Costs associated with a major oil spill in the Baltic Sea

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Summary

10,000 tons of oil contaminates a coastline in the Baltic Sea. The cost of this oil spill scenario is estimated to 100 – 400 million EUR including direct (e.g. clean-up), market (e.g. tourism and fisheries industry) and non-market costs (i.e. environmental and other impacts that are not easily measured in a market).

What has happened?

A tanker carrying 90,000 tons of Russian heavy crude oil collides with a smaller ship in one of the bigger fairways of the Baltic Sea. The tanker is damaged in the collision and oil is spilled. The crude oil is thick and sticky and thereby difficult to remove from water and beaches. The season is late winter or early spring with an upcoming breeding and tourist season.

The weather during the first days of the operation is very bad and the wind-force is so high that no operation can be carried out at sea. Due to the bad weather conditions, oil is carried by waves and currents and strands far up on the shores. This will, for sure, make the cleaning of the beaches even more difficult.

Where did it happen?

The locations of the studied areas are shown in figure 1.

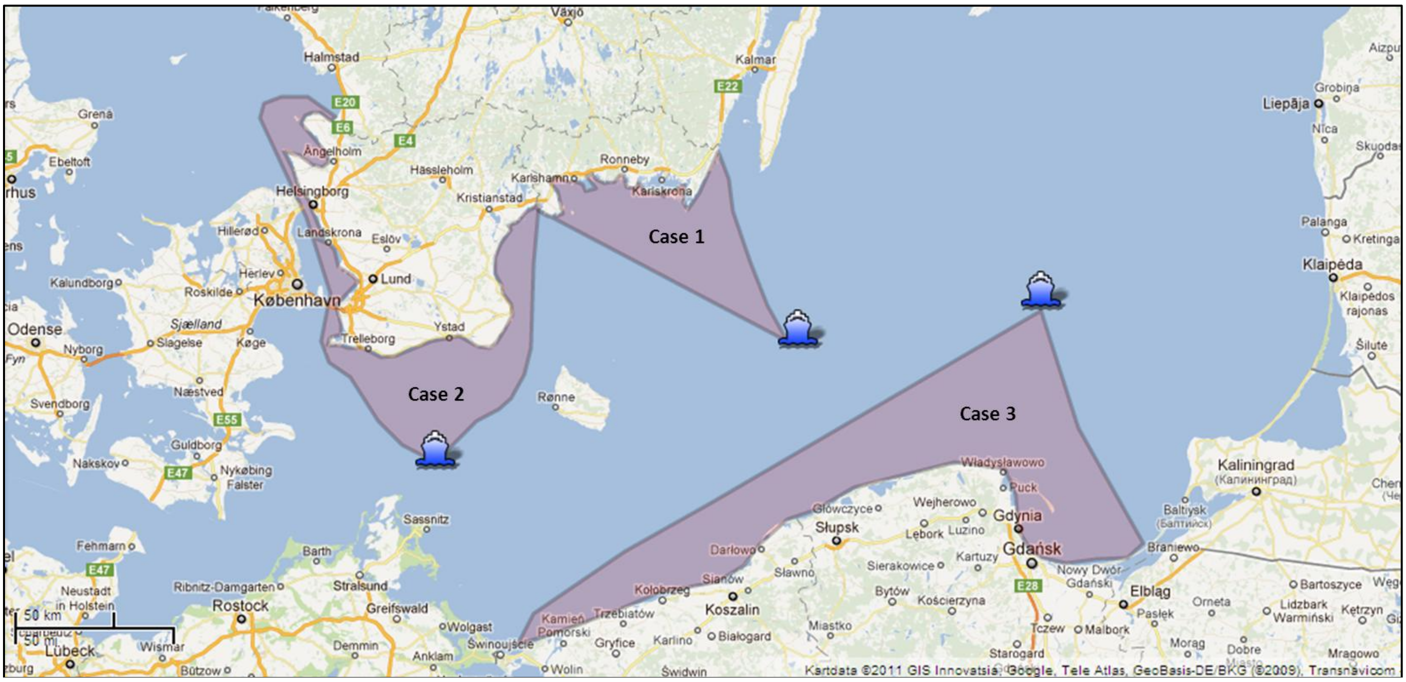

Figure 1. Three oil spill scenarios located in the Baltic Sea. Case 1: Blekinge, Case 2: Skåne and Case 3: the Polish coast of the Baltic Sea.

Background information

The Baltic Sea is one of the busiest seas in the world and about 3,500-5,000 ships operate the Baltic Sea every month. The maritime transport is increasing and oil transportation is growing steadily. The number of large tankers is also expected to grow with more tankers carrying 100,000-150,000 tons of oil. More ships on the Baltic Sea will increase the risk for pollution accidents.

IVL Swedish Environmental Research Institute (IVL) has conducted a study, in cooperation with Enveco Environmental Economics Consultancy (Enveco), and the aim of the study was to identify costs associated with a spill of 10,000 tons of oil. Three case studies have been carried out, based on scenarios of potential oil spills: the county of Blekinge, Sweden, the county of Skåne, Sweden, and the Polish coast of the Baltic Sea. The total cost associated with an oil spill in Blekinge amounts to approximately 100 million EUR. In Skåne, the figure corresponds to approximately 200 million EUR. In the Polish case, the cost is estimated to approximately 400 million EUR.

Costs related to oil spills are categorized in three groups. *Direct costs* refer to costs for cleaning the beaches. *Market costs* refer to losses of profits in different industries that are dependent on a clean coastal environment (e.g. tourism or fisheries). *Non-market costs* refer to environmental costs and other costs that are not priced in a market. Today, there is no clear international system for compensation of non-market costs. Our case studies indicate that the non-market costs may be substantial. The distribution of the costs into the above categories is illustrated below. The differences that can be observed in the distributions between direct, market and non-market costs are to a large extent explained by differences in the number of potential recreational users in the regions.

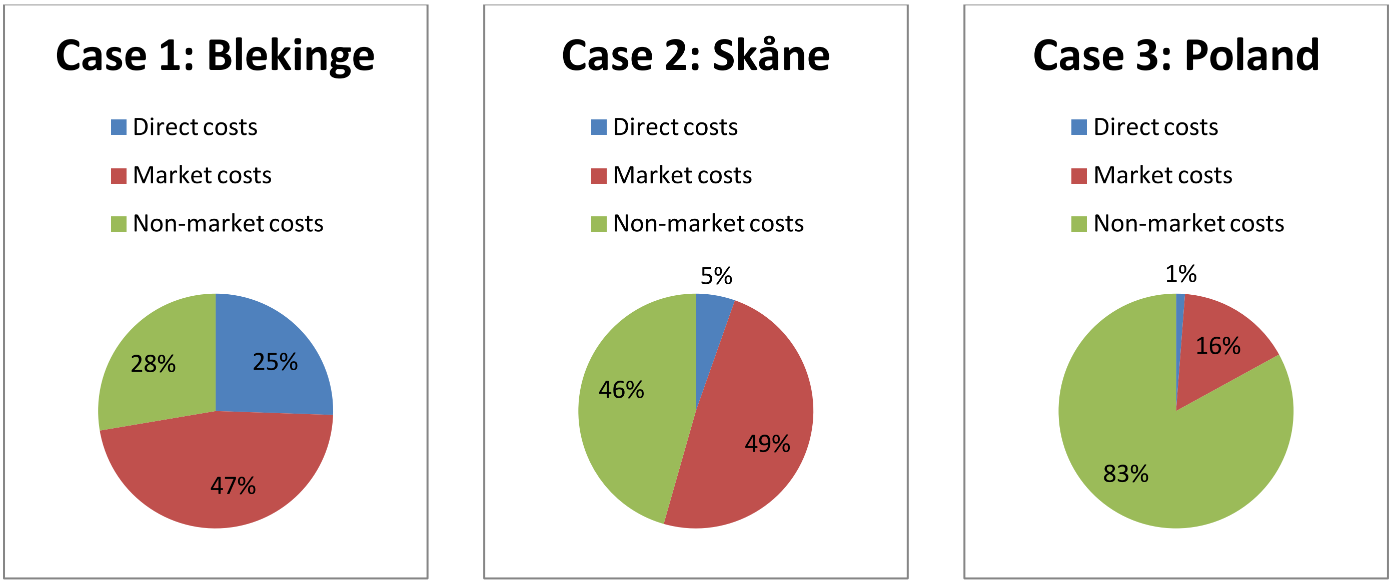

Figure 2. The distribution of the three categories of costs in Blekinge, Skåne and Poland.

The analysis relies on several assumptions and the estimates are uncertain, due to a lack of data concerning financial damage costs and non-market costs, which is likely to lead to an underestimate of the total costs. Good cost estimates can be useful in different contexts. Before an oil spill, estimates of *direct costs* are essential to have the right preparedness for future oil spills. Estimates of market costs are needed for estimating the sensitivity of fisheries and tourism to an oil spill, and estimates of non-market costs are needed e.g. for estimating the importance of an area for recreation. Altogether, these estimates can help policy makers decide on which is the "optimal" level of precautionary measures, such as marine safety and response preparedness. These measures are costly, and the costs should be weighed against the benefits in terms of avoiding potential damage. *After* an oil spill, cost estimates can be used to scale compensation.

More information about the Baltic Master II project can be found at www.balticmaster.org.

1 Introduction

Baltic Master II is an international project which aims at improving maritime safety by integrating local and regional perspectives. It focuses on the Baltic Sea Region (BSR) and issues concerning pollution prevention, coastal zone management and on land response capacity to an oil spill at sea. IVL Swedish Environmental Research Institute (IVL) has been contracted by Region Blekinge (coordinator of Baltic Master II) and Region Skåne to conduct a brief desk-top study on costs associated with oil spills. IVL is conducting the study in cooperation with Enveco Environmental Economics Consultancy Ltd. (Enveco).

The Baltic Sea accounts for up to 15% of the world's cargo transportation and is one of the busiest seas in the world. About 3,500-5,000 ships operate the Baltic Sea every month and the number of ships in the entire BSR (in 2010) is illustrated in Figure 1 (HELCOM 2009b). The maritime transport in the BSR is increasing and the transport of goods is estimated to double by 2017. General cargo and container traffic are expected to triple and oil transportation is thought to increase by 40 % (HELCOM 2009a). Until 2030, oil transport (in the BSR) is predicted to grow by 64 % (WWF 2010, Rytkönen et al. 2002, Helcom 2009b). The number of large tankers is also expected to grow, with more tankers carrying 100,000-150,000 tons of oil (Helcom 2009c, Brisk 2011). The intensified shipping will increase the risk for pollution accidents.

The consequences of an oil spill can be severe and associated with high socioeconomic and ecological impacts and response costs. The aim of this study is to identify the costs associated with a spill of 10,000 tons of oil. Three case studies are included.

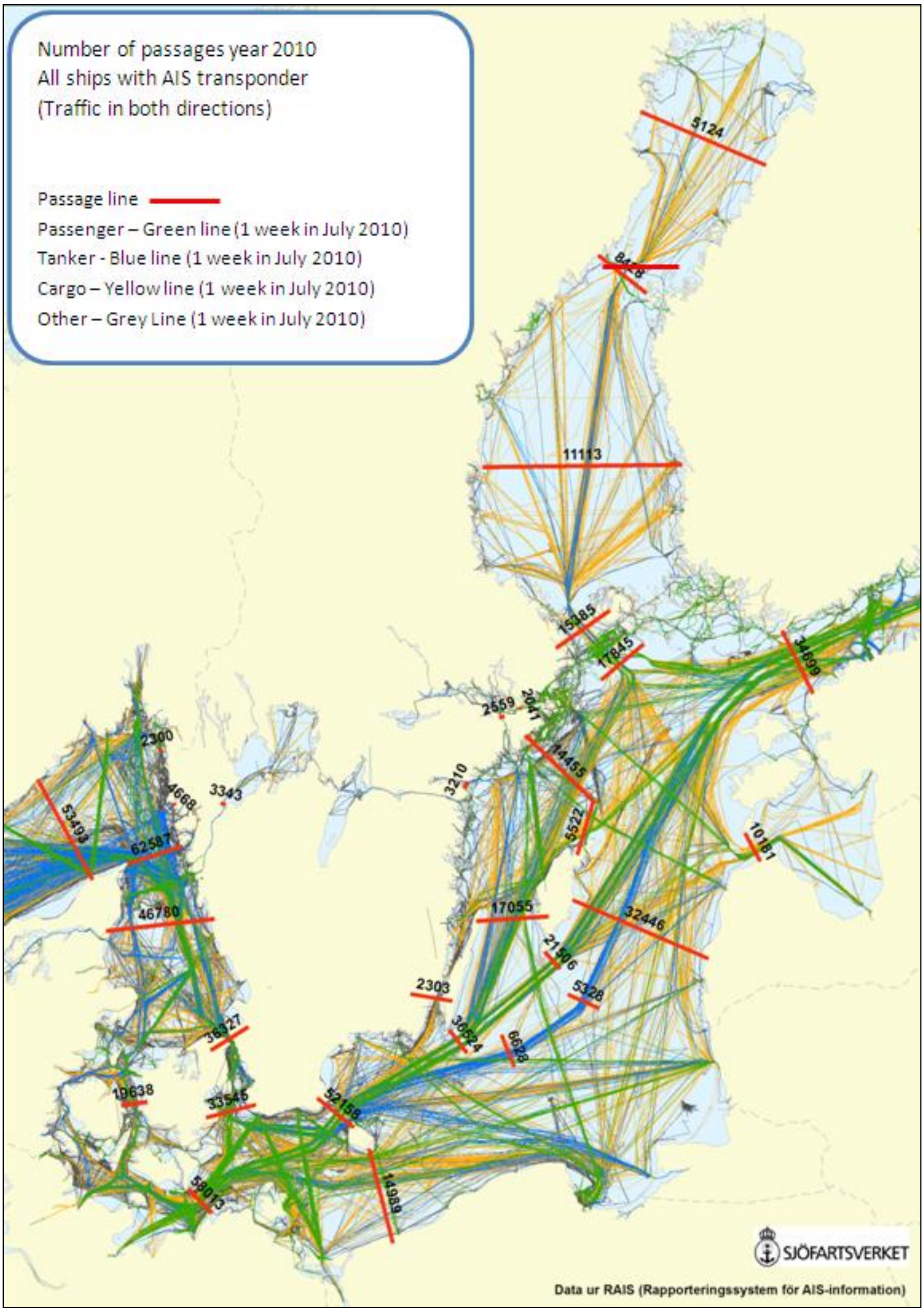

Figure 1. Number of passages in both directions over fixed AIS lines, passage lines, in the North Sea and Baltic Sea (source: Swedish Maritime Administration 2011).

2 Case studies

In the previous Baltic Master project (Baltic Master I) a study was conducted, aiming at estimating potential socioeconomic impact from major maritime oil spills (Forsman 2007). The methodology used is based on regional statistics on economic value. Oil spill scenarios with tanker accidents were used for illustrative purposes.

Three case studies are included in this report; Sweden (Blekinge), Sweden (Skåne) and the Polish coast of the Baltic Sea (Poland). The Blekinge and the Skåne scenario derive from Forsman (2006) and are modified to suit this study.

The BRISK project has produced maps on e.g. risk for exceptional spills (BRISK 2011, Figure 2). In the present report, one assumption is that the volume of spilled oil equals 10,000 tons, i.e. an exceptional spill according to the definition made by the BRISK project.

Some assumptions are used in all cases. The description of the case studies will therefore start with some background information and general assumptions, followed by more specific details regarding each case.

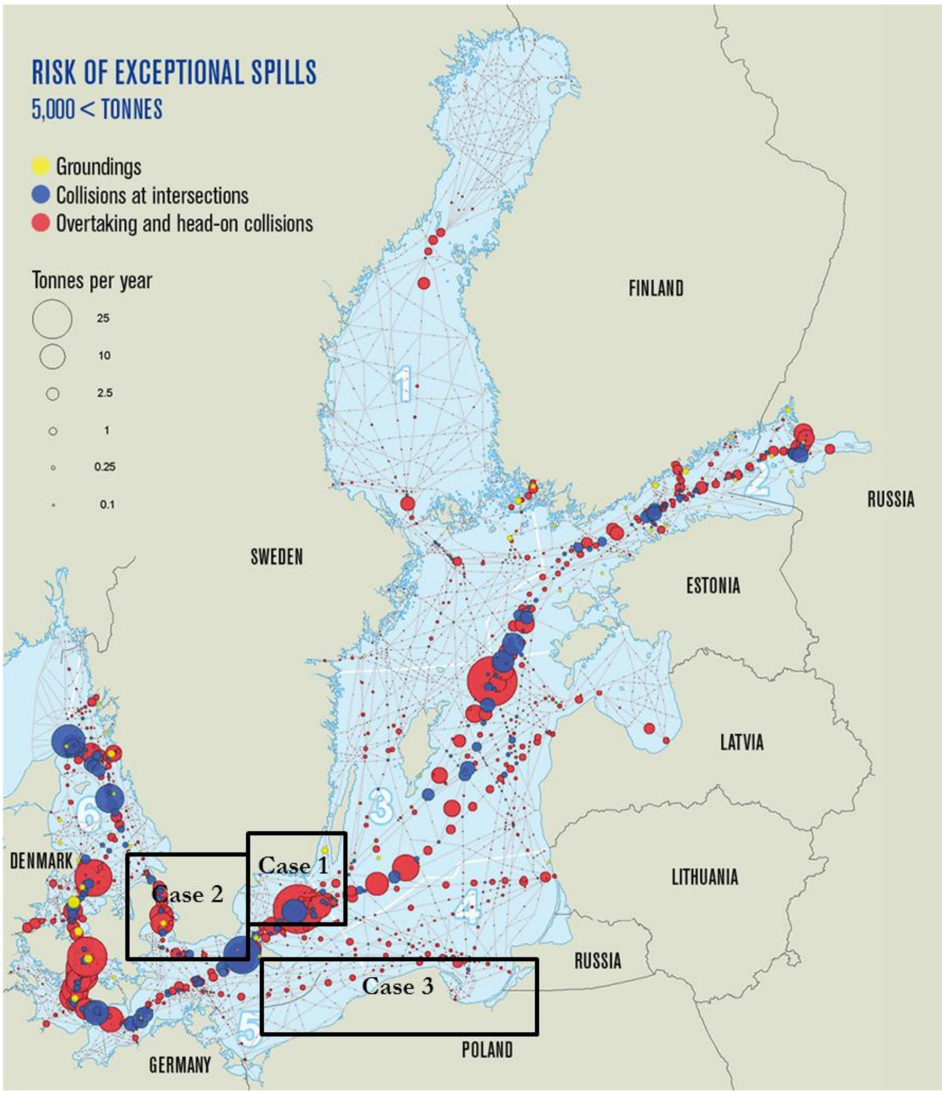

Figure 2. Risk of exceptional spills (BRISK 2011). The black rectangles are drawn by IVL and are showing the locations of case study 1: Sweden (Blekinge), 2: Sweden (Skåne) and 3: Poland.

2.1 Background

The most important technical factors that affect the cost of oil spill are type of oil, the location of the spill and the characteristics of the affected area. The quality of the contingency plan and control of the actual response operations are also important (ITOPF 2011).

2.1.1 Properties of oil

When oil is spilled on water, a number of transformation processes occur (Figure 3). Weathering changes the physical and chemical properties after a spill and one example of a weathering process is evaporation. The rate at which oil evaporates depends above all on the composition; the more volatile, the greater the extent of evaporation.

Some types of oil emulsifies in water, whereby the volume increases. In Figure 4, the volume of oil and water-in-oil emulsion remaining on the sea surface is shown as percentage of the original volume spilled. The density of the oil affects the emulsification rate and the oils have been grouped by ITOPF (2011) according to density (Table 1).

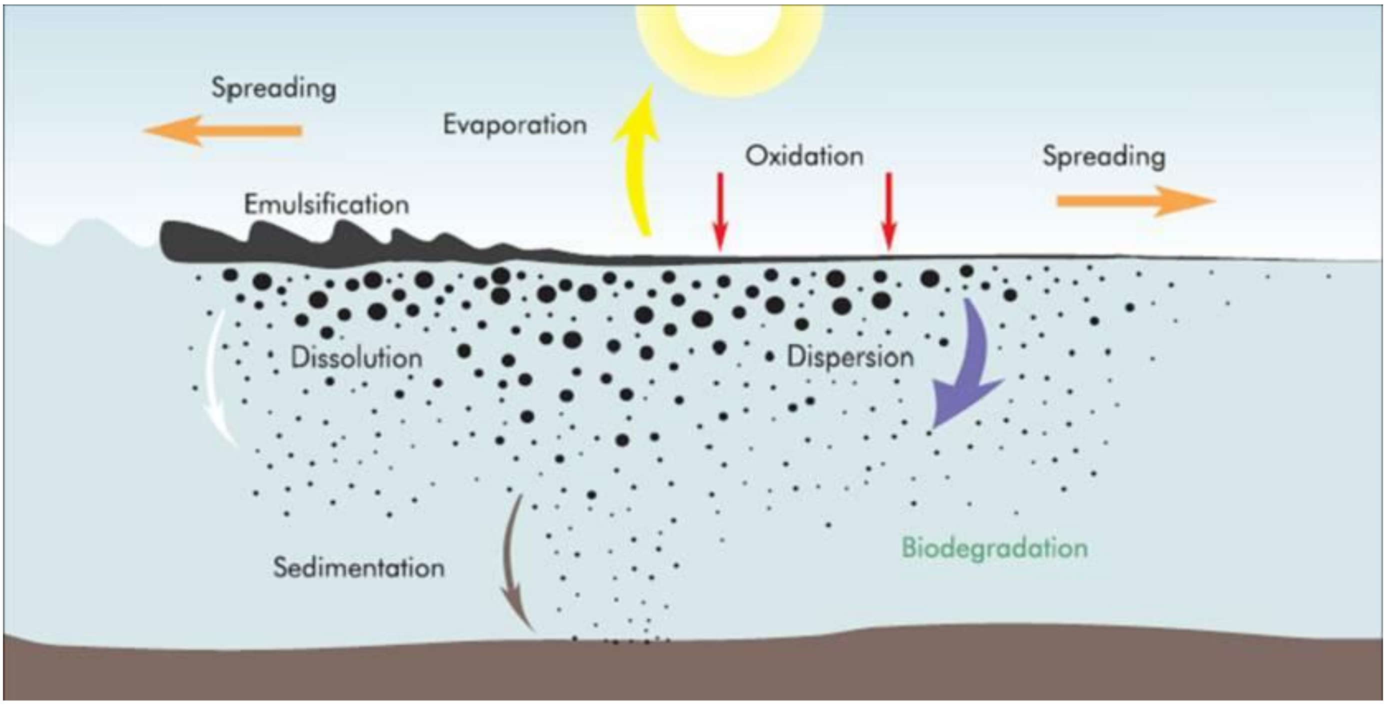

Figure 3. The weathering processes. A set of processes whereby the physical and chemical properties of the oil change after an oil spill (ITOPF 2002).

Table 1. Groups of oil (ITOPF 2011)

Group	Density	Examples
Group I	<0.8	Gasoline, Kerosene
Group II	0.8 - 0.85	Gas Oil, Abu Dhabi Crude
Group III	0.85-0.95	Arabian Light Crude, North Sea Crude Oils (e.g. Forties)
Group IV	> 0.95	Heavy Fuel Oil, Venezuelan Crude Oils

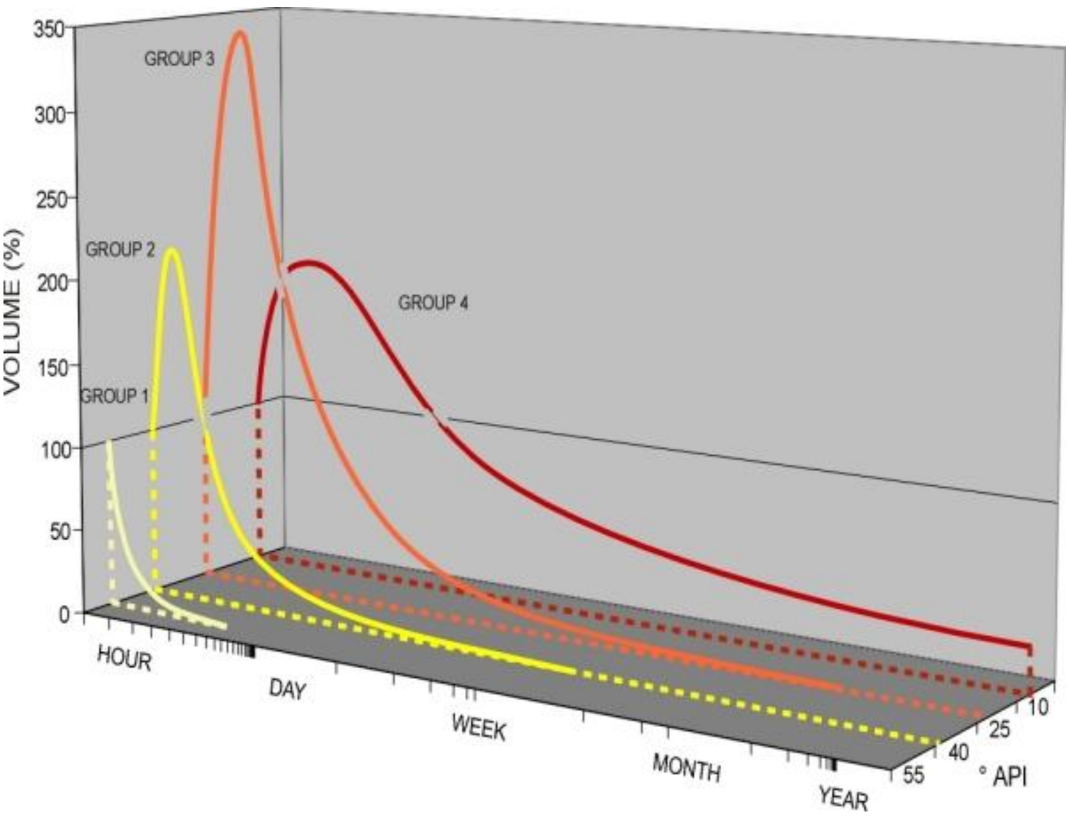

Figure 4. Volume of oil and water-in-oil emulsion remaining on the sea surface, as a percentage of the original volume spilled (ITOPF 2011) Group 1, e.g., dissipates naturally in less than a day.

2.1.2 Tankers

Tankers are ships designed to transport liquids in bulk. Tankers can carry hundred (small vessels) to several hundred thousand tons of e.g. oil (Table 2). Today, ships carrying up to 150,000 tons of oil can be seen in the Baltic Sea. The maritime oil trade in the Baltic Sea is limited to a maximum draught of 15 metres. A common tanker in the Baltic Sea Region is Aframax (VTT 2004), which has a DWT[I] of 100,000 (i.e. the maximum amount of oil transported by an Aframax is <100,000 tons).

Table 2. Crude oil tankers. (*source: UN 2010)

Class	Length	Beam	Draught	Typical Min DWT*	Typical Max DWT*
Seawaymax	226 m	24 m	7.92 m	10,000 DWT	60,000 DWT
Panamax	228.6 m	32.3 m	12.6 m	50,000 DWT	79,999 DWT
Aframax	253.0 m	44.2m	11.6m	80,000 DWT	124,999 DWT
Suezmax			16 m	125,000 DWT	199,999 DWT
VLCC (Malaccamax)	470 m	60 m	20 m	200,000 DWT	319,999 DWT
ULCC				320,000 DWT	550,000 DWT

2.1.3 Coastal sensitivity

There are many factors influencing the sensitivity of an environment affected by an oil spill.

- Type of oil; i.e. does the oil dissipate naturally or remain in the ecosystem for a long time?
- Volume
- Season; are there breeding birds in the area? Tourists?
- Type of shore; a more sensitive area? A more sheltered or exposed area?

[I] Deadweight tonnage (DWT) is an expression of a ship's carrying capacity.

Coastal sensitivity index

The Swedish coast is categorized in 9 classes (0-8), where 8 is most ecologically vulnerable to oil spills. In Sweden, information about oil spill clean-up and sensitivity is gathered in a Clean-up manual (MSB 2010).

Table 3. Coastal sensitivity index.

Coastal sensitivity index	
0	Manmade constructions
1	Cliffs and Walls
2	Sand beaches
3	Gravel beaches
4	Pebble beaches
5	Stone beaches
6	Rock beaches
7	Cobble beaches
8	Fine sediment beaches

Recovery time

The general relationship between shore energy levels and biological recovery times is shown in Figure 5, which is based on international scientific literature. Recovery times tend to be longer for more sheltered areas because of oil persistence, but in reality, other variables (such as oil type) are also involved.

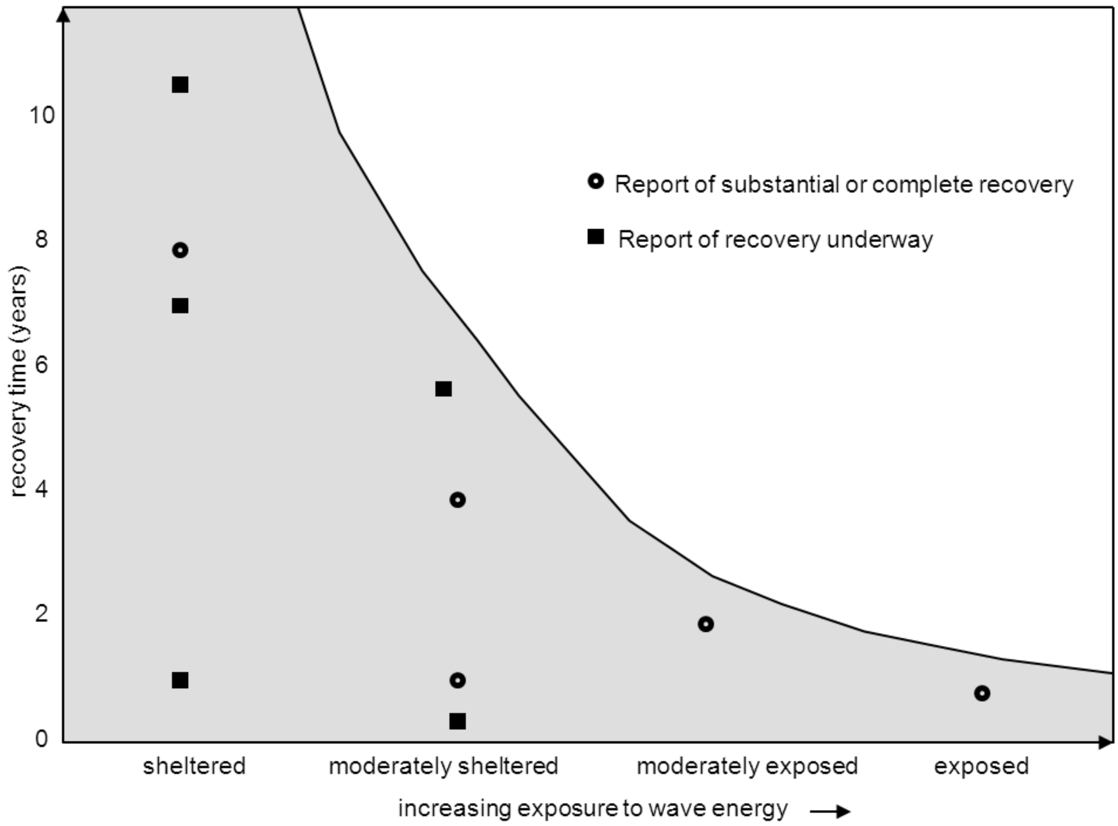

Figure 5. Biological recovery depends on exposure to wave energy – but other variables, such as oil type, are also involved. (Modified from Baker J. 2000)

2.2 General assumptions

A tanker carrying 90,000 tons of Russian heavy crude oil collides with a smaller cargo ship in one of the bigger fairways. The crude oil has a high viscosity, which complicates the response at sea and clean-up on shore, especially during colder seasons. The tanker has double-hull, but both hulls are damaged in the collision. The collision gives rise to one damaged tank on board the tanker whereby half of the content is spilled (in total 5,000 tons).The oil is spilled momentarily. The season is late winter or early spring and the weather is windy. The 5,000 tons emulsify and the volume is therefore doubled. 10,000 tons[II] of emulsified oil pollutes a shoreline of 500 km.

The weather during the first days of the combat operation is bad and the wind-force is high (> 5 m/s), implying that no oil can be recovered at sea. Normally, it is more cost effective to recover oil at sea and this scenario (no operation at sea) is therefore considered as a worst case scenario.

Due to the bad weather conditions, oil is carried by waves and currents and strands far up on the shores. This complicates and prolongs the clean-up.

2.3 Sweden

In Sweden, the Coastguard is responsible for the operation at sea, and the Civil Contingencies Agency coordinates public sector activities within the rescue services on shore. The municipalities are responsible for the rescue services within their areas and any costs in connection with the response operation and clean-up is reimbursed by the Swedish Government. The national combating capacity for oil spills in the Swedish response zone is at present 10,000 m^3.

2.3.1 Case 1: Blekinge

The affected shoreline in Blekinge amounts to about 500 km, including the archipelago. Studies have been made on the importance of taking the actual coast length into account when planning a response operation and the amount of more sensitive shore lengths have been calculated by Ryegård (2006).

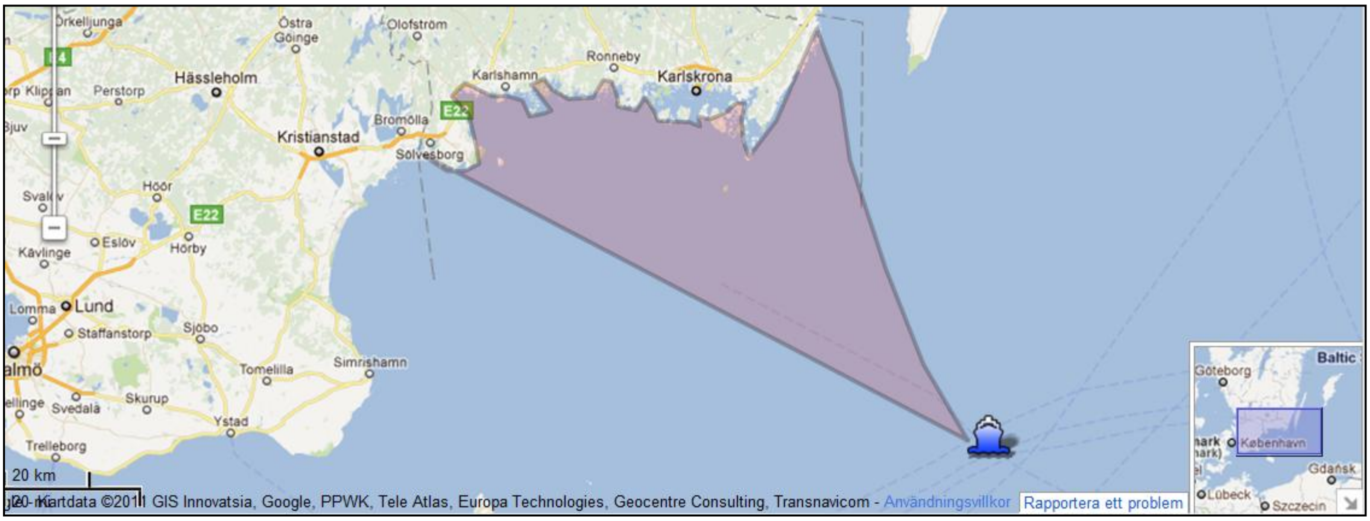

Figure 6. The Blekinge oil spill scenario. The actual length of the affected shoreline is 500 km.

IIII The general assumptions derives from Forsman (2006) and all parameters are similar, accept for the amount of oil, which is 5,000 in this scenario and 30,000 in Forsman's.

2.3.2 Case 2: Skåne

The affected shoreline in Skåne amounts to about 500 km[III] , which includes the entire county of Skåne[IV].

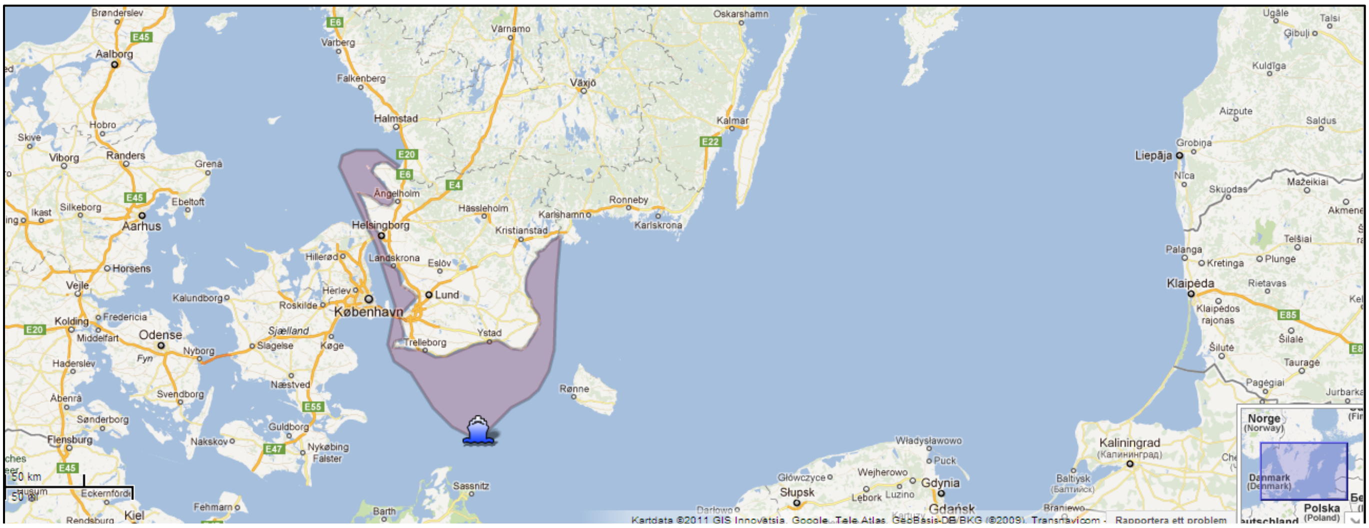

Figure 7. The Skåne oil spill scenario. The actual length of the affected shoreline is 500 km.

2.4 Case 3: Poland

Poland has a National Contingency plan (NCP) and the NCP, together with local plans (harbours, oil handling terminals and repairing shipyards), make up the national response system for maritime spill incidents with oil and other harmful substances in the Polish Baltic Sea Response zone. The NCP should also include beach cleaning, but there is an administrative division between sea and land and the present plan does not cover beach cleaning (LCP 2011). The Maritime Search and Rescue Service is responsible for spills at sea, and the National State Fire Service is responsible on land. The national combating capacity for oil spills in the Polish response zone is at present about 3,500 m^3 (LCP 2011).

The Polish part of the Baltic Sea coast is 528 km. There is a 3 km wide coastal belt (Figure 5) consisting of a technical belt and a protective belt where aspects of safety and risk management must be considered (Gauss 2006). The affected shoreline in Poland amounts to 500 km.

[III] According to SCB (in regionfakta.com, 2012), the total length of the mainland of Skåne is 646 km.
[IV] The scenario is set up to suit this study, thereby including the entire county.

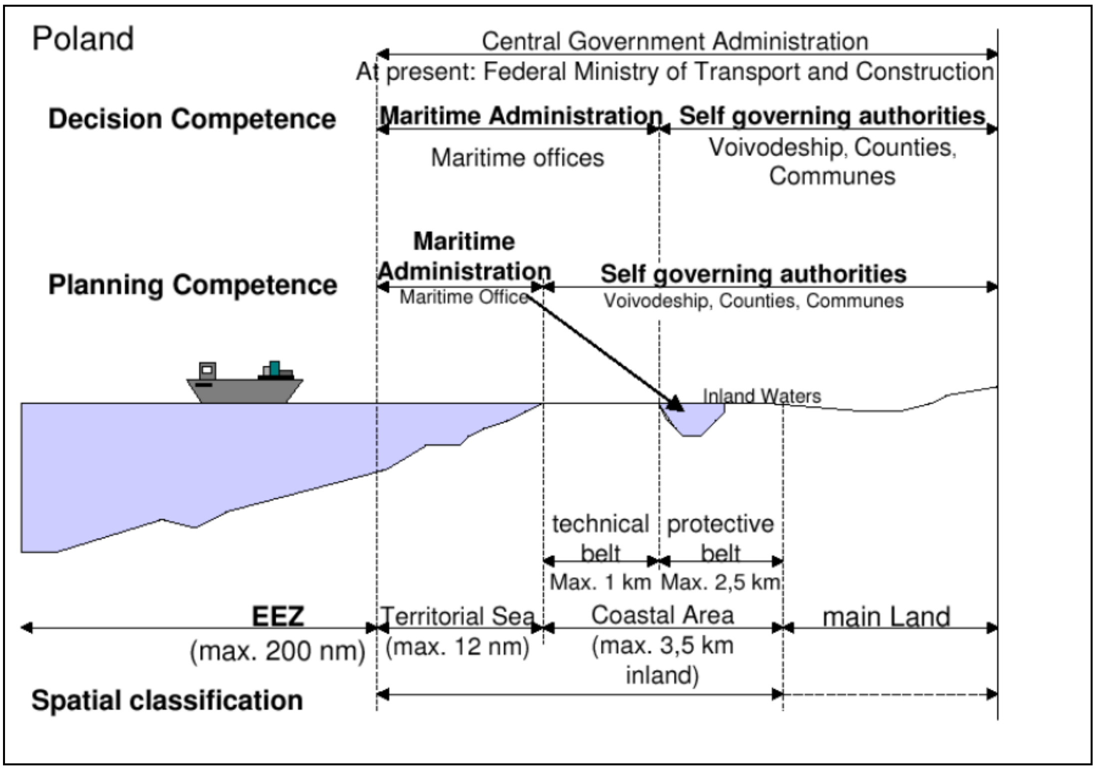

Figure 8.Spatial planning practise with special focus on marine area spatial planning (Gauss 2006)

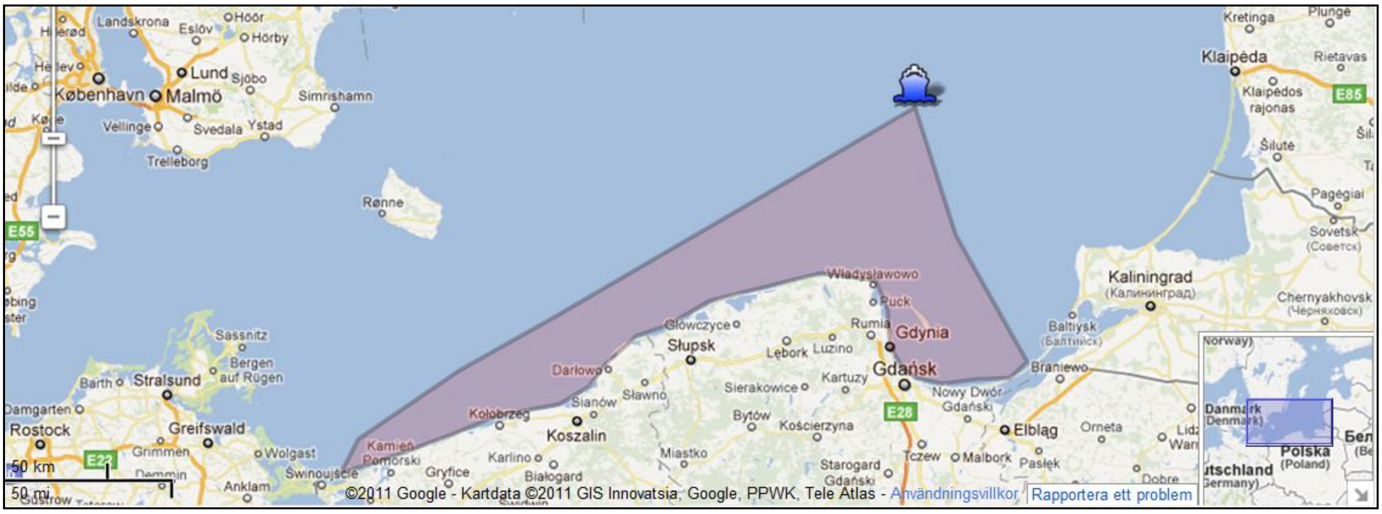

Figure 9. The Polish oil spill scenario. The actual length of the affected shoreline is 500 km.

3 Costs

The costs of an oil spill affect different actors in society to various extents. Fejes et al. (2011) categorize costs from oil spills into three categories: Direct costs refer to costs for clean-up and financial damage. Market costs refer to losses of profits and welfare in coastal markets that are dependent on a clean environment, such as tourism and fisheries. Non-market costs refer to social welfare losses that are not priced in a market. There are several difficulties involved in estimating these three cost categories, and an analysis by necessity has to rely on several assumptions. Below, we attempt to quantify Direct, Market, and Non-market costs in our case studies. The analysis will be as transparent as possible to uncertainties and assumptions. The estimations are based on existing literature. Where no data is available, a cost item is given a zero value in the analysis. This does not, however, mean that the actual cost is zero. It should rather be seen as an indication of a knowledge gap.

For Blekinge and Skåne, Forsman (2006) made calculations of clean-up and market costs. These estimates will serve as a basis for our analysis. In general, the assumptions by Forsman are very uncertain, and so are also other assumptions used below. The analysis should be seen as indicative, rather than exact. In Section 3.4, the key assumptions are summarized.

3.1 Direct costs

This section presents cost estimates for clean-up and financial costs in our three cases. Both clean-up and financial cost estimates are sensitive to the location of the spill in the scenarios.

The currency has been converted from SEK to EUR by using the Spot price of 9.1674, 18/11/11 (trader.di.se).

3.1.1 Clean-up costs

Sweden (Blekinge)

The estimated clean-up cost for the Blekinge case is 113.7 million SEK or 12.4 million EUR.

In the scenario by Forsman (2006), the oil recovery on shore was estimated to go on for 30,000 man days. The shore length equals Forsman's, but the amount of oil is smaller and number of days is therefore assumed to be 75 % of Forsman's value, i.e. 22,500. Price per man day is 1,500 SEK (Forsman 2006). The cost amounts to 33.8 million SEK or 3.7 million EUR. Forsman included man days that were paid by the affected municipalities, but costs associated with e.g. military personnel and home defence were excluded and thereby also excluded from this analysis.

When 10,000 tons (spilled oil + oil-in-water emulsion) contaminates a shoreline, the oil is mixed with e.g. sand or debris and multiplies in volume. The total amount of waste is 5 times as high as the volume of oil. In this case, this implies 25,000 tons during response operation and 25,000 tons during clean-up. Price per ton is 600 SEK (Forsman 2006). The cost adds up to 30 million SEK or 3.2 million EUR.

In the scenario by Forsman (2006), the oil clean-up on shore was estimated to go on for 75-150 man days per km. The amount of oil is smaller in this scenario and the clean-up will end faster, compared to the Forsman scenario. The number of man days per km is estimated to 75. The affected coast is 500 km and the number of man days is 37,500 at a price per man day at 1,333 SEK (Forsman 2006). The cost amounts to 50 million SEK or 5.5 million EUR.

Sweden (Skåne)

The estimated clean-up cost for the Skåne case is 103.7 million SEK or 11.3 million EUR.

In the scenario by Forsman (2006), the oil recovery on shore was estimated to go on for 30,000 man days. The amount of oil is smaller and number of days is therefore assumed to be 75 % of Forsman's value, i.e. 22,500. Price per man day is 1,500 SEK (Forsman 2006). The cost amounts to 33.8 million SEK or 3.7 million EUR. Forsman included man days that were paid by the affected municipalities, but costs associated with e.g. military personnel and home defence were excluded and thereby also excluded from this analysis.

When 10,000 tons (spilled oil + oil-in-water emulsion) contaminates a shoreline, the oil is mixed with e.g. sand or debris and multiplies in volume. The total amount of waste is 5 times as high as the volume of oil. In this case, this implies 25,000 tons during response operation and 25,000 tons during clean-up. Price per ton is 600 SEK (Forsman 2006). The cost adds up to 30 million SEK or 3.2 million EUR.

In the scenario by Forsman (2006), the oil clean-up on shore was estimated to go on for 75-150 man days per km. The amount of oil is smaller in this scenario and the clean-up will end faster, compared to the Forsman scenario. The number of man days per km is estimated to 60. The affected coast is 500 km and the number of man days is 30,000 at a price per man day at 1,333 SEK (Forsman 2006). The cost amounts to 40 million SEK or 4.4 million EUR.

Poland

The estimated clean-up cost for the Polish case is 46.6 million SEK or 5.1 million EUR.

Two different factors have been used to calculate the clean-up costs for the Polish case: a shore type factor and a price level factor.

<u>The shore type factor:</u> The shore type will affect the response and the clean-up operation. There are many sandy beaches along the Polish Coast and the operation is assumed to last a bit shorter than in Blekinge. On the other hand, the national combat capacity is higher in Sweden compared to Poland, suggesting that Sweden is a bit more capable of handling oil spills of this magnitude. Poland will have to rely on cooperation agreements to a higher extent. However, the shore type factor is set to 0.8 indicating that the sandy shores of the Polish coast will be easier to clean, compared to the coast of Blekinge.

<u>The price level factor:</u> The price level in Poland is lower than in Sweden. According to OECD (2011), the same bundle of goods costing 100 Euros in Sweden, costs only 48 Euros in Poland. That is – we assume that the cost estimates for Sweden should be multiplied by the factor 0.48 in order to achieve an estimate for Poland. Note that this difference in real prices measures an average difference, for a "representative" bundle of goods. This does not necessarily correspond to differences in the costs for oil clean-up (salaries and equipment are the large cost items). Future studies should use estimates based on Polish original data.

In case 1 (Blekinge), the oil recovery on shore was estimated to go on for 22,500 man days. Price per man day is 1,500 SEK *0.48 (the price level factor) = 720 SEK. The cost amounts to 13 million SEK or 1.4 million EUR.

When 10,000 tons (spilled oil + oil-in-water emulsion) contaminates a shoreline, the oil is mixed with e.g. sand or debris and multiplies in volume. The total amount of waste is 5 times as high as the volume of oil. In this case, 25,000 tons during response operation and 25,000 tons during clean-up. The estimated price per ton is 288 SEK. The cost adds up to 14.4 million SEK or 1.6 million EUR.

The number of man days per km is, in case 1(Blekinge), estimated to 75. The affected coast is 500 km and the number of man days is 30,000 at a price per man day at about 640 SEK. The cost amounts to 19.2 million SEK or 2.1 million EUR.

3.1.2 Financial damage costs

Financial damage costs, such as physical damages to property, have not been estimated quantitatively due to a lack of data. These costs are given a zero value in the estimation.

3.2 Market costs

Market costs refer to costs in terms of losses in profits ("producer surplus") and consumer well-being ("consumer surplus") in industries that are dependent on a clean coastal environment. The tourism industry and the fisheries industry are two such industries that are affected by an oil spill (Forsman, 2006). The damage to these industries might be of the following types:

- Short-term profit losses to producers caused by oiling of water and beaches. This results e.g. in decreased fishery and a reduction in the demand for tourism and fish caught in the area. These costs are usually recovered through compensation claims, but they nevertheless represent a socioeconomic loss.
- (Potential) long-term profit losses to producers, due to (potential) remaining ecological effects, such as contents of hazardous substances in fish and disturbance of the local environment, which might lower the demand for tourism. These potential effects have not been well-studied in the literature, and a common perception is that ecosystems usually recover pretty well from oil spill damages. In our analysis, these effects will be disregarded.
- Short-term losses in consumer surplus caused by reductions in the availability of tourism services and local fish production.
- (Potential) long-term losses in consumer surplus due to (potential) remaining adverse effects in the market in the case of remaining ecological effects.

This case-study will only consider short-term losses in producer surplus, i.e. the first bullet-point above.

3.2.1 Tourism

Sweden (Blekinge)

Forsman (2006) estimates the damage cost from an oil spill to tourism by using data over value added in tourism and an assumption that the yearly value added will be reduced by 20-50 per cent in the affected region. We assume that the loss in value added is an approximation of profit-losses.

Forsman's estimate is based on 20,000 tons of oil that pollute the shores, and in our case, we assume 10,000 tons over the same shoreline. It is hard to say whether a lower amount of oil would have a lower impact on tourism even though the clean-up most likely will be finalised sooner – however, an assumption by Forsman is that the length of the affected shoreline is more important to the impacts than the amount of oil spilled. We assume the same impact to tourism as in Forsman's case – i.e. a loss corresponding to 20-50 per cent in the affected municipalities. Forsman presents this as a point estimate corresponding to 175 million SEK (20 million EUR).

Sweden (Skåne)

The coast of Skåne is heavily used for tourism, with many beaches and warm weather during the summers. Forsman (2006) estimates that the yearly value added in the tourism industry in the affected area will be reduced by 25 to 50 per cent, corresponding to 380 million SEK (42 million EUR). This is based on a scenario where 215 km of the coast in Skåne is affected by the oil spill. In our scenario, 500 km is affected, and using a proportional scaling (a strong assumption), the corresponding value is 888 million SEK (98 million EUR). The expected impact to the tourism industry in different geographical areas of Skåne should be further assessed in future studies.

As for the case of Blekinge, we assume that the loss in value added is an approximation of profit loss.

Poland

The Polish coast is heavily used for tourism. 30% of the tourist investments in Poland are located in the coastal zone, and every summer the beaches of the Polish coast are visited by more than 10 million guests (Schernewski & Löser, 2004).

The value added of coastal tourism in Poland is assessed to 70 million EUR (EC, 2008). Assuming a 20-50 per cent reduction in the value added as a result from the oil spill, in line with Forsman's scenario, the loss to marine tourism producers in Poland can be estimated to 14 – 35 million EUR.

3.2.2 Fisheries

Sweden (Blekinge)

For fisheries, Forsman uses socioeconomic sensitivity index, the affected length of the shoreline, and the turnover in the fishery industry. Further, he uses an assumption that turnover is affected by 25-50 per cent. The point estimate for Blekinge is 18 million SEK (2 million EUR), as a loss in turnover. The measure is likely to overstate the losses in producer surplus, since the variable costs from operating are not taken into account.

Sweden (Skåne)

As for the Blekinge case, Forsman uses socioeconomic sensitivity index, the affected length of the shoreline, and the turnover in the fishery industry. Also for Skåne, Forsman uses the assumption that the yearly turnover in the industry is reduced by 25 – 50 per cent in the affected municipalities, depending on the impact from the oil spill. The point estimate for Skåne is 9 million SEK (1 million EUR). This is based on 215 km affected shoreline. Adjusting this value up to correspond to 500 km affected shoreline, as for the impact to tourism, the resulting loss in turnover for fisheries corresponds to 21 million SEK (2.3 million EUR). The reader should bear in mind that the result relies on a strong assumption. Further, this measure is likely to overstate the profit loss (producer surplus loss), since the variable costs from operating are not considered.

Poland

The total value of landed fish in commercial fisheries in Poland is 60 million Euros (Weslawski et al., 2006). Using the same assumptions as Forsman, i.e. a 25-50 per cent reduction in turnover, the losses in turnover can be estimated to 15-30 million Euros. Note that this, as for Sweden, is an overstatement since the variable costs from operation are not taken into account.

3.3 Non-market costs

An oil spill may lead to environmental and other impacts that are not easily measured in a market. These effects are challenging to quantify but may be large. The following are examples of non-market costs imposed by an oil spill:

- Recreational fisheries. The public value the possibility for recreational fisheries to a large extent, and a large share of the population around the Baltic Sea fishes at the coast (Söderqvist et al., 2010)
- Other recreation. Other recreation by the beach, such as swimming, walking, sunbathing and boating are also activities that are highly valued by the population around the Baltic Sea. An oil spill decreases the possibilities for these activities, which reduces well-being.[V]
- Non-use values. A clean environment might be important also to people who do not visit or plan to visit the affected area. The effect in terms of lost non-use values from an oil spill is well-recognized; see for example Carson et al. (2003). This effect could for example be compared to a willingness to pay among the public for safeguarding the rain forest or rare species, reflecting that people attach a value to the environment for its own sake.

The impact from an oil spill could potentially have two categories of effects to these non-market costs. The first is a direct and temporary effect from oiling at the shore that reduces the possibility for recreational use. The second effect is more indirect, where visitors can use the area, but the utility provided from the use is lower than previously, due e.g. to remaining oil or a disturbed ecosystem. We will only consider the first, more direct, effect.

3.3.1 Recreational fisheries

Sweden (Blekinge)

Forsman estimates that 25-50 per cent of the year's catches in recreational fisheries might be lost due to the spill scenario. He uses the market value of the fish caught to estimate the loss to recreational fisheries. However, research has showed that the value of recreational fisheries might be better assessed by other methods, more directed to measuring the consumer surplus from recreational fisheries. The fish is not sold to the market; rather the activity in itself provides utility to the public. For example, the Swedish board of Fisheries (2007) has calculated the consumer surplus per fishing day to 55 SEK (6 EUR) per person. The number of fishing days along the southern coast of Sweden is 624,000 per year (ibid.). Assuming that 50 % of the fishing days (312,000 days) are in the area affected by oil spill, and that 50 % of the fishing days in a year are lost due to the oil spill, the number of lost fishing days would correspond to approximately 150,000. The value forgone would thus correspond to 8.25 million SEK (0.9 million EUR).

Sweden (Skåne)

As for Blekinge, Forsman estimates that 25-50 per cent of the year's catches in recreational fisheries might be lost in the affected area due to a large oil spill. However, we use the approach suggested in the case above, for Blekinge. We use the same data on the number of fishing days per year along the southern coast of Sweden from the Swedish Board of Fisheries (2007), presented above, and assume that 50 % of these fishing days (312 000 days) are situated in Skåne. Assuming further that 50 % of the fishing days in a year are lost due to the oil spill, and that the value of a fishing day corresponds to 55 SEK (6 EUR), the value forgone would correspond to 8.25 million SEK (0.9 million EUR).

[V] Note that this cost category refers costs that are not included in loss of consumer surplus (as part of market costs).

Poland

The population in Poland is 38 million. Söderqvist et al. (2010) studied the Poles' recreational habits connected to the Baltic Sea. During April 2009 – March 2010, 38.3 per cent of the Poles visited the Baltic Sea for recreation, and the average number of visits for those who visited the Baltic Sea at least once (14.6 million Poles), was 13.7 during April – September, and 3.84 during October – March (all year average thus corresponds to 8.77 visits). Using these figures, the total number of visits by Poles to the Baltic Sea corresponds to 128 million.

6 per cent of the Poles that had visited the Baltic Sea during the year stated in the study that they had been fishing in the Baltic Sea during the year: 3.7 per cent had been fishing between 1-4 days, and 2.3 per cent had been fishing between 5-9 days. Using weighting – and the midpoints in the intervals – the average number of fishing days for the 6 per cent that had been fishing during the year corresponds to 4.4 days. Summing to total number of days, this corresponds to 3.8 million fishing days.

Using the value per day that was used for Sweden (55 SEK/6 EUR), but adjusted for a lower general price level in Poland (0.48 * the Swedish price level), the consumer surplus of the present number of fishing days under the above assumptions corresponds to 11 million EUR. Assuming further that the number of fishing days lost due to an oil spill corresponds to 50 per cent of the total, as for Sweden, the lost consumer surplus from the oil spill can be estimated to 5.5 million EUR.

3.3.2 Other recreation

Sweden (Blekinge)

The coast of Blekinge is an important area in Sweden for coastal recreation, with many beaches and warm weather during the summer. Recreational activities are to various extents depending on the state of the environment. For example, the consumer surplus from swimming or diving is likely to be more dependent on the water quality than the consumer surplus from sunbathing and walking by the beach. However, in the event of an oil spill, it might be that in principle no recreational activities are possible for a period of time after the spill.

A first step towards estimating the value forgone by lost recreational opportunities according to the above reasoning is to provide a value of a recreational day. No Swedish (or Polish) studies of this kind have been performed. However, Kinell et al. (2009) estimate the increase in consumer surplus per visit to the sea from a one meter increase in water transparency (due to decreased eutrophication) to 130 SEK (14 EUR). If we assume that this value corresponds to the decrease in consumer surplus from a decrease in water transparency, a lower bound estimate for the consumer surplus value of one visit could perhaps be indirectly estimated at 130 SEK. However, this may be a strong assumption. Nevertheless, a study in the US uses the value $27 (20 EUR) per lost recreational day from The Chalk Point oil spill (Byrd et al. 2001), which is of the same magnitude.

A lower boundary for the number of Swedes' visits to the sea during April-September 2009 is 207 million visits, according to a survey in all the nine Baltic Sea countries by Söderqvist et al. (2010; this is based on a finding that 5.92 million Swedes visited the Baltic on average every fifth day). Scaling this down proportionally to the population in Blekinge (152 000; www.blekinge.se), the number of visits to the affected area during April – September corresponds to approximately 3.5 million visits, or 1.5 per cent of the visits in Sweden totally. Assuming that 25 % of the visits (0.25*3.5 million = 0.875 million) during April – September are not carried out due to the oil spill, and using the per-day value by Kinell et al. (14 EUR), the loss in consumer surplus corresponds to 12 million EUR. These figures obviously rely on strong assumptions.

Sweden (Skåne)

The calculations for Skåne follow the same methodology as above for Blekinge. The population in Skåne is 1.2 million (www.skane.se). The number of recreational visits to the Baltic Sea by people from Skåne during April – September 2009 (derived from Söderqvist et al., 2010 and adjusted using the above methodology) would thus correspond to 26 million visits. Again, assuming that 25 per cent of the visits in the area during April – September are not carried out due to the oil spill (6.6 million recreational visits), and using the per-day value by Kinell et al (2009 – 14 EUR), the loss in consumer surplus corresponds to 92 million EUR. The strong assumptions behind these calculations should again be noted. However, the calculations indicate that large recreational values are at stake.

Poland

As presented in Section 3.3.1., the average number of recreational visits by Poles to the Baltic Sea during April – September corresponds to 13.7 (for Poles who have visited at least once during the year). In total, this means 200 million visits during April – September.[VI] Assuming, as for Sweden, that 25 % of the visits (0.25 * 200 million) during April – September are not carried out due the oil spill (50 million recreational visits), and again using the per-day value by Kinell et al. (14 EUR – however adjusted for relative price level, i.e. multiplied by the factor 0.48), the loss in consumer surplus from the oil spill corresponds to 336 million EUR.

3.3.3 Non-use values

Non-use values (existence values) refer to values a person attaches to a healthy environment despite that he or she does not particularly visit the area, or even plan to visit the area. Related to non-use values are also passive use values, which are values attached to a clean environment because of the possibility to visit the area later in life. These types of values are complicated to assess, since they per definition are not related to any observable behaviour in a market. The quote below, by Michael Greenstone (2010) regards non-use values connected to the Mexican Gulf spill:

> "The most difficult type of damages to measure is those that are not easily connected to an economic activity. And for many Americans — particularly the majority who live outside of the gulf region — these are the very damages that have created a public outcry. One classic example is the value that people place on knowing that some types of wildlife are healthy and thriving, which economists refer to as non-use values.
> Consider the pictures of the brown pelicans coated in oil that many people, including myself, find heartbreaking. How much would they be willing to pay for this not to have happened to the pelicans or other wildlife (even if they have no intention of going to the gulf)? "

Michael Greenstone, 17/6/2010 on www.env-econ.net.

Several studies have assessed non-use values in relation to oil spills. Three examples below:

- Carson et al. (2003) reports on a study from 1989, in connection to the Exxon Valdez oil spill. The study estimated the total non-use value from a typical oil spill by asking respondents about their willingness to pay for a hypothetical program where an escort vessel service would guide ships into harbour, reducing the probability of an oil spill to zero, according to the scenario. The willingness to pay was estimated to $2.8 billion (2.1 billion EUR).

[VI] Of these, some days are related to recreational fisheries and thus these days should be subtracted from the 200 million, but this figure is in practice negligible in this context.

- Van Biervliet et al. (2006) estimate the loss of non-use values from hypothetical oil spill scenarios along the Belgian Coast, by estimating the willingness to pay among Belgian households to improve response capacity and marine safety. The study estimates lost value ranging from 120 to 606 million EUR, depending on the size and the frequency of the oil spill scenario.

- Ahtiainen (2007) estimates the willingness to pay among Finns to improve the oil spill response capacity in the Gulf of Finland, and thereby reducing the risk for damages to the nature and the environment, as well as to recreational opportunities. The willingness to pay was estimated to 89 – 330 million EUR.

Further, a study that perhaps can be used also in an oil spill context is Zylicz et al. (1995). They estimate the willingness to pay among the Poles to reduce eutrophication along the Polish coast to the extent that all beaches could be open for swimming. Their estimate corresponds to 137 EUR per person per year. One could perhaps argue that this estimate could be used as a proxy for the willingness to pay for making sure that oil spills do not lead to beach closures. Summing to the Polish population, this value would give a total willingness to pay corresponding to 5 billion EUR! However, this assumption is uncertain. The willingness to pay is very likely to depend on the number of affected beaches, and the nature of the environmental problem. Thus, we leave it to future studies to find out how this estimate can be used. At the moment, however, it can serve as an indication of the relatively large value of keeping Polish beaches open.

These studies use “contingent valuation”, where respondents to a survey are provided with a scenario describing some environmental change, and then they are asked to state their willingness to pay to achieve that change. This method is widely used for valuation, but has also been criticized, mainly because of its hypothetical characteristic. Further, this method usually does not allow separation between use and non-use values. Some of the stated willingness to pay is likely to be a manifest of the benefits derived from recreation in the area, or from potential future recreation. Thus, calculating the share of “existence values” from the willingness to pay estimates is complicated. See e.g. Champ et al. (2003) for a detailed review of non-market valuation methods.

It is further complicated to use any of the studies above in order to say something about the lost non-use value from an oil spill along the Swedish or the Polish coast. Nevertheless, the results by Carson, Van Biervliet et al., and Ahtiainen suggest that the non-use values might be substantial. Due to the lack of original data from Sweden or Poland, we choose not to present any figure for the non-use value related to oil spills according to our cases.

3.4 Key assumptions

The analysis has been based on several assumptions. Table 4 below provides an overview of the key assumptions used in our analysis and our best estimate of how the assumption is likely to affect our results.

Table 4. Key assumptions.

Key assumption	Effect on the analysis. + means "tends to lead to overstatement of costs" - means"tends to lead to understatement of costs"
Estimates not adjusted for increasing price levels	-
Some costs have not been estimated quantitatively. These costs are given a zero value in the estimations. The costs not included are: • Financial damage costs • Lost consumer surplus in tourism and fisheries • Potential long-run ecological effects, which might affect consumer and producer surpluses. • Non-use values	-
Number of recreational fishing days, and number of other recreational days lost does not consider the availability of potential substitute locations.	+
Turnover is used as proxy for profit loss in fisheries.	+
Loss 20-50 % of value added from tourism.	+/-
10 000 tons of oil has the same effects to producer surplus in the fisheries and tourism industries as 20 000 tons, if the affected shoreline is of the same length.	+
Cost for 500 km affected shoreline in Skåne adjusted proportionally up from the value by Forsman (2006), which was based on 215 km affected shoreline.	+/-
Number of lost fishing days: 50 % of total	+/-
Value of a fishing day in Poland: 0.48 * value of fishing day in Sweden (adjusted for relative price differences).	+/-
Value of a recreational day in Sweden: 14 EUR	+/-
Value of a recreational day in Poland: 0.48 * value of recreational day in Sweden (adjusted for relative price differences)	+/-
Number of lost recreational days in Blekinge, Skåne and Poland, respectively, during April - September: 0.875 million, 6.6 million, and 50 million, respectively.	+/-

3.5 Summary costs

Table 5 provides a summary of the estimated costs in Sweden (Blekinge), Sweden (Skåne) and Poland. The summary is illustrated in Figure 9 and Figure 10. Note that these estimates build on the assumptions in Section 3.4, which are uncertain. These figures should thus be seen as indicative rather than precise estimates.

Table 5. Summary of cost estimates for Sweden and Poland (amounts in million EUR).

	Sweden (Blekinge)	Sweden (Skåne)	Poland
Clean-up	12	11	5
Financial costs	--	--	--
Sum Direct costs	12	11	5
Tourism	20	98	14-35
Fishery	2	2	15-30
Sum Market costs	22	100	29-65
Recreational fishing	1	1	5.5
Beachside recreation	12	92	336
Non-use values	--	--	--
Sum Non-market costs	13	93	341.5
Total costs	99	204	376 - 412

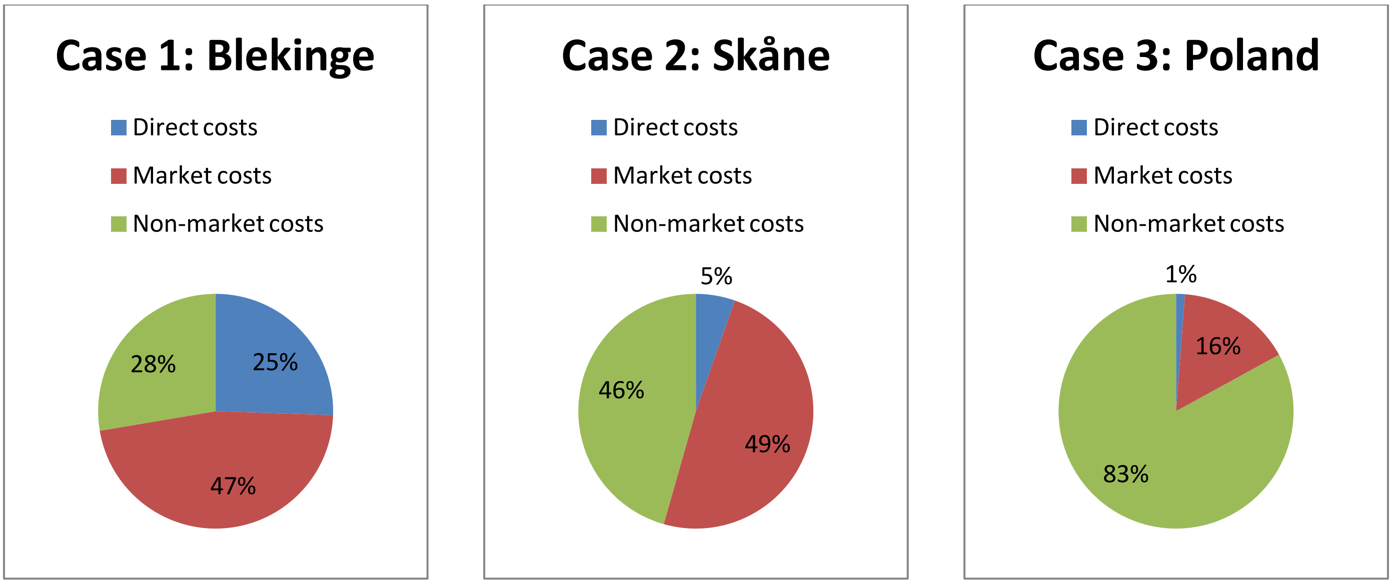

Figure 10. The distribution of the three categories of costs in Sweden and Poland.

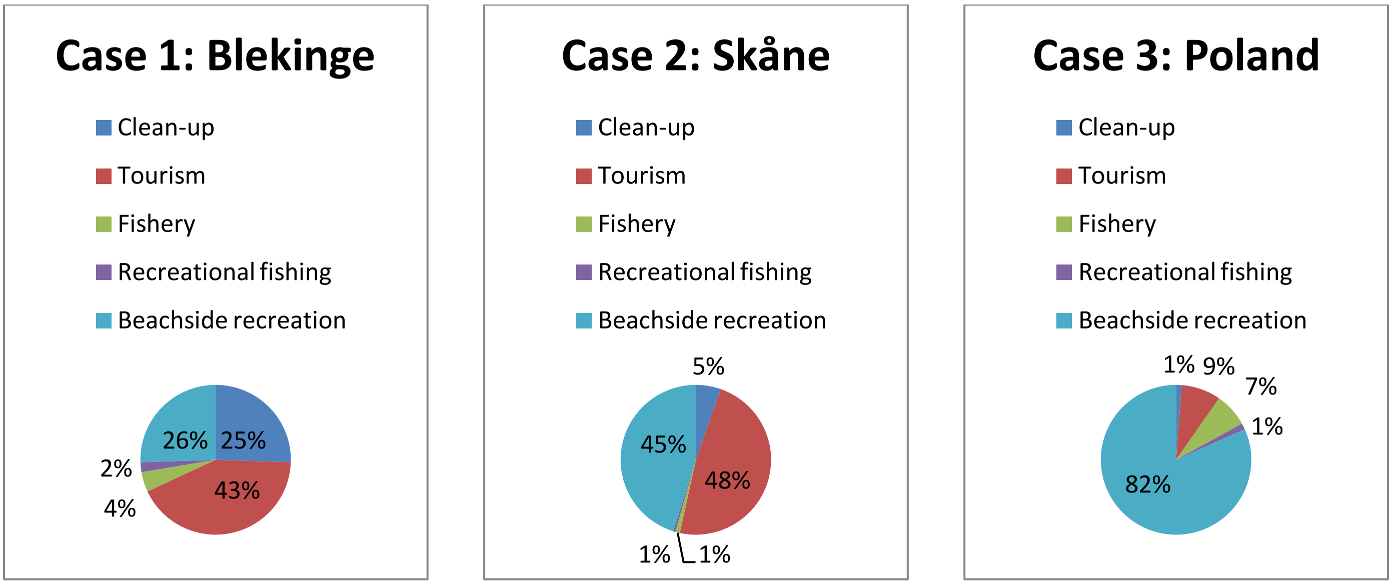

Figure 11. A more detailed illustration of costs associated with oil spills in Sweden and Poland.

3.6 Discussion

The estimates are uncertain due to several factors. First, there is a lack of data concerning financial damage costs and non-market costs, which is likely to lead to an underestimate of the total costs. Further, our analysis relies on several strong assumptions. Future studies should evaluate these assumptions more thoroughly. Future studies should also focus on gathering more data connected to the value of recreational usage of the Baltic Sea in order to more precisely be able to predict the costs from oil spills.

The differences that can be observed in the distributions between direct, market and non-market costs are to a large extent explained by differences in the number of potential recreational users in the regions. For example, the Polish coast is heavily used for recreational purposes, and an oil spill can thus affect the recreational possibilities for many poles. This is here reflected in the fact that 83 % of the estimated costs from the oil spill scenario are non-market costs.

Good cost estimates are usable in different contexts. Ex ante, i.e. before an oil spill, estimates of direct costs are essential in order to have the right preparedness for future oil spills. Estimates of market costs are needed for estimating the sensitivity of fisheries and tourism to an oil spill, and estimates of non-market costs are needed e.g. for estimating the importance of an area for recreation. Altogether, these estimates can help policy makers decide on which is the "optimal" level of precautionary measures, such as marine safety and response preparedness. These measures are costly, and the costs should be weighed against the benefits in terms of avoiding potential damage. Ex post, i.e. after an oil spill, estimates are needed e.g. in order to evaluate the actual damage cost that should be compensated.

Today, there is no clear international system for compensation of non-market costs. Our case studies indicate that the non-market costs may be substantial. Fejes et al. (2011) argue that a failure of assessing and recovering non-market costs implies a potential violation of the Polluter Pays Principle (PPP; REDED 1992), and that this might lead to an inefficient market outcome, with too high risk. This is often referred to as market failure by economists. A first step towards understanding the extent of this potential market failure is to further evaluate the non-market component of the welfare loss associated with an oil spill. See Fejes et al. (2011) for a more in-depth discussion and analysis on this topic.

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Baltic Master II is a flagship project in the EU Strategy for the Baltic Sea region that brings together countries from around the whole Baltic Rim. Its aim is to improve maritime safety by integrating local and regional perspectives with cross-border cooperation. This involves increasing the land based capacity to respond to maritime oil spills and working to prevent pollution from maritime transport. The project runs from January 2009 to January 2012.