Fulmar Litter EcoQO Monitoring in the North Sea - results to 2006

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See Appendix D

Contents

Photo 1 *(Front page picture)* **Northern Fulmars foraging near the Faroe Islands.**

Photo 2 **Example of stomach contents of a Fulmar beached in the Netherlands in 2006.** To the right many user plastic fragments, including pieces of a bottle cap. To the bottom left several industrial plastic granules. The top left item is not plastic, but an granule of expanded clay as used in horticulture.

Summary
Fulmar Litter EcoQO Monitoring in the North Sea - results to 2006

Operational and cargo related wastes from ships are an important source of litter in the marine environment in the southern North Sea and cause serious economical and ecological damage. Inadequacies in the ship to shore waste delivery procedures are considered a major factor in illegal discharges. The European Union therefore addressed the problem with the Directive on Port Reception Facilities (Directive 2000/59/EC). Obligatory waste delivery to shore and indirect financing of the costs are key-elements of the Directive to stimulate and enforce proper disposal of shipwaste in harbours. Monitoring the effect of the EU Directive is required.
A 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)' (OSPAR-MASH 2007). 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 *Netherlands Ministry of Transport (VenW)* has commissioned IMARES to update the Fulmar-Litter monitoring database for the Netherlands with the year 2006. In addition, the *NYK Group Europe Ltd.* has awarded the Fulmar study with a Corporate and Social Responsibility award. This support has been used to analyse stomach samples from other North Sea countries for years 2005 and 2006 and to continue the international coordination of the project into 2008. Jointly, these efforts represent a continuation of the international fulmar study that was initiated in the European *'Save the North Sea'* project 2002-2004. Benefits from both projects merge in this final report which provides a complete update of the OSPAR North Sea Fulmar-Litter-EcoQO up to the year 2006.

Monitoring in the Netherlands 1979-2006

The year 2006 was characterized by low numbers of beached Fulmars. From the Netherlands, only 27 beached birds with undamaged stomachs could be secured. A sample-size of 40 or more is recommended for reliable annual 'average' data. For multi-year trends, years of lower sample size are not a problem because analyses are based on individual data for each bird, and not on annual averages.
Results 2006: Among the 27 stomachs, 25 contained plastic (93% incidence), with an overall average number of 34 items per bird and average mass of 0.30 gram per bird (Table 1).
Current levels: As standard recommendation, and especially true in years of lower sample size, it is better to describe the current situation as the mean of values over the most recent 5 years. Over the 2002-2006 period in 304 Fulmars, plastic incidence was 95% with an average number of 31 pieces, and average mass of 0.30 gram plastic (Table 2). Thus, the year 2006 was very 'average' for the situation over the past 5 years.
Trends: As convened in earlier reports, the metric for discussion of trends uses the mass of plastics in stomachs, in which the

- *'long-term trends'* refer to the full dataset (now 1979-2006)
- *'recent trends'* are defined as trends over the past 10 years (now: 1997-2006)

Trends are tested for significance by linear regressions of ln-transformed plastic data of individual birds against year.

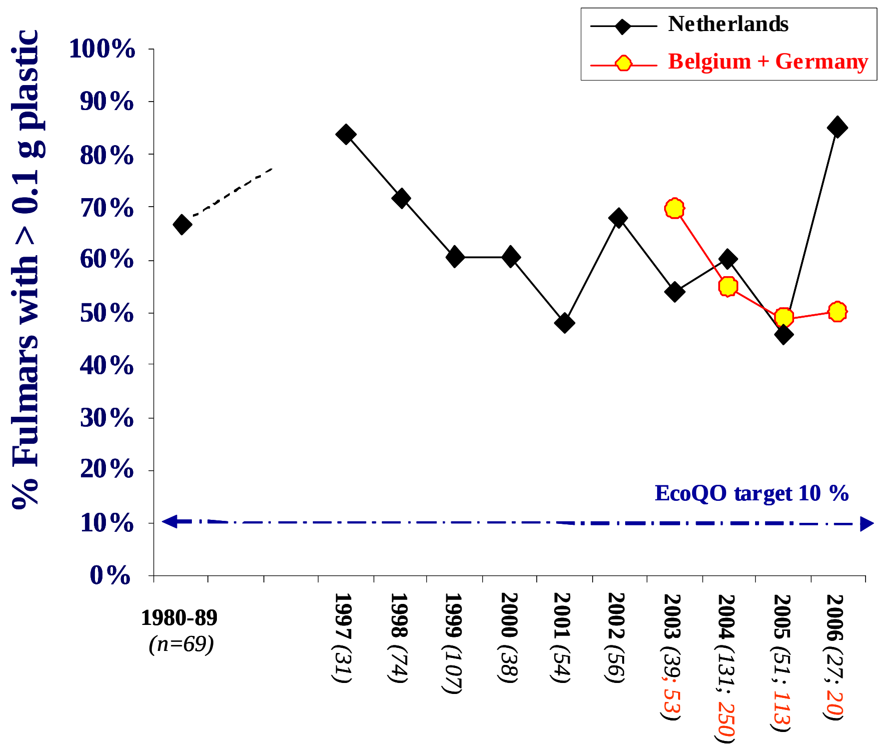

Figure *i* **EcoQO performance Netherlands 1982-2006 –** Annual percentages of beached Fulmars in the Netherlands having more than 0.1 gram plastic in the stomach. Recent data for surrounding countries added.

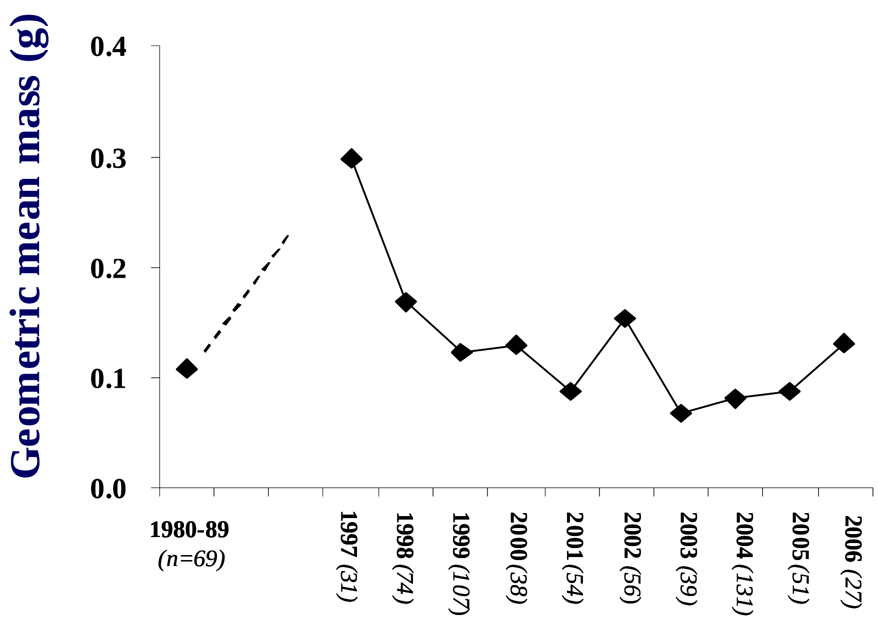

Figure *ii* **Plastic mass Netherlands 1982-2006 –** Annual geometric means for the mass of plastic in the stomach of beached Fulmars in the Netherlands.

Long term trend 1979-2006 For the 'all plastics' category, the long term analysis (Table 3A) shows no significant change for several reasons. Firstly, the overall mass of plastics strongly increased from the 1980s to the 1990s but has subsequently decreased to approximately the initial level. A general impression of that trend is visible in Fig's ***i*** and ***ii.*** Linear analyses do not 'see' the variable components in non-linear trends. But data are also somewhat complicated because different types of plastic have shown different trends. User plastics were responsible for the above described increase and later decrease. Industrial plastics on the other hand have been decreasing consistently since the early 1980s, resulting in a highly significant long-term reduction ($p<0.001$). As a consequence of these mixed trends, the composition of plastic litter has strongly changed since the early 1980s, with nowadays a strongly reduced proportion of industrial plastics (reduced from about 50% to 20% of total mass) and an increased mass of user plastics from discarded waste.

Recent 10 year trend 1997-2006. Regression analyses (Table 3B) show that a strongly significant ($p<0.001$) decrease in total plastic has occurred since the late 1990s. The reduction is largely due to a decrease in user plastic over this period ($p<0.001$). The long term decrease in industrial plastics has slowed down to a rate that gives no significant result over the 10 year period tested here. The decreases over the 1997-2006 period showed the sharpest reductions in the initial years. A significant plastic reduction is still visible if tested over the past 9 years (1998-2006; $p=0.012$), but significance is lost in tests over period 1999-2006. So, although the recent 10-year trend is still significantly downward, the effect is mostly due to initial changes and lacks similar rates of improvement over the second part of the 10 year period.

In the ***Ecological Quality Objective*** for marine litter, OSPAR views these same data in terms of the percentage of birds exceeding a critical value of plastic in the stomach. The target for acceptable ecological quality is 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".

The EcoQO situation for the Netherlands is shown in Fig***. i.*** In 2006, a disappointing proportion of 85% of Fulmars exceeded the critical value of 0.1g plastic in the stomach. The year 2005 had shown a figure of 45%, the lowest annual value on record. Annual figures in the EcoQO metric are sensitive to relatively minor change, especially where sample size is suboptimal and where many values are close to the critical level (see Appendix C). Underlying data do not confirm a strong change as seen in the EcoQO metric. In Fig.*i* this is shown by adding data for directly neighbouring countries Belgium and Germany (see below for further detail). Averaged over the current 5 year period 2002-2006, 61% of Fulmars off the Dutch coast exceeds the critical 0.1 gram plastic in the stomach. Conclusions on significance of trends and changes are not derived from annual EcoQO percentages, but are based on the statistical analyses of plastic mass in individual birds as discussed above. In terms of annual means, those analyses are best visualised by the use of geometric mean mass (Fig. *ii*), because trendanalyses and geometric means are both derived from logaritmic transformation of data (see also Appendix C). As already indicated, the excessive change in EcoQO percentage from 2005 to 2006 is not supported by a similar increase in geometric mean mass, which is much more moderate. Nevertheless, Fig.*ii* plus the test results in Table 3 show that stomach contents of Fulmars in the Netherlands do not yet reveal an immediate effect of implementation of EU Directive 2000/59/EC.

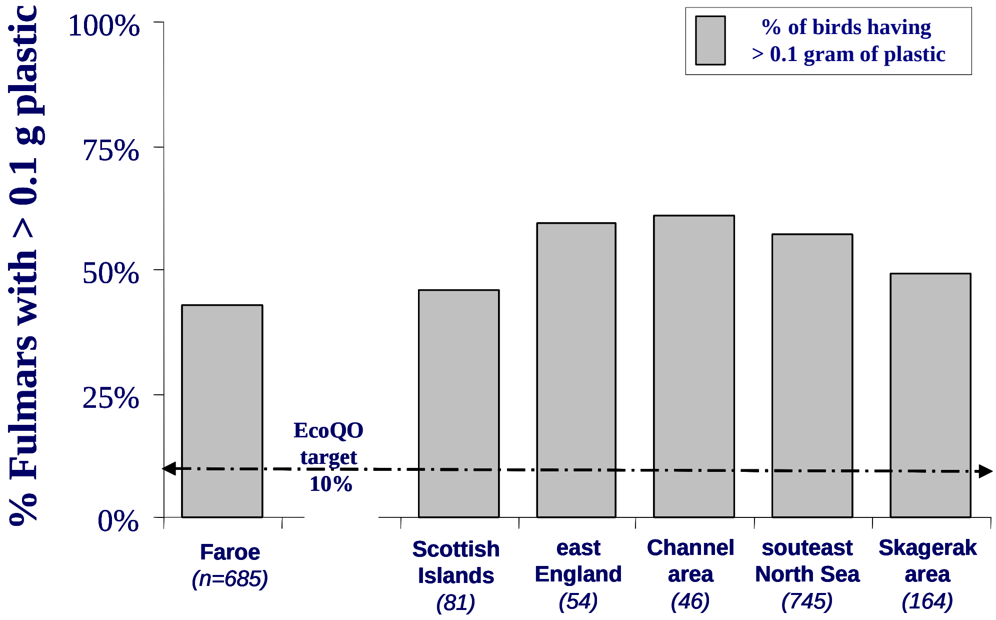

Figure *iii* **North Sea regional EcoQO performance 2002-2006 –** Regional percentages of beached Fulmars having more than 0.1 gram plastic in the stomach.

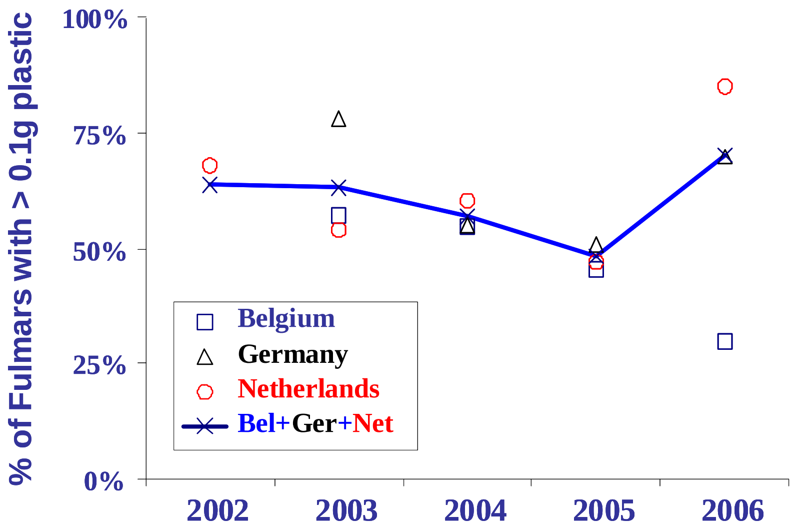

Figure *iv* **EcoQO performance in the southeastern North Sea 2002-2006 –** Annual percentages of beached Fulmars having more than 0.1 gram plastic in the stomach in Belgium, Netherlands, Germany and the combined region (cf Table. 7)

EcoQO monitoring in the North Sea 2002-2006

Over the period 2002-2006, 1090 Fulmar stomachs from the North Sea were analysed, 304 from the Netherlands, 786 from other locations. Preliminary results from a study on the Faroe Islands (685 birds), supported by Chevron Upstream Europe, have been added for comparison.
Details on sample sizes by year and location (Table 4) show that high spatial or temporal resolution is often not yet available. But the data very well describe the baseline of current (5-year) levels of plastic abundance in Fulmar stomachs in different geographical regions of the North Sea. Full details on separate locations are shown in Chpt 5.2 and Appendices A and B.
EcoQO compliance by Fulmars in the North Sea and on the Faroe Islands is shown in Fig. *iii* : in spite of clear regional differences, the percentage of Fulmars with more than 0.1 gram plastic in the stomach ranges from about 45% to over 60% anywhere in the North Sea and even on the Faroe Islands. The Channel area is the most heavily polluted, with plastic incidence 100%, average number of plastic particles 56 pieces, weighing 0.26 gram (geometric mean mass 0.14 g). Moving further to the north, pollution levels are reduced. As discussed in earlier reports this pattern, and relative abundances of subcategories of litter, indicate a major role of shipping and fisheries in marine litter in the North Sea. The Scottish Islands are the 'cleanest' region in the North Sea, with 91% incidence and on average 18 pieces per bird weighing 0.21 gram. The geometric mean mass for plastics in Fulmars from the Scottish Islands is 0.05g, representing only about a third of the level encountered in the Channel, a significant difference (T-test p=0.002). Compared to the Scottish Islands, the situation on the Faroe Islands is only marginally better. In our earlier studies, a small sample of Fulmars from the Faroe Islands suggested substantially lower levels, but at this stage it is very difficult to assess whether data indicate if levels around the Faroes are increasing.
The 2002-2006 study period is too short to properly analyze for trends in separate locations or regions. However, good sample sizes were obtained in Belgium and Germany, which are of specific interest as they permit a closer examination of the somewhat confusing data for the most recent years in the Netherlands. Annual geometric means for Belgium, The Netherlands and Germany, and the combined data for these three locations (region: southeastern North Sea) in Fig.*iv* show a weak general downward trend. In 2006, the German mean went up, like in the Netherlands, but the Belgian mean continued to decrease from 2003 onwards. Linear regressions of the individual data (Table 7) mark all three, and the combined trends over the 2002-2006 period, as negative (decreasing plastic mass). However, only the Belgian decrease was significant (p=0.05). Nevertheless, this wider regional perspective leads to a somewhat more optimistic view on developments in the litter situation than is the case with the isolated analysis of just the Dutch data, and hopefully indicates (slow) improvements following implementation of the EU Directive on harbour reception facilities.

Conclusions

Amounts of plastic in stomach contents of beached Fulmars in the Netherlands in 2006 were very average for the levels observed in the past 5 years 2002-2006 (95% incidence; 31 pieces and 0.30 gram per bird; 61% exceeding the critical EcoQO level of 0.1g of plastic). With small sample size and many birds close to the critical level (see Appendix C), not too much credence should be given to year to year comparisons such as the jump in EcoQO percentage from 45% to 85% between 2005 and 2006. Neither underlying data on mass of plastics, nor comparisons to neighbouring countries supported the suggestion of a sudden strong increase. Fulmar stomachs indicate a significant decrease in marine litter over the past 10 years, but most change occurred in the late 1990s. Recent data indicate at best weak and mostly insignificant further reductions from the southeastern North Sea, and provide no evidence for a direct strong effect of implementation of the EU Directive on Port Reception Facilities. Evidence for gradual improvements will require longer dataseries.

Between locations and regions in the North Sea, significant differences in pollution levels are observed, with levels in the Channel area about three times higher than those around the Scottish Islands and intermediate levels in between. Averaged for the whole North Sea, 94% of investigated birds contained plastic, on average 34 pieces and 0.30 gram mass and 55% of all birds exceeded the critical EcoQO level of 0.1 gram of plastic in the stomach.

Anywhere in the North Sea over 90% of Fulmars have plastic in the stomach, and 45% to 60% exceed the critical EcoQO level of 0.1 gram of plastic. Such high figures may cast doubt on the achievability of a policy target aiming to have less than 10% of birds exceeding the critical level. In considering this issue, it has to be kept in mind that currently a large proportion of birds fluctuates closely around the critical level (Appendix C). Relatively minor but consistent improvements can then quickly lead to a rapid progress towards the EcoQO target. Also, our focus on the North Sea and nearby areas may leave the impression that no matter where, Fulmar stomachs are always loaded with plastics. To escape from this geographically limited view, a valuable study was published on plastic ingestion by Fulmars in the Canadian Arctic (Mallory et al. 2006). Only about one third of Fulmars in the Canadian Arctic were found to have plastic in the stomachs and the average number of items and mass are an order of magnitude below what is currently common in the North Sea (Fig.v). Faroe Fulmars have an intermediate position. This wider view demonstrates a real potential for improvement when working towards ecological quality in the North Sea.

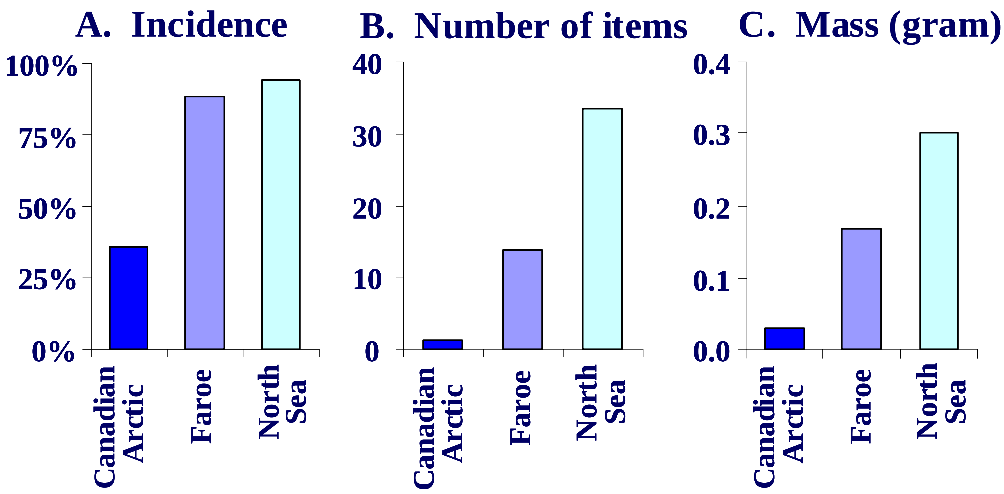

Figure v **Large scale variation in plastic abundance in stomachs of Fulmars in the North Atlantic.** Incidence (proportion of birds with plastic in stomach), average number of plastic particles per bird and average mass (arithmetic) of plastic per bird for the Canadian Arctic in 2002 (data Mallory et al. 2006), and for Faroe and North Sea over period 2002-2006 (this report) (cf Table. 5)

Samenvatting

Stormvogel Zwerfvuil EcoQO monitoring in de Noordzee – resultaten tot 2006

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. Tekortkomingen in afgifteprocedures in havens worden gezien als een belangrijk achtergrond voor het illegaal overboord zetten van scheepsafval. De EU heeft dit probleem aangepakt met de 'Richtlijn betreffende havenontvangstvoorzieningen' (Richtlijn 2000/59/EC; de zogenaamde 'HOI-Richtlijn'). Verplichte afgifte van afval en indirecte financiering van de kosten vormen de kern van de maatregelen waarmee de Richtlijn correcte afvalafgifte wil stimuleren en afdwingen. Het monitoren van de effecten van de HOI-Richtlijn is noodzakelijk.
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. Dit graadmeter instrument wordt ook internationaal verder ontwikkeld als een 'Ecological Quality Objective (EcoQO)' door OSPAR (OSPAR-MASH 2007). De Noordse 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.

Het *Ministerie van VenW* heeft Wageningen IMARES opdracht gegeven de Nederlandse graadmeter aan te vullen met gegevens van het jaar 2006. Daarnaast heeft de *NYK Group Europe* Ltd. het stormvogelonderzoek een bedrijfsmaatschappelijke prijs toegekend. Deze extra steun is gebruikt om in 2005 en 2006 verzamelde magen van stormvogels elders uit het Noordzeegebied te analyseren, en om de internationale coördinatie van het project tot in 2008 voort te zetten. Tezamen resulteren deze inspanningen in een voortzetting van het internationale stormvogelonderzoek dat was begonnen in het Europese *'Save the North Sea'* project 2002-2004. De resultaten van beide projecten smelten samen in dit rapport dat voorziet in een volledige bijwerking van OSPAR's Noordzee Stormvogel-Zwerfvuil-EcoQO tot en met het jaar 2006.

Nederlands graadmeter onderzoek 1979-2006

In 2006 spoelden relatief weinig stormvogels aan. Van de Nederlandse kust konden 27 vogels met onbeschadigde magen worden verzameld. Voor een betrouwbaar jaargemiddelde voor een bepaalde locatie wordt een bemonsterd aantal van 40 of meer vogels aanbevolen. Voor het analyseren van meerjarige trends vormt een jaar met een beperkt aantal monsters geen probleem omdat de berekeningen gebaseerd worden op inviduele gegevens van iedere vogel, en niet op jaargemiddeldes.
Resultaten 2006: Van de 27 magen bevatten er 25 (93%) plastic met een gemiddeld aantal van 34 stukjes en gemiddeld gewicht van 0.30 gram per vogel (Tabel 1).
Huidige situatie: De standaard aanbeveling, die zeker belangrijk is in een jaar met een beperkt aantal monsters, is om de huidige situatie te beschrijven als de gemiddelde situatie over de vijf meest recente jaren. Gemeten over de 2002-2006 periode had 95% van de 304 onderzochte stormvogels plastic in de maag. Het gemiddelde aantal stukjes was 31 per vogel en het gemiddeld gewicht 0.30 gram per vogel (Tabel 2). Het jaar 2006 gaf dus een uitgesproken 'gemiddeld' beeld voor de afgelopen vijf jaar.

Trends: Op basis van eerdere rapporten worden trendmatige ontwikkelingen geanalyseerd op basis van het plastic gewicht in de magen, waarbij

- *'lange termijn trends'* verwijzen naar de complete periode 1979-2006
- *'recente trends'* zijn gedefinieerd als de trends over the voorgaande 10 jaar (1997-2006)

Trends worden getest op statistische significantie door lineaire regressie analyses van ln-getransformeerde plastic gewichten in individuele vogels tegen jaar van verzamelen.

Figuren i en ii

Figuur i *(blz. 6) EcoQO waardes Nederland 1982-2006. – Jaarlijkse percentages van in Nederland aangespoelde stormvogels met meer dan 0.1 gram plastic in de maag. Recente gegevens van omliggende landen zijn ter vergelijking toegevoegd.*

Figuur ii *(blz. 6) Plastic gewicht Nederland 1982-2006 - Jaarlijkse geometrische gemiddeldes for het gewicht aan plastic in magen van in Nederland aangespoelde Noordse Stormvogels.*

Lange termijn trend 1979-2006 Voor alle plastic soorten tezamen ('all plastics' in Tabel 3A) is over de volledige studieperiode geen significante trend waarneembaar. De eerste reden daarvoor is dat plasticgewicht tussen jaren '80 en '90 sterk toenam, maar daarna weer is teruggezakt naar ongeveer het beginniveau. Een algemene indruk van die ontwikkeling is te zien in figuren i en ii. Lineaire regressies "zien" de schommelingen in niet rechtlijnige verbanden niet. Maar daarnaast worden lange-termijn trends enigzins verdoezeld omdat verschillende vormen van plastic een afwijkende ontwikkeling hebben doorgemaakt. Gebruiks plastics zijn verantwoordelijk voor de hierboven omschreven toename en afname. Maar industrieel plastic heeft over de volle periode een significante afname vertoond ($p<0.001$). Ten gevolge van deze afwijkende trends is de samenstelling van het plastic in de stormvogelmagen sterk veranderd van een aanvankelijk gelijk gewicht aan industrieel en gebruiksplastic naar een situatie waarin ca 80% van het plastic tot het van afval afkomstige gebruikers type behoort.

Recente 10 jaar trend 1997-2006. Regressie analyses in Tabel 3B laten zien dat sinds het eind van de jaren '90 een sterk significante ($p<0.001$) afname zichtbaar is voor alle plastics samen, die in belangrijke mate te danken is aan de afname van gebruiksplastic. De langdurige afname van industrieel plastic is niet meer zo sterk als voorheen, en is niet meer significant als alleen naar de afgelopen tien jaar wordt gekeken. De sterkste afnames in de 1997-2006 periode zijn zichtbaar in de begin jaren. Getest over de afgelopen 9 jaar is de plastic afname nog steeds significant (1998-2006; $p=0.012$), maar is dat niet meer in tests over de periode 1999-2006. Dus hoewel de trend over de recente 10 jaar significant omlaag is, is deze vooral bepaald in de eerdere jaren en ontbreken vergelijkbare verbeteringen in de latere jaren..

In de ***Ecological Quality Objective*** voor zwerfvuil op zee bekijkt OSPAR deze zelfde gegevens als een percentage van de vogels waarbij de maaginhoud een grensgewicht aan plastic uitkomt. OSPAR definieert de 'doelwaarde voor aanvaardbare ecologische kwaliteit' als de situatie waarin The target for acceptable ecological quality is formulated as:

> *"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 regios over een periode van tenminste 5 jaar"*

De EcoQO ontwikkelingen in Nederland zijn getoond in Fig***. i***. In 2006 overschreed een teleurstellende 85% van de onderzochte stormvogels de kritische grens van 0.1g plastic in de maag. In 1985 was juist de laagst bekende jaarwaarde gehaald van slechts 45% van de vogels boven de grenswaarde. Jaargemiddeldes voor de EcoQO zijn gevoelig voor kleine veranderingen, vooral wanneer de monstergroote beperkt is, omdat zeer veel vogels een maaginhoud hebben die dicht tegen de grenswaarde van 0.1 gram aan ligt (zie Appendix C). De onderliggende gegevens ondersteunen de sterke EcoQO verandering niet. In Fig.*i* wordt dit getoond door de gegevens van buurlanden België en Duitsland (zie onder voor verdere uitwerking) Het 5-jaar gemiddelde voor de periode 2002-2006 is dat 61% van de Stormvogels van de Nederlandse kust uitkomt boven de grenswaarde van 0.1 gram plastic in de maag. Conclusies over al dan niet betekenisvolle trends worden *niet* afgeleid van jaarlijkse EcoQO percentages, maar alleen uit de statistischel analyses van het gewicht aan plastic in individuele vogels (Tabel 3). In de zin van 'jaargemiddeldes' worden die testresultaten het best weergegeven door het geometrische gemiddeld gewicht aan plastic (Fig. *ii*), omdat trendanalyses en geometrische gemiddeldes beide gebruik maken van logaritmisch getransformeerde gegevens (zie ook Appendix C). De uitzonderlijke stijging in EcoQO percentage van 2005 naar 2006 wordt dan ook niet ondersteund door een vergelijkbare toename van het geometrisch gemiddeld plastic gewicht. Desalniettemin laten de figuren en testresultaten in Tabel 3 zien dat de maaginhouden van stormvogels nog geen aanwijzing geven van een direct merkbaar resulaat van de invoering van de HOI Richtlijn 2000/59/EC.

EcoQO monitoring in de Noorzee 2002-2006

In de periode 2002-2006, zijn 1090 stormvogelmagen uit het Noordzee gebied geanalyseerd, waarvan 304 uit Nederland en 786 van andere locaties. Voorlopige resultaten van een door Chevron Upstream Europe gefinancierd onderzoek op de Faroe Eilanden (685 vogels) zijn ter vergelijking bij de resultaat vergelijking betrokken.
Het tot dusverre per jaar en locatie aantal beschikbare vogels (Tabel 4) laat zien dat in deze fase van het onderzoek nog geen echt gedetailleerde analyses van trends door de tijd of verschillen per locatie mogelijk zijn. Maar de gegevens vormen wel een uitstekende beschrijving van de huidige (5-jaars) situatie over het voorkomen van plastic in magen van stormvogels in de verschillende Noordzee regios. Detailgegevens van de verschillende locaties zijn te vinden in hoofdstuk 5.2 en de Appendices A and B.

Figuren iii en iv

Figuur iii *(blz. 8) Noordzee regionale EcoQO waardes 2-2006 – Regionaal gemiddelde percentages van aangespoelde stormvogels met meer dan 0.1 gram plastic in de maag.*
Figuur iv *(blz. 8) EcoQO waardes in de zuioostlijke Noordzee 2002-2006 - Jaarlijkse percentages van aangespoelde Noordse Stormvogels met meer dan 0.1 gram plastic in de maag in België, Nederland, Duitsland en de gecombineerde regio (zie ook Tabel 7).*

De EcoQO situatie van de Noordse Stormvogels in de Noordzee en op de Faroe eilands is weergegeven in Fig. *iii*: ondanks duidelijke regionale verschillen varieert het percentage stormvogels met meer dan 0.1 gram plastic in de maag overal in de Noordzee, en zelfs op de Faroe eilanden tussen ca 45% en 60%. In het Engels Kanaal is de vervuiling het ernstigst: 100% van de onderzochte vogels had plastic in de maag (gemiddeld per vogel 56 stukjes en 0.26 g; geometrisch gemiddelde 0.14 g). Verder naar het noorden ligt de vervuilingsgraad lager. Zoals in eerdere rapportages is besproken weerspiegelt dit patroon, en de verhouding tussen diverse subcategoriën zwerfvuil, een belangrijke rol van scheepvaart en visserij bij zwerfvuil in het Noordzeegebied. De Schotse eilandend zijn relatief de schoonste Noordzee regio, met 91% besmette vogels en een gemiddelde van 18 stukjes per vogel met een gewicht van 0.21 gram. Het geometrisch gemiddelde plastic gewicht (zie Appendix C) is op de Schotse eilanden 0.05 gram, ongeveer éénderde van dat in het Kanaal en daarvan significant verschillend (T-test p=0.002). Vergeleken met de Schotse Eilanden is de situatie op de Faroe eilanden niet eens veel beter. In ons eerder onderzoek suggereerde een klein monster dat stormvogels van de Faroe

substantieel lagere hoeveelheden plastic in de maag hadden. Op dit moment kan nog niet worden vastgesteld of deze gegevens duiden op een toename van vervuiling rond de Faroe eilanden.
De 2002-2006 onderzoeksperiode is nog te kort om trends voor de afzonderlijke locaties of regios goed te kunnen analyseren. Maar, in zowel België als Duitsland konden goede aantallen monsters worden verzameld, die juist interessant zijn om de enigszins onduidelijke gegevens van de meest recente jaren in Nederland nader te bekijken. Jaarlijkse geometrische gemiddelde plasticgewichten voor België, Nederland en Duitsland, en de gecombineerde gegevens voor deze drie locaties (regio: zuidoostelijke Noordzee) in Fig. *iv* tonen een zwak afnemende trend. In 2006 gingen zowel het Duitse als Nederlandse gemiddelde omhoog, maar het Belgisch gemiddelde zette de daling vanaf 2003 voort. Lineaire regressies van de individuele gegevens (Tabel 7) bereken voor alle drie locaties en de regio een negatieve (afnemende) trend, doch alleen de Belgische afname is statistisch significant ($p=0.05$). Dit bredere regionale perspectief leidt toch tot een wat optimistischer kijk op de ontwikkelingen in de zwerfvuilsituatie dan de alleen op Nederland gebaseerde analyse, en wijst hopelijk op langzame verbeteringen na de invoeren van de EU Richtlijn voor Havenontvangstvoorzieningen.

Conclusies

De hoeveelheden plastic in magen van Noordse Stormvogels in Nederland in het jaar 2006 weerspiegelden een gemiddelde van de situatie in de afgelopen vijf jaar 2002-2006 (95% frequentie; 31 stukjes en 0.30 gram per vogel; 61% van de dieren boven de kritische EcoQO grens van 0.1 gram plastic). Bij een betrekkelijk klein aantal bemonsterde vogels en vele dieren dicht rond de kritische EcoQO waarde (Appendix C), moet niet al te veel waarde worden gehecht aan vergelijkingen van jaargemiddeldes zoals de sprong in EcoQO waarde van 45% naar 85% tussen 2005 e 2006. Onderliggende gegevens van het plasticgewicht en vergelijkingen met buurlanden wijzen niet op een plotselinge sterke toename. De maaginhouden van stormvogels wijzen op een significante afname in plastic zwerfvuil in de afgelopen tien jaar, maar wel is het zo dat die afname vooral eind jaren 90 is opgetreden. Recente gegevens laten op zijn best een zwakke, veelal niet significante verdere afname zien in de zuidoostelijke Noordzee, en demonstreren nog geen direct duidelijk effect van de invoering van de EU Richtlijn voor Havenontvangstvoorzieningen. Meer geleidelijke veranderingen kunnen alleen langere series gegevens worden aangetoond.

Significante verschillen in vervuilingsniveaus zijn waarneembaar tussen locaties en regios, waarbij het niveau in het Kanaal gebied ongeveer drie maal zo hoog ligt als dat rond de Schotse eilanden, en daartussen intermediaire waardes worden geregistreerd. Gemiddeld over het hele Noordzeegebid had 94% van de onderzochte vogels plastic in de maag, met gemiddeld 34 stukjes per vogel en een gewicht van 0.30 gram. In totaal bevatte 55% van de onderzochte vogelmagen meer dan 0.1 gram plastic.

Waar dan ook in de Noordzee heeft meer dan 90% van de stormvogels plastic in de maag, en 45% tot 60% overschrijdt daarbij de kritische EcoQO waarde van 0.1 gram plastic. Dergelijke hoge waardes kunnen twijfel doen rijzen over de haalbaarheid van een politieke EcoQO doelstelling waarbij minder dan 10% van de vogels het kritische niveau zou mogen overschrijden. In de gedachtvorming daarover moet worden meegenomen dat in de huidige situatie zeer veel vogels een maaginhoud hebben die dicht rond de kritieke waarde hangt (zie Appendix C). Verhoudingsgewijs geringe maar aanhoudende verbetering kunnen in die situatie snelle verbeteringen opleveren t.a.v. het EcoQO doel. Daarnaast zou onze op de Noordzee gerichte blik kunnen leiden tot het beeld dat, ongeacht waar op de wereld, stormvogelmagen 'vol' zouden zitten met plastic. Recent onderzoek in Arctisch Canada (Mallory et al. 2006) helpt ons ontsnappen uit dit geografisch beperkte blikveld. In Arctisch Canada werd slechts in één op de drie Stormvogelmagen plastic gevonden, en het gemiddeld aantal stukjes en gemiddeld gewicht ligt een orde van grootte beneden het in de Noordzee gebruikelijke niveau. (Fig.v). Stormvogels van de Faroe Eilanden bezetten een intermediare positie. Deze bredere kijk op de zaken bewijst dat er zeker ruimte is voor verbetering wanneer inspanning wordt geleverd voor de ecologische kwaliteit in de Noordzee.

Figuur v

Figuur v *(blz. 10) Grootschalige variatie in hoeveelheden plastic in magen van Noordse Stormvogels in het Noord Atlantisch gebied voor Arctisch Canada (Mallory et al. 2006) en de Faroe eilanden en de Noordzee (dit rapport; zie ook tabel 5).* ***A****. Frequentie (het percentage vogels met plastic in de maag);* ***B.*** *gemiddeld aantal stukjes plastic per vogel; en* ***C.*** *gemiddeld plastic gewicht per vogel.*

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 microscopically small particles, 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 have 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 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 2005, 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 data from 2006, and publish the result in a new report;
- To continue co-ordination of the beached bird sampling in the Netherlands into 2008

The fulmar study additionally received a 'Corporate and Social Responsibility Award from the NYK Group Europe Ltd. This funding made it possible:

- To analyse samples from other North Sea locations collected in the years 2005 and 2006.
- To continue international co-ordination of EcoQO sampling in the North Sea area into 2008, including the organisation of an international workshop. Collected samples from 'foreign' Fulmars to be stored frozen, awaiting future sources of funding).
- To promote expansion of the litter monitoring network to new groups and locations

The efforts from these projects were combined into this report, which not only provides an update to year 2006 for the Dutch Fulmar monitoring project, but also an update of the international North Sea monitoring results over the period 2002-2006. Effectively, this provides a five year monitoring period of the marine litter EcoQO in the North Sea area as requested by North Sea Ministers and OSPAR.

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 (they regurgitate indigestible remains); are coastal only and/or find part of their food on land (e.g. *Larus* gulls); ingest litter only incidentally (e.g. North Sea alcids) or are too infrequent in beached bird surveys for the required sample size or spatial coverage (e.g. other tubenoses or Kittiwake *Rissa tridactyla*).

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

At dissection of birds, their sex, age, origin, condition, likely cause of death and a range of other potentially relevant parameters are determined. Standardized dissection procedures for EcoQO monitoring have been described in detail in a manual (Van Franeker 2004b). Stomach contents are sorted into main categories of plastics (industrial and user-plastics), non-plastic rubbish, pollutants, natural food remains and natural non food-remains. Each of these categories has a number of subcategories of specific items. For each individual bird and litter category, data are recorded on presence or absence ("incidence"), the number of items, and the mass of 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 an 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 fairly poor, and further study is required. With financial support from Chevron Upstream Europe, we have started a cooperative project with the Faroese Fisheries Laboratory using Fulmars from the Faroe Islands, where birds are hunted for consumption and large numbers of samples are easily obtained. Additional samples have been obtained from fisheries by-catch in the area. Stomach contents are analysed for both normal diet and for accumulated litter. Samples have been obtained from all months of the year over the period 2003-2005. Detailed analyses are still to be conducted, but overall averaged data have already been used in this new report.

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

Significant long term trends from 1982 to 2000 were detected in incidence, number of items and mass of industrial plastics, user plastics and suspected chemical pollutants (often paraffine-like substances). Over the 1982-2000 period, only industrial plastics decreased while user plastics significantly increased. When comparing averages in the 1980s to those in the 1990s, industrial plastics 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, rather than incidence or number of items, should be considered the most useful unit of measurement in the long term. It is also the most representative unit in terms of ecological impact on organisms. Incidence looses its sensitivity as an indicator when virtually all birds are positive (as is the case in Fulmars). In regional or time-related analyses, mass of plastics is a more consistent measure than number of items, because the latter appears to vary with changes in plastic characteristics.

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

The pilot study concluded that the formal indicators which would be recommended in future Dutch Fulmar-Litter monitoring were abundances by mass of industrial plastic, user plastic and suspected chemicals. Each of these represents different sources of pollution, and thus specific policy measures aimed 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.

After publication of the pilot study, the Dutch monitoring has continued annually and has resulted in a series of reports (Van Franeker & Meijboom 2003 to 2007). These studies confirmed a continuing decrease of industrial plastics and also gradually provided evidence for significant decreases in user plastics after the late 1990s.

In 2002, the Fulmar Litter monitoring was boosted by participation in the 'Save the North Sea' project. The Save the North Sea ('SNS') campaign, co-funded by EU Interreg IIIB, aimed at increasing awareness among stakeholders so as to reduce littering behaviour. Expanding the Dutch Fulmar study to locations all around the

North Sea was one of the project components. Co-operation was established with interested groups in all countries around the North Sea. In 2005 the final project report (Van Franeker et al 2005) showed that Fulmars from the southern North Sea had almost two times more plastic in the stomach than Fulmars from the Scottish Islands, and almost four times as much as that in a small sample from the Faroe Islands. Location differences and relative abundances of different types of litter suggested a major role of shipping, and show that the bulk of the litter problem in the North Sea region is of local origin.

In 2002, North Sea Ministers in the Bergen Declaration, decided to start a system of Ecological Quality Objectives for the North Sea. One of the EcoQO's to be developed was for the issue of marine litter pollution, using stomach contents of a seabird, the Fulmar, to monitor developments, and set a target for 'acceptable ecological quality'. OSPAR was requested to look after implementation of the ecological quality objectives. Since then, a number of steps have been taken, based on reports from the Dutch studies and the Save the North Sea project. The preliminary wording of the EcoQO on target level for ecological quality is that:

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

So, the basis of the EcoQO monitoring system is mass of plastics as recommended from the Dutch studies. But rather than using average plastic mass for the target definition, a combination is used of frequency of occurrence of plastic masses above a certain critical level. The background of this is that a few exceptional outliers can have a strong influence on the calculated average. The wording of the target level basically excludes influence of exceptional outlying values. A background document on the EcoQO is now being considered for formal implementation by OSPAR (OSPAR-MASH 2007). The EcoQO approach is also considered in discussions on the European Marine Strategy Directive.

Anticipating further development of the EcoQO approach in OSPAR and EU, the international Save the North Sea Fulmar study group was kept active after completion of the 2002-2004 EU-project. However, funding for international activity was only available for maintenance of coordinating activities to ensure collection of stomachs, but not their analysis. Only recently, the additional funding from NYK Europe has made it possible to analyse stomachs from outside the Netherlands collected after 2004. Dutch government funding, plus the support from NYK Europe, has now ensured a North Sea EcoQO update covering data from the period 2002-2006.

3 Shipping, marine litter and policy measures

In historic times all waste products from ships were discarded almost anywhere and at any time. The relatively low intensity of shipping and generally decomposable nature of wastes allowed such practice to continue for centuries without significant problems except inside harbour areas. However, exponential population growth and global industrialization has boosted marine transports by fast mechanically-powered ships with ever increasing quantities of poorly decomposable and toxic wastes from fuel, cargo and household practises. Old habits are hard to change, particularly if such change involves costs in an extremely competitive international industry such as shipping. For example, the dramatic environmental consequences of oil discharges from ships were already known in the early 1900s. More than a century later, under continuous public pressure and a continuous sequence of policy measures, the oil pollution problem is to some extent under control, but definitely not solved.
Compared to the problems from dumping of oil or toxic wastes, the issue of disposal of 'garbage' into the marine environment has long been considered of minor importance. It might still be considered that way if not for plastics. Plastics, although known since the early 1900s, started their real development only after 1960. Since then, they have found their way into almost every application, replacing old materials in existing products, and creating new use in for example an endless array of 'disposable' packaging products.
Unfortunately, the same factors that made plastics such a popular product have resulted in them becoming an environmental problem. Low production costs have promoted careless use and low degradability leads to accumulation in the environment. By 2003, the world production of plastics amounted to about 165 million metric tons, 40% of which is used 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. 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, coastal tourism, influx from rivers or direct dumping of wastes along seashores. The relative importance of various sources differs strongly in different parts of the world, and is almost impossible to quantify. Dutch Coastwatch studies (e.g. Stichting de Noordzee 2003) score litter into categories 'from sea' (shipping, fisheries, offshore); 'beach-tourism'; 'dumped from land'; and 'unknown'. In the Netherlands, the 'from sea' category consistently represents in the order of 40% of litter items recorded. The 'unknown' category scores a similar percentage. Considerable uncertainties are linked to this categorization. More specific information may come from the OSPAR initiative for monitoring litter on beaches in a somewhat more systematic approach. In a first German report (Fleet 2003), ten years of Coastwatch-like surveys, plus two years of the more detailed OSPAR pilot project, were evaluated. From both studies it is concluded that shipping, fisheries and offshore installations are the main sources of litter found on German North Sea beaches. The larger proportion of litter certainly originates from shipping, with a considerable proportion of this originating in the fisheries industry. In the Netherlands, data to this effect were collected in a large beach litter study on Texel (van Franeker 2005) suggesting that up to 90% of plastic litter originates from shipping and fisheries in the Dutch area.
So, although there may be uncertainties in details, there is little doubt that waste disposal by ships is one of the important sources of marine litter worldwide, a fact also recognized by the International Maritime Organization (IMO) in a specific 'garbage-annex' to the MARPOL Convention.

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

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

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

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

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

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

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

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

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

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 Materials and Methods

In 2006 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, beads or granules. They can be considered as “raw” plastic or a half-product in the form of which, plastics are usually first produced (mostly from mineral oil). The raw industrial plastics are then usually transported to manufacturers that melt the granules and mix them with a variety of additives (fillers, stabilizers, colourants, anti-oxidants, softeners, biocides, etc.) that depend on the user product to be made. For the time being, included in this category is a relatively small number of very small, usually transparent spherical granules, also considered to be a raw industrial product.

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

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

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

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

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

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

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

2.1 **paper (pap)** which besides normal paper includes silver paper, 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 **fish hook (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 sub-categories are not used in this litter survey study.

5 **NATURAL NON-FOOD REMAINS (NFO)**

Numbers of subcategories eg 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 laboratory temperatures. For marine litter (categories 1 to 3 above), this is done separately for all subcategories. In the early Fulmar study we also weighed the natural-food and natural-non-food categories as a whole, but this was discontinued in 2006 to reduce costs. Weights are recorded in grams accurate to the 4th decimal (= tenth of milligram).

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.

5 Results and discussion

5.1 Monitoring in the Netherlands 1979-2006 and trends

The year 2006 was characterized by low numbers of beached Fulmars over most of the North Sea area. From the Netherlands, only 28 corpses were collected. Fulmars from the Dutch coast are collected by volunteers in 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 27 Fulmar corpses with complete stomachs for the monitoring program. A sample-size of 40 or more is recommended to reliably characterize the pollution level in a particular time-frame and area (i.e. the annual 'average'). However, for multi-year trends a lower sample size in a particular year is not a problem, as analyses are not based on annual averages but on individual data for each bird. One additional sample for 2005 and a very old Fulmar corpse of 1979 could be added to the database.

In the year 2006, 25 of 27 stomachs (93%) contained plastic, with an overall average number of 34 items and mass of 0.30 gram per bird (Table 1). Non-plastic rubbish was found in about one in five stomachs, most frequently being galley food wastes. Suspected chemicals, i.e. paraffine or palmfat-like substances were encountered in 37% of stomachs with an overall average mass of 0.3 gram per bird. Incidence and numerical and mass abundance of plastics in 2006 were somewhat disappointing with a tendency for increased levels as compared to 2005. However, the 2006 sample size is relatively small and is better viewed in a wider perspective.

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

- 'current situation' is described by the last 5-year average as above;
- ''long-term trends' refer to the full dataset (now 1979-2006)
- recent trends' are defined as trends over the past 10 years; and
- Trends are tested for significance by linear regressions of ln-transformed plastic data of individual birds against year.

The **current situation** (5 year average in bottom line of table 2) fits in with the pattern of reduced plastic loads in Fulmar stomachs after peak levels in the 1990s, with mass of plastic returning to levels similar to those in the early 1980s. Mean values over the most recent 5 years (2002-2006; 304 Fulmars) are that 95% of birds had plastic in the stomach, with an average number of 31 pieces, and average mass of 0.30 gram plastic. Thus, the year 2006 was very 'average' for the situation over the past 5 years, which implies that there is no clear evidence of improvement within this period.

The **long term 1979-2006 trend** analysis for "all plastics" ignores the 1990s peak in pollution levels and sees no significant change (Table 3A), i.e. indicates comparable levels in the 1980s and recent period. However, compared to the 1980s, the composition of plastic litter has strongly changed, with a significantly reduced proportion of industrial plastics and a somewhat increased mass of user plastics from discarded waste (Table 3A).

Statistical tests for **recent trends over the past 10 years (1997-2006)** (Table 3B) show a highly significant reduction in total plastic load ($p<0.001$). However, this is only visible in the category of user plastics (decrease $p<0.001$). Contrary to earlier analyses, industrial plastics no longer contribute and show no significant reduction. The decreases over the 1997-2006 period showed the sharpest reductions in the initial years. A significant plastic reduction still exists if tested over the past 9 years (1998-2006; $p=0.012$), but significance is lost in tests over period 1999-2006. So, although the recent 10-year trend is still significantly downward, the trend observed is due to initial changes and lacks continued recent improvements.

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

Table 1
Summary of sample characteristics and stomach contents of Fulmars collected for Dutch marine litter monitoring in the year 2006. *The top line shows sample composition in terms of age, sex, origin (by colourphase; darker phases are of distant Arctic origin), cause of death 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.*

YEAR	nr of birds	adult	male	LL colour	death oil	avg condition
2006	27	67%	42%	85%	7%	1.5

	Year 2006 (*n*=27)	incidence	average number of items	average mass of litter (g/bird) ± standard deviation	max. mass recorded	geometric mean mass (g/bird)
1	**ALL PLASTICS**	**93%**	**33.9**	**0.305 ± 0.416**	**2.0**	**0.1308**
1.1	**INDUSTRIAL PLASTIC**	**78%**	**3.5**	**0.077 ± 0.074**	**0.2**	**0.0280**
1.2	**USER PLASTIC**	**93%**	**30.4**	**0.228 ± 0.388**	**1.9**	**0.0862**
1.2.1	sheets	59%	2.9	0.005 ± 0.008	0.0	0.0018
1.2.2	threads	41%	2.4	0.010 ± 0.028	0.1	0.0014
1.2.3	foamed	67%	4.0	0.010 ± 0.022	0.1	0.0022
1.2.4	fragments	81%	20.4	0.189 ± 0.370	1.9	0.0494
1.2.5	other plastic	30%	0.7	0.015 ± 0.031	0.1	0.0019
2	**OTHER RUBBISH**	**22%**	**0.6**	**0.018 ± 0.065**	**0.3**	**0.0009**
2.1	paper	7%	0.1	0.000 ± 0.000	0.0	0.0000
2.2	kitchenwaste (food)	15%	0.4	0.004 ± 0.017	0.1	0.0005
2.3	rubbish various	7%	0.1	0.013 ± 0.064	0.3	0.0004
2.4	fishhook	0%	0.0	0.000 ± 0.000	0.0	0.0000
3	**POLLUTANTS**	**37%**	**2.1**	**0.028 ± 0.067**	**0.3**	**0.0028**
3.1	slags	0%	0.0	0.000 ± 0.000	0.0	0.0000
3.2	tar	0%	0.0	0.000 ± 0.000	0.0	0.0000
3.3	suspected chemical	37%	2.1	0.028 ± 0.067	0.3	0.0028
3.4	feather lumps	0%	0.0	0.000 ± 0.000	0.0	0.0000
4	**FOOD NATURAL**	**93%**	**5.5**			
5	**NONFOOD NATURAL**	**85%**	**9.0**			

Table 2
Major litter categories in stomachs of Fulmars from the Netherlands per year.
In each major litter category, incidence (%) represents the proportion of birds with one or more items of that litter-type 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.*

			INDUSTRIAL PLASTICS			USER PLASTICS			ALL PLASTICS (industrial + user)			SUSPECTED CHEMICALS		
YEAR	*n*	% adult	%	n	g	%	n	g	%	n	g	%	n	g
1979	*1*	0%	100%	2.0	0.07	100%	3.0	0.17	100%	5.0	0.24	0%	0.0	0.00
1980														
1981														
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	***51***	**67%**	**53%**	**2.0**	**0.05**	**96%**	**15.8**	**0.22**	**98%**	**17.8**	**0.27**	**31%**	**2.2**	**0.69**
2006	***27***	**59%**	**78%**	**3.5**	**0.08**	**93%**	**30.4**	**0.23**	**93%**	**33.9**	**0.30**	**37%**	**2.1**	**0.03**
02-06 *	***5***	**63%**	**61%**	**3.0**	**0.06**	**94%**	**28.1**	**0.24**	**95%**	**31.1**	**0.30**	**26%**	**2.0**	**0.59**

* Five-year averages in this table were calculated from annual figures above. Data for the 2002-2006 period in Table 4 and appendices may be slighty different, because those data were averaged over all individual birds in the five year period.

Table 3 Details of linear regression analyses of indicators selected in the Dutch Fulmar litter monitoring program.

Analysis of trends was conducted by linear regression, fitting ln-transformed litter mass values for individual birds on the year of collection. Tests were conducted over the full time period 1979-2006 (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 1979-2006
in marine litter indicators, The Netherlands

INDUSTRIAL PLASTIC (lnGIND)	*n*	Constant	estimate	s.e.	t	p	
all ages	*689*	129	-0.0665	0.0146	-4.55	**<.001**	- - -
adults	*394*	84.1	-0.0443	0.0217	-2.04	**0.042**	-
non adults	*287*	118	-0.061	0.0204	-2.99	**0.003**	- -

USER PLASTICS (lnGUSE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*689*	-31.6	0.0145	0.0126	1.15	0.249	
adults	*394*	-19.8	0.0085	0.0192	0.44	0.658	
non adults	*287*	-82.1	0.0399	0.017	2.35	**0.019**	+

ALL PLASTICS COMBINED (lnGPLA)	*n*	Constant	estimate	s.e.	t	p
all ages	*689*	36.3	-0.0192	0.0121	-1.59	0.113
adults	*394*	15.4	-0.0089	0.0189	-0.47	0.639
non adults	*287*	8.9	-0.0053	0.0154	-0.35	0.729

SUSPECTED CHEMICALS (lnGCHE)	*n*	Constant	estimate	s.e.	t	p
all ages	*689*	-32.2	0.0131	0.0152	0.87	0.386
adults	*394*	14.3	-0.0101	0.0227	-0.44	0.657
non adults	*287*	-70	0.0321	0.0217	1.48	0.140

B.

RECENT 10-year TRENDS (1997-2006)
in marine litter indicators, The Netherlands

INDUSTRIAL PLASTIC (lnGIND)	*n*	Constant	estimate	s.e.	t	p
all ages	*608*	113	-0.0587	0.0331	-1.77	0.077
adults	*359*	22.8	-0.0137	0.0443	-0.31	0.757
non adults	*243*	138	-0.0708	0.0513	-1.38	0.169

USER PLASTICS (lnGUSE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*608*	181	-0.0915	0.0275	-3.33	**<.001**	- - -
adults	*359*	138	-0.0701	0.039	-1.8	0.073	
non adults	*243*	164	-0.0829	0.0387	-2.14	**0.033**	-

ALL PLASTICS COMBINED (lnGPLA)	*n*	Constant	estimate	s.e.	t	p	
all ages	*608*	186	-0.0942	0.0269	-3.5	**<.001**	- - -
adults	*359*	128	-0.065	0.0386	-1.69	0.093	
non adults	*243*	177	-0.0895	0.0362	-2.47	**0.014**	-

SUSPECTED CHEMICALS (lnGCHE)	*n*	Constant	estimate	s.e.	t	p	
all ages	*608*	62.1	-0.0339	0.0343	-0.99	0.322	
adults	*359*	224	-0.1147	0.0459	-2.5	**0.013**	-
non adults	*243*	-151	-151	109	-1.39	0.166	

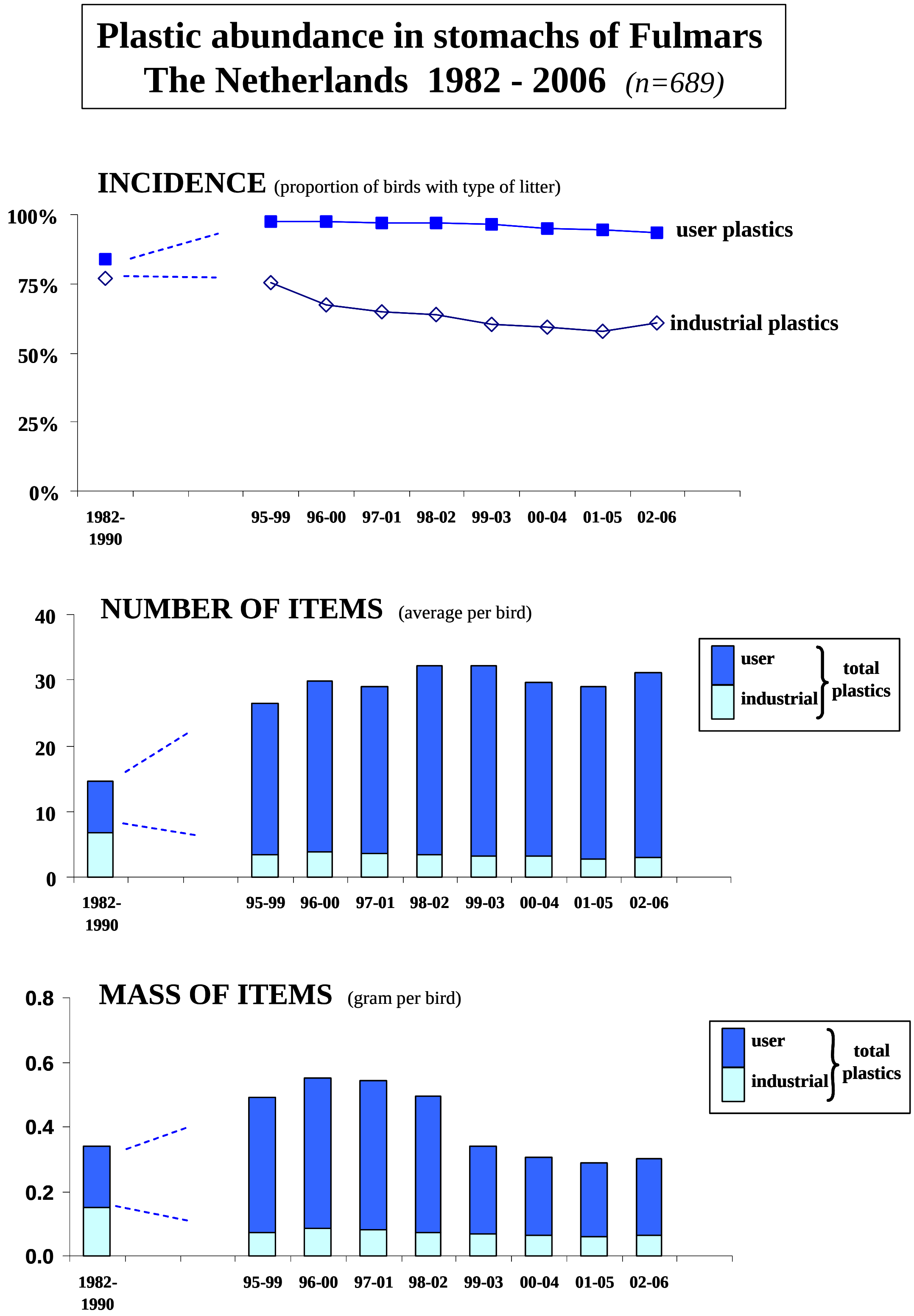

Figure 1. **Summary view of Fulmar-Litter monitoring results in the Netherlands 1982-2006**, comparing average data for incidence, number of items and mass (arithmetic average) in the 1980s with running 5-year averages for the more recent period.

Annual data: geometric means

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

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

Annual geometric means for total plastic mass in the Fulmar stomachs since 1997 and the combined figure for the early 1982-1990 period are shown in Fig. 2. Graphs illustrate the trends also found by regressions in Table 3, and clearly illustrate the effects of age. Differences between the age groups are mostly consistent between annual samples indicating that summarized monitoring results can be expressed as the figure for all ages combined (Summary Fig. *ii*). As suggested with tables 1-3 and Fig.1, the year 2006 shows no evidence for continued improvement in the marine litter situation but suggests stabilization or even a weak increase in pollution levels after 2003. So, although the 'recent trend' over the past 10 year period including year 2006 is still significantly downward, the most recent years do not further contribute.

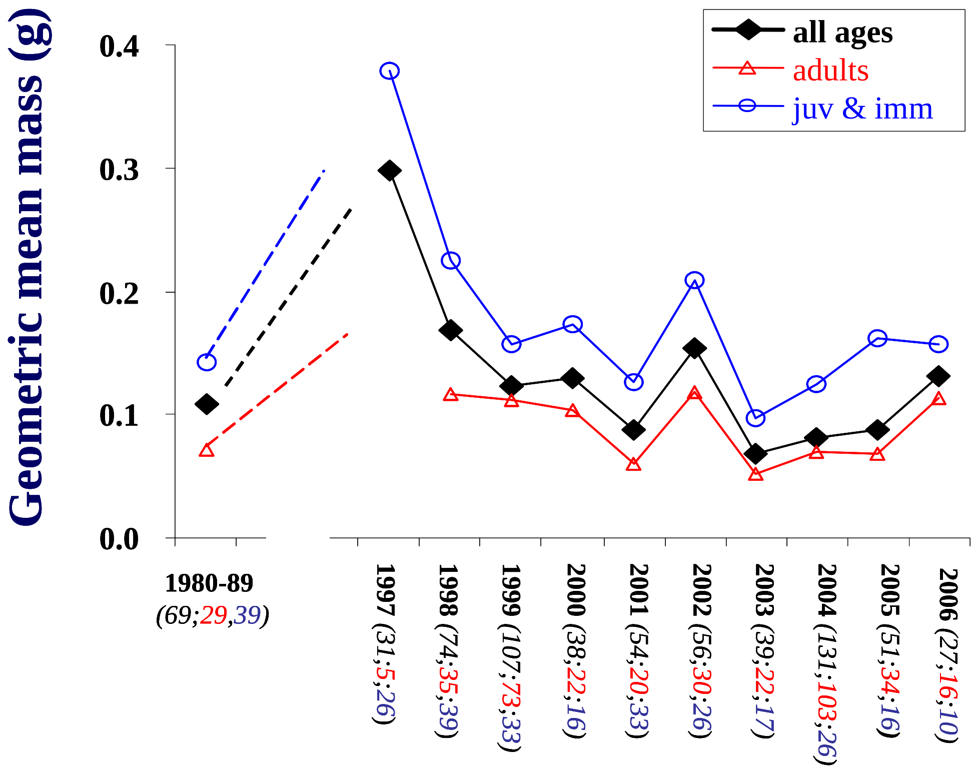

Figure 2 **Annual geometric means for mass of plastics in stomachs of Fulmars from the Netherlands** illustrating trends over time and consistency of age differences that allow usage of the all-age trendline in summaries. Sample sizes for each year are given in italics in brackets for all ages

(including unknowns); adult birds; and non-adults (juveniles and immatures) .

Geometric mean masses are also an appropriate basis to compare the separate trends in abundance of industrial and user plastics (Fig.3). Both have gone up in 2006, which could be interpreted as a somewhat reassuring sign, because the sources of these plastic types are different and unlikely to show parallel change. Increases could then indicate short term aberrant conditions. For example, high levels in 1997 and 2002 were maybe linked to flooding in central Europe, with temporarily elevated riverine pollution. Although flooding was not relevant in 2006, other factors may incur short temporal variations. In the 1980s about equal masses of both types of plastic were present in the stomachs of Fulmars, but nowadays user plastics represent ± 80% of the plastic mass in Fulmar stomachs and exceed levels seen the 1980s.

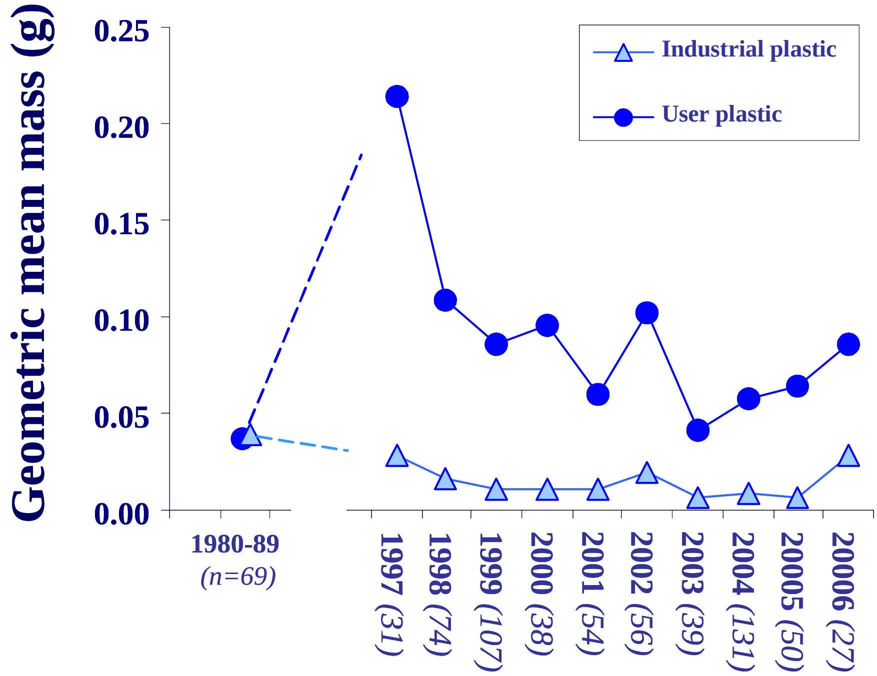

Figure 3 **Annual geometric means for industrial and user plastics** in stomachs of Fulmars from the Netherlands (all ages) illustrating differences in trends over time.

Dutch data in terms of the OSPAR 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. 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 that avoids the mathematical problems caused by a few excessive stomach contents distorting comparative analyses. In the testing procedures and geometric means used above, such problems were overcome by logarithmic transformation of data. And although this is a standard statistical procedure, it is not easily conveyed to the general public, and differences between means (arithmetic versus geometric) can be confusing. The EcoQO metric avoids such problems by using classes of birds in which the exceptional stomach contents loose their influence. Currently, the target for acceptable ecological quality has been defined as the situation in which *"less than 10% of Northern Fulmars has 0.1 gram or more plastic in the stomach".*

Until now, the simplified mode of presentation of annual datapoints for the EcoQO metric as in Fig. 4 showed fairly good similarity to the more sophisticated use of geometric means as in Fig.2. In 2005, the EcoQO situation for the Netherlands was that 45% of Fulmars exceeded the critical value of 0.1g plastic, which was the lowest annual value on record. However, for 2006 this percentage sharply increased to 85%, very much "out of proportion" with the more moderate changes observed in the underlying data (preceding tables and graphs). The explanation for the disproportionate response is not only a relatively small sample size (averaging data for a single year), but more the fact that the usage of a 'critical' level (0.1 gram) in this type of metric may create sudden changes if many individuals are close to the critical level. These results re-emphasize the fact that evaluations should not be based on a year to year comparison, but must be based on averages and trends over a larger number of years! Calculated from individual data, 61% of Dutch Fulmars over the past 5 years exceeded the 0.1g critical level (averaged from yearly figures, 63 ± 15%). Fig.4 shows results for separate ages as well as all ages combined. For general EcoQO reporting, as in Fig.*i* of the Summary, only the 'all age' data are shown in relation to the provisional target level. The significant gap between observed values and the target level leaves no doubt that there is still a long way to go, and stepwise reduction targets may be an appropriate approach.

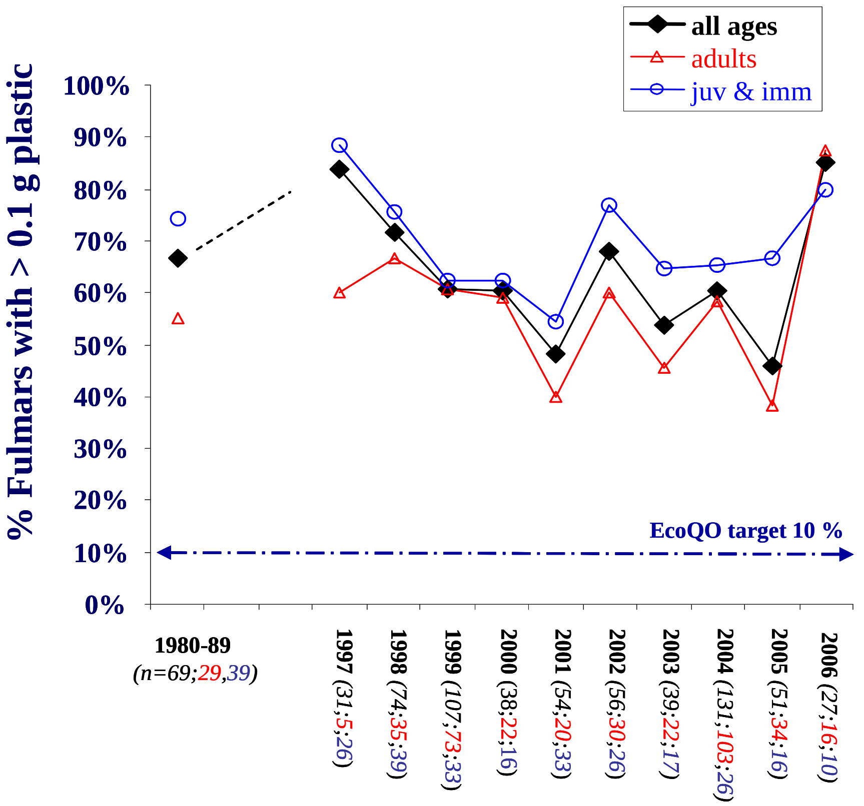

Figure 4 **EcoQO performance of Fulmars from the Netherlands 1980s to 2006.** Annual percentages of beached Fulmars having more than 0.1g plastic in the stomach for adult birds, non adults and for all age groups combined. Target level for acceptable ecological quality as in preliminary OSPAR documentation.

5.2 North Sea EcoQO monitoring 2002-2006

Funding from the NYK Group Europe Ltd has made it possible to process stomach samples from other North Sea locations for years 2005 and 2006 and to continue the international coordination of the Fulmar project into 2008. This effectively permitted continuation of the EU funded Save the North Sea Fulmar study 2002-2004. The combined projects implement the work for the OSPAR litter EcoQO as requested by North Sea Ministers at the Bergen meeting in 2002.
Numbers of samples from different locations over the 5 year period 2002-2006 have been specified in Table 4. Overall, 1,090 stomachs of full grown birds from the North Sea area were processed. Chicks or fledgling birds on their way to sea are occasionally found in the Orkney and Shetland surveys, but these have not been included in this listing and in analyses for this report. Preliminary data from a detailed diet and plastic ingestion study at the Faroe Islands, funded by Chevron Upstream Europe, are included for comparative reasons. The Faroe study will look into details of differences between all age categories and their backgrounds.
A small number of samples from the Skagerak area 2006 is still in local freezers. Sampling years 2003 and 2005 are probably best considered as average sampling years. In 2004, a massive die-off of Fulmars sharply increased the samplesize, in contrast with 2006, when low numbers of birds beached throughout the area.
In the sampling network, the east coast of Britain and the Channel area have been weak links. However, from our project, gradually, a regular Beached Bird Survey is being re-established in northeast England (Dan Turner). In the Channel area, more regular sampling has been started in Normandy in 2007, but the French Pas de Calais or English Channel coasts are still poorly represented, as beach sampling has been limited so far to mass mortality events. Efforts will continue to gradually strengthen the sampling network to further improve good regional coverage in the EcoQO research.

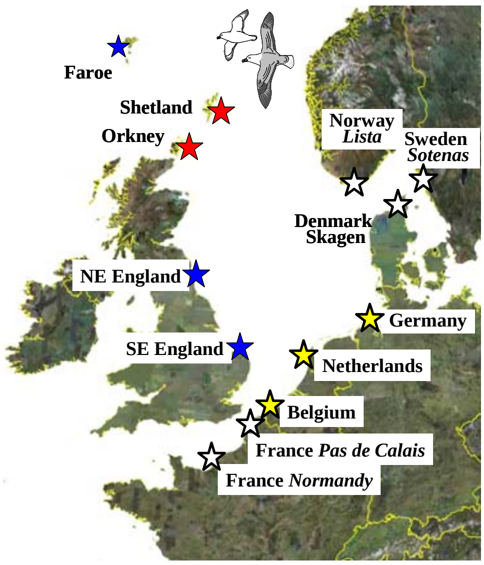

Figure 5 Fulmar-Litter-EcoQO study sites
(colours of stars indicate regional groups)

Table 4 Sample sizes for the Fulmar Litter EcoQO by location and region, and selected parameters for plastic abundance over the 2002-2006 period of study. Full details in Appendices A and B. Location sequence in tables, graphs and appendices is anticlockwise around the North Sea. Insufficiently sampled locations printed in light italics.

		BY LOCATION												REGION COMBINATIONS					North Sea
		Scottish Islands		East England		Channel		SE North Sea			Skagerak area								
number of stomachs analysed	***Faroe***	**Shetland**	**Orkney**	*Northeast-England*	**Southeast England**	*France Normandy*	**France Pas de Calais**	**Belgium**	**Netherlands**	**Germany**	**Denmark Skagen**	**Norway Lista**	*Sweden Sotenas*	**Scottish Islands**	**East England**	**Channel**	**Southeastern North Sea**	**Skagerak area**	**NORTH SEA**
2002	*38*	11	6					1	56	4	1			17	0	0	61	1	**79**
2003	*277*	13	10	*1*				21	39	32	55	7	*6*	23	1	0	92	68	**184**
2004	*84*	17	8	*5*	40	*6*	36	97	131	153	51	26		25	45	42	381	77	**570**
2005	*238*	5	2	*6*		*4*		44	51	69	7	10		7	6	4	164	17	**198**
2006	*48*	9	0	*2*				10	27	10		1		9	2	0	47	1	**59**
total 2002-2006	***685***	**55**	**26**	*14*	**40**	*10*	**36**	**173**	**304**	**268**	**114**	**44**	*6*	**81**	**54**	**46**	**745**	**164**	**1090**
acronyms	**FAE**	**SHE**	**ORK**	*NEE*	**SEE**	*NMD*	**FRA**	**BEL**	**NET**	**GER**	**SKA**	**LIS**	*SWE*	**SCOI**	**EENG**	**CHAN**	**SENS**	**SKAG**	**North Sea**
summarized plastic abundance:																			
incidence	88%	91%	92%	*100%*	93%	*100%*	100%	95%	94%	94%	94%	98%	*83%*	91%	94%	100%	94%	95%	**94%**
avg items / bird	13.8	14.9	25.6	*24.8*	29.8	*52.3*	57.6	47.6	29.3	26.1	36.8	51.8	*48.2*	18.3	28.5	56.4	32.4	41.3	**33.5**
avg gram / bird	0.17	0.18	0.28	*0.27*	0.21	*0.31*	0.25	0.29	0.30	0.30	0.35	0.36	*0.63*	0.21	0.22	0.26	0.30	0.36	**0.30**
geometric mass	0.045	0.048	0.072	*0.205*	0.086	*0.147*	0.137	0.083	0.094	0.084	0.066	0.105	*0.071*	0.054	0.108	0.139	0.088	0.075	**0.085**
EcoQO % > 0.1 g	43%	45%	46%	*71%*	55%	*70%*	58%	51%	61%	57%	46%	55%	*67%*	46%	59%	61%	57%	49%	**55%**

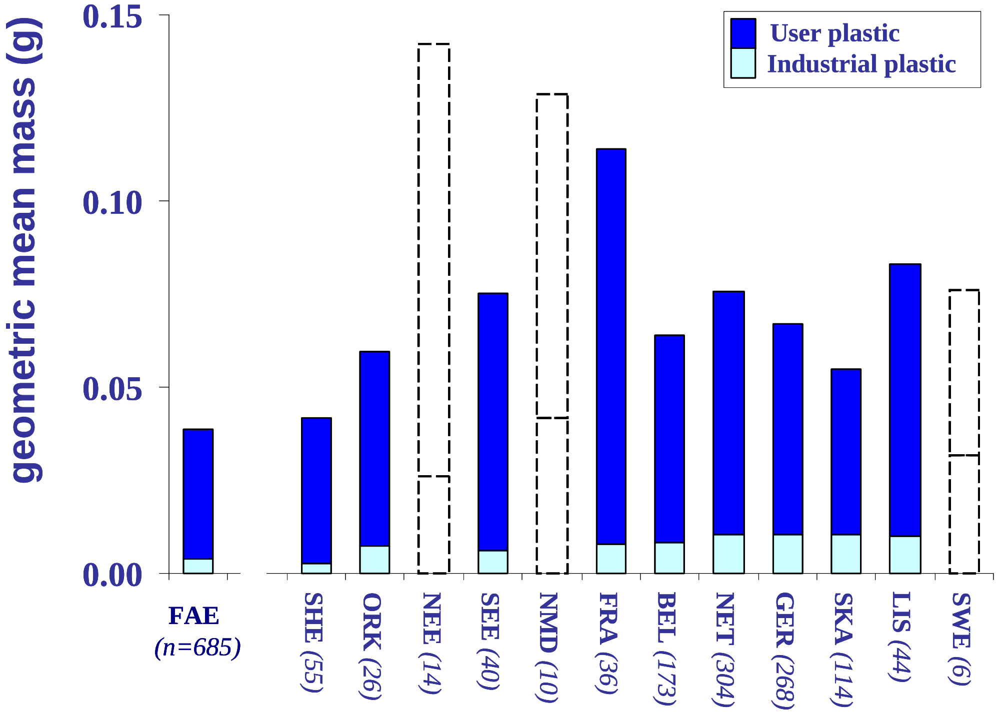

Figure 6 **Location differences in geometric mean mass of industrial and user plastics** in stomachs of Fulmars from study areas around the North Sea and the Faroe Islands over the 5 year period 2002-2006. Blank bars with dashed contourlines indicate insufficient sample size. Data for all age groups combined.

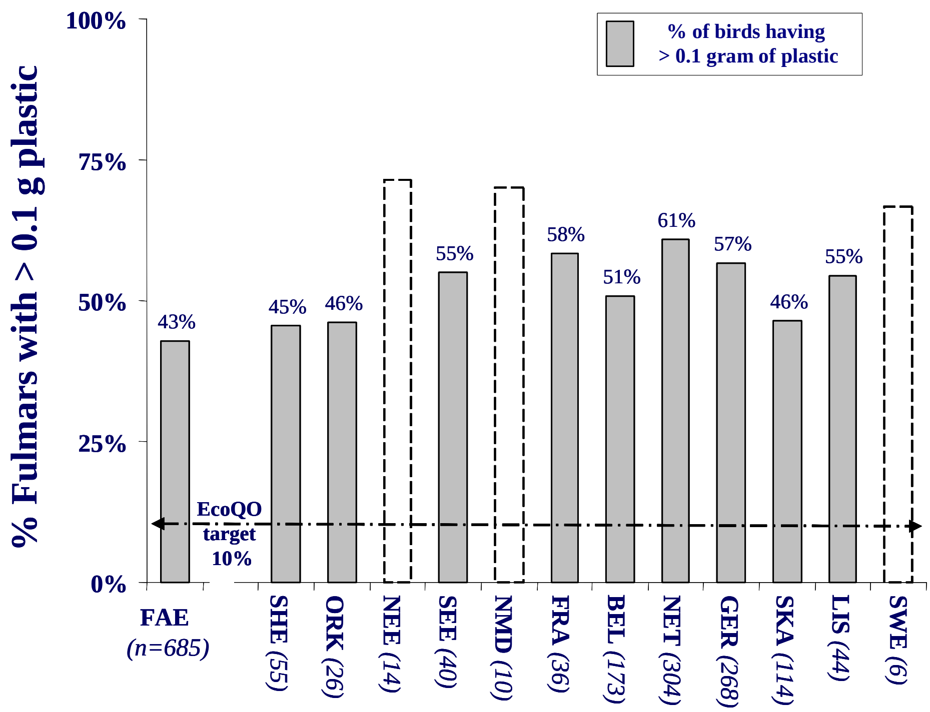

Figure 7 **Location differences in EcoQO performance of Fulmars from study areas around the North Sea and the Faroe Islands over the 5 year period 2002-2006.** The proportion of beached Fulmars having more than 0.1g plastic in the stomach. All age groups combined. Blank bars with dashed contours indicate insufficient sample size. Target level for acceptable ecological quality as in preliminary OSPAR documentation.

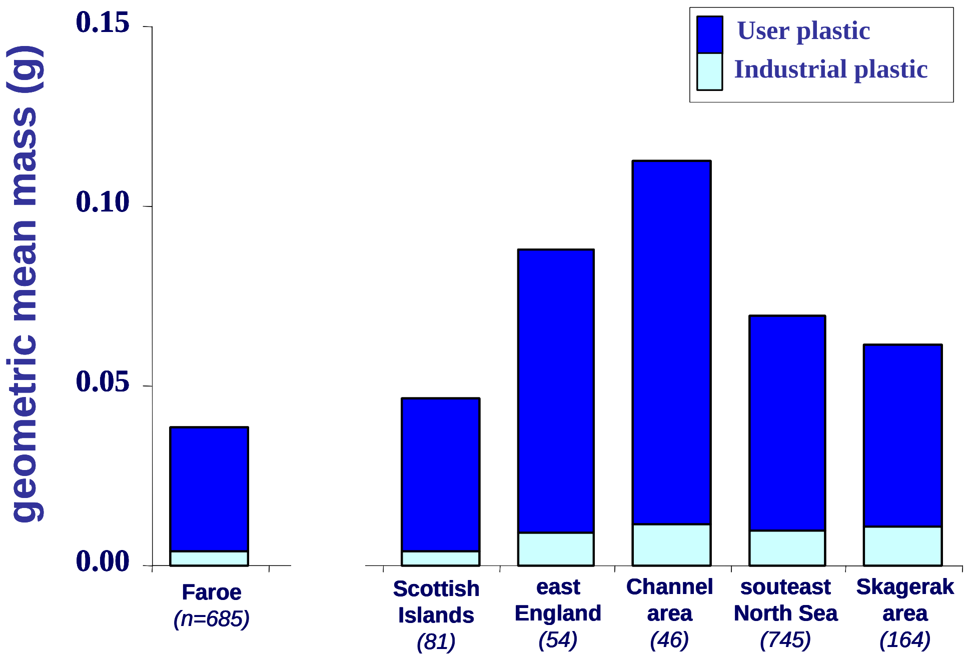

Figure 8 Regional differentiation in geometric mean mass of industrial and user plastics in stomachs of Fulmars over the period 2002-2006.

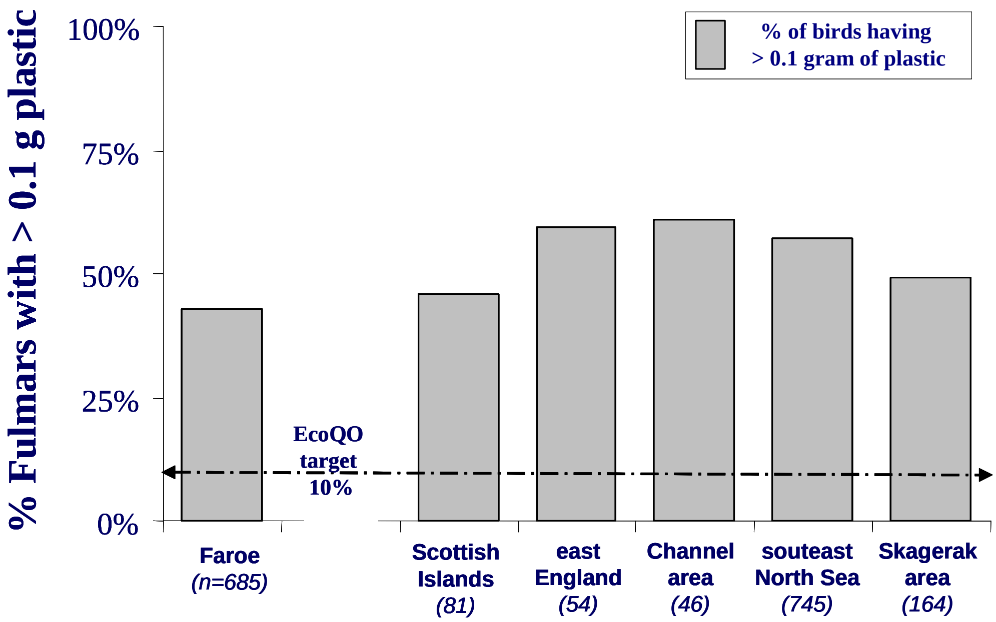

Figure 9 Regional differenctiation in EcoQO performance of Fulmars over the period 2002-2006.

Location and regional differences

Anywhere in the North Sea area, over 90% of Fulmars have plastic in the stomach, with Channel area locations showing 100% incidence. Calculated over all North Sea Fulmars from 2002-2006, 94% of birds have plastic in the stomach. Averaged over all individuals, each bird carries more than 33 pieces of plastic, weighing about 0.3 gram. The proporton of birds exceeding 0.1g of plastic in the stomach, ranges from about 45% in the Scottish Islands, to around 60% in the southern parts of the North Sea.

Compared to the earlier analysis in the Save the North Sea report (van Franeker et al 2005), the strongly enlarged sample for the outside reference situation at the Faroe Islands, suggests that that location is either less clean than initially thought, or is becoming more polluted. The Save the North Sea report found that Fulmars from the most polluted southern North Sea had about two times more plastic in the stomach than those from around the Scottish Islands and four times more than those from the Faroe Islands. The pattern of overall pollution and details of various sub-categories indicated the strongest pollution to occur towards the Channel area in relation to the highest shipping intensity, and gradual decreases when moving away further to the north of the North Sea (van Franeker et al. 2005; van Franeker & Meijboom 2006). In the current dataset, the differentiation between locations (Fig's 6 and 8) or regions (Fig's 7 and 9) is somewhat less pronounced. Variability in samples sizes or composition and discrepancies in years of sampling (Table 4) may play a role. Nevertheless, the spatial pattern remains evident, especially when data are combined in regions. Geometric means for ingested plastics in the Channel area are about three times those seen at the Faroe Islands, more than double those at the Scottish Islands, with intermediate levels for other North Sea locations (Fig. 8). The current sample for the Channel area is fairly limited, but a preliminary look at new material from Normandy in 2007 supports the suspicion of there being a very high level of plastics in Fulmar stomachs in the Channel area. T-tests for differences in plastic mass in stomachs between regions or locations are often significantly different if geographically further apart. Faroese Fulmars have significantly different stomach contents from those from the North Sea as a whole ($p<0.001$) and from any separate region except the Scottish Islands.

Seemingly subtle differences in plastic abundance in Fulmar stomachs within the North Sea, and still considerable levels of pollution measured for an out of the North Sea location like the Faroe Islands, might raise doubts on achievability of the EcoQO target levels. A recent study in the Canadian Arctic by Mallory et al. (2006) allows a wider geographical comparison for incidence and arithmetic averages for number and mass of plastics in Northern Fulmars (unfortunately no data available to compare geometric mean masses of plastic or EcoQO performance). Table 5 clearly shows the huge difference between incidence, number and mass of ingested plastics in the North Sea and the Canadian Arctic, with an order of magnitude difference in mass. Possibly the Canadian Arctic is somewhat less polluted than the northeastern part of the north Atlantic, where Gulf Stream waters may transport pollution from western Europe to the north. In the early 1980s, Fulmars from the northeastern part of the North Atlantic on Jan Mayen and Bear Island had ca. 4 to 5 pieces of plastics per bird, about one third of the level of 12 particles per bird in the Southern North Sea in that period (van Franeker 1985). The extremely evident differences on wider spatial scales from North Sea, to Faroe Islands, and to the Arctic, reconfirm the realistic character of the EcoQO monitoring approach and target levels. But it is also clear that where current data show that 45-60% of North Sea Fulmars exceeds the 0.1 gram critical level, significant effort and time will be needed to reach the target for acceptable ecological quality as currently defined, and a long term stepwise policy approach may need to be considered.

Table 5. **Abundance of ingested plastics in North Atlantic Fulmars** (data for the Canadian Arctic from Mallory et al. 2006)

area	*number of birds examined*	**Incidence** (proportion of birds affected)	**average number of particles per bird**	**average mass of plastic per bird (gram)**
Canadian Arctic	*42*	36%	1.3	0.03
Faroe Islands	*685*	88%	13.8	0.17
North Sea	*1090*	94%	33.5	0.30

Regional and North Sea trends

The list of annual sample sizes in Table 4 indicates that detailed analyses of trends for separate locations are mostly premature. Samples sizes were low at the start of the international *Save the North Sea* project in 2002, and were low by natural causes on most locations in 2006. As a consequence the timespan of available data is even less than 5 years for many locations. Regionally grouped data may also suffer from these effects. Linear regressions for the five different regions and for the North Sea as a whole do not reveal a significant overall trend in the litter situation over the years 2002-2006 (Table 6).

However, a relatively well-sampled region is the southeastern North Sea with Germany, the Netherlands and Belgium. Since annual data for the Netherlands for 2006 were somewhat confusing (sharp increase in EcoQO metric), Fig.10 and Table 7 provide some further detail for the neighbouring countries. The geometric mean masses of plastics for separate years and locations (Fig.10) indicate that the German birds showed an increase from 2005 to 2006 similar to that in the Netherlands. However, Belgian birds showed a decrease from 2005 to 2006 in line with persistent decreases each year from 2003 to 2006. Linear regression of the Belgian data 2002-2006 actually marks that trend as significantly downward (P=0.05). Regressions for the Netherlands, Belgium and the whole region are all downward but combined they are not at a significant level. Although circumstantial, this information indicates that the sharp change in the Dutch EcoQO metric from 2005 to 2006 (Fig.4 and Fig. *i*) is not representative for events over the past few years in the region. To indicate this, German plus Belgian data for EcoQO performance have been inserted in the summary in Fig. *i*.

It is noteworthy that geometric mean masses of plastics in Belgian, Dutch and German Fulmars were very similar in years 2004 and 2005 (Fig.10), when minimum sample size per location and year was 44 birds (Table 4) and showed stronger variability in 2003 (minimum sample 21 birds) and 2005 (minimum sample 10 birds). This reconfirms early calculations from the projects' pilot study (Van Franeker & Meijboom 2002), indicating that a reliable value for a location at a particular point in time required a sample size of 40 or more birds. In turn, this suggests that individual datapoints for some years and separate locations in Fig.10 may be inaccurate, but that the overall trendline for the Southern North Sea is realistic, with a downward regional trend over years 2002-2005, only broken by a somewhat elevated figure for 2006.

Table 6 **Results of linear regression analyses for changes in plastic abundance in stomachs of Fulmars from different locations and regions over 5-year period 2002-2006.** Regressions of ln-transformed data of mass of plastic in individual stomachs with year as explanatory variable. For further details see caption of Table 3.

Trends North Sea - 2002-2006

location / region	*n*	Constant	estimate	s.e.	t	p	
Belgium	*173*	729	-0.365	0.185	-1.98	**0.05**	-
Germany	*268*	103	-0.053	0.155	-0.34	0.735	
Netherlands	*304*	130	-0.0661	0.091	-0.73	0.468	
Southeastern North Sea	*745*	228	-0.1151	0.0711	-1.62	0.106	
Skagerak area	*164*	372	-0.187	0.218	-0.86	0.392	
Scottish Islands	*81*	-229	0.113	0.182	0.62	0.537	
East England	*54*	-1257	0.635	0.443	1.43	0.158	
Channel area	*46*	921	-0.461	0.674	-0.68	0.498	
NORTH SEA	*1090*	97	-0.0498	0.0608	-0.82	0.413	

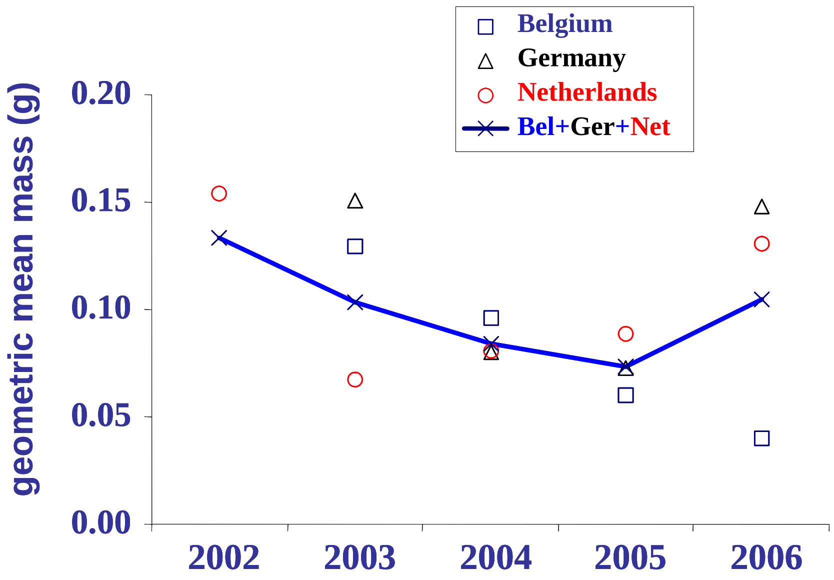

Figure 10 **Southeastern North Sea marine litter trends:** geometric mean mass of plastic in stomachs of Fulmars from Belgium, the Netherlands and Germany, and combined, over the period 2002-2006.

Table 7 **EcoQO performance in the southeastern North Sea –** The percentage of Fulmars with more than 0.1 gram plastic in the stomach – in the southeastern North Sea, by location and year

ECOQO PERFORMANCE				
	Belgium	**Germany**	**Netherlands**	**Combined SE North Sea**
2002			68%	**64%**
2003	57%	78%	54%	**63%**
2004	55%	55%	60%	**57%**
2005	45%	51%	47%	**48%**
2006	30%	70%	85%	**70%**
2002-2006	**51%**	**61%**	**57%**	**57%**

6 Conclusions

With an increasing number of study years after the initial pilot study (Van Franeker & Meijboom 2002), the Fulmar-Litter monitoring program has strongly matured. Good annual samples for the Netherlands for most years since 1997, and international expansion of the project since 2002, have delivered a wealth of data and firmly established the approach of plastic abundance in stomachs of the Northern Fulmar as being suitable for monitoring marine litter in the framework of Ecological Quality Objectives (EcoQO's) for the North Sea. At the request of OSPAR, a *Background Document* has been prepared for further consideration of the Fulmar-Litter-EcoQO (OSPAR-MASH 2007) which may also become an element in the European Marine Strategy.
This report updates Dutch long term monitoring information for the Netherlands up to the year 2006 and completes the first 5-year period of wider monitoring all around the North Sea. Relevant background information is presented to assist a correct interpretation of the strongly summarized information presented in the metric developed for the EcoQO.

- In 2006 in the Netherlands, 25 out of 27 Fulmar stomachs contained plastic (incidence 93%) with an overall average of 34 items per bird and average mass of 0.30 gram per bird. Sample size was rather low as a sample of 40 or more stomachs is recommended for reliable annual averages.
- In terms of mass, these data suggest a slight increase for plastic abundance in stomachs of Dutch Fulmars from 2005 (0.27g per bird) to 2006. The increase was disproportionately large in terms of the metric used in the Fulmar-Litter-EcoQO, viz. the percentage of birds with more than 0.1 gram of plastic in the stomach, which increased from 45% in 2005, to 85% in 2006. Insufficient sample size plus the fact that a large proportion of birds has stomach contents close to the critical value (see Appendix C), confound conclusions from annual data and re-emphasize earlier recommendations to describe the 'current level' as the average situation over the 5 most recent years, and to run statistical tests for change over at least 10-year periods. These metrics have no problem with incidental small sample size or aberrant incidents.
- The current 5-year level in the Netherlands, calculated for 304 Fulmars beached in the 2002-2006 period, is that 95% of the birds have plastic in the stomach with an overall average of 31 particles per bird and average mass of 0.30 gram per bird. Overall, 61% of the birds exceed the critical EcoQO level of 0.1g of plastic in the stomach.
- Tested over the 10-year period 1997-2006, a highly significant reduction in plastic mass ($p<0.001$) has occurred which is primarily due to a reduction of user plastics. However, strongest reductions have occurred in the early years and are not as clearly continued in the latest period.
- Tests for long-term trends 1979-2006 do not reveal significant change, because total plastic mass in Fulmar stomachs peaked in the late 1990s, but has now returned to a level similar to that in the 1980s.
- However, over the years the composition of the ingested plastic has strongly changed from about equal mass proportions of industrial and user plastics in the 1980s to about 80% of user plastics in the current situation.

- For a wide range of locations around the North Sea, data are now available over the 2002-2006 period, from a total of 1,090 birds, with an additional 685 stomachs analysed from the Faroe Islands.
- These data are adequate to describe regional variation in the 'current level' of plastic pollution and show that pollution in the Channel area is the worst, where plastics in stomachs are about three times more abundant.
- On average in the North Sea, 94% of Fulmars has plastic in the stomach, 33.5 items per bird, and 0.30 gram per bird. Overall 55% (45-60%) of the birds exceeds the critical EcoQO level of 0.1 g of plastic in the stomach
- Most local data need longer time series in order to analyse for significant trends. However, a comparative analysis of the Belgian, Dutch and German data over the 2002-2006 period indicated a reduction of plastic pollution in the area in the past few years, but only significantly so in Belgium. Although this is also not firm evidence, it suggests that increases in some 2006 samples are not reflecting a more general trend.
- Our detailed attention for pollution levels within the North Sea may give the impression that plastic abundance in Fulmar stomachs is "always" high, resulting in a pessimistic perspective on reaching the target level. Data from a wider geographical area clearly show that clean environments are reflected in the amounts of plastic in Fulmar stomachs and that target levels are probably not so unrealistic after all.

7 Acknowledgements

In several stages of this long-term project coordinating activities, dissection work, data analysis and writing of reports have been financially supported by the Netherlands Ministry of Transport, Public Works and Water Management (VenW). Internationally, the Fulmar project truly expanded during the ***Save the North Sea*** project 2002-2004, which was co-funded by the EU Interreg IIIB program for the North Sea. Continuation of the international North Sea work has recently been supported by an award from the NYK Group Europe. Preliminary data on the Faroe Islands used in this report were derived from a running diet and litter study funded by Chevron Upstream Europe.

Beached Fulmars are mostly collected by volunteers associated with the coordinators from a wide range of organisations listed in Appendix D. The number of people involved likely runs into the hundreds. There are too many to be named. However, without that huge amount of volunteer effort, a project like this would be totally impossible. Therefore, this report is dedicated to all our project helpers all around the North Sea.

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Quality Assurance

IMARES utilises an ISO 9001:2000 certified quality management system (certificate number: 08602-2004-AQ-ROT-RvA). This certificate is valid until 15 December 2009. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. The last certification inspection was held the 16-22 of May 2007. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2000 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2009 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation, with the last inspection being held on the 12th of June 2007.

Justification

Rapport C033/08
Project Number: 439.61001.03

The scientific quality of this report has been peer reviewed by the Scientific Team of Wageningen IMARES.

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Appendix A. Location data EcoQO Monitoring 2002-2006

Fulmar Litter EcoQO monitoring North Sea 2002-2006
stomach content details (all ages excl pulli/fledgling)

LOCATION DETAILS

	Faroe	Shetland	Orkney	Northeast-England	Southeast England	France Normandy	France Pas de Calais	Belgium	Netherlands	Germany	Denmark Skagen	Norway Lista	Sweden Sotenas
sample size 2002	*38*	*11*	*6*					*1*	*56*	*4*	*1*		
sample size 2003	*277*	*13*	*10*	*1*				*21*	*39*	*32*	*55*	*7*	*6*
sample size 2004	*84*	*17*	*8*	*5*	*40*	*6*	*36*	*97*	*131*	*153*	*51*	*26*	
sample size 2005	*238*	*5*	*2*	*6*		*4*		*44*	*51*	*69*	*7*	*10*	
sample size 2006	*48*	*9*	*0*	*2*				*10*	*27*	*10*		*1*	
total 2002-2006	***685***	***55***	***26***	***14***	***40***	***10***	***36***	***173***	***304***	***268***	***114***	***44***	***6***
proportion adult	81%	65%	65%	50%	93%	60%	92%	73%	67%	63%	75%	68%	50%
proportion male	41%	35%	54%	43%	10%	20%	3%	23%	33%	35%	40%	50%	50%
proportion colour LL	*	*85%*	*96%*	*86%*	*93%*	*80%*	*89%*	*91%*	*88%*	*91%*	*96%*	*93%*	*100%*
proportion oil fouled	*	*11%*	*8%*	*0%*	*0%*	*10%*	*0%*	*10%*	*6%*	*5%*	*10%*	*16%*	*0%*

ALL PLASTICS (industrial + user)

	Faroe	Shetland	Orkney	Northeast-England	Southeast England	France Normandy	France Pas de Calais	Belgium	Netherlands	Germany	Denmark Skagen	Norway Lista	Sweden Sotenas
incidence	88%	91%	92%	100%	93%	100%	100%	95%	94%	94%	94%	98%	83%
nr of pieces per bird	13.8	14.9	25.6	24.8	29.8	52.3	57.6	47.6	29.3	26.1	36.8	51.8	48.2
average mass per bird (g)	0.17	0.18	0.28	0.27	0.21	0.31	0.25	0.29	0.30	0.30	0.35	0.36	0.63
max mass in single bird	6.50	1.66	1.24	0.55	1.12	1.34	0.92	4.32	11.12	4.34	20.59	1.82	2.98
geometric mean mass	0.0448	0.0478	0.0716	0.2053	0.0861	0.1470	0.1375	0.0833	0.0943	0.0845	0.0656	0.1054	0.0712

Industrial plastic details

	Faroe	Shetland	Orkney	Northeast-England	Southeast England	France Normandy	France Pas de Calais	Belgium	Netherlands	Germany	Denmark Skagen	Norway Lista	Sweden Sotenas
incidence	42%	35%	54%	79%	45%	90%	58%	55%	58%	61%	61%	57%	67%
nr of pieces per bird	1.0	1.1	2.5	3.4	2.0	6.4	3.4	2.7	2.9	2.8	2.4	4.7	18.8
average mass per bird (g)	0.02	0.03	0.06	0.08	0.05	0.15	0.04	0.06	0.06	0.06	0.05	0.07	0.44
max mass in single bird	0.38	0.38	0.47	0.26	0.29	0.77	0.32	1.26	0.93	1.71	0.44	0.62	2.40
geometric mean mass	0.0039	0.0027	0.0072	0.0260	0.0061	0.0418	0.0077	0.0083	0.0106	0.0106	0.0102	0.0102	0.0319

User plastic details

	Faroe	Shetland	Orkney	Northeast-England	Southeast England	France Normandy	France Pas de Calais	Belgium	Netherlands	Germany	Denmark Skagen	Norway Lista	Sweden Sotenas
incidence	87%	91%	92%	100%	93%	100%	100%	94%	93%	94%	94%	98%	83%
nr of pieces per bird	12.8	13.7	23.1	21.4	27.8	45.9	54.1	44.9	26.4	23.3	34.4	47.1	29.3
average mass per bird (g)	0.14	0.15	0.22	0.18	0.16	0.16	0.21	0.24	0.24	0.24	0.30	0.29	0.18
max mass in single bird	6.50	1.66	1.12	0.49	0.97	0.57	0.69	3.36	10.65	4.33	20.57	1.74	0.58
geometric mean mass	0.0347	0.0391	0.0525	0.1161	0.0691	0.0868	0.1061	0.0558	0.0649	0.0561	0.0446	0.0730	0.0440

NON PLASTIC RUBBISH (paper, foil, foodwastes, wood, etc.

	Faroe	Shetland	Orkney	Northeast-England	Southeast England	France Normandy	France Pas de Calais	Belgium	Netherlands	Germany	Denmark Skagen	Norway Lista	Sweden Sotenas
incidence	6%	2%	4%	14%	5%	10%	31%	17%	21%	21%	9%	9%	17%
nr of pieces per bird	0.1	0.0	0.9	0.1	1.2	1.2	0.6	0.7	1.1	1.2	0.5	0.7	0.2
average mass per bird (g)	0.13	0.00	0.00	2.14	0.00	0.00	0.02	0.05	0.06	0.16	0.06	0.09	0.03
max mass in single bird	75.40	0.02	0.03	20.00	0.00	0.02	0.22	3.93	3.49	20.00	4.10	3.42	0.21
geometric mean mass	0.0002	0.0001	0.0001	0.0029	0.0000	0.0004	0.0016	0.0009	0.0013	0.0016	0.0004	0.0007	0.0014

SUSPECTED CHEMICALS (mainly paraffine like substances)

	Faroe	Shetland	Orkney	Northeast-England	Southeast England	France Normandy	France Pas de Calais	Belgium	Netherlands	Germany	Denmark Skagen	Norway Lista	Sweden Sotenas
incidence	2%	2%	8%	7%	13%	10%	28%	17%	23%	30%	21%	23%	17%
nr of pieces per bird	0.1	0.0	0.1	0.9	0.4	0.1	3.5	1.0	1.9	4.1	1.8	2.5	12.5
average mass per bird (g)	0.00	0.00	0.05	0.02	0.03	0.00	0.01	0.05	0.48	0.52	0.20	0.04	1.08
max mass in single bird	0.06	0.00	1.25	0.26	1.00	0.01	0.11	6.00	65.00	34.00	7.00	1.00	6.46
geometric mean mass	0.0000	0.0000	0.0004	0.0005	0.0004	0.0002	0.0008	0.0006	0.0016	0.0029	0.0012	0.0016	0.0033

EcoQO COMPLIANCE (% of birds having more than 0.1 gram of plastic in the stomach)

	Faroe	Shetland	Orkney	Northeast-England	Southeast England	France Normandy	France Pas de Calais	Belgium	Netherlands	Germany	Denmark Skagen	Norway Lista	Sweden Sotenas
proportion with > 0.1g plastic	43%	45%	46%	71%	55%	70%	58%	51%	61%	57%	46%	55%	67%

Faroe | Shetland | Orkney | Northeast-England | Southeast England | France Normandy | France Pas de Calais | Belgium | Netherlands | Germany | Denmark Skagen | Norway Lista | Sweden Sotenas

Appendix B. Regional data EcoQO Monitoring 2002-2006

Fulmar Litter EcoQO monitoring North Sea 2002-2006
stomach content details (all ages excl pulli/fledgling)

REGIONAL AND NORTH SEA AVERAGES

	Faroe	Scottish Islands	East England	Channel	Southeastern North Sea	Skagerak area	NORTH SEA	NORTH SEA adults	NORTH SEA non-adults
sample size 2002	38	17	0	0	61	1	79	45	34
sample size 2003	277	23	1	0	92	68	184	101	75
sample size 2004	84	25	45	42	381	77	570	452	100
sample size 2005	238	7	6	4	164	17	198	125	68
sample size 2006	48	9	2	0	47	1	59	32	24
total 2002-2006	**685**	**81**	**54**	**46**	**745**	**164**	**1090**	**755**	**301**
proportion adult	81%	65%	81%	85%	67%	73%	69%	100%	0%
proportion male	41%	41%	19%	7%	31%	43%	32%	30%	41%
proportion colour LL	61%	89%	91%	87%	90%	95%	**90%**	94%	82%
proportion oil fouled	0%	10%	0%	2%	6%	11%	**7%**	5%	12%

ALL PLASTICS (industrial + user)

	Faroe	Scottish Islands	East England	Channel	Southeastern North Sea	Skagerak area	NORTH SEA	NORTH SEA adults	NORTH SEA non-adults
incidence	88%	91%	94%	100%	94%	95%	**94%**	93%	97%
nr of pieces per bird	13.8	18.3	28.5	56.4	32.4	41.3	**33.5**	33.5	33.7
average mass per bird (g)	0.17	0.21	0.22	0.26	0.30	0.36	**0.30**	0.27	0.35
max mass in single bird	6.50	1.66	1.12	1.34	11.12	20.59	**20.59**	20.59	11.12
geometric mean mass	0.0448	0.0545	0.1079	0.1395	0.0881	0.0748	**0.0854**	0.0733	0.1188
Industrial plastic details									
incidence	42%	41%	54%	65%	59%	60%	**57%**	53%	66%
nr of pieces per bird	1.0	1.6	2.4	4.1	2.8	3.6	**2.9**	2.5	3.6
average mass per bird (g)	0.02	0.04	0.06	0.06	0.06	0.07	**0.06**	0.05	0.08
max mass in single bird	0.38	0.47	0.29	0.77	1.71	2.40	**2.40**	1.71	2.40
geometric mean mass	0.0039	0.0038	0.0090	0.0113	0.0100	0.0107	**0.0094**	0.0075	0.0153
User plastic details									
incidence	87%	91%	94%	100%	94%	95%	**94%**	93%	97%
nr of pieces per bird	12.8	16.8	26.1	52.3	29.6	37.6	**30.6**	31.0	30.0
average mass per bird (g)	0.14	0.17	0.17	0.20	0.24	0.29	**0.24**	0.23	0.26
max mass in single bird	6.50	1.66	0.97	0.69	10.65	20.57	**20.57**	20.57	10.65
geometric mean mass	0.0347	0.0430	0.0790	0.1016	0.0595	0.0509	**0.0589**	0.0520	0.0779

NON PLASTIC RUBBISH (paper, foil, foodwastes, wood, etc.

	Faroe	Scottish Islands	East England	Channel	Southeastern North Sea	Skagerak area	NORTH SEA	NORTH SEA adults	NORTH SEA non-adults
incidence	6%	2%	7%	26%	20%	9%	**17%**	16%	19%
nr of pieces per bird	0.1	0.3	0.9	0.7	1.0	0.5	**0.9**	1.0	0.7
average mass per bird (g)	0.13	0.00	0.56	0.01	0.09	0.07	**0.10**	0.12	0.06
max mass in single bird	75.40	0.03	20.00	0.22	20.00	4.10	**20.00**	20.00	3.93
geometric mean mass	0.0002	0.0001	0.0004	0.0013	0.0013	0.0005	**0.0010**	0.0009	0.0011

SUSPECTED CHEMICALS (mainly paraffine like substances)

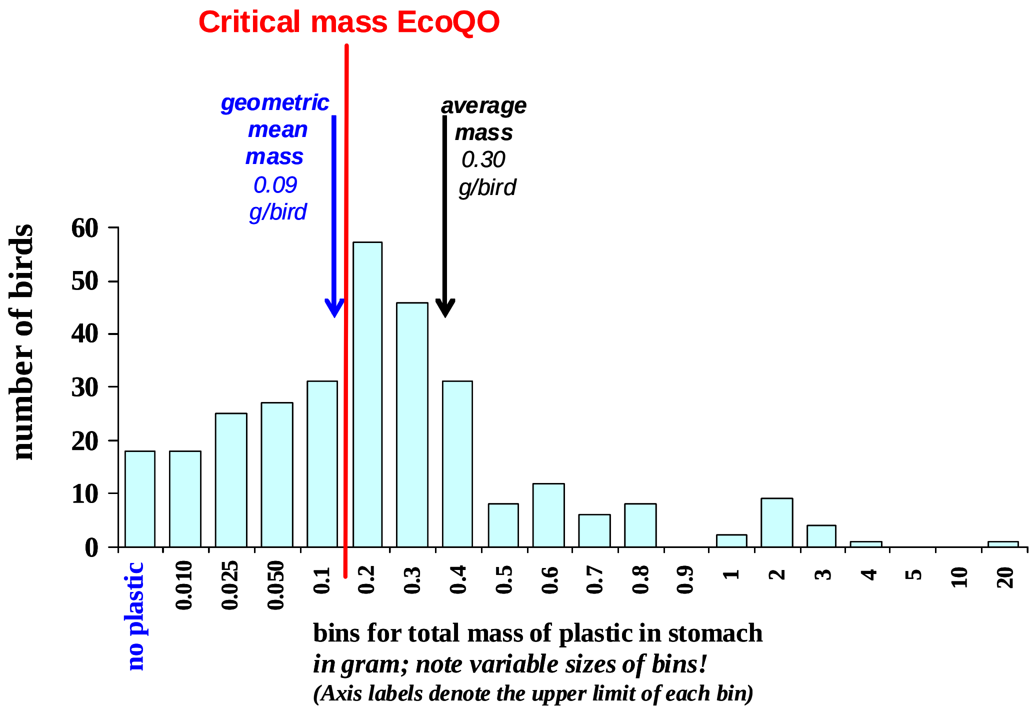
	Faroe	Scottish Islands	East England	Channel	Southeastern North Sea	Skagerak area	NORTH SEA	NORTH SEA adults	NORTH SEA non-adults
incidence	2%	4%	11%	24%	24%	21%	**22%**	21%	22%
nr of pieces per bird	0.1	0.0	0.5	2.8	2.5	2.4	**2.2**	2.3	1.9
average mass per bird (g)	0.00	0.02	0.02	0.01	0.40	0.19	**0.30**	0.25	0.34
max mass in single bird	0.06	1.25	1.00	0.11	65.00	7.00	**65.00**	65.00	26.00
geometric mean mass	0.0000	0.0001	0.0004	0.0007	0.0017	0.0014	**0.0014**	0.0012	0.0017

EcoQO COMPLIANCE (% of birds having more than 0.1 gram of plastic in the stomach)

proportion with > 0.1g plastic	43%	46%	59%	61%	57%	49%	**55%**	52%	63%
	Faroe	Scottish Islands	East England	Channel	Southeastern North Sea	Skagerak area	NORTH SEA	NORTH SEA adults	NORTH SEA non-adults

Appendix C. Plastic mass frequency distribution

Average mass, geometric mean mass and critical value in the EcoQO definition seen in relation to the frequency distribution of plastic mass in stomachs of Dutch Fulmars 2002-2006 (304 birds)



Strong fluctuations in year to year comparisons in ingested plastic and differences in EcoQO performance are easier to understand with some insight in the frequency distribution of data. Here, numbers of birds falling in categories ('bins') of plastic mass are shown for the Netherlands over the period 2002-2006 (304 birds). The labels on the x-axis show the upper limit of each bin, i.e. the bin labeled 0.2 g represents the category for all birds with plastic masses in the stomach between 0.1g and 0.2g. In reading the graph, be aware that bin sizes are arbitrarily chosen representing ranges of a few mg at the left end of the scale to several grams at the right end of the scale.
Incidence of plastic can be read from the graph by comparing the first bar (no plastic; 0 gram) to the sum of all other bars.
The (arithmetic) average mass of plastic is well above the most frequently occurring values because it includes extreme cases of over 10 gram of ingested plastic, 2 orders of magnitude above the most common type of stomach contents. In small samples (e.g. annual figures) the presence or absence of such an extreme may cause significant fluctuations in the average.
The geometric mean mass reduces such strong fluctuations by logarithmic transformation of data (which reduces high values and results in a mean closer to the most commonly occuring values). Thus, the geometric mean mass is a more appropriate basis to compare smaller samples between years or between locations. The disadvantage is that many people will read it as an 'average' which it is not, and it even underestimates the most abundantly occurring stomach contents.
The definition of the ***EcoQO*** uses another approach to reduce the influence of extreme values by comparing the number of birds having less than 0.1 g of plastic to those above that critical value. In that system, a bird with 0.2g of plastic is no different from the extreme bird with 20 grams of plastic. The fact that this report showed sudden interannual fluctuations is thus not attributable to extremes, but has a different background in the fact that currently, a very large proportion of the birds is very close to the critical value. In small samples (annual or regional), this may lead to sudden fluctuations in the EcoQO result. Such instability of the EcoQO figure will disappear when the most commonly occurring mass of plastics shifts away from the critical value.
In conclusion, the above implies that (changes in) normal average data and EcoQO performance are best viewed over longer periods and larger sample-sizes. Where interannual or regional comparisons do require usage of smaller sample-sizes, geometric means give the best guidance for interpretation of data.

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(main coordinating participants representing groups of volunteers involved in the project)

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