Fulmar Litter EcoQO Monitoring in the Netherlands 1979-2008
in relation to EU Directive 2000/59/EC on Port Reception Facilities

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Northern Fulmars *(Fulmarus glacialis)* Faroe Islands

SUMMARY

Fulmar Litter EcoQO Monitoring in the Netherlands 1979-2008
in relation to EU Directive 2000/59/EC on Port Reception Facilities

Operational and cargo related wastes from ships are an important source of litter in the marine environment in the southern North Sea and cause serious economical and ecological damage. Inadequacies in the ship to shore waste delivery procedures are considered a major factor in illegal discharges. The European Union therefore addressed the problem with the Directive on Port Reception Facilities (Directive 2000/59/EC). Obligatory waste delivery to shore and indirect financing of the costs are key-elements of the Directive to stimulate and enforce proper disposal of shipwaste in harbours. Monitoring the effect of the EU Directive is required.

A marine litter monitoring program using plastic abundance in stomachs of a seabird, the Northern Fulmar, was already operational in the Netherlands and was further developed for international implementation by OSPAR as one of the 'Ecological Quality Objectives (EcoQO's)' for the North Sea (OSPAR 2008). Fulmars are purely oceanic foragers, ingest all sorts of litter from the sea surface, and do not regurgitate poorly degradable diet components, but slowly wear these down in the stomach. Accumulated plastic items in stomachs of beached Fulmars thus integrate litter levels encountered over a number of weeks in a particular marine area.

In the Netherlands, the *Ministry of VenW* commissions regular updates of Dutch data in the Fulmar-Litter monitoring database maintained by IMARES. North Sea wide monitoring was started in 2002 in the '*Save the North Sea*' project supported by the EU Interreg IIIB program, and was continued to 2007 using CSR awards from the *NYK Group Europe Ltd.* These efforts will merge in a scientific publication on approach and results of the Fulmar-Litter-EcoQO up to the year 2007. At the moment there is no funding to continue the international analyses. As a consequence, this IMARES report only provides the update on Dutch monitoring results up to 2008.

Monitoring in the Netherlands 1979-2008
Volunteers of the Dutch Seabird Group (NZG) and other interested organizations collect Fulmars found dead on Dutch beaches. In 2008, in spite of considerable effort, only 22 beached Fulmars could be collected. Twenty of these corpses contained a suitable intact stomach. A sample-size of 40 or more is recommended for a reliable annual 'average', but occasional years of low sample size are not a problem in the analysis of trends.

Results 2008: Among the 20 stomachs, 19 contained plastic (95% incidence), with an overall average number of 45 items per bird and average mass of 0.31 gram plastic per bird. Industrial plastics represented a minority (4 'pellets' per bird, 0.08g) compared to discarded user plastics (41 items and 0.23g) (Table 1). The 2008 figures do not show substantial change from those in 2006 and 2007.

Current levels 2004-2008: Because of occasional years of low sample size and high variability, the 'current pollution level' has been defined as the average situation over the most recent 5 years. Over the 2004-2008 period in a sample of 290 Fulmars, plastic incidence was 93% with an average number of over 27 pieces, and average mass of 0.30 gram plastic (further details in Table 2). Thus, although plastics in 2008 appeared above average in number of particles, they were 'average' in terms of mass.

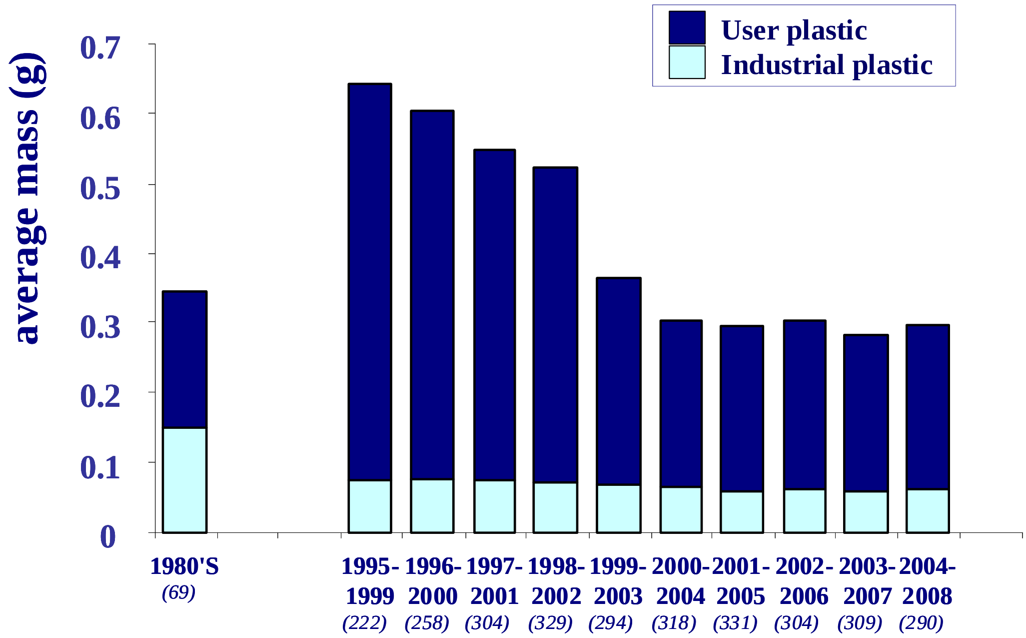


Figure i ***Plastic mass in Fulmars from the Netherlands 1980-2008*** *– Trend in 5 year averages for mass of plastic in stomachs of Fulmars beached in the Netherlands (running average over 5 year periods, i.e. bars shift one year ahead at at time; period and number of birds shown below each bar) (AVGGUSE = user plastic; AVGGIND = industrial plastic).*

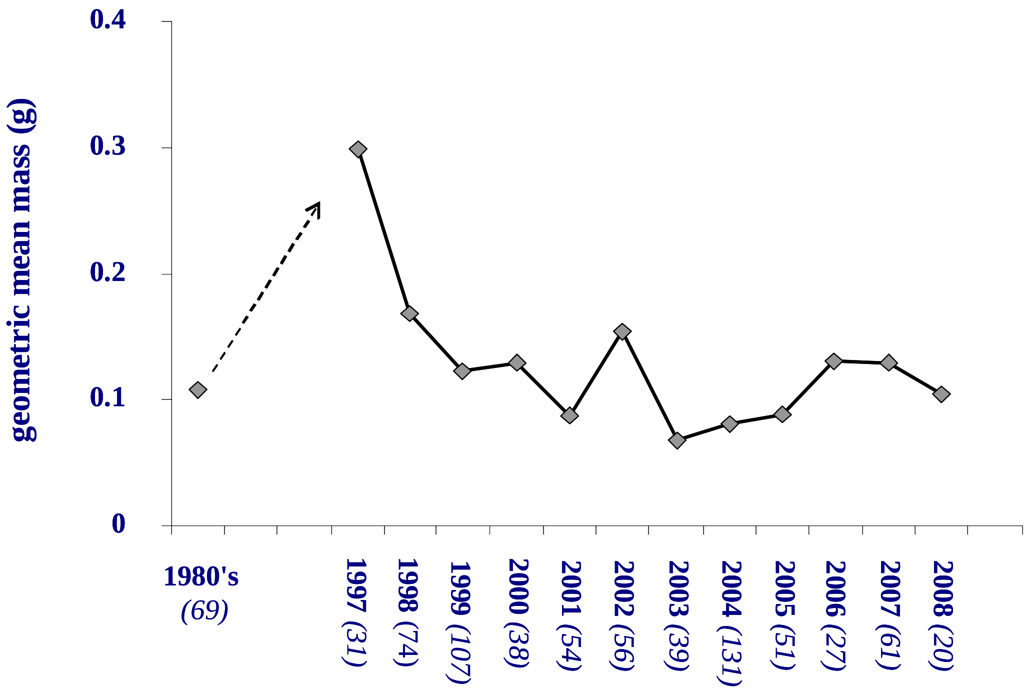


Figure ii ***Annual geometric mean mass of plastic in Fulmars from the Netherlands*** *– Annual changes as suggested by means calculated from ln-transformed data (transformation reducing the impact extremes). Sample sizes before 1997 were too small to calculate annual geometric means.*

Trends: As convened in earlier reports, the metric for discussion of trends is based on the mass of plastics in stomachs, rather than on incidence or number of plastic particles. In trend discussions, a distinction is made between:

- *'long-term trend'* which calculates the trend over all years in the dataset (now 1979-2008)
- *'recent trend'* defined as trend over the past 10 years (now: 1999-2008)

Average figures for plastic mass may be strongly influenced by a few exceptionally polluted stomachs, especially when sample sizes are small. Therefore, for a visual representation of trends over time, Fig.i uses averages over 5 year periods as of 1995, and a single overall average for the 1980's. As an alternative, Fig. ii does use annual data as off 1997, but gives 'geometric mean mass' calculated from logarithmically transformed data, which reduces the importance of higher values in the dataset.
Statistical tests for significance of trends use neither averages nor annual geometric means. Tests are based on linear regressions of ln-transformed data for the mass of plastics against year of collection in individual stomachs.

Long term trend 1979-2008
In spite of evident strong changes shown by Fig's i and ii, the 'all plastics' category (Table 3A) shows no clear long term linear trend. This has several reasons. Firstly, the overall mass of plastics strongly increased from the 1980s to the 1990s but has subsequently decreased to approximately the initial level. Linear analyses as in our tests do not 'see' the variable components in non-linear trends. But trend calculations are also compromised because different types of plastic have shown strongly different trends. User plastics were responsible for the above described increase and later decrease. Industrial plastics on the other hand have strongly decreased since the early 1980s, resulting in a highly significant long-term reduction ($p<0.001$). As a consequence of these mixed trends, the composition of plastic litter has strongly changed since the early 1980s, with nowadays a strongly reduced proportion of industrial plastics (reduced from about 50% to 25% of total mass) and an increased mass of user plastics from discarded waste.

Recent 10 year trend 1999-2008
Until 2006, regression analyses for recent trends showed significant decreases in litter since the mid 1990's. However, in the 2007 and 2008 (Table 3B) analyses trends are no longer detected. From Fig.ii the loss of significance can be explained from loosing the high 1997 and 1998 values from the start of the tested period, and their replacement by relatively elevated values for 2007 and 2008. Changes may continue in both user (since 1990's) and industrial plastic (from start in 1980's) but not at a statistically relevant level, and even signs of ***t*** values in table 3B are no longer all negative (negative or positive sign of t reflects decreases or increases over time). Fortunately, the suggestion of an steady increase since 2003 made in the previous report, is not supported by the 2008 data (Fig. ii).

Ecological Quality Objective (EcoQO) for the North Sea
In OSPAR, the Dutch studies initiated the development of an Ecological Quality Objective for marine litter based on the amount of plastic in Fulmar stomachs. In this EcoQO approach, the above data are viewed in a slightly differently manner, that is they focus on 'the percentage of birds exceeding a critical value of plastic in the stomach'. This is an alternative approach (compared to using 5 yr averages or log transformed data) to moderate the influence of a few exceptional birds on the dataset.
The OSPAR ***Ecological Quality Objective*** for marine litter currently formulates its target for acceptable ecological quality in the North Sea as:

> *"There should be less than 10% of Northern Fulmars having 0.1 gram or more plastic in the stomach in samples of 50-100 beached fulmars from each of 5 different regions of the North Sea over a period of at least 5 years".*

In 2008, 55% of Dutch Fulmars exceeded the critical value of 0.1g plastic in the stomach (Table 2). Although this is still far above the ultimate target of 10%, this represents a substantial improvement compared to the exceptionally high figure of 85% of birds exceeding 0.1g of plastic in 2006 and the 70% score for 2007. Over the latest five years, an average of 62% of Fulmars beached in the Netherlands exceeds the critical level of 0.1 g of plastic in the stomach. Following the EcoQO target definition, Fig. iii shows the Dutch data in terms of EcoQO performance over 5-year periods, which does not yet reflect the recent improvement. The EcoQO graph supports the suggestion made under 'Recent trends' that plastic loads decreased substantially after the mid-1990's (ca 10% improvement in EcoQO performance!), but that improvements seem to have halted now. Implementation of the EU Directive 2000/59/EC on Port Reception Facilities started in 2004 in our region, but the Fulmar study so far is unable to detect effective improvement in the litter situation out at sea. Strong (28%) increase in shipping activity since 2003 and about 5% annual increases in plastic production may obscure positive effects.

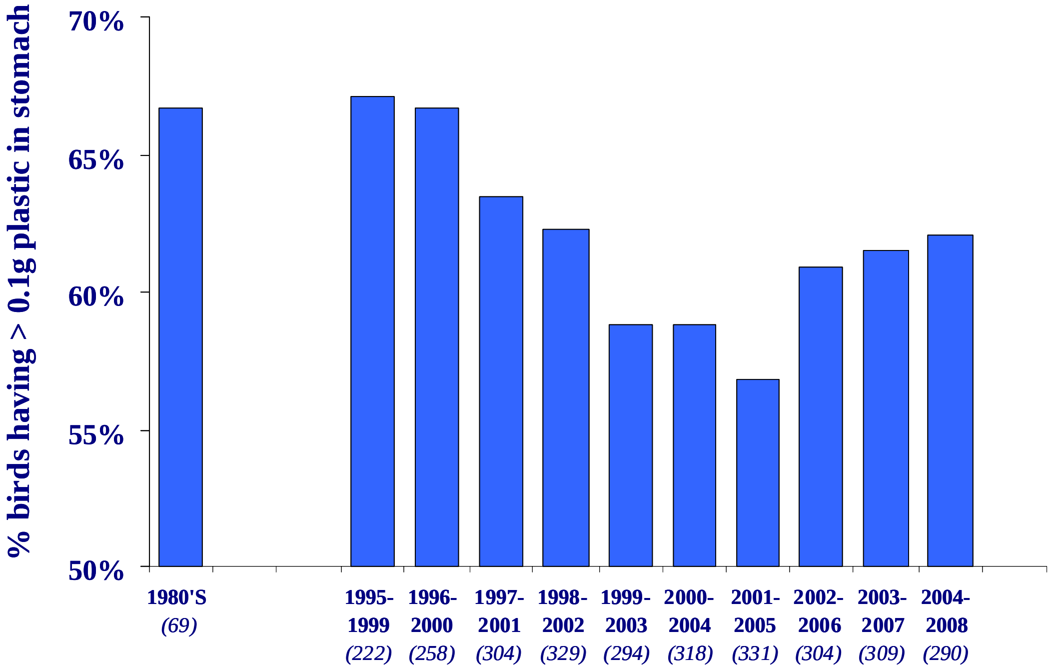


Figure iii ***EcoQO performance in the Netherlands 1980-2008*** *– Trend in percentage of beached Fulmars in the Netherlands having more than 0.1 gram plastic in the stomach (running average over 5 year periods, each bar shifting one year; number of birds in brackets below each bar). Note that for clarity, the Y-axis only shows the 50 to 70% range where the OSPAR target for the EcoQO is that less than 10% of birds has more than 0.1 g plastic in the stomach.*

Conclusions

- In 2008, 95% of Fulmars beached in the Netherlands had plastic in the stomach, with an average of 45 pieces and 0.31 g of plastic per bird. The 'critical' OSPAR EcoQO level of 0.1 gram of plastic was exceeded by 55% of these birds.

- The 2008 figures are from a small sample, but do not substantially differ from averages over the past 5 years (2004-2008), in which 93% of Dutch Fulmars had plastic in the stomach, with an average of 27 pieces and 0.30 gram per bird, and 62% exceeded the EcoQO level of 0.1g.

- Statistical tests show that since the 1980's industrial plastics have significantly decreased to about half their original level, but mostly so in the earlier years. This positive aspect has been overshadowed by an increase in user plastics over the same period. This has occurred in an up- and down pattern which complicates linear tests for trends. Overall, no significant change is observed.

- Litter in the southern North Sea mainly originates from merchant shipping and fisheries. Results thus indicate that the initial implementation of the EU Directive on Port Reception Facilities has not yet resulted in detectable ecological improvement in the Southern North Sea. Strong increases in shipping activity and usage of plastics may obscure positive results.

Samenvatting

Stormvogel Zwerfvuil EcoQO monitoring in Nederland 1979-2008
in relatie tot Richtlijn 2000/59/EG betreffende havenontvangstvoorzieningen voor scheepsafval en ladingresiduen

Operationeel en aan lading gerelateerd scheepsafval is één van de belangrijke bronnen van zwerfvuil in de zuidelijke Noordzee. Zulk afval heeft ernstige economische en ecologische gevolgen. Tekortkomingen in afgifteprocedures in havens zijn een belangrijke achtergrond bij het illegaal overboord zetten van afval. De EU heeft dit probleem aangepakt met de 'Richtlijn betreffende havenontvangstvoorzieningen' (Richtlijn 2000/59/EC; de zogenaamde 'HOI-Richtlijn'). Verplichte afgifte van afval en indirecte financiering van de kosten vormen de kern van de maatregelen waarmee de Richtlijn correcte afvalafgifte wil stimuleren en afdwingen. Het monitoren van de effecten van de HOI-Richtlijn is noodzakelijk.

Trends in zwerfafval op zee worden in Nederland onderzocht in een graadmeter onderzoek gebaseerd op de hoeveelheid plastic in magen van dood aangespoelde zeevogels: de Noordse Stormvogel. Dit graadmeter instrument wordt ook inmiddels ook internationaal door OSPAR in de Noordzee toegepast als een 'Ecological Quality Objective (EcoQO)' (OSPAR 2008). De Noordse Stormvogel foerageert uitsluitend op zee, eet geregeld afval, en hoopt slecht verteerbaar materiaal zoals plastic op in de maag. Daardoor geeft de maaginhoud een geïntegreerd beeld van de hoeveelheden afval die de vogels in voorgaande weken op zee zijn tegengekomen.

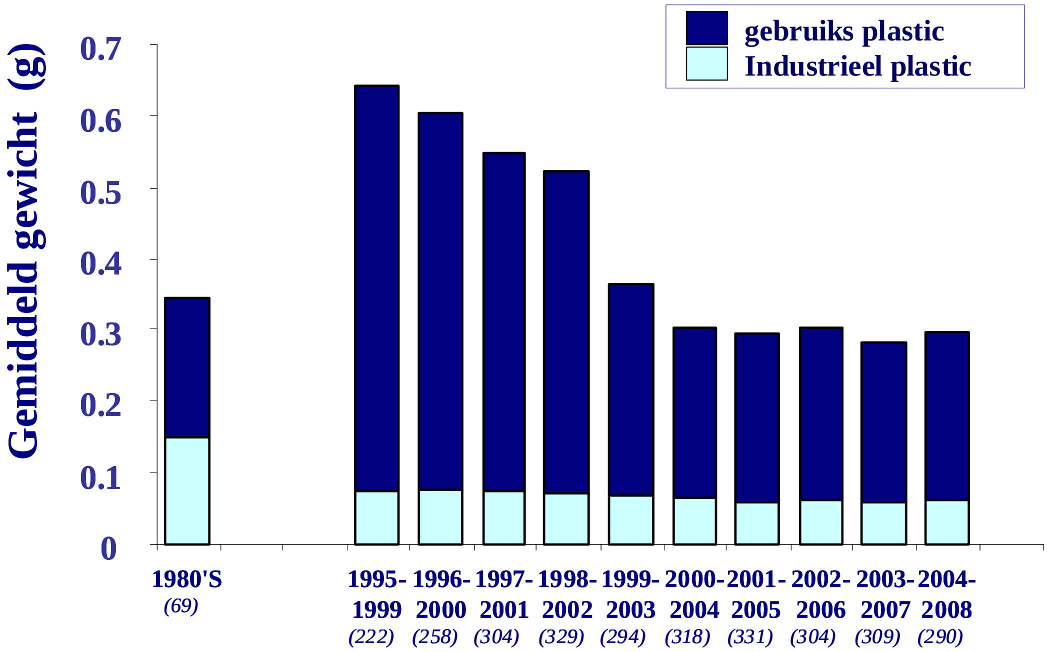
Het Ministerie van VenW is voor IMARES de opdrachtgever voor de Nederlandse stormvogel graadmeter. Vergelijkbare internationale monitoring van stormvogels in de hele Noordzee is in 2002 opgestart als onderdeel van het Europese 'Save the North Sea' project en tot en met 2007 voortgezet met bedrijfsmaatschappelijke prijzen toegekend door de NYK Group Europe Ltd. Resultaten van het gecombineerde nationale en internationale onderzoek tot en met 2007 worden verwerkt in een wetenschappelijke tijdschriftpublicatie over de OSPAR Stormvogel-Zwerfvuil-EcoQO in de Noordzee. Momenteel is er geen financiering beschikbaar voor het continueren van de internationale analyses. Dit IMARES rapport behandelt derhalve alleen de analyses van de Nederlandse monitoring resultaten tot en met 2008.

Nederlands graadmeter onderzoek 1979-2008

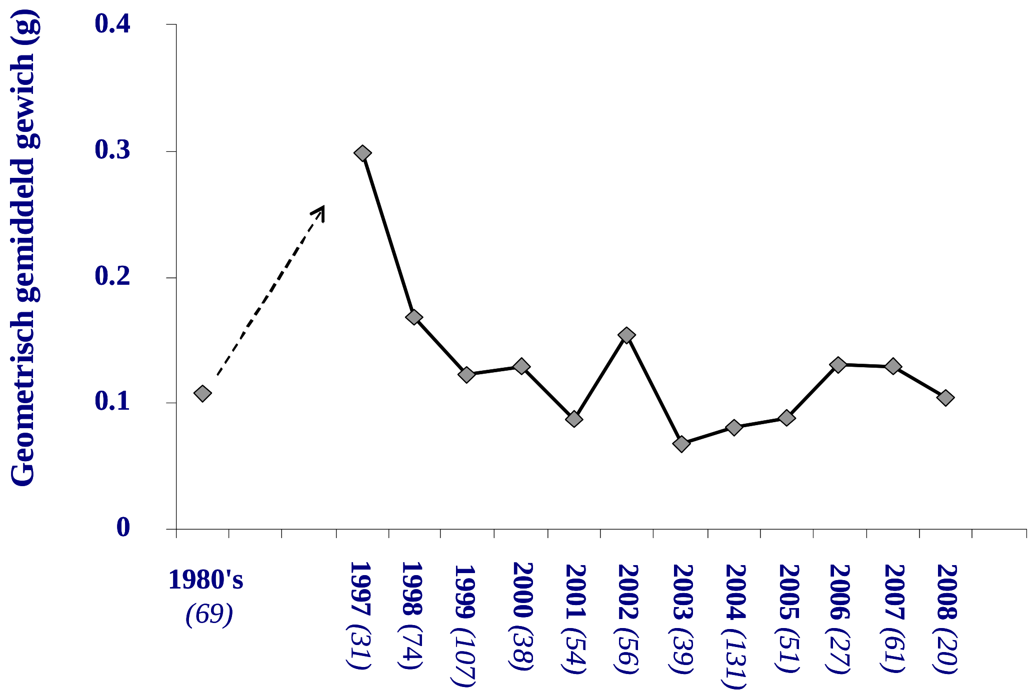
Vrijwilligers van de Nederlandse Zeevogelgroep (NZG) en een reeks andere organisaties verzamelen Noordse Stormvogels die dood op de stranden aanspoelen. In 2008 konden ondanks extra inspanningen slechts 22 stormvogels worden verzameld, waarvan er 20 nog een voor onderzoek geschikte intacte maag bevatten. Voor een betrouwbaar jaargemiddelde voor een bepaalde locatie wordt een bemonsterd aantal van 40 of meer vogels aanbevolen, maar voor het analyseren van trends zijn incidentele jaren met kleine monstergroottes geen probleem.

Resultaten 2008: Van de 20 magen bevatten er 19 (95%) plastic met een gemiddeld aantal van 45 stukjes en gemiddeld gewicht van 0.31 gram per vogel. Industriële plastic korrels vormden daarin een minderheid (4 korrels, 0.08 gram per vogel) ten opzichte van gebruiksafval (41 stukjes, 0.23 gram per vogel) (Tabel 1). De waardes voor het jaar 2008 onderscheiden zich niet duidelijk van de voorgaande jaren 2006 en 2007.

Huidige situatie 2004-2008: omdat toevallige jaarfluctuaties of te kleine monstergrootte het beeld kunnen beïnvloeden, wordt geadviseerd om "de huidige situatie" te beschrijven als het gemiddelde over de vijf meest recente jaren. Gemeten over 2004-2008 periode had 93% van de 290 onderzochte stormvogels plastic in de maag. Gemiddelde hadden de vogels 27 stukjes met een gewicht 0.30 gram in de maag (Tabel 2). Binnen de recente 5-jaarsperiode was het jaar 2008 dus relatief hoog qua aantal stukjes plastic, maar standaard gemiddeld voor wat betreft het gewicht van deze plastics.



Figuur i *Trend in plastic gewicht in magen van in Nederland aangespoelde Noordse Stormvogels – getoond aan de hand van lopende 5-jaars gemiddeldes waarbij grafiek staven telkens één jaar verschuiven; de jaren en het aantal vogels in de berekening staan bij iedere staaf vermeld. Voor de jaren '80 is een enkel gemiddelde berekend.*



Figuur ii *Trend in plastic gewicht in magen van in Nederland aangespoelde Noordse Stormvogels – getoond aan de hand van geometrische gemiddeldes per jaar berekend uit logaritmisch getransformeerde data die de invloed van extreem hoge waardes onderdrukken. In de jaren voor 1997 was de het aantal monsters ontoereikend voor jaarlijkse gemiddeldes. Voor de jaren '80 is een enkel gemiddelde berekend.*

Trends: Zoals vastgelegd in eerdere rapportages worden trendmatige ontwikkelingen geanalyseerd op basis van het gewicht van het plastic in de magen, waarbij

- 'lange termijn trends' verwijzen naar de complete periode (1979-2008)
- 'recente trends' zijn gedefinieerd als de trends over the voorgaande 10 jaar (1999-2008)

Gemiddelde waardes voor het gewicht aan plastic kunnen bij een beperkte monstername sterk worden beïnvloed door een enkele incidenteel extreem vervuilde magen, Derhalve toont Fig. i een totaalgemiddelde voor de jaren tachtig plus zogenaamd 'lopende' 5-jaar gemiddeldes over latere periodes waarbinnen de gebruikte gegevens telkens één jaar opschuiven. Als alternatief worden in Fig. ii. toch afzonderlijke jaargegevens getoond, maar dan 'geometrische gemiddeldes' die zijn berekend aan de hand van logaritmisch omgevormde getallen die de invloed van uitschieters in de getallen beperkt. Statistische berekeningen om de 'significantie' van bepaalde trends te toetsen zijn niet op gewone, lopende of geometrische gemiddeldes gebaseerd. De trends worden getoetst door lineaire regressie analyses van ln-getransformeerde plastic gewichten in individuele vogels tegen het jaar waarin de vogels werden verzameld.

Lange termijn trend 1979-2008

Ondanks de in de figuren i en ii zichtbare veranderingen, is voor alle plastic soorten tezamen ('all plastics' in Tabel 3A) over de volledige studieperiode geen significante trend waarneembaar. De eerste reden daarvoor is dat plasticgewicht tussen jaren '80 en '90 sterk toenam, maar daarna weer is teruggezakt naar ongeveer het beginniveau. Lineaire regressies "missen" per definitie niet-rechtlijnige verbanden. Maar daarnaast worden lange-termijn trends enigszins verdoezeld omdat verschillende vormen van plastic een afwijkende ontwikkeling hebben doorgemaakt. Gebruiks plastics zijn verantwoordelijk voor de hierboven omschreven toename en afname. Maar industrieel plastic heeft over de volle periode een significante afname vertoond ($p<0.001$). Ten gevolge van deze afwijkende trends is de samenstelling van het plastic in de stormvogelmagen sterk veranderd van een aanvankelijk gelijk gewicht aan industrieel en gebruiksplastic naar een situatie waarin nog slechts ca 25% van het plastic van industriële herkomst is.

Recente 10 jaar trend 1999-2008

Tot en met het jaar 2006 lieten de statistische analyses een significante afname in hoeveelheid plastic zien t.o.v. de piek in de jaren '90. Maar analyses t/m 2007, en ook 2008 laten geen significante afname meer zien (Tabel 3B). De verklaring is te zien in Fig. ii, die toont dat de hoge waardes uit midden jaren '90 nu buiten de toetsperiode van 10 jaar vallen, en dat een patroon van afname over de vroege jaren wordt 'tegengewerkt' door een stabilisering of zelfs lichte toename sinds 2003. Tezamen resulteert dit in 'géén trend' voor de afgelopen tien jaar. De suggestie van een licht toenemende trend over periode 2003-2006 is met de getallen van 2007 en 2008 gelukkig wel onderbroken (Fig.ii).

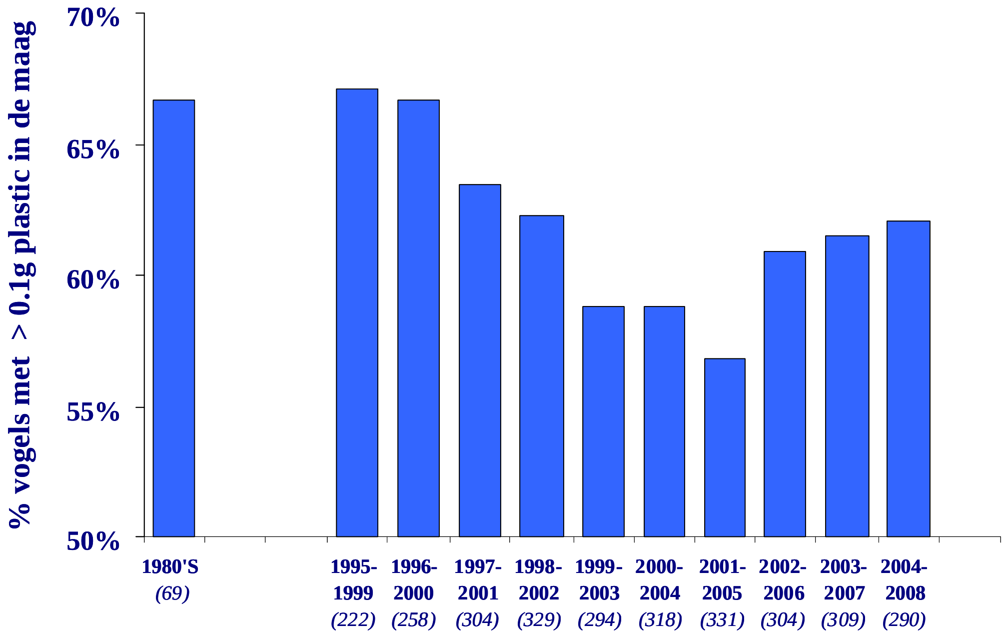
Ecologische Kwaliteitsdoelstelling voor de Noordzee

In de Ecological Quality Objective (EcoQO) voor zwerfvuil op zee bekijkt OSPAR dezelfde gegevens op een iets andere manier, namelijk als een percentage van de vogels waarbij de maaginhoud een grensgewicht aan plastic overschrijdt. OSPAR definieert de '**doelwaarde voor aanvaardbare ecologische kwaliteit'** in de Noordzee als de situatie waarin:

> "minder dan 10% van aangespoelde Noordse Stormvogels 0.1 gram of meer plastic in de maag heeft, in monsternames van 50 tot 100 vogels uit 5 verschillende Noordzee regio's over een periode van tenminste 5 jaar"

In 2008 overschreed 55% van de onderzochte stormvogels de kritische grens van 0.1g plastic in de maag (Table 2). Hoewel dit nog ver verwijderd is van de OSPAR doelstelling van onder de 10%, betekent dit wel een aanzienlijke verbetering ten opzicht van de buitengewoon hoge waarde van 85% vogels boven norm van 0.1g plastic in 2006 en de 70% score voor 2007. Het 5-jaar gemiddelde voor de periode 2004-2008 is nauwelijks veranderd en staat op 62% van de Stormvogels van de Nederlandse kust boven de grenswaarde van 0.1 gram plastic in de maag.
De trend in EcoQO ontwikkelingen in Nederland wordt getoond in Fig.iii als lopend 5-jaars-gemiddelde, dwz de ook in de EcoQO doelstelling verwoorde periode. De figuur ondersteunt de eerder opmerking (Recente trend) dat na een periode van afname in vervuiling (in de orde van 10% in de EcoQO!) in de allerlaatste jaren de afname is gestopt. Dit betekent dat het stormvogelonderzoek tot dusverre géén effect kan aantonen van de invoering van de EU Richtlijn voor havenontvangstvoorzieningen 2000/59/EG. Mogelijkerwijs worden positieve effecten van de

Richtlijn tegengewerkt door een sterke groei van de scheepvaartactiviteit (28% sinds 2003) en een aanhoudende jaarlijkse groei in plastic gebruik (jaarlijks ca 5% in plastic productie).



Figuur iii *Ontwikkeling in de Stormvogel-Zwerfvuil Ecologische Kwaliteitsdoelstelling 1980-2008. Trend in het percentage Noordse Stormvogels dat méér dan 0.1 gram plastic in de maag heeft, als lopend gemiddelde op basis van 5-jaar-periodes. Voor de jaren '80 is een enkel gemiddelde berekend. Let op dat voor het helder tonen van veranderingen de y-as is beperkt tot een 50-70% bereik, waardoor de EcoQO-doelwaarde van 10% niet is getoond (zie daarvoor Fig.5).*

Conclusies

- In 2008 had 95% van de in Nederland aangespoelde Noordse Stormvogels plastic in de maag, met gemiddeld 45 stukjes en een gewicht van 0.31 gram per vogel. De kritieke waarde van 0.1 gram uit de definitie voor de Ecologische Kwaliteits Doelstelling (EcoQO) van OSPAR voor zwerfvuil in de Noordzee werd door 55% van de vogels overschreden.
- De getallen voor 2008 werden berekend over een kleine monstername, doch verschilden niet substantieel van gemiddelde waardes over de afgelopen 5 jaar (2004-2008) waarin 93% van de vogels plastic in de maag had, met een gemiddelde van 27 stukjes en 0.30 gram plastic, waarbij 62% de EcoQO norm overschreed.
- Statistische toetsen laten zien dat industrieel plastic vanaf de 80'er jaren significant is afgenomen tot ca. de helft van de beginwaarde, doch met de sterkste afname in de eerste jaren. Het effect hiervan is teniet gedaan door een toename in gebruiksplastics over dezelfde periode. Deze groei trad op in een wisselvallig patroon van toe- en afname die trendanalyse hindert. Over het geheel zijn geen statistische veranderingen aantoonbaar.
- Scheepvaart en visserij zijn de belangrijkste bron van zwerfvuil in de Noordzee. De resultaten laten daarom zien dat de invoering van de EU Richtlijn voor havenontvangstvoorzieningen nog niet heeft geresulteerd in aantoonbare ecologische verbetering in de Zuidelijke Noordzee. Sterke toenames in scheepvaartactiviteit en plasticgebruik overschaduwen mogelijk de positieve effecten.

1 Introduction

Marine litter, in particular plastic waste, represents an environmental problem in the North Sea with wide ranging economical and ecological consequences.

The **economical consequences** of marine litter are firstly experienced by coastal municipalities who find themselves confronted with excessive costs for beach clean-ups. Tourist business suffers damage because guests stay away from polluted beaches, especially when the litter poses a health-risk. Fisheries are confronted with a substantial by-catch of marine litter which causes loss of time and sometimes necessitates discarding of tainted catch. Shipping suffers financial damage and -more importantly- safety-risks from fouled propellers or blocked water-intakes. Coastal litter blowing inland can even seriously affect farming practices. The overall economical damage from marine litter is difficult to estimate, but a detailed study in the Shetlands with additional surveys elsewhere indicates that extrapolated costs for the whole North Sea area may exceed one billion Euro per year (Hall 2000; pers.inf.).

The **ecological consequences** of marine litter are most obvious in the suffering and death of marine birds or mammals entangled in debris. Entangled whales are front page news and strongly attract public attention. However, only a small proportion of such mortality becomes visible among beached animals. Even less apparent are the consequences from the ingestion of plastics and other types of litter. Ingestion is extremely common among a wide range of marine organisms including many seabirds, marine mammals and sea-turtles. It does cause direct mortality but the major impact may well occur through reduced fitness of many individuals. Sub-lethal effects on animal populations remain largely invisible. In spite of spectacular examples of mortality from marine litter, the real impact on marine wildlife remains difficult to estimate (Laist 1987, 1997; Derraik 2002). Plastics gradually break down to microscopically small particles, but even these may pose serious problems to marine ecosystems (Thompson *et al.* 2004). Concern about microplastics attracts more and more attention as evidence is growing that plastics in seawater strongly bind organic pollutants and microplastics may enter the base of the food-web by ingestion by filterfeeding marine organisms (Endo et al 2005; Teuten et al. 2007; Browne et al. 2008; Moore 2008; Arthur et al 2009; Thompson et al. 2009). Thus, in addition to the toxic substances incorporated into plastics in the manufacturing process, plastics may concentrate much more pollutants from the environment and act as a pathway boosting their accumulation in marine organisms that ingest plastic. Evidently, this same mechanism operates at all levels of organisms and sizes of ingested plastic material, from small zooplankton filterfeeders to large marine birds and mammals, but it is the microplastic issue and their ingestion by small filterfeeders that has emphasized the potential scale and urgency of the problem.

Recognizing the negative impacts from marine debris, a variety of international policy measures has attempted to reduce input of litter. Examples of these are the London Dumping Convention 1972; Bathing Water Directive 1976; MARPOL 73/78 Annex V 1988; Special Area status North Sea MARPOL Annex V 1991; and the OSPAR Convention 1992. In the absence of significant improvements, political measures have been intensified by for example the EU-Directive 2000/59/EC on Port Reception Facilities (EC 2000), the Declaration from the North Sea Ministerial Conference (2002) in Bergen, and recently in the development of the European Marine Strategy Framework Directive (EC 2008).

Policy initiatives have recognized the need to use quantifiable and measurable aims. Therefore, the North Sea Ministers in the 2002 Bergen Declaration decided to introduce a system of Ecological Quality Objectives for the North Sea (EcoQO's). A number of these EcoQO's was implemented in an immediate pilot program. For example, the oil pollution situation in the North Sea is measured by the rate of oil-fouling among beached Guillemots (*Uria aalge*) (OSPAR 2005). The ecological quality target is set at a level in which less than 10% of beached Guillemots have oil on the plumage. Among a second group of EcoQO's, OSPAR has decided to use the abundance of plastic in stomachs of seabirds, *in casu* the Northern Fulmar (*Fulmarus glacialis*) to measure quality objectives for marine litter. (OSPAR 2008). The EcoQO approach has also been included as an element in the approach for Good Environmental Status in the intended European Marine Strategy Framework Directive (MSFD GES Task Group 2010).

Within the Netherlands, the Ministry of Transport, Public Works and Water Management (VenW) has a coordinating role in governmental issues related to the North Sea environment. As such, VenW is involved in the development of environmental monitoring systems ("graadmeters") for the Dutch continental shelf area. As a part of this activity, VenW have commissioned several earlier projects by IMARES working towards a Fulmar-Litter-EcoQO. The first pilot project for the North Sea Directorate considered stomach contents data of Dutch Fulmars up to the year 2000 and made a detailed evaluation of their suitability for monitoring purposes (Van Franeker & Meijboom 2002). A series of later reports commissioned by the Directorate-General for Civil Aviation and Maritime Affairs (DGLM) (see 'References') have provided annual updates on the Dutch time-series up to the year 2007 (van Franeker et al 2009), paying special attention to shipping issues and EU Directive 2000/59/EC.

Internationally, as of 2002, the Dutch Fulmar research was expanded to all countries around the North Sea as a project under the ***Save the North Sea (SNS)*** program. SNS was co-funded by EU Interreg IIIB over period 2002-2004 and aimed to reduce littering in the North Sea area by increasing stakeholder awareness. The Fulmar acted as the symbol of the SNS campaign. SNS project results and issues related to the development of the Fulmar-Litter-EcoQO were published in Van Franeker *et al*. 2005 (Alterra-rapport 1162). Findings strongly supported the important role of shipping (incl. fisheries) in the marine litter issue. For further publications of the SNS Fulmar study see e.g. Save the North Sea 2004, Van Franeker 2004b and 2004c, Edwards 2005, Guse *et al* 2005, Olsen 2005. The European SNS funding ceased after 2004, but the international work could be continued because the project twice received Corporate and Social Responsibility Awards from the NYK Group Europe Ltd. (van Franeker *et al* 2008 and in prep). In addition to North Sea work, these awards have been used to promote of Fulmar work in other areas of the world (eg. Canadian Arctic and Pacific) and to explore the use of other bird species in areas where Fulmars do not occur.

The current assignment from the Dutch Ministry of Transport, through its Directorate-General for Civil Aviation and Maritime Affairs (DGLM) included the following tasks:

- To update the time series on litter in stomach contents of Dutch Fulmars with the data from year 2008, and publish the result in a new report;
- To continue co-ordination of the beached bird sampling in the Netherlands into 2010

Although the NYK support has facilitated the continued samping of stomachs from other countries around the North Sea in 2008 and 2009, the funding is not sufficient to analyze stomach contents of 2008 and after. These stomachs are stored frozen waiting for new sources of funding for their analysis. Up to 2007, the integrated results from the combined national and international projects are currently prepared for publication as an article in a scientifically reviewed journal to ensure public and scientific 'quality control' on the Fulmar Litter EcoQO research.

Therefore, this report provides the full details of the addition of data over the year 2008 to the long term time series for the Netherlands, but provides little new information on developments in the wider North Sea area.

2 The Fulmar as an ecological monitor of marine litter

The interpretation of monitoring information presented in this report requires a summary of earlier findings.

In their pilot study, Van Franeker & Meijboom (2002) discussed the feasibility of using stomach contents of beached Northern Fulmars to measure changes in the litter situation off the Dutch coast in an ecological context. Samples of Fulmars available for the feasibility study mainly originated from the periods 1982 to 1987 and 1996 to 2000, with smaller number of birds from the years in between.

Reasons for selection of the Fulmar out of a list of potential seabird monitoring species are of a practical nature:

- Fulmars are abundant in the North Sea area (and elsewhere) and are regularly found in beached bird surveys, which guarantees supply of an adequate number of bird corpses for research.
- Fulmars are known to consume a wide variety of marine litter items.
- Fulmars avoid inshore areas and forage exclusively at sea (never on land).
- Fulmars do not normally regurgitate indigestible items, but accumulate these in the stomach (digestive processes and mechanical grinding gradually wear down particles to sizes that are passed on to the gut and are excreted).
- Thus, stomach contents of Fulmars are representative for the wider offshore environment, averaging pollution levels over a foraging space and time span that avoids bias from local pollution incidents.
- Historical data are available in the form of a Dutch data series since 1982 (one earlier 1979 specimen); and literature is available on other locations and related species worldwide (Van Franeker 1985; Van Franeker & Bell 1988).
- Other North Sea species that ingest litter either do not accumulate plastics (they regurgitate indigestible remains); are coastal only and/or find part of their food on land (e.g. Larus gulls); ingest litter only incidentally (e.g. North Sea alcids) or are too infrequent in beached bird surveys for the required sample size or spatial coverage (e.g. other tubenoses or Kittiwake *Rissa tridactyla*).

Beached birds may have died for a variety of reasons. For some birds, plastic accumulation in the stomach is the direct cause of death, but more often the effects of litter ingestion act at sub-lethal levels, except maybe in cases of ingestion of chemical substances. For other birds, fouling of the plumage with oil or other pollutants, collisions with ships or other structures, drowning in nets, extremely poor weather or food-shortage may have been direct or indirect causes of mortality.

At dissection of birds, their sex, age, origin, condition, likely cause of death and a range of other potentially relevant parameters are determined. Standardized dissection procedures for EcoQO monitoring have been described in detail in a manual (Van Franeker 2004b. Stomach contents are sorted into main categories of plastics (industrial and user-plastics), non-plastic rubbish, pollutants, natural food remains and natural non food-remains. Each of these categories has a number of subcategories of specific items. For each individual bird and litter category, data are recorded on presence or absence ("incidence"), the number of items, and the mass of subcategory (see methods). For efficiency/economy reasons, some of the details in manual and earlier reports have been reduced.

The pilot study undertook extensive analyses to check whether time-related changes in litter abundance were susceptible to error caused by bias from variables such as sex, age, origin, condition, cause of death, or season of death. If any of these would substantially affect quantities of ingested litter, changes in sample composition over the years could hamper or bias the detection of time-related trends.

A very important finding of the pilot study was that no statistical difference was found in litter in the stomach between birds that had slowly starved to death and 'healthy' birds that had died instantly (e.g. because of collision or drowning). This means that our results, which are largely based on beached starved birds, are representative for the 'average' healthy Fulmar living in the southern North Sea.

Only age was found to have an effect on average quantities of ingested litter, adults having less plastic in their stomachs than younger birds. Possibly, adults loose some of the plastics accumulated in their stomach when they feed chicks or spit stomach-oil during defence of nest-sites. Another factor could be that foraging experience may increase with age. Understanding of the observed age difference in plastic accumulation is still fairly poor, and further study is required. With financial support from Chevron Upstream Europe, we have started a cooperative project with the Faroese Fisheries Laboratory using Fulmars from the Faroe Islands, where birds are hunted for consumption and large numbers of samples are easily obtained. Additional samples have been obtained from fisheries by-catch in the area. Stomach contents are analysed for both normal diet (Faroese component in the study) and for accumulated litter (Dutch contribution to the study). Samples have been obtained from all months of the year over the period 2003-2006. Detailed analyses still need to be conducted.

Although age has been shown to affect absolute quantities of litter in stomach contents, changes over time follow the same pattern in adults or non-adults. As long as no directional change in age composition of samples is observed, trends may be analysed for the combined age groups. However, background information for the presentation of results and their interpretations always requires insight in age composition of samples.

Significant long term trends from 1982 to 2000 were detected in incidence, number of items and mass of industrial plastics, user plastics and suspected chemical pollutants (often paraffine-like substances). Over the 1982-2000 period, only industrial plastics decreased while user plastics significantly increased. When comparing averages in the 1980s to those in the 1990s, industrial plastics approximately halved from 6.8 granules per bird (77% incidence; 0.15g per bird) to 3.6 granules (64%; 0.08g). User-plastics almost tripled from 7.8 items per bird (84%; 0.19g) to 27.6 items (97%; 0.52g). An analysis for shorter term recent trends over the period of 1996 to 2000 revealed continued significant decrease in industrial plastics and suggested stabilization or slight decreases in other litter categories.

Analysis of variability in data and Power Analysis revealed that reliable figures for litter in stomachs in a particular region are obtained at a sample size of about 40 birds per year and that reliable conclusions on change or stability in ingested litter quantities can be made after periods of 4 to 8 years, depending on the category of litter.

Mass of litter, rather than incidence or number of items, should be considered the most useful unit of measurement in the long term. Mass is also the most representative unit in terms of ecological impact on organisms. Incidence looses its sensitivity as an indicator when virtually all birds are positive (as is the case in Fulmars). In regional or time-related analyses, mass of plastics is a more consistent measure than number of items, because the latter appears to vary with changes in plastic characteristics.

The pilot study concluded that stomach content analysis of beached Fulmars offers a reliable monitoring tool for (changes in) the abundance of marine litter off the Dutch coast. By its focus on small-sized litter in the offshore environment such monitoring has little overlap with, and high additional value to beach litter surveys of larger waste items. Furthermore, stomach contents of Fulmars reflect the ecological consequences of litter ingestion on a wide range of marine organisms and create public awareness of the fact that environmental problems from marine litter persist even when larger items are broken down to sizes below the range of normal human perception. As indicated there is an increasing awareness of the dangers from microplastics, but monitoring quantities and effects in these species is more difficult than that of intermediate sized plastics in seabirds.

The pilot study concluded that the formal indicators which would be recommended in future Dutch Fulmar-Litter monitoring were abundances by mass of industrial plastic, user plastic, their combined total and suspected chemicals. Each of these represents different sources of pollution, and thus specific policy measures aimed at reduced inputs. Because no specific funding was raised the suspected chemicals plastics have become the main focus. Addition of further formal indicators from other litter (sub-)categories would produce little added value in the current situation. However, data-recording procedures are such that at the raw data-level, these categories continue to be recorded and can be extracted from databases, should the need arrive.

After publication of the pilot study, the Dutch monitoring has continued annually and has resulted in a series of reports (Van Franeker et al 2003 to 2009) that initially confirmed further decrease of industrial and especially user plastics but that later noted a halt to such trends and a lack of further change.

In 2002, the Fulmar Litter monitoring was boosted by participation in the 'Save the North Sea' project. The Save the North Sea ('SNS') campaign, co-funded by EU Interreg IIIB, aimed at increasing awareness among stakeholders so as to reduce littering behaviour. Expanding the Dutch Fulmar study to locations all around the North Sea was one of the project components. Co-operation was established with interested groups in all countries around the North Sea. In 2005 the final project report (Van Franeker et al 2005) showed that Fulmars from the southern North Sea had almost two times more plastic in the stomach than Fulmars from the Scottish Islands, and almost four times as much as that in a small sample from the Faroe Islands. Location differences and relative abundances of different types of litter suggested a major role of shipping, and show that the bulk of the litter problem in the North Sea region is of local origin.

Also in 2002, North Sea Ministers in the Bergen Declaration, decided to start a system of Ecological Quality Objectives for the North Sea. One of the EcoQO's to be developed was for the issue of marine litter pollution, using stomach contents of a seabird, the Fulmar, to monitor developments, and set a target for 'acceptable ecological quality'. OSPAR was requested to look after implementation of the ecological quality objectives. Since then, a number of steps have been taken, based on reports from the Dutch studies and the Save the North Sea project. The current wording of the EcoQO target level is:
"There should be less than 10% of Northern Fulmars having 0.1 gram or more plastic in the stomach in samples of 50-100 beachwashed fulmars from each of 5 different regions of the North Sea over a period of at least 5 years".

So, as recommended from the Dutch studies the **mass** of plastics forms the basis of the EcoQO monitoring system. But rather than using average plastic mass for the target definition, a combination is used of frequency of occurrence of plastic masses above a certain critical mass level. The background of such approach is that a few exceptional outliers can have a strong influence on the calculated average. The wording of the target level basically excludes influence of exceptional outlying values. A similar effect can be obtained by calculating mean values from logarithmically transformed data. A background document on the EcoQO has been published on the OSPAR website (OSPAR 2008). The EcoQO approach to marine litter is also considered in the European Marine Strategy Framework Directive (MSFD Task Group 10, 2010).

Anticipating further development of the EcoQO approach in OSPAR and EU, the international Save the North Sea Fulmar study group was kept active after completion of the 2002-2004 EU-project. For a number of years CSR awards (Corporate Social Responsibility) from NYK Europe Ltd made it possible to analyse stomachs from outside the Netherlands and to continue international coordination and outreach and the publication of integrated results. Dutch government funding, plus the support from NYK Europe, has ensured a North Sea EcoQO update covering data from the period 2002-2006 (van Franeker 2008) and the preparation of an update to 2007 for a publication on this EcoQO in a refereed scientific journal. Unfortunately, no financial contributions from OSPAR partners have been obtained, in spite of the only minor 'per country' funding proposed (OSPAR 2008),

Texel, the Netherlands *(April 2005)*
Merchant shipping and fisheries are major sources of marine litter in the Dutch area.

3 Shipping, marine litter and policy measures

In historic times, waste products from ships were discarded almost anywhere and at any time. The relatively low intensity of shipping and generally decomposable nature of wastes allowed such practice to continue for centuries without significant problems except inside harbour areas. However, exponential population growth and global industrialization has boosted marine transports by fast mechanically-powered ships with ever increasing quantities of poorly decomposable and toxic wastes from fuel, cargo and household practises. Old habits are hard to change, particularly if such change involves costs in an extremely competitive international industry such as shipping. For example, the dramatic environmental consequences of oil discharges from ships were already known in the early 1900s. More than a century later, under continuous public pressure and a continuous sequence of policy measures, the oil pollution problem is to some extent under control, but definitely not solved.
Compared to the problems from dumping of oil or toxic wastes, the issue of disposal of 'garbage' into the marine environment has long been considered of minor importance. It might still be considered that way if not for plastics. Plastics, although known since the early 1900s, started their real development only after 1960. Since then, they have found their way into almost every application, replacing old materials in existing products, and creating new use in for example an endless array of 'disposable' packaging products.
Unfortunately, the same factors that made plastics such a popular product have resulted in them becoming an environmental problem. Low production costs have promoted careless use and low degradability leads to accumulation in the environment. In 2007, the world production of synthetic polymers amounted to about 315 million metric tons, over 40% of which is used for packaging (PlasticsEurope2008). Annual growth rates are between 5 to 10%!
At the same time, intensity of shipping has increased. Between 1994 and 2008, the world's active merchant fleet grew from 437 to 742 million gross tons. Fleets grow faster and faster. Over the 1994-2003 decade, tonnage showed 30% growth, matched by a similar growth over the 5 year period 2003-2008. The tonnage of new merchant ships (>100 gtons) leaving shipyards was 18 million gross tons in 1994 and reached an all time peak of 57 million gross tons over 2007. (Department for Transport 2008).

Marine litter originates from a variety of sources, including merchant shipping, fisheries, offshore industry, recreational boating, coastal tourism, influx from rivers or direct dumping of wastes along seashores. The relative importance of various sources differs strongly in different parts of the world, and is almost impossible to quantify. Dutch Coastwatch studies (e.g. Stichting de Noordzee 2003) score litter into categories 'from sea' (shipping, fisheries, offshore); 'beach-tourism'; 'dumped from land'; and 'unknown'. In the Netherlands, the 'from sea' category consistently represents in the order of 40% of litter items recorded. The 'unknown' category scores a similar percentage. Considerable uncertainties are linked to this categorization. More specific information may come from the OSPAR initiative for monitoring litter on beaches in a somewhat more systematic approach. In a first German report (Fleet 2003), ten years of Coastwatch-like surveys, plus two years of the more detailed OSPAR pilot project, were evaluated. From both studies it is concluded that shipping, fisheries and offshore installations are the main sources of litter found on German North Sea beaches. The larger proportion of litter certainly originates from shipping, with a considerable proportion of this originating in the fisheries industry. In the Netherlands, data to this effect were collected in a large beach litter study on Texel (van Franeker 2005) suggesting that up to 90% of plastic litter originates from shipping and fisheries in the Dutch area.
So, although there may be uncertainties in details, there is little doubt that waste disposal by ships is one of the important sources of marine litter worldwide, a fact also recognized by the International Maritime Organization (IMO) in a specific 'garbage-annex' to the MARPOL Convention.

The International Convention for the Prevention of Marine Pollution from Ships (MARPOL 73/78) entered into force on 2nd October 1983 for Annexes I (oily wastes) and II (bulk liquid chemicals), but its Annex V, covering garbage, only achieved sufficient ratifications to enter into force on 31st December 1988. MARPOL Annex V contains the following main prohibitions for discharge of solid wastes:

- No discharge of plastics.
- No discharge of buoyant dunning, lining or packaging material within 25 nautical miles (nm).
- No discharge of garbage within 12 nm. Food waste may be discharged if ground to pieces smaller than one inch.
- No discharge of any solid waste, including food waste, within 3 nm.

Unfortunately, control of compliance with Annex V regulations on ships is difficult. During Port State Inspections, garbage-related issues will definitely not receive the strongest attention. Nevertheless, in the year 2002, 13% of deficiencies recorded related to Annex V garbage regulations (OECD-MTC 2003).

In the European region, and especially the North Sea area, the sheer intensity of merchant shipping and fisheries makes them an undisputed source of marine litter. From that background, North Sea states promoted that the North Sea received the status of MARPOL Special Area for its annexes I (oil) and V (garbage). Amendments to that effect were made in 1989, and the Special Area status for the North Sea entered into force in February 1991. "Special Areas" under MARPOL Annex V have a more restrictive set of regulations for the discharge of garbage, with the main additions being:

- No discharge, not only of plastics, but also of any sort of metal, rags, packing material, paper or glass.
- Discharge of food wastes must occur as far as practicable from land, and never closer than 12 nm.

Within the European Union, progress under worldwide MARPOL regulations was considered insufficient. In the port of Rotterdam, approximately 5 to 10% of visiting ships used port reception facilities. Clearly not every ship needs to discharge wastes at every port visit, but the level of waste delivery was clearly too low. High costs of proper disposal in combination with low risk of being fined for violations are a clear cause. Poor functioning of available reception facilities definitely plays a role as well. Compliance with MARPOL regulations is hard to enforce at sea, especially when many ships fall under jurisdiction of cheap flag-states with little concern for environmental issues. Compliance can only be promoted by measures that can be enforced when ships visit the harbour. From this perspective, the European Commission and parliament have installed the EU-Directive on Port Reception Facilities for ship-generated waste and cargo residues (Directive 2000/59/EC). Key elements of the Directive are:

- Obligatory disposal of all ship-generated waste to reception facilities before leaving port. Ship-generated waste includes operational oily residues, sewage, household and cargo-associated waste, but not residues from holds or tanks.
- Indirect financing, to a 'significant' degree, of the delivery of ship-generated waste. Finances for such 'free' waste reception should be derived from a fee system on all ships visiting the port. Delivery of cargo residues remains to be paid fully by the ship
- Ports need to develop and implement a 'harbour waste plan' that guarantees appropriate reception and handling of wastes

The term 'Significant' was later identified as meaning 'in the order of at least 30%'. Implementation date for the Directive was December 2002, but unfortunately suffered some delay in several countries. In the Netherlands, the Directive became implemented in late 2004, operating at or above the minimum level of indirect financing depending on the harbour. On an annual basis, results are evaluated by the Minister of Transport, Public Works and Water Management.

The Netherlands Ministry of Transport, Public Works and Water Management wants to measure whether implementation of the EU Directive for Port Reception Facilities has the intended effect. As far as litter is concerned, the Fulmar-Litter-EcoQO approach can be used. This tool complements surveys of quantities of litter delivered in ports, or beach surveys for quantities of waste washing onto beaches. These approaches have their specific merits but do not measure residual levels of litter in the marine environment itself. The Fulmar-Litter-EcoQO does look at this marine environment and at the same time places such information in the context of ecological effects.

4 Material and methods

In 2008 IMARES has continued the collection of beached Fulmars from Dutch beaches with the assistance of the Dutch Seabird Group (Nederlandse Zeevogelgroep NZG) through its Working Group on Beached Bird Surveys (Nederlands Stookolieslachtofffer Onderzoek - NSO). Also several coastal bird rehabilitation centers support the collection program. Since the start of the ***Save the North Sea*** project in 2002, IMARES co-ordinates similar sampling projects at a range of locations in all countries around the North Sea. Organizations involved differ widely, and range from volunteer bird groups to governmental beach cleaning projects.

Bird corpses are stored frozen until analysis. Standardized dissection methods for Fulmar corpses have been published in a dedicated manual (Van Franeker 2004b). Stomach content analyses were described in full detail in Van Franeker & Meijboom (2002) as were the methods for data analysis and presentation of results. For convenience, some of the methodological information from earlier reports is repeated here in a condensed form.

At dissections, a full series of data is recorded that is of use to determine sex, age, breeding status, likely cause of death, origin, and other issues. Age, the only variable found to influence litter quantities in stomach contents, is largely determined on the basis of development of sexual organs (size and shape) and presence of *Bursa of Fabricius* (a gland-like organ positioned near the end of the gut which is involved in immunity systems of young birds; it is well developed in chicks, but disappears within in the first year of life or shortly after). Further details are provided in Van Franeker 2004b. In the near future, an updated version of the manual should be published to improve details and maximize efficiency of methods.

After dissection, stomachs of birds are opened for analysis. Stomachs of Fulmars have two 'units': initially food is stored and starts to digest in a large glandular stomach (the *proventriculus*) after which it passes into a small muscular stomach (the *gizzard*) where harder prey remains can be processed through mechanical grinding. In early phases of the project, data for the two individual stomachs were recorded separately, but for the purpose of reduction in monitoring costs, the contents of proventriculus and gizzard are now combined.

If oil or chemical types of pollutants are present, these may be sub-sampled and weighed before rinsing the remainder of stomach content. Although this was a standard component at the start of our studies, requirements for the Dutch “graadmeter” and international EcoQO have a focus on plastic or at best MARPOL Annex V litter types. Thus, for financial efficiency, potential chemical pollutants in the stomachs are no longer part of the project. If sticky substances hamper further processing of the litter objects, hot water and detergents are used to rinse the material clean as needed for further sorting and counting under a binocular microscope.

The following categorization is used for plastics and other rubbish found in the stomachs:

1 PLASTICS (PLA)

1.1 Industrial plastic pellets (IND). These are small, often cylindrically-shaped granules of ± 4 mm diameter, but also disc and rectangular shapes occur. Various names are used, such as pellets, beads or granules. They can be considered as “raw” plastic or a half-product in the form of which, plastics are usually first produced (mostly from mineral oil). The raw industrial plastics are then usually transported to manufacturers that melt the granules and mix them with a variety of additives (fillers, stabilizers, colourants, anti-oxidants, softeners, biocides, etc.) that depend on the user product to be made. For the time being, included in this category is a relatively small number of very small, usually transparent spherical granules, also considered to be a raw industrial product.

1.2 User plastics (USE) (all non-industrial remains of plastic objects) differentiated in the following subcategories:

1.2.1 **sheetlike user plastics (she)**, as in plastic bags, foils etc., usually broken up in smaller pieces;

1.2.2 **threadlike user plastics (thr)** as in (remains of) ropes, nets, nylon line, packaging straps etc. Sometimes ‘balls’ of threads and fibres form in the gizzard;

1.2.3 **foamed user plastics (foa)**, as in foamed polystyrene cups or packaging or foamed polyurethane in matrasses or construction foams;

1.2.4 **fragments (fra)** of more or less hard plastic items as used in a huge number of applications (bottles, boxes, toys, tools, equipment housing, toothbrushes, lighters etc);

1.2.5 **other (oth)**, for example cigarette filters, rubber, elastics etc., so items that are 'plastic-like' or do not fit into a clear category.

2 **RUBBISH (RUB)** other than plastic:

2.1 **paper (pap)** which besides normal paper includes silver paper, aluminum foil etc, so various types of non-plastic packaging material;

2.2 **kitchenfood (kit)** for human food wastes such as fried meat, chips, vegetables, onions etc, probably mostly originating from ships' galley refuse;

2.3 **various rubbish (rva)** is used for e.g. pieces of timber (manufactured wood); paint chips, pieces of metals etc.;

2.4 **fish hook (hoo)** from either sport-fishing or long-lining.

Further optional categories of stomach contents

3 POLLUTANTS (POL)

for items indicating industrial or chemical waste remains such as slags (the remains of burning ovens, eg remains of coal or ore after melting out the metals); tar-lumps (remains of mineral oil); chemical (lumps or 'mud' of paraffin-like materials or sticky substances arbitrarily judged to be unnatural and of chemical origin) and feather-lumps (indicating excessive preening by the bird of feathers sticky with oil or chemical pollutants).

4 NATURAL FOOD REMAINS (FOO)

Numbers of specific items may be recorded in separate subcategories (fish otoliths, eye-lenses, squid-jaws, crustacean remains, jelly-type prey remains, scavenged tissues incl feathers, insects, other).

5 NATURAL NON-FOOD REMAINS (NFO)

Numbers of subcategories eg. plant-remains, seaweed, pumice, stone and other may be recorded.

For the main categories 1 (plastic) and 2 (rubbish) we record for each bird and each (sub)category:

- incidence (Presence or absence) and
- abundance by number (count of Number of items)
- abundance by mass (Weight in grams) using Sartorius electronic weighing scale after a one to two day period of air drying at laboratory temperatures. For marine litter (categories 1 to 3 above), this is done separately for all subcategories. In the early Fulmar study we also weighed the natural-food and natural-non-food categories as a whole, but this was discontinued in 2006 to reduce costs. Weights are recorded in grams accurate to the 4th decimal (= tenth of milligram).

To be able to sort out items of categories 1 and 2, all other materials in the stomachs described in categories 3 to 5, have to be cleaned out. However in these latter categories, further identification, categorization, counting, weighing and data-processing is not essential for the EcoQO. Whether details are recorded depends of the interest of the participating research group and their reasons to collect beached Fulmars.

In addition to the acronyms used for (sub)categories as above, further acronyms may be used to describe datasets. Logarithmic transformed data are initiated by 'ln'; mass data are characterized by capital G (gram) and numerical data by N(number). For example lnGIND refers to the dataset that uses ln-transformed data for the mass of industrial plastics in the stomachs; acronym NUSE refers to a dataset based on the number of items of user plastics.

Analysis

Data from dissections and stomach content analysis are recorded in Excel spreadsheets and next stored in Oracle relational database. GENSTAT 8 was used for statistical tests. As concluded in the pilot study (Van Franeker & Meijboom 2002) and later reports, statistical analysis of data for presence of trends over time is conducted using mass-data. Tests for trends over time are conducted using linear regressions fitting ln-transformed plastic mass values for individual birds on the year of collection. Logarithmic transformation is needed because the original data are strongly skewed and need to be normalized for the statistical procedures. Tests for 'long term' trends use the full data set; 'recent' trends only use the past ten years of data.

For earlier Dutch reports, the tests on significance of trends on the chosen indicators of 'total plastic', 'industrial plastic' and 'user plastic' were the final main output. Focus was on significance of trends in specified categories without defining the final target. However, the wording of the Fulmar-Litter-EcoQO as now proposed in OSPAR is:

> *"There should be less than 10% of Northern Fulmars having 0.1 gram or more plastic in the stomach in samples of 50-100 beached fulmars from each of 5 different regions of the North Sea over a period of at least 5 years".*

Thus, the information requested now focuses more on the information on 'total plastic' and 5-year averages for mass of the combined plastics in the bird stomachs. Such information is already incorporated in the Dutch approach, and merely requires a simplified data-presentation for EcoQO purposes. In the background however, tests using individual data as described above, and data collection on specified main litter categories, continue to play an important role for correct interpretation of the EcoQO metric.

Table 1 ***Summary of sample characteristics and stomach contents of Fulmars collected for Dutch marine litter monitoring in the year 2008.*** *The top line shows sample composition in terms of age, sex, origin (by colourphase; darker phases are of distant Arctic origin), death cause oil, and the average condition-index (which ranges from emaciated condition=0 to very good condition=9). Although only age is currently relevant in the Dutch dataset, this is not necessarily true in later international comparisons. For each litter-(sub)category the table lists: Incidence, representing the proportion of birds with one or more items of the litter category present; average number of items per bird stomach; average mass per bird stomach; and the maximum mass observed in a single stomach. The final column shows the geometric mean mass, which is calculated from ln-transformed values as used in trend-analyses.*

YEAR	nr of birds	adult	male	LL colour	death oil	avg condition
2008	**20**	**58%**	**32%**	**90%**	**5%**	**1.3**

	Year 2008 *(n=20)*	**incidence**	**average number of items**	**average mass of litter (g/bird) ± standard deviation**	**max. mass recorded**	**geometric mean mass (g/bird)**
1	**ALL PLASTICS**	**95%**	**44.5**	**0.315 ± 0.452**	**1.9**	**0.1036**
1.1	**INDUSTRIAL PLASTIC**	**65%**	**3.8**	**0.083 ± 0.112**	**0.4**	**0.0164**
1.2	**USER PLASTIC**	**95%**	**40.8**	**0.232 ± 0.363**	**1.6**	**0.0779**
1.2.1	sheets	75%	6.1	0.015 ± 0.025	0.1	0.0042
1.2.2	threads	35%	1.8	0.003 ± 0.006	0.0	0.0011
1.2.3	foamed	70%	9.6	0.023 ± 0.043	0.2	0.0046
1.2.4	fragments	90%	23.3	0.190 ± 0.352	1.6	0.0562
1.2.5	other plastic	5%	0.1	0.001 ± 0.005	0.0	0.0002
2	**OTHER RUBBISH**	**40%**	**2.6**	**0.031 ± 0.078**	**0.3**	**0.0027**
2.1	paper	0%	0.0	0.000 ± 0.000	0.0	0.0000
2.2	kitchenwaste (food)	30%	2.5	0.014 ± 0.037	0.2	0.0016
2.3	rubbish various	15%	0.2	0.017 ± 0.072	0.3	0.0006
2.4	fishhook	0%	0.0	0.000 ± 0.000	0.0	0.0000

5 Results & Discussion

5.1 Monitoring in the Netherlands 1979-2008 and trends

Few Fulmars beached in the southern North Sea area over the year 2008. In spite of considerable extra effort to motivate the volunteers patrolling beaches, only 22 corpses could be collected. Of these, 20 birds contained an intact stomach that was adequate for the EcoQO research. A sample-size of 40 or more is recommended to reliably characterize the pollution level in a particular time-frame and area (i.e. the annual 'average'). However, for multi-year trends a lower sample size in a particular year is not a problem, as analyses do not rely on annual averages but on individual data for each bird.

In the year 2008, 19 out of 20 stomachs (95%) contained plastic, with an overall average number of 45 items and mass of 0.31 gram per bird (Table 1). Non-plastic rubbish was found in 40% of the stomachs, most frequently being galley food wastes. Numerical abundance of plastic particles in 2008 was somewhat higher than in 2007 but mass abundance somewhat lower. In the light of the small sample, this represents no noticeable change between the two years.

As convened in earlier reports, the metric for discussion of trends focuses on the mass of plastics in stomachs, in which the

- **'current situation**' is described by the average for the last 5-year period (now: 2004-2008);
- **'long-term trend**' refers to the full dataset (now 1979-2008)
- '**recent trend**' is defined as trend over the past 10 years (now 1999-2008); and
- Trends are **tested** for statistical significance by linear regressions of ln-transformed plastic data of individual birds against year.

The **current situation** as shown in the 5 year average in the bottom of table 2 fits in with the pattern of reduced plastic loads in Fulmar stomachs after peak levels in the 1990s. Mean values over the most recent 5 years (2004-2008; 290 Fulmars) are that 93% of birds had plastic in the stomach, with an average number of 27 pieces, and average mass of 0.30 gram plastic. Thus, the year 2008 was very 'average' for the situation over the past 5 years, which implies that earlier improvements seen around the turn of the century seem to have stopped, and that the amounts of ingested plastic are more or less stable over the past five years.

The **long term 1979-2008 trend** analysis for "all plastics" ignores the 1990s peak in pollution levels and sees no significant change (Table 3A), i.e. indicates comparable levels in the 1980s and recent period. However, compared to the 1980s, the composition of plastic litter has strongly changed, with a significantly reduced proportion of industrial plastics and an increased mass of user plastics from discarded waste (Table 3A).

Statistical tests for **recent trends over the past 10 years (1999-2008)** (Table 3B) no longer show significant changes. As already seen in the 2007 update, the significant downward trends over 10 year periods up to 2006 have ceased in the more recent tests. Both industrial and user plastics contributed to this change.

A general visual impression of the various trends in plastic pollution since the 1980s is best obtained from Fig.1, which is based on the data from Table 2, recalculated to 'stable' 5-year means, each time shifting one year ahead. Shown are trends in plastic incidence, average number and average mass of plastic per bird, detailed into industrial and user plastics. In all three aspects, the increase in plastic pollution between the 1980s and the second half of the 1990s is visible, and is completely caused by increased user plastics, masking substantial decreases in industrial plastic over that period. In the late 1990s nearly 100% of Fulmars had plastic in the stomach, approaching 30 particles and 0.6 gram mass of plastic per bird. The graphs show that these late 1990s figures represented peak levels and that since then, on top of the continued decrease of industrial plastic, user plastics also started a downward trend. Remarkably, this is not the case when looking at the average number of plastic items, which has remained at a more or less constant high level of near 30 pieces per bird. Apparently, characteristics of user plastics are changing with smaller fragments becoming more dominant. However, Fig.1 clearly illustrates that plastic ingestion continues to occur at a very high level, and that decreases in plastic mass seen around the change of the century have slowed down and so far provide no evidence for improvement following implementation of the EU Port Reception Facilities Directive in late 2004.

Table 2 ***Annual details for plastic abundance in Fulmars from the Netherlands.*** *For separate and combined plastic categories, incidence (%) represents the proportion of birds with one or more items of that litter present; number (n) abundance by average number of items per bird; and mass (g) abundance by average mass per bird in grams. The column on the far right indicates level of performance in relation to the OSPAR EcoQO, viz. the percentage of birds having more than the critical level of 0.1 gram of plastic in the stomach. The bottom line of the table shows the 'current' situation as the average over the past 5 years. Note sample sizes (n) to be very low for particular years implying low reliability of the annual averages for such years, not to be used as separate figures. Also note erratic variability in age proportions of birds in samples, where age is known to influence amount of litter in the stomach. Trend analyses (table 3) are not based on annual averages, but on values from all individual birds, together and in age-groups, to overcome problems of years of poor sample size or variable age composition.*

			INDUSTRIAL PLASTICS			USER PLASTICS			ALL PLASTICS (industrial + user)			EcoQO
YEAR	*n*	% adult	%	n	g	%	n	g	%	n	g	> 0.1 g
1979	*1*	0%	100%	2.0	0.07	100%	3.0	0.17	100%	5.0	0.24	100%
1980												
1981												
1982	*3*	0%	100%	5.0	0.11	67%	6.0	0.50	100%	11.0	0.61	100%
1983	***19***	**41%**	**84%**	**8.8**	**0.19**	**89%**	**7.2**	**0.31**	**100%**	**16.0**	**0.49**	**89%**
1984	***20***	**40%**	**70%**	**9.6**	**0.19**	**90%**	**8.4**	**0.17**	**90%**	**17.9**	**0.35**	**55%**
1985	*3*	33%	100%	5.3	0.14	100%	5.0	0.14	100%	10.3	0.28	100%
1986	*4*	25%	50%	0.8	0.02	75%	4.8	0.06	75%	5.5	0.08	25%
1987	***15***	**67%**	**80%**	**3.9**	**0.11**	**67%**	**8.9**	**0.09**	**80%**	**12.7**	**0.20**	**53%**
1988	*1*	0%	0%	0.0	0.00	100%	2.0	0.04	100%	2.0	0.04	0%
1989	*4*	50%	75%	5.3	0.14	100%	11.0	0.16	100%	16.3	0.29	75%
1990												
1991	*1*	0%	0%	0.0	0.00	100%	11.0	0.14	100%	11.0	0.14	100%
1992												
1993												
1994												
1995	*2*	50%	100%	1.5	0.02	100%	3.5	0.03	100%	5.0	0.06	0%
1996	*8*	63%	75%	2.9	0.07	100%	24.5	0.19	100%	27.4	0.26	63%
1997	***31***	**16%**	**74%**	**5.9**	**0.13**	**97%**	**29.8**	**0.60**	**97%**	**35.8**	**0.73**	**84%**
1998	***74***	**45%**	**69%**	**3.1**	**0.07**	**95%**	**25.9**	**0.88**	**96%**	**29.0**	**0.95**	**72%**
1999	***107***	**70%**	**58%**	**3.4**	**0.06**	**97%**	**31.8**	**0.38**	**98%**	**35.3**	**0.44**	**61%**
2000	***38***	**58%**	**61%**	**3.4**	**0.08**	**100%**	**18.6**	**0.27**	**100%**	**22.0**	**0.35**	**61%**
2001	***54***	**38%**	**63%**	**2.6**	**0.06**	**96%**	**20.4**	**0.18**	**96%**	**22.9**	**0.24**	**48%**
2002	***56***	**54%**	**68%**	**4.6**	**0.09**	**96%**	**47.2**	**0.41**	**98%**	**51.8**	**0.50**	**68%**
2003	***39***	**56%**	**51%**	**2.3**	**0.05**	**92%**	**26.3**	**0.12**	**95%**	**28.5**	**0.17**	**54%**
2004	***131***	**80%**	**54%**	**2.6**	**0.06**	**91%**	**20.8**	**0.22**	**91%**	**23.4**	**0.27**	**60%**
2005	***51***	**68%**	**53%**	**2.0**	**0.05**	**96%**	**15.8**	**0.22**	**98%**	**17.8**	**0.27**	**47%**
2006	***27***	**62%**	**78%**	**3.5**	**0.08**	**93%**	**30.4**	**0.23**	**93%**	**33.9**	**0.30**	**85%**
2007	***61***	**42%**	**70%**	**3.1**	**0.07**	**90%**	**32.5**	**0.30**	**92%**	**35.6**	**0.37**	**70%**
2008	***20***	**58%**	**65%**	**3.8**	**0.08**	**95%**	**40.8**	**0.23**	**95%**	**44.5**	**0.31**	**55%**
2004-08 *	***290***	**65%**	**60%**	**2.8**	**0.06**	**92%**	**24.7**	**0.24**	**93%**	**27.4**	**0.30**	**62%**

* Five-year data were averaged over all individual birds in the five year period (so not from annual averages)

Table 3 ***Details of linear regression analyses of the selected litter indicators****. Analysis of trends was conducted by linear regression, fitting ln-transformed litter mass values for individual birds on the year of collection. Tests were conducted over the full time period 1979-2008 (Table 3A) and the most recent 10 years of data (Table 3B). The regression line ('trend') is described by y = Constant + estimate*x in which y is the calculated value of the regression-line for year x. When the t-value of a regression is negative it indicates a decreasing trend in the tested litter-category; a positive t-value indicates increase. A trend is considered significant when the probability (p) of misjudgement of data is less than 5% (p<0.05). Significant trends in the table have been labeled with positive signs in case of increase (+) or negative signs in case of decrease (-). Significance at the 5% level (p<0.05) is labeled as - or + ; at the 1% level (p<0.01) as – or ++; and at the 0.1% level (p<0.001) as — or +++.*

A. LONG TERM TRENDS 1979-2008
for plastics in Fulmar stomachs, the Netherlands

INDUSTRIAL PLASTIC (lnGIND)	*n*	Constant	estimate	s.e.	t	p	
all ages	*770*	97.3	-0.0507	0.0134	-3.77	**<.001**	- - -
adults	*429*	57.5	-0.0310	0.0204	-1.52	0.130	*n.s.*
non adults	*328*	99.4	-0.0516	0.0181	-2.85	**0.005**	- -

USER PLASTICS (lnGUSE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*770*	-36.2	0.0168	0.0116	1.45	0.149	*n.s.*
adults	*429*	-21.1	0.0091	0.0183	0.5	0.617	*n.s.*
non adults	*328*	-74.5	0.0361	0.0150	2.40	**0.017**	+

ALL PLASTICS COMBINED (lnGPLA)	*n*	Constant	estimate	s.e.	t	p	
all ages	*770*	27.3	-0.0147	0.0113	-1.31	0.192	*n.s.*
adults	*429*	11.8	-0.0071	0.0181	-0.39	0.694	*n.s.*
non adults	*328*	10.9	-0.0064	0.0139	-0.46	0.646	*n.s.*

B. RECENT 10-year TRENDS (1999-2008)
for plastics in Fulmar stomachs, the Netherlands

INDUSTRIAL PLASTIC (lnGIND)	*n*	Constant	estimate	s.e.	t	p	
all ages	*584*	-68.2	0.0319	0.0332	0.96	0.338	*n.s.*
adults	*356*	-74.9	0.0351	0.0436	0.8	0.421	*n.s.*
non adults	*217*	4	-0.0039	0.0517	-0.08	0.940	*n.s.*

USER PLASTICS (lnGUSE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*584*	22.3	-0.0124	0.0279	-0.45	0.656	*n.s.*
adults	*356*	93.1	-0.0479	0.0386	-1.24	0.216	*n.s.*
non adults	*217*	-37.7	0.0177	0.0387	0.46	0.649	*n.s.*

ALL PLASTICS COMBINED (lnGPLA)	*n*	Constant	estimate	s.e.	t	p	
all ages	*584*	33.2	-0.0177	0.0275	-0.64	0.52	*n.s.*
adults	*356*	81.6	-0.042	0.0383	-1.1	0.274	*n.s.*
non adults	*217*	9.7	-0.0058	0.0373	-0.16	0.877	*n.s.*

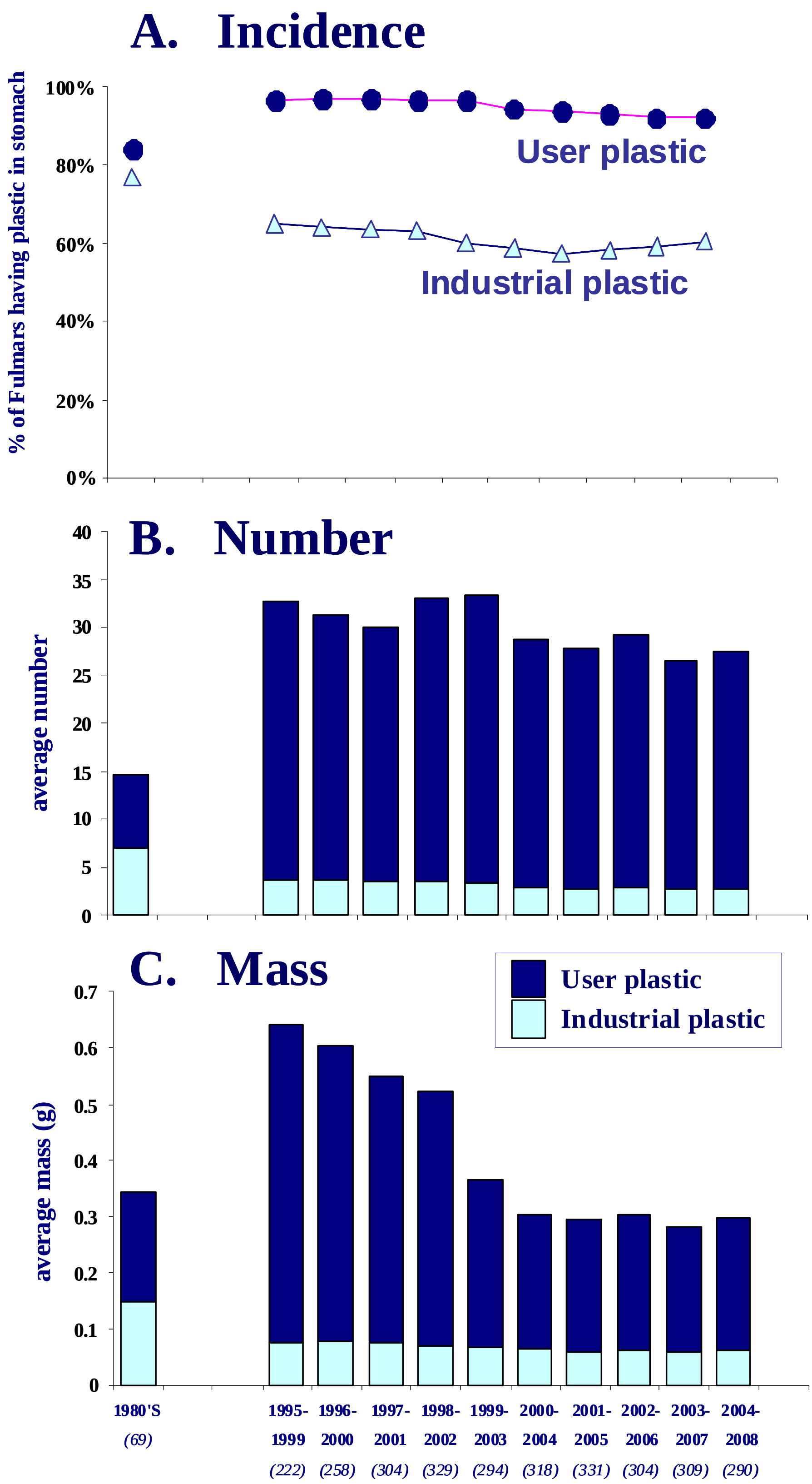


Figure 1 ***Visual summary of Fulmar-Litter monitoring results in the Netherlands 1982-2007****, comparing average data for incidence, number of items and mass in the 1980's with running 5-year averages for the more recent period.*

Annual data: geometric means

As explained in methods, the statistical tests (Table 3) for trends over time do not use annual or multi-year averages, but are based on stomach contents data from individual birds and year of collection. This allows greater detail and the inclusion of data from years where only small samples of birds were collected. Values for plastic contents are logarithmically transformed, because data are not normally distributed with a few high values obscuring trend analysis. Logarithmic transformation normalizes the distribution of data and reduces the influence of the exceptionally high values.

However, annual figures are more convenient for regular annual updates in a monitoring program and since 1997 the Dutch annual sample sizes have usually been large enough to calculate annual means. Logarithmic transformation of data is still needed, but the average of logarithmic values can be transformed back into a 'normal' value, which is then known as the 'geometric mean'. Geometric means are appropriate to make comparisons between groups of samples (years, but also regions), but it has to be kept in mind that they can be very different from normal averages ('arithmetic means'). Since logarithmic transformation reduces the role of higher values, the geometric mean is usually considerably lower than the arithmetic mean for the same data. In mass data for plastics in the Fulmar stomachs, geometric means are only about one third of the arithmetic means (see table 1).

Annual geometric means for total plastic mass in the Fulmar stomachs since 1997 and the combined figure for the early 1982-1990 period are shown in Fig. 2. Graphs illustrate the trends also found by regressions in Table 3, and clearly illustrate the effects of age. Differences between the age groups are mostly consistent between annual samples indicating that summarized monitoring results can be expressed as the figure for all ages combined (Summary Fig. *ii*). As shown in tables 1-3 and Fig.1, recent years including the year 2008 show no evidence for consistent improvement in the marine litter situation. However, where over the period 2003 to 2006 concern for increasing trends was growing, the more recent data of 2007 and 2008 actually show stabilization rather than further change.

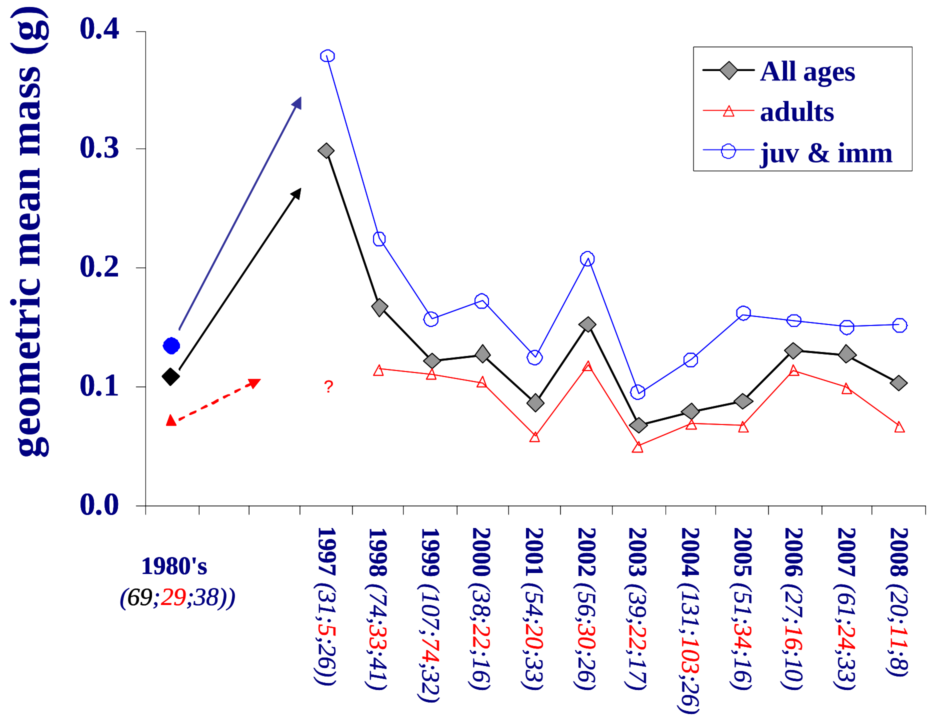


Figure 2 ***Annual geometric means for mass of plastics in stomachs of beached Fulmars from the Netherlands 1982-2008*** *for all age groups combined (including birds of unknown age), adult birds and non-adults, with sample sizes in brackets in the x-axis labels. Data illustrate the trends and consistency in age-differences that allow usage of the all-age trend-line in the summary.*

Geometric mean masses are also an appropriate basis to compare the separate trends in abundance of industrial and user plastics (Fig.3). . In the 1980s about equal masses of both types of plastic were present in the stomachs of Fulmars, but nowadays user plastics represent over 75% of the plastic mass in Fulmar stomachs and exceeds levels seen the 1980s. Decreases in industrial plastics have also been observed in other parts of the world (Vlietstra & Parga 2002); Ryan 2008; Ryan et al. 2009)

The remarkable increase in industrial plastic mass in the small 2006 sample was not fully confirmed in the 2007 and 2008 samples, but nevertheless relatively high within the recent years. The high level of user plastics in 2006 was also confirmed in the 2007 and 2008 samples. Figure 3 suggests that user plastics irregularly decreased from the mid 1990's to 2003, but after that slowly increased up to 2007. Fortunately, the slightly lower value for 2008 now suggests a break in this pattern

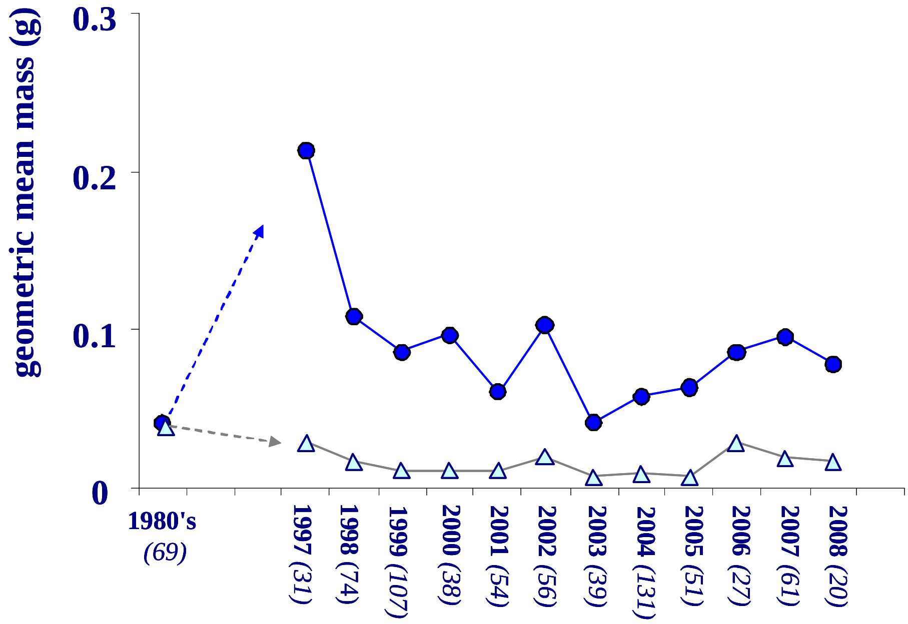


Figure 3 ***Annual geometric means for masses of industrial and user plastics in stomachs of beached Fulmars from the Netherlands 1982-2008*** *(all ages)*

Interpretation of trends and evaluation of policies

The lack of continuation of a downward trend in the abundance of plastic pollution in the Dutch sector of the North Sea after 2003 is disappointing because the breakpoint around 2003 coincides with the start of the implementation of the EU Directive on Port Reception Facilities, which clearly had the intention to reduce marine litter abundance. However, a proper evaluation of the effect of measures taken, needs to consider various circumstances.

The shipping industry is a growing sector worldwide. Shipping activity in the Dutch sector, measured by the so-called 'throughput' in gross tonnage in and out of Rotterdam harbour (Port of Rotterdam 2010; Fig.4) indicates that moderate growth prior to 2003 (4.6% over the 1997-2003 period) changed to rapid growth after 2003 (28.4% increase in tonnage in the 2003-2008 period).

The global production of plastics has, in recent years, increased by about 5% to 6% per annum (Fig.5; Plastics*Europe* 2008, 2009). Plastics are more and more replacing other materials in all sorts of applications and therefore represent a growing proportion of debris, including those originating from ships.

It is not possible to quantify balances between policy measures derived from the harbour directive on the one hand and sector growth and changes in debris composition on the other hand. Clearly, abundance of litter in the marine environment is currently not decreasing as intended by the EU Directive, but increased shipping intensity and increased plastic usage give some explanation, that this is a tough battle. Stability in marine litter abundance (e.g. Fig.1c) can be seen as insufficient effect from policy measures, but does not imply no effect.

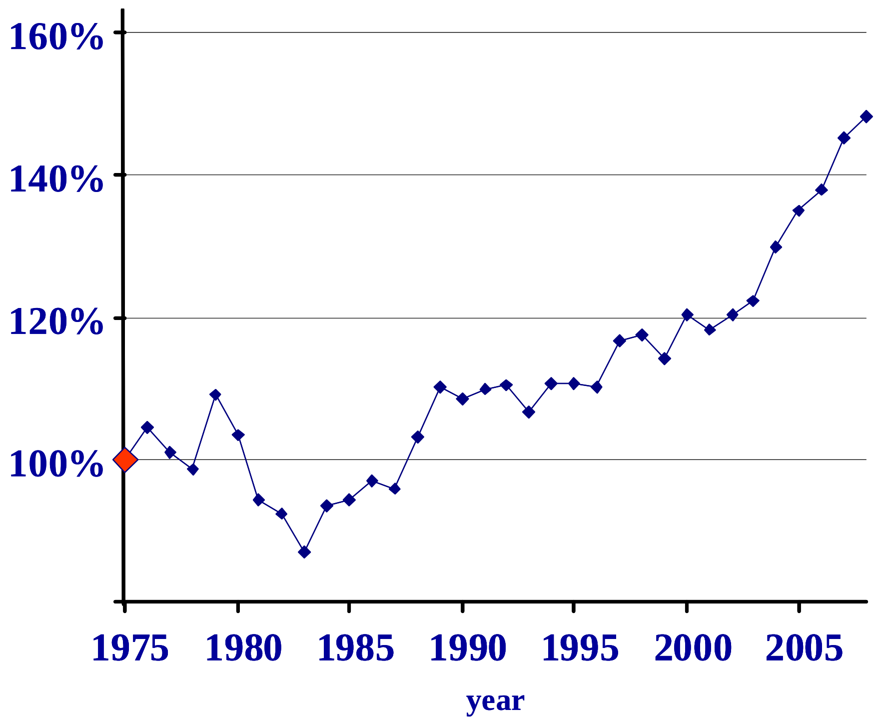


Figure 4. ***Growth in throughput for Port of Rotterdam in gross Tons in and out 1975-2008*** *(percentage growth compared to situation in 1975 of 270 Million Ton throughput) (source: Port of Rotterdam 2010)*

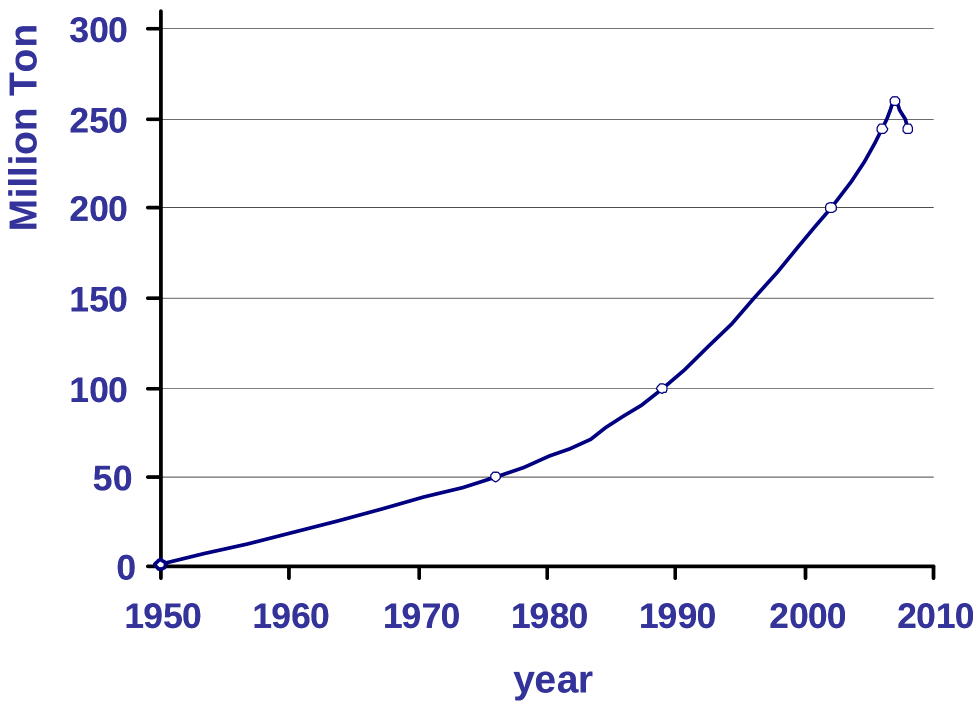


Figure 5. ***Global production of plastics in million tons since 1950 (source: PlasticsEurope 2008, 2009).***

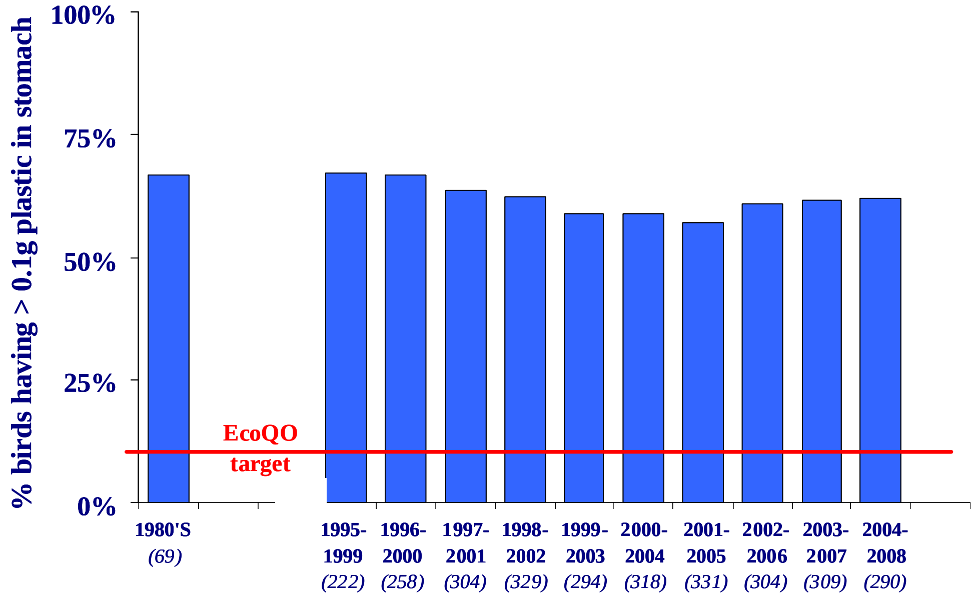


Figure 6. ***EcoQO performance of Fulmars from the Netherlands 1980s to 2008**. Running 'five-year-averages' for the percentage of beached Fulmars having more than 0.1g plastic in the stomach (all ages). Samples sizes in brackets in x-axis labels. Target level for acceptable ecological quality as currently set by OSPAR is that 10% of birds exceeds the critical level.*

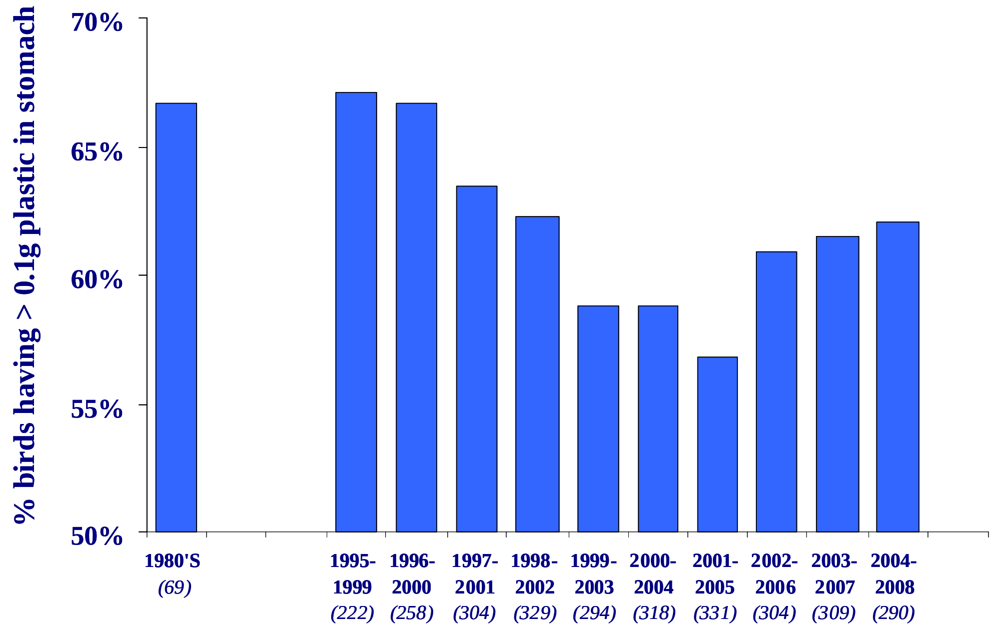


Figure 7. ***EcoQO performance of Fulmars from the Netherlands 1980s to 2008**. See caption fig. 6. Detail of changes over time.*

5.2 Dutch data in terms of the OSPAR EcoQO metric

ICES working groups, followed by OSPAR, have always described the EcoQO metric for marine litter in terms of a percentage of birds exceeding a critical value of plastic in the stomach. At first sight, one might argue that it would be easier to use an EcoQO definition based on for example only the average mass of plastics. However, whether intentional or not, the 'percentage plus critical value' definition represents a sort of simplified procedure that avoids the mathematical problems caused by a few excessive stomach contents distorting comparative analyses. In the testing procedures and geometric means used above, such problems are overcome by logarithmic transformation of data. And although this is a standard statistical procedure, it is not always easily conveyed to the general public, and differences between means (arithmetic versus geometric) can be confusing. The EcoQO metric avoids such problems by using classes of birds in which the exceptional stomach contents loose their influence. Currently, the target for acceptable ecological quality has been defined as the situation in which *"less than 10% of Northern Fulmars has 0.1 gram or more plastic in the stomach; in all North Sea regions; for a consecutive period of at least five years".* So in such a definition an excessive stomach content of e.g. over ten grams does not change the metric compared to the situation in which that bird would have had only an average amount of plastic of ca. 0.3 g in the stomach.
Using the same data as in earlier sections of this report, Figure 6 shows the time trends in the 5-year average EcoQO performance of Fulmars found in the Netherlands. With the Y-axis scaled to a 100% range, the distance from the 10% EcoQO target set by OSPAR is strongly visualised and emphasizes the need for further improvement. At this axis scale the graphs insufficiently shows the changes since the mid 1990's. The same data at a finer scale can be seen in Fig. 7 (= Fig iii of the summary), showing gradual improvements in EcoQO performance from 67% down to 57% exceeding 0.1g level in the 2001-2005 period, but following by a smaller increase. Over the most recent 2004-2008 period, 62% of Dutch Fulmars exceeds the 0.1g critical EcoQO level.

5.3 Results North Sea

Funding from the NYK Group Europe Ltd has made it possible to process stomach samples from other North Sea locations up to the year 2007, results of which are in preparation for publication in a reviewed scientific journal. For the latest published international update of the Fulmar EcoQO, please see van Franeker et al 2008.
Quantities of plastics decrease from the southern North Sea to the north: Fulmars from the Netherlands have about twice as much plastic in their stomach than Fulmars from the Scottish Islands.

After 2007, the International coordination of sampling for the Fulmar project has continued but birds or their stomachs are stored frozen until new funds allow their processing. At this moment also options for continued sampling are at risk. The continued combination of the Dutch and the international research would effectively implement the OSPAR litter EcoQO as requested by North Sea Ministers at their Bergen meeting in 2002.

5.4 Preview 2009

In spite of considerable sampling effort, few beached Fulmars could be collected in 2008. Also observers at sea reported very low numbers of Fulmars in the southern North Sea. The variability in bird occurrence became once again evident, when in the first week of January 2009, a sudden passage of fulmars along our coast was reported, soon followed by beached specimens. Within the first two weeks more than 50 birds were found beached.
To balance work effort between contract years, it was agreed with DGLM to include part of the 2009 birds in the contract for the 2008 update. We dissected 35 Fulmars from early 2009, 30 of which contained stomachs of which results have been summarized in table 4.

Table 4 *Preview of results for plastic abundance in Fulmars from the Netherlands in year 2009. See caption table 2 for explanations.*

YEAR	*n*	% adult	INDUSTRIAL PLASTICS %	n	g	USER PLASTICS %	n	g	ALL PLASTICS (industrial + user) %	n	g	EcoQO > 0.1 g
2009	***30***	**43%**	**30%**	**0.5**	**0.01**	**97%**	**11.1**	**0.10**	**100%**	**11.6**	**0.11**	**43%**

In contrast with the high figure for incidence of plastics (100% for the combined categories) in this first part of the 2009 sample, the number of items per bird as well as the average mass of plastic per bird and the EcoQO figure are low.

However, caution must be applied when looking at these partial data. Values are promising in suggesting an improvement of environmental quality off the Dutch coast in 2009, as they are the lowest on record. But in interpretation of the data it has to be considered that all birds in this initial sample originate from a single wreck in early January 2009: all 35 dissected specimens were found between 4 and 10 January 2009. A sudden influx of birds into our area plus almost immediate mortality potentially results in a biased view: these birds may have resided for a longer time in somewhat cleaner locations further north, compared to a full annual dataset involving birds from different times of year and situations. The data need to be completed with the other birds collected in 2009, including more birds from the January wreck. It may seem tempting to discard further birds from the wreck from the 2009 sample, but selective omission because of hypothetical bias, would represent data manipulation that is unacceptable in scientific monitoring. Samples in the Fulmar monitoring systems are often not equally distributed over the year. But resulting deviations in stomach contents, if they occur, are leveled out in multi-year trends, re-emphasizing that a minimum period of 10 years is a sound approach for statistical testing. Single year or short term interpretations can be indicative and informative, but should not be seen as conclusive.

Fulmar beached on Texel.
(Dark colourphase indicates arctic origin)

6 Conclusions

With an increasing number of study years after the initial pilot study (Van Franeker & Meijboom 2002), the Fulmar-Litter monitoring program has strongly matured. Good annual samples for the Netherlands for most years since 1997, and international expansion of the project since 2002, have delivered a wealth of data and firmly established the approach of plastic abundance in stomachs of the Northern Fulmar as being suitable for monitoring marine litter in the framework of Ecological Quality Objectives (EcoQO's) for the North Sea (OSPAR 2008). The EcoQO approach is also considered as an element the European Marine Strategy Framework Directive (EC 2008).

This report updates Dutch long term monitoring information for the Netherlands up to the year 2008.

- In the **year 2008** in the Netherlands, 19 out of 20 Fulmar stomachs contained plastic (incidence 95%) with an overall average of 45 items per bird and average mass of 0.31 gram per bird. The sample is smaller than desirable for annual figures, but this does not affect validity of trend analyses. In terms of the metric used in the Fulmar-Litter-EcoQO, viz. the percentage of birds with more than 0.1 gram of plastic in the stomach, 55% of the Dutch Fulmars exceeded the critical level in 2008.

- The **'current situation'** calculated as the five year average over years 2004-2008 (290 birds) shows that incidence of plastics in Dutch Fulmars was 93%, with an average number of 27 items and average mass 0.30 g per bird, and that 62% of these Fulmars exceeded the critical EcoQO level of 0.1gram of plastic in the stomach.

- Thus, in 2008, the plastic mass and EcoQO data were not very different from the current 5 year average for the Netherlands. which indicates lack of change in the current situation. Proper statistical tests however, consider periods of at least ten years.

- In the **long term since 1979**, the overall plastic mass in stomachs of Dutch Fulmars peaked in the late 1990s, but since then has returned to a level similar to that in the 1980s. For this reason, linear tests over the full period show no significant changes. However, over these years the composition of the ingested plastic has strongly changed from about equal mass proportions of industrial and user plastics in the 1980's to over 75% of user plastics in the current composition.

- Statistical tests over the recent **10-year period 1999-2008** confirm that earlier downward trends for the Netherlands (significant to 1997-2006 period) have come to a halt, and that no significant change can be detected at the moment.

- These results imply that **no improvement** has occurred in the litter situation off the Dutch coast following the implementation of the EU Directive on Port Reception Facilities since 2004. It is important to reiterate that there is no doubt that within the Dutch area, merchant shipping and fisheries are the main source of marine debris, estimated in the order of 90% of the mass of litter washed ashore (van Franeker 2005)

- When considering the strong growth in shipping since 2003 and the continuous increase in proportion of plastics in waste streams, the stability in marine litter pollution may be seen as a positive, although insufficient result with regard to the policy intentions of the EU Directive on Port Reception facilities.

- Fulmar EcoQO data for 2008 from other North Sea countries or regions, as required in the OSPAR EcoQO, have to wait for new sources of funding allowing analyses and reporting.

7 Acknowledgements

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Beached Fulmars are mostly collected by volunteers associated with the coordinators from a wide range of organizations. There are too many persons involved to be named. However, without that huge amount of volunteer effort, a project like this would be totally impossible.

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9 Quality Assurance

Methodology used in this report has been developed over a number of years into a published methodology in the OSPAR approach of Ecological Quality Objectives for the North Sea.

OSPAR 2008. Background Document for the EcoQO on plastic particles in stomachs of seabirds. OSPAR Commission, Biodiversity Series. ISBN 978-1-905859-94-8 Publication Number: 355/2008. http://www.ospar.org/documents/dbase/publications/p00355_EcoQO%20Plastics%20in%20seabird%20stomachs.pdf

IMARES utilises an ISO 9001:2000 certified quality management system (certificate number: 12703-2007-AQ-ROT-RvA). This certificate is valid until 15 June 2010. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

Justification

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The scientific quality of this report has been peer reviewed by a colleague scientist and the head of the department of Wageningen IMARES.

Approved:

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