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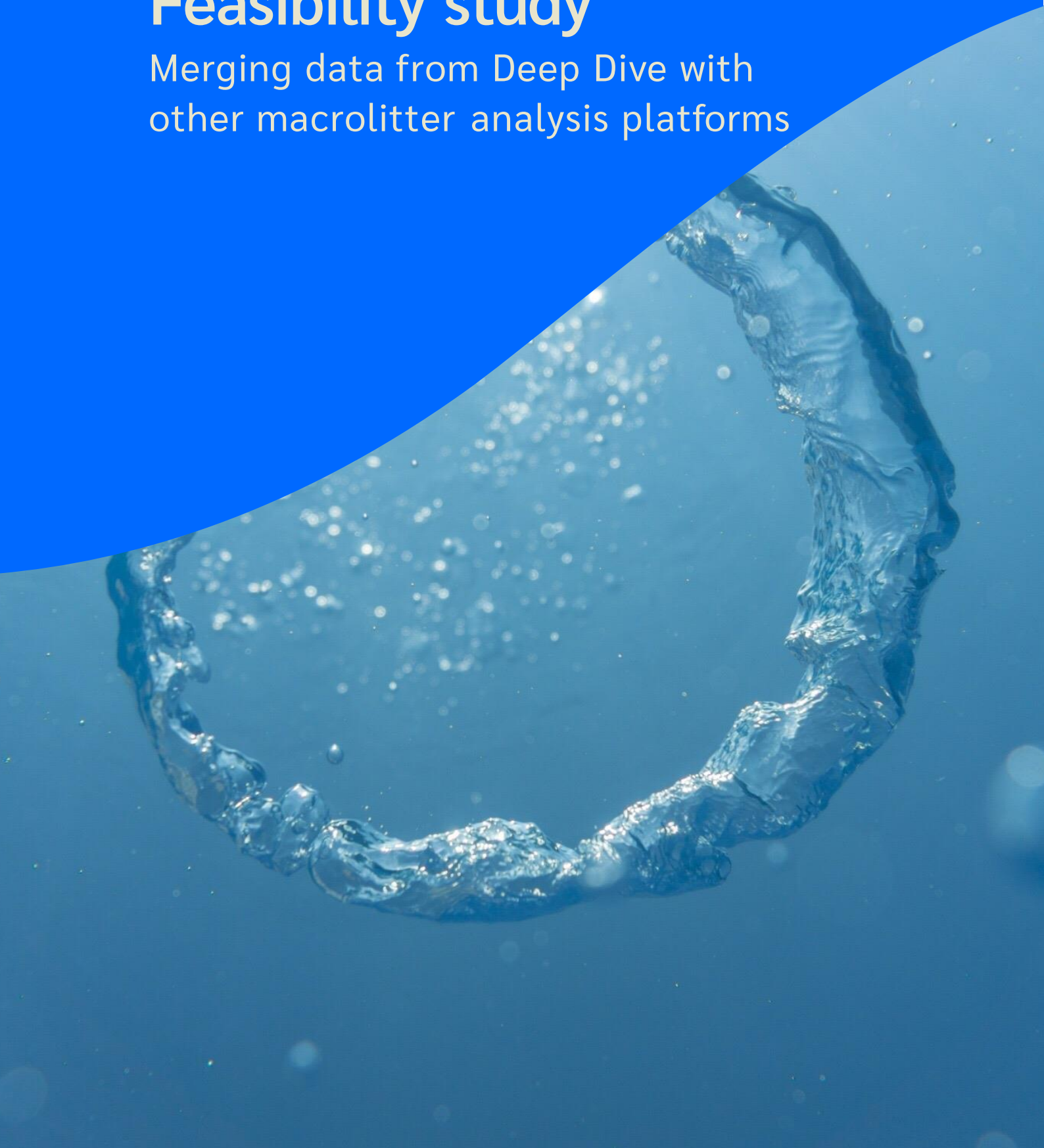
Feasibility study

Merging data from Deep Dive with other macrolitter analysis platforms



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Abstract
This study evaluates the technical feasibility of merging data used in the Deep Dive platform for the Arctic with a selection of established platforms for macrolitter registrations.

Keywords: Feasibility study, Deep Dive, Litter monitoring, Data platforms
Emneord: Mulighetsstudie, Deep Dive, Søppelovervåking, Dataplattformer

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1 Project background

Plastics continue to pollute the marine environment around the world -including the Arctic. The Deep Dive method for the Arctic (https://Deep_Dive.grida.no/) enables a better understanding of where beach litter comes from and why it ends up on shorelines in Arctic regions – knowledge that can be and has been used to improve practices and policies to help prevent litter ending up in our seas, as exemplified in Section 2. This free platform is designed for researchers, university students, and others interested in conducting beach litter research in the Arctic.

Several platforms for macrolitter registration and analysis are currently in use by both experts and citizen scientists conducting clean-ups, which creates a challenge when it comes to data harmonization and for finding, getting access to and compiling data for regional to global analysis. It is also a disadvantage that organisations that do not have a stable funding mechanism hosts such platforms. The Deep Dive developers (NIVA, SALT, GRID-Arendal) have therefore decided to look into the possibility of merging the data used in Deep Dive with other established platforms. This feasibility study will look at different platforms for macrolitter registration and analysis to establish whether it would be desirable and/or possible to merge the data. **The relevant platforms considered are OSPAR, ICES, Rydde and Rent Hav, NOAA (MDMAP), and the Marine Debris Tracker.**

In this feasibility study we first introduce the Deep Dive method for the Arctic, illustrating the relevance and importance of such data collection for decision makers in complementing established data protocols on macrolitter. We developed a standard for comparing Deep Dive with other platforms, including the ownership of data and platform, cost analysis and compatibility of the platform with respect to implementation of Deep Dive data in the platforms. Based on this an assessment of the platforms was made to evaluate the feasibility and desirability to merge Deep Dive data with these platforms. Finally, a budget for merging Deep Dive data with the most relevant platforms was set up based on some assumptions.

1.1 Important terminologies

API: An API, or Application Programming Interface, is a set of defined rules that enable different applications to communicate with each other.

Comparable data: Comparable data refers to data that are similar in nature and can be compared or contrasted with each other. This could mean that the data are of a similar type, from similar sources, or measured using the same units.

Compatible data: Compatible data refers to data that are consistent in structure and content across different datasets, allowing for easy integration and interoperability.

Data format: A data format in information technology refers to the syntax, encoding, and file format or media type for storing or transmitting data.

Data Merge: Data merging is the process of integrating two or more comparable datasets into a unified database.

Data migration: Data migration is the process of transferring data from one storage system or computing environment to another.

Database Platform: A database platform is a type of data platform that specifically focuses on the creation, management, and use of databases.

Data schema: A data schema is a logical structure that represents the organization and relationship of data in a database. It includes elements like table names, fields, data types, and the relationships between these entities.

Data structure: A data structure is a way of organizing and storing data in a computer so that it can be accessed and used efficiently.

Database technology: Database technology refers to the software and hardware systems that allow us to create, manage, and use databases.

Data post-processing: refers to the activities and procedures carried out on collected data after the initial acquisition phase. It involves various tasks such as cleaning, filtering, organizing, and analyzing the data to enhance its quality, accuracy, and usability.

Data Interoperability: The seamless exchange and use of data among different systems, ensuring compatibility and efficient collaboration.

GUI: A GUI, or Graphical User Interface, is a type of user interface that includes graphical elements, such as windows, icons, and buttons, allowing users to interact with electronic devices.

Harmonization: The development of a cluster of monitoring procedures – including sampling strategy, sample collection, sample preparation, analysis, quality assurance and quality control criteria, data management protocols – that provide cross-comparable data which can be validated. Monitoring is a key step in plastic pollution control and management, and harmonization is important in this context.

Litter protocol: A manual that describes the type of data on litter items (e.g. material categories, source categories) and metadata (e.g. time and place of data collection) to be recorded.

Map Layers: A map layer in Geographic Information Systems (GIS) is a database containing groups of point, line, or area (polygon) features representing a particular class or type of real-world entities.

Maps: A map is a symbolic representation of selected characteristics of a place, usually drawn on a flat surface. Maps present information about the world in a simple, visual way.

Merge objectives: The objectives of data merging include integrating comparable data into a unified database, adding parameters to a database, appending instances or observations, and removing repetitions and other inaccurate data.

Merge options: Data merge options include concatenation (appending datasets), join (merging datasets along columns), and merge (combining datasets with SQL-style joining).

UI: UI, or User Interface, refers to the visual elements that users interact with in a software application or hardware device. It's about how the product is laid out and how users interact with it.

UX: UX, or User Experience is about the overall experience a user has when using a product, including its functionality, ease of use, and efficiency.

2 Introduction to Deep Dive

The beach litter Deep Dive concept has been developed in dialogue with a variety of researchers and stakeholders as a response to an apparent mismatch between the knowledge needed for stakeholders to take action against marine litter and the knowledge gathered on litter through on-going data collection (Falk-Andersson, 2021). When entering dialogue with fisheries stakeholders in the Barents Sea, it was difficult to use existing data on beach litter to engage fishers in conversations on their roles and responsibilities with respect to littering. While knowledge of litter sources is available through data on beach litter from citizen science and OSPAR (Falk-Andersson et al., 2019), even the rather extensive OSPAR protocol come short of identifying the type of fisheries responsible, whether the litter had a local or global origin, and whether the littering behaviour is on-going or that the litter we find on our beaches is a result of "old sins". This because established macrolitter protocols, although they in some cases are very extensive (e.g. the Joint List of Litte Categories recommended in the EU Fleet et al. (2021)), only identifies types of items in terms of number of items per litter category. Furthermore, these protocols have been developed outside the Arctic region, which is a limitation in securing their relevance.

Clean-up actors also retained a greater in-depth understanding of the litter than could be derived from established protocols as they could often at least partially link the litter cleaned to specific polluters in time and space, as well as polluting behaviour. There was a need to formalise this knowledge to get more scientifically robust data to hold polluters accountable, to collect knowledge that could aid polluters in identifying their roles in contributing to the pollution, and to identify actions needed to reduce their environmental footprint (Falk-Andersson, 2021). Workshops and data analyses were conducted together with a range of stakeholders and experts through a series of smaller projects to identify what type of knowledge needs to be documented and how to collect meaningful data that can aid decision makers.

Here we will first describe the Deep Dive concept and illustrate, using the Barents Sea as a case study, what type of data were identified as important to collect and why, and then describe the history behind development of a Deep Dive data collection portal for the Arctic.

2.1 The Deep Dive concept

The Deep Dive method was originally developed and described in Falk-Andersson (2021) as a concept for knowledge gathering and dialogue on littering that can take different forms depending on the objective of the study (Figure 1). In what was termed "Professional Deep Dives", the focus is on data collection where people trained in the method register information relevant for the research or management question of concern. This is the purpose of the Deep Dive portal for the Arctic. *Professional* in this instance simply refers to a any person with some training in applying the protocol and may include citizen scientists and volunteers. In "Deep Dives with Experts", people knowledgeable of the activities where the litter originates from, are invited to give insight into various items found. Key informants in the Arctic have been fishers who have identified items from different types of vessels, as well as items that are likely discarded (Falk-Andersson, 2021). This knowledge can be formalised in terms of identifying the parameters needed to be recorded to document a phenomenon. For example, fishers and fisheries technologists were used to help identify the origin of a fishing net and the reason behind its loss. This insight was used to develop a set of parameters that should be recorded for documentation which included information on the mesh size, diameter of the mesh, colour, and material type, as well as whether the sides have been ripped or cut. This information has been used to identify that the majority of the nets found along the coast of Svalbard are cut-offs after repair of trawl nets that have been discarded in the region (Falk-Andersson & Strietman, 2019). In "Deep Dive Workshops" the aim is to

engage stakeholders in dialogue to raise awareness. Initial dialogue with fisheries stakeholders in the Barents Sea, found that physical interaction with the litter was a catalyst for the stakeholders taking responsibility for preventive measures (Falk-Andersson, 2021).

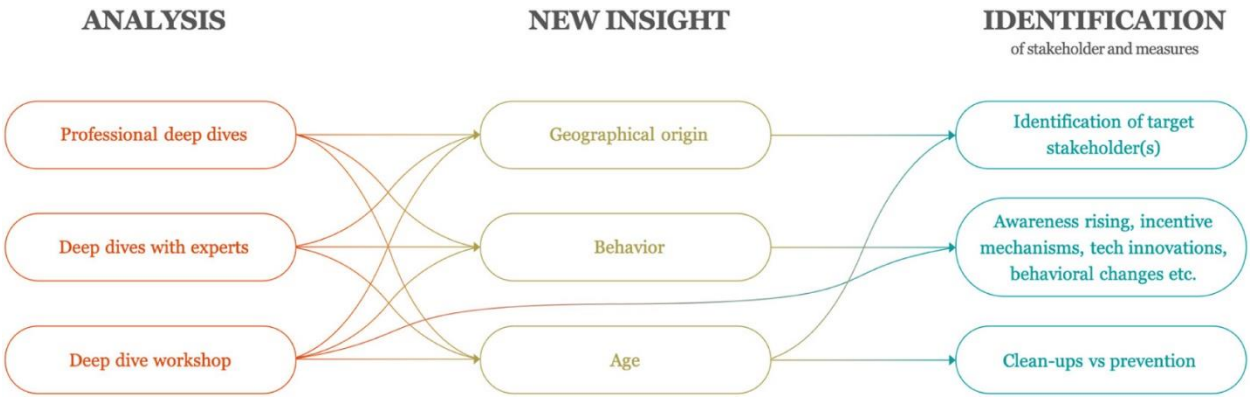

Figure 1: Illustration of the different types of Deep Dive analysis and how they contribute to awareness rising, and insights into geographical origin, littering behaviour, and identification of stakeholders and measures (Illustration from Falk-Andersson (2021)).

Deep Dive has proven useful in complementing existing monitoring data and has given new knowledge that can be used to understand the origin of and behaviour behind littering. In addition to insights on fishing nets, such analyses have identified specific items that are discarded from trawlers (e.g., bundles of strapping bands and conveyor belts) and documented that ropes found along beaches in the Barents Sea are largely cut-offs related to repair of trawl nets. It has also been used to document the relative contribution of litter items and major sources of litter in weight compared to numbers (Falk-Andersson, 2021; Falk-Andersson & Strietman, 2019). Furthermore, a method has been developed to collect high-quality data on the geographical origin and age of litter items. Such information has been used to document that there is still on-going littering at Svalbard, and that the geographical origin of litter items corresponds to the major fishing nations operating in the area (Falk-Andersson et al., 2021). Information from Deep Dives have formed the basis for training programs for fishers and awareness raising putting focus on particular behaviours that need to change in order to reduce plastic pollution (Falk-Andersson, 2021; Johnsen et al., 2019). An example of this is the importance of avoiding cut-offs ending up being washed out to sea when repairing trawl nets.

While the Deep Dive concept has developed based on beach litter data, the method can be applied to any environment. An on-going project at NIVA working with the agricultural sector is exploring the use of methods within anthropology combined with design thinking in developing a new, structured method for engaging stakeholders and experts in dialogue to understand the problem and identify sustainable solutions (PROLAND - Protecting agricultural lands from plastic pollution | NIVA).

2.2 A Deep Dive portal for the Arctic

The success in using Deep Dives to collect stakeholder relevant data and engage stakeholders in preventive measures, inspired the development of a Deep Dive portal for the Arctic. The portal facilitates a so-called "professional Deep Dive" where information on the litter is recorded according to a pre-defined protocol. The data collected through this on-line protocol is based on knowledge gained through beach litter Deep Dives in the Barents Sea, both along the coast of Northern Norway and Svalbard. The citizen science protocol of Ocean Conservancy was used as a starting point for the protocol to secure harmonization with an internationally established protocol, with central items from the OSPAR protocol (Ospar, 2010), as well as items identified through analysis of litter at Svalbard and Arctic Norway as important, added to the protocol. Data are collected through an open access electronic platform (Deep Dive.grida.no) that also provides a step-by-step guideline guiding users throughout the process, from acquiring litter for analysis, to data collection and waste management. In the data portal, Deep Dive data can be entered and downloaded, as well as viewed in the form of graphs showing summary statistics.

The data entry form facilitates recording of data on packaging and identifying geographical origin and age, documentation of net cut-offs, and documentation of fishing gear, including items typically discarded from trawlers, and rope cut-offs from repair of trawls. The entry form also allows recording of other litter items as the likely source of an item may be identified from the context in which it is found. An example of the latter is that a soda bottle found on a beach with lots of snack-related items and sunscreen is likely of local, land-based origin, while the same bottle found among fishing related items is more likely to be discarded at sea. In documentation of litter, only the number of items is typically recorded in established litter protocols. The Deep Dive protocol also record the weight of items. Comparison of age and weight data has shown large differences in the dominating sources of litter depending on the unit used. In Northern-Norway, maritime litter dominates in terms of weights, due to the high weigh of marine sourced litter, while this is not the dominating source when using counts data (Haarr et al., 2022). An overview of the litter categories registered is given in Table 1. The type of material is also recorded (soft plastic, hard plastic, foam, metal, paper, glass, wood, other, unknown) for all litter categories. In addition, certain metadata are collected regarding the sampling site, such as location, date of the cleaning, and length of the coastline cleaned.

The target user group of the Deep Dive portal are "semi-professionals", which in this context means that they have received training in the method and use of the portal. It is not regarded as suitable for traditional citizen scientists as data collection requires training, is quite time intensive, and requires some extra tools, such as appropriate scales for weighing litter items and callipers for measuring the dimensions of net cut-offs. Training workshops have been held with students at the UArctic summer school on marine plastics (Haarr et al., 2023), with students at the Svalbard Folkehøgskole (Tur med mening - Svalbard folkehøgskole (svalbardfolkehogskole.no)), and the Arctic Research Group (Arctic Research Group | Expeditions and Research). Training has also been given to volunteers and partners on Deep Dive projects, including staff at Keep Norway Beautiful and Oslofjorden Friluftsråd.

The Deep Dive portal for the Arctic is considered mature in terms of the protocol applied for data collection, although there is a need to further develop the analysis of the trawl cut-offs to determine if it is possible to link the combination of parameter recorded to the type of fishery (whitefish bottom trawl, shrimp trawl, Danish seine/ whitefish trawl, pelagic trawl, redfish, shrimp or whitefish bottom trawl, purse seine, seine net). Currently, experts, such as fisheries technologists, must be used to determine the type of fishery the nets originate from. This is manually assessed by combining the data entered with pictures uploaded in the entry form. There is also a need to develop and test guidelines for documenting rope cut-offs. Investigations into the potential use of identical objects in different

industries are also needed to be able to link items with sources with a higher degree of certainty. Blue industrial plastic sheeting, packaging tube rolls and strapping bands are all items that may be used across industries.

Observations during training workshops have also identified the need to test if semi-professionals can accurately identify blue industrial plastic sheeting typically used on freezer trawlers. Observing semi-professionals conduct a Deep Dive analysis only assisted by the online training material available is also recommended as it would identify any need for clarifications and additional training materials. Furthermore, the ambition has been that this portal should be relevant for the Arctic as a whole. This would require data collection and analyses with knowledge holders across the Arctic to identify items important to include in the portal, including the data entry form, to make it representative for the entire Arctic. To be more user-friendly, the Deep Five portal for the Arctic needs some further development in terms of interface for data collection, instructions, and guidelines (in particular photo-guides).

While the Deep Dive portal for the Arctic exists and can be used for data collection, development of multiple platforms for collection of data on litter is problematic. It can make it difficult to find data and could limit harmonization of data. This has consequences for comparison of data on a larger spatial scale (e.g. across the Arctic or regions within the Arctic for example across the Norwegian Arctic), and development of indicators used for monitoring types and amounts of litter (Addamo et al., 2018; Smail et al., 2020). Furthermore, the lack of funding prevents the Deep Dive portal for the Arctic from being updated and improving the user-friendliness of the portal. While there is a clear demand for a platform that can support collection of deep dive data, integration of the Deep Dive portal into existing, well-established platforms is therefore to be preferred.

This report evaluates the potential for Deep Dive data on macro-litter (items >25mm) to be integrated in key existing platforms that are either globally or regionally relevant in an Arctic context. The platforms evaluated are OSPAR (ODIMS - Home (ospar.org)), ICES (DATRAS (ices.dk)), Rydde (Rydde (ryddenorge.no)/ Rent Hav (Rent hav | Senter mot marin forsøpling (marfo.no)), NOAA (Monitoring | OR&R's Marine Debris Program (noaa.gov) , Marine Debris Tracker (Home | Marine Debris Tracker).

Table 1 Litter categories in the Deep Dive portal for the Arctic

Main category	Sub-category	Item
PACKAGING	FOOD	Crisps/sweet packets, ice cream wrappers, lolly sticks
		Food containers (incl. cans, bottles, bags, tubs, etc.)
		Drinks (incl. cans, bottles and cartons)
	OIL & CHEMICALS	Engine oil
		Aerosol/spray cans
		Injection gun containers grease
		Injection gun containers silicone
		Injection gun containers other/unknown
		Oil drums
		Paint tins
		Other (describe in "notes")
	DOMESTIC	Sun lotion
		Other cosmetics (shampoo, soap, deodorant, etc.)
		Toilet cleaner
		Other cleaners (detergent, chlorine, bathroom sprays, etc.)
	TOBACCO	Cigarette packaging
		Snuff boxes
FISHING GEAR AND ROPES		Rope fisheries cut-offs (ends cut, ~0.5 cm in diameter, <20 cm long)
		Other rope cut-offs (clear cut in both ends)
		Other rope (torn in one or two ends)
		Tangled nets/cord/rope and string
		Dolly rope (strings, ropes or bundles)
		Trawl and seine nets
		Gillnets
		Parts of conveyor belt used for fish processing
		Packaging film rolls
		Strapping bands (bundle)
		Strapping bands (single)
		Blue industrial plastic sheeting
		Items related to crab/ lobster fishery, including bait holders
		Items related to mussel/oyster culture
		Fish boxes/crates
		Fishing line (angling)
		Other fishing vessel items (fish basket etc.)
		Plastic trawl floats (trawl bobbins)
		Other floats/buoys
OTHER LITTER ITEMS		Bags (any bag that is not packaging: e.g., grocery bags, fruit bags, garbage bags)
		Domestic use (household/private use items excl. packaging: e.g., balloons, shotgun cartridges, clothing, etc.)
		Industrial use (e.g., detonation cord, building materials, work clothes such as high vis jackets, hard hats, etc.)
		Agricultural use (e.g., baling plastic or twine, bags/packaging for animal feed or fertilizer, etc.)
		Sanitary or medical use (e.g., sanitary pads, tampons, diapers, condoms, cotton bud sticks/Q-tips, syringes, etc.)
		Tobacco (non-packaging tobacco related items: cigarette butts, cigarette filters, snuff pouches, lighters, etc.)
		Food and drink (non-packaging food related items: straws, 4/6-pack yolks, single-use cups, plates, cutlery, etc.)
		Other items (any item not fitting any above category)

3 Comparison of the Deep Dive platform with other platforms

Migrating or merging the Deep Dive platform to another platform will provide long-term stability and maintenance for this valuable scientific database that has a wide range of applications. However, merging Deep Dive to another platform is not a straightforward process. It involves complex tasks such as mapping/merging protocols, database schemas (including existing data), and visual elements of the platform (data visualization, data capture UI). Although many similar platforms have a common goal of macrolitter monitoring and analysis, none of them has the exact same functionality as the Deep Dive. This poses a challenge for Deep Dive to be fully integrated with the other available/suitable platforms.

In Table 2, we assess the feasibility of merging Deep Dive to other platforms in terms of data/platform ownership, cost analysis, and compatibility with existing platforms. When studying data/platform ownership of different platforms, we try to address what type of data sharing policies are applicable to them, as we are mainly interested in and value the open data policies of the platforms. Another important aspect we assess is the cost analysis of merging and migrating Deep Dive to another platform, considering the existing system and workflow of the software in general. Such cost analysis can be more accurate if we have a dialogue with the partners in a more organized way with IT teams and administrative procedures. Although we sent emails to various platform providers, we have limited time/budget to follow up with them. Analysis in this report is therefore largely based on the available technical information on their websites, such as platform accessibility, data format, storage, web services, API, data capture method, etc. This type of information is very important for us to find out where the cost will go if we plan to merge the platform.

We also assess the compatibility with the platforms in general, since it is out of the scope of the project to match each category one-to-one with the different platforms. Also, it is difficult to get the details of the categories and subcategories used by these platforms, as they are not readily available on their websites. Since most of the platforms evolved with their own objectives and specific problems to address, they focus on different data collection approaches. Although some of the major categories can match in the different protocols across the platforms, they are different in detail and captured in the database in a unique way. Keeping the above considerations in mind, we have compared the different platforms in by describing the data and platform ownership, foundations for evaluation of costs and, finally, given an evaluation of the compatibility of the platforms in terms of integrating Deep Dive data in the different platforms (Table 2).

Table 2: Comparison of macrolitter data collection platforms with the Deep Dive platform describing data and platform ownership, cost analysis and the compatibility of the platform with integration of Deep Dive data.

Platform	Data/Platform ownership	Cost Analysis	Compatibility with other Platform
OSPAR	OSPAR is a body that safeguards the marine environment of the North-East Atlantic. OSPAR has a system (ODIMS) that contains data and information from its monitoring and assessment activities. OSPAR data policy and conditions of use state that the data and information under ODIMS belong to the providers who submitted them to OSPAR. The data and information have the Creative Commons Attribution 4.0 International License (CC BY 4.0), which allows users to share and adapt the data and information for any purpose, as long as they credit the source and indicate any changes. Users are also advised to cite the corresponding OSPAR publication or product when using the data and information. Member states of OSPAR can determine or maintain the data/platform ownership	Deep Dive platform and OSPAR use a relational data schema1. Deep Dive platform uses PostgreSQL, while OSPAR uses Microsoft SQL Server. These databases have different features, functions, and syntaxes that affect the data schema and merging. However, Deep Dive data can exist as map layers and tables for OSPAR. Given that Deep Dive operates as a continuous data collection and harvesting portal, an additional web service API is necessary to conform the data to the required OSPAR theme format. The disparities in database systems and data formats between Deep Dive and OSPAR may pose challenges, and the integration process may require careful consideration of these differences and potential costs.	Deep Dive is using the citizen science protocol of Ocean Conservancy as a starting point to provide context around litter. Deep Dive has added key items from the OSPAR protocol as well as items identified as important through Deep Dive analysis in the Barents Sea. Some degree of compatibility may be possible, but further research and harmonization are needed to ensure consistent and comparable data and information. Since most of the data are listed as individual layers and maps, DD can be listed under OSPAR.
ICES	ICES is an organization that fosters marine research in Atlantic Ocean. It also extends into the Arctic, the Mediterranean Sea, the Black Sea, and the North Pacific Ocean. ICES has a data center that offers various datasets from its members and other providers. ICES relies on expert groups and working groups to produce scientific evidence and advice for governments and international regulatory bodies. ICES data policy states (page 5, page 8) that the data and information belong to the providers who submitted them to ICES. The data and information have different licenses, from public domain (CC0) to restricted access (CC BY-NC-ND 4.0), and users must credit the source and follow the terms of use of each dataset. As a member state of ICES, Norway can easily determine the data/platform ownership.	ICES uses different types of database technology to store and manage its data, depending on the data source and format. The data formats, guidelines and vocabularies are specific to the type of data, and whether it is associated with a marine convention monitoring programme. The ICES data on macrolitter from the International Bottom Trawl Survey and Deep Dive data operate on entirely distinct data schemas and structures, making it less practical to merge these two datasets seamlessly. The differences in their foundational designs may introduce challenges and considerations, rendering a merger between the two datasets less feasible.	Deep Dive and ICES may have some overlap in their data sources and methods, but they are not directly comparable or compatible, because they use different data schemas and structures to collect and display data. ICES uses different types of database technology and data formats, depending on the data source and format, and whether it is associated with a marine convention monitoring program. Deep Dive uses a custom data schema and a web-based system to collect and display data.

Platform	Data/Platform ownership	Cost Analysis	Compatibility with other Platform
Rydde	Rydde is a service that is owned by the Norwegian Environment Agency (NEA). It is a tool for volunteers to plan and conduct clean-ups, as well as enter data. It has been developed and is managed in cooperation with NEA and Keep Norway Beautiful (KNB). After successfully registering, users can download data directly from the web solution. Data generated from the Rydde service share ownership with NEA and HNR to support the development of the national marine litter action plan and the annual beach clean-up campaign	The Rydde database, hosted on a cloud service provider, is accessible through a web API. Its database schema is intentionally designed to accommodate data collected by the Rydde application. Data collection in Rydde is executed through the application, adhering to a predefined database schema. The Rydde application is available on various digital devices, such as mobile devices and computers. In contrast, the DD database collection and development follows the MTV Django approach. This implies that the DD data schema aligns with the DD data collection form and data visualization, showcasing a distinct approach from Rydde's data collection and display module. The differences in database structures may introduce complexities and potential costs for integration of DD data in Rydde.	Deep Dive uses the citizen science protocol of Ocean Conservancy, with some extensions of litter categories. Rydde is also based on Ocean Conservancy. Thus, the protocols may be possible to harmonize, but this needs to be investigated further. However, Rydde and Deep Dive have low compatibility of analysis of existing categories because they use different data schemas and structures to collect and display data. Rydde data is a simple workflow to enter data in a row-column approach, whereas in the Deep Dive platform a nested data for each Form (1-4) is used. Therefore, it may be demanding merge data from DD with Rydde unless they are converted or transformed to a common format and standard.

Platform	Data/Platform ownership	Cost Analysis	Compatibility with other Platform
Rent Hav	Rent Hav is a tool for those working with marine litter. It is used for registration, planning and prioritization of clean-ups. The platform is hosted by the Norwegian Environment Agency. Rent Hav has a data platform that allows users to register, plan and report on beach clean-up activities and other environmental actions. It also displays clean-up data from OSPAR and mapping data from a number of resources. According to the Rent Hav data policy, the data and information presented on the Rent Hav platform are owned by the data providers that have submitted them to Rent Hav. Some of the data in Rent hav are intended for researchers and national and local authorities and is therefore access-controlled. This applies to figures and data from national clean-up activities. Authenticated users can downloadable clean-up data and statistics that can also be exported to external systems. In addition to clean-up operation data, users can also extract information about e.g., coastlines that have been cleaned, findings and reports.	Rent hav presents data from clean-up operations registered in Rydde and all data registered in Rent hav. Rent hav also displays map data from other participants relating to clean-up operations and the extent of marine litter. Rent Hav has both a website and an app for data submission. The website is accessed via a web browser where users register their email and desired role. Rent Hav has an app for iOS or Android that allows the user to register data in the field. Rent Hav integrates map-based information from key thematic maps that are publicly available and other mapped information, including map based date from Rydde and a number of other actors in the form of thematic map/layers. It may be possible to produce a map layer with Deep Dive data for Rent Hav.	Rydde and Rent Hav employ comparable technology. To merge data from Deep Dive with these platforms, it's anticipated that adjustments will be necessary due to Rydde using a different data schema to DD (described above) , Rent Hav has no schema.

Platform	Data/Platform ownership	Cost Analysis	Compatibility with other Platform
NOAA- MDMAP Database	The data and information collected by the MDMAP partners and volunteers are owned by the data providers that have submitted them to NOAA-MDMAP. NOAA- MDMAP only manages and provides access to the data and information but does not claim ownership or responsibility for them. The data and information are subject to the terms and conditions of the data providers, which may vary depending on the type and level of data. Data collected using the methods MDMAP protocol is stored in a secure database managed by NOAA, where it is viewable and accessible by other researchers and members of the public worldwide.	The platform technology used by NOAA- MDMAP is based on the NOAA GeoPlatform, which runs on Esri's ArcGIS Online technology. This is a cloud-based GIS data, analytics, and visualization platform that provides access to various map services and story maps. The platform currently incorporates various NOAA data sources and tools like the Marine Debris Tracker app and the Marine Debris Clearinghouse, both of which are external third-party applications. Similarly, Deep Dive can be integrated to NOAA-MDMAP platform. However, the merging of databases requires a comprehensive analysis of data sources, merge objectives, and available merge options. It is essential to thoroughly compare the benefits and risks associated with each merging method before proceeding with integration due to potential complexities and associated costs.	The compatibility of existing categories between NOAA-MDMAP Database and Deep Dive is not very high as they use different protocols (NOAA MDMAP protocols) and categories to classify and record marine debris. NOAA- MDMAP Database uses a standardized list of items that are grouped into categories, such as plastic, metal, rubber, etc1. Deep Dive uses a modified/customized list of items that are further grouped into categories, such as fishing gear, packaging, other items, etc. Some of the items and categories are common between the two systems, but others are unique or have different definitions. Therefore, the data and information from the two systems are not directly comparable or compatible and may require additional processing and harmonization to ensure consistency and accuracy. NOAA strictly apply the NOAA MDMAP protocols and will not accept other marine debris data.

Platform	Data/Platform ownership	Cost Analysis	Compatibility with other Platform
Marine Debris Tracker	The Marine Debris Tracker website states that the data collected by the app are open and free for anyone to use. The app was created in 2010 by the NOAA Marine Debris Program and the College of Engineering at the University of Georgia. The app is now powered by Morgan Stanley in partnership with National Geographic Society and the University of Georgia, with additional support from 11th Hour Racing.	The Marine Debris Tracker platform technology consists of a mobile app and a web-based data platform. The app allows users to log litter items using GPS technology and choose from different lists of litter categories or create their own. The data platform allows users to view, filter, and download the data collected by the app for free. In contrast, Deep Dive operates as a web-based platform with post-processing of information conducted at the data collection site. The differences in these technological approaches suggest that integration or collaboration between Marine Debris Tracker and Deep Dive may necessitate adjustments and could involve associated costs.	DD quite focuses on a protocol developed for the Arctic region, while Marine Debris Tracker allows user to select the type of protocol they want to apply from a range of protocols applied different places in the world. The Marine Debris Tracker does not allow for recording of detailed analysis of specific litter items, while DD analyses for example packaging and key categories of fishing gear more in depth. Some of the litter items and categories are common between the two systems, but others are different or have different definitions. Therefore, the data and information from the two systems are somewhat comparable or compatible, but may require some adjustments and harmonization to ensure consistency and accuracy

4 Assessment of different existing platforms on macrolitter registration and analysis

The Deep Dive platform is a unique platform that was carefully built after a year of discussion with various stakeholders and considering various beach litter platforms. The development focused on building an application that is easy to use, understandable, and accepted by a wide range of users in general. Deep Dive also tries to address data storage issues that other platforms fail to address; many platforms register information in a one-to-one approach in which information is registered in row and column views, which makes data entry more ambiguous and redundant. Moreover, many platforms develop a dictionary to read the categories of beach litter, and such codification of the database is again a challenge for the common user to read and retrieve the data. On the other hand, the Deep Dive platform tries to include information in a nested and non-coded approach, where one main entry is linked to sub-entries and grouped under a specific theme. There is still no specific methodology to assess which platform is most compatible with the Deep Dive platform. In Table 3, we compare different platforms with criteria such as geography, scope, type of litter, data sharing policies, GUI, security, etc., to make some sensible comparison. We also make an overall assessment of compatibility.

Table 3: Assessment of litter data collection platforms summarizing how compatible they are with Deep Dive (rank from 1, high compatibility, to 6, low compatibility) in the last row.

Criteria/ Platform	OSPAR	ICES	Rydde	Rent Hav	NOAA-MDMAP Database	Marine Debris Tracker	Deep Dive GRID-A
Geographic Coverage	Regional data for the North-East Atlantic	International data for the North Atlantic and adjacent seas	National data for Norway	National data for Norway and the North Sea	The entire territory of the U.S., as well as its exclusive economic zone	International data coverage as mobile app allows users to report and map marine debris around the world	Platform for beach litter analysis and data collection in the Arctic.
Location and scope	Beach litter, seabed litter, floating litter, ingested litter	Seabed litter, floating litter, ingested litter	Beach litter, fresh water, Seabed (dive clean-ups), other	Beach litter, benthic litter, fresh water, Seabed (dive clean-ups), other	Beach litter	Beach litter, floating litter	Beach litter
Type of Litter Analyzed	Material, litter items (counts)	Materia, litter items (counts)	Litter items (counts)	Data collected varies between external clean-up maps	Material, litter items (counts)	Data collected varies depending on protocol chosen.	Material, litter items (counts) and weights), degradation rate, nationality and age of packaging, identifies likely discarded fisheries items
Data Sharing and Accessibility license	OSPAR data are licensed according to Creative Commons Zero (CC0), which means they are placed in the public domain and can be freely reused for any purpose	ICES data are licensed according to Creative Commons Attribution 4.0 International (CC BY 4.0), which means they can be freely reused for any purpose, as long as the original source is credited4	Rydde data are licensed according to Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0), which means they can be freely reused for non-commercial purposes, as long as the original source is credited and the derived works are shared under the same license	Rent Hav data are licensed according to Creative Commons Attribution-Non Commercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0), which means they can be freely reused for non-commercial purposes, as long as the original source is credited and the derived works are shared under the same license	NOAA-MDMAP data are licensed according to Creative Commons Attribution 4.0 International (CC BY 4.0), which means they can be freely reused for any purpose, as long as the original source is credited	Marine Debris Tracker data are licensed according to Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0), which means they can be freely reused for non-commercial purposes, as long as the original source is credited and the derived works are shared under the same license	Deep Dive GRID-A data are licensed according to Creative Commons Attribution 4.0 International (CC BY 4.0), which means they can be freely reused for any purpose, as long as the original source is credited

Criteria/ Platform	OSPAR	ICES	Rydde	Rent Hav	NOAA-MDMAP Database	Marine Debris Tracker	Deep Dive GRID-A
User-Friendly Interface and Data Visualization Tools	OSPAR employs a comprehensive data capture interface, allowing researchers and contributors to submit diverse marine environmental data through online forms and standardized protocols. The visualization interface on the official website includes interactive maps, charts, and graphs for stakeholders to explore and analyze water quality, biodiversity, and pollution levels in the North-East Atlantic.	ICES provides an integrated data capture interface for scientists and contributors engaged in marine science and fisheries-related research. This includes standardized data collection forms and reporting mechanisms. The visualization interface offers tools such as maps and graphs, facilitating the exploration of fisheries data, population trends, and other pertinent parameters.	Rydde and Rent Hav provides a web-based interface that allows users to register, report, and join cleanup actions, as well as view statistics and maps of the litter situation.		NOAA's Marine Debris Monitoring and Assessment Project features a data capture interface with standardized protocols and reporting tools. The visualization interface includes maps, charts, and graphs for users to explore trends, hotspots, and patterns in marine debris distribution	The Marine Debris Tracker app serves as a user-friendly data capture interface, allowing users to report and track marine debris. The visualization interface includes map-based displays showing reported debris locations, enabling users to explore trends and patterns in marine debris data.	Deep Dive GRID-A is a web-based interface designed to enable users to access, download, and visualize data from Beach info. The interface offers interactive features such as maps, charts, and graphs to illustrate the spatial distribution of litter items.
Community Engagement Feature	OSPAR and ICES may engage with the community through outreach programs, publications, and collaborative research. They might organize conferences, workshops, and events to involve stakeholders in discussions and decision-making processes related to marine environmental issues.		Rydde and Rent Hav are two platforms that aim to reduce marine litter in Norway by engaging the community in various ways. They both have features that allow users to report and contribute data on marine litter using mobile applications and web portals. The data collected by the users can help identify and prioritize the most affected areas, as well as provide valuable information on the sources of marine litter. In addition, Rydde and Rent Hav also involve the community in awareness campaigns, educational initiatives, and involvement in clean-up activities. They collaborate with other organizations and stakeholders to organize and support clean-up events and groups, as well as to educate and inspire others to join the fight against marine litter		NOAA may engage with the community through educational programs, citizen science initiatives, and public outreach. The Marine Debris Monitoring and Assessment Project (MDMAP) Database might encourage community participation in reporting and monitoring marine debris.	Marine Debris Tracker is designed for community engagement, allowing users to actively contribute by reporting and tracking marine debris. Users play a direct role in data collection, enhancing community involvement in addressing marine litter issues	Deep Dive GRID-A does not have a community engagement feature per se, but it relies on the data collected by Deep Dive partners, who are mostly NGOs, researchers, universities, and local communities. Deep Dive GRID-A also provides information and guidance for those who want to learn more about the Deep Dive method and

Criteria/ Platform	OSPAR	ICES	Rydde	Rent Hav	NOAA-MDMAP Database	Marine Debris Tracker	Deep Dive GRID-A
							how to conduct their own beach litter analysis
Historical Data Availability Availability of time series (historical data availability)	OSPAR has historical data availability, as it maintains an archive of historic data on various aspects of the marine environmen. The OSPAR data portal allows users to access and download data and metadata from different sources and formats.	ICES has historical data availability, as it provides data portals for different themes, such as fisheries, marine ecosystems, ocean climate, and vulnerable marine ecosystems3. The ICES data portal allows users to access and download data and metadata from different sources and formats	Rydde does not have historical data availability accessible through their platform. While data from beach clean-up operations dates back to 2013, only recent year's data can be downloaded. Rydde provides a web-based interface that allows users to register, report, and join cleanup actions, as well as view statistics and maps of the litter situation.	Rent Hav is hosting data on litter from several actors. For some data sets there is historical time series, but it is not necessarily complete for the different data sets in Rent Hav.	NOAA-MDMAP has historical data availability, NOAA-MDMAP Database contains data from shoreline surveys conducted by volunteer monitoring programs around the world since 2012. The database allows users to explore and download data on the amount and types of marine debris on shorelines and visualize the data on an interactive map.	Marine Debris Tracker does not have historical data availability, as it only collects and manages data from users who log and track marine debris items from anywhere in the world.	Deep Dive GRID-A have historical data availability, but only for a few years as it was launched in 2020. The interface allows users to access, download, and visualize data from the GGGI Deep Dive project has generated.
Security and Privacy Features	OSPAR has security and privacy features, as it follows the European Union General Data Protection Regulation (GDPR) and the OSPAR Data Policy, which specify the rules and principles for the collection, processing, and sharing of personal and non-personal data	ICES has security and privacy features, as it follows the European Union General Data Protection Regulation (GDPR) and the ICES Data Policy, which specify the rules and principles for the collection, processing, and sharing of personal and non-personal data.	Rydde has security and privacy features, as it follows the Norwegian Personal Data Act and the Rydde Privacy Policy, which specify the rules and principles for the collection, processing, and sharing of personal and non-personal data.	Rent Hav has security and privacy features, as it follows the Norwegian Personal Data Act and the Rent Hav Privacy Policy, which specify the rules and principles for the collection, processing, and sharing of personal and non-personal data.	NOAA-MDMAP Database has security and privacy features, as it follows the U.S. Federal Information Security Management Act (FISMA) and the NOAA Privacy Policy, which specify the rules and principles for the collection, processing, and sharing of personal and non-personal data.	Marine Debris Tracker has security and privacy features, as it follows the U.S. Federal Trade Commission (FTC) and the Marine Debris Tracker Privacy Policy, which specify the rules and principles for the collection, processing, and sharing of personal and non-personal data.	Deep Dive GRID-A has security and privacy features, as it follows the GRID-Arendal Privacy Policy, which specify the rules and principles for the collection, processing, and sharing of personal and non-personal data.

Criteria/ Platform	OSPAR	ICES	Rydde	Rent Hav	NOAA-MDMAP Database	Marine Debris Tracker	Deep Dive GRID-A
Support and Training	OSPAR provides support and training for data providers and users through its Data and Information Management Group (DIM) and its Data and Information Management System (ODIMS). OSPAR also offers online tutorials, manuals, and FAQs on its data portal	ICES provides support and training for data providers and users through its Data Centre and its Data and Information Group (DIG). ICES also offers online guides, workshops, and webinars on its data portals.	Rydde provides support and training for data providers and users through its website and its partner organizations. Rydde also offers online videos, instructions, and tips on how to use its interface.	Rent Hav provides support and training for data providers and users through its website and its partner organizations. Rent Hav also offers online videos, instructions, and tips on how to use its interface	NOAA-MDMAP Database provides support and training for data providers and users through its website and its partner organizations. NOAA-MDMAP Database also offers online manuals, protocols, and resources on how to use its interface.	Marine Debris Tracker provides support and training for data providers and users through its website and its partner organizations. Marine Debris Tracker also offers online guides, tutorials, and FAQs on how to use its app.	Deep Dive GRID-A provides support and training for data providers and users through its website and its partner organizations. Deep Dive GRID-A also offers online manuals, protocols, and resources on how to use its interface.
Platform rank compatible with Deep Dive	3	5	1	2	6	4	----------

5 Budget for merging Deep Dive data with another platform

In estimating the cost for merging Deep Dive data with another platform, we must make some assumptions. This budget is set up without dialogue with the potential platform owner. It is necessary to have a close dialogue with the platform owner before a more precise budget can be developed. However, this budget gives an overview of some key necessary steps that should be performed and (gu)estimates of hours needed. An average hourly rate of NOK 2000 is assumed. We do not estimate the cost of dialogue with platform owners to assess their willingness to integrate Deep Dive data into their platform. Such dialogue will require that each platform owner is approach, and in some cases organisational issues may result in these decisions being time consuming as they will have to have wider organisational support. We do not include in the budget administrative costs related to following up formalities related to project work (e.g. contracts, reporting etc). The activities and estimated hours needed for the platform owner and the Deep Dive team is specified in Table 4, giving an overall cost of around NOK 1,7 million for merging the Deep Dive platform with another platform.

Table 4 Overview of key activities, hours and costs of merging the Deep Dive platform with another platform.

Activity	Hours needed platform owner	Hours needed DD implementation	Costs (assume 2000 NOK/hour)
Assessment and Planning • *Evaluate the current platform's architecture, components, and dependencies.* • *Identify the features and functionalities that need to be migrated.* • *Define the scope and objectives of the migration.* • *Set a timeline and allocate resources for the migration.*	80	80	320000
Choose a New Platform • *Research and select a suitable data visualization platform.* • *Ensure the new platform supports the required features and integrations.* • *Dialogue with platform owner to secure common goal and integration potential*	10	30	80000
Data Analysis and Mapping • *Analyze the existing database structure and data.* • *Map the data schema from the old database to the new database.* • *Identify any data transformation or normalization requirements.*	20	20	80000
Infrastructure Setup • *Set up the infrastructure for the new platform, including servers, databases, and any required third-party services.*	20	20	80000
Database Migration • *Export data from the old database.* • *Import data into the new database, ensuring compatibility and addressing any schema differences.* • *Test data integrity and consistency after migration.*	40	40	160000
Application Migration • *Migrate the data visualization application code to the new platform.* • *Update and refactor code as needed to adapt to the new platform's APIs and frameworks.*	45	45	180000
User Interface (UI) and User Experience (UX) Migration: • *Adjust the UI components and design to match the new platform's guidelines.* • *Ensure a consistent and intuitive user experience.*	40	40	160000
Data Entry Form Migration: • *Recreate or adapt the data entry form for the new platform.* • *Update form validation and handling based on the new platform's requirements.* • *Integration Testing:* • *Conduct thorough testing of the entire system to identify and resolve any issues.* • *Test data entry, data visualization, and any other critical functionalities.*	45	45	180000
User Acceptance Testing (UAT): • *Involve end-users in testing to ensure the migration meets their expectations.* • *Gather feedback and make necessary adjustments* .	20	30	100000

Activity	Hours needed platform owner	Hours needed DD implementation	Costs (assume 2000 NOK/hour)
Documentation: • *Update documentation for the new platform, including user manuals, API documentation, and any technical documentation.*		20	40000
Training: • *Train users and administrators on the new platform.* • *Provide support and resources for any changes in workflows.*	20	40	120000
Rollout: • *Plan and execute a phased rollout or cutover to minimize downtime.* • *Monitor the system closely after the migration to address any issues promptly.*	10	20	60000
Post-Migration Support: • *Provide ongoing support to address any post-migration issues.* • *Gather feedback for continuous improvement.*		30	60000
Backup and Rollback Plan: • *Develop a backup plan in case of unforeseen issues during migration.* *Establish a rollback plan to revert to the previous platform if necessary.*		20	40000
Total	700000	960000	1 660 000

6 Discussion and conclusion

In this assignment the technical feasibility of entering, merging, and importing Deep Dive data into existing data platforms has been assessed. We have not evaluated organisational issues related to this question. Neither have we evaluated the feasibility of the platforms to host the training and guidance material available through the Deep Dive platform. This has been a quick assessment of some of the platforms available. A full review of platforms would give additional information.

The Deep Dive data protocol records more information for each litter item, which makes it difficult to merge with other existing protocols and platforms. Moreover, we did not plan for the data Interoperability aspect of the platform when we developed and designed the Deep Dive. However, we ranked Rydde, Rent Hav, and OSPAR high based on the comparison criteria in Table 1 and Table 2. The ranking mainly considers the database schema complexity, design challenges, and the potential cost of migrations. For example, the ICES data schema is very complex and requires a lot of effort for data harmonization get low rank. We also value the positive responses we received during email communication, such as Marine Debris Tracker being very willing to integrate Deep Dive into their platform, whereas NOAA-MDMAP has a very strict rule for third-party data integration.

While this preliminary review has focused primarily on technical considerations, strategic considerations regarding the future use of both the protocol and its results should be weighted heavily in a full review. As the key objective behind the development of Deep Dives was to provide decision makers with necessary information currently unavailable based on traditional composition ("species") based protocols, one must consider the likelihood of each platform to facilitate reaching this goal. Inclusion

into the platform of an organisation that has a formal monitoring role, such as ICES and OSPAR, presumably gives the greatest likelihood of Deep Dive data reaching decision makers. However, such organisations also have working and/or advisory groups that guide decisions and advice on monitoring protocols. Without a formal role in these organizations, it may be difficult to establish a cooperation aiming at supplementing their litter monitoring protocols. However, documentation of rope cut-offs from Deep Dives has inspired inclusion of the category "other plastic string and filaments exclusively from fishery" in the EU Joint List of Categories (Fleet et al., 2021), showing that some influence is possible.

In addition to technical feasibility, each platform should be carefully assessed in a full review to determine (1) who primarily collects the data entered into the platforms (e.g., citizen scientists, paid professionals) and (2) who extracts data from the platform and to what end. Firstly, given that Deep Dives require additional training beyond what is given for traditional citizen science beach litter registration protocols to avoid bias and high error rates, the possibility for providing this training and ensuring that it occurs prior to volunteers or professionals utilising the protocol should be assessed. Secondly, an assessment should be made of how data currently entered into each platform are used and by whom. This can be done through a systematic review and metanalysis of scientific publications and grey literature looking for mentions of different platforms and documenting and analysing data usage. It can also be achieved, or added to, through dialogue and direct contact with the organisation behind each platform.

When these two aspects have been thoroughly reviewed, the feasibility of achieving the original objectives behind Deep Dives of providing decision makers with necessary and currently lacking information, and of doing so with high quality data, must be assessed. This assessment should then be weighed against this technical pilot feasibility assessment. If the most desirable platform in terms of meeting Deep Dive objectives poses significant technical challenges with the current format of the Deep Dive protocol in its current portal, one should consider if and how the protocol can be amended without significant loss of information or quality. Having been originally designed to complement existing protocols and provide information classic composition protocols do not, the protocol can be revised in its format without losing content if desirable (e.g., nationality and age data can be added to all packaging items in another protocol rather than collected in its own form as in the current format). Such flexibility may help alleviate certain technical challenges if necessary. It should also be considered whether Deep Dive goals can be achieved by simply moving to a single other platform or whether one should lobby to include it fully or partially into multiple national and international platforms to maximise its reach into decision making and management.

Migration of the Deep Dive platform also requires agreements related to the ownership of the deep dive protocol. Ownership of the protocol should also be moved to the new owner of the data platform to allow for development of the deep dive method to match the need of users.

The promising platforms for integration with Deep Dive data represent a national, a regional and a global platform. The Rydde/Rent Hav platform has Norwegian owners and is in Norwegian. Given the close dialogue that NIVA, SALT and Grid-Arendal have with the platform owner, that would increase the likelihood of the owners being willing to integrate Deep Dive data. The owners have also expressed interest in the Deep Dive data and recognize the value of such data. The drawback of choosing a national database is that the potential user group is limited to those speaking Norwegian. Thus, the regional and global use of this platform is severely limited. The authors have been approached by international teams that would like to enter data into the Rydde/Rent Hav platform, but have been limited by language issues.

OSPAR is a regional platform in English. This increases the global relevance of the platform as English is a language that is spoken by a large number of people. A limitation of using the OSPAR platform is that it is currently linked to monitoring obligations by member states. Thus, the platform only accepts data entries from member states and established OSPAR beaches. This is a limitation in terms of the number and types of users that can enter data. The authors know that this is a real issue that various teams that would like to collect advanced data on beach litter have encountered.

OSPAR data is available through EMODnet that stands as a collaborative network among organizations in Europe, offering diverse data and information on various aspects of the marine environment across a wide range of topics and regions. In contrast, Deep Dive is a specialized system designed for beach litter analysis and data collection in the Arctic, focusing on a specific environmental concern. Deep Dive could potentially become a part of EMODnet if it can adhere to the specific protocols, formats, and tools established by EMODnet for data submission and validation. The Marine Litter Database (MLDB) managed by EMODnet Chemistry accepts data from a variety of sources, including external research or monitoring projects, NGOs, citizens, and private companies. If Deep Dive can format its data according to the common beach and seafloor formats developed by EMODnet then it could potentially contribute to the database. The data would need to pass the validation process using the EMODnet Beach Litter Format Validator or the Seafloor Litter Format Validator. However, while this would open up for a larger user group to add deep dive data, it would result in another platform, rather than integration in an existing platform.

The Marine Debris tracker is an example of a global platform. It is not restricted by language or type of users. Thus, this is a platform that would secure the global relevance of the deep dive data without any restrictions on who can enter data.

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