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Inconsistencies in How Environmental Risk Is Evaluated in Sweden for Dumping Dredged Sediment at Sea

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Millions of tons of dredged sediment are dumped at sea annually. International conventions limit dumping when there is a risk of adverse ecological effects, for example if the sediment is contaminated. However, the perception of risk differs substantially among stakeholders and in Sweden there is a lack of guidelines for how to address such risk. In the current study, we examined exemptions to the Swedish ban on dumping at sea, to explore the extent of dumping and how ecological aspects were considered in the evaluation of risks. We analyzed data from all cases granted exemption by county administrative boards and all court cases considering exemption to the ban from the beginning of 2015 to June 2020. We found that while dumping is the least common alternative management method for dredged sediment in total number of cases (98/792), dumping is the main method in terms of volume (30.8/38.2 million m^3). When considering exemptions, the courts mainly evaluated the risk of exposure to contaminants and resuspended sediment for the environment adjacent to the dumpsite. The risks from contaminants were characterized based on various lines of reasoning, mainly relying on reference values not based on a scientific correlation to environmental risk. We argue that the evaluations were not in line with current regulations and international conventions as they insufficiently accounted for the ecotoxicological risk of the dumped sediment. These issues are potentially similar in other Baltic Sea countries, where there is a similar dependency on binary chemical limit values.

Keywords: sediment, contaminant, risk assessment, risk evaluation, risk management, regulation, sea dumping

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INTRODUCTION

Sediments play an important role for the functions and processes of the marine environment. They contribute to our food supply and recreational values as well as providing services such as filtering and storage of excess nutrients (Troell et al., 2005; Schmidt et al., 2011). However, sediment ecosystems and their functions are threatened by the historical and ongoing input of contaminants

(Elmgren, 2001; Sundqvist and Wiberg, 2013). One source of contaminants to sediment comes from disposing, or dumping, of waste at sea. Large scale dumping at sea started in the late 19th century (Nihoul, 1991). The most common waste that is dumped today consists of sediment dredged in close proximity to urban or industrial areas, such as harbors and river outlets, where the sediment can be highly contaminated (Cundy et al., 2003; Taylor et al., 2004; Helsinki Commission [HELCOM], 2010; Sundqvist and Wiberg, 2013; Staniszewska and Boniecka, 2017).

Dumping dredged sediments can increase water turbidity and cause structural changes to the sea floor habitat, disturbing, for example, reproduction, and availability of light and food (Shackle et al., 1999; Stelzenmüller et al., 2010; Kemp et al., 2011; Kraufvelin et al., 2018; Virtasalo et al., 2018; Dias et al., 2019; Mossa and Chen, 2021). Contaminants bound to dumped sediment particles may spread through a range of processes. Storms, trawling and bioturbation can cause contaminants dissolved in water or adsorbed to sediment particles to move through the water column and food web causing adverse effects to the ecosystem (Malins et al., 1985; Varanasi et al., 1985; Davis, 1993; Eggleton and Thomas, 2004; Knott et al., 2009; Roberts, 2012; Donázar-Aramendíaa et al., 2020). The potential effects from dumping dredged sediment are the result of a combination of the chemical and physical characteristics of the dumped sediment and the characteristics of the dumpsite, such as habitat type and ecological conditions. The rate and outcome of ecological recovery differs substantially due to these characteristics. Opportunistic species can recolonize quickly given the right circumstances and ecological functions can be regained after a few years. However, the species composition can be slow in recovering (Pearson and Rosenberg, 1978; Blomqvist, 1982; Hill et al., 1999; Bolam et al., 2006; Guerra-García and García-Gómez, 2006; Larson and Sundbäck, 2012).

After 1972, dumping at sea was limited on a global scale through the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, with exemptions for waste originating at sea, such as dredged sediment from maintenance of thoroughfares and harbors. The initiative was soon followed by additional conventions, including the Barcelona Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft, 1976; the Marine Protection, Research and Sanctuaries Act, 1972; the Convention for the Protection of the Marine Environment of the North-East Atlantic, i.e., the OSPAR Convention (1992); and the Convention on the Protection of the Marine Environment of the Baltic Sea Area, i.e., the citeBR670.

Prior to 1972, the annual dumping of sediment from land-based activities in the United States alone exceeded 100 million tons, including petroleum products, heavy metals, chemicals, and radioactive waste (USEPA, 2020). Similar statistics for Europe are not available, but given the region's industrialized societies, a similar situation can be expected to have occurred in Europe (Nihoul, 1991). Even though there are restrictions in place, large amounts of dredged sediment, with various levels of contaminants, are still dumped annually. There are no reports providing a complete overview, but OSPAR reports that over a 1,000 million tons of sediment were dumped annually in the OSPAR maritime area alone during 2008–2014 (OSPAR Commission, 2021). Similarly, for the EU, over 200 million tons have earlier been reported to be dumped (Mink et al., 2006).

In Sweden, dumping is a common practice in comparison to the neighboring HELCOM member states (Helsinki Commission [HELCOM], 2020b). This is in spite of a national ban on dumping in the territorial and exclusive economic zone [15:27 Environmental Code (EC), SFS 1998:808, EC]. Exemptions from the national ban on dumping should only be authorized if there is no detriment to human health or the environment (15:29 EC). The EC also prohibits activities jeopardizing the achievement of a good ecological status of water bodies as part of the EU Water Framework Directive[1] (WFD) (5:4 EC) and includes an obligation to only dispose of waste as a last alternative after reuse has been ruled out as an option (2:5, 15:10 EC).

Under such strict regulations, it is especially important that the risk of environmental detriment from dumping is properly assessed and addressed when exemptions to the ban of dumping are considered. Recently, a lack of national sediment risk assessment guidance, resulting in a variation in assessment approaches, has been reported. It has further been shown that the current practice of assessing contaminated sediment sites frequently relies on arguably too narrow sets of indices of risk and ecological impairment (Severin et al., 2018; Bruce et al., 2020). In the light of this, it is relevant to investigate both how common exemptions to the ban are and also on what grounds it has been ruled that there is no risk of environmental detriment. Hence, we aim to provide an improved understanding of the exemption process, focusing on: (1) The environmental aspects assessed when dumping is considered in practice, and (2) How the regulations are implemented in relation to ensuring that there will be no environmental detriment.

Restrictions on dumping are laid down in both the global London Convention and the regional OSPAR and HELCOM conventions, to which Sweden is a party (SÖ 2000:48; SÖ 1974:8; SÖ 1992:9). Sweden is moreover a member of the European Union (EU) and thus bound by *inter alia* the WFD and the Waste Framework Directive[2]. The obligations laid down in the conventions and the directives have been implemented into national law, mainly in the EC. While dumping waste at sea is forbidden (15:27 EC), exemptions can be granted on the condition that the waste can be dumped *without detriment to human health or the environment* (15:29 EC). The condition is to be interpreted restrictively. Moreover, the burden of proof lies on the applicant (2:1 EC) and the risk of detrimental effects to the environment is sufficient for requiring protective measures (2:3 EC). According to the preparatory works, the room to apply for exemption is limited to dredged sediments.

The condition "without detriment to human health or the environment" must moreover be interpreted in the light of other obligations laid down in the EC and in EU-law,

[1]Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy.

[2]Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

such as the obligation to achieve a good water status under the WFD and a favorable conservation status of species and natural habitats protected by the Habitat Directive[3]. The European Court of Justice has clarified that member states are required to refuse authorization of individual projects that risk causing a deterioration of the environmental status of a water body or jeopardizing the attainment of good surface water status (in case C-461/13). As a result of the case, deterioration or jeopardizing the achievement of a good ecological status of water bodies [as defined by Environmental Quality Standards (EQS) set for the respective water body to fulfill the WFD (Swedish Agency for Marine and Water Management [SwAM], 2019)] is prohibited since January 2019 EC (5:4 EC). Under certain restrictive conditions, derogation may nevertheless be authorized (5:6 EC, 4:11–12 Water Management Ordinance).

A balancing of costs and benefits in the particular case, according to 2:7 EC, is not possible given that exemptions can only be permitted if the dumping will not cause *detriment to human health or the environment*. In extension, as exemption only can be granted if there is no detriment to the environment, the regulation for Environmental Impact Assessment[4] (EIA) is not necessarily applicable. Moreover, exemptions on dumping are the last resort and should not be granted if reuse or recycling of the waste is possible (2:5, 15:10 EC). An exemption to dump at sea may be granted with conditions. If dumping causes adverse effects, the operator can be held responsible for remediation (15:33 EC).

The regulatory authority with the main responsibility for marine environmental management is the Swedish Agency for Marine and Water Management (SwAM). In a guidance document adopted by SwAM, environmental detriment is defined as a level of contamination so high that it causes risk of negative effects to plants and animals in the ecosystem, or considerable contamination of the bottom at and surrounding the dumpsite [free translation from Swedish Agency for Marine and Water Management [SwAM] (2018)].

Exemptions are most commonly authorized by the regional County Administrative Boards. In the rare case that the sites for dredging and dumping are situated in different counties, SwAM is the authorizing body. The decisions, or part thereof, can under certain circumstances be appealed to the Land and Environment Courts (District Courts). Moreover, when the dumping is part of other related water activities that require a permit from the Land and Environment Court, the room to authorize exemptions to dump waste in the sea will be tried by the District Court as a first instance. A concerned party, such as landowners that are at risk of being affected by the activity and environmental governmental or non-governmental organizations, can also appeal decisions under certain circumstances. Cases from the District Courts can be appealed to the Swedish Land and Environment Court of Appeal (here abbreviated LECA), the highest national environmental court and a court of precedent, given that the court grants a leave to appeal. To grant exemption, the ruling authority decides whether the condition of no environmental detriment is fulfilled. See **Figure 1** for a map of involved parties and their roles in exemption from the ban on dumping waste at sea.

[3]Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

[4]Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment.

MATERIALS AND METHODS

Data Collection

We compiled data from SwAM on the frequency and extent of dredging, dumping and other methods for disposal of dredged sediments in Sweden. SwAM is the national intermediary for reporting all national marine dumping activities to HELCOM and OSPAR and has data on all national granted dumping exemptions from 2015 to 2019.

The data compiled by SwAM includes the granting authority, county, dumpsite, identification number, volume and type of the masses that are to be dumped and dates for when the exemption was given and its duration. However, the data only includes information on *granted* exemptions. Attempting to find information on non-granted applications, we contacted the County Administrative Boards that have granted the highest number of exemptions during 2015–2019. However, only the county of Skåne could provide data on the number of non-granted applications, i.e., 1 out of 21 counties of which 11 have granted exemptions during 2015–2019.

To investigate how the regulations are implemented in practice and the implication thereof, we assessed court cases (**Table 1**) with applications or appeals to exemptions to the ban on dumping determined by District Courts, or by the LECA if appealed from the District Courts. We searched for all relevant court cases from January 2015 to June 2020. We did not look further back in time as we wanted the cases to illustrate the current practice and since SwAM's register was less structured before 2015. The court cases were all publicly available and a majority of them could be found on the online platforms of e.g., the Supreme Environmental Court and jpinfonet.se[5]. Some cases were only available on request from the individual courts. In those cases where a verdict was appealed, we focused on the latest case. The cases include the courts' and other involved parties' arguments and reasoning for why exemption should or should not be granted.

We excluded cases that dealt with dumping at other locations than the sea as well as one case where the details were classified as confidential. We also later excluded four cases from the District Courts where the courts did not consider the potential environmental detriment as other requirements were not met. In total 14 cases were included, nine from District Courts and five from the LECA (**Table 1** and **Supplementary Appendix 1**). Two

[5]jpinfonet.se is a website serving as a repository for judiciary information such as court cases.

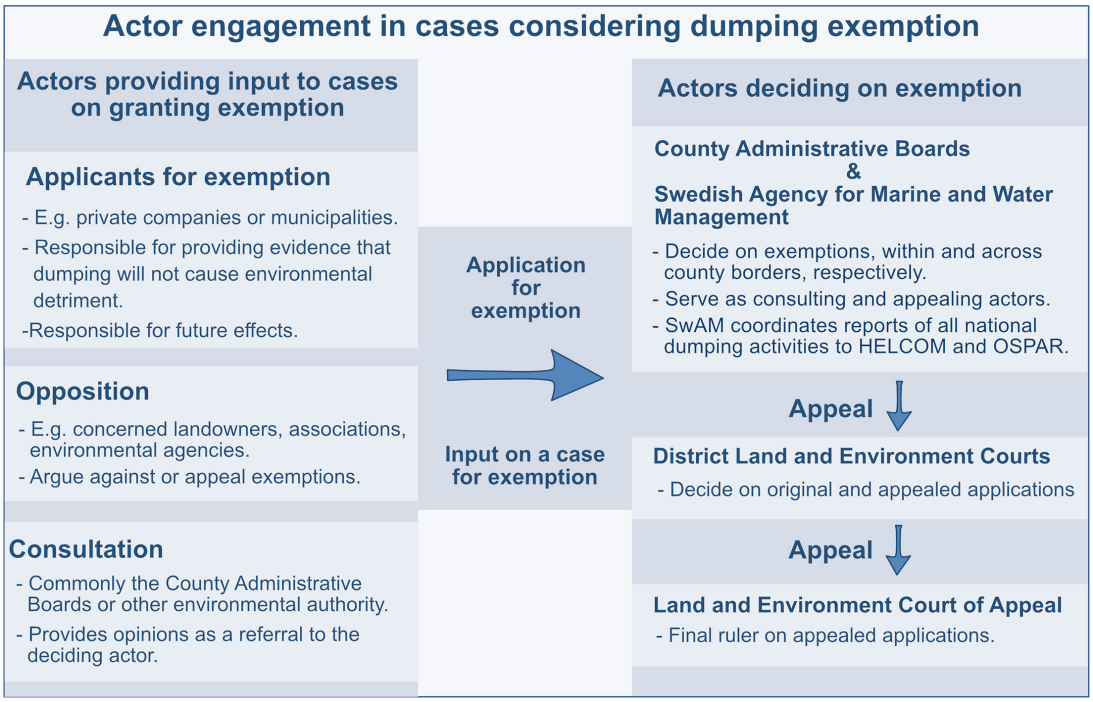

FIGURE 1 | Involved actors in Sweden and their engagement in relation to applications for exemption to dumping dredged sediment at sea.

TABLE 1 | Cases by land and environmental District Courts (DC) or the Land and Environmental Court of Appeal (LECA), processing applications or appeals to exemption from the ban on dumping waste at sea.

Instance	Case	Reg. no	Year	Decision	Disposal volume m^3
LECA[A]	A	M 1260-14	2015	Granted	4,000,000
LECA[A]	B	M 9616	2015	Granted	900,000
Växjö DC[A]	C	M 3089-15	2015	Rejected	85,000
LECA[A]	D	M 1732-16	2016	Granted	220,000
LECA[A]	E	M 837-16	2016	Rejected	Not available
Vänersborg DC	F	M 108-15	2016	Granted/Rejected*	5,000
Vänersborg DC	G	M 4016-15	2016	Granted	4,000
Vänersborg DC	H	M 4017-15	2016	Granted	12,000
Östersund DC	I	M 1697-15	2017	Granted	60,000
Vänersborg DC	J	M 2553-15	2017	Granted	4,200
LECA[A]	K	M 4685-17	2018	Granted	21,100,000
Växjö DC	L	M 3021-17	2018	Granted	2,500,000
Vänersborg DC	M	M 3522-17	2018	Rejected	Not available
Vänersborg DC[A]	N	M 5122-19	2020	Rejected	Not available

Cases marked with "[A]" were appealed from a lower instance. See ***Supplementary Appendix 1*** *for a more extensive description of the cases.*
**In case F, the application was denied for one proposed dumpsite and granted for another.*

of the cases in the District Courts were appealed from County Administrative Boards.

Method of Analysis

We analyzed the full court cases to find content connected to our aims. To do so we used content analysis, a method commonly used to scrutinize large sets of text-based information in order to identify and divide it into categories (Neuendorf, 2002; Krippendorff, 2004; Bryman, 2008; Julien, 2008). We conducted the analysis manually by systematically reading and categorizing the documents' content in the analysis with the software NVivo (QSR International, 2020).

To find the information needed, we organized the content of the court cases into categories describing the grounds on which the courts based their decisions, as well as the factors and reasoning that were considered in relation to

evaluating environmental detriment from the requested dumping exemption. From this content, we focused on the verdict and set conditions for exemption and the grounds for the decision where the courts expressed their reasoning. In appealed cases, only part of the previous judgments were contested. For example, in case A (**Table 1**) the conditions for the maximum limit concentrations of TBT were appealed, whereas limit values for other contaminants were not. The court therefore only considered the limit value for TBT. In such cases we included content from the preceding cases pertaining to the parts that were not appealed. Moreover, when the courts in their reasoning referred to content from a preceding appealed case or to content in the same case expressed in the opinions by the applicants, consultant bodies or other parties, we also included such content. The appealed cases were added as appendices to the case material.

We organized the content of the cases into the following categories:

- Clean sediment – content describing the courts' reasoning when determining whether the dredged sediments were safe to dump from the perspective of risk of environmental detriment.
- Suitable dumpsite – content where the courts described their reasoning when determining if a proposed dumpsite was suitable.
- Ecology – content describing ecological factors in the courts' reasoning when characterizing risk of environmental detriment. Only content directly relating to ecological risks or conditions was included in this category. We only included content that dealt with potential spreading of sediment off-site or contaminant levels on-site if the content related those factors to ecological risks or conditions.
- Climate change – content describing the courts' arguments and reasoning when relating to changes in conditions due to climate change.
- Rejection – content describing the courts' arguments and reasoning for rejecting exemption.

A benefit of this approach is that the documents provide the explicit reasoning and conclusions expressed by the courts when considering appeals or applications for exemption to the ban on dumping. The documents are intended to offer a full account of the grounds for the courts' decisions. However, the level of detail differed between the cases providing a varying level of transparency and insight to the underlying data provided to the courts and the courts' reasoning.

RESULTS

Dumping as an Alternative for Management of Dredged Sediments in Sweden

In Sweden, dumping at sea was the least common management alternative for dredged marine sediment in terms of *number* of cases. However, dumping constituted *a majority of the volume* disposed from dredging of sediments, exceeding any of the other alternatives by a factor of ten. In 79%, corresponding to 762 of the cases, the dredged sediments were disposed on land, e.g., in landfills. In 11%, corresponding to 109 cases, the sediments were used for "beneficial use," which can include, but is not limited to, bolstering of shorelines, filling during construction in water or on land and recycling of metals and nutrients. In 10%, corresponding to 98 cases, exemption was granted to dump approximately 30,847,424 m^3 of sediment at sea (**Figure 2**). The exemptions were unevenly distributed among the counties bordering the sea (**Figure 3**). SwAM and some counties did not keep readily available records on cases that were rejected. However, the southernmost County Board of Skåne stated that they had rejected roughly one application per year compared to granting 3–13 per year during 2015–2019 (**Table 2**) (Personal communication with the Skåne County Administrative Board, 2020-08-11).

The requirements for reporting data to SwAM on alternative methods for managing dredged sediment were less strict than those for dumping at sea. Therefore, it was not always clear for each individual case what beneficial method or type of disposition on land that had been used. The less restrictive requirements were also the reason for a number of disposal activities marked as not registered. The unregistered cases were supposedly distributed among the different alternatives for beneficial use and storage on land (Personal communication with SwAM, 2020-08-26).

Clean Sediment

When determining if dumping could be conducted without detriment to the environment, the courts had to address both the dredged sediments and the dumpsite. When evaluating the risk from the dredged sediments the courts considered the contaminant concentrations in the sediments to determine if they were "clean," as phrased by the courts in some cases. Common for all cases was that when maximum limit concentrations were set for the contaminants in the dredged sediments, they were defined in the conditions for the exemption. However, the courts used different reasoning to conclude what constituted clean sediments in different cases. The conclusions reached by the courts can be seen in **Table 3** and we illustrate the variability among the conclusions with two sets of examples below.

The first set covers three examples of reasoning where the court considered sediments contaminated by TBT. In case A (2015), the LECA decided that the level of TBT in the dumped sediments should *not exceed the already occurring concentrations* of TBT in the sediment at the sampling site adjacent to the dumpsite, thus setting a limit at 50 μg TBT/kg dry weight (dw). The court also stated that they perceived that level to be harmful. The court explains their reasoning stating that: "An assessment must be conducted based on the circumstances at hand in each individual case" (case A, p. 8). This could be interpreted to mean that limit values should be based on the contaminant levels, or other conditions, at the dumpsite and that if the TBT concentrations at the dumpsite were lower than 50 μg TBT/kg dw, the limit value should also be set lower.

Case A was interpreted in different ways by later cases. The limit values for TBT and a range of other contaminants set in case

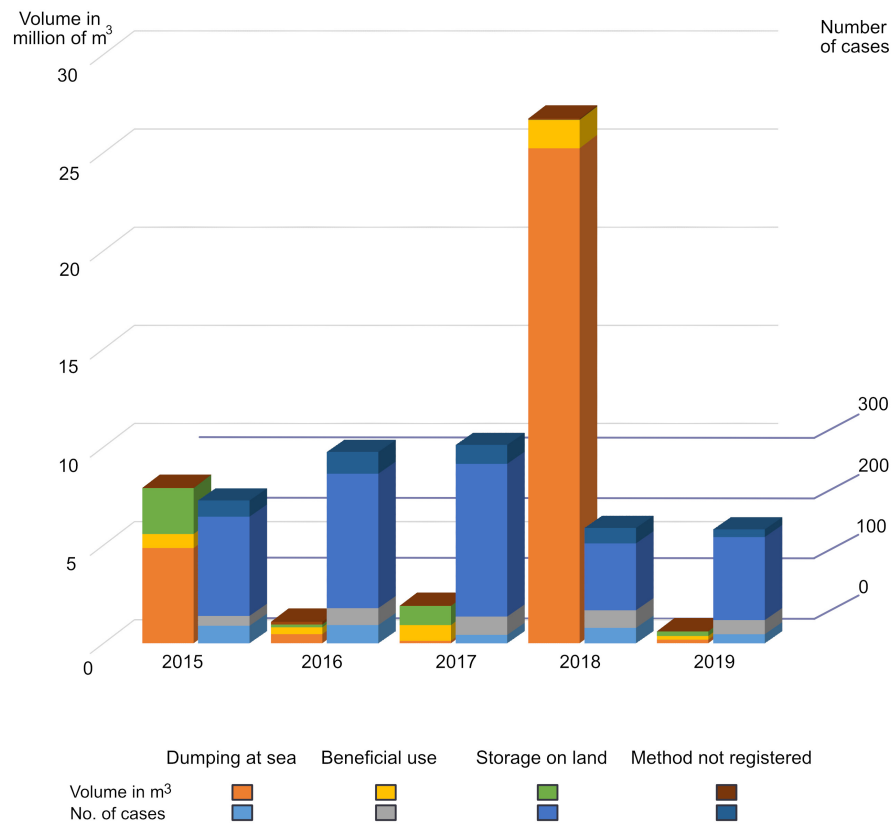

FIGURE 2 | Granted permits and exemptions for the disposal of dredged marine sediments in number of cases and volume between the start of 2015 and end of 2019. For some dredging projects several methods of disposal were registered, however, the distribution of volume was in general not reported. Therefore, the figure shows volume per method as if the respective method was used for 100% of the dredged sediment, thus showing the potential maximum volume. Since the requirements are strict for reporting dumping exemptions, the volume specifically for dumping ought to be accurate.

A, were used as a precedent in some cases. In case L (2018), the District courts set the limit values for TBT to 50 μg/kg dw with referral to case A, without making an argument for the limit based on the site-specific conditions at the dumpsite.

In other cases during the same time period, higher levels of TBT were allowed. In case D (2016), the LECA set a limit concentration for TBT at 100 μg/kg dw for the sediments to be dumped. Compared to case A, the circumstances differed in case D. The concentrations of TBT at the dumpsite prior to dumping, 123–534 μg/kg dw, exceeded the set limit concentrations of 100 μg/kg dw. A condition for the exemption was that the contaminated masses had to be covered with clean sediments, without further defining the characteristics of the cover. A higher concentration of TBT was thus allowed in a case where the background concentration at the dumpsite was higher and the dumped sediment would be covered with cleaner sediment, although "clean" was not defined.

In case K (2018), the LECA set a limit value for TBT at 200 μg/kg dw in sediments that were to be dumped. As in case D, a condition was set to cover the contaminated sediment with 3 m of cleaner sediments (with a maximum concentration of 50 μg/kg dw TBT), but with the difference that the concentration for TBT, set as a condition, in the dredged sediment (200 μg/kg dw) exceeded the concentrations at the dumpsite (3.4–163 μg/kg dw). The LECA thus concluded that sediment with a higher concentration of TBT was allowed to be dumped at a site with lower concentrations, if the dumped sediment would be covered with cleaner sediment.

The second set of examples demonstrate the variability in conclusions regarding organic and metal contaminants. Nine of the cases describe the concentrations of contamination in sediments using a system where the contamination degree is classified in relation to the occurrence of contaminants in marine sediment along the Swedish coast. The degree of contamination is divided into the classes 1–5 (very low contamination to very high contamination, at the 5th, 25th, 75th, and 95th percentiles, respectively) (Swedish Environmental Protection Agency [SEEPA], 1999). The system was updated 2017 based on data from 1986 to 2014 (Josefsson, 2017;

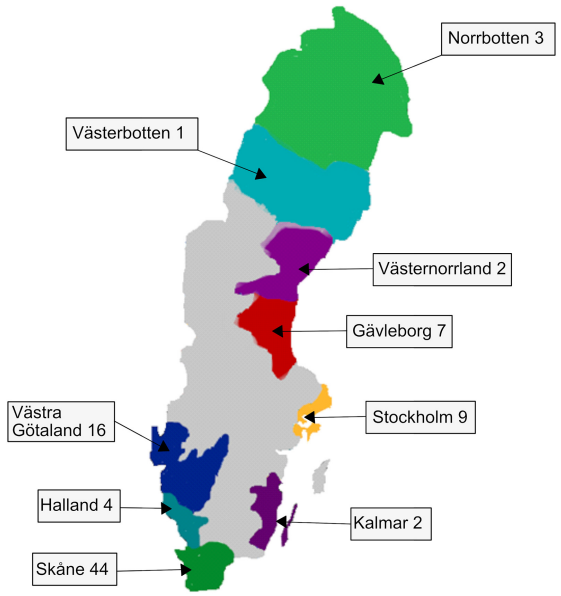

FIGURE 3 | Number of exemptions to the ban on dumping waste at sea granted in Sweden by county, 2015–2019.

TABLE 2 | Exemption applications granted and rejected, in Skåne county.

Year	Granted exemptions	Rejected exemptions
2015	11	1
2016	3	1
2017	6	2*
2018	13	
2019	10	

Based on personal communication with Mats Lindén, County Administrative Board of Skåne (2020-08-11).
**During 2017–2019 two applications were rejected but it is not clear at what individual year the rejections occurred.*

Swedish Environmental Protection Agency [SEEPA], 2020) but all cases used the version from 1999.

Starting again with case A (2015), the LECA did not change the maximum contaminant limit concentration for contaminants other than TBT set by the District Court. The limit was the lower threshold of class 4, corresponding to high concentrations of contaminants according to the used classification system (Swedish Environmental Protection Agency [SEEPA], 1999). Class 4 was in general considerably higher than the concentrations of metals and similar to the concentrations of organic contaminants adjacent to the dumpsite. In contrast to the LECA's condition for TBT in the same case, the contaminant concentration limits were set considerably higher than the background concentrations at the dumpsite.

Shortly after case A, a District Court did not authorize an exemption to dump dredged sediments that contained contaminant levels exceeding class 3, corresponding to medium high concentrations, in case C (2015). The District Court considered such concentrations incompatible with the demand of no environmental detriment, even though the suggested dumpsite exhibited higher concentrations of contaminants. In case B (2015), the LECA also set the limit to class 3, based on the assessment that it would not infringe on the EQS for the general waterbody.

In case D (2016), the LECA set the maximum limit to class 5, corresponding to very high levels, without relating to the concentrations at the dumpsite and with the condition that the dumpsite had to be covered with cleaner sediment (clean was not defined).

In case H (2016), the District court authorized an exemption for sediments with contaminants up to class 4 in general but with levels of copper at class 5, justified by the dumpsite being an accumulation bottom from which the sediment was unlikely to spread. In one of the latest cases (case K 2018) where the classification system of the degree of contamination was used, the LECA granted exemption for sediments with concentrations of specific groups of PCBs and PAHs exceeding the lower limit for class 5, with the condition that they had to be covered with sediments with a maximum contaminant concentration corresponding to class 5 for PAH-11 and PCB-7, and 50 μg/kg dw for TBT (**Table 3**).

There are general limit values produced as part of the WFD for some of the substances that are relevant in the court cases, such as mercury and PAHs. These limit values were available for all of the court cases included in the study (Swedish Agency for Marine and Water Management [SwAM], 2013, updated in Swedish Agency for Marine and Water Management [SwAM], 2019). However, they were not used in any of the analyzed cases.

Suitable Dumpsite

We identified several key factors addressed by the courts when determining if a proposed dumpsite was suitable in relation to the dredged sediments to be dumped (**Table 4**). The most prevalent factor was the capacity of the dumpsite to act as a sediment sink where the dumped sediments could accumulate with little or no risk of being spread to the surroundings. This was explicitly highlighted in 10 out of the 14 cases. As an example, the LECA stated that:

"The (proposed) site for planned dumping is a sediment sink, which means that there are good conditions for sediment transport not to occur. With that, the site can be considered to be suitable for dumping of dredged sediment" (Case A, p. 8, translated from Swedish).

In a case where the application was denied, the LECA also stated that:

"According to the judgment of the LECA, the performed seabed characterization does not provide sufficient support to suggest that this is an accumulation bottom suitable for dumping of dredged material" (Case E, p. 7, translated from Swedish).

In cases M and N, the applications were rejected based on inadequate information on the hydrological conditions at the dumpsites. The courts did not specify what hydrological information was missing. However, based on previous reasoning by the courts on accumulating properties of the dumpsites, it is likely that such information was, at least in part, what was missing in cases M and N.

TABLE 3 | Maximum contaminant level accepted for dumping with summaries of reasoning by the courts when determining whether the dredged sediments were safe to dump without risk of environmental detriment.

Case	Year	Maximum contaminant level in sediment granted exemption	Summary of the courts' motivation for the maximum allowed contaminant levels in sediments to be dumped
A	2015	50 μg/kg dw TBT, class 4* for other contaminants	The court set the limit value to 50 μg/kg dw for TBT, with the motivation that the concentration of TBT in the dredged masses that were to be dumped at the dumpsite could not exceed the existing concentrations in the sediment at the dumpsite, as those levels were already at a level of ecological risk. The limit values for other contaminants were set, without additional discussion provided by the court, to class 4, "highly contaminated" (page 8, preceding case M 2684-13 page 25)
B	2015	Class 3	No motivation was given for the limit value: the court set the limit to class 3 (specified in the preceding case M 2414-12, page 6), as suggested by the parties in their opinions
C	2015	Class 3	The application was rejected with the motivation that the court considered dredged sediments exceeding contaminant class 3 to be too contaminated to be dumped at sea without detriment to the environment or human health (page 8)
D	2016	100 μg/kg dw TBT, class 5 for other contaminants	The court increased the limit value set by the district court in the previous case, from 50 to 100 μg/kg dw TBT. The motivation was that the limit should be based on case-specific conditions (referring to case A) and the dumpsite exhibited sediment accumulating properties reducing the risk of sediment transportation. Furthermore, the site exhibited high levels of TBT, and a condition for the exemption was to cover the dumped sediments with cleaner sediment (without defining the characteristics of the cover) (page 10, appealed case M 2587-14 page 5)
E	2016	Not available	The application was rejected
F	2016	Not available	The court considered the dredged sediments as clean since they contained lower contaminant concentrations than the limit values set in case A. The type of contaminants were not defined (pages 20, 56)
G	2016	Class 4	The court considered the dredged sediments to exhibit low concentrations of contaminants, class 4 or below. No concentration limits were set (pages 11, 27)
H	2016	Class 4 with the exception of Cu at class 5	The court stated that the reported levels of contaminants were low enough to be safely dumped due to sediment sink conditions at the dumpsite. No limit value was set. The dredged sediments contained contaminants up to class 4, and class 5 for copper (pages 22–23)
I	2017	Class 3	No limits were set but the concentrations were described to not exceed class 3 (page 204)
J	2017	Not available	The court allowed the dredged sediments to be dumped as they were considered clean. No maximum contaminant limit was set (page 52)**
K	2018	200 μg/kg dw TBT, PAH-11 and PCB-7 are allowed to exceed the lower limit for class 5	The LECA raised the limit value set by the District Court in the appealed case, from 50 to 200 μg/kg dw TBT. The motivation was that the limit value should be based on case specific conditions (referring to case A) and the dumpsite exhibited sediment accumulating conditions, making transport of the sediment and contaminants from the site unlikely. The condition was that the dumped sediment had to be covered with 1 m of sandy masses followed by 2 m of moraine masses all of which were within set contaminant limits, 50 μg/kg dw for TBT and for PAH-11 and PCB-7 at the lower limit of class 5 (pages 21–23, preceding case M2415-15 pages 4–6)
L	2018	Class 3, except for TBT (50 μg/kg dw) and chromium (90 mg/kg dw)	The court set the maximum limit value for chromium to 90 mg/kg dw, with the motivation that the limit had grounds in guidelines for specific contaminating substances (Swedish EPA report NV5799). For TBT, the court set the limit to 50 μg/kg dw TBT, with the motivation that the dredged sediments exhibited levels below 4.7 μg/kg dw and that the Environmental Court of Appeal had set limits between 50 and 200 μg/kg dw in cases A and K. For other contaminants the limit value was set to class 3 without further motivation by the court (page 82)
M	2018	Not available	The application were rejected
N	2020	Not available	The application were rejected

For each case, the specific page intervals indicate where the content connected to the suitability of the dumpsite can be found.
**For a description of the classification system see the first paragraph in the section "Clean Sediment" in the results or Swedish Environmental Protection Agency [SEEPA] (1999).*
***In case J, neither of the involved parties or the court defines clean sediments. One definition could be that sediments are clean if they are of class 3 or below, as the County Administrative Board (Västra Götaland) in their opinion describes that contaminants at class 4 would have warranted additional discussion, page 22.*

A second factor addressed in out of the 14 cases, was if the proposed dumpsite had been used for dumping previously. In the four cases F, I, J, and K, the courts describe that the dumpsites had been used previously as part of their reasoning for why the site was suitable for dumping. In cases M and O, the proposed dumpsites had been used previously but the courts stated that previous use in itself was not sufficient justification that the site was suitable for new dumping.

A third factor was the ecological situation at the dumpsite prior to dumping, addressed by out of 14 cases when considering the suitability of the dumpsite. In case I, the court described the site as suitable partially due to a lack of benthic flora and fauna. In cases F and M, the courts stated that a lack of information about the ecological implications of dumping at the dumpsites was part of the reason for rejecting the exemption applications (**Table 5**). Ecological aspects are further covered in the next section of the results.

TABLE 4 | Key factors considered by the courts when determining the suitability of proposed dumpsites, with summaries of the reasoning by the courts and contaminant levels at the dumpsite previous to the planned dumping.

Case	Year	Key factors	Summary of the courts' reasoning	Contaminants at the dumpsite
A	2015	Sediment sink	The court stated that the site was a sediment sink, exhibiting conditions under which sediment were likely not to spread (page 8)	Measured adjacent to the dumpsite. Multiple below class 3, class 4 for some PAHs, 47 μg/kg dry weight for TBT
B	2015	Sediment sink, Hypoxia	The court described that the general waterbody, of which the dumpsite was part, exhibited a moderate ecological status and a good chemical status, as per the WFD (Pages 25–26). The suitability of the site for dumping was not considered in more detail by the court. The applicant described the site as a hypoxic sediment sink at a 100 m depth (preceding case M2414-12 pages 15–16)	Good chemical status as per the WFD EQS
C	2015	Contaminants	While the court denied the application for exemption the court also stated that the proposed site was well situated and that there would be an environmental benefit to dump and cover the proposed site with cleaner sediment due to the contaminants on site (page 8)	Not available
D	2016	Sediment sink, Contaminants	The court stated that the site was a sediment sink, exhibiting conditions under which sediment was likely not to spread, making the site suitable for dumping of dredged sediments. A condition was set to cap the contaminated dumped sediments with cleaner sediment, without a definition of clean. The court further described that the dumpsite was suitable as it was contaminated with TBT, anoxic and void of life (page 10, preceding case M-2587-14 pages 83–85)	123–534 μg/kg dw TBT
E	2016	Sediment sink, Contaminants, Surrounding environmental values	The court stated that the information offered by the applicant did not adequately show that the dumpsite exhibited conditions under which dumped sediments would accumulate without considerable spread, a necessity as the site was adjacent to areas of high environmental value. The court further stated that the proposed dumpsite's sediment exhibited elevated levels of contaminants and that it was not adequately shown that dumping would not cause the contaminants to spread (pages 6–8)	The dumpsite is described as contaminated without additional detail on the types or levels of contaminants
F	2016	Sediment sink, Local environmental values, filling capacity, previous use	The court stated that one of the proposed sites was suitable for dumping as the applicant adequately verified that the site had been used previously, the capacity at the dumpsite was sufficient and that the site was a sediment sink. The court further stated that another proposed site was unsuitable as it was not adequately verified that there were no environmental values worthy of protection or conditions for sediment accumulation. The court considered the site to be too small to ensure that dumped sediment would not spread during the dumping and that it was preferable to choose a site that had been previously disturbed by dumping (pages 56–57)	Not available
G	2016	Sediment sink	The court stated that it had been verified that dumped sediment could accumulate at the dumpsite without considerable risk of being spread and that the court considered this to be of particular importance for dumping (page 26)	Class 1–2 for metals, 4 for some organic pollutants
H	2016	Sediment sink	The court stated that it had been verified that dumped sediments could accumulate at the dumpsite without considerable risk of being spread and that the court considered this to be of particular importance for dumping (page 22)	Class 1–2 for metals, 4 for some organic pollutants
I	2017	Previous use, Reduced sediment, Benthic community, Depth	The court stated that the site was suitable for dumping in relation to the water depth (50–60 m), that it had been used previously for dumping and that the sediment was reduced without flora or fauna (page 204)	Not available
J	2017	Sediment sink, Previous use, Depth	The court stated that the dumpsite was acceptable as it was adequately verified that it was a sediment sink, at a depth down to 60 m, and that the site had been used for dumping previously (page 54)	Not available
K	2018	Sediment sink	The court stated that the site is a sediment sink, exhibiting conditions under which sediment are likely not to spread; this, in conjunction with a condition to cover the contaminated dumped sediments with clean sediments (clean was defined as below 50 μg/kg dw TBT and below class 5 for PAH-11 and PCB-7), made the site suitable. The fact that the area was used for shipping did not affect the assessment (pages 22–23)	TBT 3.4–163 μg/kg Dry weight
L	2018	Sediment sink, Previous use	The court stated that the site was suitable for dumping as it was adequately verified that the dumpsite was a sediment sink and that it had been used previously (pages 80–81)	Not available
M	2018	Hydrology, Previous use, Ecosystem	The court stated that the fact that the site had been considered suitable previously was not adequate verification that the conditions had not changed over time and that the current hydrological, benthic and ecological conditions were not adequately assessed (page 8)	Not available
N	2020	Previous use	The court stated that the fact that the site had been considered suitable previously was not adequate verification that the conditions had not changed over time (page 6)	Not available

For each case, the specific page intervals indicate where the content connected to the suitability of the dumpsite can be found.

TABLE 5 | Ecological factors considered by the courts when evaluating if exemption could be granted without environmental detriment, followed by summaries of the courts' reasoning considering ecological factors.

Case	Year	Ecological factors	Summary of the courts consideration of ecological factors
A	2015	Ecological effects of contaminants	The court set the condition that the concentration of TBT in the dredged sediments that were to be dumped at the dumpsite could not exceed the concentration of TBT in the sediment at the dumpsite, and that the concentrations at the site already posed an ecological risk (page 8, preceding case M 2684-13 page 4)
B	2015	EQS	The court considered it adequately verified that dumping would not infringe on the ecological status set for the entire water body of which the dumpsite was part (pages 24–28)
C	2015	Not available	The court did not directly consider ecological factors
D	2016	Not available	The court stated that the site was degraded to such an extent that the site could be used for dumping without environmental detriment (preceding case M-2587-14 pages 83–85)
E	2016	Areas of ecological value close to the dumpsite	The court stated that there were areas of very high ecological value adjacent to the dumpsite and that it had to be shown that the dumping would not cause negative environmental effects via turbidity during the dumping and subsequent erosion and transport of the dumped sediment as well as of the already contaminated sediments at the dumpsite (pages 6–7)
F	2016	Inadequate evidence to determine ecological values at dumpsite	The court stated that it was not adequately shown that no valuable benthic environments would be affected by dumping. The court further stated that it was preferable to dump at sites that had been used previously rather than to dump at pristine sites (pages 56–57)
G-H	2016	Not available	The court did not directly consider ecological factors
I	2017	Degraded ecological conditions at dumpsite	The court considered the level of contaminants in the dredged sediments and the ecological conditions at the dumpsite, and stated that the site was degraded to such an extent that the site could be used for dumping without environmental detriment (pages 203–204)
J	2017	Not available	The courts did not directly consider ecological factors
K	2018	Not available	
L	2018	Not available	
M	2018	Inadequate evidence to determine potential effects on marine ecosystem	The court stated that the accounts on potential effects on the marine ecosystem were lacking (page 8). The court did not describe what such accounts should have covered
N	2020	Not available	The court did not directly consider ecological factors

For each case, the specific page intervals indicate where the content connected to the suitability of the dumpsite can be found.

Ecology

The seven cases, A, B, D, E, F, I, and M, considered ecological factors as defined by our methods (**Table 5**). In the two cases F and M, applications for exemption were denied partially due to a lack of account of the effects dumping would have on the local ecosystem. The courts did not further describe how or what ecological effects should be accounted for.

In the majority of the cases, the courts did not discuss the ecological effects of dumping, such as local effects of added contaminants, changes in topography or burial. However, in cases D and I, the courts considered poor ecological conditions to make the proposed site suitable for dumping. Case I stated: "The bottom in Draget (the waterbody) is composed of black reduced sediments without other life than sulfate-reducing microorganisms. The Land and Environmental Court considers the site to be suitable for dumping of the dredged masses as long as it can be conducted without aforementioned inconvenience" (Case I, p. 204, translated from Swedish).

In case E, the court stated that it is important that the dumping would not cause excessive turbidity during the dumping and that the dumped masses would not spread from the dumpsite as there were areas of high ecological value adjacent to the dumpsite (**Table 5**).

In addition, to limit the potential effect of dumping, the courts routinely included conditions restraining dumping activities to months when biological activity was reduced at the dumpsites. Otherwise, ecological effects were not included in any of the conditions set for exemption (See **Supplementary Appendix 1** for a list of conditions).

Climate Change

Changes in future conditions due to climate change in relation to risk of environmental detriment due to the dumped sediments was raised occasionally by the applicants or consultation bodies. However, the issue was not raised by the courts in any of the cases. Future changes in conditions due to climate change were not mentioned or accounted for in the conditions set for exemption in any of the cases.

Rejection

Five cases, C, E, F, M, and N, did not authorize exemption, neither in part nor fully (**Tables 1**, **6**). In all of those cases the applications were rejected as the applicants *have not adequately verified that the dumping would not cause detriment to the environment or human health*. However, the applications were considered to be lacking on different accounts. In case C (2015), the contaminant levels were considered too high. The District Court stated that dredged sediment with contaminant levels exceeding class 3 were not suitable to be dumped at sea. The court further stated that they considered the proposed dumpsite to be well suited for dumping with cleaner sediment.

In case E, the LECA stated that it *was not adequately verified that the dumped sediments would not spread from the proposed dumpsite*. Hence, it was not verified that dumping could be

TABLE 6 | A comparison between concentrations used in Norwegian guidelines for sediment risk assessment indicating when ecological risk cannot be excluded; and concentrations in sediment corresponding to highly contaminated Swedish background levels from 1999 (updated values from 2014 in parentheses); and EQS for chemical status as per the WFD.

Substance	Concentrations indicative of ecological risk[1] μg/kg dw	Class 4[2] μg/kg dw	EQS[3] μg/kg dw
Arsenic	18,000	28,000–45,000	
Cadmium	25,000	1,200–3,000	2,300
Mercury	520	40–1,000	
Nickel	42,000	66,000–99,000	
Lead	150,000	65,000	120,000
Fluoranthene	400	80–270 (140–390)	2,000
Anthracene	4.6	8–30 (11–45)	24
TBT	35*	Not available (19–55)	1.6

[1] *Norwegian Environment Agency guideline 02:2013 used in Breedveld et al. (2015).*
[2] *Swedish Environmental Protection Agency [SEEPA] (1999) and Josefsson (2017).*
[3] *Swedish Agency for Marine and Water Management [SwAM] (2019).*
**The limit for TBT is based on a compromise between ecological effects and background levels.*

conducted without environmental detriment (**Table 4**). In case F, the applicant proposed two dumpsites. The court rejected one based on a *lack of information regarding the site's capacity to act as a sediment sink* and the *potential ecological values at the site* (**Tables 4–6**). The court further stated that it was *preferable to use a site that previously had been used for dumping*. In cases M and N, the courts stated that *the previous exemption to dump at the proposed dumpsites was not an adequate basis to evaluate if the dumpsites were still suitable* and *that the contaminant levels in the sediments that were to be dredged were not adequately measured* (**Tables 3–6**).

DISCUSSION

Many factors, both environmental, scientific and societal, affect the perception of risk, which in turn controls the outcome of an assessment (Slovic, 1999). When considering applications for exemption, the courts exhibited quite different perceptions of risk and the exemptions were given with varying conditions that had to be met. While the case-specific assessments of risk were potentially reasonable from an environmental risk perspective, the overall procedure appears to have been arbitrary when comparing the cases. The consequence is, as shown in this study, that the courts arrived at seemingly contradictory conclusions.

It is common among the cases that the risk to the local benthic community is not an environmental aspect that is considered (**Tables 4–6**). This leads to a risk of a long-term loss of the benthic community. A full recovery back to the community found before dumping can be a slow process and is not guaranteed (Pearson and Rosenberg, 1978; Blomqvist, 1982; Bolam et al., 2006; Guerra-García and García-Gómez, 2006; Larson and Sundbäck, 2012). The risk to the local benthic community was accepted without comment by the courts that authorized exemptions, with the exception of cases D and I, where the courts considered that the degraded state of the local benthic ecosystems made the sites more suitable for dumping. In the cases where the applications were rejected, the courts did not specifically state that the risk for the local benthic community was a concern. However, since part of the reason for rejection in cases F and M was a lack of information of the local ecosystem, there appears to be at least a possibility of rejecting an application based on the risk for the local ecosystem.

The long term effects stemming from geophysical changes from dumping, as well as the differences between the sediment texture at the dumpsite and the dredged sediment, do not appear to have been addressed in the court cases (recommended in e.g., Munns et al., 2002; OSPAR Commission, 2009; Helsinki Commission [HELCOM], 2020a). In areas that are sediment sinks, dumping can cause long-lasting mounds of deposited material, changing the benthic habitat and increasing the risk of erosion (Blomqvist, 1982; Stockmann et al., 2009; Virtasalo et al., 2018; Mossa and Chen, 2021). Changing the morphology of the bottom can cause barriers for migration for fish and crustaceans and should be considered when considering dumping according to the OSPAR guidelines (OSPAR Commission, 2009; Kraufvelin et al., 2018).

In short, a degraded local ecosystem has been used as an argument for granting exemption, but the risk of burying a local ecosystem is not used as an argument for rejecting exemption. Therefore, there appears to be an acceptance of loss of the local ecosystem potentially hindering the achievement of the UN Global Sustainable Development Goals (SDGs) "Life under water" and the Swedish national objectives, e.g., "A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos," according to which Sweden aims to recover lost and degraded marine ecosystems (Swedish Environmental Protection Agency [SEEPA], 2012; UN, 2015; Swedish Government Offices, 2018).

Another perspective on risk is presented in case A, where the LECA argued that exemptions should be considered based on case-specific conditions. In that case, exemption was granted to dump dredged sediments with concentrations of TBT that the court perceived as harmful, as long as those concentrations did not clearly exceed the concentrations at the dumpsite. That is, *exemption was granted since the dumping did not result in additional environmental detriment* (**Table 3**).

The reasoning in case A later gave cause for two other perspectives. In cases D and K, the LECA referred to the argument made in case A that applications for exemption should be considered on a case-specific basis and concluded that there was *no risk of environmental detriment if sediments with high levels of TBT were isolated with a cap of cleaner sediments.* A condition for a cap to be effective is that it is not eroded, and sediment sink conditions are a prerequisite for exemption in the majority of cases (**Table 4**). However, it is noteworthy that the courts in none of the cases expressed consideration for potentially increased resuspension due to climate change, future or current boat traffic or fishing.

In contrast to cases D and K in the previous paragraph, the District Court in case L referred to the specific maximum contaminant concentrations limits set in case A without relating to case-specific conditions. The court concluded that *if the*

limits set in case A were not exceeded there would be no risk of contamination, without relating to the conditions at the dumpsite (**Tables 3–5**). The use of predetermined limit values not based on site-specific background concentrations, as in case L and in several Baltic countries (Staniszewska and Boniecka, 2017), could prolong the prevalence of high contaminant levels at a site. If combined with the reasoning in case A, the contaminant concentrations at a site could then be used as an argument to continuously authorize exemption to dump sediments with contaminant concentrations as high as at the dumpsite. This is in contrast to the intention to achieve a good ecological status according to the WFD, and restore deteriorated marine ecosystems as per the SDG "Life below Water" and the Swedish objective – "A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos."

The contaminant limit concentrations set as conditions for exemption by the courts add a measure of uncertainty to their evaluations from an ecotoxicological perspective. In Sweden, there are no scientifically based criteria or limit concentrations for the contaminant levels that dumped sediments can contain. However, as seen in cases F and L, the limits set by the LECA can be used as precedents. In guidelines for managing dredged sediment (**Table 3**), SwAM also refers to the lowest and highest concentration limits set by the LECA as reference points (Swedish Agency for Marine and Water Management [SwAM], 2018). The limits the courts have set are based on other factors than the contaminant toxicity. For example, case G set the limits at class 4 (highly contaminated) as defined in the report from SEEPA classifying background concentrations, based on data from before 1999. There seems to be a practical reliance in considering exemption on the version from 1999 as it was used even in cases K and L conducted after 2017 when the updated version was published (Josefsson, 2017). It was also used in spite of SwAM already in 2015, in case A, recommending that their guidelines should be used when applicable. The SwAM guidelines were produced taking ecological effects into account and prescribe intervention values that for some substances were lower than for class 4 (in Swedish Environmental Protection Agency [SEEPA], 1999), for example for several PAHs, but higher for e.g., lead (Swedish Agency for Marine and Water Management [SwAM], 2013, updated in Swedish Agency for Marine and Water Management [SwAM], 2019).

To put the use of the classification system for contaminated sediments in another perspective, class 3 is the lowest concentration limit set by any of the cases (**Table 3**), but already at those concentrations PAHs correlate to adverse effects on benthic communities in the Baltic Sea (Raymond et al., 2021). There are also examples of individual PAHs such as fluoranthene in class 4, set as the limit in cases A, G, and H, that are above limits where ecological effects are estimated to be able to occur compared to Norwegian guidelines (Breedveld et al., 2015). The Norwegian guidelines are relevant to compare with as Norway shares a coastline with the west of Sweden where cases F-H are located. However, several contaminants at class 4, such as arsenic, exceed the expected effect limits used by the Norwegian guidelines. The concentrations can also be compared to the Swedish general limit values set for the fulfillment of the WFD, with higher limits for e.g., fluoranthene but lower limits for TBT than in the Norwegian guidelines and class 4 values (Swedish Agency for Marine and Water Management [SwAM], 2019; **Table 6**). There are also limits set by the other HELCOM signatories for when dredged sediment can be considered as contaminated. In Denmark, Finland, Germany, and Latvia the limit for sediment to be considered contaminated in relation to TBT ranges between 3 and 20 μg/kg dw. Those countries, except Germany, also distinguish between concentrations of TBT that can be considered safe for less and more contaminated areas. The range for more contaminated areas range between 60 and 200 μg/kg dw (Staniszewska and Boniecka, 2017).

As described earlier, the concentration limit in case A for TBT (50 μg/kg dw) was based on the concentrations at the dumpsite, a concentration above the limit for potential environmental effects (according to e.g., Sahlin and Ågerstrand, 2018; Swedish Agency for Marine and Water Management [SwAM], 2019; **Table 6**). The highest allowed concentration of TBT, set in case K at 200 μg/kg dw, was based on the condition that the sediments would be isolated with cleaner sediment (**Tables 3–5**). The basis for the allowed concentrations of contaminants and evaluation of risk of toxicity from the dredged sediments in all the court cases was connected with an unknown level of uncertainty. Even if the assessments had used concentration levels that were derived from toxic effects in relation to contaminant concentrations, they would have some level of uncertainty as other factors such as bioavailability, unknown contaminants and additive or synergistic effects can impact the observed effects caused by contaminants (Swartz et al., 1994; Keiter et al., 2008; Mustajärvi et al., 2019; Pheiffer et al., 2019; Vogt et al., 2019). It is therefore important to include measures that account for these effects (Munns et al., 2002; OSPAR Commission, 2009; Gerbersdorf et al., 2011; Chapman and Maher, 2014; Helsinki Commission [HELCOM], 2020a). Furthermore, none of the courts requested or laid down conditions for the exemptions demanding measurements directly related to ecological effects, such as recolonization of the benthic community, to monitor potential effects after dumping. However, the courts routinely left the responsibility of establishing a monitoring program to the applicant together with the local County Administrative Board (**Supplementary Appendix 1**).

A common recommendation for better understanding the potential of environmental detriment is to address both the potential effects of the dredged sediments and the concentrations of contaminants. Such an approach can reduce uncertainty and provide information for management (e.g., Gerbersdorf et al., 2011; Chapman and Maher, 2014; Brack et al., 2019). Several guidelines argue that biological testing should be a standard part of assessing risks from contaminated sediments (Munns et al., 2002; Algar et al., 2014; Simpson and Batley, 2016). OSPAR and HELCOM also recommend in their guidelines for managing dredged sediment that when chemical characterization is not enough to determine the risk, biological tests of e.g., bioaccumulation and toxicity should be conducted (OSPAR Commission, 2009; Helsinki Commission [HELCOM], 2020a). However, with the precedents set by the courts, the definition on what constitutes environmental detriment is unclear. Therefore,

before advocating for specific assessment methods the definition of environmental detriment and the objective of considering an application for exemption needs to be better defined.

The focus on chemical and physical measurements in the court cases corresponds to earlier observations of how sediments are evaluated in European and Baltic nations. Several HELCOM members around the Baltic Sea have action list levels for contaminant concentrations that are used to determine if dredged sediments can be dumped. Some countries distinguish between sensitive and less sensitive areas with different concentrations for each type of area, adding some flexibility. Nevertheless, they also appear to focus on the risk from single contaminants and do not include ecological effects in their evaluations (Apitz, 2008; Staniszewska and Boniecka, 2017).

There might be a historical background for the focus on chemistry rather than ecology in risk assessments. Environmental quality standards are a relatively new legal instrument. They were not implemented into Swedish law until Sweden entered the EU in 1995 and the EU has only specified limit values on chemical substances for surface water status. In Sweden, quality standards for chemical status have therefore been implemented as legally binding values in individual cases, whereas quality standards for ecological status have been implemented only as guiding values, until recently. The difference in legal status results in different possibilities to reject or require protective measures in the individual case. Not until 2019, after a clarification by the European Court of Justice, was the Swedish legislation changed. However, what this change might entail is too early to tell. The only case after the clarification by the European Court of Justice, case N, did not indicate a change in practice.

Based on the perspectives and criteria used by the courts when considering applications for dumping, it appears that rather than evaluating *if dumping would cause environmental detriment* the courts evaluate *if the detriment from dumping would be acceptable*. While this practice might be warranted from a practical point of view, it is not in line with relevant environmental obligations. For example, as local benthic communities are buried and potentially harmful levels of contaminants are allowed, it can be said that the law is not respected as it stipulates that exemption only can be granted if it has been shown that there will be no environmental detriment (15, 27:29 EC). The practice also appears to deviate from the commitment to the OSPAR Convention (1992) that stipulates that only lightly contaminated sediments can be dumped; exemption is granted for sediments defined as medium to very highly contaminated [**Table 3**; Swedish Environmental Protection Agency [SEEPA] (1999)]. The application of the law is neither in line with the precautionary principle as future changes in local conditions, such as changes in anthropogenic use or climate change, are not well accounted for.

If the practice is to grant exemption based on some measure of acceptable detriment rather than when detriment is absent, there is arguably a need for the party applying for exemption to thoroughly consider alternative management methods and dumpsites. That practice is already required, in the form of EIA, for other activities that risk causing environmental effects, according to the EU Directive 2011/92/EU. As exemption should not be granted for cases where there is a detriment to the environment, according to 15:29 EC, applicants for exemption to the ban on dumping are not required to conduct an EIA. However, as indicated by the results of this study, there is a risk that exemption is granted even though the risk of environmental detriment has not been adequately evaluated and there might be more sound alternatives than dumping, or more suitable dumpsites. There is therefore a need to further consider alternatives in the practice of applying for and considering exemption.

CONCLUSION AND RECOMMENDATIONS

It is not clear that current regulations are applied to ensure that no environmental detriment will be caused by dumping of sediment. The process in the court cases was characterized by different, and sometimes contradictory, perspectives on acceptable risk. None of the expressed perspectives included site-specific assessments of ecological effects. Too strict guidelines or regulations for how to assess risk and evaluate applications could hinder case-specific considerations (as discussed in Dale et al., 2008). However, the results of this study indicate that the current practice in Sweden does not lead to well informed and rigorous site-specific evaluations and that a more structured process is needed.

The study highlights a gap in the practical definition of what a risk of environmental detriment entails. That gap needs to be addressed, followed by the implementation of scientifically sound and practical criteria well connected to the definition of risk determining the assessment objectives. These challenges are likely similar among the HELCOM members around the Baltic Sea, where there is a similar dependency on binary chemical limit concentrations (Staniszewska and Boniecka, 2017). However, the majority of the HELCOM members have set such limits while the Swedish practice is supposed to rely on case-specific evaluation.

To improve the process of assessing and evaluating the risk of environmental detriment and the ability of the process to fulfill relevant obligations, the objective of considering an application for exemption and the definition of environmental detriment needs to be better defined and appropriate tools for assessment and evaluation developed or adapted accordingly. The evaluations should require a scientifically sound basis and move away from the use of reference concentrations not related to environmental risk. As discussed above, there are already guidelines relating contaminant concentrations to ecological risk (Breedveld et al., 2015; Swedish Agency for Marine and Water Management [SwAM], 2019). However, additional research might be needed to implement the already existing guidelines to ensure that they align with the specific purpose of evaluating risks from dumping dredged sediment, for example adapting them to provide a range of risk estimates and accounting for site-specific conditions.

Moreover, if chemical and physical measurements are not enough to evaluate risk with certainty, as this study indicates is the situation in the Swedish cases, the guidelines from

both OSPAR Commission (2009) and Helsinki Commission [HELCOM] (2020a) recommend that biological testing should be conducted [as has been done in e.g., United States (Munns et al., 2002) and in Greece (Kapsimalis et al., 2013)]. However, biological testing is not frequently used when assessing risk from contaminated sediment in Sweden (Bruce et al., 2020). Additional development and implementation of biological testing, with the specific purpose of assessing risk from dumping dredged sediment, would provide the courts with more comprehensive and pluralistic grounds for evaluation.

It is important to address the gaps highlighted in this study as the current practice is not in compliance with current legislation and risk hindering the achievement of environmental objectives on all levels. Furthermore, there is a risk that current inconsistent evaluations reach unequal decisions or are too lax in relation to risk of marine environmental detriment as defined by law.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: Public data regarding the frequency and extent of dumping dredged sediment in Sweden was provided by the Swedish Agency for Marine and Water Management. The data can be requested via following link: https://www.havochvatten.se/en/our-organization/contact-us.html. All cases from the Land and Environment Court of Appeal can be found in the data base accessible with the following link: https://www.domstol.se/mark–och-miljooverdomstolen/mark–och-miljooverdomstolens-avgoran den/. The cases from District Land and Environment Courts can be requested from the individual courts via the following link: https://www.domstol.se/domar-och-beslut/bestall-domar-beslut-eller-handlingar/. Please note that the Swedish courts joint webpage is currently being updated and that some parts are not yet available in English. Please contact the corresponding author if you have any questions regarding the material.

AUTHOR CONTRIBUTIONS

PB had the main responsibility for planning, design, data gathering, analysis, and writing. AC guided the process in relation to the juridical aspects and made considerable contributions to the introduction to relevant regulations. All authors contributed to the development of the main objective of the study, provided input on the layout and content of the text as well as proofreading.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2021.755443/full#supplementary-material

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