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Economic Impacts of Marine Litter






KIMO
KOMMUNERNES INTERNATIONALE MILJØORGANISATION

John Mouat
Rebeca Lopez Lozano
Hannah Bateson

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Executive Summary

Marine litter is now present in every ocean (Cheshire et al 2009) and poses numerous threats to the marine environment. Marine litter is defined as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores." (UNEP 2005: 3)

Although marine litter has received increasing attention in recent years, very few studies have explored the economic impact of marine litter. Therefore, the objective of this research was to investigate the economic impact of marine litter on coastal communities throughout the Northeast Atlantic region. This study updates and extends the pilot project carried out by Hall (2000) and uses a similar methodology to examine how marine litter affects key industries that rely on the marine environment. These industries include agriculture, aquaculture, fisheries, harbours, industrial seawater users, marinas, municipalities, power stations, rescue services and voluntary organisations.

Municipalities throughout the Northeast Atlantic region continue to face high costs associated with the removal of beach litter. UK municipalities spend approximately €18 million each year removing beach litter, which represents a 37% increase in cost over the past 10 years. Similarly, removing beach litter costs municipalities in the Netherlands and Belgium approximately €10.4 million per year. For most municipalities, the potential economic impact of marine litter on tourism provides the principal motivation for removing beach litter. In this respect, regularly removing beach litter costs less than the potential reduction in revenue that could result from taking no action. The potential economic impact of marine litter also provides a more powerful incentive for removing beach litter than current legislation, particularly in the UK.

Voluntary organisations also remove a significant amount of litter from beaches and the coastline throughout the Northeast Atlantic region. In the UK, for instance, each volunteer contributes the equivalent of €16.23 of their time each year on average to removing marine litter. Volunteer involvement in 2 of the largest clean up schemes in the UK, MCS Beachwatch and KSB National Spring Clean, is therefore worth approximately € 131,287.47, which suggests that the total cost of voluntary action to remove marine litter could be considerable.

For many areas, the clean and unspoiled coastline is the principal attraction for tourists. The organisations surveyed during this study were clear that marine litter can threaten the image and reputation of an area potentially leading to a decline in tourist numbers and revenue. With coastal tourism worth between €7 billion (Tourism Alliance 2007) and €11 billion (Deloitte 2008) annually in the UK, this could have a significant negative impact, particularly as tourism tends to make a disproportionately large contribution to coastal economies.

Fishing vessels can also experience a variety of issues due to marine litter and of the Scottish vessels surveyed, 86% had experienced a restricted catch due to marine litter, 82% had had their catch contaminated and 95% had snagged their nets on debris on the seabed. Incidents such as fouled propellers and blocked intake pipes were also relatively common with an average of just under 1 incident reported per vessel per year. Marine litter therefore costs the Scottish fishing fleet between €11.7 million and €13 million on average each year, which is the equivalent of 5% of the total revenue of affected fisheries.

Marine litter presents fewer problems for aquaculture producers and therefore the total cost to the aquaculture industry was comparatively low at approximately €155,548.66 per year. The majority of costs for aquaculture producers relate to fouled propellers on workboats and while the individual cost of these incidents was high, the average cost of marine litter was relatively low due to the infrequent occurrence of these incidents.

Harbours and marinas remove marine litter to ensure that their facilities remain clean, safe and attractive for users. Marine litter costs harbours in the UK a total of €2.4 million each year with an average cost of €8,034.37 per harbour, although these costs are considerably higher for larger facilities and busy fishing ports. While Spanish harbours experienced similar issues to the UK, the economic cost of marine litter was almost 7 times higher than in the UK.

The information provided by harbours and marinas also suggests that incidents involving vessel damage caused by marine litter are widespread with over 70% of UK harbours and marinas reporting that their users had experienced incidents involving marine litter. Fouled propellers were the most common type of incident reported but in general, incidents only occurred occasionally. The most frequently reported cause of fouled propellers was derelict fishing gear, which suggests that this type of marine litter can pose disproportionately high health and safety risks.

Marine litter therefore continues to pose a significant navigational hazard to vessels in the North Atlantic and while the safety of crew members is clearly the foremost concern in these situations, rescue operations involving the coastguard will also have financial implications. The rising trend in the number of rescues to vessels with fouled propellers is therefore of particular concern. In 2008, for example, there were 286 rescues to vessels with fouled propellers in UK waters at a cost of between €830,000 and €2,189,000.

Coastal agriculture producers experience a wide range of issues due to marine litter including damage to property and machinery, harm to livestock and the cost of litter removal. Marine litter cost each croft an average of €841.10 per year and the vast majority of these costs are incurred during the removal of marine litter, although harm to livestock and damage to machinery can result in high costs when these incidents occur. Overall, marine litter costs the agriculture industry in Shetland approximately €252,331 per year but it is unknown how marine litter affects farmers in other coastal regions.

Marine litter clearly affects a wide range of industries and a case study of the Shetland Islands, in the United

Kingdom, shows how these costs can affect one coastal community. Overall, marine litter costs the Shetland economy between €1 million and €1.1 million on average each year. As fishing is one of the main industries in Shetland, it bears the brunt of these costs but this is likely to vary in other coastal communities where industries such as tourism may be more important and thus affected by marine litter to a larger extent. Since Shetland represents only a single case study, these findings also suggest that the total economic impact of marine litter on coastal communities in the Northeast Atlantic region could be extremely high.

This study also investigated the wider context of the impacts of marine litter and in particular, the sensitivity and priorities of various sectors as regards marine litter. Although organisations stressed the importance of a clean and high quality environment, marine litter affects almost 66% of the organisations surveyed during this project. Overall, marine litter affects these organisations either by directly impacting on their core activities or through the need to remove litter, which requires additional resources and expenditure. The majority of organisations surveyed during this project also stated that absolutely no litter was acceptable in the marine environment, although many recognised that achieving a minimal level of marine litter is perhaps a more realistic target. These organisations were therefore agreed that current levels of marine litter are unacceptable.

Several general themes also emerged in this study and these were evident in virtually every industry surveyed. Firstly, it is clear that in the case of marine litter, the polluter does not pay with many organisations forced to find the resources and funds to deal with litter caused by other parties. Similarly, it is important to acknowledge that while many of these efforts mitigate the short-term impact of marine litter, they do not directly address the underlying marine litter problem. Furthermore, marine litter represents an additional and completely unnecessary cost to these organisations, many of which face increasing difficulties balancing service provision with limited funds.

This research also highlights that while the economic impact of marine litter occurs at a local level, action to reduce it must be global. With marine litter originating from many diffuse sources, there needs to be a step change in how the problem is treated at a national and international level. As a starting point, marine litter needs to be regarded as a pollutant on the same level as heavy metals, chemicals and oil and therefore given the same political credibility.

Attention also needs to be given to the way we design and treat products, particularly those made of plastic, with too many currently designed for one use and then thrown away. Similarly, the enforcement of litter legislation must be improved if the sources of marine litter are to be significantly reduced. In principle, current legislation does much to reduce marine litter but in practice, stronger networks of enforcement and significant fines are required to realise the full potential of these regulations.

These challenges are not new but the way we address them must be if we are to significantly reduce marine litter. What is clear is that without strong action to tackle the sources of marine litter, the costs associated with it will continue to rise.

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1. Introduction

Marine litter is now present in every ocean (Cheshire et al 2009) and poses numerous threats to the marine environment. Marine litter is defined by the United Nations Environment Program as:

> "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores." (UNEP 2005: 3)

Marine litter therefore originates from a diverse range of land- and ocean-based sources and includes numerous different types of litter, although plastics account for the majority of items (Derraik 2002). Determining how much marine litter is present in the oceans is challenging, however, given the variety of ways litter can enter the marine environment and the relatively slow rate of degradation of most marine litter items, particularly plastics. Nevertheless, the amount of litter reaching the marine environment is significant (Derraik 2002) with estimates suggesting that there are between 13,000 and 18,000 pieces of marine litter per square kilometer of ocean (UNEP 2005; UNEP 2006).

Figure 1.1: A littered beach in the UK. Image: © Jacki Clark, MCS.

Marine litter can cause a wide variety of negative environmental, social, economic and public health and safety impacts. As a result, marine litter has attracted increasing attention in recent years from both policy makers and researchers. In terms of legislation, marine litter is specifically addressed as part of the UN Resolution A/RES/60/30 – Oceans and the Law of the Sea – and under the EU Marine Strategy Framework Directive (2008/56/EC). Various studies have also focused on marine litter and this research has generally concentrated on identifying the types, sources, amounts, trends and environmental impacts of marine litter. Very few studies, however, have explored the economic impacts of marine litter.

The main objective of this project therefore is to investigate the economic impact of marine litter on coastal communities throughout the Northeast Atlantic region. This study updates and extends the pilot project carried out by KIMO International in 2000, which investigated the financial and social costs of marine litter (Hall 2000). Using a similar methodology to Hall (2000), this study examines how marine litter affects key industries that rely on the marine environment including:

- Agriculture
- Aquaculture
- Fisheries
- Harbours

- Industrial seawater users
- Marinas
- Municipalities
- Power stations
- Rescue services
- Voluntary organisations
- Water Authorities

To present the findings of this research, the following structure has been adopted in this report. Chapter 2 provides a review of existing literature about the types, sources, amounts and impacts of marine litter. Chapter 3 outlines the key international agreements and legislation that directly and indirectly address the problem of marine litter. Chapter 4 sets out the methodology used in the project and describes the data collection process. In chapters 5 – 13, the key findings are presented for each sector involved in the project. These chapters explore how marine litter affects each sector, how much it costs to deal with and the types of litter prevention methods adopted by each sector. Chapter 14 draws together the various strands of the project into a case study of the economic impact of marine litter on one coastal community in the United Kingdom. The project also investigated the wider context of the impacts of marine litter and these findings are presented in Chapter 15. Finally, Chapter 16 outlines the conclusions of the project.

2. Literature Review

Marine litter is one of the most pervasive pollution problems affecting the marine environment and "unless effective action is taken, the global marine litter problem will only continue to worsen in the years to come" (UNEP 2009: 11). Marine litter originates from numerous sources and can cause a wide range of environmental, social, economic and public health and safety impacts. Research to date has focused on the types, sources, amounts, trends and environmental impacts of marine litter while studies into the economic impacts of marine litter remain relatively rare. Although the dynamic and diffuse nature of marine litter makes systematic assessments of the problem difficult (UNEP 2009), research is crucial to provide a strong foundation for confronting the marine litter problem.

2.1 Types of marine litter

Marine litter includes a wide variety of different types of debris and these can be classified into several distinct categories:

- **plastics** including moulded, soft, foam, nets, ropes, buoys, monofilament line and other fisheries related equipment, smoking related items such as cigarette butts or lighters, and microplastic particles
- **metal** including drink cans, aerosol cans, foil wrappers and disposable barbeques
- **glass** including buoys, light globes, fluorescent globes and bottles
- **processed timber** including pallets, crates and particle board
- **paper and cardboard** including cartons, cups and bags
- **rubber** including tyres, balloons and gloves
- **clothing and textiles** including shoes, furnishings and towels
- **sewage related debris (SRD)** including cotton bud sticks, nappies, condoms and sanitary products (Cheshire et al 2009; Beachwatch 2009a).

2.1.1 Plastics and synthetic materials

Plastics dominate marine litter and represent a significant threat to the marine environment due to their abundance, longevity in the marine environment and their ability to travel vast distances. Despite representing only 10% of all waste produced (Thompson et al 2009a), plastics account for between 50-80% of marine litter (Barnes et al 2009) and this is expected to continue to grow for the foreseeable future (Thompson et al 2009b).

Plastics are relatively cheap to produce which has led to more items being discarded. Since they are also lightweight and long lasting, plastic items can travel extremely long distances and continue to pose a hazard to marine life for long periods of time (Laist and Liffmann 2000). Consequently plastics present a long-term threat to marine ecosystems as they can directly harm wildlife (Sheavly and Register 2007), damage benthic environments (Moore 2008), transport non-native

and invasive species (Cheshire et al 2009), and concentrate toxic chemicals from seawater (Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts et al 2008). A growing area of concern is the potential impact of microplastic particles, which are now abundant throughout the world's oceans and beaches, but the environmental significance of this type of pollution is yet to be fully understood (Thompson et al 2004).

2.2 Sources of marine litter

Marine litter results from human actions and behaviour, whether deliberate or accidental, and is the product of poor waste management, inadequate infrastructure and a lack of public knowledge about the potential consequences of inappropriate waste disposal (UNEP 2009). Marine litter therefore originates from numerous different sources with approximately 80% of litter entering the marine environment from land-based sources and the remaining 20% originating from ocean-based sources (GESAMP 1991), although this varies between areas (Allsopp et al 2006).

2.2.1 Land-based sources of marine litter

Marine litter can be generated on land in coastal areas including beaches, piers, harbours, marinas and docks (Allsopp et al 2006) as well as many kilometers inland, due to the long distances litter can travel in the environment (Ten Brink et al 2009). Litter is both intentionally and inadvertently discharged into the environment and can result from a wide range of activities including coastal tourism, fly-tipping, local businesses and poorly managed waste disposal sites (Allsopp et al 2006; UNEP 2009).

Land-based sources of marine litter include (Allsopp et al 2006):

- **Public littering** – A wide variety of litter items are discarded, either intentionally or accidentally, by the public at the beach, coast or into rivers resulting in their introduction into the marine environment. Tourist and recreational visitors are a key source of litter with public littering accounting for 42% of all debris found during the 2009 UK Beachwatch survey (Beachwatch 2009b).
- **Poor waste management practices** – Poor waste management practices can result in debris from waste collection, transportation and disposal sites entering the marine environment. Although litter can originate many kilometers inland, poorly managed coastal and riverine landfill sites, and fly tipping are key concerns.
- **Industrial activities** – Industrial products can be introduced into the marine environment when they are either poorly disposed of or accidentally lost during transport, both on land and at sea. Small plastic resin pellets, the feedstock for plastic production, are a widely recognised example of this and are regularly found during marine litter monitoring surveys.
- **Sewage related debris (SRD)** – Sewage related debris results from the discharge of untreated sewage into the marine environment, either due to a lack of waste treatment facilities or from combined sewer overflows

Figure 2.1 Small plastic resin pellets. Image: Dr Jan van Franeker, IMARES.

during storm events. SRD constitutes a small proportion of the overall litter problem, accounting for only 5.4% of marine litter found during the 2009 UK Beachwatch survey (Beachwatch 2009a), but it can be particularly offensive in nature (ENCAMS 2007).

- **Storm water discharges** – Litter can collect in storm drains and subsequently be discharged into the marine environment during storm events.

2.2.2. Ocean-based sources of marine litter

Ocean-based sources of marine litter include shipping, the fishing industry and offshore oil/gas installations. Ocean-based litter enters the environment through both accidental and deliberate discharges of items ranging from galley waste to cargo containers (Allsopp et al 2006).

Ocean-based litter is generated by (Allsopp et al 2006):

- **The fishing industry** – Nets, ropes and other fishing debris are among the most visible elements of marine litter and result from a failure to remove gear, accidental loss of gear or the deliberate dumping of nets, ropes and other waste by fishing crews.
- **Shipping** – Despite international legislation prohibiting the disposal of manufactured items at sea, these continue to be accidentally released, stored inappropriately or discarded deliberately by shipping vessels, particularly on long journeys. A key concern is the frequent loss of cargo containers from commercial shipping with up to 10,000 of these containers lost worldwide each year (Podsada 2001).
- **The leisure industry** – Recreational boat owners and operators may accidentally or deliberately discharge waste and other manufactured items into the marine environment. Such litter can include food containers, plastic bottles and recreational fishing gear (Sheavly 2005).
- **Offshore oil and gas platform exploration** – Offshore oil and gas activities can result in the release, both accidental and deliberate, of a wide variety of items into the marine environment. These include everyday items such as gloves and hard hats as well as waste generated from exploration and resource extraction.

2.3 Amount and persistence of marine litter

2.3.1 Amount of marine litter

While it is clearly evident that marine litter is now present in every ocean (Cheshire et al 2009), establishing the amount of litter in the oceans is extremely difficult (Allsopp et al 2006). Quantifying the amount of marine litter in the oceans has thus far been approached in three main ways: estimating the amounts of litter already in the ocean, determining how much is added each year and through marine litter monitoring surveys.

2.3.1.1 Amount of marine litter already in the ocean

Global estimates of marine litter levels are inherently complex and reliable estimates are thus relatively rare. In 2005, UNEP estimated that on average there are 13,000 pieces of marine litter per square kilometre (UNEP 2005) but a separate UNEP report a year later suggested that there are 46,000 pieces of marine litter per square mile (approximately 18,000 per square kilometre) (UNEP 2006). Although these figures must be regarded with a degree of caution since no data was provided to support these estimates, the amount of marine litter reaching the oceans is undoubtedly "substantial" (Derraik 2002: 843).

2.3.1.2 Yearly increases in marine litter

Various attempts have been made, both at a global and regional scale, to estimate how much litter enters the marine environment every year. Globally, estimates suggest approximately 6.4 million tonnes of litter enter the oceans each year (US National Academy of Science 1975 cited in Cheshire et al 2009), although this figure is now somewhat outdated. In the early 1980s, it was estimated that up to 8 million items of marine litter enter the oceans daily (Horsman 1982) but this figure now needs to be updated and multiplied several fold (Barnes 2005). At a regional level, the OSPAR Commission suggested that approximately 20,000 tonnes of marine litter enters the North Sea each year (OSPAR 1995), although no sources were provided to support this estimate. Despite variable overall estimates, however, it is widely accepted that both the levels of marine litter and the rate of input into the oceans are rising (Barnes 2002; Derraik 2002).

2.3.1.3 Marine litter monitoring

Marine litter monitoring programmes are currently carried out in a number of different countries throughout the world but differences in study design, methodology and purpose makes comparison between monitoring programmes challenging (Cheshire et al 2009). Approximately 70% of marine litter sinks to the seabed, 15% floats in the water column and 15% washes up on shore (OSPAR 1995), and different methods of assessment are required to investigate each of these litter sinks. Generally, these programmes aim to establish long-term data sets from which it is then possible to interpret trends in the composition and abundance of litter over time.

2.3.1.3.1 Amounts found on the coastline

Beach litter surveys are the most common type of monitoring programme and are frequently undertaken with the help of volunteers. On a global scale, the Ocean Conservancy co-ordinate the International Coastal Clean-up (ICC), where volunteers from across the globe conduct litter surveys on one day in September. Volunteers in 2009 collected 10.24 million items of debris in 108 different countries with the top 3 items – cigarette butts, plastic bags and food containers – accounting for over 40% of the debris collected (ICC 2010). Between 2001and 2006, the Ocean Conservancy also conducted a project on behalf of the U.S. Environmental Protection Agency to establish baseline data about the extent of the marine litter problem in the U.S. Using over 600 volunteers, the project monitored 'indicator' items of litter over the five year period in 21 different states. While there were wide variations in the number of litter items reported at each location, an average of 96 litter items were removed per survey with only Hawaii reporting an appreciable decrease in litter levels over the course of the study (Sheavly 2007).

In the OSPAR region, a pilot study published in 2007 found an average of 542 items of marine litter of various sizes per 100-metre survey on the reference beaches. Surveys were also made on 1-km stretches for larger items (>50cm in any direction) and on average 67 marine litter items were recorded per kilometre. The total number of marine litter items found per survey varied considerably between regions with, on average, significantly higher levels occurring on beaches in the northern regions (Northern North Sea and the Celtic Seas) than on the beaches on the Iberian coast and in the Southern North Sea. The overall amount of marine litter in the North Atlantic remains consistently high with no statistically significant increase or decrease in the average number of items recorded (OSPAR 2009).

Beach monitoring surveys are also often conducted at a national level. In the UK, the Marine Conservation Society co-ordinates Beachwatch, a volunteer monitoring programme which has been running since 1994.

On average, 1,849 items were found per km of beach surveyed in 2009, although this was highly variable between regions with South West England recording the highest levels. Overall, the 2009 results represent a 77% increase in litter since the first Beachwatch survey in 1994 when 1,045 items/km were recorded. Plastics have consistently accounted for over 50% of litter recorded in all Beachwatch surveys and the 2009 survey recorded the highest percentage of plastics to date at 63.5% (Beachwatch 2009a).

Figure 2.2: Volunteers participating in the Marine Conservation Society's Beachwatch scheme. Image: © Jacki Clark, MCS.

2.3.1.3.2 Amounts found at sea

With 70% of litter sinking to the seabed and 15% floating in the water column (OSPAR 1995), the vast majority of marine litter is found at sea but comparatively few studies have investigated the abundance of marine litter at sea. In terms of litter on the seabed, a study by Galgani et al (2000) used trawl nets to investigate the density of marine litter on the seafloor along European Coasts. Densities were subject to significant geographical variation and ranged from 0 to 101,000 pieces of litter per km². Plastics, particularly bags and bottles, accounted for more than 70% of litter collected at most stations with accumulations of specific debris such as fishing gear also frequently encountered. The mean density of debris for each area was 126 items/km² in the Baltic Sea; 156 items/km² in the North Sea; 528 items/km² in the Celtic Sea; 142 items/km² in the Bay of Biscay; 143 items/km² in the Gulf of Lion; 1935 items/km² in the North-Western Mediterranean; 229 items/km² in East Corsica; and 378 items/km² in the Adriatic Sea (Galgani et al 2000).

A number of different methods exist for monitoring the amounts of marine litter floating in the oceans including visual surveys and the use of biological monitoring tools. In 2002, a study of floating litter in the North Atlantic was conducted using visual sightings of litter on the ocean surface from a ship. Densities ranged between 0 to 20 litter items per square km in latitudes between 0-50°N with the highest densities occurring around the UK and North-Western Europe. Densities of litter floating in the English Channel, for example, were as high as over 100 items/km² (Barnes and Milner 2005).

A key source of information about the amounts and trends of litter in the North Atlantic is an ongoing OSPAR project that uses fulmars as a marine litter monitoring tool. North Sea Ministers adopted a system of 'Ecological Quality Objectives for the North Sea' (EcoQOs) in 2002 as a means to measure human impacts on the North Sea environment. One of the EcoQOs specified in the Ministerial Declaration focused on the use of seabirds to monitor litter levels in the North Sea and delegated the implementation of the EcoQO to OSPAR. Fulmars (*Fulmarus glacialis*) were identified as a robust tool for measuring the abundance and distribution of marine litter as they frequently mistake plastic particles for food and feed exclusively at sea.

The results of the 2002 to 2004 pilot project found that in the North Sea area 95% of beachwashed Fulmars

have plastic in their stomachs with an average mass of 0.33 grams and an average of over 40 pieces per bird. Regional variations within this were considerable with the southeastern North Sea four times more polluted than the seas around the Faroe Islands. These geographical differences suggest that marine litter in the North Sea is largely determined by local sources of pollution as all study regions are subject to the same background levels of marine litter arriving on the Gulf Stream (Van Franeker et al 2005). In terms of appreciable trends in marine litter, a background study for the EcoQO found that there was a reduction in the amount of litter at sea during the late 1990s, with the average amount of plastic per bird falling from 0.5g to 0.3g, but this trend has since stagnated and there has been no significant reduction in recent years (OSPAR 2009).

Studies have also been undertaken investigating the extent and abundance of microplastic particles at sea. Research by Thompson et al (2004) has shown that microscopic plastic particles and fibres are present throughout the oceans and have collected both in pelagic zones and sedimentary habitats. This research also examined long-term trends in the abundance of microplastics and found that levels had significantly risen over the past 40 years. While marine organisms have been shown to ingest microplastic particles, research into the full biological and environmental implications of this is still in its early stages.

2.3.2 Persistence of marine litter

The persistence of many types of litter in the marine environment, particularly glass and plastics, is widely accepted (Cheshire et al 2009) but differing interpretations of when 'degradation' occurs mean that estimates of breakdown rates vary widely. The breakdown process occurs in stages ranging from initial embrittlement to fragmentation and the eventual chemical decomposition of litter items. Different studies, however, pinpoint different stages of this process as when 'degradation' occurs resulting in the range of estimates of breakdown rates. Plastics illustrate this well as they fragment to microplastics over timescales of hundreds of years but the length of time required for their full chemical decomposition is unknown (Andrady 2005) and they "may never truly biodegrade" (DEFRA 2010: 78) In practice, degradation rates can also vary substantially due to varying UV levels, temperatures, oxygen levels, wave energy and the presence of abrasive factors such as sand or gravel (Cheshire et al 2009). Guideline estimates of degradation rates are shown in Table 2.1 below.

Material	Degradation Rate (years)	Reference
Cotton rope	1	Ten Brink 2009
Untreated plywood	1-3	Ten Brink 2009
Cigarette butts	1-5	Cheshire et al 2009
Plastic bag	10-20 20-30	Ten Brink 2009 Cheshire et al 2009
Commercial netting	30-40	Ten Brink 2009
Foamed plastic buoy	80	Ten Brink 2009
Aluminium can	80-200 80-500	Ten Brink 2009 Cheshire et al 2009
Plastic beverage bottle	450	Ten Brink 2009
Monofilament fishing line	600	Ten Brink 2009
Glass bottle	1 million	Ten Brink 2009

Table 2.1: Guideline estimates of degradation rates of selected types of litter

2.4 The impacts of marine litter

Litter in the marine environment gives rise to a wide range of negative environmental, social, economic and public health and safety impacts. While these impacts are diverse, they are often also interrelated and frequently dependent upon one another (Ten Brink et al 2009). Ghost fishing, for example, can result in harm to the environment, economic losses to fisheries and reduced opportunities for recreational fishing (Macfadyen et al 2009). Our understanding of these impacts is variable and limited in areas, particularly as regards the socio-economic effects of marine litter.

2.4.1. Environmental impacts of marine litter

Marine litter can cause a wide variety of adverse environmental impacts to individual organisms, species and ecosystems. Ingestion and entanglement of wildlife are among the most well known impacts of marine litter (Gregory 2009; Thompson et al 2009) and have now been recorded in over 267 species (Laist 1997). This includes 86% of all sea turtle species, 44% of all seabird species and 43% of all marine mammal species as well as numerous fish and crustacean species (Allsopp et al 2006). Marine litter can also cause damage to benthic environments (Moore 2008), affect biodiversity (Derraik 2002) and potentially lead to the loss of ecosystem functions (Ten Brink 2009).

2.4.1.1 Ingestion

The ingestion of marine litter has been reported to date in over 111 species of seabird (Allsopp et al 2006), 31 marine mammal species (Allsopp et al 2006) and 26 species of cetaceans (Derraik 2002). The main impacts of ingestion include:

- Physical damage to the digestive tract including wounds, scarring and ulceration which can lead to infection, starvation and potentially death
- Mechanical blockage of the digestive tract
- Reduced quality of life and reproductive capacity
- Drowning and reduced ability to avoid predators
- Reduced feeding capacity and malnutrition
- A false sense of satiation leading to general debilitation, starvation and possibly death
- Toxic chemical poisoning from contaminated plastics leading to reproductive disorders, increased risk of diseases, altered hormone levels and possibly death (Derraik 2002; Gregory 2009; OSPAR 2009)

Establishing the full extent of the problem is very difficult and the Fulmar monitoring program in the North Atlantic developed by OSPAR remains one of the few projects to examine the extent of ingestion within a species. Over the whole North Sea, 95% of birds examined had ingested plastic with an average of 40 pieces and 0.33 grams

Figure 2.3: The average quantity of marine litter inside a fulmar's stomach. On the left is the average quantity of litter permanently held within a fulmar's stomach and on the right is the equivalent volume of plastic if it were in a human's stomach. Image: Dr Jan van Franeker, IMARES.

Figure 2.4: Entangled seal at Gweek Seal Sanctuary in Cornwall. Image: Caroline Curtis.

found per bird (Van Franeker et al 2005). Typically, evidence of ingestion is more commonly reported on a case-by-case basis such as the discovery by American scientists of a dead sperm whale with just under 200kg of fishing gear in its stomach (ICC 2009). In the UK, the post-mortem of a large adult grey seal revealed it had swallowed a plastic sea angling line splitter, which had lacerated the seal's gut, and prevented it from feeding (OSPAR 2009).

2.4.1.2 Entanglement

Entanglement in nets, ropes and other debris poses a significant risk to marine animals and has been recorded in over 130 species of marine animals including 6 sea turtle species, 51 seabird species and 32 marine mammal species (Ten Brink 2009). The main effects of entanglement include:

- External cuts and wounds which can lead to infection, ulceration and possibly death
- Suffocation, strangulation and drowning of air-breathing species
- Asphyxiation of fish species that require constant motion for respiration
- Impaired mobility and reduced predator avoidance
- Reduced fitness and increased energy cost of travel due to entangled debris
- Reduced ability to hunt for food
- Restricted growth and prevention of circulation to limbs (Derraik 2002; Gregory 2009)

While entanglement is more likely than ingestion to cause death (Laist and Liffmann 2000), estimating the frequency of entanglement is challenging given that many casualties are likely to go unrecorded as they either sink to the ocean floor or are eaten by predators (Derraik 2002). Overall, entanglement is estimated to cause the deaths of over 100,000 marine mammals each year in the North Pacific (Moore 2008) and the limited data available suggests rates of entanglement are increasing (Thompson et al 2009b).

Often evidence of entanglement is reported anecdotally and tends to relate to individual species. The Hebridean Whale and Dolphin Trust, for example, reported that 21% of minke whales stranded in Scotland between 1992 and 2000 had died due to entanglement (OSPAR 2009) and a study of northern fur seals in the Bering sea suggested that up to 40,000 seals are killed every year by entanglement in plastic (Derraik 2002). There are also particular concerns that entanglement can hamper the recovery of endangered species such as Australian sea lions (Allsopp et al 2006), Hawaiian monk seals (Derraik 2002) and North Atlantic right whales (Ocean Conservancy 2008a).

2.4.1.3 Ghost fishing

Derelict fishing gear, including nets, traps and pots, can continue to 'ghost fish' for long periods of time after its abandonment in the marine environment. The catching efficiency of ghost fishing gear is highly dependent on environmental conditions but a single net has been shown to continue fishing for decades. The indiscriminate nature of ghost fishing means that this affects a diverse range of species including seabirds,

seals and cetaceans as well as both commercially important and non-target fish species (Macfadyen et al 2009). A key concern is the impact this could be having on already vulnerable species such as North Atlantic deepwater sharks (Allsopp et al 2006) and Hawaiian monk seals (Derraik 2002). Commercial fishing interests are also likely to be affected as ghost fishing nets may capture immature fish and thus reduce the reproductive potential of fish stocks as a whole (Williams et al 2005).

Ghost fishing can therefore act as direct competition to commercial fisheries (Macfadyen et al 2009) and could have particularly detrimental effects on the conservation of vulnerable fish stocks (Sheavly and Register 2007). On the whole, ghost fishing catches are likely to be low compared to commercial fishing efforts (Brown et al 2005). For example, ghost fishing is not believed to account for more than 5% of commercial EU landings for gillnet and tangle fisheries (Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts et al 2008) and less than 1.5% of commercial landings of monkfish in the Cantabrian sea (Brown et al 2005). The impact of ghost nets on other species tends to be reported anecdotally but estimates suggest that approximately 130,000 cetaceans are killed each year by ghost fishing gear (USEPA 1992 cited in Ten Brink 2009) and in the North East pacific, 15% of the mortality of young fur seals (*Callorhinus usrinus*) was attributed to ghost fishing (Ten Brink 2009).

2.4.1.4 Harm to benthic organisms and habitats

While approximately 70% of marine litter is thought to accumulate on the seafloor (OSPAR 1995), very few studies to date have investigated the considerable threat this poses to benthic organisms and habitats. Accumulations of litter can prevent gas exchange between overlying waters and the pore waters of sediment leading to reduced oxygen in sediments. This can result in adverse impacts on ecosystem functioning, smothering of benthic organisms and changes to the composition of biota on the seafloor (Derraik 2002). Marine litter can also cause physical damage to benthic habitats through abrasion, scouring, breaking and smothering (Sheavly and Register 2007) while derelict fishing gear in particular can “pluck” organisms and translocate sea-bed features (Macfadyen et al 2009). Benthic organisms are also at risk from entanglement and ingestion of marine litter (Derraik 2002).

2.4.1.5 Transport of non-native and invasive species

Natural debris floating in the oceans has always acted as a means of travel for non-native species but the proliferation of marine litter, particularly plastics, has radically increased the prospects for dispersal of non-native and potentially invasive species (Gregory 2009). The slow travel rates of marine litter also provide non-native species with more time to adjust to changing environmental conditions (Moore 2008) and as a consequence, marine litter may be a more effective vector for the transport of non-native species than ships hulls and ballast water (Moore 2008). Overall, marine litter is estimated to have doubled the opportunities for marine organisms to travel at tropical latitudes and more than tripled it at high (>50°) latitudes (Allsopp et al 2006).

Although marine litter can be colonised by a diverse range of species (Gregory 2009), some of the most common hitchhikers include barnacles, bryozoans and polychaete worms (Allsopp et al 2006). The invasive and exotic acorn barnacle (*Eliminius modestus*), for example, has been found on plastic on the shoreline of the Shetland Islands (Barnes and Milner 2005) and plastic debris has also been implicated in the northward range extension of the large barnacle *Perforatus perforatus* (Rees and Southward 2008 cited in Moore 2008).

The introduction of invasive non-native species can have devastating environmental effects including loss of

biodiversity, changes to habitat structure and changes to ecosystem functions (Derraik 2002; Donnan 2009). Invasive species can also out compete native species as well as impact upon trophic structures and cause genetic changes (Donnan 2009). As a consequence, invasive species have been recognised as one of the greatest threats to global biodiversity (Barnes and Milner 2005) and pose particular dangers for previously inaccessibly conservation islands (Derraik 2002).

2.4.1.6 Loss of biodiversity

Marine litter can act as an additional pressure on already vulnerable species and threaten their continued survival (Allsopp et al 2006; Derraik 2002.). The injury and death of individual animals from entanglement and ingestion of marine litter, in particular, can have profound implications for the survival of an endangered species but to date very little research has investigated the population-level effects of marine litter (Laist and Liffmann 2000). For the Hawaiian monk seal (*Monachus schauinslandi*), which numbers just 1,200 in the wild today, entanglement in marine litter "is arguably the most significant documented impediment to the species' recovery" (Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts et al 2008: 36).

Similarly, only 300 - 350 North Atlantic right whales (*Eubalaena glacialis*) are left in the wild and entanglement accounts for a high proportion of right whale mortality rates (Ocean Conservancy 2008a). A total of 24 North Atlantic right whales were injured or died due to entanglement in marine litter between 1999 and 2008 (Ocean Conservancy 2008b). A further 6 endangered species have been classified by the Australian Government as adversely affected by marine litter and these species include loggerhead turtles, blue whales and 2 species of albatross (Australian Government 2009). The loss of habitat and reduced ecosystem functions resulting from physical damage and smothering of benthic environments can also "alter the make-up of life on the sea floor" (Derraik 2002: 844). As outlined above, marine litter can also act as a vector for the transportation of invasive alien species and this can have devastating consequences for biodiversity in host habitats (Derraik 2002).

2.4.1.7 Microplastics

While it is widely accepted that microplastics are an important threat to the marine environment, their full environmental implications are not yet understood (Thompson et al 2009b). Microplastics are either derived from the breakdown of larger litter items or enter the oceans directly from their application as 'scrubbers' in commercial activities such as cleansing and air blasting (Derraik 2002; Thompson et al 2009b). The abundance of microplastics has increased over the past 40 years and given the longevity of plastics in the marine environment, it is expected that the abundance of microplastics will continue to increase in future (Thompson et al 2004).

Figure 2.5 Microplastics collected using trawling equipment. Image: Dr Frederik Norén.

Microplastics pose a particular threat to the marine environment as they are extremely difficult to remove and can "be ingested by a much wider range of organisms than larger items of debris" (Barnes et al 2009: 1994). Although the full environmental impacts of microplastics are not yet known (Thompson et al 2009b),

a key concern is the ability of plastics to concentrate persistent organic pollutants such as PCBs, DDE and nonylphenols (Moore 2008) and potentially transfer these to living organisms and the food chain (Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts et al 2008; DEFRA 2010). Microplastics in particular provide "a likely route for the transfer of these chemicals because they have a much greater surface area to volume ratio than larger items of debris…and because of their size they are available to a wide range of organisms (Barnes et al 2009: 1995). To date, marine organisms have been proven to ingest microplastic fragments but whether this represents a pathway for the transport of these pollutants to the food chain is currently unknown (Thompson et al 2009b).

2.4.1.8 Long-term ecosystem deterioration

Establishing the long-term effects of marine litter on the environment is very challenging due to the wide range of uncertainties involved (Hyrenbach and Kennish 2008). Currently, it is unclear how and to what extent the diverse environmental impacts of marine litter such as entanglement, ingestion, damage to benthic environments and loss of biodiversity will combine and interact to cause ecosystem deterioration.

Marine litter also acts as an additional pressure on oceans already under stress from over fishing, coastal development, climate change and other forms of anthropogenic disturbance (Derraik 2002). Together these pressures may combine to cause rapid ecosystem deterioration and reduce the resilience of the oceans to withstand and adjust to large perturbations (ICC 2009). Marine litter is thereby in effect "one of the straws that together could break the camel's back – in this case, the ocean's health" (ICC 2009: 19).

2.4.2 Social impacts of marine litter

The social impacts of marine litter are rooted in the ways in which marine litter affects people's quality of life and include reduced recreational opportunities, loss of aesthetic value and loss of non-use value (Cheshire et al 2009). Few studies to date have investigated these issues and establishing exactly how and at what level marine litter starts to have an appreciable social impact therefore requires more research (Cheshire et al 2009).

2.4.2.1 Reduced recreational opportunities

Beaches, coasts and seas are used for countless different recreational activities including swimming, diving, boating, recreational fishing and a wide variety of water sports. Accumulations of marine litter can have a strong deterrent effect and discourage recreational users from visiting polluted areas (Ballance et al 2000; Sheavly and Register 2005). The level of litter required to actively deter people from visiting certain areas is clearly highly subjective depending on personal preference, purpose of activity and litter levels in surrounding areas but very little research into how marine litter acts as a deterrent to marine recreational users has been undertaken to date.

Beach users, for instance, frequently rank cleanliness as their top priority when choosing where to visit (Ballance et al 2000; ENCAMS 2005). A pioneering South African study found that 85% of tourists and residents would not visit a beach with more than 2 debris items per metre and 97% would not go to a beach with 10 or more large items of litter per metre (Ballance et al 2000). Marine litter also deters other recreational users such as sailors and divers (Sheavly and Register 2007) due to both the reduced aesthetic quality of an area and concerns about the health and safety risks posed by accumulations of marine litter (Cheshire et al 2009). More research is required to determine the approximate levels at which marine litter affects recreational use

of the coastline, beaches and seas.

2.4.2.2 Loss of aesthetic value

Marine litter can negatively affect people's quality of life by reducing their enjoyment of the landscape and scenery (Cheshire et al 2009). The loss of visual amenity can have significant effects on people's recreational use of the marine environment, as outlined above, but it can also simply be about the loss of a previously beautiful view. The marine environment is often the focus of many of the creative arts including paintings, literature and films and a loss of aesthetics could also negatively affect the inspirational quality of the marine environment (Naturvårdsverket 2009).

2.4.2.3 Loss of non-use value

Non-use value relates to the benefits generated by knowing that a particular ecosystem in maintained. There are 3 main categories of non-use value, which are existence value, bequest value and altruistic value, although these may overlap to some degree. Marine litter therefore threatens the non-use value derived from the "knowledge of the existence of desirable coastal environment, the value derived from being able to bequest unimpaired resources to future generations, the altruistic benefits of preserving attractive coastal resources for other users, and the value associated with the belief that maintaining a litter-free coast and ocean is intrinsically desirable" (Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts et al 2008: 40).

2.4.3 Public health and safety impacts

Marine litter presents a number of public health and safety concerns including navigational hazards (Macfadyen et al 2009), injuries to recreational users (Cheshire et al 2009) and the risks associated with the leaching of poisonous chemicals (Thompson et al 2009b). However, establishing the extent and frequency of incidents involving marine litter is very difficult as most incidents, both in terms of vessel damage and injuries, go unrecorded (Laist and Liffmann 2000; Sheavly 2005). More research is therefore required to assess the risks posed by marine litter to public health and safety.

2.4.3.1 Navigational hazards

Marine litter can present numerous different safety risks for vessels but entanglement in derelict fishing gear such as nets, ropes and lines presents a key concern. Plastic bags are also a common cause of blocked water

intakes, resulting in burnt out water pumps in recreational vessels (Sheavly and Register 2007). The main risks to navigation from marine litter, particularly derelict fishing gear, include:

- Fouling and entanglement of a vessel's propeller, which can reduce both its stability in the water and ability to manoeuvre. This puts vessel crews in danger, particularly during poor weather conditions
- Benthic and subsurface debris can foul anchors and equipment deployed from trawlers and research vessels, endangering both the vessel and its crew
- Collisions with marine litter can damage a vessel's propeller shaft seal
- Incidents may require divers to clear the debris and depending on the sea state, working in close proximity to the vessel's hull may be highly risky (Macfadyen et al 2009)

Often evidence of incidents endangering vessels' safety is anecdotal and the majority of incidents go unreported. In 2005, a Russian submarine became entangled in derelict fishing nets 600 ft below the surface off the Kamchatka Peninsula and was trapped on the seabed for 4 days until an international rescue effort managed to cut it free (Allsopp et al 2006; Chivers and Drew 2005). A passenger ferry travelling off the west coast of Korea in 1993 became entangled in 10mm nylon rope, which coiled around both propeller shafts and the right propeller, causing the vessel to suddenly turn, capsize and sink with the loss of 292 of the 362 passengers (Cho 2004 cited in Macfadyen et al 2009). These examples demonstrate that marine litter poses navigational hazards to all kinds of vessels and can result in extremely serious consequences, including loss of life.

2.4.3.2 Hazards to swimmers and divers

Entanglement in marine litter, particularly nets, ropes, lines and other discarded fishing gear, presents serious hazards for swimmers and divers as well as wildlife and vessels (Cheshire et al 2009). Poor visibility and colonization of debris by marine organisms may camouflage debris and once entangled, swimmers and divers may find it difficult to free themselves and/or seek help (Cheshire et al 2009). In January 2009, an experienced diver became entangled in fishing net in Plymouth Sound, off the south coast of England. It took the diver almost 20 minutes to free himself and further inspection revealed the net to be 50m long and at least 2m in height with a seal pup already entangled within it. This incident occurred within an area where the use of fishing nets is banned suggesting the net had potentially traveled some distance (The Herald 2009).

Since 1998, 10 incidents involving derelict nets have been reported to the British Sub Aqua Club (BSAC)

with 4 of these resulting in no harm to the diver, 5 requiring medical attention and 1 fatality, although it is unclear whether entanglement caused this fatality or occurred later. Most incidents involved monofilament netting and very often the diver had to remove their equipment and/or seek help from a buddy to escape from the netting. The BSAC captures all fatal incidents but it is likely that more non-fatal incidents have gone unreported (British Sub Aqua Club, 2010, Personal Communication).

2.4.3.3 Cut, abrasion and stick (needle) injuries

Beach washed marine litter commonly causes minor cut, abrasion and stick (needle) injuries. These are generally the result of broken glass, ring pulls, fishing line and hooks, and medical wastes such as discarded syringes (Sheavly and Register 2007). In addition, there is a relatively low risk that contact with infected sanitary products, fluids in syringes or other medical equipment, or ingestion of any of these could cause disease (Williams et al 2005). The overall extent of these incidents is unknown as most incidents are minor and self-treated while no monitoring systems are in place to report the frequency of more serious incidents.

2.4.3.4 Leaching of poisonous chemicals

While plastics themselves are believed to be biochemically inert in the marine environment, they can carry toxic compounds that potentially pose health risks to both wildlife and humans. Some of these compounds are added during the manufacture of plastics, while others are absorbed from the surrounding seawater (Thompson et al 2009b). These compounds include persistent organic pollutants (POPs) such as PCBs, DDT and bisphenol-A and many of these chemicals are known to have endocrine disrupting effects. There has therefore been "much speculation that, if ingested, plastic has the potential to transfer toxic substances to the food chain" (Thompson et al 2009b). Given the increasing proliferation of plastics in the marine environment and the emergent threat of microplastics, more research is required to evaluate the environmental and health risks associated with chemicals derived from marine plastics (Teuten et al 2009; Thompson et al 2009b).

2.4.4 Economic Impacts of Marine Litter

The marine environment is tremendously important economically to communities throughout the world and supports a diverse range of activities including fishing, commercial shipping and tourism. In the UK, for instance, the marine environment contributed an estimated £38.9 billion to Gross Domestic Product in 2000, which accounts for almost 5% of GDP that year (Pugh and Skinner 2002). Marine litter can cause a broad spectrum of economic impacts that both reduce the economic benefits derived from marine and coastal activities, and/or increase the costs associated with them (Committee on the Effectiveness of International and National Measures to Prevent Marine Debris and Its Impacts et al 2008).

In practice, the wide diversity of impacts makes measuring the full economic cost resulting from marine litter extremely complex. Primarily, this is because some impacts can be much more readily evaluated in economic terms than others. Direct economic impacts such as increased litter cleansing costs are clearly easier to assess than the economic implications of ecosystem degradation or reduced quality of life. However, a lack of recording mechanisms often means that the direct economic costs of marine litter also go unreported.

Establishing the economic costs of marine litter is further complicated by the wide variety of approaches available for valuing the environment and detrimental anthropogenic impacts. Several approaches aim to determine the economic value of ecosystem goods and services and these methods are particularly useful as they take into account the full spectrum of impacts, both direct and intangible. Unfortunately, very few

studies have applied this kind of methodology in a marine and coastal context and it has never been used to calculate the economic impacts of marine litter.

Other methods generally focus on establishing the economic value of human activities that are reliant upon the environment and how this can be affected by various factors, including marine litter. Although these methods are more commonly used in research, they provide only a partial insight because they do not take into account the economic cost of intangible social and ecological impacts. These types of methodology have successfully been applied to both the marine and coastal environment as a whole (see Welsh Enterprise Institute 2006) and to the marine litter problem (Hall 2000; Macfadyen et al 2009). Often studies investigating the economic impacts of marine litter are small-scale, rely on anecdotal evidence and focus on particular aspects of the marine litter problem such as ghost fishing. Our understanding of the economic significance of marine litter therefore remains relatively limited (Ten Brink et al 2009).

2.4.4.1 Litter cleansing costs

Removing marine litter is necessary to ensure beaches remain aesthetically attractive and safe for potential users and this often results in substantial litter cleansing costs (Ten Brink et al 2009). The vast majority of beach cleansing activities are undertaken and paid for by local authorities but community groups and landowners may also conduct beach cleans of their own (Hall 2000). The cost of clean ups generally includes the cost of collection, transportation and disposal of litter (Hall 2000; OSPAR 2009) but there may be additional 'hidden' costs such as contract management, program administration (Fanshawe and Everard 2002) and volunteer time (Macfadyen et al 2009). The costs involved can be significant but a lack of reporting mechanisms, use of volunteer labour and no standardised methodology outlining exactly what is included as a cost makes litter cleansing costs difficult to quantify and compare.

Figure 2.6 Many municipalities use mechanical beach cleaners to remove beach litter. Image: © iStockphoto/matsou

Very limited research has therefore been conducted into the costs of marine litter removal and estimates tend to be based mostly on anecdotal evidence. Research in 2000 found that 56 UK local authorities spent a total of £2,197,138 a year on beach cleansing, taking into account the cost of collection, transport, disposal charges, workforce, equipment and administration (Hall 2000). More recent estimates suggest that the total cost of marine litter removal to all UK local authorities is approximately £14 million per year (Environment Agency 2004 cited in OSPAR 2009).

Similarly, cleansing of the Swedish Skagerrak coast in 2006 was estimated to cost 15 million SEK (about €1.5 million) and took approximately 100 people 4 months to complete (OSPAR 2009). Previous research from this area also reported that only about 30% of marine litter was recovered during these operations (Fanshawe and Everard 2002). Research in Poland found that the cost of removing marine litter from the shoreline of

5 municipalities and 2 ports amounted to €570,000 (Naturvårdsverket 2009).

Numerous voluntary beach cleaning programs also exist including Beachwatch in the UK, the International Coastal Clean-up coordinated by the Ocean Conservancy and Coastwatch in the Netherlands. These initiatives often have multiple aims including removal of debris, monitoring of litter abundance and composition, and raising awareness of marine litter issues. Local community groups also regularly operate their own beach cleans such as the highly acclaimed Voar Redd Up[1] conducted annually in the Shetland Islands, UK and these are often conducted in conjunction with local authorities. There is therefore immense voluntary involvement in the removal of marine litter but quantifying the costs of this, particularly in terms of volunteer time, is challenging (OSPAR 2009). What is clear is that in this case the polluter does not currently pay with local authorities and voluntary groups picking up the bill for the removal of marine litter (Ten Brink et al 2009).

2.4.4.2 Losses to tourism

Marine litter is unsightly and potentially hazardous, and can therefore act as a deterrent to tourists. In this way, marine litter can reduce tourism revenue and consequently weaken coastal economies. While beach users regularly highlight cleanliness as a critical factor in choosing where to visit (Ballance et al 2000; ENCAMS 2005), determining the extent to which marine litter affects tourist revenue is very difficult, particularly as it is unclear at what density litter starts to deter tourists (Ballance et al 2000).

Examples of how marine litter affects tourist revenue are thus relatively scarce but a South African study found that a drop in beach cleanliness standards could reduce tourism revenue by up to 52% in the area studied. This project also investigated the densities of litter that exerted a deterrent effect on tourists and found that 85% of beach users would not visit a beach with 2 or more large debris items per meter with 97% stating they would not visit a beach with 10 or more large items of debris per meter. Interestingly, however, only 44% of people surveyed classified the beach they were on as “clean” suggesting that there may be considerable differences between people’s priorities and their actions in practice (Ballance et al 2000).

Research from Sweden suggests that marine litter inhibits tourism there by between 1-5% resulting in a loss of £15million in revenue and 150 person-years of work (Ten Brink et al 2009). In extreme cases, marine litter can also lead to the closure of beaches, as was the case in New Jersey and New York in 1988. This was estimated to cost the regional economy between $379million and $3.6billion in lost tourist and other revenue (Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts et al 2008).

2.4.4.3 Losses to fisheries

Marine litter has a twofold impact on fisheries by increasing costs to fishing vessels as well as reducing potential catches and revenue through ghost fishing. The direct costs associated with marine litter have rarely been studied but include repairing damage to the vessel and equipment including disentangling fouled propellers, replacement of lost gear, loss in earnings from reduced fishing time and restricted and/or contaminated catch due to the presence of marine litter in hauls. Research focusing on the Shetland fishing fleet found that marine litter could cost a vessel up to £30,000 a year (Hall 2000). A separate study looking at the Scottish Clyde fishery reported that losses of up to $21,000 in lost fishing gear and $38,000 in lost fishing time were experienced by a single trap fisher in 2002 (Watson and Bryson 2003 cited in Macfadyen et al 2009).

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1 Voar Redd Up means ‘spring clean’ in Shetland dialect.

Ghost fishing also reduces the catch available to fishing vessels and therefore results in a loss of fisheries revenue (Macfadyen et al 2009). Several studies have investigated the economic importance of ghost fishing and this appears to be highly variable between different types of fisheries (Brown et al 2005). Ghost fishing in the tangle and gillnet fisheries is equivalent to less than 5% of EU commercial landings (Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts et al 2008) while the ghost catch of monkfish in the Cantabrian sea equates to approximately 1.46% of landings (Brown et al 2005). In the USA, an estimated $250million worth of marketable lobster is lost to ghost fishing annually (Allsopp et al 2006) and between 4-10million blue crabs are trapped in ghost fishing gear each year in Louisiana (Macfadyen et al 2009).

In the longer term, the impact of ghost fishing on the conservation and recovery of vulnerable fish stocks may have much deeper economic effects (Sheavly and Register 2007). As the ICC suggests "in the Chesapeake Bay and its tributaries, where the blue crab population has crashed, every crab lost means one step further away from recovery for a species that provides economic support for entire communities" (ICC 2009: 17) and the viability of other vulnerable species may be similarly affected (Sheavly and Register 2007).

2.4.4.4 Losses to aquaculture

Marine litter can result in economic losses to aquaculture producers (UNEP 2009) as a result of damage to vessels and equipment, removal of debris and staff downtime. Entangled propellers and blocked intake pipes present the most common problems for aquaculture operators and can result in costly repairs and lost time. In addition, the time required to remove debris floating in or around stock cages can represent a considerable cost to aquaculture organisations. Research quantifying the extent of these issues is sparse but a study in 2000 found that on average one hour per month was spent removing debris and disentangling fouled propellers could cost up to £1,200 per incident (Hall 2000).

2.4.4.5 Costs to shipping

Shipping faces increased costs from marine litter resulting from vessel damage and downtime (Ten Brink et al 2009), litter removal and management in harbours and marinas (UNEP 2009), and emergency rescue operations to vessels stricken by marine litter (Macfadyen et al 2009). For vessel operators, entangled propellers and rudders are the most common issue and can seriously damage vessels resulting in expensive repairs, crew downtime and safety concerns for the crew (Hall 2000). While this can affect both recreational craft as well as commercial shipping, the vast majority of incidents go unreported making it extremely difficult to assess the true extent of the problem (Laist and Liffmann 2000; Sheavly 2005).

Figure 2.7: Removing marine litter can be costly for harbours and marinas. Image: KIMO International.

Harbours and marinas face increased costs associated with marine litter removal in order

to ensure that their facilities are safe and attractive for users. This can involve both the manual removal of floating debris and additional dredging to remove items obstructing the seabed. Although the costs of these activities are believed to be significant (UNEP 2009), only one study, undertaken by Hall in 2000, has investigated the costs marine litter poses for harbours and marinas. For harbours in the UK, the removal of debris could cost up to £15,000 a year with manual clearance of the harbour required up to four times per week. Incidences of fouled propellers were also reported by 82% of harbours, although these costs are borne by vessel operators themselves. Anecdotal evidence received from marinas during the same study suggested that some marinas had to be manually cleaned on a daily basis at a cost of up to £10,000 a year (Hall 2000).

The cost of emergency rescues to vessels stricken by marine litter can also be substantial and most operations are commonly a result of entangled or fouled propellers. Research in 1998 found that 230 rescues were undertaken to vessels with fouled propellers in UK waters at a cost of £2,200 to £5,800 per incident, depending on the type of lifeboat required. This amounted to an overall cost of between £506,000 and £1,334,000 for that year (Hall 2000). In 2005, the US Coastguard made 269 rescues to incidents involving marine litter resulting in 15 deaths, 116 injuries and $3 million in property damage (Moore 2008).

2.4.4.6 Control and eradication of invasive non-native species

Non-native species can travel by a number of means including through the colonisation of marine litter (Moore 2008; Gregory 2009). While tracing occurrences of non-native species back to marine litter is extremely difficult, marine litter is estimated to have doubled the opportunities for marine organisms to travel at tropical latitudes and more than tripled it at high (>50°) latitudes (Allsopp et al 2006). The introduction of invasive non-native species can have a highly damaging impact on the environment (Derraik 2002; Gregory 2009) and result in substantial economic costs and losses (Donnan 2009).

At the very least, the discovery of invasive species results in increased costs due to monitoring, control and eradication measures. Additional losses can be incurred from the fouling of equipment and vessels, deterioration of ecosystem functions, loss of amenity value and impacts on human health (Donnan 2009). In a relatively short period of time, invasive species can destroy entire ecosystems and decimate the industries that relied upon them. The introduction of the American comb jellyfish into the Black Sea during the 1990s, for instance, is widely accepted to have caused the collapse of the anchovy fisheries with economic losses of €240million (Naturvårdsverket 2009).

The discovery of the Carpet sea squirt (*Didemnum vexillum*) in Holyhead Harbour in Wales in 2009 illustrates the range of costs involved in the control and eradication of invasive species. The carpet sea squirt has no known predators and its thick, sheet-like growths can smother organisms and marine habitats. The means by which the carpet sea squirt reached Holyhead Harbour are unknown but an eradication and monitoring program over the next 10 years is expected to cost approximately £525,000. The costs of inaction, however, could amount to up to £6,875,625 over the same period for the nearby mussel fisheries alone and could be significantly higher were the carpet sea squirt to become established elsewhere in UK waters (Holt 2009).

2.4.4.7 Costs to coastal agriculture

Marine litter can cause a broad spectrum of hazards and costs for the agriculture industry including damage to property and equipment, harm to livestock, additional vets bills and lost time removing debris (Hall 2000). Virtually no research, however, has been undertaken to document the extent and significance of these impacts. A project in 2000 focusing on agriculture in Shetland found that 96% of responding farmers had

experienced problems with debris blowing onto their land and this could cost them up to £400 a year (Hall 2000). Unfortunately, no similar research has been undertaken to assess the extent of the problem in other locations.

2.4.4.8 Costs to power stations

The effects of marine litter on power stations can include blockage of cooling water intake screens, increased removal of debris from screens and additional maintenance costs. Determining the extent of these costs is complex, particularly as costs resulting from marine litter are difficult to differentiate from those due to natural debris such as seaweed. Anecdotal evidence suggests that marine litter can cost companies up to £50,000 to remove with additional costs for pump maintenance (Hall 2000) but it is unknown how widespread these impacts are.

2.4.4.9 Environmental damage and ecosystem degradation

From the entanglement of wildlife to the loss of biodiversity, marine litter can affect the environment in numerous ways. While these effects are all likely to have economic implications, evaluating environmental damage in economic terms is extremely challenging and has generally not been addressed by research. Therefore "we do not have a complete picture of the magnitude of economic damages associated with the ecological effects of marine debris" (Laist and Liffmann 2000).

Establishing what the long-term effects of marine litter will be on the environment is similarly highly complex and difficult to translate into economic damages. The potential for marine litter to contribute to ecosystem deterioration and affect the oceans' resilience to large-scale perturbations in future is a critical concern (Derraik 2002; ICC 2009) and research is urgently required to investigate what the costs, both environmental and economic, of taking no further action to reduce marine litter will be.

3. Legislation and Policy Context

3.1 Key international legislation

A wide range of international agreements and legislation both directly and indirectly address the problem of marine litter. Several pieces of legislation are specifically designed to reduce marine litter and prevent the discharge of waste into the marine environment but many of the existing agreements take a broader approach and outline fundamental principles for the sustainable use and conservation of the oceans. The key pieces of international legislation are briefly outlined below.

3.1.1 United Nations Convention on Oceans and the Law of the Sea (UNCLOS)

UNCLOS is designed to comprehensively govern the management of marine resources and their conservation for future generations. Provisions of the Convention include territorial sea limits, conservation and management of living marine resources, protection of the marine environment, economic and commercial activities, marine scientific research and a binding procedure for the settlement of disputes relating to the oceans.

The protection and preservation of the marine environment is addressed by Part XII of the Convention (Articles 192-237) which outlines basic obligations to prevent, reduce and control pollution from land-based sources; pollution from sea-bed activities subject to national jurisdiction; pollution from activities in the Area; pollution by dumping; pollution from vessels; and pollution from or through the atmosphere. Marine litter was specifically addressed in November 2005 as part of UN General Assembly Resolution A/RES/60/30 – Oceans and the Law of the sea, which states:

"…The General Assembly,

65. Notes the lack of information and data on marine debris and encourages relevant national and international organisations to undertake further studies on the extent and nature of the problem, also encourages States to develop partnerships with industry and civil society to raise awareness of the extent of the impact of marine litter on the health and productivity of the marine environment and consequent economic loss;

66. Urges States to integrate the issue of marine debris within national strategies dealing with waste management in the coastal zone, ports and maritime industries, including recycling, reuse, reduction and disposal, and to encourage the development of appropriate economic incentives to address this issue including the development of cost recovery systems that provide an incentive to use port reception facilities and discourage ships from discharging marine debris at sea, and encourages States to cooperate regionally and subregionally to develop and implement joint prevention and recovery programmes for marine debris;…"

3.1.2 International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) Annex V

The MARPOL Convention is the key international agreement to prevent pollution of the marine environment by ships and has six annexes concentrating on different types of pollution, as shown in Table 3.1 overleaf. Annex I (Oil) and Annex II (Chemicals) are compulsory but the other annexes are voluntary.

Annex I	Oil
Annex II	Noxious liquid substances by bulk
Annex III	Harmful substances carried by sea in packaged form or freight containers, portable tanks, or road and rail tank wagons
Annex IV	Sewage
Annex V	Garbage
Annex VI	Air pollution

Table 3.1 Pollution types covered by MARPOL Annexes I-VI

MARPOL Annex V regulates the types and quantities of garbage that ships may discharge into the sea and specifies the distances from land and manner in which they may be disposed of. For the purposes of Annex V, garbage includes "all kinds of food, domestic and operating waste, excluding fresh fish, generated during the normal operation of the vessel and liable to be disposed of continuously or periodically" (IMO 2002).

Under these regulations, the disposal of plastic anywhere into the sea is strictly prohibited and the discharge of other wastes is severely restricted in coastal waters and "Special Areas". The North Sea and adjacent areas are designated "Special Areas" under MARPOL Annex V and in accordance with these regulations, discharges of garbage, except food waste, into the sea are strictly prohibited.

As of March 2010, 140 states have ratified MARPOL Annex V and these regulations now cover 97.5% of the world's shipping tonnage (IMO 2010). The International Maritime Organisation (IMO) is currently reviewing MARPOL Annex V, in consultation with relevant stakeholders, to assess and improve its effectiveness in addressing ocean-based sources of marine litter.

3.1.3 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, and 1996 Protocol relating thereto

The London Convention aims to promote the effective management of all sources of marine pollution and prevent the dumping of wastes and other matter at sea. It operates using a "black- and grey-list approach" whereby dumping of all blacklist items is strictly prohibited; dumping of grey-list materials requires a special permission and is subject to strict control; and the dumping of all other items is allowed with a general permit. Annex I of the London Convention explicitly prohibits signatories from dumping persistent plastics and other non-biodegradable materials into the sea from ships and other man-made structures.

Agreed in 1996, the London Protocol aims to modernise the Convention and will eventually replace it. The Protocol's objective is to protect the marine environment from all sources of pollution and therefore all dumping is prohibited under the Protocol with the exception of possibly acceptable wastes on the "reverse list". States can be a Party to either the London Convention 1972, or the 1996 Protocol, or both.

3.1.4 Other international agreements

The following international agreements are also important for the protection of the marine environment and the prevention of marine litter.

- Agenda 21: The United Nations Programme of Action from Rio and the Johannesburg Plan of Implementation
- Convention on Biological Diversity 1992, with the Jakarta Mandate on the Conservation and

Sustainable Use of Marine and Coastal Biological Diversity 1995

3.2 Key European legislation

The European Union has introduced a number of directives that affect the marine litter problem. Although this legislation addresses a wide range of issues, they can be broadly categorised into directives that address the sustainable use of the marine environment; directives that focus on reducing ship based pollution and directives that address the wider issue of waste in general. The key pieces of European legislation are outlined below.

3.2.1 EU Marine Strategy Framework Directive (2008/56/EC)

The Marine Strategy Framework Directive (MSFD) was agreed in 2008 and is the first integrated policy for the protection of the marine environment. The MSFD aims to address multiple threats to the marine environment including climate change, over fishing, loss of biodiversity, eutrophication, introduction of alien species and pollution from land- and ocean-based sources. Under the MSFD, Member States are required to develop strategies to achieve or maintain good environmental status in the marine environment by the year 2020 and must meet a strict timetable for implementation.

Good environmental status is defined under the MSFD as "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations". The MSFD also 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. 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"[2]

3.2.2 EU Directive on port reception facilities for ship-generated waste and cargo residues (EC2000/59)

This Directive aims to significantly reduce the illegal discharge of ship-generated waste and cargo residues into the marine environment by improving the availability and use of port reception facilities. The regulations entered into force in July 2003 and key terms include:

- The mandatory provision of waste reception facilities in all ports, tailored to the size of port and type of vessels calling there. Ports must draw up waste reception and handling plans to be inspected and approved by Member States every three years
- All ships must deliver their waste to the port reception facilities before leaving the port or terminal, unless they are exempt or have sufficient dedicated storage capacity to store the waste until the next port of call
- Captains of ships bound for a port or terminal must notify it of certain information including the types and quantities of waste for discharge and the date and last port where waste was discharged
- Ships that do not deliver waste in one port and who are not subject to an exemption will be reported to their next port of call and required to undergo a detailed inspection before cargo and passengers

[2] For the full text of the Marine Strategy Framework Directive, including Annexes, see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF

can be transferred
- Ports must establish a cost-recovery system to encourage vessels to discharge their waste on land and discourage dumping at sea. All ships must pay a mandatory charge to make a significant contribution to the cost of the port reception facilities for ship generated waste, irrespective of whether they use them or not
- Member states must ensure proper monitoring of compliance with the directive, both by ships and ports, and submit a progress report to the European Commission every three years about the status of the Directive's implementation

3.2.3 Other European legislation

The following European directives also contain provisions that affect marine litter:

- EU Bathing Water Directive (76/160/EEC and 2006/7/EC)
- EC Urban Waste Water Treatment Directive (91/271/EEC and 98/15/EC)
- EU Environmental Liability Directive (2004/35/EC)
- EU Directive on Packaging and Packaging waste (2004/12/EC)
- EU Waste Framework Directive 2006/12/EEC (to be replaced by 2008/98/EC with effect from 12 December 2010)

3.3 National legislation

There is no national legislation or policy dedicated to addressing marine litter in any country within the North Atlantic region. Many countries have, however, passed legislation to enact the European directives and key pieces of international legislation, such as MARPOL, that have a bearing on marine litter. National legislation to address waste management, littering and the illegal discharge of waste is also common in countries throughout this region.

In 2009, the United Kingdom became the first country in the world to introduce a single piece of legislation to protect the marine environment when it passed the Marine and Coastal Access Act. This act outlines the Government's vision for "clean, healthy, safe, productive and biologically diverse oceans and seas" (DEFRA 2009) and sets out a framework for delivering sustainable marine and coastal development, taking into account environmental, social and economic concerns.

4. Methodology

Taking Hall's (2000) pioneering project as a starting point, the methodology adopted here focuses on the economic impact of marine litter on human activities and uses a sector-based approach to investigate the increased costs and potential loss of revenue associated with marine litter for key industries. This approach does not include an evaluation of the economic cost of degradation of ecosystem goods and services due to marine litter and the findings presented in this report are therefore likely to significantly underestimate the total economic costs of marine litter.

4.1 Developing a methodology

Marine litter can directly cause numerous economic impacts, particularly in terms of litter clearance and removal. Marine litter can also result in a wide range of indirect economic impacts, which are associated with the environmental, social, and public health and safety impacts of marine litter. Evaluating the direct economic impacts of marine litter such as increased litter cleansing costs is relatively straightforward but many other impacts, particularly environmental effects, can be difficult to translate into economic terms. Loss of ecosystem functions and reduced biodiversity, for example, will clearly have economic implications but in practice these are very difficult to measure. Estimating the full economic impact of marine litter is therefore complex as many impacts are challenging to quantify in economic terms.

As a result, "to date, very little information has been reported on the economic impacts of marine litter" (UNEP 2009a: 10) and Hall's (2000) project remains one of the few studies to investigate the economic cost of marine litter. The approach adopted by Hall focused on establishing how marine litter affected the economic value of human activities that relied upon a healthy marine environment. In practice, this was applied in terms of the increased costs or potential loss of revenue incurred due to marine litter by various key industries.

It was decided to follow a similar approach in this assessment for several reasons. Firstly, research focusing on the economic value of human activities has a strong theoretical basis and has been applied previously in a marine litter context. This approach was similarly attractive due to its relative simplicity and, as it is based on actual expenditure, the increased likelihood that data would be available. Narrowing the focus of the project to examine the economic impacts of marine litter upon human activities, rather than the full spectrum of economic impacts, also enabled the project to balance key time and resource constraints.

Putting this approach into practice firstly involved identifying the key sectors of human activity that could be affected by marine litter. The sectors involved in this project are:

- Agriculture
- Aquaculture
- Fisheries
- Harbours
- Industrial seawater users
- Marinas
- Municipalities
- Power stations
- Rescue services
- Voluntary organisations
- Water Authorities

Each sector was then assessed individually to determine how marine litter could affect them and the ways in which it could result in increased costs and/or a loss of revenue, as outlined in Figure 4.1 overleaf. Separate questionnaires were then developed for each sector based on these issues and these were distributed to organisations throughout the Northeast Atlantic region. Questionnaires were identified as the most suitable method for collecting data as the project focused on a wide variety of sectors in a number of different countries.

Short follow up questionnaires were also developed to investigate the wider context of the impacts of marine litter. These follow up questionnaires were broadly similar for all sectors and were designed to provide insights into the perceptions, sensitivity and priorities of various sectors with regard to marine litter and its impact on the marine environment.

4.2 Data collection

The project began in 2007 and was conducted over a 3-year period due to changes in personnel. The project's focus on the Northeast Atlantic region required the distribution of questionnaires in a number of countries and this was carried out in conjunction with KIMO networks. Often, the support of industry organisations and associations was invaluable in making contacts and distributing the questionnaires. The majority of questionnaires were sent out via post or email but some were also conducted over the telephone and distributed at meetings.

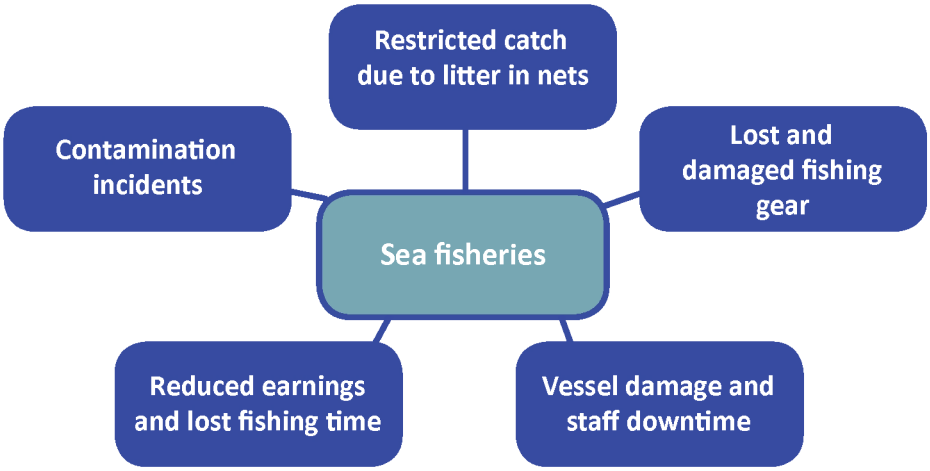
The main project questionnaires were distributed in all the countries involved in 2007/2008. Based on the responses received, a clear format for the project emerged structured around a UK core with case studies and anecdotal evidence from other countries wherever data was available. To achieve this, it was necessary to strengthen the number of UK responses received and therefore a second set of questionnaires was distributed within the UK in 2009. In total, 2,090 questionnaires were distributed and Table 4.1 below shows how these were divided between countries. Reflecting the final structure of the project, the majority of questionnaires were distributed within the UK.

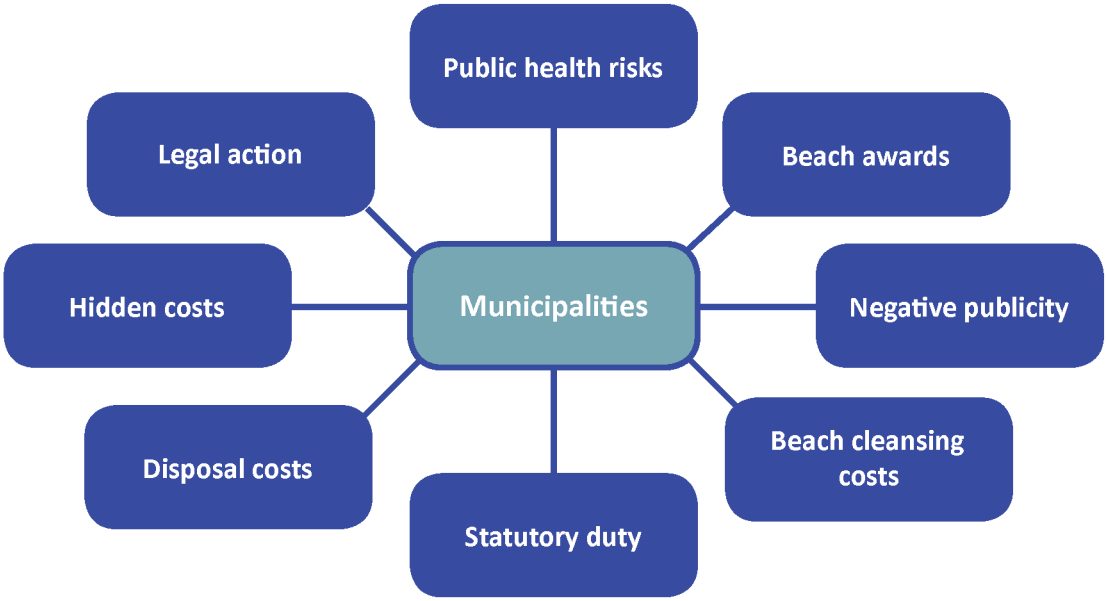
Country	Number of questionnaires distributed
Belgium	Distributed by partner KIMO Network
Denmark	41
Ireland	Distributed by partner KIMO Network
Netherlands	Distributed by partner KIMO Network
Norway	363
Portugal	114
Spain	462
Sweden	87
UK	1023
Total	**2090 (plus network distribution)**

Table 4.1 Number of questionnaires distributed per country

Responses were received from a total of 352 individuals and organisations overall, which represents a 16.9% response rate on average. Based on the structure of this report, a breakdown of the responses in each sector is given in Table 4.2 overleaf.

Short follow up questionnaires were also developed to examine the wider context of the impact of marine





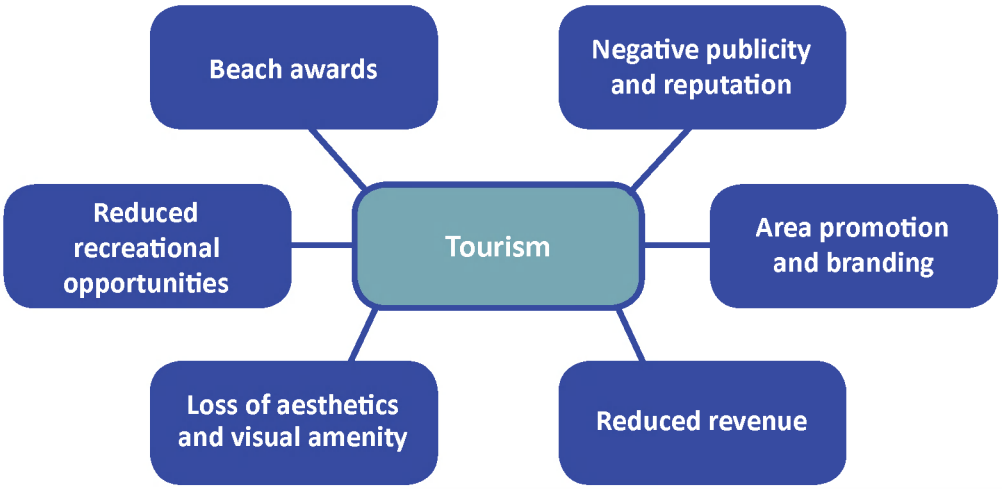
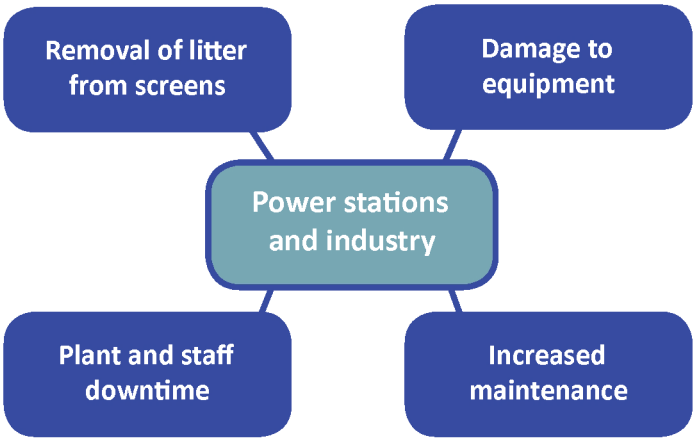
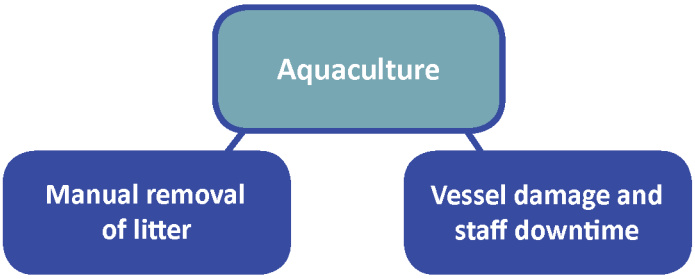


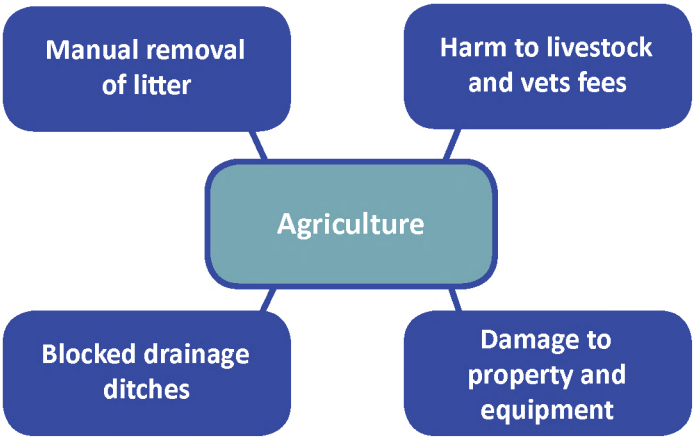
Figure 4.1: The impacts of marine litter on sectors which rely on the marine environment


Removal of litter from screens
Damage to equipment
Power stations and industry
Plant and staff downtime
Increased maintenance


Aquaculture
Manual removal of litter
Vessel damage and staff downtime


Vessel damage and incidents
Cost of coastguard rescues
Statutory duty
Awards such as ISO 14001 and Golden Anchors
Shipping
Negative publicity
Removal of litter from harbours and marinas
Additional dredging in harbours and marinas


Volunteers' time
Voluntary organisations
Financial assistance
Operational costs


Manual removal of litter
Harm to livestock and vets fees
Agriculture
Blocked drainage ditches
Damage to property and equipment

litter and provide insights into the perceptions, sensitivity and priorities of various sectors with regard to marine litter and its impact on the marine environment. These were distributed in early 2010 to 141 participants who had already completed the main project questionnaire. Follow up questionnaires were only distributed within the UK and emailed to participants from 6 sectors: agriculture, aquaculture, local authorities, harbours, marinas and fishing vessels. In total, 45 responses were received and this represents a 31.9% response rate. This was highly variable between sectors, however, with the majority of follow up questionnaires completed by local authorities and harbours.

Sector	UK Responses	Case Study Responses	Additional Responses
Municipalities	58	Netherlands and Belgium: 14	9
Voluntary Organisations	24	N/A	N/A
Tourism	16	N/A	N/A
Fisheries	22	Portugal: 21 Spain: 6	N/A
Aquaculture	11	N/A	N/A
Harbours and marinas	91	Spain: 21	14
Rescue Services	1	Norway: 1	N/A
Agriculture	31	N/A	N/A
Power Stations	3	N/A	N/A
Industrial seawater users	7	N/A	N/A
Water Authorities	2	N/A	N/A
Follow up questionnaires	45	N/A	N/A

Table 4.2: Breakdown of responses in each sector

All questionnaires were completed in each country's respective currency and then converted into Euros. As the main questionnaires were completed in two separate stages, the conversion was conducted according to the deadlines for completion set for each group of questionnaires in order to take account of inflation. For the first group of questionnaires, this was 1 April 2008 and for the second set it was 1 December 2009.

4.3 Limitations

While the methodology adopted in this project has largely been highly successful, it is important to acknowledge several key limitations. Principle among these is the use of an approach that focuses solely on the economic value of human activities. This approach can only provide a partial insight into the economic cost of marine litter because it excludes the economic cost of the environmental and social effects of marine litter from analysis. This project is therefore likely to substantially underestimate the full economic cost of marine litter to coastal communities around the Northeast Atlantic.

Similarly, the methodology used in this project is limited to cases where individuals and organisations actually spend money to deal with marine litter. Economic constraints may prevent organisations from fully dealing with marine litter and therefore the true economic impact of marine litter may be greater than the findings

here suggest. Local authorities, for example, may only remove a proportion of beach washed marine litter due to budget restrictions and the cost to remove all litter could be significantly higher. Establishing the costs of marine litter is further complicated by a lack of data recording mechanisms, which means that costs may often go unreported.

5. Municipalities

5.1 Introduction

The principle economic impact of marine litter on municipalities is the cost of keeping beaches clean and free of litter. The costs associated with removing marine litter include the collection, transportation and disposal of litter as well as hidden costs such as contract management, program administration and volunteer time. A questionnaire was developed to find out more about beach cleansing activities and this was distributed to local government organisations in countries throughout the Northeast Atlantic region.

5.2 United Kingdom

5.2.1 Beach cleansing

In total, 54 municipalities or 93.1% of respondents removed marine litter from their coastline. These municipalities were asked to select the main reason(s) why they undertake beach cleans and the results are shown in Figure 5.1 below. Only 4 municipalities reported that they did not undertake beach cleans, primarily because they had very little or no direct responsibility for the coastline in their area.

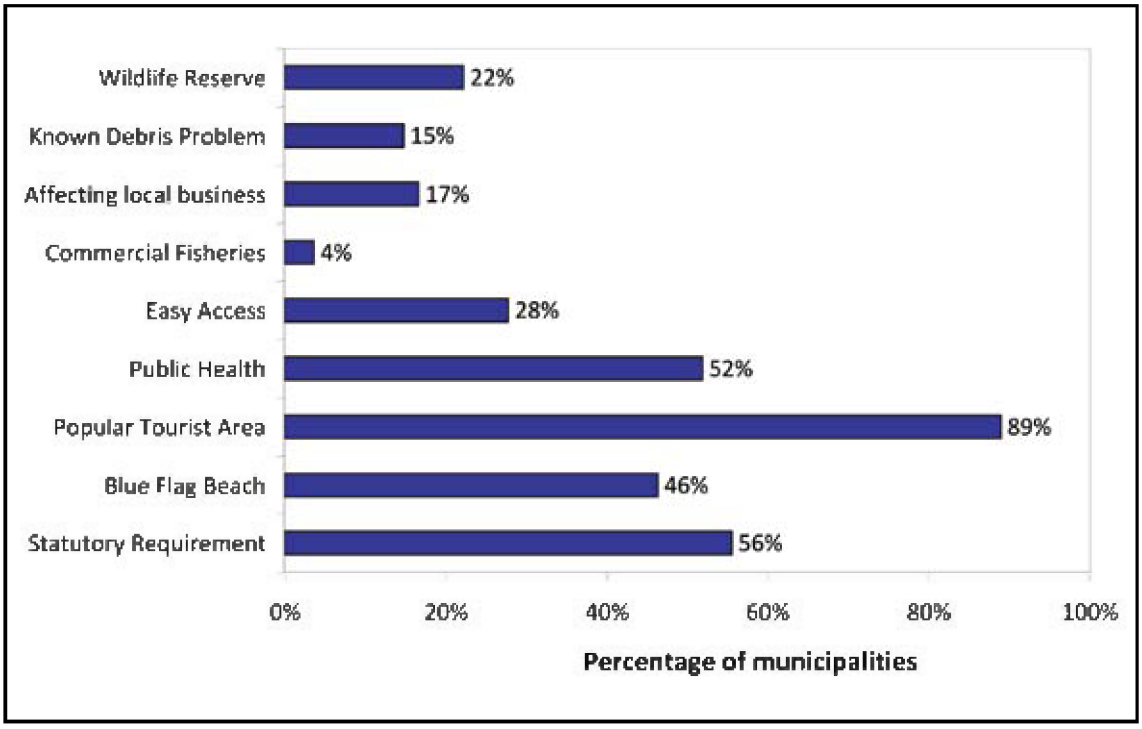
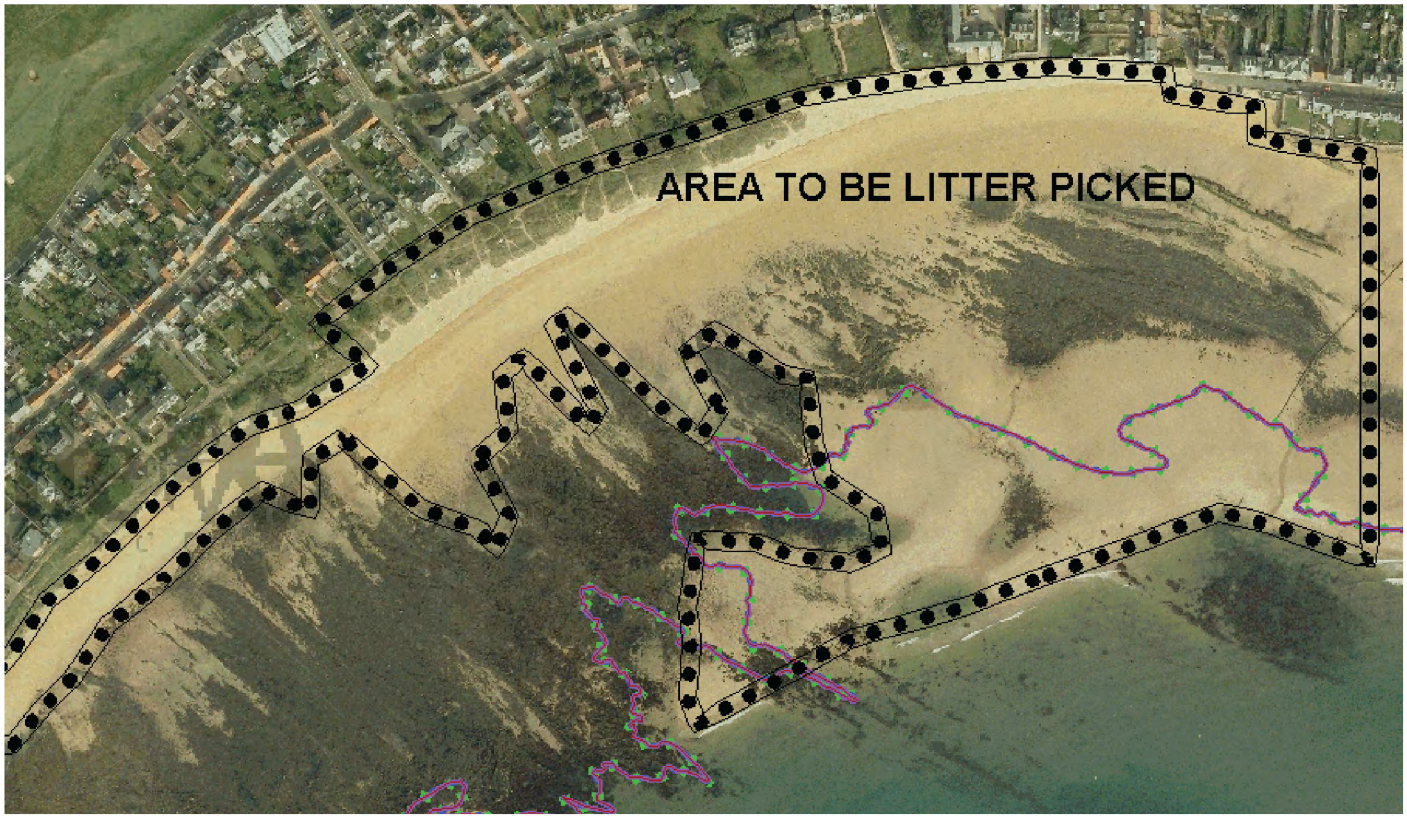


Figure 5.1: Reasons why municipalities undertake beach cleans

Figure 5.1 clearly shows that ensuring beaches are clean, attractive and safe for tourists is a key priority for municipalities and justifies the cost of removing marine litter. Protecting tourism and the local economy also appears to provide a more powerful incentive for removing marine litter than current legislation and statutory requirements. The negative economic impacts associated with marine litter therefore act as a key means to justify and stimulate action to tackle marine litter.

The prestigious Blue Flag Awards also contribute to tourism as they are designed to "guarantee to tourists

Figure 5.2: Extract from Fife Council's Litter Picking Procedures which outlines the areas where beach litter is to be picked. Image: Robbie Blyth, Fife Council.



that a beach…is one of the best in the world" (Keep Britain Tidy 2010) and that it meets recognised standards in terms of safety, water quality, cleanliness and facilities. Marine litter was removed by 46.3% of municipalities to ensure that a beach or beaches in their area met the criteria for the Blue Flag Awards. These awards tend to apply only to busier resort beaches and a number of other award systems have been introduced to recognise beaches that are managed to a high standard but are not eligible for Blue Flag Awards. These include the Quality Coast Awards, the Green Coast Awards and the Seaside Awards. Several municipalities reported that they undertook beach cleans in order to pursue these types of awards.

Municipalities were also keenly aware of the public health risks that marine litter poses with 51.9% of respondents identifying this as a reason to carry out beach cleans. Similarly, concerns about how marine litter could affect wildlife reserves led 22.2% of municipalities to remove marine litter. Comparatively few municipalities removed marine litter because "marine debris was affecting local businesses" while 8 municipalities reported that they undertook beach cleans because the coastline was known to have a marine debris problem. Although only a small minority of municipalities reported these issues, it is nonetheless a cause for concern that marine litter affects any municipality to this degree.

Municipalities often collaborated with other organisations to remove beach litter and 64.8% of municipalities received some form of external help with their beach cleaning activities. This assistance came from a variety of sources, including commercial sponsorship, but municipalities mostly worked in partnership with voluntary groups. In several cases, the municipality did not directly clean any of its beaches but instead provided support and resources for voluntary groups to undertake beach cleans instead.

Many organisations also conducted independent beach cleans with no council involvement and this was the case for 72.4% of participating municipalities. The vast majority of these beach cleans were undertaken by voluntary groups such as schools, environmental groups, university societies, surf clubs and the Scouts. Several municipalities also reported that the probation service and commercial businesses undertook independent beach cleans. Overall, municipalities reported a high level of volunteer engagement in beach cleaning activities.

5.2.2 Beach characteristics and cleansing regimes

Several questions were designed to build up a picture of the beaches cleaned and to identify any trends in cleansing regimes. These questions focused on the number of beaches cleaned by each municipality in terms of type, usage, ownership and user groups. Questions were also asked about how often beaches were cleaned and the methods used to do so. Unfortunately, the majority of municipalities found it difficult to provide this information for each beach they cleaned and the figures in this section therefore refer to the number of municipalities answering a question rather than the number of beaches involved. As a consequence, these results are therefore not comparable with the findings reported by Hall in 2000.

Within each municipality area, cleansing was generally carried out on more than one type of beach and the percentage of municipalities cleaning each type of beach is shown in Figure 5.3 below. Municipalities most commonly cleaned sandy beaches, which reflects both tourists' preferences for this type of beach and the increased difficulty involved in cleaning rocky beaches.

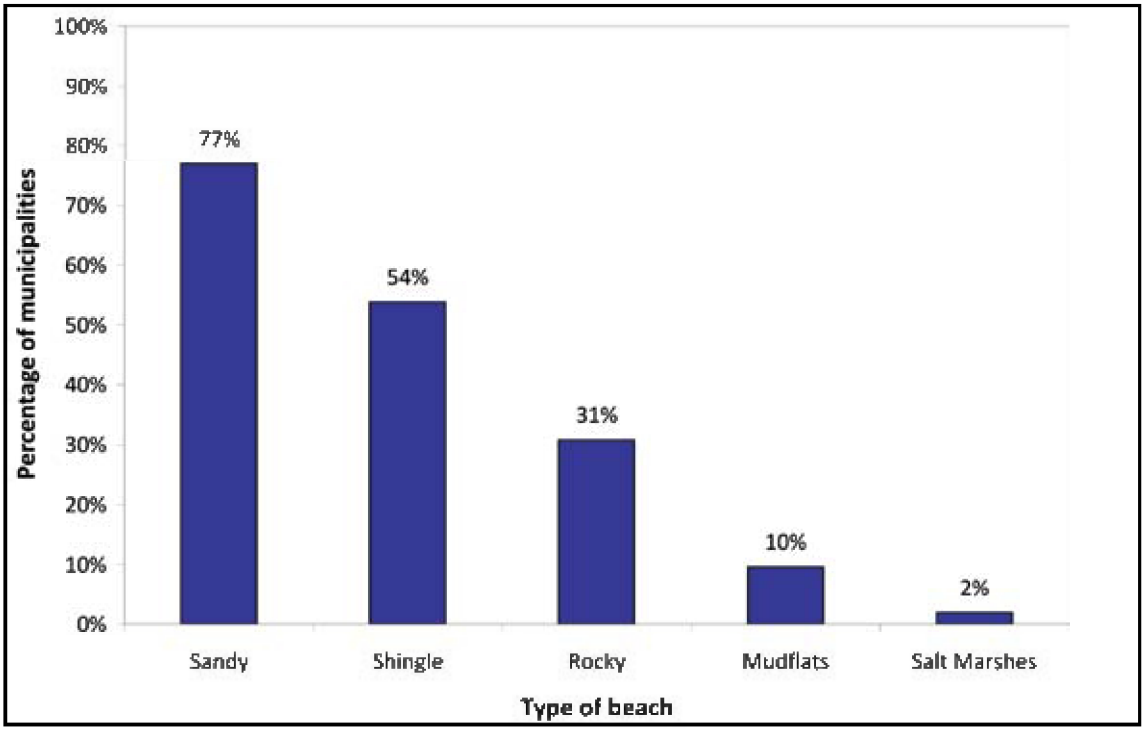


Figure 5.3: Percentage of municipalities remove beach litter from each type of beach

Over 90% of municipalities owned the beaches and coastlines where they removed beach litter with a small number reporting that private businesses and individuals also owned some of the beaches cleaned in their area. Approximately 25% of municipalities also identified 'other' owners of the beaches and coastline cleaned including:

- The Ministry of Defence
- The Crown Estate
- The Church Commission
- The National Trust

A general trend was also evident in terms of beach usage with more popular beaches more likely to be cleaned by municipalities. Highly used beaches were most commonly cleaned with 90.2% of municipalities reporting that they removed marine litter from these beaches. Over half of municipalities (54.9%) undertook cleans on beaches with medium usage and slightly less (43.1%) removed marine litter from beaches with low usage. A small minority of 11.8% of respondents also carried out clean up operations on isolated beaches.

Municipalities were also asked to identify the key user groups of the coastline where clean ups were located and the results are displayed in Figure 5.4 below. Over 95% of municipalities identified tourists as a key user group of the coastline in question, which again reflects the importance of tourism as a stimulus for the removal of marine litter. Highlighting the diverse uses of the marine environment, several municipalities also suggested additional user groups such as water sports enthusiasts, power stations and wildlife tour operators.

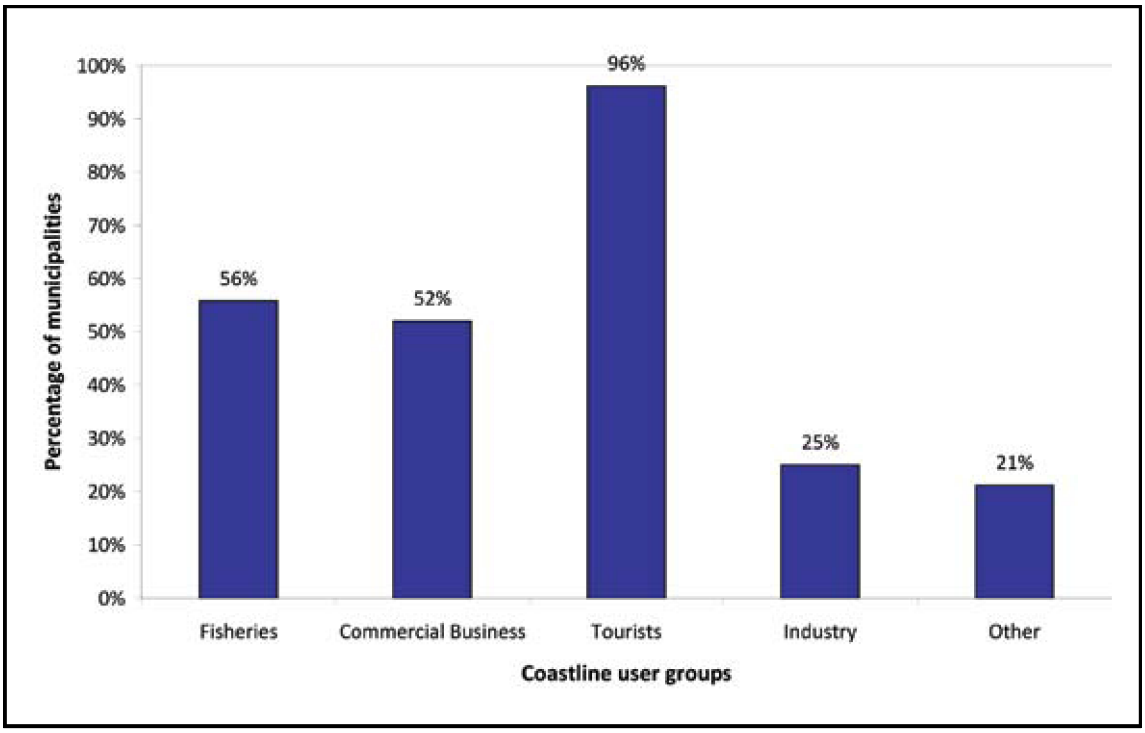


Figure 5.4: Percentage of municipalities which identified each group as key users of the coastline

Obtaining information about how frequently beaches were cleaned was more challenging since many municipalities operate variable cleansing regimes according to the beach and the season. While it is difficult to pick out any trends in the data, 76.3% of municipalities did report that they cleaned beaches on a daily/ weekly basis but this was often only during the high season. Many municipalities cleaned less well-used beaches on an as necessary basis, particularly during the winter months.

Beach cleans can either be conducted manually or using various types of machinery. In total, 51% of

municipalities removed marine litter manually while 47% used a combination of both mechanical and manual methods. Only 1 municipality used mechanical methods alone.

5.2.3 Length of coastline where marine litter is removed

As part of the questionnaire, municipalities were asked to specify the length of coastline where marine litter was removed and 48 municipalities were able to provide this information. In total, these municipalities cleaned 839 km of beaches and coastline with an average of 17.5km per municipality. The smallest distance cleaned by a single authority was 400m and the largest was 150km. Overall, the distance cleaned by the municipalities surveyed represents approximately 4.7% of the total UK coastline[3].

5.2.4 Weight and volume of litter collected

A total of 19 municipalities were able to provide information about the weight of litter removed from beaches in their area. This ranged from 1 to 12,000 tonnes and amounted to 21,757 tonnes of litter in total. Therefore the average amount of marine litter removed per municipality was 1,145 tonnes.

A further 10 municipalities were able to provide information about the volume of litter they removed in terms of the number of refuse sacks collected. A total of 28,561 refuse sacks were collected by these municipalities and several also gave details of other large items of marine litter they had encountered, including:

- Crates
- Plastic oil drums
- Fish boxes
- Tyres
- Barbeques
- Complete fishing nets

However, it is important to note that the impact of marine litter is not necessarily related to the quantities of litter involved. This is particularly true in terms of visual impact as small lengths of synthetic rope and cord, for example, weigh very little but can have an extremely high visual impact.

5.2.5 Disposal methods and litter prevention measures

Landfill, incineration and recycling are the three main options available for the disposal of marine litter and many municipalities often use a combination of these methods. Landfill is most commonly used with 88.5% of municipalities reporting that they disposed of marine litter using this approach. Marine litter is recycled by 43.3% of municipalities and 17.3% incinerate the litter they collect. Only one municipality recycled all their litter with many using a combination of landfill and recycling to dispose of marine litter.

These results suggest that the way in which municipalities dispose of marine litter has changed significantly since Hall's pilot project in 2000. In Hall's study, 100% of participating municipalities disposed of marine litter using landfill with 21.5% also using recycling and just 3.6% using incineration. While the increasing emphasis

[3] The Ordnance Survey (OS) has measured the length of mainland Britain's coastline as 11,072 miles (OS 2010). This is equal to 17,818.66 km. This was used to calculate the percentage of the UK coastline cleaned by the municipalities in this project (839km as a percentage of 17,818.66km).

on recycling is encouraging, it remains difficult to determine whether a significant quantity of marine litter is being recycled.

Virtually all the municipalities involved had put in place some type of litter prevention measures with only 1 municipality reporting that it took no action whatsoever to prevent litter. Litter bins were the most common prevention method with 94.3% of municipalities reporting that they used these on beaches and coastlines within their area. Notices were also popular and 71.7% of municipalities used these to discourage littering and promote responsible waste practices. Many municipalities were also taking additional action to prevent litter such as:

- Fixed penalty notices and fines for littering
- Raising awareness of litter issues in the community through newsletters, talks, school visits and other promotional activities
- Warden and staff patrols on busy beaches
- Providing specific recycling bins and facilities on beaches for particular types of litter
- The promotion of national awareness raising campaigns such as 'No butts on the beach' and 'Bin it, don't flush it'
- A beach litter pledge where members of the public pledge not to drop litter and to pick up 1 piece of litter every time they visit the coast. This initiative is operated by Fife Council[4]

5.2.6 Economic cost of beach litter

A key aim of this project focused on establishing the direct costs to municipalities resulting from marine litter, particularly in terms of beach cleansing costs. Of the 58 UK municipalities surveyed during this project, only 28 were in a position to provide figures relating to beach cleansing costs and budgets. Virtually all the municipalities that could not provide cost data attributed this to a lack of budget or contract breakdowns rather than because marine litter posed no cost to their authority. Similarly, very few municipalities were aware of the specific costs involved in supporting voluntary groups to undertake beach cleans.

Questions in this section focused on the cost of clean ups, the budget for such activities and the cost of litter prevention measures. Keep Scotland Beautiful also kindly shared data collected during one of their projects, which contained information about the economic cost of marine litter for a further 3 municipalities in Scotland.

5.2.6.1 Total cost and breakdown of expenditure

The total cost of removing beach litter reported by 28 municipalities in the UK was €3,893,209.93 with an average of €139,043.21 spent on removing beach litter per municipality each year. With the inclusion of the Keep Scotland Beautiful data, this rises to a total expenditure of €4,513,189.28 by 31 municipalities with an average cost of €145,586.75 per municipality. The total cost of marine litter to all coastal municipalities in the UK is therefore in the region of €17,936,000 - €18,780,000.

Municipalities were asked to break these costs down as far as possible into workforce, materials, collection, disposal and administration and 16 municipalities were able to provide detailed information at this level. The

[4] For more information about the Fife Beach Pledge, visit https://www.fifedirect.org.uk/doitonline/index.cfm?fuseaction=form.GetForm&Start=1&ModNo=1&sxl=0&forid=D46B06EE-EE92-A35B-5E0E0B27016A686A

expenditure on beach cleansing by these municipalities amounted to €2,610,100.86 and Table 5.1 shows how this is split between categories.

Category	Cost
Disposal	€309,970.95
Workforce	€1,646,495.33
Materials	€185,521.67
Collection	€249,202.18
Administration	€133,695.51
Total Cost	**€2,610,100.86**

Table 5.1: Break down of costs to 16 municipalities

For these municipalities, labour costs clearly represented a key area of expenditure and accounted for almost two thirds of the total spent on beach cleansing activities. On average each municipality spent over €100,000 on workforce costs alone. The costs associated with litter collection and disposal were also important, accounting for 10% and 12% of total expenditure respectively as shown in Figure 5.5 below. Expenditure on materials and administration of clean ups were both relatively low.

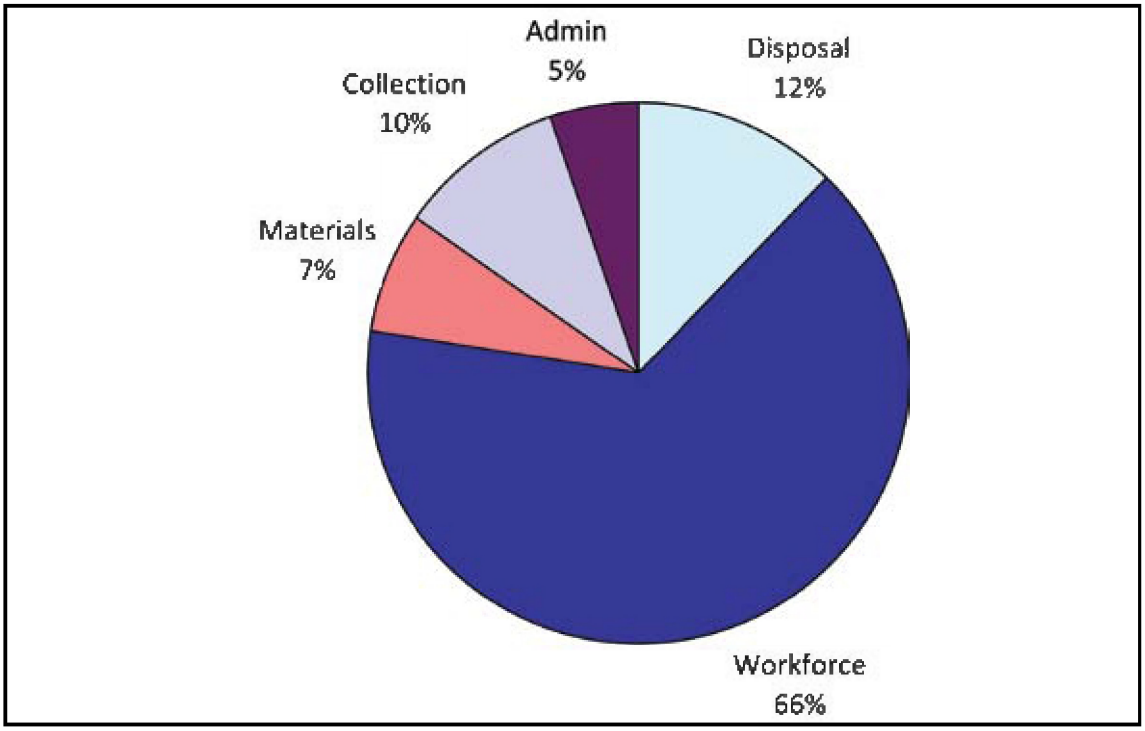


Figure 5.5: Breakdown of the average cost of removing beach litter to municipalities

5.2.6.2 Budget allocated to beach cleansing

This project also investigated whether the budget allocated by municipalities to beach cleansing was adequate to cover their costs. Unfortunately, a lack of data hampered this analysis as only 15 municipalities were able to report both the budget allocated to beach cleansing activities and the actual cost of clean ups. In total, the budget for beach cleansing allocated by these municipalities covered 93.5% of their reported costs. This varied substantially between different municipalities with beach cleansing budgets covering between 60 – 105% of total costs.

5.2.6.3 Beach cleansing expenditure per head of population and per km

Analysis was undertaken to determine the cost of marine litter per head of population and per km of beach cleaned. The data relating to costs and distance cleaned was drawn from the questionnaires while census data from 2001 was used to provide a reliable population baseline for each municipality.

On average, marine litter removal cost €0.85 per person per year but this was highly variable between municipalities and ranged from less than €0.01 per person in some municipalities to €3.99 per person in others. Higher per person costs tended to occur where municipalities had responsibility for large areas of coastline or popular tourist beaches which are generally more expensive to keep free of litter.

For 28 municipalities, it was also possible to work out how much beach litter removal cost annually per km and on average municipalities spent between €7,031.33 and €7,294.82 per km per year removing beach litter. There was wide variation within this however with beach litter removal costing from €171.05 to €82,101.55 per km each year. High per km costs often coincided with more intense beach cleansing operations that focused on regularly removing marine litter from small areas of coastline, particularly in tourist areas.

5.2.6.4 Cost of Litter Prevention Measures

While municipalities employ a diverse range of litter prevention measures, this project focused on the costs associated with the provision of coastal litterbins, as these are one of the most commonly used methods of litter prevention. Only 27 municipalities were able to provide this information, however, due to difficulties breaking down waste and litter prevention costs. In total these municipalities spent €159,496.60 per year on the provision of litterbins. Expenditure on maintenance amounted to €74,837.85 while the cost of replacement bins was lower at €48,423.16. These findings are likely to underestimate the costs associated with marine litter prevention as they do not take into account the diverse range of measures, as outlined above, employed by municipalities to tackle littering.

5.2.6.5 Trends in the economic cost of marine litter

This research has been conducted in a broadly similar manner to the project undertaken by Hall in 2000 which enables a degree of comparison between the two studies and an insight into how the economic impact of marine litter has changed over the last 10 years. Unfortunately, it is not possible to compare the total cost to municipalities reported in each study, as many of the municipalities involved in each project are different.

The average cost of beach cleansing activities per municipality however has increased by 37.4% over the last 10 years, taking into account inflation. In 2000, beach cleansing cost approximately €87,037.00[5] per municipality on average while this project found the current average cost to be €139,043.21 per municipality. Based on these averages, beach cleansing therefore cost municipalities in the UK approximately €11,488,885 in 2000 with municipalities now spending approximately €17,936,000 dealing with marine litter.

A small group of 9 municipalities responded to both projects and these results can be used to provide a more detailed and direct comparison of changes in beach cleansing expenditure over the last 10 years. Figure 5.6 overleaf illustrates the percentage change in beach cleansing expenditure experienced by these municipalities between 2000 and 2010. Overall these municipalities have experienced a 38% rise in beach

5 Hall's figures have been adjusted for inflation and converted into Euros.

cleansing expenditure, taking into account inflation, from €1,210,092.32 in 2000 to €1,669,571.36 in 2010. This is broadly in line with the increase seen in the average cost of beach cleansing activities and further suggests that beach cleansing costs have significantly increased over the past 10 years.

There were vast differences, however, in the changes in cost experienced by this group of municipalities with 5 respondents experiencing increased costs and 4 reporting lower costs than in 2000. The magnitude of change in costs over the last 10 years was also quite dramatic and ranged from a decrease of 259% experienced by the City of Edinburgh Council to an increase in expenditure on beach cleansing of 270% for Aberdeenshire Council.

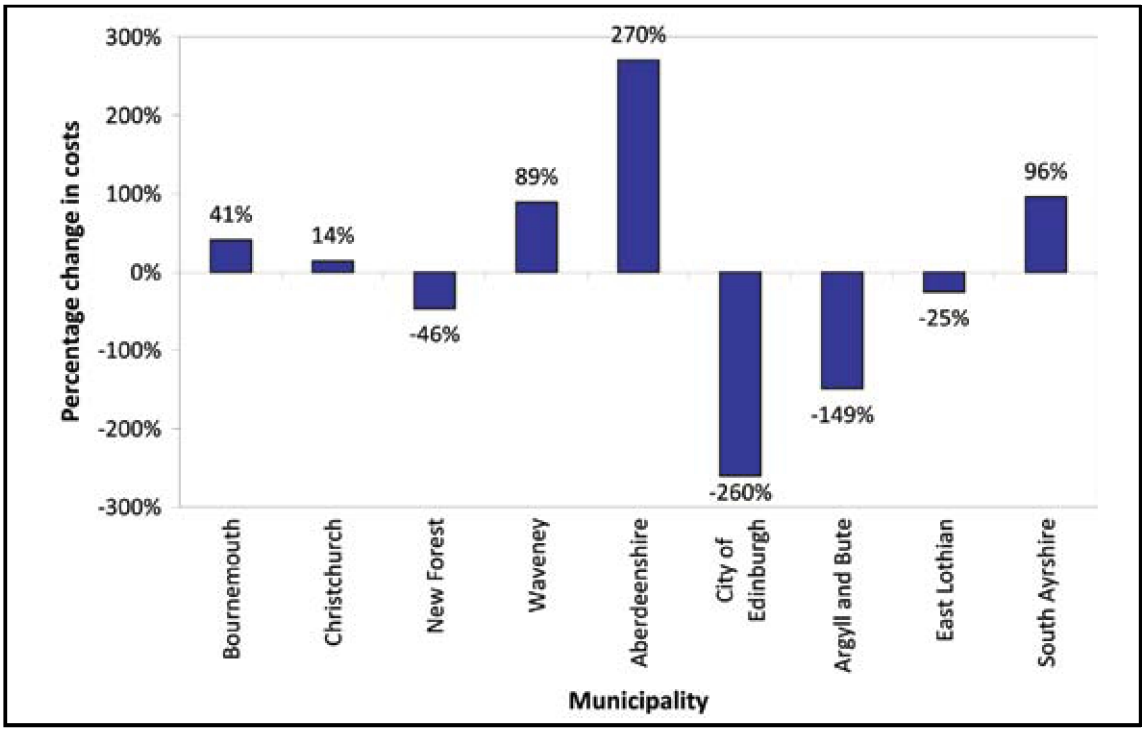


Figure 5.6: Changes in beach cleansing expenditure for municipalities between 2000 and 2010

As part of the current project, all municipalities were asked whether their beach cleansing costs had increased in the last few years and the reasons behind the change. Overall, 55.6% of municipalities reported that their costs had increased over the past few years. Municipalities suggested that the increased costs were due to:

- Higher disposal costs including landfill taxes
- Increased need for beach cleansing as a result of rising levels of litter
- Increases in staff pay and labour costs
- Inflation
- The need to pursue higher standards of beach cleanliness both to meet public expectations and fulfil the requirements of beach awards
- Increases in the cost of maintenance and fuel for vehicles
- The cost of implementing legislation
- The need to accommodate and support the increasing number of voluntary groups conducting beach cleans

Several municipalities also highlighted that despite rising costs, they were under considerable pressure to

reduce expenditure on beach cleansing. One municipality, for example, has stopped pursuing beach awards due to budget cutbacks.

5.3 Case study: The Netherlands and Belgium

5.3.1 Beach cleansing

Almost all the municipalities that responded to this questionnaire undertook some form of beach cleansing with only 1 municipality reporting that it did not operate beach cleans. This municipality did not conduct beach cleans because there was no marine debris problem in their area and other organisations cleaned the coastline when necessary.

The main reasons identified by municipalities for removing marine litter are shown in Figure 5.7 below. The most common reason for undertaking beach cleans was to maintain and enhance popular tourist areas and 92.3% of participating municipalities carried out beach cleans for this reason. Similarly, the pursuit of Blue Flag awards stimulated beach cleans in 46.2% of the municipalities surveyed. These results are broadly similar to those from the UK and show that tourism acts as the principle driving force for beach cleaning programs. The influence of legislation and statutory requirements was particularly low in the Netherlands and Belgium, however, with only 30.7% of municipalities identifying this as a reason they undertook beach clean ups.

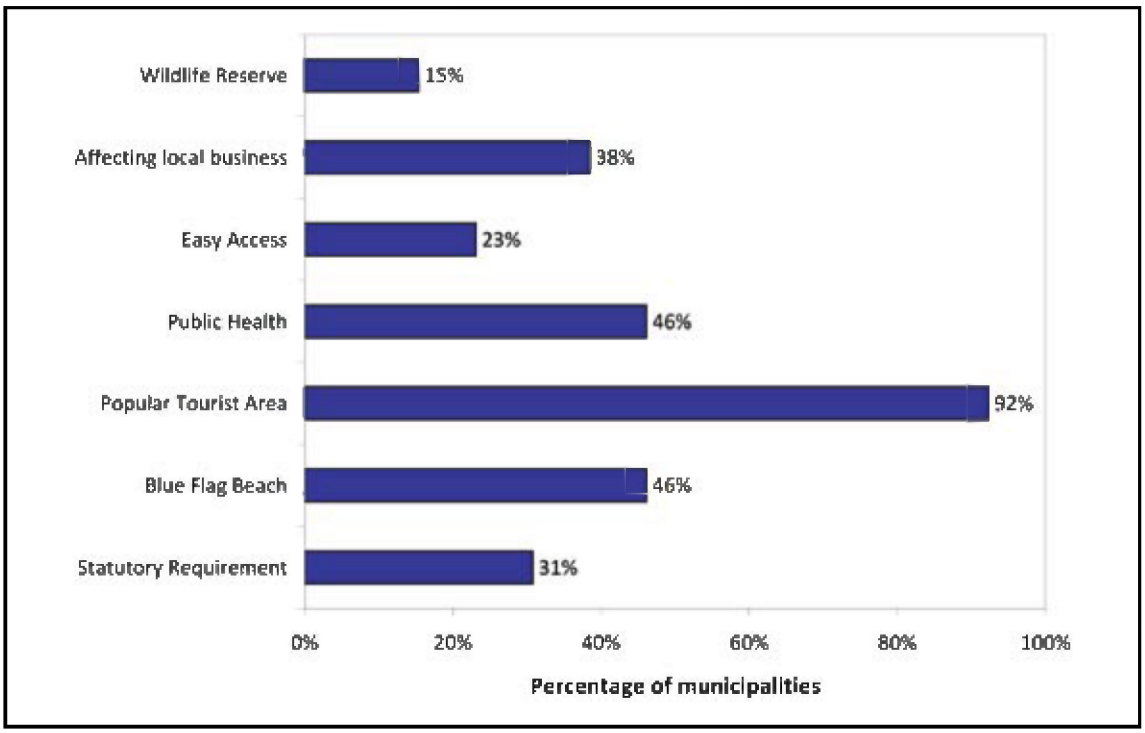


Figure 5.7: Reasons why municipalities undertake beach cleans

Municipalities often worked in partnership with other organisations to remove marine litter and 61.5% of municipalities reported that they received external assistance to run their clean ups. External organisations also operated their own beach cleans without municipality involvement and 69.2% of municipalities reported that independent beach cleans occurred in their areas.

5.3.2 Beach characteristics and cleansing regime

Municipalities were asked to identify several key characteristics of the beaches they cleaned and provide information about the methods and frequency at which clean up operations occurred. Marine litter was only removed from sandy beaches in the Netherlands and Belgium and 69.2% of municipalities were the owners of the beaches where litter was removed. The rest were generally owned by the national government and only one municipality reported that local businesses were responsible for maintaining sections of the coastline in their area.

A wide spread of beaches were cleansed in terms of usage but municipalities were still more likely to clean more popular beaches. In total, 84.6% of municipalities removed marine litter from high usage beaches, 53.9% removed litter from medium usage beaches and 23.1% removed litter from low-usage beaches. Similar to the UK, the most commonly reported user group of the coastlines where clean ups occurred was tourists with 92.3% of municipalities reporting that this was the case. For just over 75% of municipalities, commercial businesses also represented key users of the coastline in question and a much smaller proportion of municipalities also identified commercial fisheries as a key user group.

The vast majority of municipalities surveyed used a combination of manual and mechanical cleaning methods. This was the case for 76.9% of participating municipalities and only 1 municipality reported that it used no machinery whatsoever to clean its beaches. The high use of machinery for beach cleansing is possible in the Netherlands and Belgium as the beaches cleaned are generally sandy in nature. This represents a sharp contrast to the UK where beach cleansing is more often carried out manually in order to accommodate the varying nature of the beaches involved.

The frequency of clean up operations often varied to match the season and this made it difficult to draw any conclusions in terms of how regularly clean ups occurred. Overall, most municipalities operated a variable cleansing regime, removing litter on a daily or weekly basis in summer and only as necessary in winter.

5.3.3 Length of coastline cleaned and weight of litter removed

The total length of coastline cleaned by participating municipalities amounted to 68.6km in total spread across 11 municipalities. Each municipality therefore removed marine litter from 6.2km of coastline on average. For most of these municipalities, the distance where marine litter was removed represented the entire length of coastline under their jurisdiction. In this respect, municipalities in the Netherlands and Belgium cleansed a much higher proportion of the coastline than in the UK.

Figure 5.8: Beach litter collected in Ameland, the Netherlands. Image: KIMO Netherlands and Belgium

Municipalities found it more difficult to give details about the weight of litter they removed from their coastlines and only 6 municipalities were able to provide this data. The quantity of litter removed by these municipalities amounted to 724 tonnes in total.

5.3.4 Disposal methods and litter prevention measures

Municipalities were asked to identify the main methods they utilised to dispose of marine litter and 12 were able to provide this information. Municipalities in the Netherlands and Belgium overwhelmingly relied upon incinerators to dispose of the litter they collected with 11 reporting that they used this method. One municipality disposed of marine litter using a combination of landfill and recycling. These figures suggest that the Netherlands and Belgium put less emphasis on recycling marine litter than the UK but without a breakdown of the quantities of litter disposed of using each method, it is difficult to determine whether this difference is significant.

In terms of anti-litter measures, litterbins were again the most common method of litter prevention with all but one of the participating municipalities reporting that they used coastal litterbins. 5 municipalities also used notice boards that discouraged littering and promoted responsible waste practices. In addition, a small number of municipalities used other litter prevention methods such as raising public awareness of litter issues and control by the police force.

In 2009, 9 municipalities also launched the "Zwerend langs Zee" project in conjunction with KIMO Netherlands and Belgium, Rijkswaterstaat and the North Sea Foundation. The 2-year project aims to promote the responsible disposal of litter by tourists and therefore decrease the amount of litter visitors leave at the beach. "Zwerend langs Zee" therefore involves a variety of different initiatives such as displaying the amount of litter left behind in a single day, introducing "cleanteams" on the beaches to discuss marine litter with tourists, organising free lectures on the theme "The beach is more than sand" and encouraging shopkeepers at the beaches to use more sustainable packaging materials.

5.3.5 Costs of marine litter

5.3.5.1 Total cost and budget for marine litter

In total, 10 municipalities in the Netherlands and Belgium were able to supply figures as regards the total cost of removing beach litter but very few of these were able to provide a breakdown of these costs. The total cost of beach litter removal reported by municipalities was €2,265,415.30 with an average cost of €226,541.53 per municipality per year. Based on this average, removing beach litter costs all municipalities in the Netherlands and Belgium a total of €10.4 million per year.

All the municipalities that reported the cost of removing marine litter were also able to provide data about the budget allocated to beach cleansing activities. The budget reported by these municipalities amounted to €1,816,968 in total and this covered approximately 80% of the costs reported by these municipalities. The ability of the budget to meet the costs involved in removing marine litter however varied substantially between municipalities and ranged from 21.5% to 160% of costs reported. Unfortunately, many municipalities that experienced budget deficits did not report where the funding to cover these shortfalls came from. 4 municipalities did receive assistance with their beach cleansing programs but this was often delivered 'in kind' in the form of equipment, labour and/or machinery. This support came either from the national government or from local businesses within the area.

5.3.5.2 Beach cleaning expenditure per km

In the Netherlands and Belgium, removing beach litter cost an average of €34,441.04 per km per year. In

practice, this varied substantially with municipalities experiencing annual costs of between €627.91 and €97,346.15 per km for the removal of beach litter. Higher costs per km tended to occur in tourist areas where small lengths of beach were cleaned on a regular basis to ensure beaches remained safe and attractive for visitors.

5.3.5.3 Trends in the economic cost of marine litter

As the Netherlands and Belgium were not featured in Hall's (2000) study, no comparison can be drawn between the two sets of findings. The municipality of Den Haag, however, responded to both projects and details of this municipality's approach to marine litter is given in 5.3.6 below. Municipalities were also asked as part of the current project whether their costs had increased in the past few years and the reasons behind any change. Overall, 7 out of the 13 municipalities surveyed reported that their beach cleansing costs had increased in the past few years. The reasons given for this included:

- Increased labour costs
- Inflation
- More intense use of the beach all year round
- More litter being washed ashore from the sea and more rubbish being dropped by tourists
- Use of a mechanical cleaner
- More voluntary clean up operations and increasing number of people becoming involved in clean ups resulting in more litter being collected

5.3.6 Den Haag

The municipality of Den Haag in the Netherlands is responsible for a 13km stretch of coastline divided into the North and South beaches. The municipality cleans both beaches due to statutory requirements and because they are popular with tourists and easily accessible. These beaches are cleaned daily during the high season (May to October) using both mechanical and manual methods. The weight of debris collected can be highly variable and all litter removed is incinerated. Litter prevention measures utilised by the municipality include litterbins and a communications campaign beach team.

The total cost of Den Haag's beach cleansing program is an estimated €1,265,500 which is the highest cost reported by any municipality in this project. Removing marine litter therefore costs each person in Den Haag an estimated €2.64, although Den Haag's budget for beach cleansing covers only 75% of the total costs. Den Haag also experiences a relatively high per km cost of €97,346.15 per km per year due to the need to repeatedly clean small areas of beach to ensure they remain attractive to tourists. While Den Haag reported that its beach cleansing costs have remained static in the past few years, comparison with Hall's research[6] reveals that expenditure on beach cleansing has risen in real terms by approximately 83.2% over the last 10 years.

5.4 Additional Information

In several countries, only a few responses from municipalities were received and a brief summary of these questionnaires is provided in Table 5.2 overleaf.

6 Hall's figures have been adjusted for inflation and converted to euros

5.5 Conclusion

For most municipalities, the potential economic impact of marine litter, particularly in terms of lost tourist revenue, provides the principal motivation for removing beach litter. In this respect, regularly removing beach litter represents a lower cost to municipalities than the potential reduction in revenue that would result from taking no action. It is also striking that the potential economic impact of marine litter provides a much more powerful incentive for removing marine litter than current legislation and statutory requirements, particularly in the UK.

Coastal municipalities in the UK spend approximately €18 million each year removing beach litter with an average cost of €139,000 per municipality. Over the past 10 years, the average cost of removing beach litter has also increased by 37.4%. Given the considerable pressure to reduce expenditure, municipalities are finding it increasingly difficult to balance limited budgets with increasing demand for service provision. It is also clear that in this case the polluter does not pay, as municipalities must find the resources and funds to deal with litter caused by other parties. Similarly, it is important to acknowledge that although the repeated beach clean-up efforts reduce the amount of litter on the shore in the short-term, they do not directly address the underlying problem.

In the Netherlands and Belgium, coastal municipalities spend a total of €10.4 million each year removing beach litter. The highest costs are experienced in the municipality of Den Haag, which spent an estimated €1,265,000 removing beach litter in 2008. Although tourism provides the main motivation for removing beach litter, it is of particular concern that almost 40% of municipalities in the Netherlands and Belgium removed beach litter because it threatened local business interests.

While the challenges involved in dealing with marine litter vary from municipality to municipality, the findings outlined here suggest that marine litter continues to pose significant issues for municipalities throughout the Northeast Atlantic region. With many of the areas cleaned by municipalities popular with tourists, more action is required to understand why people litter and develop ways to positively influence their behaviour. The “Zwerend langs Zee” project in the Netherlands and Belgium is a good example of joint action to reduce the amount of marine litter visitors leave at the beach. The project involves a variety of initiatives designed to change tourists’ attitudes to litter and also aims to develop examples of best practice to share with other municipalities.

There are a number of other initiatives which could also help to reduce the amount of litter visitors leave at the beach and several of these are already in operation in some countries. The introduction of a deposit scheme on drinks packaging in Denmark, Germany and Malta, for example, has been used to encourage recycling. Similarly, the tax on plastic bags in Ireland has reduced the number of bags issued by 90% (Ten Brink et al 2009). More work is required to assess the potential of these schemes on a larger scale and develop methods for stakeholders to easily share information and examples of best practice to prevent litter. The development of new funding mechanisms for beach-cleaning programmes, which respect the polluter pays principle, would also increase the capacity of municipalities to deal with marine

Country	Denmark	Ireland	Portugal	Spain	Sweden
No. of Responses	1	1	3	2	2
Reasons why beach litter removed	• Protect and maintain tourist areas • Pursue Blue Flag Awards • Public health risks • Maintain easily accessible beaches	• Protect and maintain tourist areas • Pursue Blue Flag Awards • Coastline known to have a marine debris problem	• Protect and maintain tourist areas • Pursue Blue Flag Awards • Statutory requirement • Public health risks • Maintain easily accessible beaches	• Protect and maintain tourist areas • Pursue Blue Flag Awards • Protect wildlife reserves	• Protect and maintain tourist areas • Pursue Blue Flag Awards • Statutory requirement • Coastline known to have a marine debris problem
Total distance where beach litter is removed	18km	8km	15km (2 municipalities)	12km	157km
Total cost of beach litter removal per year	€6,701.59	€89,950 - €102,800	€318,169.65	€655,518	€64,114
Cost of beach litter removal per km per year	€ 372.31	€11,243.75 - €12,850	€8,277.78 - €31,768.49	€38,189.75 - €87,500	€213.71 - €4,579.59
Increased costs over the past few years	Yes	Yes	Yes	Yes	Yes
Reasons behind increased costs		• Inflation • Increasing public expectations and therefore a greater frequency of clean ups	• More people using beaches resulting in more litter • Increasing cost of meeting the requirements for Blue Flag Awards • Increased disposal costs, particularly related to a higher demand for recycling	• Inflation • Increasing public expectations	• Increased amount of litter

Table 5.2: Brief summary of questionnaires from countries where a small number of responses were received

6. UK Voluntary Organisations

6.1 Introduction

Voluntary organisations play a key role in removing litter from around the coast and raising public awareness of marine litter issues. These organisations range from small community groups dedicated to beach cleaning to large umbrella organisations that focus on diverse marine and coastal issues. Several national campaigns have also been set up to tackle marine litter issues including the Beachwatch and Adopt-a-Beach schemes, operated by the Marine Conservation Society (MCS), and the Return To Offender campaign organised by Surfers Against Sewage (SAS).

The primary economic impact of marine litter on voluntary groups is the cost of running beach cleans in terms of operational expenditure, financial assistance and the value of volunteers' time. A questionnaire was developed to find out more about voluntary beach cleansing initiatives and this was distributed to voluntary organisations within the UK.

Figure 6.1: Public beach clean organised by the Isles of Scilly Area of Outstanding Natural Beauty. Photography: Clare Lewis.

6.2 Volunteer involvement and distance cleaned

The voluntary groups surveyed during this project varied greatly in size and the number of volunteers involved in each group ranged from 1 to 4125 people. In total, between 6219 and 6753 volunteers took part in beach cleans organised by the voluntary groups surveyed in this project. These groups carried out beach cleans at various frequencies ranging from daily tidy ups to annual clean up events.

The length of coastline over which marine litter was removed was similarly variable for these organisations and ranged from just 20m to over 1000km. Many of the distances recorded are relatively small, reflecting the involvement of these groups in the Beachwatch and Adopt-a-Beach schemes. Several of the larger organisations were unable to provide figures about the distances cleaned, as this was generally not recorded by the voluntary groups they supported.

6.3 Quantity of litter collected and disposal

The voluntary organisations surveyed during this project reported the quantity of beach litter they removed either in terms of weight or the number of refuse sacks collected. 15 participating groups recorded the weight of litter removed during their beach cleans and this amounted to 71.5 to 73.1 tonnes in total. In effect, therefore, each volunteer taking part in these beach cleans removed between 12.8kg and 14.3kg of beach litter on average.

Another 9 organisations recorded the number of refuse sacks collected by their volunteers and a total of 1,851 refuse sacks of beach litter were removed by these groups. On average, therefore, each volunteer involved in these beach cleans removed 1.7 refuse sacks of beach litter. Volunteers also encountered a number of large items of marine litter including an armchair, fish boxes, oil drums and several complete fishing nets.

The options for the disposal of marine litter include incineration, landfill or recycling and 22 voluntary groups were able to provide details of how they disposed of the litter they collected. In total, 83.3% of these groups sent the litter they collected to landfill and 45.8% recycled marine litter. A small minority of voluntary groups disposed of their litter using incineration with just 8.3% of organisations using this method. Two organisations were unsure about what happened to the litter they collected as the municipality disposed of it on their behalf.

6.4 Economic cost of marine litter

6.4.1 External assistance

Among the voluntary groups surveyed, 54.2% received some form of assistance from external organisations and agencies. Municipalities were the main providers of support and financial assistance with 86.7% of voluntary groups receiving help from this source. A small number of groups also received assistance from private businesses and through sponsorship.

Direct financial assistance from external organisations was received by 5 organisations and this amounted to € 13,273.25 per year. Another 9 groups received support in the form of 'in kind' assistance, which included:

- Supplies and materials such as gloves, tabards, refuse sacks and litter pickers
- Staff to supervise the beach cleans
- Liability insurance
- Collection and transportation of litter to disposal facilities
- Disposal of litter including the associated landfill tax

Figure 6.2: Beach clean conducted by volunteers from 824 Squadron, RAF Culdrose. Photography: Clare Lewis.

6.4.2 Cost of volunteers' time

Voluntary groups were asked to estimate either the amount of money it would take to pay manual workers to do the same job or the number of hours their volunteers spent on beach cleans over the course of a year. Many voluntary groups, particularly larger organisations, found this difficult as they do not usually record these details and therefore only 9 organisations were able to estimate the value of their volunteers' time. Volunteers from these organisations spent a total of 13,228 hours over the course of a year removing marine

litter from beaches. These hours are equal to € 84,579.34 in labour costs to pay manual workers to do the same job at the British minimum wage.

6.4.3 Total cost of voluntary initiatives

Overall, 10 voluntary organisations were able to provide data about the costs associated with their beach cleans. For these groups, the total cost of voluntary clean ups amounts to €97,852.59 and Figure 6.3 below shows how these costs are divided between direct financial assistance and volunteer time. The cost to pay manual workers to do the same job is relatively high and in effect each volunteer involved in these groups contributes the equivalent of €16.23 of their time on average each year. In reality, the full cost of voluntary clean ups is likely to be substantially higher as this analysis does not include the administrative costs involved in organising beach cleans or the cost of in kind support and assistance provided by external organisations.

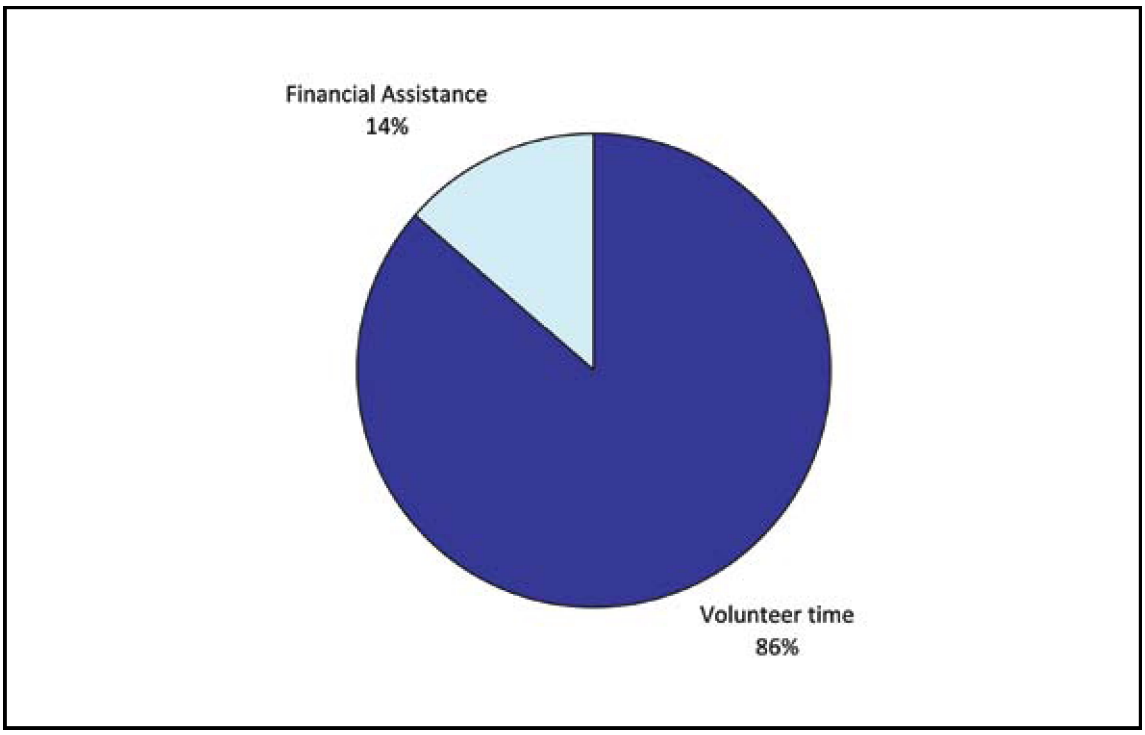


Figure 6.3: Breakdown of the average cost of marine litter to voluntary organisations

On a broader scale, it is difficult to calculate the total cost of voluntary clean up efforts due to the sheer diversity and widespread nature of these groups. However, estimating the contribution volunteers make to some of the big voluntary clean up initiatives in the UK gives some indication of the cost of these efforts. Within the UK, the MCS Beachwatch scheme and Keep Scotland Beautiful's (KSB) National Spring Clean both remove a substantial quantity of litter from around the UK coastline and a total of 8,809 adult volunteers were involved in the most recent events held by these organisations. Volunteers involved in these events therefore contribute the equivalent of € 131,287.47[7] of their time on average each year. Given the high

[7] In 2009, MCS Beachwatch volunteers spent a total of 9,995 volunteer hours removing beach litter at a cost of €63,868.05 at the British minimum wage. In 2010, coastal clean ups held under the KSB National Spring Clean banner involved 4,154 adult volunteers but unfortunately the number of volunteer hours is unknown. However, applying the average cost of time contributed by volunteers surveyed during this project (€16.23) suggests that these volunteers contributed the equivalent of approximately €67,419.42 of their time. In total, therefore, volunteers contributed the equivalent of €131,287.47 of their time to these events.

level of volunteer involvement in removing beach litter in the UK, these figures suggest that the full cost of voluntary beach litter removal in the UK is likely to be significant.

6.5 Conclusion

Voluntary organisations clearly make a significant and extremely positive contribution to ensuring the UK's coastline remains clean and litter free. With each volunteer contributing €16.23 on average of their time each year, the full economic cost of voluntary involvement in removing beach litter is likely to be substantial. Indeed, the 8,809 volunteers involved in the most recent MCS Beachwatch and KSB National Spring Clean campaigns contributed approximately € 131,287.47 of their time to removing beach litter. In reality, the full cost of voluntary clean ups is likely to be substantially higher as this analysis does not include the administrative costs involved in organising beach cleans or the cost of in kind support and assistance provided by external organisations. It is also important to acknowledge that while these repeated beach cleans reduce the amount of litter on the shore in the short-term, they do not directly address the underlying problem.

Although volunteers contribute their time for free, most voluntary groups often seek small grants from external bodies to cover operating costs such as equipment for volunteers and administrative costs. Within the current financial climate, however, voluntary groups are finding it increasingly difficult to source the external funding necessary to support their work and it is therefore unclear whether some groups will be able to continue in their present form.

While this project has focused on the UK, countless voluntary groups around the world are involved in similar activities aimed at reducing the amount of litter in the marine and coastal environment. More research is required to fully account for the efforts of these organisations and ensure that voluntary action does not mask the true cost of marine litter.

7. UK Tourism

7.1 Introduction

Tourism is one of the UK's largest industries and directly accounts for approximately 3.7% of national GDP (Deloitte 2008). Coastal tourism, in particular, contributes between €7 billion (Tourism Alliance 2007) and €11 billion (Deloitte 2008) to the UK economy each year. For visitors to the coastline, beach cleanliness is a key priority when choosing where to visit (ENCAMS 2005) and the presence of marine litter can therefore act as a deterrent to tourists (Ballance et al 2000). Marine litter can consequently have a negative effect on tourism revenue and weaken coastal economies. A questionnaire was developed to investigate the effects of marine litter on tourism and this questionnaire was distributed to tourist authorities within the UK.

7.2 Coastal visitors and tourist revenue

A total of 8 local and regional tourist organisations were able to provide figures regarding the number of tourists visiting their area. They recorded approximately 39.4 million visitors to their areas, of which between 16.5 and 17.4 million visited the area specifically to go to the beach or coastline. The percentage of tourists specifically attracted by the beach or coastline varied significantly between areas and ranged from 18% to 90% of total visitors to an area. Any drop in cleanliness standards could therefore result in a serious decline in tourist numbers.

For the 5 organisations that provided figures, tourism generated an estimated € 3.4 billion in their areas and, assuming visitors spend the same regardless of the attraction, tourists therefore spend € 1.8 billion while visiting coastal locations. Clearly any reduction in tourist revenue due to marine litter could have a detrimental effect on coastal economies, particularly as tourism often makes a disproportionately high contribution to coastal economies (Deloitte 2008; Visit Wales 2008).

7.3 Awards and Complaints

Within the UK, various awards schemes have been developed to recognise beaches that are managed to a high standard. These include:

- Blue Flag Awards. These are judged according to recognised standards in terms of safety, water quality, cleanliness and facilities. Throughout the UK, 122 beaches have successfully achieved Blue Flag Awards in 2010.
- Quality Coast Awards. This scheme operates only in England and aims to raise standards at the coast. A total of 111 Quality Coast Awards have been presented in 2010.
- Green Coast Awards. This initiative was developed to recognise more remote rural beaches in Wales and Ireland that are managed to a high standard and meet the guideline standards for bathing water. During the 2010 season, a record 50 beaches in Wales achieved Green Coast Awards.
- Seaside Awards. This scheme is split into two categories, resort and rural beaches, and operates in Scotland, Wales and Northern Ireland. It recognises beaches that meet mandatory water quality standards and are clean, safe and well managed. In 2010, a total of 173 beaches met the criteria for Seaside Awards.

In this project, 10 out of the 16 tourist authorities surveyed reported that beaches in their area held at least one type of award. Among this group, Blue Flag Awards were the most commonly held type of award closely

followed by Quality Coast Awards.

All the tourist organisations surveyed during this project reported that complaints about marine litter and rubbish on the beach were extremely rare. Altogether, these organisations had only received 13 complaints about marine litter in total with tourists more likely to switch to other destinations rather than complain. Reports of illness and injuries resulting from marine litter were similarly rare and in most cases these were minor incidents that generally go unrecorded.

7.4 Importance of a clean and high quality coastal environment to tourism branding

The tourist organisations surveyed during this project agreed that a clean and high quality coastal environment was important or very important for tourism branding. For many areas, the coast is the principal attraction for tourists and therefore ensuring it remains attractive, clean and safe is critically important. As one participant stated, "visitors and locals alike want to visit unspoiled coastal sites and appreciate the beauty there. They don't want to be confronted with rubbish strewn across the landscape."

Public perceptions of the cleanliness and quality of a beach were also very important with several tourist organisations suggesting that bad visitor experiences would damage their branding position as a clean and high quality destination. Several organisations therefore felt it was important to actively demonstrate to prospective visitors that their beaches were managed to a high standard, generally through participation in awards schemes and initiatives such as the Blue Flag Awards.

Participants also highlighted the potential economic impact of a reduction in tourism due to marine litter. A participant stated, "The coastline/beaches is the main reason visitors choose to visit this area and with an industry worth more than £1 billion then anything which affects this would be hugely detrimental." Ensuring visitors have a positive experience at the beach is also a key part of encouraging repeat visits to the area. One organisation stated that "visitors are attracted to a clean beach and a beach is remembered for the cleanliness, resulting in repeat visits to the area. We also have a lot of water sports, such as surfing and kite surfing on our coastline, this would be hugely affected if the water and beach area were not clean."

Figure 7.1: The Blue Flag awards are used by municipalities to demonstrate that their beaches are managed to a high standard. Image: Keep Scotland Beautiful.

As a result, the vast majority of organisations surveyed believed that only natural debris such as seaweed was acceptable in the marine and coastal environment; all man-made litter is unnecessary and unacceptable. Several organisations, however, felt that litter was nearly impossible to control.

7.5 Litter prevention and removal campaigns

Tourist authorities were keenly aware that the tourism industry itself results in a significant amount of litter entering the marine environment and many of these organisations therefore actively worked both to prevent and remove litter from the coastline in their areas. These activities included:

- Visible beach cleansing operations, numerous bins and signage promoting responsible waste practices
- Promotion of responsible behaviour in publications and on the organisation's website such as the 'Green Travel Code'[8] developed by the Northern Ireland Tourist Board which specifically includes messages about littering
- Participation in beach clean up initiatives such as Beachwatch and the Adopt-a-Beach scheme operated by the Marine Conservation Society
- Supporting and encouraging voluntary community beach cleans
- Educational talks about beach safety, ecology and biodiversity
- Participation in the Blue Flag and Quality Coast awards schemes and their accompanying local advisory groups and forums
- Sharing best practice with other organisations through the United Kingdom Beach Managers Forum (UKBMF) and the National Water Safety Beach Safety Council Forum (NWSBSCF)

7.6 Conclusion

For many areas, the clean and unspoiled coastline is the principal attraction for tourists. From the findings presented in this chapter, it is clear that marine litter can threaten the image and reputation of an area and potentially lead to a decline in the number of tourists visiting the area. This could have a significant negative impact on tourism revenue and the local economy as a whole, particularly as tourism tends to make a disproportionately large contribution to coastal economies (Deloitte 2008). It is also important to remember that the direct costs of removing beach litter tend to be borne by municipalities rather than tourist organisations.

There is now a pressing need for more research, similar to that conducted by Ballance et al (2000), to determine at what level marine litter acts as a deterrent to tourists. This is particularly important given that tourist authorities receive relatively few complaints about marine litter with tourists more likely to switch to other destinations rather than complain. Many tourist authorities have therefore put in place numerous measures to both actively demonstrate to visitors how clean their coastline is and minimise the amount of marine litter generated by tourists in their area.

Figure 7.2: Beach litter in South West England. Image: Sarah Crosbie.

8 For more information about the Green Travel Code, see http://www.discovernorthernireland.com/Green-Travel-Code-A2639

8. Sea Fisheries

Figure 8.1: Marine litter can result in numerous problems and high costs for fishing vessels. Image: David Linkie.

8.1 Introduction

Sea fisheries are extremely important to many coastal communities throughout the Northeast Atlantic region and they continue to provide a key source of income and employment, especially in areas where other economic opportunities are scarce. The fishing industry is often highlighted as a source of marine litter but less attention has been paid to the negative impact marine litter has on fishing vessels and the industry as a whole (OSPAR 2009).
Marine litter affects the fishing industry in a variety of ways, which can result in both additional costs and reduced revenue for fishing vessels. This project focuses on the economic impacts associated with marine litter which include:

- Repairing damage to fishing gear and the vessel
- Replacement of lost gear
- Reduced and/or contaminated catch
- Loss of earnings due to reduced fishing time

A questionnaire was developed to investigate how marine litter affects fishing vessels and the associated costs of dealing with it. These questionnaires were distributed to fishing vessels in countries throughout the Northeast Atlantic region.

8.2 Scottish fishing vessels

8.2.1 Introduction

Despite restructuring over the past decade, the Scottish fishing industry remains one of the largest in Europe and many coastal communities throughout Scotland rely on fishing for their livelihoods. In 2008, the Scottish fleet landed approximately 371,000 tonnes of fish with a commercial value of £396 million. Over 5,400 people are employed in the catching sector (Scottish Government 2009a) with another 5,250 employed in the onshore fish processing industry (Scottish Government 2009b).

This project aimed to investigate the extent to which marine litter affects the fishing industry in Scotland and the associated economic costs of dealing with it. The vast majority of questionnaire responses received came from twin and single rig trawlers but responses were also received from scallopers, seine netters and pair trawlers.

8.2.2 Common types of litter and worst areas

Fishermen were asked to identify the types of litter that commonly accumulate in their hauls and the results are shown in Figure 8.2 below. The most common type of litter was rope closely followed by plastic with over 90% of fishermen experiencing these types of litter accumulating in their nets. Bottles, wire, derelict fishing nets and tyres were also very common and over 70% of fishermen found these types of debris in their hauls. Fishing vessels had also encountered a wide range of other types of debris including:

- Oil and fuel filters
- Tins of paint and grease
- Debris from oil related activities
- Foreign gill nets
- Washing machines
- Cars

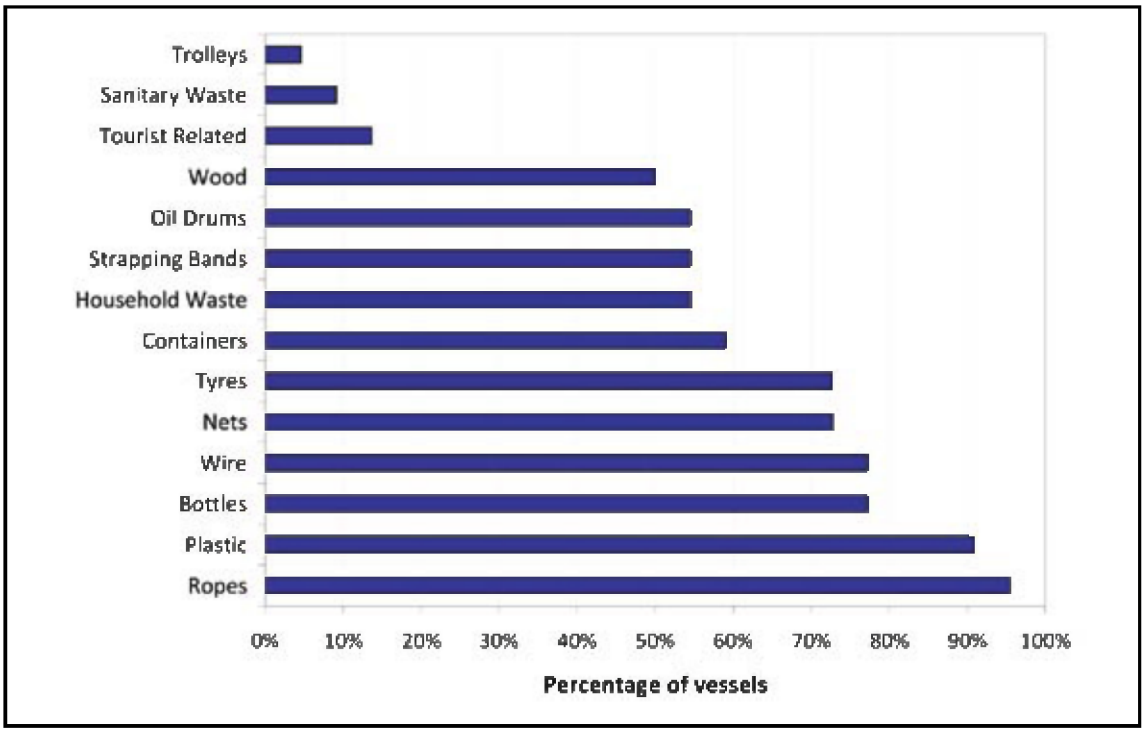


Figure 8.2: Most common types of litter accumulating in hauls

Fishermen were also asked to identify the "worst area" for collecting or snagging marine litter in their nets but it quickly became apparent that there is no single "worst area" for litter. Fishing vessels can experience problems with marine litter wherever they are, although a small number of vessels specifically reported problems near areas of recent oil related activity. One vessel suggested that "80% of torn and damaged gear, and lost nets is due to oil debris".

8.2.3 Impact on catch and damage to nets

Marine litter can restrict the amount vessels catch by accumulating in their nets during hauls and this affected approximately 86% of vessels surveyed during this project. As one vessel reported "Plastics in my net restrict

my trawl fishing to its full potential, as the cod-ends fill up with silt quickly. This then alters the geometry of the twin trawl resulting in a poor trawl tow". Several fishermen also commented that they were now experiencing less litter on the fishing grounds than in past years due to the Fishing for Litter project, which actively removes litter from the seas around Scotland.

Various types of marine litter can also contaminate a vessel's catch resulting in the fish having to be dumped, additional costs to clean the vessel and equipment, and lost fishing time. Approximately 82% of vessels surveyed had discarded fish due to contamination with one vessel reporting that it had to "dump three boxes of prawns last trip due to paint". Every boat that had experienced a contaminated catch identified paint as a cause with 88% also reporting that oil filters have fouled their catch. A small number of vessels had also experienced problems with grease and detergents. Contamination incidents could occur quite regularly with some vessels experiencing as many as one incident per month.

Over 95% of vessels had snagged their nets on debris on the seabed, although it is not always possible to identify whether this debris is natural or man-made. Fishermen commented that debris from oil related activities and old wires on the seabed were particular problems in terms of damaging nets.

8.2.4 Incidents involving marine litter

Marine litter can pose navigational hazards for fishing vessels and potentially result in vessel damage. The types of incidents involving marine litter include fouled propellers, fouled anchors, fouled rudders and blocked intake pipes and valves. For many vessels, it was difficult to estimate the number of incidents that occur in a year but only 4 vessels reported that they had experienced no incidents with marine debris in the last year.

For the 18 vessels that had experienced incidents with marine litter, fouled propellers were generally the most common type of incident closely followed by blocked intake pipes and valves. Only one vessel had experienced a fouled rudder and no vessels reported having fouled their anchor on marine litter.

In terms of specific figures, 7 vessels were able to provide data about the number of incidents involving marine litter they had experienced over the course of a year. These vessels reported 20 incidents in total including 6 fouled propellers and 14 cases of blocked intake pipes or valves. On average therefore each vessel participating in the project experienced just under 1 incident per year involving marine litter.

8.2.5 Economic cost of marine litter to fishing vessels

This project concentrated on the direct economic impact of marine litter on fishing vessels including:

- The value of dumped catch
- The cost of repairs to fishing gear and nets
- The overall cost of fouling incidents[9]
- Lost earnings as a result of reduced fishing time due to clearing litter from nets[10]

On average, marine litter costs each fishing vessel in the Scottish fishing fleet between €17,219 and €19,165

[9] Calculated using the cost of a fouling incident as reported by each vessel.

[10] Calculated using the average value of one hour's fishing time as estimated by vessels surveyed during this project.

each year and Figure 8.3 below shows how this is split on average between different categories. The loss of fishing time incurred due to clearing nets of marine litter accounts for the majority of costs experienced by fishing vessels as a result of marine litter. On average, each vessel spends 41 hours per year clearing litter from their nets at a cost of approximately €12,000[11]. With continuing European restrictions on the number of days fishing vessels can spend at sea, lost fishing time due to marine litter is a cost few fishing vessels can afford.

The relatively low average cost incurred due to fouling incidents reflects the overall infrequency of these events across the fishing fleet. It is also important to note that the economic impact of an incident involving marine litter is highly dependent upon how good the fishing is when an incident occurs. As one fisherman put it, this can result in virtually no cost if the fishing is poor but "a hell of a lot of money" if the fishing is good.

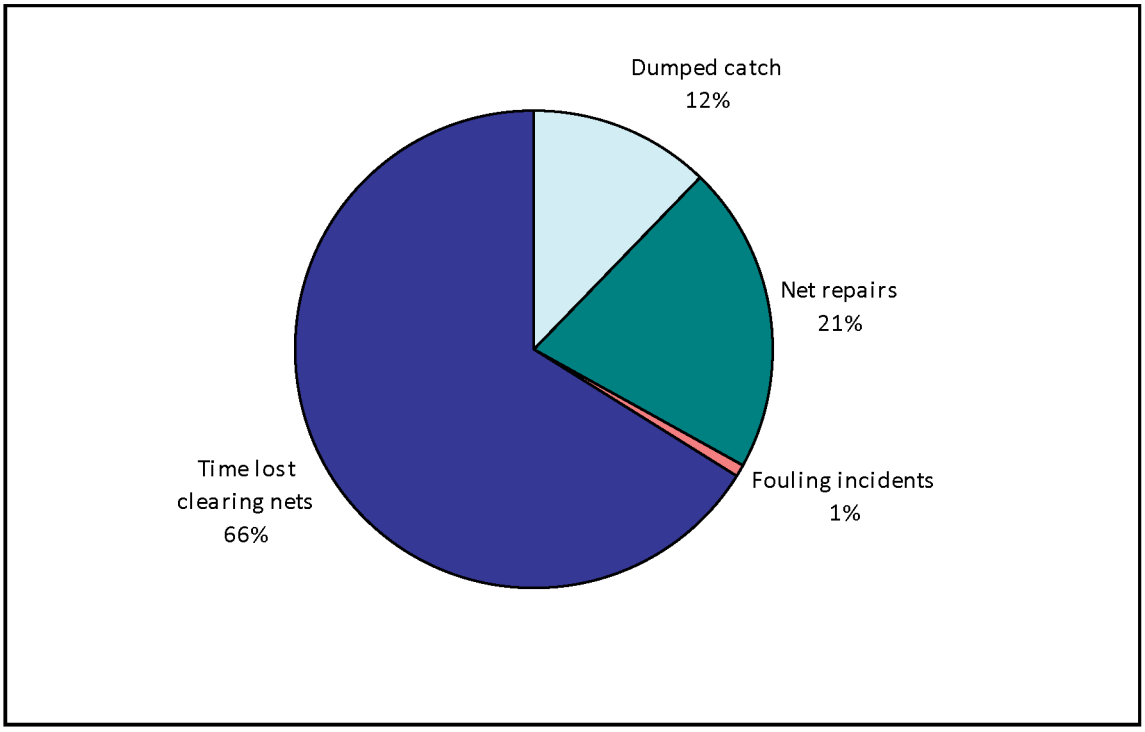


Figure 8.3: Breakdown of the average cost of marine litter to Scottish fishing vessels

The economic impact of marine litter on fishing vessels can clearly be substantial and represents an additional burden on an industry already under pressure. Based on the average figures, marine litter costs the Scottish fishing industry between €11.7 million and €13 million each year[12]. Marine litter therefore reduces the revenue generated by affected fisheries by up to 5% per year[13].

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11 Calculated using the average value of one hour's fishing time as estimated by vessels surveyed during this project.

12 Calculated using the average cost of marine litter per vessel and the number of vessels involved in affected fisheries. Number of vessels in affected fisheries taken from Table 5 of Scottish Government (2009a): demersal (355 vessels), nephrops trawl (274 vessels), mechanical dredging (91 vessels) and suction dredging (3 vessels). Total of 678 vessels in affected fisheries.

13 Calculated based on the average cost of marine litter to all vessels in affected fisheries as a percentage of the value of landings for these fisheries. Value of landings for affected fisheries taken from Table 30 of Scottish Government (2009a): demersal (£139,416,000), nephrops (£91,287,000) and scallops (£28,485,000). Total value of landings in affected fisheries: £259,188,000. Converted to Euros: €272,112,428.02.

In general, very few vessels received any assistance to cover costs incurred due to marine litter. Only 27% of vessels have claimed insurance for incidents involving marine litter and just 9% had claimed income support. Many vessels also commented that it was very difficult to get compensation for incidents involving oil related debris as it is quite challenging to provide the evidence necessary to support a claim.

8.2.6 Working practices

The fishermen surveyed during this project acknowledged that fishing vessels do contribute to marine litter with one fisherman stating, "A lot of beach litter is coming from fishing vessels dumping their rubbish on the way to fishing grounds". The fishing industry overall however has adopted a number of positive measures to tackle marine litter and reduce its environmental impact.

Figure 8.4: Full bags of marine litter deposited by vessels involved in the Fishing for Litter South West scheme. Image: Sarah Crosbie

All the vessels surveyed had signed up to the Fishing For Litter scheme, which actively removes marine litter from the seas. Several fishermen commented that they were already seeing the positive effects of this project since "fishing grounds do appear to have less debris on them as we are not seeing the same amounts of plastics etc". Over 77% of the vessels surveyed were also members of a responsible fishing scheme, which includes commitments to prevent and remove marine litter.

8.3 Portuguese fishing vessels

Since most of the Portuguese vessels surveyed used long-lines rather than nets, they encountered very few problems with marine litter affecting their catch. Therefore, only 29% of vessels had experienced a restricted catch due to marine litter and 38% had experienced a contaminated catch, which was caused by oil filters in all cases.

In terms of incidents, only 4 Portuguese vessels had sustained no incidents involving marine litter whatsoever. Fouled propellers were the most common type of incident with 12 vessels sustaining at least one fouled propeller per year. These vessels recorded a total of 19 fouled propellers per year, which is significantly higher than the number reported by Scottish vessels. A further 5 Portuguese vessels reported that they experienced fouled propellers approximately once every five years.

Blocked intake pipes and valves were much less common than in the Scottish fleet with only 4 Portuguese vessels experiencing one or more blocked intake pipes or valves per year. Just one vessel had fouled its rudder on marine litter in the past year and fouled anchors were extremely rare with only one incident of this

type occurring in the past 20 years. Overall, the Portuguese vessels surveyed experienced 1.1 incidents per vessel per year on average, slightly above the incidence rate for Scottish vessels.

The economic impact of marine litter upon Portuguese vessels was on average relatively low, particularly in comparison to the Scottish figures. Marine litter cost each Portuguese vessel €2,930 per year on average and over 80% of these costs related to fouled propellers. Indeed, fouled propellers could cost as much as €15,000 per incident. Although repairing nets makes up only 18% of the average cost, this is relatively high considering the small number of vessels using a net-based approach. Despite high costs for individual vessels, the average cost of marine litter appears quite low, as these problems seem to affect only a small proportion of the Portuguese fleet.

Portuguese vessels were often successful in claiming insurance to cover the cost of incidents with 81% of vessels reporting this to be the case. The number of vessels able to claim income support was also slightly higher than in Scotland and 19% of vessels had been able to do so in the event of an incident. Just under half of the vessels surveyed were also involved in a responsible fishing scheme.

8.4 Spanish Fishing Vessels

A total of 6 responses were received from Spanish fishing vessels and all of these vessels fished within the Mediterranean Sea. These responses came from trawlers and vessels using seine nets. While representing only a small sample, the Spanish vessels surveyed experienced broadly similar problems with marine litter to those occurring in Scotland.

All the vessels surveyed had experienced a restricted catch due to marine litter accumulating in their nets and plastic, particularly plastic bottles, was the most common type of debris. Marine litter had contaminated the catch of 3 vessels with paint the most common cause, although grease and oil filters also proved to be a problem. Virtually all the vessels surveyed had snagged their nets on debris on the seabed.

Every vessel surveyed had experienced at least one incident involving marine litter but only 3 vessels were able to report how often this occurred per year. These vessels had experienced 1 fouled propeller and 3 blocked intake pipes or valves in the past year. With minimal data, it is not possible to determine the economic cost of these incidents. All of the vessels surveyed were also signed up to a responsible fishing scheme.

8.5 Conclusion

The findings presented in this chapter clearly show that marine litter poses numerous and widespread issues for the fishing industry. Of the Scottish vessels that responded, 86% had experienced a restricted catch due to marine litter, 82% had had their catch contaminated and 95% had snagged their nets on debris on the seabed. Incidents such as fouled propellers and blocked intake pipes were also relatively common with an average of just under 1 incident reported per vessel per year.

Although subject to variability depending on the quality of fishing, it is also clear that marine litter results in high costs both to individual fishing vessels and to the industry as a whole. Marine litter costs the Scottish fishing industry €11.7 - €13 million each year, which is the equivalent of up to 5% of the total revenue of affected fisheries. Given the continuing restrictions on the number of days fishing vessels can spend at sea, the large amount of lost fishing time due to marine litter is an area of particular concern.

Vessels surveyed during this project also acknowledged that the fishing industry is both a source and a victim of marine litter. Within Scotland, plastics and rope were the most common types of litter encountered by fishing vessels and oil industry debris continued to pose significant problems. The fishing industry is also making a considerable effort to reduce marine litter by both preventing litter entering the marine environment and removing existing marine litter through the Fishing for Litter scheme.

While the impacts of marine litter are variable, case studies from Portugal and Spain demonstrate that marine litter can cause widespread problems for fishing vessels. Fouled propellers posed the main issues for Portuguese vessels and although individual incidents could be very costly, the average cost of marine litter per vessel was relatively low as only a small proportion of the vessels surveyed were affected. Although the small group of Spanish vessels surveyed fished in the Mediterranean Sea, they experienced fairly similar problems with marine litter to those reported by the Scottish fleet in the Northeast Atlantic.

Marine litter poses numerous issues for fishing vessels and there are a number of actions the industry could take to reduce its own contribution to marine litter. In particular, environmental awareness training, incorporating marine litter issues, for all professional fishermen could be implemented and made compulsory. Port waste reception facilities regulations could also be expanded to include fishing vessels, which are currently exempt, in order to monitor waste disposal and deter illegal discharges at sea. In addition, Scottish fishermen are finding less litter on their fishing grounds thanks to the Fishing for Litter scheme and therefore encouraging further participation in this scheme and extending it into new areas would be beneficial for both fishermen and the environment.

9. Scottish Aquaculture

9.1 Introduction

Since the 1970s, the Scottish aquaculture industry has rapidly developed and expanded to include species such as rainbow trout, halibut and a wide variety of shellfish as well as salmon. With a farm gate value of over £350 million, the aquaculture industry is a key source of income and employment in Scotland, particularly in rural areas where it is often a key contributor to the economy (Scottish Government 2009c).

Marine litter can result in additional costs to the aquaculture industry, particularly in terms of time spent removing debris from around fish farm sites and the costs associated with fouled propellers on work boats. A questionnaire was developed to investigate how marine litter affects the aquaculture industry and the associated economic costs. This questionnaire was distributed to a mixture of finfish and shellfish producers throughout Scotland. As many of the companies involved are multi-site, most of the questionnaires in this project cover more than one fish farm location.

9.2 Impact and types of litter

A total of 8 producers experienced problems with marine litter accumulating in cages and around mussel rafts at their fish farm sites. Figure 9.1 below shows the most common types of debris affecting aquaculture producers.

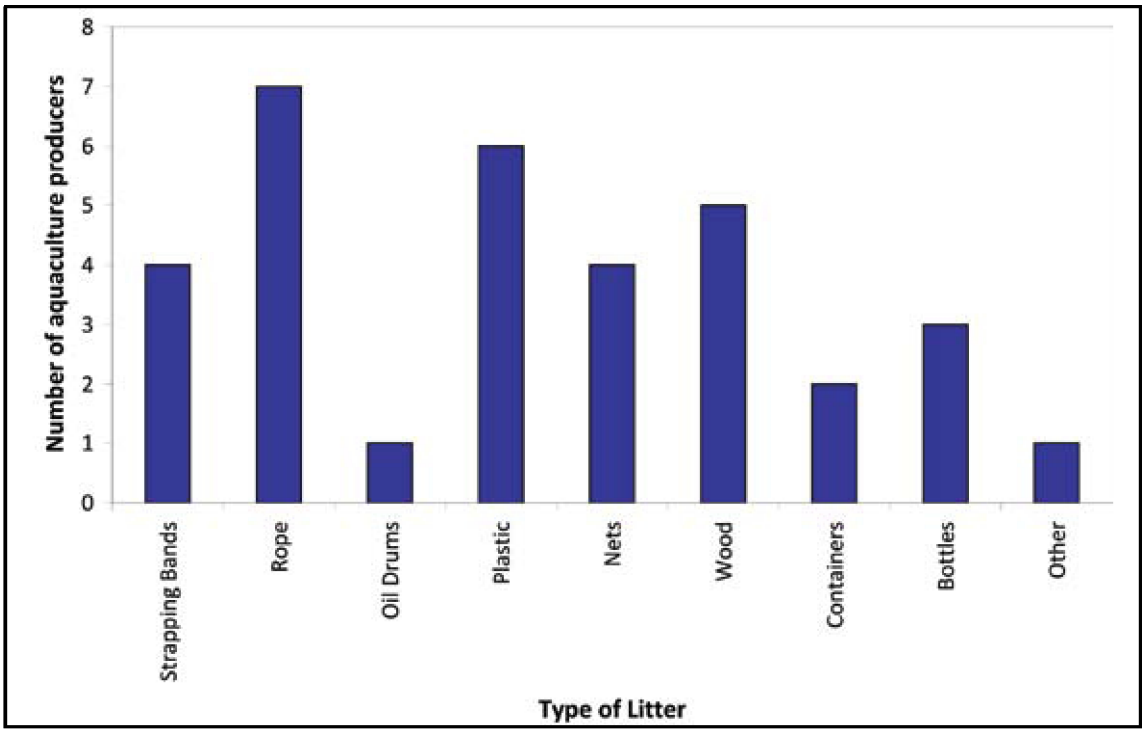

Figure 9.1: Types of litter which affect aquaculture producers

The most prevalent items of litter affecting the aquaculture industry are rope, closely followed by plastic and wood. Producers were also concerned about the impact of fishing debris with one producer stating “old nets and ropes floating in the area cause most concern as these do get caught in propellers or moorings on cages and can take time to clear”.

9.3 Time spent clearing and removing litter

The amount of time producers spent removing marine litter from around their cages and mussel rafts was highly variable. For some producers, marine litter posed no issues and therefore they did not have to spend any time removing it. For others, marine litter proved to be a regular problem and these producers could spend up to half a day per month removing litter. Overall, producers most commonly spent somewhere between 1 – 2 hours per month removing litter from around their fish farm site.

The time taken to untangle fouled propellers and clear blocked intake pipes was also similarly variable. For fouled propellers, the amount of time necessary to untangle the propeller ranged from quarter of an hour to 2.5 hours and this could be considerably higher if divers were required. Blocked intake pipes could take between half an hour and 6 hours to clear depending on the severity of the incident.

9.4 Economic cost of marine litter

This project focused on the economic costs incurred by aquaculture producers due to time spent removing marine litter, the cost of untangling fouled propellers and any costs resulting from the repair or replacement of propellers on workboats. On average, marine litter costs each producer surveyed approximately € 580.41 per year and Figure 9.2 below shows how these costs are split between categories. Marine litter therefore costs the aquaculture industry in Scotland an estimated € 155,548.66 per year on average[14].

Over 90% of these costs relate to fouled propellers, either in terms of the use of divers to untangle the propeller or to repair any damage caused by the litter. Just 9% of the costs incurred by producers related to the time spent removing litter from cages and mussel lines.

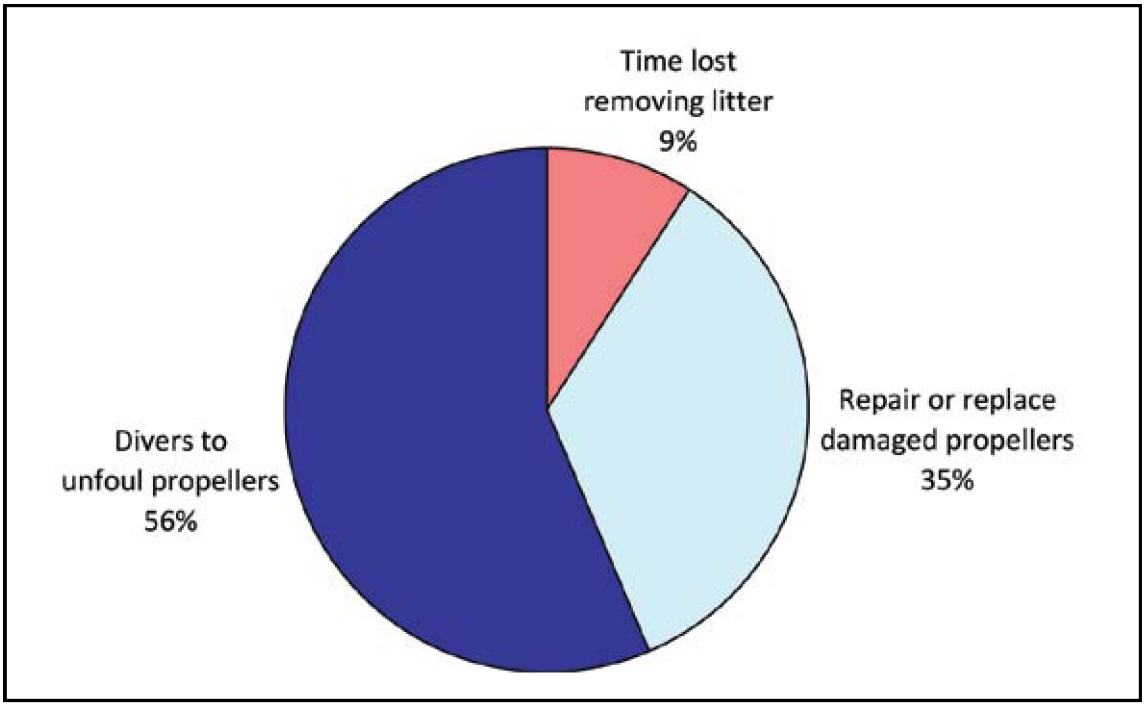

Figure 9.2: Breakdown of the average cost to aquaculture producers

[14] Calculation based on 268 finfish and shellfish producers in Scotland in 2007, the most recent year for which data is available for both types of aquaculture production (Fisheries Research Service 2008a and 2008b).

9.5 Waste disposal and efforts to minimise marine litter

Responsible waste disposal is a key part of minimising the release of litter into the environment and over 90% of producers surveyed sent their waste to landfill. Over 60% also recycled some of their waste. Aquaculture producers were also taking a number of other steps to reduce the amount of litter entering the marine environment with 82% actively trying to reduce the amount of packaging taken to sea. Similarly, 73% of producers surveyed try to provide supplies with minimal packaging and 82% bring ashore any waste seen floating in their cages or around mussel rafts.

9.6 Conclusion

While representing only a small sample, the aquaculture producers surveyed experienced highly variable problems with marine litter. Overall, fouled propellers on work boats presented the most common issue and could lead to high costs in terms of repairing and replacing damaged propellers. In comparison, removing marine litter from around production sites was less of an issue for aquaculture producers.

While the cost of individual incidents was high, the average cost of marine litter to aquaculture producers was low at € 580.41 per year, reflecting the infrequent occurrence of fouled propellers. Marine litter therefore costs the aquaculture industry in Scotland an estimated €155,548.66 per year on average, which is relatively low, particularly in comparison to other industries such as sea fisheries.

10. Harbours and Marinas

10.1 Introduction

With over 90% of global trade carried by sea (IMO 2009), ports and harbours are essential gateways for the transportation of goods around the world. Marinas also make an important contribution to many coastal communities by attracting tourists and generating income and employment. In the UK for example, the marina industry has a turnover of approximately £113 million and directly employs more than 1,700 people (BMF 2007).

The primary economic impact of marine litter on harbours and marinas is the cost of removing marine litter in order to ensure that these facilities remain clean, safe and attractive for users. This can involve both the manual removal of floating debris and dredging specifically to remove marine litter items obstructing the seabed. Questionnaires were developed to investigate the impact of marine litter and the associated cost of dealing with it for harbours and marinas. These were distributed to harbours and marinas in countries throughout the Northeast Atlantic region.

10.2 United Kingdom

10.2.1 Litter removal: dredging and manual cleansing

Overall, 46.1% of harbours and marinas surveyed took action to remove marine litter. Within this, 6 harbours and marinas dredged specifically to remove marine litter and a further 36 organisations manually removed marine litter. It is worth noting that the number of harbours that manually remove marine litter may be higher than these results suggest as these figures are drawn solely from harbours' comments. In addition, one harbour used a 'seabed dragging program' and biennial dive surveys to remove dumped wire and other debris from within harbour limits.

The time these organisations spent on litter clearance activities varied considerably depending on the method they used to remove litter. Dredging due to marine litter was generally required only once every few years in most cases while the manual removal of marine litter tended to occur on a monthly basis. This could take anything from 1 hour per month to more than 36 hours per month, although the majority of organisations spent between 1 and 5 hours per month manually removing marine litter. On average, this was part of the duties of 2 members of staff in each harbour and marina.

Harbours were also asked to identify the most common types of litter removed during dredging and manual removal of litter, and the results are displayed in Figure 10.1 overleaf. Rope and plastic were the most common types of litter found with over 70% of those surveyed reporting that they collect these types of litter. Wood and nets were also relatively common and these were found by 58.3% and 54.2% of harbours respectively.

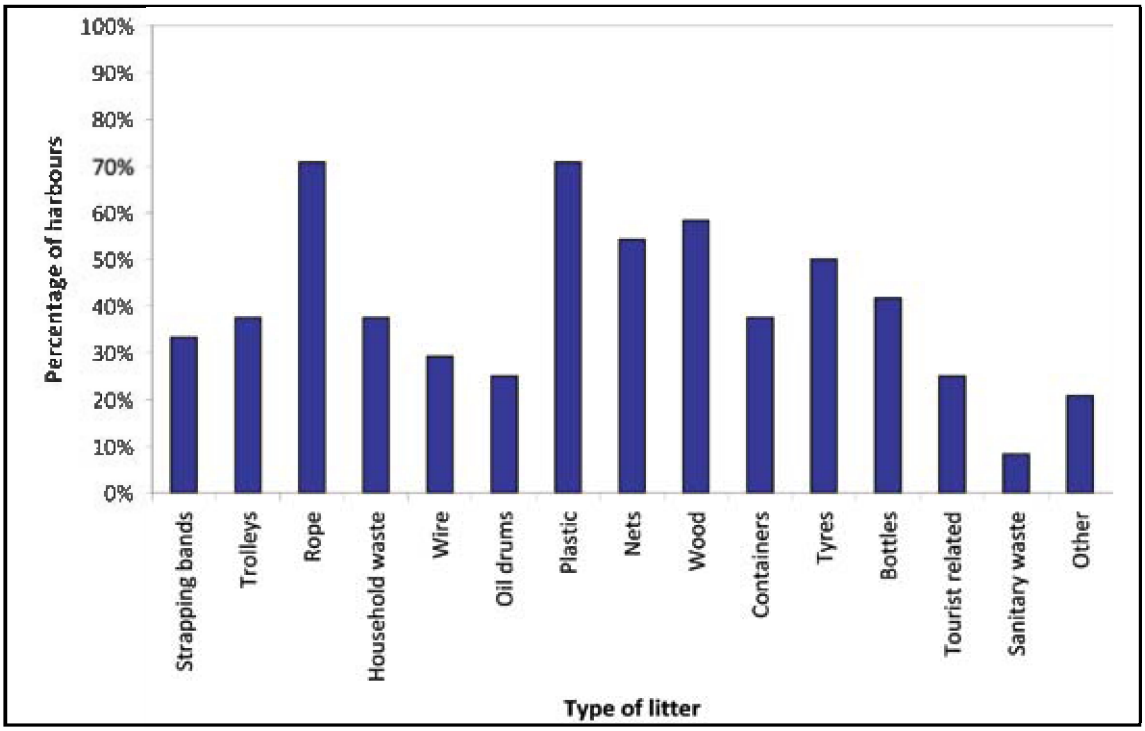

Figure 10.1: Most common types of litter removed by harbours

Harbours disposed of marine litter using a variety of methods including landfill, incineration and recycling. Landfill was the most popular means of disposal with 91.9% of harbours using this method to dispose of marine litter. The uptake of recycling among harbours was also very encouraging and 48.7% of harbours sent at least some of the marine litter they collected to be recycled. Only 16.2% of harbours incinerated marine litter.

10.2.2 Incidents

To gage the extent to which marine litter affects vessels, harbours and marinas were asked whether their users had experienced any incidents with marine debris over the last year. Over 71% of harbours and marinas reported that their users had experienced incidents such as fouled propellers, fouled anchors, fouled rudders and blocked intake pipes and valves.

10.2.2.1 Fouled Propellers

Fouled propellers were by far the most commonly reported type of incident with 69% of harbours and marinas stating that their users had experienced this type of incident. These organisations were asked to identify how often their users either sustained a fouled propeller within harbour limits or entered the harbour having fouled their propeller elsewhere at sea. As Figure 10.2 overleaf illustrates, harbours and marinas most commonly reported between 1 and 5 fouled propellers among their users per year. Only a small proportion of organisations reported that vessels using their facilities sustained more than 5 fouled propellers per year, although one harbour did report that its users had experienced as many as 20 fouled propellers over the course of a year.

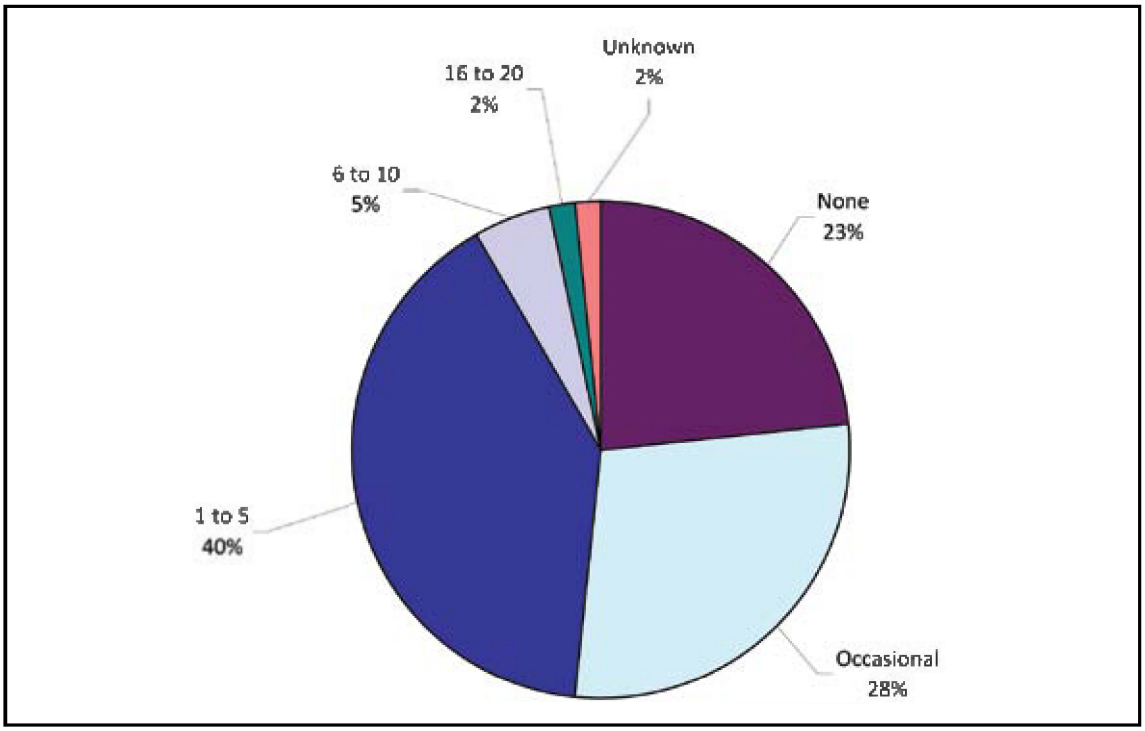

Figure 10.2: Frequency of fouled propellers among harbour and marina users per year

The most common types of marine litter causing fouled propellers are shown in Figure 10.3 overleaf. Rope was the most frequently identified cause of fouled propellers with over 90% of organisations reporting that this type of litter caused entangled propellers among their users. Nets were also identified as a cause by 52% of these organisations with plastic (28%) and wire (27%) also relatively common. These findings suggest that derelict fishing debris, such as ropes and nets, can pose disproportionately high health and safety risks in the marine environment.

10.2.2.2 Other types of incident

Users experienced problems with fouled anchors caused by marine litter in 7.7% of harbours and marinas surveyed. A further 13.2% of these organisations reported that their users had experienced fouled rudders due to marine litter. Approximately 28.6% of harbours and marinas also reported that their users had experienced blocked intake pipes and valves due to marine litter. Harbours described a range of other incidents including:

- Collisions with floating logs and sleepers
- Fouling of navigation buoy moorings and damage to buoys
- Plastic bags and crisp bags blocking instruments
- Vessel damage during lifting operations to repair damage caused by marine litter

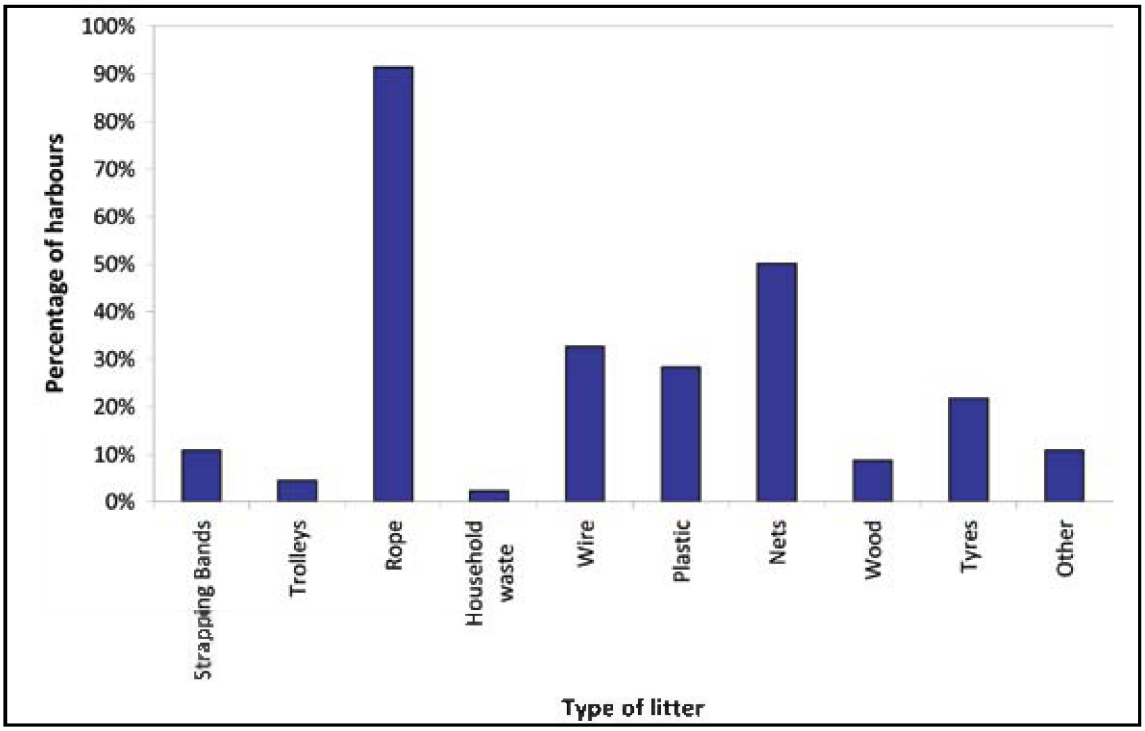

Figure 10.3: Commonly reported types of marine litter which cause fouled propellers

10.2.3 Measures and campaigns to prevent marine litter

10.2.3.1 Harbours

The harbours surveyed during this project had introduced a number of measures and campaigns to prevent litter from reaching the marine environment. All of the harbours surveyed meet the EU Directive on Port Waste Reception Facilities (EC2000/59) and 96.8% of harbours encourage vessels to dispose of waste, particularly old ropes and nets, using harbour facilities. In total, 88.9% of harbours had also set up recycling facilities for vessels' waste. The most common types of recycling facilities are displayed in Figure 10.4 overleaf and facilities for oil, galley waste and old batteries were most frequently provided.

Similarly, 58.7% of harbours highlight the problem of marine litter in their area and ways to prevent it. This is typically done through posters, letters and pamphlets but harbours also used harbour liaison meetings, articles in newsletters and publications, and local publicity to raise awareness of marine litter issues. In addition, 47.6% of harbours had launched campaigns to highlight the harm marine litter can do to the environment and the shipping industry.

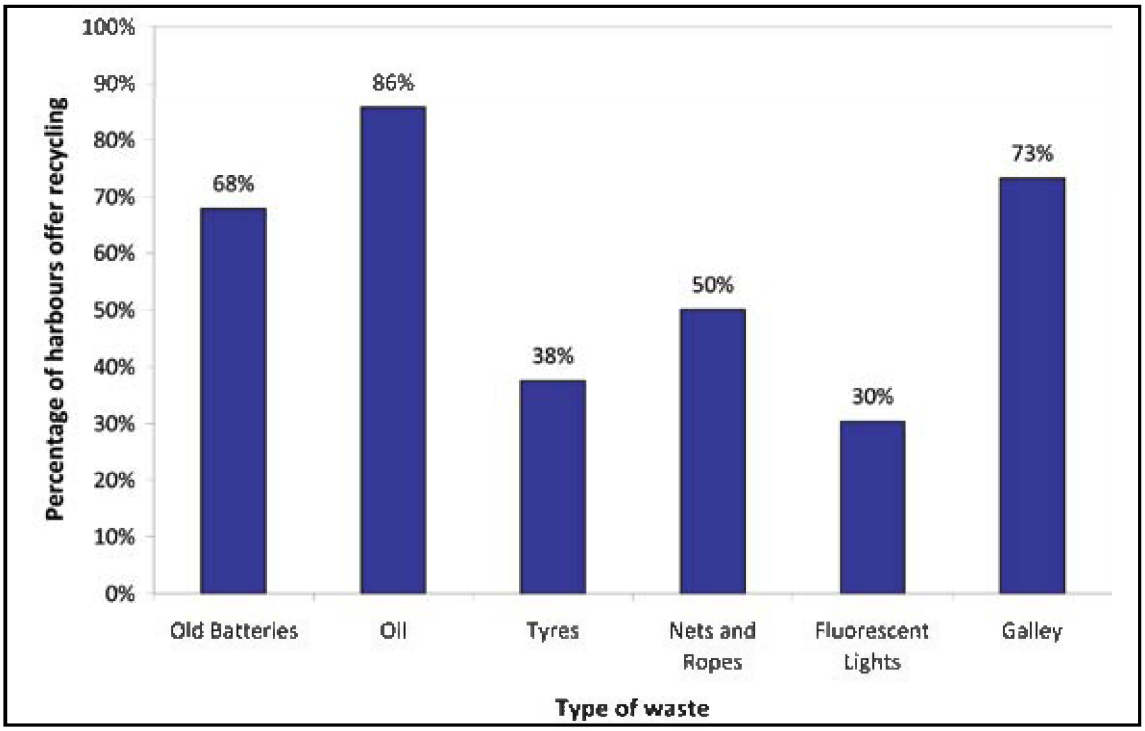

Figure 10.4: Most common types of recycling offered by harbours

10.2.3.2 Marinas

The marinas involved in this project were keenly aware of the issues marine litter can pose, both to the environment and to vessels, and 92.3% therefore encouraged better waste management practices among their users. In addition, 76.9% publicised these facilities and tried to promote recycling among their users.

Approximately 30% of the marinas surveyed held some form of award and the most popular was the Golden Anchor award scheme operated by the Yacht Harbour Association. This award scheme includes provisions for a port waste management plan and the marinas involved in this scheme generally held either 4 or 5 Golden Anchors depending on the level of facilities available. A smaller number of marinas met the requirements for Blue Flag awards, Green Tourism awards and ISO 14001 status.

10.2.4 Economic cost of marine litter

10.2.4.1 Harbours

The total cost of marine litter removal reported by 34 harbours in the UK was €273,168.58 with an average cost of €8,034.37 per harbour per year. Based on this average, marine litter costs the ports and harbours industry in the UK approximately €2.4 million each year[15]. Costs to individual harbours ranged between €0 and €72,935.07 per year with just 6 harbours experiencing above average costs. The wide difference in costs between harbours is in part due to the differing size and use of harbours with costs generally higher in large facilities and busy fishing ports.

A breakdown of the average cost of removing litter to harbours is given in Figure 10.5 overleaf. Disposal of

15 Calculated based on 300 active ports and harbours in the UK (UKHMA, 2010, Personal Communication)

marine litter represents the biggest cost to harbours and accounts for approximately 36.8% of the average cost of litter removal, although these costs are dominated by landfill. The manual removal of litter also constitutes a key cost to harbours, making up 31.7% of the average cost of litter removal. While dredging represents a relatively low proportion of the average cost to harbours, this is relatively high considering the small number of harbours which use this method to remove marine litter.

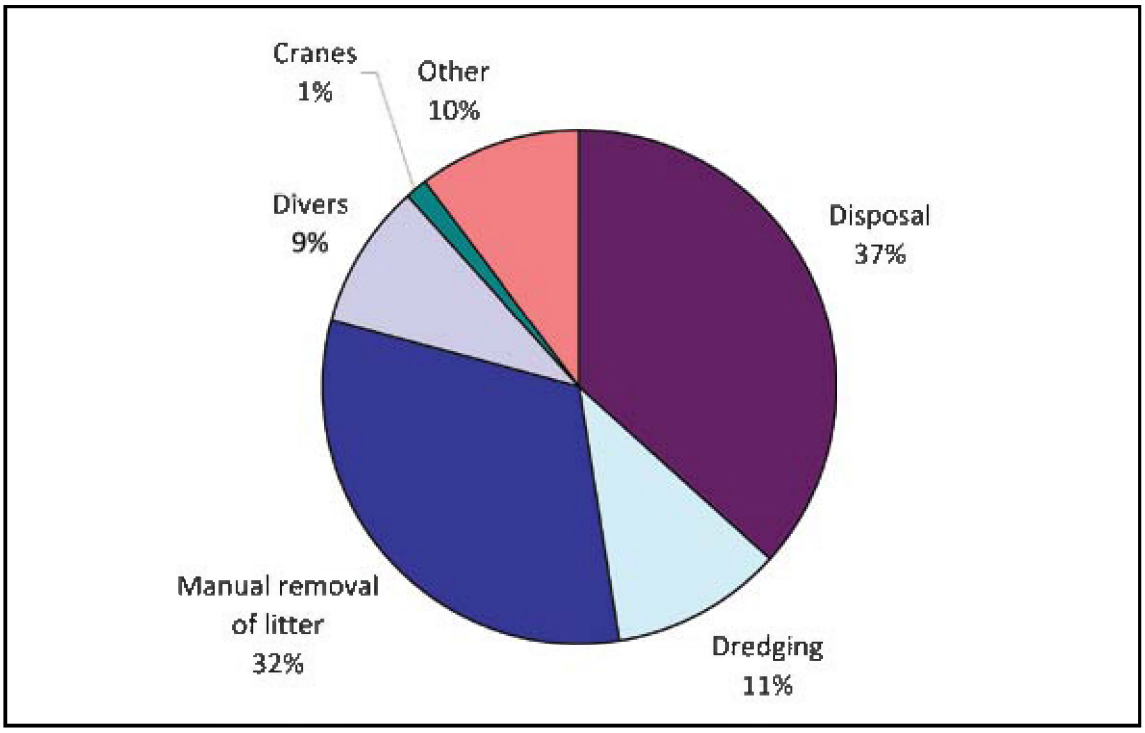

Figure 10.5: Breakdown of the average cost of marine litter to harbours in the UK

10.2.4.2 Marinas

Only 6 marinas were able to report the costs associated with litter clearance operations and these marinas spent a total of €56,954.47 per year on marine litter removal. The cost of removing marine litter ranged from between €127.76 and €38,537.55 and there was a clear split between the level of costs experienced by community marinas and those experienced by larger, commercially operated marinas. Smaller, community marinas tended to have much lower costs while large, tourist oriented marinas generally experienced significantly higher costs driven by the need to remain attractive in a highly competitive market.

10.3 Case Study: Spain

10.3.1 Litter removal: dredging and manual cleansing

Virtually all of the Spanish harbours and marinas surveyed manually removed marine litter floating in their harbour but none had to dredge specifically to deal with marine litter accumulating on the seabed. Only one marina took no action to remove marine litter. The main types of litter removed by harbours are displayed in Figure 10.6 overleaf. Plastics were the most common type of litter removed by harbours with all of those surveyed reporting that they collected this type of litter. Wood, rope and bottles were also commonly found during harbour clearance activities.

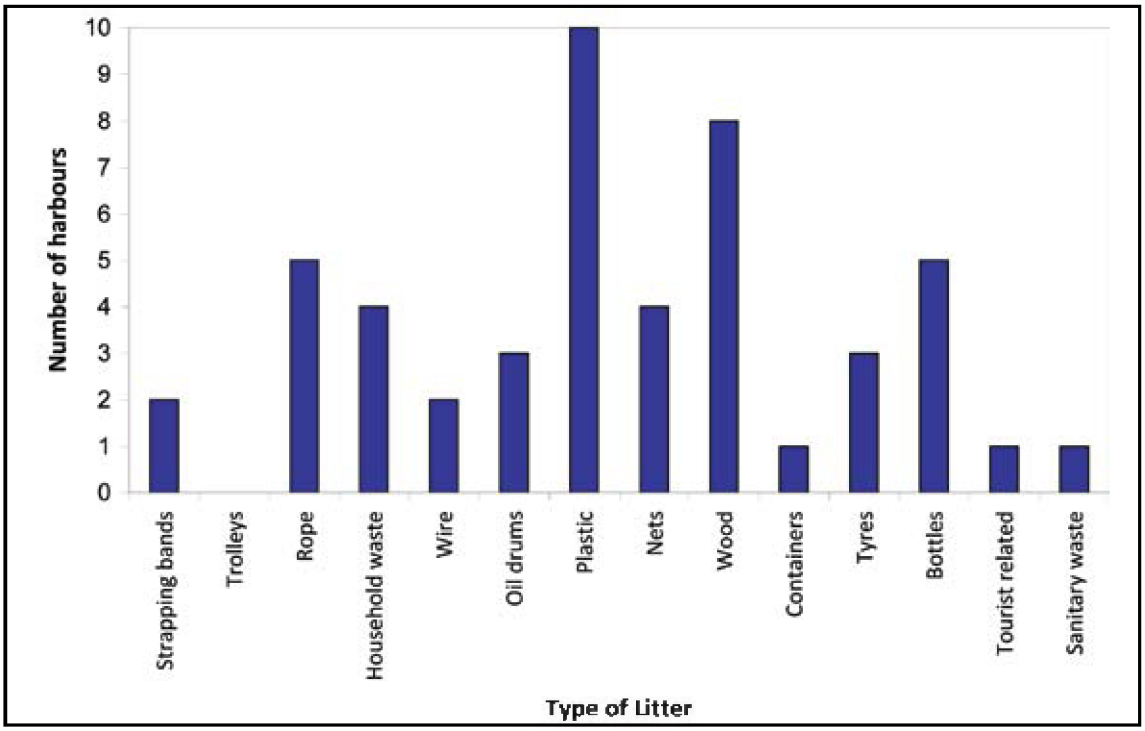

Figure 10.6: Most common types of litter collected by Spanish harbours

The manual removal of litter was a relatively time intensive activity for most of the Spanish harbours and marinas surveyed during this project, as shown in Figure 10.7 below. In total, 7 harbours and marinas spent more than 36 hours per month removing litter that collected within their harbour limits.

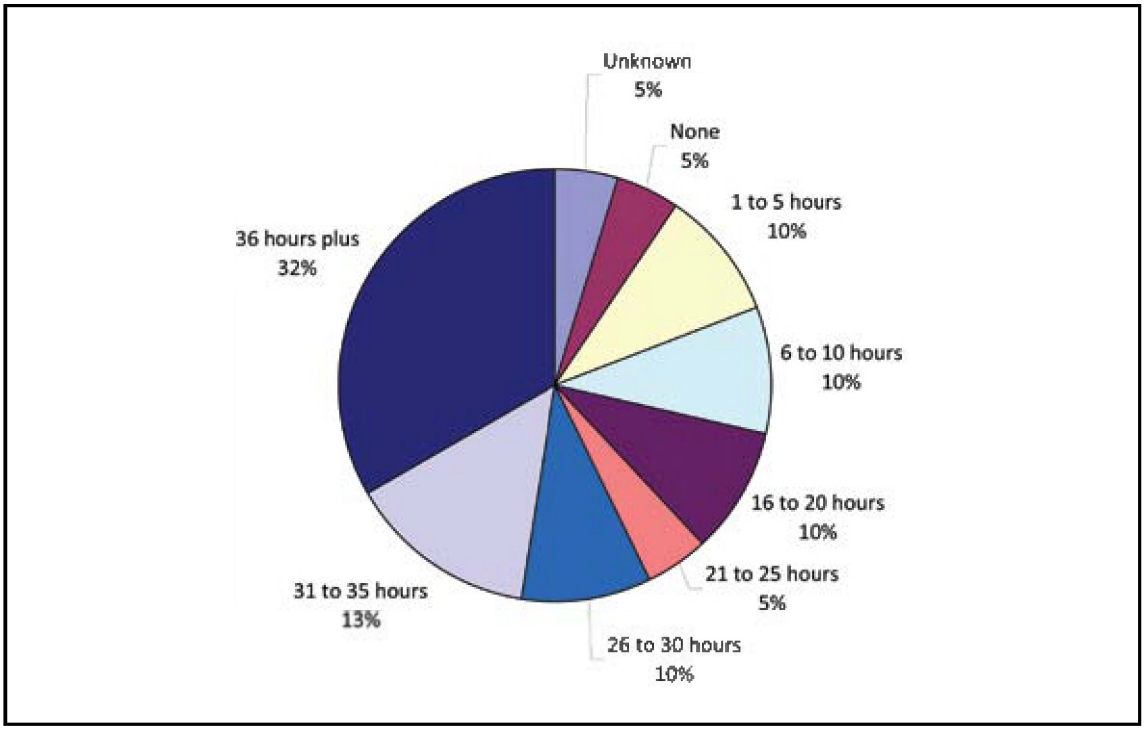

Figure 10.7: Amount of time spent by Spanish harbours and marinas removing marine litter

In terms of disposal, 8 harbours sent marine litter to landfill while 7 used recycling facilities. Therefore 2 harbours exclusively relied on recycling to dispose of marine litter and this is very encouraging as marine litter is generally thought to be difficult to recycle due to contamination and difficulties separating waste streams.

10.3.2 Incidents

Spanish harbours and marinas were also asked whether their users had experienced any incidents with marine litter over the last year to gage how marine litter affects vessels in that area. Over half of the organisations surveyed reported that their users had experienced some kind of incident involving marine litter. The most common type of incident was a fouled propeller with 10 harbours and marinas reporting that their users had experienced this type of incident. Fouled propellers generally only occurred occasionally but 1 marina did report that its users had sustained as many as 15 fouled propellers over the course of a year. The causes of fouled propellers were broadly similar to those reported in the UK with rope, nets and plastics identified as the main causes of these incidents.

Other types of incidents involving marine litter were relatively rare according to Spanish harbours and marinas. Only 3 organisations reported that vessels using their facilities had experienced blocked intake pipes caused by marine litter. A further 2 organisations reported that their users had sustained fouled rudders and only 1 marina reported a fouled anchor among its users.

10.3.3 Measures and campaigns to prevent marine litter

The Spanish harbours surveyed during this project have introduced a number of measures to tackle marine litter and all those surveyed met the requirements of the EU Directive on Port Waste Reception Facilities (EC2000/59). 9 out of 10 harbours also encouraged users to dispose of their waste using harbour facilities, particularly ropes, nets and fish boxes. In addition, 8 harbours had set up recycling areas and these mostly focused on oil, nets, ropes and galley waste.

Just over half of the harbours surveyed highlighted the issue of marine litter in their area and ways to prevent it. This was typically done using posters, letters and pamphlets but several harbours also offered free lectures and courses about marine litter. Half of the harbours surveyed had launched campaigns to raise awareness of the harm marine litter can cause to the environment and the shipping industry.

Similarly, all the marinas surveyed as part of this project encouraged their users to practice better waste management techniques. In addition, 10 marinas publicised their facilities and promoted recycling among their users. More than half the marinas surveyed also held some form of award that required them to meet environmental and waste management commitments. The most common types of awards were Blue Flags and ISO 14001 certification.

10.3.4 Economic cost of marine litter

10.3.4.1 Harbours

The total cost of marine litter reported by 9 Spanish ports and harbours amounted to €549,117.33 with an average cost of €61,013.04 per harbour per year. A breakdown of costs is presented in Figure 10.8 overleaf and the vast majority of costs clearly relate to the manual removal of litter. While this is a small case study,

these costs are relatively high with the average cost to Spanish harbours approximately 7 times higher than that reported by harbours in the UK.

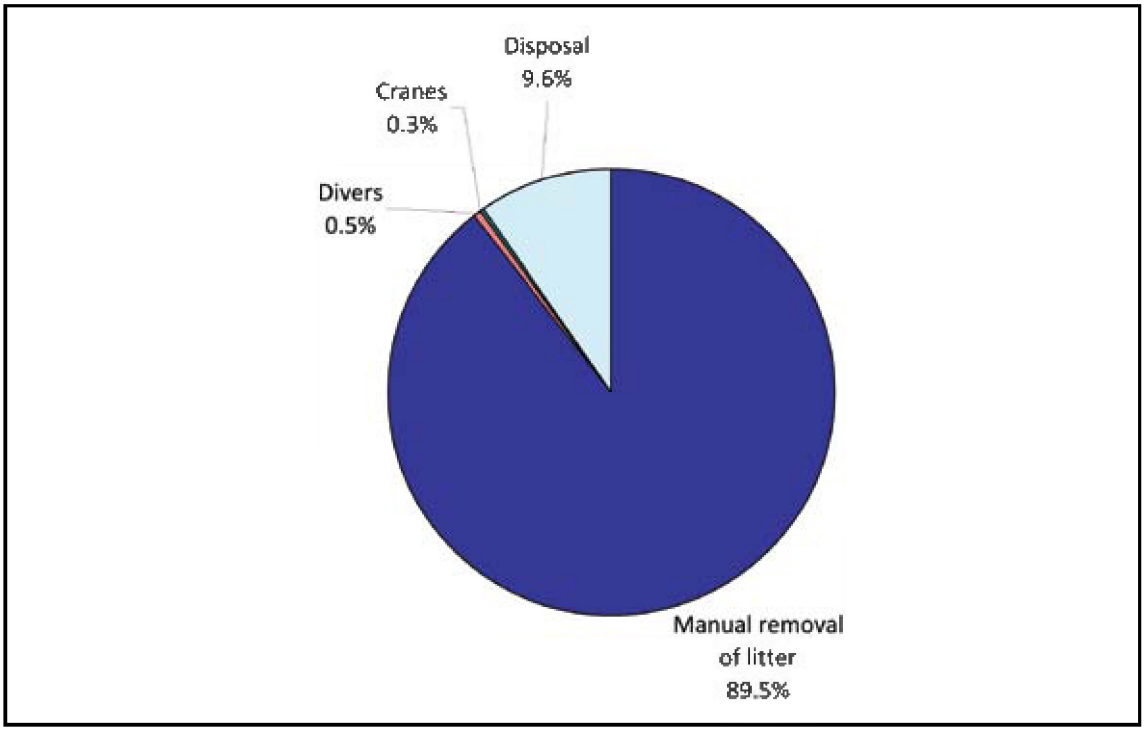

Figure 10.8: Breakdown of the average cost of marine litter to Spanish harbours

10.3.4.2 Marinas

The total cost of marine litter removal reported by 5 marinas in Spain was €14,800. All of these costs related to the manual removal of litter and included the collection, transportation and disposal of marine litter. Overall, the costs reported by each marina ranged between €100 and €8,500 per year with higher costs generally experienced by larger marinas.

10.4 Additional Information

A small number of responses were received from harbours and marinas in Denmark, Norway and Portugal and a brief summary of these questionnaires is provided in Table 10.1 overleaf.

10.5 Conclusion

Harbours and marinas remove marine litter to ensure that their facilities remain clean, safe and attractive for users. Depending on its severity, removing marine litter can be relatively time intensive and put a considerable strain on these organisations' resources. The UK ports and harbours industry therefore spends approximately €2.4 million each year[16] removing marine litter with an average cost of €8,034.37 per harbour. However, these costs can be considerably higher in individual harbours, particularly for large facilities and busy fishing ports. Removing marine litter could also be costly for marinas with costs as high as €38,537.55 per year reported

16 Calculated based on 300 active ports and harbours in the UK (UKHMA, 2010, Personal Communication)

in the UK but the small size of the sample prevented the calculation of the cost of marine litter to the marina industry.

The information provided by harbours and marinas also suggests that incidents involving vessel damage caused by marine litter are widespread with over 70% of UK harbours and marinas reporting that their users had experienced incidents involving marine litter. Fouled propellers were the most common type of incidents reported but overall, incidents involving marine litter generally only occurred occasionally. The most common cause of fouled propellers was derelict fishing gear such as ropes and nets, which suggests that this type of marine litter can pose disproportionately high health and safety risks.

The harbours and marinas surveyed during this project were making a considerable effort to prevent marine litter and promote responsible waste practices among vessels using their facilities. All the harbours surveyed met the EU Directive on Port Waste Reception Facilities (EC2000/59) and many organisations had put in place additional measures to encourage the responsible disposal of ships' waste including recycling facilities, information boards and publicity campaigns about the detrimental impact of marine litter on shipping and the environment. Marinas were similarly keen to promote responsible waste practices amongst their users and many held some form of award that included commitments towards responsible waste disposal.

In addition to current efforts by harbours and marinas to reduce marine litter, there are a number of other programs and measures that could also help to reduce the amount of litter entering the marine environment. Improvements to the enforcement of the EU Directive on Port Waste Reception Facilities (EC2000/50), the introduction of compulsory waste disposal for all vessels and the implementation of a "no special fee" system for the use of waste reception facilities would increase the incentive for vessels to responsibly dispose of waste in harbours.

Similarly, the introduction of a zero waste policy for all vessels, which bans the disposal of any waste at sea, including incinerator ash, and higher minimum penalties for illegal dumping could deter vessels from illegally discharging waste. Action is also required to improve the monitoring and enforcement of current legislation, as there have been very few prosecutions to date under MARPOL Annex V legislation. Finally, environmental awareness training, including marine litter issues, should be made compulsory for all ship owners and operators, crew members, fishermen and recreational boat owners.

Country	Denmark	Norway	Portugal
Number of responses	4 harbours and 1 marina	4 harbours	5 marinas
Dredge for marine litter	1 harbour, once or twice per year	1 harbour, once or twice per year	None
Manually remove marine litter	4 organisations, plastic items are a particular problem	3 harbours	1 marina, 6-10 hours per month
Cost of removing marine litter	Between €0 and €21,520.41 per harbour per year	Between €0 and €20,104.13 per harbour per year	Unknown
Incidents involving marine litter per year	Between 1 and 5 fouled propellers: 2 harbours and marinas Occasional fouled propellers: 1 harbour None: 2 harbours Blocked intake pipes: 1 marina	Between 1 and 5 fouled propellers: 1 harbour Occasional fouled propellers: 2 harbours None: 1 harbour	Between 11-15 fouled propellers: 1 marina Occasional fouled propellers: 2 marinas None: 2 marinas Fouled anchors: 1 marina Fouled rudders: 1 marina Blocked intake pipes: 1 marina
Satisfy EU Directive on Port Waste Reception Facilities (EC2000/59)	All harbours	All harbours	Not asked
Recycling areas in port	4 organisations, wide variety of items including nets and ropes, galley waste, oil and tyres	All harbours, wide variety of items including old batteries, nets and ropes, oil and galley waste	All marinas
Runs campaigns to draw attention to harm marine litter can cause to the environment and shipping industry	3 harbours	3 harbours	Not asked

Table 10.1: Brief summary of questionnaires from countries where a small number of responses were received

11. Rescue Services

11.1 Introduction

Marine litter can pose significant navigational hazards to vessels and incidents such as fouled propellers, fouled anchors and equipment, and blocked intake pipes and valves can endanger the safety of both the vessel and its crew. Many of these incidents will require assistance, either from other vessels or the emergency services, in order to ensure the vessel's immediate safety and to assist it to return to port where any necessary repairs can be made.

While the safety of crew members is clearly the foremost concern in these situations, rescue operations involving the coastguard will also have an economic cost. A questionnaire was developed to investigate how fouled propellers affect the coastguard and the associated costs of providing rescue services in these situations. This questionnaire was distributed to coastguard services in countries throughout the Northeast Atlantic region.

11.2 United Kingdom

The Royal National Lifeboat Institution (RNLI) provides a 24-hour lifeboat search and rescue service around the coast of the UK and the republic of Ireland. The RNLI has an active fleet of more than 300 lifeboats, including all weather and inshore lifeboats, and a relief fleet of approximately 100 vessels. The RNLI costs approximately £147.7 million (€166.59 million) to run every year and this includes the cost of vessels, lifeguards, crew kits, lifeboat refit costs and the cost of launching lifeboats in the event of emergency (RNLI 2010).

Figure 11.1: Marine litter poses significant navigational hazards for vessels and incidents involving marine litter may require assistance from the emergency services. Image: © www.austintaylorphotography.com

11.2.1 Rescues to vessels with fouled propellers

During 2008, the last year for which data is available, the RNLI made 286 rescues to vessels with fouled propellers and Figure 11.2 overleaf shows the types of vessels that required assistance. Approximately 67.5% of rescues to vessels with fouled propellers were made to pleasure craft and 31.1% involved fishing vessels. Just 7 rescues were undertaken to commercial vessels with fouled propellers and the lifeboat also attended one incident involving a rescue vessel with a fouled propeller.

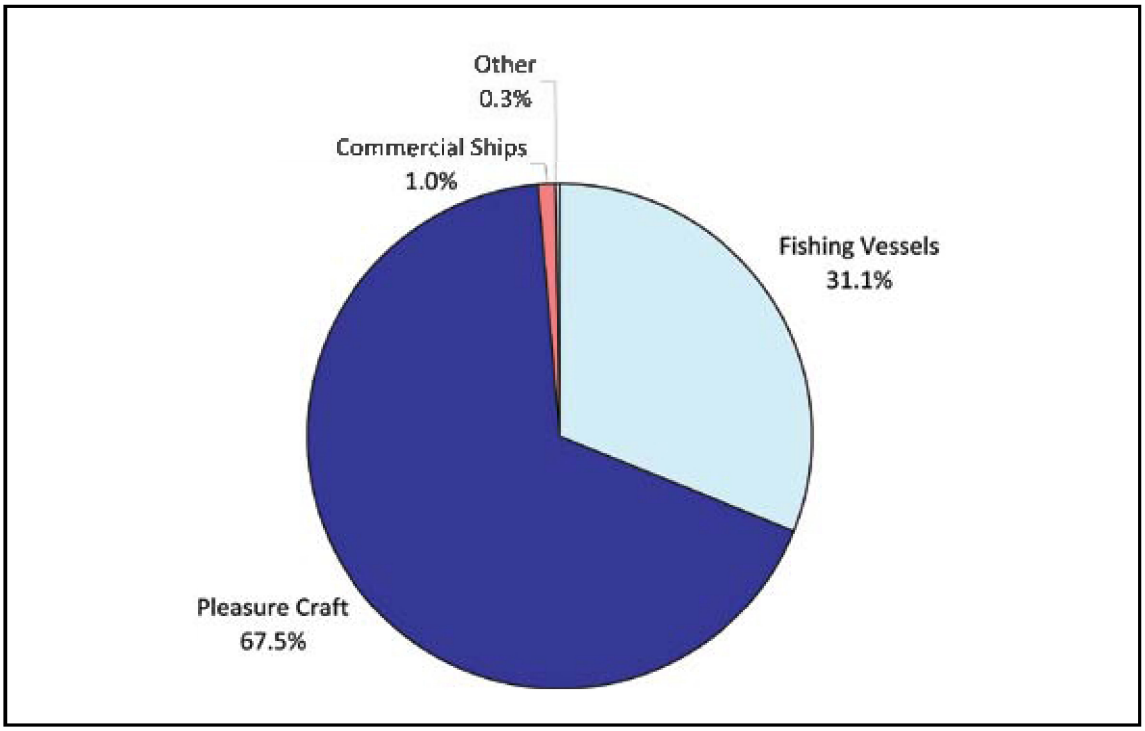

Figure 11.2: Types of vessel rescued due to a fouled propeller in 2008

These incidents occurred throughout the UK's waters and Figure 11.3 overleaf shows the location of rescues to vessels with fouled propellers in 2008. The geographical pattern of vessels with fouled propellers is broadly similar to that recorded by Hall (2000) with the south coast of England remaining a hotspot for these incidents. Comparison with Hall's (2000) findings also reveals a clear shift in the types of vessels requiring rescue over the past 10 years. In 1998, fishing vessels were more likely than pleasure craft to require emergency assistance due to fouled propellers but in 2008, the opposite was true with this type of rescue more likely to involve pleasure craft.

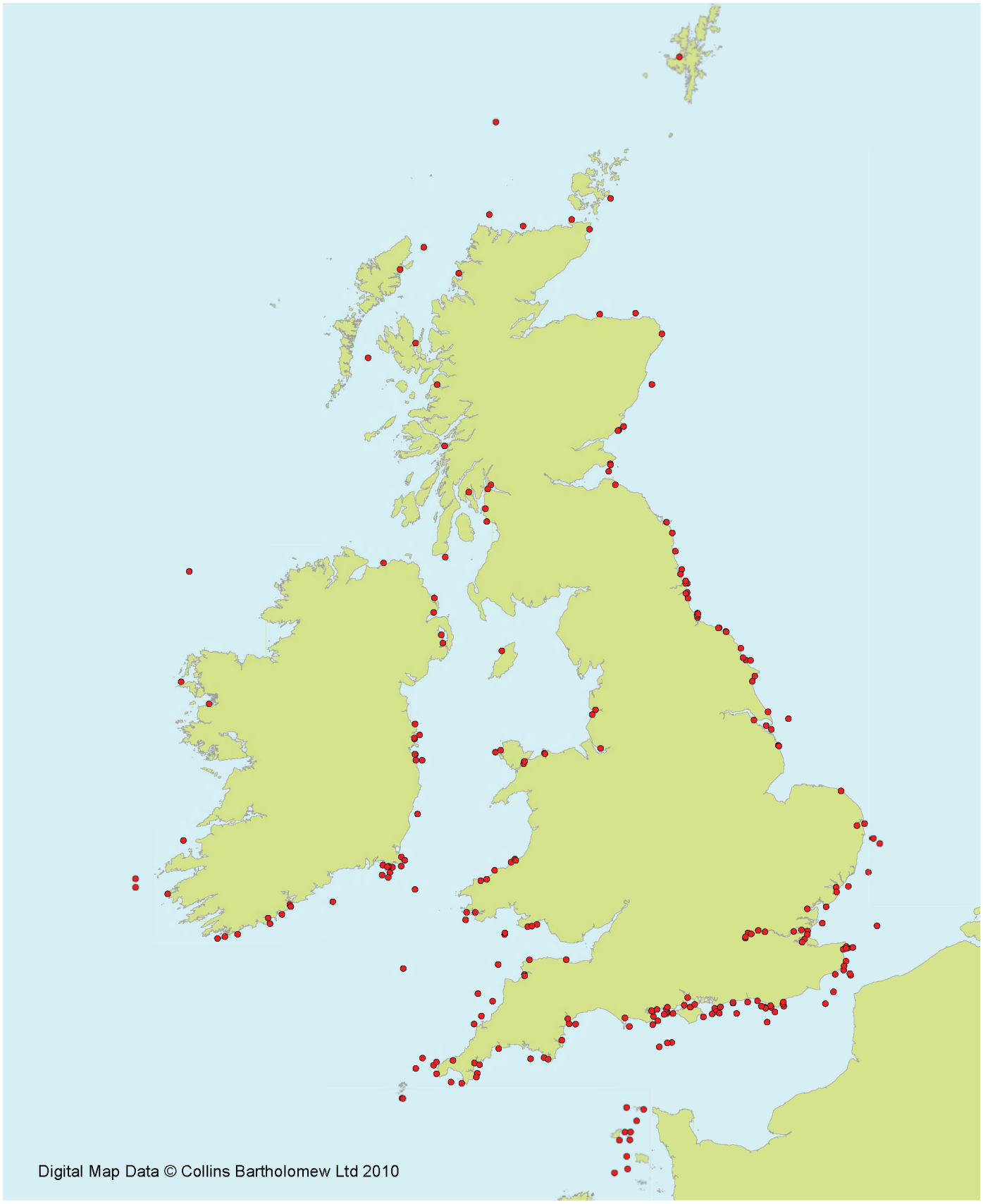

Figure 11.3: Map showing the location of vessels with fouled propellers attended to by the RNLI during 2008. Image: RNLI.

Over the period 2002-2008, the RNLI attended an average of 267 rescues per year to vessels with fouled propellers. On average, 104 of these rescues were to fishing vessels, 157 to pleasure craft, 4 to commercial ships and 2 to 'other' vessels. Over this 7-year period, there is also evidence of a rising trend in the total number of rescues to fouled propellers each year, as shown in Figure 11.4 below. Most of this increase can be accounted for by the rising number of pleasure craft requiring lifeboat assistance with the number of fishing vessels sustaining fouled propellers generally remaining broadly static over the 7-year period.

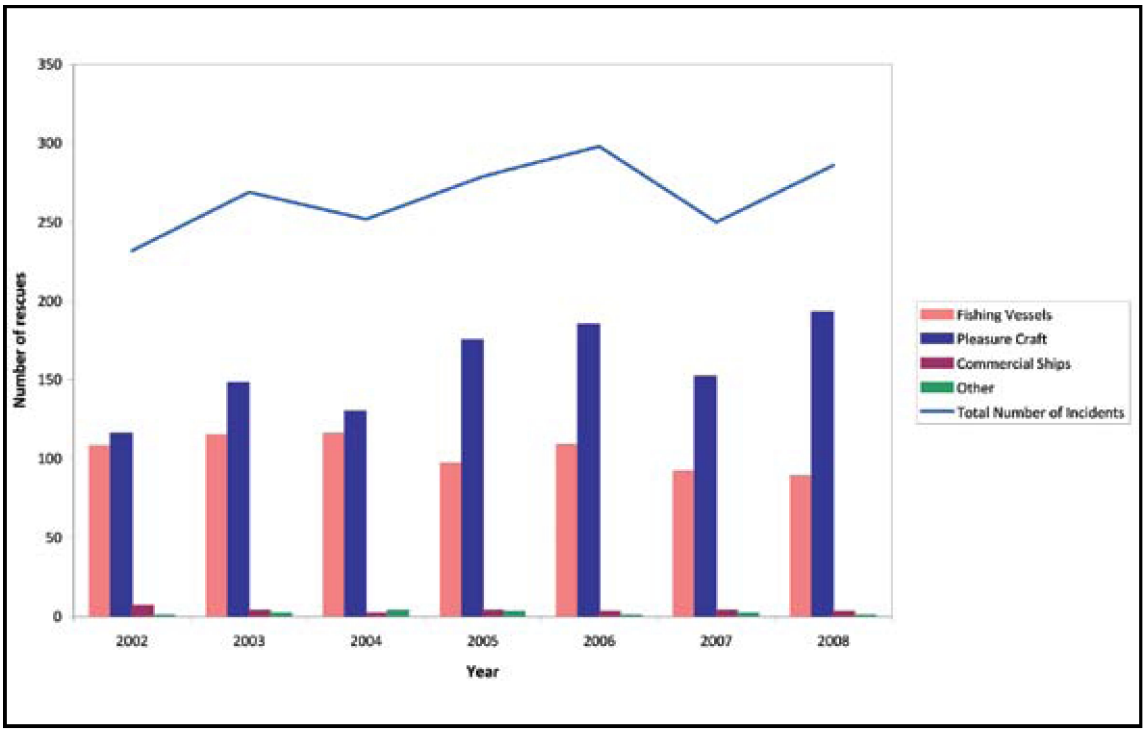

Figure 11.4: Changes in number and type of rescues carried out by the RNLI 2002 - 2008

The RNLI does not record the causes of fouled propellers and therefore it is possible that a small number of these incidents may not be the result of marine litter. Furthermore, it is also important to note that not all fouled propellers require the help of the emergency services as other vessels may be available to provide assistance and tow vessels with fouled propellers back to port.

11.2.2 Levels of danger

A fouled propeller can affect the stability of a vessel in the water and its ability to manoeuvre, potentially placing the vessel and its crew in serious danger. During 2008, vessels were judged by the RNLI to be in life threatening danger in just 0.7% of rescues to vessels with fouled propellers. Another 7.7% of fouled propeller rescues were to vessels in danger while 91.6% of vessels with fouled propellers were judged to be in no danger by the RNLI.

11.2.3 Economic cost of rescues to vessels with fouled propellers

The cost of undertaking 286 rescues to vessels with fouled propellers during 2008 was between €830,000

and €2,189,000[17], depending on whether an inshore or all weather lifeboat was used. This includes the running costs of a lifeboat station such as training crews, lifeboat maintenance and station maintenance, but does not take into account the substantial cost of depreciation of the lifeboat.

The total cost of rescues to vessels with fouled propellers between 2002 and 2008 is €6.4 – €17 million and Figure 11.5 below illustrates how the annual cost of rescues to vessels with fouled propellers changed between 2002 and 2008. The highest costs were recorded in 2006 when 298 fouled propeller rescues were carried out at a cost of between €1,132,003.66 and €2,984,371.66.

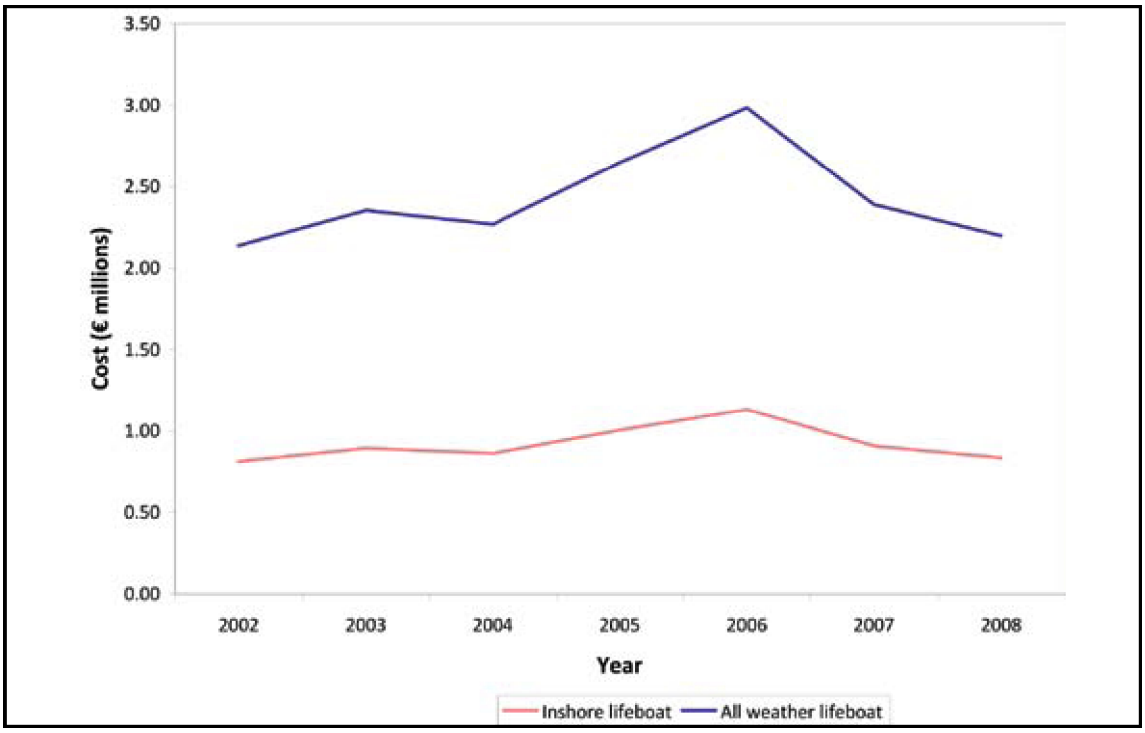

Figure 11.5: Changes in the total cost of rescues carried out by the RNLI to vessels with a fouled propeller 2002 - 2008.

It is important to note that the RNLI's official estimates of the cost of launching a lifeboat has not changed since 1998 and therefore the findings presented here are likely to underestimate the full cost of rescues to vessels with fouled propellers. Similarly, lifeboat crews are often volunteers who give up their own time to take part in rescue operations and the findings presented here do not include the cost of volunteers' time and lost working hours.

11.3 Norway

The Norwegian Society for Sea Rescues (NSSR) provided data about the number of rescues it undertakes each year to vessels with fouled propellers. Between 2002 and 2007, the NSSR carried out an average of 110 rescues to vessels with fouled propellers each year. Approximately 78.3% of these rescues were to pleasure craft, 17.3% to fishing vessels and 4.4% to commercial ships on average. Figure 11.6 overleaf shows how the number and types of vessels with fouled propellers has changed between 2002 and 2007.

17 The RNLI officially puts the cost of launching an inshore lifeboat at £2,200 and an all weather lifeboat at £5,800. These figures have been adjusted for inflation and converted to Euros.

Over this 6-year period, there is also an increasing trend in the number of rescues to vessels with fouled propellers and the highest number of rescues was recorded in 2007. During 2007, the NSSR undertook 138 rescues to vessels with fouled propellers. Over 86% of these rescues were to pleasure craft with just 8% made to assist fishing vessels with fouled propellers. In addition, approximately 5.8% of rescues to vessels with fouled propellers were made to commercial ships. Unfortunately, the NSSR was unable to provide data as regards the level of danger these vessels were in or the associated cost of rescues over this period.

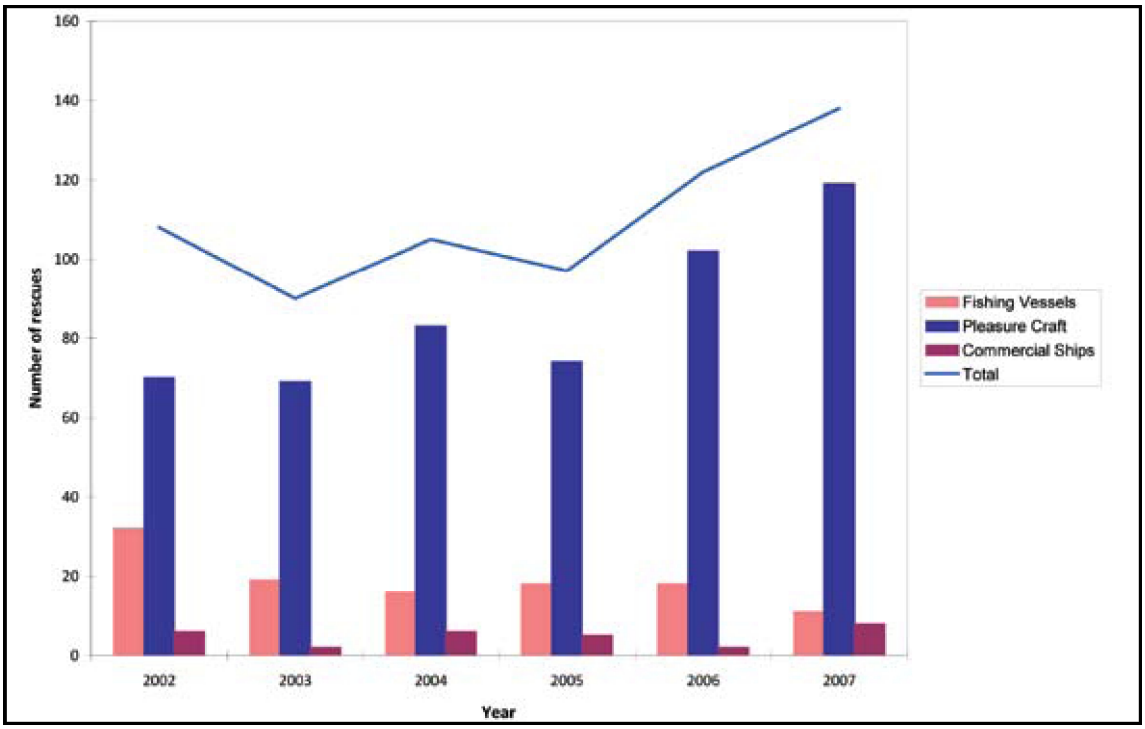

Figure 11.6: Changes in types and numbers of rescues carried out by NSSR between 2002-2007

11.4 Conclusion

From the results presented in this chapter, it is evident that marine litter continues to pose a significant navigational hazard to vessels in the Northeast Atlantic. The rising number of rescues to vessels with fouled propellers is of particular concern because it means that more lives are unnecessarily being put at risk each year due to marine litter. Most of the increase in rescues is accounted for by a rise in the number of fouled propellers sustained by pleasure craft with the number incurred by fishing vessels remaining broadly static.

While the safety of crew members is clearly the foremost concern in these situations, rescue operations involving the coastguard can result in high costs for the emergency services. In 2008, rescues to vessels with fouled propellers cost between €830,000 and €2,189,000[18] and this is likely to be considerably higher in reality given that the RNLI has not updated the cost of launching a lifeboat since 1998. Similarly, these figures do not take into account any costs incurred through rescues to other incidents such as fouled anchors, fouled rudders, blocked intake pipes and incidents involving swimmers and divers. A rising trend is also evident in the number of rescues to vessels with fouled propellers in Norwegian waters, which suggests that marine litter poses widespread and growing problems for navigation.

18 The RNLI officially puts the cost of launching an inshore lifeboat at £2,200 and an all weather lifeboat at £5,800. These figures have been adjusted for inflation and converted to Euros.

12. Shetland Agricultural Industry

12.1 Introduction

Marine litter can cause a wide range of problems for agricultural producers in coastal communities including damage to property and equipment, harm to livestock and the cost of litter removal. A questionnaire was developed to investigate these impacts further and assess the economic cost of marine litter to coastal agricultural producers. This questionnaire was only distributed to crofters[19] within the Shetland Islands, UK.

Figure 12.1 Marine litter can accumulate on fences and result in significant costs for crofters to remove the litter and repair the fences.

12.2 Types and levels of litter

Marine litter blows onto the land of 90% of the crofters surveyed during this project and Figure 12.2 below shows the main types of litter that accumulate on their land. Plastic is by far the most common type of litter and over 95% of crofters found this type of litter on their land. Rope, strapping bands and nets are also relatively common and each of these types of litter was found by more than 65% of the crofters surveyed during this project. In total, 64.3% of crofters found more than 5 different types of marine litter on their land.

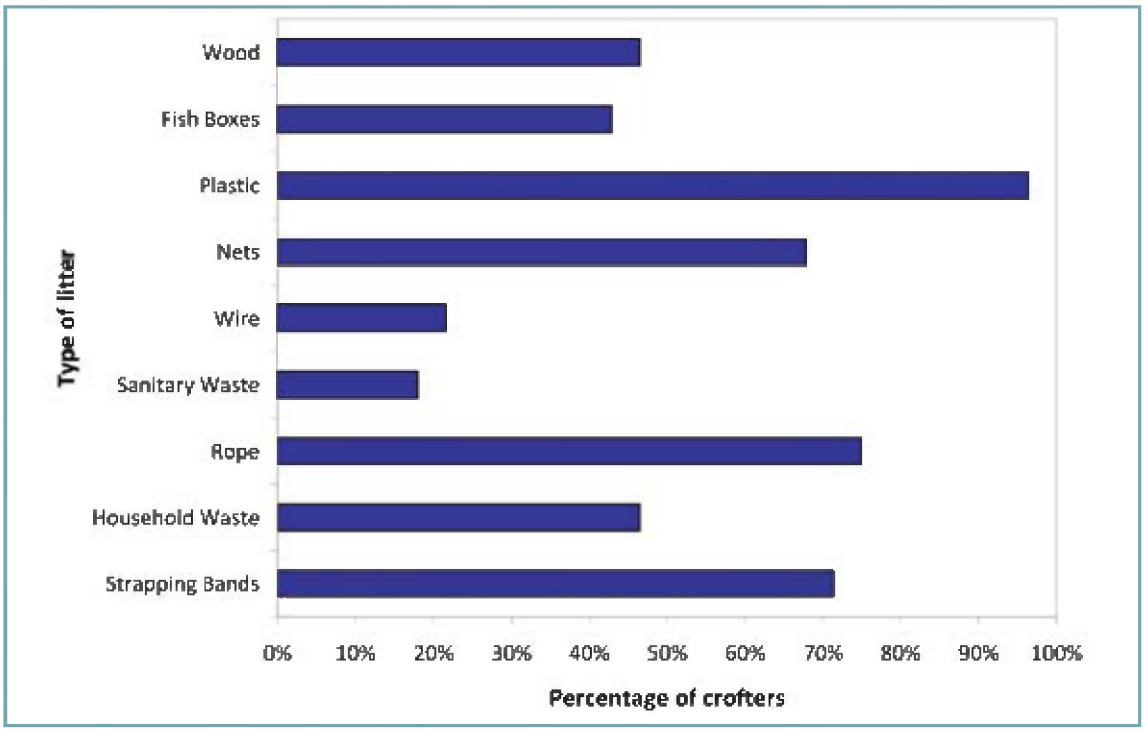

Figure 12.2: Types of litter which affects crofters' land

[19] Crofts are small agricultural holdings unique to the Highlands and Islands of Scotland. For more information, visit: http://www.crofterscommission.org.uk

Crofters experienced particular problems with specific types of litter and several crofters had difficulties with mussel floats from nearby aquaculture sites. These measure almost a meter in width and could cause substantial damage to walls and fences, although this was a fairly localised issue. Oil drums also continued to cause problems and one crofter reported watching 2 oil drums come ashore immediately after he had seen a fishing vessel pass by. This was particularly frustrating as "there's absolutely no need for boats to be dumping with the facilities on offer."

However, crofters were generally agreed that the overall level of litter coming ashore had substantially decreased over the past 5-10 years. One crofter stated "Certainly, fences used to be absolutely clad in litter in wind but there is significantly less litter now." This was generally thought to be due to the decommissioning of fishing vessels, better working practices in the aquaculture industry and the rapid decline in factory fishing vessels visiting the isles from Eastern Europe.

12.3 Harm to livestock

Marine litter can harm livestock, as well as wildlife, and approximately 41.9% of crofters reported that their livestock had either ingested marine litter or become entangled in it over the past year. A total of 24 animals had become entangled in marine litter over the past year at 10 different crofts. One crofter had experienced several cases where a sheep became trapped in nets that were snagged on rocks and then drowned when the tide came in. In addition, 5 crofters reported that animals had ingested marine litter on their crofts and this affected a total of 8 animals. The rates of entanglement and ingestion reported in this project are comparable with those reported by Hall (2000) and have not significantly changed over the past 10 years.

Figure 12.3: Cattle eating derelict fishing net, Shetland Islands, United Kingdom. Image: John Bateson.

12.4 Removal of marine litter and damage to property

Marine litter had caused damage to fences on 71.4% of the crofts surveyed and crofters spent between 1 and 30 hours per month removing litter from their fences. In total, 11 crofters had spent 840 hours over the past year removing marine litter from their fences with an average of 76.4 hours per year spent removing litter from fences at each croft. Similarly, 60.7% of crofters reported damage to their drainage ditches caused by marine litter. Removing marine litter from drainage ditches took 10 crofters a total of 342 hours per year and time spent removing litter from drainage ditches ranged from 30 minutes per month to over 8 hours a month. Damage to machinery caused by marine litter was relatively rare among the crofters surveyed and just 3 crofters had experienced this problem.

12.5 Economic cost of marine litter

Marine litter can result in increased costs for crofters in terms of additional vets bills, repairs to machinery and fences, and removing marine litter from their land, fences and drainage ditches. Marine litter cost each croft an average of €841.10 per year with overall costs ranging from €0 to €4,742.08 depending on how severely the croft was affected. A breakdown of the average cost of marine litter to crofters is provided in Figure 12.4 below. Removing marine litter accounts for the vast majority of costs to crofters and clearing land, ditches and fences accounted for approximately 87% of the average cost of marine litter to crofters. Additional vets bills and repairs to machinery were relatively costly for those affected but made up only a small proportion of the average cost of marine litter since these incidents were relatively rare.

Calculating the cost of marine litter to the agriculture industry in Shetland as a whole is relatively complicated, particularly as it is virtually impossible to determine how many of Shetland's 1,200 active crofters have land adjacent to the coast. Marine litter will also not affect all coastal crofts in Shetland due to geography and tidal patterns. This research therefore estimates that marine litter will cost the agriculture industry in Shetland approximately €252,331, based on the assumption that 25% of crofters in Shetland are affected by marine litter[20]. The extent to which these issues affect the agricultural industry elsewhere is unknown but one farmer from the south of England remarked elsewhere in the project that "[his farm] meadows often flood and debris creates problems - damage to machinery, contaminated hay, occasional damage to livestock." Similarly a Swedish farmer commented that marine litter "is a big problem and it costs a lot of money to keep our land in a proper order".

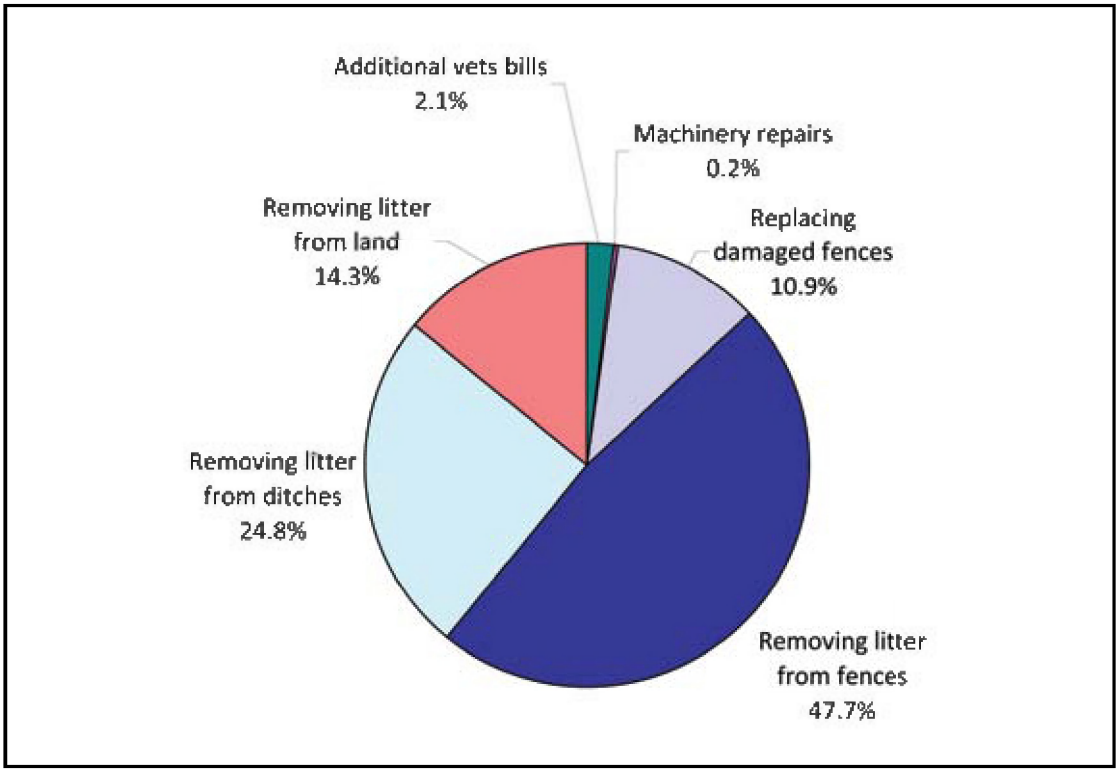

Figure 12.4: Breakdown of the average cost of marine litter to crofters

[20] Calculation based on average cost of marine litter to 300 crofters (25% of the total 1,200 active crofters in Shetland.)

12.6 Conclusion

Marine litter continues to present a wide range of issues for crofters in coastal regions including damage to property and machinery, harm to livestock and the cost of litter removal. While harm to livestock and damage to machinery were relatively infrequent, most crofters had to regularly remove marine litter from their fences, ditches and land. This could be particularly time intensive with the removal of marine litter from fences alone taking an average of 76.4 hours or the equivalent of almost 10 working days per year.

The crofters surveyed during this project were broadly agreed however that the amount of marine litter coming ashore had decreased during the past 5-10 years, although plastics and derelict fishing gear continue to pose problems. Generally, this decrease was thought to be the result of localised factors including decommissioning of fishing vessels, better working practices in the aquaculture industry and the rapid decline in factory fishing vessels visiting the isles from Eastern Europe

Despite a decrease in the quantity of litter, the average cost of marine litter to crofters was considerable. Marine litter costs the agriculture industry in Shetland approximately €252,331 per year with an average cost of €841.10 per crofter. The vast majority of costs are incurred removing marine litter from ditches, fences and the land, although harm to livestock and damage to machinery can result in high economic costs when these incidents occur. The cost of marine litter to crofters is particularly concerning given that many crofters are small producers and therefore have relatively tight profit margins. While the economic impact of marine litter on crofters in Shetland is clearly significant, more research is required to determine how marine litter affects farmers in other coastal regions.

13. UK Power Stations, Industrial Seawater Abstractors and Water Authorities

13.1 Introduction

Seawater is an essential resource for several industries, particularly power generation facilities, and these industries use a variety of means to screen out both natural and man-made debris. Marine litter, however, can result in the blockage of cooling water intake screens, increased removal of debris from screens and additional maintenance costs to these industries.

While these companies prevent marine litter entering their facilities, water authorities use screens to prevent litter, particularly sewage related debris (SRD), reaching the marine environment in the first place. Questionnaires were developed to investigate the impact of marine litter on industrial seawater abstractors, including power stations, and the efforts of water authorities to prevent SRD reaching the marine environment. These questionnaires were distributed to organisations within the United Kingdom.

13.2 Power Stations

Although many power stations within the UK rely on seawater as part of their cooling process, only 3 responses were received from this sector and therefore these responses are featured individually below.

13.2.1 Lerwick Power Station, Shetland

Lerwick Power Station in Shetland has 3 seawater intake pipes from the harbour, which are situated approximately 3 meters down. The 'A' Station receives seawater from 1 of these pipes while the other 2 supply the 'B' station. Each station has 2 flushing debris screens that run for approximately 1 hour per day.

The outer intake screens on these pipes are inspected every 2 years and the flushing screens are cleared once a month. Approximately ½ tonne of debris is removed each year but most of this is organic debris. Lerwick Power Station is not affected by much man-made waste due to the position of the intake pipes and marine litter therefore results in very little cost to the station.

13.2.2 Peterhead Power Station, Aberdeenshire

The cooling water system at Peterhead Power Station supplies seawater and the cooling water inlet is located a short distance away at Boddam harbour. Coarse screening of the cooling water is carried out in the harbour by twelve bar screens and fine screening is done using four rotating drum screens. Each drum screen serves one main cooling water pump and is only required in service when the pump is running. During normal operation at Peterhead Power Station, only 1 of the main units is in operation at any one time and this requires two water cooling pumps and the associated drum screens to be in operation continuously.

The coarse screens at Boddam harbour are cleaned approximately 3 times a year. Debris collected from the cooling water using the rotating drum screens is washed into 2 trash pits via rubbish gullies and regular visual inspections are carried out to assess the need to empty the trash pits. During the first 9 months of 2009, a total of 24.78 tonnes of debris was collected using the intake screens at Peterhead Power Station. Approximately 5% of this waste is marine litter and the rest is organic debris, although it is very difficult to determine the quantity of waste that comes from human activities.

The cost of cleaning the screens and disposing of the waste removed is € 16,516.09 per year. Marine litter therefore costs the power station approximately € 825.80[21] per year but a reduction in marine litter is unlikely to result in any significant cost savings since the station would still have to remove organic debris.

13.2.3 Magnox North, Wylfa Site, Anglesey

At Wylfa, there are 4 48' diameter drum screens and each of these serves a cooling water pump. These screens are in service 24 hours a day and are used to screen out seaweed, fish, shells and floating debris. The clearance of the drum screens is very dependent on the prevailing weather conditions with a combination of north or northwesterly winds, low water and an incoming tide resulting in the highest quantities of debris.

Under normal operating conditions, the daily volume of debris is generally small and amounts to approximately 1 cubic metre per drum screen. In extreme situations, there could be station personnel clearing debris from the drum screens continuously for up to 24 hours. Marine litter, such as plastic bottles and carrier bags, accounts for up to 1% of the debris removed using screens and organic debris, particularly seaweed, presents the most problems for Wylfa.

13.3 Industrial seawater abstractors

While many industrial seawater abstractors experience similar issues with marine litter to power stations, the response rate was similarly low and 7 organisations completed the questionnaire in total.

13.3.1 Problems with marine litter

The companies surveyed during this project used seawater for a variety of functions including:

- Flushing sewerage facilities
- Suppression of dust at a coal terminal
- Cooling purposes
- To feed a salt-water fire main

Each company was asked to rate the extent to which marine litter posed problems for their company. In total, 4 respondents stated that marine litter posed no problems for their company and the remaining 3 identified marine litter as an "occasional problem".

13.3.2 Debris screening and removal

Most of the companies surveyed during this project used screens to remove marine debris and these screens

[21] Calculated using the total cost of clearing debris from intake screens and the percentage of debris collected that is man-made.

needed cleansing on variable frequencies depending on the build up of litter. The level of debris experienced by some companies meant they had to clean intake screens every week while others only needed to clean screens once a year. The amount of debris removed using these screens was generally small and ranged from 3 cubic metres to several large trailer loads a year.

Determining what percentage of the debris removed using these screens was marine litter was difficult but companies estimated that between 40 – 90% of the debris removed was man-made. Only 1 company was able to provide data about how much marine litter cost to remove and this amounted to approximately € 132.13[22]. These costs would be unlikely to decrease in the event that less marine litter accumulated on screens since cleansing operations would still be necessary to deal with organic debris.

13.4 Water authorities

Questionnaires were distributed to all water authorities in the UK with responsibility for water and sewerage services in coastal areas in order to investigate their efforts to prevent marine litter.

13.4.1 Scottish Water

Scottish Water provides water and waste water services to over 2.4million households across an area of 79,000 square kilometres. During 2008/2009, Scottish water removed a total of 11,345 tonnes of grit and solid items using its screens. Unfortunately, it is not possible to determine what proportion of these screenings was SRD.

In addition, approximately 6.7% of domestic dwellings in Scotland are not connected to the public sewerage system. Scottish Water has participated in the national 'Bag It and Bin It' campaign, which aims to protect the UK's beaches, rivers and canals from SRD.

13.4.2 South West Water Ltd

South West Water Ltd. (SWW) is the water and sewerage services provider for Devon, Cornwall and small parts of Dorset and Somerset. Although the smallest of the water and sewerage companies in England and Wales, it has 33% of the countries' designated bathing beaches within its area. During 2009, 4,023 tonnes of debris were removed using screens but this includes all material removed from sewerage treatment works and combined sewer overflows (CSO's) and therefore not all of this will be SRD.

Since privatisation of the water industry in 1989, SWW has invested €2.26 billion in its Clean Sweep programme to improve bathing waters around its coast. This has included the removal of 250 crude sewage outfalls that previously existed and were inherited by the company during privatisation. Over the last 10 years, SWW has also invested €84.6 million in improving the quality of discharges from CSO's throughout the region. South West Water also point out that "much of what is described as sewage related debris may not have come from sewers at all but actually have been discarded on the beach (e.g. condoms, sanitary items) or offshore via shipping and pleasure craft for example."

South West Water actively promotes the responsible use of sewers and is part of the Sewer Network Abuse Prevention (SNAP) group, which is concerned with inappropriate discharges into sewers. The company has

22 Calculated using the total cost of clearing debris from intake screens and the percentage of debris collected that is man-made.

also produced a number of leaflets and posters over the past few years to highlight various issues such as 'The Dirty Dozen', targeting the 12 most common causes of sewer blockages. South West Water has also participated in the 'Bin It Don't Flush it' campaign and operates a customer caravan at numerous shows and events throughout the year to draw attention to the problems caused by inappropriate discharges.

13.5 Conclusion

Marine litter can result in multiple issues for seawater abstractors including the blockage of cooling water intake screens, increased removal of debris from screens and additional maintenance costs to these industries. From the examples provided in this chapter, it appears that the impact of marine litter on seawater abstractors, including power stations, can be quite variable but generally tends to occur at a relatively low level. Unfortunately, it is very difficult to determine the economic cost of marine litter to these companies, as most do not record this kind of information.

Water authorities play a key role in preventing SRD reaching the marine environment and the examples in this project demonstrate the diverse measures and initiatives water authorities use to promote responsible use of sewage facilities and reduce the amount of SRD entering the sewage system.

14. Case Study: Shetland Islands, UK

14.1 Introduction

Marine litter clearly affects a wide range of industries and the aim of this chapter is to draw together the various sections of this project into a case study of the economic impact of marine litter on one coastal community, the Shetland Islands in the United Kingdom. Located midway between the UK mainland and Norway, Shetland is a group of over a 100 islands with a population of approximately 22,000 people spread across 15 inhabited islands. With more than 2,700km of coastline, Shetland has a strong connection to the sea and many industries rely on the marine environment for their livelihoods. Shetland therefore provides a strong foundation for a case study of the economic impact of marine litter on a single coastal community.

Analysing the cost of marine litter in a Shetland context was carried out in two ways. Where a single body was responsible for a sector, such as the municipality, these results were taken as the total cost for that sector. For broad based sectors, such as fisheries and agriculture, the average cost of marine litter to one organisation was used to find the overall cost for that sector.

14.2 Economic cost of marine litter

Marine litter costs the Shetland economy between €1 million and €1.1 million each year. As Figure 14.1 overleaf shows, the fishing industry shoulders the highest burden of costs and losses due to marine litter with the industry losing between € 637,110 and € 709,105[23] as a result of marine litter each year. Lost earnings as a result of time spent removing marine litter from nets make up a relatively high proportion of these costs and this is of particular concern in view of the continuing European restrictions on the number of days vessels can spend at sea.

Marine litter also poses widespread issues for Shetland's crofters particularly in terms of the cost of litter removal but also through harm to livestock and damage to property and equipment. Marine litter therefore costs the agricultural industry in Shetland approximately €252,331 per year[24]. Since many crofters in Shetland operate on a small scale, marine litter puts additional pressure not only on their time but also on their profit margins.

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23 Extrapolation based on average cost of marine litter to fishing vessels based in Shetland involved in demersal and scallop fisheries. Total of 37 vessels based in Shetland and actively involved in these fisheries (Shetland Fishermen's Association, 2010, Personal communication)

24 Calculation based on average cost of marine litter to 300 crofters (25% of the total 1,200 active crofters in Shetland.)

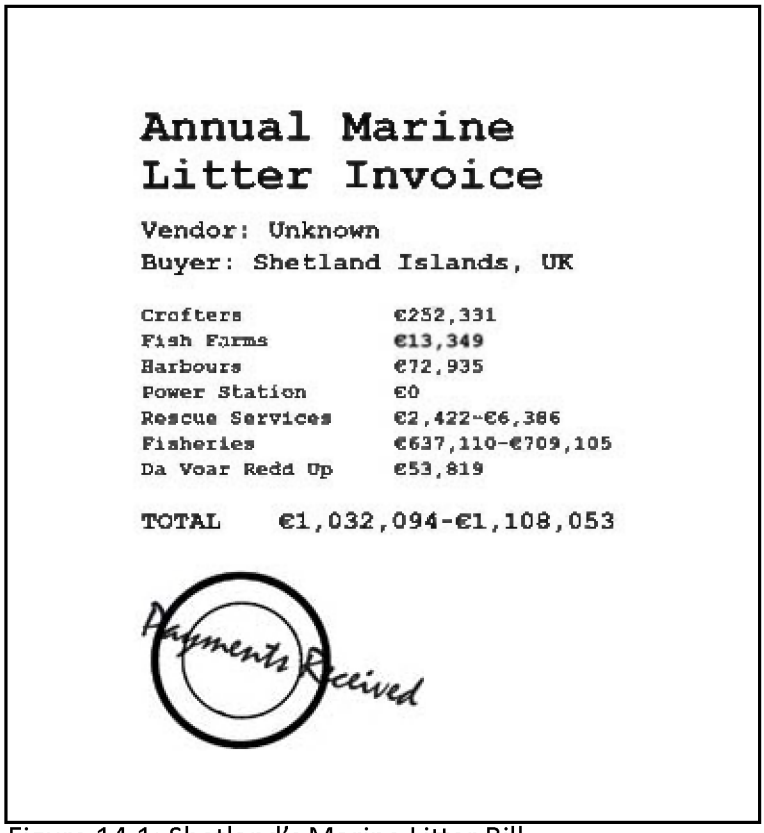

Figure 14.1: Shetland's Marine Litter Bill.

Shetland takes an active response to marine litter in the form of the annual Voar Redd Up[25] where volunteers remove litter that has collected on beaches and roadsides during the year. As the largest community clean up event in Scotland, Da Voar Redd Up has removed well over 1,000 tonnes of litter and has won numerous awards including the United Nations Dubai International Award for Best Practice to Improve the Living Environment.

During the 2009 Redd Up, volunteers spent over 8,250 hours removing a total of 65 tonnes of marine litter from around Shetland. In 2009, Da Voar Redd Up cost approximately € 53,819 to run based on the value of volunteers' time and a small donation from BP towards operational costs. This figure is likely to underestimate the total cost of the Redd Up, however, as it does not include the contribution of the Shetland Amenity Trust, who organise the event, or the cost of disposing of the litter collected, which is generally covered by Shetland Islands Council.

Relatively low costs were experienced by the Shetland aquaculture industry, which accounted for just 1.2% of the total cost of marine litter to Shetland, as shown in Figure 14.2 overleaf. Similarly, the rescue services experienced relatively low costs since the coastguard attended just 1 vessel with a fouled propeller during 2008. The Lerwick Power Station reported very few problems with marine litter and therefore incurred zero costs as a result. It was unfortunately not possible to meaningfully calculate the economic cost of marine litter to either the tourism industry or marinas within Shetland.

25 Da Voar Redd Up means "the spring clean" in Shetland dialect.

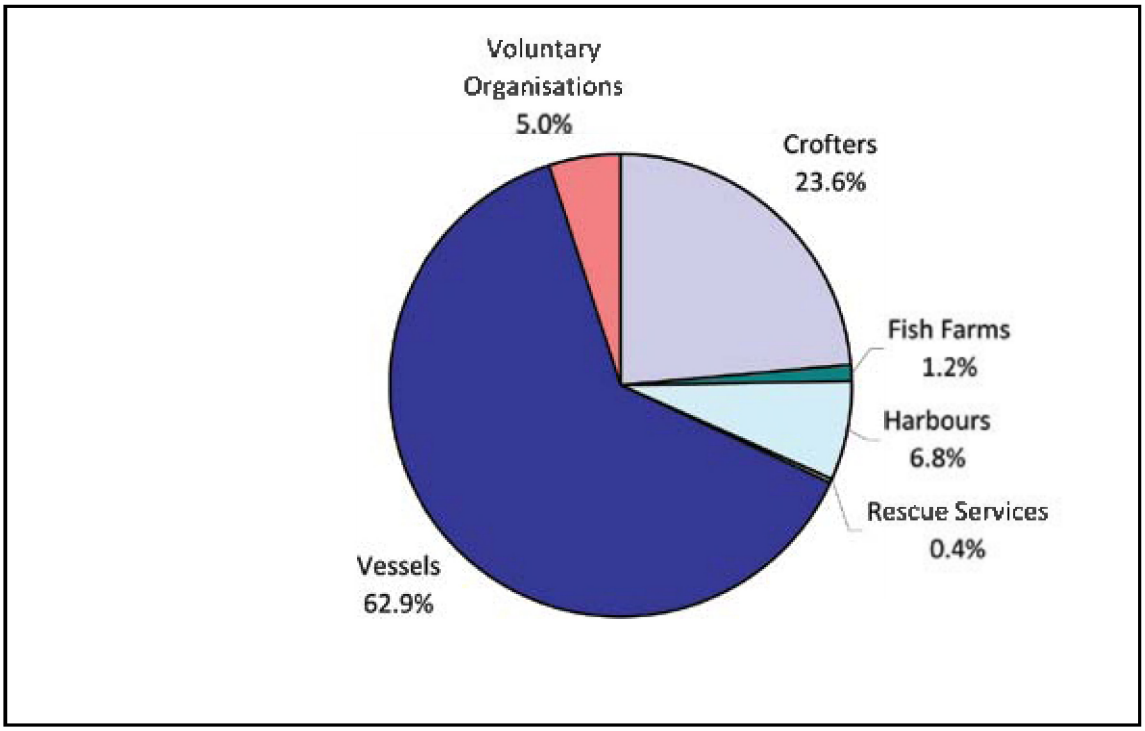

Figure 14.2: Breakdown of the average annual cost of marine litter to Shetland

14.3 Conclusion

Marine litter costs the Shetland economy between €1 million and €1.1 million on average each year, based on the increased costs and losses affecting key industries that rely on the marine environment. As fishing is one of the main industries in Shetland, it bears the brunt of these costs but this is likely to vary in other coastal communities where industries such as tourism may be more important and thus affected by marine litter to a larger extent.

As marine litter is a highly dynamic problem, it is inevitable that these costs will vary to some degree but it is important to recognise that the economic cost of marine litter to Shetland is both significant and entirely unnecessary. Since Shetland represents only a single case study, these findings also suggest that the total economic impact of marine litter on coastal communities in the Northeast Atlantic region could be extremely high.

15. Wider Context of the Impacts of Marine Litter

15.1 Introduction

One of the key aims of this project was to investigate the wider context of the impacts of marine litter and gain a deeper insight into how different sectors view the marine litter problem. In particular, the project focused on the perception, sensitivity and priorities of various sectors as regards marine litter and its impact on the environment. Key questions were also asked about what level of marine litter is acceptable in the marine environment and the implications of any potential rise in marine litter in future. Short follow up questionnaires were developed for each sector to investigate these questions and these were distributed to organisations that had already completed the main project questionnaire.

15.2 Level of litter in the local marine environment

As part of the follow up questionnaires, organisations were asked to rate the level of litter present in the local marine environment and the results are shown in Figure 15.1 below. The majority of organisations surveyed during this project judged the level of litter in the local marine environment to be either moderate or low with 45% and 34% of organisations identifying these levels respectively. Just 13% of organisations felt that the marine litter level was very low while a very small minority suggested that the marine litter level was high or very high in their areas.

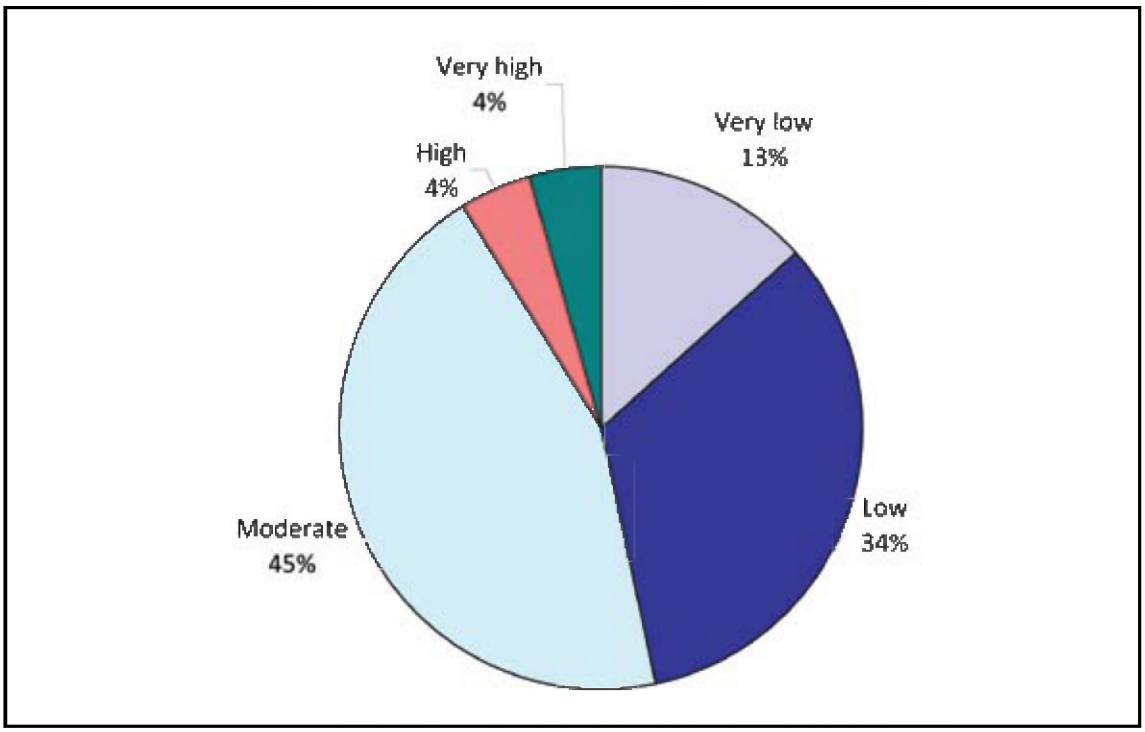

Figure 15.1: Level of litter in the local marine environment

15.3 Impact of marine litter

15.3.1 Organisations affected by marine litter and types of impact

Marine litter affected 62.2% of the organisations surveyed as part of this project and two common themes

emerged in the ways these organisations are affected by marine litter. For many organisations, this was a question of the increased resources and expenditure necessary to remove marine litter and prevent it from having any further impacts upon their organisation. Other organisations observed that the presence of marine litter was already having an effect on their organisation in terms of reduced trade, catch or visitor numbers. Several organisations also used a combination of both these reasons to describe how marine litter had affected them. Examples of how organisations are affected by marine litter include:

- "Apart from visual impact and threat to environment, litter collection is a manpower issue." (Harbour)
- "Providing financial support and assistance to local community groups and organisations in beach cleanup initiatives." (Harbour)
- "Marine litter can…result in wasted time and less catch. It could also spoil the catch if it were paint" (Fishing vessel)
- "There has been fairly regular feedback to the council that the shorefront area in the town centre would be better used if the amount of litter was less" (Municipality)
- "Mainly affected by rope, netting, plastic sheet, packing straps occasionally wrapping around longlines and dropper ropes on mussel farm sites. These can chafe off rope droppers or at least take time to disentangle and create nuisance in disposal." (Mussel farm)
- "Increases the maintenance of boats, rubbish affecting the propellers, filters etc. For this reason the harbour launch removes rubbish build-up in the marina and this means extra work" (Marina)
- "Harbour staff has litter retrieval/cleaning duties built into their daily work routines thus affecting other operational duties. Negative impact on visitors/tourists. Environmental concerns in terms of damage to marine eco-systems. Damage caused to vessel propulsion systems. Direct/indirect costs to the Harbour when enforcing harbour byelaws on offenders – time/effort/money etc." (Harbour)
- "The knock-on effect in the enjoyment of visitors, from tourists to local people, to the local beaches could be affected. The designated bathing beaches and coast around the area have to be kept regularly cleaned by employed cleansing staff, which is increased from Easter to September each year." (Municipality)

A key issue, particularly among municipalities, was that public expectations of beach cleanliness were increasing and becoming harder to meet. One municipality stated, "Members of the public have greater expectations and want the beach to be clean." This could cause competition between areas with another municipality concerned that "Residents and visitors have been discouraged from using the beaches because of litter. When deciding which beaches to visit, tourists have chosen to go to other areas where the beaches are cleaner."

Another municipality directly linked this to a potential reduction in tourist revenue, stating, "Marine litter generates negative comments locally and from visitors from outside the area. This can tarnish the reputation of tourist destinations and therefore contribute to economic loss." This municipality was also particularly concerned about how to cost-effectively remove marine litter and commented, "Some community groups do come forward to carry out voluntary collections at 'hotspots', but this is not sustainable and cannot resolve the problems alone."

Municipalities and harbours accounted for the majority of organisations surveyed during this stage of the project and there were notable differences between these two sectors in terms of how they were affected by marine litter. Approximately 83.3% of harbours reported that they were affected by marine litter, mainly because they either experienced additional costs for removing marine litter or because the litter in the

harbour was unsightly. In contrast, 68.4% of municipalities reported that marine litter did not affect the level of beach use. Municipalities suggested that this was because appropriate litter removal measures are in place to ensure beaches remain free of litter and attractive to beach users.

15.3.2 Organisations not affected by marine litter and reasons why

Approximately 37.8% of the organisations surveyed stated that they were not affected by marine litter. One of the most common reasons given by organisations for this is that they had sufficient litter removal plans and measures in place to ensure that litter did not have a knock on effect on their organisation. As one organisation stated, marine litter has no impact because the organisation has "a robust cleansing regime in place to keep on top of the debris coming ashore." There is a valid argument, however, that these organisations are actually affected by marine litter since they have adopted measures and allocated resources to deal with marine litter. Many organisations that stated they were affected by marine litter in fact used a broadly similar reason – increased workload, resources and expenditure required to remove marine litter - to show how they were affected.

A number of other explanations were given by organisations for why they were not affected by marine litter with several organisations stating that marine litter had no impact on them for the simple reason that "there's not much litter" in their local area. For some municipalities, in particular, the level of litter present on beaches was not enough to deter tourists and visitors with one stating, "we are in a high tourist area, and the level of marine litter is not sufficient to affect this". In these cases, demand was so high that marine litter had very little effect and "the public will come anyway". Several municipalities also felt that there were "very few commercial interests [in their area] that could be affected" by marine litter.

15.4 Importance of a clean and high quality marine and coastal environment

The organisations surveyed during this stage of the project were agreed that a clean and high quality marine and coastal environment was either 'important' or 'very important'. While these groups clearly have a vested interest in ensuring the marine environment remains clean and litter free, they nonetheless gave a wide variety of reasons as to why a clean and high quality marine and coastal environment was important. For many organisations, the local marine and coastal environment was key to the continued success of the tourist industry and the contribution it made to the local economy. As one organisation commented "it is the high quality marine environment that attracts the recreational visitors (sailors, walkers and more) which sustain the local economy". Another suggested that "without significant efforts by the local authority in terms of beach cleansing, the tourism economy would be negatively affected."

Many organisations also felt that ensuring the marine environment remained clean and free of litter was important to maintain their corporate reputation and meet clients' expectations. A clean marine environment was "indicative of good port stewardship" according to one harbour and this type of attitude was generally shared by many organisations. One marina commented "We try to present a high quality marine environment for our customers, who are paying a high price for leaving their very expensive vessels here with me, under my care. The customers are also bringing a lot of money to the local economy and the last thing they wish to see is a large amount of litter…that could potentially cause damage to their vessel." Similarly, a shellfish producer was "reliant on [their] "clean" reputation, and the reality of clean water for a healthy product".

Another key theme among the responses was that a clean and high quality marine and coastal environment was important for the protection of ecosystems, wildlife and the environment in general. A municipality

summed this position up by stating that it was important to maintain a "safe, natural environment for people, animals and birds". Several organisations also specifically linked this to a litter free environment with one harbour stating "Having litter in the environment is horrible – it is bad for the animals that are such a delight to watch and the general environment." For some organisations, protecting the marine environment also had commercial benefits with one fishing vessel stating "We need clean seas so that fish can reproduce in their natural habitat."

Harbours and marinas placed particular emphasis on maintaining a clean marine environment in order to ensure vessel safety. Reasons such as "A littered marina could cause damage to boats" and "to avoid rope and nets from going into propellers and causing incidents that are avoidable" were common among responses from harbours and marinas. These organisations were concerned about damage both to visiting vessels and vessels used in the operation of the harbour. One harbour, for instance, stated "we operate a fast craft and they are susceptible to damage by drawing in large pieces of refuse into the water jet intakes".

15.5 Future sensitivity to marine litter

Looking to the future, organisations were asked what impact any increase in marine litter level would have on their organisation and responses ranged from no effect whatsoever to extremely negative impacts on organisations' core activities. For several organisations, an increase in marine litter would have very little effect with one harbour stating an increase in marine litter would have a "minimal effect, ships would still come and go." Generally, these organisations were also of the opinion that it would take a substantial increase in litter levels before any impact was felt. One municipality, for instance, commented that marine litter "would have to dramatically increase to directly affect beach usage."

For many organisations, additional resources and expenditure would be required to prevent increased levels of litter having a negative impact on their core activities. Dealing with more marine litter would increase costs at every stage of the removal process, from collection to disposal, and result in increased staffing pressures to cope with the additional workload. One harbour, for example, commented that increased levels of marine litter "would require more time spent by harbour staff in cleaning up, leading to less time for other operations such as structure maintenance etc."

There were also concerns that increased levels of litter "would have increased costs not only in beach cleaning but in potential litigation and increased liability." This could have significant financial implications for organisations, such as municipalities, which have a statutory duty to ensure the environment remains clean and free of litter. In this respect, organisations were also concerned about the possibility of higher insurance premiums as a result of increased levels of marine litter.

Several organisations had deep reservations, however, about their ability to meet increased costs resulting from higher levels of marine litter. These organisations would find it difficult to locate the necessary resources, staff and budgets to deal with an increase in marine litter and therefore they would be unable to prevent marine litter from building up and affecting their core business. As one municipality stated, "With reducing budgets to provide clearance teams, any increase in litter would have an impact on the local tourist industry." For some organisations, current marine litter levels are already challenging to deal with and one harbour commented that "it is impossible with current labour levels to remove it and some areas remain unkempt."

Approximately half the organisations surveyed during this stage of the project reported that any increase in marine litter levels in future would have a negative impact on their core activities, including tourist numbers,

harbour usage and fishing vessels' catch. An increase in marine litter would, for example, "cause usage to drop across the board i.e. those coming for the scenery, water sports, days on the beach with the family etc. This would then have a negative impact on the local economy that relies on tourists and visitors." An increase in marine litter could likewise "result in the fishing industry losing precious fishing time."

Any increase in marine litter could also affect an organisation's corporate image and potentially encourage clients and tourists to go to another destination. As one marina remarked, marine litter "is bad for business. It makes it look as if none of us care about our environment and that we find pollution acceptable – and that cannot be the way forward. Customers vote with their feet and will go elsewhere."

In extremely rare cases, an increase in marine litter levels could put companies out of business with one marina commenting that "Less people would want to visit the area or keep their boats with us if the area was generally littered or polluted. This would, in the extreme, mean there would be no need for the marina." Similarly, an increase in marine litter "could mean the end" for one aquaculture producer, due to the low currents and oxygen levels at their aquaculture sites.

15.6 What level of litter is acceptable in the marine and coastal environment?

Developing appropriate programs and measures to tackle marine litter in future relies upon a clearly defined objective about the level of marine litter that is acceptable in the marine and coastal environment. Defining what constitutes an acceptable level of marine litter is also particularly important in the current context given the ongoing work to determine how the EU Marine Strategy Framework Directive (2008/56/EC) will be implemented. Therefore, a key aim at this stage of the project was to gather grassroots perspectives on what level of marine litter is acceptable in the marine and coastal environment.

Out of the 45 organisations surveyed, 13 categorically stated that absolutely no litter was acceptable in the marine environment. As one marina stated "None! There is no need for litter at sea, or in a marina, when waste disposal is provided for at marinas and harbours alike." There was a general view among these organisations that litter in the marine environment was completely unnecessary and several organisations had therefore adopted a "zero tolerance" approach to marine litter.

A further 18 organisations agreed "no litter would be the ideal" but believed this was impractical and that minimal levels of marine litter would be a more realistic target. As one municipality remarked, "No litter is acceptable. However, being pragmatic, and knowing that we have little control over what reaches our shores, I think we need to understand that there will always be a little amount. It is a case of controlling what we can." Several organisations recognised that historical levels of marine litter would also be a barrier towards achieving minimal levels of marine litter with one organisation suggesting, "There should be no new littering. It is accepted that large volumes of litter are already present within the marine environment."

Image: Dr Jan van Franeker, IMARES.

In total, 11 organisations explicitly stated that marine litter levels should be "the lowest possible". For many organisations, this was about achieving as low a level of marine litter as possible given the limited funds and resources available. As one harbour remarked, "the practicalities and cost constraints of achieving the acceptable and accepting the reality have to be acknowledged." For others, "the lowest possible" level of litter was determined according to the level of litter which is acceptable to clients and visitors. Thus, for one municipality, a small amount of litter was acceptable since "a reasonably small degree of littering on the main beaches is probably seen as reasonable by most visitors." Organisations therefore generally shared the view that the current level of marine litter is unacceptable.

15.7 Conclusion

Although organisations stressed the importance of a clean and high quality environment, marine litter affects almost 66% of the organisations surveyed during this project. Overall, marine litter tends to affect these organisations in two main ways either by directly impacting on their core business or through the need to remove litter, which requires additional resources and expenditure. For many organisations, however, it is difficult to find the resources and funds necessary to support the level of service provision required to ensure their area is clean and free of litter.

The impact of any future increase in marine litter could be quite variable. At one end of the spectrum, several organisations stated that they would not be affected by any increase in marine litter while many suggested it would put additional pressure on their resources and budgets. In a few extreme cases, a significant increase in marine litter could put the organisation out of business.

A key aim at this stage of the project was to determine what level of marine litter is acceptable in the marine and coastal environment and the responses ranged from no litter whatsoever to the minimum amount of litter possible. The organisations surveyed during this project were therefore agreed that current levels of marine litter are unacceptable. This suggests that concerted action is now required at all levels to reduce existing levels of marine litter and prevent new litter from entering the marine environment.

16. Conclusion

This research clearly demonstrates that the economic impact of marine litter on coastal communities in the Northeast Atlantic region is considerable with many industries significantly affected by marine litter. A key concern is the high cost marine litter continues to pose for municipalities. UK municipalities spend approximately €18 million each year removing beach litter, which represents an increase of 37.4% over the past 10 years. Similarly, removing beach litter costs municipalities in the Netherlands and Belgium approximately €10.4 million per year.

For most municipalities, the potential economic impact of marine litter on tourism provides the principal motivation for removing beach litter. In this respect, regularly removing beach litter costs less than the potential reduction in revenue that could result from taking no action. The potential economic impact of marine litter also provides a more powerful incentive for removing beach litter than current legislation, particularly in the UK. This suggests that more research is required into the economic costs of marine litter as this could provide a powerful tool for stimulating and justifying action to tackle the problem.

The economic impact of marine litter on fisheries is also relatively high and marine litter costs the Scottish fishing industry between €11.7 million and €13 million on average each year, which is the equivalent of 5% of the total revenue of affected fisheries. The loss of earnings due to reduced fishing time is of particular concern given the continuing EU restrictions on the number of days vessels can spend at sea. Marine litter also presents a significant ongoing navigational hazard for vessels, which is reflected in the increasing number of coastguard rescues to vessels with fouled propellers both in the UK and Norway. In 2008, for example, there were 286 rescues to vessels with fouled propellers in UK waters at a cost of between €830,000 and €2,189,000.

Marine litter clearly affects a wide range of industries and a case study of the Shetland Islands, in the United Kingdom, highlights how these costs can affect one coastal community. Overall, marine litter costs the Shetland economy between €1 million and €1.1 million on average each year. As fishing is one of the main industries in Shetland, it bears the brunt of these costs but this is likely to vary in other coastal communities where industries such as tourism may be more important and thus affected by marine litter to a larger extent. Since Shetland represents a single case study, these findings also suggest that the total financial cost of marine litter to all coastal communities in the North Atlantic region could be extremely high.

Several general themes also emerged in this study and these were evident in virtually every industry surveyed. Firstly, it is clear that in the case of marine litter, the polluter does not pay with many organisations forced to find the resources and funds to deal with litter caused

by other parties. Similarly, it is important to acknowledge that while many of these efforts mitigate the short-term impact of marine litter, they do not directly address the underlying marine litter problem. Furthermore, marine litter represents an additional and completely unnecessary cost to these organisations, many of which face increasing difficulties balancing service provision with limited funds.

This study also investigated the wider context of the impacts of marine litter and in particular, the sensitivity and priorities of various sectors as regards marine litter. Although organisations stressed the importance of a clean and high quality environment, marine litter affects almost 66% of the organisations surveyed during this project. Overall, marine litter affects these organisations either by directly impacting on their core activities or through the need to remove litter, which requires additional resources and expenditure. The majority of organisations surveyed during this project also stated that absolutely no litter was acceptable in the marine environment, although many recognised that achieving a minimal level of marine litter is perhaps a more realistic target. These organisations were therefore agreed that current levels of marine litter are unacceptable.

This research also highlights that while the economic impact of marine litter occurs at a local level, action to reduce it must be global. With marine litter originating from many diffuse sources, there needs to be a step change in how the problem is treated at a national and international level. As a starting point, marine litter needs to be regarded as a pollutant on the same level as heavy metals, chemicals and oil and therefore given the same political credibility. In most countries, NGO's and volunteers currently undertake monitoring of marine litter and there are no national monitoring programmes, as there are for other pollutants. The level of resources committed to tackle marine litter by states is also far less than for other pollutants although, as we have shown here, the impacts can be significant.

At a broader level, we also need to consider the way we design and treat products, especially those made of plastic, with too many currently designed for one use and then thrown away. In the Northeast Atlantic, plastics make up 80-62% of marine litter and yet we continue to design and develop disposable products that encourage littering. Systems need to be implemented to place value on these products to encourage their reuse and encourage manufacturers to design them for reuse and recycling. There are already several initiatives, such as deposit schemes and reverse vending, which incentivise the reuse of plastic bottles and these could be extended to include a wider range of plastic containers. For higher value items, extended produce responsibility should be adopted with fishing nets, for example, rented by the producers rather than sold. The net would then be returned at the end of its life and it would be the producer's responsibility to recycle them, reducing the temptation to dispose of them at sea.

The enforcement of litter legislation also needs to be improved if the sources of marine litter are to be significantly reduced. The dumping of all plastic at sea is banned under MARPOL Annex V, for example, but with poor enforcement and insignificant fines, it holds very little deterrent for polluters. Despite holding Special Area status under MARPOL Annex V, the North Sea remains polluted by large quantities of plastic and other litter. Similarly, the provisions of the EU Port Waste Reception Directive must be improved to include all vessels, introduce significant fines and ensure that those who break the law can be prosecuted. In principle, current legislation does much to reduce marine litter but in practice, stronger networks of enforcement and significant fines are required to realise the full potential of these regulations.

These challenges are not new but the way we address them must be if we are to significantly reduce marine litter. What is clear is that without strong action to tackle the sources of marine litter, the costs associated with it will continue to rise.

References

Allsopp, M., Walters, A., Santillo, D. and Johnston, P. (2006) Plastic debris in the world's oceans. Available from: http://www.unep.org/regionalseas/marinelitter/publications/docs/plastic_ocean_report.pdf [accessed July 2010.]

Andrady, A. (2005) Plastics in the Marine Environment: A Technical Perspective. White Paper for the Plastic Debris Rivers to Sea Conference, Sept 7-9 2005. Redondo Beach, California.

Australian Government (2009) Harmful Marine Debris. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html [accessed July 2010.]

Ballance, A., Ryan, P.G. and Turpie, J.K. (2000) How much is a clean beach worth? The impact of litter on beach users in the Cape Peninsula, South Africa. *South Africa Journal of Science* 96: 5210 – 5213.

Barnes, D.K.A. (2002) Invasions by marine life on plastic debris. *Nature* 416: 808-809.

Barnes, D.K.A. (2005) Remote Islands Reveal Rapid Rise of Southern Hemisphere Sea Debris. *The Scientific World Journal* 5: 915-921.

Barnes, D.K.A. and Milner, P. (2005) Drifting plastic and its consequences for sessile organism dispersal in the Atlantic Ocean. *Marine Biology* 146: 815-825.

Barnes, D.K.A., Galgani, F., Thompson, R.C. and Barlaz, M. (2009) Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 1985-1998.

Beachwatch (2009a) Methods and Full Results. Available from: http://www.mcsuk.org/downloads/pollution/beachwatch/Beachwatch%20Big%20Weekend%202009%20-%20methods%20and%20full%20results.pdf [accessed July 2010.]

Beachwatch (2009b) Summary Report. Available from: http://www.mcsuk.org/downloads/pollution/beachwatch/Summary%20report_2009_e-mail.pdf [accessed July 2010.]

BMF (2007) Economic Benefits of Coastal Marinas UK and Channel Islands: Executive Summary. Available from: http://www.britishmarine.co.uk/upload_pub/2027.pdf [accessed July 2010.]

Brown, J., Macfadyen, G., Huntington, T., Magnus, J. and Tumilty, J. (2005). Ghost Fishing by Lost Fishing Gear. Final Report to DG Fisheries and Maritime Affairs of the Euopean Commission. Fish/2004/20. Institute for European Environmental Policy/Poseidon Aquatic Resource Management Ltd joint report.

Cheshire, A.C., Adler, E., Barbière, J., Cohen, Y., Evans, S., Jarayabhand, S., Jeftic, L., Jung, R.T., Kinsey, S., Kusui, E.T., Lavine, I., Manyara, P., Oosterbaan, L., Pereira, M.A., Sheavly, S., Tkalin, A., Varadarajan, S., Wenneker, B. and Westphalen, G. (2009) UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter. UNEP Regional Seas Reports and Studies, No. 186; IOC Technical Serious No. 83.

Chivers, C.J. and Drew, C. (2005) All 7 Men Alive as Russian Submarine Is Raised. Available from: http://nytimes.com/2005/08/07/international/europe/07russia.html?_r=1 [accessed July 2010.]

Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts, National Research Council, Ocean Studies Board and Division on Earth and Life Sciences (2008) *Tackling Marine Debris in the 21st Century*. Washington D.C.: The National Academies Press.

DEFRA (2009) Marine and Coastal Access Act 2009. Available from: http://www.defra.gov.uk/environment/marine/legislation/mcaa/index.htm [accessed July 2010].

DEFRA (2010) Charting Progress 2: The state of UK seas. Available from: http://chartingprogress.defra.gov.uk/ [accessed July 2010.]

Deloitte (2008) The economic case for the Visitor Economy: Final report. Available from: http://www.visitbritain.org/Images/EconomicCaseforTourism_tcm139-168288.pdf [accessed July 2010.]

Derraik, J.G.B. (2002) The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin* 44: 842-852.

Donnan, D. (2009) Marine non-native species: responding to the threat. Presentation to the Scottish Natural Heritage Conference 'Marine non-native species: responding to the threat', 27 Oct 2009. Battleby, Scotland.

ENCAMS (2005) Beach and surrounding area user segmentation. Available from: http://www.keepbritaintidy.org/ImgLibrary/beach_segmentation_2005_637.pdf [accessed July 2010.]

ENCAMS (2007) Sewage Related Litter: Flushing Toilets onto Beaches. Available from: http://www.keepbritaintidy.org/ImgLibrary/sewagelitter_report_651.pdf [accessed July 2010.]

Fanshawe, T. and Everard, M. (2002) The Impacts of Marine Litter: Report of the Marine Litter Task Team (MaLiTT). Available from: http://www.marlab.ac.uk/Uploads/Documents/Impacts%20of%20Marine%20Litter.pdf [accessed July 2010.]

Fisheries Research Service (2008a) Scottish Fish Farms Annual Production Survey 2007. Available from: http://www.frs-scotland.gov.uk/FRS.Web/Uploads/Documents/surveytext2007final.pdf [accessed July 2010.]

Fisheries Research Service (2008b) Scottish Shellfish Farm Production Survey 2007. Available from: http://www.frs-scotland.gov.uk/FRS.Web/Uploads/Documents/shell%202007v7.pdf [accessed July 2010.]

Galgani, F., Leaute, J.P., Moguedet, P., Souplet, A., Verin, Y., Carpentier, A., Goraguer, H., Latrouite, D., Andral, B., Cadiou, Y., Mahe, J.C., Poulard, J.C. and Nerisson, P. (2000) Litter on the Sea Floor Along European Coasts. *Marine Pollution Bulletin* 40(6): 516-527.

GESAMP (Group of Experts on the Scientific Aspects of Marine Pollution) (1991) *The State of the Marine Environment*. London: Blackwell Scientific Publications.

Gregory, M.R. (2009) Environmental implications of plastic debris in marine settings – entanglement, ingestion, smothering, hanger's on, hitch-hiking and alien invasions. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2013-2025.

Hall, K. (2000) Impacts of Marine Debris and Oil: Economic and Social Costs to Coastal Communities. Available from: http://www.kimointernational.org/Portals/0/Files/Karensreport.pdf [accessed July 2010.]

Holt, R. (2009) The carpet sea squirt Didemnum vexillum: Eradication from Holyhead Marina. Presentation to the Scottish Natural Heritage Conference 'Marine non-native species: responding to the threat', 27 Oct 2009. Battleby, Scotland.

Horsman, P.V. (1982) The Amount of Garbage Pollution from Merchant Ships. *Marine Pollution Bulletin* 13(5): 167-169.

Hyrenbach, D. and Kennish, J. (2008) Question 6: How Does Marine Debris Affect Wildlife and the Environment? In: Williams, M., and E. Ammann (eds.) *Marine debris in Alaska: Coordinating our efforts*. Alaska: Alaska Sea Grant College Program pp 109-120.

ICC (2009) A Rising Tide of Ocean Debris. Available from: http://www.oceanconservancy.org/pdf/A_Rising_Tide_full_hires.pdf [accessed July 2010.]

ICC (2010) Trash Travels: From Our Hands to the Sea, Around the Globe, and Through Time. Available from: http://www.oceanconservancy.org/images/2010ICCReportRelease_pressPhotos/2010_ICC_Report.pdf [accessed July 2010.]

IMO (2002) Prevention of Pollution by Garbage from Ships. Available from: http://www.imo.org/Environment/mainframe.asp?topic_id=297 [accessed July 2010.]

IMO (2009) International Shipping and World Trade: Facts and Figures. Available from: http://www.imo.org/includes/blastDataOnly.asp/data_id%3D28127/InternationalShippingandWorldTrade-factsandfiguresoct2009rev1__tmp65768b41.pdf [accessed July 2010.]

IMO (2010) Summary of Status of Conventions. Available from: http://www.imo.org/Conventions/mainframe.asp?topic_id=247 [accessed July 2010.]

Keep Britain Tidy (2010) Blue Flag. Available from: http://www.keepbritaintidy.org/Programmes/Beaches/BlueFlag/Default.aspx [accessed July 2010.]

Laist, D.W. (1997) Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: Coe, J.M. and D.B. Rogers (eds.) *Marine Debris: Sources, Impacts, Solutions*. New York: Springer Verlag, pp 99-140.

Laist, D.W. and Liffmann, M. (2000) Impacts of Debris: Research and Management Needs. Issue Papers of the International Marine Debris Conference, Aug 6-11, 2000. Honolulu, Hawaii.

Macfadyen, G., Huntington, T. and Cappell, R. (2009) Abandoned, lost or otherwise discarded fishing gear. UNEP Regional Seas Reports and Studies No. 185; FAO Fisheries and Aquaculture Technical Paper No. 523. Rome: UNEP/FAO.

Moore, C.J. (2008) Synthetic polymers in the marine environment: a rapidly increasing, long-term threat. *Environmental Research* 108: 131-139.

Naturvårdsverket (2009) What's in the Sea for Me? Ecosystem Services Provided by the Baltic Sea and Skaggerak. Report 5872. Available from: http://www.naturvardsverket.se/Documents/publikationer/978-91-620-5872-2.pdf [accessed July 2010.]

Ocean Conservancy (2008a) North Atlantic Right Whale: The Right Time to Take Action. Available from: http://www.oceanconservancy.org/site/DocServer/North_Atlantic_RW_final1.pdf?docID=4541 [accessed July 2010.]

Ocean Conservancy (2008b) Summary of North Atlantic Right Whale Incidents 1999-2008. Available from: http://www.oceanconservancy.org/site/DocServer/SummaryRWDeaths20042006_WhaleDolphinSociety.pdf?docID=2121 [accessed July 2010].

Ordnance Survey (2010) An introduction to Ordnance Survey. Available from: http://www.ordnancesurvey.co.uk/oswebsite/media/features/introos/ [accessed July 2010.]

OSPAR (1995) Summary Record of the Oslo and Paris Conventions for the Prevention of Marine Pollution Working Group on Impacts on the Marine Environment (IMPACT) Group, IMPACT 95/14/1-E.

OSPAR (2009) Marine litter in the North-East Atlantic Region: Assessment and priorities for response. London: United Kingdom.

Podsada, J. (2001) Lost Sea Cargo: Beach Bounty or Junk? Available from: http://news.nationalgeographic.co.uk/news/2001/06/0619_seacargo.html [accessed July 2010.]

Pugh, D. and Skinner, L. (2002) A new analysis of marine-related activities in the UK economy with supporting science and technology. IACMST Information Document No. 10.

RNLI (2010) Money matters. Available from: http://www.rnli.org.uk/what_we_do/money_matters [accessed July 2010.]

Scottish Government (2009a) Scottish Sea Fisheries: Statistics 2008. Available from: http://www.scotland.gov.uk/Resource/Doc/284286/0086304.pdf [accessed July 2010.]

Scottish Government (2009b) The Scottish Government's Response to the European Commission's Green Paper on Reform of the Common Fisheries Policy. Available from: http://www.scotland.gov.uk/Resource/Doc/297585/0092572.pdf [accessed July 2010.]

Scottish Government (2009c) A Fresh Start: The renewed Strategic Framework for Scottish Aquaculture. Available from: http://www.scotland.gov.uk/Resource/Doc/272866/0081461.pdf [accessed July 2010].

Sheavly, S.B. (2005) Marine Debris – an Overview of a Critical Issue for Our Oceans. Presentation at Sixth Meeting of the UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea. Available from: http://www.un.org/Depts/los/consultative_process/documents/6_sheavly.pdf [accessed July 2010.]

Sheavly, S.B. (2007) National Marine Debris Monitoring Program: Executive Summary. Prepared for U.S. Environmental Protection Agency by Ocean Conservancy, Grant Number X83053401-02. Available from: http://www.oceanconservancy.org/site/DocServer/NMDMP_ExecSummary.pdf?docID=3221 [accessed July 2010.]

Sheavly, S.B. and Register, K.M. (2007) Marine Debris and Plastics: Environmental Concerns, Sources, Impacts and Solutions. *Journal of Polymers and the Environment* 15: 301-305.

Ten Brink, P., Lutchman, I., Bassi, S., Speck, S., Sheavly, S., Register, K. and Woolaway, C. (2009) Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter. Institute for European Environmental Policy (IEEP), Brussels, Belgium, and Sheavly Consultants, Virginia Beach, Virginia, USA.

Teuten, E.L., Saquing, J.M., Knappe, D.R.U., Barlaz, M.A., Jonsson, S., Björn, A., Rowland, S.J., Thompson, R.C., Galloway, T.S., Yamashita, R., Ochi, D., Watanuki, Y., Moore, C., Viet, P.H., Tana, T.S., Prudente, M., Boonyatumanond, R., Zakaria, M.P., Akkhavong, K., Ogata, Y., Hirai, H., Iwasa, S., Mizukawa, K., Hagino, Y., Imamura, A., Saha, M. and Takada, H. (2009) Transport and release of chemicals from plastics to the environment and to wildlife. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2027-2045.

The Herald (2009) Terror as diver is trapped in net. Available from: http://www.thisisplymouth.co.uk/news/TERROR-DIVER-ENTANGLED-NET/article-602003-detail/article.html [accessed July 2010.]

Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle, D. and Russell, A.E. (2004) Lost at Sea: Where is all the Plastic? *Science* 304: 838.

Thompson, R.C., Swan, S.H., Moore, C.J. and vom Saal, F.S. (2009a) Our Plastic Age. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 1969-2166.

Thompson, R.C., Moore, C.J., vom Saal, F.S., and Swan, S.H. (2009b) Plastics, the environment and human health: current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2153-2166.

Tourism Alliance (2007) Facts and Figures. Available from: http://www.tourismalliance.com/TA_Bchr_2008.pdf [accessed July 2010.]

UNEP (2005) Marine Litter: An Analytical Overview. Available from: http://www.unep.org/regionalseas/marinelitter/publications/docs/anl_oview.pdf [accessed July 2010.]

UNEP (2006) Ecosystems and biodiversity in deep waters and high seas. UNEP Regional Seas Reports and Studies No. 178. Switzerland: UNEP/IUCN.

UNEP (2009) Marine Litter: A Global Challenge. Nairobi: UNEP.

Van Franeker, J.A., Heubeck, M., Fairclough, K., Turner, D.M., Grantham, M., Stienen, E.W.M., Guse, N., Pedersen, J., Olsen, K.O., Andersson, P.J. and Olsen, B. (2005) Save the North Sea Fulmar Study 2002-2004: a regional pilot project for the Fulmar-Litter EcoQO in the OSPAR area. Wageningen, Alterra, Alterra-rapport 1162.

Visit Wales (2008) Coastal Tourism Strategy. Available from: http://wales.gov.uk/docs/drah/publications/Tourism/090612coastaleng.pdf [accessed July 2010.]

Welsh Enterprise Institute (2006) Taking Forward Valuing Our Environment: A Study That Applies the VoE Framework to the Marine and Coast Environment of Wales. Available from: http://www.nationaltrust.org.uk/main/w-wales-valuing_our_environment-full_report.pdf [accessed July 2010.]

Williams, A.T., Gregory, M. and Tudor, D.T. (2005) Marine Debris – onshore, offshore, seafloor litter. In: M.L. Schwartz (ed.) *Encyclopedia of Coastal Science*. The Netherlands: Springer, pp 623-628.