Marine litter monitoring by Northern Fulmars: progress report 2002

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ABSTRACT

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An earlier pilot study on litter contents in stomachs of Fulmars indicated that this seabird can be used as a suitable indicator for levels of marine litter pollution on the North Sea off the Dutch coast. This progress report updates the existing dataset with data on Fulmar stomach contents in the year 2001 and analyses and discusses trends. Information is supplied on the background and planning for a European Fulmar study, related to the 'Save the North Sea (SNS)' campaign 2002-2004 which, co-funded by the EU Interreg IIIB program, aims to reduce marine litter in the North Sea region. The Dutch and SNS Fulmar studies are relevant for the development of an Ecological Quality Objective for the North Sea by ICES and OSPAR.

Keywords: beached-bird-surveys BBS, chemicals, Ecological-Quality-Objective EcoQO, EU-Directive, Fulmarus glacialis, graadmeter, ICES, ingestion, marine litter, metric, North Sea, OSPAR, plastic, Port-Reception-Facility, stomach-contents

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Summary

Corpses and stomach contents of 53 Fulmars beachwashed in the Netherlands during the year 2001 were investigated on the presence of marine litter ingested by these birds. These data were added to the existing database on this topic covering the years 1982 to 2000. Litter quantities in 2001 were relatively low as compared to some earlier years, but still 96% of birds in 2001 had plastics in the stomach, the average per bird being 22.7 plastic particles weiging 0.24 gram. Also, about 13% of the birds had ingested suspect chemical-like substances.
Analyses of long-term (1982-2001) and short-term (1996-2001) trends indicated that industrial plastic particles continue their steady decline, whereas user-plastics show signs of decrease in a few recent years after peak pollution levels in the late 1990's.
With participants in many countries around the North Sea, a similar study of litter in Fulmar stomachs has been started in 2002. This is a part of the 'Save the North Sea' campaign against marine litter, which is co-funded by the EU-Interreg IIIB program for the North Sea. This international Fulmar study will run from 2002 to 2004.
Information collected by the combination of the Dutch and European Fulmar study will supply essential background information for the implementation of decisions by the Ministers of North Sea countries in Bergen (March 2003). It was decided that a system of Ecological Quality Objectives for the North Sea (EcoQO's) will be implemented. One of the EcoQO's envisaged for implementation in 2005 uses abundance of plastics in stomachs of Fulmars as a measure for marine litter (Fulmar-Litter-EcoQO). Details for EcoQO measurement systems and target levels need to be developed by ICES and OSPAR, and the fulmar studies discussed here will facilitate that process.

Samenvatting

Maaginhouden van 53 in het jaar 2001 in Nederland aangespoelde Noordse Stormvogels zijn onderzocht op de aanwezigheid van zwerfvuil. Deze zeevogels eten allerlei afval van het zee-oppervlak. De gegevens werden toegevoegd aan de bestaande database over dit onderwerp over de periode 1982-2000. De hoeveelheid afval in de magen in 2001 was relatief laag in vergelijking met eerdere jaren, maar desondanks had 96% van de vogels plastic in de maag, met een gemiddelde van 22,7 plastic objecten per vogel en een gewicht van 0,24 gram per vogel. Daarnaast werden mogelijk chemische substanties aangetroffen bij 13% van de vogels.
Analyses van lange-termijn (1982-2001) en korte-termijn trends (1996-2001) toonden aan dat de gestage afname van industriële plastics zich voortzet. De tussen 1982 en laat 90'er jaren zeer sterk gestegen hoeveelheden gebruiks-plastics lijken in de meest recente jaren weer wat af te nemen.
Met deelnemende groepen in vele landen, is in 2002 begonnen met een vergelijkbaar stormvogelonderzoek op een aantal verschillende locaties rond de Noordzee. Dat onderzoek vormt een onderdeel van de 'Red de Noordzee (Save the North Sea)' campagne tegen zwerfvuil op zee, die wordt medegefinancierd vanuit het EU Interreg IIIB programma voor de Noordzee. Het internationale stormvogel onderzoek loopt voorlopig van 2002 t/m 2004.
De gegevens die worden verzameld in de combinatie van het Nederlandse en Europese project verschaffen essentiële informatie voor de invoering van een systeem van Ecologische Kwaliteits Doelstellingen voor de Noordzee. Ministers van de Noordzeelanden hebben in maart 2003 in Bergen besloten dat er een systeem van 'Ecological Quality Objectives EcoQO's' voor de Noordzee moet komen. Een van de EcoQO's die in 2005 ingevoerd moet zijn, gebruikt de aanwezigheid van plastics in maaginhouden van stormvogels als graadmeter voor de mate van zwerfvuil op zee. Werkgroepen van ICES en OSPAR moeten dit meetsysteem en de te gebruiken doelwaardes nog nader bepalen. De stormvogelonderzoeken in Nederland en in internationaal verband kunnen de daarvoor benodigde gegevens verschaffen.

1 Introduction

1.1 General background

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

Coastal municipalities are confronted with costs for beach clean-ups. Tourism suffers damage from polluted beaches and various types of litter are a health-risk for tourists. Fisheries are confronted with an increasing bycatch of marine litter. All sorts of shipping suffer financial damage and safety-risks from fouled propellors or blocked water-intakes. Coastal litter blowing inland is even affecting farmers. The economical damage from marine litter is difficult to estimate, but a detailed study in the Shetlands with additional surveys in other countries indicates that costs in the North Sea area are running into billions of Euro's per year (Hall 2000)!

Marine wildlife suffers from marine litter. Entangled seabirds and marine mammals are the most conspicuous evidence of damage to marine wildlife. However, only a small proportion of such mortality becomes visible among beachwashed animals. Even less apparent are the consequences from the ingestion of plastics and other litter. Ingestion is common among a wide range of marine organisms and may also lead to direct mortality. However, the major impact throught reduced fitness of many individuals in animal populations remains 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).

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 1991 and Special Area status 1999; and the OSPAR Convention 1992. In the absence of significant improvement, 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 2003 Bergen Declaration have decided to introduce a system of Ecological Quality Objectives for the North Sea (EcoQO's). A number of these EcoQO's will be 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. The ecological quality target is set at a level in which less than 10% of beachwashed Guillemots has oil on the plumage.
An other set of EcoQO's has to be developed for implementation in 2005. 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.
For convenience the above two seabird EcoQO's will be referred to in this report as the 'Guillemot-Oil-EcoQO' and the 'Fulmar-Litter-EcoQO'.

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 commissioned Alterra to conduct a pilot study for the monitoring of marine litter. This pilot project was conducted in 2001 and results were published in Alterra Report 401 (Van Franeker & Meijboom 2002)

1.2 Availability of data - Dutch pilot study

The Van Franeker & Meijboom (2002) pilot study report discussed the feasibility of using stomach contents of beachwashed Northern Fulmars to measure changes in the litter situation off the Dutch coast. Reasons for selection of the Fulmar out of a potential list of monitoring species were largely 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 representative for the wider offshore environment and ingest marine litter regularly, averageing pollution levels over a foraging space and time span that avoids bias from local pollution incidents;
- historic data are available in the form of a Dutch dataseries since 1982; and literature is available on other locations and related species worldwide.
- Other North Sea species that ingest litter either do not accumulate plastics (regurgitate indigestable remains); are coastal only (e.g. Larus gulls); ingest litter only incidentally (eg North Sea alcids) or are too infrequent in beached bird surveys for required sample size or spatial coverage (eg other tubenoses or Kittiwake).

A total number of 329 Fulmars, beachwashed in the Netherlands between 1982 and 2000 was available for the pilot study. These beachwashed birds may have died for a variety of reasons. For some birds, plastic accumulation in the stomach was the direct cause of death, but more often the effects of litter ingestion act at sublethal 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 finding date were determined. Stomach contents were 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 had a number of subcategories of specific items. Data were collected on presence or absence ("incidence"), the number of items, and the mass of items for each individual bird and litter category.

Extensive analyses were conducted to check whether time-related changes in litter abundance were susceptible to error caused by bias from variables such as sex, age, origin, condition, deathcause, 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. Only age was found to have some effect on ingested litter, adults having somewhat less plastics 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 defense of nest-sites. Another factor could be that foraging experience may increase with age. However, our understanding of the observed age difference in plastic accumulation is still poor, and further study should be promoted where possible.

Although age did affect absolute levels of ingested litter, changes over time were the same in adults or non-adults. Since no directional change in age composition of samples was observed, trends were analysed for the combined age groups. By using individual sample data rather than annual averages, optimal use of data was made. 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.

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 categories, rather than incidence or number of items, may be considered the most useful unit of measurement in the long term, and also is the most representative in terms of ecological impact on organisms. Incidence looses sensitiviy 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 may vary strongly with changes in plastic characteristics.

The pilot study therefore concluded that stomach content analysis of beachwashed 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 potential coastal 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 speficic policy measures aiming at reduced inputs. Addition of further indicators from other litter (sub-)categories would produce little added value in the current situation. Anyway, 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.

1.3 Link to the Ecological Quality Objective for the North Sea

The pilot study in Van Franeker & Meijboom (2002) analysed the monitoring potential of Northern Fulmars in the Dutch situation. Evidently, this work has close linkage to the decision by the North Sea Ministerial Conference in Bergen (March 2002) on the implementation of a Fulmar-Litter-EcoQO for the whole North Sea in the year 2005.
The ICES Working Group on Seabird Ecology (ICES-WGSE), the OSPAR-Biodiversity -Committee (OSPAR-BDC) and the Advisory Committee on Ecosystems (ACE) are involved. In spite of the fact that further studies were still required, a preliminary and tentative target-value was proposed by ACE for the Fulmar-Litter-EcoQO. This EcoQO-target was formulated as:

> *"a maximum of no more than 2% of individuals having ten or more plastic particles within a sample of at least 50 Northern Fulmars".*

Since these issues were considered prior to publication of the Dutch pilot study, no distinction was made between industrial and user plastics, and chemical substances were not considered. Looking at proportions of plastic types and average masses of items in the Netherlands, the the general EcoQO-target could be 'translated' into less than 2% of birds having 2 or more industrial pellets (0.03g)), and less than 2 % of birds having 8 or more user particles (0.12g).
Available data show a huge gap between the current situation and the tentative EcoQO target for plastics: over the full 1982-2000 period, 58% of Dutch Fulmars had more than 10 plastic particles (industrial + user) in the stomach.
The pilot study proposed to ICES and OSPAR to consider usage of separate plastic categories and chemicals, and to base a measuring system on mass. In the current EcoQO-target, the unit of measurement combines 'incidence' and 'number of items', which is not easily intelligble. As indicated, in such a measuring system, samples of about 40 birds per year and location should be sufficient.

1.4 Further steps required

Looking at the results of the Dutch pilot study, the anticipated implementation of the Fulmar-Litter-EcoQO for the whole North Sea in 2005 necessitates two further lines of activity:

1. 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)
2. exploratory research on Fulmar samples from a number of different locations around the North Sea to assess degrees of regional variability in Fulmar stomach contens and their backgrounds. Such work is essential for a sound advise on a cost-efficient EcoQO monitoring system (in terms of number and spread of sampling locations around the North Sea and in terms of metrics to be used), differentation in EcoQO-target levels, and finally the designation of effective measures to reach targets.

This progress report covers the initial steps of both these lines of activity by:

1. reporting on Dutch Fulmar research by updating the 1982-2000 time series with new data on Fulmars collected on Dutch beaches in the year 2001
2. reporting on the setup and planning of an international fulmar study as a part of the 'Save the North Sea (SNS)'-project under the European Interregional Program Interreg IIIB. The SNS campaign wants to increase awareness on marine litter problems in order to change attitudes and behaviour among target groups such as shipping, fisheries, and offshore industries and the recreational sector.

2 Material and methods

In 2001 Alterra has continued to collect beachwashed Fulmars from Dutch beaches with the assistance of the Dutch Seabird Group (Nederlandse Zeevogelgroep NZG). The collection of birds is part of the activities by the NZG-Working Group on Beached Bird Surveys (Nederlands Stookolieslachtofffer Onderzoek - NSO) co-ordinated by Kees Camphuysen.
Additionally, assistance has been sought from coastal bird rehabilitation centers that occasionally receive Fulmars from the general public.

Bird corpses were stored frozen until analysis. Dissection methods and 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 Van Franeker & Meijboom 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 deathcause, 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 therafter).

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 a small muscular stomach (the gizzard) where harder prey remains can be processed. 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 subsampled 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 under 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 iron 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)** is used for lumps of parafine 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 out under binocular microscope all above categories, we recorded 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).

Data from dissections and stomach content analysis are recorded in Excel spreadsheets and stored in Oracle relational database. GENSTAT 6.1 was used for statistical tests .
As concluded in the pilot study (Van Franeker & Meijboom 2002) statistical analysis of data for presence of trends over time was conducted using mass-data. Mass values for litter categories were ln-transformed to allow stastistical tests based on linear regressions fitting mass values for individual birds on the year of collection.
In addition to mass, incidental data on incidence and numbers of items have been provided as well. Until a final decision has been made on methodological aspects for the North Sea Fulmar-Litter-EcoQO, broad based data-collection during dissection and stomach content sorting will be continued to allow for future adaptations in analytical methods and presentation of trends without loss of historical data.

Being aware of the EcoQO developments in the framework of ICES, OSPAR and the North Sea Ministerial Conference there was an apparent need for a wider geographical coverage of Fulmar studies. Therefore Alterra participated in a proposal for an EU funded project on marine litter initiated by the Keep Sweden Tidy foundation and submitted to the Interreg IIB programme for the North Sea. Separate chapters in this report describe the current status of this project and its linkage to the Dutch study and the EcoQO process, including the EcoQO on oil pollution in the North Sea.

3 Results

3.1 The year 2001

Sixty Fulmars could be collected from the Dutch beaches in the year 2001. Five of these were birds that had lived in rehabilitation centres for some time before their death. These birds are not suitable for the long-term monitoring because of wear of plastics in their stomachs, but they can be of use in a study for disappearance rates of litter from the bird stomachs. Two of the remaining 55 bird corpses found on beaches proved to be incomplete and lacked stomachs, reducing the final sample for 2001 to 53 Fulmars with suitable stomach contents, sufficient for the desirable annual sample size of about 40 birds. In collections delivered to Alterra, one 'old' corpse of a bird found in 1998 popped up: data from this bird were added to our existing time-series and included in trend analyses.

Table 1 Summary of sample characteristics and stomach contents of Fulmars collected for Dutch marine litter monitoring in the year 2001 (n=53). See explanatory text at next page.

YEAR	nr of birds	adult	male	LL colour	death oil	avg condition
2001	**53**	**37%**	**44%**	**79%**	**11%**	**1.6**

		Incidence	average number of items (n/bird)	average mass of items (g/bird) ± standard deviation	max. mass recorded (g)	geometric mean mass (g/bird)
1	**ALL PLASTICS**	**96%**	**22.68**	**0.235 ± 0.389**	**2.2**	**0.0764**
1.1	**INDUSTRIAL PLASTIC**	**62%**	**2.36**	**0.053 ± 0.108**	**0.7**	**0.0045**
1.2	**USER PLASTIC**	**96%**	**20.32**	**0.182 ± 0.350**	**2.1**	**0.0516**
1.2.1	sheets	58%	3.15	0.016 ± 0.076	0.6	0.0011
1.2.2	threads	47%	1.53	0.009 ± 0.034	0.2	0.0005
1.2.3	foamed	47%	5.92	0.025 ± 0.072	0.5	0.0009
1.2.4	fragments	87%	9.15	0.072 ± 0.088	0.4	0.0209
1.2.5	other plastic	26%	0.57	0.059 ± 0.279	1.7	0.0003
2	**OTHER RUBBISH**	**8%**	**0.70**	**0.014 ± 0.060**	**0.4**	**0.0001**
2.1	paper	0%	0.00	0.000 ± 0.000	0.0	0.0000
2.2	kitchenwaste (food)	2%	0.04	0.001 ± 0.004	0.0	0.0000
2.3	rubbish various	6%	0.66	0.013 ± 0.060	0.4	0.0001
2.4	fishhook	0%	0.00	0.000 ± 0.000	0.0	0.0000
3	**POLLUTANTS**	**28%**	**1.06**	**0.566 ± 2.684**	**18.0**	**0.0008**
3.1	slags	8%	0.15	0.001 ± 0.005	0.0	0.0000
3.2	tarlumps	0%	0.00	0.000 ± 0.000	0.0	0.0000
3.3	suspected chemical	13%	0.58	0.497 ± 2.685	18.0	0.0002
3.4	feather lumps	17%	0.32	0.069 ± 0.189	1.0	0.0003
4	**FOOD NATURAL**	**89%**	**10.42**	**2.983 ± 14.72**	**80.0**	**0.0235**
5	**NONFOOD NATURAL**	**87%**	**5.58**	**0.107 ± 0.132**	**0.5**	**0.0177**

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-tranformed values as used in trend-analyses. The geometric mean is similar to the median value of the observations.

3.2 Trends 1982-2001 in the Netherlands

Data for 2001 (Table 1) show relatively low quantities of litter in the stomachs of birds as compared to those in several of the preceding years. Table 2 shows annual data for incidence and abundance by number and by mass for the three formal litter indicators proposed in the pilot study: industial plastics (Fig.1), user plastics (Fig.2) and suspected chemicals (Fig.3). Data for overall plastic abundance (industrial and user plastics combined) have been added because at the moment, the EcoQO and its target level are defined in terms of overall plastic abundance.

Depending on litter category and units of measurements, peak values for litter appear to have occurred from 1997 to 1999 with subsequent reductions. The low values occur in spite of the fact that the 2001 sample had a relatively high proportion of non-adult birds (only 37% adult) compared to the years immediately before. Non-adult birds in general have somewhat more litter in the stomach than adult ones.

Graphical presentations for trends (Fig's 4-7) also follow the format proposed in Van Franeker & Meijboom (2002). Graphs show linear regression trend lines of ln-transformed litter mass against year of collection (for all birds, and for adults/non-adults separate). As in table 2, a graph for 'overall plastics' has been added to conform to current EcoQO definitions. Full details of the regression lines in the graphs are listed in Table 3.

Long-term trends show strong similarity to those in the pilot study because only one year of new data have been added to the 1982-2000 series. In the long term, industrial plastics are significantly decreasing and user-plastics increasing. These opposite trends confound the figure for the long-term trend in overall plastics. No long-term statistical change can be concluded for chemical substances in the stomachs.

Table 2 Major litter categories per year

			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***	**39%**	***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
1991	*1*	0%	*0%*	0.0	0.00	*100%*	11.0	0.14	*100%*	11.0	0.14	*0%*	0.0	0.00
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***	**47%**	***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**	***97%***	**18.5**	**0.27**	***97%***	**21.9**	**0.35**	***26%***	**2.4**	**0.06**
2001	***53***	**37%**	***62%***	**2.4**	**0.05**	***96%***	**20.3**	**0.18**	***96%***	**22.7**	**0.23**	***13%***	**0.6**	**0.50**

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. However, trend analyses (table 3 and graphs) are based on values from all individual birds which avoids problems of years of poor sample size or variable age composition. Shown are incidence (%) representing the proportion of birds with one or more items of the litter category present; abundance by number of items per bird (n); and abundance by mass per bird in grams (g).

3.3 Short term trends 1996 - 2001

A closer look at the recent years shows that both industrial plastic and user plastic have decreased. Indications for such change were visible in the 1996-2000 analysis of the pilot study, but trends were not significant. However, the trends have continued and show significant decreases for both industrial and user plastics over the 1996-2001 period. Combined they lead to an even stronger significance for recent decrease in overall plastics. Short-term trends were not shown in separate graphs in the pilot study, but because of their increased significance in the current analysis, separate 1996-2001 graphs have been added to the information on formal indicators in this progress report.

The current approach in data-analysis is based on linear trends and does not provide possibilities to deal statistically with curves caused by reversal of trends in a single time-series. This is an issue to be considered in the implementation of the EcoQO metrics in a later phase.

3.4 Interpretation of trends

The overall conclusion from the various indicators is that the litter situation in the southern North Sea in the 1996-2001 period is still considerably worse than during the early and mid 1980's, but that there appears a tendency of improvement after peak litter abundance in the years 1997-99, largely due to an apparent reversal in trend in user plastics. The period over which recent trends can be analysed is still fairly short. Calculations in the pilot study indicated that 4 to 8 years are needed for reliable conclusions. Research in the years to come has to show whether the recent trends are consistent.

Table 3 Details of linear regression analyses of selected litter indicators.

		LONG TERM TRENDS (1982-2001) IN LITTER INDICATORS							SHORT TERM TRENDS (1996-2001) IN LITTER INDICATORS						
INDUSTRIAL PLASTIC		*n*	Constant	estimate	se	t	p		*n*	Constant	estimate	se	t	p	
all ages	**lnGIND**	***383***	**153.4**	**-0.079**	**0.020**	**-3.99**	**<0.001**	**- - -**	***311***	**395.0**	**-0.200**	**0.095**	**-2.10**	**0.037**	**-**
adults	LnGINDad	*189*	119.5	-0.062	0.031	-1.98	0.049	-	*159*	210.0	-0.107	0.156	-0.69	0.492	
non adults	LnGINDna	*191*	144.8	-0.074	0.025	-2.96	0.004	- -	*150*	436.0	-0.220	0.117	-1.88	0.062	
USER PLASTIC		*n*	Constant	estimate	se	t	p		*n*	Constant	estimate	se	t	p	
all ages	**lnGUSE**	***383***	**-99.5**	**0.049**	**0.017**	**2.83**	**0.005**	**++**	***311***	**371.0**	**-0.187**	**0.079**	**-2.36**	**0.019**	**-**
adults	lnGUSEad	*189*	-90.1	0.044	0.027	1.64	0.103		*159*	335.0	-0.169	0.133	-1.27	0.207	
non adults	lnGUSEna	*191*	-127.6	0.063	0.023	2.79	0.006	++	*150*	309.0	-0.156	0.094	-1.66	0.100	
ALL PLASTICS COMBINED		*n*	Constant	estimate	se	t	p		*n*	Constant	estimate	se	t	p	
all ages	**lnGPLA**	***383***	**-0.9**	**-0.001**	**0.016**	**-0.03**	**0.973**		***311***	**421.0**	**-0.212**	**0.076**	**-2.77**	**0.006**	**- -**
adults	lnGPLAad	*189*	-29.0	0.013	0.027	0.50	0.615		*159*	363.0	-0.183	0.131	-1.40	0.164	
non adults	lnGPLAna	*191*	-9.4	0.004	0.020	0.19	0.848		*150*	362.0	-0.182	0.087	-2.10	0.038	-
SUSPECTED CHEMICALS		*n*	Constant	estimate	se	t	p		*n*	Constant	estimate	se	t	p	
all ages	**lnGCHE**	***383***	**-70.6**	**0.032**	**0.022**	**1.51**	**0.132**		***311***	**308.0**	**-0.157**	**0.107**	**-1.46**	**0.145**	
adults	lnGCHEad	*189*	-84.7	0.040	0.036	1.11	0.269		*159*	589.0	-0.298	0.184	-1.62	0.107	
non adults	lnGCHEna	*191*	-50.1	0.022	0.027	0.82	0.413		*150*	170.0	-0.088	0.129	-0.68	0.497	

Ln transformed litter mass values for individual birds were fitted on year of collection. The regression line is described by y = Constant + estimate*x. Negative t-values indicate decreasing quantities of the litter category over the years for which the test was performed. Significance (p) of the trend was labelled - or + for significance at level $p<0.05$; -- or ++ for level $p<0.01$ and --- or +++ for level $p<0.001$ for decrease or increase respectively.

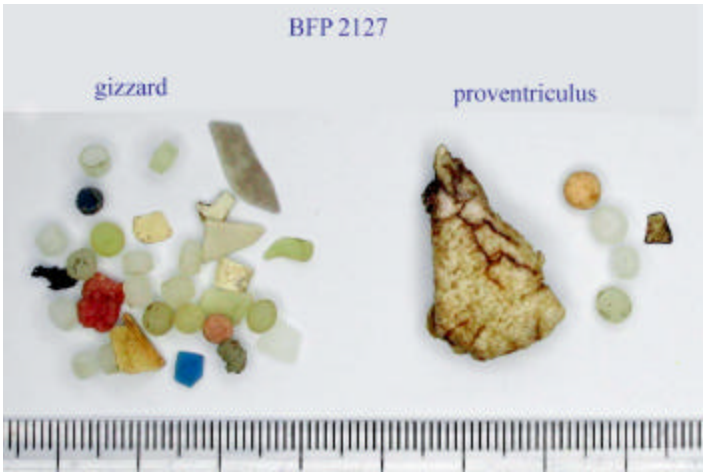


Fig. 1
Fulmar stomach content with high proportion of industrial granules (proventriculus is the first large glandular stomach, that passes material on to the smaller and muscular stomach called gizzard)

Fig. 2
Fulmar stomach content with extreme quantity of user plastics (top mainly fragments, left under sheets; central under foamed; center right shows 2 industrial granules)

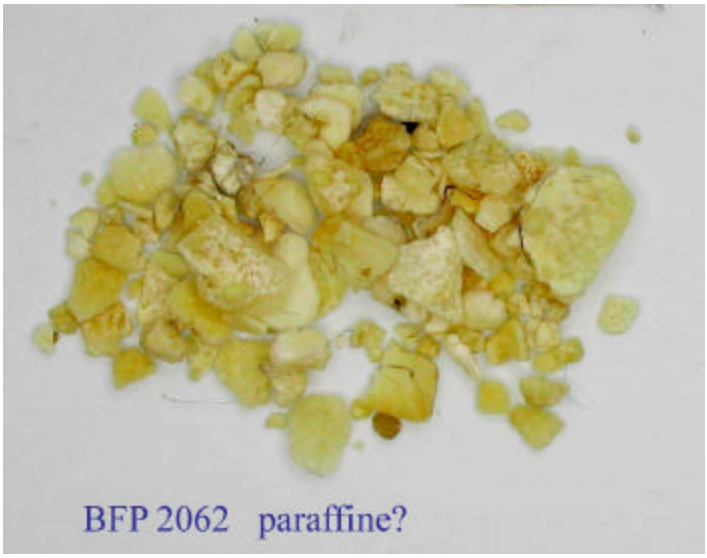


Fig. 3
Example of a Fulmar stomach content with a considerable quantity of 'suspected chemical' substances, resembling paraffine.

MONITORING TOOL MARINE LITTER NETHERLANDS
Stomach contents of Northern Fulmar Fulmarus glacialis
(beachwashed birds)

Three indicators have been selected for litter monitoring in Dutch offshore waters using litter abundance in stomachs of Northern Fulmars. Industrial plastics, user-plastics and suspected chemicals were selected as separate indicators because they supply information on different sources and pathways of litter pollution in the North Sea.

INDICATOR 1 INDUSTRIAL PLASTICS

TRENDS 1982-2001, THE NETHERLANDS

indicator:	Industrial plastics present in proventriculus and gizzard
units	mass per bird (total mass of industrial plastics per bird in grams)
trend calculation	linear regression analysis of ln tranformed mass data fitted on year
litter sources	commercial shipping very likely (*poor packaging; deck and hold cleaning*); land-based likely (*loss at factories*)
area:	Southern North Sea, offshore environment
basic data:	1982-2001, mainly early-mid 1980's and 1996-2001
reference:	pre-pollution era: zero industrial plastics
developments	**Long-term decrease** 1982-2001 highly significant ($p<0.001$) **Short-term decrease** 1996-2001 significant ($p<0.05$)
current situation	0.07 ± 0.16 g/bird (arithmetic mean mass ± sd; 1996-2000; n=311) (3.4 ± 7.4 granules/bird; incidence 64%)
EcoQO North Sea	*tentative target:*

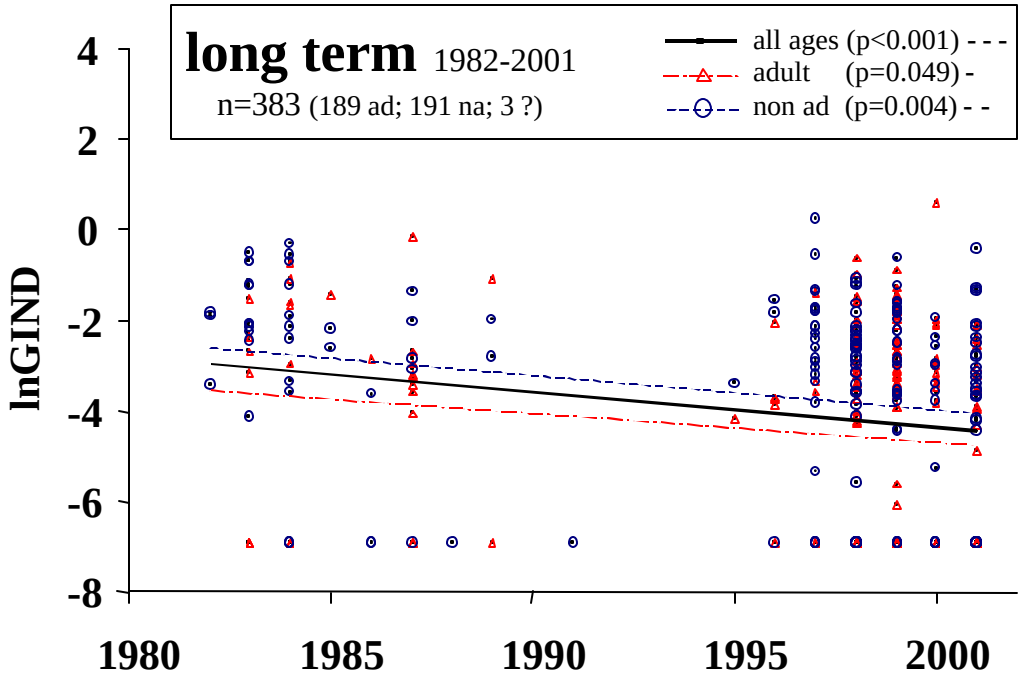
less than 2% of Fulmars having more than 0.03 gram or 2 granules of industrial plastic.

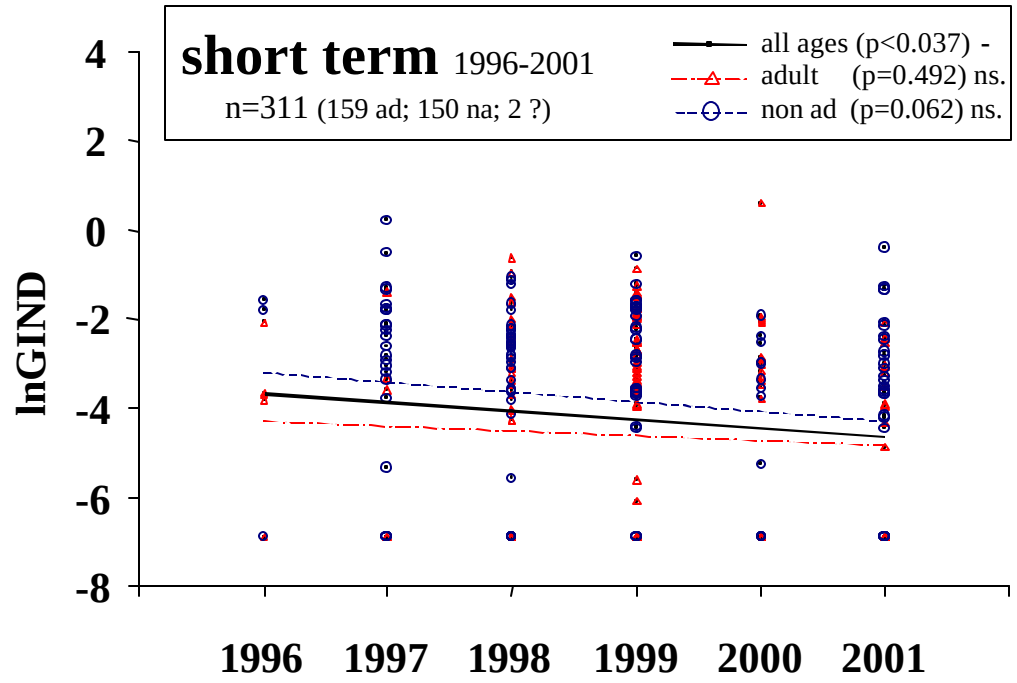
Discussion

The long-term and recent decreases reported in the previous assessment have continued and increased in significance. The gradual disappearance of these hard plastic granules from the marine environment is remarkable since wear and degradation are likely very low, and expected was a gradual increase through accumulation even in case of reduced input. The trends indicate a combined effect of reduced inputs and of unexpected pathways of disappearance (in which ingestion by birds may play a role).

Fig. 4

INDUSTRIAL PLASTICS





MONITORING TOOL MARINE LITTER NETHERLANDS
Stomach contents of Northern Fulmar Fulmarus glacialis
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Three indicators have been selected for litter monitoring in Dutch offshore waters using litter abundance in stomachs of Northern Fulmars. Industrial plastics, user-plastics and suspected chemicals were selected as separate indicators because they supply information on different sources and pathways of litter pollution in the North Sea.

INDICATOR 2 USER PLASTICS

TRENDS 1982-2001, THE NETHERLANDS

indicator:	all non-industrial plastics present in proventriculus and gizzard
units	mass per bird (total mass of user plastics per bird in grams)
trend calculation	linear regression analysis of ln tranformed mass data fitted on year
litter sources	commercial shipping and fisheries very likely; (*household and operational cargo and equipment wastes*) coastal recreation, land-based and offshore industry possible
area:	Southern North Sea, offshore environment
basic data:	1982-2001, mainly early-mid 1980's and 1996-2001
reference:	pre-pollution era: zero user plastics
developments	**Long-term increase** 1982-2001 significant ($p<0.01$) **Short-term decrease** 1996-2001 significant ($p<0.05$)
current situation	0.47 ± 1.68 g/bird (arithmetic mean mass ± sd; 1996-2001; n=311) (26.4 ± 45.5 items/bird; incidence 96%)

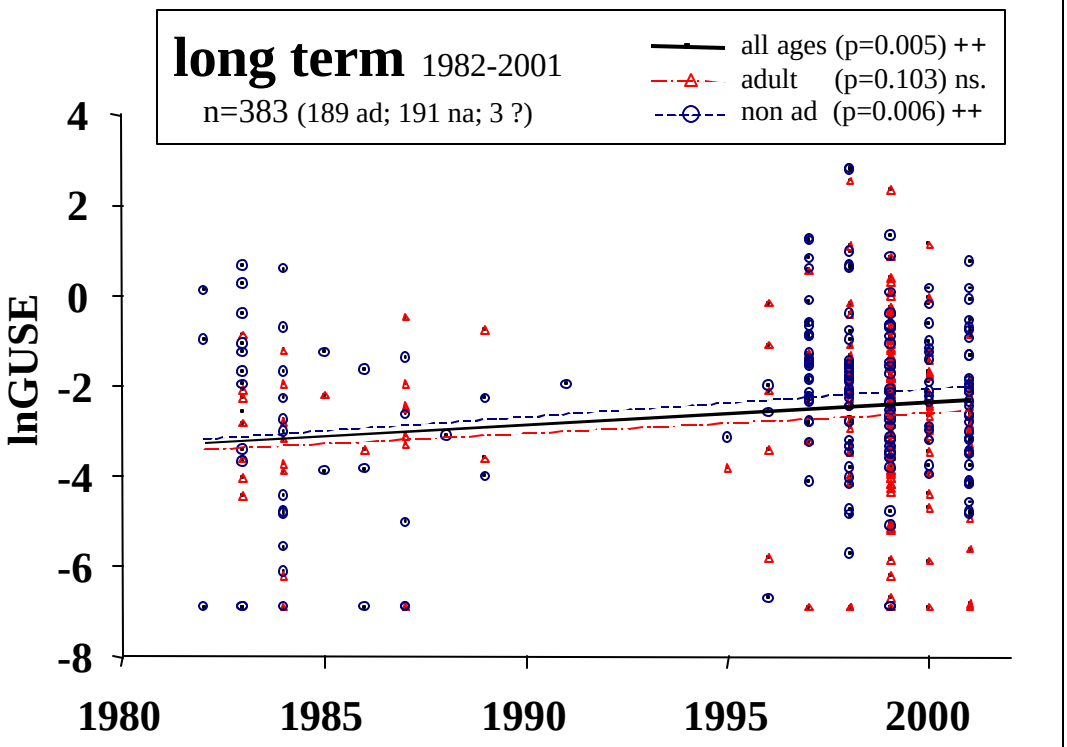
EcoQO North Sea tentative target:
less than 2% of Fulmars having more than 0.12 gram or 8 pieces of user plastics

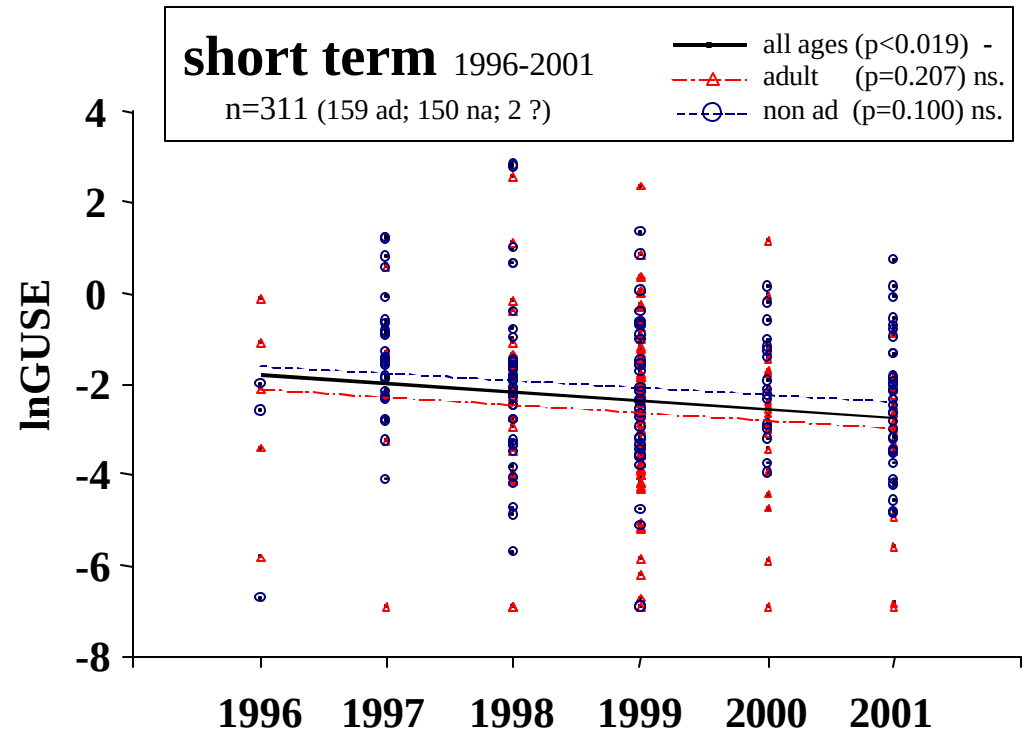
Discussion

The short-term decrease which was seen at insignificant level in the previous assessment appears to have continued in 2001, resulting in a significant decrease in user plastics over the period 1996-2001. The long-term trend of increase has therefore been weakened, although average levels over recent years are still much higher than during the 1980's. The current information suggests that peak pollution with user plastics was reached in the period 1997-99 with subsequent improvement. However, earlier analyses suggested that up to about 8 years of data may be needed before consistency in trends in user plastics can be reliably concluded. Records for subcategories (sheet, thread, foam, fragment, other) are recommended as they may assist in refining changes in quantitative contributions from different sources.

Fig. 5

USER PLASTICS





MONITORING TOOL MARINE LITTER NETHERLANDS
Stomach contents of Northern Fulmar Fulmarus glacialis
(beachwashed birds)

Three indicators have been selected for litter monitoring in Dutch offshore waters using litter abundance in stomachs of Northern Fulmars. Industrial plastics, user-plastics and suspected chemicals were selected as separate indicators because they supply information on different sources and pathways of litter pollution in the North Sea.

INDICATOR 1+2 ALL PLASTICS COMBINED

TRENDS 1982-2001, THE NETHERLANDS

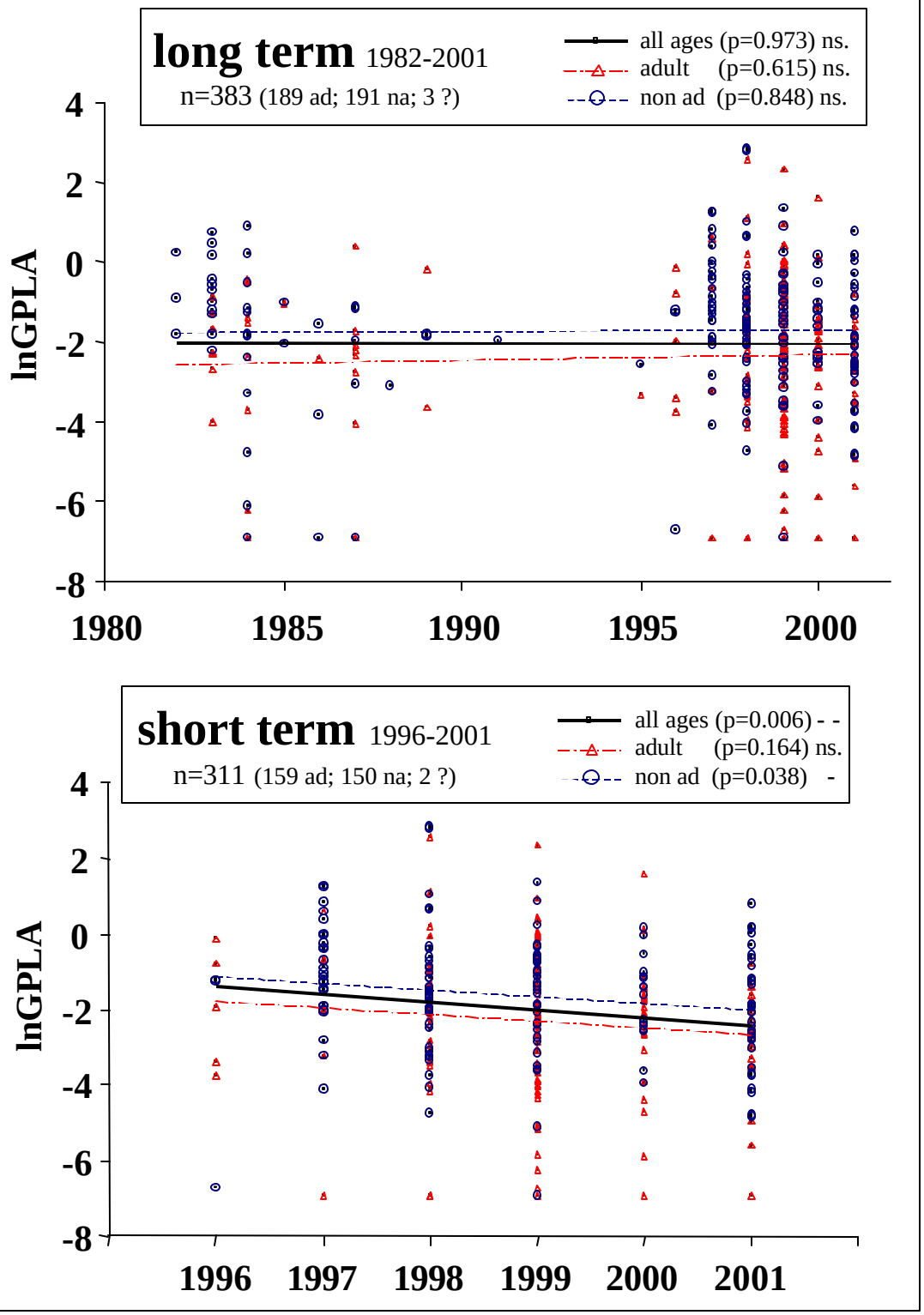
indicator:	all plastics present in proventriculus and gizzard
units	mass per bird (total mass of user plastics per bird in grams)
trend calculation	linear regression analysis of ln tranformed mass data fitted on year
litter sources	commercial shipping land fisheries very likely; coastal recreation, land-based and offshore industry possible
area:	Southern North Sea, offshore environment
basic data:	1982-2001, mainly early-mid 1980's and 1996-2001
reference:	pre-pollution era: zero plastics
developments	**Long-term no trend** 1982-2001 no significant linear change **Short-term decrease** 1996-2001 significant ($p<0.05$)
current situation	0.54 ± 1.70 g/bird (arithmetic mean mass ± sd; 1996-2001; n=311) (29.8 ± 49.2 items/bird; incidence 97%)

EcoQO North Sea tentative target:
less than 2% of Fulmars having more than 0.15 gram or 10 pieces of plastic.

Discussion
Due to the opposite trends in abundance of industrial and user plastics on the long term, there is no significant trend in the long-term abundance of plastics in the birds stomachs. However, more recently, both types appear to be declining as marine litter, resulting in a first time significant decline of all plastics combined. If trends remain similar one could reconsider the original preliminary EcoQO proposed in OSPAR which did not distinguish between litter types. Evidently, this would simplify presentation of information to general public and policy-makers, but at the background the different categories with their different sources would need to be investigated continuously.

Fig. 6

ALL PLASTICS



MONITORING TOOL MARINE LITTER NETHERLANDS
Stomach contents of Northern Fulmar Fulmarus glacialis
(beachwashed birds)

Three indicators have been selected for litter monitoring in Dutch offshore waters using litter abundance in stomachs of Northern Fulmars. Industrial plastics, user-plastics and suspected chemicals were selected as separate indicators because they supply information on different sources and pathways of litter pollution in the North Sea.

INDICATOR 3 "CHEMICALS" (suspected chemical substances)

TRENDS 1982-2001, THE NETHERLANDS

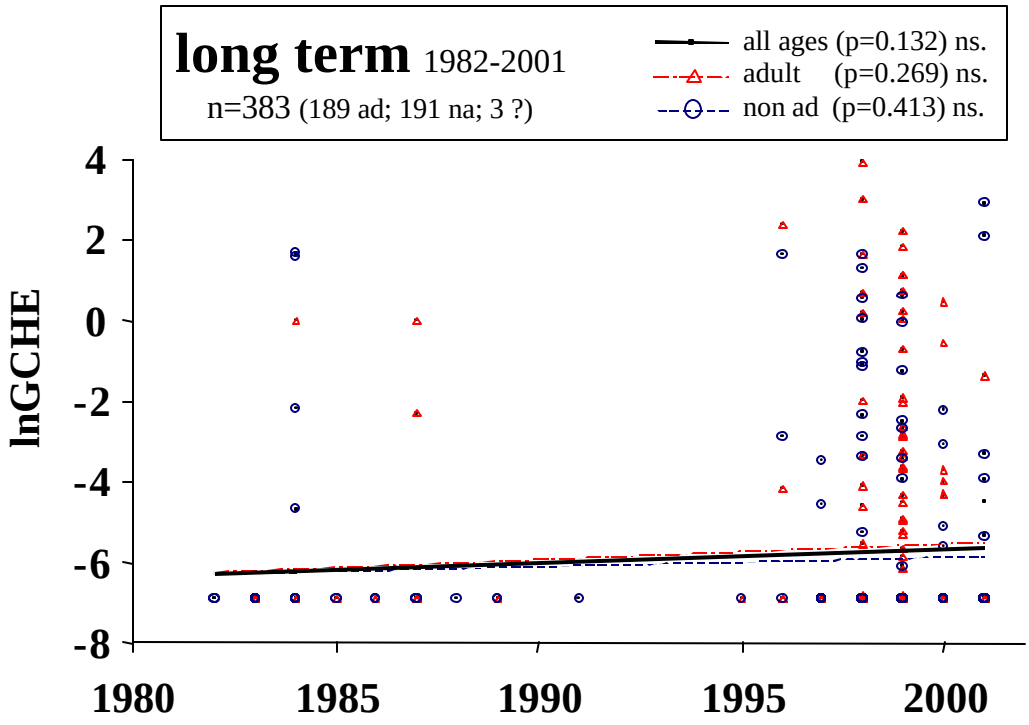
indicator:	chemical-like substances present in proventriculus and gizzard
units	mass per bird (total mass of chemical substance per bird in grams)
trend calculation	linear regression analysis of ln tranformed mass data fitted on year
litter source	commercial shipping most likely (tank washing and possibly fuel residues)
area:	Southern North Sea, offshore environment
basic data:	1982-2001, mainly early-mid 1980's and 1996-2001
reference:	pre-pollution era: zero chemicals
developments	**Long term** no trend 1982-2001 earlier increase no longer significant. **Short term no trend** 1996-2001 possibly declining but not significant.
current situation	0.53 ± 3.39 g/bird (arithmetic mean mass ± sd; 1996-2001; n=311) (1.9 ± 6.1 "items" per bird; incidence 26%)

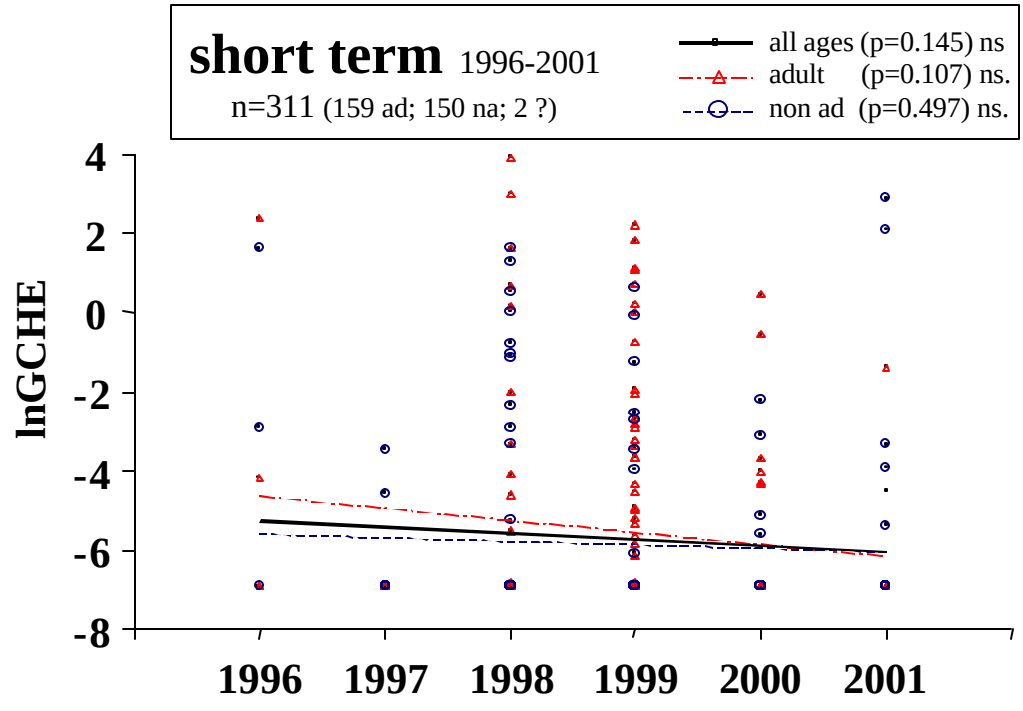
EcoQO North Sea
potential use of chemical indicator and target to be considered by OSPAR

Discussion
Although the current situation seems slightly improved as compared to the late 1990's, no significant trends are present in either long-term or short-term datasets. Nevertheless it is of concern that more than 25% of beachwashed birds since 1996 has suspect substances in the stomach, especially considering the fact that these substances are mostly fairly soft to fluid and probably quickly digested. Although it is often suggested that such substances are relatively harmless at ingestion (paraffine, animal or vegetable oil, ….) some incidents on beaches have shown that toxic substances may be involved. Chemical analyses of substances found in bird stomachs is urgently required to assess their characteristics, and could serve as an important indicator of compliance with MARPOL Annex II procedures. Separate funding for such analyses is required.

Fig. 7

SUSPECTED CHEMICALS





4 Towards a Fulmar-Litter-EcoQO for the North Sea

4.1 The 'Save the North Sea (SNS)' project.

In 2001/2002 a group of organizations from around the North Sea decided to start a project working towards a reduction of marine litter in the North Sea. The project, ambitiously titled 'Save the North Sea (SNS)' was successful in obtaining co-funding from the European Interregional Program for the North Sea (Interreg IIIB). The central aim of the Save the North Sea initiative is to create awareness among target groups in shipping, fishing and offshore industries and among recreational users. By changing human attitudes and behaviour, the SNS campaign will contribute to a reduced input of marine litter in the North Sea. A range of activities falls under the SNS project such as publicity campaigns; education via eco-school projects and courses for target groups; the 'individual blue flag' campaign for leisure boat owners that pledge not to pollute; a fisheries material recycling system; and widening of the currently Dutch 'Fishing for Litter' project by fishing vessels from Den Helder and Texel. These activities are accompanied by market research studies to make the SNS campaign more efficient and measure its effects. An essential part of the SNS project is also a study on litter in stomachs of Northern Fulmars because such is not only a monitoring tool, but also a symbol easily connected to by the general public. The Fulmar is a convincing example to show that effects of marine litter are not just a problem to humans (esthetical, economical, safety or health-risk), but seriously affect marine wildlife and ecosystems. The Fulmar will act as the symbol for the Save the North Sea campaign.

Fig. 8 Graphic symbol of the Save the North Sea campaign against marine litter.

Partners in the SNS project are

- Keep Sweden Tidy Foundation, Sweden (Lead Partner)
- ALTERRA, Texel – Marine and Coastal Zone Research, The Netherlands
- Foundation for Environmental Education (FEE), Norway
- Keep Scotland Beautiful Foundation, UK
- KIMO International, Local Authorities International Environmental Organisation
- Skagen Uddannelsescenter, Denmark
- Swedish Environmental Protection Agency, Sweden.

Many other organisations are linked to the SNS project through these official partners.
Co-funding from the EU Interreg IIIB program has been obtained for the period May 2002 to December 2004.

4.2 The SNS Fulmar study

Alterra participates in the SNS-project as a member of the Steering Group (J.A. van Franeker) and by coordinating a North Sea wide study of litter in stomach contents of Fulmars. From just the SNS viewpoint, widening the study of Fulmars to all North Sea countries serves the purpose of enhancing the symbol function of the Fulmar. 'Local' research brings the issue more prominent to each national doorstep than a single distant study in the Netherlands. Therefore, local groups are promoted to publicize their findings nationally as widely as possible to attract attention for the marine litter initiative in the SNS campaign.
At the same time, the SNS-Fulmar study creates a unique opportunity to facilitate the process of implementation of the Fulmar-Litter-EcoQO for the North Sea (see introduction). As indicated by ICES and OSPAR, EcoQO-implementation requires knowledge on a range of locations around the North Sea. Such is relevant to the efficiency of a future monitoring system in terms of number of sampling locations, measuring methods and target values. Furthermore, an international study will allow better insight into background processes involved in the ingestion of litter by seabirds like the Fulmar.

Since the start of the SNS project, cooperation for the Fulmar study has been obtained for a number of locations around the North Sea

- Shetland Islands (Shetland Beached Bird Survey coordinated by SOTEAG)
- Orkney Islands (Orkney Beached Bird Survey coordinated by RSPB)
- Belgium (Belgian Beached Bird Survey coordinated by Inst. Nature Conservation)
- Netherlands (Dutch Beached Bird Survey, coordinated by the seabird group NZG-NSO)
- Germany (German Beached Bird Survey, coordinated by the Nationalparkamt)
- Denmark (Skagen Uddannelsescenter and Naturhistorisk Museum)
- Faeroer (different institutions involved in Fulmar sampling)

Contacts with further groups in eg central east of UK, Norway and Sweden have been made, but as yet no formal partnerships for the project have been established here.

Most of these partners already attended a training and planning workshop for the SNS Fulmar project, held on Alterra-Texel from 21 to 25 sep 2002. The majority of partners will participate by organizing collection and storage of beachwashed Fulmars in their region and by dissection of the birds according to standard methods and procedures. For this purpose a dissection-manual was prepared (Van Franeker, in prep) which was used during the workshop training sessions. After incorporating

some suggestions for improvements and additions, this report will be published as a SNS Report in early 2003.
After dissection, participants will forward dissection data plus stomachs of the birds to Alterra for the analysis of stomach contents. Categorizing and sorting of stomach contents as described in Van Franeker & Meijboom (2002) is a rather 'specialist' task. In this phase of the project concentration of the stomach-work on one location gives the best guarantee for standard methods and comparability of results. In a later phase a manual will be produced on details of methods for stomach content analysis.
Results from stomach analyses will be returned to national participants for local and/or national reports, whereas the overall dataset will be managed on Alterra Texel to be used for overall analyses and interpretations for SNS reports. As much as possible, the activities in the SNS Fulmar project will be made in a format that may assist in the North Sea EcoQO implementation via ICES and OSPAR. The final report to the EU-Interreg IIIB program needs to be submitted by Dec. 2004, which date seems to match implementation of the EcoQO in 2005.

Study elements covered in the SNS-Fulmar project and of relevance to EcoQO implementation will be:

1. **Regional aspects of abundance of litter in Fulmar stomachs.** Assumed behavioural aspects and long flying ranges of Fulmars have led to to the expectation that regional variability would be relatively low within the North Sea. However, a first small SNS sample of 7 Fulmars from the Shetlands collected in 2002 was noticeably different from Dutch Fulmars: in the Shetland birds incidence of plastics was 57%; number of items 9.7 per bird; mass 0.09g per bird (cf 1996-2001 average for the Netherlands 97% incidence; 29.8 particles per bird; 0.54g per bird). The Shetland sample is much too small for conclusions, but regional variability in the North Sea may be stronger than expected. The aim of the SNS Fulmar study is to sample about 40 birds per region per year. In several locations this is probably not possible but an overall sample of about 40 birds per region may be expected. Combined, the results in late 2004 should allow at least a proper 'one-off' evaluation of regional variability as a basis for EcoQO monitoring. As an expected "outlier" in the sense of North Sea pollution levels, cooperation from the Faeroer has been welcomed to supply a 'reference-value' that may be compared to the North Sea data.
2. **In depth study: variables influencing abundance of litter in Fulmar stomachs.** From the Van Franeker & Meijboom (2002) pilot study only age was found to influence litter quantities in stomach contents. However, the Dutch sample of course is rather one-sided. Therefore, at the end of the SNS project a full analysis involving all variables such as age, sex, deathcause, condition, origin will be performed on the full dataset to further reduce risks of bias in the EcoQO monitoring system. Based on findings, variables to account for in interpreation (now only age), choice for units of measurements (now mainly litter mass) and statistical procedures (now linear regression of ln-transformed individual values) may have to be adapted for optimal performance in a North Sea EcoQO system.
3. **In depth study - backgrounds of age influence.** Since we already know, but do not quite understand why non-adult Fulmars have more plastic in the

stomach than adult ones, the SNS-Fulmar project will attempt to gain further insight by collecting stomachs from recently fledged chicks in eg Scottish Islands and Faeroer in addition to the older birds collected in those regions. This may shed light on the quantitative role of chick-feeding in different residual plastic quantities in different age groups.

4. **In depth study - digestion rates.** Although not essential for monitoring purposes, it would be desirable to gain insight in residence times of different types of plastics in stomachs of Fulmars. Such will not only enhance understanding patterns of regional variability, but will also give a better idea of quantity and availibility of litter at sea and the 'clearance rate' of marine pollution by ingestion by birds. Without experimental setup, this type of work is very difficult. At the moment it is attempted to have rehabilitation centers to supply birds that have been in rehabilitation for some time, but ultimately died. By comparing the number of days spent in the rehabilitation center (where no plastic ingestion occurs) to the amount of litter of different categories in the stomach, digestion rates could be quantified. The main problem is whether we will be able to obtain a proper sample size for the analyses, and this can not be predicted at the moment.
5. **In depth study - suspected chemicals.** In current project fundings, there is no money for expensive chemical analyses of suspect substances found in the stomachs of Fulmars. We need to attempt to find funding for at least a survey type of study of the range of substances involved. Not only could the ingested substances be an important mortality factor for Fulmars (and other organisms), but awareness of substances involved would be of major importance to evaluate this indicator on its value for monitoring (effects of) marine pollution by tanker washings (related to MARPOL Annex II). Efforts will be undertaken to obtain funding for chemical analyses and support for this initiative from ICES/OSPAR would be helpful. Chemical analyses of substances from stomachs of Fulmars is closely interlinked with intended studies in the Guillemot-Oil-EcoQO into the origin of fouling agents in plumages.
6. **EcoQO-Manuals** - as indicated above, a draft manual for dissection procedures has already been prepared for the SNS Fulmar study and is circulating for comments by participants before formal publication. A second manual on stomach content analyses will be produced in a later phase. Both manuals will be based on broad-based and detailed datacollection as in the pilot study. Methods can only be narrowed down after an EcoQO system has been agreed on, and this will only be possible towards the end of the SNS project.

4.3 Conclusions for the Fulmar-Litter-EcoQO implementation by ICES and OSPAR.

The Save the North Sea Fulmar study, in combination with the long-term work in the Netherlands, will supply much, if not all of the information required for an efficient and scientifically sound implementation of a Fulmar-Litter-EcoQO system in the North Sea region in 2005. The methodological set-up of both current projects is such that changes in ideas on types of metrics or target-values remain possible.

All results from the Dutch and EU-Interreg SNS study will be communicated to international bodies via the Dutch government representatives involved in EcoQO implementation. A number of issues to be considered by ICES/OSPAR has already been formulated in the pilot study, e.g. on metrics (mass of litter as unit of measurement rather than number of items), choice of indicators and complexity of targets. Until further data come available from the SNS project there seems no need to work these out in more detail. Relevant information to make decisions on the setup of the Fulmar-Litter-EcoQO will gradually become available and will only be complete in 2004. If desired, reports will include detailed proposals on metrics and target values for the EcoQO.
ICES and OSPAR are invited to comment on or make requests to Alterra in relation to the Dutch and the SNS studies. As far as possible, within practical and financial frameworks of these projects, study topics or methods of analysis or reporting can be adapted to supply maximum service.

During the final stage of writing this report, the EcoQO workplan became available. Many of the issues mentioned in Annex 3.I of this workplan (Ecological Quality Element: plastic particles in stomachs of seabirds) have been dealt with in the earlier pilot study (van Franeker & Meijboom 2002) and this progress report. However, as specific points may not always be easy to trace in relation to the listed items of Annex 3.I, the text of the Fulmar workplan has been copied in an appendix to this report with short annotations summarizing relevant information.

4.4 Concurrence of the Fulmar-Litter-EcoQO and the Guillemot-Oil-EcoQO.

The North Sea Ministers, in their Bergen Declaration March 2003, have decided to immediately implement some selected EcoQO's as pilot projects. Among these is the EcoQO on marine oil pollution in the North Sea, using the oil rate of corpses of beachwashed Guillemots *Uria aalge* (oil-rate = the proportion of beachwashed birds of which the plumage is fouled by oil). Usage of oil rate, after being proposed in Camphuysen & Van Franeker (1992) has been widely accepted as a policy instrument and is used by many Beached Bird Survey ('BBS') programs around the North Sea and elsewhere. Policy usage of oil-pollution data collected by beached bird surveys has cross-fertilized the system of Beached Bird Surveys and has been a stimulus for their continuation. The implementation of a formal Guillemot-oil-EcoQO for the North Sea will definitely further boost BBS programs.

Since its start in 1982, the Dutch study on stomach contents of Fulmars has been possible thanks to the existence of the Beach Bird Survey of the Dutch Seabird group (NZG-NSO). Members of the NZG-NSO have been prepared to collect Fulmars for this specific study.
In the new SNS Fulmar study, collection of birds from many locations at no or low extra cost is largely possible thanks to cooperation from existing Beached Bird Surveys. The planned implementation of the Fulmar-Litter-EcoQO will further increase the awareness among BBS participants that their efforts are worthwile and

will thus generate extra support. For example, the SNS Fulmar study has been able to activate some local groups operating in areas without a currently active beached bird survey system. Since search activities for Fulmar corpses on beaches largely overlap with requirements for the Guillemot-Oil-EcoQO, this increases opportunities for a good North Sea spatial coverage in the collection of Guillemot oiling rates.
Similarly there is overlap in needs for chemical analyses of oil and suspect substances involved in either plumage fouling of Guillemots (OSPAR) or ingestion by Fulmars (this report). Currently, only in the most obvious or excessive cases, pollution by unknown and sometimes seriously toxic substances is noticed by beached bird surveys (Camphuysen et al. 1999; van Franeker 1999). Analyses for the two EcoQO's in this respect can be easily and efficiently combined.

Experience learns that where there is a good system of data-usage and publication of data collected by amateur ornithologists, that a rather inexpensive system of data-collection is possible, supported by volunteers and organisations that incorporate activities in their standard program. Costs for maintenance of a particular monitoring system are then limited to incidental material support, co-ordination, data-maintenance and analysis and reporting.
In case of the Fulmar-Litter-EcoQO it is expected that collection of Fulmar corpses will remain possible at low cost, and that main expenses will originate from professional time needed for dissections, stomach-content sorting, analyses and publication of results. The amount of effort needed here is hard to predict at the moment because it strongly depends on the outcome of the SNS Fulmar study and the design of longer term monitoring in terms of number of locations and detail required in dissections and stomach content analysis. In the Netherlands, the current level of effort of ± 50 birds and relatively high detail in dissections, stomach analysis and reporting represent an expense in the order of 20K€.

As indicated, 'cross-fertilization' is important. The detailed Fulmar studies for litter can give important additional information on trends in oil pollution in the offshore environment based on Fulmar data not only on the proportion of birds fouled, but also on the amount of oil on individual birds (Fig. 9) or the presence of oil remains in stomachs. Vice versa, Guillemot surveys as a part of the BBS systems will supply information of entanglement rates of organisms on beaches as additional litter indicators.
When both the Guillemot-Oil-EcoQO and the Fulmar-Litter-EcoQO become formal international and frequently published monitoring tools used in environmental policies, this will be the best possible guarantee for continued volunteer and organisational support for a relatively inexpensive system of beached bird surveys.

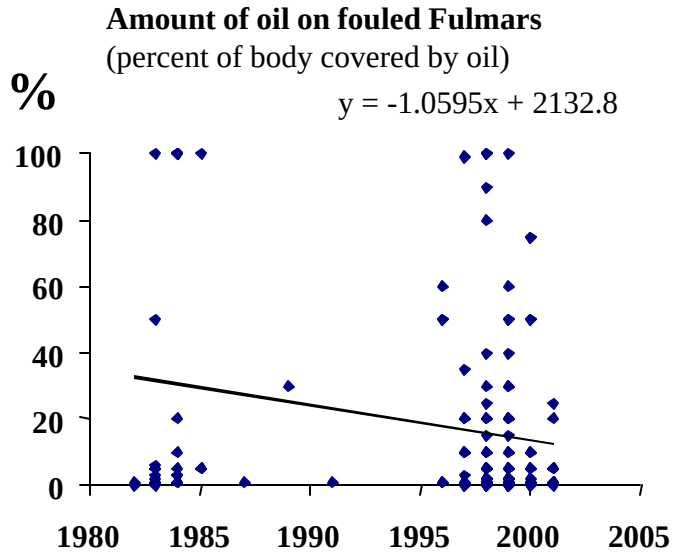


Fig. 9 Changes in amount of oil on the plumage of Fulmars. Not only oil rates (proportions of birds oiled), but also the amounts of oil on those Fulmars that are fouled, have gradually decreased over the past 20 years, confirming reductions in oil pollution also in the areas further offshore.

5 Conclusions and recommendations

- Based on studies of Dutch beachwashed Fulmars it has been concluded that abundance of litter in stomachs of these seabirds is an adequate monitoring tool to track (changes in) the marine litter situation in the Southern North Sea. The choice for the Fulmar as a monitoring species is a practical one, based on abundance of the species, available knowledge and accumulation of litter in the stomach over representative offshore areas and time-periods.

- For the Dutch situation, three formal indicators from Fulmar stomach contents have been proposed: mass of industrial plastics, mass of user plastics, and mass of suspected chemical substances. Each of these represents different sources of pollution demanding different measures for reduction of inputs.

- Mass of accumulated litter is considered the best long-term unit of measurement for indicators. Incidence (proportion of birds with litter present, irrespective of quantity) or number of items are considered to be less sensitive or susceptible to bias from changes in material characteristics.

- In the Netherlands, of all variables potentially distorting trend analysis, only age of birds (adult versus non-adult) was found to have some potential risk if age-composition of samples changes directionally over time. Slightly lower abundances of plastics in stomachs of adult birds are possibly related to chick feeding but need further investigation. Both age-groups showed similar trends, and data could be combined in overall analyses of Dutch material.

- Over the 1982 to 2001 period there was a consistent decrease in industrial plastics in Dutch Fulmar stomachs. User plastics sharply increased when looking at the long term data, but appear to decrease recently. The overall conclusion from the various Fulmar indicators is that the marine litter situation in the southern North Sea in the 1996-2001 period is still considerably worse than during the early and mid 1980's. But there appears to be a tendency of recent improvement after peak litter abundance in the years 1997-99. Research in the years to come has to show whether this recent trend is consistent.

- Suspect chemical substances are a prominent phenomenon in stomachs of Dutch Fulmars, and formal indicator usage is proposed for consideration also in the North Sea EcoQO. Urgently needed is funding for chemical analysis of substances (closely linked to similar analyses envisaged in the Guillemot-Oil-EcoQO).

- The current Fulmar-Litter-EcoQO for the North Sea is defined for unspecified plastics in terms of a combination of incidence and numerical abundance (OSPAR has tentatively defined an EcoQO-target as "less than 2% of Fulmars having more than 10 plastic items"). Redefinition of the EcoQO into terms of

mass, maybe for separate plastic categories (industrial and user plastics) is one of the issues to be considered by ICES and OSPAR before implementation of the EcoQO.

- Implementation of a Fulmar-Litter-EcoQO for the whole North Sea region requires investigations into aspects of regional variability. Alterra acts as the co-ordinator of an international Fulmar study as part of in the 'Save the North Sea' marine litter campaign (cofunded by EU Interreg IIIB; period 2002 to 2004).The setup of this North Sea wide Fulmar study largely concurs with information requirements from ICES/OSPAR and will augment understanding of potential variables.

- Output from the SNS project will be a full analysis of variables potentially affecting litter quantities found in stomachs and thus potentially interfering with trend-analyses over time. All variables included in the earlier Dutch pilot study (in which only age was found to be a factor to control for) will be reconsidered with the addition of the variable of regional variation. Further output from the SNS project will relate to background studies into age-related variation and digestion-rates for different types of litter.

- Indicators and units of measurement as currently used in the Dutch monitoring system are not a priori also optimal for a North Sea wide Fulmar-Litter-EcoQO, and will be reconsidered on the basis of all data from the SNS study.

- The combination of a long-term Dutch study (the only long-term dataset for the region) with the international SNS-Fulmar study (covering regional and other aspects) will supply most if not all information required by ICES/OSPAR to prepare and implement the Fulmar-Litter-EcoQO for the North Sea in 2005 and after. Final reporting requirements for the current SNS project in December 2004 match the EcoQO time schedule.

- Requirements for, and benefits from the Fulmar-EcoQO studies closely interact with those of the Guillemot-Oil-EcoQO. Both EcoQo's profit from existing beached bird survey programs (BBS) around the North Sea and at the same time promote the continuation of such BBS as a relatively inexpensive network providing important environmental data and research material.

- Relevant information for final decisions in the design of the Fulmar-Litter-EcoQO will be completed in late 2004, because based on Fulmars collected in a number of locations over the period 2002-2004. If requested, the final report will include recommendations on the set-up of an efficient monitoring network for the Fulmar-Litter-EcoQO in terms of sampling locations, indicators, units of measurements and EcoQO-target(s).

- ICES and OSPAR are invited to make comments or requests to the Dutch and SNS Fulmar studies in order to accommodate information requirements as early and as fully as possible.

References

(extensive list of references given in Van Franeker & Meijboom 2002)

Camphuysen, C.J., & Van Franeker, J.A. 1992. The value of beached bird surveys in monitoring marine oil pollution. Techn. Rapp. Vogelbescherming Nr. 10, 191 pp, Vogelbescherming Nederland, Zeist.

Camphuysen, C.J., Barreveld, H., Dahlmann, G., & Van Franeker, J.A. 1999. Seabirds in the North Sea demobilised and killed by polyisobutylene (C4H8)n (PIB). Marine Pollution Bulletin 38(12): 1171-1176.

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 L 332, 28/12/2000 P.0081).

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.

van Franeker, J.A. 1999. Twee totaal verschillende 'fulmar-wrecks' in de winter van 1998/99. Nieuwsbrief NZG 1: 2-4.

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

Appendix

***Annotations (in italics)* to EcoQO Workplan** (in regular font),

Annex 3I: Ecological Quality Element: (i) Plastic particles in stomachs of seabirds.

1.1 Determine a Baseline/Reference Level

1.1a Propose a list of species (initial list: IMM '97), consider aggregated indicators (index)

(ICES - 2003 Work Programme)

Reasons for selection of the Fulmar out of a potential list of monitoring species have been explained in the pilot study. Fulmars are representative for the wider offshore environment; ingest marine litter regularly; average pollution levels over a foraging space and time span that avoids bias from local pollution incidents; historic data are available in the form of a Dutch dataseries since 1982; and literature is available on other locations and related species worldwide. Other North Sea species that ingest litter either do not accumulate or are coastal only (e.g. Larus gulls), ingest litter only incidentally (eg North Sea alcids) or are too infrequent in beached bird surveys for required sample size or spatial coverage (eg other tubenoses or Kittiwake).

1.1b To be established for each species (ICES - 2003 Work Programme)

The baseline/reference level for marine litter and plastics in particular in the environment or the Fulmar stomach is basically zero, because such litter totally originates from man-made sources and is totally forbidden in waste-dumping regulations.

1.2 Determine an appropriate EcoQO

Formulate appropriate EcoQO(s) intelligible for experts and non-experts

As discussed in pilot study, an EcoQO defined as 'number of plastic particles in stomach' seems not fully adequate as different types of plastic litter, with different sources (and thus different counteractive measures) are included in this definition and may show opposite trends (industrial and user plastics). So, at least at the underlying data-level, and probably better in separate EcoQO's, the specific litter types should be identifiable. Since data on chemical like pollutants become available in the same study procedures, it seems sensible to use such data in the sense of EcoQO as well.

The preliminary formulation of a potential EcoQO target level in a combined definition of incidence and abundance ("less than 2% of birds having 10 or more items in the stomach in a sample of 50 birds") does not really qualify for being very 'intelligible'. For one, it appears better to base the system on mass of litter items, rather than their number. It is proposed to wait with final decisions on how to formulate the EcoQO and target-levels until data from more locations and circumstances become available from the SNS-Fulmar study 2002-2004.

1.3 Determine the information requirements

1.3a Determine the information required to establish whether the EcoQO is being met

1.3b Assess what information is available

1.3c Assess what information can be made available (taking into account practicability and costs)

The reports on Dutch research (Van Franeker & Meijboom 2002; and this progress report) illustrate availability of a long-term dataseries for the Netherlands (1982 onwards) and data that will be collected over the period 2002-2004 to cover regional aspects that may be relevant to the EcoQO. Methods of data collection in both projects are broad-based (in record keeping of dissections and stomach analysis), meaning that in 2004 choices will be possible for specific types of EcoQO requirements, without losing information from former datasets.
Beached Bird Surveys are the basis for future work, and from that level collection of Fulmar corpses is expected to remain practical on the long term at low cost. Costs to be envisaged for professional dissections and stomach analysis plus subsequent data-handling and reporting can only be determined when information requirements for the EcoQO have been determined.

1.4 Collecting and using the information currently available

1.4a Obtain what information is available (ICES - 2003 Work Programme)
see 1.3
1.4b Assess whether each EcoQO is being met (ICES - 2003 Work Programme)
Comparisons of the preliminary EcoQO-target formulated by OSPAR to the current levels of litter inDutch Fulmars have been made in Van Franeker & Meijboom 2002. However, EcoQO metrics and target levels are best reconsidered in later stages of the SNS Fulmar study, when regional aspects can be included in decision making.
Evaluate the performance of the metric
Performance of various approaches (incidence, number of items, mass) has been analysed in Dutch material (Van Franeker & Meijboom 2002) and similar analysis will be repeated in 2004 on the wider dataset coming out of the SNS project.
1.4c Distinguish human impact from natural influences
Not applicable (all litter categories considered 100% human impact)

1.5 Obtaining further information in addition to that already available

1.5a Develop where necessary relevant monitoring and assessment tools (guidelines) for
evaluating the status of and compliance with each EcoQO (ICES - 2003 Work Programme)
1.5b Improve monitoring and data handling
see notes in previous sections

1.6 Measures

1.6a Determine those measures that are in place that will influence each EcoQO
1.6b Assess the reasons for not meeting any EcoQOs
1.6c Review the policies and practices contributing to any failures
1.6d Propose further management measures that could be taken to help meet each EcoQO (ICES- 2003 Work Programme)
Although out of the direct scope of the Fulmar study projects, some comments can be made. Major sources of the marine litter considered are from shipping and thus measures related to shipping are most relevant, i.e. compliance with MARPOL regulations. The recent EU Directive on Port Reception Facilities may be considered to have high potential of influencing the litter EcoQO, depending on effectiveness of its implementation in North Sea ports. See introduction chapter in Van Franeker & Meijboom 2002.

In relation to the suggested indicator use of ingested 'suspected chemicals', MARPOL Annex II and the revision of classification of substances is of major importance.

1.7 Review

1.7a Reconsider the formulation of each EcoQO
Review formulation of EcoQO (“beyond” instead of “above”)

1.7b Determine whether more specific EcoQOs are needed: specification to metrics, time and geographical areas

see notes above