

# Marine litter in Sweden

A study for the Economic and Social Analysis of the Initial Assessment of the Marine Strategy Framework Directive



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Swedish Agency for Marine and Water Management, report 2012:3

Havs- och vattenmyndighetens rapport 2012:3

Havs- och vattenmyndigheten

Datum: 2012-09-06

Ansvarig utgivare: Björn Risinger

ISBN 978-91-87025-03-7

Havs- och vattenmyndigheten

[www.havochvatten.se/en/start.html](http://www.havochvatten.se/en/start.html)

# Foreword

The marine waste found on beaches and in the water along the Swedish coast each year is a major environmental problem. The purpose of this report is in part to describe the extent of the problem in different areas in terms of quantity and composition, and also to describe the impact on marine life and people who spend time on or by the sea.

Within Europe, the efforts to implement new legislation around the marine environment have begun in earnest. In order to gather all maritime activities into a single framework, the EU has formulated a maritime strategy designed after three main directions: the Common Fisheries Policy, marine spatial planning, and common environmental legislation for the marine environment. The common environmental legislation has been formulated within the EU Marine Strategy Framework Directive (2008/56/EG) which was introduced into Swedish legislation through the Marine Environmental Regulation (SFS 2010:1341).

In Sweden, marine issues received a new home on 1 July 2011 with the creation of a new, central administrative authority, the Swedish Agency for Marine and Water Management. The new agency will use an integrated approach in working with issues pertaining to water, marine, and fisheries management. The introduction of the Marine Strategy Framework Directive (MSFD) in Sweden and the development of marine spatial planning will become central to operations in the coming years.

As a first step in Sweden's work with MSFD, an initial assessment of the marine environment's status has been conducted and assembled into "Good Environmental Status 2020 – Part 1: Initial Assessment of the State of the Environment and Socio-economic Analysis." As the name suggests, the assessment gives an overall picture of the current state of the environment. It also describes the socio-economic importance of the different activities and operations currently in progress in marine areas as well as the stresses they generate on the ecosystem.

The report "Marine Litter in Sweden" is an important part of the documentation produced by the Swedish Agency for Marine and Water Management for the initial assessment. The connection made in the report between marine waste and related ecosystem services provides a good overview of the impact on the marine ecology while it illuminates the sea's importance to human activities such as recreation.

Mats Ivarsson, Augusti 2012

# Förord

Det marina avfall som hittas på stränderna och i vattnet längs de svenska kusterna varje år utgör ett stort miljöproblem. Syftet med den här rapporten är dels att beskriva omfattningen på problemet i olika områden i termer av kvantiteter och sammansättning, och dels att beskriva de konsekvenser som det ger upphov till för livet i havet och för människor som vistas på eller vid havet.

I Europa har arbetet med att genomföra ny lagstiftning på havsmiljöområdet inletts på allvar. Med syfte att samla all maritim verksamhet i ett och samma ramverk har EU formulerat en maritim strategi som utformats efter tre huvudriktningar; gemensam fiskeripolitik, fysisk planering till havs samt gemensam miljölagstiftning för den marina miljön. Den gemensamma miljölagstiftningen har formulerats i Havsmiljödirektivet (2008/56/EG) som omsatts i svensk lag genom Havsmiljöförordningen (SFS 2010:1341).

I Sverige fick de marina frågorna en ny hemvist 1:e juli 2011 genom inrättandet av en ny central förvaltningsmyndighet, Havs- och vattenmyndigheten. Den nya myndigheten ska arbeta på ett integrerat sätt med vatten-, havs och fiskförvaltningsfrågor. Införandet av havsmiljödirektivet i Sverige, samt utvecklingen av den marina fysiska planeringen kommer att vara centrala delar av verksamheten under de kommande åren.

Som ett första steg i det svenska arbetet med Havsmiljödirektivet har en inledande bedömning av havsmiljöns tillstånd gjorts, *God miljöstatus 2020 – Del 1: Inledande bedömning av miljötilståndet och socioekonomisk analys*. Som namnet antyder ger den inledande bedömningen en bild av det nuvarande miljötilståndet. Den beskriver också den samhällsekonomiska betydelsen av olika aktiviteter och verksamheter som pågår i våra havsområden idag, samt den belastning på ekosystemen som nyttjandet ger upphov till.

Rapporten *Marine litter in Sweden* är en viktig del i det underlag som tagits fram av Havs – och vattenmyndigheten för den inledande bedömningen. Kopplingen som görs i rapporten mellan marint avfall och berörda ekosystemtjänster ger en bra bild över påverkan på den marina ekologin samtidigt som den belyser havets betydelse för mänskliga aktiviteter som exempelvis rekreation.

Mats Ivarsson, augusti 2012

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# 0 Summary

The initial assessment (IA) of the implementation of the EU Marine Strategy Framework Directive (MSFD) includes an economic and social analysis (ESA). This analysis is about two areas: (1) the use of marine waters and (2) the cost of degradation of the marine environment. Marine litter is one descriptor relevant for assessing good environmental status (GES) within the MSFD. Based on the ecosystem approach this report provides information on marine litter in Sweden involving status of marine litter (amounts, composition, sources etc.), how marine litter affects the provision of ecosystem services and costs and benefits connected to marine litter. The four indicators of marine litter listed in Table 0.1 were used for assessing the status of marine litter in Sweden. An aim was also to gather information on marine litter for the two Swedish management areas the North Sea and the Baltic Sea.

**Table 0.1. GES descriptor 10 on marine litter and associated indicators.**  
Source: COM (2011a).

Criterion	Indicator
10.1 Characteristics of litter in the marine and coastal environment	10.1.1 Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source
	10.1.2 Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea-floor, including analysis of its composition, spatial distribution and, where possible, source
	10.1.3 Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro-plastics)
10.2 Impacts of marine litter on marine life	10.2.1 Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis)

This report is based on a literature review and a survey carried out in October 2011 to Swedish organizations causing marine litter or affected by marine litter. From the literature review and the survey it was evident that there is a general lack of data on the status of marine litter in Sweden as well as a lack of socioeconomic data describing effects of marine litter. The literature review and the survey also show that marine litter is an urgent environmental problem that causes negative effects on the provision of ecosystem services and causes costs to affected organizations and to society as a whole.

The lack of data on marine litter might be explained by the fact that there is no uniform way in which marine litter is monitored and measured in Sweden. The data found of amounts of marine litter in Sweden only covered the coast of the North Sea and no data were found for the coast of the Baltic Sea. Data on composition of litter showed that the litter commonly consists of plastic, packages, oil cans and fishing equipment etc. The most important sources of marine litter are both based on land and at sea and involve the fishing industry, shipping sector, tourism sector and other recreational activities.

Several ecosystem services are judged to be affected by marine litter including supporting, regulating, provisioning and cultural ecosystem services. There are however several policy instruments in place for handling marine litter. The main sources of marine litter are also covered by the current legislation. Marine litter and effects of marine littering has however been apparent in the literature review and the survey in this report. This indicates that the current policy instruments might be inefficient or need to be complemented. The development of marine litter is uncertain and is likely to depend of the drivers of marine litter. Potential drivers of marine litter are closely related to the sources of marine litter and probably involve changes in consumption levels (affecting the use of packages), coastal and marine recreation and tourism, commercial fishing and shipping.

Data on cost of degradation due to marine litter are scarce and the data collected only covered the coast of the North Sea. Cost data indicate that cleaning the beaches from marine litter in the province of Bohuslän in the northern part of the Swedish west coast costs about 5-10 MSEK yearly based on data from the survey and over 10 MSEK based on data from the literature review. Data on benefits of reduced marine litter are even more scarce. The benefits of reduced marine litter involve increased aesthetic values, increased possibilities for coastal and marine recreational and tourism.

# 1 Introduction

Swedes generally spends some of their leisure time close to the Baltic Sea and the North Sea, see Enveco et al. (2012) for details.<sup>1</sup> They are also concerned about the marine environment and regard the coastal and marine environment to be an important environmental issue. Among other environmental problems in the marine and coastal environment, litter is regarded to be a rather big problem (Söderqvist et al., 2010). The aim of this report is to provide information on marine litter in Sweden, effects on the provision of ecosystem services following from marine litter and costs and benefits connected to the presence of marine litter.

## 1.1 Background

The initial assessment (IA) of the implementation of the EU Marine Strategy Framework Directive (MSFD) includes an economic and social analysis (ESA). This analysis is about two areas: (1) the use of marine waters and (2) the cost of degradation of the marine environment. COM (2010) describes two different approaches for analysing (1): the ecosystem service approach and the marine water accounts approach; and three different approaches for analysing (2): the ecosystem service approach, the thematic approach and the cost-based approach.

The Swedish ESA will be based on the ecosystem service approach associated with each of the two areas. For the use of marine waters, this approach entails the following components (COM, 2010:17):

- 1a. Identifying ecosystem services of marine areas in cooperation with the analysis of status, pressures and impacts
- 1b. Identifying and, if possible, quantifying and valuing the wellbeing derived from the ecosystem services
- 1c. Identifying the drivers and pressures affecting the ecosystem services

For the cost of degradation, the ecosystem service approach is about the following (COM, 2010:35):

- 2a. Defining good environmental status (GES) using qualitative descriptors, list of elements and list of pressures.
- 2b. Assessing the environmental status in a business-as-usual (BAU) scenario.
- 2c. Describing in qualitative and, if possible, quantitative terms the difference between the GES and the environmental status in the BAU scenario. This difference at a particular point of time defines the degradation of the marine environment at this point of time.
- 2d. Describing the consequences to human well-being of degradation of the marine environment, either qualitatively, quantitatively or in monetary terms. These consequences are the cost of degradation.

This report provides input regarding marine litter of these two ecosystem service approaches. A main aim of the report is to present data on the status of

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<sup>1</sup> If not otherwise stated, "the Baltic Sea" refers in this report to the Swedish marine waters of the Bothnian Bay, the Bothnian sea and Baltic Sea Proper. "The North Sea" refers to the Swedish marine waters of the Skagerrak, the Kattegat and the Sound (Öresund). The Sound is interpreted as having its southern border at the Drogden threshold, i.e. at the Öresund Bridge.

marine litter in Sweden and costs connected to the presence of marine litter. The report is based on literature reviews and a survey carried out to Swedish organizations in October 2011 (further described in Section 1.2). The report reflects the DPSIR-framework by covering central aspects of the framework e.g. describing status and drivers of marine litter.

Finally, important points of departure for the report was the definitions of marine ecosystem services of Garpe (2008) and SEPA (2009) and the definition of Good Environmental Status (GES) as provided by the GES descriptor D10 and associated indicators, see Table 1.1 below.<sup>2</sup> Indicators 10.1.1-10.1.3 are indicators of pressure whereas indicator 10.2.1 is seen as an indicator of impact (COM, 2011a).

**Table 1.1. GES descriptor 10 on marine litter and associated indicators. Source: COM (2011a).**

Criterion	Indicator
10.1 Characteristics of litter in the marine and coastal environment	10.1.1 Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source
	10.1.2 Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea-floor, including analysis of its composition, spatial distribution and, where possible, source
	10.1.3 Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro-plastics)
10.2 Impacts of marine litter on marine life	10.2.1 Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis)

After an introduction to the methodology and the definitions used in this report (Sections 1.2-1.3) it contains the following:

- Chapter 2 describes the status of marine litter in Sweden by giving information on amount, composition, spatial distribution and sources of marine litter. The information is given for each of the criterias and indicators of marine litter (COM, 2011a and 2011b).
- Chapter 3 provides information on how marine litter affects the provision of ecosystem services. Each of the indicators of marine litter can be assumed to affect ecosystem services in different ways, reflected in the chapter. The ecosystem services are described in four main categories, supporting, regulating, provisioning and cultural ecosystem services. Chapter 3 also summarizes how intermediate and final ecosystem services affected by marine litter are related.

<sup>2</sup> The Swedish quantitative definition of good environmental status for indicators in descriptor D10 is not yet resolved at the time of writing of this report.

- Chapter 4 gives an overview of the current international and national policy instruments and regulations for managing marine litter. Chapter 4 also includes potential policy instruments for managing marine litter.
- Chapter 5 describes the development and trends of marine litter following from BAU and after an introduction of the potential policy instruments suggested in Chapter 4. Further, this chapter describes the effect on the provision of ecosystem services following from these two scenarios and potential drivers of marine litter.
- Chapter 6 presents information on the cost of degradation, including changes in human well-being measured as benefits of reduced marine litter and costs of marine litter. It describes costs in terms of degradation of the provision of ecosystem services. Finally it compares information on costs and benefits related to marine litter.
- Chapter 7 summarizes the report with a concluding discussion.

## 1.2 Methodology

A literature review was carried out to gather information on the current status of marine litter in Swedish waters. The aim was to gather information on amount, composition and sources of marine litter. Another analysis of interest was the spatial distribution of marine litter, divided into the two management areas; the Baltic Sea and the North Sea.

Further the literature review was complemented with a survey on marine litter, carried out in October 2011. The aim of the survey was to gather information on the status of marine litter (amount, composition, sources etc.) but also to collect data on costs of marine litter and benefits of reduced marine litter. The survey was sent out to a broad range of Swedish organizations (public as well as private) that affect or are affected by the current situation with marine litter. The questionnaire was constructed and carried out as a web survey. The initial send list included about 100 recipients of mainly central national organizations but also regional and local public bodies. Regarding public bodies only coastal municipalities and county administrative boards were included in the send list. A more comprehensive send list would probably have needed pre-studies for finding the most relevant organizations and persons to target in the survey. The questionnaire included questions on e.g. composition and amount of marine litter, sources of marine litter and costs connected to problems with marine litter. The complete questionnaire (translated into English) is available in Annex A. An important feature of the questionnaire was that each question was followed by a field where the respondents also had the possibility to give general comments to the question. The additional comment fields made it possible to capture reflections, protests or additional information for each question. In contrast to Mouat et al. (2010) an identical version of the questionnaire was sent out to all of the respondents, i.e. the questionnaire was not adjusted to different groups of respondents like the tourism sector, fishing sector etc.

The questionnaire resulted in 47 responses. The respondents included county administrative boards, municipalities, trade organizations, non-governmental organizations, harbors and national authorities. Non-governmental organizations related to environmental protection, waste management and sport fishermen as well as trade organizations representing water treatment plants and waste management organizations responded to the questionnaire.

National authorities leaving an answer were the Swedish Maritime Administration, the Swedish Environmental Protection Agency, the Swedish Transport Agency, the Swedish Civil Contingencies Agency, the Swedish Coast Guard and the Laboratory of Sea Fishing. Some organizations responded with more than one answer. Some respondents represented e.g. several municipalities whereas other represented just one municipality or a national organization. Some municipalities or county administrative boards also gave two answers. No obvious overlaps in the answers have been found and due to the scarce amount of data all answers are analyzed individually and included in the results. A few questions resulted in very low response rates or answers mainly consisting of “don´t know”-answers, results of such questions have not been presented in this report.

The survey also aimed to include a spatial dimension and respondents representing the Baltic Sea and the North Sea were included in the send list. With one exception, all the county administrative boards of counties with a coastline (10 situated on the Baltic coast, 2 situated on the coast of the North Sea and one facing both seas) answered the questionnaire. Eight municipalities on the coast of the North Sea and ten on the Baltic coast answered the questionnaire. Also harbors as well as archipelagic foundations on both coasts were among the respondents. In total 24 answers concerned the Baltic Sea, 9 answers concerned the North Sea and 14 answers concerned both the Baltic and the North Sea. Hence, both management areas were well represented among the respondents.

## 1.3 Definitions

### 1.3.1 Marine litter

The definition of marine litter (also called marine debris) used in this report and in the survey corresponds to the definitions used in UNEP (2005) and in COM (2011a). The definition used is: Marine litter is any persistent, manufactured or processed solid material discarded, disposed or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded or unintentionally lost into the sea and on beaches including such materials transported into the marine environment from land by rivers, draining or sewage systems or winds. For example, marine litter consists of: plastics, wood, metals, glass, rubber, fabrics or paper, including micro particles and litter ingested by marine animals. Micro particles originate from wearing on different materials such as fabrics, paint or from wearing on roads or tires. Micro particles are embedded by animals (e.g. animals filtering water).

### 1.3.2 Additional definitions used in the survey

Some additional definitions were also used in the survey (see also Annex A). The survey used the concept of “your organization” for addressing the respondent. In the survey this concept referred to all kinds of organizations, e.g. authorities, companies, federations, associations including their members and the activities of their respective members. This definition of organization will to some extent also be used when presenting the answers from the survey.

The survey also needed to define the Swedish marine environment to frame the area targeted in the survey. Swedish marine environment was defined as Swedish beaches, coastlines, water bodies off-shore close to the coastline as well as water columns and sea floors in the Swedish economic zone. The blue line in Figure 1.1 illustrates the border of the Swedish economic zone and the

green arrow points out a preliminary border between the management areas of the Baltic Sea and the North Sea. The management area of the Baltic Sea includes Swedish water bodies from the Gulf of Bothnia in the north to the green arrow in the south. The management area of the North Sea includes Swedish water bodies from the green arrow in the south to the Norwegian border in the north.

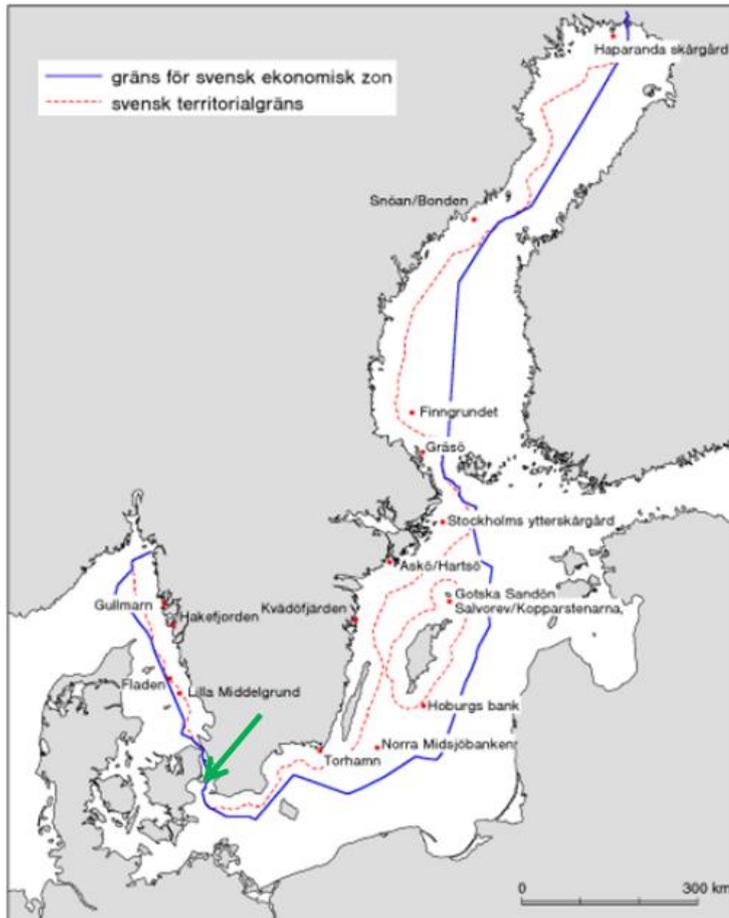


Figure 1.1. Swedish economic zone is illustrated by a blue line and the green arrow points out a preliminary border of the management areas of the Baltic Sea and the North Sea.

## 2 Marine litter: Status

### 2.1 Literature review

A literature review was carried out to determine the status of marine litter in Sweden. The analysis is based on the GES marine litter indicators: litter washed ashore or deposited on the coastline (indicator 10.1.1), litter in the water column and deposited on the sea floor (indicator 10.1.2), micro-particles (indicator 10.1.3) and litter ingested by marine animals (indicator 10.2.1). See Table 1.1 for a more detailed description of the indicators. The indicators describe the *trends* in amount, spatial distribution, composition and sources of litter. We are, however, interested both in the current status and in the trends. In this chapter we focus on the present status of marine litter and in Chapter 5.1 we look at the trends.

There are very little data on marine litter available for Swedish coastal waters. The literature review has therefore been supplemented with data from the whole North Sea area and the whole Baltic Sea area. The main references are reports from OSPAR (2009) for the North Sea and UNEP (2009b) for the Baltic Sea.

#### 2.1.1 Litter on the coast and in the sea

In this section we look at marine litter on the coast and in the sea (indicators 10.1.1 and 10.1.2). Based on the available literature we try to determine the amount, spatial distribution, composition, and sources of marine litter along the coast of Sweden.

##### 2.1.1.1 AMOUNT OF LITTER

The Bohus Coast in the northern parts of the Swedish west coast is the area most affected by marine litter due to its geographical location and the large-scale current patterns.



Figure 2.1. Average surface currents in the Baltic Sea and North Sea. The coast of the province of Bohuslän is marked with a red square. Source: SEPA (2011).

Figure 2.1 shows the average surface currents in the Baltic Sea and North Sea. The Bohus Coast (marked with a red square in Figure 2.1) is located in an area where several currents converge. Buoyant litter (e.g. plastic items) at the sea surface will drift with the surface currents as shown in Figure 2.1. Marine litter can therefore be expected to accumulate at the Bohus Coast. Based on the surface currents it is unlikely that litter from the Bohus Coast will drift with the currents into the Baltic Sea.

Since the early 1990's marine litter has been collected and measured at six beaches in the province of Bohuslän on the Swedish west coast (illustrated by the red square in Figure 2.1 and corresponding to Figure 2.2).



Figure 2.2. The province of Bohuslän and coastal municipalities of Bohuslän (Strömstad, Tanum, Sotenäs, Lysekil, Uddevalla, Orust, Stenungsund, Tjörn, Kungälv, Öckerö and Göteborg (partly)). This figure corresponds to the red square in Figure 2.1 (County maps 2009).

The amount of litter found is shown in Table 2.1. In addition to the volume the number of day labours, sacks of litter, fish boxes and oil cans found are also shown. The reason for the high volume (15 500 m<sup>3</sup>) value in 1992 is that this was the first year the litter was collected and large amounts had accumulated. The relative low numbers in 1996, a total volume of 4000 m<sup>3</sup>, is partly a result of extensive ice coverage during the winter season as well as long periods with easterly winds which transported the litter off-shore (Olin, 2010).

**Table 2.1. Amount and composition of litter collected in the province of Bohuslän 1992-2006 (Olin, 2010). Also the number of day labours for collecting the litter is shown.**

Year	Volume (m <sup>3</sup> )	Day labour (number of)	Sacks of litter (number of)	Fish boxes (number of)	Oil cans (number of)
1992	15500	25000	89200	2410	
1993	5500	6000	36071	1412	2500
1994	6000	7163	36210	1231	733
1995	6000	6508	34427	1229	589
1996	4000	5840	22607	575	1316
1997	6000	7885	36206	2020	2292
1998	6000	6480	35825	1620	2290
1999	8000	7023	39103	1899	2673
2000	7000	8081	48581	3046	4021
2001	5000	6214	34066	1361	2393
2002	4000	5880	30119	2186	2937
2003	3000	5364	24335	1631	2150
2004	3000	5472	24620	1453	2099
2005	3000	4964	24131	1640	2114
2006	3000	4156	19944	1072	1553

The province of Bohuslän in the northern part of the Swedish west coast consists of several municipalities (see Figure 2.2). For some of the coastal municipalities more recent data on marine litter are available. The municipality of Sotenäs have collected marine litter from beaches from 2007 to 2010 (Sotenäs, 2011 and pers. comm. Elise Hellström, see Table 2.2). The collection is carried out between March and October each year. Among the items found are fish boxes, oil cans, medical waste, and refrigerators. Here the percentage of beaches cleaned is also reported. In 2007 and 2008, marine litter was collected on only 25% of the beaches while between 2009 and 2010 about half the beaches were cleaned. This shows that marine litter data based on beach clean-up efforts can underestimate the total amount of litter on a beach as not all of it is collected.

**Table 2.2. Marine litter collected in Sotenäs in the Bohus Coast (Sotenäs, 2011 and pers. comm. Elsie Hellström).**

Year	Volume (m <sup>3</sup> )	Mass (tons)	Percentage of beaches cleaned
2007	199	19.4	25
2008	152	14.4	25
2009	364	31.9	50
2010	455	42.1	53

Table 2.3 presents volume and composition of litter collected in 2009-2011 on beaches in the municipality of Lysekil (see figure 2.2). In contrast to Sotenäs the total amount of litter collected in Lysekil is measured in sacks. Fish boxes and oil cans were commonly found when collecting litter in Lysekil (pers. comm. Elsie Hellström).

**Table 2.3. Marine litter collected in the municipality of Lysekil (pers. comm. Elsie Hellström).**

Year	Sacks of litter (number of)	Fish boxes (number of)	Oil cans (number of)
2009	4400	290	270
2010	5600	190	430
2011	5300	120	310

The municipality of Tanum (see Figure 2.2) also carried out beach cleaning in 2009-2011. The volume found in these years were 1000, 250 and 185 m<sup>3</sup> respectively. There are at present no exact numbers available for the volumes of litter found on beaches in the municipality of Strömstad (see Figure 2.2). The volume collected in Strömstad is however roughly corresponding to the amounts collected in Sotenäs municipality (pers. comm. Elsie Hellström).

OSPAR collects data at a number of reference beaches along the coast in Europe. Six beaches from the Bohus Coast are included in the OSPAR North Sea programme. Figure 2.3 shows the amount of litter in different OSPAR regions and shows that the North Sea is one of the areas most affected by marine litter (OSPAR, 2009).

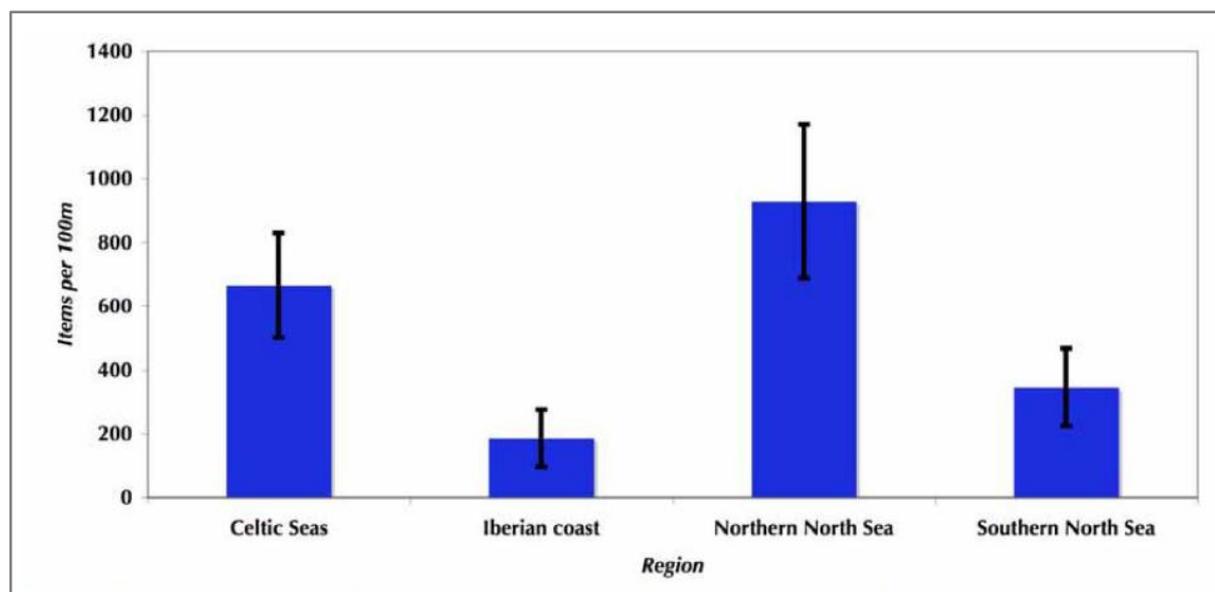


Figure 2.3. Average number of litter items per 100 meters on the reference beaches in the OSPAR regions. (Figure from OSPAR, 2009, p. 5)

For the Swedish east coast along the Baltic Sea marine litter data are very scarce. When it comes to marine litter, the Swedish east coast receives little attention compared to the west coast, in particular the Bohus Coast. We will therefore use data from elsewhere in the Baltic Sea to estimate the amount of litter on the Swedish Baltic Sea coast.

Municipalities and NGOs (e.g. WWF and the Ocean Conservancy) gather information on the amount of litter found at beaches in the Baltic Sea. UNEP and the Ocean Conservancy collect information from beach clean-up efforts in the Baltic Sea. Although the UNEP report (2009b) does not include data

specific for Sweden we will use it to illustrate typical values for the Baltic Sea. The highest concentration of marine litter found on beaches in the Baltic Sea is 700 to 1200 items per 100 m coastline. These values are very similar to those reported by OSPAR (2007) for the northern North Sea. More typical values for the Baltic Sea are 6 to 16 pieces of litter per 100 m coastline. From these figures we conclude that marine litter on beaches is a larger issue in the North Sea than in the Baltic Sea. However, it is important to keep in mind that local variations can be large. Close to the source of the litter (e.g. at a public beach) the amount of litter may be higher.

For comparison we cite a Finnish study where marine litter was collected at 15 beaches in Finland (UNEP, 2009b). The number of items found on the beaches per 100 m coastline range from 21 to 691 pieces, with an average of 260 pieces. Expressed in mass these numbers correspond to 1 kg to 45 kg of litter per 100 m coast, with an average of 11 kg.

Data of marine litter in the sea are even more difficult to come by. At sea a common source of marine litter is related to fishing. The Swedish Board of Fisheries carried out a survey from 2000 to 2004. In 2004, 24 km of lost fishing nets were found (UNEP, 2009b). However, the amount of litter found on the beach may give an estimate of marine litter at sea, not of the actual amount but of general trends. The fate of the sea-based litter depends on the density of the item, i.e., what the item is made of. Heavy items will sink to the sea floor while lighter ones will drift with the currents. The currents will determine where the item ends up. In regions with currents towards the coast the item may be washed ashore (see discussion about the Bohus Coast above) otherwise it may drift large distances.

Information on litter on the sea bottom is also very scarce. In the western Baltic Sea, marine litter at the sea bottom was collected by trawling (Galgani, 2000). The study found  $1.26 \pm 0.82$  items of litter per hectare. This value is similar to what has been measured previously in the North Sea (UNEP, 2009b). An inventory of wrecks in the Swedish sea territory that might pose a threat to the environment has been carried out 2009-2011. 17 000 wrecks were found of which 2 700 wrecks need further investigation, about 300 wrecks might pose a threat to environment and 31 wrecks are prioritized objects containing fuel. The presence of wrecks in Swedish coastal and marine waters, or close to Swedish sea territory, can lead to emission of hazardous substances such as oil, ammonia or fertilizers from e.g. wrecks of tankers affecting the marine environment. The diffuse chronic emissions from wrecks pose the largest threat to the coastal and marine environment. Long-term effects on marine ecosystem services are probable but further research is needed (Sjöfartsverket, 2011).

#### 2.1.1.2 SPATIAL DISTRIBUTION OF MARINE LITTER

The amount of marine litter on the coast varies greatly from one location to another and depends on a number of factors. The amount of litter on the coast is influenced by human activities on land (e.g. being at the beach) and by what is washed ashore by the currents. Thus two very nearby locations may differ greatly in the amount of litter. This makes it difficult to extrapolate marine litter data to determine what the situation is at other locations along the coast. Figure 2.4 shows the amount of litter found on two nearby locations on the same island in Estonia (UNEP, 2009b).

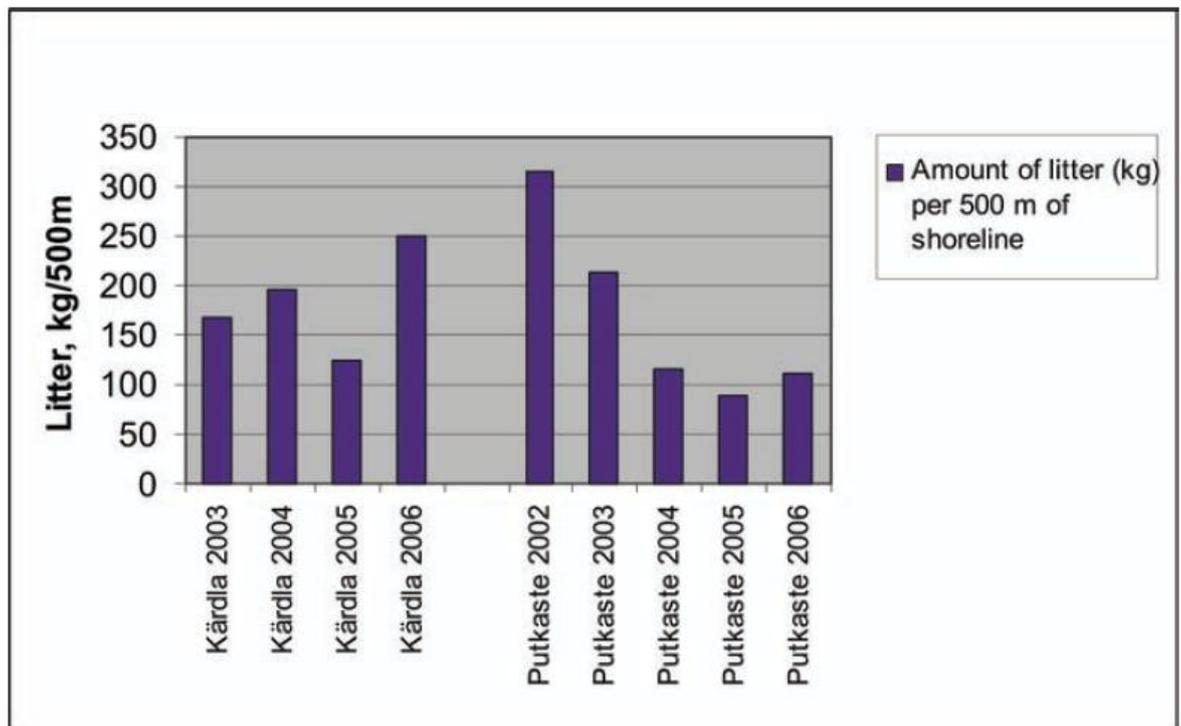


Figure 2.4. Amount of litter as kg/500 m of shoreline in Kärdla and Putkaste districts in Hiiumaa area, Estonia. Data provided by State Forest Management Centre (RMK), Estonia (figure from UNEP, 2009b, p. 30).

The amount of litter also varies in time. There are seasonal variations which can be exemplified by comparing the amount of litter on the beach during summer and winter. There are also inter-annual variations as can be seen in the data presented above. These variations may depend on the weather as was seen in the marine litter data from the Bohus Coast (see Table 2.1). The variations may also be due to the number of days of labour or fraction of beaches that were cleaned as was seen in the data from the Bohus Coast and Sotenäs (see Tables 2.1 and 2.2).

#### 2.1.1.3 COMPOSITION OF MARINE LITTER

The composition of the marine litter is an important descriptor as it gives information about the possible sources of the litter. Furthermore, the material determines whether the item is buoyant or not. This is especially interesting for marine litter deposited at sea. A buoyant item will drift with the currents (sometimes very large distances) before being washed ashore. In this case it is either indicator 10.1.2 or 10.1.1 that will be affected. Items of heavy materials, on the other hand, will sink and affect indicator 10.1.2 only.

Figure 2.5 shows the average composition of litter on the coast and beaches of the Baltic Sea per 500 m coastline based on data from the Naturewatch Baltic project (1998-2005). The values are for a specific time at specific locations and thus they only provide a snapshot of the litter composition. It should also be kept in mind that there are large differences between countries. The figure shows that of the litter collected on the coast and beaches of the Baltic Sea, 31-43% is plastic bottles. Some of the years plastic bags were reported and they made up 19-27% of the litter (UNEP, 2009b). Hence, plastic bags and plastic bottles make up a large fraction of the litter on the coast. The situation is very similar on the west coast of Sweden where plastic items also dominate. These items are often attributed to marine recreation (UNEP, 2009b).

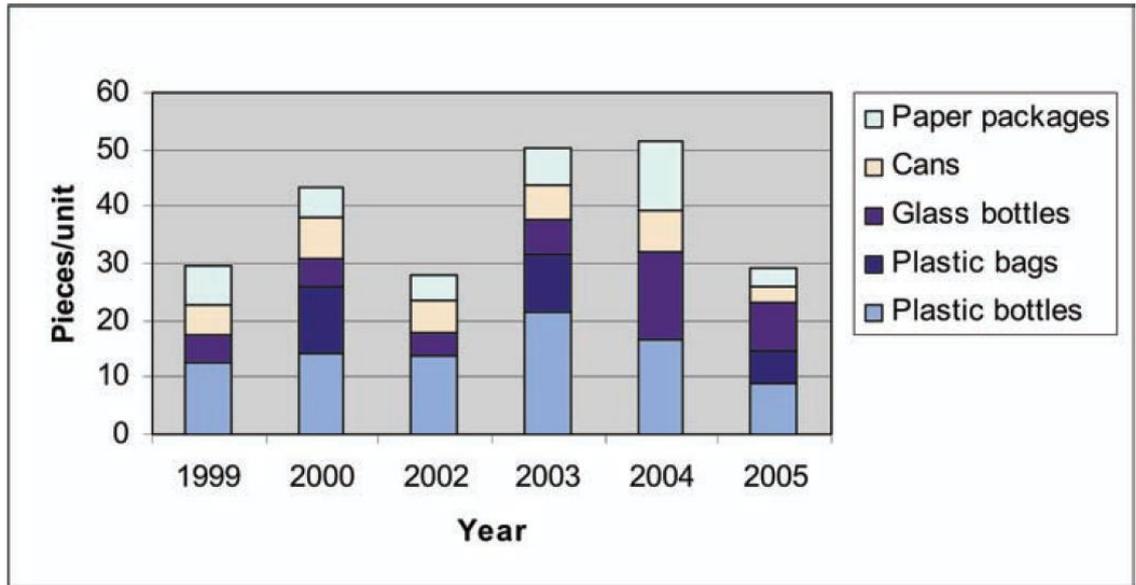


Figure 2.5. Averages of different types of litter found on beaches by WWF Naturewatch Baltic, measured as pieces of litter per 500 m of coastline (figure from UNEP, 2009b, p. 29).

Figure 2.6 from OSPAR (2009) shows the composition of the marine litter found at a number of reference beaches. At all the reference beaches plastic and polystyrene pieces were the most common objects.

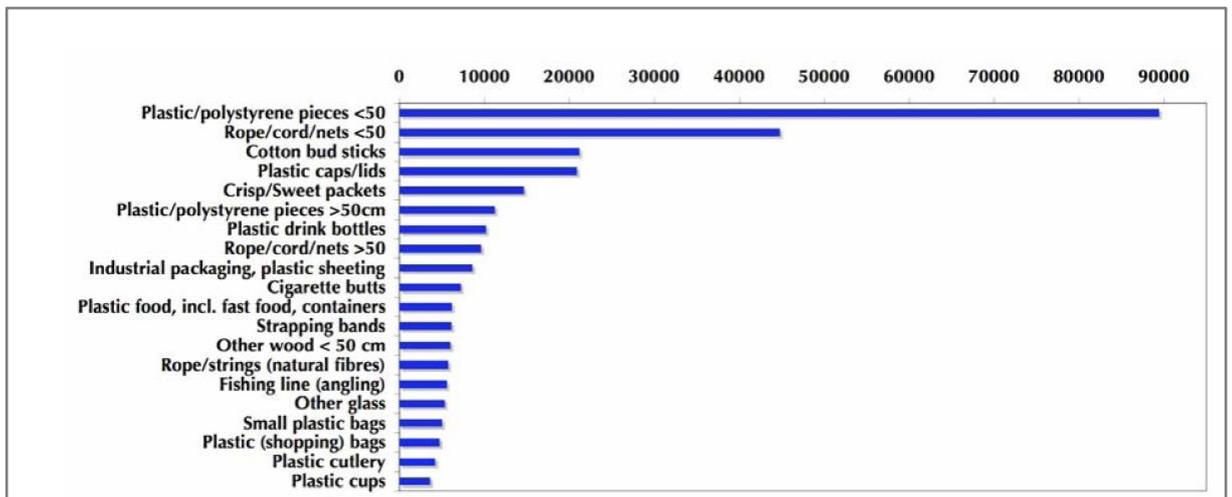


Figure 2.6. Total numbers of items collected on reference beaches in the North East Atlantic (Figure from OSPAR, 2009, p. 6)

In a Finnish study, litter was collected at 15 beaches along the coast of Finland (UNEP 2009b) and 54 % of the items were found to be plastic items. According to the “Save the North Sea” project, in the early 2000’s, the most common objects found in the North Sea were: plastic bags, cans, plastic cups, buoys, and pieces of fishing nets (Håll Sverige Rent, 2011).

A study by Galgani (2000), measured the amount of litter on the sea floor along the European coast and 36% of the litter was plastic bottles.

Based on these studies, we conclude that plastic items make up a large fraction of marine litter. Plastic items are often buoyant and can therefore drift large distances with the currents and end up far away from their original source.

#### 2.1.1.4 SOURCES OF MARINE LITTER

Marine litter found at sea and on the coast originates from both sea- and land-based sources. Sea-based sources includes shipping (commercial, recreational) and fishing. Land-based sources include for example tourism and recreational visitors at the coast, and riverine transport of litter from inland (OSPAR, 2009).

As part of the HELCOM report on marine litter, countries around the Baltic Sea responded to a questionnaire about marine litter. Five of the countries reported marine recreation and tourism to be the most common sources of land-based litter (UNEP, 2009b). This litter is made of plastic and glass bottles, plastic bags, packing material (plastic, polystyrene, paper, cardboard), cans and tins.

In the same HELCOM questionnaire, the major sea-based sources in the Baltic Sea were determined to be commercial shipping (e.g., fishing boats, cargo ships, tankers, and passenger ships), recreational fishing boats, and pleasure crafts. The relative importance of these sources varies in different areas of the Baltic Sea.

The sea-based source of marine litter in Sweden include fisheries (fishing nets and floats), commercial shipping, off-shore oil and gas installations in the North Sea (oil drums, paint, chemicals, gas flask), and recreational boating whose contribution can be locally very high.

### 2.1.2 Micro-particles

Micro-particles (indicator 10.1.3) are very small particles found in the sea. They consist of many different materials and have a wide range of sources. The size of the particles is similar to the size of phytoplankton, and thus marine animals that filter water for food may ingest these particles. The environmental effect of these particles is just beginning to be studied. As these particles are impossible to clean up and many of them consist of plastic it is expected that their concentration will increase in the future.

Micro-particles vary in shape and colour depending on their origin. The main distinction is made based on the shape. Fibrous particles have a small diameter (approximately 0.02 mm) and vary in length from 0.2 mm to a couple of mm. Non-fibrous particles have a more rounded shape.

In November 2008 N-research (Norén, 2010) carried out a survey along the coast of Sweden. The concentrations of fibrous and non-fibrous particles were measured at 19 stations ranging from the Gulf of Bothnia to Skagerrak. The results are summarized in Table 2.4. This is to date the most comprehensive study of micro-particles performed in Sweden.

**Table 2.4. Concentration of micro-particles measured at 19 stations along the Swedish coast (Norén, 2010).**

Station	Number of fibrous particles/m <sup>3</sup>	Number of non-fibrous particles/m <sup>3</sup>
Lysekil West	340	760
Lysekil	880	2420
Orust West	1180	7200
Fladen	480	1040
Anholt E	400	900
Falkenberg	1320	1520
Landskrona West	340	1520
Arkona	1340	3060
Bornholmsdjupet	940	3340
Hanöbukten	620	60
Kalmar	1040	1920
Gotlandsdjupet	720	3200
Karlsödjupet	480	1620
Norrköpingsdjupet	1080	3040
Landsortsdjupet	1160	3260
Bottenhavet	9960	20280
Höga kusten	5520	2500
Umeå, Norrbyn	14620	104780
Bottenviken, utsjö	5380	9540

For both fibrous and non-fibrous particles the concentrations were highest in the Gulf of Bothnia. The reason for this is not entirely clear. It could be that different sampling methods were used for the northernmost stations, that the river runoff is higher or that the Gulf of Bothnia has a smaller exchange with the North Sea, which is believed to have a lower concentration of micro-particles.

On average the composition of fibrous particles at the 19 stations surveyed by N-research was: 62% were natural fibres such as cotton and wool, 23 % were plastic polymers and the remaining ones were too oxidized to determine. The main source of fibrous particles is textile (lint). Among the non-fibrous micro-particles the black particles dominate. They originate from road and tire wear.

### 2.1.3 Marine litter ingested by marine animals

An additional issue with marine litter is that some items may be ingested by marine animals; especially smaller plastic items may be taken for prey. Indicator 10.2.1 deals with the amount and composition of marine litter ingested by marine animals. The indicator does not include entanglement in litter which is an additional problem with marine litter and animals.

There have been very few studies to determine the amount of litter ingested (stomach analysis). A Dutch survey during 1982 to 1985 found that 92 % of the birds had on average 12 pieces of plastic in their stomach. A similar study in the late 90's showed that 98 % of the birds had plastic pieces in their stomach. (UNEP, 2009b).

## 2.2 Results from the survey

Questions regarding GES indicator affected, amounts, composition and sources of marine litter as well as spatial distribution of marine litter were included in the survey (questions 4-9, 15-18 and 21-24 in Annex A). The questions targeted organizations causing marine litter as well as organizations affected by marine litter.

### 2.2.1 Marine litter caused by Swedish organizations

In total 7 respondents stated that their organization contributed to marine littering (question 3 in Annex A). They were also asked to state what GES indicators the marine littering affected (question 4 in Annex A). The majority of the respondents indicated that their littering affected indicator 10.1.3 concerning micro particles. Some respondents indicated that the marine littering from their organizations affected indicator 10.1.1 concerning litter washed ashore and/or deposited on coastlines and indicator 10.1.2 concerning litter in the water column (including floating at the surface) and deposited on the sea floor. Some explanations were given to the impacts on indicator 10.1.3. The respondents stated that the use of boats and cars contribute to the amount of micro particles. Also paint from wear on vessels and wear on different kind of equipment used in harbors can cause micro particles, e.g. wear on jetties or rust from equipment. Traffic and wear on equipment contribute to the amount of micro particles almost daily and over long time horizons according to the respondents (question 10 in Annex A). The respondents were also asked how the volume of different types of litter from their own organization had changed over the last ten years (question 12 in Annex A). These types of litter included paper, plastic, wood, metals, glass, rubber, fabrics, micro particles and other. However, this question proved difficult to answer and the question did not result in any specific information.

### 2.2.2 Marine litter affecting Swedish organizations

#### 2.2.2.1 AMOUNT OF LITTER

In total 25 respondents out of 47 stated that their organizations were affected by marine littering (question 14 in Annex A). The respondents were asked to estimate the volume of each kind of litter affecting their organization (question 17 in Annex A). Only a few organizations had access to this kind of data. The general comments indicate that it is hard to estimate the volume of litter and that the volume is unknown for most respondents. However, the general comments also indicated that the volumes of marine litter are causing problems to the organizations particularly by affecting the environment.

The county administrative board of Halland on the coast of the North Sea stated that the following volumes of litter were collected yearly: 30 sacks of plastic, 30 sacks of paper, 5 sacks of wood, 10 sacks of glass, 10 sacks of rubber and 15 sacks of other litter. In total about 100 sacks of litter per year.

The municipality of Öckerö on the coast of the North Sea (see Figure 2.2) stated that the following volumes of litter were collected: 30 boxes (for fish), 2 bikes, 34 disposable barbecues, 95 pair of rubber or plastic gloves and 46 plastic or metal cans. In total about 400 sacks of litter. The municipality did not leave any information on how often the volume of litter was collected.

The municipality of Göteborg on coast of the North Sea (see Figure 2.2) stated the following yearly volumes for different types of litter: 5.6 tonnes of plastic, 250 kg of glass, 50 kg of rubber, 300 kg of other litter and 65 liter of oil.

The county administrative board of Västra Götaland on the coast of the North Sea stated that about 4000 m<sup>3</sup> litter is yearly collected on the coast of the province of Bohuslän, this estimate covered all of the different types of litter.

#### 2.2.2.2 COMPOSITION OF LITTER

The respondents were asked to state what types of litter that affected their organizations (question 15 in Annex A). Table 2.5 presents the alternatives and the answers to question 15 for both management areas.

**Table 2.5. Results of question 15.**

Respondents representing... (22 out of a total of 47 respondents gave an answer)	...the North Sea (8 out of 9 respondents gave an answer)	...the Baltic Sea (10 out of 24 respondents gave an answer)	...the North Sea and the Baltic Sea (4 out of 14 respondents gave an answer)
Type of litter			
Plastic	8	9	4
Paper	5	5	3
Metal	6	6	4
Wood	6	7	3
Glass	7	8	4
Rubber	8	6	4
Fabrics	6	7	3
Micro particles	6	6	3
Other	6	7	3

All of the categories were highly relevant for most respondents. The majority of the respondents indicated that their organizations were affected by several categories. This was a uniform answer for both the Baltic and the North Sea. For each category of litter about half of the respondents also specified what kind of litter their organizations was affected by. Packaging was frequently mentioned as a specific type of waste affecting several organizations. Further, bottles, styrofoam, plastic bags, sacks, oil spill, tires, cans and boats or parts of boats were litter affecting several organizations. Other types of litter mentioned were fishing equipment, boxes and disposable barbecues. In the general comments some respondents pointed out other important aspects related to problems with marine littering, for example that environmental toxins are closely related to marine litter and that litter also affects the water quality.

#### 2.2.2.3 SOURCES

The respondents were asked about their view on possible sources of the litter affecting their organization (question 21 in Annex A). The general picture of sources is quite diverse and only a few respondents gave an answer. Fishing, the fishing industry and shipping were seen as possible sources by several respondents. Out-door activities, tourists, the public and the public's boating were also suggested as possible sources.

**Table 2.6. Results of question 23.**

Respondents representing... (22 out of a total of 47 respondents gave an answer)	...the North Sea (response rate shifting between types of litter)		...the Baltic Sea (response rate shifting between types of litter)		...the North Sea and the Baltic Sea (response rate shifting between types of litter)	
	National	Inter-national	National	Inter-national	National	Inter-national
Plastic		6	2	1		2
Paper	2	2	2	1	1	1
Metal	2	2	2			2
Wood	1	3	1	1		2
Glass	3	2	3			2
Rubber	3	2	1			2
Fabrics		2	1			2
Micro particles		3		2		1
Other	1	4	1	1		1

The respondents were also asked to state whether they believed the source of litter to be national or international for each type of marine litter (question 23 in Annex A). The types of litter and the answers to the question are presented in Table 2.6. Many respondents stated “don’t know” as an answer to this question and wrote in the comment field that they did not have enough information to answer. The survey does not provide a clear picture of whether the sources of marine litter mainly are national or international. The assessment that the source of marine litter was international was somewhat more common for the respondents representing the North Sea. The respondents were asked to state whether they believed the source of litter to be national or international for each type of marine litter. However, this classification did not result in any clear conclusions.

## 2.3 Discussion

Very little data on marine litter are available for the Swedish coast and seas. Most of the data available are for litter found on the beaches. This litter is the most visible one and often concentrated to small areas along the coast making it relatively easy to collect. Since the early 1990's, marine litter has regularly been collected on the Swedish west coast, on average about 4000 m<sup>3</sup>/year. Data found in the literature suggest that the amount of litter is higher in the North Sea than in the Baltic Sea.

There are very little data on marine litter in the open sea. Compared to litter on beaches, this litter is spread out over a larger area making it more difficult to collect and measure. Based on the dominating surface currents in the Baltic Sea and North Sea, one may expect the Bohus Coast on the Swedish west coast to be most affected by marine litter. The large-scale surface currents are on average directed out of the Baltic Sea towards the North Sea, thus any litter that is buoyant will be transported away from the Baltic Sea.

For litter on the sea bottom there are even less data. This litter is out of sight to the general public thus gaining little attention. There have been a few oceanographic surveys where the sea floor has been surveyed in order to determine the amount of litter. Spatial variations are large and depending on the bathymetry and bottom currents there will be locations where litter will accumulate.

This picture is supported by the answers in the survey as most respondents found it difficult to state the amount of litter caused by their organization or affecting their organization. However, the respondents did point out that the amount of marine litter constitutes a problem.

A large fraction of the marine litter, whether found on the coast, drifting with the currents or being at the sea floor, consists of items made of plastic. Plastic items take very long time to decay, decades to centuries depending on type of plastic. Thus marine litter in the marine environment may be very persistent and accumulate unless cleaned-up.

Plastic items may also be broken down to smaller pieces and ingested by animals. This, together with marine animals getting entangled in litter, is one of the main environmental issues of marine litter. Plastic was commonly mentioned also by respondents in the survey as a common type of litter, but also many other types of litter were mentioned by the respondents such as paper, metal, wood, glass etc. The results from the literature review and the survey are mainly consistent regarding the sources of marine litter.

The presence of micro-particle in the sea has been gaining attention lately. These are very small particles, about the same size as phytoplankton. Marine animals, e.g. filter feeders, may ingest these particles. Furthermore, there particles are made of slow-decaying materials which make an increase in the concentration in the sea likely. Very little is known about the environmental effect of these particles. Results from the survey indicate that micro-particles is a common type of litter that causes problems in the marine environment.

An issue that became apparent both in the literature review and in the survey was the lack of common methods for measuring marine litter and of a monitoring program for marine litter in Sweden. These are both likely to be important explanations of the scarce amounts of data. The literature review and the survey show that the methods for measuring litter e.g. collected on beaches are diverse. The amounts of litter are measured in several different units, e.g. m<sup>3</sup>, number of sacks and kg. The literature review also showed that measuring and collecting marine litter on beaches involved several methods and units, e.g. items per 100 m coastline and kg litter per 500 m coastline. The lack of monitoring programs of marine litter in Sweden probably also explains the scarce amount of data on marine litter. This is also supported by the results from the surveys as monitoring programs and financial support for such programs are seen as desirable. However, there have been several regional and global initiatives to develop methods for monitoring and assessing marine litter, e.g. Cheshire et al. (2009) and OSPAR (2007).

It is difficult to compare marine litter data from different sources as there are no common methodologies to collect the data, no common method to measure and report the data. Some of the litter collection is also carried out by volunteers, which means that the amount collected will depend on the number of volunteers that participate. The scarce amount of data also makes comparisons between the two management areas less fruitful. However, since there seem to be more data available for the coast of the North Sea it might

indicate that marine litter is a larger problem there than on the coast of the Baltic Sea.

Finally, we note that the sources of litter as described in Section 2.1.1.4 and 2.2.2.3 give indications on important drivers of marine litter. These drivers are likely to include consumption levels (affecting the use of packages), coastal and marine recreation, commercial fishing and marine transports. Many of these drivers in turn depend on the general economic and financial development. The drivers might also be influenced by existing and future policy instruments, which are subject to review in Chapters 4 and 5.

## 3 Impacts of marine litter on ecosystem services

The European Commission conclude that there are little knowledge on impacts from marine litter on ecosystem services but that the issue is a global problem of great interest (COM, 2011a). Hence, in this section we look at the impact of marine litter on the ecosystem services. For each ecosystem service we study if it is affected by a change in the indicators. If there is a change in the indicator (e.g. more litter washed ashore), is the ecosystem service affected? We look at two impacts of marine litter. Firstly, the physical impact deals with that the mere presence of litter affecting the ecosystem service. This is, for example, the case for marine litter washed ashore and its effect on the ecosystem service Enjoyment of scenery (C2). And secondly, the chemical impact taking into consideration that marine litter may contain toxic materials and get into the food web. For the ecosystem services that are considered to be affected by litter, we also differentiate between intermediate and final services. Final ecosystem services are those whose supply depends on the input of another ecosystem service. For example, the ecosystem service Enjoyment of recreation (final) (C1) depends on the ecosystem service Enjoyment of scenery (intermediate) (C2).

Tables 3.1-3.4 describe how marine litter, according to the GES indicators, affect: supporting, regulating, provisioning and cultural marine ecosystem services. In Section 3.5 we summarize the impact on marine litter on the ecosystem services and show the linkage between intermediate and final ecosystem services.

### 3.1 Impacts of marine litter on supporting ecosystem services

Table 3.1 identifies the main impacts of marine litter on the supporting ecosystem services. Generally speaking a large amount of litter, micro-particles, and litter ingested by marine animals act as a disturbance on the ecosystem and can have a negative impact on the ecosystem services Food web dynamics (S3), Maintenance of biodiversity (S4), Maintenance of habitat (S5) and Maintenance of resilience (S6). For example, large amounts of litter washed ashore or deposited on the coastline (10.1.1) affect the Maintenance of habitat (S5) as it may destroy habitats along the shoreline or prevent animals from reaching land. This is also the case for marine litter deposited on the seafloor (10.1.2) which may destroy habitats. The impact of large objects is not only negative as it can create new habitats. Although not litter, the pillars of the Öresund bridge have become the site of new marine habitats. Large amounts of litter on the sea surface (10.1.2) may hinder light from penetrating and thereby reduce primary production (S2). Toxic marine litter affects the Food web dynamics ecosystem service (S3) if the toxic chemical enters the food web by, e.g. animals ingesting toxic materials.

**Table 3.1. Impacts of marine litter on supporting ecosystem services.**

Ecosystem services		Marine litter			
		10.1.1 Marine litter washed ashore or deposited on coastlines.	10.1.2 Marine litter in the water column and deposited on the sea-floor.	10.1.3 Micro-particles including micro-plastic	10.1.4 Litter ingested by marine animals
S1	Biogeochemical cycling				
S2	Primary production		X		
S3	Food web dynamics	X	X	X	X
S4	Maintenance of biodiversity	X	X	X	X
S5	Maintenance of habitat	X	X		
S6	Maintenance of resilience	X	X	X	X

## 3.2 Impact of marine litter on regulating ecosystem services

Table 3.2 describes the regulating ecosystem services affected by marine litter. For the regulating services we focus on the toxicity of marine litter as there is no major impact by the sheer presence of litter. Toxic marine litter impacts the regulating ecosystem service Regulation of hazardous substances, R5. With increasing toxic marine litter, this ecosystem service will not be sufficient to maintain a clean sea. This ecosystem service is considered an intermediate service for the provision of food (P1) and Provision of inedible goods (P2).

**Table 3.2. Impact of marine litter on regulating ecosystem services.**

Ecosystem services		Marine litter			
		10.1.1 Marine litter washed ashore or deposited on coastlines.	10.1.2 Marine litter in the water column and deposited on the sea-floor.	10.1.3 Micro-particles including micro-plastic	10.1.4 Litter ingested by marine animals
R1	Climate and atmospheric regulation				
R2	Sediment retention				
R3	Eutrophication mitigation				
R4	Biological regulation				
R5	Regulation of hazardous substances	X	X	X	

### 3.3 Impact of marine litter on provisioning ecosystem services

Marine litter affects the provisioning ecosystem services in a number of different ways. The service Provision of food (P1) is primarily affected if the litter is toxic and the contaminant enters the food web and reaches fish and shellfish consumed by humans. As this ecosystem service has a direct impact on humans it is considered a final service. Fish fodder is one of the goods supplied by the ecosystem service Provision of inedible goods (P2). Similarly to P1, if the litter is toxic it may affect the fodder production by entering the food web. The ecosystem service Provision of energy (P6) could possibly be impacted by marine litter getting entangled in wave and tidal power turbines. In case of large amounts of litter the ecosystem Space and waterways (P7) may be affected negatively by blocking the way in e.g. narrow passages.

**Table 3.3. Impact of marine litter on provisioning ecosystem services.**

Ecosystem services		Marine litter			
		10.1.1 Marine litter washed ashore or deposited on coastlines.	10.1.2 Marine litter in the water column and deposited on the sea-floor.	10.1.3 Micro-particles including micro-plastic	10.1.4 Litter ingested by marine animals
P1	Provision of food	X	X	X	
P2	Provision of inedible goods	X	X	X	
P3	Provision of genetic resources				
P4	Provision of chemical resources				
P5	Provision of ornamental resources				
P6	Provision of energy	X	X		
P7	Space and waterways	X	X		

### 3.4 Impact on cultural ecosystem services

The impact of marine litter on the cultural ecosystem services is through the visual aspect of litter in the coastal environment. This implies that the indicators Marine litter washed ashore or deposited on the coastlines (10.1.1) and Marine litter in the water column or deposited on the sea-floor (10.1.2) all have an impact on the cultural ecosystem services. Micro-particles are considered to have little impact on the cultural ecosystem services as they are not visible. They have, however, been gaining more attention lately and are thus considered to be relevant for the ecosystem service Legacy of the sea (C6). We consider the cultural ecosystem services C1-C5 to be unaffected by micro-particles.

Litter ingested by marine animals (indicator 10.2.1) affect the Enjoyment of recreation (C1) as bird watching and recreational fishing is included in this ecosystem service. Ingested litter may increase the mortality of marine animals and thereby reducing the values of enjoying the sea. The ecosystem service Legacy of the sea (C6) is impacted by all marine litter indicators. An increase may lead to an increase in the appreciation of the sea for ethical reasons and to an increase in interest in conserving the sea.

An increase in litter may affect the ecosystem service Science and education (C3) in different ways. If the marine environment is more littered, it may become more difficult to promote awareness and interest in the marine environment in terms of science and education. It can also work the other way, causing an increased interest to use the marine environment for science and education in order to remedy the situation.

**Table 3.4. Impact of marine litter on cultural ecosystem services.**

Ecosystem services		Marine litter			
		10.1.1 Marine litter washed ashore or deposited on coastlines.	10.1.2 Marine litter in the water column and deposited on the sea-floor.	10.1.3 Micro-particles including micro-plastic	10.1.4 Litter ingested by marine animals
C1	Enjoyment of recreation	X	X		X
C2	Enjoyment of scenery	X	X		
C3	Science and education	X	X		
C4	Maintenance of cultural heritage	X	X		
C5	Inspiration for art and advertisement	X	X		
C6	The legacy of the sea	X	X	X	X

### 3.5 Summary

Figure 3.5 summarizes the findings of chapter 3 and shows what ecosystem services are affected by marine litter and the linkages between these ecosystem services. The ecosystem services identified to be affected by marine litter are classified as intermediate (blue boxes) or final (red boxes for the strongly impacted ones and orange boxes for the weakly impacted ones) services.

An intermediate service is one that affects another ecosystem service. For example, marine litter affects the ecosystem service Enjoyment of scenery (C2), as an increase in marine litter leads to a deterioration of the scenery.

Enjoyment of recreational activities (C1) depends on the ecosystem service Enjoyment of scenery. Thus the ecosystem service Enjoyment of scenery is an intermediate service and Enjoyment of recreational activities a final service in terms of marine litter.

The final services are classified according to how strongly they are impacted by marine litter. For example, both the Provision of food (P1) and the Provision of inedible goods (P2) are affected by toxic marine litter. The ecosystem service Provision of inedible goods provides fodder, which is affected by toxic litter, and other goods which are unaffected by marine litter. Provision of inedible goods (P2) is therefore rated to be weakly impacted. Provision of food is strongly affected by toxic litter as all goods provided would be toxic.

The ecosystem services Enjoyment of scenery, Regulation of hazardous substances and the supporting ecosystem services S1-S6 are affected by marine litter either by physical effect of marine litter (just by the litter being present) and/or by the fact that marine litter may be toxic. As other ecosystem services depend on these services they are considered intermediate.

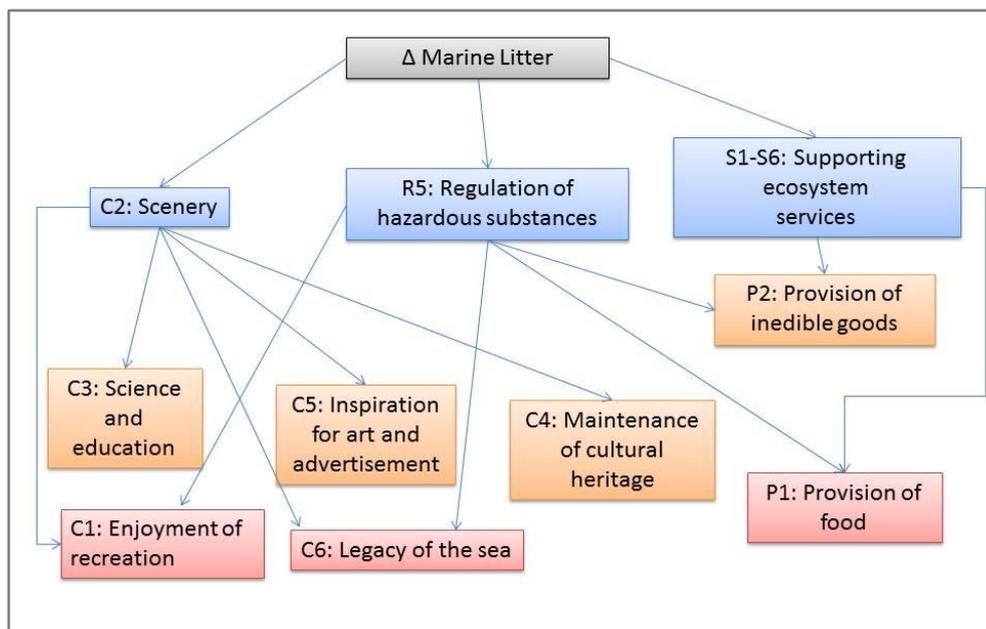


Figure 3.5. Ecosystem services affected by marine litter. Blue = intermediate ecosystem services, Orange = final services, less important, Red = final services, more important.

All cultural ecosystem services are considered to be affected by the visual aspect of marine litter, especially by litter found on the coast and washed ashore. The ecosystem services mostly affected by deterioration in the ecosystem service Enjoyment of scenery are: Enjoyment of recreation and the Legacy of the sea (red boxes in Figure 3.5). The other cultural services, Science and education, Inspiration and Cultural heritage, are also dependent on the Enjoyment of scenery but to a lesser degree (orange boxes).

In the case of the litter being toxic, the ecosystem service Regulation of hazardous substances may not be sufficient. If so, the Provision of food and the Provision of inedible goods (e.g. fodder) may be affected by the toxic chemicals entering the food web. The ecosystem service Regulation of hazardous substances also impacts the services Legacy of the sea as well as Enjoyment of Recreation.

## 4 Policy instruments

### 4.1 Current policy instruments

A literature review was carried out to gather information on current policy instrument on marine litter. The review is based on the following reports: OSPAR (2009), HELCOM (2007), UNEP (2005, 2009), Galgani (2010) and Mouat et al. (2010). The policy instruments described below are divided into the following groups: “International/Global”, “European Union”, “Regional”, “National” and “Other”. Some of the policy instruments listed below are legally binding whereas other are initiatives carried out on a voluntary basis. The most important policy instruments are summarized in Table 4.1, which also indicates the main target of each policy instrument.

#### 4.1.1 International/Global

*The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)* is a main international convention controlling pollution from the shipping sector. The MARPOL Convention regulates types and quantities of waste that ships may discharge into the sea. Annex V is specifically relevant since it regards garbage. Annex V of the MARPOL Convention prohibits the dumping of garbage, specifically all plastics and synthetic materials including ropes and fishing nets into the ocean and is the leading international instrument to control marine litter from shipping, including fishing vessels and leisure craft. The North Sea is a Special Area for the purpose of Annex V to MARPOL 73/78. This means that for Special Areas, discharges of garbage (except food waste) into the sea are prohibited. The Convention also requires countries surrounding Special Areas to provide appropriate reception facilities for ship-generated waste in their ports and harbors. The MARPOL has been subject to review the last few years also covering adjustments of Annex V.

*London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (LC)* was signed in 1972 and regulates the disposal of waste at sea. Annex I of the London Convention prohibits signatories (which include Sweden) from dumping persistent plastics and other non-biodegradable materials as well as other compounds into the sea from ships and other manmade structures. The convention does not address wastes that have been generated during the normal operation of ships. The Convention was recently reviewed to further strengthen the rules on dumping at sea, although there is still no direct reference to marine litter.

*United Nations Convention on the Law of the Sea (UNCLOS) and the General Assembly (GA)* is a legal framework within which all activities in the oceans and seas must be carried out. Part XII of the Convention (Articles 192-237) addresses protection and preservation of the marine environment and gives basic obligations to prevent, reduce and control pollution from e.g. land-based sources, pollution from sea-bed activities, pollution by dumping and pollution from vessels.

Further, articles 65-70 of *resolution A/60/L.22 Oceans and the Law of the Sea* from 2005 include a call for national, regional and global actions to address the problem of marine litter. The resolution notes e.g. the lack of information and data on marine litter and urges states to integrate the issue of marine litter within national environmental strategies, and encourages states to cooperate regionally and sub-regionally to develop and implement joint prevention and recovery programmes for marine litter.

*Basel Convention on the Transboundary Movements of Hazardous Wastes and Their Disposal* addresses the problems and challenges posed by the transboundary movements of hazardous wastes and other wastes.

*Agenda 21 and the Johannesburg Plan of Implementation* is a comprehensive plan for global, national and local action by organizations of the United Nations system, governments, and major groups in every area in which human activity impacts the environment. Chapter 17 of Agenda 21 deals with the protection of the oceans, also including waste. Issues related to the protection of the marine environment are included in *the Johannesburg Plan of Implementation* adopted in 2002. Paragraphs in the Johannesburg plan deals with e.g. prevention and minimization of waste and encourages maximization of reuse, recycling and use of environmentally friendly alternative materials. For land-based sources it emphasizes the importance of the implementation of the UNEP Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. Paragraph 33 deals with marine pollution from shipping, it states that relevant international conventions should be ratified and implemented.

*Convention on Biological Diversity, with the Jakarta Mandate* is part of the UN Convention on Biological Diversity (CBD). The work programme is focused on five key elements; marine and coastal biodiversity resource management, sustainable use of marine and coastal biodiversity, marine and coastal protected areas, mariculture and alien species. Marine litter is relevant for the thematic areas of marine and coastal biodiversity (by e.g. ingestion of litter by marine animals) and alien species (litter transporting alien species).

*Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP GPA)* was adopted in 1995. Litter is one of the nine pollution sources identified by the GPA. This programme proposes a number of actions which should be addressed at international, regional and national levels to handle the problem.

*FAO Code of Conduct for Responsible Fisheries* was adopted in 1995. Management objectives in the Code include that states should take appropriate measures to "minimize waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and negative impacts on associated or dependent species, in particular endangered species".

#### **4.1.2 European Union**

*The EU Directive on port reception facilities for ship-generated waste and cargo residues (Directive 2000/ 59/EC, December 2002)* has the same aim as the MARPOL 73/78 on the prevention of pollution from ships but the Directive focuses on ship operations in Community ports. It requires e.g. ports to set up waste handling plants and make available adequate reception facilities. It also requires ships to deliver all ship-generated waste to ports.

*EU Marine Strategy Framework Directive* outlines 11 qualitative descriptors for determining good environmental status, one of which explicitly identifies marine litter as an issue to be addressed by the MSFD (see also Section 1.1). The descriptor states that to achieve good environmental status, the "properties and quantities of marine litter do not cause harm to the coastal and marine environment".

The main objective of the *EU Directive on Packaging and Packaging waste (Directive 2004/12/EC)* is to prevent packaging waste by encouraging packaging re-use and recycling. The Directive requests that Member States introduce systems for the return and/or collection of used packaging and defines specific targets for packaging waste recovery and recycling.

The objective of the *the EU Directive on the landfill of waste (Directive 1999/31/EC)* is to prevent or reduce as far as possible negative effects on the environment from the landfilling of waste, including the pollution of surface water, by introducing stringent technical requirements for waste and landfills. The Directive is applicable to collected marine litter entering landfills, as well as the garbage from the landfills entering the seas and becoming marine litter.

Other related EU Directives are: EC Urban Waste Water Treatment Directive (97/27/EEC), EU Environmental Liability Directive (2004/35/EC), The EU Directive on waste (Directive 2006/12/EC), The EU Directive on the conservation of natural habitats and of wild fauna and flora (DIRECTIVE 92/43/EEC), The Water Framework Directive (Directive 2000/60/EC) for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater and the EU Directive concerning the management of bathing water quality (Directive 2006/7/EC).

#### **4.1.3 Regional**

Under the *HELCOM Convention* the countries bordering the Baltic Sea have been implementing e.g. a complex set of measures known as the Baltic Strategy on Port Reception Facilities for Ship-generated Wastes (the Baltic Strategy) to prevent illegal discharges of waste into the Baltic Sea and providing for economic incentive to deliver wastes, including garbage, onshore. Today, all discharges into the Baltic Sea of garbage (defined in Annex V to MARPOL 73/78) are prohibited. In Annex V the Baltic Sea is seen as a “special area”. To uphold this prohibition, HELCOM requires all ships to deliver all garbage to reception facilities before leaving the port. To further encourage delivery, the countries bordering the Baltic Sea have agreed that ships should not be charged for using such reception facilities, under the “no-special-fee” system.

Under the *OSPAR Convention* fifteen Governments of the coasts and catchment areas of Western Europe, cooperate together with the European Community aiming to protect the marine environment of the North-East Atlantic. OSPAR covers five subregions where the Greater North Sea is the region relevant for Sweden. Marine litter is one issue relevant for achieving the aim of OSPAR. Some relevant projects are OSPAR Pilot Project on Monitoring and OSPAR’s Assessment of the Marine Litter Problem in the North-East Atlantic Maritime Area and Priorities for Response (see e.g. OSPAR, 2007).

#### **4.1.4 National**

Chapter 15 of the *Swedish Environmental Code (Miljöbalken)* concerns littering and dumping. Litter is prohibited in areas accessible by the public. Dumping of all kind of litter is prohibited within the Swedish sea territory and economic zone. Further waste intended to be dumped in the open sea cannot be brought out of the country or out of the (Swedish) economic zone. The same rules as for dumping of waste also apply to combustion of waste.

#### **4.1.5 Other policy instruments**

The *International Council for Cruise Lines* has adopted mandatory environmental standards for cruise ships in to “implementing a policy of zero

discharges of MARPOL Annex V solid waste products (garbage)...” into the marine environment.

#### 4.1.6 Results from the survey

The respondents were asked about their knowledge on current legislation concerning marine litter (question 41 in Annex A). Most of the respondents stated one or several national or international policy instruments. About 15 of the respondents mentioned the Swedish Environmental Code. About 10 of the respondents mentioned the Marine Strategy Framework Directive and the Directive on Packaging and Packaging waste. Most of the policy instruments in Sections 4.1.1-4.1.4 were mentioned by one or several respondents. In addition to the policy instruments listed in Sections 4.1.1-4.1.4, the following Swedish regulations and policy instruments were mentioned by several respondents:

*The law of measures against pollution from ships (SFS 1980:424)* involves require free-of-charge reception of ballast water in specific Swedish harbors. Such free-of-charge reception also includes flushing water of tanks which might contain concentrations of oil or other hazardous substances.

*The decree of measures against pollution from ships (SFS 1980:789)* involves prohibition of emissions of oil, chemicals or other fluent hazardous substances. The constitution also involves requirements of reception of e.g. ballast water and flushing water of tanks similar to those in the law of 1980:424. The decree also includes requirements of reception of other waste from ships other than ballast water and flushing water of tanks in all harbors (chapter 3 § 5). Further, ships are generally required to leave all of their ship generated waste at Swedish harbors before leaving the harbor (chapter 3 § 12).

*The prescriptions and general advices of the Swedish Maritime Administration concerning reception of waste from ships (SJÖFS 2001:12)* concerns mainly commercial harbors and yards where waste concerns ship generated waste in general. The prescriptions require all harbors and yards to supply reception of all ship generated waste. This reception of waste is not required to be free-of-charge.

*The prescriptions and general advices of the Swedish Transport Agency concerning measures against pollution from ships (TSFS 2010:96)* is closely related to the law 1980:424, the constitution 1980:789 and MARPOL 73/78. It includes prohibition of emission oil, fluent hazardous substances and sewage in the Swedish economic zone. Further the prescriptions generally prohibit e.g. dumping of packaged hazardous substances and solid waste (such as plastic, paper, glass, metal and fabrics) in the Swedish economic zone and sea territory.

Furthermore, the Swedish municipalities have a rather high degree of independence and can influence the management of waste within their own municipality. As a consequence the regulations for waste can be expected to be somewhat different at a local level.

**Table 4.1. Overview of the most important policy instruments concerning marine litter.**

Level of policy instrument	Policy instrument	Mainly targeting...
Global	The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	Prohibits the dumping of garbage from ships
	London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (LC)	Regulates the disposal of waste at sea and prohibits dumping of persistent plastics and other non-biodegradable materials
	United Nations Convention on the Law of the Sea (UNCLOS) and the General Assembly (GA)	Several areas concerning pollution in the sea
	Basel Convention on the Transboundary Movements of Hazardous Wastes and Their Disposal	Hazardous wastes
	Agenda 21 and the Johannesburg Plan of Implementation	Several areas e.g. protection of the oceans, also including waste management
	Convention on Biological Diversity, with the Jakarta Mandate	Several areas are mentioned related to marine litter
	Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP GPA)	Several areas concerning pollution
	FAO Code of Conduct for Responsible Fisheries	Several areas e.g. protection of the oceans, also including waste management
Regional - European	The EU Directive on port reception facilities for ship-generated waste and cargo residues (Directive 2000/59/EC, December 2002)	Prevention of pollution from ships
	EU Marine Strategy Framework Directive	Marine litter is one descriptor relevant for achieving the goal of good environmental status
	The EU Directive on Packaging and Packaging waste (Directive 2004/12/EC)	Management of packaging
	The EU Directive on the landfill of waste (Directive 1999/31/EC)	Landfill
Other related directives	EC Urban Waste Water Treatment Directive (97/27/EEC), EU Environmental Liability Directive (2004/35/EC), The EU Directive on waste (Directive 2006/12/EC), The EU Directive on the conservation of natural habitats and of wild fauna and flora (DIRECTIVE 92/43/EEC), The Water Framework Directive (Directive 2000/60/EC) for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater and the EU Directive concerning the management of bathing water quality (Directive 2006/7/EC)	Several areas
National	The Swedish Environmental Code (Miljöbalken)	Prohibition of dumping of litter within the Swedish sea territory and economic zone
	The law of measures against pollution from ships (SFS)	Reception of ballast

	1980:424)	water
	The decree of measures against pollution from ships (SFS 1980:789)	Prohibition of emissions of oil, chemicals or other fluent hazardous substances
	The prescriptions and general advices of the Swedish Maritime Administration concerning reception of waste from ships (SJÖFS 2001:12)	Reception of all ship generated waste
	The prescriptions and general advices of the Swedish Transport Agency concerning measures against pollution from ships (TSFS 2010:96)	Prohibition of emission oil, fluent hazardous substances and sewage in the Swedish economic zone.

## 4.2 Effects on sources of marine litter

The main sources of marine litter identified in Chapter 2 were both sea-based and land-based sources including the shipping industry, the fishing industry, recreational activities and tourism. From Table 4.1 it is evident that most of the sources of marine litter identified are covered by existing international and national legislation in some way. The presence of marine litter is however apparent. This might be explained by the lack of acknowledgement of the current policy instruments, lack of public awareness of marine litter and its effects, lack of monitoring of litter in Sweden and current legislation and also that current legislation might not be strict enough. The lack of fines and prosecution if violating the legislation might also be an important explanation of the current volumes of marine litter. Also the current system of e.g. reception of waste in harbors and the number of garbage cans on the beaches might not be enough for existing demands.

## 4.3 Potential policy instruments

### 4.3.1 Results from literature review

HELCOM aims to recommend the Governments of the Baltic Sea countries to take actions to raise public awareness on environmental and economic effects of marine litter, including e.g. “ghost fishing” of lost fishing nets, and to mobilize the participation in the beach cleanup initiatives (HELCOM, 2007).

OSPAR works on developing a method for conducting surveys for the purpose of providing data on marine litter on beaches. However a monitoring programme for marine litter is yet to be made mandatory within OSPAR and is currently proceeding on a voluntary basis only (OSPAR, 2009).

### 4.3.2 Results from the survey

In the survey the respondents were asked to propose policy instruments to reduce marine littering and problems following from marine litter (question 45 in Annex A). About 35 % of the respondents stated that they could not answer or left a blank space in this question. However, several potential policy instruments and management measures were proposed in the survey and can be roughly divided into the following sub-categories: collection of marine litter, information, improved monitoring, legislation, packaging and other.

#### 4.3.2.1 COLLECTION OF MARINE LITTER

To increase the number of recycling centers was generally the most common measure proposed to reduce marine litter. Among the policy instruments proposed in this category were also that all harbors should collect litter free of charge and physical limitation of harbor activities to prevent litter from being spread from harbors to the sea.

#### 4.3.2.2 INFORMATION

Information was commonly proposed as a policy instrument for reducing marine litter. The respondents suggested improved information on e.g. effects of marine litter to public and private actors. They also proposed information efforts to build awareness of e.g. marine litter in general, of current legislations and on information on existing recycling centers.

#### 4.3.2.3 IMPROVED MONITORING

A frequently proposed policy instrument was improved monitoring and also supervision and examination of current legislation. Further the respondents requested financial support for monitoring and management measures, information on responsibility of monitoring and increased collaboration between organizations concerning monitoring and management measures.

#### 4.3.2.4 LEGISLATION

An often proposed policy instrument for reducing marine litter concerned the legislation. It included better defined rules and legislation, to review and strengthen the current legislation (regarding marine litter in general, by prohibiting dumping of all kinds of litter). The respondents also requested new legislation such as penalties or fines for marine littering, certification of vessels, to develop existing projects such as clean shipping and to prohibit emission of sewage from large vessels. The polluter pays principle (PPP) was acknowledged by many respondents. Improving sewage treatment to prohibit litter to end up in the seas was also seen as a possible measure.

#### 4.3.2.5 PACKAGING

Other policy instruments proposed to reduce marine litter concerned packaging. The proposals included reducing the use of packaging, introduction of a deposit system for packaging, shifting to biodegradable materials, increased demand on recycling and to increase the producers' responsibility of their produced packages. Plastic was seen a particularly serious problem since it, if left in the seas for long time periods, often tears down to small pieces and particles. To analyze the composition of litter was seen as important to improve the knowledge on sources.

#### 4.3.2.6 OTHER

To increase the cleaning of beaches was commonly mentioned as a measure to reduce marine litter and financial support for cleaning beaches was requested. Research on the effects of marine litter on the marine ecosystem was also seen as important concerning development of new policy instruments.

The policy instruments proposed by respondents in the survey indicate that the current legislation is not fully known to actors that are contributing to marine litter or to actors that are affected by marine litter. The results also indicate that the current legislation can be complemented and strengthened in several ways and that this is seen as a desirable development for most of the respondents.

## 5 Forecasted development of marine litter

Section 5.1 is based on results from the survey and from the literature review summarizing potential forecasts on the trends in marine litter in the business as usual scenario, i.e. the situation of today with current policy instruments and legislation. Section 5.2 is based on results gathered in the survey. It gives a potential forecast on the trends in marine litter (to 2020 and 2050 respectively) if the policy instruments proposed by the respondents in Section 4.3.2 were to be implemented.

### 5.1 BAU

The business as-usual scenario corresponds to the conditions of today regarding e.g. regulations. It is however unlikely that the situation with and effects of marine litter will be unchanged in the future as a consequence of the BAU scenario. This section gives some indications of the development of marine litter and effects following from marine litter in the BAU scenario.

#### 5.1.1 Results from the survey

The respondents were asked to state their view on the general development of marine littering until 2020 and 2050 given the current legislation and policy instrument (question 43 in Annex A). The question regarded the development of marine litter in general and was not divided into the four different indicators of marine litter. The alternatives and the answers are presented in Table 5.1.

**Table 5.1. Results of question 43.**

Question 43 (Annex A)	Respondents representing	Decrease substantially (number of answers)	Decrease Somewhat (number of answers)	Remain unchanged (number of answers)	Increase somewhat (number of answers)	Increase substantially (number of answers)
Until 2020 the situation of marine litter in will....	the North Sea (7 out of 9 respondents gave an answer)		3	4		
Until 2050 the situation of marine litter in will....	the North Sea (7 out of 9 respondents gave an answer)	2	5			
Until 2020 the situation of marine litter in will....	the Baltic Sea (13 out of 24 respondents gave an answers)		5	4	4	
Until 2050 the situation of marine litter in will....	the Baltic Sea (11 out of 24 respondents gave an answers)	2	5	2	1	1
Until 2020 the situation of marine litter in will....	The North Sea and the Baltic Sea (11 out of 14 respondents gave an answer)		5	3	2	1
Until 2050 the situation of marine litter in will....	The North Sea and the Baltic Sea (11 out of 14 respondents gave an answer)	4	3	1	1	2

Most respondents, representing both the Baltic Sea and the North Sea believed that marine litter would decrease somewhat until 2020 and 2050. Many respondents also believed that marine litter would be unchanged or increase somewhat, some respondents believed it to decrease substantially. The answers to the question are quite few when divided into the different management areas. Hence, differences between 2020 or 2050 or when comparing answers representing the Baltic Sea with answers representing the North Sea are particularly uncertain.

Lots of respondents commented that they lacked knowledge to assess the development of marine litter. Other comments were that legislation might not be efficient since the sources are unknown. Several respondents mentioned that they experienced an increased consciousness on marine litter and on effects of marine litter and believed it to be an important factor that would contribute to reduced marine litter. Some respondents meant that the consciousness on these problems increases but so does also the use of packages and the outcome might be ambiguous. Other respondents meant that the use of the marine environment increases which probably also will increase the volumes of litter. Increased consumption and increased shipping was also believed to contribute to increased volumes of marine litter. Several respondents requested a stricter legislation to reduce marine litter.

One question in the survey (question 25 in Annex A) regarded how the volume of litter affecting the respondents' organizations had changed during the last 10 years. The alternatives given in the survey were: The volume...has been unchanged/ has decreased somewhat/ has substantially decreased/ has increased somewhat/ has substantially increased/ do not know. The question generally proved difficult to answer and resulted in a low response rate. The answers given to this question did not provide a clear picture of the whether marine litter had changed during the last ten years or not. This conflicting picture might however be explained by additional detailed regional analyses. It is possible that e.g. islands have been affected by litter regularly the last few years whereas coastal municipalities as a whole have not. Thus, the results from this question cannot be used for supporting descriptions of BAU.

### 5.1.2 Results from literature

As we saw in Chapter 2, there is a general lack of marine litter data in Sweden. There are very few time series available that can be used to determine trends in the GES indicators for marine litter. An exception is the time series from the beaches of the Bohus Coast where litter has been collected since 1992. This data set includes information about the volume collected, as well as number of sacks, fish boxes and oil containers (see Table 2.1). This time series is used to determine the trend in the indicator 10.1.1 Marine litter found on the coast and/or washed ashore. Data from UNEP (2009b) and OSPAR (2009) are used as well to illustrate similar or contrasting trends.

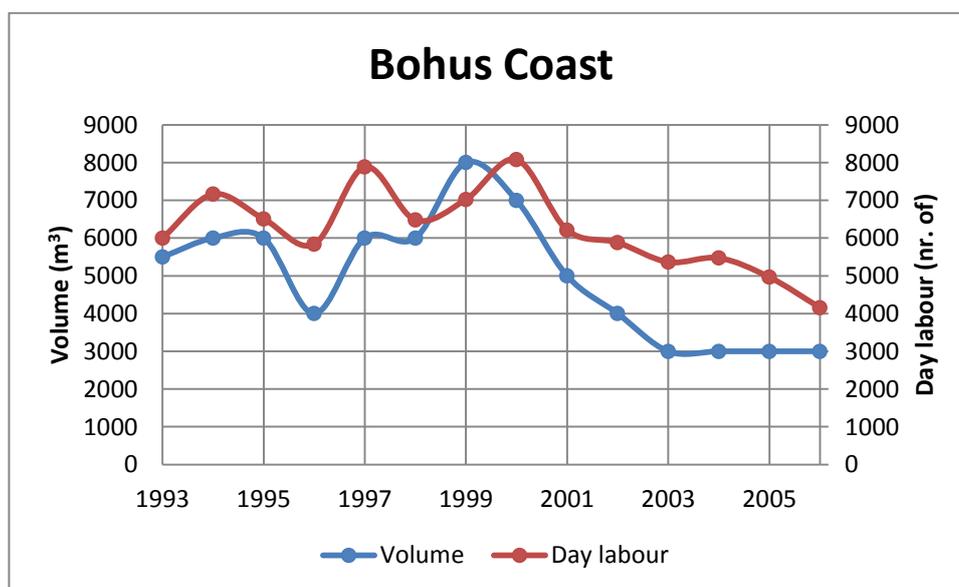


Figure 5.1. Amount of litter collected on the Bohus Coast in 1993-2006 and number of day labours used to collect the litter (see also Table 2.1). The year of 1992 has not been included in the plot as this was the first year of the beach clean-up effort and large amounts of accumulated litter were collected.

Figure 5.1 shows the amount of litter collected along the Bohus Coast in terms of volume (m<sup>3</sup>) and the number of day labours used to collect the litter. Although the amount of litter seems to have been decreasing from 1999 to 2003 and then stagnated, it may not be that there is less litter. This data are for litter *collected* and during the early 2000's there was less money available for the clean-up programmes. As discussed earlier, the amount of litter collected at beaches depends on a number of factors, such as weather conditions, number

of people that collect, etc. The years with lower volume coincide with lower numbers of day labour (see Table 2.1 and Figure 5.1).

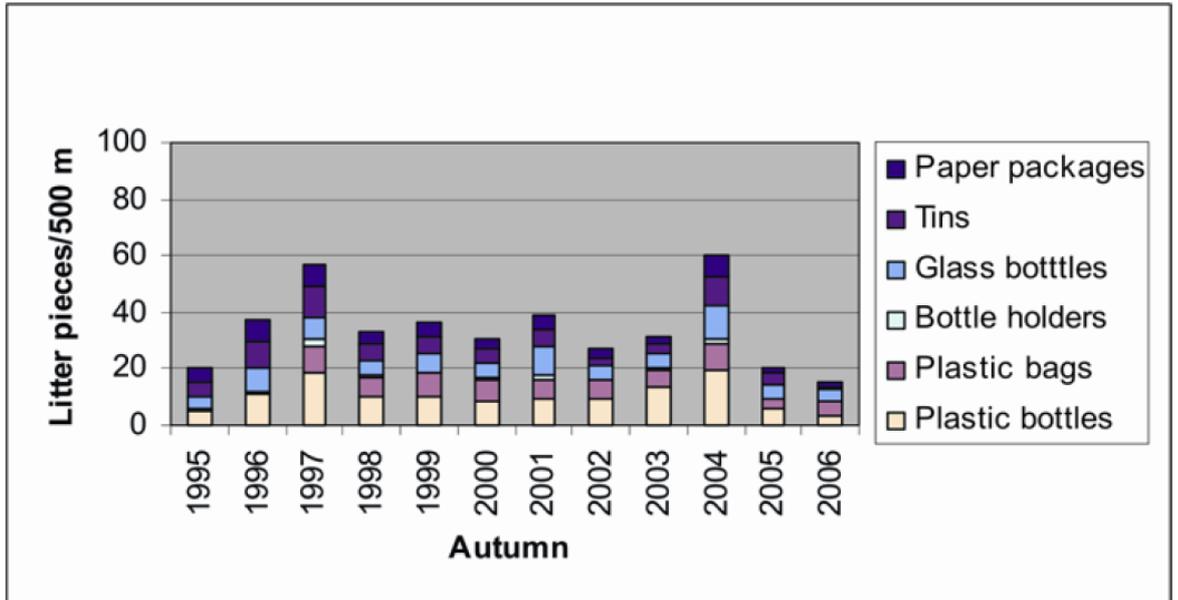


Figure 5.2. The amount of litter items per 500 m of beach found during autumn, 1995-2006. Data provided by Coastwatch Estonia. (Figure from UNEP, 2009b, p. 29).

For comparison, Figure 5.2 shows the amount of litter collected by volunteers on beaches in Estonia during the autumns of 1995-2006. There is no clear trend in this data set either.

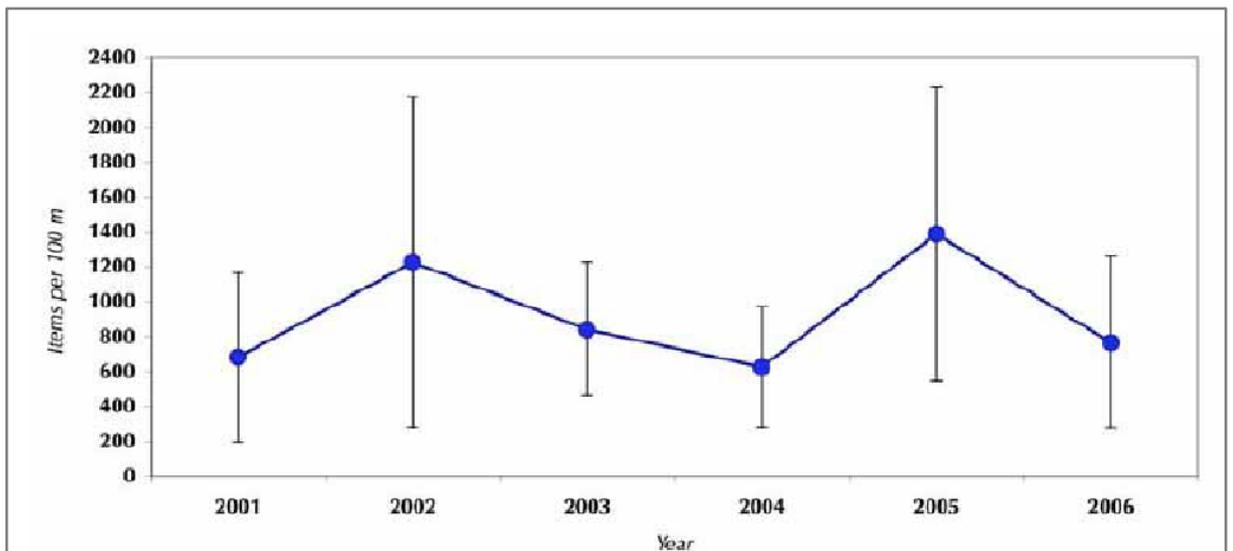


Figure 5.3. Average number of marine litter items on the Northern North Sea references beaches. This data set includes 6 beaches on the Bohus Coast. (Figure from OSPAR, 2009, p. 7)

Figure 5.3 shows the number of marine litter items on the Northern North Sea references beaches 2001-2006. This data set includes 6 beaches on the Bohus Coast. The decreasing trend in the Bohus Coast data cannot be seen here.

Based on Figures 5.1-5.3, there is no clear increasing or decreasing trend in the amount of marine litter found on beaches. Hence, if no new measures against marine littering are introduced, it might be expected that the amount of litter on the coast in the near future remains at about today's levels. There will always be inter-annual variations, but no long-term changes can be forecasted on current data.

For the long-term trend of marine litter on the coast we take into account that this litter can be collected as it is often found in relatively limited areas (compared to the size of the open sea). There are several beach clean-up programmes in place today along the coasts in the Baltic Sea and the North Sea. Given BAU and no change in people's behaviour, the long-term trend in the status of marine litter in the coastal environment is dependent on the beach clean-up programmes.

For the indicators 10.1.2, Litter found in the sea, and 10.1.3, Micro-particles in the sea, we have no time series available but will discuss probable trends for the future. To determine the long term trends for these indicators we take into account the development of the sources of litter, whether the litter can be collected or not, and what the litter is made of. Marine litter on beaches is generally the only type of marine litter that is regularly collected. Marine litter found at sea, both at the surface and at the bottom, is very difficult to clean up, if not impossible, as it is spread out over very large areas. Furthermore, the litter at the sea floor is difficult to detect and impossible to clean-up regularly. A large percentage of the litter found in the sea is made out of plastic which decays slowly. The facts that these litter is not cleaned-up and that it is made of a slow-decaying material suggest that an increase in the amount of litter found at sea can be expected in the future, given business as usual.

The situation is similar for micro-particles. These are very difficult to clean up due to their size and distribution in the water. Many of the micro-particles are made of slow-decaying materials such as plastic and asphalt. Micro-particles in the water can therefore also be expected to increase in the future.

The development of marine litter ingested by animals (indicator 10.2.1) is uncertain and probably depends on the general development of marine litter.

## 5.2 Introduction of new policy instruments

The respondents were asked to state their view on the development of marine littering until 2020 and 2050 given the implementation of the new policy instrument they suggested (see Section 4.3.2 and question 46 in Annex A). In general this question resulted in a lower response rate than the question of suggesting new policy instruments. Table 5.2 presents the alternatives and the answers to the question.

**Table 5.2. Results of question 46.**

Question 46 (Annex A)	Respondents representing	De-crease substantially (number of answers)	De-crease Some-what (number of answers)	Remain un-changed (number of answers)	Increase some-what (number of answers)	Increase substan-tially (number of answers)	Don't know (number of answers)
Until 2020 the situation of marine litter in will....	the North Sea (5 out of 9 respondents gave an answer)	1	4				
Until 2050 the situation of marine litter in will....	the North Sea (5 out of 9 respondents gave an answer)	5					
Until 2020 the situation of marine litter in will....	the Baltic Sea (14 out of 24 respondents gave an answer)	3	6	2			3
Until 2050 the situation of marine litter in will....	the Baltic Sea (14 out of 24 respondents gave an answer)	5	6				3
Until 2020 the situation of marine litter in will....	The North Sea and the Baltic Sea (10 out of 14 respondents gave an answer)	1	7		1		1
Until 2050 the situation of marine litter in will....	The North Sea and the Baltic Sea (10 out of 14 respondents gave an answer)	4	5				1

For the respondents whose answers concerned the Baltic Sea most of the respondents believed marine littering to decrease somewhat to the year 2020 given the implementation of their suggested policy instruments. Some respondents believed marine littering to be unchanged or to decrease substantially to the year 2020. For the corresponding question concerning the year 2050 the respondents believed marine littering to decrease somewhat or decrease substantially. Comments to the question of forecasting marine littering in the Baltic Sea until 2020 and 2050 respectively, given the implementation of their suggested policy instruments, involved that it takes time to implement changes and to change people's behavior. The year of 2020 was seen as a rather short time horizon and the respondents stated that the result depends on how marine litter is assessed (units, techniques etc.). Some respondents thought sanctions or prohibitions would result in desirable changes, while other respondents believed economic incentives would be more efficient.

For the North Sea the answers were similar to the answers for the Baltic Sea concerning the view on the development of marine littering until 2020 given the implementation of their suggested policy instruments. However, until 2050 the respondents believed marine littering to decrease substantially. The respondents' comments to the question of forecasting marine littering in the North Sea until 2020 and 2050 respectively were similar to those concerning

the Baltic Sea. Economic incentives were seen as important and the respondents stated that they thought the desired changes of the proposed policy instruments probably would need some time. For the respondents whose answers concerned both the Baltic and the North Sea most of the respondents believed marine littering to decrease somewhat to the year 2020 and to decrease somewhat or decrease substantially to the year 2050 given the implementation of their suggested policy instruments.

Compared to the answers in Table 5.1 the results in Table 5.2 show a somewhat clearer difference between 2020 and 2050 for both management areas. This might indicate the need for new policy instruments for managing marine litter in Sweden.

## 5.3 Effects on the provision of ecosystem services

Chapter 3 described the potential effects of the provision of ecosystem services following from marine litter. The following sections describe the potential effects of the provision of ecosystem services following from marine litter according to the business-as-usual scenario and following from the introduction of new policy instruments.

### 5.3.1 Following from BAU

With the policy instruments of today, described in Chapter 4, it is probable that the effects on the provision of ecosystem services following from a business-as-usual scenario, described in Section 5.1, will remain until 2020 and 2050 respectively (see also Chapter 3 for effects on the provision of ecosystem services). However, the effects described in Section 5.1 might be enhanced until 2020 and 2050 if the amount of marine litter generally increases. Due to the probable continuation of increased use of packages, increased consumption and increased demand for coastal and marine recreation and tourism marine litter might also increase as a consequence. Despite efforts the volume of marine litter in the North East Atlantic region has remained high and has not decreased during 2001-2006 (UNEP, 2009b). On the other hand it is possible that the effects described in Section 5.1 will diminish if the current international policy instrument and national legislation is further acknowledged, reviewed and implemented.

### 5.3.2 Following from the introduction of new policy instruments

An important determinant of the effects on the provision of ecosystem services after the introduction of new policy instruments is probably the general development of marine litter. The development of marine litter is in turn likely to be determined by potential drivers, such as consumption levels, use of packages, demand for coastal and marine recreation and marine transports (see Section 5.4). Due to the general characteristics of the policy instruments proposed in Section 4.3 it is difficult to point out effects on the provision of specific ecosystem services. Improved reception and collection of waste and marine litter as well as improved information and awareness of the problems following from marine litter will probably reduce negative effects on the provision of ecosystem services in general. Improved monitoring and potentially introduction of penalties or fines for marine littering are also likely to reduce negative effects on the provision of ecosystem services. To improve the system for use of packages by e.g. change to biodegradable materials or introduce deposit system for packages are measures that also might reduce negative effects on the provision of ecosystem services by reducing the amount of marine litter.

## 5.4 Discussion

The development of marine litter described in Sections 5.1 and 5.2 is dependent on what happens with the drivers of marine litter. Recall from Section 2.5 that potential drivers of marine litter are consumption levels (affecting the use of packages), coastal and marine recreation, commercial fishing and marine transports. Increased consumption might lead to an increased use of packages, this in turn probably also increases the amount of litter. However, it is possible that the patterns in use of packages will shift due to raised awareness of caused problems, use of other materials or improved incentives for recycling. An increased demand for coastal and marine recreation will potentially lead to an increased amount of marine litter since lots of the current litter found on beaches comes from coastal and marine recreation and tourism. It is also possible that improved possibilities for reception of litter and growing awareness of marine litter and its effect could lead to reduced volumes of marine litter from recreational activities. Commercial fishing and fishing in general contribute to marine litter. Hence, marine litter will be affected by changes in the fishing sector which in turn probably depend e.g. on fishing regulations and sizes of fish stocks. Yet, lost fishing gear causes cost to the fishing industry which is an incentive to improve systems to keep the fishing equipment complete. Shipping and other marine transports are seen as another source and potential driver of marine litter. It is likely that the demand for marine transports increases with increased market demand for goods. This might lead to increased volumes of marine litter. But an important determinant is also the knowledge, acknowledgement and implementation of current legislation and policy instruments which would generally prevent increased amounts of marine litter.

Many of these potential drivers will probably depend on the general economic and financial development. The common awareness of marine litter and its effects as well as knowledge and acknowledgement of current legislation and policy instruments are also likely to be important factors affecting the drivers of marine litter.

## 6 Cost of degradation

### 6.1 Benefits of reducing marine littering

#### 6.1.1 Results from literature

In the following information regarding benefits of reduced marine litter in Sweden is gathered by a literature review. The estimates are based on results from an ongoing research programme. It is obvious that data on benefits of reduced marine litter in Sweden are scarce although reduced marine litter potentially involves significant benefits.

Within the research program PlusMinus – Economic Assessment for the Environment, Östberg et al. (2011) carried out a valuation study to estimate the value of e.g. establishing special consideration zones in two case studies on the east coast and on the west coast respectively. Establishing special consideration zones implies a number of recommendations that mainly involve less noise and littering. The value of establishing special consideration zones on the east coast was estimated to approximately 500 SEK per year and household. The corresponding estimate for the west coast is approximately 900 SEK per year and household. A share of these values is likely to be attributable to less marine litter.

There were no studies found valuing benefits of reduced marine litter in Sweden in the SEPA report “The economic value of ecosystem services provided by the Baltic Sea and Skagerrak- Existing information and gaps of knowledge” (Söderqvist and Hasselström, 2008). The conclusion from Section 6.1.1 is that data on benefits of reduced marine litter are very scarce and there are very few primary valuation studies carried out to value benefits of reduced marine litter in Sweden.

#### 6.1.2 Results from the survey

The survey also contributes with information on potential benefits of reduced marine litter. In the survey the respondents were asked about potential positive effects following from reduced marine litter (question 35 in Annex A). Table 6.1 presents the alternatives given in the question and the number of answers.

**Table 6.1. Results of question 35.**

Respondents representing... (19 out of a total of 47 respondents gave an answer)	...the North Sea (8 out of 9 respondents gave an answer)	...the Baltic Sea (7 out of 24 respondents gave an answer)	...the North Sea and the Baltic Sea (4 out of 14 respondents gave an answer)
A more efficient production	2	2	1
Increased catch	-	1	1
Increased aesthetic values	7	7	1
Increased attraction values	8	6	1
Other (specify)	6	3	3
No positive effects would arise	-	-	-

Increased aesthetic values and increased attraction values and other (specify) were the most common positive effects following from reduced marine litter. The specifications of the effects involved less costs, less remediation, less complaints from inhabitants and less damage. It also involved improved environmental quality, increased tourism, increased catches, more content inhabitants, less wear on equipment and that rescue actions are more easily carried out. The respondents were also asked to state the economic value of the positive effects arising from reduced marine litter (questions 35 and 37 in Annex A). It is clear from the results that it was easier for all respondents to assign positive effects to the suggested alternatives than to state economic values of the effects.

Question 37 did not result in any specific estimates. One municipality presented the avoided costs for beach cleaning as a value (0.8 MSEK per year). This cost is also presented as a cost in Section 6.2 and to avoid double counting it is not included in the present section. Comments on the question to state the economic value of the positive effects arising from reduced marine litter are that it is difficult to estimate and that data are lacking. However, the respondents indicate that increased tourism, positive effects on marketing, avoided costs (savings and increased resources allocated to other projects for environmental improvements) are significant positive effects arising from reduced marine litter.

Further, the results in Section 6.2 clearly suggest that a large share of the costs consists of lost aesthetic values and lost attraction values. This implies that potentially large recreational and aesthetic benefits would follow from reduced marine litter.

### **6.1.3 Benefits of reduced marine litter related to the provision of ecosystem services**

The benefits of reduced marine litter arise from positive effects on the provision of the ecosystem services described in Chapter 3. This section gives a further description of relationship between the benefits of reduced marine litter and effects on the provision of ecosystem services.

The positive effects of reduced marine litter pointed out by the respondents in the survey concerned aesthetic and attraction values of the coastal and marine environment. These positive effects are probably closely related to changes in

cultural ecosystem services such as Enjoyment of recreation (C<sub>1</sub>) and Enjoyment of scenery (C<sub>2</sub>). The positive effects of reduced marine litter stated by respondents also involved e.g. improved environmental quality and increased catches. Improved environmental quality probably relates to all ecosystem services described in Chapter 3 whereas increased catches is related to provision of food (P<sub>1</sub>). If marine litter in Sweden would be reduced it would generally imply positive effects for all ecosystem services indicated in Tables 3.1-3.4 that currently are negatively affected by the presences of marine litter.

A conclusion from Section 6.1 is that there are several benefits connected to the provision of ecosystem services arising from reduced marine litter in Sweden that have not been quantified in monetary terms. These benefits are potentially large.

## 6.2 Costs of marine litter

### 6.2.1 Results from literature

In the following information regarding costs of marine litter are gathered by a literature review based on two SEPA reports.

The SEPA report “The economic value of ecosystem services provided by the Baltic Sea and Skagerrak- Existing information and gaps of knowledge” (Söderqvist and Hasselström, 2008) was a subproject in a program to gather information about the economic impacts of the human influence on the Baltic Sea and the Skagerrak environment<sup>3</sup>. Söderqvist and Hasselström (2008)<sup>4</sup> reviewed Swedish valuation studies on ecosystem services in the Swedish parts of the Baltic Sea and Skagerrak. The following reviewed studies concern marine litter and effects of marine litter.

Hall (2000) has surveyed socio-economic consequences following from oil spill and marine debris in the UK, Ireland, Denmark, Sweden, Norway, the Netherlands and Germany. Swedish data describe clean-up costs for the Swedish west coast. This data have been gathered for cleaning up the coast line from marine debris and oil every summer since 1992. Due to the changeable and jagged characteristics of the Swedish west coast the cleaning are more expensive than in other areas. In the year 1997 the beach cleaning costs were estimated to be at least 1.2 MEUR<sup>2007</sup> for the province of Bohuslän. The total cost for fouled propellers, blocked intake pipes, damaged nets and destroyed catch following from marine litter was estimated to 0.74 MEUR<sup>2007</sup> per year along the Swedish west coast.

Franzén et al. (2006) has studied socioeconomic aspects of the environmental situation in Skagerrak and describe the socioeconomic effects in the area, related to e.g. marine debris and to ecosystem services such as recreation and aesthetic values. Franzén et al. refers to Väst kuststiftelsen (2005) who estimated the costs for cleaning beaches in Bohuslän from debris in 2004 to 1.2 MEUR<sup>2007</sup>. This number can be compared to the volumes of litter collected in 2004 which are described in Table 2.1 in Section 2.1. If costs regarding the

<sup>3</sup> The project defines the Baltic Sea and the Skagerrak as the waters of the Bothnian Bay, the Bothnian sea, the Gulf of Finland, the Gulf of Riga, the Baltic Proper, the Danish Straits, the Kattegat and the Swedish coast of the Skagerrak.

<sup>4</sup> Monetary amounts are recalculated to EUR2007, using Mean Year Consumer Price Indexes from Statistics Sweden and the exchange rate valid 1 Jan 2008.

fishing-industry caused by fouled propellers, blocked intake pipes, damaged nets and destroyed catch reported in Hall (2000) estimated to 0.74 MEUR<sup>2007</sup> are added to the cost for marine debris in Bohuslän. A total cost estimate for marine debris can be estimated to 1.94 MEUR<sup>2007</sup>. Söderqvist and Hasselström (2008) consider this to be a likely underestimation, since it does not include indirect economic effects of debris, such as effects on the tourism industry. Söderqvist and Hasselström (2008) conclude that further research is needed on socioeconomic effects of marine debris and suggest e.g. a primary study of the public willingness to pay for cleaner coasts.

BalticSurvey (Söderqvist et al., 2010) was carried out to study the public use of and attitudes towards the Baltic Sea. The study was carried out in all of the Baltic Sea countries. Regarding marine litter the results showed that litter is a marine issue that was regarded as a rather big or very big problem in the Baltic Sea by a majority of the respondents in all countries. In Sweden litter was regarded to be a rather big problem compared to other environmental problems in the marine and coastal environment.

The costs gathered in the literature review mainly points out three types of costs, costs for cleaning beaches from marine litter, costs for damages on equipment and lost production (e.g. damaged catch). Unfortunately no cost data for the east coast was found in the literature review.

### 6.2.2 Results from the survey

A main aim of the questionnaire was to survey costs arising for Swedish organizations following from marine litter. A first question intended to group costs arising from marine litter (question 27 in Annex A). Table 6.2 presents the alternatives given in the question and the answers for each alternative. It is important to note that the questions and categories regarding costs might be partly overlapping and the respondents were asked to try to avoid double counting in their answers.

**Table 6.2. Results of question 27.**

Respondents representing... (20 out of a total of 47 respondents gave an answer)	...the North Sea (9 out of 9 respondents gave an answer)	...the Baltic Sea (6 out of 24 respondents gave an answer)	...the North Sea and the Baltic Sea (5 out of 14 respondents gave an answer)
Lost aesthetic values	8	6	1
Lost production	2	2	1
Damages on equipment	3	-	5
Lost working hours	2	2	1
Lost attraction values	9	5	1
Cleaning of marine litter	8	5	4
Other	3	2	-

The answers were uniform for the two coasts and lost aesthetic values, lost attraction values and cleaning of marine litter constituted the most common groups of costs following from marine litter. Damaged equipment was quite frequently mentioned. It is however notable that very few private actors

answered to the questionnaire and categories such as lost production and lost working hours might be more relevant for this group of respondents.

The respondents were also asked to specify the costs arising within each group. Most costs were assigned to less tourism, deteriorated possibilities for recreation and tourism, increased resources needed to handle marine litter (increased costs, working hours and time taken from other activities) and reduced income (e.g. deteriorated fishing). Frequently mentioned costs were also damages on equipment and harmed visitors or animals and damages on ecosystems. Due to marine litter farmers no longer use fields close the coast to avoid harmed animals, this can in turn cause other effects on the ecosystem if the landscape changes. Further consequences following from marine litter mentioned were e.g. chemicals from cans dispersed to the marine environment and increased levels of bacteria due to marine litter.

The respondents were also asked to state the size of the problems arising from marine litter within each group of costs (question 29 in Annex A). It proved difficult for the respondents to estimate the size of the problems arising from marine litter. The majority of the respondents stated that the data were unknown, not estimated or not documented and that such overview were not available and that there are no instruments or tools for collecting the requested data. Several respondents also stated the size of the damage or problems depends on the effort to clean the beaches.

A main aim of the survey was to estimate the costs of the problems or damages that follow from marine litter (question 33 in Annex A). However, it turned out to be difficult for the respondents, since the lack of data was obvious and very few respondents could estimate costs.

The municipality of Göteborg on the coast of the North Sea stated that cleaning of beaches entails an annual cost of 0.6 MSEK. This cost can be compared to the volumes of litter presented for the municipality in Section 2.2.2.1. Sotenäs municipality, also on coast of the North Sea stated 0.8 MSEK as the annual cost for cleaning of beaches.

The County Administrative Board of Västra Götaland stated that cleaning beaches in the north of the province of Bohuslän would cost 5 MSEK per year. Costs for cleaning the beaches of the whole province have been estimated to 10 MSEK per year or 5000 days of work by the foundation Västkoststiftelsen. The County Administrative Board of Västra Götaland (which includes the province of Bohuslän) estimates costs for cleaning the coast of the whole county to 8 MSEK yearly, i.e. somewhat lower than for the smaller area including only the province of Bohuslän according to the cost estimates of the Foundation Västkoststiftelsen.

The County Administrative Board of Halland estimates the costs for damages on equipment to 10 000 SEK per year and cleaning of beaches to 40 000 SEK per year. The costs for cleaning beaches can be compared to the volumes of litter presented for the county in Section 2.2.2.1.

The Laboratory of Sea Fishing states that costs depends on e.g. the size and extent of damages on the trawl, a new trawl costs about 150 000 SEK.

Costs for cleaning beaches have also been gathered after the survey was completed. Cost data from 2010 for most of the municipalities in the province of Bohuslän (see Figure 2.2) have been gathered in an ongoing project (pers. comm. Elsie Hellström). The costs in Table 6.3 include costs for cleaning

beaches, transports, renting of boats and storage and costs for clearance work to reach the litter. Additional costs not included in Table 6.3 are costs for leaving the collected litter to land fill stations. For most of the province of Bohuslän the costs for cleaning beaches estimate to about 7 MSEK in 2010.

The costs in Table 6.3 can be compared to the volumes of litter collected in 2010 in the municipalities of Strömstad, Tanum, Sotenäs and Lysekil respectively, presented in Section 2.1.1.

The costs in Table 6.3 is however somewhat contradictory to the costs stated by the same municipalities in the survey. The costs for cleaning the coast of the province of Bohuslän and for cleaning the coast of the county of Västra Götaland are also somewhat conflicting. These different cost estimates might be explained by the fact that the costs can concern different years or different cost items.

Data on coasts for cleaning beaches are available for Swedish coast of the North Sea, in particular for the province of Bohuslän. Unfortunately no specific cost estimations were found in literature for the coast of the Baltic Sea or stated by respondents representing the Baltic Sea coast.

**Table 6.3. Cost of marine litter collected in municipalities in the province of Bohuslän 2010 (pers. comm. Elsie Hellström).**

Municipality	Costs (MSEK)
Strömstad	1.1
Tanum	0.9
Sotenäs	1.1
Lysekil	1.1
Uddevalla	NA
Orust	0.6
Tjörn	0.2
Stenungsund	0.4
Kungälv	0.6
Göteborg	0.5
Öckerö	0.4
Summed costs	6.9

### **6.2.3 Costs of marine litter related to the provision of ecosystem services**

The costs following from marine littering are in many cases related to degradation in the provision of ecosystem services described in Chapter 3. This section gives a further description of relationship between the costs of marine litter and effects on the provision of ecosystem services.

Costs from the literature review related to ecosystem services are lost production in the case of damaged catch. This would correspond to deterioration in the ecosystem service Provision of food (P1) due to marine litter.

Results from the survey indicate that the costs of marine litter are mainly connected to the loss of aesthetic values and attraction values of the coastal and

marine environment. Respondents also stated that costs involved less tourism, deteriorated possibilities for recreation and tourism. These negative effects are likely to correspond to deterioration in the cultural ecosystem services Enjoyment of recreation (C1) and Enjoyment of scenery (C2).

Frequently mentioned costs in the survey were also harmed visitors or animals and damages on ecosystems. Due to marine litter farmers no longer use fields close the coast to avoid harmed animals. These effects of marine litter imply that the supporting ecosystem service Maintenance of habitat (S5) might be affected if e.g. cattles are important for supporting the status of the shoreline or areas close to the shoreline. Damages on the ecosystem probably involve effects for most of the ecosystem services indicated in Tables 3.1-3.4. Other costs of marine litter mentioned by the respondents were chemicals and increased levels of bacteria due to marine litter. These effects are likely to influence the regulating ecosystem service Regulation of hazardous substances (R5) and most probably additional ecosystem services as well. It is likely that marine litter in Sweden generally imply negative effects for all ecosystem services indicated in Tables 3.1-3.4.

A conclusion from Section 6.2 is that there are several costs connected to the provision of ecosystem services arising from marine littering in Sweden. Many of these costs have not been quantified in monetary terms or are likely to be underestimated in the costs presented in Section 6.2, especially for the Baltic Sea.

### 6.3 Comparing costs and benefits

Data on the economic effects of marine litter in Sweden are scarce. However, marine litter does cause a number of different effects on the provision of ecosystem services. Results from the surveys indicate that negative effects following from marine litter are significant.

There are almost no data on benefits of reduced marine litter but there are some data available for costs of marine litter. The cost data are only valid for the Swedish west coast and no data were found for the Swedish east coast.

Many of the costs arising from marine littering in Sweden have a non-market character. Hence, costs presented in Section 6.2 are likely to be an underestimation of the costs arising from marine littering in Sweden. In this sense costs and benefits reflect the same changes in provision of ecosystem services. For example aesthetic values are lost due to marine litter and they would also increase if marine litter would be reduced. Cost savings can be seen as a minimum estimation of benefits if marine litter would be reduced. Due to the lack of data it is not possible nor reasonable to compare benefits and costs gathered in this chapter.

## 7 Concluding discussion

From the literature review and the survey it is clear that there is a general lack of data on the status of marine litter in Sweden as well as a lack of socioeconomic data describing effects of marine litter. The literature review and the survey also show that marine litter is an urgent environmental problem that causes negative effects on the provision of ecosystem services and causes costs to affected organizations and to society as a whole. More research and data is probably also needed for assessing how marine litter effects the provision of ecosystem services.

The organizations targeted in the survey carried out in this study were mainly central or national organizations. This approach probably affected the results of the survey in several ways. Some respondents stated that information concerning marine litter might be available but would require further investigations within their own organizations such as contact with regional or local departments. However, the time available for answering the survey was quite limited and did not allow such in depth investigations. This indicates that there potentially are more data on marine litter available in Sweden and that further surveys or large scale data collection might be rewarding. Another conclusion from the survey is that it would probably have been rewarding to carry out a pre-study for investigating the most suitable person within each organization or level at each organization to address. Further, the survey in Annex A was quite complex in order to cover as many aspects of marine litter and effects of marine litter as possible. Several respondents stated that the survey was too complicated or too time consuming to answer. The same survey was also sent out to all of the respondents. A less complex survey in several versions adjusted for different organizations (like the surveys used in Mouat et al., 2010) might have increased response rates and improved the answers.

The lack of data on marine litter might be explained by the fact that there is no uniform way in which marine litter is monitored and measured in Sweden. The lack of data involves amount and composition of marine litter as well as spatial distribution and sources of marine litter. Knowledge on the source of marine litter is important in order to manage marine litter in an efficient way. Both the literature review and the survey showed a heterogeneous way of measuring marine litter. The litter collected was measured in different units e.g. m<sup>3</sup>, number of sacks and kg. The literature review also showed that measuring and collecting marine litter on beaches involved several methods and units e.g. items per 100 m coastline and kg litter per 500 m coastline. Increased monitoring and financial support for monitoring of marine litter was seen as important and desirable by respondents in the survey. The need for monitoring of marine litter is also acknowledged by the European commission (COM, 2011a). Further, the Commission points out the MSFD as a possibility for standardization of monitoring and assessment methods concerning marine litter. Regarding information on marine litter the UN suggests a coordinated approach at the national level for collecting data on marine litter (UNEP, 2009b).

There are several policy instruments in place for handling marine litter. The main sources of marine litter are also covered by the current legislation. Marine litter and effects of marine littering has however been apparent in the literature review and the survey in this report. This indicates that the current policy instruments might be inefficient or need to be complemented. Results from the survey point out that raising public awareness and knowledge of marine litter

and its effects and potentially introducing fines for those violating the legislation would improve current policy instruments.

It is evident from the survey that marine litter causes large problems and imposes costs to Swedish organizations. The data on costs of marine litter are however scarce and respondents to the survey state that marine litter does cause costs to their organizations although the size of the costs are unknown. Mouat et al. (2010) point out that if marine litter causes substantial costs to society this might be an incentive, stronger than current legislation, to handle the problem. The respondents also state that there are benefits connected to the reduction of marine litter. These benefits involve aesthetic values, increased possibilities for coastal and marine recreational and tourism. Some data on costs of marine litter were found for the Swedish west coast but no corresponding data could be gathered for the Swedish east coast. Data on benefits of reduced marine litter are even more scarce. We therefore chose to not compare benefits and costs related to marine litter.

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# Annex A. The survey

## Survey on marine litter

Definitions in the survey:

### *Your organization*

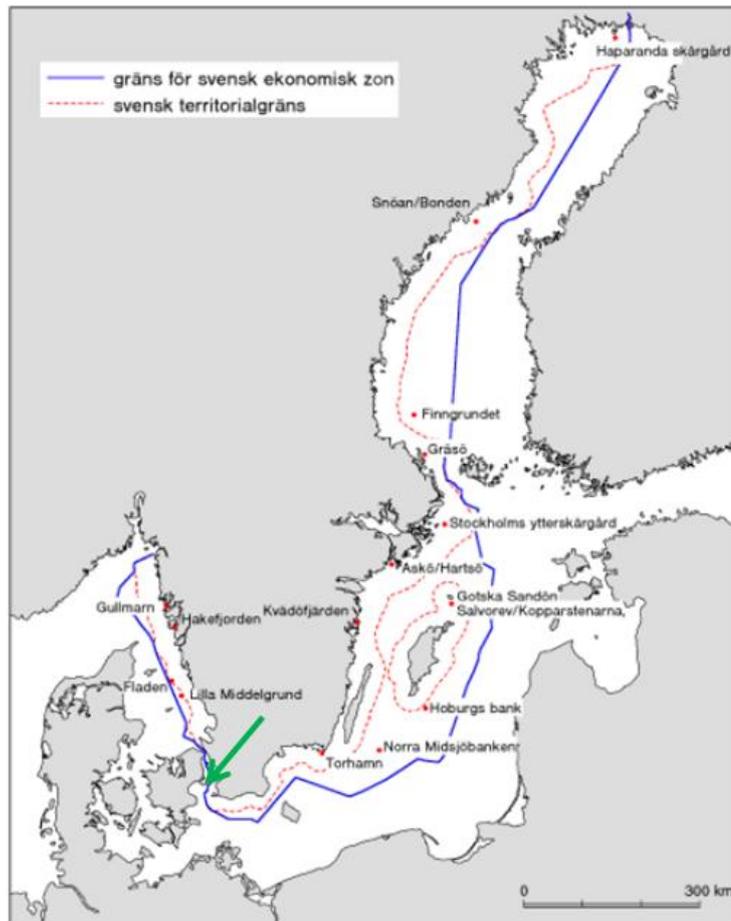
In the questions below the concept “your organization” will be used. In this concept we include all kinds of organizations, e.g. authorities, companies, federations, associations, including their members and the activities of their respective members.

### *Marine litter*

Marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded or unintentionally lost into the sea and on beaches including such materials transported into the marine environment from land by rivers, draining or sewage systems or winds. For example, marine litter consists of: plastics, wood, metals, glass, rubber, fabrics or paper, including micro particles and litter ingested by marine animals. Micro particles originate from wearing on different materials such as fabrics, paint or from wearing on roads or tires. Micro particles are embedded by animals (e.g. animals filtering water).

### *The marine environment*

The questions in the survey regard litter that is present in Swedish water bodies which are defined as Swedish beaches, coastlines, water bodies off-shore close to the coastline as well as water columns and sea floors in the Swedish economic zone. The blue line in the figure below illustrates the border of the Swedish economic zone and the green arrow points out a preliminary border of the two management areas of the Baltic Sea and the North Sea. The management area of the Baltic Sea includes Swedish water bodies from the Gulf of Bothnia in the north to the green arrow in the south. The management area of the North Sea includes Swedish water bodies from the green arrow in the south to the Norwegian border in the north.



The Swedish economic zone is illustrated by a blue line and the green arrow points out a preliminary border of the two management areas of the Baltic Sea and the North Sea.

1. In order to register the answers and to be able to divide the answers into different sectors we ask you to fill in your name, your organization and your professional title below.

*Your name will not appear in the reporting of the survey but if you would be willing to give additional information concerning your answers please also fill in your telephone number and your email address.*

Thank you!

2. Which of the following management areas will your answers mainly concern?

- The North Sea
- The Baltic Sea
- Both

3. Does your organization contribute to marine littering in Sweden?

- Yes
- No

4. It is of importance to gather information on the locations affected by marine litter from your organization. Mark the statements valid for your organization.

My organization contributes to marine litter...

- ...on the beaches or by the coastline
- ...in the open waters, in coastal open waters or at sea bottoms
- ...by affecting the level of micro particles
- ...by affecting the level of items ingested by marine animals
- ...other, please specify:

5. If any, please add additional comments to the previous question.

6. Please state what kind of litter your organization affects the coastal and marine environment with at the location previously indicated.

*Example: In the open waters, in coastal open waters or at sea bottoms: fishing gear and plastic cans.*

- ...on the beaches or by the coastline (followed by a field for specification of type of litter)
- ...in the open waters, in coastal open waters or at sea bottoms (followed by a field for specification of type of litter)
- ...by affecting the level of micro particles (followed by a field for specification of type of litter)
- ...by affecting the level of items ingested by marine animals (followed by a field for specification of type of litter)
- ...other, please specify: (followed by a field for specification of type of litter)

7. If any, please add additional comments to the previous question.

8. Please state the volumes of marine litter caused by your organization at the location previously indicated.

*Example: In the open waters, in coastal open waters or at sea bottoms: 5 m<sup>3</sup> or 1 tonne or 15 sacks*

- ...on the beaches or by the coastline (followed by a field for specification of volume of litter)
- ...in the open waters, in coastal open waters or at sea bottoms (followed by a field for specification of volume of litter)

- ...by affecting the level of micro particles (followed by a field for specification of volume of litter)
- ...by affecting the level of items ingested by marine animals (followed by a field for specification of volume of litter)
- ...other, please specify: (followed by a field for specification of volume of litter)

9. If any, please add additional comments to the previous question.

10. Please state how often your organization causes the volumes of litter at the locations previously indicated.

- ...on the beaches or by the coastline (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- ...in the open waters, in coastal open waters or at sea bottoms (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- ...by affecting the level of micro particles (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- ...by affecting the level of items ingested by marine animals (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Other location (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)

11. If any, please add additional comments to the previous question.

12. How has the volume of litter to the coastal and marine environment caused by your organization changed during the last 10 years?

Please state the change for each of the different types of litter specified below.

- Plastic (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Paper (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Metal (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)

- Wood (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Glass (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Rubber (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Fabrics (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Micro particles (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Other (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)

13. If any, please add additional comments to the previous question.

14. Is your organization affected by marine litter?

- Yes
- No

15. It is of importance to gather information marine litter affecting your organization. Which of the following types of marine litter affects your organization (please also see the definition of marine litter)? Please also specify what the type of litter implies for your organization.

*Example: Plastic: sacks, boxes, lines, styrofoam*

- Plastic (followed by a field for specification of type of litter)
- Paper (followed by a field for specification of type of litter)
- Metal (followed by a field for specification of type of litter)
- Wood (followed by a field for specification of type of litter)
- Glass (followed by a field for specification of type of litter)
- Rubber (followed by a field for specification of type of litter)
- Fabrics (followed by a field for specification of type of litter)
- Micro particles (followed by a field for specification of type of litter)

- Other (followed by a field for specification of type of litter)

16. If any, please add additional comments to the previous question.

17. Please state the volume of litter affecting your organization for the types of marine litter indicated previously.

*Example: Plastic: totally 200 kilos or 5m<sup>3</sup> or 15 sacks etc*

- Plastic (followed by a field for volume of type of litter)
- Paper (followed by a field for volume of type of litter)
- Metal (followed by a field for volume of type of litter)
- Wood (followed by a field for volume of type of litter)
- Glass (followed by a field for volume of type of litter)
- Rubber (followed by a field for volume of type of litter)
- Fabrics (followed by a field for volume of type of litter)
- Micro particles (followed by a field for volume of type of litter)
- Other (followed by a field for volume of type of litter)

18. If any, please add additional comments to the previous question.

19. Please state how often your organization is affected by the volume of marine litter previously indicated for each type of litter.

- Plastic (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Plastic (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Paper (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Metal (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Wood (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Glass (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Rubber (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Fabrics (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)

- Micro particles (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Other (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)

20. If any, please add additional comments to the previous question.

21. Please state what you assume to be the dominating source for each type of marine litter affecting your organization.

- Plastic (followed by a field for specification of source)
- Paper (followed by a field for specification of source)
- Metal (followed by a field for specification of source)
- Wood (followed by a field for specification of source)
- Glass (followed by a field for specification of source)
- Rubber (followed by a field for specification of source)
- Fabrics (followed by a field for specification of source)
- Other (followed by a field for specification of source)

22. If any, please add additional comments to the previous question.

23. Please state whether you believe the dominating source for each type of litter is national or international.

- Plastic (followed by the alternatives national/ international/ don't know)
- Paper (followed by the alternatives national/ international/ don't know)
- Metal (followed by the alternatives national/ international/ don't know)
- Wood (followed by the alternatives national/ international/ don't know)
- Glass (followed by the alternatives national/ international/ don't know)
- Rubber (followed by the alternatives national/ international/ don't know)
- Fabrics (followed by the alternatives national/ international/ don't know)

- Other (followed by the alternatives national/ international/ don't know)

24. If any, please add additional comments to the previous question.

25. How has the volume of litter affecting your organization changed during the last 10 years?

Please state the change for each of the different types of litter specified below.

- Plastic (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Paper (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Metal (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Wood (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Glass (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Rubber (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Fabrics (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Micro particles (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)
- Other (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat/ don't know)

26. If any, please add additional comments to the previous question.

*In the following the alternatives might be overlapping but please try to avoid double counting when stating potential damage caused by marine litter.*

27. Marine litter probably implies damage and costs (e.g. lost income) to a number of organizations.

Please state below what types of damage marine litter cause to your organization. Please also specify the consequences to your organization due to the damage. Please note how your organization is defined since it might affect the size of the damage to your organization.

*Example: Lost production: less catch (lost income)*

- Lost aesthetic values (followed by a field for specification)
- Lost production (followed by a field for specification)
- Damage on equipment (followed by a field for specification)
- Lost work hours (followed by a field for specification)
- Lost attraction values (followed by a field for specification)
- Cleaning of marine litter (followed by a field for specification)
- Other (followed by a field for specification)

28. If any, please add additional comments to the previous question.

29. Please state the size of the damage to your organization for the damage previously indicated.

*Example: Lost production: less catch: 200 tonnes*

- Lost aesthetic values (followed by a field for specification)
- Lost production (followed by a field for specification)
- Damage on equipment (followed by a field for specification)
- Lost work hours (followed by a field for specification)
- Lost attraction values (followed by a field for specification)
- Cleaning of marine litter (followed by a field for specification)
- Other (followed by a field for specification)

30. If any, please add additional comments to the previous question.

31. Please state how often your organization is affected by the damage previously indicated.

- Lost aesthetic values (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Lost production (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Damage on equipment (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)

- Lost work hours (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Lost attraction values (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Cleaning of marine litter (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Other

32. If any, please add additional comments to the previous question.

33. Please state the cost to your organization of the damage with the frequencies previously indicated.

*Example: Lost production: less catch, 40 MSEK*

- Lost aesthetic values (followed by a field for specification)
- Lost production (followed by a field for specification)
- Damage on equipment (followed by a field for specification)
- Lost work hours (followed by a field for specification)
- Lost attraction values (followed by a field for specification)
- Cleaning of marine litter (followed by a field for specification)
- Other (followed by a field for specification)

34. If any, please add additional comments to the previous question.

35. Which of the following positive effects (apart from decreased costs) would arise for your organization if marine litter would be reduced?

Please, specify the positive effects to your organization.

*Example: Increased aesthetic values, at least a 10 % increase of visitors*

- Lost aesthetic values (followed by a field for specification)
- Lost production (followed by a field for specification)
- Damage on equipment (followed by a field for specification)
- Lost work hours (followed by a field for specification)
- Lost attraction values (followed by a field for specification)
- Cleaning of marine litter (followed by a field for specification)
- Other (followed by a field for specification)

36. If any, please add additional comments to the previous question.

37. Please state the value of the positive effects arising to your organization if marine littering would be reduced.

*Example: Increased aesthetic values, at least a 10 % increase of visitors, increased turnover of 0.5 MSEK*

Please, specify the unit for the value stated!

- A more efficient production (followed by a field for specification)
- Increased catches (followed by a field for specification)
- Increased aesthetic values (followed by a field for specification)
- Increased attraction values (followed by a field for specification)
- Other (followed by a field for specification)
- No other positive effects would arise

38. If any, please add additional comments to the previous question.

39. Please state how often the positive effects previously indicated would arise for your organization.

- A more efficient production (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Increased catches (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Increased aesthetic values (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Increased attraction values (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)
- Other (followed by the alternatives every day/ every week/ every month/ every year/ every second year/ every fifth year)

40. If any, please add additional comments to the previous question.

41. What current legislation and policy instruments affecting marine litter in Swedish coastal and marine waters do you know of?

*Example: the EU Directive on Packaging and Packaging waste (Directive 2004/12/EC)*

42. How are these legislations and policy instruments affecting the activities of your organization?

Example: *the EU Directive on Packaging and Packaging waste (Directive 2004/12/EC): increased costs due to management of packaging waste*

43. How do you, as a representative for your organization, assess the development of marine litter until 2020 and 2050 respectively, given the current legislation and policy instruments?

We are aware of the fact that this question involve very long time horizons but we would still like you to make an assessment of how marine litter and its effects will develop in these years.

- Until 2020 the marine litter has... (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat)
- Until 2050 the marine litter has... (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat)

44. Please give a motivation to your answer to the previous question.

45. Which additional legislation or policy instruments would be motivated to implement in order to reduce marine litter and its negative effects?

46. Given the implementation of the legislation or policy instruments proposed in the previous question, how do you, as a representative for your organization, assess the development of marine litter until 2020 and 2050 respectively?

We are aware of the fact that this question involve very long time horizons but we would still like you to make an assessment of how marine litter and its effects will develop in these years.

- Until 2020 the marine litter has... (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat)
- Until 2050 the marine litter has... (followed by the alternatives increased substantially/ increased somewhat/ remained unchanged/ decreased substantially/ decreased somewhat)

47. Please give a motivation to your answer to the previous question.

48. If any, please leave your additional comments on or opinions of the survey.

You have now finished the survey! Thank you for your answers!