Wageningen IMARES
Institute for Marine Resources & Ecosystem Studies

Location IJmuiden	Location Yerseke	Location Den Helder	Location Texel
P.O. Box 68	P.O. Box 77	P.O. Box 57	P.O. Box 167
1970 AB IJmuiden	4400 AB Yerseke	1780 AB Den Helder	1790 AD Den Burg Texel
The Netherlands	The Netherlands	The Netherlands	The Netherlands
Tel.: +31 255 564646	Tel.: +31 113 672300	Tel.: +31 223 638800	Tel.: +31 222 369700
Fax: +31 255 564644	Fax: +31 113 573477	Fax.: +31 223 630687	Fax: +31 222 319235

Internet: www.wageningenimares.wur.nl
E-mail: imares@wur.nl

Report
Number: C019/07

Fulmar Litter EcoQO Monitoring in the Netherlands 1982-2005 in relation to EU Directive 2000/59/EC on Port Reception Facilities

J.A. van Franeker & A. Meijboom

Commissioned by:	Ministry of Transport, Public Works and Water Management Directorate-General for Civil Aviation and Transport (DGTL) PO Box 20904, 2500 EX Den Haag, The Netherlands
Contact:	Drs. T.M. van Bommel-Reehoorn tel: + 31 (0) 70 351 1889 @ Tineke.van.Bommel-Reehoorn@minvenw.nl
contract / nr:	DGTL 06061 'Graadmeter Stormvogel-Zwerfvuil 1982-2005'
Project number:	IMARES 439.61001.02

Number of copies:	30
Number of pages:	40
Number of tables:	3
Number of figures:	5

Project committee

DGTL
Drs. T.M. (Tineke) van Bommel-Reehoorn
Ministry of Transport, Public Works and Water Management
Directorate-General for Civil Aviation and Transport (DGTL)
PO Box 20904
2500 EX Den Haag
The Netherlands
tel: + 31 (0) 70 351 1889 fax: + 31 (0) 70 351 1478
Tineke.van.Bommel-Reehoorn@minvenw.nl

RWS-DN
P. (Peter) Heslenfeld
Ministry of Transport, Public Works and Water Management
North Sea Department
PO Box 5807
2280 HV Rijswijk
The Netherlands
Tel +31-70-33.66.605 Fax +31-70-3194238
P.Heslenfeld@dnz.rws.minvenw.nl

Citation

Van Franeker, J.A. & Meijboom, A. (2007) Fulmar Litter EcoQO Monitoring in the Netherlands 1982-2005 in relation to EU Directive 2000/59/EC on Port Reception Facilities.
Wageningen IMARES Report No. C019/07. IMARES Texel, 40pp.

Author Contact details: Dr. J.A. (Jan Andries) van Franeker
Wageningen IMARES, *Dept. Ecology*
PO Box 167, 1790 AD Den Burg (Texel), The Netherlands
tel +31-(0)0222-369724
@: jan.vanfraneker@wur.nl

I. Table of Contents

II. Summary - 2005 status report

Fulmar Litter EcoQO Monitoring in the Netherlands 1982-2005
in relation to EU Directive 2000/59/EC on Port Reception Facilities

Operational and cargo related waste from ships is an important source of litter in the marine environment in the southern North Sea and causes 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 involved are key-elements of the Directive to stimulate and enforce proper disposal of shipwaste in harbours. Monitoring the effect of the implementation of the EU Directive is required.
A monitoring program using litter abundance in stomachs of a seabird, the Northern Fulmar, is in effect in the Netherlands and is being developed internationally as an 'Ecological Quality Objective (EcoQO)' by OSPAR. Fulmars are purely oceanic foragers, regularly ingest litter, and accumulate wear-resistant items like plastic in their stomach. Stomach contents thus provide an integrated picture of litter abundance at the sea surface.
The Dutch Ministry of Transport has therefore commissioned IMARES to update the Fulmar-Litter monitoring database for the Netherlands with the year 2005. Further project tasks are the preparation of a EcoQO background document for OSPAR and the continued co-ordination of the international Fulmar Study network ('Save the North Sea' project) to ensure undisrupted sampling for continued monitoring for the Fulmar-Litter-EcoQO in the North Sea area.

A total of 50 stomachs of beached Fulmars in the Netherlands in the year 2005 was processed. Of these, 49 birds (98%) had plastic in the stomach, with an overall average number of 18 items and mass of 0.27 gram per bird (Table 1). Because individual years may vary, the “current” situation is better described by mean values over the most recent 5 years (2001-2005; 330 Fulmars): 96% of birds had plastic in the stomach, with an average number of 28.9 pieces, and average mass of 0.29 gram plastic(Table 2).
These recent data fit in the pattern of reduced plastic loads in Fulmar stomachs since the late 1990’s, with mass of plastic returning to levels similar to those in the early 1980's after peak levels in the 1990’s. However, compared to the 1980's, the composition of plastic litter has changed, with a reduced proportion of industrial plastics and an increased mass of user plastics from discarded waste (Table 3A). Statistical tests for the trends over the past 10 years (1996-2005; Table 3B) show a highly significant reduction in total plastic load ($p<0.001$) to which both industrial plastics ($p=0.007$) and user plastics ($p<0.001$) contributed. The sharpest reductions have occurred in the initial years of this period. Nevertheless, when leaving out the high initial values up to 1998 and testing for trends over period 1999-2005, there is still a significant reduction in plastic load ($p=0.04$).

In the Ecological Quality Objective for marine litter, OSPAR views these data in terms of the percentage of birds exceeding a critical value of plastic in the stomach. The target for acceptable ecological quality is now formulated 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 beachwashed fulmars from each of 5 different regions of the North Sea over a period of at least 5 years”.*

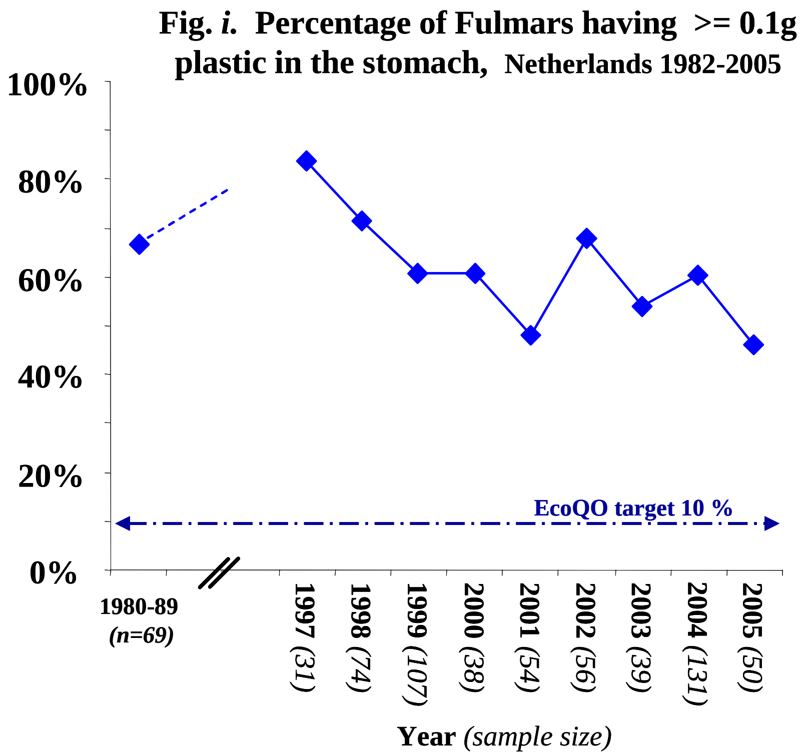

Fig. *i*. Percentage of Fulmars having >= 0.1g plastic in the stomach, Netherlands 1982-2005
100%
80%
60%
40%
20%
0%
EcoQO target 10 %
1980-89 (n=69)
1997 (31)
1998 (74)
1999 (107)
2000 (38)
2001 (54)
2002 (56)
2003 (39)
2004 (131)
2005 (50)
Year (sample size)

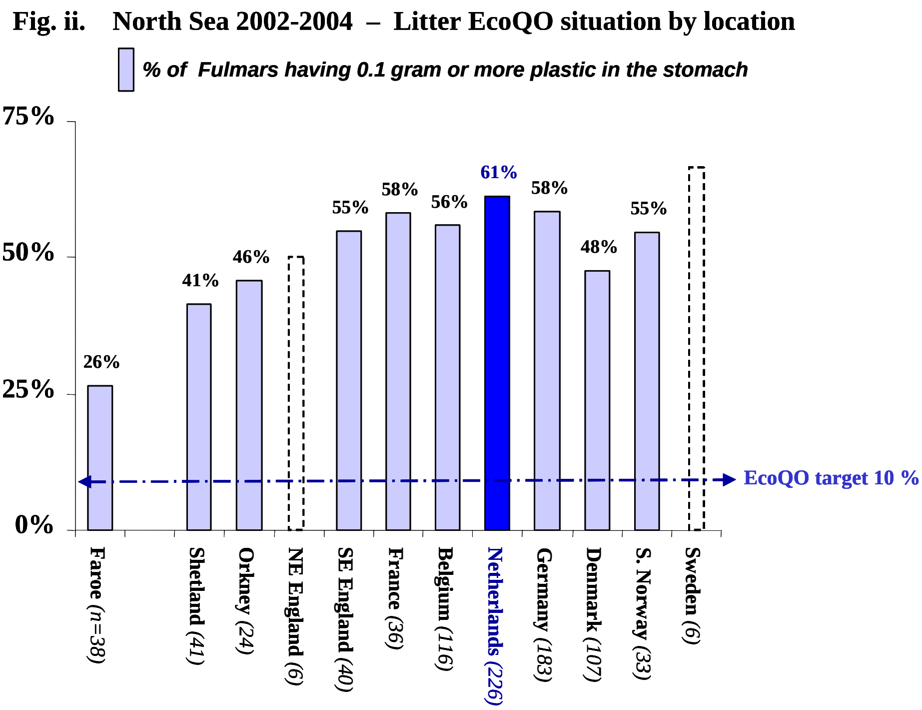

Fig. ii. North Sea 2002-2004 – Litter EcoQO situation by location
% of Fulmars having 0.1 gram or more plastic in the stomach
75%
50%
25%
0%
26%
41%
46%
55%
58%
56%
61%
58%
48%
55%
EcoQO target 10 %
Faroe (n=38)
Shetland (41)
Orkney (24)
NE England (6)
SE England (40)
France (36)
Belgium (116)
Netherlands (226)
Germany (183)
Denmark (107)
S. Norway (33)
Sweden (6)

The EcoQO situation for the Netherlands is shown in Fig. ***i***. In 2005, 46% of Fulmars exceeded the critical value of 0.1g plastic. This is the lowest annual value on record. Averaged over the recent 5 year period, 55% (range 46%-68%) of Fulmars off the Dutch coast has 0.1 gram or more plastic in the stomach. Trends over time in annual EcoQO values as in Fig. *i* are similar to the patterns calculated from individual data in the previous section.

Dutch EcoQO data may be compared to those in other locations around the North Sea. For this, no new data (year 2005) could be added *(in 2005 and onwards, samples have been collected at all locations but stomachs are stored in freezers awaiting funding for their analysis)*. Data from the international Save the North Sea project 2002-2004 (EU Interreg IIIB) showed that the Dutch waters and southern North Sea in general are most strongly polluted (Fig. ***ii***). However, anywhere in the North Sea, about 40 to 60 percent of beached Fulmars has 0.1 gram or more plastic in the stomach. Even in an supposedly cleaner area outside the North Sea, the Faroe Islands, about one in four birds exceeds the 0.1 g critical value (preliminary sample 2002 only). Evidently, trends in the litter situation in the areas outside the Netherlands can only be determined after a longer time series.

In addition to plastics, various other types of rubbish and pollutants are regularly found in the Fulmar stomachs (Table 1). Possible chemical substances, often probably containing paraffine- or palmfat-like residues, were encountered in 32% of the Fulmar stomachs in 2005 with an average mass of 0.70 gram per bird (Table 2). Averaged over the 5 year period 2001-2005, 22% of Fulmars had this type of substances in the stomach, with average mass of 0.93 gram per bird. Although formally not marine litter, the high abundance of such substances in bird stomachs and on beaches justifies treatment as marine litter and continued surveillance under this project. Monitoring is relevant in relation to the implementation of the revised MARPOL Annex II starting 2007.

Conclusions

- In the Dutch marine environment, raw industrial plastics (from which later all sorts of user products are manufactured) in bird stomachs have shown a steady decrease since the early 1980's with current values less than half of their initial abundance.
- User-plastics from discarded wastes, showed a sharp increase from the 1980's to the late 1990's but then started to decrease, initially at a fast rate, slower in recent years.
- Overall plastic mass in bird stomachs is now (2001-2005 average 29 pieces and 0.3 g per bird) similar or slightly lower than in the 1980's but in a changed composition. User plastics now largely dominate the amounts observed, which show a significant decrease in recent years. As demonstrated in earlier reports, shipping and fisheries are major sources of user plastic in the Southern North Sea.
- The year 2005 fits in the recent pattern of gradual decrease of marine litter, but has not shown an abrupt change following the implementation of the Directive on Port Reception Facilities in October 2004 in the Netherlands, and similar dates in surrounding countries.
- In 2005, 98% of Fulmars beached in the Netherlands had some plastic in the stomach; 46% exceeded the critical level of 0.1 gram of plastic. Even if this is the lowest annual value on record, the slow rate of change emphasizes the major gap to the EcoQO target which requires that less than 10% of birds exceed the 0.1 gram critical value.

III. Samenvatting - 2005 status rapport

EcoQO Graadmeter Stormvogel-Zwerfvuil in Nederland 1982-2005

in het kader van de HOI Richtlijn 2000/59/EC betreffende havenontvangstvoorzieningen

Het door schepen overboord zetten van operationeel en aan lading gerelateerd afval is één van de belangrijke bronnen van zwerfvuil in de zuidelijke Noordzee. Zulk afval heeft ernstige economische en ecologische gevolgen. Gezien deze rol van de scheepvaart en de tekortkomingen in afgifteprocedures in havens heeft de EU de 'Richtlijn betreffende havenontvangstvoorzieningen' ingevoerd (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.
In Nederland worden trends in zwerfafval op zee reeds onderzocht in een monitoring programma dat is gebaseerd op de hoeveelheid afval in magen van dood aangespoelde zeevogels: de Noordse Stormvogel. Deze stormvogel fourageert uitsluitend op zee, eet geregeld afval, en hoopt slecht verteerbaar materiaal op in de maag. Daardoor geeft de maaginhoud een geintegreerd beeld van de hoeveelheden afval op zee.
Deze graadmeter wordt ook verder ontwikkeld als één van de EcoQO's (Ecologische Kwaliteitsdoelstellingen) van OSPAR. Het Ministerie van VenW heeft Wageningen IMARES opdracht gegeven de Nederlandse graadmeter aan te vullen met gegevens van het jaar 2005. Daarnaast zal een EcoQO-Achtergrond Document voor OSPAR worden opgemaakt. Tevens wordt de internationale coördinatie van het EcoQO onderzoek uit het 'Save the North Sea' project voortgezet ten behoeve van continuiteit in monstername in de hele Noordzee.

Een totaal van 50 magen van in 2005 in Nederland aangespoelde stormvogels kon voor het onderzoek worden geanalyseerd. Hiervan hadden er 49 (98%) plastic in de maag, met een gemiddeld aantal van 18 stukjes plastic en gewicht van 0.27 gram per vogel (Tabel 1). Omdat individuele jaren kunnen variëren, kan de 'huidige situatie' beter worden beschreven aan de hand van gemiddeldes over de 5 meest recente jaren (2001-2005; 330 stormvogelmagen): 96% van de vogels had plastic in de maag, gemiddeld 28.9 stukjes en 0.29 gram plastic (Tabel 2).
Deze gegevens passen in het patroon van afgenomen plastic hoeveelheden in de stormvogelmagen sinds eind jaren '90 tot een niveau vergelijkbaar met dat in de eerste helft van de jaren '80, na piekwaardes in de tweede helft van de jaren '90.
Maar in vergelijking met de tachtiger jaren is de huidige samenstelling van het plastic afval sterk veranderd, met een duidelijk afgenomen aandeel industrieel plastic en een toegenomen massa van gebruiksplastics uit afval (Tabel 3A). Statistische tests van trends over de afgelopen 10 jaar (1996-2005; Tabel 3B) tonen een sterk significante afname in de totale hoeveelheid plastic ($p<0.001$) waaraan zowel industrieel plastic ($p=0.007$) als gebruiksplastics ($p<0.001$) een bijdrage leveren. De scherpste afnames vonden plaats in de beginjaren van deze periode. Maar ook als de hoge aanvangswaardes tot en met 1998 worden weggelaten, en de test tot de periode 1999-2005 wordt beperkt, dan is de afname in plastic massa significant ($p=0.04$).

De Ecologische Kwaliteitsdoelstelling van OSPAR hanteert als eenheid het percentage vogels dat een kritische hoeveelheid plastic in de maag overschrijdt. De EcoQO-Doelwaarde voor 'acceptabele' ecologische kwaliteit wordt daarbij geformuleerd als de situatie waarin: *'minder dan 10% van de 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'.*

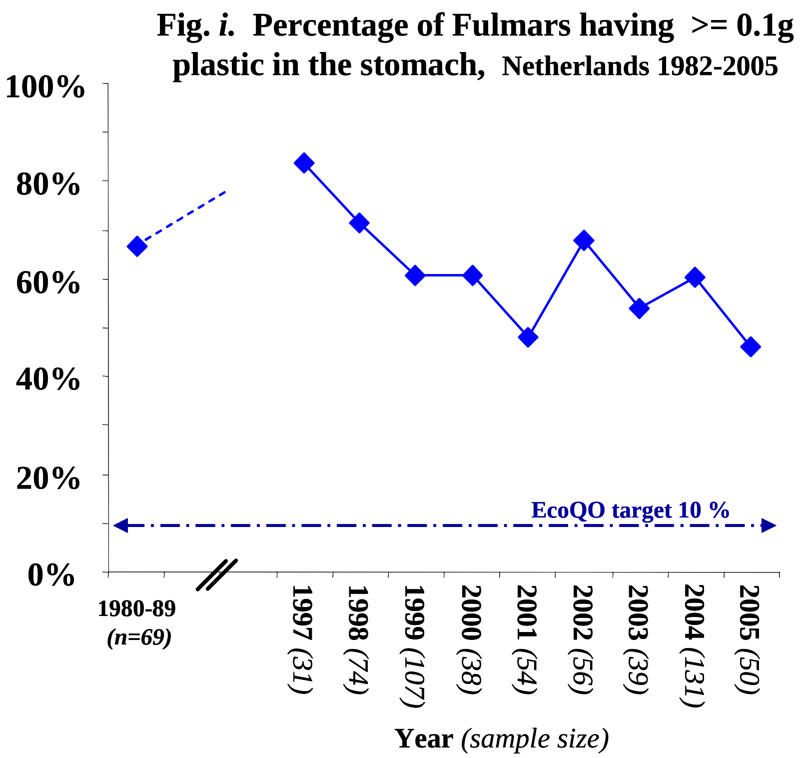
Fig. i. Percentage of Fulmars having >= 0.1g plastic in the stomach, Netherlands 1982-2005
100%
80%
60%
40%
20%
0%
EcoQO target 10 %
1980-89 (n=69)
1997 (31)
1998 (74)
1999 (107)
2000 (38)
2001 (54)
2002 (56)
2003 (39)
2004 (131)
2005 (50)
Year (sample size)

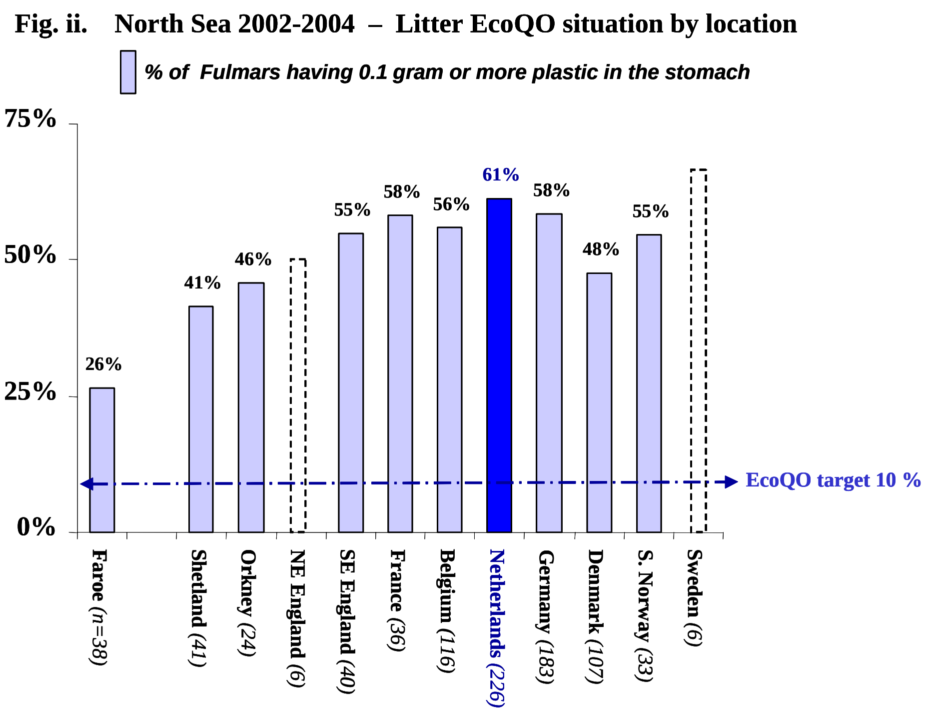
Fig. ii. North Sea 2002-2004 – Litter EcoQO situation by location
% of Fulmars having 0.1 gram or more plastic in the stomach
75%
50%
25%
0%
26%
41%
46%
55%
58%
56%
61%
58%
48%
55%
EcoQO target 10 %
Faroe (n=38)
Shetland (41)
Orkney (24)
NE England (6)
SE England (40)
France (36)
Belgium (116)
Netherlands (226)
Germany (183)
Denmark (107)
S. Norway (33)
Sweden (6)

De EcoQO situatie voor Nederland is samengevat in Fig. ***i***. In 2005, overschreed 46% van de stormvogels de kritische waarde van 0.1g plastic in de maag. Dit is de laagst gemeten jaarwaarde tot dusverre. Gemiddeld over de 5 meest recente jaren overschreed 55% (range 46%-68%) van de stormvogels van de Nederlandse kust de grenswaarde van 0.1 gram. De trends die zichtbaar zijn in de EcoQO jaarwaardes in Fig.*i* zijn vergelijkbaar met de patronen die werden berekend uit individuele gegevens in de voorgaande paragraaf.

Nederlandse EcoQO gegevens kunnen worden vergeleken met die van andere locaties rond de Noordzee. Helaas kunnen geen nieuwe gegevens over het jaar 2005 worden toegevoegd *(in 2005 en daarna zijn wel vogels verzameld, maar magen zijn opgeslagen in vriezers in afwachting van fondsen die analyse mogelijk maken)*. Gegevens van het internationale 'Save the North Sea' project 2002-2004 (EU Interreg IIIB) hebben aangetoond dat de Nederlandse wateren en zuidelijke Noordzee in het algemeen het sterkst zijn vervuild (Fig. ***ii***). Aan de andere kant blijkt dat waar dan ook in de Noordzee, 40% tot 60% van gestrande stormvogels 0.1 gram of meer plastic in de maag te heeft. Zelfs in een relatief 'schoon' zeegebied rond de Faroe Islands overschrijdt ca. één op de vier vogels de 0.1 g grenswaarde (voorlopig monster uit alléén 2002). Trends in de buitenlandse locaties kunnen pas worden vastgesteld als langere tijdseries zijn opgebouwd.

Naast plastics worden geregeld verschillende andere vormen van afval en vervuilende stoffen in de magen van stormvogels aangetroffen (Tabel 1). Mogelijke chemische stoffen, veelal vermoedelijk paraffine- or palmvet residuen werden aangetroffen in 32% van de magen uit 2005 met een gemiddelde massa van 0.70 gram per vogel (Tabel 2). Gemiddeld over de 5 jaar periode 2001-2005, had 22% van de vogels dit soort stoffen in de maag, gemiddeld 0.93 gram per vogel. Hoewel deze stoffen formeel niet onder de noemer 'zwerfvuil' vallen, vormt het frequente voorkomen in vogelmagen en op stranden voldoende aanleiding om ze als dusdanig te behandelen en blijvend in het onderzoek te betrekken. Voortzetting van deze monitoring is hoogst relevant in relatie tot de gewijzigde procedures onder MARPOL Annex II die in 2007 ingaan.

Conclusies

- In het Nederlandse zeemilieu zijn industriële plastics (waaruit later allerlei vormen van gebruiksproducten worden gemaakt) in vogelmagen sterk afgenomen sinds het begin van de jaren '80, waarbij de waardes ten minste zijn gehalveerd.
- Gebruiksplastic afkomstig uit afval vertoonde een sterke toename van begin jaren '80 tot eind jaren '90, maar begon vervolgens af te nemen, aanvankelijk sterk, maar in een trager tempo in meer recente jaren.
- De gecombineerde hoeveelheid van alle plastics samen is momenteel (2001-2005 gemiddelde 29 stukjes en 0.3 g per vogel) vergelijkbaar of iets lager dan in de jaren '80, maar in een sterk veranderde samenstelling. Het zijn de gebruiksplastics die domineren in de waargenomen hoeveelheden en die de trend van significante afname over de laatste 10 jaar het sterkst bepalen. In eerdere rapportages is aangetoond dat scheepvaart en visserij de belangrijke bronnen van gebruiksplastic in onze regio zijn.
- Het jaar 2005 past in het recente patroon van geleidelijke afname van zwerfvuil, maar heeft géén scherpe verandering laten zien na de implementatie van de HOI Richtlijn in October 2004 in Nederland, en vergelijkbare tijdstippen in omringende landen .
- In 2005 had 98% van de Nederlandse stormvogels plastic in de maag, en 46% overschreed de grenswaarde van 0.1 gram plastic. Hoewel dit laatste de laagst bekende jaarwaarde is, is het tempo van verandering traag en de afstand groot tot de EcoQO doelstelling die streeft naar 10% of minder vogels die de 0.1 gram waarde overschrijden.

1. Introduction

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

Economic consequences of marine litter are suffered 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 various types of litter are a health-risk for tourists. Fisheries are confronted with a substantial by-catch of marine litter which causes loss of time and sometimes necessitates discarding of tainted catch. All sorts of shipping suffer financial damage and more importantly, safety-risks from fouled propellers or blocked water-intakes. Coastal litter blowing inland is even seriously affecting farmers. The 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 most pronounced ecological consequence of marine litter is the suffering and death of marine wildlife. Entanglement of seabirds and marine mammals regularly attracts 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 microscopic particle sizes, but even these may pose serious problems to marine ecosystems (Thompson *et al*. 2004).

Recognizing the negative impacts from marine litter, 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 recently been intensified by for example the EU-Directive on Port Reception Facilities (Directive 2000/59/EC) and the Declaration from the North Sea Ministerial Conference in Bergen, March 2002.

Recent policy initiatives have recognized that policy aims need to be quantifiable and measurable. Therefore, the North Sea Ministers in the 2002 Bergen Declaration have decided to introduce a system of Ecological Quality Objectives for the North Sea (EcoQO's). A number of these EcoQO's is implemented in an immediate pilot program. For example, the oil pollution situation in the North Sea will be measured by the rate of oil-fouling among Guillemots (*Uria aalge*) found on beaches (Camphuysen 2005). The ecological quality target is set at a level in which less than 10% of beached Guillemots has oil on the plumage.
Another set of EcoQO's has to be developed for future implementation. Among this latter group is an EcoQO for marine litter, to be measured by the abundance of plastic in stomachs of seabirds, in casu the Northern Fulmar (*Fulmarus glacialis*). Working Groups in ICES and in OSPAR are involved in the further development and implementation of the EcoQO system including the advice on realistic target levels (OSPAR 2005). For convenience the EcoQO for marine litter is referred to as the 'Fulmar-Litter-EcoQO'.
The EcoQO approach has also been included as an element in the approach for the intended European Marine Strategy (EC 2005).

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 (formerly Alterra) working towards a Fulmar-Litter-EcoQO. The first pilot project 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 (see 'References') have provided annual updates on the Dutch time-series up to the year 2004, paying special attention to shipping issues and EU Directive 2000/59/EC.

As of 2002, the Dutch Fulmar research was also 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).

Building upon this earlier work, the current assignment from the Dutch Ministry of Transport included the following tasks:

- To update the time series on litter in stomach contents of Dutch Fulmars with the year 2005, and publish the result in a new report;
- To continue international co-ordination of EcoQO sampling in the North Sea area until mid 2007 (collected samples from 'foreign' Fulmars to be stored frozen, awaiting alternative sources of funding).
- The production of a "Background Document" for OSPAR, assisting decisions on further implementation of the Fulmar-Litter-EcoQO.

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.

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 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 adequate samples 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; 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 (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 required sample size or spatial coverage (e.g. other tubenoses or Kittiwake).

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 items (see methods).

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.

An 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 effect on 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 poor, and further study should be promoted where possible. A first start with such study has been made in the Save the North Sea project. A trial was made analyzing some stomachs of Fulmars from the Faroe Islands, where Fulmars are hunted for consumption and large numbers of samples are easily obtained: differences between adults and chicks, and seasonal differences within adults suggest that the 'chick-feeding' hypothesis may be true. For a proper analysis a substantial sample of stomachs was collected in each month of the years 2003 with further sampling in 2004/2005. With financial support from Chevron Upstream Europe, analysis of the Faroe samples has recently started.

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. Presentation of results always includes information on age groups.

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; others significantly increased. When comparing averages in the 1980's to those in de 1990's, industrial plastics decreased from 6.8 granules per bird (77% incidence; 0.15g per bird) to 3.6 granules (64%; 0.08g). User-plastics increased from 7.8 items per bird (84%; 0.19g) to 27.6 items (97%; 0.52g). Chemical incidence between the decades increased from 10% to 28% (0.18 to 0.53 g per bird).

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. The later monitoring reports (Van Franeker & Meijboom 2003 to 2006) confirmed that industrial and user plastics are both decreasing since the late 1990's.

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. It also is 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.

Formal indicators recommended in a future Dutch Fulmar-Litter monitoring system were abundances by mass of industrial plastic, user plastic and suspected chemicals. Each of these represents different sources of pollution, and thus specific policy measures aiming at reduced inputs. 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.

The anticipated implementation of the Fulmar-Litter-EcoQO for the whole North Sea necessitated two further lines of activity:

- continuation of the time-series of data on stomach contents of Fulmars from the Netherlands (the only existing long-term series of data allowing immediate analysis of trends)
- research on Fulmar samples from a number of different locations around the North Sea to assess degrees of regional variability in Fulmar stomach contents and their backgrounds.

Such work is essential for a sound advice on a cost-efficient EcoQO monitoring system, the definition of EcoQO-targets, and the designation of effective measures to reach targets.

Over the period 2002-2005 both these lines have been implemented by funding from the Dutch government and the EU. The current report extends the Dutch series to include 2005. Following EU funding 2002-2004, continued collection of samples from other countries in 2005 has been supported by the Dutch government, but funding for the analysis of those samples has not yet been secured. Thus, EcoQO litter monitoring in the North Sea, as requested by the North Sea Ministers in the Bergen Declaration 2002, is operational but its funding structure needs attention, possibly in connection to incorporation of the EcoQO approach in the European Marine Strategy.

3. Shipping, marine litter and policy measures

In historic times any waste products from ships were simply discarded on a convenience base, meaning almost anywhere and 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 1900's. 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 1900's, started their real development only after 1960. Since then, they have found their way into almost any 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 turned them into an environmental problem. Low production costs have promoted careless use and low degradability leads to accumulation in the environment. By 2003 the world production of plastics amounted to about 165 million metric tons, 40 % of which for packaging (www.plastemart.com). Growth rates of this production exceed 5% per year!

At the same time, intensity of shipping has increased. Between 1994 and 2003 the world's active merchant fleet grew from 437 to 571 million gross tons, a more than 30% growth in 10 years time. The tonnage of new merchant ships (>100 gtons) leaving shipyards doubled from 17.9 million gross tons in 1994 to 35.4 million gross tons in 2003. (Dept. of Transport 2004).

Marine litter originates from a variety of sources, including merchant shipping, fisheries, offshore industry, recreational boating and 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.

Even if sources can not be fully specified, 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 2 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

31 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 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 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

'Significant' was later identified as meaning 'in the order of at least 30%'. Implementation date for the Directive was December 2002. However, implementation has suffered delay in various countries. In the Netherlands the Directive became implemented in late 2004. Initially, the Netherlands had planned to use a 100% level of indirect financing, following examples from Baltic states. However, the current level used is approximately the minimum of 30%. Political intentions are to gradually work towards full indirect financing over a number of years, based on annual evaluations 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.

Although marine pollution under MARPOL Annex II (noxious liquid substances carried in bulk) is usually not seen as a 'litter-issue', the wide occurrence of paraffine and palmfat like substances at sea and on beaches does deserve such a qualification. Under the original MARPOL Annex II regulations, considerable quantities of such substances could be legally discharged, as they were considered harmless (non-toxic; not accumulating). However, as of January 2007, a revision of Annex II has entered into force, which includes much stricter regulations also on this type of discharges.
Paraffine and fat like substances are also eaten by marine animals, and their abundance in Fulmar stomachs is monitored in the Fulmar-Litter study.

4. Material and methods

In 2005 Wageningen 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 centres 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. Organisations involved differ widely, and range from volunteer bird groups to governmental beach cleaning projects.

Bird corpses are stored frozen until analysis. Standardized dissection methods 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.

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. For the purpose of this study, contents of proventriculus and gizzard are combined.

If oil or chemical types of pollutants are present, these are first sub-sampled and weighed before rinsing the remainder of stomach contents under cold water. If sticky substances hamper further processing, hot water and detergents are used to rinse the material as clean as needed for further sorting under a binocular microscope, during which items of different categories are separated.

The following categorization is used for objects 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, or beads or granules. They can be considered as “raw” plastic or a half-product in 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 ore less hard plastic items as used in a huge number of applications (bottles, boxes, toys, tools, equipment housing, toothbrush, lighters etc);
1.2.5 **other (oth)**, for example sigarette filters, rubber, elastics etc., so items that are ‘plastic like’ or do not fit a clear category.

2 **RUBBISH (RUB)** other than plastic:
2.1 **paper (pap)** which besides normal paper includes silver paper, aluminium 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 **fishhook (hoo)** from either sportfishing or longlining.

3 **POLLUTANTS (POL)** (industrial or chemical waste remains):
3.1 **slags (sla)** that is the remains of burning ovens, eg remains of coal or ore after melting out the metals. Often pumice like material: if doubtful, materials classified as pumice;
3.2 **tar (tar)** is the category for lumps of tarry substances or for more fluid heavy mineral oil;
3.3 **chemical (che)** for lumps of paraffine like materials or sticky substances arbitrarily judged to be unnatural and of chemical origin;
3.4 **featherlump (fea)** is used when excessive amounts of preened feathers were found in the stomach, indicating excessive preening by the bird of feathers sticky with oil or chemical pollutants. Presence of a few remains of preened feathers in the stomach is normal and was not recorded under this category. Featherlumps of other species were considered as ‘natural food’ from scavenging on corpses, unless it was evident that these feathers were heavily polluted.

4 **NATURAL FOOD REMAINS (FOO)**
Numbers of specific items were recorded in separate subcategories (fish otoliths, eye-lenses, squid-jaws, crustacean remains, jelly-type prey remains, scavenged tissues, insects, other), but details of these subcategories are not used in this litter survey study.

5 **NATURAL NON-FOOD REMAINS (NFO)**
Numbers of subcategories plant-remains, seaweed, pumice, stone and other were counted separately, but details are not used in analyses. Separately we also made rough estimates of numbers of parasitic worms in the stomach and of ‘normal’ remains of preened feathers.

After sorting under binocular microscope all above categories, we record for each stomach 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 lab temperatures. For marine litter (categories 1 to 3 above) this was done separately for all subcategories, but the natural-food and natural-non-food categories were each weighed as a whole only. Weights were recorded in grams accurate to the 4th decimal (= tenth of milligram).

Acronyms may be used to describe datasets. Logarithmic transformed data are initiated by ‘ln’; mass data are characterised by capital G (gram) and numerical data by N(number); and categories are described as in the listing above. 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 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 are conducted by 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', 'user plastic' and 'suspected chemicals' were the final 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 focuses on the information on 'total plastic' and annual or 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 form of easily comprehensible 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 2005. *For each litter-(sub)category (see methods) 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. The geometric mean is similar to the median value of the observations. The 2005 sample had 72% adult birds among birds of known age; 53% male sex; 4% dark coloured birds of high-arctic origin; 4% of birds with cause of death attributed to oil fouling; and average body condition 1.3 (on a scale from emaciated condition=0 to very good condition=9). In the Dutch dataset, only age composition has been shown to affect litter loads in stomachs, but this is not necessarily true in later and wider international comparisons, so it is important to keep track of different variables.*

	Year 2005 *(n=50)*	incidence	average number of items	average mass of litter (g/bird) ± standard deviation	max. mass recorded	geometric mean mass (g/bird)
1	**ALL PLASTICS**	**98%**	**18.1**	**0.273 ± 0.444**	**2.4**	**0.0875**
1.1	**INDUSTRIAL PLASTIC**	**54%**	**2.1**	**0.049 ± 0.094**	**0.5**	**0.0072**
1.2	**USER PLASTIC**	**96%**	**16.0**	**0.224 ± 0.400**	**2.2**	**0.0626**
1.2.1	sheets	42%	1.6	0.006 ± 0.027	0.2	0.0008
1.2.2	threads	38%	1.0	0.008 ± 0.026	0.2	0.0013
1.2.3	foamed	66%	5.3	0.020 ± 0.057	0.3	0.0026
1.2.4	fragments	94%	8.0	0.156 ± 0.344	2.1	0.0371
1.2.5	other plastic	16%	0.2	0.032 ± 0.170	1.2	0.0009
2	**OTHER RUBBISH**	**32%**	**2.9**	**0.078 ± 0.236**	**1.2**	**0.0028**
2.1	paper	2%	0.0	0.002 ± 0.016	0.1	0.0001
2.2	kitchenwaste (food)	18%	2.4	0.049 ± 0.190	1.2	0.0012
2.3	rubbish various	16%	0.5	0.027 ± 0.144	1.0	0.0007
2.4	fishhook	0%	0.0	0.000 ± 0.000	0.0	0.0000
3	**POLLUTANTS**	**34%**	**2.3**	**0.803 ± 4.294**	**30.0**	**0.0033**
3.1	slags	4%	0.0	0.000 ± 0.002	0.0	0.0001
3.2	tar	0%	0.0	0.000 ± 0.000	0.0	0.0000
3.3	suspected chemical	32%	2.3	0.703 ± 4.253	30.0	0.0025
3.4	feather lumps	2%	0.0	0.100 ± 0.707	5.0	0.0002
4	**FOOD NATURAL**	**94%**	**5.7**	**0.319 ± 0.691**	**4.2**	**0.0617**
5	**NONFOOD NATURAL**	**84%**	**7.8**	**0.219 ± 0.301**	**1.6**	**0.0580**

5. Results and discussion

In the year 2005, 51 corpses of beached Fulmars were collected for the study by participants of the Beached Bird Survey of the Dutch Seabird Group (NSO-NZG) and participating rehabilitation centres. Wrecks of large numbers of Fulmars, as observed in 2004, did not occur. One of the birds proved to be scavenged, leaving a total of 50 Fulmar corpses with complete stomachs for the monitoring program. This sample size is adequate to provide a reliable annual average figure, because earlier analyses indicated that annual samples of 40 birds and above are suitable (Van Franeker & Meijboom 2002).

Of the 50 stomachs analysed for the year 2005 (Table 1), 49 (98%) contained plastic, with an overall average number of 18 items and mass of 0.27 gram per bird. Over 80% (0.22 g; 16 particles) of the plastics were of the user type, originating from garbage or lost materials. Less than 20% (0.05 g; 2 particles) were industrial plastic granules lost in manufacturing processes or during transport. User plastics were found in nearly every Fulmar stomach (96%), industrial plastics in “only” 54% of the birds.
Non-plastic rubbish was found in about one in three stomachs, most frequently being galley food wastes. Suspected chemicals, i.e. paraffine or palmfat like substances were encountered in 32% of stomachs with an overall average mass of 0.7 gram per bird.

Because individual years may show some variability, more stable figures to describe the “current” situation are calculated as mean values over the most recent 5 years (Table 2, bottom line). Averaged annual figures over the period 2001-2005 for in total 330 Fulmars show that nowadays, 96% of Fulmars has plastic in the stomach, with an average mass of 0.29 gram in 28.9 pieces. Incidences and masses of user and industrial plastics in 2005 fit well in the 5 year averages. The number of user plastic items was relatively small in 2005, but not so much their combined mass, i.e. particles were apparently large this year. The 5-year means for chemicals indicate that 2005 was a relatively ‘bad’ year.

An initial view of trends in plastic pollution since the 1980’s 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, and average number and the average mass of plastic per bird, and specifies industrial and user plastics in those figures.
In all three aspects, a clear increase of plastic pollution between the 1980’s and the second half of the 1990’s is visible, completely caused by increased user plastics that completely overshadow decreases in industrial plastic over that period. In the late 1990’s nearly 100% of Fulmars had plastic in the stomach, approaching 30 particles and 0.6 gram mass of plastic per bird.
Figures for incidence and mass of plastics show that these late 1990’s figures represented peak levels and that since then, on top of the continued decrease of industrial plastic, user plastics are also on their return. 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. The relatively low number of particles in 2005 (18 per bird) but fairly unchanged mass, may indicate that this may change again.
Fig.1. shows that the 2005 data fit in the pattern of reduced plastic loads in Fulmar stomachs since the late 1990’s, with mass of plastic returning to levels similar to those in the early 1980's after peak levels in the 1990’s. However, compared to the 1980's, the composition of plastic litter has changed considerably, with a reduced proportion of industrial plastics and an increased mass of user plastics from discarded waste. Whether visually suggested trends in Fig.1 are statistically valid, needs testing.

Table 2
Major litter categories per year.

In each major litter category, incidence (%) represents the proportion of birds with one or more items of that litter present; abundance by average number of items per bird (n); and abundance by average mass per bird in grams (g). The bottom line shows the 'current' situation as the mean of the annual averages over 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. However, trend analyses (table 3) are based on values from all individual birds, together and in age-groups, to overcome problems of years of poor sample size or variable age composition. Proportion adult here given as % of all birds in sample including birds of unknown age.*

			INDUSTRIAL PLASTICS			USER PLASTICS			ALL PLASTICS (industrial + user)			SUSPECTED CHEMICALS		
YEAR	*n*	% adult	%	n	g	%	n	g	%	n	g	%	n	g
1982	*3*	0%	100%	5.0	0.11	67%	6.0	0.50	100%	11.0	0.61	0%	0.0	0.00
1983	*19*	37%	84%	8.8	0.19	89%	7.2	0.31	100%	16.0	0.49	0%	0.0	0.00
1984	*20*	40%	70%	9.6	0.19	90%	8.4	0.17	90%	17.9	0.35	25%	0.3	0.56
1985	*3*	33%	100%	5.3	0.14	100%	5.0	0.14	100%	10.3	0.28	0%	0.0	0.00
1986	*4*	25%	50%	0.8	0.02	75%	4.8	0.06	75%	5.5	0.08	0%	0.0	0.00
1987	*15*	67%	80%	3.9	0.11	67%	8.9	0.09	80%	12.7	0.20	13%	0.2	0.07
1988	*1*	0%	0%	0.0	0.00	100%	2.0	0.04	100%	2.0	0.04	0%	0.0	0.00
1989	*4*	50%	75%	5.3	0.14	100%	11.0	0.16	100%	16.3	0.29	0%	0.0	0.00
1990														
1991	*1*	0%	0%	0.0	0.00	100%	11.0	0.14	100%	11.0	0.14	0%	0.0	0.00
1992														
1993														
1994														
1995	*2*	50%	100%	1.5	0.02	100%	3.5	0.03	100%	5.0	0.06	0%	0.0	0.00
1996	*8*	63%	75%	2.9	0.07	100%	24.5	0.19	100%	27.4	0.26	50%	1.8	1.97
1997	*31*	16%	74%	5.9	0.13	97%	29.8	0.60	97%	35.8	0.73	6%	0.2	0.00
1998	*74*	45%	69%	3.1	0.07	95%	25.9	0.88	96%	29.0	0.95	30%	1.3	1.23
1999	*107*	69%	58%	3.4	0.06	97%	31.8	0.38	98%	35.3	0.44	33%	3.3	0.28
2000	*38*	58%	61%	3.4	0.08	100%	18.6	0.27	100%	22.0	0.35	26%	2.4	0.06
2001	*54*	37%	63%	2.6	0.06	96%	20.4	0.18	96%	22.9	0.24	15%	0.6	1.73
2002	*56*	54%	68%	4.6	0.09	96%	47.2	0.41	98%	51.8	0.50	23%	2.9	0.03
2003	*39*	56%	51%	2.3	0.05	92%	26.3	0.12	95%	28.5	0.17	21%	0.9	1.94
2004	*131*	79%	54%	2.6	0.06	91%	20.8	0.22	91%	23.4	0.27	18%	1.7	0.25
2005	*50*	68%	54%	2.1	0.05	96%	16.0	0.22	98%	18.1	0.27	32%	2.3	0.70
2001-05	*	59%	58%	2.8	0.06	94%	26.1	0.23	96%	28.9	0.29	22%	1.7	0.93

** means of 5 most recent annual averages*

For EcoQO monitoring, mass of plastic is the chosen metric, because it is the most relevant to describe the amounts of litter in the environment and the effects on the animals that ingest it. Further results and discussion are thus focused on the mass of plastics, but in the background of the monitoring, it remains important to be aware of changes in incidence and numbers of items, as well as on subcategories of plastic involved. Table 3 provides the details of statistical tests on the significance of changes in mass of plastics as observed in Fig.1c. As explained in methods, these tests 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.

Plastic abundance in stomachs of Fulmars
The Netherlands 1982 - 2005 *(n=660)*

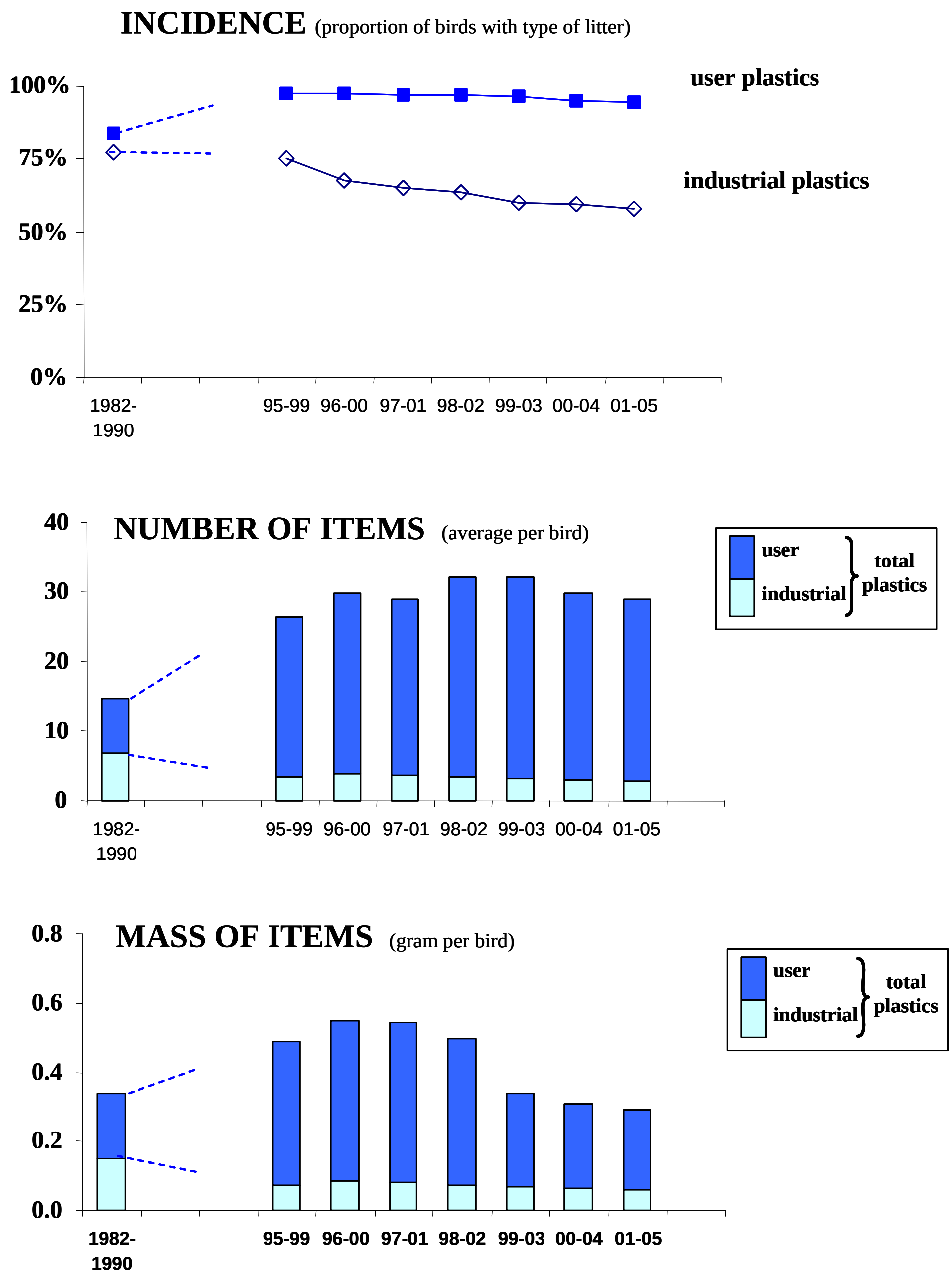

Fig.1 Visual summary of Fulmar-Litter monitoring results in the Netherlands 1982-2005, comparing average data for incidence, number of items and mass of plastic in stomachs in the 1980's with running 5-year averages for the more recent period.

Table 3 Details of linear regression analyses of the selected litter indicators. Analysis of trends was conducted by lineair regression, fitting ln-transformed litter mass values for individual birds on the year of collection. Tests were conducted over the full time period 1982-2005 (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 labelled with positive signs in case of increase (+) or negative signs in case of decrease (-). Significance at the 5% level (p<0.05) is labelled 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 (1982-2005) in marine litter indicators, The Netherlands

INDUSTRIAL PLASTIC (lnGIND)	*n*	Constant	estimate	s.e.	t	p	
all ages	*660*	146.2	-0.075	0.015	-4.97	**<.001**	- - -
adults	*378*	102.5	-0.054	0.022	-2.40	**0.017**	-
non adults	*275*	132.3	-0.068	0.021	-3.20	**0.002**	- -

USER PLASTICS (lnGUSE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*660*	-32.1	0.015	0.013	1.13	0.261	
adults	*378*	-15.1	0.006	0.020	0.31	0.756	
non adults	*275*	-91.8	0.045	0.018	2.50	**0.013**	+

ALL PLASTICS COMBINED (lnGPLA)	*n*	Constant	estimate	s.e.	t	p	
all ages	*660*	40.4	-0.021	0.013	-1.69	0.091	
adults	*378*	21.8	-0.012	0.019	-0.63	0.532	
non adults	*275*	7.7	-0.005	0.016	-0.29	0.770	

SUSPECTED CHEMICALS (lnGCHE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*660*	-27.6	0.011	0.016	0.69	0.493	
adults	*378*	10.9	-0.008	0.024	-0.36	0.722	
non adults	*275*	-53.9	0.024	0.023	1.05	0.293	

B. RECENT 10-year TRENDS (1996-2005) in marine litter indicators, The Netherlands

INDUSTRIAL PLASTIC (lnGIND)	*n*	Constant	estimate	s.e.	t	p	
all ages	*588*	184.1	-0.094	0.035	-2.72	**0.007**	- -
adults	*348*	89	-0.047	0.046	-1.03	0.304	
non adults	*235*	210	-0.107	0.055	-1.94	0.054	

USER PLASTICS (lnGUSE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*588*	196.2	-0.099	0.029	-3.43	**<.001**	- - -
adults	*348*	167.5	-0.085	0.040	-2.13	**0.034**	-
non adults	*235*	150.3	-0.076	0.043	-1.79	0.074	

ALL PLASTICS COMBINED (lnGPLA)	*n*	Constant	estimate	s.e.	t	p	
all ages	*588*	209.4	-0.106	0.028	-3.75	**<.001**	- - -
adults	*348*	163.3	-0.083	0.039	-2.10	**0.036**	-
non adults	*235*	174.4	-0.088	0.040	-2.22	**0.028**	-

SUSPECTED CHEMICALS (lnGCHE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*588*	125.6	-0.066	0.037	-1.79	0.073	
adults	*348*	253.8	-0.130	0.048	-2.69	**0.008**	- -
non adults	*235*	-34	0.014	0.060	0.23	0.815	

Linear regressions were performed on data of industrial plastic, user plastic, all plastic (industrial and user combined) and suspected chemicals. Each of these was done both for the long term dataset (1982-2005; Table 3A) and for the recent 10-year dataset (1996-2005; Table 3B). Furthermore, each test was repeated for separate age groups because the early pilot study as well as later reports showed that adults tend to have less plastic in the stomach. As long as trends in adults and non-adults appear to be the same, and no directional change in age composition of samples occurs, data for all ages combined can be safely used for monitoring. However, for the robustness of the monitoring system it is important that insight into potential age effects is always provided (Tables 1-3). The influence of age will be discussed further below and is also a focus of further study on the Faroe Islands.

Earlier reports in this monitoring series included graphic presentations of all the tests in Table 3, visualising the differences in absolute levels of stomach contents, but similarity in trends between birds of different age groups. However, these graphs are omitted here because the development of the EcoQO has contributed to a more regular sampling program that allows more accessible visualisation of trends based on annual figures.

Long-term trends: When considering changes over the 1982-2005 long term dataset in Table 3A, decreases (negative signs of t value) in industrial plastics are highly significant for the all age group ($p<0.001$). Because of the smaller sample sizes in split age groups, significances are somewhat lower. Where Fulmar stomachs in the 1980's contained 6 to 7 industrial granules, this has been gradually reduced to 2 to 3 granules per bird in recent years.
For user plastics however, the tests tend to indicate increase (positive sign of t-values). After strong increases between the 1980's and 1990's, the subsequent decrease (Fig 1C) has largely deleted the long term effect, although the overall balance appears to be that current loads of user plastics still exceed those in the 1980's. The opposite long-term trends for industrial and user plastics make that there is no clear direction of trend in the combined 'all plastics' category. For paraffine like substances in the stomachs, no clear direction of the long-term trend is visible.

Short-term trends: Statistical tests for the trends over the past 10 years (1996-2005; Table 3B) show a highly significant reduction in total plastic load ($p<0.001$) to which both industrial plastics ($p=0.007$) and user plastics ($p<0.001$) contributed. The sharpest reductions have occurred in the initial years of this period. Nevertheless, also when the high initial values up to 1998 are left out and testing for trends are restricted to the period 1999-2005, there is still a significant reduction in plastic load ($p=0.04$). For presence of suspected chemicals in stomachs, adult birds suggest decreases over the past ten years, but non-adult birds confuse the overall picture.

Annual data: geometric means: Testing methods as above, using regressions of individual data against year of collection were needed because the long-term dataset contains many years with small sample sizes (Table 2), preventing usage of annual averages. Values for plastic contents of a stomach were logarithmically transformed, because data were not normally distributed, but skewed with a few high values obscuring trend analysis. Logarithmic transformation normalises the distribution of data and reduces the influence of the exceptionally high values (see Van Franeker & Meijboom 2002 for a more extensive discussion). Since 1997, annual sample sizes have been adequate to calculate annual figures that are much more convenient for regular updates in a monitoring program. However, logarithmic transformation of data is still needed. 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 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 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.

Age effects: Annual geometric means for total plastic mass in the Fulmar stomachs since 1997 are shown in Fig.2, and compared with the combined figure for the early 1982-1990 period. Graphs nicely show the trends also found by regressions in Table 3, as well as clearly illustrating the effects of age. Differences between the age groups are consistent between annual samples. The line for all ages combined adequately describes the patterns for both subgroups. It is for example clear that the higher values for 2002 are not caused by an unusual proportion of younger birds or maybe just a few exceptional outliers: increased levels that year were observed in the geometric means for both adult and non-adult birds. In 1997 there was an insufficient sample size of adult birds. The conclusion is that monitoring results can be expressed as the figure for all ages combined: variations between years in the age composition of samples have relatively minor influence on the overall trend. The option to calculate an annual average from the mean between age-group averages, or just a single age-group is rejected because the smaller sample sizes may invoke stronger uncertainties than the variations in age composition of the sample.
In a later phase, when a longer series of annual samples of adequate size becomes available, it may become appropriate to complement statistical testing procedures on individual data with tests using annual data.

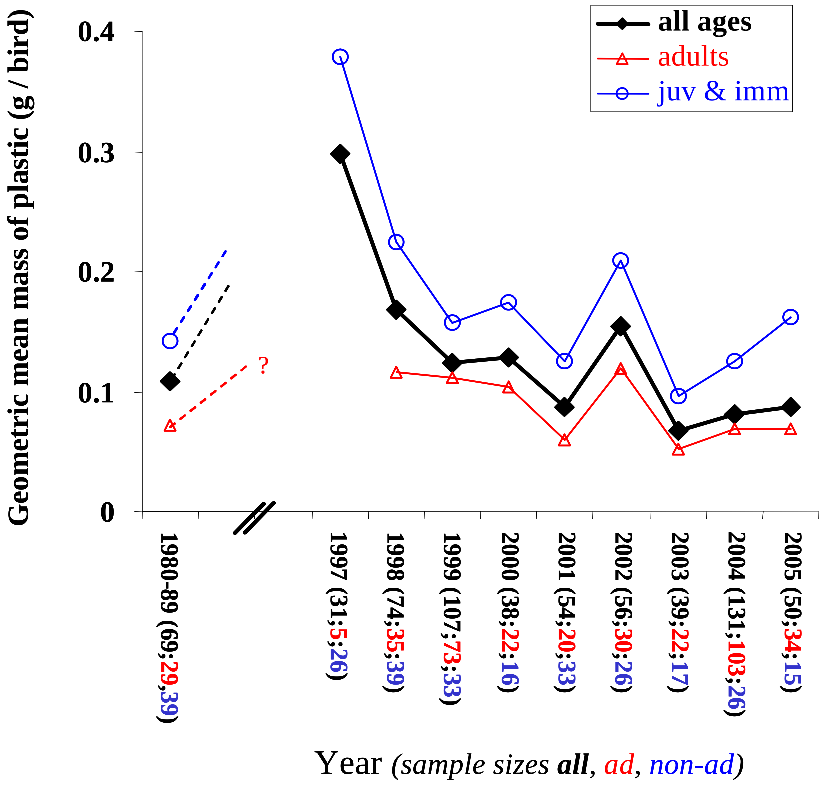

Fig.2 Trends in plastic load of different age groups of Fulmar. Annual geometric mean mass of total plastics (industrial plus user) in stomachs of Fulmars found in the Netherlands 1997-2005, and mean for 1980-1989 decade.

It is tempting to link outlying values for 1997 and 2002 with excessive rains and especially extensive flooding in central Europe in those years. Flooding is likely to cause a substantial increase in contributions from rivers to marine litter levels in the southern North Sea. However, other factors may be involved, and a closer analysis will have to be conducted later, also considering other aspects like storm conditions and more specific periods when events took place and when birds were collected. Sample sizes are expected to be a problem for such detailed analyses.

Industrial versus User plastics: Geometric mean masses are also an appropriate basis to compare the trends in abundance of industrial and user plastics (Fig.3). In the 1980's about equal masses of both types of plastic were present in the stomachs of Fulmars. However, industrial plastics have been decreasing from the very beginning, whereas user plastics first showed a sharp increase, and only started decreasing after the late 1990's. Currently, user waste plastics represent ± 80% of the plastic mass in Fulmar stomachs, and are still at least as abundant in Fulmar stomachs as during the 1980's.

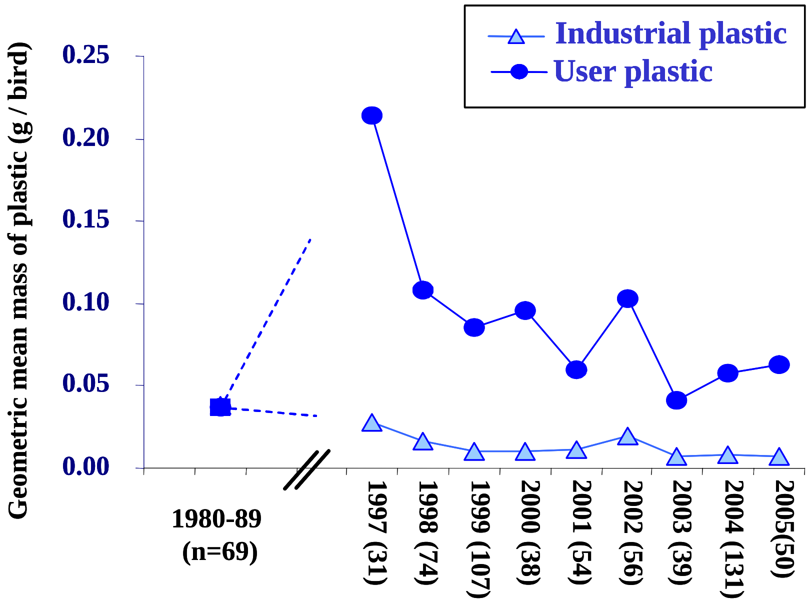

Fig.3 Trends in industrial and user plastics. Annual geometric mean mass of the two main categories of plastic in stomachs of Fulmars found in the Netherlands 1997-2005, and mean for 1980-89 decade.

EcoQO metric

From the start, ICES working groups, followed by OSPAR, have described the EcoQO metric for marine litter in terms of a percentage of birds exceeding a critical value of plastic in the stomach. 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".* At first sight, one might argue that it would be easier to use a 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: it 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 were overcome by logarithmic transformation of data. And although this is a standard statistical procedure, it is not easily conveyed to general public, and differences between means (arithmetic versus geometric) can be confusing. The EcoQO metric avoids problems by using classes of birds in which the exceptional stomach contents loose their influence.

Thus, the simplified mode of presentation of the EcoQO metric in Fig.4 shows sufficient similarity to the more sophisticated use of geometric means as in Fig.2 and is easy to understand in terms of trends and distance to EcoQO target levels. Both the figures 2 and 4 show the overall results for birds of all ages combined as well as the separate data for adults and non-adults. For EcoQO reporting, it is sufficient to show the 'all age' data, as done in Fig.*i* of the Summary of this report. However, in the background, data processing to identify trends and methods to assign statistical significance to the observed trends will need to follow the procedures as in this report.

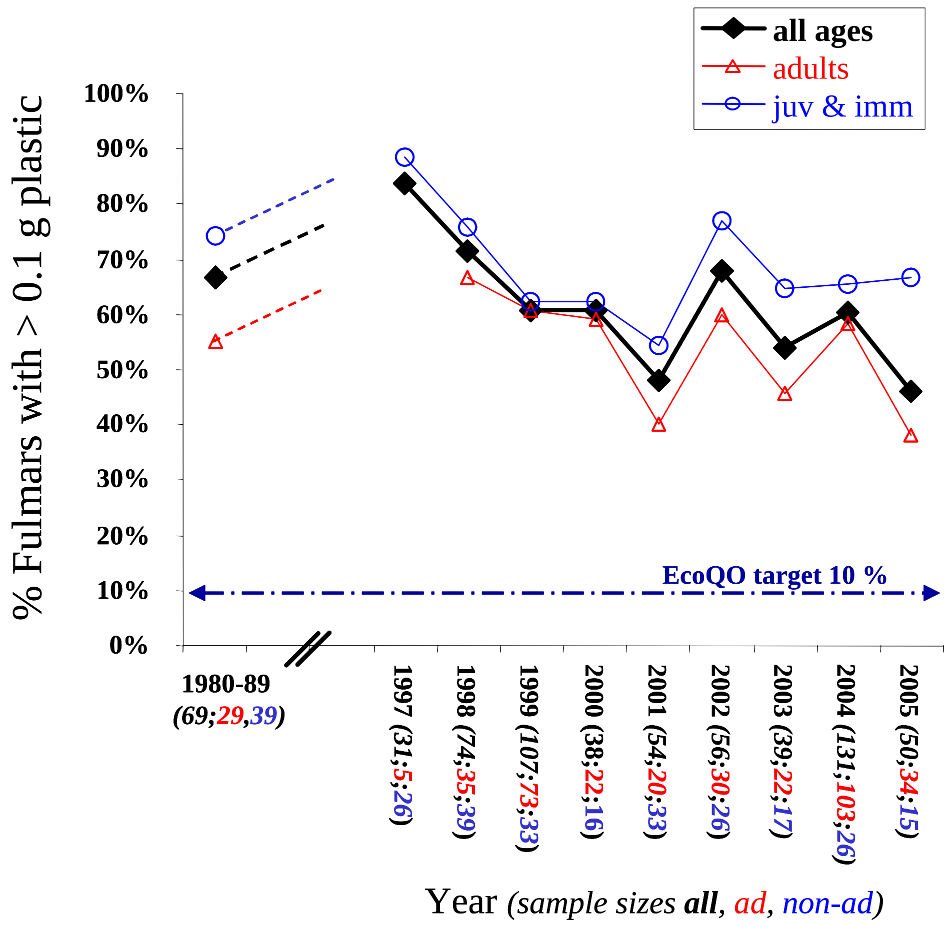

Fig.4. The Fulmar-Litter-EcoQO in the Netherlands. Trends in the proportion of Fulmars having more than 0.1 gram plastic in the stomach in relation to target level. (Annual figures 1997-2005; mean figure for 1980-89 decade).

The EcoQO situation for the Netherlands in 2005 was that 46% of Fulmars exceeded the critical value of 0.1g plastic. This is the lowest annual value on record, but close to the level reached in 2001, indicating that the rate of change over recent years is low. Averaged over the recent 5 year period, 55% (range 46%-68%) of Fulmars off the Dutch coast had 0.1 gram or more plastic in the stomach. Significance of trends should be derived from Table 3, which indicated a significant reduction for the combined plastics over the past 10 years ($p<0.001$), which was lowered but still just significant ($p=0.04$) if calculated over the period 1999-2005.

Fulmar-Litter-EcoQO situation in other North Sea countries

As a part of this and the previous project, coordination of collecting beached Fulmars in all countries around the North Sea was continued after ending of the ***Save the North Sea*** project 2002-2004. So far, for the year 2005 a total of 145 birds has been dissected and stomachs have been stored frozen (Belgium 46; Germany 62; Norway 11; NE England 7; France 4; Orkney 2; Shetland 5; Denmark 7). Effort has been made to obtain alternative funding for the analysis of these foreign stomachs from the shipping sector (NYK Line). Expectations are positive, but if granted, funding will take place after the deadline for the writing of this report.
Consequently, no new data on Fulmars from other parts of the North Sea are available and information has not changed since the report by Van Franeker & Meijboom (2006). For convenience data from that report are copied in Fig.5. Note that the data in this graph are for the 2002-2004 period, explaining the relatively high figure (61%) of Dutch Fulmars exceeding the critical limit of 0.1 gram of plastic in the stomach. Within the recent 5-year period, lowest

values in the Netherlands were obtained in 2001 and 2005, not included in this comparative graph. Sample sizes for northeast England and Sweden were to low and are shown with dashed lines only. Data for the Faroe Islands have been inserted as a reference point and are for a sample of 2002 only. Considerable numbers of additional stomachs have been obtained in following years for a study of age effects. Funds from Chevron Upstream have been obtained to start analyses in 2007.

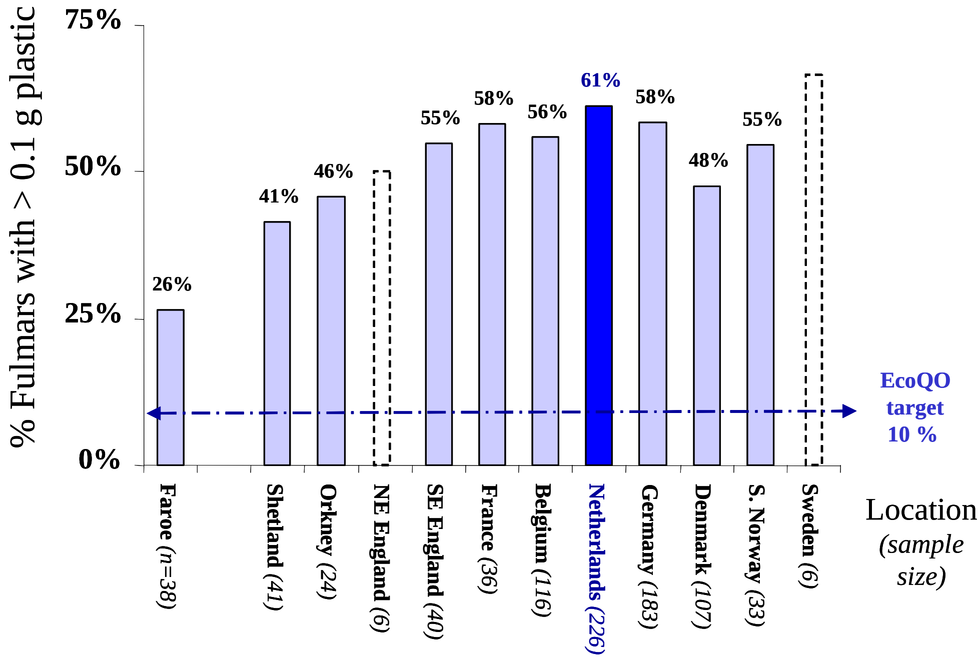

Fig.5. The Fulmar-Litter-EcoQO around the North, Sea 2002-2004. Proportion of Fulmars having more than 0.1 gram plastic in the stomach by country, and in relation to target level (figures for 3 years of the EU Interreg ***Save the North Sea*** project)

In absolute quantities (Van Franeker *et al.* 2005) the Fulmars from the southern North Sea have about twice as much plastic in the stomach as birds from the Scottish Islands, and four times as much as Fulmars from the outside reference at the Faroe Islands. Between neighbouring locations the differences are often not significant, but they are between regions (Scottish Isles; England; France-to-Germany; Skagerak). Patterns suggest an important relation to shipping intensity (Van Franeker *et al* 2005; Van Franeker & Meijboom 2006).

In EcoQO metrics, differences between locations/regions reflect similar patterns, but are are not as sharp as in mass measurements. Anywhere in the North Sea, between 40 and 60% of beached Fulmars has more than 0.1 gram of plastic in the stomach. Even in a supposedly cleaner area outside the North Sea, the Faroe Islands, about one in four birds exceeds the 0.1 g critical value (preliminary sample 2002 only). Evidently, trends in the litter situation in the areas outside the Netherlands can not yet be determined and will only become possible after a longer time series of data collection.

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 since 1997, and international expansion of the project since 2002, have delivered a wealth of data and firmly established the approach as being suitable for monitoring marine litter in the framework of Ecological Quality Objectives (EcoQO's) for the North Sea. At the request of OSPAR, a *Background Document* is being prepared for further consideration of the Fulmar-Litter-EcoQO.
This report updates monitoring information for the Netherlands up to the year 2005 and discusses details that are relevant to a correct interpretation of the strongly summarized information presented in the metric developed for the EcoQO.

- In the Dutch marine environment, raw industrial plastics (from which later all sorts of user products are manufactured) in bird stomachs have shown a steady decrease since the early 1980's with current values (2 to 3 granules per bird) less than half of their initial abundance.
- User-plastics from discarded wastes, showed a sharp increase from the 1980's to the late 1990's but then started to decrease, initially at a fast rate, slower in recent years.
- Overall plastic mass in bird stomachs is now (2001-2005 average: 0.3 g per bird; 29 pieces) similar or slightly lower than in the 1980's but in a changed composition. User plastics currently represent 80% of plastic mass and dominate in the significantly decreasing trend in recent years. As demonstrated in earlier reports, shipping and fisheries are major sources of user plastic in the Southern North Sea.
- The year 2005 fits in the recent pattern of a decrease in marine litter, but has not shown an abrupt change following the implementation of the Directive on Port Reception Facilities in October 2004 in the Netherlands, and similar starting dates in surrounding countries.
- In 2005, 46% of Fulmars beached in the Netherlands exceeded the critical EcoQO level of 0.1 gram of plastic (98% had some plastic). Even if this is the lowest annual EcoQO value on record, the slow rate of change emphasizes the major gap to the EcoQO target which requires that less than 10% of birds exceeds the 0.1 gram critical value.
- Within the wider North Sea, over the 2002-2004 period, litter pollution was the worst in its south-eastern sector (from the French Channel to Germany). In this region, up to 60% of birds exceeded the critical EcoQO value of 0.1 gram of plastic in the stomach. But even in less polluted northern parts of the North Sea, over 40% of birds exceeded the limit. Collection of birds around the North Sea has continued since 2004.

7. Acknowledgements

In the Netherlands, beached Fulmars are collected by volunteers of the Dutch Beached Bird Survey (NSO) of the Dutch Seabird Group (NZG) and by several seabird rehabilitation centres. Similarly in other countries many volunteers are involved, with or without additional (semi-)professional co-ordinating organisations. Without the huge amount of volunteer effort, a project like this would be totally impossible.
In several stages of this long term project, the dissection work, data analysis and writing of reports has been financially supported by the Netherlands Ministry of Transport, Public Works and Water Management (VenW).
Internationally the Fulmar project co-operates in the ***Save the North Sea*** project, which was co-funded by the EU Interreg IIIB program for the North Sea in the period 2002-2004. Co-operation in the Save the North Sea project with a wide range of organisations has been extremely rewarding and stimulating.

8. References

Breen, H. 2002. Plastics discarded at sea. MARMAM Network message of 29 Jul 2002

Camphuysen, C.J. 2005. Oiled-guillemot-EcoQO - Implementation Document. North Sea Pilot Project on Ecological Quality Objectives, Issue 4. Seabirds, EcoQO element (f). NIOZ Report, Royal Netherlands Institute for Sea Research, Texel. 12pp.

Department for Transport 2004. Transport Statistics Report. Maritime Statistics 2003. Department of Transport, London. (see www.transtat.dft.gov.uk).

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

EC 2000. Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues. Official Journal of the European Communities L 332: 81-90 (28 Dec 2000).

EC (Commission of the European Communities) 2005. Proposal for a Directive of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Directive). COM(2005) 505 final, 24-10-2005 *(incl communication 504 final and Impact Assessment Annex SEC(2005)1290).*

Edwards, R. 2005. Litter at sea means a bellyful of plastic. New Scientist 185(2481): 11.

Fleet, D.M 2003. Untersuchung der Verschmutzung der Spülsäume durch Schiffsmüll and der deutschen Nordseeküste. (UFOPLAN) FAZ 202 96 183, im Auftrag des Umweltbundesamtes, Hochschule Bremen. 194pp.

Guse, N., Fleet, D., van Franeker, J. & Garthe, S. 2005. Der Eissturmvogel (*Fulmarus glacialis*)-Mülleimer der Nordsee? Seevögel 26(2): 3-12.

Hall, K. 2000. Impacts of marine debris and oil: economic and social costs to coastal communities. KIMO, c/o Shetland Islands Council, Lerwick. 104 pp.

Laist, D.W. 1987. Overview of the biological effects of lost and discarded plastic debris in the marine environment. Mar. Pollut. Bull. 18(6B): 319-326.

Laist, D.W. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. pp 99-140 in: Coe, J.M. and Rogers, D.B. (eds.). Marine debris sources, impacts and solutions. Springer Series on Environmental Management. Springer Verlag, New York. 432pp.

OECD-MTC (Organisation for Economic Co-operation and Development - Maritime Transport Committee) 2003. Cost savings stemming from non-compliance with international enviromental regulations in the maritime sector. MEPC 49/INF.7. 14 March 2003. 53pp.

Olsen, K. 2005. Havhesten - en flygende söppelbötte. Var Fuglefauna 28: 28-32.

OSPAR 2004. OSPAR Commission Summary Record. OSPAR 04/23/1-E, Annex 17.

OSPAR Commission BDC 2005. Plastic particles in the stomachs of seabirds. BDC 05/3/1 Add.1 : 39-40.

Save the North Sea. 2004. Reduce marine litter: 'Save the North Sea' project results. Keep Sweden Tidy Foundation, Stockholm, 17pp.

Stichting De Noordzee 2000. HOI's: beschikbaarheid en rendement. Inzamelfaciliteiten voor oliehoudend- en vast afval in Nederlandse zeehavens. Verslag Stichting de Noordzee, Utrecht.16pp.

Stichting De Noordzee 2003. Coastwatch Onderzoek 2002. Stichting de Noordzee, Utrecht. 17pp + addenda.

Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle. D. & Russell, A.E. 2004. Lost at sea: Where is all the plastic?. Science 304 (5672): 838-838.

Van Franeker, J.A. 1985. Plastic ingestion in the North Atlantic Fulmar. Marine Pollution Bulletin 16: 367-369.

Van Franeker, J.A. & Bell, P.J. 1988. Plastic ingestion by petrels breeding in Antarctica. Marine Pollution Bulletin 19: 672-674.

Van Franeker, J.A. & Meijboom, A. 2002. Litter NSV - Marine litter monitoring by Northern Fulmars: a pilot study. ALTERRA-Rapport 401. Alterra, Wageningen, 72pp.

Van Franeker, J.A. & Meijboom, A. 2003. Marine Litter Monitoring by Northern Fulmars: progress report 2002. Alterra-rapport 622. Alterra, Wageningen, 49 pp.

Van Franeker, J.A. 2004a. The Fulmar-Litter-EcoQO in relation to EU Directive 2000/59/EC on Port Reception Facilities. Rapportage in opdracht van Directoraat Generaal Goederenvervoer, Ministerie van Verkeer en Waterstaat. Contract DGG-27020138. DGG-VenW, Den Haag. 47pp.

Van Franeker, J.A. 2004b. Save the North Sea - Fulmar Study Manual 1: Collection and dissection procedures. Alterra Rapport 672. Alterra, Wageningen. 38pp.

Van Franeker, J.A. 2004c. Fulmar wreck in the southern North Sea: preliminary findings. British Birds 97: 247-250.

Van Franeker, J.A., Meijboom, A. & De Jong, M.L. 2004. Marine litter monitoring by Northern Fulmars in the Netherlands 1982-2003. Alterra Rapport 1093. Alterra, Wageningen. 48pp.

Van Franeker, J.A. 2005. Schoon strand Texel 2005: onderzoeksresultaten van de schoonmaakactie van het Texelse strand op 20 april 2005. Alterra speciale uitgave 2005/09. Alterra, Texel. 23pp.

Van Franeker, J.A., Heubeck, M., Fairclough, K., Turner, D.M., Grantham, M., Stienen, E.W.M., Guse, N., Pedersen, J., Olsen, K.O., Andersson, P.J. & Olsen, B. 2005. 'Save the North Sea' Fulmar Study 2002-2004: a regional pilot project for the Fulmar-Litter-EcoQO in the OSPAR area. Alterra-rapport 1162. Alterra, Wageningen. 70pp.

Van Franeker, J.A. & Meijboom, A. 2006. Fulmar Littter EcoQO Monitoring in the Netherlands 1982-2004 in relation to EU Directive 2000/59/EC on Port Reception Facilities.. Report for the Ministry of Transport, Public Works and Water Management (VenW), contract nr DGTL/ZH/2.53.2.5012. Alterra, Texel. 41pp..

Vlietstra, L.S. & Parga, J.A. 2002. Long-term changes in the type, but not the amount, of ingested plastic particles in Short-tailed Shearwaters in the southeastern Bering Sea. Marine Pollution Bulletin 44: 945-955.

Signature: Dr. H.J. Lindeboom – *Science Director IMARES*

Date: 26 February 2007