- Data collection performed by trained citizen scientists - Transect was defined parallel to the water level. Along the transect, consecutive 1 m^2 quadrats were used to sample the top 5 cm for macroplastic. - All macroplastic was counted and categorised.
Van Emmerik et al., 2020[23]	River Rhine, the Netherlands	Survey (citstandn science)	- Sampling area defined as width between water line and either the high water line or the riparian vegetation. Length of sampling area is 1, 5, or 10 m long. - Counts and categorisation recorded in CrowdWater app.

As for all monitoring, it is important to select sites that can be accessed safely during the sampling periods and have the necessary infrastructure needed to undertake monitoring. The sites should be representative of the local environment at a relevant spatiotemporal scale and be chosen based on the questions the data are supposed to answer. Comparison between different sites requires consideration of how different hydrogeomorphic processes can influence comparability. Thus, appropriate metadata needs to be collected providing information on these factors.

3.4.2.10 Monitoring of plastics in lakes

Studies of macroplastic in lakes are limited in number compared to other environmental compartments and focus largely on shoreline surveys (Lechthaler et al., 2020). Macroplastic surveys of lake beaches have adopted recommendations established for coastal shorelines. This includes the use of transects to cover a representative proportion of the beach (e.g. Free et al., 2014; Blettler et al. 2017; Rohaningsih et al., 2022) or the use of quadrats to sample visible plastic pieces across a defined spatial extent (e.g. Corcoran et al., 2015; Egessa et al., 2020). Lake shorelines have also been included in citizen science initiatives such Ocean Conservancy's Coastal Clean-up or the Adopt-a-Beach program from the Alliance for the Great Lakes (Earn et al., 2020; Hoellein et al., 2015a). Earn et al. (2020) extracted data from Coastal Cleanup records to determine the distribution and abundance of plastic litter collected along shorelines of the Great Lakes over a three-year period, where over 3.5 million items were recorded across all five lakes. Several studies further investigated the origin or polymer type of recorded litter, using FTIR analysis (e.g. Corcoran et al., 2015; Zbyszewski & Corcoran, 2011; Zbyszewski et al., 2014), ASTM codes (e.g. Blettler et al. 2017) or a parent company audit (e.g. Arturo & Corcoran, 2022) to infer additional information about the potential sources of plastic debris. A single study has tested the potential for UAV surveys to be used to monitor lake shorelines (Hengstmann & Fischer, 2020); although, further testing and optimisation is needed before this approach can be used routinely, as for other environmental compartments.

Very few studies have monitored macroplastic in lake waters or on lakebeds. A bottom trawl net was used by Ngupula et al. (2014) to collect macrolitter deposited along the bed of Lake Victoria, identifying several categories of macroplastic related to transportation, fisheries, and littering. Vaughan et al. (2017) used a bathyscope to perform a visual assessment of macroplastic debris on the surface of a lakebed at defined points along a transect. However, this technique is only applicable in shallower lakes with sufficiently high visibility, where the lake bottom can be reliably surveyed. Small macroplastics have also been reported from trawl net surveys targeting microplastic pollution across lake surface waters (Baldwin et al., 2016), demonstrating the potential for this technique to monitor floating macroplastic, as for marine and riverine systems.

No specific protocols have been established for monitoring of litter in lakes, but similar methods as applied to marine environments to monitor litter on the ocean floor, in the water column, and on the ocean surface could also be used in lakes. As for river environments, transfer of knowledge between environmental compartments should consider important differences and unique challenges posed by these different environments, and adaptations should be proposed and tested to account for these, where necessary (Hengstmann & Fischer, 2020).

3.4.2.11 Monitoring of plastics in terrestrial environments

Monitoring of litter on land, as opposed to aquatic systems, is amongst the least well-developed in terms of methodology and has been applied in only a small number of published studies thus far. This may be related to the different perceptions of the presence of litter in perceived natural vs non-natural environments (De Veer et al., 2022), with a higher degree of "litter blindness" and lower motivation towards remediation in non-natural settings such as urban areas. Most of the studies addressing terrestrial environments focus on agricultural land, with an increase in the number of articles reporting macroplastic data released over the past 12 months. This corresponds with the increasing attention towards the role of agricultural environments as an important source and recipient of plastic pollution. It is expected that method development and implementation of macroplastic surveys will increase for agricultural soils and this may be an important new arena for macroplastic monitoring in the future.

Two main approaches have been followed for quantifying macroplastic in agricultural soils. Stefano & Pleissner (2022) present a method for surveying litter on the soil surface by delineating a representative plot within a farm field and traversing the plot, collecting visible plastic pieces encountered along the way. They identified higher macroplastic abundance close to field edges, and in particular along edges close to roads. This transect-based approach across a defined plot has been followed in several studies of agricultural fields (e.g. Piehl et al., 2018; Sa'adu & Farsang, 2022). Other studies instead used a quadrat (e.g. 1 x 1 m) to isolate specific areas of the field surface and excavate soils to a defined depth (e.g. up to 0.5 m) to search for buried macroplastic items (e.g. Wang et al., 2022; Li et al., 2022). Soil is typically passed through a coarse screen to facilitate disaggregation of the soil material and identification of plastic pieces. Yu and Flury (2021) identified this approach as being a representative method for assessing microplastic pollution in soils. The application of a corresponding approach for macroplastic surveys could then produce data that map neatly onto microplastic data obtained for the same fields. However, excavating soils represents a more time-consuming approach. The representativeness of both approaches still needs to be assessed specifically for macroplastic surveys and balanced in terms of time, infrastructure, and personnel demands.

In addition to agricultural soils, one study quantified plastic litter in roadside ditches (Pietz et al., 2021), defining a transect and appropriate width based on the dimensions of typical ditches. Two citizen science projects addressing terrestrial litter have also been published (Syberg et al., 2020; Ballatore et al., 2021). Syberg et al. (2020) developed a protocol tailored towards school children to survey plastic pollution across the Danish Realm along forest paths and roadsides, and parks and arctic/subarctic settings, as well as beaches, dunes, and banks associated with aquatic environments. The EU Joint Litter Category List was used for the classification of plastic debris. The results revealed that roadside ditches had the highest abundance of plastic and coastal shorelines (beaches and dunes) has comparatively low levels of macroplastic pollution, indicating that these environments that are typically the focus of plastic surveys may not represent the worst case for plastic pollution on land. Ballatore et al. (2021) present results from crowdmapping of litter in urban environments using applications such as Litterati and Google Points of Interest (POI), demonstrating the potential for using this approach to obtain larger datasets and observe broad spatiotemporal trends.

A single study has quantified macroplastic in the Norwegian terrestrial environment thus far: an assessment of plastic litter in soil and peat close to the coastal shorelines of several islands along an archipelago in Central Norway (Cyvin et al., 2021).

3.5 Assessment of Technological Readiness Level (TRL)

All of the methods identified as relevant for performing monitoring of litter and plastics in the environment have been assessed for the Technological Readiness Level (TRL) in monitoring. In this scale, 9 is the highest score where the methods have shown successful implementation, with either a standard protocol which is enforced and applied, or the approach is widely used for monitoring operations (**Figure 11**).

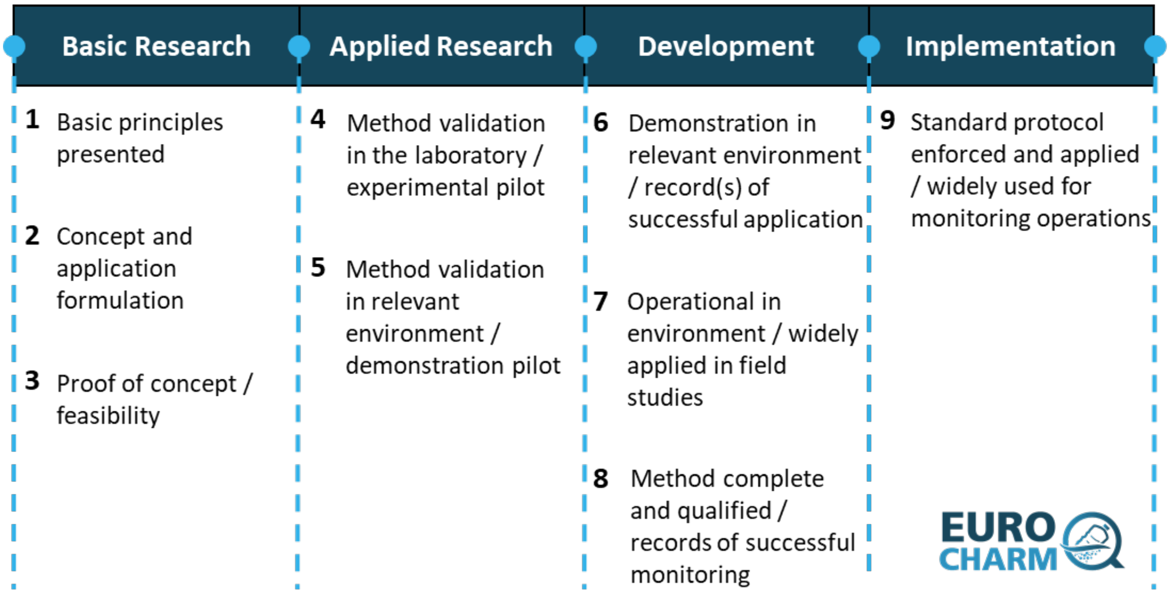


Figure 11. Overview of the nine Technological Readiness Levels (TRLs). TRLs 1-3 represent fundamental R&D (basic research), TRLs 4-5 include scaling and integration (applied research), and TRLs 6-9 include demonstration and full exploitation (development and implementation). Figure adapted from the EUROqCHARM project (Aliani, under review).

3.5.1 TRLs for coastal beaches and shorelines

Considering the already widespread use of shoreline surveys for marine litter, the TRLs for coastal beaches are regarded as high. This is true for both types of surveys: Accumulation and standing stock surveys. Both approaches have been widely applied and generally follow recommended procedures, which includes clearly defined reporting units and protocols for litter classification. A lack of use of the data limits quality control and methods have not been tested for human bias in data recording. Most data are already accessible in international open-access databases, with some raw data limited to publications. Nationally, Norway has begun to implement the same methods, although the TRL is lower given variable access to citizen science data in Rydde. In **Table 11**, the specific surveys have been compared to the EUROqCHARM TRL scale and compared for national and international status.

We recommend that monitoring using accumulation surveys and that this is expanded to account for more locations in Norway.

Table 11. TRL evaluation for coastal shorelines and beaches

	Survey design	Sample collection	Sample preparation	Quantification	QAQC	Data reporting	Average TRL
Accumulation surveys – International	9	9	5	9	3	8	**7**
Accumulation surveys – Norway	9	9	5	9	3	8	**7**
Standing stock surveys- International	6	8	n.r.	9	3	9	**8**

3.5.2 TRLs for sea surface and water column

Broadly classifying, there are two methods for monitoring plastic in surface waters: visual observations and net sampling.

Note: Fulmars are used as an indicator under OSPAR to assess changes in the quantities of floating litter. They are included in this report in the sub section for biota (Section 3.4.2.6).

Visual observations are already being successfully applied in the environment, and recent guidelines suggests harmonised guidelines (JRC 2022). For this reason, the methods are classified as TRL 9, with further development needed to address cost-efficient item documentation (**Table 24**). For Norway, this still falls under Applied Research, TRL 5, as the monitoring protocol applied is not internationally harmonized and data access is challenging.

Net surveys in the surface waters, which mostly target meso and macro litter, score higher than visual surveys but they are still in the development phase both nationally and internationally. Internationally, more work is required to improve survey design, by application is a wider context and explore item documentation needs. The TRL for water column sampling is limited to TRL 5 both nationally and internationally, as methods have been validation, but there are limited records of successful application. The quantification and data reporting can be considered similar to sampling because the approach is the same. Nationally, water column sampling is limited to application in the Barents Sea region (Grøsvik et al., 2018). **We recommend that monitoring using both approaches is considered and expanded to account for more locations in Norway. Further research and development will be needed before water column sampling for macroplastics should be considered for monitoring.**

Table 12. TRL evaluation for sea surface and water column

	Survey design	Sample collection	Sample preparation	Quantification	QAQC	Data reporting	Average TRL
Visual surveys (surface) – International	9	9	n.r	8	8	9	**9**
Visual surveys (surface) – Norway	5	5	n.r	5	5	5	**5**
Net surveys (surface) – International	9	9	7	9	8	9	**8**
Water column – International	5	5	5	5	5	5	**5**
Water column – Norway	3	3	3	5	5	5	**4**

3.5.3 TRLs for the seafloor and benthic sediments

Of the approaches available for monitoring the seafloor, all methods receive a high TRL (7-8). Nationally, only the IBTS is currently in place for routine monitoring in the Norths Sea, with monitoring in the Barents Sea not following internationally established guidelines (thus TRL 7 for combined evaluation for Norway). Data access is variable, although there are databases in place. Raw data mostly in supplementary publications, less so for international open access databases. Divers, towed cameras and ROVs are less used in Norway and not currently implemented to the level of national monitoring but implemented for baseline assessments through MAREANO.

We recommend that the IBTS monitoring is continued and optimised to secure data on benthic litter in Norwegian waters.

Table 13. TRL evaluation for the seafloor using available international data.

	Survey design	Sample collection	Sample preparation	Quantification	QAQC	Data reporting	Average TRL
IBTS – trawling	9	9	9	9	5	7	**8**
By-catch bottom trawling Norway	7	9	7	7	5	7	**7**
Divers	9	8	n.r	7	5	7	**7**
Video/camera tows	9	8	n.r	7	5	7	**7**
Submersibles (ROVs)	9	8	n.r	7	5	7	**7**

3.5.4 TRLs for biota

Internationally, monitoring plastic in surface waters/ingested by Northern Fulmar is ranked high in the plastic pollution TRL scale. All elements of the analysis chain are ranked 9 demonstrating that the method elements show records of successful monitoring, with a standard protocol (Lusher et al., 2022; van Franeker et al., 2021) enforced and applied, as well as ODIMS[16] for data reporting. In comparison for Norway, there are fewer records of monitoring, with few beaches currently being routinely monitored. For this reason, the average TRL is reduced to 8. There is clear drive from the research community to continue investigations (e.g., Collard et al. (2022)). **We recommend that monitoring is expanded to account for more locations in Norway, with an option for expansion to additional species to account for regional variation.**

For comparison the use of mammals for macroplastic monitoring is included in **Table 1** when survey design and sample collection are considered the TRLs both internationally and within Norway are still limited to applied research: TRL 5. However, if methods similar to those applied for seabirds are considered for sample preparation and plastic quantification it could be argued that these fall under development/ TRL 6 – records of successful application. **Further research and development will be needed before mammals should be considered for monitoring.**

Table 14. TRL evaluation for biota

	Survey design	Sample collection	Sample preparation	Quantification	QAQC	Data reporting	Average TRL
Seabirds – International	9	9	9	9	9	9	**9**
Seabirds – Norway	8	8	8	9	9	8	**8**
Mammals – International	5	5	6	6	6	3	**5**
Mammals – Norway	5	5	5	5	5	1	**4**

[16] ODIMS - Home (ospar.org)

3.5.5 TRLs for river surface and water column

Several methods are available for monitoring macroplastic in river channels (Hurley et al., submitted). No single method is capable of measuring the full macroplastic load in a river and instead several methods in combination or an upscaling is needed to estimate total macroplastic flux. Visual observation of the river surface is the most commonly utilised approach, and several guidelines exist for this method (e.g CBD, 2021; González-Fernández & Hanke, 2017; van Emmerik et al., 2018). Other methods do not yet have established guidelines for deployment specific to macroplastic, but they draw upon existing techniques or infrastructure. Coordination and some methods testing are needed to establish or optimise effective and reliable guidelines or achieve harmonisation. Adaptions to methods are likely to be necessary in many cases due to the wide variety in river systems and local environmental contexts. For this reason, TRLs for river surface and water column are all set as ≤7 (**Table 15**). These values have been defined based on international data as no information was found for Norway.

There are some internationally developed standard data collection forms on meta-data to be collected and protocols describing how macroplastics and litter should be quantified (including units used) and categorised, as well as systems for reporting data and making them available. Due to the absence of available data in Norway, further research is needed to understand how suggested approaches can be modified to adjust to Norwegian river systems, and what data should be collected to meet local needs for knowledge on river plastics.

Mobile applications (e.g. CrowdWater and the Floating Litter Monitoring app) have been developed to guide and collect data from visual observation surveys, but they have not yet been applied as part of coordinated monitoring efforts in Norway. Nor are there any internationally coordinating agents that have established open-access data basis for litter monitoring in rivers.

We recommend that macroplastic monitoring in rivers using selected methods (e.g. visual surveys) is considered, while further research and development should be carried out before establishing a programme using physical interception-based techniques (e.g. nets). Methods testing should focus on establishing guidelines for safe and effective deployment of monitoring methods in Norwegian rivers.

Table 15. TRL evaluation for rivers based on internationally available data

	Survey design	**Sample collection**	**Sample preparation**	**Quantification**	**QAQC**	**Data reporting**	**Average TRL**
Visual surveys (surface)	7	7	n.r	7	5	6	**6**
Net surveys (surface)	5	7	7	7	5	6	**6**
Booms (surface)	3	5	3	5	3	5	**4**
Trash rack (surface)	2	2	3	3	3	3	**3**
Net surveys (water column)	5	7	7	7	5	6	**6**
Net surveys (riverbed –	5	6	6	6	5	6	**5**

benthic transport)							
Riverbed surveys	2	2	2	3	1	2	**2**
Riverbank surveys	5	6	6	6	3	6	**5**

3.5.6 TRLs for riverbeds

Only a small number of published studies have thus far measured benthic transport of plastic close to the riverbed (Hurley, 2021). These utilise trawl nets following a similar method to that used for river surface waters or the water column. Net surveys for riverbed or benthic transport therefore have a TRLs of <6 corresponding with the extent to which they have been used by studies thus far (**Table 15**).

Some technologies for riverbed clean-up have been discussed for their potential to be adapted into methods for monitoring riverbed macroplastic but they are still in the basic research phase (Hurley, 2021). There are also potential parallels to be drawn from the seafloor surveys in this regard, which have a TRL of 9. However, riverbeds vary in their bed substrate and this can present some challenges in establishing a method that can be used widely in different river systems. Some riverbeds can be very rocky while others are composed of soft and unconsolidated sediments. There may also be high flow velocities close to the riverbed due to subsurface currents in rivers. Further work is needed to assess the suitability of different techniques and establish appropriate guidelines for monitoring. For this reason, the TRLs for riverbed surveys are still <3 (**Table 15**).

We recommend further research and development is carried out before establishing a macroplastic monitoring programme for riverbeds.

3.5.7 TRLs for riverbanks

Several approaches to monitor riverbanks for macroplastic have been developed and demonstrated in published studies (**Table 10**). These draw upon knowledge developed for beaches and coastal shoreline surveys and some utilise existing frameworks developed for those environments, such as by using OSPAR and MSFD guidelines for categorisation of litter. The use of citizen science for undertaking riverbank surveys has been demonstrated, although the safety of different riverbank environments during different periods of the year should be considered when setting guidelines. Mobile applications (e.g. the CrowdWater app) have also be used to record riverbank survey data. These approaches have not yet been demonstrated in Norway. Based on international experiences, riverbank surveys have a TRL of 6 (**Table 15**).

Further research would improve these methods by assessing the minimum requirements for undertaking representative sampling, including consideration of different riverbank environments (e.g. river beaches, floodplain systems, valley sides) that may occur in different catchments globally. This may include assessing buried plastics in relevant riverbank sediments (versus surveying the riverbank surface) or establishing methods for quantifying macroplastic accumulation in riparian vegetation.

Monitoring of riverbanks could be considered as part of a monitoring programme in Norway. Research and development focusing on adapting methods to the Norwegian context would help to develop effective guidelines.

3.5.8 TRLs for lakes

Only a limited number of studies have monitored macroplastics in lakes thus far. These studies typically draw from methods developed for marine environments, including adopting classification schemes for data analysis and reporting. Macroplastic monitoring in lakes can further draw upon the foundations set for monitoring microplastics in lakes and monitoring macroplastic in marine and coastal environments; although, modifications may potentially be needed to adapt methods to different environmental compartments. Most studies on macroplastic in lakes have focused on shoreline surveys using transects or quadrats based on existing coastal shoreline methods. For this reason, shoreline surveys have a TRL of 5. Only a small number of studies have explored methods for other parts of the lake environment, so these present lower TRLs of <3 (**Table 26**). Methods testing and optimisation is needed to identify appropriate guidelines for monitoring lake environments.

We recommend further research and development is carried out before establishing a macroplastic monitoring programme in lakes.

Table 26 TRL evaluation for lakes based on internationally available data

	Survey design	Sample collection	Sample preparation	Quantification	QAQC	Data reporting	Average TRL
Shoreline surveys	5	6	6	6	5	6	**5**
Net surveys (lake surface water)	2	3	3	3	1	3	**2**
Lakebed surveys	2	3	3	3	1	3	**2**

3.5.9 TRLs for terrestrial environments

Only a small number of published studies have monitored plastic litter in terrestrial environments thus far. Two approaches for quantifying macroplastic in agricultural soils have been described and tested in a small number of studies. On this basis, TRLs of <5 are given for these two methods in **Table 27**. Additional methods for assessing plastic pollution in terrestrial environments require further development.

We recommend further research and development is carried out before establishing a macroplastic monitoring programme in terrestrial environments.

Table 27 TRL evaluation for agricultural soils based on internationally available data

	Survey design	Sample collection	Sample preparation	Quantification	QAQC	Data reporting	Average TRL
Transect surveys	5	5	5	5	3	5	**5**
Quadrat and excavation	5	5	5	5	3	5	**5**

3.6 Mapping of data available on plastic pollution in Norway today

There are several initiatives applying different types of protocols that either use other platforms for data sharing and storage, as well as initiatives that do not use such platforms. Many of the data collection initiatives are once off, and do not have any long-term funding connected to them. There is currently no centralized location where all data on plastic pollution in the Norwegian environment is collected.

3.6.1 Macrolitter data in established data bases

Data entries in both professional and citizen science data bases were identified (Summarised in Table 1, for detailed information see Appendix 7). EMODnet (7 entries) and the OSPAR database (8 entries) had partly overlapping data with both reporting OSPAR beach litter registrations. The OSPAR database was the most up-to date holding information on past and on-going (7 beaches) OSPAR beaches in Norway. One of the entries in EMODnet was a registration according to the TSG_ML protocol, the 2015 entry in Marine Litter Watch where the MSFD harmonised list is applied on a beach in Møre and Romsdal. The Norwegian Directorate of Fisheries (NDF) clean-up cruises have reported data from 2017-2022. Information recorded includes the number of nets, pots, trawls, anchors, buoys, and meters of rope, wire and line. In the map application ***Yggdrasil***[17], the findings are geotagged allowing for comparison across regions. We have not found any reference to application of a harmonised protocol.

Rydde is the most extensively applied application for collecting citizen science data on litter in Norway. Data should be available from 2015-2022, but limitations of the web-platform make it difficult to access data back in time and get access to all the data recorded. The same limitations apply to identifying the type of environment the data is collected. For example, while the Norwegian Diving Association register data in Rydde, these entries are not possible to identify from data downloaded from Rydde. Data entries for the Debristracker app were registered according to region to look for differences in the number of entries. Most of the entries were for Agder (713 hits), followed by Troms and Finnmark (266) and Nordland (98). Different types of environments were represented, with urban and shoreline areas dominating. The Debristracker app allows for the use of multiple protocols. With over 1000 hits for Norway, it would be too time consuming to collect data on all these entries. Miljølære has entries for 36 beaches across Norway in the time period 2017-2022, with most entries on the west-coast. There was no information on the origin of the protocol applied. The Deep Dive for the Arctic database is not included in the overview since the webpage is still under development and the database has not been quality checked. The protocol applied is modified from Ocean Conservancy to include items dumped from trawlers and identify geographical origin and age according to guidelines developed in Falk-Andersson et al (2021). For the Empact and Floating Litter Monitoring applications, there were no functioning app or webpage, while for CrowdWater there were only one entry of a single item (Appendix 7).

Table 28. Summary of Norwegian macrolitter entries in databases identifying type of environment, year(s) of study, sites sampled, and protocol applied (For more detailed information See Appendix 7)

Reference	Type of Environment	Year(s) of study	Sites	Litter registration protocol
NDF clean-up	Seafloor	2017-2022	Dependent on lost gear reported	Own protocol

[17] Kart i Fiskeridirektoratet (arcgis.com)

OSPAR beach litter	Beach	2011-2022	Currently 7 beaches regularly monitored	OSPAR
Rydde	All, mostly beach	2015-2022	Differs between years	Rydde
Debristracker	Shoreline, urban	N/A	>1000 hits	Allows multiple protocols
Miljølære	Shoreline/beach	2017-2022	36	Own protocol
Arctic Deep Dive Database	Shoreline/beach	N/A	N/A	Deep Dive for the Arctic

3.6.2 Macrolitter data in research papers

The 8 research papers documenting macroplastics and litter in Norway covered different marine environmental compartments (surface coastline/ ocean, shoreline/beaches, seafloor, ocean water column, soil, and biota) (Tabell 2). None of the studies collecting data or analysing plastics in samples applied established litter monitoring protocols. If item categories were recorded, the resolution was low, only identifying one specific source (fisheries) or very coarse source categories (Cyvin et al., 2021). Apart from Falk-Andersson et al (2019), none of the papers analysed data or samples from the same location over time. For two of the papers, the data should be available through Norsk Marint Datasenter (The Norwegian Marine Data Centre[18]), although when searching for data on plastic, there were no hits on litter/ macroplastic. One paper was a review of beach litter data, using data from OSPAR, Lofoten Avfalsselskap (LAS) and Rydde. The raw data from LAS is only available on their private server (Falk-Andersson et al., 2019), while the Rydde data should in theory be available through the Rydde portal. For four of the papers, it was not possible to find the data open access, so it is assumed it is at a private server.

[18] NMDC - Havforskningsintituttet

Table 1 Summary of Norwegian macrolitter entries in research papers identifying type of environment, year(s) of study, sites sampled, and protocol applied (For more detailed information See Appendix 7)

Reference	Type of Environment	Year(s) of study	Sites	Litter registration protocol	Data storage
The rise in ocean plastics evidenced from a 60-year time series	Coastline surface	1957-2016	Locations along Norwegian coast	Own protocol- occurrence of microplastic in CPR tows	www.cprsurvey.org
Marine litter in the Nordic Seas: Distribution composition and abundance	Seafloor	2006-2017	1778 video transects in the Norwegian Sea	Own protocol- 12 material types and fishing gear	Norsk Marint Datasenter
Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins	Seafloor	2007	3 stations along the Norwegian coast	Own protocol. 4 material types, fishing gear, other	Private server
Assessment of Marine Litter in the Barents Sea, a Part of the Joint Norwegian–Russian Ecosystem Survey.	Surface, pelagic and seabed	2010-2016	Barents Sea	Own protocol adapted from OSPAR – 6 material types, 3 fisheries related items, other	Norsk Marint Datasenter
Citizen science for better management: lessons learned from three Norwegian beach litter data sets	Shoreline/ beaches	OSPAR/LAS: 2011-2016 KNB: 2015-2016	Norwegian coast, including Lofoten Islands and Svalbard	No primary data collected	N/A
Methods for determining the geographical origin and age of beach litter: Challenges and opportunities.	Shoreline/ beaches	2019	Svalbard	Suggests method for identification of age and geographical origin	Private server
Macroplastic in soil and peat. A case study from the remote islands of Mausund and Froan landscape conservation area, Norway	Soil	2020	Mausund and Foran	Own protocol- 5 source categories	Private server
Plastic ingestion by Atlantic cod (Gadus morhua) from the Norwegian coast.	Biota	Not reported	Oslo, Bergen, Sørfjorden, Karihavet, Lofoten and Varangerfjorden	Own protocol- polymer types identified	Private server

3.6.3 Macrolitter data in reports

Of the 22 reports documenting macrolitter found, one report discussed monitoring methods for littering in urban environments and three documented litter in freshwater environments (Table 3). 10 reports analysed shoreline/ beach litter and 6 the ocean floor, with 5 of those reports being from the Fishing For Litter (FFL) program (see section 3.8.2.5). All reports refer to single studies and none of the initiatives have long-term funding. FFL reports data on items landed however this is not an established monitoring method. Information on this activity is presented only for data available in Norway. The FFL program has until now received funding through a public grant scheme[19], but with limited opportunities for data collection. FFL will be phased out when a new system on port reception facilities for the delivery of waste from ships is implemented (Directive (EU) 2019/883)[20]. The cost of handling litter caught as bycatch will be covered by a fee. The directive only requires weight/volume of litter to be reported, while more extensive reporting is voluntary.

Data is publicly available for only one study, while the rest are in private servers. All studies apply their own protocol, with some of them being adapted from Ocean Conservancy or OSPAR. The OSPAR report on the status of seabed litter only reported number of litter items caught in trawl catches, which was the data available for the study at the time. The deep dive projects have explored and applied different types of protocols, depending on the case study and what has been learned from dialogue with stakeholders and previous analysis. The deep dive protocols are either adapted from OSPAR or Ocean Conservancy.

The reports marked with KNB in Table 3 are projects where KNB are involved in development and testing of protocols[21]. Some of the protocols are adapted from Ocean Conservancy, but also OSPAR is referred to although it is stressed that the data is not comparable to OSPAR. The urban protocol refers to methods from Clean Europe Network and Keep Sweden Beautiful. For all these methods, there is a lack of documentation of how the method was developed and the reasons behind methodological choices, including justifications of the items included in the monitoring protocol. This is not unique to these activities, but a general limitation of citizen science protocols and even protocols applied in "professional" monitoring. For example, there is no documentation of the decisions behind including source categories in the OSPAR beach litter protocol. The lack of documentation and harmonisation of protocols registering litter in Norway, makes it difficult to compare data across compartments.

[19] Tilskuddsordningen for opprydding og forebygging av marin forsøpling | Senter mot marin forsøpling (marfo.no)
[20] Skipsavfallsdirektiv - regjeringen.no
[21] In addition, KNB are involved in The Arctic coastal clean-up, which is a cooperation with Ocean Conservancy and volunteers in Finnmark, Alaska and Iceland. A protocol modified from Ocean Conservancy adapted to the Arctic was applied in that project, but there are no reports out yet documenting the method.

Table 29. Summary of Norwegian macrolitter entries in reports identifying type of environment, year(s) of study, sites sampled, and protocol applied (For more detailed information See Appendix 7).

Reference	Type of Environment	Year(s) of study	Sites	Litter registration protocol	Data storage
Forsøplings langs vassdrag og innsjøer i Norge 2021 (KNB)	Along waterways and lakes	2017-2021	38 locations across Norway	Ocean Conservancy litter item protocol adapted to Norway	Private server
Søppelanalyse Akerselva	River surface	2021	Akerselva, Oslo	Adapted deep dive	Private server
Makroplast i elver på Vestlandet	River	2019	Locations Western Norway	Own protocol	Private server
Beach litter deep dives (8)	Shoreline/ beaches	2016-2021	Locations across Norway and Svalbard	Deep dive protocols adapted to case	Private server
Nordic Coastal clean-up (KNB)	Shoreline/ beaches	2017-2018	Nordic beaches	Own protocol adapted from Ocean Conservancy and OSPAR	Private server
Marin forsøpling i Norske fylker	Shoreline/ beaches	2019-2022	Oslofjord, Agder, Møre og Romsdal, Troms og Finnmark	Deep dive items and MAP	Private server
MEPEX dypdykk i plasthavet	Beaches	Not reported	Locations across Norway	Own protocols	Private server
FFL Norway (5)	Seafloor	2017-2021	Unknown	Own protocol	Private server
OSPAR seabed litter	Seafloor	2017	NE Atlantic, including Norwegian stations off-coast	Litter items from trawl survey	ODIMS
Oversikt forsøpling i Norske kommuner (KNB)	Urban environment	N/A	N/A	Combination of methods from Clean Europe Network og Håll Sverige Rent on sampling and litter item registration.	Private server

3.7 Current monitoring of litter and macroplastic in Norway

The data collected that are a part of long-term initiatives and monitoring programs are the OSPAR monitoring of beach litter, OSPAR Monitoring in Northern fulmars, citizen science data entered in Rydde and assessment of marine litter is some on-going fisheries surveys. These are described in detail below and represents the status of monitoring of macroplastic and litter in Norway today.

3.7.1 OSPAR

3.7.1.1 Monitoring of beaches

Professional OSPAR beach litter surveys are currently conducted at seven sites along the Norwegian shoreline within a time interval of once to twice a year (**Table 11**). The data are collected on reference beaches (100 m stretches) and the standardised OSPAR beach litter monitoring guidelines are followed, compromised of 112 predefined litter source items of 11 material types.[22] Data from OSPAR are also reported to the European Marine Observation and Data Network (EMODnet).[23]

Table 30. Overview of OSPAR monitoring beaches in Norway, years of survey and number of surveys conducted annually. (Information retrieved from https://beachlitter.ospar.org/, 16.11.2022)

Name of site	Location	Period of OSPAR survey	Surveys per year
Været	Arctic Seas (Trøndelag)	2015-2020	1
Brucebukta	Arctic Seas (Svalbard)	2011-2019	1
Luftskipodden	Arctic Seas (Svalbard)	2011-2020	1
Rekvika	Arctic Seas (Troms og Finnmark)	2011-2020	2
Kviljo	Northern North Sea (Agder)	2011-2020	2
Sandfjordneset	Arctic Seas (Troms og Finnmark)	2011-2014 (terminated)	2
Ytre Hvaler	Northern North Sea (Viken)	2012-2020	1
Åpenvikbukta	Arctic Seas (Troms og Finnmark)	2018-2020	1

3.7.1.2 Plastic monitoring in Northern fulmars

The OSPAR Data & Information Management System (ODIMS) gathers data on the monitoring of plastic particles in Northern Fulmar stomachs. The dataset contains findings from professional surveys following the OSPAR protocol that have been conducted between 2003-2017 in Norway and provides information on the number of surveyed birds, sex, age, and amount of ingested plastic particles. Currently, only beaches in Rogaland and Agder are monitored (**Figure 11**) and a total amount of 104 individuals have been surveyed in the given time period.[24]

The Norwegian Polar Institute have conducted sporadic investigations of plastic in Northern fulmars from Kongsfjorden, Svalbard applying the OSPAR protocol to study plastic ingestion in 2013, 2018, 2020 and 2021. (NP/NEA, 2022). But there is also data available from other previous studies in 1980, 1997 (Collard et al., 2022). A summary was also made available by AMAP (Lusher et al., 2022).

[22] Beach litter | OSPAR Commission (last accessed 16.11.2022)
[23] EMODnet Central Portal | Geoviewer (europa.eu) (last accessed 16.11.2022)
[24] ODIMS - Search (ospar.org) (last accessed 16.11.2022)

Recommendations from both AMAP (2021a) and a SEAPOP workshop facilitated by NINA in 2019 (Dehnhard et al., 2019) highlighted that regionally different species of seabird might be necessary to garner a full understanding of plastic ingestion in seabirds using the OSPAR approach. Specifically, that origin of beached seabirds are unknown making it impossible to assess how plastics affect populations. Outcomes from the SEAPOP workshop were that:

1) Baseline information on plastic ingestion across all seabird species is needed to identify which species and populations are most suitable for monitoring.

2) In the absence of information from (1), eight species that are complementary in their foraging behaviour and have a wide distribution range were identified as preliminary species of interest to monitor plastic ingestion.

Figure 12. Location of areas used for monitoring of plastics in the Northern Fulmar in Norway (green circles)

3) For minimally invasive monitoring, regurgitates, fresh prey items and faeces are most suitable;

4) More information on prevalence of plastic ingestion is needed to identify optimal sample sizes for long-term monitoring.

3.7.2 Assessment of Marine Litter in through existing fisheries surveys

The Norwegian-Russian ecosystem survey in the Barents Sea exemplifies how plastics monitoring can be implemented in existing monitoring programs (AMAP, 2021a). Marine litter distribution and abundance is calculated from recordings of bycatch from pelagic trawling in the upper 60 m, bottom trawling close to the seafloor, and floating marine debris at the surface by visual observations by whale observers between transects (Grøsvik et al., 2018). The survey covers the entire Barents Sea with 35 nautical miles between stations. Litter caught by trawling is weighed and categorised by material type. For litter spotted in the visual survey, volume and material type is recorded (Grøsvik et al., 2018). **Figure** 12 shows the area surveyed in the period 2010-2016, including data from surface and pelagic trawls.

IMR also takes part in bottom trawling surveys from the International Bottom Trawl Surveys (IBTS) in the North Sea. Here the protocol from ICES WGML is used and the data are reported to the ICES DATRAS database (ICES, 2021). ICES WGML has recently published a photo guide[25] as part of their Manual for seafloor litter data collection and reporting from demersal trawl samples. The litter registration protocol applied in the Barents Sea originates from the OSPAR beach litter guidelines (OSPAR, 2010), but since this protocol is made for beaches a simplified registration is conducted. These are registered in Norwegian Marine Data Centre[26]. Both weight and number of items is registered according to the following categories: metal, glass, ceramics, paper, processed wood, rope/line, pieces of nets, bouys/bobbins, other plastic, other. Thus, recording of litter as bycatch from bottom trawl is at present performed differently at the IBTS cruises in the North Sea and the ecosystem survey in the Barents Sea, with aim to use the ICES WGML protocol for all recordings in the future.

[25] ICES Manual for Seafloor Litter Data Collection and Reporting from Demersal Trawl Samples (figshare.com)
[26] About NMDC | NMDC

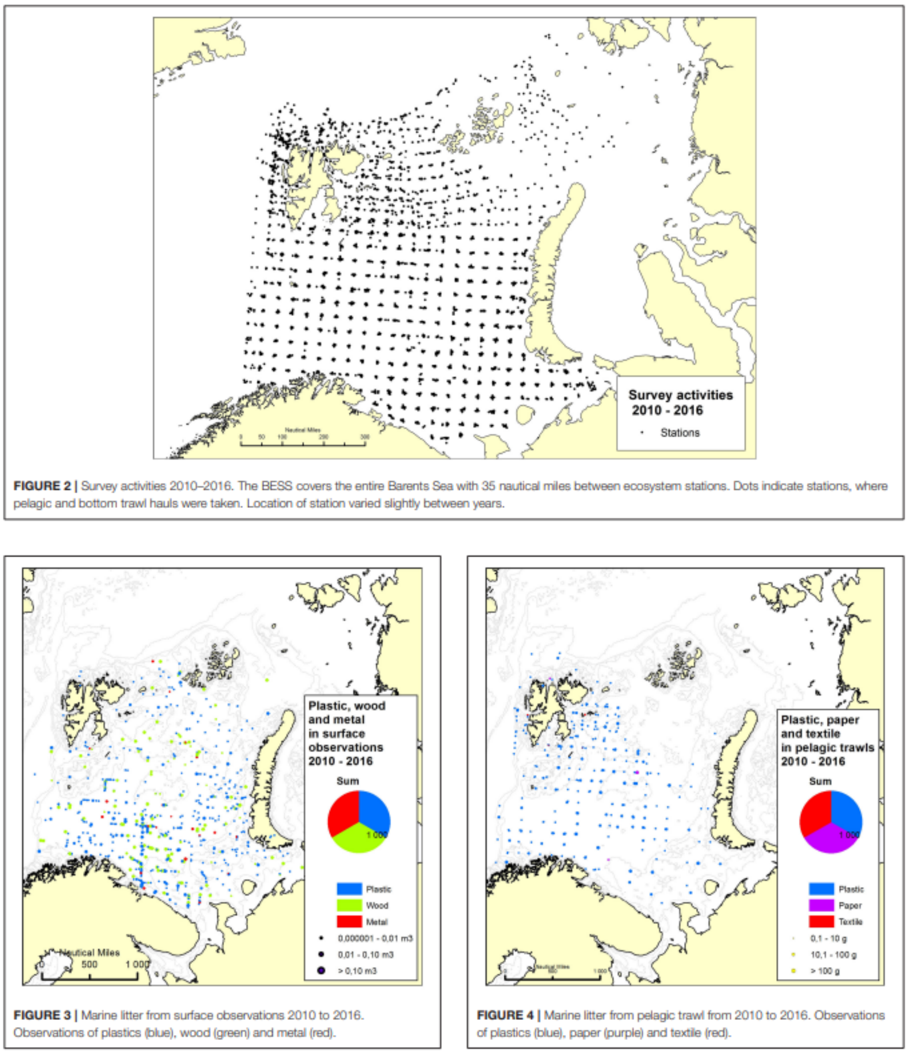


Figure 13. Barents Sea survey activities for data collection on litter (From Grøsvik et al 2018).

3.7.3 Citizen science initiative Rydde

The Norwegian Association *Keep Norway Beautiful* (KNB, *Hold Norge rent* in Norwegian) has over many years built up a datahub for citizen-science led clean-up actions, facilitating collection of data and providing practical information for volunteers. This initiative has migrated to a new platform (https://ryddenorge.no) called Rydde and is a collaboration between KNB and MARFO (Norwegian Centre against Marine Litter). Rydde is a digital tool for volunteers that gives an overview of planned and conducted clean-ups, shows clean-up statistics, and allows for reporting of littered areas. "Rent hav" is a tool for those working with marine litter, such as managers, coordinators, and researchers. It provides an overview of data available, allows for coordination of different actors from planning to action, and shows where there are clean-up needs. Rent hav has a map application to support these actions, which also shows information on nature and environment, fisheries, aquaculture, cultural heritage and communication infrastructure[27].

27 Rent hav | Senter mot marin forsøpling (marfo.no)

Data is recorded in "Rydde", which is the most important data portal for litter in Norway. It includes data from citizen science beach clean-ups from 2013, as well as OSPAR beach litter data[28]. The number of registrations per region differs, however. **Figure 10** shows the number of clean-up actions in Norway in 2022, illustrating the difference in geographical coverage of clean-ups across the country. However, data is not collected for all clean-up actions.

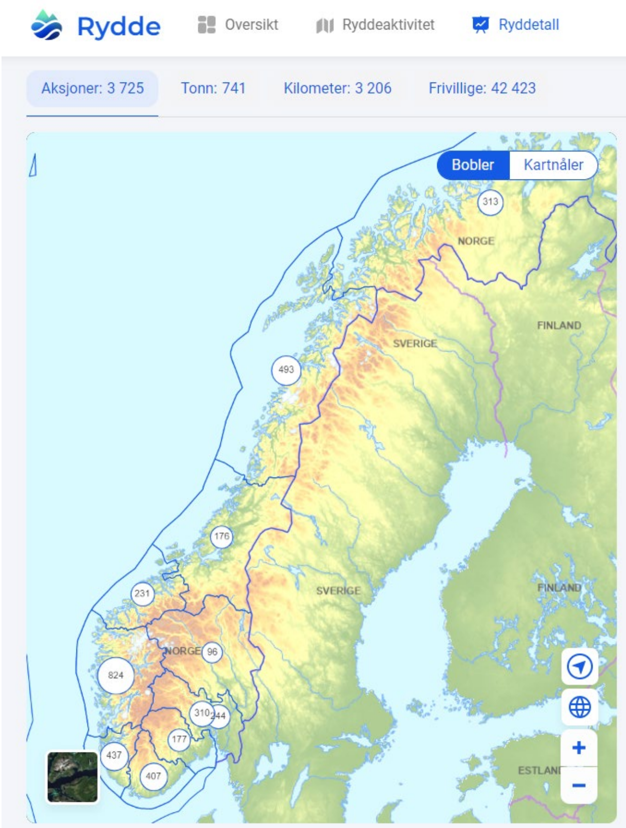


Figure 14. Overview of the number of clean-up actions registered in Rydde in 2022 (retrieved 02.11.2022).

When looking at the number of actions where data was registered in 2022, there are large differences in spatial coverage (**Table 11**). Only 8 actions recorded data in Troms and Finnmark, giving very poor data coverage for this relatively large geographical area. Nordland, on the other hand, recorded data for 90 actions. There were data registered in 13 locations in Trøndelag, but two of these did not report the length of the beach. There are also within county differences, with 40 of the 90 data points for Nordland being registered in Hattfjelldal municipality. When downloading data from Rydde, the GPS locations are lacking, so it is difficult to know if the locations represent a coastal area. This also makes it difficult to compare data across years, which was also pointed out as a limitation to the use of the data in Falk-Andersson et al. (2019).

Table 31. Number of clean-up actions registering data in Rydde per county in 2022 (retrieved 02.11.2022).

Region	Number of data points registered
Agder	68

[28] Rent hav – kartet, dataen og verktøyet | Senter mot marin forsøpling (marfo.no)

Innlandet	4
Møre og Romsdal	33
Nordland	90
Oslo	24
Rogaland	3
Troms og Finnmark	8
Trøndelag	13
Vestfold og Telemark	19
Vestland	105
Viken	71

Currently, most clean-up actions are focused at the shoreline but they also conduct actions in urban areas and fresh water ecosystems. In a recently published report, KNB report experiences from mapping litter along waterways and lakes in Norway from 2017 to 2021 (KNB, 2022). Using the Ocean Conservancy protocol as a basis, KNB developed a protocol based on analysis of litter from 39 surveys in 19 freshwater sources across all the Norwegian countries. A transect of 100 m is chosen, and the protocol including 77 source items is applied. The latter includes products identified in EU's single-use plastics directive (EU, 2019), products that are a part of existing return systems, as well of litter of particular interests (KNB, 2022). KNB are also integrated to the Regional Action Plan on Marine Litter from the Arctic Council, which apply the Ocean Conservancy protocol modified to the Arctic (Only information available from Facebook groups[29] and description of the cooperation[30]).

[29] https://www.facebook.com/photo?fbid=5375116385843546&set=pcb.1365696577248404; https://kommunikasjon.ntb.no/pressemelding/arktisk-strandrydding?publisherId=89961&releaseId=17911590&fbclid=IwAR18N4HJfRMsben7CJM4gD5qc8FgpJDx0KJBkxxZlHQ_PuX4C7upkFfS09s; https://www.pame.is/projects-new/arctic-marine-pollution/current-marine-litter-projects/424-arctic-coastal-cleanup?fbclid=IwAR1pqZT7UdLCeurFO-PQWWCjV3DHtmngulTTmt5BdRapvurupHnzElZQk4Q

[30] PAME - Arctic Coastal Cleanup

3.8 Norwegian monitoring activities compared to identified needs

The data collection requirements identified through reviewing international requirements and local needs is summarised in **Tabell 3**. It shows that for some marine compartments, there is some on-going monitoring. There is no monitoring of non-marine environmental compartments, although KNB has initiated monitoring through citizen science of freshwater shorelines (KNB, 2022). The OSPAR protocol includes material and source categories, while the Rydde protocol includes source categories only[31]. Both protocols include SUP items. There is no on-going monitoring that identifies items that are specific to the Arctic, although shotgun cartridges are recorded in OSPAR and Rydde. However, in depth analysis through Deep Dives have identified some of the Arctic specific items, explored the possibility to separate items from commercial fishers, recreational fishing and aquaculture, identify items of high concern (e.g. bundles of packaging strips), and document specific sources of litter (e.g. Falk-Andersson (2021), Drægni and Falk-Andersson (2019), Johnsen, Falk-Andersson, et al. (2019)). Both OSPAR and Rydde data can say something about the density of litter on the stretches of beaches cleaned, but not reflect the overall density of litter along the Norwegian coast. The Barents Sea visual and trawl survey gives information on litter at the surface, on the ocean floor, in the water column. Currently the protocol applied does not have sufficient resolution to give information requested on sources, nor is reporting in line with the IBTS guidelines applying the ICES reporting guidelines. These are applied in the IBTS in the North Sea where Norway participates. There is no routine monitoring of litter on the water surface, in the water column and the seafloor in coastal areas, as the current monitoring efforts in these compartments are at sea. Only the Northern Fulmar is monitored for plastics in biota.

Table 2 Overview of data collection requirements to meet international obligations and national needs for different environmental compartments and on-going monitoring in Norway

Compartment/ type	Data required	On-going monitoring
Litter classification	Specific protocols according to material and source categories: UNRP/IOC- guidelines, OSPAR beach litter survey guidelines, Joint-list	7 OSPAR beaches Rydde citizen science protocol
	SUP items	OSPAR beach litter protocol Rydde citizen science protocol
	Items specific to the Arctic: melted plastic pieces, detonating cords for explosives, aquaculture/animal feed bags, plastic sanitary bags, trawl nets, gill nets, shotgun cartridges, riffle cartridges.	
	Items from commercial fisheries, recreational fishing and aquaculture	
	Litter items of high concern	
	Identification of polluters and producers	
Beach/Shoreline	Amounts (items) per km^2, amounts (items) per 100 m	7 OSPAR beaches Rydde citizen science
Floating ocean surface	Number of items per km^2. Trawl surveys: amounts including composition and source where possible	Barents Sea visual survey

[31] Rydde differentiate between drinking bottles in plastic, glass, and metal.

Water column ocean	Trawl surveys: amounts (items per km^3) including composition and source where possible	Barents Sea trawl survey
Seafloor	Trawl surveys: amounts (items per $km^{2.}$) including composition and source where possible	Barents Sea trawl survey North Sea IBTS
Biota	Ingestion, litter in nests, entanglement	
	Plastic ingestion by Fulmars	Northern Fulmars OSPAR
River	River litter	
Across marine compartments	Composition, amount, spatial distribution	
Across compartments	Composition, amount, spatial distribution, transportation pathways	

The number of OSPAR beaches is insufficient to be representative for litter in Norway, both with respect to sources and amounts of litter. Norway has a long and heterogenous coastline, with high regional and local variability in the density and composition of litter (M.L. Haarr et al., 2022). Thus, regional replication is needed to allow the generation of regional means to be able to do regional comparisons. Furthermore, OSPAR beach litter registrations only take place 1-2 times a year, while the requirements are four registrations annually representing different season. Thus, both the replication and the geographical coverage are insufficient to generate datasets that have sufficient quality to be used for research and management. Neither can the data be used to confirm the quality of the Rydde registrations (Falk-Andersson et al., 2019; MARFO, 2021; Standal et al., 2019).

An evaluation of expansion of the number of OSPAR beaches in Norway identified knowledge needs of different stakeholders, which included knowledge that could be used to identify focus areas for clan-ups and regional differences in sources and litter loads (Standal et al., 2019). The evaluation identified 3 opportunities for expansion: Moderate expansion to 17 beaches in total, which would give a better geographical coverage along the Norwegian coast and allowing for coarse comparisons of geographical differences. Large expansion to 37 beaches in total, where 3-4 localities in a cluster are identified for 10 areas. This would give a higher resolution of the data set and improve the statistical power, thereby allowing to measure changes over time with higher certainty compared to fewer localities. This alternative was regarded as being able to cover the Norwegian part of the OSPAR area (Standal et al., 2019). However, this conclusion has been questioned by our experts that point to the need for additional analysis to identify the appropriate sampling design (M.L. Haarr, pers.com). For new beaches that are established, it is recommended that the number of annual registrations should be four, but due to winter conditions this may have to be reduced to three or two times a year. For existing beaches, it was recommended to not change the frequency of registrations as this may break the established time series, given that this still would allow for use of the data either by OSPAR or nationally (see section 3.8.1.1 for overview of Norwegian OSPAR beaches). However, this may limit the use of the data from these beaches by OSPAR as they cannot be compared to beaches that follow the recommended survey interval (e.g. Schulz et al. (2013)).

The IMR/PINRO ecosystem trawl surveys where bycatch of litter is registered and visual observations on litter on the sea surface is made, only cover the northern part of the Region I, Arctic Waters, of the OSPAR area. The North Sea is covered as part of the International Bottom Trawl Surveys (IBTS) where the protocol from ICES WGML is followed, and data are reported to ICES. Coastal areas are not covered by the trawl surveys. The UNEP/IOC guidelines on benthic operational guidelines (Cheshire et al., 2009), recommends that sampling units are stratified relative to sources within a region, thus sampling on urban coasts (i.e. mostly terrestrial inputs), rural coasts (i.e. mostly oceanic inputs), within close distance to major riverine inputs and in offshore areas (major currents, shipping lanes, fisheries areas etc). This is echoed in the recent guidelines for monitoring floating marine macrolitter (Vighi, 2022)

2022), recommending that sampling should be stratified according to the distribution of litter. If preliminary surveys providing information to plan the stratification of samples cannot be done, a basic stratification of the survey by coastal and open areas is recommended. Seasonal replicates are also recommended (Vighi, 2022). The UNRP/IOC guidelines recommends that benthic surveys are conducted annually, and that some of the coastal surveys should be conducted close to beach survey sites both in time and space to allow for analysis of the relationship between benthic litter loads and the flux of litter onto beaches (Cheshire et al 2009). Current benthic and ocean surface litter sampling in Norwegian waters takes place on an annual basis.

The geographical coverage of monitoring of plastics in the Northern Fulmar is limited, with only some beaches in Rogaland and Agder being monitored. The Rydde protocol does not report dead, injured, or entangled animals, which is included in the OC and OSPAR protocol. The two latter also include reporting on the type of litter the animal is entangled in.

3.8.1 Cost estimates of extending on-going monitoring activities

This section identifies potential measures to extend on-going monitoring activities and the relative cost of such extensions.

Beaches

1. Expansion to registration of 37 OSPAR beaches in total, where 3-4 locations in a cluster are identified for 10 areas[32]. Application of the Joint List for registration of material and sources of litter.
2. Involvement of expert scientists in future development of Rydde and optimise the use of citizen science data by: exploring available data, provide advice on how to improve the value of the citizen science data including harmonisation of the protocol (including documentation of the method/protocol), securing data quality, facilitating more extensive exploration of the data for research and management, and identifying the spatial and temporal resolution needed for data to be more suitable for monitoring changes in the amount and sources of litter.

In combination, this would improve the ability of monitoring data from beaches to capture trends in the amount of litter, their material composition, and source. Application of the Joint List would capture changes in single-use plastic items identified through the SUP-Directive. Neither the Joint List, nor the Rydde protocol would enable differentiation between the type of fisheries, recreation vs commercial fisheries and aquaculture-related items. These protocols do not record information on the label (brand name, barcode, address, and production country) to infer origin.

Ocean surface

1. Perform visual observations in connection with on-going trawl surveys (illustration of 2021 research cruises in **Figure 14**).

Ocean water column and seafloor

2. Record by-catch of litter in the water column and at the seafloor for waters outside of the Barents Sea in connection with on-going trawl surveys applying the Joint List for litter identification.

[32] Note that since this report was published, new knowledge on beach litter characteristics and dynamics have questioned the conclusions of this report. Thus, for a proper evaluation of the number and distribution of OSPAR beaches, further analysis is needed. We use this number in this report for it to be easier to make cost estimates.

Offshore survey activities in 2021 covered large parts of the OSPAR I and II regions, with a higher density of trawl stations in the Barents Sea and closer to the coastline, with more scattered locations further offshore (**Figure 14**). This overview does not indicate which stations are covered through regular surveys and which stations are sporadically covered, nor what type of trawl used and what part of the water column they cover. However, the activities illustrate a potential for using existing survey activities to collect data on macroplastic and litter.

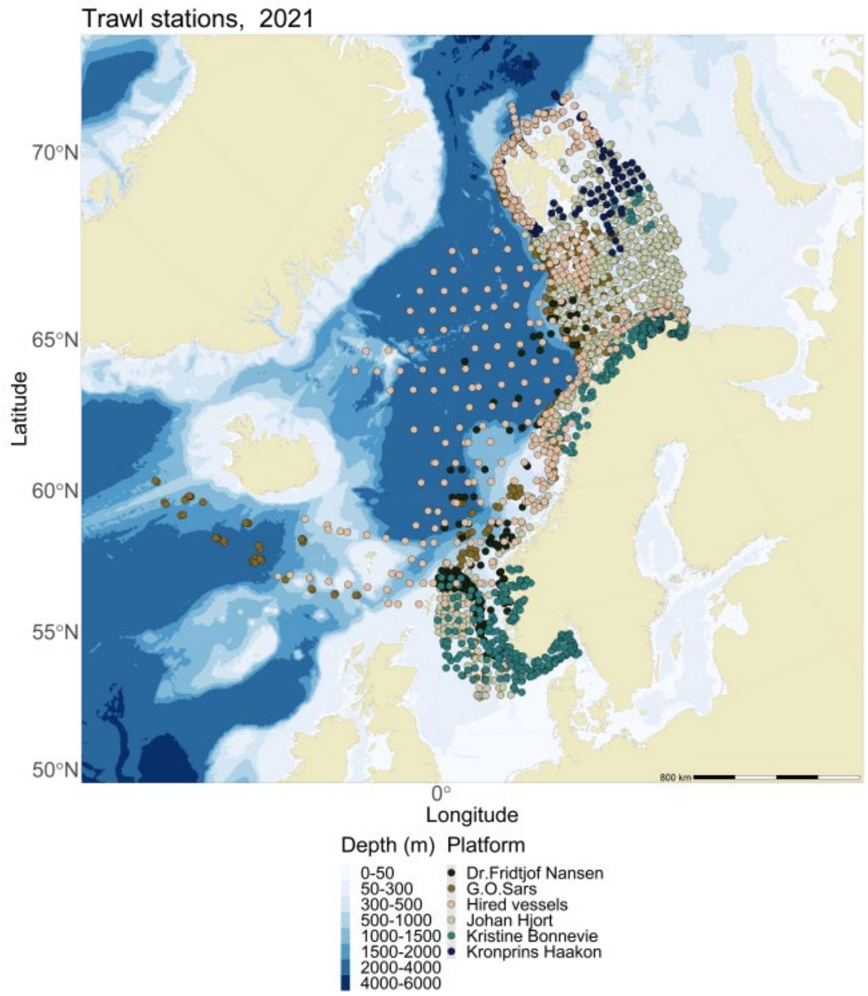


Figure 15. Overview of trawl stations covered by cruises in 2021, by the Institute of Marine Research, University of Bergen and Tromsø, and the Norwegian Polar Institute (Illustration from Smith-Johansen and Sagen (2022))

Biota

1. Increase the geographical coverage of the OSPAR fulmar survey to cover the entire coast of Norway and Svalbard.

The on-going program monitoring the population of Fulmars at Svalbard by the Norwegian Polar Institute can be used to monitor plastic (NP/NEA, 2022). Current monitoring in Southern Norway is conducted by the Norwegian Institute of Nature Research on behalf of NEA that cooperates with volunteers in BirdLife Norway who conduct the fieldwork (Dehnhard et al., 2020). Development of new methods that are not dependent on dead birds, would allow for sufficient data without damaging the birds (NP/NEA, 2022). Plastic contents have been investigated in fulmars collected as unintentional bycatch in fisheries off North Norway (Dehnhard et al., 2020). Continuing and extending this cooperation could provide a better geographical coverage.

There were disagreements among the experts in evaluation of the costs estimates for extending the number of OSPAR beaches (**Table 14**). This can be explained by perceptions regarding the logistics needed and that the number of OSPAR beaches would have to be higher than 37 to be representative. Expansion of the number of OSPAR beaches would require establishment of new logistics from sampling to processing for 30 beaches across Norway. The OSPAR method require on-site collections that should be executed by trained personnel, but logistical challenges driving up the cost may require use of personnel involved in other field activities (AMAP, 2021a). Cooperation with citizen-science based projects for collecting and bringing litter to a centralised place for analysis by professionals can reduce the costs (as done in many Deep Dive projects, see for example Falk-Andersson and Strietman (2019); (M.L. Haarr et al., 2022)). However, while this type of cooperation can keep the sampling costs low, the required expertise for data analysis drives up the cost curve (GESAMP, 2019).

Involving experts in developing the quality of the citizen science data may initially have a high cost, but once the methodological aspects has been settled, the cost will be lower as the expertise needed would largely be for minor adjustments and data analysis. Visual observation of floating litter during trawl surveys is assessed to have a relatively low extra cost. While visual surveys are relatively simple to implement, there is still need for training of observers to secure high data quality.

The additional cost of doing visual observations and record litter during existing trawl surveys assumes that on-going monitoring activities can be used for collecting data on litter. If any modifications have to be done to accommodate for documenting litter, this would increase the cost. While on-going trawl surveys could be used for collecting data on litter, there is a need to evaluate each cruise for feasibility of litter data collection as this will require time for sorting and data recording, as well as training. There may be logistical challenges in terms of fitting additional data analysis into a tight cruise schedule. If the extensive Joint List is to be applied, this will be more time consuming compared to recording information at a lower resolution. Ideally, personnel should be allocated specifically to this task on the research cruises, but according to Grøsvik at IMR (pers.com.), this is too resource demanding. Given that application of the Joint List is recommended across environmental compartments, this is the foundations for assessing the cost for the ocean water column and the seafloor. However, application of the ICES WGML would make it easier to accomplish data collection on bycatch of litter in trawl surveys (B.E. Grøsvik, IMR, pers.com).

Expert assessments in AMAP (2021a) evaluated that collection of data on plastic could be extended at a low cost to research programs already in place on Northern Fulmar colonies. The sampling and required expertise for such an additional assessment can be regarded as medium. The observation of other seabird species for macrolitter ingestion was not recommended at this stage.

Table 32 Cost estimate of expanding on-going monitoring of macroplastic and litter (0 - litter and plastic pollution monitoring already in place with regular funding, $ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse

litter and macroplastic pollution, $$$ - development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

Expansion	Expert evaluation
Expansion to 37 OSPAR beaches	$-$$$
Involve experts in citizen science beach litter data	$
Visual observation surveys	$
By-catch litter trawl surveys applying the Joint List	$-$$
OSPAR Fulmar Norwegian coast	$$$

3.8.2 Opportunities to expand data collection through coordinating with existing activities and inclusion of other affected sectors

Extending on-going monitoring activities would improve data availability on amounts, material composition and sources of litter for beaches, the ocean surface, water column and ocean floor, and the amount of litter in Northern Fulmars. However, there would still be large data gaps on litter on the sea surface, in the water column and on the seabed in coastal areas, as well as in freshwater and terrestrial environments. Improving data availability would be beneficial for all environmental compartments. Expanding the OSPAR beaches and the improving the usefulness of data from citizen science beaches, would give data from shorelines that are highly polluted. If the MSFD's target of less than 20 macrolitter items per 100 meter beach relates to polluted beaches, the data from these monitoring programs would give information on this. **However, if the target is to be applied to reflect the pollution level on an average beach along the Norwegian coastline, the sampling strategy would have to be changed to collect data from a representative sample of beaches.**

This section gives an overview of existing activities, clean-up initiatives, and specific sectors or actors that could be activated to contribute to data collection on litter and macroplastic. For each activity the environmental compartment, type of knowledge and relative cost of implementation is evaluated. Cost evaluations have been performed based on the initial cost of expanding data collection, and comments are made to indicate if this cost is expected to change over time.

3.8.2.1 Coordinating with existing monitoring programs of the Norwegian Environment Agency

The evaluation of the coordination potential for the different monitoring programs of the NEA can be found in Appendix 8. None of the current monitoring programs were rated by the experts as having a high coordination potential for collecting samples of macroplastics and litter. The two programs evaluated as having the highest potential (Table 15) were the SEAPOP program and Monitoring of migratory birds at Jomfruland and Lista, where both physical collection and videos/pictures could be used for sampling data. These programs could be used to assess the degree to which birds are affected by plastic pollution. Some of the evaluated monitoring programs were found to have a low coordination potential because of limited geographical scope and coverage, while for others, the information available from the overview of the programs did not allow for an evaluation of whether the sampling locations also were relevant for macroplastic.

Table 33 Summary of expert evaluation of the coordination potential with existing NEA monitoring programs

Coordination potential	Number of monitoring programs
High	2
Low	22

Irrelevant/NA	37
Don't know	4

A general comment from the experts evaluating the potential for coordination was that their suitability was evaluated based on relevant environmental compartment. For all programs, there is no overlap in methods for collecting data on macroplastics and the data collected in the NEA programs. For this reason, most programs were assessed as being irrelevant or having a low potential for coordination. Collection of data on macroplastic will require specific protocols and involve more time in the field. Any possibility to coordinate collection of macroplastic samples with other monitoring will rely on the capacity and training of the scientists or other personnel performing field work in a location that could be suitable for plastic monitoring. The timing of collection could influence whether macroplastic samples and data collection can be made. For example, the water flow, flooding or other weather- or seasonally dependent parameters may determine the presence of macroplastic. To be able to compare data in time and space, these parameters should be described.

For a more complete evaluation of the potential to coordinate with existing NEA monitoring programs, an overview of the sampling in time and space and an in-depth understanding of the logistics involved is needed. Such an evaluation is outside the scope of this project.

3.8.2.2 The Rydd Norge program

The national Clean Norway (Rydd Norge) program was established and is led by the Norwegian Retailers Fund (NRF). The aim of the project is to clean 40% of the Norwegian coast, as well as prioritised waterways and areas on Svalbard by 2023[33]. Currently, the weight of the litter is recorded for all sites, and the criteria for what can be considered a clean beach (all litter above 2.5 cm that can be collected efficiently wearing working gloves[34]) secures that the degree of cleaning is similar across beaches. A working group has given NRF advice on how the project can contribute to collecting data on beach litter (MARFO, 2021). This section is based upon the working group advice, with some modifications to meet international and national needs.

Coordination with the Rydd Norge program would benefit from on-going logistics of clean-ups to increase the amount of data from beaches/shorelines and freshwater. The latter compartment is currently a key knowledge gap to get information on litter loads and sources in freshwater and understand the importance of waterways in transportation of litter to the ocean. The clean-up crew does not have the capacity to record data, but by clearly marking the bags the litter can be sorted and categorised after being transported to a suitable facility. Given that the clean-ups are conducted by professionals, they can provide better quality metadata on the location compared to citizen science data. Information on the area cleaned (e.g. length*depth of the beach) and opportunities to get data from the same area within and between years would improve the reliability of the analysis and allow for answering specific questions of interest for research and management. Furthermore, the clean-up crew could target areas that are chosen based on advice from experts on sampling design to improve the possibility of the data to show local trends.

Analysis of the litter should be performed by trained personnel applying the Joint List. Trained personnel could also use Deep Dive analysis to identify geographical origin, age, brand name, items specific to the Arctic region and differentiate between aquaculture, different types of commercial fisheries and recreational fisheries, and items dumped from the trawl fleet. This would give

[33] Rydding i gang i alle fylker - HMF (handelensmiljofond.no)
[34] Her er kriteriene for "ferdig ryddet" - HMF (handelensmiljofond.no)

information that could allow for more targeted mitigation strategies, support implementation of extended producer responsibility, and improve our understanding of transportation pathways. AMAP (2021) evaluated that Deep Dives have a high relevance in that it provides a detailed overview of litter sources and AMAP therefore recommends developing this methodology further for research purposes. Due to high expertise levels, the costs of this methodology remain considerable.

Given that Rydd Norge targets polluted locations on the exposed outer coasts, the data would not be representative, but it would provide data from all the Norwegian counties. The initial cost of establishing suitable facilities for indoor registration could be high and availability may differ between regions. Given that the litter will be handled by waste management companies, cost could be reduced if data recording could be done at waste management facilities. Furthermore, there are few people that are trained in recording this type of data to secure that data collection applying the Joint List is efficient and of high quality. The initial cost of training people will be high, but as competence increases, the cost will go down. The Deep Dive method would have to be developed further to identify clear criteria and photo guides for the items not included in the Joint List. Given that several characteristics will have to be recorded for some of the items, there is also a need to develop a protocol and database facilitating recording and storing of deep dive data. The initial cost may therefore be higher compared to the long-term cost.

Table 34. Evaluation of cost of extending monitoring through coordination with Rydd Norge, ($ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter and macroplastic pollution, $$$ - development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

	Compartments	Expert evaluation
Rydd Norge Joint List	Beach/shoreline, freshwater	$-$$
Rydd Norge Deep Dive	Beach/shoreline, freshwater	$$$

3.8.2.3 The Norwegian Polar Institute survey activities

The Norwegian Polar Institute (NP) could not give input to this investigation. This section is based on a report on the current situation and needs for developing environmental monitoring at Svalbard (NP/NEA, 2022). The input from the report on monitoring of the Northern Fulmar is reported in the section on expansion of on-going monitoring (section 3.8.2). NP has collected sporadic data on plastic in the Northern Fulmar, kittiwake, and the common eider, as well as from snow, ocean, sediment, benthic species, and soil from nesting areas of bids. The type of plastic samples is not specified in the report, but it can be assumed that apart from plastic in the birds the focus has been microplastics. The report does not say anything of the type of data that has been collected on plastic from kittiwake and the common eider. Based on the report, NP does not suggest any expansion that would involve data collection of macroplastic and litter.

The report of NP/NEA (2022) gives an overview of current monitoring performed by other institutions at Svalbard, including sporadic collection of data on plastic. Given that the focus of this investigation is mainland Norway and Norwegian waters, these activities are not reported here.

3.8.2.4 The Institute of Marine Research survey activities

In addition to collection of data during the trawl surveys in the Barents Sea and North Sea, all video transects (700 m length) recorded during the MAREANO surveys are analysed for litter. MAREANO cruises have been conducted since 2005, as part of the Norwegian seabed mapping program (Buhl-Mortensen & Buhl-Mortensen, 2017). **Figur 2** shows the MAREANO stations and the number of litter items recorded over time. The data collected gives information on the litter densities (number of items[35]), composition, and accumulation areas. In general, the highest abundance of litter was found close to the coast and in areas with high fishing intensity. The highest litter densities were represented by fishing gear, with indications of intentional discards of for example wires as they occurred in bundles (Buhl-Mortensen & Buhl-Mortensen, 2018). These surveys are not used for trend monitoring, and publications from the MAREANO surveys are reported as aggregated litter densities over time (Buhl-Mortensen & Buhl-Mortensen, 2017; Buhl-Mortensen & Buhl-Mortensen, 2018). The same protocol as for the Barents Sea trawl survey is used, thus it is not compatible with the IBTS ICES Manual (ICES, 2022).

AMAP (2021a) recommends between 100-200 stations to cover plains and landscapes in a representative way (the AMAP region is largely covered by the most densely populated MAREANO stations in **Figur 2**). The cost of establishing monitoring stations would be relatively high as it would require that the same stations are sampled over time, which is not done today. Furthermore, there would be extra cost for analysis of the samples (**Tabell 5**). Adaptation to the ICES manual, or the outcome of future harmonisation efforts, could increase the cost of analysis somewhat as these manuals are more extensive compared to the current protocol. In the future, the cost of analysis could be reduced as the used of imagery for monitoring purpose is yet to be realised (Grøsvik et al., accepted manuscript)

[35] The data is sometimes reported in mass, but the conversion factor from numbers to weigh as reported in Buhl-Mortensen and Buhl-Mortensen 2017, used is not well documented

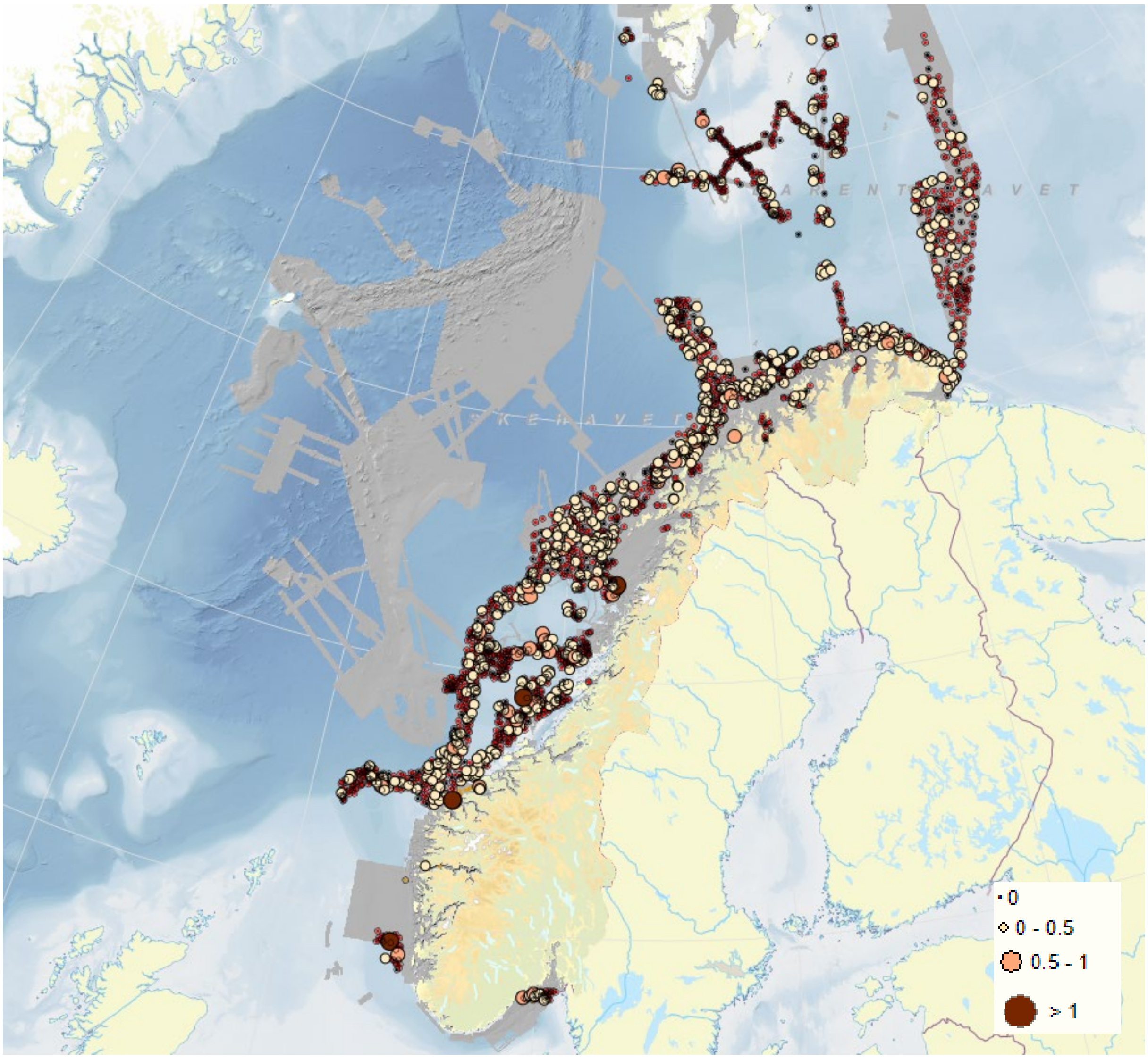


Figure 1. MAREANO video stations (red dots) showing number of litter observations per 100 m (0, 0-0.5, 0,5-1, <1) (Stations from 2005 until today, retrieved 08.12.2022).

Table 3 Evaluation of cost of extending monitoring the MAREANO programme, ($ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter and macroplastic pollution, $$$ - development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

	Compartments	Expert evaluation
Video recordings, repeated visits of MAREANO stations applying the ICES protocol for litter item registrations	Seafloor	$$

3.8.2.5 Fishing for Litter

Fishing for Litter is an international program where fishers deliver marine litter free of charge to appointed marinas. The program started up in 2016 with 20 vessels in three harbours, by 2020 it had grown to include 202 vessels in 11 ports along the Norwegian cost[36]. The company SALT Lofoten AS has been managing the program since the start and have evaluated the potential for gaining knowledge from the litter retrieved (Havas et al., 2018). **Figure 15** shows the fishing activities of FFL vessels prior to delivering litter in 2020 and 2021, showing that the litter would mainly be from open sea areas, but that FFL may also provide some data on litter in coastal areas.

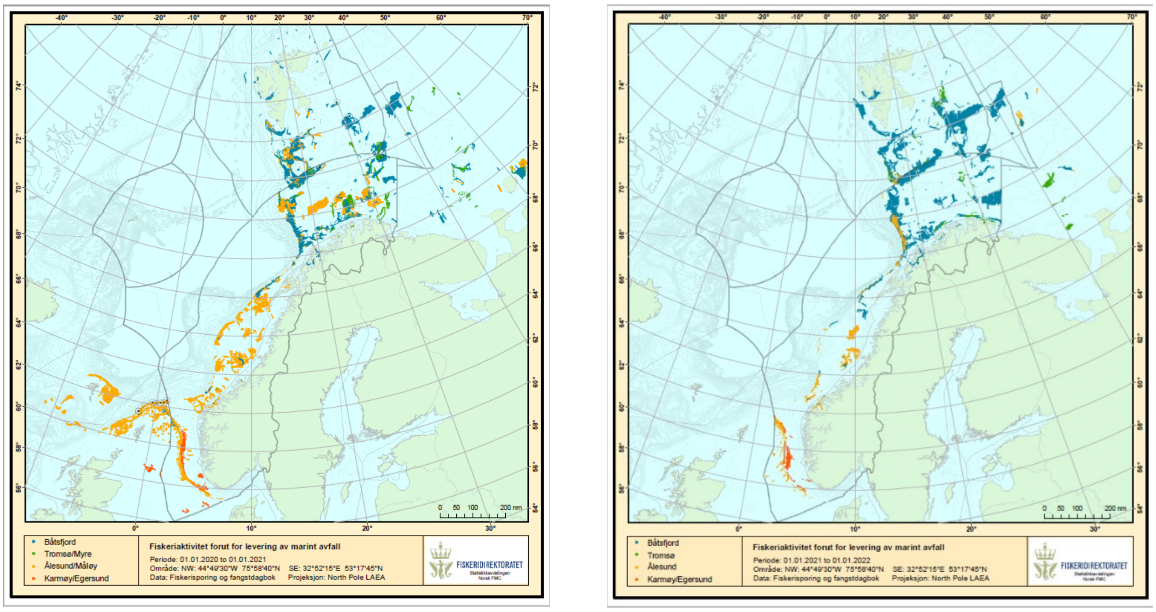


Figure 16. Fishing activity of FFL vessels before delivering litter in 2020 and 2021

Litter collected through FFL has been analysed with the aim of identifying regional differences in litter landed and developed more standardised methods for documenting the litter retrieved from the FFL scheme. The potential for gaining valuable knowledge about marine litter through analysis of the FFL litter is seen as high (Havas et al., 2018). Using FFL schemes to get data on benthic litter reduces the costs of data collection and avoids implementation of specific litter surveys trawling for litter, thereby potentially causing a negative environmental impact on benthic environments and bycatch (Cheshire et al., 2009). However, to improve the value of the data from FFL there is a need to solve issues related to securing meta data, that the samples can be tracked back to specific vessels, and that the sample is not polluted by other litter. Furthermore, there is a need for method development on the protocol applied for recording data.

Most of the litter analysed could not be linked to the specific vessel delivering this waste. This is a limitation in terms of getting knowledge on the original location of the litter but could be solved if the litter is marked with the position of retrieval. For accurate position and effort data it would have to be linked to individual trawl hauls, which will add a lot of work for the fishermen involved (ideally they would also record clean hauls). The fishing companies may have to get compensated for this. Density estimates of litter can be obtained if the area covered and time of fishing is known as this can be used to calculate catch per unit effort. Vessel tracking data can be used for this. However, the experience from the FFL project is that the bags of litter are often not marked, tags with this information can be

[36] https://fishingforlitter.org/norway/

lost during handling and transport, and litter from multiple vessels can be collected in one container without any record of what litter originated from the different vessels. When the vessel is unknown, information on the fishing gear applied will also be unknown. The potential for catching litter will differ between e.g. a bottom trawl and a pelagic trawl, and will also represent different environmental compartments of the ocean (Havas et al., 2018).

Some of the litter in the FFL containers were clearly produced on the ship itself (e.g., household waste and parts of trawl nets that had not been in use) or dumped by outsiders in the container. Dangerous waste has also been found during analysis, which represents a risk to those sorting and registering the litter. Thus, there is a need for a good control of the logistics to also secure that other waste and dangerous waste is not put in the FFL containers. Feedback from fishers involved in FFL indicates that correct sorting onboard the vessel can be challenging due to bad weather, a lack of space, and shifting crew. Another logistical challenge is that the waste management companies handling the litter often have limited time to make space and manpower available to do analysis.

Litter from FFL vary in size, from many hundreds of kilograms to small, unidentified pieces of litter. Efficient data recording therefore requires establishment of efficient systems for sorting and reporting. Method development has therefore included first weighting and recording data for large items first (e.g. trawls nets, bobbins), before sorting and weighing smaller items (e.g. packaging, pieces of rope, bottles) that are more time consuming to record. Two protocols have been developed, one extensive deep dive protocol that can be used by SALT in cooperation with the waste management companies, and one for more simple analysis that can be used by the waste management companies on their own. The former includes information on the age of packaging, the type of fishing gear, while the latter includes potential for recycling. Both protocols record source in broad litter categories (e.g., fisheries, household, land-based industry), material type, and if it is fouled or not to indicate the recycling potential for the litter (less than 20% fouling a requirement for recycling by Nofir). It was not possible to estimate age on fisheries related items as no clear criteria for this was available at the time (Havas et al., 2018). However, discussion among experts in the recent years suggest that this issue could be re-visited as the degree of degradation of cut-off ends of ropes and nets could identify items that have not been in the environment for a long time.

Today the litter from FFL can be used to inform about the sources, material, and potential for recycling. The latter would include recording both material type and degree of fouling. To study the spatial distribution of litter on the ocean floor, there is a need to mark and register the litter to secure metadata on where it was caught, type of fishing gear used, area covered and time of fishing. Further development of the protocol is needed to secure harmonisation of data collected within and across environmental compartments for example through application and modification of the IBTS (ICES 2017) and/or the Joint List or key elements within the list to follow up policies. Once the litter has been delivered, the cost of data collection is relatively low, but funding is needed to secure the logistics from sampling to analysis (**Table 17**). Data analysis would have to be done by trained personnel in cooperation with waste management facilities that receive this litter as many of the items are too large to handle without machinery. However, suitable facilities for analysis are generally lacking. Coordination is required to secure the logistics from vessel to facilities for analysing the data and thereby the metadata needed for interpreting the data.

Table 35. Evaluation of cost of extending monitoring through coordination with FFL. (0 - litter and plastic pollution monitoring already in place with regular funding, $ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter

and macroplastic pollution, $$$ - development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

	Compartments	expert evaluation
FFL	Ocean floor, water column	$-$$

3.8.2.6 Norwegian Directorate of Fisheries clean-up cruises

The Directorate of Fisheries has removed lost fishing equipment from the seabed since the early 1980s. This reduces ghost fishing as well as the amount of litter in the marine environment. Fishers are obliged to report all equipment lost with accurate description of where it was lost. Apps have been developed both for professional fishers and recreational fishers to facilitate reporting of lost fishing gear[37]. The removal of lost fishing equipment has traditionally focused on offshore areas, but since 2019 coastal areas have been included. Gear lost by both professional coastal fishers and recreational fishers have been recovered in these operations.

Information on equipment recovered through clean-up cruises includes the number of nets, pots, trawls, anchors, buoys, and meters of rope, wire and line. In the map application ***Yggdrasil***[38], the findings are geotagged allowing for comparison across regions. However, the effort spent, and area covered is not recorded, limiting the use of this data in terms of calculating catch per unit effort. On the other hand, the sampling is taking place in targeted areas based on reported losses, which limits the use of these data for monitoring as standardising efforts would conflict with cost-efficient recovery of the lost fishing gear. The Directorate of Fisheries have observed that some of the gear recovered are sinking rope and net rope that is too worn or inadequate for use[39], indicating that intentional discards are taking place. A thorough analysis of the equipment recovered could give information on the reason behind loss and provide data needed for implementation of EPR.

While the clean-up program aims at ensuring that the recovered gear is reused or recycled, they do not collect data on material type and the degree of fouling. This would give information on the potential for recycling. Information on the effort and area searched would increase the potential for using the data in monitoring. Method development could explore the possibility to differentiate between lost and discarded equipment and identify the type of fisheries the recovered items originate from. Further development of the protocol is needed to secure harmonisation of data collected within and across environmental compartments for example through application and modification of the IBTS (ICES 2017) and/or the Joint List or key elements within the list to follow up policies. The additional cost of this is evaluated to be relatively low, with potential for further reductions in costs once a suitable protocol for litter identification is developed (Table 18).

Table 36 Evaluation of cost of extending monitoring through coordination with the Fisheries Directorate clean-up cruises. (0 - litter and plastic pollution monitoring already in place with regular funding, $ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter and macroplastic pollution, $$$ - development of

[37]https://www.fiskeridir.no/Areal-og-miljo/Marin-forsoepling/Redskapsopprensking
[38] Kart i Fiskeridirektoratet (arcgis.com)
[39] Redskapsopprensking (fiskeridir.no)

sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

Expansion	Compartments	Expert evaluation
DF clean-up cruise harmonised protocol	Ocean floor, offshore and coastal	$$

3.8.2.7 Citizen science initiatives

Keep Norway Beautiful has been and is the driving factor behind clean-ups and data collection initiatives on litter in Norway. They coordinate initiatives that include clean-ups by divers in coastal areas and harbours, clean-ups along rivers and waterways, and in urban areas. Their program "min bit av Norge" encourages people or organisations to adopt an area for clean-ups and data registration at least three times a year[40]. These adopted areas may have a particularly high value for collection of good quality data for research and management. However, currently it is not possible to identify these beaches when downloading data from Rydde.

The value of the data from the KNB initiatives would be improved by involvement of expert scientists in future development of Rydde and optimise the use of citizen science data by: exploring available data, provide advice on how to improve the value of the citizen science data including harmonisation of the protocol (including documentation of the method/protocol), securing data quality, facilitating more extensive exploration of the data for research and management, and identifying the spatial and temporal resolution needed for data to be more suitable for monitoring changes in the amount and sources of litter. Given that the KNB initiatives spans many environmental compartments, including compartments where monitoring guidelines are poorly developed, the initial cost of involving experts would be high, but as guidelines are developed, the cost will be reduced. NIVA evaluated the cost to be relatively high, while one of the experts sat a lower cost arguing that this would be a desktop job (**Table 19**). Given the low maturity of monitoring in non-marine compartments, involving the scientists should in the whole process from sampling to analysis would be an advantage.

The review of data available on litter in Norway found that the Norwegian Diving Society register their clean-up actions in Rydde. They also encourage registration of lost fishing gear in the App developed for recreational fishing by the Fisheries Directorate[41]. Given that the App is already developed, the cost to improve data collection would mainly be related to encouraging more users to register data (**Table 19**). Currently the data downloaded from Rydde does not identify the clean-up actions that have been conducted by divers. This is an example of how cooperation with experts could improve the value of the Rydde system. The data registered by divers have potential in providing knowledge on amounts and sources of litter on the seafloor in near-shore areas, an area that is not covered by on-going monitoring. The value of this data must be assessed.

Miljølære (www.miljolare.no) provides teaching material as support for lectures related to sustainable development. It includes teaching material on investigation of marine litter that is aimed at schools and volunteers that have the capacity to clean an area multiple times in a systematic way[42]. There is no documentation of the development of the protocol, but it includes an option to register litter from different, pre-defined countries. The expertise of the people analysing the litter has a significant influence the assigned geographical origin and age of litter items. To improve the quality of this type

[40] https://holdnorgerent.no/minbitavnorge
[41] https://ndf.no/klubb/marin-forsopling/
[42] https://www.miljolare.no/aktiviteter/avfall/marint/

of data, clear criteria for registration should be followed (Falk-Anderssen et al 2021 methods). Registration of this type of information through citizen science should therefore be done based on clear instructions, that should be modified for non-professionals. The Arctic Clean-up project have developed a protocol based on Ocean Conservancy, adapted to the Arctic, but there is no documentation of the development of the protocol. Many of the citizen science initiatives In Norway encourages use of Rydde (e.g. In the Same Boat, the Norwegian Society for the Conservation of Nature), and there are only sporadic data registrations using other Apps applying different protocols. Harmonisation efforts would increase the usefulness of data registered by citizen science initiatives and would not be very costly (**Table 19**).

Cooperation with cruise operators provides an opportunity to get access to litter in remote areas. Many cruise operators are motivated to make a positive difference and, their clients are interested in learning about plastic pollution and contribute to clean-ups. Deep Dive analysis of litter at Svalbard and in Tromsø has benefited from cooperation with the local cruise operators involved in the Clean-up Svalbard campaign[43] (Falk-Andersson & Strietman, 2019), and tourists have also been involved in collecting data on marine litter in the high Arctic[44]. Many of the guides on these vessels have a science background, which could secure the quality of the meta data. Cooperation could be established for cruise operators to apply a harmonised citizen science protocol, or to collect litter that is later analysed by experts either applying the Joint List or Deep Dive analysis. Guides could also be trained to apply more advanced protocols. The cost of cooperating with cruise operators will depend on the level of detail of registration and is therefore evaluated to be low to moderate (**Table 19**).

Table 37 Evaluation of cost of extending monitoring through coordination with citizen science initiatives. (0 - litter and plastic pollution monitoring already in place with regular funding, $ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter and macroplastic pollution, $$$ - development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

Expansion	Compartment	NIVA evaluation
Involve experts in KNB citizen science litter data	Beach/coast, waterways, terrestrial, coastal seafloor	$$-$$$
Recreational fishing App on ghost gear by divers	Coastal seafloor	$
Harmonisation of citizen science protocols applied in Norway	Marine, but potentially all	$
Cooperation cruise operators	Beach/coast	$-$$

3.8.2.1 Clean-up technology initiatives

Clean-up technologies (CLT) are implemented some areas in Norway to capture floating litter that has entered the environment. The TrashTrawl is set up in Akerselva, Oslo (Jacob et al., 2021), while the SeaBin has been tested out in marinas[45]. While these measures are quite inefficient in recovering litter compared to other clean-up actions and also risk by-catch of biota (Falk-Andersson et al., 2020; Jacob et al., 2021), recording data on litter and by-catch caught, could provide knowledge useful for research and management (Falk-Andersson et al., in prep.). Deep Dives on litter caught by the TrashTrawl in Akerselva identified key sources of litter, as well as capture of biological material, included red-listed species (Jacob et al., 2021). In combination with collection of appropriate meta data, these initiatives

[43] Cleanup Guidelines - AECO
[44] https://www.akvaplan.niva.no/mynewsdesk-articles/arctic-cruise-tourists-assist-plastic-scientists/
[45] https://drammenhavn.no/nyheter/tester-flytende-soppelspann/

could provide new knowledge on floating litter, insights in to cost-benefit analysis on applying clean-up technologies and contribute to a better understanding of transportation processes. This will require development of guidelines for data capture from CLTs, including adjustment of the protocol, either citizen science or Deep Dive, to document by-catch of non-litter items. The cost of this would be moderate (**Table 20**). Once this has been developed, the cost of data collection would be reduced.

Table 38 Evaluation of cost of extending monitoring through coordination with clean-up technology initiatives. (0 - litter and plastic pollution monitoring already in place with regular funding, $ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter and macroplastic pollution, $$$ - development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

Expansion	Compartment	Expert evaluation
Apply adjusted citizen science protocol to CLT litter	Floating litter rivers, harbours	$$
Apply Deep Dive protocol to CLT litter	Floating litter rivers, harbours	$$

3.8.2.2 Aquaculture, fisheries, agriculture and building industry

Involving actors in the fisheries and agriculture sector as well as conducting Deep Dive analysis have been identified as actions that are easy to implement and will have a relatively high impact in terms of reducing littering from these sectors (Johnsen, Haarr, et al., 2019). NIVA and KNB cooperates with the agriculture sector on plastic pollution, and the building industry have been involved in Deep Dives to get insight into litter originating from their activities (Roland & Cyvin, 2021). The construction sector (building and roads) and the maritime sector (aquaculture and floating docks) are both potential sources of expanding plastic materials (EPS), which is number five on the top 10 list of most found plastic littering items in Norway (Eggen et al., 2021). These industries could be encouraged to contribute to clean-ups and data collection applying the citizen science protocol to increase awareness among their members on plastic pollution. Mandatory participation could also be evaluated, combined with development of a sampling scheme that would provide data useful for monitoring. To provide feedback to the industry on mitigating actions Deep Dive analysis adjusted to capture key litter items that the industry should target to reduce littering is likely needed (Falk-Andersson, 2021). For each of the industries, the Deep Dive protocol would have to be developed, which would have an initial cost. Setting up a monitoring scheme for the industry would also have some costs, while encouraging participation in on-going citizen science efforts would have a low cost (**Table 21**).

Table 39 Evaluation of cost of extending monitoring through coordination with citizen science initiatives. (0 - litter and plastic pollution monitoring already in place with regular funding, $ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter and macroplastic pollution, $$$ - development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

Expansion	Compartment	Expert evaluation
Involve industry in collecting citizen science data	Beach/coast, waterways, terrestrial	0-$
Industry specific Deep Dive	Beach/coast, waterways, terrestrial	$$

3.8.2.3 Producers

Contribution to cover the costs of data collection and reporting is one of the costs that producers of single-use products (SUP) should cover when EU's plastics directive is implemented (NEA, 2022). Identification of the relative proportion of different items littered, through representative analysis of the litter, is needed as part of determining the distribution of costs between different sectors. This can be challenging due to a high number of producers, actors, products, and variations in products, in addition to a lack of reporting and overview of the different actors. Such data collection would be very costly, and it is recommended that the producers themselves should take this responsibility. Thus, the producers would have to conduct analysis of litter, or buy this service from others. To secure neutrality, it is suggested that the analysis is done by a third party (NEA, 2022).

The analysis conducted by/ on behalf of producers would be at the level of municipalities. It could be expected that the litter analysed would be mainly from urban environments as these are the areas where municipalities have clean-up actions and responsibilities. However, it may also be relevant to secure representativity across different types of environments to calculate the proportion of single-use products. Some of these may be more likely to end up away from urban environments due to differences in behaviour and transportation pathways (e.g. wet wipes may be used when hiking or be transported with sewage systems to the ocean). Documentation of SUP will require development of guidelines for representative sampling and data capture, including development of adjusted Deep Dive. This would be relatively costly (**Table 22**), but once this has been developed, the cost of data collection would be reduced somewhat, although the sampling scheme needed would still be extensive. Note, we do not assess here who would carry that cost.

Table 40 Evaluation of cost of extending monitoring through coordination SUP producers. (0 - litter and plastic pollution monitoring already in place with regular funding, $ - relatively inexpensive because new litter and macroplastic monitoring programs can use existing programs to obtain samples, but need to have some additional capacity to process samples for litter and plastic pollution, $$ - either sampling networks and/or capacity need to be developed to obtain samples, process, and analyse litter and macroplastic pollution, $$$ - development of sampling networks, processing and analysis capacity of samples, and reporting all need to be developed).

Expansion	Compartment	Expert evaluation
Deep Dives to document producer responsibility	Beach/coast, waterways, terrestrial	$$$

4 Advice for a Norwegian monitoring program

A monitoring program for macroplastic and litter in Norway should provide information on the amount and composition of litter and knowledge that can be used to identify measures and monitor the effect of implementation of these measures. The monitoring program should cover both international obligations and national needs, but at the same time be adjusted to Norwegian conditions. This section gives recommendations that are general to all data collection (logistics and litter classifications to be applied), as well as monitoring programs of marine compartments. It also identifies research needs to develop these programs. For non-marine compartments, general advice is given on steps forward to establish monitoring programs as this is an area where methods are not yet fully established or have a record for previous implementation in Norway. **Activities that should be prioritised are marked in bold.**

4.1 Logistical responsibility

A key question which needs to be addressed is who will be responsible for collecting monitoring data. To ensure that the data is of good quality – including appropriate and good quality metadata[46] – and that it can be used for monitoring purposes, it is important to identify responsible actor(s) to secure the data collection process from planning to reporting. **It is recommended that those actors are given resources to secure this process for the different environmental compartments.** If this responsibility is shared between different actors, coordination is needed to facilitate harmonisation across compartments. Hiring professionals throughout the process from data collection to analysis would give the greatest control of data quality but would also be costly. Coordination with clean-up activities, both professional and volunteer, can increase the data volume at a lower cost, but with a certain loss of control over all data parameters (see Haarr et al. 2022a for an in-depth discussion and evaluation). **Different models for how the logistics of macroplastic and litter monitoring could be organised should be assessed.**

Bad weather is a limitation to doing data analysis in the field as it may affect the quality of the data[47] and increase the chance of littering. It is therefore recommended that data analysis is performed indoors, but appropriate facilities are not readily available across the country. **It is recommended that appropriate facilities for litter analysis are identified and established to secure similar and good quality working conditions for data collection.**

It is crucial that data are reported into a common data portal so that it is available for use. **It is recommended that data are reported in open access databases established through international collaborations.** Examples include ICES DATRAS, OSPAR, EMODnet, and Rydde. There are ongoing international effort to harmonise and synchronise the dataflow between national and databases. **Norway should follow the recommendations for each chosen indicator according to OSPAR requirements.**

For floating litter, the FLM app developed by the JRC is recommended as it allows categorisation of litter objects according to the Joint List, and record geographical coordinates, sampling date and time,

[46] See eg. Grøsvik et al (accepted manuscript) and OSPAR (2010)/ Cheshire et al 2009 for meta data requirement for seafloor and beaches, respectively.
[47] At Hvaler the OSPAR data is analysed indoors, resulting in the data being so different to the other OSPAR sites that they had to be obmitted from analysis. This due to registration of a large number of smaller and unidentifiable pieces at the Hvaler site (Falk-Andersson et al. 2019).

litter type and size information. The Rydde portal is not currently optimal for accessing data collected through citizen science**. It is important to continue to develop the functionalities of Rydde and Rent Hav.** Integration of these tools into international databases would also be an advantage. **It is recommended that citizen science data are made fully open access including all information recorded by the volunteers**, with geographical location and specification of the type of action (beach/ coastal clean-up, freshwater, diving). Active use of the data is the best mechanism for quality control. Currently, data available on litter are underutilized in Norway due to a lack of funding to explore these data. **It is recommended that resources are secured for in-depth analysis of the data to evaluate what questions they can answer and any weaknesses that should be addressed to increase the value of the data.**

Close collaboration and communication with stakeholders are key, both to get an understanding of the sources and reasons behind littering, as well as their data needs to implement preventive measures and monitor their effects. It is also important to secure that the polluters take ownership of the problem and the solutions. Deep Dive workshops with stakeholders is one tool that has proven effective in creating dialogue with stakeholders, but the methodology needs to be further developed (Falk-Andersson, 2021). Such interactions have been based on short-time funding targeting specific stakeholders (e.g. Johnsen, Haarr, et al. (2019)). KNB is a key actor involving stakeholders over longer time periods, but with limited resources. **Long-term funding should be made available to work with stakeholders over time and develop methodologies or guidelines on how to engage with stakeholders to identify sustainable solutions to litter problems.**

4.2 Litter classification systems

Identification of litter items is an important foundation for management decisions as they enable identification of the likely sources of the litter, which again can be used to implement mitigation measures. There is no "one-size fits all" option and multiple strategies are needed to meet all obligations and needs identified, while at the same time balance the resources needed to record data. Data that are collected by professionals can be recorded at a higher level of detail, while at the same time securing quality. When using volunteers to collect data, the protocol must be simplified to avoid exhausting the volunteers and to secure that information recorded is of good quality.

The Joint List is the most extensive monitoring protocol today, it is harmonised with established monitoring protocols, including the OSPAR beach litter protocol, and enable compatibility and comparability of data with data collection protocols that have different levels of details through the hierarchical system. This also allows for higher resolution of data where this is needed, as can be identified through Deep Dive analysis for different compartments and cases. The Joint List also includes SUP items, which are targeted for mitigation policies in Norway as well as the EU. **For national monitoring, the Joint List is therefore recommended across environmental compartments.** For beaches where the OSPAR beach litter protocol is applied, the extra cost in terms of expertise and time to apply the Joint List, may not be high. Experience from OSPAR monitoring of beaches in Denmark, suggest that incorporation of the Joint List into the OSPAR monitoring protocol does not require a lot of extra work, given that there are not extreme amounts of litter (Ryan d'Arcy Metcalfe, KIMO, pers.com.). However, it is recommended that this is looked further into in a Norwegian context to evaluate the extra burden before a decision is made.

While application of the Joint List is generally recommended across compartments, this may not be feasible given the method applied or resources available. The FML app is recommended for floating litter in rivers and the ocean as it allows categorisation according to the Joint List. **The app should be tested in Norway to evaluate its applicability. For seabed mapping it is recommended that data is**

collected according to the ICES IBTS monitoring guidelines. The MSFD TGML is discussing including litter items for which mitigation measures are planned (e.g. SUP items and fishing gear). **Inclusion of these items in monitoring protocols should be considered implemented already now.** It is recommended that Norway contributes to the on-going harmonisation efforts on seabed and floating litter mapping.

The Joint List is not able to separate items from commercial fisheries, recreational fishing, and aquaculture in Norway. Deep Dive analyses and stakeholder communication with the fishing industry have identified some items that should be registered as discards from trawlers: bundles of strapping bands, parts of conveyor belts, packaging tube rolls, clearly cut sections of trawl nets and rope cut-offs from mending the nets. Similar analysis has been done for the aquaculture and construction industries and information from these studies should be evaluated to identify items that are unique to their activities and should be targeted for mitigation actions. Some of the items specific to the Arctic could also be identified, such as melted plastics, detonating cords for explosives and feed bags from aquaculture. **It is recommended that Deep Dive protocols are developed to separate the marine litter categories, as well as identifying construction related items. Clear categorisation criteria and photo guides should be developed** to secure correct identification of items identified as important to monitor to evaluate policies.

Identification of litter items of high concern is at the early research phase as criteria for this need to be developed, likely using expert evaluation starting with items defined in the Joint List. Identification of polluters and producers would require development of representative sampling, and a higher level of detail including brand name, age, and geographical origin. Identification of geographical origin and age of litter items has been used to document that chemical containers, food packaging, bottles, and household products along the coast of Norway and Svalbard are likely related to maritime activities, and that littering is still on-going (Falk-Andersson et al., 2021). This type of information allows more targeted mitigation actions and indicates whether clean-ups and/or prevention are needed to reduce the amount of litter in the environment. The feasibility to get data across compartments that enables implementation of producer responsibility should be evaluated in dialogue with the producers. **An evaluation of the data requirements, logistics, costs, potential conflicts, and responsibilities is recommended. It is recommended that for selected environmental compartments, including beaches, production/expiry date and text[48] indicating geographical origin is recorded**. Research should be done to explore how the method can be extended to identify what characteristics are necessary to document to follow up the SUP directive. **Snuff bags and boxes should be added to the item list** as it is a litter item specific to Norway and contributes significantly to tobacco related litter. This is also an item that is easy to document and link to specific producers.

It is recommended that all citizen science initiatives should be harmonised with Rydde. It is not recommended to increase the complexity of the registration as this may exhaust volunteers and require specific training. **Harmonisation efforts in cooperation between expert researchers and key actors involved with engaging citizens are recommended** to secure harmonisation with existing citizen science protocols and across compartments, as well as securing that the data collected has monitoring value.

4.3 Beach litter monitoring

Beach litter data, in particularly citizen science data, is currently a highly underused management tool for identifying the sources of litter and working systematically to mitigate plastic pollution and littering

[48] These are the two identifiers that introduces the least bias in such documentations (see Falk-Andersson et al 2021).

in Norway. Monitoring of litter on shorelines and beaches using accumulation surveys is the preferred long-term monitoring strategy. Accumulation surveys are less subject to extreme variability, and it is the most widely used indicator of marine litter globally, providing data on amounts, composition, and potential sources of litter. Good quality data from beach litter surveys would meet many of Norway's key global obligations and, with modification of the protocol discussed in 4.2, cover most of the obligations and national needs identified for this compartment. OSPAR beach litter monitoring is an accumulation survey. **It is recommended that the number of OSPAR beaches be increased considerably to secure that they are more representative for litter in Norway,** thus reflecting both the amounts and sources of litter along the Norwegian coast. This would give information litter for 100m beach sections (in line with MSFG/OSPAR) and, given that the OSPAR protocol also record the beach width, it would give a measure of the number of items per area as required by the SDGs.

The need for representative site selection has been stressed by recent guidelines, including the MSFD. Given the long and heterogenous nature of the Norwegian coastline in terms of substrate, curvature and other geomorphological characteristics, there is a need for local adaptations. There may not be sufficient beaches that meet the OSPAR requirements, and it is not known if such beaches would be representative for the region. **The development of a GIS-based site selection tool is recommended.** Such a tool should stratify the coastline (e.g., into a hexagonal grid) and include different layers of information to allow for the exclusion or inclusion of sites from the selection pool, from which sites could be randomly selected. **The adaptations suggested for shoreline surveys in the Arctic** by AMAP (2021a), are relevant for Norway. This includes selecting a site with a beach-like shoreline, allowing shorter segments than 100 m if limited by rocky shores, selecting reference shorelines in remote areas exposed to the open sea, and including the zone deposited during high-water levels caused by stormier conditions (see Appendix 9 for details). This deposition zone has been identified as a possible major sink for marine litter (Olivelli et al., 2020) and including at least a portion of this zone to monitor the accumulation of litter here is recommended (GESAMP, 2019).

Given local differences in litter composition and likely sources it will be necessary to divide the coast into sub-regions to track regional trends. The MSFD TGML recommends 40 monitoring surveys per country-sub region to obtain a robust median assessment value for beach litter. The length and heterogeneity of the Norwegian coastline combined with high regional and local variability in density and composition/sources has implications for the need for within-region replication to generate regional means. **Research is needed to establish the appropriate sub-regions for Norway and their scale**, and the implications of having fewer available survey data in time and space for Norway compared to the TGML recommendations. While citizen science initiatives are likely to be biased towards highly polluted beaches, appropriate sampling design of OSPAR beaches could collect data from a representative sample of beaches. **Experts should be consulted to identify the appropriate sampling strategy to allow for detection of changes over time**, which will depend on what level of accuracy is needed and how the threshold value should be defined. **As part of this process, one should define the effect sizes (magnitudes of change) one wishes to be able to detect over certain time scales for different indicators (e.g., average total litter influx, items within the SUP directive) to facilitate power analyses and the determination of requisite sample sizes. This must be done for all environmental compartments to be monitored. It is recommended that NEA is involved in this evaluation.**

Selection of survey locations will also depend on the information requested, for example if locations should predominantly receive litter from the open sea, and/ or detect contributions from local (land-based) sources (AMAP, 2021a). Thus, **the expert investigation should be done in dialogue with managers and key stakeholders to identify their priorities for type of information and detection**

level. For new OSPAR beaches the number of annual registrations should be higher, ideally four times of year as the OSPAR beach litter protocol suggests. Due to winter conditions, local adaptations may be needed, but 3 replications should be achievable for most locations (time-period April to mid-October), assuming that those doing data collection are flexible to prevent being hindered the weather conditions and that the appropriate sites are selected for monitoring. **It is recommended that experts are consulted on the importance of securing seasonal replications for the data to be useful for comparisons across the OSPAR region and beyond, and it if is possible to compensate for lost data points due to snow and ice cover.**

It is recommended that data should be recorded in terms of number of litter items, ideally in 100 m survey units. For comparison of data between locations, data should be standardised to items/100m. Weight can be recorded as a supplement per item or per source category, with the management question guiding the resolution of the source categories.

Beach litter data can be collected quite cost- and time effectively, depending on the logistics involved. It is also possible to establish cooperation with volunteers or professional beach-cleaners to collect the litter and bring it to an appropriate facility for analysis. With appropriate training non-academic personnel can conduct and/or contribute under supervision to analysis. **It is important that GPS positions are recorded for the survey sites to ensure that the same site (and extent) is monitored during each survey. Coordination with the Rydd Norge program is recommended to explore opportunities for cooperation in sample and/or data collection**. If coordinating with clean-up activities, volunteer or professional, it is important to note that the area cleaned and surveyed will vary widely, something which is generally avoided in ecological surveys or which needs to be addressed statistically. **A statistical evaluation of the implications of variable survey area in macrolitter surveys, its implications for trend detection and power, and the need (or lack thereof) of standardisation is recommended.** While the extensive clean-up activities taking part on the Norwegian coastline is positive for reducing the litter loads, it is important to coordinate with these initiatives and **secure that beaches included in a monitoring scheme are not interfered with**.

Given the great need for replication to cover such a long coastline, it is recommended that monitoring is combined with clean-up activities. While citizen science has some clear advantages in terms of being able to collect data cost-effectively, there are also some limitations. Quality control is difficult, and mostly takes place after data collection through excluding data that is incomplete. Of 15 000 data points available from the Norwegian citizen science data on beach litter, only 20% could be used after the first round of cleaning at the national level, and even more had to be excluded when cleaning the data at the county level (M.L. Haarr et al., 2022). Citizen science protocols must be simple to avoid exhaustion of the volunteers and secure data quality. Securing data from the same stretch of beach over time and that the beach is fully cleaned is important. The former is facilitated in Rydde as the area cleaned is marked digitally on a map, although the litter status of the beach is not reported. Clean-up actions are targeting polluted beaches, and for volunteers the beaches are often close to infrastructure. This results in a bias in the site selection. It can also be challenging to engage volunteers in continuing beach cleaning and registration of data if the litter load is reduced. Continuous engagement of volunteers is important to secure citizen science data and the “adopt a beach program” run by KNB has the potential to secure high quality citizen science data from specific locations. **It is recommended that the work of KNB on citizen science and adopt a beach is secured long-term funding and that experts are involved to give advice on how to increase the monitoring value of these initiatives.**

Both KNB and the Rydd Norge program are funded by the Norwegian Retailers' Environmental Fund (NRF). The continued funding of these key initiatives to secure monitoring data is therefore dependent on a non-governmental source of funding. If this funding is discontinued, there is a risk that key competence and logistics related to securing monitoring data is lost. **It is recommended that this risk is evaluated, that NEA has a close dialogue with these actors, and that mechanisms to compensate for any reduction in funding for these initiatives are identified.**

4.4 Monitoring of the ocean surface

Extensive areas of water are needed to monitor floating macrolitter as their presence is highly variable in time and space. Limited data on floating litter is a constraint to understanding litter transportation routes and evaluate the cost-effectiveness of applying clean-up technologies targeted at this compartment (e.g. Falk-Andersson et al. (2020)). Visual observations of floating litter can be done quite cost-effectively in parallel with existing monitoring activities, as exemplified by the Barents Sea Ecosystem survey where whale observers also record litter data. **It is recommended that visual surveys are included in connection with on-going vessel-based research activities in Norway.** Many of these activities are offshore. **To get a better coverage of coastal areas using ships of opportunity should be evaluated**. Monitoring guidelines provided by the MSFD TGML (Vighi, 2022) should be followed. It is important that those collecting the data receive appropriate training.

Physical collection of litter by trawl surveys allows for a higher resolution of litter classification systems to be used, which is needed for identification of material and sources. This can also allow for comparison with other compartments, thereby improving our understanding of transportation routes and sources of litter. For vessel-based research activities, **visual observation should be combined with surface tow nets to ground-truth observation methods, get information on sources of litter by applying the Joint List and provide data to estimate the mass of floating litter.** Collection of extra information as described in section 4.2 should also be considered as this would give in-depth information on sources and transportation pathways.

As for beach litter, the Norwegian coastline is long and complex, which is challenging with respect to securing replication and representativeness. International guidelines recommend that both urban and rural coasts, as well as sites within proximity to major river outlets and shipping routes, are covered. Thus, it is recommended that experts **are consulted to identify the appropriate sampling strategy for monitoring of macrolitter on the water surface in oceans and coast, given the requested effect sizes for different indicators one would like to be able to detect.**

Apart from the size and complexity of the Norwegian waters and reduced day-light hours during the winter season, there are no other factors that require specific adjustments to Norwegian conditions. Weather conditions can be too rough for sampling, as relatively calm conditions are required, but this is a feature that is common particularly in exposed ocean areas. Technological advances may soon make visual methods reliable, which could make monitoring more cost-efficient. **Norway should contribute to and follow closely these advances and implement international recommendations with respect to adopting these technologies when they are regarded mature.**

4.5 Monitoring in the water column

While data on litter and macroplastics in the water column is scarce, this can give information on transportation pathways and sinking mechanisms. While technically feasible, as for example demonstrated by the Barents Sea survey, it is not recommended in regular monitoring programs today (AMAP, 2021a). **It is recommended that monitoring in the water column though pelagic trawling is**

continued for the Barents Sea survey. For other surveys, the opportunity to monitor by-catch in pelagic trawl catches should be evaluated as the extra cost is assumed to be low.

4.6 Monitoring of the ocean floor

IMR is conducting ocean floor surveys though monitoring of by-catch of litter as part of trawl surveys in the Barents Sea and the North Sea. **It is recommended that these surveys are continued and optimised to secure data on benthic litter in Norwegian waters.** The surveys should follow international recommendations and data collection procedures as described by ICES (2022) and implement recommendations developed by the MSFD TGML. Additional data collection applying the Joint List and Deep Dives should be considered for comparisons across compartments and to get in-depth information on sources and transportation pathways.

Phasing out of trawl techniques for seafloor assessment has been proposed due to their destructive nature. Visual censuses have been suggested as particularly suitable in Arctic areas as there are few large trawl-based fish stock assessments in these areas, issues may be more at the local scale, and great depths limits trawling operations (Grøsvik et al., accepted manuscript). Visual surveys using towed cameras, ROVs and submersibles are also suitable for rocky bottoms and can collect data on the impacts of litter on the seafloor (e.g., entanglement, coverage etc). Such documentation would give information on the impact of macrolitter on biodiversity, which are suggested indicators of SGD 14 and MSFG. **Documentation of impacts on biodiversity should be considered.**

ROV surveys, as implemented through MAREANO, are costly and require highly trained expertise. It is therefore recommended that priority is given to marine canyons and other areas that are inaccessible to trawls and are known to accumulate litter (Galgani, Hanke, Werner, Oosterbaan, et al., 2013; GESAMP, 2019). **Establishing monitoring stations in connection with the MAREANO program should be evaluated.** The joint benefit of monitoring for other stressors at these stations should be included in such an evaluation due to the high cost. **Continued documentation of litter through the MAREANO program is recommended for baseline data. The data should be collected following internationally established guidelines.** Deep Dive analyses could be considered to document items that are discarded. **Norway should contribute to and follow closely technological advances and implement international recommendations with respect to adopting these technologies when they are regarded mature.** This is expected to reduce future monitoring costs.

Apart from the size and complexity of the Norwegian waters there are no other factors that require specific adjustments to Norwegian conditions for seabed monitoring. To be able to detect trends, the sampling design should be optimised. International guidelines recommend that both urban and rural coasts, as well as sites within proximity to major river outlets and shipping routes, are covered. Different depths and substrates should also be covered. **It is recommended that experts are consulted to identify the appropriate sampling strategy for ocean and coastal monitoring, given the requested effect sizes for different indicators one would like to be able to detect.** Analysis by experts of litter recovered in clean-up actions by divers should be considered to evaluate the knowledge gained for litter hot spots in coastal areas.

Data collection through the Fishing for Litter scheme is recommended as the additional cost would be relatively small, the value of the information is expected to be high, and sampling through FFL could reduce the need for specific litter surveys trawling for litter. To improve the value of the data from FFL there is a need to solve issues related to securing meta data, that the samples can be tracked back to specific vessels, and that the sample is not polluted by other litter (see section 4.1 on logistical responsibility). Furthermore, there is a need for method development on the protocol applied for recording data. **It is recommended that a protocol is developed that is harmonised with the Joint List and that captures management relevant information to follow up policies, particularly related to producer responsibility of the fishing industry.** Application of the same protocol should be evaluated to document fishing gear recovered by the Fisheries Directorate.

4.7 Monitoring of biota

Seabirds are recommended as an indicator species for marine litter as they forage over a relatively large geographical area, they also breed in colonies making them easy to access for study purposes. Plastic in the stomachs of the Northern Fulmar is an established indicator (AMAP, 2021a). **It is recommended that monitoring of the Northern Fulmar is expanded to account for more locations in Norway**, with an option for expansion to additional species to account for regional variation. Monitoring of impact on other biota is outside the scope of this report, but in line with (AMAP, 2021a) **it is recommended that Norway contributes to and implement research and monitoring advice as these are developed in the future**.

4.8 Other environmental compartments

Monitoring of litter and macroplastic is much less well-established for non-marine environmental compartments. Still, in line with (AMAP, 2021a), it is **recommended that an initiative is taken to start baseline mapping across a wide range of environmental compartments with the aim of generating monitoring data.** Several methods already exist for monitoring macroplastics in these environments and these are likely to be applicable to the Norwegian context with minimal adaptation. Several of the lessons learnt from establishing methods for marine environments can be implemented for other environments, including the process of optimising approaches and incorporating them into monitoring programmes. However, this needs to be performed with recognition of the unique challenges associated with different environmental compartments. **It is recommended that Norway contributes to research and development of monitoring guidelines for non-marine compartments, including harmonisation efforts to secure cross-environmental comparisons and harmonisation with established marine guidelines.**

Citizen science initiatives have been initiated, but a lack of funding and communication hinders involvement of researchers in contributing to these initiatives. **It is recommended that citizen science initiatives and experts cooperate closely to secure the value of these initiatives for monitoring and other stakeholders.**

5 Conclusion

While high spatial and temporal resolution, as well as detailed information on litter items, will give the best quality monitoring data, this is costly in terms of time, money, and personnel. This report has given an overview of key obligations and needs, which is the basis for general recommendations on what a Norwegian monitoring program for litter and microplastic should include. However, giving more specific advice on the sampling strategy and level of detail of data recorded require that the purpose and aim for what the monitoring program should address is further specified. The suggested consultations with experts would be a good starting point for in dialogue with management and stakeholders identify the appropriate level of monitoring for different environmental compartments. Such investigations as well as practical experience once monitoring is implemented will determine the number of samples needed in time and space, the level of detail that should be recorded, and the logistics, equipment needs, and level of expertise required.

6 References

Aliani, S., Lusher, A. L., Primpke, S., Strand, J., de Witte, B., Nikiforov, V., Herzke, D., Roscher, L., Suaria, G., Hugo da Silva, V., Verle, K., Vanavermaete, D., Hairabedian, G., & Kallanbacj, E. (2022). *Critical Review of methods and protocols for the analysis of nano-, micro-, and macro-plastic in different environmental matrices.* Report prepared as Deliverable D1.1 for EUROqCHARM. Version 1.0 (unpublished).

Aliani, S., Lusher, A.L., Galgani, F., Herzke, D., Nikiforov, V., Primpke, S., Roscher, L., de Silva, V.H., Strand, J., Suaria, G., Vanavermaete, D., Verle, K., de Witte, B., van Bavel, B. . (under review). Reproducibility and Readiness Levels in Plastic Monitoring.

Arturo, I. A., & Corcoran, P. L. (2022). Categorization of plastic debris on sixty-six beaches of the Laurentian Great Lakes, North America. *Environmental Research Letters*, *17*(4). https://doi.org/10.1088/1748-9326/ac5714

AMAP. (2021a). *AMAP Litter and Microplastics Monitoring Guidelines. Version 1.0.*

AMAP. (2021b). *AMAP Litter and Microplastics Monitoring Plan.*

Baldwin, A. K., Corsi, S. R., & Mason, S. A. (2016a). Plastic Debris in 29 Great Lakes Tributaries: Relations to Watershed Attributes and Hydrology. *Environmental Science and Technology*, *50*(19), 10377–10385. https://doi.org/10.1021/acs.est.6b02917

Ballatore, A., Verhagen, T. J., Li, Z., & Cucurachi, S. (2021). This city is not a bin: Crowdmapping the distribution of urban litter. *Journal of Industrial Ecology*, *26*(1), 197–212. https://doi.org/10.1111/jiec.13164

Blettler, M. C. M., Ulla, M. A., Rabuffetti, A. P., & Garello, N. (2017). Plastic pollution in freshwater ecosystems: macro-, meso-, and microplastic debris in a floodplain lake. *Environmental Monitoring and Assessment*, *189*(11). https://doi.org/10.1007/s10661-017-6305-8

Brennan, E., Wilcox, C., & Hardesty, B. D. (2018). Connecting flux, deposition and resuspension in coastal debris surveys. *Science of The Total Environment*, *644*, 1019-1026. https://doi.org/10.1016/j.scitotenv.2018.06.352

Browne, M. A., Chapman, M. G., Thompson, R. C., Amaral Zettler, L. A., Jambeck, J., & Mallos, N. J. (2015). Spatial and Temporal Patterns of Stranded Intertidal Marine Debris: Is There a Picture of Global Change? *Environmental Science & Technology*, *49*(12), 7082-7094. https://doi.org/10.1021/es506057210.1021/es5060572</p>

Buhl-Mortensen, L., & Buhl-Mortensen, P. (2017). Marine litter in the Nordic Seas: Distribution composition and abundance. *Marine Pollution Bulletin*, *125*(1), 260-270.https://doi.org/10.1016/j.marpolbul.2017.08.048

Buhl-Mortensen, P., & Buhl-Mortensen, L. (2018). Impacts of Bottom Trawling and Litter on the Seabed in Norwegian Waters [Original Research]. *Frontiers in Marine Science*, *5*. https://doi.org/10.3389/fmars.2018.00042

Canals, M., Pham, C. K., Bergmann, M., Gutow, L., Hanke, G., van Sebille, E., Angiolillo, M., Buhl-Mortensen, L., Cau, A., Ioakeimidis, C., Kammann, U., Lundsten, L., Papatheodorou, G., Purser, A., Sanchez-Vidal, A., Schulz, M., Vinci, M., Chiba, S., Galgani, F., Langenkämper, D., Möller, T., Nattkemper, T. W., Ruiz, M., Suikkanen, S., Woodall, L., Fakiris, E., Jack, M. E. M., & Giorgetti, A. (2021). The quest for seafloor macrolitter: a critical review of background knowledge, current methods and future prospects. *Environmental Research Letters*, *16*(2), 023001. https://doi.org/10.1088/1748-9326/abc6d4

CBD, U. (2020). *PROPOSED HEADLINE INDICATORS OF THE MONITORING FRAMEWORK FOR THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK*. https://www.cbd.int/doc/c/d716/da69/5e81c8e0faca1db1dd145a59/wg2020-03-03-add1-en.pdf

CBD, U. (2021). *PROPOSED HEADLINE INDICATORS OF THE MONITORING FRAMEWORK FOR THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK.* https://www.cbd.int/doc/c/d716/da69/5e81c8e0faca1db1dd145a59/wg2020-03-03-add1-en.pdf

CBD, U. (2022). *REPORT OF THE EXPERT WORKSHOP ON THE MONITORING FRAMEWORK FOR THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK*. https://www.cbd.int/doc/c/3190/c3f4/1d9fe2d2dedc8c8b97023750/id-om-2022-01-02-en.pdf

Cheshire, A., Adler, E., Barbiere, J., & Cohen, Y. (2009). *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter* [Regional Seas Report and Studies](186). (IOC Technical Series, Issue.

COBSEA. (2022). *Regional Guidance on Harmonized National Marine Litter Monitoring Programmes. Monitoring Efforts and Recommendations for National Marine Litter Monitoring Programmes.*

Collard, F., Bangjord, G., Herzke, D., & Gabrielsen, G. W. (2022). Plastic burdens in northern fulmars from Svalbard: Looking back 25 years. *Marine Pollution Bulletin*, *185*, 114333. https://doi.org/https://doi.org/10.1016/j.marpolbul.2022.114333

Commission, E., Centre, J. R., Van Loon, W., Hanke, G., Fleet, D., Werner, S., Barry, J., Strand, J., Eriksson, J., Galgani, F., Gräwe, D., Schulz, M., Vlachogianni, T., Press, M., Blidberg, E., & Walvoort, D. (2020). *A European threshold value and assessment method for macro litter on the coastlines : guidance developed within the Common Implementation strategy for the Marine Strategy Framework Directive MSFD Technical Group on Marine Litter*. Publications Office. https://doi.org/doi/10.2760/54369

Corcoran, P. L., Norris, T., Ceccanese, T., Walzak, M. J., Helm, P. A., & Marvin, C. H. (2015). Hidden plastics of Lake Ontario, Canada and their potential preservation in the sediment record. *Environmental Pollution*, *204*, 17–25. https://doi.org/10.1016/j.envpol.2015.04.009

Cózar, A., Martí, E., Duarte, C. M., García-de-Lomas, J., van Sebille, E., Ballatore, T. J., Eguíluz, V. M., González-Gordillo, J. I., Pedrotti, M. L., Echevarría, F., Troublè, R., & Irigoien, X. (2017). The Arctic Ocean as a dead end for floating plastics in the North Atlantic branch of the Thermohaline Circulation. *Science Advances*, *3*(4). https://doi.org/10.1126/sciadv.1600582

Cyvin, J. B., Ervik, H., Kveberg, A. A., & Hellevik, C. (2021). Macroplastic in soil and peat. A case study from the remote islands of Mausund and Froan landscape conservation area, Norway; implications for coastal cleanups and biodiversity. *Science of The Total Environment*, *787*, 147547. https://doi.org/https://doi.org/10.1016/j.scitotenv.2021.147547

Dehnhard, N., Herzke, D., Gabrielsen, G. W., Anker-Nilssen, T., Ask, A., Christensen-Dalsgaard, S., Descamps, S., Hallanger, I., Hanssen, S. A., Langset, M., Monclús, L., O'Hanlon, N., Reiertsen, T. K., & Strøm, H. (2019). *Seabirds as indicators of distribution, trends and population level effects of plastic in the Arctic marine environment – Workshop Report.* . https://brage.nina.no/nina-xmlui/handle/11250/2627392?locale-attribute=en

Dehnhard, N., Langset, M., & Anker-Nilssen, T. (2020). *Short report from the EcoQO monitoring of plastic particles in stomachs of*
fulmars beached on the coast of Southern Norway in 2002-2020. file:///C:/Users/JAF/Downloads/Short%20Report%20Fulmar%20EcoQO%20Norway%202002-2020.pdf

de Veer, D., Drouin, A., Fischer, J., González, C., Holtmann, G., Honorato-Zimmer, D., Leyton, A., Núñez, P., Sepúlveda, J. M., Vásquez, N., & Thiel, M. (2022). How do schoolchildren perceive litter? Overlooked in urban but not in natural environments. *Journal of Environmental Psychology*, *81*. https://doi.org/10.1016/j.jenvp.2022.101781

Drægni, T., Falk-Andersson, J., & Roland, A. O. (2020). *Strandsøppel dypdykk Oslofjoden. Analyser fra midtre og ytre deler av Oslofjorden* [SALT rapport](1045).

Drægni, T. T., & Falk-Andersson, J. (2019). *Strandsøppel Dypdykk Oslofjorden (Beach litter deep dives in the Oslo fjord)* [SALT rapport](1032).
Earn, A., Bucci, K., & Rochman, C. M. (2021a). A systematic review of the literature on plastic pollution in the Laurentian Great Lakes and its effects on freshwater biota. *Journal of Great Lakes Research*, *47*(1), 120–133. https://doi.org/https://doi.org/10.1016/j.jglr.2020.11.001
EC. (2022). *MSFD CIS Guidance Document*. https://circabc.europa.eu/d/d/workspace/SpacesStore/d2292fb4-ec39-4123-9a02-2e39a9be37e7/GD19%20-%20MSFDguidance_2022_Art.8Assessment(1).pdf
Egessa, R., Nankabirwa, A., Basooma, R., & Nabwire, R. (2020). Occurrence, distribution and size relationships of plastic debris along shores and sediment of northern Lake Victoria. *Environmental Pollution*, *257*. https://doi.org/10.1016/j.envpol.2019.113442
Eggen, S., Kristensen, K., & Sklet, S. (2021). *Reduced littering from expanded plastics - Mapping and evaluation of measures*. https://salt.nu/assets/projects/M2189-1650544348.pdf
Eriksson, C., Burton, H., Fitch, S., Schulz, M., & van den Hoff, J. (2013). Daily accumulation rates of marine debris on sub-Antarctic island beaches. *Marine Pollution Bulletin*, *66*(1), 199-208. https://doi.org/https://doi.org/10.1016/j.marpolbul.2012.08.026
DIRECTIVE (EU) 2019/904 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on the reduction of the impact of certain plastic products on the environment, 19 (2019). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0904&from=EN
Falk-Andersson, J. (2021). Beach litter deep dives- A method for improved understanding of sources of and behaviour behind littering. *Marine Pollution Bulletin*, *167*, 112346. https://doi.org/https://doi.org/10.1016/j.marpolbul.2021.112346
Falk-Andersson, J., Berkhout, B. W., & Abate, T. G. (2019). Citizen Science for Better Management: Lessons Learned from Three Norwegian Beach Litter Data Sets. *Marine Pollution Bulletin*, *138*, 364-375.
Falk-Andersson, J., Larsen Haarr, M., & Havas, V. (2020). Basic principles for development and implementation of plastic clean-up technologies: What can we learn from fisheries management? *Science of The Total Environment*, *745*, 141117. https://doi.org/10.1016/j.scitotenv.2020.141117
Falk-Andersson, J., Lindquist, A., Leone, G., Dijkstra, H., De Frond, H., Rognerud, I., Lantagne, J., Ammendolia, J., Fürst, F., Eriksen, E., Karasik, R., Utz, R., Walker, T. R., & Diana, Z. (in prep.). Cleaning up without messing up: maximizing benefits of plastic clean-up technologies through new regulatory approaches.
Falk-Andersson, J., Olaussen, E. D., & Macintyre, C. (2018). *Strandsøppel dypdykk for forebygging av marin forsøpling* (1025).
Falk-Andersson, J., & Strietman, W. J. (2019). *Svalbard Beach Litter Deep Dive* [SALT rapport](1033).
Falk-Andersson, J., Tairova, Z., Tokvam Drægni, T., & Larsen Haarr, M. (2021). Methods for determining the geographical origin and age of beach litter: Challenges and opportunities. *Marine Pollution Bulletin*, *172*, 112901. https://doi.org/https://doi.org/10.1016/j.marpolbul.2021.112901
Fleet, D., Vlachogianni, T., & Hanke, G. (2021). *A Joint List of Litter Categories for Marine Macrolitter Monitoring*.
Free, C. M., Jensen, O. P., Mason, S. A., Eriksen, M., Williamson, N. J., & Boldgiv, B. (2014). High-levels of microplastic pollution in a large, remote, mountain lake. *Marine Pollution Bulletin*, *85*(1), 156–163. https://doi.org/10.1016/j.marpolbul.2014.06.001
Galgani, F., Hanke, G., Werner, S., & De Vrees, L. (2013). Marine litter within the European Marine Strategy Framework Directive. *ICES Journal of Marine Science*, *70*(6), 1055-1064.
Galgani, F., Hanke, G., Werner, S., Oosterbaan, L., Nilsson, P., Fleet, D., Kinsey, S., Thompson, R. C., van Franeker, J., Vlachogianni, T., Scollos, M., Veiga, J. M., Palatinus, A., Matiddi, M., Maes, T., Korpinen, S., Budizak, A., Leslie, H., Gago, J., & Liebezeit, G. (2013). *Guidance on*

Monitoring of Marine Litter in European Seas (EUR 26113 EN). https://publications.europa.eu/en/publication-detail/-/publication/76da424f-8144-45c6-9c5b-78c6a5f69c5d/language-en

GESAMP. (2019). *Guidelines for the Monitoring and Assessment of Plastic Litter in the Ocean*. GESAMP. http://www.gesamp.org/publications/guidelines-for-the-monitoring-and-assessment-of-plastic-litter-in-the-ocean

González-Fernández, D., & Hanke, G. (2017). Toward a Harmonized Approach for Monitoring of Riverine Floating Macro Litter Inputs to the Marine Environment [Technology Report]. *Frontiers in Marine Science*, *4*. https://doi.org/10.3389/fmars.2017.00086

Grøsvik, B. E., Buhl-Mortensen, L., Bergmann, M., Booth, A. M., Gomiero, A., & Galgani, F. (accepted manuscript). Status and future recommendations for recording and monitoring litter on the Arctic seafloor. *Arctic Science*, *0*(ja), null. https://doi.org/10.1139/as-2022-0017

Grøsvik, B. E., Prokhorova, T., Eriksen, E., Krivosheya, P., Horneland, P. A., & Prozorkevich, D. (2018). Assessment of Marine Litter in the Barents Sea, a Part of the Joint Norwegian–Russian Ecosystem Survey. *Frontiers in Marine Science*, *5*, 72. https://doi.org/10.3389/fmars.2018.00072

Haarr, M. L., Falk-Andersson, J., & Fabres, J. (2022). Global marine litter research 2015–2020: Geographical and methodological trends. *Science of The Total Environment*, *820*, 153162. https://doi.org/https://doi.org/10.1016/j.scitotenv.2022.153162

Haarr, M. L., Hojman, C., Martinussen, K., C.J., B., Solbakken, V. S., Pieres, R., & Falk-Andersson, J. (2022). *Marin forsøpling i norske fylker. Mengder, sammensetning, kilder og veivalg videre i forvaltningsøyemed* (SALT rapport, Issue. https://salt.nu/assets/projects/Marin-forsopling-i-norske-fylker---KVANTESPRANG-Sluttrapport-2022.pdf

Haarr, M. L., Westerveld, L., Fabres, J., Iversen, K. R., & Busch, K. E. T. (2019). A novel GIS-based tool for predicting coastal litter accumulation and optimising coastal cleanup actions. *Marine Pollution Bulletin*, *139*, 117-126. https://doi.org/10.1016/j.marpolbul.2018.12.025

Havas, V., Rødås, H. J., & Haarr, M. L. (2018). *Kunnskapsinnhenting i Fishing For Litter* [SALT rapport](1020).

Héder, M. (2017). From NASA to EU: the evolution of the TRL scale in Public Sector Innovation. *The Innovation Journal*, *22*, 1.

Hengstmann, E., & Fischer, E. K. (2020). Anthropogenic litter in freshwater environments – Study on lake beaches evaluating marine guidelines and aerial imaging. *Environmental Research*, *189*. https://doi.org/10.1016/j.envres.2020.109945

Hoellein, T. J., Westhoven, M., Lyandres, O., & Cross, J. (2015). Abundance and environmental drivers of anthropogenic litter on 5 Lake Michigan beaches: A study facilitated by citizen science data collection. *Journal of Great Lakes Research*, *41*(1), 78–86. https://doi.org/https://doi.org/10.1016/j.jglr.2014.12.015

Hong, S., Lee, J., Kang, D., Choi, H.-W., & Ko, S.-H. (2014). Quantities, composition, and sources of beach debris in Korea from the results of nationwide monitoring. *Marine Pollution Bulletin*, *84*(1), 27-34. https://doi.org/https://doi.org/10.1016/j.marpolbul.2014.05.051

Hurley, R. (2021). *Literature review of current methods for monitoring of macroplastic in environment*. Sino-Norwegian cooperation project on capacity building for reducing plastic and microplastic pollution (SINOPLAST)

Hurley, R., Braaten, H. F. V., Nizzetto, L., E.S., H., Lin, Y., Clayer, F., van Emmerik, T., Buenaventura, N. T., Eidsvoll, D. T., Økelsrud, A., Norling, M., Adam, H., & Olsen, M. (submitted). Measuring riverine macroplastic: Methods, harmonisation, and quality control.

ICES. (2017). *SISP 15 - Manual of the IBTS North Eastern Atlantic Surveys. Series of ICES Survey Protocols (2012–2020). Report.* . https://doi.org/10.17895/ices.pub.3519

ICES. (2021). *Working Group on Marine Litter (WGML; outputs from 2020 meeting).* (ICES Scientific Reports, Issue.

ICES. (2022). *ICES Manual for Seafloor Litter Data Collection and Reporting from Demersal Trawl Samples.* (ICES Techniques in Marine Environmental Science (TIMES). , Issue. https://doi.org/10.17895/ices.pub.21435771.v1

Jacob, M., Moe, N., & Falk-Andersson, J. (2021). *Søppelanalyse Akerselva (TrashTrawl)* (SALT rapport, Issue. https://salt.nu/assets/projects/Soppelanalyse-Akerselva--TrashTrawl.pdf

Johnsen, H. R., Falk-Andersson, J., Haarr, M. L., Roland, A. O., Sanli, E., By-Larsen, I., Nogueira, L. A., Vangelsten, B. V., & Pedersen, V. (2019). *HAVPLAST: Delrapport Tiltak og Indikatorer. (HAVPLAST: report on measures and indicators)* [SALT rapport](1304).

Johnsen, H. R., Haarr, M. L., Roland, A. O., Johannessen, E. R., Bye-Larsen, I., Vangelsten, B. V., & Nogueira, L. A. (2019). *Sluttrapport HAVPLAST – Marin plast fra norsk sjømatnæring – kartlegging, kvantifisering og handling. (Final report HAVPLAST- Marine plastics from the Norwegian seafood industry- mapping, quantification and actions)* [SALT rapport](1040).

KLD. (2021). *Norges plaststrategi*. https://www.regjeringen.no/contentassets/ccb7238072134e74a23c9eb3d2f4908a/nn-no/pdfs/noregs-plaststrategi.pdf

KNB. (2022). *Forsøpling langs vassdrag og innsjøer i Norge 2021* (Hold Norge Rent Rapport, Issue. https://holdnorgerent.no/wp-content/uploads/2022/10/HNR-Vassdrag-og-innsjoerrapporten-2021-digital.pdf

Krebs, C. J. (1999). *Ecological Methodology*

Lechthaler, S., Waldschläger, K., Stauch, G., & Schüttrumpf, H. (2020). The way of macroplastic through the environment. In *Environments - MDPI* (Vol. 7, Issue 10, pp. 1–30). MDPI AG. https://doi.org/10.3390/environments7100073

Li, S., Ding, F., Flury, M., Wang, Z., Xu, L., Li, S., Jones, D. L., & Wang, J. (2022). Macro- and microplastic accumulation in soil after 32 years of plastic film mulching. *Environmental Pollution*, *300*. https://doi.org/10.1016/j.envpol.2022.118945

Lusher, A. L., Provencher, J. F., Baak, J. E., Hamilton, B. M., Vorkamp, K., Hallanger, I. G., Pijogge, L., Liboiron, M., Bourdages, M. P. T., Hammer, S., Gavrilo, M., Vermaire, J. C., Linnebjerg, J. F., Mallory, M. L., & Gabrielsen, G. W. (2022). Monitoring litter and microplastics in Arctic mammals and birds. *Arctic Science*, *8*(4), 1217-1235. https://doi.org/10.1139/as-2021-0058

MARFO. (2021). *Forslag til modell for datafangst fra Rydd Norge Prosjektet*.

Michida, Y., Chavanich, S., Chiba, S., Cordova, M. R., Cozsar Cabanas, A., Glagani, F., Hagmann, P., Hinata, H., Isobe, A., Kershaw, P., Kozlovskii, N., Li, D., Lusher, A. L., Marti, E., Mason, S. A., Mu, J., Saito, H., Shim, W. J., Syakti, A. D., Takada, H., Thompson, R., Tokai, T., Uchida, K., Vasilenko, K., & Wang, J. (2019). *Guidelines for Harmonizing Ocean Surface Microplastic Monitoring Methods. Ministry of the Environment Japan,* . http://dx.doi.org/10.25607/OBP-867

NEA. (2022). *Videreutvikling av produsentansvaret i Norge*. https://www.miljodirektoratet.no/aktuelt/nyheter/2022/november-2022/produsenter-far-storre-ansvar-for-produktene-som-avfall/

Ngupula, G. W., Kayanda, R. J., & Mashafi, C. A. (2014). Abundance, composition and distribution of solid wastes in the Tanzanian waters of Lake Victoria. *African Journal of Aquatic Science*, *39*(2), 229–232. https://doi.org/10.2989/16085914.2014.924898

NMCE. (2017). *Update of the integrated management plan for the Norwegian Sea*. https://www.regjeringen.no/contentassets/e24684b247d64455a90070daba993291/en-gb/pdfs/stm201620170035000engpdfs.pdf

NP/NEA. (2022). *Vurdering av nåsituasjon og behovene for videreutvikling av miljøovervåkningen på Svalbard knyttet til ferskvann og kyst*.

Olivelli, A., Hardesty, B. D., & Wilcox, C. (2020). Coastal margins and backshores represent a major sink for marine debris: insights from a continental-scale analysis. *Environmental Research Letters*, *15*(074037). https://iopscience.iop.org/article/10.1088/1748-9326/ab7836

OSPAR. (2010). *Guideline for monitoring marine litter on the beaches in the OSPAR maritime area*.
OSPAR. (2022a). *Monitoring and assessing marine litter*. Retrieved 17.08.2022 from https://www.ospar.org/work-areas/eiha/marine-litter/assessment-of-marine-litter
OSPAR. (2022b). *The second OSPAR Regional Action Plan on Marine Litter*. https://www.ospar.org/documents?v=48461#:~:text=This%20Second%20OSPAR%20Regional%20Action%20Plan%20%28RAP%20ML,objectives%20of%20the%20North-East%20Atlantic%20Environment%20Strategy%202030.
Piehl, S., Leibner, A., Löder, M. G. J., Dris, R., Bogner, C., & Laforsch, C. (2018). Identification and quantification of macro- and microplastics on an agricultural farmland. *Scientific Reports*, *8*(1). https://doi.org/10.1038/s41598-018-36172-y
Pietz, O., Augenstein, M., Georgakakos, C. B., Singh, K., McDonald, M., & Walter, M. T. (2021). Macroplastic accumulation in roadside ditches of New York State's Finger Lakes region (USA) across land uses and the COVID-19 pandemic. *Journal of Environmental Management*, *298*. https://doi.org/10.1016/j.jenvman.2021.113524
Rohaningsih, D., Henny, C., Suryono, T., & Santoso, A. B. (2022). Macroplastic abundance at Lake Singkarak riparian, West Sumatera. *IOP Conference Series: Earth and Environmental Science*, *1062*(1). https://doi.org/10.1088/1755-1315/1062/1/012025
Roland, A. O., & Cyvin, J. B. (2021). *Dypdykk med byggnæringen*. https://salt.nu/assets/projects/Dypdykk-byggenaeringen-2021.pdf
Ryan, P. G., Lamprecht, A., Swanepoel, D., & Moloney, C. L. (2014). The effect of fine-scale sampling frequency on estimates of beach litter accumulation. *Marine Pollution Bulletin*, *88*(1), 249-254. https://doi.org/https://doi.org/10.1016/j.marpolbul.2014.08.036
Sa'adu, I., & Farsang, A. (2022). Greenhouse farming as a source of macroplastic and microplastics contamination in agricultural soils: a case study from Southeast-Hungary. *Agrokemia Es Talajtan*, *71*(1), 43–57. https://doi.org/10.1556/0088.2022.00120
Sander, G., Cochrane, S., Platjouw, F. M., Hermman, D. Ø., & Andersen, J. H. (2022). *To veier mot god miljøtilstand. En sammenlikning av EU sitt havstrategidirektiv med de norske havforvaltningsplanene.*
Schulz, M., Neumann, D., Fleet, D. M., & Matthies, M. (2013). A multi-criteria evaluation system for marine litter pollution based on statistical analyses of OSPAR beach litter monitoring time series. *Marine Environmental Research*, *92*, 61-70. https://doi.org/10.1016/j.marenvres.2013.08.013
Smith-Johansen, S., & Sagen, H. (2022). *Report on cruises and data stations 2021* (Rapport fra havforskningen, Issue. https://www.hi.no/templates/reporteditor/report-pdf?id=59792&36846524
Smith, S. D. A., & Markic, A. (2013). Estimates of Marine Debris Accumulation on Beaches Are Strongly Affected by the Temporal Scale of Sampling. *PLOS ONE*, *8*(12), e83694. https://doi.org/10.1371/journal.pone.0083694
Solbakken, V. S., Kleiven, S., & Haarr, M. L. (2022). Deposition rates and residence time of litter varies among beaches in the Lofoten archipelago, Norway. *Marine Pollution Bulletin*, *177*, 113533. https://doi.org/https://doi.org/10.1016/j.marpolbul.2022.113533
Standal, E., Nashoug, B. F., Haarr, M. L., & Busch, E. T. (2019). *Utredning av OSPAR-strender* (SALT rapport, Issue.
Stefano, N., & Pleissner, D. (2022). Quantification and analysis of surface macroplastic contamination on arable areas. *Journal of Soils and Sediments*, *22*(3), 757–768. https://doi.org/10.1007/s11368-021-03114-7
Syberg, K., Palmqvist, A., Khan, F. R., Strand, J., Vollertsen, J., Clausen, L. P. W., Feld, L., Hartmann, N. B., Oturai, N., Møller, S., Nielsen, T. G., Shashoua, Y., & Hansen, S. F. (2020). A nationwide assessment of plastic pollution in the Danish realm using citizen science. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-74768-5

UNEP. (1995). *Global programme of action for the protection of the marine environment from land-based activities.*
UNEP. (2021a). *Understanding the State of the Ocean: A Global Manual on Measuring SDG 14.1.1, SDG 14.2.1 and SDG 14.5.1*. https://wedocs.unep.org/20.500.11822/35086
UNEP. (2021b). *Understanding the State of the Ocean: A Global Manual on Measuring SDG 14.1.1, SDG 14.21 and SDG 14.5.1*. https://wedocs.unep.org/handle/20.500.11822/35086
UNEP. (2022). *UNEA Resolution 5/14 entitled "End plastic pollution: Towards an international legally binding instrument"*. https://wedocs.unep.org/bitstream/handle/20.500.11822/39812/OEWG_PP_1_INF_1_UNEA%20resolution.pdf
van Emmerik, T., Kieu-Le, T. C., Loozen, M., Oeveren, K. van, Strady, E., Bui, X. T., Egger, M., Gasperi, J., Lebreton, L., Nguyen, P. D., Schwarz, A., Slat, B., & Tassin, B. (2018). A methodology to characterize riverine macroplastic emission into the ocean. *Frontiers in Marine Science*, *5*(OCT). https://doi.org/10.3389/fmars.2018.00372
van Franeker, J. A., Kühn, S., Anker-Nilssen, T., Edwards, E. W. J., Gallien, F., Guse, N., Kakkonen, J. E., Mallory, M. L., Miles, W., Olsen, K. O., Pedersen, J., Provencher, J., Roos, M., Stienen, E., Turner, D. M., & van Loon, W. M. G. M. (2021). New tools to evaluate plastic ingestion by northern fulmars applied to North Sea monitoring data 2002–2018. *Marine Pollution Bulletin*, *166*, 112246. https://doi.org/https://doi.org/10.1016/j.marpolbul.2021.112246
van Sebille, E. A., Stefano ; Law, Kara Lavender ; Maximenko, Nikolai ; Alsina, Jose ; Bagaev, Andrei ; Bergmann, M. ; Chapron, Bertrand ; Chubarenko, Irina ; Cózar, Andres ; Delandmeter, Philippe ; Egger, Matthias ; Fox-Kemper, Baylor ; Garaba, Shungudzemwoyo P. ; Goddijn-Murphy, Lonneke ; Hardesty, Britta Denise ; Hoffman, M. ; Isobe, Atsuhiko ; Jongedijk, Cleo ; Kaandorp, Mikael ; Khatmullina, Liliya ; Koelmans, A.A. (2020). The physical oceanography of the transport of floating marine debris. *Environmental Research Letters*, *15*.
Vaughan, R., Turner, S. D., & Rose, N. L. (2017). Microplastics in the sediments of a UK urban lake. *Environmental Pollution*, *229*, 10–18. https://doi.org/10.1016/j.envpol.2017.05.057
Vighi, M., Ruiz-Orejón, L.F.,Hanke,. (2022). *Monitoring of Floating Marine Macro Litter–State of the art and literature overview* (JRC Technical Report, Issue.
Wang, S., Fan, T., Cheng, W., Wang, L., Zhao, G., Li, S., Dang, Y., & Zhang, J. (2022). Occurrence of macroplastic debris in the long-term plastic film-mulched agricultural soil: A case study of Northwest China. *Science of the Total Environment*, *831*. https://doi.org/10.1016/j.scitotenv.2022.154881
WCMC, U. (2020). *Indicator metadata sheet*. https://www.post-2020indicators.org/pdfs/178?type=headline
Yakushev, E., Gebruk, A., Osadchiev, A., Pakhomova, S., Lusher, A., Berezina, A., van Bavel, B., Vorozheikina, E., Chernykh, D., Kolbasova, G., Razgon, I., & Semiletov, I. (2021). Microplastics distribution in the Eurasian Arctic is affected by Atlantic waters and Siberian rivers. *Communications Earth & Environment*, *2*(1), 23. https://doi.org/10.1038/s43247-021-00091-0
Zbyszewski, M., & Corcoran, P. L. (2011). Distribution and degradation of fresh water plastic particles along the beaches of Lake Huron, Canada. *Water, Air, and Soil Pollution*, *220*(1–4), 365–372. https://doi.org/10.1007/s11270-011-0760-6
Zbyszewski, M., Corcoran, P. L., & Hockin, A. (2014). Comparison of the distribution and degradation of plastic debris along shorelines of the Great Lakes, North America. *Journal of Great Lakes Research*, *40*(2), 288–299. https://doi.org/https://doi.org/10.1016/j.jglr.2014.02.012

Appendix 1

Participants and their affiliation invited to the NORqCHARM workshop. Organisers are marked in yellow.

Name	Organisation
Helga Bårdsdatter Kristiansen	MARFO
Anja Meland Rød	MARFO
Liv-Marit Hansen Toverud	Oslofjordens friluftsråd
Malin Dahl	Hold Norge Rent
Tor Nordam	SINTEF
Nicolay Moe	Oslofjordens friluftsråd
Sjur Nesheim	Handelens miljøfond
Ingvild Sundal Joys	Naturvernforbundet
Marthe Larsen Haarr	SALT
Bert van Bavel	NIVA
Eirik Oland	Handelens miljøfond
Randi Kjærstad Hagerup	Sunnmøre friluftsråd
Kine Martinsen	Miljødirektoratet
Carina Thomassen	Grid Arendal
Ieva Rucevska	Grid Arendal
Eirik Okkenhaug	Bymiljøetaten Oslo
Håkon Vikøren	Bymiljøetaten Oslo
Mari Mo Osterheider	Hold Norge Rent
Jannike Wika	Sysselmesteren på Svalbard
Jannike Falk-Andersson	NIVA
Kathinka Furst	NIVA
Tora Tokvam Drægni	Bymiljøetaten Oslo
Torjus Solheim Eckhoff	Grid Arendal
Johannes Röhrs	Meteorologisk institutt
Eivind Farmen	Miljødirektoratet
Therese Fosholt Moe	Handelens miljøfond
Helene Svendsen	GRID-Arendal
Tove Lill Karlsen	
Helene Skjeie Thorstensen	SALT
Sverre Hjelset	NIVA
Siri Karine Hanslien	WWF
Frode Skjævestad	Kystverket
Synnøve Fagerhaug Dalen	Handelens miljøfond
Eirin Husabø	Grid Arendal
Anja Alvestad	SINTEF
Hilde Sofie Berg	Fiskeridirektoratet
Jonas Oliver Elnes	Statsforvalteren

Appendix 2

Table 41**. Norwegian microplastic and litter entries in databases and applications by type of environment, area, year(s) of study, protocol used, data storage and date the data was accessed.**

Full Reference	Type	Remarks	Type of environment	Area	Year(s) of study	Protocol used	Data storage	Date of access
Emodnet	Database	Beach name Kviljo - Survey type Monitoring	Beach	Agder	2011-2019	OSPAR	EMODnet	02.11.2022
Emodnet	Database	Beach name Været - Survey type Monitoring	Beach	Trondheim	2015-2019	OSPAR	EMODnet	02.11.2022
Emodnet	Database	Beach name Følvika - Survey type Cleaning	Beach	Møre og Romsdal	2015	TSG_ML	EMODnet	02.11.2022
Emodnet	Database	Beach name Rekvika - Survey type Monitoring	Beach	Tromsø	2012-2019	OSPAR	EMODnet	02.11.2022
Emodnet	Database	Beach name Sandfordneset - Survey type Monitoring	Beach	Finnmark	2011-2014	OSPAR	EMODnet	02.11.2022
Emodnet	Database	Beach name: Åpenvikbukta- Survey type Monitoring	Beach	Finnmark	2018-2019	OSPAR	EMODnet	28.11.2022
Emodnet	Database	Beach name: Brucebukta- Survey type Monitoring	Beach	Svalberd	2011-2019	OSPAR	EMODnet	28.11.2022

Debristracker	Database	Tracks individual items at locations with the date recorded- You can filter by categori (material type) and timeframe. Eeach individual recording has to be investigated to get information on composition. Over 1000 hits for Norway, so too time consuming to investigate this.				Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Oslo	Database	33 hits - mostly beach - some urban	Mostly shoreline, some urban	Oslo		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Viken	Database	65 Hits - all Urban	Urban environment	Viken		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Agder	Database	713 hits - mostly beach	Mostly shoreline	Agder		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Rogaland	Database	1 hit - food wrapper collected on 2019-08-27	Few items registered	Rogaland		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Innlandet	Database	2 hits - collected in Urban enrionvments	Few items registered	Innlandet		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Nordland	Database	98 hits - mostly collected along the shorelines - some urban	Mostly shoreline, some urban	Nordland		Allows for multiple protocols	Debristracker	02.11.2022

Debristracker Troms og Finmark	Database	226 hits - most collected by urban areas, but some collected by shorelines	Mostly urban, some shoreline	Troms og Finmark		Allows for multiple protocols	Debristracker	02.11.2022
Marine Litter Watch - European Environment Agency	Database	The data presented is provided by the user community using either the EEA marine litterwatch smartphone app or and agreed data exchange mechanism with the EEA marine litterwatch databesa (external import).1 event hit when searching in Norway - the hit is registered at 2015/09/14 - at Følvika beach - 241 no of items were registered with material, and litter item - detailed description for each piece.	Shoreline	Nordland	2015	MSFD harmonised list	Marine LitterWatch data viewer	02.11.2022
RyddNorge database	Database	Based on Falk-Andersson et al (2019) data is available from 2015. The data portal crashed when trying to access data from 2000 onwards, so not	Shoreline		2015-2022	Ocean Conservancy adapted to Norway	RyddNorge data	02.11.2022

		possible to verify the first year of data using Ryddenorge.no						
Fiskedirektoratets kart av tapte redskap	Database	Coordinates of recovered fishing equipment, date and time, depth, type of equipment. Mostly off-shore, but some close to the coast.	Seafloor	Norwegian coast/sea	2017-2022	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2022	Database	189 recoveries	Seafloor	Norwegian coast/sea	2022	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2021	Database	165 recoveries	Seafloor	Norwegian coast/sea	2021	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2020	Database	163 recoveries	Seafloor	Norwegian coast/sea	2020	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2019	Database	94 recoveries	Seafloor	Norwegian coast/sea	2019	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2018	Database	165 recoveries	Seafloor	Norwegian coast/sea	2018	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2017	Database	135 recoveries	Seafloor	Norwegian coast/sea	2017	Own protocol	Yggdrasil	02.11.2022
DeepDive database. https://deepdive.grida.no/	Database	Shows location on a worldmap beach cleanup events - currently only 6 events along beaches in Norway, and 8 points in Svalbard. Database under development, thus do not report here the data points.	Shoreline	Svalbard, Troms, Trøndelag	N/A	Deep dive protocol for the Arctic modified from Ocean Concervancy	Private server	03.11.22

Empact (webpage no longer working 29.11.2022)	Application	Pick up trash along the way, get points for every piece of litter you pick up that you may use on rewards or donate to even more litter clean up. Application also tracks how much litter is cleaned up	All			Protocol included in the application	N/A	
Miljølære	Database	Records much time has been spent cleaning up, how many people involved, how many items, weight, source categories, and pre-defined nationality categories.	Shoreline	36 beaches in Norway	2017-2022	No documentation of protocol development. Own protocol including pre-defined nationalities.	Miljolare.no	07.11.22
CrowdWater	Application	Users may register findings and add pictures of findings in the app. For Norway there are only 1 finding of documented plastics in Oslo, in Akerselva. The findings are poorly described only stating "plastics observed" and a picture which is hard to interpret	Freshwater	Oslo	N/A	Register in application	CrowdWater	09.11.2022
Floating Litter Monitoring app	Application	Could not find resources of this application or where	Floating	N/A	N/A	N/A	N/A	N/A

		to download it? maybe it's not released yet?						
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year August/ September following OSPAR protocol	Beach	Arctic Seas Været, Trøndelag	2015-2020	OSPAR 100m beach litter survey	OSPAR	14.11.2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year June/July following OSPAR protocol	Beach	Arctic Seas, Brucebukta, Svalbard	2011-2019	OSPAR 100m beach litter survey	OSPAR	15.11.2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year June/July following OSPAR protocol	Beach	Arctic Seas, Luftskipodden, Svalbard	2011-2020	OSPAR 100m beach litter survey	OSPAR	15.11.2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted almost twice a year (April/May and September/October) following OSPAR protocol	Beach	Arctic Seas, Rekvika, Troms	2011-2020	OSPAR 100m beach litter survey	OSPAR	15.11.2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted almost twice a year (April and October) following OSPAR protocol	Beach	Northern North Sea, Kviljo, Agder	2011-2020	OSPAR 100m beach litter survey	OSPAR	15.11.2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted twice a year (June and	Beach	Arctic Seas, Sandfjordneset, Finnmark	2011-2014	OSPAR 100m beach litter survey	OSPAR	15.11.2022

		October) following OSPAR protocol						
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year (April/March) following OSPAR protocol	Beach	Northern North Sea, Ytre Hvaler, Viken	2012-2020	OSPAR 100m beach litter survey	OSPAR	15.11.2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year (September/October) following OSPAR protocol	Beach	Arctic Seas, Åpenvikbukta, Finnmark	2018-2020	OSPAR 100m beach litter survey	OSPAR	15.11.2022

Table 42 Norwegian macrolastic and litter data reported in research papers by type of environment, area, year(s) of study, protocol used and data storage

Full Reference	**Remarks**	**Type of environment**	**Area**	**Year(s) of study**	**Protocol used**	**Data storage**
The rise in ocean plastics evidenced from a 60-year time series	Macroplastic entanglement on the Continuous Plankton Recorder applied by Ships of Opportunity.	Coastline surface	Different locations around the Norwegian coast	1957-2016	Own protocol - recorded occurrence of macroplastic entanglement.	All data used can be accessed via www.cprsurvey.org
Citizen science for better management: Lessons learned from three Norwegian beach litter data sets	Analysis of data from OSPAR beaches and citizen science data from KNB and Lofoten Waste Management (LAS).	Shoreline	Beaches from the Norwegian coast including Lofoten Islands and west coast of Svalbard	OSPAR/ LAS: 2011-2016 KNB: 2015-2016	No primary data collected.	N/A
Marine litter in the Nordic Seas: Distribution composition and abundance.	1778 video transects. Presents density, distribution and	Sea floor	Norwegian Sea - 1778 stations Data from	Aggregated results from	Video transects. Litter categorised according 12 material types. One	Norsk Marint Datasenter

https://doi.org/10.1016/j.marpolbul.2017.08.048	composition of litter from large-scale mapping of seabed litter in arctic and subarctic waters. Count number of items and use an undocumented item-to weight table to convert from items to weight.		Mareano programme 2006-2017	surveys in 2006-2017	source category: fishing gear.	
Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins	Data from 588 video and trawl surveys across 32 sites in European waters. Norwegian stations documented using imaging imaging technology	Seafloor	3 stations along the Norwegian coast	2007	Items counted and categorised into: plastic (all plastic with exception of fishing line and net), derelict fishing gear (fishing line or net), metal, glass, clinker (residue of burnt coal), and Other.	Private server
Methods for determining the geographical origin and age of beach litter: Challenges and opportunities. https://doi.org/10.1016/j.marpolbul.2021.112901	Method paper on how age and geographical origin should be reported to produce reliable data. Reports findings from Svalbard.	Shoreline	Svalbard	2019	Standardised method for identifying age and geographical origin of packaging	Private server
Assessment of Marine Litter in the Barents Sea, a Part of the Joint Norwegian–Russian Ecosystem Survey. Frontiers in Marine Science, 5, 72. Grøsvik et al 2018 (https://core.ac.uk/display/153657646)	Large-scale monitoring of marine litter conducted by joint Norwegian-Russian ecosystem survey. Data from bycatch trawling in the pelagic waters, bottom trawling close to seafloor & floating	Surface, pelagic and seabed	Barents sea	2010-2016	Both weight and number of items is registered according to the following categories: metal, glass, ceramics, paper, processed wood, rope/line, pieces of nets, buoys/bobbins, other plastic, other.	Norsk Marint Datasenter

	marine litter by visual observation.					
Macroplastic in soil and peat. A case study from the remote islands of Mausund and Froan landscape conservation area, Norway; implications for coastal cleanups and biodiversity. https://doi.org/10.1016/j.scitotenv.2021.147547	Soils samples of 27-33 m depth. Weight in grams and divided into: commercial ropes, not ropes, private (on the fly) and household items, pyroplastic, other. Type of plastic analysed using Raman Spectrometer.	Soil	Mausund and Froan landscape conservation area	2020	Own protocol described in the paper	Private server
Plastic ingestion by Atlantic cod (Gadus morhua) from the Norwegian coast. https://doi.org/10.1016/j.marpolbul.2016.08.034	Cod stomachs from 6 sites in Norway investigated for plastic. Counts of microplastic, mesoplastic and macroplastic. Polymer types identified.	Biota	Oslo, Bergen, Sørfjorden, Karihavet, Lofoten and Varangerfjorden	Not reported	Own protocol described in the paper	Private server

Table 43 Norwegian macroplastic and litter data reported in reports by type of environment, area, year(s) of study, protocol used and data storage.

Full Reference	**Remarks**	**Type of environment**	**Area**	**Year(s) of study**	**Protocol used**	**Data storage**
OVERSIKT FORSØPLING I NORSKE KOMMUNER (holdnorgerent.no)	Summarises methods for macroplastic documentation in urban environments.	Urban environment			Combination of methods from Clean Europe Network og Håll Sverige Rent on sampling and litter item registration.	Private server

Forsøpling langs vassdrag og innsjøer i Norge 2021 . https://holdnorgerent.no/wp-content/uploads/2022/10/HNR-Vassdrag-og-innsjoerrapporten-2021-digital.pdf	Mapping of littering along waterways and lakes in Norway. 38 locations.	Waterways and Lakes	Oslo, møre og Romsdal, Viken, Vestland, Agder, Innlandet, Trøndelag, Vestfold og Telemark, Nordland, Troms og Finmark, Rogaland and Troms	2017-2021	Ocean Conservancy litter item protocol adapted to Norway. Origin of sampling methodology not described.	Private server
Sources of Marine Litter - Workshop report from WP 1.2 in the Marp^3 project. https://salt.nu/en/projects/marp3-sources-of-marine-litter	Workshop to collate experts from relevant industries to determine the degree to which it is possible to precisely identify marine litter and examine the sources, causes of loss, and ages of different pieces of debris	Shoreline	Svalbard	2016	Exploratory protocol identifying origin, nationality and relative age of identifiable items.	Private server
Strandsøppel dypdykk for forebygging av marin forsøpling. https://salt.nu/assets/projects/1024-Dypdykk-sluttrapport.pdf	Research report exploring and implementing appropriate Deep Dive protocol for coastal Northern-Norway. Summarizes the knowledge gained from implementing deep dives in Finnmark, Tromsø and Lofoten in 2018.	Shoreline	Lofoten: Vikten, Årrstrand, Røst-Stavøya, Røst-Storfjellet, Valberg, Tromsø: Rekvika, Nipøya, Finnmark: Svinøybukta, Svartnes, Steilneset, Smelror.	2018	Deeep dive based on OSPAR, Ocean Conservancy, LAS expanded to include items of concern in the region, including items dumped from trawlers, nationality of packaging (included in the report)	Private server
Svalbard Beach Litter Deep Dive. https://salt.nu/assets/projects/1033-Svalbard-Beach-litter-deep-dive.comp_-1614689906.pdf	Research report exploring and implementing appropriate Deep Dive protocol for Svalbard	Shoreline	Svalbard, Franzøya	2019	Deep Dive modified from Deep Dive in coastal Northern-Norway (included in the report)	Private server

Strandsøppel Dypdyk for forebygging av marin forsøpling Tromsøregionen 2019. https://salt.nu/assets/projects/SALT-1041-Dypdykk-Tromsoregionen-kopi.pdf	Compare beach litter of two different areas: exposed coastal and close to Tromsø. Identify nationality and age on packaging reporting how nationality and age was evaluated.	Shoreline	Tromsø, Krokelvdalen, Kvaløya	2019	Deep Dive protocol modified (included in the report)	Private server
Dypdykk Byggenæringen 2021. https://salt.nu/assets/projects/Dypdykk-byggenaeringen-2021.pdf	Research report exploring key litter items from construction industry.	Shoreline	Tromsø, Tønsnes	2021	Identification of relevant deep dive categories for construction items	Private server
Dypdykk ren kyst 2020 plastdetektivene. https://salt.nu/assets/projects/Dypdykk-Ren-Kyst-2020-1643127401.pdf	Workshop with school children applying Plastics Detective protocol.	Shoreline	Tromsø, Karlsøy	2020	Deep dive protocol modified for Plastics Detective (no protocol included)	Private server
Kartlegging av fiskerirelater plastavfall i Trøndelag. https://salt.nu/prosjekter/kartlegging-av-fiskerirelatert-plastavfall-i-trondelag	Identify of fishery plastic littering in Trøndelag	Shoreline	Trøndelag, Hitra og Froan, Nærøysund	2020	Deep dive on fisheries related items (no protocol included)	Private server
Strandsøppel Dypdykk Oslofjorden. https://salt.nu/assets/projects/Sluttrapport-Dypdykk-Oslofjorden.pdf	Identify beach litter deep dive in to different areas, quantify littercategories with respect to numbers and weight. Form a better picture of sources of littering in the Oslofjord. Compare sources of littering localy, number of fishery related litter, nationaly by checking food and drink packaging	Shoreline	Oslo, inner and outer fjord	2019	Deep dive protocol adjusted to the Oslo fjord (included in the report)	Private server

	origins. finally do a deep dive workshop.					
Søppelanalyse Akerselva https://salt.nu/assets/projects/Soppelanalyse-Akerselva--TrashTrawl.pdf	Identy data that can be used as a foundation to say the most important sources to littering in the river	River surface	Oslo	2020	Deep dive protocol modified for Akerselva (no protocol included)	Private server
Rapport - Kunnskapsinnhenting i FFL. https://salt.nu/assets/projects/Rapport-Kunnskapsinnhenting-i-FFL.pdf	Includes two registration forms, one deep dive for professionals and one simplified protocol. Both adapted to FFL, Investigate opurtunities about recycling resources that is taken up from the sea as marine litter by registering % fouling.	Seafloor	Unknown as litter could not be traced to vessel or position.	2017	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional and simplified (included in the report)	Private server
Fishing for litter - årsrapport 2018. https://salt.nu/prosjekter/fishing-for-litter	Includes two registration forms, one deep dive for professionals and one simplified protocol. Both adapted to FFL, Investigate opurtunities about recycling resources that is taken up from the sea as marine litter by registering % fouling.	Seafloor	Unknown as litter could not be traced to vessel or position.	2017-2018	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional and simplified (included in the report)	Private server

Fishing for litter - årsrapport 2019. https://salt.nu/prosjekter/fishing-for-litter	Includes two registration forms, one deep dive for professionals and one simplified protocol. Both adapted to FFL, Investigate opurtunities about recycling resources that is taken up from the sea as marine litter by registering % fouling.	Seafloor	Unknown as litter could not be traced to vessel or position.	2019	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional and simplified (included in the 2018 report)	Private server
Fishing for litter - årsrapport 2020. https://salt.nu/prosjekter/fishing-for-litter	Deep dive adapted to FFL for professionals	Seafloor	Unknown as litter could not be traced to vessel or position.	2022	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional (included in the 2018 report)	Private server
Fishing for litter - årsrapport 2021. https://salt.nu/assets/projects/Fishing-For-Litter---Rapport-2021.pdf	Deep dive adapted to FFL for professionals	Seafloor	Unknown as litter could not be traced to vessel or position.	2021	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional (included in the 2018 report)	Private server
Norid Coastal cleanup policy brief	Presents a clean-up protocol for comparison across the Nordic countries. Assesses 100*10 m areas. Method not documented. The project groups within are CSR greenland, Hold Danmark rent. Hold Norge Rent. Håll Sverige Rent. Landvernd. Pida saaristo siistina ry.	Coastal	Nordic beaches	2017-2018	Own Nordic Coastal clean-up protocol, based on Ocean Conservancy and OSPAR, but not comparable with OSPAR data	Private server

	Ringras and Ålands natur å miljø.					
OSPAR Seabed litter (https://www.ospar.org/work-areas/eiha/marine-litter/assessment-of-marine-litter/seabed-litter)	OSPAR indicator using information on litter caught during fisheries survey trawls (counts of plastic items in trawls). Format and field descriptions in ICES website https://datsu.ices.dk/web/selRep.aspx	Seafloor	North East Atlantic, including stations off-coast of norway	2012-2014	Trawl survey data (Grand Ouverture Vertical trawl). Number of litter items.	ODIMS
Haarr, M. L., Hojman, C., Marinussen, K., Cuvin, J. B., Solbakken, V. S., Pires, R. & Falk-Andersson, J. 2022. Marin forsøpling i norske fylker	Analysis of data from Rydde, registration of specific Deep Dive items and quantitative studies applying the MAP protocol for Oslo , Agder, Møre og Romsdal, Troms og Finnmark. Some data are summary of previous data collections.	Shoreline	Data from Indre Oslofjord, Agder, Møre og Romsdal, Troms og Finnmark	2019-2022	Deep dive items and MAP	Private server
MEPEX dypdykk i plasthavet. https://marintavfall.mepex.no/dypdykk-i-plasthavet#240051 Protokoller for analyse av marint avfall (mepex.no)	Analysis of beach litter from across Norway. Registers number of items and individual weight. Allows for comments on potential for recycling. Suggests protocol for citizen science, professjonal cleaners and	Beach	Norwegian shorelines	Not reported	DLitter sorted in 140 categories (type, weight, amount) documented on photo and registered location/material type. NIR-technology used to idenfify type of plastics	Private server. Map application does not work.

	professional analysts. The latter includes material type, relative age, and Norwegian vs foreing packaging. No documentation of criteria for such assessment.					
Makroplast i elver på Vestlandet Gaute Velle, Bjørn Barlaup, Espen Olsen Espedal, Marte Haave, Yngve Landro, Eirik Normann, Christoph Postler, Helge Skoglund, Sebastian Stranzl, Elisabeth Stöger og Tore Wiers. 2020. NORCE LFI rapport 390. NORCE Bergen. ISSN 1892-8889 https://norceresearch.brage.unit.no/norceresearch-xmlui/handle/11250/2684935	Report on plastic content (macro) in rivers in 43 Vestlandet. Plastic registration performed by three people (depending on the width of the river) wearing wetsuits, snorkel and masks. Number of visible plastic pieces (lower limit about 2 cm) registered and location of registrations. Semi quantitative mapping: amounts from 0 (none), 1 (<1 item per 100m), 2 (1 item per 100m), 3 (1 item per 10 m), 4 (1 item per 1 m). Quantitative mapping: Number of pieces, length of pieces, type (silage balls, food/drinks, bags, household, rope/net, road/vehicles, construction, other). Area of mapping	River	Vestlandet	2019	Quantitative / Semi-quantitative- Protocol described in report.	Private server

	calculated to estimate pollution level.					

Appendix 3

The four experts that gave input to the report were:

Dr F Galgani, has 40 years of research in oceanography and environmental sciences (marine pollution, ecotoxicology and marine debris). He also supported the EU commission for Marine litter issues (Chair of the EU DG ENV/ MSFD/ Technical Group Marine Litter, 2010-2022; Member of the mission board / mission " Restore our oceans and waters" for the EU commission, DG Research & Innovation, 2019-2022; expert member of the bluemed program) and Coordinated or participated in several international groups (United Nations environment Programme / UNEA, UN World Ocean Assessment 2, EU/MSFD/ TGML, UN Ocean Decade / Mediterranean Sea, UNESCO/ IOC/ GESAMP Working Group on plastic pollution /chair , CIESM /committee chair / 2013-2019, ICES/ WG Marine litter / Chair /2018-2021, OSPAR , Barcelona Convention).

Dr. Rachel Hurley is a scientist at the Norwegian Institute of Water Research who has been working on the topic of plastic pollution in freshwater and terrestrial environments for over 8 years. She has expertise in optimising methods and capacity building related to riverine macroplastic monitoring through several large projects in India, China, and the ASEAN countries. She has produced seminal work related to hydrological controls on (micro)plastic transport dynamics in river systems.

Dr. Marthe Larsen Haarr is a senior research scientist at Salt Lofoten AS and has worked in the field of macroplastics research for the past six years. She has a PhD in marine biology from the University of New Brunswick, Saint John in Canada where she studied reproductive and evolutionary biology of lobsters in the context of fisheries and other anthropogenic stressors. Her current research focuses on mapping, quantification, movement, and source identification of macrolitter, primarily on Arctic beaches, with a special emphasis on study design considerations and statistical analyses when working with spatiotemporally variable data.

Dr. Bjørn Einar Grøsvik is a scientist at the Norwegian Institute of Marine Research working with monitoring of different types of marine pollutants including plastics and microplastics, studies of their effects on marine organisms and involved in advice to Norwegian authorities. He is member of ICES working group for biological effects of contaminants and member of AMAPs expert group of litter and microplastics.

Appendix 4

Identified international obligations and national needs for knowledge and data collection for different environmental compartments.

Source	Obligations and needs identified	Environmental compartment
SDG 14.1.1b national indicators of marine plastic debris	Beach litter – average count of items per km^2 of coastline (surveys and citizen science data)	Shoreline
SDG 14.1.1b national indicators of marine plastic debris	Floating plastic debris density – average count of items per km^2	Floating ocean
SDG 14.1.1b national indicators of marine plastic debris	Water column plastic density- average count per km^3 (demersal trawls)	Water column ocean
SDG 14.1.1b national indicators of marine plastic debris	Seafloor litter density- average count per km^2 (benthic trawls)	Seafloor
SDG 14.1.1b national indicators of marine plastic debris	Conducting beach litter surveys applying the UNEP/IOC-UNESCO operational guidelines. National data collection efforts can be supported by citizen science.	Shoreline
SDG 14.1.1b national indicators of marine plastic debris	Recommends GESAMP guidelines for monitoring of floating and seafloor plastics	Suggested guidelines
SDG 14.1.1b supplementary indicators	Plastic ingestion by biota	Biota
SDG 14.1.1b supplementary indicators	Plastic litter in nests	Biota
SDG 14.1.1b supplementary indicators	Entanglement	Biota
SDG 14.1.1b supplementary indicators	Plastic pollution potential (based on the use and landfilling of plastics)	Other
SDG 14.1.1b supplementary indicators	River litter	River
SDG 14.1.1b supplementary indicators	Other parameters related to plastic consumption and recycling	Other
SDG 14.1.1b supplementary indicators	Health indicators (human- and ecosystem health)	Other
The OSPAR convention	OSPAR beach litter monitoring protocol	Protocol litter identification
The OSPAR convention	OSPAR beach litter survey	Shoreline

The OSPAR convention	Based on existing fisheries trawl surveys: document trends in the amount of litter (counts) in the water column (including floating at the surface) and deposited on the seafloor, including analysis of its composition, spatial distribution and, where possible, source.	Floating, water column and ocean
The OSPAR convention	Plastic particles in the stomack of fulmars.	Biota
The OSPAR convention	To reach litter levels that do not cause adverse effects to the marine and coastal environment	General
The OSPAR convention	By 2023 reduce by at least 50%, and by 2030 at least 75%, the prevalence of the most commonly found single-use plastic items and of maritime-related plastic items on beaches	Shoreline
The OSPAR convention	Develop additional regionally coordinated quantitative reduction targets for all marine litter on beaches and as soon as possible for other relevant environmental compartments	Shoreline
The OSPAR convention	Develop approaches to prevent and reduce riverine marine litter inputs	River
The OSPAR convention	Develop and implement measures to substantially reduce marine litter from fishing and aquaculture gear	General
AMAP	Levels, spatial and temporal trends in litter and macroplastic pollution	General
AMAP	Sources of litter	General
AMAP	Priority areas for monitoring: water (marine and freshwater), sediments (freshwater and marine), beaches/shorelines and seabirds	Marine and freshwater compartments
AMAP	Items specific to the Arctic: melted plastic pieces, detonating cords for explosives, aquaculture/animal feed bags, plastic sanitary bags, trawl nets, gill nets, shotgun cartridges, riffle cartridges.	Protocol litter identification
MSFG	Environmental quality objective of less than 20 items over 2,5 cm per 100 meter beach	Shoreline
MSFG	Monitoring of the composition (source), amount and spatial distribution of litter on the coastline, surface layer of the water column and the seabed.	Marine compartments
MSFG	Amount of litter (numbers) per category per 100m coastline	Shoreline

MSFG	Amount of litter (numbers) per category per km2 for surface layer of water column and seabed	Surface and seabed
MSFG	Number of individual animals affected (e.g. strandings of dead animals, entangled animals in breeding colonies, affected individuals per survey).	Biota
MSFG	Amount of litter in grams (g) and number of items per individual for each species in relation to size (weight or length, as appropriate) of the individual sampled. Threshod defined by Fulmar OSPAR indicator.	Biota
MSFG	Trend assessments for three litter categories: artificial polymer materials, single use plastics and fishing gear.	Protocol litter identification
MSFG	Application of J-list across marine compartments	Protocol litter identification
CBD	Floating plastic debris density	Surface
CBD	Trends in amount of litter in the water column and the seafloor	Water column and seafloor
Plastic treaty (expected)	Monitoring across environmental compartments (terrestrial and aquatic)	All compartments
Norwegian plastic strategy	Sources of litter	Litter identification all compartments
Norwegian plastic strategy	Transportation pathways of litter	All compartments
Producer responsibility implementation in Norway	The relative proportion of packaging (take away and fast-food containers, drink packaging under 3 l, beverage containers including lids, plastic bags), wet wipes and balloons, tobacco products, compared to the total amount of litter	Litter identification all compartments
Producer responsibility implementation in Norway	Impact of extended producer responsibility for fisheries, aquaculture and recreational fishing	Litter identification all compartments
Stakeholder workshop	Amount of and input of litter in time and space across different environments	All compartments
Stakeholder workshop	Knowledge on litter items of high concern	Protocol litter identification
Stakeholder workshop	Identification on key actors and sources to implement polluter-pays principle, follow up producer responsibility, develop targeted campaigns and ban specific products	Protocol litter identification

Stakeholder workshop	Knowledge guiding where, when and how to do clean-ups	All compartments
Stakeholder workshop	Environmental and health impacts of litter	Other

Appendix 5

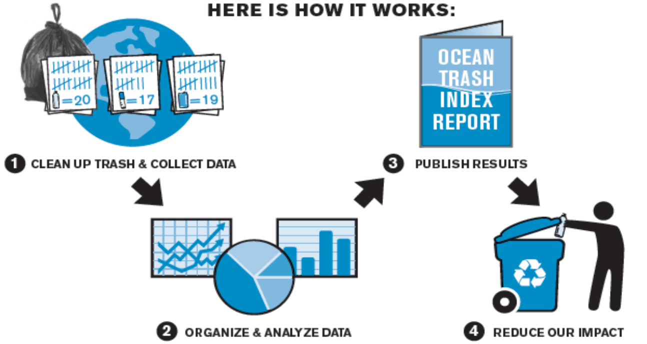
Registration form Ocean Conservancy 2017

VOLUNTEER
OCEAN TRASH DATA FORM

Ocean Conservancy

Ocean and waterway trash ranks as one of the most serious pollution problems choking our planet. Far more than an eyesore, a rising tide of marine debris threatens human health, wildlife, communities and economies around the world. The ocean faces many challenges, but trash should not be one of them. Ocean trash is entirely preventable, and data you collect are part of the solution. The International Coastal Cleanup is the world's largest volunteer effort on behalf of ocean and waterway health.

HERE IS HOW IT WORKS:



SITE INFORMATION:

Cleanup Site Name:

State or Province: Zone or County:

Country: Nearest Crossroad or Landmark:

NUMBER OF VOLUNTEERS WORKING ON THIS CARD: adults / children (under 12)

MOST UNUSUAL ITEM COLLECTED:

TYPE OF CLEANUP: Land: ☐ Underwater: ☐ Watercraft: ☐

Please return this form to your area coordinator.
If you are unable to do so, please mail or email it to:

Ocean Conservancy
Attn: International Coastal Cleanup
1300 19th Street, NW, 8th Floor
Washington, DC 20036
cleanup@oceanconservancy.org

Trash Free Seas: www.oceanconservancy.org/cleanup
Be a Green Boater: www.oceanconservancy.org/do-your-part/green-boating
Sponsors: www.oceanconservancy.org/cleanupsponsors

OCEAN CONSERVANCY'S International Coastal Cleanup®

TRASH COLLECTED

Citizen scientist: Pick up all trash and record all items you find below. No matter how small the items, the data you collect are important for Trash Free Seas®

EXAMPLE: Plastic Bags: 𝍸 III = 8 (TOTAL #)

Please DO NOT use words or check marks. Only **numbers** are useful data.

MOST LIKELY TO FIND ITEMS: (TOTAL #)

Cigarette Butts:	=	Beverage Bottles (Plastic):	=
Food Wrappers (candy, chips, etc.):	=	Beverage Bottles (Glass):	=
Take Out/Away Containers (Plastic):	=	Beverage Cans:	=
Take Out/Away Containers (Foam):	=	Grocery Bags (Plastic):	=
Bottle Caps (Plastic)	=	Other Plastic Bags:	=
Bottle Caps (Metal)	=	Paper Bags:	=
Lids (Plastic) :	=	Cups & Plates (Paper):	=
Straws/Stirrers:	=	Cups & Plates (Plastic):	=
Forks, Knives, Spoons:	=	Cups & Plates (Foam):	=

FISHING GEAR:	TOTAL #	PACKAGING MATERIALS:	TOTAL #
Fishing Buoys, Pots & Traps:	=	6-Pack Holders	=
Fishing Net & Pieces:	=	Other Plastic/Foam Packaging:	=
Fishing Line (1 yard/meter = 1 piece):	=	Other Plastic Bottles (oil, bleach, etc.):	=
Rope (1 yard/meter = 1 piece):	=	Strapping Bands:	=
		Tobacco Packaging/Wrap:	=

OTHER TRASH:	TOTAL #	PERSONAL HYGIENE:	TOTAL #
Appliances (refrigerators, washers, etc.):	=	Condoms:	=
Balloons:	=	Diapers:	=
Cigar Tips:	=	Syringes:	=
Cigarette Lighters:	=	Tampons/Tampon Applicators:	=
Construction Materials:	=		
Fireworks:	=		
Tires:	=		

TINY TRASH LESS THAN 2.5CM:	TOTAL #
Foam Pieces	=
Glass Pieces	=
Plastic Pieces	=

2.5cm (actual size)

DEAD/INJURED ANIMAL	STATUS	ENTANGLED	TYPE OF ENTANGLEMENT ITEM
	Dead or Injured	Yes or No	

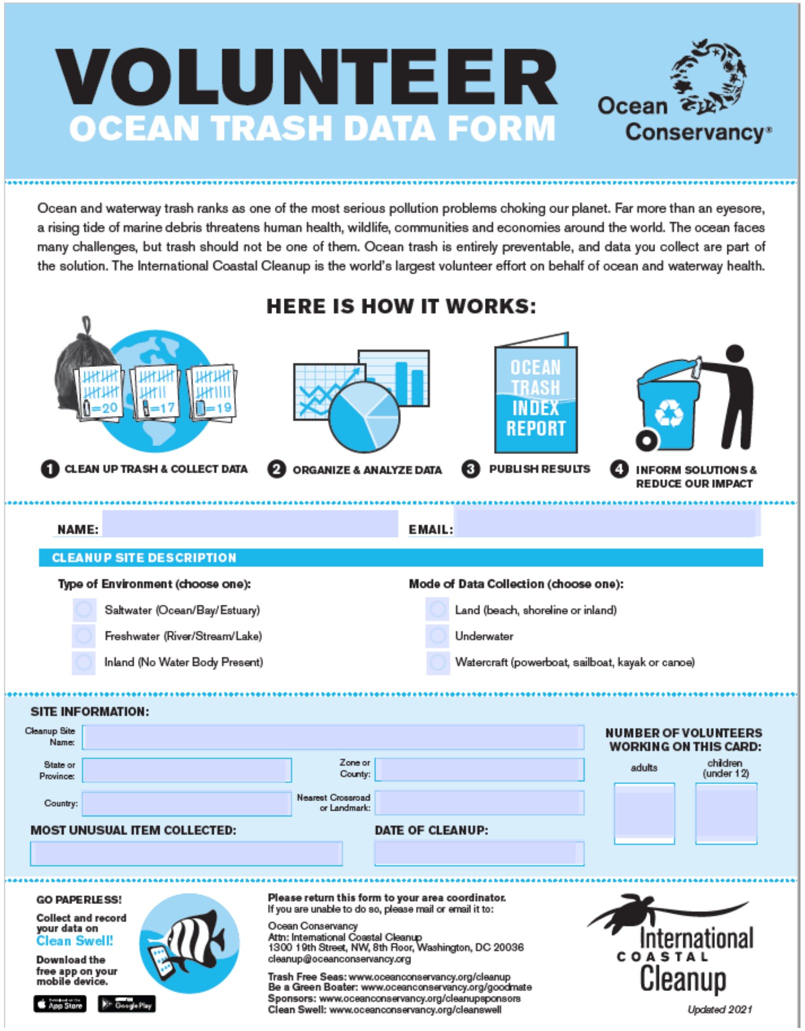
ITEMS OF LOCAL CONCERN:

1. 2. 3.

CLEANUP SUMMARY (circle units)

Number of Trash Bags Filled: Weight of Trash Collected: lbs/kgs Distance Cleaned: miles/km

Ocean conservancy registration form 2022



VOLUNTEER
OCEAN TRASH DATA FORM

Ocean Conservancy

Ocean and waterway trash ranks as one of the most serious pollution problems choking our planet. Far more than an eyesore, a rising tide of marine debris threatens human health, wildlife, communities and economies around the world. The ocean faces many challenges, but trash should not be one of them. Ocean trash is entirely preventable, and data you collect are part of the solution. The International Coastal Cleanup is the world's largest volunteer effort on behalf of ocean and waterway health.

HERE IS HOW IT WORKS:

1. CLEAN UP TRASH & COLLECT DATA
2. ORGANIZE & ANALYZE DATA
3. PUBLISH RESULTS
4. INFORM SOLUTIONS & REDUCE OUR IMPACT

NAME: EMAIL:

CLEANUP SITE DESCRIPTION

Type of Environment (choose one):
- Saltwater (Ocean/Bay/Estuary)
- Freshwater (River/Stream/Lake)
- Inland (No Water Body Present)

Mode of Data Collection (choose one):
- Land (beach, shoreline or inland)
- Underwater
- Watercraft (powerboat, sailboat, kayak or canoe)

SITE INFORMATION:

Cleanup Site Name:
State or Province: Zone or County:
Country: Nearest Crossroad or Landmark:

NUMBER OF VOLUNTEERS WORKING ON THIS CARD: adults / children (under 12)

MOST UNUSUAL ITEM COLLECTED: DATE OF CLEANUP:

GO PAPERLESS!
Collect and record your data on Clean Swell!
Download the free app on your mobile device.
App Store / Google Play

Please return this form to your area coordinator.
If you are unable to do so, please mail or email it to:

Ocean Conservancy
Attn: International Coastal Cleanup
1300 19th Street, NW, 8th Floor, Washington, DC 20036
cleanup@oceanconservancy.org

Trash Free Seas: www.oceanconservancy.org/cleanup
Be a Green Boater: www.oceanconservancy.org/goodmate
Sponsors: www.oceanconservancy.org/cleanupsponsors
Clean Swell: www.oceanconservancy.org/cleanswell

International Coastal Cleanup

Updated 2021

TRASH COLLECTED

Citizen scientist: Pick up all trash and record all items you find below. No matter how small the items, the data you collect are important for Trash Free Seas®

EXAMPLE: Plastic Bags: ~~||||~~ ||| = 8 (TOTAL #)

Please DO NOT use words or check marks. Only **numbers** are useful data.

MOST LIKELY TO FIND ITEMS:	TOTAL #		TOTAL #
Grocery bags (plastic):	=	Cups, plates (foam):	=
Other bags (plastic):	=	Cups, plates (paper):	=
Beverage bottles (glass):	=	Cups, plates (plastic):	=
Beverage bottles (plastic):	=	Food containers (foam):	=
Beverage cans:	=	Food containers (plastic):	=
Beverage sachets/pouches:	=	Food wrappers (candy, chips, etc.):	=
Bottle caps (metal):	=	Lids (plastic):	=
Bottle caps (plastic):	=	Straws/stirrers (plastic):	=
Cigarette butts:	=	Utensils (plastic):	=

FISHING & BOATING:	TOTAL #
Line, nets, traps, rope, etc.:	=
Foam dock pieces:	=

PACKAGING MATERIAL:	TOTAL #
6-pack holders:	=
Foam packaging:	=
Other plastic bottles (oil, bleach, etc.):	=
Strapping bands:	=

PERSONAL HYGIENE:	TOTAL #
Condoms:	=
Cotton bud sticks (swabs):	=
Diapers:	=
Gloves & masks (PPE):	=
Syringes:	=
Tampons & applicators:	=

OTHER ITEMS NOT LISTED:	TOTAL #
1.	=
2.	=
3.	=
4.	=
5.	=

ILLEGAL DUMPING:	TOTAL #
Appliances:	=
Construction materials:	=
Tires:	=

OTHER ITEMS/DEBRIS:	TOTAL #
Balloons:	=
Clothing:	=
E-cigarettes:	=
Electronic waste (phones, batteries):	=
Footwear (shoes/slippers):	=
Paper bags:	=
Tobacco products (lighters, cigar tips, wrap):	=
Toys:	=
Other plastic waste:	=
Other waste (metal, paper, etc.):	=

TINY TRASH LESS THAN 2.5CM	TOTAL #
Plastic/foam pieces:	=

DEAD/INJURED ANIMAL
Type of animal:
Status: dead/injured Entangled: yes/no
Type of entanglement item:

2.5cm (actual size)

CLEANUP SUMMARY (circle units)

Number of Trash Bags Filled: | Weight of Trash Collected: lbs/kgs | Distance Cleaned: miles/km | Area Cleaned: miles²/km²

Registration form Keep Norway Beautiful 2016

Registreringsskjema Strandryddedagen 2016

hold Norge rent

Takk for at du bidrar til å registrerer hva som finnes av søppel ute på strendene. Dette hjelper oss til å for en oversikt over mengden og innholdet i det marine søppelet i Norge. På denne måten kan vi spore kilder til forsøpling og lokalisere utslipp. Informasjonen vil brukes til å opplyse myndigheter, bedrifter og privatpersoner om omfanget og de alvorlige konsekvensene som marin forsøpling forårsaker.

Tusen takk, vi kan ikke gjøre det uten deg og din innsats! For mer informasjon, se: **www.holdnorgerent.no**

1. Stedsinformasjon

Kyst/innland: ☐ Strand/kystlinje ☐ Innland (innsjø, elv, bekk etc.)
Fremkomstmåte: ☐ Til fots ☐ Dykking ☐ Båt, kano, kajakk e.l.

Navn på område som er ryddet: ____________
Ryddedato: ____________ Navn på koordinator: ____________
Antall personer som ryddet ____________ Ca. avstand ryddet (i m. eller km.): ____________
Antall sekker ryddet ____________ Ca. vekt på avfall ryddet: ____________
Hvor lang tid brukte dere på å rydde? ____________

2. Kontaktinformasjon (navn på alle i ryddelaget)

Navn:		E-post:	
Navn:		E-post:	
Navn:		E-post:	
Navn:		E-post:	
Navn:		E-post:	
Navn:		E-post:	

3. Dyr funnet skadde eller døde pga. forsøpling

Noter her om dere finner dyr som har satt seg fast i søppel i naturen. Skriv ned hva slags avfall de satte seg fast i (fiskesnøre, plastposer, tau, ståltråd, six-pack holdere, bånd etc). Vennligst vær så spesifikk som mulig. Fint om dere også tar bilder og sender til Hold Norge rent.

Hva slags dyr/fisk?	Død eller levende/satt fri?	Type søppel dyret satt fast i

4. Hva var den rareste tingen dere fant?

5. Kommentarer eller andre ting du vil rapportere fra ryddeaksjonen?

Dette skjemaet er basert på Ocean Conservacy's Coastal Cleanup Datacard og oversatt av Hold Norge Rent. Ferdigutfylte skjemaer kan registreres online på wwwholdnorgerent.no

Hold Norge Rent — Kontaktperson: Malin Jacob
Øvre Vollgate 6 — E-post: malin.jacob@avfallnorge.no
0158 Oslo — Telefon: 901 31 416

REGISTRERINGSSKJEMA MARINT AVFALL

Det er kun tingene som står på listen som trenger å registreres, men vær vennlig og plukk opp alt søppel du finner. Bruk streksystem (Eks: | | |) for å holde tellingen, fyll inn totalantall i boksen til slutt.

Privatavfall

☐ Engangstallerkener, bestikk, kopper, glass ____
☐ Plastikkposer ____
☐ Ballonger ____
☐ Drikkeflasker (plast) ____
☐ Glassflasker ____
☐ Drikkebokser ____
☐ Korker (plast og metall) ____
☐ Sko ____
☐ Udefinerbare plastibiter ____
☐ Metallring fra øl- og brusbokser ____
☐ Matemballasje/ take away ____
☐ Sugerør/rørepinner ____
☐ Patronhylser ____
☐ Leker ____
☐ Klær ____
☐ "Six-pack"-holder av plast ____
☐ Papirposer ____
☐ Plastflasker (mat) ____

Fiskeriutstyr

☐ Agnemballasje/ bokser ____
☐ Oppvaskmiddelflasker ____
☐ Bøyer og flottører ____
☐ Teiner ____
☐ Kasser ____
☐ Fiskesnøre ____
☐ Fiskekroker ____
☐ Pakkebånd/strips ____
☐ Garn ____
☐ Lyspærer ____
☐ Olje-/bensinkanner ____
☐ Paller ____
☐ Presenninger/ plastduker ____
☐ Tau (under 50 cm) ____
☐ Tau (over 50 cm) ____
☐ Isopor ____

Røyk og hygiene

☐ Sigaretter/filter ____
☐ Lightere ____
☐ Tobakk- og røykpakker ____
☐ Kondomer ____
☐ Bleier ____
☐ Sprøyter ____
☐ Tamponger ____

Dumpet avfall

☐ Hvitevarer ____
☐ Elektriske artikler ____
☐ Batterier ____
☐ Byggematerialer ____
☐ Biler/bildeler ____
☐ Dekk ____
☐ Oljefat ____

Annet – andre ting som bekymrer deg eller som du har funnet mye av

☐ ____ ☐ ____
☐ ____ ☐ ____
☐ ____ ☐ ____

Registration form Keep Norway Beautiful 2021

Ryddeskjema — Skjemaet til Rydde er utviklet av Hold Norge Rent og Senter for oljevern og marint miljø, basert på Ocean Conservancys protokoll. 1/2 Rydde

1 Om dere

Aksjonsnavn

Ryddelagets navn

Organisasjon

2 Stedsinformasjon

Stedsnavn

Kommune

Koordinater

Skriv inn GPS-koordinater dersom dere har dette

Hva slags område har dere ryddet?

- ☐ Kyst / Strand
- ☐ Ferskvann (elv, bekk, innsjø)
- ☐ Dykking
- ☐ Annet (by, skog, fjell, vei, osv.)

Meter strand: ___ meter

Omtrent hvor mange meter strandlinje har dere ryddet?

3 Om aksjonen

Aksjonen startet → Aksjonen sluttet

Antall søppelsekker: ___ sekker (1 full sekk = ca 10 kg)

Kilo ryddet: ___ kg (Har dere veid avfallet? Skriv inn antall kg her)

Antall deltakere: ___ personer

Aksjonskode

4 Funnskjema

ⓘ Skriv inn antall du har funnet av hvert objekt

Personlig forbruk

Engangsservise (Bestikk, kopper, tallerkener)	stk
Sugerør og rørepinner	stk
Ballonger (Inkl. ventil og bånd)	stk
Klær og tekstiler	stk
Sko	stk
Leker, smokker osv.	stk
Matemballasje	stk
Take-away emballasje	stk
Godteri- og snacksemballasje	stk
Glassflasker	stk
Lokk, korker og drikkeboksringer	stk
Handleposer (plast)	stk
Søppelsekker (plast)	stk
Småposer og fruktposer (plast)	stk
Papirposer	stk
Engangsgrill	stk
Sigarettsneiper	stk
Snusposer (porsjon)	stk
Snusbokser	stk
Sigarettpakker (inkl. tilbehør)	stk
Lightere	stk

Husholdnings- og rengjøringsprodukter

Norske	stk
Utenlandske	stk
Vet ikke hvor de kommer fra	stk

Plastflasker (drikke)

Norske	stk
Utenlandske	stk
Vet ikke hvor de kommer fra	stk

Metallbokser (drikke)

Norske	stk
Utenlandske	stk
Vet ikke hvor de kommer fra	stk

Brukerstøtte
Hold Norge Rent
post@holdnorgerent.no
Nedre Vollgate 9, 0158 Oslo

Ansvarlig for Rydde
Senter for Oljevern og Marint Miljø
post@marintmiljo.no
Fiskergata 22, 8300 Svolvær

Funnskjemaet fortsetter på neste side →

Ryddeskjema 2/2 Rydde

4 Funnskjema

ⓘ Skriv inn antall du har funnet av hvert objekt

Fiskeri og havbruk

Agnemballasje og bokser	stk
Fiskekroker (Sluk, dupp osv.)	stk
Kanner (Olje, bensin og kjemikalier)	stk
Teiner og ruser	stk
Bøyer, flottører og garnringer	stk
Fiskekasser og isoporkasser	stk
Fiskesnøre	stk
Fiskegarn – Under 50 cm (Inkl. not og trål)	stk
Fiskegarn – Over 50 cm (Inkl. not og trål)	stk
Tau – Under 50 cm	stk
Tau – Over 50 cm	stk

Hygiene og sanitærartikler

Bind og tamponger	stk
Bleier	stk
Sprøyter og sprøytespisser	stk
Emballasje til hygieneartikler (Linser, tamponger, kondomer)	stk
Bomullspinner (q-tips)	stk
Kondomer	stk
Våtservietter	stk
Munnbind	stk
Engangshansker	stk

Industri og næring

Rør og rørdeler	stk
Armeringsfiber	stk
Behandlet trevirke	stk
Fat og kar (Olje, kjemikalier, oppsamlingskar)	stk
Pakkebånd	stk
Strips	stk
Paller	stk
Byggematerialer	stk
Presenning og plastduker	stk
Malingsspann og lignende	stk
Biomedier og rensefiltre	stk
Isolasjonsmateriale	stk
Sprengkabler (skyteledning)	stk
Rundballplast (landbruksplast)	stk
Plastpellets (Små råplastkuler, nurdles)	stk
Isopor – Under 5 cm	stk
Isopor – Over 5 cm	stk

Annet

Batterier	stk
Dekk	stk
Hvitevarer	stk
Lyspærer	stk
Brøytestikker	stk
Bildeler	stk
Elektriske artikler	stk
Patronhylser	stk
Forladninger	stk
Uidentifiserte plastbiter – Under 50 cm	stk
Uidentifiserte plastbiter – Over 50 cm	stk

Annet dere har funnet:

Beskriv gjerne spesielle gjenstander, nasjonaliteter som peker seg ut, gjenstander dere ikke vet eller gjenstander dere ikke finner navnet på i skjemaet.

5 Mulige lokale kilder

Kryss av en eller flere

- ☐ Fulle søppelbøtter
- ☐ Avfallsstasjon, miljøstasjon
- ☐ Kloakkutslipp, utløp
- ☐ Biltrafikk
- ☐ Serveringssteder
- ☐ Turisme
- ☐ Landbruk
- ☐ Fiskeri, havbruk
- ☐ Dumpet avfall, villfylling
- ☐ Bygg, anlegg og industri
- ☐ Havn, marina, kai, småbåthavn

Andre mulige kilder:

Appendix 6

Details of ancillary data that should be recorded and reported alongside macroplastic data. Some criteria relate to specific method(s) only; this has been highlighted in the table using parenthesis. This does not represent an exhaustive list, due to the variability in river catchments globally. Other site specific information or details of method deployment that are relevant should also be reported (From Hurley et al submitted).

	Observation-based methods	Physical interception methods
Measurement parameters	• Location • Duration of observation • Date and time of observation • Section of the river analysed • Distance from water surface/height of vantage point • Lower size limit of detection • Parameters of deployment, e.g. flight height, angle, camera/filters used, processor, field of view, flight duration (non-human observation) • Name and details of visual processing algorithms used (non-human observation)	• Location • Duration of measurement/deployment • Date and time of observation • Deployment depth and location (relative to river cross-section) • Net aperture • Mesh size • Degree of submersion (surface nets) • Spatial extent (clean-up activity) • Time elapsed since previous cleaning activities (booms, clean-up activity) • Estimate of capture rate (clean-up activity)
Environmental conditions and location context	• Meteorological conditions for duration of measurement • Antecedent conditions • Flow velocity and discharge • Water level • Visibility (turbidity) • Measurement/estimate of total suspended load • Waste management practices • Plastic consumption patterns • Relevant social or cultural factors	• Meteorological conditions for duration of measurement • Antecedent conditions • Flow velocity and discharge • Water level • Measurement/estimate of total suspended load • Waste management practices • Plastic consumption patterns • Relevant social or cultural factors

Appendix 7

Data available on litter and macroplastic in Norway by type of environment, area, year of study, protocol use and data storage. Data of access indicated for data bases.

Full Reference	Type	Remarks	Type of environment	Area	Year(s) of study	Protocol used	Data storage	Date of access
OVERSIKT FORSØPLING I NORSKE KOMMUNER (holdnorgerent.no)	Report	Summerises methods for macroplastic documentation in urban environments.	Urban			Combination of methods from Clean Europe Network og Håll Sverige Rent on sampling and litter item registration.	Private server	
Forsøpling langs vassdrag og innsjøer i Norge 2021 . https://holdnorgerent.no/wp-content/uploads/2022/10/HNR-Vassdrag-og-innsjoerrapporten-2021-digital.pdf	Report	Mapping of littering along waterways and lakes in Norway	Waterways and Lakes	38 locations: Oslo, møre og Romsdal, Viken, Vestland, Agder, Innlandet, Trøndelag, Vestfold og Telemark, Nordland, Troms og Finmark, Rogaland and Troms	2017-2021	Ocean Conservancy litter item protocol adapted to Norway. Origin of sampling methology not described.	Private server	

The rise in ocean plastics evidenced from a 60-year time series	Research paper	Macroplastic entanglement on the Continuous Plankton Recorder applied by Ships of Opportunity. Time series, from 1957 to 2016 and covering over 6.5 million nautical miles.	Coastline surface	Differnt locations around the Norwegian coast	data from 1957-2016	Own protocole-recorded occurrence of macroplastic entanglement.	All data used can be accessed via www.cprsurvey.org	
Citizen science for better management: Lessons learned from three Norwegian beach litter data sets	Research paper	Analysis of data from OSPAR beaches and citizen science data from KNB and Lofoten Waste Management (LAS) company to identify the most abundant litter types and sources on a broad scale. Comparing OSPAR to citizen science data and examine how to improve the managment relevance of beach litter data	Shoreline	Beaches from the Norwegian coast including Lofoten Islands and west coast of Svalbard	OSPAR/LAS:2011-2016 KNB: 2015-2016	No primary data collected.	N/A	
Buhl-Mortensen and Buhl-Mortensen 2017 Marine litter in the Nordic Seas: Distribution composition and abundance. https://doi.org/10.1016/j.marpolbul.2017.08.048	Research paper	1778 video transects. Presents density, distribution and composition of litter from large-scale mapping of sea bed litter in arctic and subarctic waters. Count number of items and use an undocumented item-to weight table to convert from items to weight.	Sea floor	Norwegian Sea - 1778 stations Data from Mareano programme 2006-2017	Aggregated results from surveys in 2006-2017	Video transects. Litter categorised according 12 material types. One source category: fishing gear.	Norsk Marint Datasenter	

Emodnet	Database	Beach name Kviljo - Survey type Monitoring	Beach	Agder	2011-2019	OSPAR	Edmodnet	02.11.2022
Emodnet	Database	Beach name Været - Survey type Monitoring	Beach	Trondheim	2015-2019	OSPAR	Edmodnet	02.11.2022
Emodnet	Database	Beach name Følvika - Survey type Cleaning	Beach	Møre og Romsdal	2015	TSG_ML	Edmodnet	02.11.2022
Emodnet	Database	Beach name Rekvika - Survey type Monitoring	Beach	Tromsø	2012-2019	OSPAR	Edmodnet	02.11.2022
Emodnet	Database	Beach name Sandfordneset - Survey type Monitoring	Beach	Finnmark	2011-2014	OSPAR	Edmodnet	02.11.2022
Emodnet	Database	Beach name: Åpenvikbukta- Survey type Monitoring	Beach	Finnmark	2018-2019	OSPAR	Edmodnet	28.11.2022
Emodnet	Database	Beach name: Brucebukta- Survey type Monitoring	Beach	Svalberd	2011-2019	OSPAR	Edmodnet	28.11.2022
Debristracker	Database	Tracks individual items at locations with the date recorded- You can filter by categori (material type) and timeframe. Eeach individual recording has to be investigated to get information on composition. Over 1000 hits for Norway, so too time consuming to investigate this.				Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Oslo	Database	33 hits - mostly beach - some urban	Mostrly shoreline, some urban	Oslo		Allows for multiple protocols	Debristracker	02.11.2022

Debristracker Viken	Database	65 Hits - all Urban	Urban	Viken		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Agder	Database	713 hits - mostly beach	Mostly shoreline	Agder		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Rogaland	Database	1 hit - food wrapper collected on 2019-08-27	Few items registered	Rogaland		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Innlandet	Database	2 hits - collected in Urban enrionvments	Few items registered	Innlandet		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Nordland	Database	98 hits - mostly collected along the shorelines - some urban	Mostly shoreline, some urban	Nordland		Allows for multiple protocols	Debristracker	02.11.2022
Debristracker Troms og Finmark	Database	226 hits - most collected by urban areas, but some collected by shorelines	Mostly urban, some shoreline	Troms og Finmark		Allows for multiple protocols	Debristracker	02.11.2022
Marine Litter Watch - European Environment Agency	Database	The data presented is provided by the user community using either the EEA marine litterwatch smartphone app or and agreed data exchange mechanism with the EEA marine litterwatch databesa (external import).1 event hit when searching in Norway - the hit is registered at 2015/09/14 - at Følvika beach - 241 no of items were registered with material,	Shoreline	Nordland	2015	MSFD harmonised list	Marine LitterWatch data viewer	02.11.2022

		and litter item - detailed description for each piece.						
RyddNorge database	Database	Based on Falk-Andersson et al (2019) data is available from 2015. The data portal crashed when trying to access data from 2000 onwards, so not possible to verify the first year of data using Ryddenorge.no	Shoreline		2015-2022	Ocean Conservancy adapted to Norway	RyddNorge data	02.11.2022
Fiskedirektoratets kart av tapte redskap	Database	Coordinates of recovered fishing equipment, date and time, depth, type of equipment. Mostly off-shore, but some close to the coast.	Seafloor	Norwegian coast/sea	2017-2022	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2022	Database	189 recoveries	Seafloor	Norwegian coast/sea	2022	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2021	Database	165 recoveries	Seafloor	Norwegian coast/sea	2021	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2020	Database	163 recoveries	Seafloor	Norwegian coast/sea	2020	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2019	Database	94 recoveries	Seafloor	Norwegian coast/sea	2019	Own protocol	Yggdrasil	02.11.2022
Fiskedirektoratets kart av tapte redskap 2018	Database	165 recoveries	Seafloor	Norwegian coast/sea	2018	Own protocol	Yggdrasil	02.11.2022

Fiskedirektoratets kart av tapte redskap 2017	Database	135 recoveries	Seafloor	Norwegian coast/sea	2017	Own protocol	Yggdrasil	02.11. 2022
Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins	Research paper	Data from 588 video and trawl surveys across 32 sites in European waters. Norwegian stations documented using imaging imaging technology	Seafloor	3 stations along the Norwegian coast	2007	Items counted and categorised into: plastic (all plastic with exception of fishing line and net), derelict fishing gear (fishing line or net), metal, glass, clinker (residue of burnt coal), and Other.	Private server	
Norges Dykkerforbund	Organisation	The Norwegian Diving Society register clean-up actions in Rydde. It is not possible to identify these clean-up actions in the Rydde portal.	Coastal under water	Norwegian coast	?	Registers findings in Rydd Norges database	RyddNorge data	
Sources of Marine Litter - Workshop report from WP 1.2 in the Marp^3 project. https://salt.nu/en/projects/marp3-sources-of-marine-litter	Report	Workshop to collate experts from relevant industries to determine the degree to which it is possible to precisely identify marine litter and examine the sources, causes of loss, and ages of different pieces of debris	Shoreline	Svalbard	2016	Exploratory protocol identifying origin, nationality and relative age of identifiable items.	Private server	

Strandsøppel dypdykk for forebygging av marin forsøpling. https://salt.nu/assets/projects/1024-Dypdykk-sluttrapport.pdf	Report	Research report exploring and implementing appropriate Deep Dive protocol for coastal Northern-Norway. Summarizes the knowledge gained from implementing deep dives in Finnmark, Tromsø and Lofoten in 2018.	Shoreline	Lofoten: Vikten, Årrstrand, Røst-Stavøya, Røst-Storfjellet, Valberg, Tromsø: Rekvika, Nipøya, Finnmark: Svinøybukta, Svartnes, Steilneset, Smelor.	2018	Deeep dive based on OSPAR, Ocean Conservancy, LAS expanded to include items of concern in the region, including items dumped from trawlers, nationality of packaging (included in the report)	Private server	
Svalbard Beach Litter Deep Dive. https://salt.nu/assets/projects/1033-Svalbard-Beach-litter-deep-dive.comp_-1614689906.pdf	Report	Research report exploring and implementing appropriate Deep Dive protocol for Svalbard	Shoreline	Svalbard, Franzøya	2019	Deep Dive modified from Deep Dive in coastal Northern-Norway (included in the report)	Private server	
Strandsøppel Dypdyk for forebygging av marin forsøpling Tromsøregionen 2019. https://salt.nu/assets/projects/SALT-1041-Dypdykk-Tromsoregionen-kopi.pdf	Report	Compare beach litter of two different areas: exposed coastal and close to Tromsø. Identify nationality and age on packaging reporting how nationality and age was evaluated.	Shoreline	Tromsø, Krokelvdalen, Kvaløya	2019	Deep Dive protocol modified (included in the report)	Private server	

Methods for determining the geographical origin and age of beach litter: Challenges and opportunities. https://doi.org/10.1016/j.marpolbul.2021.112901	Research paper	Method paper on how age and geographical origin should be reported to produce reliable data. Reports findings from Svalbard.	Shoreline	Svalbard	2019	Standardised method for identifying age and geographical origin of packaging	Private server	
Dypdykk Byggenæringen 2021. https://salt.nu/assets/projects/Dypdykk-byggenaeringen-2021.pdf	Report	Research report exploring key litter items from construction industry.	Shoreline	Tromsø, Tønsnes	2021	Identification of relevant deep dive categories for construction items	Private server	
Dypdykk ren kyst 2020 plastdetektivene. https://salt.nu/assets/projects/Dypdykk-Ren-Kyst-2020-1643127401.pdf	Report	Workshop with school children applying Plastics Detective protocol.	Shoreline	Tromsø, Karlsøy	2020	Deep dive protocol modified for Plastics Detective (no protocol included)	Private server	
Kartlegging av fiskerirelater plastavfall i Trøndelag. https://salt.nu/prosjekter/kartlegging-av-fiskerirelatert-plastavfall-i-trondelag	Report	Identify of fishery plastic littering in Trøndelag	Shoreline	Trøndelag, Hitra og Froan, Nærøysund	2020	Deep dive on fisheries related items (no protocol included)	Private server	
Strandsøppel Dypdykk Oslofjorden. https://salt.nu/assets/projects/Sluttrapport-Dypdykk-Oslofjorden.pdf	Report	Identify beach litter deep dive in to different areas, quantify littercategories with respect to numbers and weight. Form a better picture of sources of littering in the Oslofjord. Compare sources of littering localy, number of fishery related litter,	Shoreline	Oslo, inner and outer fjord	2019	Deep dive protocol adjusted to the Oslo fjord (included in the report)	Private server	

		nationaly by checking food and drink packaging origins. finally do a deep dive workshop.						
Søppelanalyse Akerselva https://salt.nu/assets/projects/Soppelanalyse-Akerselva--TrashTrawl.pdf	Report	Identy data that can be used as a foundation to say the most important sources to littering in the river	River surface	Oslo	2020	Deep dive protocol modified for Akerselva (no protocol included)	Private server	
DeepDive database. https://deepdive.grida.no/	Database	Shows location on a worldmap beach cleanup events - currently only 6 events along beaches in Norway, and 8 points in Svalbard. Database under development, thus do not report here the data points.	Shoreline	Svalbard, Troms, Trøndelag	N/A	Deep dive protocol for the Arctic modified from Ocean Concervancy	Private server	03.11.22
Rapport - Kunnskapsinnhenting i FFL. https://salt.nu/assets/projects/Rapport-Kunnskapsinnhenting-i-FFL.pdf	Report	Includes two registration forms, one deep dive for professionals and one simplified protocol. Both adapted to FFL, Investigate opurtunities about recycling resources that is taken up from the sea as marine litter by registering % fouling.	Seafloor	Unknown as litter could not be traced to vessel or position.	2017	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional and simplified (included in the report)	Private server	

Fishing for litter - årsrapport 2018. https://salt.nu/prosjekter/fishing-for-litter	Report	Includes two registration forms, one deep dive for professionals and one simplified protocol. Both adapted to FFL, Investigate opurtunities about recycling resources that is taken up from the sea as marine litter by registering % fouling.	Seafloor	Unknown as litter could not be traced to vessel or position.	2017-2018	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional and simplified (included in the report)	Private server	
Fishing for litter - årsrapport 2019. https://salt.nu/prosjekter/fishing-for-litter	Report	Includes two registration forms, one deep dive for professionals and one simplified protocol. Both adapted to FFL, Investigate opurtunities about recycling resources that is taken up from the sea as marine litter by registering % fouling.	Seafloor	Unknown as litter could not be traced to vessel or position.	2019	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional and simplified (included in the 2018 report)	Private server	
Fishing for litter - årsrapport 2020. https://salt.nu/prosjekter/fishing-for-litter	Report	Deep dive adapted to FFL for professionals	Seafloor	Unknown as litter could not be traced to vessel or position.	2022	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional (included in	Private server	

						the 2018 report)		
Fishing for litter - årsrapport 2021. https://salt.nu/assets/projects/Fishing-For-Litter---Rapport-2021.pdf	Report	Deep dive adapted to FFL for professionals	Seafloor	Unknown as litter could not be traced to vessel or position.	2021	Weight of litter delivered. Some litter analysed using Deep Dive adapted for FFL, professional (included in the 2018 report)	Private server	
Norid Coastal cleanup policy brief	Report	Presents a clean-up protocol for comparison across the Nordic countries. Assesses 100*10 m areas. Method not documented. The project groups within are CSR greenland, Hold Danmark rent. Hold Norge Rent. Håll Sverige Rent. Landvernd. Pida saaristo siistina ry. Ringras and Ålands natur å miljø.	Coastal	Nordic beaches	2017-2018	Own Nordic Coastal clean-up protocol, based on Ocean Conservancy and OSPAR, but not comparable with OSPAR data	Private server	
Empact (webpage no longer working 29.11.2022)	Application	Pick up trash along the way, get points for every piece of litter you pick	All			Protocol included in	N/A	

		up that you may use on rewards or donate to even more litter clean up. Application also tracks how much litter is cleaned up				the application		
Miljølære	Database	Records much time has been spent cleaning up, how many people involved, how many items, weight, source categories, and pre-defined nationality categories.	Shoreline	36 beaches in Norway	2017-2022	No documentation of protocol development. Own protocol including pre-defined nationalities.	Miljolare .no	07.11. 22
In the same boat	Organisa tion	Do beach clearing in big scale and have developed profesional methods and is run primarily by voulentary work	Shoreline			Rydde	Rydde	07.11. 22
Plastpiratene	Organisa tion	Voulentary organisation - On their homepage they say they raise shipwrecks that the commune or insurance company wont take responsibility for, they state that this is mainly financed by the members	Marine	Oslo, innlandet og Rogaland	N/A	No information found	N/A	07.11. 22
CrowdWater	Applicati on	Users may register findings and add pictures of findings in the app. For Norway there are only 1 finding of documented plastics in	Freshwater	Oslo	N/A	Register in application	CrowdW ater	09.11. 2022

		Oslo, in Akerselva. The findings are poorly described only stating "plastics observed" and a picture which is hard to intrepret						
Floating Litter Monitoring app	Application	Could not find resources of this application or where to download it? maybe it's not released yet?	Floating	N/A	N/A	N/A	N/A	N/A
Arctic Cleanup https://www.facebook.com/photo?fbid=5375116385843546&set=pcb.1365696577248404; https://kommunikasjon.ntb.no/pressemelding/arktisk-strandrydding?publisherId=89961&releaseId=17911590&fbclid=IwAR18N4HJfRMsben7CJM4gD5qc8FgpJDx0KJBkxxZlHQ_PuX4C7upkFfS09s; https://www.pame.is/projects-new/arctic-marine-pollution/current-marine-litter-projects/424-arctic-coastal-cleanup?fbclid=IwAR1pqZT7UdLCeurFO-PQWWCjV3DHtmngulTTmt5BdRapvurupHnzElZQk4Q	Project. Results not published.	Keep Norway Beaturiful in cooperation with Ocean Conservancy and volunteers in Finnmark, Alaska and Iceland. Part of the Arctic Counsil's Regional Action Plan on Marine Litter.	Ocean, Freshwater, Innland	Troms og Finnmark	2022	Ocean Conservancy adapted to the Arctic	Unknown	
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year August/ September following OSPAR protocol	Beach	Arctic Seas Været, Trøndelag	2015-2020	OSPAR 100m beach litter survey	OSPAR	14.11.2022

OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year June/July following OSPAR protocol	Beach	Arctic Seas, Brucebukta, Svalbard	2011-2019	OSPAR 100m beach litter survey	OSPAR	15.11. 2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year June/July following OSPAR protocol	Beach	Arctic Seas, Luftskipodden , Svalbard	2011-2020	OSPAR 100m beach litter survey	OSPAR	15.11. 2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted almost twice a year (April/May and September/October) following OSPAR protocol	Beach	Arctic Seas, Rekvika, Troms	2011-2020	OSPAR 100m beach litter survey	OSPAR	15.11. 2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted almost twice a year (April and October) following OSPAR protocol	Beach	Northern North Sea, Kviljo, Agder	2011-2020	OSPAR 100m beach litter survey	OSPAR	15.11. 2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted twice a year (June and October) following OSPAR protocol	Beach	Arctic Seas, Sandfjordneset, Finnmark	2011-2014	OSPAR 100m beach litter survey	OSPAR	15.11. 2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year (April/March) following OSPAR protocol	Beach	Northern North Sea, Ytre Hvaler, Viken	2012-2020	OSPAR 100m beach litter survey	OSPAR	15.11. 2022
OSPAR, https://beachlitter.ospar.org/	Database	Professional. Surveys conducted once a year (September/October) following OSPAR protocol	Beach	Arctic Seas, Åpenvikbukta, Finnmark	2018-2020	OSPAR 100m beach litter survey	OSPAR	15.11. 2022

Lofoten Avfallsselskap, https://www.cleanuplofoten.no/rydding-av-strender-og-kystlinje-2022/	Organisation	Volunteers. Data also converted and included in Rydde. Protocol can be found here: https://www.cleanuplofoten.no/wp-content/uploads/2022/03/skjema_strandryddeuka22.pdf	Shoreline	Lofoten	2011-2022	Protocol adapted from Keep Norway Beautiful to Lofoten. Data cleaned and entered in Rydde.	Lofoten Avfallsselskap. Rydde	14.11.2022
GRØSVIK, B. E., PROKHOROVA, T., ERIKSEN, E., KRIVOSHEYA, P., HORNELAND, P. A. & PROZORKEVICH, D. 2018. Assessment of Marine Litter in the Barents Sea, a Part of the Joint Norwegian–Russian Ecosystem Survey. Frontiers in Marine Science, 5, 72. Grøsvik et al 2018 (https://core.ac.uk/display/153657646)	Research paper	Comprehensive study of large-scale monitoring of marine litter conducted by joint Norwegian-Russian ecosystem survey. Data from bycatch trawling in the pelagic waters, bottom trawling close to seafloor & floating marine litter by visual observation. Marine litter observed in entire Barents Sea, plastic is dominant material.	Surface, pelagic and seabed	Barents sea	2010-2016	Both weight and number of items is registered according to the following categories: metal, glass, ceramics, paper, processed wood, rope/line, pieces of nets, bouys/bobbins, other plastic, other.	Norsk Marint Datasenter	
OSPAR Seabed litter (https://www.ospar.org/work-areas/eiha/marine-litter/assessment-of-marine-litter/seabed-litter)	Report	OSPAR indicator using information on litter caught during fisheries survey trawls (counts of plastic items in trawls). Format and field descriptions in ICES website https://datsu.ices.dk/web/selRep.aspx	Seafloor	North East Atlantic, including stations off-coast of norway	2012-2014	Trawl survey data (Grand Ouverture Vertical trawl). Number of litter items.	ODIMS	

HAARR, M. L., HOJMAN, C., MARINUSSEN, K., CYVIN, J. B., SOLBAKKEN, V. S., PIRES, R. & FALK-ANDERSSON, J. 2022b. Marin forsøpling i norske fylker	Report	Analysis of data from Rydde, registration of specific Deep Dive items and quantitative studies applying the MAP protocol for Oslo , Agder, Møre og Romsdal, Troms og Finnmark. Some data are summary of previous data collections.	Shoreline	Data from Indre Oslofjord, Agder, Møre og Romsdal, Troms og Finnmark	2019-2022	Deep dive items and MAP	Private server	
MEPEX dypdykk i plasthavet. https://marintavfall.mepex.no/dypdykk-i-plasthavet#240051 Protokoller for analyse av marint avfall (mepex.no)	Report	Analysis of beach litter from across Norway. Registers number of items and individual weight. Allows for comments on potential for recycling. Suggests protocol for citizen science, professjonal cleaners and professional analysts. The latter includes material type, relative age, and Norwegian vs foreing packaging. No documentation of criteria for such assessment.	Beach	Norwegian shorelines	Not reported	DLitter sorted in 140 categories (type, weight, amount) documented on photo and registered location/material type. NIR-technology used to idenfify type of plastics	Private server. Map application does not work.	

Makroplast i elver på Vestlandet Gaute Velle, Bjørn Barlaup, Espen Olsen Espedal, Marte Haave, Yngve Landro, Eirik Normann, Christoph Postler, Helge Skoglund, Sebastian Stranzl, Elisabeth Stöger og Tore Wiers. 2020. Plast i elver på Vestlandet. NORCE LFI rapport 390. NORCE Bergen. ISSN 1892-8889 https://norceresearch.brage.unit.no/norceresearch-xmlui/handle/11250/2684935	Report	Report on plastic content (macro) in rivers in 43 Vestlandet. Plastic registration performed by three people (depending on the width of the river) wearing wetsuits, snorkel and masks. Number of visibile plastic pieces (lower limit about 2 cm) registered and location of registrations. Semi quantitativ mapping: amounts from 0 (none), 1 (<1 item per 100m), 2 (1 item per 100m), 3 (1 item per 10 m), 4 (1 item per 1 m). Quantitative mapping: Number of pieces, length of pieces, type (silage balls, food/drinks, bags, household, rope/net, road/veichles, construction, other). Area of mapping calculated to estimate pollution level.	River	Vestlandet	2019	Quantitative / Semi-quantitative-Protocol described in report.	Private server	

Macroplastic in soil and peat. A case study from the remote islands of Mausund and Froan landscape conservation area, Norway; implications for coastal cleanups and biodiversity. https://doi.org/10.1016/j.scitotenv.2021.147547	Research paper	Soils samples of 27-33 m depth. Weight in grams and divided into: commercial ropes, not ropes, private (on the fly) and household items, pyroplastic, other. Type of plastic analysed using Raman Spectrometer.	Soil	Mausund and Froan landscape conservation area	2020	Own protocol described in the paper	Private server	
Plastic ingestion by Atlantic cod (Gadus morhua) from the Norwegian coast. https://doi.org/10.1016/j.marpolbul.2016.08.034	Research paper	Cod stomachs from 6 sites in Norway investigated for plastic. Counts of microplastic, mesoplastic and macroplastic. Polymer types identified.	Biota	Oslo, Bergen, Sørfjorden, Karihavet, Lofoten and Varangerfjorden	Not reported	Own protocol described in the paper	Private server	

Appendix 8

Expert evaluation of the potential to coordinate with existing NEA monitoring programs to collect visual or physical samples of macroplastic and litter. The description of the monitoring programs is copied from Programmer for miljøovervåking - Miljødirektoratet (miljodirektoratet.no)

Name of Project	Start of monitoring	Goals of project	Coordination potential	Sample type	Comments	Miljø
Arealrepresentativ Naturovervåkning	2019	Establish operational monitoring areas in Norway. Give data about the ecological state	Don't know			Ukjent
Arealrepresentativ overvåkning av skog i verneområder	2012	Overvåkingen gir arealrepresentative data for tilstandsutvikling i norske skogvernområder	Irrelevant/NA			
Arealrepresentativ overvåkning av norske verneområder	2012	Arealrepresentativ overvåking av norske verneområder er en forventningsrett og arealrepresentativ undersøkelse av inngrep i form av linjeelement, punktelementer og arealdekke i norske verneområder generelt og myrreservater spesielt.	Irrelevant/NA			
Biologisk mangfold i ferskvann (Alta og Vikedalen)	1985	Skaffe ferskvassøkologiske overvåkingsdata og etablere lange tidsseriar for ferskvassøkologi i utvalgte vassdrag.	Low	Both	Programmet begrenser seg til noen få utvalgte lokaliteter	Ferskvann
EcoQO Nordsjøen - havhest	2002	Plastic monitoring	Low	Both	Lokaliteter for overåkning er ikke kjent for denne vurderingen	Marint

Elveovervåkningsprogrammet	2017	Dokumentere nivåer av miljøgifter og næringssalter i norske elver. Dokumentere og gi informasjon om effekter av klimaendring, samt bidra til å klassifisere elver i tråd med EUs vanndirektiv. Dataene som innhentes skal gi grunnlag for å vurdere tiltak mot klimaeffekter, tiltak for å oppnå god miljøtilstand, og å identifisere behov for reguleringer av kjemikalier nasjonalt og/ eller internasjonalt.	Low	Both		Elv
Gloria: Klimaendringers effekt på fjelltoppvegetasjon	2007	Overvåke effekter av klimaendringer på fysiske og biologiske systemer i fjellområdene	Irrelevant/NA			
Havforsuringsprogrammet	2010	Undersøke status når det gjelder pH og karbonsystem i norske havområder, få mer kunnskap om naturlige svingninger og geografiske forskjeller, og finne ut hvor fort forsuringen skjer.	Low	Both		Marint
Helseovervåkningsprogrammet for hjortevilt (HOP)	1998	Hovedmålet med programmet er å kartlegge og overvåke ulike sykdommer hos hjortevilt og moskus, samt å finne årsak til sykdom hos enkeltindivider.	Irrelevant/NA			Biota
Inngrepsfrie naturområder i Norge med Svalbard	1994	Overvåkingen skal vise status og utviklingstrekk for større sammenhengende naturområder i Norge/Svalbard. Resultatene fra overvåkingen brukes som grunnlag for å angi status og utvikling	Don't know			

		for de nasjonale miljøindikatorene 1. 1.8 og 6.1.1.				
Kartlegging og overvåkning av større elvedelta	1990	Gi oversikt over status og endringer i arealbruken i de om lag 250 største og mest intakte elvedeltaene, og bidra med viktig beslutningsgrunnlag for forvaltningen.	Irrelevant/NA			Ferskvann
Klima, ozon, UV og atmosfærisk forurensning	1974	Følge med på utviklingen i nivåer av klimagasser, ozonreduserende stoffer og luftforurensninger, samt følge med på status for ozonlaget og UV- innstråling. Resultatene brukes som grunnlag for internasjonalt samarbeid om regionale og globale utslippsbegrensninger.	Irrelevant/NA			
Langtransporterte atmosfæriske miljøgifter	1990	Følgje med på langtransporterte miljøgifter som kjelde til forureining i Noreg, og bruke denne informasjonen i internasjonale forhandlingar for å regulere nye miljøgifter og for å for å vurdere om tiltak som er gjort for å regulere utslippene av desse miljøgiftene virker.	Irrelevant/NA			
Lokal overvåkning av sjøfugl i verneområder	Not specified	Norge har mer enn 3000 verneområder. Når et verneområde skal bidra til å beskytte sjøfugl, står dette i verneformålet. Ofte nevnes bare at det er viktig som hekkeområde, eller for andre	Don't know			BIota

		funksjoner som for eksempel fjærfelling (myting) eller overvintring.				
Mikroplast i kystområder, elver og innsjøer (Mikronor)	2021	Hensikten med en nasjonal overvåkning av mikroplast er å få bedre svar på omfanget av mikroplastforurensning i miljøet. gi informasjon om nivåer og typer av mikroplastforurensning i vannmiljø og luft I tillegg vil overvåkningen: dokumen tere forskjeller i mikroplastnivåer og type partikler mellom geografisk områder og prøvetyper se på utviklingen av mengden mikroplast i miljøet over tid	Irrelevant/NA		Programmet benytter seg av andre overvåkningsprogram for å samle inn miljøprøver	
Miljøgifter i bydyr (Milby)	2013	Hensikten med programmet er å gi informasjon om nivåer av miljøgifter og opphoping av nye miljøgifter i næringskjeder på land i by- og bynære områder. Dataene som innhentes skal gi grunnlag for å vurdere fare mot helse og miljø, og å identifisere behov for reguleringer av kjemikalier nasjonalt og/ eller internasjonalt.	Irrelevant/NA			Biota/Urban
Miljøgifter i en urban fjord	2013	Målet med programmet er å undersøke tilførsler av miljøgifter som er tilstede i et tett befolket område og studere hvordan disse påvirker et fjordsystem.	Low	Both		Marint

Miljøgifter i ferskvann (Milfersk)	2013	Følge med på miljøtilstand og effekter av miljøgiftnivåer i biota i store norske innsjøer, og spesielt undersøke om miljøkjemikalier akkumulerer i næringskjeden.	Low	Both		Ferskvann
Miljøgifter i rovfuglegg	1992	Målet er å følge innhold av metaller og noen utvalgte miljøgifter i rovfuglegg over tid	Irrelevant/NA			Biota
Miljøprøvebanken	Not specified	Miljøprøvebanken inneholder dypfryste prøver fra blant annet fisk og fugler fra hele landet, og fra Arktis. Prøvene som legges i banken blir tidskapsler fra dagens miljø, slik at de kan analyseres med framtidas kunnskap og teknologi.	Low	Both		Flere
Moseprogrammet (avsluttet)	1997	anslå atmosfæriske tilførsler og nedfallet av utvalgte tungmetaller. Undersøkelsene ga et bilde av endringer over tid og geografisk fordeling av nedfallet.	Irrelevant/NA			
Norge-Russland : Luft- og nedbørskvalitet	1974	Følge med på utviklingen i luft- og nedbørkvalitet i grenseområdene mellom Norge og Russland. Utslippene påvirker miljøet, og vi ønsker å kunne si noe om miljøbelastningen - og varsle lokalbefolkningen ved episoder med fare for eksponering for helseskadelig luft.	Irrelevant/NA			
Overvåking av semi-naturlig eng	2021	Arealrepresentativ overvåking av semi-naturlig eng i Norge.	Irrelevant/NA			Terrestrisk

Overvåking av trekkfugler ved Jomfruland og Lista	1990	Hensikten med overvåkingen er å kunne følge med på hvor mange fugler som trekker gjennom Sør-Norge, hvilke arter de er, og når de trekker. Slik kan vi fange opp eventuelle endringer i bestander og trekkmønster. Dette gjelder både norske hekkefugler, men også andre fuglearter eller bestander som trekker gjennom eller oppholder seg i Norge utenom hekkesesongen.	Medium	Both	Årlig tilstedeværelse over noe tid kan gi grunnlag for tidsserier også på lokalspesifikk makroplast-forurensning, og på konflikter mellom fugl og plastforsøpling.	Marint/ biota
Overvåking av åpen grunnlendt kalkmark	2020	Hovedformålet med overvåkingen av åpen grunnlendt kalkmark i Oslofjordområdet er å få oversikt over status og tidsutvikling for antallet forekomster, arealet og den økologiske tilstanden til forekomstene. Målet er også å identifisere hva som forårsaker endringene.	Irrelevant/NA			Terrestrisk
Overvåkning av forsuring - bunndyr i elv	1985	Målsettingen er å følge med på forsuringsutviklingen ved å overvåke forsuringsfølsomme bunndyr i faste elvenettverk på Sørlandet og Vestlandet.	Low	Both		Elv
Overvåkning av hekkende fugl på land (TOV-E)	2005	Programmet skal gi representative mål for endringer i fuglebestander i landmiljøet nasjonalt og regionalt.	Irrelevant/NA			Biota

Overvåkning av humler og sommerfugler	2009	Overvåke bestander av humler og sommerfugler på en arealrepresentativ måte, for å dokumentere tilstand og avdekke endringer over tid. Programmet skal å gi datagrunnlag for naturindeks, men også bidra til kunnskapsgrunnlag for å vurdere tiltak.	Irrelevant/NA			Biota
Overvåkning av palsmyr	2004	Følge utviklingen i palsmyr som er følsom indikator på klimaendring	Irrelevant/NA			Terrestrisk
Overvåkning i referanseelver	2017	Styrke datagrunnlaget for fastsettelse av referanseverdier i ulike elvetyper. Teste metodikk for tilstandsklassifisering i norske elver. Bidra til å oppfylle Norges rapporteringskrav med tanke på EUs vanndirektiv. Fange opp langsiktige endringer i vanntilstanden i norske vassdrag som skyldes menneskelige påvirkninger. De første årene av programmet har fokusert på å teste ut overvåkingsmetoder og å styrke datagrunnlaget for referansevassdrag.	Low	Both		Elv
Overvåkningsprogrammet for hjortevilt	1991	Hovedformålet for programmet er at det skal fungere som et økologisk varslingssystem og gi grunnlag for å vurdere utviklingen i ville hjorteviltbestander og deres naturmiljø ved hjelp av enkle data	Irrelevant/NA			Biota

		innsamlet fra utvalgte overvåkingsområder.				
Pilotprosjekter for bruk av fjernmåling i overvåkning	2016	Å vurdere bruk av nye og kostnadseffektiviserende teknologiske verktøy i kartleggings- og overvåkningsaktiviteter innenfor våre ansvarsområder, og å innarbeide data fra disse i vår dataflyt.	Don't know			
Regional overvåking av insekter	2020	Hovedformålet for programmet er å få tall for biomasse og biodiversitet av insekter i to terrestriske økosystemer, semi-naturlig mark og skog. Det skal undersøkes endringer og registreres funn for sentrale artsgrupper (f.eks. pollinerende insekter, rødlistede, trua og fremmede arter). På sikt skal overvåkningsprogrammet vise trender i insektbestandene og forklare årsakene til eventuelle endringer. Overvåkingen skal også legge grunnlag for at insektbaserte indikatorer på sikt kan inngå i fastsettelse av økologisk tilstand.	Irrelevant/NA			Biota

Terrestrisk naturovervåking (TOV) (avsluttet)	1990	Dokumentere endringer for viktige komponenter i vanlige terrestriske økosystemer under påvirkning fra klimaendringer, langtransportert forurensing og i noen grad arealbruksendringer, så vel som variasjon i naturgitte påvirkningsfaktorer.	Irrelevant/NA			
Ringmerking av fugl	1914	Opprettholde en nasjonal plattform for ivaretakelse av ringmerkingsdata, kvalitetsikre ringmerkeres leveranser og bidra til internasjonale og nasjonale sammenstillinger.	Irrelevant/NA			Biota
Screening av nye miljøgifter	2002	Screeningsundersøkelser har som mål å kartlegge forekomst, tilførsel, og miljøkonsekvens av nye miljøgifter i norsk og arktisk miljø. Screeningdata skal benyttes til å vurdere gjennomføring av lokale, nasjonale og internasjonale tiltak. Data skal også benyttes til å avgjøre om det undersøkte stoffet skal inn i løpende overvåkning.	Low	Both		Flere
Seapop	2014	Bidra til en mer helhetlig, økosystembasert forvaltning av sjøfugl i norske farvann gjennom kartlegging og overvåking, samt forklare endringene i sjøfuglbestandene og identifisere viktige miljøfaktorer som styrer sjøfuglenes bestandsutvikling.	Medium	Both	Kan gi grunnlag for å vurdere/dokumentere konflikter mellom fugl og plastforsøpling.	Marint

Teotil: Tilførsel av nitrogen og fosfor til kystområder	1994	Beregne årlige tilførsler av fosfor og nitrogen til norske kystområder fra ulike kilder. Beregningene er utført ved bruk av beregningsmodellen Teotil.	Irrelevant/NA			Marint
Økosystemovervåking i kystvann (Økokyst)	1990	Overvåkningsprogrammet ØKOKYST har som mål å overvåke økosystemer i norske kyst- og fjordområder, og skal fange opp uønskede påvirkninger av tilførsler av næringssalter, organisk materiale, og langsiktige klimaendringer. Vannforskriften med tilhørende veileder for klassifisering av miljøtilstand i vann er en viktig premissleverandør for dette overvåkingsprogrammet. Vi bruker dataene fra programmet til utvikling av metodikk og klassegrenser for klassifiseringssystemet etter vannforskriften, og i henhold til EUs vanndirektiv.	Low	Both		Marint
Økosystemovervåkning i ferskvann (Økofersk)	2009	Hensikten med overvåkningsprogrammet er å skaffe referansedata fra upåvirka vannforekomster som påvirkninger kan vurderes opp mot og følge med på langsiktige endringer i naturlige forhold og storskala menneskelig påvirkning.	Low	Both	Lokalitetene kan være egnet som referanselokaliteter for makroplasti ferskvann	Ferskvann

Økosystemovervåkning i store innsjøer (Økostor)	2021	Fastsette økologisk tilstand og ferskvannsøkologisk utvikling i et utvalg av de største norske sjøene Styrke datagrunnlaget for fastsettelse av referanseverdier for de ulike kvalitetselementene i store innsjøer. Tilpasse og teste metodikk og ny teknologi for overvåkning og klassifisering til bruk i store innsjøer.Bidra til å oppfylle Norges rapporteringsforpliktelser overfor vanndirektivet Skaffe kunnskap om effekter av klimaendringer og andre langsiktige endringer på store innsjøer. Øke kunnskapen om økologiske forhold i store innsjøer i Norge.	Low	Both	Overvåkningsområdene er kanskje ikke relevante for overvåkning av makroplast.	Ferskvann
Overvåking av bestandsutvikling til laks og sjøørret	2019	Skaffe informasjon om bestandssammensetningen hos voksen laks, antallet gytende laks og sjøørret i ulike vassdrag, og å innhente løpende informasjon om lakseinnsiget for om nødvendig kunne redusere beskatningen dersom du skulle bli behov for det. Sjøoverlevelsen hos utvandrende smolt måles i fem vassdrag på kyststrekningen fra Imsa i Rogaland til Kongsfjordelva i Finnmark.	Low	Both		Elv

Overvåking av damfrosk	2006	Følge med på bestanden, og se om noen av tiltakene har effekt på bestanden.	Low	Both	Lokaliteter for damfrosk er kanskje ikke relevante for makroplastovervåkning.	Ferskvann
Overvåking av dverggås	1987	Følge utviklingen i den fennoskandiske hekkebestanden av dverggås.	Irrelevant/NA			Biota
Overvåking av edelkreps	2001	Overvåkingsprogrammet ble startet opp i 2001, hvor det har vært prioritert 5 lokaliteter årlig, med en rullering hvert 5. år. Programmets overordnede mål er å overvåke tilstanden til et utvalg av de viktigste norske edelkrepsebestandene slik at større endringer i bestandsstatus kan avdekkes. Et nytt program ble startet i 2018 med formål å overvåke status og trender for et utvalg av de viktigste endelkrepsbestandene i Norge. I tillegg skal prosjektet gjennom bruk av ny teknologi (eDNA) implementere overvåkning av spredning av signalkreps.	Low	Both	Lokaliteter for edelkreps er kanskje ikke relevante for makroplastovervåkning.	Ferskvann

Overvåking av elvemusling	2000	Dokumentere utviklingen i bestander av elvemusling over tid i hele landet. Det gir grunnlag for å vurdere behov for tiltak for å bevare arten. Hovedmålet med dette er å sørge for at det fins livskraftige populasjoner av arten i hele Norge, at eksisterende populasjoner skal leve og sikres i et langsiktig perspektiv. I tillegg er det et mål at miljødata fra flere lokaliteter over flere år gir ny kunnskap. Det gir verdifull innsikt for videre forvaltning av arten. Elvemusling har høye krav til vannkvalitet og leveområde. Overvåking gir også en pekepinn på vannkvalitet og livsbetingelsene for øvrige arter i vassdragene som overvåkes.	Low	Both	Overvåkningsområdene er kanskje ikke relevante for overvåkning av makroplast.	Elv
Overvåking av fjellrev	2019	Innhente årlige data om bestandsutviklingen hos fjellrev (antall individer og endring over tid) på fastlands-Norge. Fjellreven er en sterkt truet art i Fennoskandia. Den er også en prioritert art med tilhørende handlingsplan og tiltak for bevaring over store deler av dagens utbredelse.	Irrelevant/NA			

		Overvåkingen skal gi kunnskap om bestandsutvikling nasjonalt og for delbestander. Data fra overvåkingsprogrammet brukes også til å vurdere effekten av de iverksatte tiltakene for å bevare arten, som brukes til å utforme mer effektive tiltak.				
Overvåking av flaggermus	2022	Alle flaggermusene i Norge er utelukkende avhengig av insekter og edderkoppdyr. Artene er derfor i stor grad utsatt for de samme generelle forstyrrelsene, og kan fungere som gode indikatorer for økosystemfunksjon og -tilstand. Mange europeiske flaggermusarter har opplevd nedang i bestandsstørrelsene. Årsakene til nedgangen er sannsynligvis komplekse, og omfatter forstyrrelser i ynglekolonier og overvintringssteder, miljøforurensning med plantevernmidler, tap av habitat og fragmentering, endringer i arealbruk og klimaendringer.	Irrelevant/NA			
Overvåking av fremmede fiskeslag	2017	Prosjektets formål er å etablere og gjennomføre en standardisert årlig overvåking av spredning av fremmede ferskvannsfisk i Norge, ved å gjennomføre innhenting av opplysninger om nye forekomster av	Irrelevant/NA			

		fremmede ferskvannsfisk i alle fylker i Norge, inkludert Svalbard.				
Overvåking av fremmede marine arter	2010	Hensikten med overvåking av fremmede marine arter er å tidlig kunne fange opp nye etableringer og, hvis mulig, iverksette tiltak for å hindre videre etablering og spredning. I henhold til "Forslag til tiltaksplan for bekjempelse av skadelige fremmede organismer (2019-2024)" vil det bli utarbeidet et samlet kunnskapsgrunnlag for framtidig vurdering av risiko, tiltak mot, kartlegging og overvåking av fremmede marine arter. Vi har også mål om i 2022 å fremme en målrettet nasjonal overvåking av fremmede marine arter i Norge med hensyn til metodikk, allerede etablerte arter, dørstokkarter og muligheter for å avdekke nyetableringer, samt hvordan de er blitt introdusert. Vi skal vurdere de mest aktuelle havnene og eventuelle andre	Don't know			

		områder for overvåking fordelt langs hele norskekysten, inkludert Svalbard.				
Overvåking av gås	Not specified	Programmet skal sikre oppdatert informasjon om kritisk viktige trekk og hekkelokaliteter for gåsearter som omfattes av et europeisk samarbeid under EGMP-plattformen (European Goose Management Platform). Videre omfattes tall for beskatning av artene i Norge gjennom jakt, planlegging av et samlet uttak gjennom jakt, og fordeling av uttak mellom land som er vert for artene til ulike tider.	Irrelevant/NA			
Overvåking av hubro	2009	Målsetning for programmet er å følge bestandsutviklingen for hubro i et representativt utvalg av territorier	Irrelevant/NA			
Overvåking av isbjørn	Not specified	Innhente ekstra data på isbjørn for å forstå økologiske endringer og kunne varsle tidlig om eventuelle endringer i bestandsutvikling som følge av endringer i miljøet. I tillegg skal overvåkingsprogrammet bidra til at man til enhver tid har oppdatert og god kunnskap som er nødvendig for best mulig forvaltning av bestanden.	Irrelevant/NA			

Overvåking av jordbrukets kulturlandskap (3Q)	1998	3Q skal gi oversikt over utviklingstendenser i jordbrukets kulturlandskap. 3Q-programmet rapporterer indikatorer for arealstruktur, biologisk mangfold, kulturminner og kulturmiljøer, og tilgjengelighet i jordbrukslandskapet.	Irrelevant/NA			
Overvåking av kalkede laksevassdrag	1985	Dokumentere vannkjemiske og biologiske effekter av kalking i lakseførende vassdrag, med sikte på at kalkingen skal skje på en økologisk og økonomisk optimal måte.	Low	Both	Overvåkningsområdene er kanskje ikke relevante for overvåkning av makroplast.	Elv
Overvåking av mink	Not specified	Fjerne mink fra utvalgte, viktige sjøfugllokaliteter for å redusere predasjon og reetablere sårbare arter av bakkehekkende fugl.	Low	Both	Overvåkningsområdene er kanskje ikke relevante for overvåkning av makroplast.	Marint
Overvåking av moskus	2004	Bidra til å opprettholde en god dyrehelse hos moskus, og for tidlig å avdekke eventuelle sykdomsutbrudd for å iverksette adekvate tiltak.	Irrelevant/NA			
Overvåking av myr- og engvegetasjon	Not specified	Hovedformålet med langtidsstudiene er å øke kunnskapen om skjøtselen av større slåttemyrarealer. Metodeutvikling med overføringsverdi til andre liknende områder står sentralt. Klimaets betydning og betydningen av smågnageraktivitet er i tillegg trukket inn.	Irrelevant/NA			

Overvåking av mårhund	2008	Hindre etablering av arten i Norge	Irrelevant/NA			
Overvåking av reindriften - produksjon og tap	2014	Det nasjonale overvåkingsprogrammet har som mål å tilrettelegge tallmateriale på reintall, rovviltforekomster og vegetasjonsmessige forhold knyttet til reindriften i Norge. Dette tallmaterialet danner grunnlaget for statistiske beregninger av tap og produksjon i reindriften i Norge.	Irrelevant/NA			
Overvåking av restaurert myr	2019	Miljødirektoratet overvåker klimagassflukser (CO_2, CH_4 og N_2O) fra en restaurert myr og fra en drenert referansemyr. Dette gjøres for å følge med på hvorvidt restaurering av myr i Norge fører til reduksjon av klimagassutslipp.	Irrelevant/NA			
Overvåking av snøugle	2005	Prosjektets overordnede mål er å kartlegge og overvåke bestandsforhold, vandringer og habitatbruk hos snøugle. Ved bruk av satellitt-telemetri og genetiske metoder har man blant annet ønsket å undersøke om Norge har en regional bestand av snøugle, eller om arten har et sirkumpolart forflytningsmønster, samt avdekke hvor snøuglene befinner seg utenom hekketiden.	Irrelevant/NA			

		Også viktige parametere som næringsvalg, hekkesuksess, informasjon om trusselfaktorer og genetisk tilhørighet blir samlet inn.				
Overvåking av spredning av fremmede karplanter	2018	Prosjektet skal utvikle og sette igang et system for tidlig oppdagelse og varsling av nye fremmede arter i terrestrisk naturmiljø.	Irrelevant/NA			
Overvåking av spredningsveien planteimport	2014	Prosjektet skal kostnadseffektivt overvåke og beregne kvantitativt hvor mange fremmede arter som kommer til Norge som blindpassasjerer via spredningsveien import av planteprodukter, og hvilken risiko disse utgjør for det stedegne biologiske mangfoldet.	Irrelevant/NA			
Overvåking av storsalamander	2013	Få en kontinuerlig oversikt over situasjonen for storsalamander, spesielt på Østlandet hvor arten er mest utsatt for påvirkninger. I tillegg trenger vi et grunnlag for rødlistevurderingene. Noe av forklaringen på	Low	Both	Overvåkningsområdene er kanskje ikke relevante for overvåkning av makroplast.	Ferskvann

		storsalamanderens tilbakegang er utsetting av fisk, igjenfylling av dammer, grøfting av myr, forurensning og urbanisering.				
Overvåking av verneområder knyttet til bevaringsmål	Not specified	Miljødirektoratet ønsker en kunnskapsbasert forvaltning av verneområdene. I fagsystemet Naturstatus for verneområder (NatStat) kan forvaltningsmyndigheten sette konkrete bevaringsmål for ønsket naturtilstand i et verneområde. Bevaringsmål overvåkes/måles ved hjelp av feltapplikasjonen NatReg. Overvåkningsresultatet angir om tilstanden er god, middels eller dårlig. Innsynsløsningen til NatStat gir oversikt over antall bevaringsmål, målt tilstand (tidsserier), og hvilke påvirkningsfaktorer (som fremmede arter) som følges opp av forvaltningsmyndigheten. NiN-basiskartlegging av natur i verneområdene gir et nødvendig kunnskaps- og vurderingsgrunnlag	Irrelevant/NA			

		for relevante bevaringsmål og tilstandsvariabler.				
Overvåking av vilt (rovvilt)	Not specified	Å standardisere, systematisere og koordinere overvåkingsaktiviteten på landsbasis, samt å sikre en nasjonal og enhetlig bearbeiding, sammenstilling og rapportering av overvåkingsdata for bjørn, jerv, ulv, gaupe og kongeørn.	Irrelevant/NA			
Overvåking av åkerrikse og svarthalespove	1995	Åkerrikse fikk egen nasjonale handlingsplan i 2009, mens svarthalespove ble utnevnt som prioritert art med egen forskrift i 2011. Den sør-norske underarten ble avprioritert i 2015.	Irrelevant/NA			
Overvåking av ål	1975	Overvåke utvikling i bestanden/bestandsstruktur av ål i Imsa ved å telle opp- og nedvandring av ål. Stasjonen er en av de viktigste overvåkingsstasjonene i Europa. Stasjonen er sentral når ICES skal gjøre sine årlige vurderinger av tilstand for ål i Europa.	Irrelevant/NA			
Petroleumsovervåking: Miljøovervåking på norsk sokkel	Not specified	No goals reported	Low	Both		Marint

Tiltaksorientert vannovervåking for landbasert industri	2016	innhente pålitelige data som kan bidra til klassifisering av økologisk og kjemisk tilstand kartlegge bedrifters påvirkning på/bidrag til iljøtilstanden i aktuelle vannforekomster, og påvirkningens utbredelse identifisere nødvendige tiltak for virksomhetene (forurenser betaler-prinsippet) bidra til tiltaksprogrammene for å oppnå miljømålene i vannforekomsten fange opp endringer i tilstanden/tilførsel som skyldes tiltak gjennomført av bedriften bidra til en enhetlig myndighetsutøvelse basert på samlet vurdering av påvirkning fra flere bidragsytere i en vannforekomst	Low	Both	Overvåkningsområdene er kanskje ikke relevante for overvåkning av makroplast.	Flere

Appendix 9

Summary of monitoring strategies recommended by AMAP with regard to criteria for selection and conduction of marine litter surveys on Arctic shorelines (From AMAP 2021a).

Coastal morphology	Beach-like shoreline with sand, gravel, pebbles, or stones of different sizes, but not shorelines with cliffs. Preferably with clear depositional wash-up lines from both normal tidal conditions as well as more extreme weather conditions.
Length of survey segment	100 m defined by start and end GPS positions, but shorter segments as low as 50 m can be accepted, if limited by rocky shores.
Type of shorelines	Reference shorelines located in remote areas, preferably at an outer coastline (not inner fjords) and pointing toward the open sea. Locally impacted shorelines, e.g., from urban activities.
Definition of survey area	From the waterline to the back of the beach including the zone deposited during high-water levels caused by stormier conditions. Slippery areas due to settlement of, e.g., bladderwrack on stones below the normal waterline in the tidal zone can be excluded because of unsafe conditions for litter collection. A consistent and well-defined survey area of the shoreline should be identified for temporal monitoring.
Accessibility and survey frequency	The coastline should be accessible from land or by a boat. At least 1-2 seasonal surveys can be performed per year per location, i.e., summer (May-July) and/or autumn (August-October).
Collection and registration of litter items	All man-made litter items sized > 2.5 cm should be collected and identified according to types of litter described in either the NOAA or OSPAR guidelines.
Removal of litter items	Should be accessible for ease of marine litter removal. Larger litter items might be moved inland away from the shoreline, if team is not able to transport these items to an appropriate waste disposal site, so the items are not registered again during the next survey. Items too large to move should be marked on site in a way that they won't be registered again.

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