Cleaning Costs Marine Strategy Framework Directive

Damage from marine litter to nets and screws

Contractor: Ministry of Infrastructure and the Environment

Rotterdam, November 20, 2012

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ECORYS

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ECORYS Nederland BV
Watermanweg 44
3067 GG Rotterdam

Postbus 4175
3006 AD Rotterdam
Nederland

T 010 453 88 00
F 010 453 07 68
E netherlands@ecorys.com
K.v.K. nr. 24316726

W www.ecorys.nl

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Foreword

This report describes the results of a study concerning the damage due to waste disposal at sea measured in nets and screws. Insights here are relevant in the light of a social cost-benefit analysis (SCBA) for the Marine Strategy Framework Directive (MSFD) that will potentially be carried out in 2013. This will strive to put together an effective and efficient package of measures that can be taken to achieve good conditions for the marine ecosystem. In the previous SCBA in 2011 for the MSFD it was indicated that litter in screws can occur that is troublesome for ships and fisheries (these must be removed, costing time and money). Additionally, litter can lead to damage of the nets in the fisheries. Despite the potentially minimal costs of damage to nets by litter and screws, it is nevertheless important to gain insight into the costs currently incurred in these sectors as a result of marine litter. Such insight is particularly useful considering that these costs/benefits (among the few hard measures) can be expressed as a value in Euros.

Within Ecorys, the study has been carried out by Manfred Wienhoven (project leader), Marius van der Flier and Maarten van Groenigen. The research is guided and coordinated by a committee of representatives of the Directorate General of Public Works and Water Management: Lex Oosterbaan, Xander Keijser and Rob van der Veeren. We thank the members of the committee and the consulted individuals (see appendix 1) for their expert advice and input for the study. Ultimate responsibility for the method, results and content presented in this report lies exclusively with Ecorys.

Summary

Background and goal

In recent years already much of the necessary work for the preparation of the implementation of the Marine Strategy Framework Directive (MSFD) in the Netherlands has been carried out. As part of the socio-economic analysis in the MSFD Initial Assessment, studies have been conducted in three areas: a description of current use, expected future developments and the annual cost incurred by society to achieve or maintain the current state of the marine ecosystem. Also, in 2011, a preliminary social cost-benefit analysis (SCBA) for the MSFD has been carried out.

In 2012, additional information will be collected for some of the impacts addressed in the CBA carried out in 2011. One of these is the economic cost of damage of marine litter for shipping, fisheries and recreation. This report presents the results of a study on the damage of marine litter to these sectors.

Research method

The project was split in two phases. In the first phase of the project literature on the costs was reviewed. Also, the questionnaire for the second phase was developed. Then, interviews were held with representatives from the sector and individual users. In total, some 30 organizations have participated in the study.

In the second phase, the information collected from the interviews was used to develop cost indicators for the damage of marine litter to marine shipping, fishing and recreation and to estimate the total economic costs and losses for these activities on the national level.

Main study results

The following summary of main conclusions is drawn:

In the literature review…

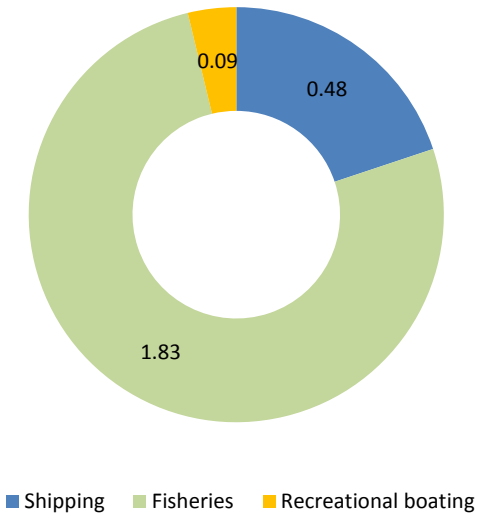
- In the literature, fishery is most often mentioned as the industry experiencing the greatest impact from marine litter. Debris is considered specifically harmful to propellers, water feed lines, anchor and fishing gear.
- Near the coastline the related damage from marine litter is higher. Smaller vessels run a higher risk of damage than relatively larger vessels.
- Few studies actually estimate the economic damage of marine litter. The few that do so, focus on fisheries. No estimates of the cost of damage to shipping and recreation were found.

On the damage to sectors in the Netherlands in particular…

- Figure 1 displays the annual economic damage reported by the participating organizations. The damage reported to sea fisheries is the largest, approx. € 1.8 million per year (of which € 1.3 million is damage to fishing gear). Total damage reported by shipping companies to, e.g. propellers, water feed lines and water jets, adds up tot approx. € 0.5 million. The damage reported for recreational users is very small. This outcome is supported by the interviews with representatives from the leisure industry.
- Relevant remarks in this context:

- In general, there exists a great diversity in the answers obtained from the interviews. This indicates that significant differences exist to the extent that marine litter causes damage to companies within the industry.
- The sources consulted do not systematically monitor the damage. The damages reported are best estimates. It is important to keep this in mind when interpreting the results.
- In addition, damages are not always reported. To some extent, ship owners make their own repairs. This holds especially for recreational boating. Consequently, part of the damage has not been captured in the interviews.

Figure 1 Total economic damage reported by interviewees (mln. €/ year)



On the total economic cost for the Netherlands …

- The literature review suggests that the risk of marine damage (probability x consequence) is dependent on:
  - vessel size
  - location / shipping area
  - precautionary measures

  Based on the interviews, especially the ship's size matters. Larger vessels are less sensitive to damage than smaller ships due to differences in navigation depth and fishing methods. The other factors are considered irrelevant.
- This study estimates that marine litter in the North Sea region is likely to cost somewhere between € 1.5 and € 4 million per year in damage to the shipping industry. The cost of damage to fisheries is estimated at € 1.2 to € 3.5 million per year. In this, it is assumed that the reported damage is representative for the part of the fleet outside the sample. It is not possible to estimate costs for leisure boating in this stage. Based on the interviews, the damage related to marine litter is expected to be very small.

Table 1 Estimate of economic costs for the Netherlands

Industry	Economic damage cost (in € mln./ year)
Shipping	€ 1.5 - € 4.0
Fisheries	€ 1.2 - € 3.5
Leisure boating	PM/ very small

Recommendations

The following are a set of recommendations:

- **Desirable follow-up research dependent on goal:** Whether or not further research into the economic cost of damage of marine litter for shipping, fisheries and recreational boating is necessary, is dependent on the role such information will play in policy making. Further research can help reduce the range in the cost estimates for the different sectors. Only in the case that these damages are expected to play a significant role in the CBA, however, is further research truly of added value. The impression is that this study gives a realistic projection of the damage costs at the national level. It is certainly important that stakeholders in each sector can identify with the findings concerning impact by sector shown here. With this in mind, a suggestion is to provide feedback on the results of the study in a workshop for representatives of the different sectors.

- **Link damage estimates to vessel movements:** Based on the interviews, reliable conclusions can be drawn about the total damage to Dutch shipping. It has been proven impossible to reliably estimate the damage caught uniquely on the Dutch Continental Shelf (DCS). Further in-depth research on vessel movements on the DCS might give insight into the share of damage that occurs on and off the DCS. The need for further research must be seen in the light of the first recommendation.

- **Approach individual recreational boaters:** Due to the tight timeframe for the study recreational boaters have not been approached individually. Marinas, shipbuilding and maintenance and repair companies have only a partial view of the total costs that marine litter might impose on boat owners. Confirmation on reported low damage costs for recreational boating can be reached by collecting additional information from recreational boaters via a questionnaire. Again, the need for further research must be seen in the light of the first recommendation.

1 Introduction

Background

The European Marine Strategy Framework Directive (MSFD) aims to achieve good environmental conditions for all European marine waters. Protection and restoration of European seas however must not be done at the cost of economic activity. The Directive serves a double function: protection of the sea and ensuring that economic activities take on a sustainable character between now and 2020.

In recent years already much of the necessary preparatory work for the implementation of the Marine Strategy Framework Directive (MSFD) in the Netherlands has been conducted. A set of three studies has been carried out for the socio-economic analysis as part of the Initial Assessment for the Netherlands: a description of the current use of the North Sea, expectations in the developments in the activity on the North Sea and an analysis of the costs of degradation of the marine ecosystem. Additionally, in 2011 a provisional social cost-benefit analysis (SCBA) was carried out.

The year 2012 is devoted to gathering detailed information for a few items in this provisional SCBA. One of those items is the damage to the sectors shipping, fisheries and recreation by the impact of debris on nets and screws. Despite the potentially minimal costs of damage to nets and screws, such insight is nevertheless important. This is one of the potential benefits in the SCBA for which the most concrete measurement will be available (with clearly identifiable costs and damages). This report describes the results of an analysis of the damage caused by marine litter for fisheries, shipping and recreation at sea.

Purpose of the assignment

The goal of the study is, by gathering and examining more information, to come to a more thorough understanding of the costs currently experienced in these sectors as a result of marine litter. The study provides the following information:

- **key figures for the cost** experienced by fisheries, shipping and recreational boating due to marine litter;
- **an estimate of the total cost** for shipping, fisheries and recreational boating in the Netherlands under the current circumstances;
- **a monetary estimate of the potential benefits** gained from a reduction of litter at the North Sea for these sectors.

Research method

The current estimate of the cost of marine litter as presented in the provisional SCBA (LEI, 2011) is based on a Scottish study (Hall, 2000). In the first phase of the project, a literature study is conducted regarding the costs of litter at sea for the sectors of shipping, recreation and fisheries. This includes, for example, an examination of a study by Macfadyen (2009), 'Abandoned, lost or otherwise discarded fishing gear', but also information from organizations within and outside of Europe regarding the cost and damage for shipping, fisheries and recreational boating.

Following the literature study, interviews were held with Dutch stakeholders, such as concerned organizations (KVNR, PVIS, HISWA among others) and individual users of the sea. In enclosure 1 an overview is included of the individuals and organizations consulted.

On the basis of the information gathered in the literature study and the interviews an estimate has been made as to the total costs from litter in nets and screws for 'The Netherlands' and the potential (financial) benefits for shipping, fisheries and recreational boating from a reduction in marine litter in the North Sea (as a result of the MSFD).

Structure

The report is structured according to the activities described above. In chapter 2 is a brief analysis of the problem: what are the damage factors that can be attributed to marine debris at sea and what are the costs involved? This chapter discusses the results of the literature review. Chapter 3 reveals the results of taking inventory of Dutch parties by sector. Then, on the basis of the gathered information, Chapter 4 makes an estimate of the total cost for Dutch shipping, fisheries and recreational boating. Chapter 5 finalizes the report with the main conclusions and recommendations aimed at applicability of the results in the next stage.

2 Problem analysis: damage of litter at sea

2.1 Introduction

This chapter contains the findings of a literature study regarding the damage experienced by shipping, fisheries and recreational boating as a result of litter at sea. The literature presented here discusses the *costs* for shipping, recreation boating and fisheries. Studies that focus exclusively on the ecological consequences of litter at sea and pay no attention to the economic impact are considered irrelevant for this investigation. Furthermore, studies in which the costs measured are quantified are of particular interest.

2.2 Literature review

2.2.1 Marine litter typology

Before an overview of the findings of the literature can be given, it is important to clarify the concept of marine litter. Thompson et al. (2011) offer a clear definition for marine debris:

"Marine debris […] consists of items made or used by humans that enter the sea, whether deliberately or unintentionally, including transport of these materials to the ocean by rivers, drainage, sewage systems or by wind."

Origin marine litter

This definition allows for a broad range of possible objects and materials. Thompson et al. (2011) provide an extensive review of scientific literature and policy papers, in which it becomes apparent that the majority of marine debris is made from plastic. The greater part of marine litter (80%) is from a land-based source, and the remainder (20%) comes from an ocean-based source (Mouat et al, 2010).

The provisional SCBA, set up by the LEI (2011) has identified a list of sources of marine litter at the North Sea. Approximations of the origins of debris are concerned here (see figure 2.1). Litter is generated primarily in the shipping and fisheries sectors. The next greatest causes of marine litter are tourists and waste disposal in the rivers. From monitoring data of litter collected along the beach, it can be inferred that 44% of the debris at the North Sea comes from shipping and fisheries, 30% from land-based sources and 26% comes from unknown (or multiple) sources (RWS Noordzee, 2011).

Hotspots for litter?

In a study by Galgani (2000), in depth research was conducted in the polluted locations of oceans and seas. Here the research shows that high concentrations of marine debris are found near shipping routes, around fishing zones and at areas bordering marine currents. The fact that debris is concentrated at these areas seems to suggest that (also) shipping and fisheries contribute to debris in the marine ecosystem. The total amount of debris eventually becomes less concentrated as it spreads to other areas.

Litter hotspots in the European region were found west of Denmark, in the southern part of the Celtic Sea and around the southeastern coast of France. Furthermore, a significant finding is the rapid fluctuation of marine debris as it spreads across the seas and oceans. The density of litter between zones can vary greatly on a daily basis.

2.2.2 *Economic cost in shipping, fisheries and recreational boating*

In recent decades, several studies have focused attention on the economic impact of marine debris in shipping and related sectors. Just a few of these have attempted an empirical research to estimate also the costs of marine debris for shipping.

In the review of **Thompson et al. (2011),** various studies that bring economic costs of marine debris are uncovered. The fisheries, transport and tourism sectors are identified as those experiencing the greatest negative economic impact due to marine debris.
For fisheries, the costs come primarily from the time taken away from fishing. Much time must be spent instead on removing debris from the nets, the screw and cleaning the cool water feed system.

Several other studies give a good reference point for establishing possible damage measures. The core of these studies is discussed below:

- **Brink et al. (2009)**, commissioned by the 'United Nations Environment Programme' (UNEP), delineates the problem of marine litter. Moreover, they cite the aforementioned Scottish study (discussed below) in order to address the costs of marine debris for fisheries.
- The study by **Jeftic et al. (2009)**, commissioned by the 'United Nations Environment Programme' (UNEP), delineates the problem of marine litter as a whole. Furthermore, in contrast to many other studies, attention has also been paid to the exact spread of marine litter across the different oceans. This is done in reference to the research of Galgani (see description of the study by Galgani above).
- A research by **McIlgrorm et al. 2009**, commissioned by the 'Asia-Pacific Economic Cooperation Marine Resource Conservation Working Group', describes the problem of marine debris for the Great Ocean. Besides an elaborate description of the problem, also the Japanese study by Takehama and the Scottish study of Hall are discussed (see these discussed below).
- A study by **MacFadyen et al. (2009)**, commissioned by the 'United Nations Environment Programme' (UNEP), focuses specifically on the costs of abandoned, lost or otherwise discarded fishing gear. Next to a description of the problem, also costs incurred due to marine debris are discussed here. There are, however, no quantifiable costs that could serve as indicators in this research.
- Research by **Fanshawe & Evard (2002)** deduces the costs for fisheries from the Scottish study of Hall (see description below). Furthermore, this study provides a delineation of the problems caused by marine litter.
- A recent Dutch study by **LEI (2011)** addresses the economic costs for Dutch shipping and fisheries. Using figures from the Scottish study (see below), a global estimate is made for

the cost for Dutch fisheries. This study calculates the damage for Dutch fishing vessels that sail on the Dutch Continental Shelf (DCS) (220 in total) to be € 40.000 per year.

As noted earlier, there are almost no studies that give a complete insight into the total costs of marine debris for shipping and other uses of the sea. Two studies have done this: a Scottish study conducted by Hall (2000) and a Japanese study by Takehama (1990). For both studies, a thorough analysis is given below:

Hall (2000)

In this Scottish study, an estimate is made on the basis of information gathered in interviews with individual ports and shippers. Of the fishermen interviewed, the majority (92%) indicated suffering from debris in their nets and damage to the nets caused by debris on the sea floor. Additionally, a great deal of fishers (69%) has regular problems with contaminated catches (due to paint or oil residue for example). Finally, many admitted to having problems with the screw and the cool water feed system because of debris.

In table 2.1, the average costs for fishers are summarized. Damage for fisheries in the United Kingdom is estimated to be about £6,000 - £30,000 per ship per year (ca. € 7.500 - € 37.500). Assuming that the entire fleet of 164 Shetland fishing vessels experience damage, the yearly damage would be a maximum of between £984,000 and £4,920,000 (ca. € 1,2 - € 6,2 million).

Table 2.1 Damage indicators and yearly economic cost per ship

Damage indicator	Damage per year per ship
due to lost time clearing nets of debris	£3,500-£7,000 *(€4.400-€8.800)*
cleaning equipment and nets of contaminants	£250-£1,000 *(€300-€1.300)*
due to time lost fixing nets	£100-£10,000+ *(€125-€12.500+)*
due to time lost with fouled propeller	£60-£500 *(€80-€600)*
to repair nets	£2,000-£10,000+ *(€2.500-€12.500)*
to un-foul propeller	£50-£300 *(€100-€400)*
for gear box inspection	£100 *(€125)*
assuming only one incident per year and working only 40 hours/week	**£6,000-£30,000** *(€7.500-€37.500)*

* In parentheses: *(damage in Euros)*

Source: Hall, 2000

In addition, data is available from the British Royal National Lifeboat Institution (RNLI). In 1998, the RNLI reported 200 rescues from jammed screws, half of which occurred in recreational boating and the other half among fisheries. The cost of these rescue efforts are estimated at € 1,1 million by the RNLI.

Takehema (1990)

In the study of Takehama (1990), insurance data is used to make an estimate of the costs for fisheries. With these figures, a distinction can be made between damage caused by collision with floating objects, jamming of the screw because of debris and engine problems as a result of litter in the cool water feed system. For damage to vessels by floating objects, incidents occur almost just as often for ships of any vessel size.

For other forms of damage, incidents occur more often among smaller vessels, with the exception of the smallest vessels (less than 5 GT; GT stands for gross tonnage, an index that is used to express the volume of a vessel).

The total annual costs as a consequence of marine debris is based on the data for Japan, estimated at 0,3% of the total income for the fisheries sector. This is equivalent to an amount of 6,6 billion Yen in damages per year (ca. € 60 million).

2.3 Summary

Marine litter is a problem with economic consequences for shipping and other related sectors. Especially fisheries seems to experience negative effects due to debris at sea, with the comment that the only studies directed towards the actual costs of litter have been conducted for the fisheries sector. Damages that occur, most often affect the screws, cool water feeds, anchors and fish nets.

There are just a few studies found in which the costs to fisheries and shipping is touched upon. From the Scottish study (Hall, 2000) it becomes apparent that the yearly costs for fisheries is between 6.000 and 30.000 Pounds per vessel (inflation has not been taken into account here). In the Japanese study (Takehema, 1990), the cost of litter at sea for Japanese fisheries is estimated at 6,6 billion Yen per year (again, inflation has not been taken into account here). This amount makes up 0,3% of the total income of fisheries.

The most damage to screws and cool water feed systems take place near the coast. In fisheries, larger vessels are less susceptible to marine debris than smaller vessels, given that their nets (due to fishing in deeper waters) usually do not come near the debris at the sea floor. Additionally, it appears that smaller ships suffer more than larger ships from other types of damage, since these operate closer to the coast where more debris is floating around. The only exception is for the smallest ships (less than 5 GT). A large portion of vessels in this category possesses an external engine, for which the signs of damage are much easier to detect and thus also easier to prevent.

3 Taking stock: damage costs per sector

3.1 Introduction

This chapter discusses the results of the interviews conducted within the shipping, fisheries and recreational boating sectors. For each user function, this section presents a picture of the sector with regards to the relevance of damage caused by litter and an overview of the various types of damage registered (paragraph 3.2). Together with the information from the literature review in chapter 2, this forms the input for chapter 4 in which the total economic costs of litter for these sectors at a national level are brought into perspective. A summary of the costs of the damage registered is included in paragraph 3.3.

3.2 Shipping

3.2.1 From the perspective of the users

The shipping sector is made up of multiple clusters, of which commercial shipping, offshore and hydraulic engineering (dredging) are the most prominent. From each cluster, at least one shipyard has been approached; from commercial shipping all shipyards have been included in the study. In addition, contact was established with the Loodswezen, the Rijksrederij and the Royal Netherlands Sea Rescue Institute (Koninklijke Nederlandse Redding Maatschappij, or KNRM). Also, the Royal Association of Netherlands Shippers (Koninklijke Vereniging van Nederlandse Reders, or KVNR) was approached to find out if it often receives reports of damage from its members. Unfortunately, the KVNR was not able to confirm this, but gave the advice to contact the Loodswezen, responsible for vessels powered by water jet and the Stena Line to investigate the damage to the stabilizers of ferries caused by marine debris. Each of these shipping organizations was contacted. All individuals approached provided their cooperation during this study.

Commercial shipping

The commercial shipping companies approached do not share similar experiences for the various types of damage. Only three shippers report damage to the screw and/or screw shaft. Moreover the number of incidents for this type of damage and the extent of the costs incurred differ greatly between companies. Just one shipper indicated damage to the helm and/or rudder. Also damage to the cool water feed system, the skin and the anchor are reported by just one shipper, albeit by another shipper for each incident.

Two other commercial shipyards responded to the questionnaire such that the types of damages listed were not observed.

Offshore

Two offshore shippers were approached. The first of these indicated to have never encountered the types of damage listed. The damages suffered by its vessels at sea could be explained by actions of the crew or by cables or lines used in offshore shipping. These incidents cannot be registered as damage caused by debris at sea. The second shipping company reported to have suffered no damage at sea.

Hydraulic engineering

Despite various attempts, it was not possible to establish sufficient contact with the sector of hydraulic engineering. An indication of any hindrance experienced by this sector due to marine litter is therefore still lacking in this study.

Loodswezen

The Loodswezen (pilotage) indicated an average of three incidents per year causing damage to the water jets of her pilot tenders; used to bring personnel on board their ships. Other types of damage are not experienced by the Loodswezen.

Rijksrederij

The Rijksrederij announced no damage, or only very rare incidents, due to marine litter in screws and nets. There were three ships used for research for fisheries that experienced damage from time to time to the screws and screw shaft entries caused by own nets and lines. Such damage does not fall within the scope of this research.

Royal Netherlands Sea Rescue Institute

The Royal Netherlands Sea Rescue Institute (Koninklijke Nederlandse Redding Maatschappij, or KNRM, could not give any examples of the types of damage listed in the questionnaire. Incidents of nets jamming the screws are usually the result of carelessness of the crew of the rescue vessel. There were reports of rescue boats with problems of seaweed growth on the vessels. This type of damage falls outside of the scope of the research.

Insurance companies

Enquiry with insurance companies and specialist offices also delivered little relevant information. It was explained that the type of damages listed are not claimable damages for the shipping companies.

North Sea Foundation

Also the North Sea Foundation was contacted to discover the extent of the problem of marine litter. The North Sea Foundation shared their point of view that the Dutch Continental Shelf (DCS) maintains a focus primarily on litter collected in netting and damage to fishing lines. This is not in line with study for the same type of debris in seas around Japan (see chapter 2). This type of debris causes great problems for the methods used by fisheries there.

3.2.2 *From the perspective of ports and shipyards*

To give an impression of the extent to which Dutch shipyards carry out repairs for damages experienced, interviews were conducted with three shipyards. All three shipyards were in agreement that repairs of damage as a result of marine litter hardly took place. At the most, once a year one shipyard carries out a repair to a screw or thruster to remove a fishing line. Where such damages took place was unknown. Potential damage to the skin are reported to be minimal and repaired only as part of a larger maintenance. It is not possible to trace the cause of damage here, nor the location of occurrence.

3.2.3 *Taking stock of damages and related costs*

Table 3.1 provides an overview of the total damages and related costs as reported by the shipping companies in the questionnaire. Concerned here are the damages and costs experienced by three commercial shipping companies in the Loodswezen. Given the great variation in costs reported, only averages are presented in the table below.

Of the 11 shippers participating in this research, 4 have reported damage due to marine litter. Five shippers, among which both offshore shippers are included, indicated to experience the types of damages listed rarely to not at all. The reported damages constitute annual costs of € 475.000, estimated for a joined fleet of approximately 330 vessels. Notable is that the damages to water jets was reported exclusively for the 12 vessels with water jets of the Loodswezen fleet.

According to the respondents, ships do not navigate at sea to steer clear of litter in order to avoid damage; this would result in extra costs of gasoline. Additionally, on the North Sea no areas are flagged for concentrations of marine litter to inform shippers. Two shippers were able to indicate areas where damage is often incurred, namely: rivers, river mouths and shallow water in general and the North Sea coastlines specifically and the many fishing nets along the Portuguese and Spanish coast. Furthermore, it was noted that much marine litter is found at anchoring sites, which causes the anchor to get stuck. In conclusion, one in four shippers found that large vessels are just as susceptible as small vessels to marine litter.

Table 3.1 Cost of damage in shipping as a result of litter at sea

Component	Type of damage	Does this occur?	How often?	Fleet (# ships)	Total costs (Euros) per year			
					Direct costs	Extra costs of gasoline	Other costs	Total costs
Screw	Damage to the screw and/or screw shaft	yes	8x per year	169	130.000	2.000		132.000
						2%		
	Damage from not being able to use the vessel	yes	5x per year	117	100.000			100.000
Helm	Damage to the helm and/or rudder	no to rarely	2x per year	52	3.000			3.000
	Damage from not being able to use the vessel							
Cool water feed	Damage to the cool water feed	yes	> 6x per year	52	18.000	3%		18.000
	Damage to pumps or electrical equipment	yes	1x per year	52	1.000			1.000
	Damage from not being able to use the vessel							
Skin	Damage to the skin (dents, bumps, cracks)	rarely						
	Damage to antifouling	yes	20x per year	52	160.000	5%		160.000
	Damage to zinc blocks (cathodic protection)	yes	10x per year	52	10.000			10.000
	Damage from not being able to use the vessel							
Engines	Damage to engine and/or gearboxes							
	Damage from not being able to use the vessel							
Water jets	Damage to the water jets	yes	3x per year	12	3.000	3.000	3.000	9.000

Component	Type of damage	Does this occur?	How often?	Fleet (# ships)	Total costs (Euros) per year			
					Direct costs	Extra costs of gasoline	Other costs	Total costs
	Damage from not being able to use the vessel	yes	unknown					
Anchor	Damage to anchor and/or anchor chain	yes	3x per year	117	41.000		1.000	42.000
	Damage from not being able to use the vessel							
Nets	Damage to nets							
	Damage to winches/beam etc.							
	Damage from not being able to use the nets							
Stabilizer	Damage to stabilizer							
	Damage from not being able to use the stabilizer or vessel							
Total costs								**475.000**

3.3 Fisheries

Within the fisheries sector, a distinction must first be made between small fisheries and deep-sea fisheries. This distinction is importance as it is expected that each category will experience problems with marine debris to a different extent. Here, it is expected that the small fisheries will experience more problems, due to their activity closer to the coast where there is a greater concentration of marine litter, the smaller size of the vessels and the fact that the nets drag along the sea floor and are thus more likely to become damaged. The findings of the interviews are presented here below.

3.3.1 From the perspective of the small fisheries

To gaina better understanding of potential damages for small fisheries, the branch association Productschap Vis (PVIS) and Visned were approached. Furthermore, contact was attempted with individual fishermen, however it proved to be very difficult to compile a list with contact details for the individual fishermen.

Visned represents fishermen from the cutter and shrimp fisheries. It appears that damage suffered from litter at sea is a very prominent problem for small fisheries. The most frequent incidents include jammed screws, damage to the nets and, to a lesser extent, damage to the helm. It is possible to address damage to the screw while still at sea and fishermen can usually resolve the problem themselves by driving backwards and forwards to release debris from the screw. Damage to the skin and the cool water feed due to litter never occur, or only rarely. Also, there are no reports of contaminated catch due to oil or paint residue for example. The shared impression is that the North Sea has become much cleaner in recent decades. In the past, the problems reported in interviews were far more serious.

3.3.2 Perspective from deep-sea fisheries

To gain a more complete picture of damage suffered by the fisheries, four large shippers were approached. One of these shippers indicates as rarely having incidents of damage due to litter at sea. Another shipper reports damage to nets a few times per year. Other types of damage seem to rarely occur.

One of the shippers for a deep-sea vessel indicated that damage to nets is not as big of a problem in comparison to other (smaller) fisheries. This is because of the floating nets used that do not come in contact with the debris at the sea floor. This is in contrast to the nets used by smaller fisheries that commonly suffer damage to the nets.

From the interviews with the fishery ports it becomes apparent that there are incidents with damage to the screw or water feed system. The exact number proves difficult to specify, given that many shippers solve such problems themselves at sea and do not report these to the ports. Problems with the screw occur primarily among vessels active along the coast. Furthermore, small vessels in fisheries run a greater risk than large vessels because deep-sea fishers often sail on open waters and their nets do not come in contact with the debris at the sea floor. This confirms the results of the Japanese study of the damage caused by marine debris for fisheries (Takehama, 1990) among others.

Finally, one shipper was able to identify specific areas of the North Sea where much plastic becomes caught in the nets. This occurs for example near the Dutch coast at the English Canal. The debris is collected by vessels and burned, and doesn't deliver any noteworthy costs for the sector. From the other interviewees, there is no mention of specific areas of higher concentration of marine litter.

3.3.3 *Taking stock of damages and related costs*

Table 3.2 gives an overview of the frequency of damage incurred and the related costs as reported by the shippers/companies interviewed based on the indicators measured in the questionnaire. Considering that the costs fluctuate greatly across indicators, average figures are presented here.

The small-scale fisheries shows damages experienced by marine litter. From the four interviews with companies of deep-sea fisheries, the damage suffered here is less than for small-scale shippers. These two types of fisheries form together the entire Dutch fisheries sector. The total costs for small-scale fisheries and deep-sea fisheries for the interviewees is ca. € 1,8 million per year, recorded for 15 vessels of deep-sea fisheries (the whole Dutch fleet) and 250 vessels from small fisheries (about 60% of the whole Dutch fleet).

Additionally, the fisheries make no effort to steer clear of the litter at sea to avoid damage. The small fisheries and two shippers report that there are no set locations at sea that can be said to cause frequent damage, with the exception of the known wrecks. One of the shippers indicates that there are areas where a higher concentration of plastic debris gets caught in nets, however this does not deliver a noteworthy contribution to extra costs. Larger vessels are less susceptible that smaller vessels because of the different fishing methods used. Nets of smaller vessels typically drag along the sea floor, making these more likely to suffer damage from debris. Large fisheries do not reach the sea floor and experience less disturbance from the debris at the sea floor. Fishers do not avoid any specific locations on the North Sea due to marine debris.

Table 3.2 Costs of damage in fisheries as result of litter at sea

Component	Type of damage	Does this occur?	How often? (per year)	Fleet (# ships)	Total costs (Euro) per year			
					Direct costs	Extra costs of gasoline	Other costs	Total costs
Screw	Damage to the screw and/or screw shaft	yes	15	250	10.000			150.000
			300	250	400			120.000
	Damage from not being able to use the vessel	yes	650	250	208			135.417
Helm	Damage to the helm and/or rudder	yes	10	250	10.000			100.000
	Damage from not being able to use the vessel							
Cool water feed	Damage to the cool water feed	rarely / never						
	Damage to pumps or electrical equipment							
	Damage from not being able to use the vessel							
Skin	Damage to the skin (dents, bumps, cracks)	rarely / never						
	Damage to antifouling							
	Damage to zinc blocks (cathodic protection)							
	Damage from not being able to use the vessel							
Engines	Damage to engine and/or gearboxes							
	Damage from not being able to use the vessel							
Anchor	Damage to anchor and/or anchor chain	rarely						

Component	Type of damage	Does this occur?	How often? (per year)	Fleet (# ships)	Total costs (Euro) per year			
					Direct costs	Extra costs of gasoline	Other costs	Total costs
	Damage from not being able to use the vessel							
Nets	Damage to nets	yes	30	250	12.500			375.000
		yes	670	250	500			335.000
		yes	5	15	5.000			25.000
	Damage to winches/beam etc.							
	Damage from not being able to use the nets	yes	700	250	833			583.333
Other	Other damage							
Total costs								**1.823.750**

3.4 Recreational boating

3.4.1 From the perspective of the users

To reveal what it is that users of the sea experience of marine litter, various individuals from three water sport branch organizations were approached: HISWA, ANWB and the Water Sport Union (*Watersportbond*). These unions have all indicated no reported incidents of damage to ships caused by debris or related causes at sea. The HISWA was able to confirm this within three of its departments. No new information was gained from these interviews. Following the advice of a regional division of the HISWA, in addition to the ANWB, also the Water Sport Confederation (*Watersportverbond)* was contacted. Also these organizations reported to have no knowledge of damage among recreational boaters due to marine litter.

3.4.2 From the perspective of shipyards

For a more thorough understanding of damage to recreational vessels, six shipyards were approached. Of these six, three were yacht shipyards and three were ship repair yards. From the interviews with shipyards, the results were varied. Four of the shipyards indicated that damage due to marine litter is rarely suffered. Damage is caused primarily by err of the shipper, for example by his own fishing line becoming caught in the screw. Just one shipyard reported marine debris to be a problem. In this case, mostly damage to the screw was observed. An estimated 100 incidents required (minor) repairs to the screw. In most cases, fishing line was the cause of the screw becoming jammed.

Shipyards do not explicitly, nor exactly, keep track of the causes of damage suffered by the vessels. They are mostly concerned with a rough estimate of the damage. Furthermore, there is a portion of the damage incurred that is not reported to the shipyards. One shipyard explained that many customers with problems contact a diver directly to clear a screw or repair damage. The shipyard is not informed in such instances.

3.4.3 Taking stock of damages and related costs

Keeping the aforementioned damage in mind, taking stock of the type and frequency of damage rarely delivers quantifiable information regarding related costs. Only one shipyard was aware of damage, for which minor repairs to the screw are enough to solve the problem. The total costs of repairs are estimated at € 90.000 on a yearly basis.

3.5 Overall results and interpretation

Overall results costs damage per sector

Table 3.5 presents an overview of the yearly costs of damage from marine litter for each sector as reported by the companies interviewed. A trend that is clearly noticeable is that the greatest damage is suffered in the fisheries sector, worth € 1,8 million, of which € 1,3 million is accounted for by damage to nets. The shipping sector reported costs of damage of nearly € 0,5 million Euros. This is generated by damage varying from the screws and the helm to the cool water feed, the skin, the water jets and the anchors. Recreational boaters only come to a total damage, primarily to the screw and screw shaft of a total of € 90.000.

Table 3.4 Total economic cost for all sectors resulting from litter at sea

Component	Type of damage	Costs (Euro) annually interviewed companies			
		Shipping	Fisheries	Recrea-tional	Total
Screw	Damage to screw and/or screw shaft	132.000	270.000	90.000	492.000
	Damage not being able to use vessel	100.000	135.000		235.000
Helm	Damage to helm and/or rudder	3.000	100.000		103.000
	Damage not being able to use vessel				
Cool water feed	Damage to cool water feed	18.000			18.000
	Damage to pumps / electrical equipment	1.000			1.000
	Damage not being able to use vessel				
Skin	Damage to skin (dents, bumps, cracks)				
	Damage to antifouling	160.000			160.000
	Damage to zinc blocks	10.000			10.000
	Damage not being able to use vessel				
Engines	Damage to motor and/or gearboxes				
	Damage not being able to use vessel				
Water jets	Damage to water jets	9.000			9.000
	Damage not being able to use vessel				
Anchor	Damage to achor and/or anchor chain	42.000			42.000
	Damage not being able to use vessel				
Nets	Damage to nets		735.000		735.000
	Damage to winches/beam etc.				
	Damage not being able to use nets		585.000		585.000
Stabilizer	Damage to stabilizer				
	Damage not being able to use stabilizer				
Total Costs		**475.000**	**1.825.000**	**90.000**	**2.390.000**

Interpretation of the results of taking stock

In general, the interviews were not detailed enough to produce an exact estimate of the costs incurred per sector. There are large differences in the extent to which certain target groups are negatively impacted by marine litter. Additionally, the following remarks can be made:

- None of the consulted organizations or individuals kept a record of structural information regarding damage incurred. In all cases, these were estimates made as precisely as possible. This needs to be taken into account when interpreting the results.
- Furthermore, it became apparent that the shipyards were not even aware of all incidents of damage. One of the interviews with a shipyard revealed that many customers resolve jammed screws by contacting divers directly to remove debris. This holds especially for recreational boaters.
- The various water sport unions are not aware of a problem with marine litter. This could suggest that problems with marine litter are rarely experienced in recreational boating.
- Damage suffered by recreational boating is difficult to quantify since the information is only available directly from the yacht ports, yacht shipyards and ship repair yards. Given the short timespan of this study, it was decided at the beginning of the research not to attempt approaching a representative amount of private yacht owners for questioning. This is an omission in the study.

4 Perspective damage costs national level

4.1 Introduction

In this chapter, the results of the interviews and findings in the literature review are translated into estimates for the current costs of damage due to marine debris for the shipping, fisheries and recreational boating in the Netherlands at a national level. To this end, paragraph 4.2 first puts into perspective the factors deemed to have the greatest impact on damages in each sector. Then, using the cost indicators, paragraph 4.3 makes an estimate of total resulting economic costs for the Dutch shipping in the current situation.

4.2 Determining factors

Vessel size

The size of the vessel plays a likely role in the incurrence of damage at sea caused by marine debris. Large ships are less susceptible to damage to the screw and screw shaft, because these ships sink deeper into the water than small ships. Considering that most debris floats at or near the surface of the water, it can be assumed that larger vessels with hulls extending into deeper waters are at less risk than small vessels in terms of damage to the screw and screw shaft.

From the responses of fisheries, the same can be concluded-large ships are less susceptible than small ships-only in this case this is applicable to damage to the nets. Smaller ships are primarily beam fishers, whereby the fishing nets drag along the sea floor. The cause of damage to these nets is mostly (unknown) wrecks. Large fishing vessels typically make use of a floating net (pelagic fisheries) and have no need to drag these over the ground, hence avoiding the risks of debris at the sea floor.

Location / waterway condition

The areas along the North Sea with a heightened risk of damage due to marine litter were not uncovered in this study. Just one shipper was able to point out problem areas throughout the North Sea, but the most of the individuals interviewed were of the opinion that shallow waters such as river mouths, rivers and port areas in general have a greater risk for damage due to litter. Furthermore, another shipper indicated that along the coast of Holland and the English canal were places where much debris became caught in nets. This, however, does not generate a high level of costs.

None of the sectors makes an effort to avoid certain areas of the North Sea, a conclusion that is more or less confirmed by the above mentioned finding that there are no reports of debris ‘hotspots’.

Precautionary measures

None of the parties studied changes course to avoid damage by litter at sea, which also means that no additional gasoline is used.

Unknown cause

The research showed that the cause of much damage is difficult to identify. Often the damage is only discovered once in the port and thus it is difficult to clarify the cause of the damage. Also, in

such cases, it is difficult to judge the where (location) the damage was incurred: on the Dutch Continental Shelf (DCS) or just outside of it? Damage that leads to great cost of repair are not reported.

4.3 Estimate of damages at national level

Shipping

The damages recorded by the companies that were interviewed constitutes yearly costs of € 475,000. There were 320 vessels affected by the damage reported. The Dutch fleet (commercial shipping, offshore and hydraulic engineering) under Dutch administration and a foreign flag consisted of 1700 ships during the base year. Assuming that these numbers have remained constant, the total costs for the entire Dutch fleet could be as much as € 2.5 million per year (1700/320 x € 475,000).

An assumption underlying this estimate is that the proportion of reported damages identical is to the portion actually measured by the fleet. Taking this assumption into account and the fact that the exact location of reported damages is often unknown, a safe estimate is made by taking a standard bandwidth within which the total cost of damage lies. Assuming that half of the number of damage claims is not reported, the upper limit of bandwidth will be approximately € 4 million (2 x € 2.5). Similarly, assuming that half of the number of Dutch vessels do not, or rarely, navigate the North Sea, the lower limit of bandwith would be € 1.5 million (€ 2.5 / 2). On the basis of these assumptions, the total damage to the Dutch fleet due to litter at sea within the Dutch Continental Shelf is between € 1.5 and € 4 million per year.

Fisheries

Given a value of € 1.8 million in cost of damage on an annual basis to the companies interviewed, the total cost to the Dutch fleet (small and deep-sea fisheries) under the Netherlands with a foreign flag could theoretically be almost € 2.5 million per year.

Here it is assumed that during the timespan of the study, the total Dutch fisheries fleet, including vessels with a foreign flag under Dutch administration consisted of about 355 vessels (340 from small fisheries and 15 from large deep-sea fisheries). The proportions of reported damages are assumed here also to be identical to actual measured damages to the fleet (measurement was taken for 250 small vessels and 150 large deep-sea vessels). Since not all vessels necessarily run the same risk of damage proportional to other vessels and the exact location of reported damages is often unknown, a safer estimate can be made taking a bandwidth within which the total damage can lie. With the assumption that the damage could be 50% higher or lower than what is found in this study, the annual damage for fisheries caused by litter at sea within the Dutch Continental Shelf is € 1.2 to € 3.5 million.

Recreation

The damage suffered by recreational boating is difficult to specify based on scarce information that was gathered from the interviews. Various water sport unions and shipyards indicate to not be aware of any problems with marine litter, a tentative conclusion can be drawn here that marine litter does not cause great problems for recreational boating, or at least none that leads to noteworthy costs for the sector.

4.4 Interpretation of results

Reflection on results provisional SCBA 2011

In 2011, the LEI made an estimate of a few damage indicators as part of the provisional SCBA on the basis of a literature review. The damage indicators are applied to the context of the Netherlands in this study. These are the following:

- damage to screws and (cool) water feed
- damage to nets
- contaminated catch

In the table below, a comparison is made between the annual damage estimated for shipping and fisheries in the provisional SCBA and the damage costs in identified in this study as specific to the situation in the Netherlands. From this table, it can be concluded that the costs of damage to fishing nets are similar across the sectors. This means that the costs of damage found in this study for Dutch fisheries are comparable with the estimates concluded by the LEI on the basis of the data used in the study of Hall (2000). It must be noted here that the LEI assumes a smaller number of vessels than in this study. LEI (2011) estimates € 12,000 in damage costs per vessel per year. This study calculates the costs of damage at € 5,300/ vessel/ year.

For damage to screws and damage s a result of contaminated catch, this study uncovers a different perspective. The average annual costs due to damage to the vessel is higher per vessel than the extent of damage concluded by Hall (2010). Hall concludes € 2,000/ year instead of € 180/ year. For this reason, the total damage to nets resulting is higher. Furthermore, the interviews reveal that there are no costs for Dutch fisheries as a result of contaminated catch.

Table 4.1 Comparison of results provisional SCBA (LEI, 2011) and this study

		Annual damage (in mln. Euro)	
		Provisional SCBA (LEI, 2011)	Ecorys, 2012
Shipping		X	€ 2.,5
Fisheries	Damage to screws and (cool) water feed	€ 0.,04	€ 0.7
	Damage to nets	€ 1.3	€ 1.8
	Contaminated catch	€ 0.5	€ 0
	Total	**€ 1.8**	**€ 2.5**
Recreational boating		X	nihil

Omission: Costs related to rescue operations

From the literature study it became apparent that the Royal National Lifeboat Institution (RNLI) of the United Kingdom carries out many rescue missions to help vessels with problems of debris in screws. This is a great source of costs. The interview with the KNRM did not deliver any concrete information from which it can be deduced the extent to which this is a problem in the Netherlands. Also, in the magazine De Reddingboot (The Lifeboat) of the KNRM, there are no reports to this effect. However, this does not mean such incidents never occur. Because the area covered by the RNLI is not comparable with that of the KNRM (not only is the work area of the RNLI much longer as the coast is more than 20x in length, but also the canals that are found here mean that the waterways are more intensely navigated), it can be expected that the costs of rescue operations in the Netherlands are a great deal lower than in the United Kingdom.

Benefits of reduced debris

The yearly damages found in this study are an indication of maximum benefit to be gained for shipping, fisheries and recreational boating sectors by a reduction in debris along the North Sea. In

general terms it can be expected that with a greater reduction achieved by measures of the MSFD, smaller damages will be incurred and lower risk of damage will result (in yearly damage expected).

The relationship between execution of the MSFD measures on the one hand, and achieved profits (benefits) in terms of damage avoided on the other hand is not a direct, one-to-one relationship. The damage reduction delivered by the measures implemented is dependent on various factors. In the first place, this is influenced by the effectiveness with which the measures are implemented. It is uncertain whether the measures will always achieve the desired result. Additionally, from a national perspective, it must be taken into account that there are costs related to implementation and monitoring of litter reduction. These costs must be deducted from the costs of damage avoided to determine the national profits enjoyed.

Moreover, it is expected that a reduction of litter at sea will not be reduced at an even rate to the reduction of damage incurred. In other words, a 10% reduction in litter at the North Sea does not have to mean that costs will decrease by the same amount. In addition to the fact that the composition of litter plays a role, this is especially affected by the way in which the litter is spread around the sea. The density of litter can vary in different locations. Driving back litter in certain areas with a high density of litter, but with little shipping and fishery can create a negative impact on the budget and deliver a minimal cost reduction in terms of reduced damage; and vice versa. Normative for the benefits is the effect on the measures taken to reduce damage in the different areas at sea where shipping, fisheries and recreational boaters are active and not the percentage of litter reduction as a whole.

5 Conclusions and recommendations

5.1 Summarizing conclusions

In this study, on the basis of a literature review combined with interviews with actors from the sectors concerned, an estimate has been made regarding the nature, gravity and extent of the economic damage resulting from litter at sea for the shipping, fisheries and recreational boating sectors.

The following conclusions can be drawn:

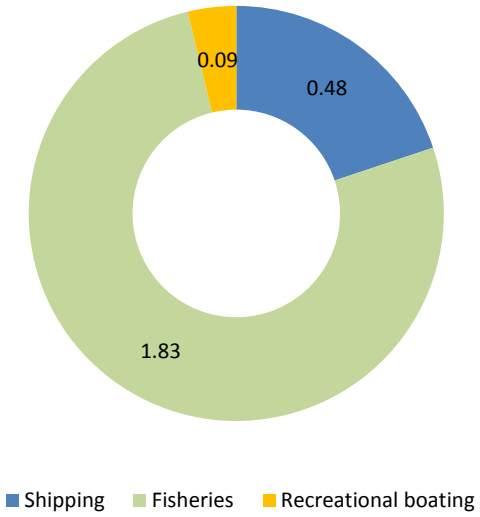
With regards to the findings of the literature review …

- The literature review showed that marine debris causes economic damage in the user functions at sea. Fisheries in particular was identified as a sector that experiences negative consequences. The damage indicators that recur often are damage to screws, cool water feed systems, anchors and fishing nets.
- Most of the damage to screws and cool water feed systems occurs nearby the coast. In fishery, the larger vessels are less susceptible to marine debris than the smaller vessels, given that their fishing nets (due to fishing in deeper waters) do not come near the debris on the sea floor. Moreover, the literature indicates that smaller vessels suffer greater damage than larger vessels from the other types of damage, except for the smallest of vessels (less than 5 GT).
- There are just a few studies available in which the economic impact of marine litter is quantified. A Scottish study (Hall, 2000) calculates a potential annual damage for fisheries of ca. € 7,500 tot € 37,500 per vessel (inflation has not been accounted for here), which comes to a maximum yearly damage for the entire Shetland fishery fleet of € 1.2 to € 6.2 million. A Japanese study (Takehema, 1990) scales the yearly damage caused by litter at sea for the Japanese sea fisheries at ca. € 60 million (again, inflation has not been taken into account here). This makes up 0.3% of the total income of fisheries. There are, to the knowledge of the researchers of this investigation, no studies in which an estimate regarding the cost of damages for shipping and recreational boating is made.

Regarding the findings of the interviews…

- Figure 5.1 provides insight into the economic impact of litter at sea from the interviewed companies. The damage for fisheries is the greatest, measured at € 1.8 million per year (of which € 1.3 million is from damage to nets). For the shipping companies approached, the damage is ca. € 0.5 million on a yearly basis. The damage to the vessels ranges from damage to screws and helm to damage to the cool water feeds, skin, water jets and anchors. The recreational boating seems to have hardly suffered any damage (€ 90,000 per year, for minor repairs to the screw). This is confirmed by the various branch organizations for recreational boating, indicating marine litter to not be a problem.

Figure 5.1 Total economic damage of interviewed companies



- Alongside these figures, a few nuanced comments can be made:
  - In general terms, there are great differences in the extent to which the companies from the various sectors experience marine litter as a problem.
  - None of the consulted organizations or individuals possesses structural information regarding damage incurred. Presented in the interpretation here are precise estimates made as accurately as possible. This must be taken into account when interpreting the damages reported.
  - Additionally, it became apparent that the shipyards were not informed of all of the damage incurred. During one of the interviews with shipyards, an indication was given that many customers to the shipyard are capable of clearing their own screws or take initiative to contact a diver for this purpose. This seems applicable especially for recreational boating, which means that a portion of the damages in this area remains out of sight.

With regards to the total damage caused by litter at a national level …

- The literature study suggests that several factors can influence the risk of marine damage (probability x consequence). This is dependent on:
  - vessel size
  - location / waterway condition
  - precautionary measures
- What becomes clear from the interviews is that vessel size matters. Large vessels are judged as less susceptible to damage than smaller vessels due to the difference in depth (shipping) and fishing ground and fishing rig (relatively shallow and beam versus deep sea and floating nets). The other factors hardly play a role.
- Based on the damage indicators measured per sector, a careful estimate has been made regarding the costs at a national level. The table below presents the results. The following remarks can be made:
  - Shipping: the damage to the Dutch fleet as a result of debris at sea within the Dutch Continental Shelf is globally estimated at between € 1.5 and € 4 million annually. Here it is assumed that the reported damages are identical to the section of the fleet not covered by the interviews.
  - Fisheries: the damage suffered in the fisheries sector as a result of litter at sea is between € 1.2 and € 3.5 million per year. Also for this estimate an extrapolation of the reported

damages has been made for the sector as a whole, adjusting for the composition of the fisheries fleet.

- Recreation: for recreational boating, the information was not readily available. On the basis of the qualitative feedback from the sector, the estimate for damage here is nihil.

Table 5.2 Estimated costs at a national level

Sector	Economic damage (in € mln./ year)
Shipping	€ 1.,5 - € 4.0
Fisheries	€ 1.2 - € 3.5
Recreation	PM/ nihil

5.2 Recommendations

The following recommendations can be made:

- **Desirable follow-up study, dependent on the goal:** The question in how far subsequent research into the damage suffered by marine litter for shipping, fisheries and recreational boating is necessary, depends on the role this information will play in policy making. In this in-depth study, effort has been made to develop a reliable and integrated picture of the economic impact for these sectors. Although the interviews have not always produced quantifiable numbers for measurement, the impression is that a reasonable and realistic estimate of the yearly costs of damage at a national level can be made here. Continued research can certainly help to reduce uncertainty in the margin of error, however, the added value of such research is limited when the relevance for the outcome for the SCBA is low. For example, because other uncertainties such as the lack of knowledge regarding the exact effects of measures taken have a bigger influence. It is certainly important that stakeholders can identify with the presented findings for each sector. With this in mind, a suggestion is to present the findings of the study in, for example, a workshop with representatives from each of the sectors.

- **Linking damage to shipping routes:** On the basis of the information presented here, it is possible to carefully, and within a certain bandwidth, to make a statement about the total costs caused by litter the Dutch sea shipping. Nevertheless, it has not been possible to determine the exact amount of damage suffered from marine debris on the DCS. In order to make a more accurate estimate here, more information is needed, in particular regarding the number of shipping routes in the DCS. This information was not offered in the interviews since shipyards did not have such information directly available or because they did not want to disclose this information to protect their competitive position. Deeper study in this area can lead to a better estimate of damages.

- **Approaching the recreational sportsman at sea:** Given the short timespan of this research, no individual yacht owners were approached. This is an omission in the study. The damage suffered in recreational boating is difficult to quantify since the data comes strictly from yachting ports, yacht shipyards and ship repair yards that seem only to have a limited view themselves on potential damage incurred. By means of supplementary field research, more certainty could be gained into whether or not the damages suffered in recreational boating are indeed so low.

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Appendices

Appendix 1 Consulted individuals

Name	Organization
Niels van de Minkelis	Koninklijke Vereniging van Nederlandse Reders
Piter Oosterhof	Wagenborg Scheepvaart B.V.
M.P. van Rijsinge	Spliethoff's Bevrachtingskantoor B.V.
Gaby Steentjes	Flinter Group
Pieter Borst	Seatrade Holding B.V.
Rob de Vries	Feederlines B.V.
Bob Brouwer	Stena Line
Marjolein van Gennip	Vroon Offshore B.V.
B. van der Wurf	Acta Marine Group
Hr. De Jong	Van Oord Groep
W. van Schothorst	Rijksrederij
Ewoud Hoek	Loodswezen
Jeroen Scharft	Bodewes Shipyards, Hoogezand
Anoniem	Shipdock, Harlingen
Hr. De Jong	Damen shiprepair, Schiedam
Mevr. Van Vliet	KNRM
Jeroen Dagevos	Stichting de Noordzee
Hr. Staal	Interlloydclaims
Geert Meun	Visned
Hans Padmos	Padmos
Johan Muller	Rederij Vrolijk
Aad Jonker	Parlevliet & van der Plas
Rob Pronk	W. van der Zwan
Dhr. R. Vermeire	Deltawerf, Breskens
Anoniem	Jachtservice
Art Hiddinga	Seaport Sailing Yachts
Jochem Admiraal	Kon. Niestern Sander BV
Dhr. Mulder	Damen Den Helder
Geert Dijks Jan Ybema Gerdina Krijger	Hiswa
Cora Seip	Productschap Vis

Postbus 4175
3006 AD Rotterdam
Nederland

Watermanweg 44
3067 GG Rotterdam
Nederland

T 010 453 88 00
F 010 453 07 68
E netherlands@ecorys.com

W www.ecorys.nl

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