

# OSPAR Pilot Project on Monitoring Marine Beach Litter

## Monitoring of marine litter in the OSPAR region



OSPAR Commission  
2007

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

*La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.*

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ISBN 978-1-905859-45-0

Publication Number: 306/2007

Cover photo: Finn Lornsen, one of the German beach surveyors, on the Sylt island reference beach. Photo courtesy of the German participants in the OSPAR pilot project.

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## Preface

Comprehensive surveys of marine litter on beaches have been made in many areas, often over a number of years, by various organisations and groups in the OSPAR region (North-East Atlantic). Valuable information about the quantity and composition of marine litter found on beaches has been available for decades. The challenges in dealing with this problem have not been due to lack of awareness of the issues surrounding marine litter or lack of data from various regions. Instead, the problem has been the lack of standardisation and compatibility between methods used and results obtained in these projects, and that has made it difficult to compare data from different regions and to make an overall assessment of the marine litter pollution situation for the entire OSPAR region.

The OSPAR Pilot Project on Monitoring Marine Beach Litter (2000–2006) has been the first region-wide attempt in Europe to develop a method for monitoring marine litter on beaches and to assess presence of marine litter on the beaches in the OSPAR region, using this standardised method.

A total of 614 regular beach surveys were conducted on altogether 51 reference beaches in eight countries during the pilot project period, 2001–2006. In addition, 10 surveys were made during 2006 on 4 beaches in France (not classified as regular reference beaches). The results presented in this report are mainly based on the statistical analyses of data from the 609 surveys made on regular reference beaches.

During the project period, close to 353,200 individual marine litter items, including close to 38,200 found on the French beaches, have been identified, counted, and registered in the pilot project database. Many people, some on a voluntary basis, have undertaken a great deal of work for many years to gather all this data. We want to thank each and everyone for all their hard work and support. The project has only been made possible by the dedicated efforts of all the people working on the beaches and with the overall operation of the project.

This final report is a summary of the results obtained during the project, and of the experience gained during this 6-year learning process. In the report one finds a presentation of the monitoring methodology, which has been developed within the pilot project, as well as an analysis of beach survey data gathered and assessments of marine litter quantities, composition, and trends in the OSPAR region. Furthermore, the report includes important lessons learned and considerations by the Steering Group regarding future marine litter monitoring.

More background material and additional information referred to in the report (see <>) can be found on the pilot project section of the Marine Litter Net web site\*, published on web pages and as separate PDF files.

March 2007

OSPAR Pilot Project on Monitoring Marine Beach Litter Steering Group

Britt Aniansson (*Sweden*), Gill Bell (*United Kingdom*), Fátima Brito (*Portugal*),  
Jeroen Dagevos (*The Netherlands*), Brian Elliott (*United Kingdom*), David M. Fleet (*Germany*),  
Arnaud Guéna (*France*), Bertil Hägerhäll (*Sweden*), Hans-Henrik Jørgensen (*Denmark*),  
Francis Kerckhof (*Belgium*), Fernando Lahuerta Mouriño (*Spain*), Rick Nickerson (*United Kingdom*),  
Per Nilsson (*Sweden*), Roland Olin (*Sweden*), Ike Span (*The Netherlands*),  
Sveiney Sverrisdóttir (*Faroe Islands*), Barbara Wenneker (*The Netherlands*)

\* <http://www.marine-litter.net/who-what/who-Europe/OSPAR-monitoring/OSPAR-Monitoring.htm>

## Executive Summary/Récapitulatif

### ABOUT THE PILOT PROJECT

#### LE PROJET PILOTE

- Although much valuable information on marine litter on beaches – quantities and composition – in the OSPAR region (North-East Atlantic) has been available for decades, there has been a lack of standardisation and compatibility between survey methods used and results obtained.

*Depuis de nombreuses années, beaucoup de données – en quantité et composition - sur la pollution du littoral par les macrodéchets dans la zone OSPAR (Atlantique Nord-Est) sont disponibles mais sans standardisation des méthodes de reconnaissance ni des résultats obtenus.*

- The six-year OSPAR Pilot Project on Monitoring Marine Beach Litter (2000–2006) has been the first region-wide attempt in Europe to develop a standard method for monitoring marine litter on beaches in Europe and, using this standardised method, to assess presence of marine litter on the beaches in the OSPAR region.

*Le projet pilote OSPAR "Marine Beach Litter" (Déchets des plages, ou macrodéchets) (2000-2006) a été le premier en Europe à développer une méthode standardisée de suivi de la pollution par macrodéchets sur les plages d'Europe, et à l'utiliser pour évaluer cette pollution dans la région OSPAR.*

- Nine countries – Belgium, Denmark, France, Germany, The Netherlands, Portugal, Spain, Sweden and the United Kingdom – have participated in the pilot project, which has been coordinated by an international Steering Group with representatives of the countries and OSPAR observer organisations.

*Neuf pays – Allemagne, Belgique, Danemark, Espagne, France, Pays-Bas, Portugal, Royaume-Uni, et Suède – ont participé à ce projet coordonné par un comité de pilotage constitué de représentants de chaque pays et d'organisations d'observateurs.*

- The statistical analysis has been based on data from 609 surveys on 100-metre stretches on 51 regular reference beaches during the pilot project period, 2001–2006, and on 335 surveys on 1-km stretches on 31 regular reference beaches during the same period.

*Les analyses statistiques ont été effectuées sur les données d'une période 2001-2006, issues de 609 échantillonnages effectués sur des transects de 100 m répartis sur 51 plages de référence, et sur 335 échantillonnages sur des transects de 1 km répartis sur 31 plages références.*

- In addition, 10 surveys were made during 2006 on 100-metre stretches, and four surveys on 1-km stretches, on four beaches in France (not classified as regular reference beaches). The results from these comparative surveys are presented separately.

*Des échantillonnages supplémentaires ont été effectués en 2006 sur 4 plages françaises (non classées plages références) : 10 sur des transects de 100 m et 4 sur des transects de 1 km. Les résultats de ces échantillonnages sont analysés séparément.*

### ABOUT THE STANDARDISED MONITORING METHOD DEVELOPED WITHIN THE PILOT PROJECT

#### LA MÉTHODE STANDARDISÉE DÉVELOPPÉE DANS LE CADRE DU PROJET

- A method for conducting surveys of marine litter on beaches, following a common, standardised survey protocol for either a 100-metre or a 1-km stretch of beach, has been developed, tested and used in fieldwork. The protocol for 100-metre surveys has included well over 100 different items of all sizes, whereas the protocol for 1-km surveys has included about 20 mainly large items (>50 cm in any direction).

*Un protocole commun et standardisé de comptage des déchets des plages sur les transects de 100 m et 1 km a été développé, testé et utilisé sur le terrain. Le protocole utilisé sur les secteurs de 100 m concerne tous les déchets, quelque soit leur taille, et permet de les classer en 100 catégories, tandis que celui appliqué sur 1 km ne concerne que les déchets dont l'une des dimensions est supérieure à 50 cm et permet de les classer en 20 catégories.*

- Five major sources – activities that generate solid waste that ends up as marine litter on beaches – in the OSPAR region were identified (alphabetical order) in the pilot project: Fishing, including aquaculture. Galley waste (non-operational waste from shipping, fisheries and offshore activities). Sanitary waste/Sewage-related waste. Shipping, including offshore activities (operational waste). Tourism and recreational activities.

*5 sources majeures générant des déchets solides finissant comme macrodéchets sur les plages ont été identifiées : pêche et aquaculture, ordures ménagères du bord (déchets non opérationnels de navigation, pêches et activités offshore), déchets sanitaires ou d'égouts, navigation et activités offshore (déchets opérationnels), tourisme et activités de loisirs.*

- The monitoring method developed within the pilot project has proved functional for the purpose of providing data on marine litter on beaches. It provides a feasible approach and could be used as a cost-effective means to monitor marine litter on beaches – quantities, composition and trends – in the OSPAR region, should the OSPAR Commission decide that such monitoring be included as a regular part of the OSPAR Joint Assessment Monitoring Programme (JAMP). Information provided through monitoring and identification of trends in the occurrence of marine litter on beaches can be used as a basis for marine management decisions and policy development. Therefore, the marine litter monitoring method developed in the pilot project could be used in the development of the JAMP.

*La méthode de suivi développée lors de ce projet pilote s'est révélée fonctionnelle, d'un rapport coût/efficacité permettant son utilisation pour suivre les déchets marins dans la zone OSPAR, en terme de quantités, composition et tendances d'évolution. La Commission OSPAR pourrait décider d'inclure un tel suivi dans son programme de suivi JAMP (Joint Assessment Monitoring Programme). Les informations fournies par un tel suivi et les tendances observées en terme d'occurrence des déchets sur les plages peuvent être à la base du développement de nouvelles décisions et règles de gestion du milieu marin. De plus, cette méthode de suivi des déchets marins pourrait concourir à développer le programme JAMP.*

#### **ASSESSMENTS OF MARINE LITTER ON BEACHES IN THE OSPAR REGION – QUANTITIES AND COMPOSITION EVALUATION DES DECHETS MARINS SUR LES PLAGES DE LA ZONE OSPAR – QUANTITÉS ET COMPOSITION**

##### Quantities of marine litter

##### *Quantités de déchets marins*

- The total number of marine litter items found per stretch of beach varied considerably among pilot project reference beaches and surveys. On average, 542 items of marine litter of varying size were found per 100-metre survey on the reference beaches throughout the OSPAR region.

*Le nombre total de déchets présents sur chaque transect de plage référence a considérablement varié au long du projet. En moyenne, 542 déchets, toute dimension confondue, ont été trouvés par transect de 100 m.*

- On the 1-km stretches on reference beaches, an average of 67 (larger) marine litter items were recorded.  
*Sur les transects de 1 km, une moyenne de 67 objets (> 50 cm) a été enregistrée.*
- The statistical analyses of the beach data indicate neither a significant increase nor a significant decrease in the average numbers of marine litter items found in the surveys made on the 100-metre stretches of the regular reference beaches over the OSPAR region as a whole during the pilot project period 2001–2006.

*Les analyses statistiques effectuées sur les résultats obtenus sur les transects de 100 m des plages références de toute la zone OSPAR ne permettent pas de mettre en évidence une variation significative (ni hausse, ni diminution) des quantités de déchets tout au long du projet (2001 – 2006).*

- On the 1-km stretches of reference beaches there was, however, a statistically significant decrease in the amount of marine litter found, although with large variations among countries.

*Cependant, sur les secteurs de 1 km, une diminution statistiquement significative des déchets a été mise en évidence, avec toutefois d'importantes disparités entre pays.*

- In addition, an average of over 3,800 marine litter items were found per 100 metres in the French beach surveys during 2006. The number is about seven times higher than the average number of items found on the regular reference beaches as a whole. However the French beaches located in shipping and fishing areas, studied in 2006 only, are well known for high concentrations of natural floating marine litter.

*Enfin, une moyenne de 3800 déchets par transects de 100 m a été trouvée sur les plages françaises lors des campagnes d'échantillonnages effectuées en 2006. Ce nombre est 7 fois supérieur à la moyenne des autres plages. Mais les plages françaises, localisées dans des zones de navigation et de pêche, étudiées uniquement en 2006, sont bien connues pour être des plages d'accumulation naturelle de déchets marins flottants.*

#### Most common items: Found in the highest numbers

##### Les déchets les plus communs (trouvés en plus grand nombre)

- Small plastic/polystyrene pieces (smaller than 50 cm) were the most common type of marine litter items – found in the highest numbers – on the regular reference beaches on the 100-metre stretches of beach. They accounted for approximately 28 per cent of the items found on these beaches.

*Les morceaux de plastique ou polystyrène de moins de 50 cm sont les déchets les plus présents en nombre sur les secteurs de 100 des plages référence, et constituent 28% des déchets comptés sur ces plages.*

- The second most common item on the regular reference beaches on the 100-metre stretches was small pieces of ropes, cords and nets (smaller than 50 cm), which accounted for approximately 14 per cent of all items found.

*La seconde catégorie de déchets présente sur ces mêmes secteurs de 100 m est celle des morceaux de cordages, fils et filets de moins de 50 cm. Cette catégorie représente 14% des déchets en nombre.*

- The most common item found on the 1-km stretches of regular reference beaches was other wooden items, which accounted for approximately 19 per cent of all items found in these surveys. Larger pieces of ropes, cords and nets (>50 cm) were the second most common item found on 1 km-stretches on regular reference beaches, accounting for approximately 18 per cent.

*Le déchet le plus fréquemment rencontré sur les secteurs de 1 km correspond aux pièces de bois (19 % en nombre), suivi de près par les morceaux de cordages, fils et filets de plus de 50 cm (18%).*

- In addition, small pieces of plastic rope, cord and net (smaller than 50 cm) were the most common type of marine litter on 100-metre stretches of beach in France. These items accounted for nearly 64 per cent of all items found. The second most common type of item on the French beaches was larger pieces of plastic rope, cord and net (larger than 50 cm), accounting for approximately 9 per cent of all items found.

*En France, les déchets les plus fréquents sur les transects de 100 m sont les morceaux de cordages, fils et filets de moins de 50 cm (64 % des déchets en nombre), suivis des mêmes morceaux de plus de 50 cm qui représentent quant à eux 9%.*

#### Most frequently occurring items: Found in the highest percentage of surveys

##### Les déchets les plus fréquents (trouvés dans la plus grand nombre de prélèvements)

- 14 of the 20 most frequently occurring marine litter items – found in the highest percentage on all 100-metre surveys on regular reference beaches – were made of plastic or polystyrene.

*14 des 20 catégories les plus fréquentes de déchets marins, trouvés dans le plus fort pourcentage, dans tous les prélèvements effectués sur 100 m, correspondent à des déchets fabriqués en plastique ou polystyrène.*

- Small pieces of plastic ropes, cords and nets (the ones smaller than 50 cm) were the most frequently occurring items, found in close to 90 per cent of the 100-metre surveys on the regular reference beaches.

*Les morceaux de cordages, fils et filets de moins de 50 cm constituent la catégorie de déchets la plus fréquente sur 90% des transects de 100 m étudiés.*

#### Composition: Types of marine litter found

##### Composition: Types de déchets marins trouvés

- Of all marine litter items found in all 100-metre surveys on the regular reference beaches, an average of 75 per cent were made of non-degradable plastic and/or polystyrene.  
*Parmi tous les déchets collectés sur les secteurs de 100 m des plages références, une moyenne de 75 % est fabriquée en plastique ou polystyrène non dégradable.*
- Plastic and polystyrene was the most common type of marine litter found also in the 1-km surveys on the reference beaches, accounting for almost 66 per cent of the total, on average.  
*Les plastiques et polystyrènes constituent également la plus grande part des déchets trouvés sur les secteurs de 1 km en constituant en moyenne 66 % de ces déchets.*
- The proportion of plastic/polystyrene marine litter items on 100-metre stretches on the regular reference beaches increased during the project period, from approximately 68 per cent in 2001 to approximately 78 per cent in 2006. This increase in proportion of plastic and polystyrene items is statistically significant.  
*La proportion de plastique et polystyrène dans les déchets marins prélevés sur les secteurs de 100 m des plages références a augmenté de manière statistiquement significative entre 2001 et 2006, passant de 68 à 78 %.*
- In addition, over 95 per cent off all marine litter items found in the 100-metre surveys on French beaches, were made of non-degradable plastic and/or polystyrene.  
*En France, sur les secteurs de 100 m étudiés, ce sont plus de 95% des déchets qui sont constitués de plastique et polystyrène non dégradable.*

#### Numbers of indicator items for five sources of marine litter

##### Nombre d'objets indicateurs pour cinq sources de déchets

- In the statistical analyses of the beach data, specific indicator marine litter items were used to pinpoint five possible sources (see above) of the marine litter found on beaches.
- *Dans l'analyse statistique des données des plages, des déchets ont été considérés comme indicateurs (ou marqueurs) spécifiques de l'une des cinq sources de déchets identifiés dans le projet (voir ci-dessus).*
- The number of indicator items for fishing, including aquaculture, found in the 100-metre surveys on the regular reference beaches increased during the project period (2001–2006). This increase is statistically significant on the reference beaches.  
*Le nombre des déchets indicateurs de l'activité pêche et aquaculture trouvés sur les secteurs de 100 m des plages références a augmenté de façon statistiquement significative entre 2001 et 2006.*
- However, for the other four sources of marine litter analysed during the project period, no statistically significant trends in numbers of indicator items could be demonstrated.  
*Pour les quatre autres sources identifiées, aucune tendance statistiquement significative n'a pu être démontrée.*
- In addition, the average number of indicator items found on French beaches in 2006, compared to the number of indicator items found on the regular reference beaches in the entire area in 2006 only, is significantly higher for two sources: fishing and shipping, respectively. The difference is particularly pronounced for indicator items for fishing, including aquaculture.  
*En France, le nombre moyen des déchets indicateurs trouvés sur les plages étudiées en 2006 est significativement supérieur au reste de la zone OSPAR pour les déchets provenant de la navigation et surtout de la pêche et de l'aquaculture.*
- It has proven difficult to create a direct relationship between indicator items from the five different sectors. It has not been practically or statistically possible to identify the full proportion of marine litter from each sector, as some marine litter items can originate from sources in more than one sector and the

sets of indicators cannot be directly compared. The use and development of a marine litter index, where the percentage change for various sources are monitored and combined into an index, was discussed, but there were insufficient resources in the pilot project to fully explore this concept. However, an indexing system could potentially be used to integrate marine litter monitoring into the OSPAR framework and JAMP, providing a mechanism for regular assessment of the problem based on the method developed in the pilot project. An index could then be integrated into an operational objective for marine litter.

*Il s'est révélé difficile d'établir des liens directs entre les indicateurs des cinq sources de déchets. Il n'a pas été possible d'identifier la totalité des déchets marins de chaque secteur car certains déchets pouvaient provenir de plusieurs origines sur un même secteur. La gamme des indicateurs de chaque secteur ne pouvait pas être comparée directement. La création d'un indice permettant de combiner les différents pourcentages a été étudiée mais les ressources du projet étaient insuffisantes pour explorer totalement cette piste. Cependant, un système d'indices pourrait être utilisé pour intégrer le suivi des déchets marins au sein du programme JAMP de la convention OSPAR. Un tel indice permettrait un suivi régulier de la situation, sur la base de la méthode développée lors de ce projet.*

#### ABOUT MARINE LITTER ON BEACHES IN THE OSPAR REGION

##### LES DÉCHETS MARINS SUR LES PLAGES DE LA ZONE OSPAR

- Beach surveys can only provide some of the information necessary to supply a full picture of the total load of marine litter in the coastal and marine environment. Any interpretation of data on beached marine litter, as a reflection of the overall marine litter situation in a given area, should be made with this uncertainty in mind.

*Le suivi des plages peut seulement fournir une partie de l'information nécessaire à obtenir une vision complète de la totalité de la charge en déchets de l'environnement marin et côtier. Toute interprétation des données sur les déchets marins échoués sur les plages comme une image de la situation globale du milieu marin doit être effectuée en gardant à l'esprit cette incertitude.*

- The fact that no statistically significant trend has been established within the framework of the pilot project of either an increase or a decrease since 2001 in the presence of marine litter on the 100-metre stretches of reference beaches in the OSPAR region should not be interpreted as a good sign as far as the coastal and marine environment is concerned.

*Le fait que dans le cadre de ce projet pilote aucune tendance statistiquement significative n'ait été établie en terme de nombre de déchets présents sur les transects de 100 m des plages références de la zone OSPAR ne doit pas être interprété comme un signe favorable tant que l'environnement marin et côtier reste menacé.*

- The overall situation with regard to marine litter on beaches in the OSPAR region as a whole, according to the results of the pilot project, has neither significantly improved nor has it significantly deteriorated since 2000. In the limited perspective of six years of monitoring, the "load" of marine litter appears to be about the same – however, it is important to note that the initial levels monitored at the start of the pilot project were high.

*Au regard des résultats de ce projet pilote, la situation générale en terme de déchets marins sur les plages de la zone OSPAR dans sa globalité, ne s'est ni significativement améliorée ni significativement détériorée depuis 2000. Dans la perspective limitée de ces six ans de suivi, la « charge » en déchets marins apparaît constante. Il est toutefois important de noter que les niveaux initiaux mesurés au début du projet étaient élevés.*

- Due to its region-wide scope, the methodology and findings of the pilot project have provided a major step forward in the analysis and better understanding of the sources and trends of marine litter in Europe. This information should be disseminated to the international community, e.g., the International Maritime Organization and the European Union, which are currently revising or formulating new marine environmental controls and policy.

*En raison de l'échelle régionale de ce projet, la méthodologie et les résultats obtenus ont constitué une étape majeure dans l'analyse et la meilleure compréhension des sources et tendances de la pollution marine par macrodéchets. Cette information devrait être diffusée à la communauté internationale et notamment à l'Organisation Maritime Internationale et l'Union Européenne en charge des contrôles et politiques maritimes.*

## 1. About the pilot project

The OSPAR Convention Area is by no means an unknown or uninvestigated zone when it comes to marine litter (marine debris). Comprehensive surveys of marine litter on beaches have been made in many areas, often for many years, by various organisations and groups. In many cases these surveys have been conducted with well-established methods and resulted in detailed documentation of findings and observations.

Thus, valuable information on marine litter – quantities and composition – on beaches has been available for decades. Survey methods have been developed, reporting forms (survey protocols) have been elaborated, tested and used. Results have been presented and evaluated. So why then start another project on monitoring of marine litter on beaches in Europe?

### 1.1 The background

In the early 1990s, Sweden expressed serious concerns about the increasing amounts of solid waste (marine litter) found in the coastal and marine environment, and presented a background document on marine litter in the OSPAR Maritime Area to the OSPAR Assessment and Monitoring Working Group (ASMO).

Marine litter was included as one issue in the OSPAR Quality Status Report 2000 (QSR). It was concluded that although the North Sea and the Baltic Sea have been designated as MARPOL Special Areas for the purpose of Annex V, and the dumping of all garbage and litter from ships is therefore prohibited, "there seems to have been no subsequent improvement in the situation with regard to litter."

It was, furthermore, concluded in the OSPAR QSR that "improved and more standardized methodologies, including the establishment of reference areas, will be needed to properly assess the scale and impact of litter both on coasts and offshore. These in turn will provide a basis for assessing trends in the quantities and significance of litter throughout the OSPAR area".

In 1995, the OSPAR IMPACT Working Group adopted a Working Strategy on Marine Litter. Sweden agreed to be Lead Party for the work. The OSPAR ASMO decided in 1999 on a pilot project. This decision was based on additional overview documents, and the work and recommendations of a Correspondence Group. The pilot project mandate was to develop a common methodology for the monitoring of beach litter, and to elaborate a draft monitoring programme for marine litter based on beach surveys.

*<> Project background: Marine Litter Net <>*

There can be many complex issues surrounding the problem of marine litter, for example:

- What should and should not be classified as marine litter? Are solid waste items, deliberately dropped and left behind by people on beaches, "marine" litter? Are any land-based sources of solid waste relevant in the context of marine litter (solid waste in the coastal and marine environment)? Should only items brought to beaches by ocean currents and waves, or flows of river water, be classified as marine litter? Or only solid waste items found in the water column or on the seabed, and not items found on land?
- Should solid waste items which are not deliberately disposed of in the sea, e.g., accidental losses of cargo or fishing gear, be classified as "marine litter" or merely as wrecked goods? How can the effects of such loss be sensibly incorporated, analysed and evaluated? Should the concept of marine litter only include solid waste items discarded as acts of deliberate pollution and deliberate neglect? Is it possible to distinguish between deliberate and accidental input?
- Is the marine litter found on beaches a correct reflection of the marine litter situation, of the total "load" of marine litter in the marine environment? Does it reflect the damage caused by marine litter in the marine environment as a whole? Since prevailing or temporary currents and winds will affect the transport of items that can end up on beaches, how can we ever estimate how many solid waste items from different sources that circulate in the seas and never come ashore?
- Should the concept of marine litter be used to classify only solid waste that is visible on beaches and in the water close to the shore, and thus constituting an eyesore and a possible health hazard to people? Or should solid waste items in the marine and coastal environment primarily be classified as marine litter?

based on the ecological effects caused by the waste? Or classified as marine litter based on the effects caused by marine litter on property, livelihood and safety of navigation?

## 1.2 Marine litter: a definition

An internationally agreed definition of the concept of marine litter (marine debris), based on definitions that have been commonly used in the context of marine litter for many years, has recently been established by the United Nations<sup>1,2</sup>. According to this definition, marine litter (marine debris) "is any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment".

Furthermore: "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."

Marine litter, thus, includes all items that are not of natural origin and would not naturally occur in the marine and coastal environment but are nevertheless found there. It consists of items that have been made or used by people and, at one point, regardless of where they were first discarded or lost, ended up in the coastal or marine environment.



Beach in the UK. Photo: Steve Trehwella, Marine Conservation Society.

## 1.3 Land-based and sea-based sources generate marine litter

Solid waste ending up as marine litter can originate from both land-based and sea-based sources. As summarised in the UNEP report, "a variety of land-based and marine activities result in the introduction of debris into the marine environment. It is generally acknowledged that land-based sources account for 60 to 80 per cent of marine debris. But the main sources of marine debris may differ from region to region and from country to country".

Furthermore: "Land-based sources are extremely widespread, and include recreational beach-goers and fishers; materials manufacturers, processors and transporters; shore-based solid waste disposal and

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<sup>1</sup> *Oceans and the law of the sea*. Report of the Secretary-General to the Sixtieth session of the UN General Assembly.

<sup>2</sup> United Nations Environment Programme, Regional Seas Programme (2005): *Marine litter – An analytical overview*.

processing facilities; sewage treatment and sewer overflows; inappropriate or illegal dumping on land; and public littering. [...] Debris can be blown, washed, or discharged into the water from land areas. A major source is sewer overflows and sewage treatment plants. [...] Legal and illegal shore-based solid waste management practices, both in coastal areas and along inland waterways, also contribute to the problem of marine debris."

And: "Accidental, deliberate or routine discharges or dumping from ships, pleasure craft, fishing vessels and offshore oil and gas platforms are among the main sea-based sources of marine debris. It is estimated that shipping contributes 10 to 20 per cent of the world's marine debris. [...] Similarly, offshore oil and gas platforms and offshore supply vessels can generate debris both from daily operations and from the crew. In the absence of appropriate treatment facilities on board and reception facilities on land, waste may be dumped intentionally. Cargo washed overboard can also constitute marine debris. [...]"

"Commercial fishing activities introduce marine debris into the ocean through accidental loss of fishing gear or through intentional disposal of worn-out gear. It is estimated that 30 per cent of all marine debris originates from the fishing industry."

According to the UNEP report, the main sources of marine litter are:

- Merchant shipping, ferries and cruise liners;
- Fishing vessels;
- Military fleets and research vessels;
- Pleasure craft;
- Offshore oil and gas platforms;
- Aquaculture installations.
- Municipal landfills (waste dumps) located on the coast;
- Riverine transport of waste from landfills etc. along rivers and other inland waterways;
- Discharge of untreated municipal sewage, incl. storm water (and occasional overflows);
- Industrial facilities (solid waste from landfills, and untreated waste water);
- Tourism (recreational visitors to the coast).

#### **1.4 Anecdotal figures and assumptions on marine litter**

Marine litter is found floating on the water surface (mainly plastic items); mixed and drifting in the water column; entangled in vegetation on shallow, tidal bottoms close to shore; lying on the seabed in shallow coastal areas and in deeper parts of seas and oceans; and on beaches, shore meadows and other land areas along the coast.

The marine litter problem is by no means limited to the solid waste items found on beaches. According to frequently quoted<sup>3</sup> but still anecdotal figures, as much as 70 per cent of the solid waste deliberately discarded from different sources, or accidentally lost at sea, sinks to the bottom of the sea and remains there, particularly on accumulation bottoms. With reference to the same anecdotal figures, an assumed 15 per cent of the solid waste ending up in the water mass could be found mixed at different levels in the water column. If both these assumptions were to be correct, beached marine litter would only account for approximately 15 per cent of all marine litter found.

Long-term, wide-scale investigations of marine litter on seabeds, or circulating in the water column, have not been made anywhere in the world. Judging from the limited knowledge available on marine litter accumulated on seabeds in different regions, combined with anecdotal knowledge about marine litter observed floating in large accumulations on the water surface, the assumptions could hold true. However, unless resources can be allocated for comprehensive investigations into the actual distribution (and, consequently, total quantities) of marine litter in the marine environment, regionally and possibly worldwide, there is no way of knowing for sure, and the anecdotal figures will remain indeterminate.

◁> *Marine litter on seabeds and in the water: Marine Litter Net* ▷<

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<sup>3</sup> For example:

- OSPAR IMPACT Working Group Summary Report. October 1995. Annex 5.
- Marine Pollution Monitoring Management Group. Report of the Marine Litter Task Team (2002): The Impacts of Marine Litter (p. 8)
- "Science for Environment policy": European Commission DG Environment News Alert Service, November 2006
- The Marine Biological Association of the United Kingdom, The Marine Life Information Network for Britain and Ireland (September 2006): Marine Life Topic Note: Marine & Coastal Litter (quoting UNEP and Keep Scotland Beautiful).

## 1.5 Currents, winds and oceanic drift

It is a fact that large-scale and/or local surface currents, bottom currents and winds (weather systems) at sea or along the coast will affect the movement and dispersion of marine litter items from different sources. Due to these forces of nature, certain amounts of marine litter will remain visible floating on the water surface, or largely invisible when mixed into the water column or accumulated on the seabed. These forces will also determine to what degree these items will be washed up on the shore.

Thus, it is important to have as much knowledge as possible about prevailing currents, circulation patterns in general, and prevailing weather systems in an area as a background to the findings of marine litter on individual beaches and on beaches at a wider regional level. Local and regional knowledge of the impact of surface currents and prevailing current patterns along the coast, as well as in sea areas further off the coast, is essential for the overall assessment of data on marine litter collected on beaches or on the water's edge along the coast. One should also be aware of this when selecting reference beaches for monitoring, as beaches acting as natural "sinks" of marine litter will stand out.

Solid waste items are transported by prevailing currents along mainland coasts, within and between coastal states, as well as between continental mainland and islands, and across oceans between continents. If identifiable marine litter items end up on beaches, the short- or long-distance transport can be recorded and confirmed. There are several examples of marine litter import/export within the OSPAR region, and between the north-western and north-eastern shores of the Atlantic (for example, originating on the east coast of North America and ending up on beaches on the Shetland Islands, Ireland, western UK, Belgium, France and Spain).

<> Transport of marine litter: Marine Litter Net <>



Beach on the Swedish west coast. Photo: West Coast Foundation, Sweden

## 1.6 Harmful, costly or just ugly?

Solid waste in the marine and coastal environment causes environmental, economic, safety, health and aesthetic problems. Whereas some of the costs are transparent (e.g., damage to people, property and livelihood, beach-cleaning), others are not so obvious and have only begun to be recognised and discussed (e.g., the suffering and death of wildlife).

Plastic and polystyrene items are consistently found to be the main contributor to marine litter all over the world. "The average proportion varies between 60 to 80% of total marine debris. In many regions, plastic materials constitute as much as 90 to 95% of the total amount of marine debris."<sup>4</sup>

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<sup>4</sup> Plastic Debris, Rivers to Sea Project: [www.plasticdebris.org](http://www.plasticdebris.org)

These materials, together with metal and glass, do not break down easily or quickly. Being long-lived and causing damage for decades, they are, directly and indirectly, a far more serious environmental threat than items made of paper, wood, rubber, textiles and leather. The fact that plastic items eventually break down into very small fragments and fibres (which are found on beaches, in sediments and in the water column), adds a new dimension to the problem. These fragments and fibres can be ingested by marine organisms and may move up the food chain. Furthermore, it has been concluded that small pieces of plastic, as well as plastic fibres and fragments, can adsorb pollutants from the water, which may spread toxic substances in the marine environment and have further impacts on marine organisms<sup>5</sup>.

It could, thus, be argued that in the coastal and marine environment, solid waste items of plastic and polystyrene, accompanied by items of glass and metal, are the items of most concern. The more persistent, potentially toxic and physically mobile the waste is in the environment, the greater its potential to cause damage.

## 1.7 First region-wide marine litter monitoring project in Europe

When designing the OSPAR Pilot Project on Monitoring Marine Beach Litter there was much previous experience to draw on. The challenges in dealing with this problem have not been lack of awareness of the issues surrounding marine litter or lack of data from various regions. Instead, the problem has been the lack of standardisation and compatibility between methods used and results obtained in these projects.

The OSPAR Pilot Project on Monitoring Marine Beach Litter has been the first region-wide attempt in Europe<sup>6</sup> to develop a method for monitoring marine litter on beaches and, by using this standardised method, to assess presence of marine litter on the beaches in the OSPAR region. That has made the pilot project special when it comes to filling some gaps in current knowledge.

## 1.8 Objectives

The overall objectives of the OSPAR Pilot Project on Monitoring Marine Beach Litter, as outlined in the Terms of Reference for the project, have been:

- to develop a method for monitoring marine litter on beaches;
- to produce a first assessment report on trends in quantities of different types and sources of marine litter in the OSPAR region;
- to suggest how marine litter monitoring could continue<sup>7</sup> as part of the monitoring of the state of the environment in the OSPAR region.

### DEVELOP A METHOD FOR MONITORING MARINE LITTER ON BEACHES

The development of a method for monitoring marine litter, according to the Terms of References for the pilot project, has included the following components:

- Identification of a representative selection of reference beaches throughout the OSPAR region, and a gradual expansion of the network of reference beaches to non-participating Contracting Parties (that did not participate in the pilot project from the outset);
- Development and testing of a harmonised survey protocol;
- Adequate quality assurance of the methods used and the data generated.

<sup>5</sup> See for example:

- Lost at Sea: Where Is All the Plastic? By Richard C. Thompson, Ylva Olsen, Richard P. Mitchell, Anthony Davies, Steven J. Rowland, Anthony W.G. John, Daniel McGonigle, and Andrea E. Russell. *Science*, Vol. 304, May 2004.

- Plastic Resin Pellets as a Transport Medium for Toxic Chemicals in the Marine Environment. By Yukie Mato, Tomohiko Isobe, Hideshige Takada, Haruyuki Kanehiro, Chiyoko Ohtake, and Tsuguchika Kaminuma. *Environmental Science & Technology*, Vol. 35, 2001.

- A comparison of neustonic plastic and zooplankton at different depths near the southern California shore. By G. L. Lattin, C. J. Moore, A. F. Zellers, S. L. Moore and S. B. Weisberg. *Marine Pollution Bulletin*, Vol. 49, Issue 4, 2004.

<sup>6</sup> In the United States, the Environmental Protection Agency (EPA), in collaboration with The Ocean Conservancy, have been running a region-wide effort – the National Marine Debris Monitoring Program – since 1996 to monitor marine litter on beaches. A total of 180 sites along the coastline of the U.S. mainland and Alaska and Hawaii are used to help determine the sources and changes in marine debris pollution. The programme, which is carried out by trained volunteers, is aimed at answering two specific questions: Is the amount of debris increasing or decreasing? What is the source of the debris? A study protocol is used, dividing the U.S. coastline into nine study regions based on prevailing ocean current patterns. Within each of the regions, a number of monitoring sites have been selected and each site must meet certain criteria. Beach surveys and cleanups are conducted on a 28-day interval. • See more about the MDM study at <http://www.oceanconservancy.org>

<sup>7</sup> The word "continue" is misleading, as no OSPAR-wide monitoring of marine litter on beaches took place in 1999, when the Terms of Reference were drafted.

PRODUCE A FIRST ASSESSMENT REPORT ON TRENDS IN QUANTITIES OF DIFFERENT TYPES AND SOURCES OF MARINE LITTER IN THE OSPAR REGION

A first assessment report would be based on the beach survey data, observations made and experience gained during the project period. Questions to be answered, if possible, would include:

*Quantities ("load of marine litter pollution")*

- What was the average number of marine litter items on 100 metres of a beach on one occasion (i.e., average number of marine litter items found per survey)?
- What is the trend in the annual average number of marine litter items found on 100 metres of beach (the average of the annual average number of marine litter items recorded per beach during the period 2001–2006)?

*Composition (types of marine litter)*

- What were the proportions of marine litter recorded in each of eleven categories (material or "use") found on 100-metre section of beaches during the period 2001–2006?
- What were the trends and changes in proportions of marine litter recorded in these eleven categories, found on 100-metre sections of beach during the period 2001–2006?

*Numbers of indicator items for five sources of marine litter*

- What is the trend regarding numbers of key indicator items of five different sources, during the period 2001–2006?

SUGGEST HOW MARINE LITTER MONITORING COULD CONTINUE AS PART OF THE MONITORING OF THE STATE OF THE ENVIRONMENT IN THE OSPAR REGION

At present (March 2007), no regular monitoring of marine litter takes place within the framework of the OSPAR Joint Assessment and Monitoring Programme (JAMP).

However, based on the results obtained in the project, the pilot project was to provide the OSPAR Commission with some of the information needed for a decision on whether to include the monitoring of marine litter as a regular part of the JAMP.

## 1.9 Project set-up

The project started in 1999, the survey protocol was tested and agreed in 2000, and the first field surveys started in early 2001.

The pilot project has been carried out in two phases, 2000–2003 and 2004–2006. The experience and results from the first phase were reported to the OSPAR Biodiversity Committee (BDC) in 2003 in a preliminary assessment report. Referring to, *inter alia*, the conclusions from a first statistical test analysis of the survey data available at that point, in which the need for longer time series of surveys to make statistically significant trend analyses was emphasised, the BDC endorsed a prolongation of the pilot project until the end of 2006.

An international Steering Group<sup>8</sup>, including the national project coordinators, has coordinated the implementation of the pilot project. The Steering Group has included representatives of Belgium, Denmark (mainland and the Faroe Islands), France, Germany, The Netherlands, Portugal, Spain, Sweden and the United Kingdom, as well as observer organisations KIMO (Local Authorities International Environmental Organization), and Seas at Risk (represented by Marine Conservation Society and Stichting De Noordzee). The Steering Group of the pilot project has reported annually to the OSPAR Biodiversity Committee (BDC).

As Lead Party, until the end of 2006, within OSPAR for the issue of marine litter, Sweden (through the Swedish Environmental Protection Agency) has funded and been in charge of pilot project management. However, the national project coordination and beach surveys were funded by a combination of national governments, NGOs and volunteers.

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<sup>8</sup> Members of the pilot project Steering Group: Annex 1

## 1.10 Points of departure for the pilot project

The marine litter issue in the wider context reflected above has been taken into account in the OSPAR Pilot Project on Monitoring Marine Beach Litter. However, following its Terms of Reference, the project has been conducted with the following points of departure:

- The internationally agreed definition of the concept of marine litter, as well as the agreed classification of possible land-based and sea-based sources of marine litter, have been accepted and incorporated.
- The limitations associated with the approach of only monitoring marine litter found on beaches were clear and have been accepted from the outset of the project. Beach surveys can only provide some of the information necessary to supply a full picture of the total load of marine litter in the coastal and marine environment. Any interpretation of data on beached marine litter as a reflection of the overall marine litter situation in a given area should be made with this uncertainty in mind. However, for the purpose of the pilot project, beach surveys were the only feasible, cost-effective way of making an assessment of the situation with regard to beached marine litter in the OSPAR region within a limited period of time. It has not been within the mandate of the pilot project to go beyond investigations of possible future monitoring of beached marine litter.
- It has not been a task of the pilot project to assess the effects of marine litter in the coastal and marine environment, but only to assess quantities, composition and trends for marine litter found on beaches in the OSPAR region. However, overall assessments of environmental, economic, safety and health effects of marine litter cannot and should not be based solely on the presence of solid waste items on beaches.



*Beach in Belgium. Photo: Francis Kerckhof, MUMM*

## 2. A method for monitoring marine litter on beaches

### SUMMARY OF THE METHOD DEVELOPED FOR MONITORING MARINE LITTER ON BEACHES

- Select which marine litter items to include in a survey protocol/survey protocols, i.e., which items and number of items to count and register in surveys.
- Establish standard rules regarding the removal or marking of all marine litter items after counting and registration.
- Establish set criteria for the selection of beaches for regular monitoring.
- Devise a universal form for the collection of data from each beach.
- Identify and select the beaches to be monitored, allocating each beach a reference number, and completing the documentation.
- Establish a standard length of survey section(s) on each beach.
- Mark this/these section(s), using permanent reference points.
- Establish annual survey periods.
- Select a data host. Set up a common, internet-based database.
- Carry out the surveys, using the agreed protocol in accordance with other agreed procedures.
- Establish a system to allow surveyors to input their gathered beach data to the database (transfer registrations and observations from survey protocols to the database) after each survey.

With regard to development of a method for marine litter monitoring on beaches in the OSPAR region, the Terms of Reference for the OSPAR Pilot Project on Monitoring Marine Beach Litter have been:

- Identification of a representative selection of reference beaches throughout the OSPAR area;
- Gradual expansion of the network of reference beaches to non-participating Contracting Parties (that did not participate in the pilot project from the outset);
- Development and testing of a harmonised survey protocol;
- Ensuring adequate quality assurance of the methods used and the data generated.

### 2.1 Identification and selection of reference beaches

The monitoring method developed in the pilot project has been based on the identification of reference beaches in each participating country.

#### 2.1.1 Criteria for identification and selection of beaches

The selection of the beaches was made according to agreed guidelines and set criteria. Preferably, the beaches should be:

- composed of sand or gravel and exposed to the open sea;
- visually and/or frequently littered (large marine litter items);
- accessible for ease of marine litter removal;
- over 1 km in length;
- not located near other input sources of waste, such as rivers;
- already included in national marine beach litter activities.

In each case, the guidelines have been followed as closely as possible. However, the national coordinators have used their expert judgement and experience of the coastal area and marine litter situation in their particular country when making the final selection of the reference beaches. For example, in some countries

the local conditions did not allow for selection of beaches composed mainly of sand, and in some places survey sections of 1 km in length could not be selected.



*Beach in the UK. Photo: Alison Conway, Marine Conservation Society.*

### **2.1.2 Selection of reference beaches. Gradual expansion of the network of beaches**

Although selected to meet with as uniform characteristics as possible, the reference beaches surveyed within the framework of the pilot project, have represented a wide spectrum of beach types from the Strait of Gibraltar to the Faroe Islands. Using the set criteria, national coordinators in Belgium, Denmark, Germany, the Netherlands, Portugal, Spain, Sweden and the United Kingdom have identified altogether 51 reference beaches<sup>9</sup>.

Beaches in Belgium, the Netherlands, Sweden, and the United Kingdom were identified from the outset of the pilot project (2000/2001). During 2002, the network of beaches expanded to include beaches in Denmark (including the Faroe Islands), Germany, Portugal, and Spain.

*<> Descriptions of the beaches: Marine Litter Net <>*

In late 2005 and early 2006, four beaches were identified in France, and additional surveys according to the pilot project methodology were made on these beaches during 2006, for comparison.

### **2.1.3 Documentation and characteristics of beaches**

For each pilot project reference beach a questionnaire was completed by persons familiar with the sites, in many cases by the field workers themselves.

The questionnaire included information on location and the physical and geographical characteristics of each beach, including the vicinity of specific sources of marine litter. Also included were questions regarding factors which could help explain the amounts, types, and composition of marine litter found on that beach, for example, degree of impact from different sources and activities, patterns of cleaning, and other features. Furthermore, previously known exceptional events such as major shipping accidents off the coast or major overflows in sewage treatment systems, etc., have been noted to signal caution in the interpretation and analysis of the results from that beach.

<sup>9</sup> List and brief facts on beaches: Annex 2

This questionnaire has provided background information for the analysis of beach survey data. The descriptions provide useful information for the interpretation of both normal and "abnormal" data from each beach.

*↔ Beach questionnaire: Marine Litter Net ↔*

#### **2.1.4 Development and testing of a harmonised/standardised survey protocol**

The survey protocol developed within the framework of the pilot project for surveys on a 100-metre stretch<sup>10</sup> includes 107 different marine litter items of all sizes, divided into 11 major groups of materials, or specific uses, or other characteristics:

- Plastic/polystyrene (48 items)
- Metal (15 items)
- Paper and cardboard (8 items)
- Wood (8 items)
- Sanitary waste (6 items)
- Cloth (6 items)
- Rubber (5 items)
- Glass (3 items)
- Pottery/ceramics (3 items)
- Medical waste (3 items)
- Faeces (2 items)

The survey protocol for surveys on a 1 km stretch<sup>11</sup> is more simplified, selecting 21 types of mainly larger marine litter items (larger than 50 cm in any direction, however also some items smaller than this) in five groups of materials to be registered:

- Plastic/polystyrene (9 items)
- Metal (2 items)
- Wood (4 items)
- Rubber (3 items)
- Cloth (3 items)



*Beach survey in the UK. Photo: Bethan Jones, Marine Conservation Society*

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<sup>10</sup> Survey protocol for 100-metre stretches: Annex 3

<sup>11</sup> Survey protocol for 1-km stretches: Annex 4

The protocols were tested, evaluated and adjusted during the spring of 2001 before they were used in regular surveys, and were further revised twice in 2002.

When Spain and Portugal joined the pilot project, new knowledge was added about items that constitute marine litter and that are frequently found on beaches in regions other than those in the northern parts of the OSPAR region (for example, items from region-specific aquaculture). It soon became evident that the protocols – especially the one for the 100-metre stretch – needed to be adjusted to include these items.

The revisions (additions and deletions) made in 2002 have not affected the accuracy of the subsequent statistical processing and analysis of the beach data. Data gathered from 2001 until the summer 2002 have been found to be as reliable as data gathered after that date. In the statistical analysis, adjustments have been made for the fact that new items were included in 2002 and it has been taken into consideration that these items might have been present on the beaches but not counted and documented during the first year of surveys. Similarly, new items can be added, during the course of long-term monitoring, to any protocol used in future marine litter surveys, without compromising the strength of the data already gathered.

The surveys on UK beaches have, throughout the pilot project, been made according to the protocol used in the annual, nation-wide Beachwatch surveys in the UK (see Adopt a Beach and Beachwatch). As most British surveyors are volunteers, and many of them have been using the Beachwatch protocol for a long time, it was most reasonable to allow them to continue as such. Their data for each survey have been transferred to the pilot project protocol by the Marine Conservation Society and thus included in the project database.

The pilot project protocols in their present versions are available in nine project languages: Danish, Dutch, English, French, German, Portuguese, Spanish (Castilian and Galician) and Swedish.

[↔ About survey protocols: Marine Litter Net ↔](#)

### **2.1.5 Beach surveys four times a year**

On each pilot project reference beach, a 100-metre long survey section was selected and marked, using permanent reference points on the beach to ensure that the same site was monitored in subsequent surveys. The 100-metre section was used for detailed surveys of marine litter washed ashore or left by people visiting the beach.

Where the physical characteristics of the coast allowed, it was also required to select a 1-kilometre long stretch of the same beach for surveys of larger marine litter items. The 100-metre sites were situated within the 1-kilometre areas.

The reference beaches were, as far as possible, surveyed 3–4 times each year. However, in some cases beaches have been inaccessible and unsafe for surveyors during the winter (heavy winds, slippery rocks and hazards such as rain, snow or ice, etc.). This has particularly been the case for beaches along the Swedish west coast, and in some parts of the UK. It should also be noted that many surveyors have been volunteers. Many have full-time jobs and have surveyed their reference beaches on their own personal time and used personal resources. For others it has not always been possible, despite their own personal commitment to the issue and the pilot project, to make complete sets of surveys throughout the project period.

The reason within the pilot project for conducting surveys four times a year, was to enable the detection of possible seasonal variations (for example, a majority of the beaches have pre-tourist and post-tourist seasons).

All surveys have been conducted in accordance with the survey protocols for the 100-metre stretch and the 1-km stretch. The survey periods were as follows:

*Table 1: Pilot project beach survey periods*

<i>Survey window</i>	<i>Survey period</i>
Winter	Mid-December–mid-January
Spring	April
Summer	Mid-June–mid-July
Autumn	Mid-September–mid-October

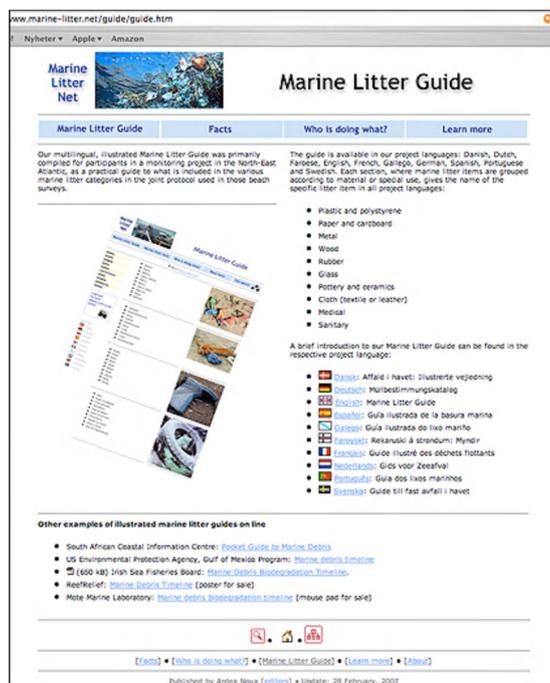


Beach survey in the U.K. Photo: Gill Bell, Marine Conservation Society.

Initially, the pilot project methodology also included requirements to take photos of the beaches for documentation at each survey. Surveyors were also to make notes of information (e.g., bar codes and country of manufacturing, or foreign markings) on labels that were intact on items found in surveys on the 1-km stretch of beach.

It was soon decided, however, that it would not be possible to require all surveyors to be equipped with a camera and take photos. Where possible, though, photos of the general state of a reference beach, and of individual items found, were taken for documentation.

Information collected from labels could provide indications as to the origin of marine litter items, and could also suggest that these items most probably originate from shipping. This notwithstanding, it was decided to delete the requirement in surveys to collect information from labels, mainly because many of the surveyors felt that this kind of information collection and analysis would be too time-consuming and call for additional resources.



### 2.1.6 Quality assurance

In all monitoring activities, including marine litter monitoring, quality assurance is essential. The beach survey protocols could be viewed as "checklists" of items referred to as marine litter. However, to assist field

workers further in their identification of marine litter items to be registered in the survey protocols, an illustrated, internet-based, multilingual Marine Litter Guide has been developed. Items are grouped in the same way as in the survey protocols, named in ten project languages (translation by the national project coordinators) and illustrated by four-colour photographs. In some cases, additional national measures for quality assurance were also carried out<sup>12</sup>.

<> *Marine Litter Guide: Marine Litter Net* <>

### **2.1.7 Common database for survey results**

The contents of the beach survey protocols were fed into an internet-based, password-protected database, hosted by the Swedish IT company SYSteam.

The national coordinators had access to the database and could input their own data and print out the contents of the database. It was not possible for coordinators to access any other entry points or data than those belonging to their own reference beaches. Only the project manager was authorised to access the entire database as administrator.

Each reference beach had been given a reference number (country code + beach number; see Annex 2), unique to that beach (for example ES1, UK3, DK2, PT5). When accessing the database, coordinators entered the reference number, chose the relevant survey period and year, opened the relevant form, and input the data.

The pilot project beach data could be analysed in numerous ways, depending on the approach chosen. Following the conclusion of the pilot project, the database will be available in the future for anyone who wishes to download it from the project web site and use the data for further statistical analysis.

<> *Descriptions of the pilot project database: Marine Litter Net* <>



*Beach survey on the Faore Islands. Photo: Sveiney Sverrisdóttir, Føroya Kommunufelag*

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<sup>12</sup> As further quality assurance, the German national coordinator in the pilot project circulated regular newsletters to the field workers and local organisers informing them of amendments to the survey protocols and other decisions within the project that could affect their work on the beaches. Through the newsletters German field workers were also made aware of "new" litter items that could occur on the beaches, reminded of survey periods, and advised on how to fill in the protocols.

### 3. Assessments of marine litter on beaches in the OSPAR region – quantities and composition

#### SUMMARY OF THE STATISTICAL ANALYSIS OF SURVEY DATA

##### *Quantities of marine litter*

- The total number of marine litter items found per stretch of beach varied considerably among pilot project reference beaches and surveys. On average, 542 items of marine litter of varying size were found per 100-metre survey on the reference beaches throughout the OSPAR region.
- Surveys made on 1-km stretches included mainly large items (>50 cm in any direction), but also some items smaller than this. On the 1-km stretches on reference beaches, an average of 67 marine litter items were recorded.
- The statistical analyses of the beach data indicate neither a significant increase nor a significant decrease in the average numbers of marine litter items found in the surveys made on the 100-metre stretches of the reference beaches over the OSPAR region as a whole during the pilot project period 2001–2006.
- On the 1-km stretches there was, however, a statistically significant decrease in the amount of marine litter found, although with large variations among countries.
- In addition, an average of over 3,800 marine litter items were found per 100 metres in the French beach surveys during 2006. This number is about seven times higher than the average number of items found on the regular reference beaches as a whole. However the French beaches located in shipping and fishing areas, studied in 2006 only, are well known for high concentrations of natural floating marine litter.

##### *Most common items: Found in the highest numbers*

- Small plastic/polystyrene pieces (smaller than 50 cm) were the most common type of marine litter items – found in the highest numbers – on the regular reference beaches on the 100-metre stretches of beach. They accounted for approximately 28 per cent of all items found on these beaches.
- The second most common item on the regular reference beaches on the 100-metre stretches was small pieces of ropes, cords and nets (smaller than 50 cm), which accounted for approximately 14 per cent of all items found.
- The most common item found on the 1-km stretches of regular reference beaches was other wooden items, which accounted for approximately 19 per cent of all items found in these surveys. Larger pieces of ropes, cords and nets (larger than 50 cm) were the second most common item found on 1 km-stretches on regular reference beaches, accounting for approximately 18 per cent.
- In addition, small pieces of plastic rope, cord and net (smaller than 50 cm) were the most common type of marine litter on 100-metre stretches of beach in France. These items accounted for nearly 64 per cent of all items found. The second most common type of item on the French beaches was larger pieces of plastic rope, cord and net (larger than 50 cm), accounting for approximately 9 per cent of all items found.

##### *Most frequently occurring items: Found in the highest percentage of surveys*

- 14 of the 20 most frequently occurring marine litter items – found in the highest percentage on all 100-metre surveys on regular reference beaches – were made of plastic or polystyrene.
- Small pieces of plastic ropes, cords and nets (the ones smaller than 50 cm) were the most frequently occurring items, found in close to 90 per cent of the 100-metre surveys on the regular reference beaches.

*Composition: Types of marine litter found*

- Of all marine litter items found in all 100-metre surveys on the regular reference beaches, an average of 75 per cent were made of non-degradable plastic and/or polystyrene.
- Plastic and polystyrene was the most common type of marine litter found also in the 1-km surveys on the reference beaches, accounting on average for almost 66 per cent of the total.
- The proportion of plastic/polystyrene marine litter items on 100-metre stretches on the regular reference beaches increased during the project period, from approximately 68 per cent in 2001 to approximately 78 per cent in 2006. This increase in proportion of plastic and polystyrene items is statistically significant.
- In addition, over 95 per cent off all marine litter items found in the 100-metre surveys on French beaches, were made of non-degradable plastic and/or polystyrene.

*Numbers of indicator items for five sources of marine litter*

- The number of indicator items for fishing, including aquaculture, found in the 100-metre surveys on the regular reference beaches increased during the project period (2001–2006). This increase is statistically significant.
- However, for the other four sources of marine litter (shipping, galley waste from ships; tourism/recreation; and sanitary waste) analysed during the project period, no statistically significant trends in numbers of indicator items could be demonstrated.
- In addition, the average number of indicator items found on French beaches in 2006, compared to the number of indicator items found on the regular reference beaches in the entire area in 2006 only, was significantly higher for two sources: fishing and shipping, respectively. The difference was particularly pronounced for indicator items for fishing, including aquaculture.

With regard to assessments of quantities and trends in the presence of marine litter on beaches in the OSPAR region, the Terms of Reference for the OSPAR Pilot Project on Monitoring Marine Beach Litter have been: "Production of a first assessment report on trends in quantities of different types of litter and sources of litter in the OSPAR area".

### **3.1 Comprehensive beach survey data as a basis for assessments**

#### NUMBER OF ITEMS FOUND

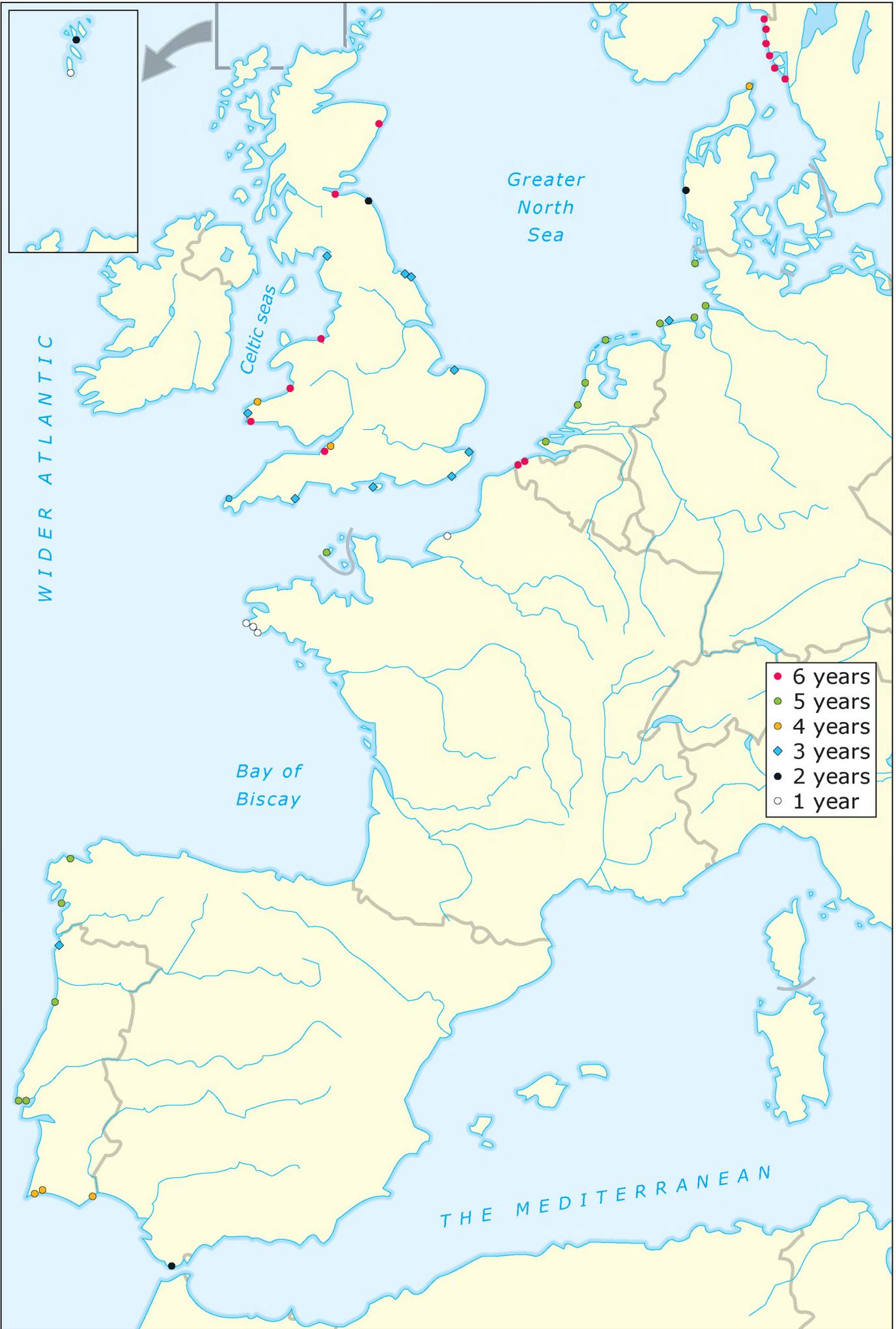
- During the project period 2001–2006, close to 353,200 individual marine litter items of all sizes were identified, counted, and registered in the pilot project database from surveys made with the more detailed survey protocol on 100 metres long stretches of beach (reference beaches and French beaches).
- In parallel, a total of over 22,400 mainly large items were recorded during surveys made on 1 km long stretches of reference beaches, during the project period, with the less detailed survey protocol.

#### SURVEYS ON 100 METRES LONG STRETCHES

- The statistical analyses of the data<sup>13</sup>, presented as the assessments made within the pilot project, have been based on data from the surveys on 100 metres long stretches of beach. The analysis has been made on data from 609 surveys made in eight countries – Belgium, Denmark, Germany, The Netherlands, Portugal, Spain, Sweden and the United Kingdom – on altogether 51 regular reference beaches<sup>14</sup> (see map, p. 26).

<sup>13</sup> On the statistical methods used: Annex 5

<sup>14</sup> List and brief facts on beaches: Annex 2



- Data from 10 surveys on 100-metre stretches on four beaches in northern France (Bretagne and Normandie) during 2006 has been analysed separately and added as complementary information.

#### Number of beach surveys on 100-metre stretches

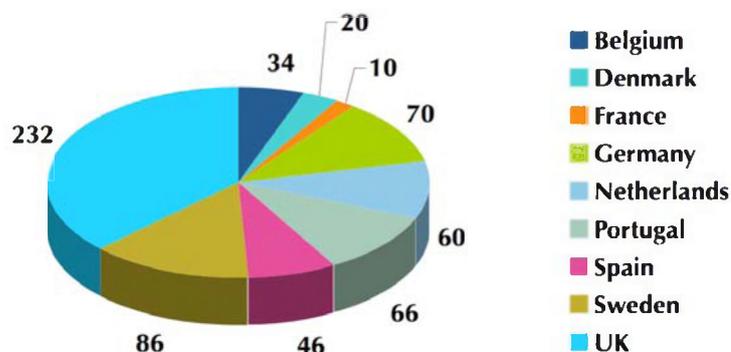


Fig 1: Number of beach surveys, on 100-metre stretches of beach, carried out within the pilot project, by country, during the period 2001–2006.

#### SURVEYS ON 1 KILOMETRE LONG STRETCHES

A less detailed but comparative analysis has been made on the data gathered in the 335 surveys on 1 km long stretches of beach, made during the period winter 2001/2002 to autumn 2006 on altogether 31 of the reference beaches in six of the participating countries. This analysis is presented separately.

In addition, four surveys were made on 1-km stretches of French beaches in 2006. However, data from those surveys has been not included in the 1-km survey analysis.

#### Number of beach surveys on 1-km stretches

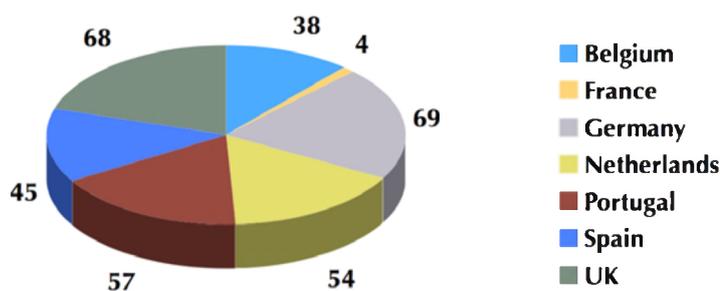


Fig 2: Number of beach surveys, on 1-kilometre stretches of beach, carried out within the pilot project, by country.

### 3.2 Not all of the beaches all the time

Surveys on 100 metre-stretches have been carried out regularly for 2–6 years on the 51 reference beaches (and on 1-km stretches on 31 of these). Not all of the beaches have been surveyed over the entire pilot project period.

For various reasons, primarily due to the fact that the work to carry out beach surveys has largely been dependant on voluntary work, the reference beaches have not all been surveyed for the same number of years. In the statistical analyses made of temporal trends, data has been used from all beaches, irrespective of for how long they have been surveyed.

Table 2: Survey beaches – numbers, participation, changes

Country	Total number of beaches surveyed	First survey	Changes during the project period in numbers or locations of beaches
Belgium	2	2001	No
Denmark • Faroe Islands	4	2002	Yes
France	4*	2006	No
Germany	5	2002	Yes
Netherlands	4	2001	No
Portugal	7	2002	Yes
Spain	3	2001	Yes
Sweden	6	2001	No
United Kingdom	20	2001	Yes

\* Not regular project reference beaches

In order to investigate whether the use of data from beaches not surveyed over the entire project period has affected the results, time trend analyses have been made on sets of beaches, classified by how many years they have been surveyed (6 years, 5 years or more, etc.). At least two aspects need to be considered:

- What would a single subset of beaches represent?
- What is the probability of detecting a trend?

If only reference beaches that were surveyed throughout the project period had been included in the analyses, only a very small portion of all reference beaches would form the basis for the analyses.

The geographical distribution of beaches would also have changed if only a subset of beaches had been included in the analyses of surveys made on 100-metre stretches; it would lead to a geographically skewed sample of beaches. For example, the 12 beaches (six of which are located in Sweden, the northernmost location of all in the project) that were surveyed for all six project years are located mainly in the Celtic Seas and Northern North Sea. When the beaches that were surveyed for five years or more (but not all six years) are included, the geographic distribution becomes more even.

Will the possibility of detecting a statistically significant trend (change in presence of marine litter) change with the number of reference beaches included in the analyses, based on the number of years these beaches were surveyed?

If more beaches are included, this larger data set should – *all other things being equal* – make the statistical test stronger. It would give a stronger relationship between time and the quantities of marine litter found. However, a larger number of beaches may also introduce more variation into the data set. Consequently it may be easier to detect significant trends in a smaller but more homogenous data set, such as, for example, the one based on beaches surveyed for six years. That was found to be the case, as the strongest time trend could indeed be detected in the analyses made on only the 12 beaches that had been surveyed for all six years.

A big difference is detected between the beaches surveyed for all six years and all the other survey times. However, none of these time trends are statistically significant. Thus, the conclusion would be similar irrespective of the time interval to be included in the analysis.

Why, then, is the trend not significant? There is a weak increasing trend in numbers of items in the 100-metre surveys, but the variation among beaches and surveys is so high that this increasing trend cannot be statistically proven: the "noise" is stronger than the signal. The other sets of survey time lengths show even more variation compared to the "six-year" survey set.

Number of beaches surveyed for 2–6 years

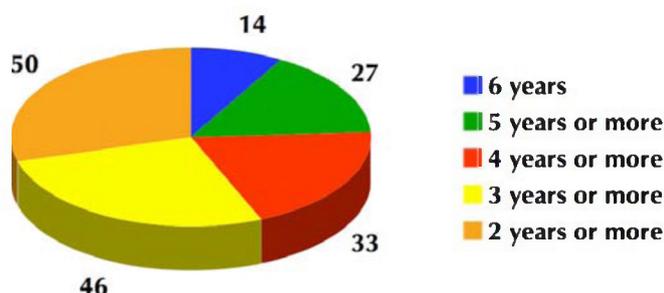


Fig 3: Number of reference beaches surveyed (on 100-metre stretches of beach) for various periods of time during the full pilot project period, 2001–2006. The figure is based on the fact that 14 reference beaches have been surveyed for six years, 13 beaches for five years, 6 beaches for four years; 13 beaches for three years; and 4 beaches for two years. In addition (not included in the figure), 5 beaches have been surveyed for one year or less.

Proportion of beaches surveyed 2–6 years, by region

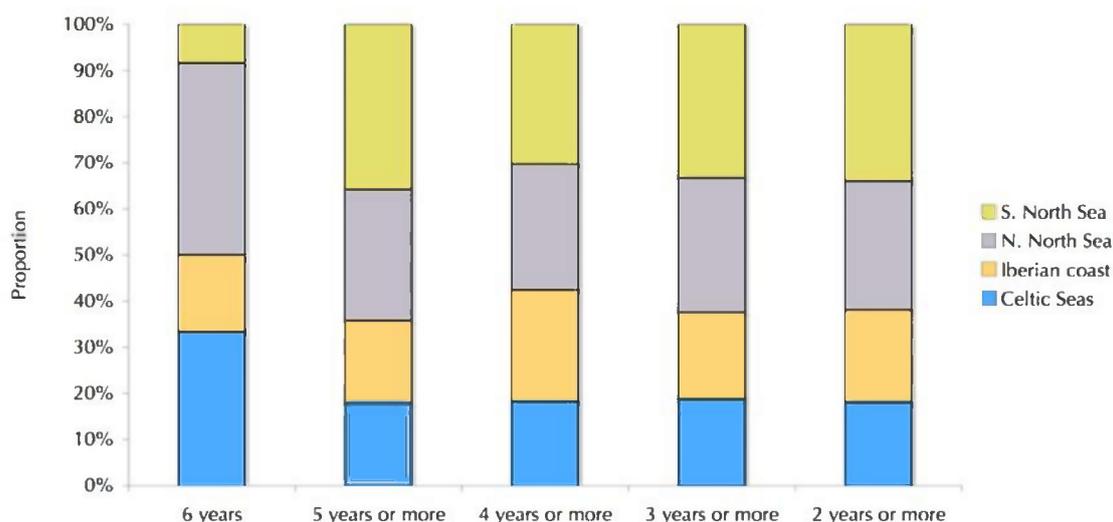


Fig 4: Proportion of reference beaches surveyed (on 100-metre stretches of beach) for various periods of time, by each of the five sub-regions identified in the OSPAR region for the purpose of the pilot project.

### 3.3 Assessments to be made of quantities and trends

In order to ensure that the statistical analysis of data from surveys made on 100-metre stretches of beach was in accordance with agreed principles and guidelines for the purpose of the project (to look for trends and variations), a spatial scale (areas, regions and beaches) and a temporal scale (years or seasons) was agreed upon by the Steering Group.

#### 3.3.1 Scales

**Spatial scale:** According to the Terms of Reference of the pilot project, an overall assessment of the trends in marine litter in the OSPAR region was to be made. Thus, the statistical analyses of the data have primarily been made on this overall scale – a North-East Atlantic scale that combines results from several heterogeneous regions – based on data from all reference beaches.

**Temporal scale:** When looking for trends on an annual scale, the results will reflect the amounts and types of marine litter accumulated over a long period covering several different seasons. This could be favourable in analyses based on indicator items. Some indicator items occur rather sparsely and in order to obtain

sufficient statistical power (more items = higher statistical power<sup>15</sup>) for such indicators, results from several surveys are necessary. Also, if seasonal data are combined, they might cancel each other out over a longer period of time (a year), i.e., negative trends observed in one season may be cancelled out by positive trends in another, giving a non-significant change in the mean value for the year as a whole.

The question of accumulation is crucial to the interpretation of the data material. The differences in beach cleaning frequency – differences between geographical areas as well as differences between seasons on the same beach – must be taken into account when considering the most relevant temporal scale for analyses.

Thus, analyses have primarily been based on yearly averages<sup>16</sup>. Data has been standardised for effects of beach cleaning frequency (time of accumulation).

### **3.3.2 Questions to be answered**

The data on presence of marine litter on the reference beaches, as collected in the 100-metre beach surveys, has been statistically analysed with regard to the following:

#### QUANTITIES ("LOAD OF MARINE LITTER POLLUTION")

- The average number of marine litter items on 100 metres of a beach on one occasion (i.e., average number of marine litter items found per survey). How many marine litter items could you expect to find on 100 metres of beach in the OSPAR region on one occasion?
- The trend in the annual average number of marine litter items found 100 metres of beach (the average of the annual average number of marine litter items recorder per beach during the period 2001–2006). Did the average number of marine litter items found on 100 metres of beach surveyed in the OSPAR region change (vary) during this six-year period?

#### COMPOSITION (TYPES OF MARINE LITTER)

- The proportions of marine litter recorded in each of eleven categories (material or "use") found on 100-metre section of beaches during the period 2001–2006. What were the marine litter items found on reference beaches in the OSPAR region made of and/or were used for as products? What types of marine litter were found on the beaches?
- The trends and changes in proportions of marine litter recorded (in the categories) found on 100-metre sections of beach during the period 2001–2006.
  - Were there changes (variations) in the numbers of marine litter in each of the eleven categories during this six-year period?
  - Were there any change in the composition of marine litter found during this six-year period?

#### NUMBERS OF INDICATOR ITEMS FOR FIVE SOURCES OF MARINE LITTER

- The trend regarding numbers of key indicator items of five different sources, during the period 2001–2006. How many marine litter items representing each of the five sources – fishing and aquaculture; galley waste from vessels and offshore activities; sanitary and sewage-related waste; shipping and offshore activities; and tourism and recreational activities – were found each year? Did the number of indicator items representing each of these sources increase, decrease or stay the same during the six-year period as a whole?

## **3.4 Preliminary assessment in 2003**

- Based on the limited data available by the end of the first phase of the pilot project (early 2003), there were, at that time, no indications that the marine litter situation had improved compared to the assessment presented in the OSPAR Quality Status Report 2000. This overall conclusion was based on the observations made by experienced field workers, some of whom had, at the time, already been making litter surveys or participated in beach cleaning operations for more than a decade, and on results of long-term studies in the United Kingdom, Germany and other OSPAR countries.

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<sup>15</sup> The statistical power of an analysis is the ability to detect differences or trends (if they exist). The power of a test, such as analysis of variance, or linear regression, is proportional to the effect size, the number of replicates, the inverse of the variation among samples, and the predetermined critical significance level of the tests. For a more detailed description of these parameters, see Annex 5.

<sup>16</sup> Trends over seasons were briefly explored, but not comprehensively enough or in enough detail to generate any conclusions.

- Furthermore, it could be concluded that a number of "new" marine litter items had been identified on several reference beaches. "New" items included, for example, so-called Tahitiens (plastic sheets with strips hanging down, used for protecting mussel cultures from predators), and light sticks (plastic tubes containing fluorescent substances, used in long-line fishery).
- Again, based on the limited data available in early 2003, the results from the field surveys thus far appeared to demonstrate quite clearly that there could be major regional differences in the composition of the marine litter within the OSPAR region. This was assumed to reflect possible important local or regional sources and activities.

### 3.5 100-m surveys: Quantities of marine litter

Based on the pilot project 100-metre beach survey data, during the project period 2001–2006, the following assessments have been made. (See also 3.9 for survey data from French beaches in 2006).

QUESTION:

What was the average number of marine litter items on 100 metres of a beach on one occasion (i.e., average number of marine litter items found per survey). How many marine litter items could you expect to find on 100 metres of reference beach in the OSPAR region on one occasion?

ASSESSMENT:

- The total number of marine litter items found per stretch of beach (100 metres) was affected by the location of the beaches<sup>17</sup> and varied considerably among pilot project reference beaches and surveys.
- An average of 542 items of marine litter of varying size were found per 100-metre survey on the reference beaches throughout the OSPAR region.
- Surveys made on 1-km stretches included mainly large items (>50 cm in any direction), but also some items smaller than this. On the 1-km stretches on reference beaches, an average of 67 marine litter items was recorded.

QUESTION:

What was the trend in the overall annual average number of marine litter items found on 100 metres of beach (the average of the annual average number of marine litter items recorded per beach during the period 2001–2006)? Did the average number of marine litter items found on 100 metres of beach surveyed in the OSPAR region change (vary) during this six-year period?

ASSESSMENT:

- The statistical analyses of the beach data do not indicate either an increase or a decrease in the average numbers of marine litter items found on the reference beaches.
- Thus, no statistically significant overall trend – neither a significant increase, nor a significant decrease – in the average numbers of items found on reference beaches for the whole OSPAR region during the project period 2001–2006 can be demonstrated (Figure 5).
- A detailed analysis demonstrates a tendency towards a decrease in numbers of items on the reference beaches between 2001 and 2004, and towards an increase thereafter. The trends were, however, not statistically significant. In both periods of increase and decrease, plastic and polystyrene marine litter items dominate.

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<sup>17</sup> The 95 per cent confidence interval corresponds to  $\pm 173$  items per 100 metres of beach. The lowest number of items found in one survey was only 9, and the highest was 43,419. However, the extremely high number 43,419 was due to a so-called "freak event" when an unprecedented number of cotton bud sticks were found on a beach. If this very rare event is excluded, the highest "normal" number of items found on a beach on one occasion was 5,907. • More specifically, on all reference beaches located in the tidal zone, the marine litter items included in this overall figure (630 items found, on average, per 100 metres of beach in the OSPAR region), were found in the area between the last high tide mark and the high tide mark of the last extreme spring tide. Only the six Swedish reference beaches are not located in what could be characterised as the tidal zone (the tidal amplitude on the Swedish west coast is 10–20 cm).

Average number of marine litter items on reference beaches

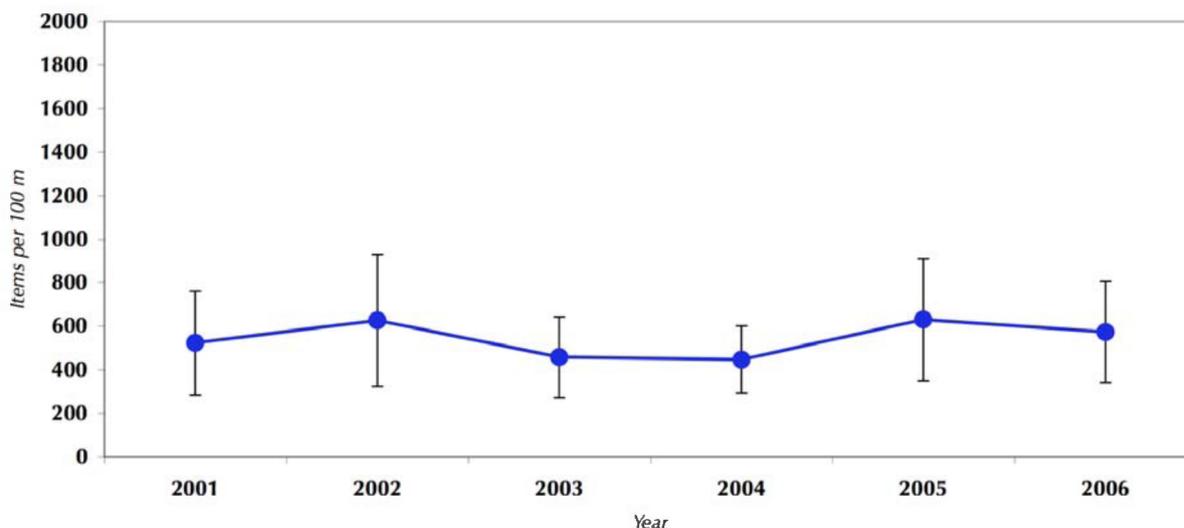


Fig 5: The annual average numbers of marine litter items found on the reference beaches, and trend in the annual average number of marine litter items found on the reference beaches. (Each error bar shows a 95% confidence interval. Each point is based on the average of annual averages for individual beaches).

More on the results on the trend in numbers of key indicator items of five different sources of marine litter during the period 2001–2006 – see 3.7.

ADDITIONAL QUESTIONS:

- Which were the most common marine litter items – found in the highest numbers – on the beaches?
- Which marine litter items occurred most frequently – were found in the highest percentage of surveys – on the beaches?

ASSESSMENT:

- Small plastic/polystyrene pieces were the most common type of marine litter items – found in the highest numbers – on all reference beaches (Figure 6).

Most common (total numbers) items on reference beaches

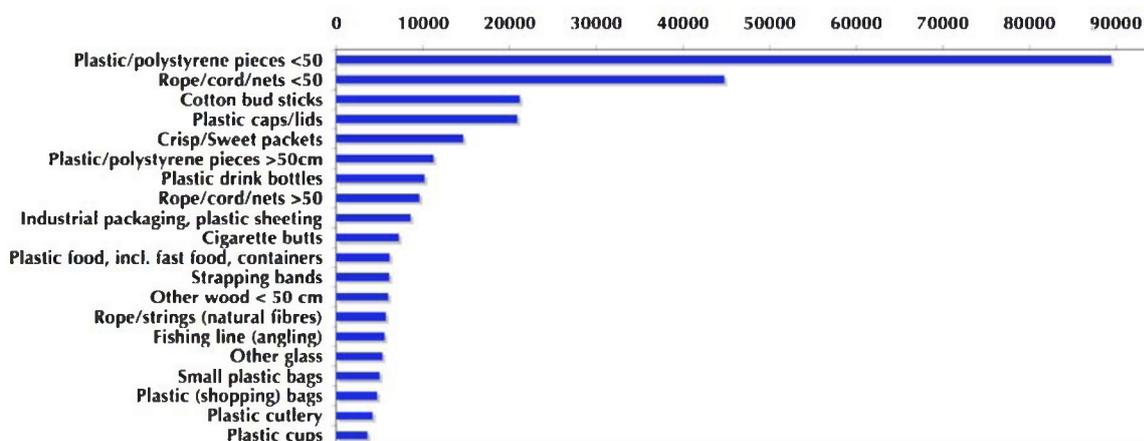


Fig 6. The most common marine litter items, i.e., found in the highest numbers on the reference beaches.

- Small pieces of plastic ropes/cords/nets (the ones smaller than 50 cm) were the most frequently occurring items – found in the highest percentage of all surveys. These items were found in close to 90 per cent of the surveys on reference beaches (*Figure 7*).
- 14 of the 20 most frequently occurring marine litter items – found in the highest percentage on all 100-metre surveys on regular reference beaches – were made of plastic or polystyrene (*Figure 7*).

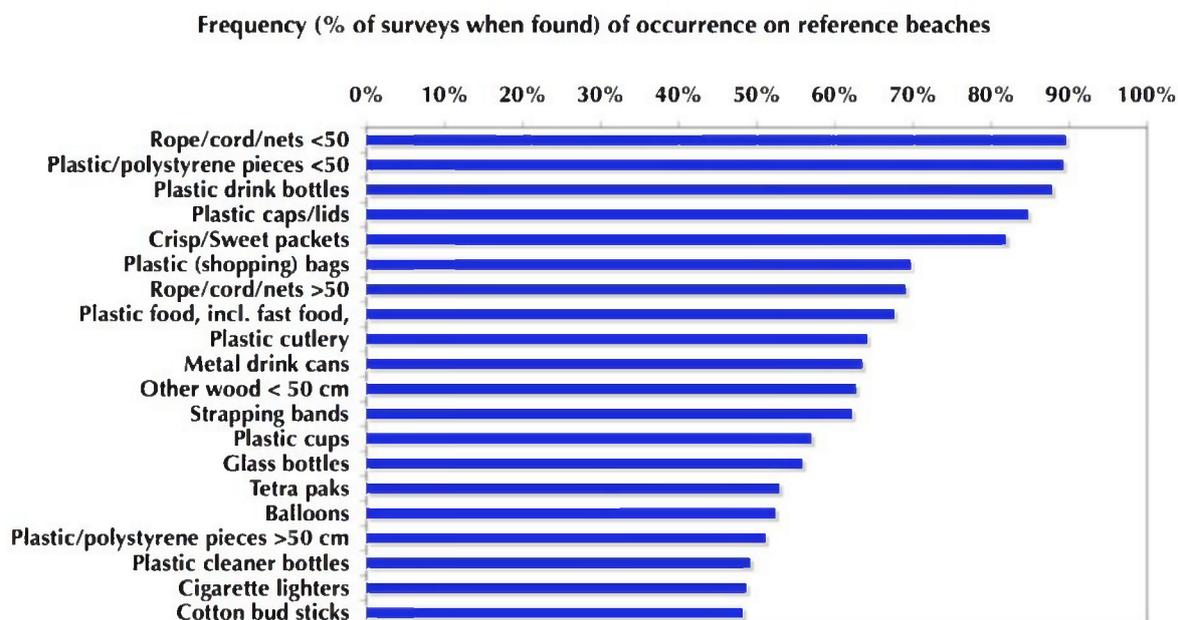


Fig 7: The marine litter items found in the highest percentage of surveys on the reference beaches.

### 3.6 100-m surveys: Composition (types of marine litter)

Based on the pilot project 100-metre beach survey data, during the project period 2001–2006, the following assessments have been made.

QUESTION:

What were the proportions of marine litter recorded in each of eleven categories (material or "use") found on 100-metre section of beaches during the period 2001–2006? What were the marine litter items found on the reference beaches in the OSPAR region made of and/or used for as products? What types of marine litter were found on the beaches?

ASSESSMENT:

- Items made of non-degradable plastic and/or polystyrene accounted for an average 75 per cent of the eleven categories of marine litter items (*Figure 8*). There were, however, regional variations, ranging from 63 to 81 per cent (see *Figures 21–24*).
- Of the other ten categories of marine litter found on beaches, sanitary waste (7.4 per cent) was the second highest category after plastic and/or polystyrene.

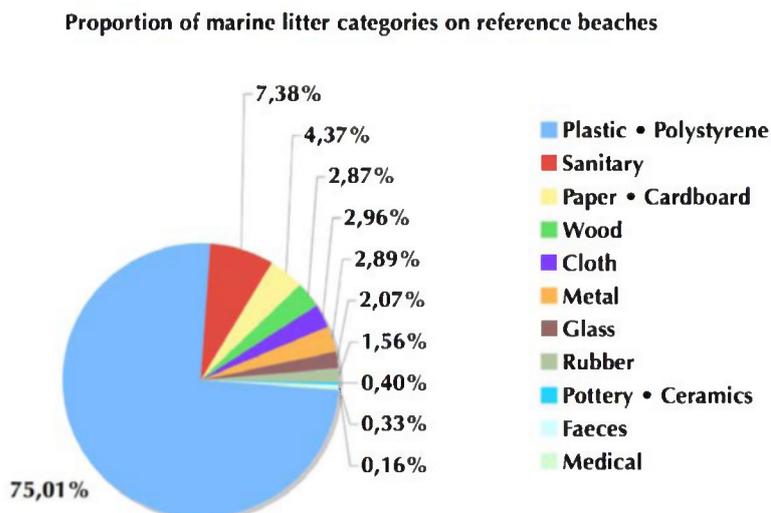


Fig 8: Proportion of different categories of marine litter found on reference beaches during the project period 2001–2006. [Please note that graphs have been made in a Swedish version of Excel, thus the use throughout of decimal commas in pie charts – like 75,01% – instead of decimal points: 75.01%].

#### QUESTIONS:

What were the trends and changes in proportions of marine litter recorded (in the categories) found on 100-metre sections of beach during the period 2001–2006.

- Have there been changes (variations) in the numbers of marine litter in each of the eleven categories during this six-year period?
- Has there been any change in the composition of marine litter found during this six-year period?

#### ASSESSMENT:

- No significant change in the numbers of marine litter items recorded for any of the eleven categories could be detected during the survey period 2001–2006 (Figures 9-10).
- The proportion of plastic/polystyrene marine litter items increased during the project period, from approximately 68 per cent in 2001 to approximately 78 per cent in 2006. This was a statistically significant increase (Figures 11-12).



Beach in Germany. Photo: The German participants in the OSPAR pilot project.

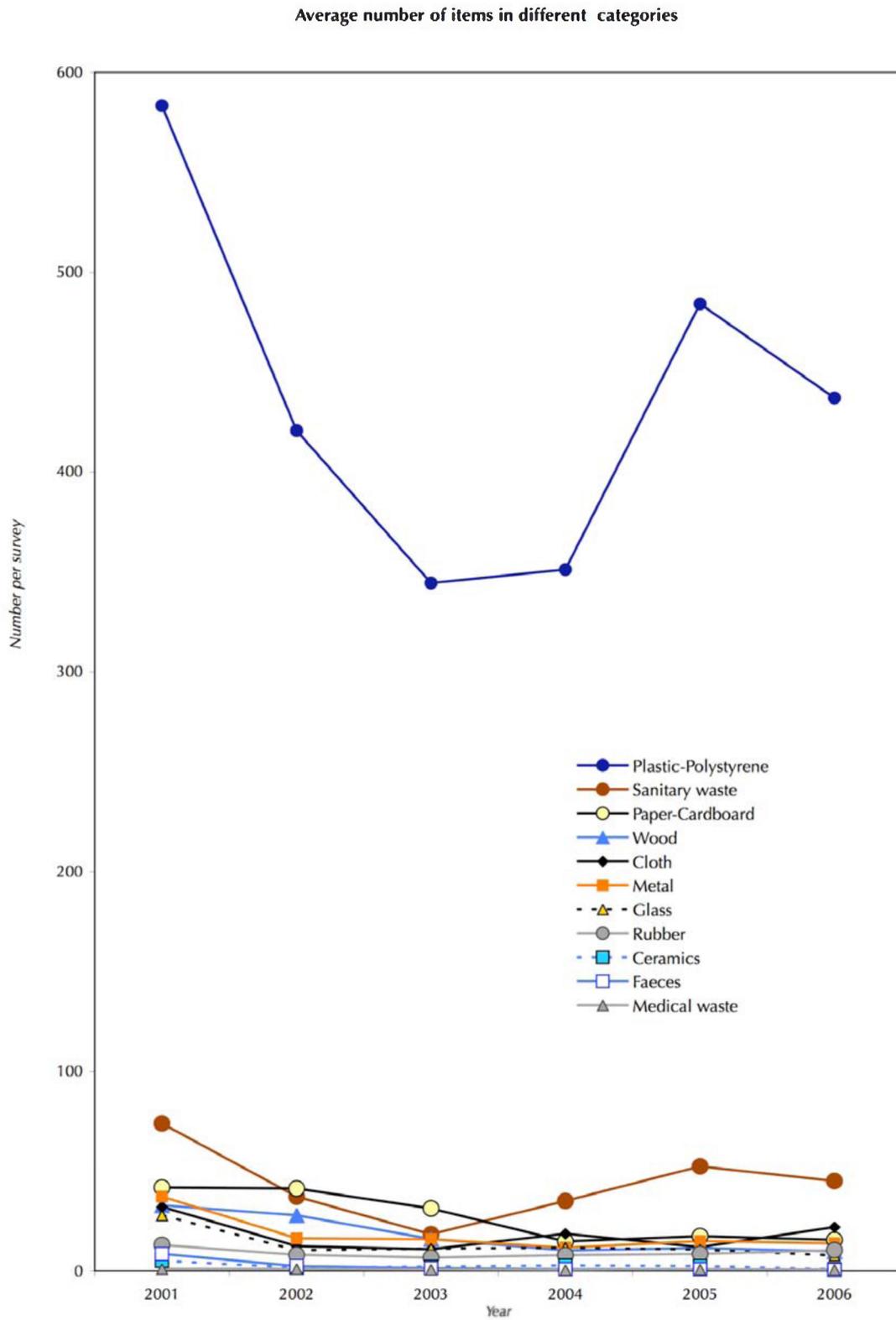


Fig 9: Average number of marine litter items on the reference beaches during the six-year period, in the eleven categories used in the beach survey protocol. Details of the composition in the ten categories except plastic and polystyrene, see next page (Figure 10).

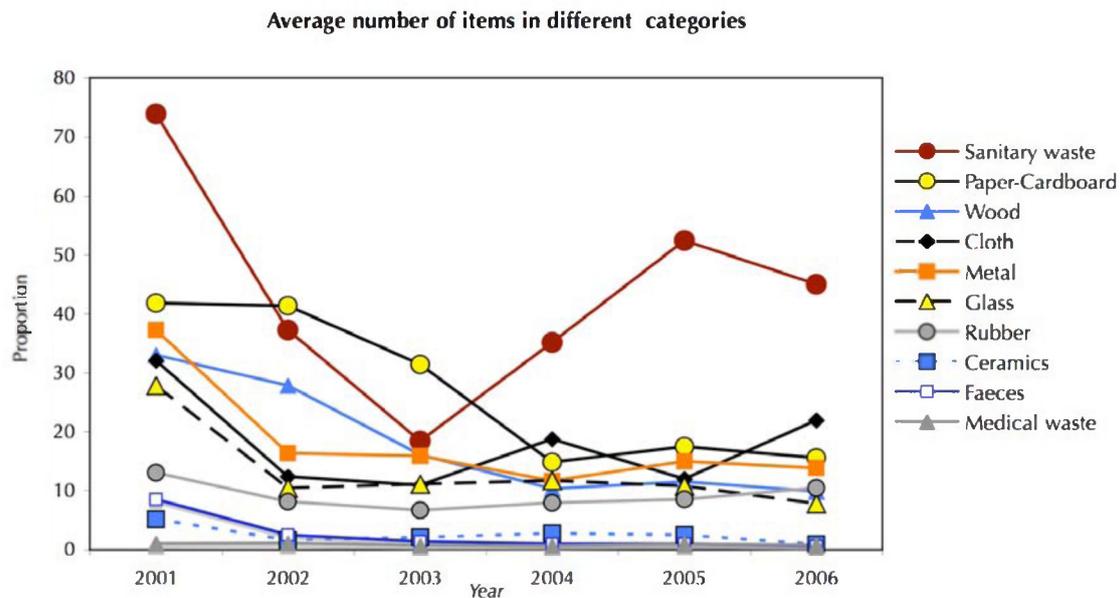


Fig 10 (detail of Figure 9): Average number of marine litter items on the reference beaches during the six-year period, in ten of the eleven categories used in the beach survey protocol.



Beach in southern Portugal. Photo: Fátima Brito, Instituto da Água.

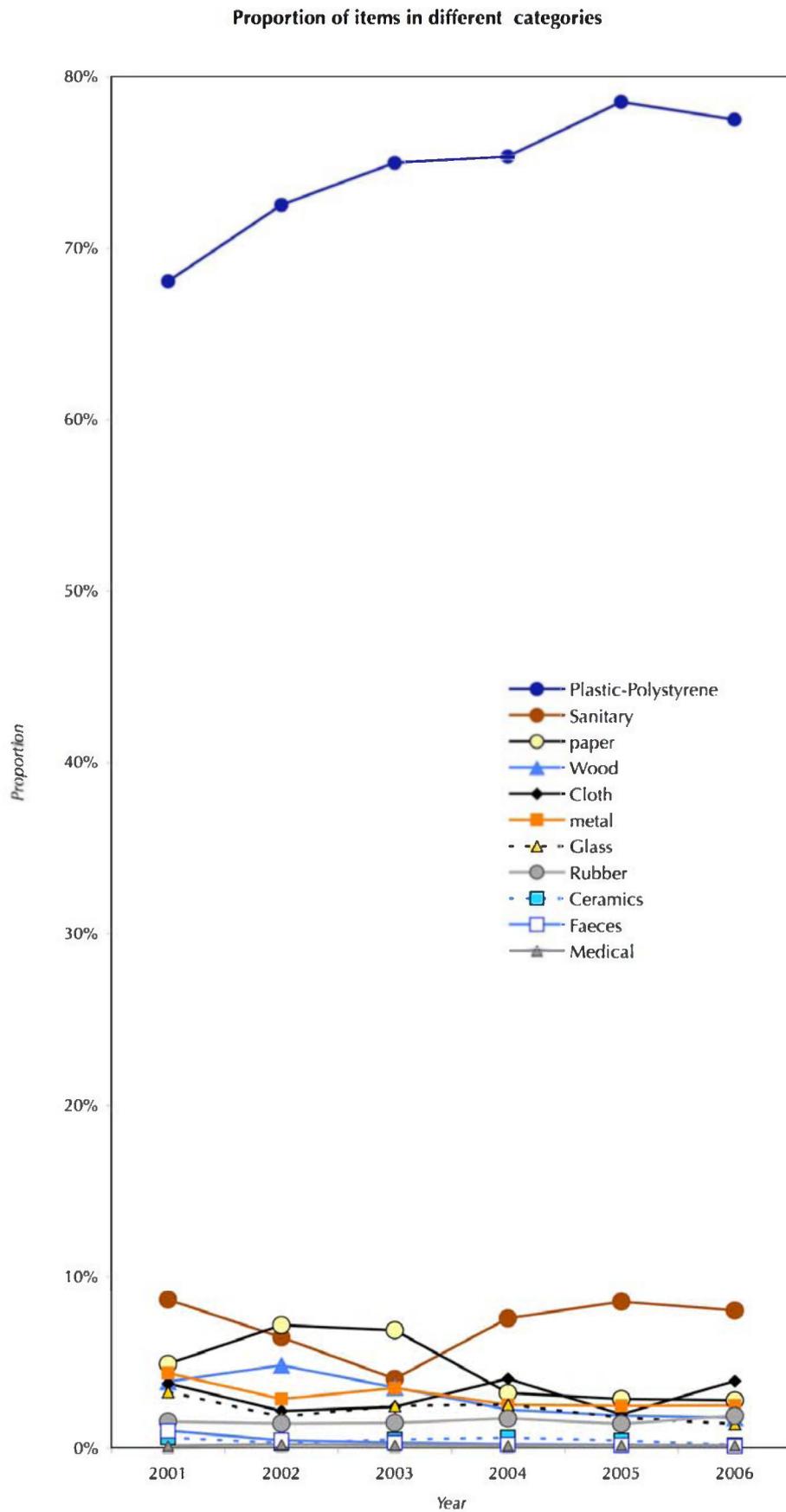


Fig 11: Changes in the composition of marine litter items on the reference beaches during the six-year period, in eleven categories used in the beach survey protocol. Details of the composition in the ten categories except plastic and polystyrene, see next page (Figure 12).

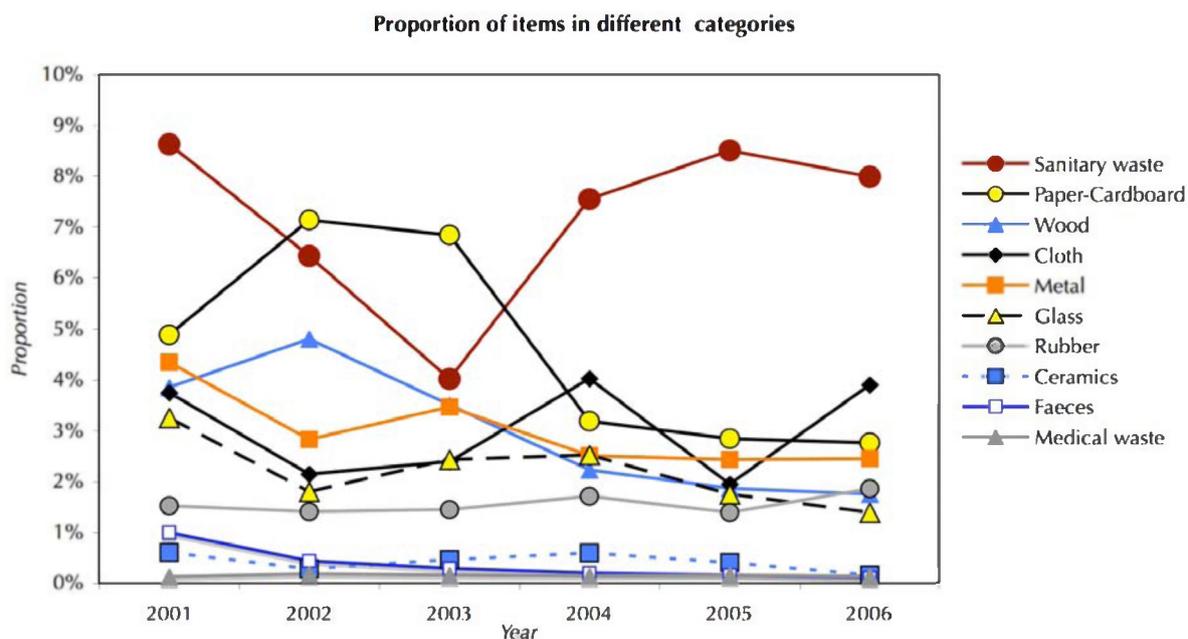


Fig 12 (detail of Figure 11): Changes in the composition of marine litter items on the reference beaches during the six-year period, in ten of the eleven categories used in the beach survey protocol.

### 3.7 Marine litter sources and indicators

#### 3.7.1 Marine litter sources

Five major sources of marine litter – activities that generate solid waste that ends up as marine litter on beaches (listed below in alphabetical order) – in the OSPAR region were identified in the pilot project:

- Fishing, including aquaculture.
- Galley waste (non-operational waste from shipping, fisheries and offshore activities).
- Sanitary waste/Sewage-related waste.
- Shipping, including offshore activities (operational waste).
- Tourism and recreational activities.

#### 3.7.2 Criteria for indicators

In order to quantify and determine the relative importance of different sources of marine litter, indicator items representing each of the described sources to be studied needed to be identified. Findings of correctly identified and selected indicator items will be a signal that marine litter from a specific source has been found.

Part of the statistical analysis of the pilot project beach survey data has been to test whether proposed indicators of sources of marine litter are relevant and could be used in regular monitoring of marine beach litter.

In order to qualify as a relevant marine litter indicator, an item should have certain properties and should be:

- typical for the source it represents.
- common and frequent in the survey area (have a high statistical power).
- easy to identify.
- easy to find (not too small or inconspicuous).
- easy to count.



Beach in the UK. Photo: Alison Conway, Marine Conservation Society

### 3.7.3 General or source-specific indicators

The pilot project Steering Group has identified a set of possible source-specific indicators of marine litter from different sources for the OSPAR region. Attempts have also been made to identify general indicators of marine litter for the area. The selection has been based on the findings and experience of other projects<sup>18</sup>, where similar difficulties have been encountered.

It should be noted that these indicators have been chosen from the 107 items included in the survey protocol for 100-metre stretches. The indicator items represent approximately 60 per cent of the total number of marine litter items found, counted and identified in the 100-metre surveys.

#### GENERAL INDICATORS

Several attempts were made within the pilot project to identify a few relevant general indicators of marine litter. In order to qualify as a general indicator of marine litter, an item should occur frequently on beaches, in sufficiently large numbers, on all reference beaches in all regions, and during all seasons of the year.

It proved difficult to single out a limited number (3–5) of items that could with sufficient accuracy cover all kinds of possible sources and reliably indicate general marine litter trends. Three items or groups of plastic items were, initially however only preliminarily, suggested as possible general trend indicators of marine litter:

- Cleaner bottles;
- Caps and lids;
- Plastic pieces up to a size of 50 cm.

<sup>18</sup> Among others:

- The Pilot Project to Establish Methodologies and Guidelines to Identify Marine Litter from Shipping, conducted in 2000 by the Maritime & Coastguard Agency.
- The methodology for sourcing of marine litter items found in the Beachwatch surveys, organised by the Marine Conservation Society in the UK
- The U.S. EPA Assessing and Monitoring Floatable Debris Programme in 2002.
- The study carried out by Ribic *et. al* on the use of indicator items to monitor marine debris on a New Jersey beach, 1991–1996.

#### SOURCE-SPECIFIC INDICATORS

An agreed set of indicators of marine litter was decided in 2005 for five sources, as a basis for the statistical analysis of the beach data:

Table 3: Source-specific indicator items selected for the purpose of the analysis of beach data in the pilot project

Source	Indicators
Fisheries, including aquaculture	Jerry cans. Fish boxes. Fishing line. Fishing weights. Rubber gloves. Floats/buoys. Ropes/cords/nets <50 cm, and >50 cm, respectively. Tangled nets/cords. Crab/lobster pots. Octopus pots. Oyster nets and mussel bags. Oyster trays. Plastic sheeting from mussel culture ("Tahitians").
Galley waste from shipping, fisheries and offshore activities ( <i>non-operational waste</i> )	Cartons/tetrapaks. Cleaner bottles. Spray cans. Metal food cans. Plastic gloves. Plastic crates.
Sanitary and sewage-related waste	Condoms. Cotton bud sticks. Sanitary towels/panty liners/backing strips. Tampons/Tampon applicators.
Shipping, including offshore activities ( <i>operational waste</i> )	Strapping bands. Industrial packaging. Hard hats. Wooden pallets. Oil drums (new and old). Light bulbs/tubes. Injection gun containers.
Tourism and Recreational activities	4-6-pack yokes. Plastic shopping bags. Plastic bottles/containers for drinks. Metal bottles/containers for drinks. Plastic food containers. Glass bottles. Crisp/sweets packets and lolly sticks.

#### 3.7.4 Additional considerations

*Indicators of marine litter from tourism-recreational activities:* Due to regional differences (habits, products) it can be difficult to identify one set of indicators for tourism-recreational activities and one might have to identify different items for different regions.

This is probably the most difficult of the five sources, where the selection of indicators will have the lowest level of credibility. As well as litter dropped by beach-users, this source also includes recreational boating, which by definition is not a beach activity but a shipping activity. In addition, items selected as indicators of tourism-recreational activities could originate from shipping or fishing. Indicators of tourism-recreational activities were also found on reference beaches on uninhabited islands, which are not used for tourism, thus indicating transport by other means. To be able to assess trends in the amount of marine litter originating from tourism-recreational activities, several indicator items will probably be needed to increase the validity of this indicator.

*Special and upcoming items:* Based on the experience of beach surveyors there are a number of items of special interest that could, possibly, be used as indicators. For example, party rubber balloons is an item that occurs frequently, as a result of organised festivities or fundraising events, which can result in marine litter, regardless of the event proximity to the coastline. Other items that appear to occur more and more frequently on beaches and could indicate new habits are wet wipes (frequently found on UK beaches) and disposable barbecues/grills (frequently found on Danish, Swedish and UK beaches).

<> Correlations between beach conditions and findings of indicator items. Accumulation rates: Marine Litter Net <>

### 3.8 100-m surveys: Numbers of indicator items for five sources of marine litter

Based on the pilot project 100-metre beach survey data, during the project period 2001–2006, the following assessments have been made.

QUESTION:

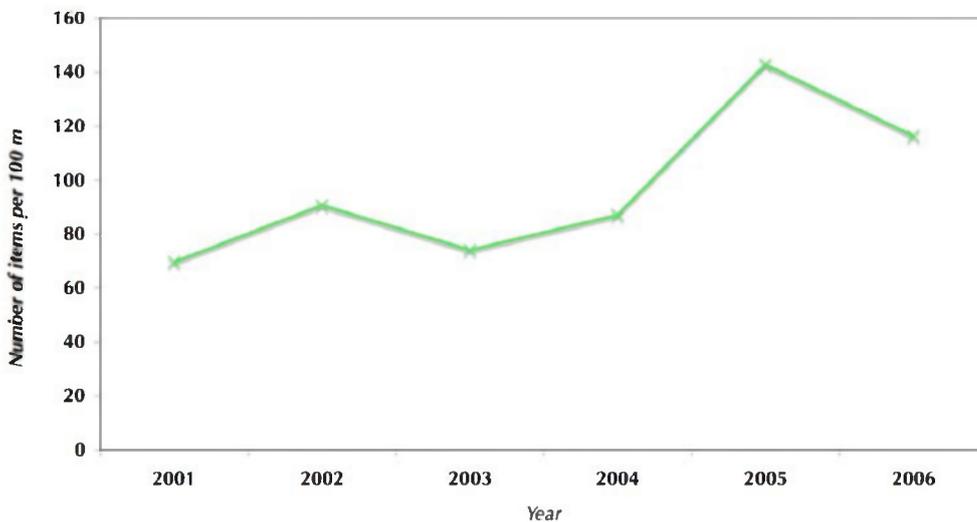
What was the trend regarding numbers of key indicator items of five different sources, during the period 2001–2006. How many marine litter indicator items representing each of the five sources – fishing and aquaculture; galley waste from vessels and offshore activities; tourism and recreational activities; sanitary and sewage-related waste; and shipping and offshore activities – were found each year? Did the number of indicator items representing each of these sources increase, decrease or stay the same during the six-year period as a whole?

ASSESSMENT:

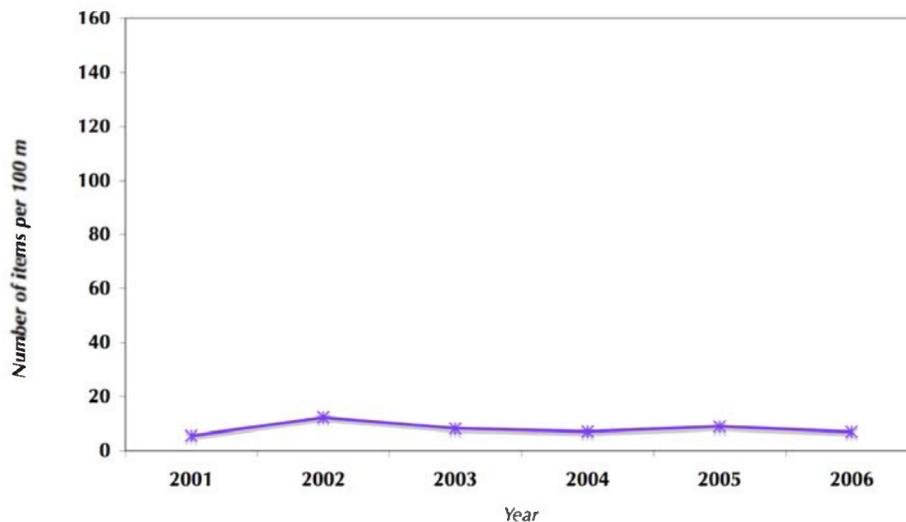
- The number of fishing indicator items (fishing including aquaculture) found in the 100-metre surveys increased during the project period (2001–2006). The increase was statistically significant on the reference beaches (Figure 13).
- No statistically significant trends in numbers of marine litter indicator items could, however, be demonstrated for any of the other four sources of marine litter analysed during the project period (Figures 14-17).

Figures 13-17 (below): Annual average number of marine litter indicator items from different sources found on the reference beaches, during the six-year pilot project period. Please note that the graphs in Figures 13-17 cannot be interpreted as a basis for comparisons or statements about the relative importance of each of the five sources as contributor to the total load of marine litter in the OSPAR region. One cannot conclude from these graphs which one is the major source of marine litter pollution in the OSPAR region. Each graph should be read and interpreted separately and only illustrates how the number of items from that particular source has changed over time during the project period, 2001-2006.

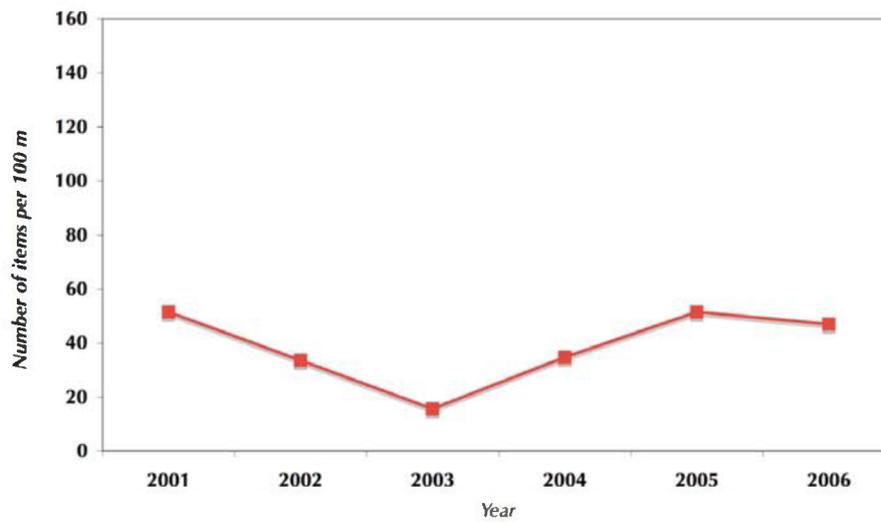
Number of marine litter indicator items: FISHING



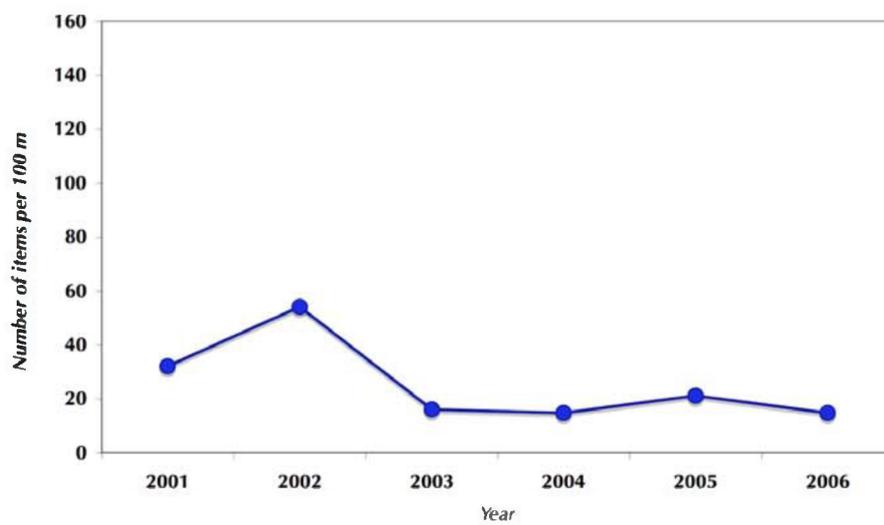
Number of marine litter indicator items: GALLEY WASTE



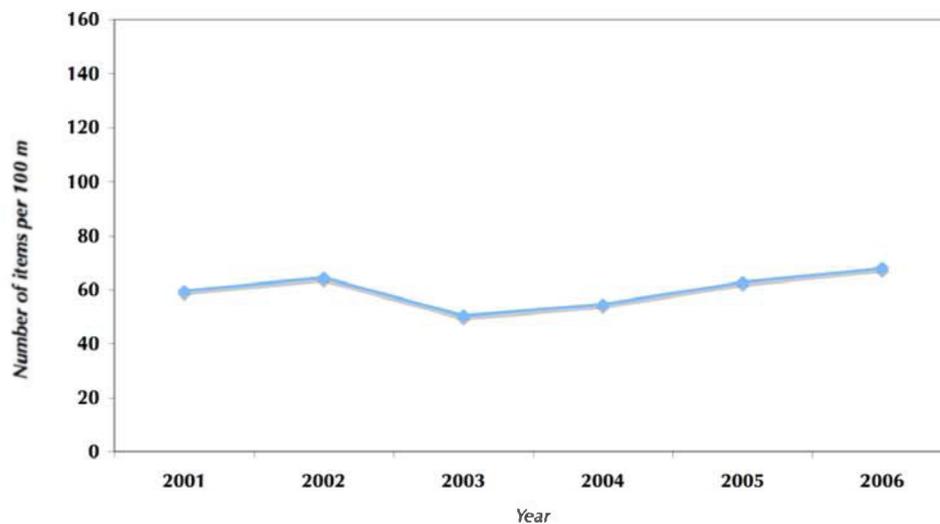
Number of marine litter indicator items: SANITARY WASTE



Number of marine litter indicator items: SHIPPING



Number of marine litter indicator items: TOURISM





Survey beach in France (Dieppe). Photo: Association E.S.T.R.A.N.

### 3.9 Marine litter on French beaches: quantities and composition

France only joined the pilot project in late 2005, but during 2006 beach surveys were carried out, for comparison, on four selected beaches that met with the criteria for reference beaches (on three beaches in Baie d'Audierne in Bretagne, and one beach in Dieppe in Normandie). Ten surveys were conducted on 100-metre stretches and four on 1-km stretches of beach, all in accordance with the project survey method and protocol.

#### 3.9.1 Quantities of marine litter on French beaches

- Close to 38,200 marine litter items were identified, counted, and registered in the pilot project database during 2006 as a result of the ten 100-m surveys on the French beaches.
- Thus, on average over 3,800 marine litter items were found per 100 metres in the French beach surveys. This is about ten times higher than the average number of items found on the regular reference beaches in the Southern North Sea region. The number is also about seven times higher than the average number of items found on the reference beaches as a whole. However the French beaches located in shipping and fishing areas, studied in 2006 only, are well known for high concentrations of natural floating marine litter.
- If the French beach data for 2006 had been included in the assessment of the overall average of items found in a 100-m beach survey in the entire OSPAR region, the contribution of items on French beaches would have increased the average number by 40 items, from 542 to 582 items of marine litter.
- Small pieces of plastic rope, cord and net (smaller than 50 cm) were the most common type of marine litter – i.e., items found in the highest numbers – on 100-metre stretches of beach in France. These items accounted for nearly 64 per cent of all items found, as compared to 14 per cent on the regular reference beaches. On the regular reference beaches, these items were the second most common type of marine litter.
- Larger pieces of plastic rope, cord and net (larger than 50 cm) was the second most common type of marine litter on 100-metre stretches of beach in France. These items accounted for approximately 9 per cent of all items found, as compared to 3 per cent on the regular reference beaches. On the regular reference beaches, these items were the eight most common type of marine litter.

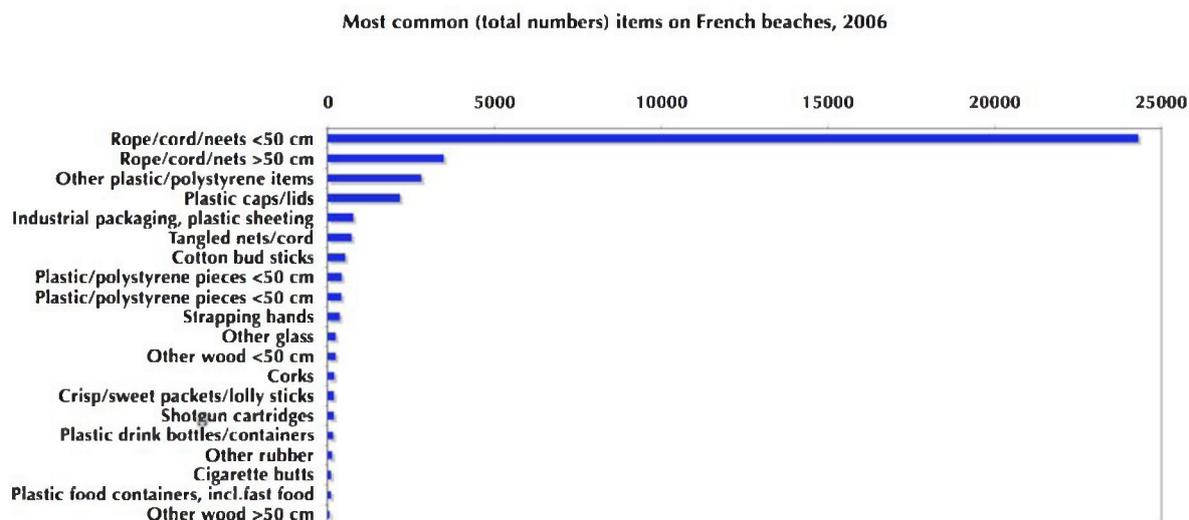


Fig. 18: Most common items on French beaches in 2006.

### 3.9.2 Composition (types of marine litter) on French beaches

- Over 95 per cent of all marine litter items found in the 100-metre surveys on French beaches, were made of non-degradable plastic and/or polystyrene. The corresponding figure for the regular reference beaches (all regions) was about 75 per cent.

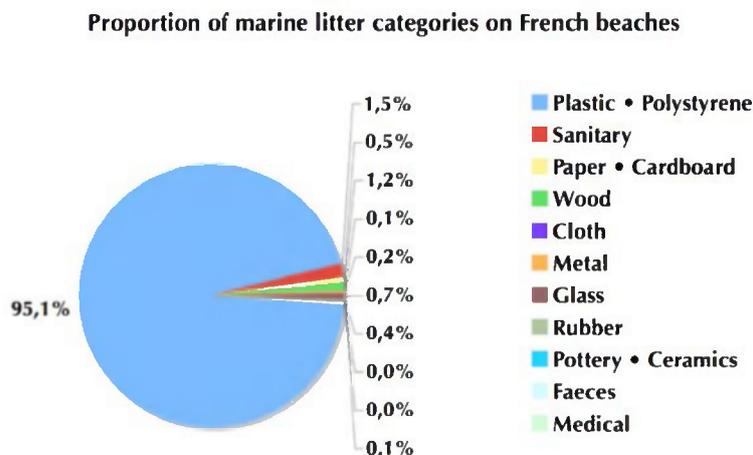


Figure 19: Proportion of different categories of marine litter found in the 100-metre surveys on French beaches in 2006.

- If the French beach data had been included in the assessment of proportion of plastic and polystyrene items found on beaches in the Southern North Sea region, the contribution of plastic/polystyrene on French beaches would have increase the proportion from close to 75 per cent to about 82 per cent.

### 3.9.3 Average number of indicator items on French beaches

- The average number of indicator items found on French beaches in 2006, compared to the number of indicator items found on the regular reference beaches in the entire area during the same period, is significantly higher for two sources: fishing and shipping, respectively. The difference is particularly pronounced for indicator items for fishing, including aquaculture.

Table 4: Average number of indicator items per source, found in 100-m surveys on French beaches in 2006.

Source	Average number of indicators on French beaches, 2006	Average number of indicators on reference beaches, 2006
Fisheries, including aquaculture	2 851	116
Galley waste from shipping, fisheries and offshore activities ( <i>non-operational waste</i> )	8	7
Sanitary waste (sewage-related waste)	52	47
Shipping, incl. offshore activities ( <i>operational waste</i> )	113	15
Tourism / Recreational activities	49	68



Beach in the UK. Photo: Steve Trehwella, Marine Conservation Society.

### 3.10 1-km surveys: Quantities of marine litter

The surveys of 1 km long stretches of reference beaches included counts of 21 large litter items. "Larger" means items generally larger than 50 cm in any one direction, but also items smaller than this (rubber gloves, and clothes and shoes which are, or can be, smaller than 50 cm) were also included in the survey forms.

A total of 22,415 items were recorded during the surveys on 1 km long stretches. On average, 67 items were recorded per survey (i.e., per km of beach). The maximum number of items recorded during an individual survey was 1,231, and the minimum was 0.

The average number of large marine litter items found per kilometre varied between the countries. The average for the respective countries were:

- Germany: 112 items
- The Netherlands: 103 items
- Spain: 94 items
- Belgium: 29 items
- United Kingdom: 26 items
- Portugal: 26 items

The most common items recorded were:

- Other wooden items: 19 per cent
- Rope and cord: 18 per cent
- Nets, including fishing nets and fishing line: 16 per cent
- Strapping bands: 9 per cent
- Other large plastic/polystyrene items: 8 per cent
- Packaging, plastic sheeting: 8 per cent

With few exceptions the composition of the marine litter, and the relative proportion of the different items recorded, were remarkably similar between the six countries analysed. The ten most common items for a given country always accounted for approximately 90 per cent of all marine litter found for that country.<sup>19</sup>

### 3.11 1-km surveys: Composition (types) of marine litter

- In the 1-km surveys, larger plastic and polystyrene items were the most common types of marine litter in all countries (range 59–74 per cent of total).
- With the exception of Belgium, where rubber items accounted for 16 per cent of the total, wooden items were the second most common type of marine litter in the 1-km surveys in all countries (range 15–32 per cent).
- Textile items, especially textile ropes, were exceptionally common in Portugal and accounted for 15 per cent of the total of all marine litter items recorded there.
- 58 per cent of all strapping bands and 76 per cent of all plastic crates found in the 1-km surveys were recorded in Spain.
- 61 per cent of all nets (including fishing nets and fishing line) found in 1 km-surveys were recorded in The Netherlands and Germany.

Proportion of marine litter categories, 1 km surveys

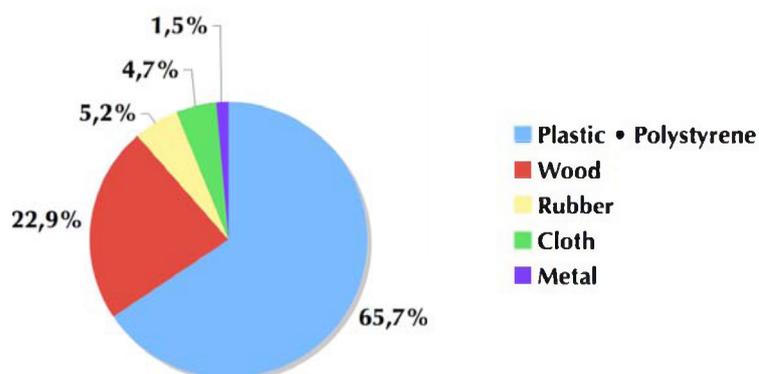


Fig. 20: Proportion of different categories of marine litter found in the 1-km surveys on reference beaches.

<sup>19</sup> Nets (including fishing nets and fishing line), other large wooden items and rope/cord were under the three most common items in the Netherlands the United Kingdom and Germany and were only less common than strapping bands in Spain. Nets (including fishing nets and fishing line) and other large wooden items were the two most common items in Belgium. Rope/cord items topped the list in Portugal, followed by other large wooden items, other large plastic/polystyrene items, rope (textile) and nets (including fishing nets and fishing line). Packaging, plastic sheeting items and other large plastic/polystyrene items were also very common in the Netherlands, the United Kingdom, Germany, Belgium and Portugal and other large plastic/polystyrene items were under the top ten most common items in Spain. Strapping bands were under the top ten items in all countries except Portugal and topped the list in Spain. Rubber gloves were under the top ten items in Belgium, the Netherlands, Germany and Spain. Jerry cans were under the top ten items in the Netherlands, Belgium, Germany, Portugal and Spain. Fish boxes were the tenth most common item in the Netherlands, the United Kingdom, Spain and Portugal. Tyres and belts were more common in Belgium and other large metal items more common in the United Kingdom than they were in the other countries. Buoys were more common in Spain and Portugal than in the other countries. Crates were exceptionally common in Spain.

### 3.12 Comparison between survey methods

#### TIME TRENDS IN THE 1-KM SURVEYS

Seen over all the 31 surveyed beaches, there was a statistically significant decrease in the amount of marine litter found in the 1-km surveys. The highest numbers of items were found during 2001, when only four beaches were surveyed. When the data gathered that year is excluded<sup>20</sup>, the decrease is less pronounced, although the trend is still significant.

However, there were large differences among beaches and countries. In some countries there were weak but non-significant increasing trends, whereas decreasing but non-significant trends were demonstrated in others, and a significant decreasing trend could be seen in one country.

#### DO THE NUMBERS OF ITEMS FOUND CORRESPOND IN THE TWO KINDS OF SURVEYS?

The total number of marine litter items found on beaches during the 100-metre surveys were tested with correlation analysis against the number of items found during the 1-km surveys. This was done for all dates and beaches where both survey protocols were used during the same season. Strong positive correlations would indicate that the pattern of total number of objects found would display the same pattern of occurrence of marine litter on the beaches. Such statistically positive correlations were found for four beaches (in three countries), which could indicate that for these beaches surveys carried out according to one protocol only might give significant information about the number of marine litter items that would be found also with the other kind of survey. However, for the other 27 beaches there was no significant correlation, thereby indicating that the 1-km survey protocol cannot be used in place of the 100-metre survey protocol, as it will not give representative and accurate data on litter sources and types.

On average, *per metre* of beach, only 5.3 per cent of the total number of marine litter items found in surveys on 100-metre stretches of beach were found when beaches were surveyed on the 1-km stretches.

Obviously, more marine litter items can be found when you look for well over one hundred different items in eleven categories, many of which are very common (and small). The low degree of correlation between the number of items found in the two kinds of surveys rather indicates that larger items (the ones that can be detected when following the protocol for 1-km surveys) have a somewhat different dynamic than the small items that dominate in surveys according to the 100-metre survey protocol.

Consequently, the conclusion from the pilot project is that surveys conducted on 100-metre stretches of beach should be the priority. Surveys made on 1-km stretches, with the less detailed protocol, do not give a representative picture of the presence of marine litter on reference beaches. Such surveys could, however, where possible, serve as a complement to surveys made on 100-metre stretches of beach.

#### AVERAGE NUMBER OF ITEMS FOUND

Regarding average number of marine litter items found per survey in the 1-km surveys, the differences among countries were statistically significant.



*Beach in Belgium. Photo: Francis Kerckhof, MUMM*

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<sup>20</sup> One of the surveys made on the German beach Scharhörn in 2005 has not been included in the analysis. During that survey such a high number of items were found that including that data would influence the entire time trend analysis.

## 4. Regional assessments of marine litter on beaches in the OSPAR region – quantities and composition

For the purpose of testing the indication of regional differences and trying to make regional analyses of the composition of marine litter on the reference beaches, as well as trying to explore possible regional trends, the reference beaches were grouped into sub-regional units.

Of the delimitations of the North-East Atlantic made for the purpose of the OSPAR Convention, only the delimitations of the Celtic Seas would be useful for the purposes of analysing regional characteristics of beached marine litter within the framework of the pilot project. Instead, as the basis for regional analyses of project beach data, the reference beaches were grouped regionally as follows. However, due to lack of data from the Bay of Biscay, beach data from only four regions have been included in the analyses.

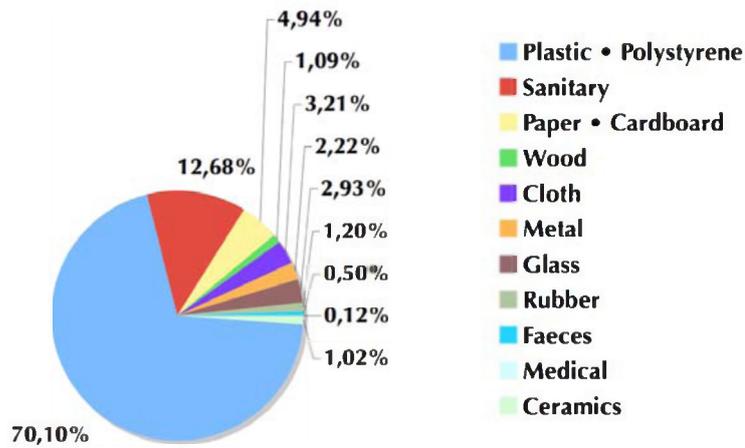
1. Northern North Sea;
2. Celtic Seas;
3. Southern North Sea;
4. Bay of Biscay;
5. Iberian coast.



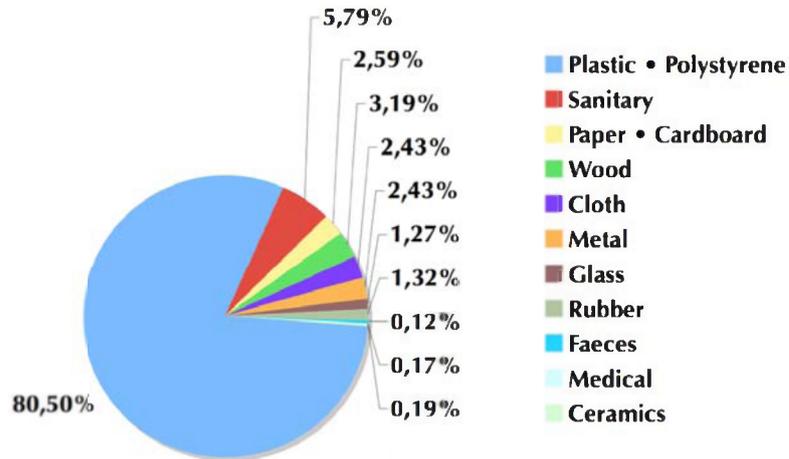
### 4.1 100-m surveys: Types of marine litter found, by region

- Plastic and polystyrene items dominated in all regions (*Figures 21-24*). The highest proportion (80 per cent) of plastic and polystyrene items was found on the Northern North Sea beaches, and the lowest (62 per cent) on the beaches on the Iberian coast.
- The proportions of the other types of materials were rather similar in all regions, with some notable exceptions (paper and sanitary items).

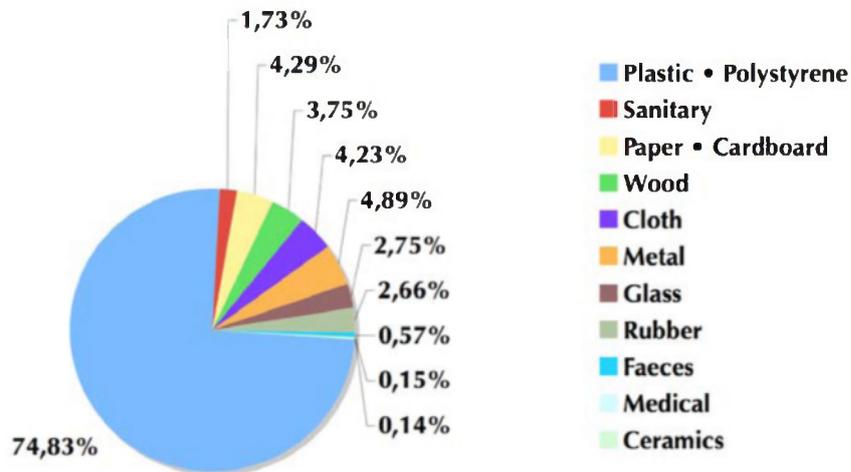
**Proportion of marine litter categories on Celtic Seas beaches**



**Proportion of marine litter categories on Northern North Sea beaches**



**Proportion of marine litter categories on Southern North Sea beaches**



### Proportion of marine litter categories on Iberian coast beaches

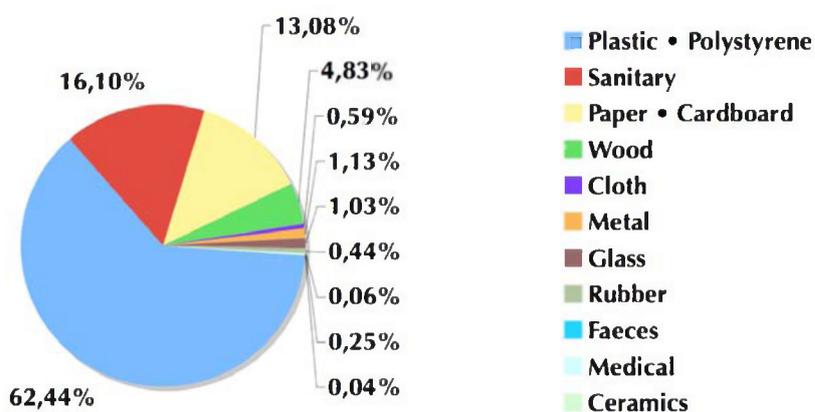


Fig 21-24: The proportions of marine litter categories on reference beaches in the Celtic Seas, Northern North Sea, Southern North Sea, and Iberian coast.

## 4.2 Total numbers of marine litter items found, by region

- The total number of marine litter items found per stretch of beach varied considerably among beaches and surveys in different regions (Figure 25).
- On average, significantly more items were found 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.

### Average number of marine litter items per 100 metres on the reference beaches

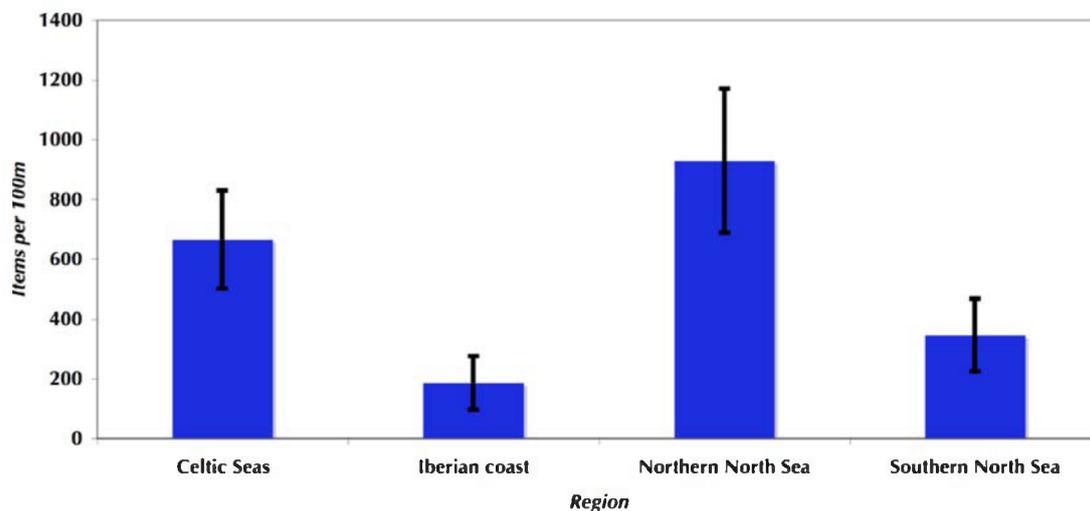


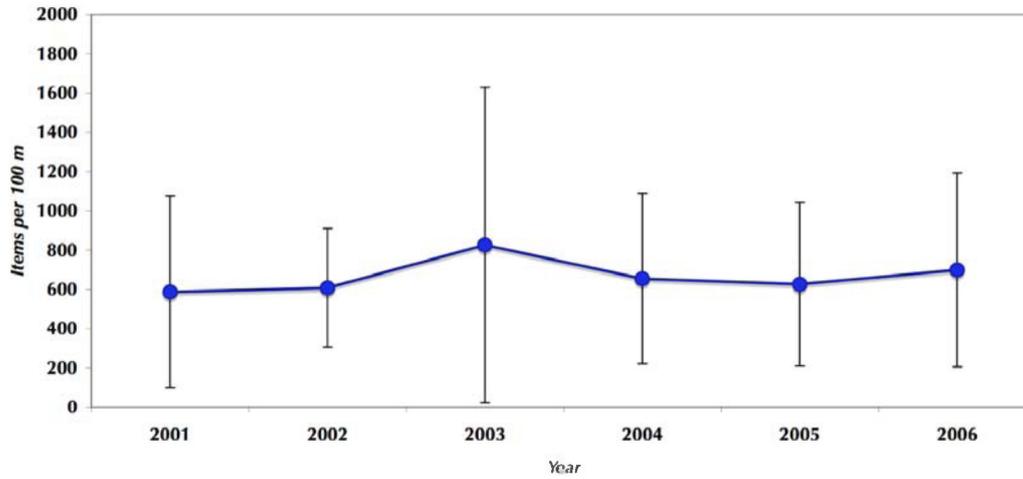
Fig 25: Average numbers of marine litter items found per 100 metres of beach on the regular pilot project reference beaches, region by region. (Data compiled from all four seasons during the project period, 2001–2006). Each error bars shows a 95% confidence interval.

## 4.3 Trends in the annual average numbers of marine litter items, by region

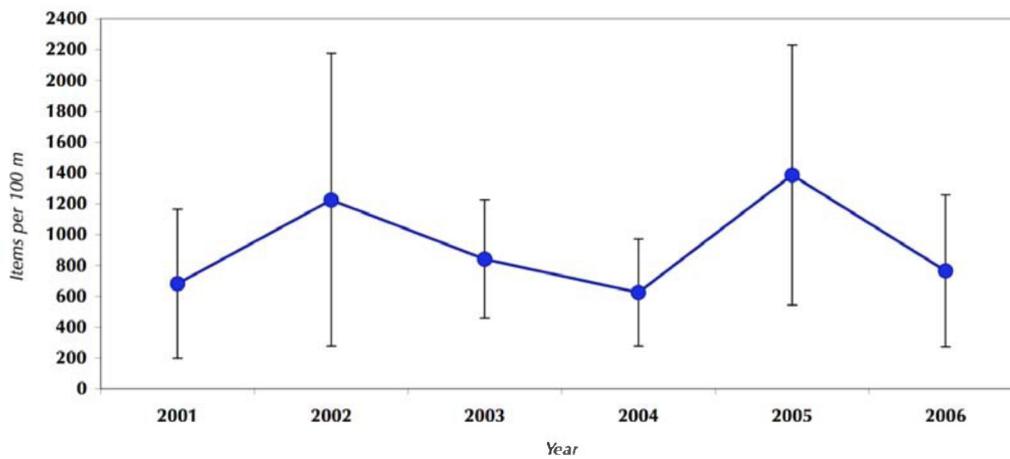
- There were no statistically significant trends of either a decrease or an increase in the average number of marine litter items found on the regular reference beaches in either one of the four regions (Figures 26-29). However, from 2003 onwards there appears to be an increasing trend in the number of marine

litter items found on the reference beaches in the Southern North Sea as well as on those on the Iberian coast, although these were not shown to be statistically significant. (This could be qualified by further monitoring.)

Average number of marine litter items on Celtic Sea reference beaches

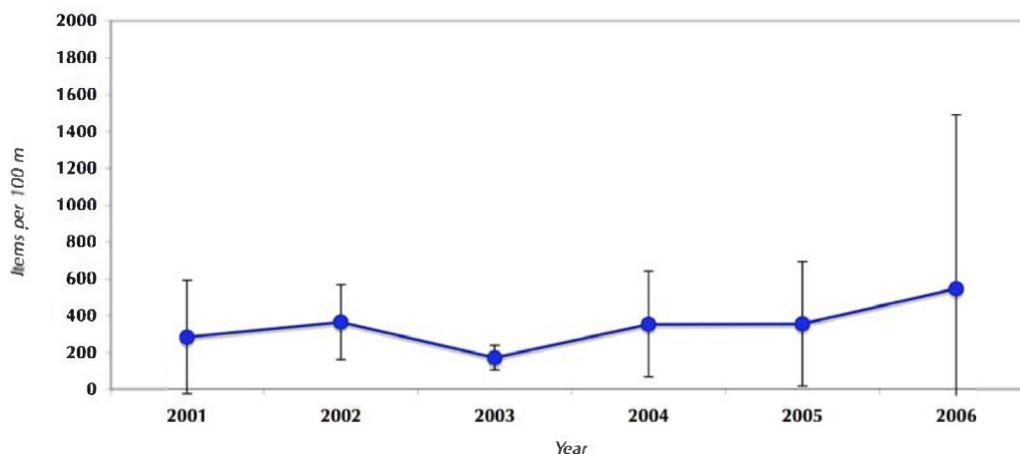


Average number of marine litter items on Northern North Sea reference beaches

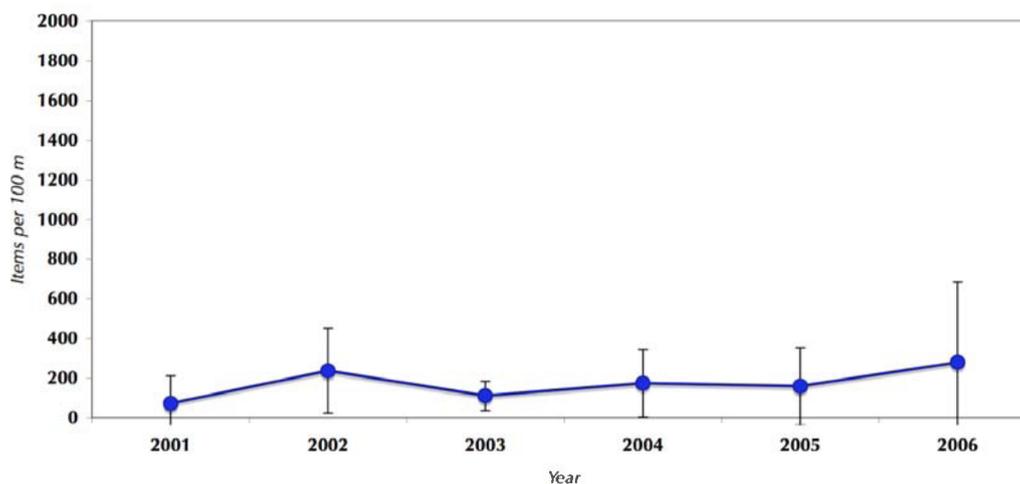


Beach and bay on the Swedish west coast. Photo: West Coast Foundation.

Average number of marine litter items on Southern North Sea reference beaches



Average number of marine litter items on Iberian coast reference beaches



Figures 26-29: The annual average numbers of marine litter items found on the reference beaches in the Celtic Seas, Northern North Sea, Southern North Sea, and Iberian coast, regions, and changes in the annual average number of marine litter items found on the reference beaches there.



Beach in northern Spain (Galicia). Photo: Fernando Lahuerta Mouriño, Ollalomar

## 5. How to monitor marine litter on beaches in the OSPAR region

With regard to considerations on monitoring of marine litter in the OSPAR region, the Terms of Reference for the OSPAR Pilot Project on Monitoring Marine Beach Litter have been: "Following the conclusion of the pilot project and on the basis of the experience gained, to suggest how the litter monitoring could continue as part of the monitoring of the state of the environment of the OSPAR maritime area".



*Beach in Germany. Photo: The German participants in the OSPAR pilot project.*

### 5.1 A method that works

The monitoring method has proved functional for the purpose of providing data on marine litter on beaches. The 100-metre surveys, supplemented by 1-km surveys, where possible, provide a feasible approach to monitoring of marine litter in the coastal and marine environment in the OSPAR region.

The monitoring method developed within the pilot project could be used to monitor marine litter on beaches in the OSPAR region, should the OSPAR Commission decide that monitoring of marine litter on beaches should be included as a regular part of the OSPAR Joint Assessment Monitoring Programme.

The handling of data – from surveyors making notes in survey protocols and putting the data into a common internet-based database, to the use of the database in making statistical analysis of the survey results – has worked smoothly. Once surveyors have been introduced to the method, beach surveys can basically be conducted independently by national coordinators and individual surveyors – provided there is an easily accessed central reference point (international coordination, Lead Party for marine litter etc.) for queries in case of problems, and provided that long-term, central maintenance of the database is cared for.

### 5.2 Lessons learned and suggestions for improvement

Based on the experience gained in the pilot project, some aspects could be highlighted where there is room for further improvement of the monitoring method in order to make it more robust.

#### 5.2.1 Expansion of the network of reference beaches

For the sake of continuity in the areas that have been included in the pilot project it would be important in future regular monitoring activities to maintain as many as possible of the project reference beaches. This is particularly true for beaches that have been monitored during the full six-year period.

The majority of the reference beaches in the network within the pilot project have been located in the northern part of the OSPAR area. In order to get an even more comprehensive and complete picture of the situation with regard to marine litter, and to reflect trends and possible regional differences throughout the

whole OSPAR region, the network of reference beaches for monitoring should preferably be further expanded into areas that have not been included in the pilot project.

The Steering Group recommends that reference beaches be added in the following locations:

- **Norway.** To obtain a picture of the marine litter situation along the long coast of Norway is of utmost importance for a more complete overview of the situation in the OSPAR region. In southern Norway, coverage of the Kristiansand–Mandal–Egersund region would be desirable.
- **Denmark.** A location halfway between Skagen and the Danish-German border. The importance of maintaining at least one reference beach in the Faroe Island should also be emphasised.
- **United Kingdom.** Northwest Scotland. Outer Hebrides. Orkney Islands. Shetland Islands. Northern Ireland. Additional reference beaches in these locations would provide a better picture of the quantities of marine litter transported into the OSPAR region from across the Atlantic or from the outer western parts of the OSPAR region (fisheries and shipping).
- **Ireland.** Inclusion of reference beaches in Ireland (particularly to the west, and to the south) would provide a better picture of the quantities of marine litter transported into the OSPAR region from across the Atlantic or from the outer western parts of the OSPAR region (fisheries and shipping).
- **France.** Inclusion of reference beaches in locations in the regions of Aquitaine, Pays de Loire, and southern Bretagne, respectively, would provide a better overall picture of the marine litter situation in the Bay of Biscay.
- **Spain.** The coast of the Basque Country and Cantabria. Reference beaches in these locations would provide a better picture of the marine litter situation in the southern part of the Bay of Biscay.



*Beach on the Swedish west coast. Photo: West Coast Foundation*

### **5.2.2 Making use of "old" data**

Even if beaches have not previously been surveyed according to a common methodology, and existing marine litter data from one project is not readily comparable with that of another project (national or regional), the data and the experience gained (knowledge of the beaches) will provide useful and valuable background information on the state of marine litter pollution in a given region. In the selection of beaches for regular, long-term monitoring of marine litter one should first undertake an unbiased "scan" of all efforts, ongoing or already made, in the country (beach-cleaning activities, monitoring, research).

*<> On marine litter surveys in parts of the OSPAR region: Marine Litter Net <>*

### 5.2.3 Improved documentation of beaches

The beach questionnaires have provided valuable background information for the interpretation of data of marine litter on individual reference beaches in the pilot project. However, in future regular monitoring, more emphasis should already from the outset be put on the elaboration of detailed documentation of reference beaches. It is vitally important to have a standard form for all beaches, but the form should also be very specific in terms of questions regarding, e.g. beach cleaning frequency (although beaches should, preferably not be regularly cleaned: see below), vicinity of the beach to a shipping lane, sewage outlet, etc.

Furthermore, in regular, long-term monitoring of marine litter on beaches, photographs of the beaches should be an integral part of the methodology and, especially, the documentation. Preferably, one (digital) picture per survey should be taken to document changes in the survey site.

### 5.2.4 Beach cleaning and removal of marine litter items

In the statistical analyses of the results of pilot project beach surveys, problems have been encountered when having to compensate for cleaning and variations in cleaning intervals on different beaches.

It would simplify the analytical work if surveys can be made on beaches that have not been cleaned<sup>21</sup> between surveys. However, the importance of removing marine litter items from such reference beaches, after each survey, should still be emphasised.

If an otherwise regularly cleaned beach must be used, it should be possible to "seal off" a small part of the beach and mark it for easy identification to make sure that it is untouched by beach cleaners when the rest of the beach is being cleaned. However, the cleaning that takes place in the sections surrounding the "sealed-off" beach section is likely to change the "litter balance" in the area, thus influencing the results of the survey carried out. It could also be argued that sealing off an area could be difficult to do for aesthetic as well as safety and health reasons.

Not in contradiction to the above it can also be noted that beach cleaning can, in some cases (like in areas with distinct tides), be less of a problem, provided that it is controlled and "regular", i.e., stays at the same intensity over time. For example, if surveys are conducted frequently, at strictly regular intervals after high tides, and before the beach is cleaned after the tide, it will be possible to detect trends in marine litter composition. It should also be noted that in some countries it is obligatory to clean beaches.



*Beach in The Netherlands. Photo: Wouter Scholten, Stichting de Noordzee*

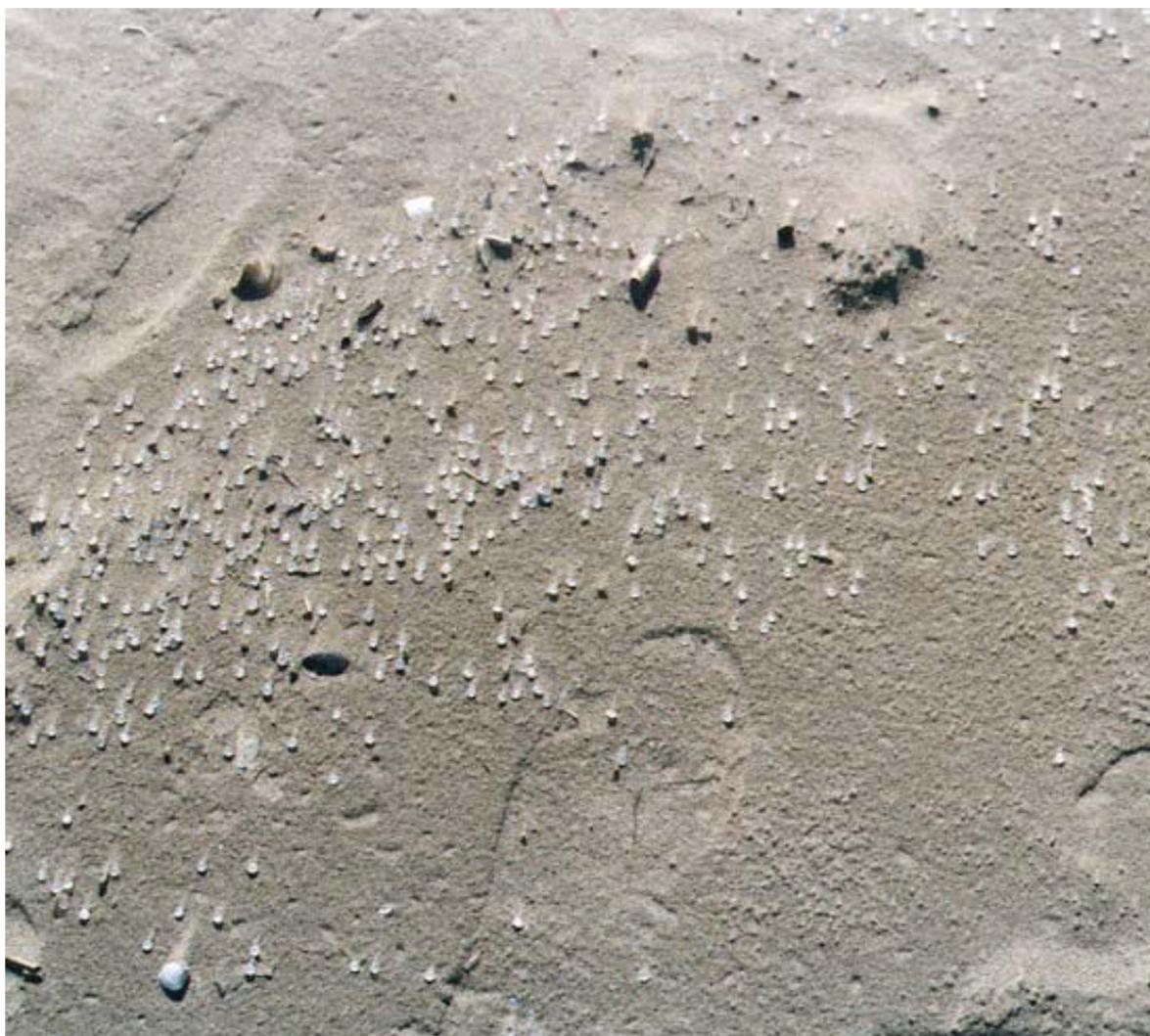
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<sup>21</sup> If beaches, including reference beaches are regularly cleaned they should, for ecological reasons, preferably be only manually cleaned, not mechanically. However, from a strict monitoring point of view it could be argued that marine litter items of all shapes and sizes are like to be very efficiently removed by means of mechanical cleaning.

### **5.2.5 Revision of the survey protocol(s)**

For the purpose of regular, long-term monitoring of marine litter on beaches, one needs to select which items to be included in the survey protocol to be used. This selection will include decisions on which specific items and number of items to count and register in surveys, and which categories of items to assign them to. The pilot project database is comprised of a list of items that have been found on the reference beaches, and how frequently and in what numbers they have been found. It is, therefore, a good starting point for a revision of the survey protocol used in the pilot project (see also the previous remark regarding addition of items during the course of long-term monitoring).

The classification of marine litter items according to material type is, in most cases, fairly easy. It is straightforward to decide whether an item is made entirely or mainly of plastics/polystyrene, rubber, wood, metal, glass, paper/cardboard, or textiles/leather. Two of the categories/item groups in the protocol – sanitary items and medical items – refer to uses and sources rather than actual composition of the item itself. The items included in these two categories do, however, mainly consist of plastic, rubber, glass or metal. In any future use of the survey protocol, or establishment of a revised one, one could thus consider whether items classified as "sanitary items" or "medical items" should be included in the respective group of fabrication materials, instead.



*Small plastic pellets scattered all over beach in Belgium. Photo: Francis Kerckhof, MUMM*

### **5.2.6 More work on indicators**

In order to quantify and determine the relative importance of different sources of marine litter, indicator items representing each of the described sources to be studied needed to be identified. Part of the statistical analysis of the pilot project beach survey data was to test whether a number of proposed indicators of five

sources of marine litter were relevant and could be used in regular monitoring of marine beach litter. These indicators were chosen from the 107 items included in the survey protocol for 100-metre stretches and, thus, represent approximately 60 per cent of the total number of marine litter items found, counted and identified in the surveys.

However, in order to further refine the analysis of marine litter sources for possible future monitoring of marine litter on beaches in the OSPAR region, the efforts to identify relevant indicator items needs to continue. This holds particularly true for indicators of the probably most difficult of the five sources identified in the pilot project (tourism-recreational activities), as well as for the identification of a few relevant general indicators of marine litter. Further attention should also be given to the choice of total number of indicators for each source.

### **5.2.7 Database and responsible data host**

Setting up a user-friendly internet-based database for surveyors to use is relatively easy and inexpensive. In the pilot project, the database comprised entry points for over 50 beaches, and people with good but not exceptional computer skills put in data with relative ease. The database was funded by the Lead Party of the pilot project and hosted by an ordinary commercial IT operator.

However, in future regular and long-term beach litter monitoring programme, one would need to find and contract a data host that is prepared to allow password-protected access by external users (surveyors), and to maintain the database on a long-term basis.



*Beach in northern France. Photo: Association E.S.T.R.A.N*

### **5.2.8 Some reflections on costs**

In terms of costs for monitoring of reference beaches in accordance with the method and work procedures developed within the pilot project, an annual budget will be needed for beach surveys (manpower, transport, material), maintenance of a database, and statistical analyses of the survey data.

- Based on experience from surveys carried out within the framework of the pilot project, it takes at least two hours for two people to survey marine litter on a 100-metre stretch of beach, and at least another hour for the survey of a 1-km stretch. In addition, it takes at least one hour to fill out the protocol (form) and put the survey data into the database. Thus, a total of at least six hours should be estimated per beach and survey.
- The time necessary for travelling to and from the beach, and the travel costs, should be added. These costs will, obviously, vary from beach to beach, depending on the distance from the "home base" of the surveyor.

- Coordination at the national level is needed, to coordinate the national survey work and to participate as the national representative in international cooperation on marine litter monitoring. The costs will be determined by national ambitions, and salary levels, as well as by the framework for monitoring set at the common OSPAR level.
- The total costs (system set-up and regular maintenance) for an internet-based database like the one used in the pilot project amount to approximately € 5,000 per year.
- The costs for making regular statistical analyses of the beach survey data will depend on the level of ambition (number and frequency of analyses), as well as on the statistical methods used, the experience of the analyst, etc. No general advice can be given; this must be decided from case to case.

### 5.3 About marine litter in the OSPAR region

In the limited perspective of six years, the "load" of marine litter in the OSPAR region appears to be about the same. The fact that no statistically significant trend has been established within the framework of the pilot project of either an increase or a decrease since 2001 in the presence of marine litter on the 100-metre stretches of reference beaches in the OSPAR region should not be interpreted as a good sign as far as the coastal and marine environment is concerned. It should be emphasised that the initial levels monitored at the start of the pilot project were already high and causing significant negative effects in the coastal and marine environment in many parts of the OSPAR region.

Thus, it is reasonable to arrive at the conclusion that there has been neither any significant improvement, nor any significant deterioration, of the overall situation since 2000 with regard to marine litter on beaches in the OSPAR region as a whole.



*Beach on the Swedish west coast. Photo: West Coast Foundation*

### 5.4 How marine litter could be part of the monitoring of the state of the environment in the OSPAR region

The method developed within the OSPAR Pilot Project on Monitoring Marine Beach Litter could be used as a cost-effective means to monitor marine litter on beaches in the OSPAR region, should the OSPAR Commission decide that such monitoring be included as a regular part of the OSPAR Joint Assessment and Monitoring Programme (JAMP).

Monitoring is presently undertaken in individual countries through a mixture of voluntary work and government funding, but currently there is no monitoring programme for marine litter under the JAMP.

However, based on the results of the pilot project it has proved feasible to monitor and identify trends in the occurrence of marine litter on beaches. Such information can be used as a basis for marine management decisions and policy development. Therefore, the marine litter monitoring method developed in the pilot project could be used in the development of the JAMP.

It has proven difficult to create a direct relationship between indicator items from the five different sectors (sources) fisheries; galley waste; sanitary waste; shipping and offshore activities; and, tourism. In the pilot project, it has been possible only to investigate and identify trends in each sector and determine whether these trends are statistically significant. It has not been practically or statistically possible to identify the full proportion of marine litter from each sector, as some marine litter items can originate from sources in more than one sector and the sets of indicators cannot be directly compared. One way to link non-comparable data is to develop an indexing system where the percentage change for each sector is monitored and then combined to give an overall index. This would then indicate potential problems that could be investigated and potentially managed.

The issue of a marine litter index was discussed by the project Steering Group in 2005, but it was decided that there were insufficient resources to fully explore this concept. However, an indexing system could potentially be used to integrate marine litter monitoring into the OSPAR framework and JAMP, providing a mechanism for regular assessment of the problem based on the method developed in the pilot project. An index could then be integrated into an operational objective for marine litter, with the goal of reducing the index by a set percentage.

Data for a marine litter index would come from national surveys, through a central co-ordinating point, with the important trends in each sector, as identified in this project, being reviewed by a wider statistical analysis every 3 or 5 years. It is important, however, that during the development of a marine litter index, the base data used has to be unbiased and proven not to be either over or under representing sectors over the whole region.

Due to its region-wide scope, the methodology and findings of the pilot project have provided a major step forward in the analysis and better understanding of the sources and trends of marine litter in Europe. This information should be disseminated to the international community, e.g., the International Maritime Organization and the European Union, which are currently revising or formulating new marine environmental controls and policy. The findings of and methodology developed by the OSPAR Pilot Project on Monitoring Marine Beach Litter, could be a tool to inform these processes, e.g., through academic publications and submissions to the appropriate bodies.



*Beach in the Netherlands. Photo: Wouter Scholten, Stichting de Noordzee*

## Annex 1: Pilot project Steering Group

The Steering Group has consisted of national project coordinators and representatives of organisations that coordinate beach surveys, as well as the project management, and representatives of OSPAR observer organisations. In Belgium, Portugal and Spain, the national project coordinators have also conducted the beach surveys.

### BELGIUM

*National project coordinator:*

Francis Kerckhof  
Koninklijk Belgisch Instituut voor Natuurwetenschappen  
Departement Beheerseenheid van het Mathematisch Model van de Noordzee  
f.kerckhof@mumm.ac.be • www.mumm.ac.be

### DENMARK

*Mainland national project coordinator:*

Hans-Henrik Jørgensen  
Skagen Kommune, Drift & Service  
hans.henrik.jorgensen@skagen.dk • www.skagen.dk

*Faroe Islands coordinator of beach surveys:*

Sveiney Sverrisdóttir  
Føroya Kommunufelag  
kontakt@fkf.fo • www.fkf.fo

*Former Danish national project coordinators:*

Steen Davidsen, Holmsund kommune (Hvide Sande beach): 2002–2003  
Anders Clausen, Skagen kommune: 2003–2005

*Former coordinators of Danish beach surveys:*

John Pedersen (Skagen beach): 2003–2005  
Keith Sørensen (Hvide Sande beach): 2002–2003

### FRANCE

*National project coordinator:*

Arnaud Guéna  
Cedre  
Arnaud.Guena@cedre.fr • www.le-cedre.fr/fr/rejet/macro\_dech.html

### GERMANY

*National project coordinator:*

David M. Fleet  
Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer  
david.fleet@nationalparkamt.de • www.wattenmeer-nationalpark.de

### THE NETHERLANDS

*National project coordinator:*

Barbara Wenneker  
RWS. Directie Noordzee  
B.Wenneker@dnz.rws.minvenw.nl • www.noordzee.org

*Coordinators of beach surveys:*

Ike Span, Jeroen Dagevos  
Stichting De Noordzee  
i.span@noordzee.nl • j.dagevos@noordzee.nl • www.noordzee.nl/

*Former Dutch national project coordinators:*

Henk Offringa, RWS. Directie Noordzee: 2000

Sander de Jong, RWS. Directie Noordzee: 2001  
Nouria Ouibrahim, RWS. Directie Noordzee: 2001–2002

*Former coordinators of Dutch beach surveys:*

Wouter Scholten, Stichting de Noordzee: 2001–2004  
Eddy van Well, Stichting De Noordzee: 2004– summer 2006

PORTUGAL

*National project coordinator:*

Fátima Brito  
Instituto da Água  
fatima.brito@inag.pt • www.inag.pt

SPAIN

*National project coordinator:*

Fernando Lahuerta Mouriño  
Ollalomar  
ollalomar@telefonica.net • www.telefonica.net/web2/ollalomar/

SWEDEN

*National project coordinator:*

Roland Olin  
Väst kuststiftelsen  
roland.olin@vastkuststiftelsen.se • www.vastkuststiftelsen.se

UNITED KINGDOM

*National project coordinator:*

Brian Elliott  
Maritime & Coastguard Agency  
environment\_environment@mca.gov.uk • www.mca.gov.uk/

*Coordinator of beach surveys:*

Gill Bell  
Marine Conservation Society  
info@mcsuk.org • www.mcsuk.org • www.adoptabeach.org.uk

*Former UK national project coordinator:*

Sharon Worth, Maritime and Coastguard Agency: 2000–2001

*Former coordinators of UK beach surveys:*

Sam Fanshawe, Marine Conservation Society: 2000  
Amy Hinks, Marine Conservation Society: 2001–2002  
Alison Conway, Marine Conservation Society: 2002–2003  
Andrea Crump, Marine Conservation Society: 2004– June 2006  
Bethan Jones, Marine Conservation Society: July–December 2006

OBSERVER ORGANISATIONS

Rick Nickerson  
KIMO International  
kimo@zetnet.co.uk • www.kimointernational.org

PROJECT MANAGEMENT

Bertil Hägerhäll and Britt Aniansson  
Ardea Nova AB (commissioned by the Swedish Environmental Protection Agency)  
bertil@ardea.se • britt@ardea.se • www.marine-litter.net

Per Nilsson  
Tjärnö Marine Biological Laboratory  
Per.Nilsson@tmbl.gu.se • www.tmbl.gu.se

## Annex 2: Pilot project reference beaches

<p><i>BE1, DK3, NL4, UK20, etc?</i></p> <p>Country code and beach number used in the project database</p>	<p><i>Which beach in which region?</i></p> <p>(1) Northern North Sea (2) Celtic Seas (3) Southern North Sea (4) Bay of Biscay (5) Iberian coast</p>
<p><b>BELGIUM</b></p> <p>BE1 = Oostende (3) BE2 = Koksijde St.-Andre (3)</p> <p><b>DENMARK</b></p> <p>DK1 = Hvide Sande (1) DK2 = Suggan, Streymoy Island, Faroe Islands (1) DK3 = Sumba/Strondin, Suderoy, Faroe Islands (1) DK4 = Skagen (1)</p> <p><b>FRANCE</b></p> <p>FR1 = Trunvel (3) FR2 = Le Stang (3) FR3 = La Torche (3) FR5 = Dieppe (3)</p> <p><b>GERMANY</b></p> <p>DE1 = Sylt (3) DE2 = Scharhörn (3) DE3 = Minsener Oog (3) DE4 = Norderney (3) DE5 = Juist (3)</p> <p><b>NETHERLANDS</b></p> <p>NL1 = Bergen (3) NL2 = Noordwijk (3) NL3 = Veere Ostkapelle (3) NL4 = Terschelling (3)</p> <p><b>PORTUGAL</b></p> <p>PT1 = Praia da Barra (5) PT2 = Praia da Duquesa (5) PT3 = Praia da Carcavelos (5) PT4 = Praia da A (5) PT5 = Praia B Mela-Praia (5) PT6 = Manta Rota (5) PT7 = Cabadelo (5)</p>	<p><b>SPAIN</b></p> <p>ES1 = A Lanzada (5) ES2 = Baldaio (5) ES3 = La Caldera Playa de Valdevaquero (5)</p> <p><b>SWEDEN</b></p> <p>SE1 = Älgön (1) SE2 = Mollön (1) SE3 = Gåsö (1) SE4 = Haby (1) SE5 = Edsvik (1) SE6 = Saltö (1)</p> <p><b>UNITED KINGDOM</b></p> <p>UK 1 = Hilbre Island (2) UK 2 = Tan-y-Bwlich (2) UK 3 = Treath Mawr Beach (2) UK 4 = West Angle Bay (2) UK 5 = Freshwater East (2) UK 6 = Burnham-on-Sea (2) UK 7 = Hastings (3) UK 8 = Margate Main Beach (3) UK 9 = Heacham Beach (3) UK 10 = Staithes Beach (1) UK 11 = Cramond Beach (1) UK 12 = Balmedie - Menie Links (1) UK 13 = Porthkidney Sands - Lelant Beach (2) UK 14 = Silloth-Allonby (2) UK 15 = St. Marys' Bay (3) UK 16 = Chilton Chine Isle of Wight (3) UK 17 = Rocquaine Guernsey (3) UK 18 = Linkim Shore - St. Abbs (1) UK 19 = Upgang Beach (1) UK 20 = Sand Bay (2)</p>



#### ABOUT THE BEACHES

**Belgium:** Two Belgian beaches have been surveyed. Both beaches are gently sloping and exposed to the open sea. They are sandy, wide, and located in dune areas, one of which is protected as a nature reserve. Both beaches are located close to urban areas; one of the beaches is close to the Oostende-Brugge canal. Neither of the beaches has a sewage outfall in the area. Tourists and local beach-goers frequently visit the beaches. The beaches are both located close to a major shipping lane (the English Channel, with extensive shipping through and across the Channel).

**Denmark, with the Faroe Islands:** During the project, four beaches have been surveyed, two of which on the Danish mainland and two on the Faroe Islands. The first beach on the mainland was surveyed for two years (2002-2003) and was then replaced by the second mainland beach (surveyed since late 2003). The beaches on the Faroe Island were surveyed mainly during one year (2002), but some additional data has been added in 2005-2006 for one of these sites. Both mainland beaches are located on the Danish west coast. They consist of sand and shingle, are wide and gently sloping from a dune area, and are exposed to the open sea. The present beach is located on the top of the Jutland peninsula, close to the marine border between the North Sea proper and the Skagerrak. Both beaches are used by tourists but are not located in the immediate vicinity of towns, rivers or sewage outfalls. They are, however, close to major shipping lanes. The beaches on the Faroe Islands are steep, exposed to the open sea and not easily accessed. They consist of gravel and stone (boulders). Neither of these beaches is located close to an urban area, a river, or a sewage outfall, and neither is used by tourists.

**France:** The four French beaches – three in Bretagne (Baie d'Audierne) and one in Normandie (Dieppe) – are not regular project reference beaches, but during 2006 beach surveys were carried out in accordance with the project survey method, for comparison. The beaches in Bretagne consist of sand and shingle and are situated in an area with mobile dunes. The beaches are gently sloping and exposed to the open sea, located close to major shipping lanes and fishing harbours but not close to urban areas, nor to river mouths or sewage outfalls. Tourists frequently visit two of them. The beach in Normandie is gently sloping, steep where there is shingle and pebbles, exposed to the open sea, and close to a major shipping lane (English Channel). It is located in a city, frequently visited by tourists and beach-goers, close to a river mouth and a sewage outfall.

**Germany:** The four reference beaches are all located on islands, two of which are uninhabited. Five beaches were originally included in the project, but one of the sites was dropped in 2004. The German beaches vary from being steep to very flat. They are all wide and sandy, border on dune areas, and are exposed to the open sea. Two of the beaches are adjacent to major shipping lanes (the Jade shipping lane and the route into River Elbe). There is heavy shipping traffic to and from major ports. Intense fisheries take place in the German Bight. The beaches on the inhabited islands are used for recreational activities and are frequently visited by tourists and local inhabitants. This is not the case for the beaches on the uninhabited islands, which are not easily accessed. Three of the beaches are close to mouths of large rivers (Ems, Weser, Elbe).

**The Netherlands:** Three of the four Dutch reference beaches are located on the mainland, and one on a small island off the coast. The beaches are sandy, wide, flat and exposed to the open sea. Three of them are part of a dune system. Three of the Dutch beaches are located at a distance of about 30 km or less from a river mouth; one is in close proximity to a small harbour. Three beaches are located close to major shipping lanes. Two of the beaches are located in or near a town; one of them is a four kilometres long stretch between two urban areas. Recreational activities impact two of the beaches, whereas two beaches are not frequently visited by tourists.

**Portugal:** Initially, five Portuguese reference beaches were surveyed. In late 2003, another two beaches were added, totalling seven Portuguese beaches. The beaches are located along the coast, from the northern to the southern Spanish-Portuguese border. All beaches are flat, or gently sloping, and are exposed to the open sea. Two beaches are located in dune areas. One of the southern sites includes a set of small sandy beaches, all surrounded by cliffs. The south-eastern-most beach is located on the border of the Ria Formosa Natural Park, close to River Guadiana. All Portuguese reference beaches are located near to urban areas. The two beaches close to Lisbon, as well as the beaches in the Algarve area, are used by beach-goers (local inhabitants and tourists) in large numbers all year round. Four of the beaches are close to river mouths. As all beaches are exposed to the open sea of the Atlantic, they are in the vicinity of shipping lanes running not far out at sea.

**Spain:** Initially, two Spanish reference beaches were surveyed. In 2004, another beach was added (surveyed until 2005). Two of the beaches are located in Galicia, the third one in Andalucia, in the Strait of Gibraltar. One of the Galician beaches is a great sandy long-shore tombola; one is located on a long sand bar, which partially closes a lagoon and a saltmarsh. These sandy beaches are wide, gently sloping, in dune areas, and exposed to the open sea. The southern beach, also wide and exposed to the open sea, consists of sand and subtidal rocks. None of the beaches are located close to urban areas, or close to a river mouth or sewage outfall. All of them are, however, located close to busy shipping lanes (the Finisterre Corridor in the north, shipping into and out of the Mediterranean in the south). Tourists also frequently visit all three beaches during the spring-summer season.

**Sweden:** The six Swedish reference beaches are located on the west coast. Four of the beaches are located on small islands, three of which can only be accessed by boat. With its indented coastline and thousands of small rocky islands, islets and skerries, this coastal area differs distinctly from the other project areas. Long uniform sandy beaches cannot be found in this archipelago area, and surveys have only been made on 100-metre stretches. Most of the beaches are narrow, gently sloping, and are exposed to the open sea. They consist of rocks and sand/gravel and/or pebbles and boulders; some of them are connected to grazed shore meadows. The beaches can only be surveyed three times a year, because they are inaccessible and unsafe for surveyors during the winter (heavy winds, ground and rocks covered with snow or ice). Four of the beaches are located close to a major shipping lane. Tourists visit three of the beaches. There are no sewage outfalls and few rivers in proximity to the survey sites in this region.

**United Kingdom:** During the project period, 20 UK beaches have been surveyed in total, 18 of which are on the mainland and two on islands. Originally, the UK had 12 reference beaches, but surveys were discontinued on 7 of these original beaches in late 2003. These were replaced with 7 alternate beaches in 2004, and an additional site was added in 2004/2005 with data being backdated to 2000. Two of the 13 current reference beaches surveyed in the period 2004–2006 are located in the Irish Sea (Celtic Seas), four in South West England (Wales, Cornwall and Somerset), three in the English Channel (two of them on islands; Guernsey and Isle of Wight), and four facing the North Sea (one in Yorkshire, three in Scotland). Of the beaches where surveys ceased in late 2003, three are located in South West England, one is in the English Channel, and three are facing the North Sea (North East England).

The present reference beaches in the United Kingdom consist of sand or sand and shingle, and also of sand and rocks. They are generally gently sloping or flat (only two of them steep), some of them are found in dune areas. A majority of the beaches are exposed to open sea, but three are located within a wide estuary or in a bay. The seven beaches surveyed only during the first project period are mainly sandy and gently sloping. Four of them are not directly exposed to the open sea. Less than half of all the British reference beaches (but a majority of the present ones) are located in the vicinity of a river mouth. Over half of all the beaches (and a majority of the present ones) are located in areas with major shipping lanes running close to the coast. About half of the beaches are found close to towns (although some of them quite small), and tourists and local beach-goers frequently use two thirds of the beaches. Two thirds of all the beaches are located in the vicinity of one or several sewage outfalls.

### Annex 3: Marine beach litter survey form for 100-metre stretches

		<i>Total</i>
<b>Plastic/ Polystyrene</b>		
1	4/6-pack yokes	
2	Bags (shopping)	
3	Small plastic bags, e.g., freezer bags	
<i>Bottles, containers, and drums</i>		
4	Drinks	
5	Cleaner	
6	Food incl. fast food containers	
7	Cosmetics ( e.g. sun lotion, shampoo, shower gel, deodorant)	
8	Engine oil <50 cm	
9	Engine oil > 50 cm	
10	Jerry cans (square plastic containers with handle)	
11	Injection gun containers	
12	Other	
13	Crates	
14	Car parts	
15	Caps/lids	
16	Cigarette lighters	
17	Pens	
18	Combs/hair brushes	
19	Crisp/sweet packets and lolly sticks	
20	Toys & party poppers	
21	Cups	
22	Cutlery/trays/straws	
23	Fertiliser/animal feed bags	
24	Mesh vegetable bags	
25	Gloves	
26	Crab/lobster pots	
27	Octopus pots	
28	Oyster nets or mussel bags	
29	Oyster trays (round from oyster cultures)	
30	Plastic sheeting from mussel culture (Tahitians)	
31	Rope/cord/nets < 50 cm	
32	Rope/cord/nets > 50 cm	
33	Tangled nets/cord	
34	Fish boxes	
35	Fishing line (angling)	
36	Light sticks (tubes with fluid)	
37	Floats/Buoys	
38	Buckets	
39	Strapping bands	
40	Industrial packaging, plastic sheeting	

41	Fibre glass	
42	Hard hats	
43	Shotgun cartridges	
44	Shoes/sandals	
45	Foam sponge	
46	Plastic/polystyrene pieces < 50 cm	
47	Plastic/polystyrene pieces > 50 cm	
48	Other plastic/polystyrene items ( <i>please specify below</i> )	
<b>Rubber</b>		
49	Balloons	
50	Boots	
51	Gloves	
52	Tyres and belts	
53	Other rubber pieces ( <i>please specify below</i> )	
<b>Cloth</b>		
54	Clothing	
55	Furnishing	
56	Sacking	
57	Shoes	
58	Rope/strings	
59	Other textiles ( <i>please specify below</i> )	
<b>Paper • Cardboard</b>		
60	Bags	
61	Cardboard	
62	Cartons/Tetrapaks	
63	Cigarette packets	
64	Cigarette butts	
65	Cups	
66	Newspapers & magazines	
67	Other paper items ( <i>please specify below</i> )	
<b>Wood (machined)</b>		
68	Corks	
69	Pallets	
70	Crates	
71	Crab/lobster pots	
72	Ice lolly sticks / chip forks	
73	Paint brushes	
74	Other wood < 50 cm ( <i>please specify below</i> )	
75	Other wood > 50 cm ( <i>please specify below</i> )	
<b>Metal</b>		
76	Aerosol/Spray cans	
77	Bottle caps	
78	Drink cans	
79	Electric appliances	
80	Fishing weights	

81	Foil wrappers	
82	Food cans	
83	Industrial scrap	
84	Oil drums (new not rusty)	
85	Oil drums (old/rusty)	
86	Paint tins	
87	Lobster/crab pots	
88	Wire, wire mesh, barbed wire	
89	Other metal pieces < 50 cm ( <i>please specify below</i> )	
90	Other metal pieces > 50 cm ( <i>please specify below</i> )	
<b>Glass</b>		
91	Bottles	
92	Light bulbs/tubes	
93	Other glass items ( <i>please specify below</i> )	
<b>Pottery • Ceramics</b>		
94	Construction material e.g. tiles	
95	Octopus pots	
96	Other ceramic/pottery items ( <i>please specify below</i> )	
<b>Sanitary waste</b>		
97	Condoms	
98	Cotton bud sticks	
99	Sanitary towels/panty liners/backing strips	
100	Tampons and tampon applicators	
101	Toilet fresheners	
102	Other sanitary items ( <i>please specify below</i> )	
<b>Medical waste</b>		
103	Containers / tubes	
104	Syringes	
105	Other medical items (swabs, bandaging etc.)	
<b>Faeces (don'touch!)</b>		
106	Human	
107	Animal	

**Presence of other pollutants**

Pollutant	Size of pieces or lumps ( <i>estimates</i> )	Frequency (estimated number per metre of strandline)
<b>Paraffin or wax pieces</b>	<i>Size range</i>	
108	0–1 cm	<input type="checkbox"/>
109	1–10 cm	<input type="checkbox"/>
110	> 10 cm	<input type="checkbox"/>
<b>Other</b> ( <i>please specify below</i> )		
111		<input type="checkbox"/>

Presence of plastic pellets:                       Yes                       No

**Special observations and notes** *(please refer to number!)*

## Annex 4: Marine beach litter survey form for 1-km stretches\*

		Total
<b>Plastic • Polystyrene</b>		
1	Buoys	
2	Fish boxes	
3	Packaging, plastic sheeting	
4	Rope/cord	
5	Jerry cans	
6	Nets (including fishing nets and fishing line)	
7	Oil drums	
8	Strapping bands	
9	Other large plastic/polystyrene items ( <i>please specify below</i> )	
<b>Metal</b>		
10	Oil drums	
11	Other large metal items ( <i>please specify below</i> )	
<b>Wood (machined)</b>		
12	Crab/lobster pots	
13	Crates	
14	Pallets	
15	Other large wooden items ( <i>please specify below</i> )	
<b>Rubber</b>		
16	Gloves	
17	Tyres & belts	
18	Other large rubber items ( <i>please specify below</i> )	
<b>Cloth</b>		
19	Rope	
20	Clothing and shoes	
21	Other large cloth/textile items ( <i>please specify below</i> )	

\* only items larger than 50 cm in any direction

**Special observations and notes** (*please refer to number!*)

## Annex 5: On statistical approach, methods and power

### STATISTICAL APPROACH AND METHODS USED FOR ASSESSMENTS

**Analysis of beach data from the 100-metre surveys:** Sorting of the beach data in the pilot project, and some of the statistical tests, have been made in Excel. More advanced statistical tests have been made using the software package SPSS, or the randomisation software Resampling deploy. The calculation of differences between years (time series for total quantities of marine litter and for indicator items) has been made by using One-way ANOVA (analysis of variance). The calculation of linear trends has been made with linear regression. Test whether variances are homogenous has been done with Cochran's test. If variances have been heterogeneous, the data has been transformed with a square-root transformation.

**Comparisons of results from 100-metre and 1-km surveys:** The differences among countries regarding average number of marine litter items were analysed with one-way Analysis of Variance (ANVA). Heterogeneity among variances was checked by inspection of residual plots. Time trends were tested with linear regression analysis, based on yearly averages for each beach. Heterogeneity among variances and influences by individual data points were checked by inspection of residual plots. Actual regression analyses were made on square-root-transformed data.

**Analysis of beach data from the 1-km surveys:** MS Excel was used for the primary analysis (totals, averages etc.) of the 1-km dataset.

### STATISTICAL POWER

The statistical power of an analysis is the ability to detect differences or trends, *if they do exist*. The power of a test such as analysis of variance or linear regression is proportional to

a) **effect size** – in this case the effects size is the difference among, e.g., regions, or the slope of the time trend.

For the analyses in this report, the effect size cannot be influenced, it is simply the amount of marine litter found on beaches. However, if there is a goal set within the OSPAR region of a certain percentage of reduction of marine litter in a certain time period, it is possible to calculate in advance how large a monitoring programme (the number of beaches) would be necessary to detect this.

b) **number of replicates** – in this case the number of beaches or the number of years, depending on the analysis.

This is something that can be influenced by the monitoring programme. If the main object of the monitoring programme is to detect differences in time, then the more years that the monitoring programme continues, the more likely it is that statistically significant trends can be detected. For the purpose of comparing marine litter amounts among regions, maximising the number of beaches per regions is the most important. If possible, a more even distribution of beaches among regions would be desirable in the future: this would increase the statistical power of comparisons among regions, and would decrease the probability that conclusions about the whole OSPAR region is more influenced by beaches from just one region.

c) **inverse of the variation among samples** – in this case the variation among beaches and seasons.

The greater the variation, the more difficult to detect statistically significant trends. The beaches in this project differed substantially. It may appear in many of the graphs that there are trends with time, but these trends are often not statistically significant because of the large variation among beaches. If beaches had been selected based on stricter criteria, the beaches would probably have been more similar, and it would have been easier to detect statistically significant trends. However, this would also mean that the results from the monitoring programme would be less general, and applicable on to a certain category of beaches rather than for beaches in the OSPAR region in general. The decision if beaches should be selected based on more strict criteria is not a statistical decision, but should be based on what is the appropriate questions for OSPAR. Furthermore, many beaches were only surveyed for a few years, and then discontinued. This made it difficult to follow time trends for individual beaches, and it may influence the characteristics of individual years (confounding the effect of years with the effect of new or discontinued beaches). For a future programme, it would be desirable if all beaches were surveyed for the whole period: this would increase the possibility of making different analyses, and it would decrease the risk of confounding beach and time

effects. However, this is not to say that surveys of beaches for just a few years are meaningless, they may be included in some types of analyses as was done in the present report.

**d) predetermined critical significance level of the tests ( $\alpha$ )** – in this case 0.05.

The meaning of this significance level is the probability to wrongly conclude that there is a difference or a trend, when in fact the result is only a coincidence. The level set here is the risk of making such a mistake only in 5 per cent of the cases, which is the level commonly used. However, it is possible to make the test less conservative, i.e.. to set this risk to 10 per cent instead ( $\alpha=0.1$ ), which would make it more likely to detect statistically significant trends. However this is a controversial subject among statisticians, and here we have followed tradition and used the common 5 per cent level. For the decision-maker, the important question is which mistake is the worst: is it more serious to incorrectly conclude that there is a trend (when in fact there is no trend), or to incorrectly miss to detect such a trend when it does in fact exist?

## Annex 6: Thank you!

Many people have done very much for many years to help the Steering Group carry out the OSPAR Pilot Project on Monitoring Marine Beach Litter. We want to thank each and every one for all the hard work, and all the support. These dedicated efforts have made this project possible.

- Germany      *Project coordination* (on behalf of the Federal Environmental Agency (Umweltbundesamt))
- Hochschule Bremen
  - Gesellschaft für Angewandten Umweltschutz und Sicherheit im Seeverkehr
  - Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer
- Beach surveys*
- Mellumrat e.V.
  - Schutzstation Wattenmeer e.V.
  - Verein Jordsand e.V.
  - Niedersächsisches Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz.
- France        *Beach surveys, Bretagne*
- S.I.V.U. de la Baie d'Audierne (Syndicat Intercommunal à Vocation Unique).
- Beach surveys, Normandie*
- E.S.T.R.A.N.
  - Aquacaux
- Contact persons*
- Samuel André, Institut des Milieux Aquatiques of Bayonne
  - Steeve Becker, formerly ADEELI/CPIE Flandre Maritime
  - Aline Chérencé, E.S.T.R.A.N.
  - Ingrid Lahille, Aquacaux
  - Patricia Lerouge, Aquacaux
  - Jeremie Quillevere, Cedre
- Portugal      *Beach surveys*
- Ana Rita Alves, on behalf of the Municipality of Lagos, Department of Environment and Urbanisation
- Spain          *Beach surveys, Galicia*
- Pilar Antelo
- Beach surveys, Andalucia*
- Jose Gracia Calvo, Calima, S.C.A.
- Sweden        *Beach surveys*
- A number of dedicated people in the municipalities of Kungälv, Lysekil, Orust, Sotenäs, Strömstad, and Tanum, on the Swedish west coast.
- United Kingdom      *Beach surveys*
- Hilbre Island: Frank Tyson
  - Tan-y-Bwlch: Jan Tomlinson and Peter Drake
  - Traeth Mawr: Sheila Paine
  - West Angle Bay: Sally Edwards
  - Freshwater East: Glen Wharton
  - Burnham on Sea: Fil Bacon
  - Hastings: Adam Hiley
  - Margate Main Sands: Brian Stewart
  - Heacham: Helen Nott
  - Staithes: Liz Kelly

- Cramond: Calum Duncan
- Menie Links Balmedie: Sarah Gosden, Carol Menlove and David Brown
- Porth Kidney Sands: Sally Morris
- Allonby: Rose Wolfe
- St Marys: Jess Churchill
- Chilton Chine: Kevin West
- Rocquaine: Martin Gavet
- Linkim Shore: Steve Willis and Liza Cole
- Upgang: Doreen Wort
- Sand Bay: Gill Bell