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Marine Litter

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3.8 Marine Litter

3.8.1 Introduction

Litter, which is omnipresent in the marine environment, is a constant threat to wildlife, a hindrance to human activities, incurs immense economic costs world-wide, is unsightly and reduces the recreational value of our coasts. Plastic, the main component of marine litter world-wide, is slow to decompose and breaks down into even smaller pieces, so-called micro plastics, the environmental impact of which is largely unknown. Sources of marine litter are varied and can be sea or land-based. Land-based sources include sewage outlets, recreational activities on the coast, illegal fly-tipping and river outlets. Sea based sources of marine litter are shipping, and fisheries including aquaculture, offshore installations and recreational sailing. In the southern North Sea, investigations have shown that shipping, including fisheries, is the main source of marine litter pollution. Numerous studies have documented the scale of marine litter pollution in the Wadden Sea region since the early 1980s (Clemens, 1992; Clemens *et al.*, 2002; Fleet, 2003, Gerlach, 1994 and 1999; Hartwig, 1994, 2000, 2001a and 2001b; Hartwig and Clemens, 1999; Nassauer, 1981; Niedernostheide and Hartwig, 1998; Schrey, 1987, van Franeker 2005). Attempts to reduce the input of litter into the marine environment have been shown to be insufficiently effective. This has led to an increase in interest in the marine litter pollution problem in recent years. Two projects were initiated at the beginning of the century within the OSPAR Convention.

First, the OSPAR Pilot Project on Marine Litter Beach Monitoring began in 2000 in response to the conclusions made on marine litter pollution in the OSPAR Quality Status Report 2000 (QSR, 2000). The QSR concluded that litter pollution of the North and Baltic Seas had not improved since their designation as Special Areas according to MARPOL Annex V. The QSR concluded further that litter pollution should be assessed on reference beaches using improved and more standardized methodologies to assess the scale, impact and trends in quantities of marine litter throughout the OSPAR area. Since 2000 surveys of beached litter have been carried out using standardized methodology at over 50 sites on the Northeast Atlantic coast as part of the OSPAR Marine Litter Beach Monitoring Program (OSPAR Commission, 2007). This chapter includes regional data from this program.

Secondly, in 2002 the results of a pilot study, commissioned by the Dutch government, on marine litter monitoring using Northern fulmars *Fulmarus glacialis* were published (van Franeker and Meijboom, 2002). The amount of litter in the stomachs of fulmars beached in the Netherlands between 1982 and 2000 was the basis of the pilot study. The pilot project was further developed (van Franeker *et al.* 2005; van Franeker and SNS Fulmar Study Group 2008) and now forms the basis of the OSPAR EcoQO "Plastic in Fulmar Stomachs" for the North Sea region (OSPAR-BDC 2008). The most recent published results from this program are presented below.

Further evidence for the environmental impact of litter is taken from the analysis of data from marine mammals and birds beached in the Wadden Sea region. To complete the picture results of marine litter programs, investigations and activities of other organizations within the Wadden Sea are presented.

3.8.2 Ecological and socio-economical importance

Marine litter causes severe ecological damage to marine life. Marine animals suffer from entanglement, suffocation, and starvation due to marine litter ingestion. The United Nations Environment Program estimated in 2004 that plastic waste kills up to 1 million seabirds, 100,000 sea mammals and countless fish each year (UNEP, 2004).

A study of socio-economic impacts of marine litter in coastal communities around the North Sea (Hall 2000) illustrated that a wide-range of impacts lead to immense costs for local communities.

Problems associated with marine litter include:

- Effects on human health and safety,
- Cleaning operations and waste disposal on beaches, in harbors and at sea,
- Effects on tourism and recreation *e.g.* on local business or publicity through annoyance of public,
- Effects on shipping *e.g.* fouled rudders, anchors and propellers, damaged hulls and engines, waste management in harbours,
- Effects on fisheries and aquaculture *e.g.* reduced catch, damaged nets, contamination of catch, contaminated cages, loss of stock,
- Effects on agriculture adjacent to the coast *e.g.* harm to livestock through ingestion and contamination of stock fences.

The main cost to local authorities throughout the study area was for beach cleaning running into many millions of Euro annually.

The impact of marine litter on the health and productivity of marine environment through direct mortality and sub-lethal effects on animal populations is difficult to quantify. The fulmar project has shown, however, that, at least in some marine species, litter can be a serious problem. Numerous records of stranded animals on the Wadden Sea coast document that marine mammals and birds ingest and become entangled in litter items regularly. The fact that 80% of foamed types of floating plastic debris freshly washed ashore on the Dutch island of Texel showed peck marks made by birds, indicates that birds mistake debris for food items or routinely test floating objects to see if they are edible (Cadée, 2002). Marine litter has been documented widely as a mode of transport for invasive species and floating and drifting litter items have increased dramatically the variability and variety of rafting materials that can be used for 'hitch-hiking' by invasive species in recent years (Aliani and Molcard, 2003).

Microscopic plastic fragments and fibres (microplastics) are now widespread in the marine environment and accumulate in the pelagic zone and sedimentary habitats. The fragments appear to have resulted from degradation of larger items. Amphipods (detritivores), lugworms (deposit feeders), and barnacles (filter feeders) have all been shown to ingest plastics within a few days (Thompson *et al.*, 2004). Small plastic particles absorb chemical substances that can be transferred to the organisms that ingest them (Teuten *et al.* 2007). The present and future environmental consequences of microplastics are unknown.

3.8.3 Policy

A series of conventions and regulations at local, national, regional and international levels have been implemented to combat marine litter pollution since the early 1970s. A comprehensive list of these measures is included in OSPAR (2009). Two of these regulations are under review at the time of writing:

Annex V of the International Convention for the Prevention of Pollution from Ships 1973 (MARPOL 73/78).

This annex, which regulates garbage from shipping world-wide, has prohibited the discharge of plastics from shipping into the marine environment since 1988. In addition the North Sea and adjacent areas were designated as Special Areas with regard to MARPOL Annex V in 1991. In accordance with the regulations for Special Areas, all discharges of garbage (except food waste) into the sea are prohibited. The Convention also comprises an obligation for countries surrounding Special Areas to provide appropriate reception facilities for ship-generated waste in their ports and harbors.

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

The Port Waste Reception Facilities Regulations, which entered into force in 2003, aim to reduce the illicit discharge of ship generated waste and other pollutants to a minimum, in order to protect the marine environment. Ports must set up waste handling plans and make available adequate reception facilities. Every ship is required to deliver all ship-generated waste and cargo residues to ports. All ships are to pay a set fee for waste disposal, irrespective of their actual use of the facilities. Ships that do not deliver waste in one port will be reported to their next port of call for a more detailed inspection. Member states must ensure proper monitoring of compliance with the directive, by means of spot checks and the exchange of information between ports. The European Maritime Safety Agency (EMSA) has been assigned by the European Commission to evaluate the functioning of the Port Reception Facilities in the different member states and to report on this in early 2009.

The need for a measure of effectiveness of these regulations led to the implementation of the two above mentioned OSPAR-Programs.

3.8.4 Available data

The beaches covered in the Beach Litter Monitoring program are exposed to the North Sea and Fulmars occur offshore of the Wadden Sea islands. Both OSPAR programs thus measure the amount of litter in North Sea waters adjacent to the Wadden Sea. However, as the main source of litter in the Wadden Sea is the North Sea, both programs actually measure the input of litter into the Wadden Sea region. Both programs mainly monitor litter items that float. Litter items that are not buoyant are underrepresented in the results. The results of some surveys of litter on the mainland coast and on islands within the Wadden Sea have been published for the period 1991-2002 (Fleet, 2003).

Five sites of the OSPAR Beached Litter Monitoring Program lie within the Wadden Sea region one – Terschelling - in the Netherlands and four - Juist, Minsener Oog, Scharhörn and Sylt - in Germany. All five sites have been monitored since 2002. Litter is assessed four times a year in spring (April), summer (mid June - mid July), autumn (mid

Sept. - mid Oct.) and, if possible, winter (mid Dec. - mid Jan.). All litter items on 100 m of beach are assessed and assigned to 107 different litter types, which are in turn assigned to eleven different categories. Litter items are removed during the survey so that litter accumulation and not the standing crop of litter is assessed.

The Fulmar Litter EcoQO Monitoring program includes birds collected on Dutch beaches from the early 1980s onward (van Franeker, 1985). For the 1980s a total of 69 fulmars beached in the Netherlands have been analyzed, the Dutch sample size for the 1990s is 223 and for the 2000s (until 2006) 396. In the period 2002-2006, a total of 268 birds from German North Sea beaches have been analyzed (van Franeker and the SNS Fulmar Study Group, 2008).

In April 2005, beached litter on the island of Texel was investigated during the "Schoon Strand" action day (van Franeker, 2005). The standing crop of litter - all litter found - on the Texel beach was collected, identified, counted, weighed and disposed of. The results, which provide a startling snapshot of the marine litter problem, are presented below. An investigation six weeks later on the same beach provides further information on the rate of accumulation of litter.

Deaths caused by litter entanglement are recorded regularly in Beached Bird Surveys on Dutch and German coasts. First overviews of entangled birds and mammals found during beached bird surveys in the period 1983-90 in the German Wadden Sea region were published by Hartwig *et al.* (1985 and 1992). A more recent analysis for the Dutch coast is in press (Camphuysen, 2008). The unpublished results of the analysis of recent beached bird data from the German Wadden Sea coast are included. Beached marine mammals in Germany are routinely examined for the occurrence of litter entanglement and ingested litter. The results of the analysis of these investigations are presented below.

Coastwatch Europe started in 1987 in Ireland and became an international network in 23 European countries of environmental groups, universities and other educational establishments, who in turn work with local groups and individuals around the coast of Europe. Common aims of Coastwatch have been the protection and sustainable use of our coastal resources, and informed public participation in environmental planning and management, including Coastal Zone Management. Annual marine litter surveys on beaches, following a set method, have been an important part of the Coastwatch work. In the Netherlands, several beaches in the Wadden Sea have been cleaned with the help of volunteers and school children. The amounts and composition of the waste collected on the beaches was assessed.

3.8.5 Levels of litter pollution

OSPAR Beached Litter Monitoring Programme

The amount of litter found on the tideline varies greatly between beaches depending on the orientation of the coast to prevailing water currents and wind. Weather conditions in the period between surveys influence the number of litter items reaching the shore and cause variation between surveys in the number of items recorded on the same beach. The number of items found per survey of a 100 m stretch of beach on four beaches in the Wadden Sea region in the period 2002-2008 ranged from 10 to 1,117 with on average 236 items of litter found per survey (no. of surveys 111). The average number per survey varied from 89 on Juist to 482 on Terschelling.

Fulmar Litter EcoQO Monitoring

On average in the southern North Sea in the period 2002-2006, 94% of all fulmars had at least one piece of litter in their stomach. The average number of items per stomach was 32.4 with an average weight of 0.30 g. In terms of the OSPAR Ecological Quality objective, on average for the same period 57% of all beached fulmars had more than 0.1 g of litter in their stomachs, which is nearly six times the value required by the EcoQO (van Franeker and the SNS Fulmar Study Group, 2008).

Schoon Strand Texel April and May 2005

During the investigation on average 739 items and 909 kg of litter were collected per km of beach. The accumulation rate of litter on the beach on Texel NL in April and May 2005 was in the order of 7-9 kg per km per day, about half of which was wood and the remainder mainly plastic (van Franeker, 2005 and unpublished data).

Beached Bird Surveys

Fifteen species of Sea- and Waterbird were recorded as victims of entanglement with litter on the German North Sea coast in the 1980s. The most common victim was the Gannet, with 20% of all corpses of this species found to be entangled (Hartwig *et al.*, 1985 and 1992). Of the 215,347 more or less complete corpses of birds found on the Dutch coast since 1970, 513 were

Table 1: The twelve species most frequently recorded as entangled in debris or fishing gear and the percentage of the total number of individuals found washed ashore in the Netherlands in the period 1979–2007. NZG/NSO database (Camphuysen, 2008).

Species	Entangled	%	Total number
Northern gannet *Morus bassanus*	126	6.5	1,946
Herring gull *Larus argentatus*	123	0.6	19,494
Common eider *Somateria mollissima*	59	0.2	37,784
Common guillemot *Uria aalge*	43	0.1	43,071
Great black-backed gull *Larus marinus*	34	1.1	2,986
Eurasian oystercatcher *Haematopus ostralegus*	17	0.1	17,859
Common coot *Podiceps cristatus*	15	0.3	4,712
Black-legged kittiwake *Rissa tridactyla*	15	0.1	11,572
Northern fulmar *Fulmarus glacialis*	13	0.2	6,441
Black-headed gull *Larus ridibundus*	10	0.2	5,654
Red-throated diver *Gavia stellata*	9	0.9	1,011
Great cormorant *Phalacrocorax carbo*	9	1.1	820

entangled in litter or fishing gear. Half these birds were Northern gannets and herring gulls. Ranked after the proportion of entangled individuals in the total number of birds found, four coastal species (great black-backed gull, red-throated diver, great cormorant, and herring gull) and one pelagic seabird (northern gannet) were the top five species affected by entanglement (Tab. 3.1) (Camphuysen, 2008). The values for sea- and waterbirds beached on the German North Sea coast in the period 1992-2007 and included in the German North Sea beached bird database are 0,26 ±0,11% (n entangled= 230; n total= 87,074). The species lists are not identical. However, as in the Netherlands, the gannet remains the species most frequently found entangled on German North Sea coasts and 12.3% of all gannets recorded there are entangled.

Marine litter is almost certainly responsible for a higher proportion of overall bird deaths as the number of deaths caused by ingestion is largely unknown.

Table 3: The proportion of items found in eleven litter categories during OSPAR Beach Litter Monitoring on beaches in the Wadden Sea region in the period 2002–2008.

Type of material / category	Proportion of total number of litter items found %
Plastic/polystyrene	75.3
Wood	8.3
Glass	5.4
Paper/cardboard	3.2
Rubber	3.0
Metal	2.4
Cloth/textile	1.4
Sanitary	0.6
Ceramic/pottery	0.2
Medical	0.1
Faeces	0.1

Beached mammals

In the period 1998-2006, the stomach contents of 47 harbour porpoises (*Phocoena phocoena*) found on the German North Sea coast were investigated in detail by the "Forschungs- und Technologie Zentrum" in Büsum (FTZ). Nylon thread and plastic material were found in the stomachs of two of these individuals. Of the 24 stomachs of harbour seals (*Phoca vitulina*) stranded on the German North Sea coast in the period 1997-2007 and analyzed by the FTZ, one was found to contain plastic material. Furthermore the FTZ investigated 1,596 seals stranded on the German North Sea coast in the period 1997-2008. Two of these individuals were entangled in fishing nets and the head of one individual was caught in a plastic ring. All three entanglements caused impairment to the health of the animals involved (U. Siebert and A. Gilles, pers. comm.).

Other Data

Denkinger *et al.* (1990) investigated the occurrence of plastic pellets in the jetsam washed ashore on the Schleswig-Holstein mainland coast in the period September 1987- April 1989. Plastic pellets were found to be ubiquitous on the west coast of Schleswig-Holstein. An extrapolation of the results gave an estimate of several tons of pellets washed ashore each year.

3.8.6 Composition of litter

OSPAR Beached Litter Monitoring Program

Three quarters of the litter items found on beaches in the Wadden Sea region in the period 2002-2008 were plastic. The proportion for the other litter categories was in each case less than 10% of the total number of items (Table 2). The most common items found on the beaches were rope, cords and nets which accounted for 30% of the total number of litter items. Various forms of packaging

Industrial plastic pellets: Small, often cylindrically-shaped, granules of about 4 mm in diameter that are the raw material for producers of plastic products.
User plastics: all non-industrial remains of plastic objects differentiated in the following subcategories:
• Sheet like user plastics *e.g.* pieces of plastic bags, foils etc.
• Thread like user plastics *e.g.* remains of ropes, nets, nylon line, packaging straps etc. Sometimes 'balls' of threads and fibres form in the gizzard;
• Foamed user plastics *e.g.* foamed polystyrene *e.g.* from cups or packaging or foamed polyurethane from *e.g.* mattresses or construction foams;
• Plastic fragments of more or less hard plastic items that are used in a huge number of applications *e.g.* bottles, boxes, toys, tools, equipment housing, toothbrushes, lighters etc;
• Other plastic-like items or items that do not fit into a clear category *e.g.* cigarette filters, rubber, elastics etc.
Rubbish other than plastic: *e.g.* paper, galley food remains, various other types of rubbish *e.g.* pieces of timber (manufactured wood); paint chips, pieces of metals etc. fish hooks
Pollutants: *e.g.* pieces of slag, tar balls and chemical lumps of paraffin-like materials or sticky substances arbitrarily judged to be unnatural and of chemical origin and feather conglomerations suggesting the preening of such substances out of the plumage.

Table 3:
Categorization of objects found in fulmar stomachs.

accounted for 28% of the total number of items and plastic and polystyrene pieces of unidentifiable origin for a further 16% of the total.

Fulmar Litter EcoQO Monitoring

The objects found in fulmar stomachs are assigned to three broad categories – plastics, non-plastics and pollutants *e.g.* paraffin and tar balls. The plastic category is divided into industrial plastics (plastic pellets) and user plastics, which is further divided into five sub-categories (Table 3).

The majority of the litter items found in fulmar stomachs in the Netherlands in the period 2002-2006 were user plastics (on average 28 items weighing 0.24 g). In comparison on average only three items of industrial plastics weighing 0.06 g and only two items of pollutants weighing 0.59 g were found in the stomachs. The average amount of the category "other rubbish" is less than one item. Composition of plastic litter in fulmar stomachs found on Dutch coasts has changed in the period 1980-2006. Although about 50% of total plastic litter mass found in the stomachs in the 1980s was industrial plastic, it accounts for only 20% of the total today.

Schoon Strand Texel April and May 2005

The composition of the litter collected in April 2005 was analysed in detail. By number 56% of the litter was plastic, 14% rope and nets (also nearly all plastic), and 16% wood. By weight 54% wood, 25% rope and nets and 19% other plastic materials. An especially interesting result of the Texel investigation was that left-hand shoes and gloves were more common on the southern part of the beach and right-hand shoes and gloves were more common on the northern part of the island in the middle of the island their distribution was more or less equal.

Beached Bird Surveys and beached mammals

Nylon fishing lines, pieces of fishing nets and all other kinds of ropes and lines, often from fisheries activities, were the main cause of entanglement in birds beached on Dutch coasts (Camphuysen 1990, 1994, 2001, 2008). The most common litter items recorded in the German beached bird database as involved in entanglement of birds were line/rope entanglements (48% of all litter victims), net entanglements (39%) and fishing hooks (7%) (OSPAR, 2009).

3.8.7 Sources

Identifying sources of marine litter is difficult as many types of items can come from multiple sources. The large diversity of items found on German North Sea coasts and the composition of the litter recorded during the OSPAR-Project, as well as during the German surveys over the period 1991-2002, indicate that shipping, the fisheries industry and offshore installations are the main sources of litter found on German and Dutch beaches. The relative proportions of litter originating from these different sources cannot be determined exactly. The larger proportion of litter recorded on German North Sea beaches certainly originates from shipping with a considerable proportion of this originating in the fisheries industry (Fleet, 2003). This has not changed since the 1980s when Vauk and Schrey (1987) stated that major sources of litter in the North Sea were commercial shipping and fisheries. According to van Franeker and Meijboom (2002) these are supplemented by coastal recreational activities, the offshore industry - although the latter is thought to be a minor source because of strict waste management practices - and litter entering the North Sea by wind, currents, or river-transport

from land based sources. Litter also enters the southern North Sea from the English Channel, as records of litter identified as originating on the French Atlantic coast have shown (Fleet, 2003). From the study on Texel in 2005 it was concluded that various indicators show that around 90% of the litter originated from shipping and fisheries (Van Franeker, 2005).

The results of the regional analysis of the OSPAR Beach Litter data (see above) indicate that one of the main sources of pollution is the fisheries industry in the form of lost or discarded nets. The data from the Dutch and German beached bird surveys show also that litter from fisheries activities is the main cause of entanglements providing a direct connection between litter discard and environmental infringement.

Various forms of packaging also account for a large proportion of the litter recorded on the OSPAR beaches. So-called professional items (nets, rope, oil cans, strapping bands etc.) accounted for 39% of the identifiable litter on these beaches and consumer items (bottles, food cans plastic bags etc.) for a further 26%.

During the "Schoon Strand" survey on Texel the origin of 119 litter items was identified by registering the language used on labels. The majority of the labels were Dutch (42%) and large proportions were English, German and French (Figure 3.1). As ships can buy supplies in foreign harbors this does not necessarily indicate the state of origin of the people disposing of litter.

3.10.8 Trends in litter pollution

OSPAR Beached Litter Monitoring Program

The amount of litter beached on the coast varies immensely between locations depending on prevailing winds and water currents and local sources of litter. Comparisons of the amount of litter reaching the shore over time are only realistic for set stretches of coast as in the OSPAR Beached Litter Monitoring Program (2002-2008) and the surveys carried out on the German Wadden Sea coast for period 1991-2002.

The OSPAR Beach Litter Program was not able to detect any general trends in the amount of litter recorded on beaches in the NE Atlantic in the period 2001-2006. A non-significant increase in the amount of litter was recorded for beaches in the southern North Sea and a significant increase in fisheries litter was recorded for the NE Atlantic (OSPAR Commission, 2007). The analysis of beached litter surveys from the German Wadden Sea coast for the period 1991-2002 was also not able to detect any general trends in the number or weight of beached litter. The amount of plastic, polystyrene and foam rubber as well as the amount of fisheries items recorded on the survey sites did not generally alter in the study period. Glass bottles and jars, milk cartons and machined wooden items, however, generally decreased (Fleet, 2003).

Initial analysis of the OSPAR Beach Litter Monitoring data indicates that in general the amount

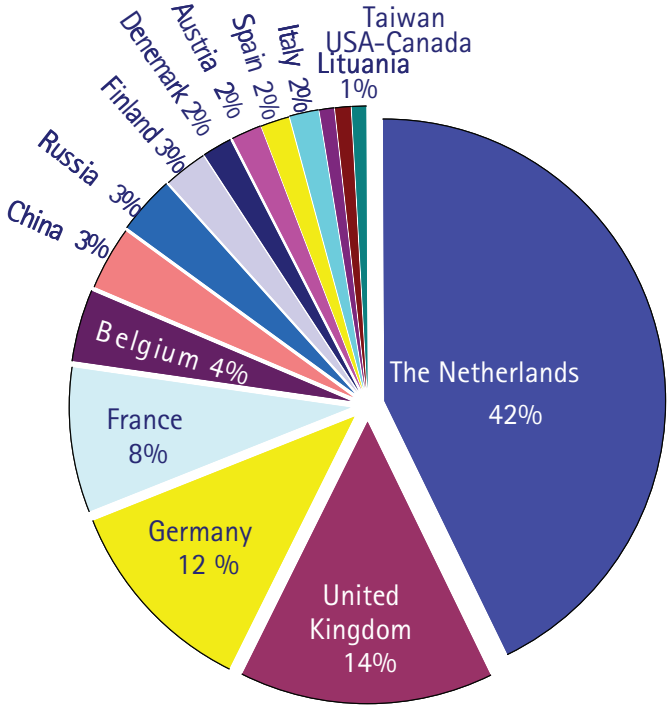

Figure 1: Proportions of countries of origin as derived from barcodes or label information on litter items found on Texel, April 2005 (translated from Van Franeker, 2005).

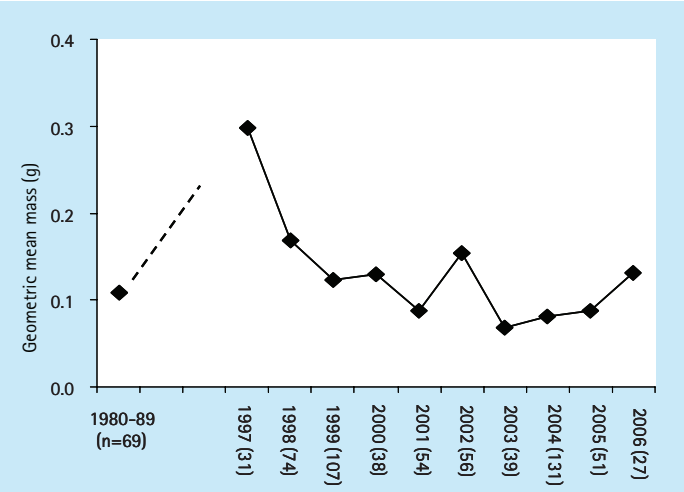

Figure 2: Plastic mass Netherlands 1982-2006 – Annual geometric means for the mass of plastic in the stomach of beached fulmars in the Netherlands (from: van Franeker and the SNS Fulmar Study Group, 2008).

of litter found on beaches in the OSPAR region has decreased in the period 2001-2008. However, the amount of litter found on southern North Sea beaches has increased in the same period. Increases in the southern North Sea were recorded for the source-categories shipping (operational waste and galley waste), fisheries and sanitary waste (TAUW 2009).

Fulmar Litter EcoQO Monitoring

Long-term trends of the overall mass of plastics in fulmar stomachs from the Netherlands for the period 1979-2006 demonstrate that litter pollution increased strongly from the 1980s to the 1990s but has subsequently decreased to approximately the level recorded at the beginning of the study period (Figure 3.2). However, different types of plastic show different trends. User plastics were largely responsible for the increase and following decrease in overall mass. The amount of industrial plastics has decreased constantly since the early 1980s and is now about half its original value. Similar observations have been done in the Pacific Ocean (Vlietstra and Parga, 2002) and South Atlantic (Ryan, 2008). Over the recent 10 year period 1997-2006 the significant strong decrease in total plastic is largely due to a reduction in user plastics. However, the decrease largely took place in the early part of the period, and appears not to continue in the most recent years. (van Franeker and the SNS Fulmar Study Group, 2008).

Beached Bird Surveys and beached mammals

In the period 1979-2003, the level of entanglements recorded in the 12 most frequently entangled species of beached birds on the Dutch coast was roughly stable at 0.31 ± 0.13% per annum (mean ± SD; 405 casualties out of a total of 142,030 birds). A higher level of entanglements (0.75 ± 0.10% per annum; 74 casualties out of 10,181 birds) was recorded during the period 2004-2007 (Figure 3.3) (Camphuysen, 2008).

The level for the German North Sea coast in the period 1992-2003 was 0.23±0,11% (n entangled=170; n total=69,508) and was 0,35±0,06% (n entangled=60; n total=17,566) in the period 2004-2007, also indicating an increase.

The recent increase in entanglements is both remarkable and unexplained and deserves future attention and further research (Camphuysen, 2008).

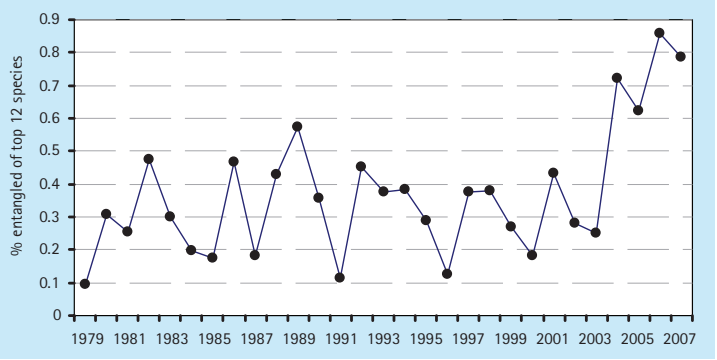

Figure 3: Percentage (%) of the top-twelve most frequently entangled species washed ashore in the Netherlands since 1979 that were recorded as entangled. Files NZG/NSO (beached bird survey program) 1979-2007.

3.8.9 Conclusion

Assuming that litter levels in the Wadden Sea region are close to those measured in the bordering parts of the North Sea, the pollution level is high, though not the highest in the North Atlantic region. The average geometric mean mass of litter in fulmar stomachs collected in the southeast North Sea is intermediate between those collected in the relatively cleaner Scottish Island waters and those from the English Channel (van Franeker and SNS Fulmar Study Group, 2008). Litter levels on OSPAR survey beaches in the southern North Sea region were significantly lower than on beaches in the northern North Sea and Celtic sea areas (OSPAR Commission, 2007).

Litter thus remains a serious ecological, environmental and economical problem in the region with plastic litter from packaging and debris from the fisheries industry the main problems. There are no indications that the amount of litter entering the marine environment has decreased in recent years, despite clear regulations targeted to reduce input. The discharge and accidental loss of fishing tackle appears to be an increasing problem for the Wadden Sea region reflected in greater numbers of fisheries related debris on beaches and higher mortality among seabirds. The fulmar data indicates that levels of industrial plastics (pellets) are decreasing, however, the amount of litter found in fulmar stomachs in the Wadden Sea region remains far higher than the targeted fulmar EcoQo level. Microplastics have not yet been investigated in the Wadden Sea region. Investigations, however, indicate that they are widespread in the marine environment and that they are certainly already present in the Wadden Sea ecosystem.

3.10.10 Recommendations

- The awareness of the issues and regulations relating to marine litter needs to be improved. In addition to raising general awareness, special efforts are recommended for the stakeholders in the shipping and the fishing industries as they are the two main sources of marine litter in the Wadden Sea region. In addition, the recreational boating sector in the Wadden Sea may need to be targeted,
- The main current monitoring systems, i.e. the OSPAR Beach Litter Survey for coastal litter and the OSPAR Fulmar Litter EcoQO for the ecological state of the marine environment should be strongly supported by Wadden Sea countries, where possible be intensified for the Wadden environment and be complemented by specially focused incidental investigations,
- The recent increase in the frequency of entanglement of birds in litter recorded during beached bird surveys should be investigated. The possibility of a relationship with the increase in fisheries litter recorded during the OSPAR beach litter needs to be discussed,
- There is no information on the occurrence of microplastics for the Wadden Sea region. An investigation of the incidence of microplastics in sediments and organisms in the Wadden Sea region should open research into this impending environmental threat.

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