ENGLISH SUMMARY

Fulmar Litter EcoQO monitoring along Dutch and North Sea coasts - *Update 2010 and 2011*

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i. Summary Report

Fulmar Litter EcoQO monitoring along Dutch and North Sea coasts *- Update 2010 and 2011*

Marine debris has serious economic and ecological consequences. Economic impacts are most serious for coastal communities, tourism, shipping and fisheries. Marine wildlife suffers from entanglement and ingestion of debris, with microparticles potentially affecting marine food chains up to the level of human consumers. In the North Sea, marine litter problems were firmly recognized by bordering countries in 2002 when they assigned OSPAR the task to include marine plastic litter in the system of Ecological Quality Objectives (EcoQOs) (North Sea Ministerial Conference 2002). At that time, in the Netherlands, marine litter was already monitored by the abundance of plastic debris in stomachs of a seabird, the Northern Fulmar *(Fulmarus glacialis)*. Fulmars are purely offshore foragers that ingest all sorts of litter from the sea surface and do not regurgitate poorly degradable diet components like plastics. Initial size of ingested debris is usually in the range of millimetres to centimeters, but may be considerably larger for flexible items like threadlike or sheetlike materials. Items must gradually wear down in the muscular stomach to a size small enough for passage to the intestines. During this process, plastics accumulate in the stomach to a level that integrates litter levels encountered in their foraging area for a period of probably up to a few weeks (Van Franeker et al. 2011). The Dutch monitoring approach using beached fulmars was developed for international implementation by OSPAR as one of its EcoQOs for the North Sea (OSPAR 2008, 2009, 2010a,b) and the same approach is now also implemented as an indicator for 'Good Environmental Status (GES)' in the Marine Strategy Framework Directive (MSFD) (EC 2008, 2010; Galgani et al. 2010; MSFD GES Technical Subgroup on Marine Litter, 2011). OSPAR has set a preliminary target for acceptable ecological conditions in the North Sea as:

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

OSPAR has set no date when this EcoQO target level should be reached. The European MSFD does have an overall target date for Good Environmental Status by the year 2020, and may therefore define its target differently. For marine areas where fulmars do not occur, other species are needed as ingestion indicators, for which methodology and targets are being developed.

The monitoring system uses fulmars found dead on beaches, or animals accidentaly killed as e.g. fisheries bycatch. In a pilot study it has been shown that the amount of plastic in stomachs of slowly starved beached animals is not different from that of healthy birds killed in instantaneous accidents. Standard procedures for dissection and stomach analyses have been documented in manuals and reports. Different categories of plastic are recorded, with as major types the industrial plastics (the raw granular feedstock for producers) as opposed to user plastics (from all sorts of consumer waste).
Information on abundance of plastics in fulmars may be expressed in different ways, such as by:

- **Incidence** – the percentage of birds having plastic in the stomach (cf. frequency of occurrence), irrespective of the quantity of plastic
- **Average ± se** –averages refer to straightforward arithmetic averages, often with standard errors. These are used for either number of particles or mass of plastic for all birds in a sample including the ones without any plastic ('population average').
- **Geometric mean** – Means refer to geometric means calculated using data transformation (natural logarithm) reducing influence of extreme outliers and facilitating comparison of smaller samples.
- **EcoQO performance** – the percentage of birds having more than 0.1 gram of plastic in the stomach, allowing direct comparison to the OSPAR target, which aims at having less than 10% of such birds
- **Pooled data** - In various graphs and tables in this report, these types of data are frequently pooled over 5 year periods to have a focus on reliable averages and consistent trends rather than on

incidental short term fluctuations. The 5 year data are not derived from annual averages or means, but are based on individual data from all birds sampled in these five years.

- **Statistics -** Statistical analyses investigating time related trends or regional differences are based on the mass of plastic. Tests for significance of trends over time are based on linear regressions of log-transformed data for the mass of plastics in individual birds against year of collection. A distinction is made between the 'long-term trend' over all years in the dataset (now 1979-2011 for the Netherlands) and the 'recent trend', which is defined as the trend over the past 10 years (now: 2002-2011). Regional differences are tested for significance by fitting individual log-transformed data in a generalized linear model and likelihood ratio test.
- **Graphs** often use pooled data for 5 years, but shifting one year by datapoint. Subsequent data points in the graph thus overlap for 4 years of data, and are only intended to visually illustrate trends over time or geographic patterns and have no statistical meaning, as statistical significance of trends or sample differences is only tested by above methods using data from individual birds.

Update of monitoring data for the Netherlands

This report adds new data for years 2010 and 2011 to earlier updates (Van Franeker & the SNS Fulmar Study Group, 2011). Beached Fulmar corpses were scarce in 2011, but an incidental lower sample size is not a problem for the monitoring system, as it only reduces certainty on the short term. Variability in abundance of live and dead Fulmars in a region is influenced by many factors, mainly in relation to food availability and weather conditions. Incidental years of low sample size are one of the reasons to recommend pooled 5-year data to consider the 'current' situation. Annual data and the most recent pooled 5-year details are summarized in *Table i.*

- **Current data for the Netherlands (years 2007 to 2011; 204 Fulmars) are that 95% of Fulmars have plastic in the stomach, with an average number of 36 particles and mass of 0.33 gram per bird. The critical EcoQO value of 0.1 gram plastic was exceeded by 60% of these birds.**

Table i Data summary for study years added to the existing monitoring series

			INDUSTRIAL PLASTICS			USER PLASTICS			ALL PLASTICS (industrial + user)			
YEAR	*n*	% adult	%	n	g	%	n	g	%	n	g	EcoQO > 0.1 g
2010	***36***	**46%**	**58%**	**10.7**	**0.23**	**94%**	**45.7**	**0.23**	**94%**	**56.4**	**0.46**	**64%**
2011	***19***	**37%**	**63%**	**6.6**	**0.15**	**95%**	**37.0**	**0.27**	**100%**	**43.6**	**0.43**	**79%**
2007-2011	*204*	43%	**59%**	**4.4**	**0.10**	**94%**	**31.1**	**0.24**	**95%**	**35.5**	**0.33**	**60%**

* Five-year data are arithmetic averages over all individual birds in the five year period (not from annual averages)

Long-term trend 1979-2011

Long term trends in the Netherlands are visualized for EcoQO performance in Fig.*i*, and for average mass in Fig.*ii.* Both graphs compare a single average for the 1980s to shifting 5-year data from 1995 onwards. The main message from the EcoQO graph is that since the 1980s ecological quality has consistently been nowhere close to the EcoQO target. EcoQO performance has varied between 57% and 67% whereas the target is that it should go down to 10%. From the mid-1990s until the early 2000's a 10% improvement was promising (Fig.*i* B), but more recently little change has been observed.

The graphs on average mass of plastics (Fig. *ii*) show more detail of changes. An initial strong increase in average plastic mass was observed from 1980s to mid-1990, followed by a period of rapid improvement until the early 2000s, but no further change since then. The current level for all plastics combined (Fig.*ii* A) is similar to the situation in the 1980s, but Fig.*ii* B shows that developments for industrial plastics have been very different than for consumer waste. User plastics were the main factor for the rise and fall seen in total plastics, but industrial granules approximately halved from the 1980s to mid 1990s and next tended to very slow continued decrease except for the exceptional last two datapoints.

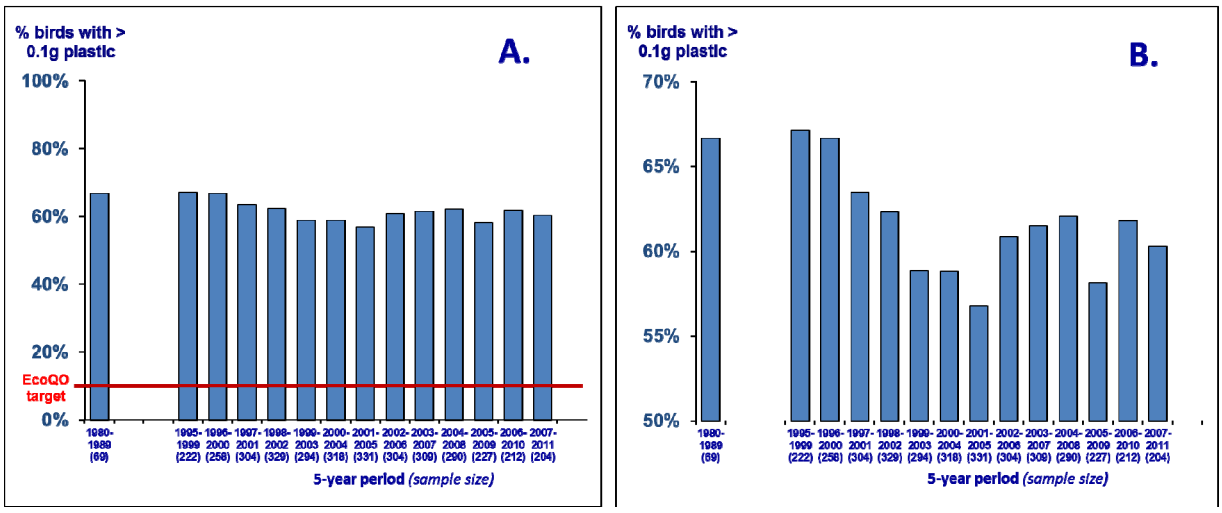

Figure i ***EcoQO performance by fulmars from the Netherlands 1980s-2011.*** *Figure A. shows data on a full 100% scale for the proportion of birds having more than 0.1 gram of plastic. This illustrates the distance to the 10% target for birds with more than 0.1 gram as defined by OSPAR. Fig.B shows the same data but has the y-axis restricted to the observed range, showing an almoste 10% improvement in the EcoQO around the turn of the century, but more or less stable and somewhat erratic performance since then. Data are shown by a single datapoint for the 1980s and annually updated 5 year performances after 1995 (i.e. data points shift one year ahead at a time).*

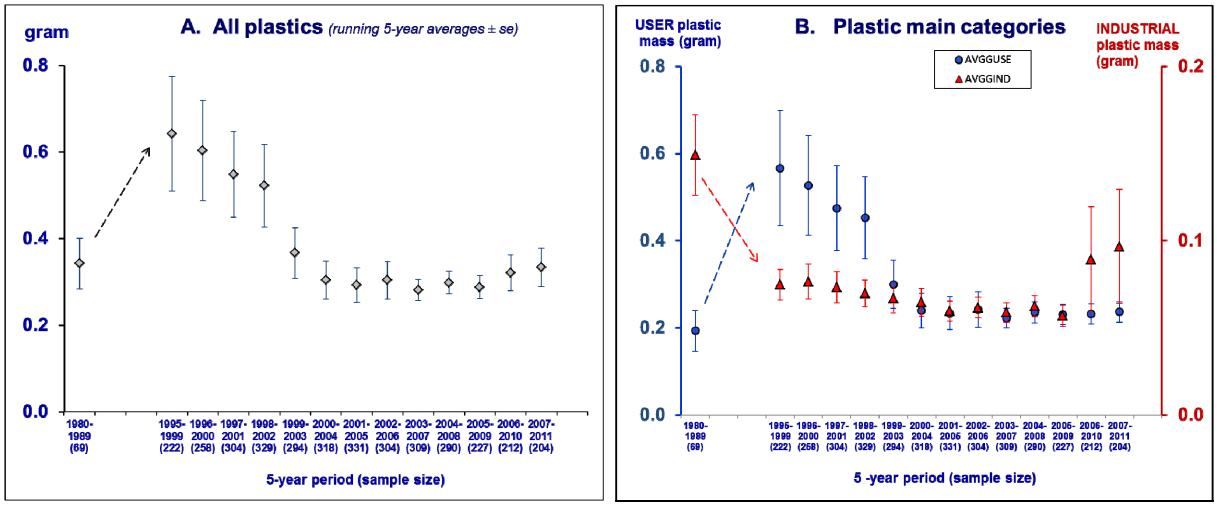

Figure ii ***Plastic mass in stomachs of Fulmars from the Netherlands 1980s-2011.*** *Figure A. shows data for all plastics combined; the figure on the right splits these data into user plastic (blue circles, left y-axis) and industrial plastic (red triangles, right y-axis). Data are shown by arithmetic average ± standard error for mass in a single datapoint for the 1980s and running 5 year averages after 1995 (i.e. data points shift one year ahead at a time).*

Statistical tests for trends, illustrated in Fig.*iii* (and listed in detail in Report Table 4) are linear and thus ignore the long term rise and fall in overall plastics and user plastics before and after the mid 1990s. Industrial plastics on the other hand have strongly decreased since the early 1980s, resulting in a persistent highly significant long-term reduction ($p<0.001$) in spite of relative stability over the last decade and even increases in averages in the most recent 5-year periods. Recent data for average mass of industrial plastics are strongly influenced by just 2 birds, one in 2010 and one in 2011, having an exceptionally large number of industrial granules in the stomach (visible as uppermost individual

datapoints for 2010 and 2011 in graphs of Fig.*iii; also see photo in Chpt.5).* Statistical tests based on ln transformed data are not really affected by the two outliers. As a consequence of this mix of long-term trends, the composition of plastic litter has strongly changed since the early 1980s, with nowadays a reduced proportion of industrial plastics (from about 50% to circa 20% of total mass) and an increased mass of user plastics. Decreases in industrial plastics have been observed in different parts of the world.

Recent 10-year trend 2002-2011

*R*egression analyses for 10-year trends showed significant decrease for the last time over the 1997-2006 period. Since then no significant trends have been observed in either industrial or user plastics. The 2002-2011 analyses suggest slowly continuing decreases for industrial plastic (negative t-values in Report Table 4B ; slope in Fig.*iii* B slightly downward) and slow increases for consumer plastics (positive t-values in Table 4B; slight upward slope in Fig.*iii* B). But none of these recent trends are statistically significant.

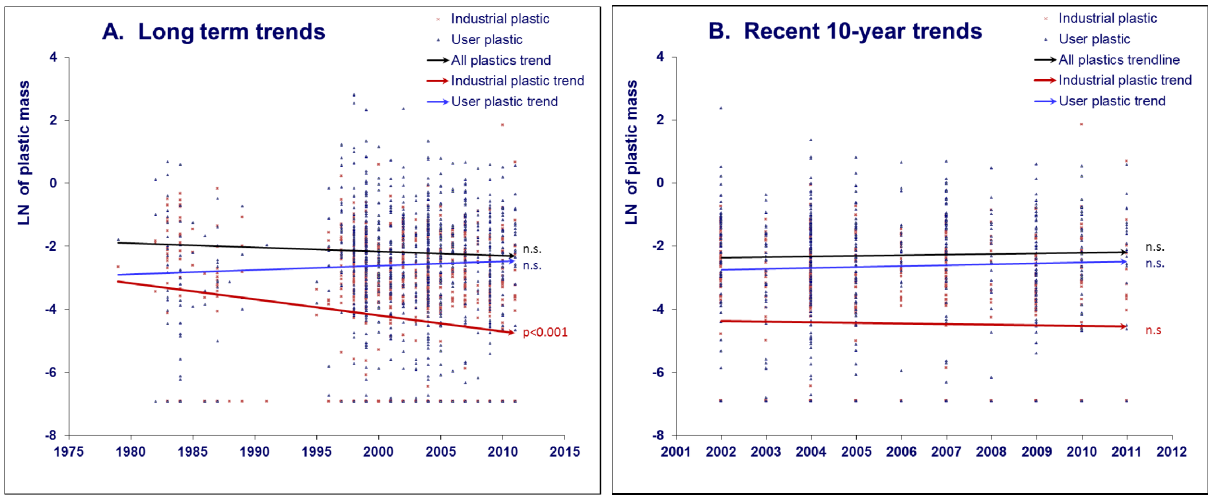

Figure iii ***Statistical trends in plastic mass in stomachs of Fulmars from the Netherlands 1980s-2011.*** *Graphs show ln transformed mass data for industrial plastic and user plastic in stomachs of individual Fulmars, plotted against year, and linear trendlines for industrial (lower, red line), user (middle blue line) and total plastics (top black line). Figure A. shows long term trends and B the recent trend over the past 10 years of data. Full details for results of statistical tests for trends are available in Table 4 of the report. N.s means that the test result is not significant.*

Monitoring data for the North Sea

Fulmar study areas in the North Sea are grouped into 5 regions, that is the Scottish Islands (Shetland and Orkney), East England (north- and southeast), Channel (Normandy and Pas de Calais), South-East North Sea (Belgium, Netherlands and Germany), and the Skagerrak (Skagen Denmark, Lista Norway and Swedish west coast).

- **Current data for the whole North Sea (years 2007 to 2011; 796 Fulmars) are that 95% of Fulmars had plastic in the stomach , with an average number of 33 particles and mass of 0.38 gram per bird. The critical EcoQO value of 0.1 gram plastic was exceeded by 62% of these birds.**

Underlying this average for the recent 5 year period is a consistent regional pattern, in which highest plastic abundance is seen in Fulmars from the Channel, with decreasing levels further to the north both along western and eastern shores of the North Sea. From our earlier analyses of geographical patterns in fulmar stomach contents and studies of beached litter, our findings are considered to reflect concentrated shipping and fisheries activities in the south rather than coastal or riverine sources in that area. The regional differences are strong, but just not at a statistically significant level. Regional EcoQO

percentages for 2007-2011 range from 55% to 86%, all far above the OSPAR target of 10% maximum (Fig. *iv; Report* Table *5*). In the North Atlantic stepwise decreases can be seen towards higher latitudes, with lowered levels visible in the Faroes and on Iceland, and the lowest levels in the Canadian Arctic. Only the Canadian Arctic approaches the OSPAR target for acceptable environmental quality.

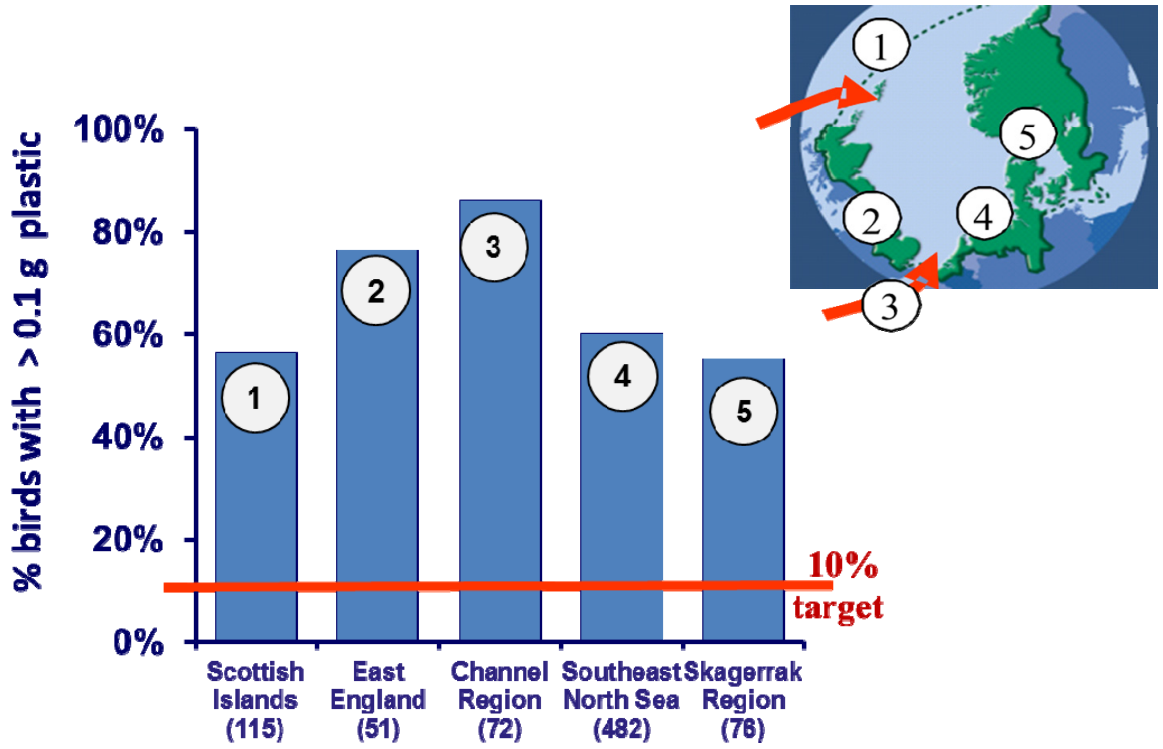

Figure iv ***EcoQO performance in North Sea regions 2007-2011*** *(see Report Table 5 for details).*

Most regional datasets now span 10 years of data, a sufficiently long period to test for trends over time. Trends for Channel area, East England and Scottish Islands are upwards but not to a statistically significant level. Skagerrak and southeastern North Sea seem fairly stable. Location specific trends in the southeastern North Sea suggest decreasing levels in Belgium, stable levels in the Netherlands, and slightly increasing levels of ingested plastics in German Fulmars. It is tempting to speculate that harbour policies in the Rotterdam-Antwerp area are relatively successful, but none of the trends is significant and more factors could be involved.

The consistent large difference in pollution between the Channel area and the Scottish Islands indicates that a large proportion of North Sea marine litter is of local origin. If debris floating into Europe with Gulfstream waters was to blame, pollution to the north and south of UK would be much more similar. In addition, high levels of litter in Normandy, well before inflow of major river systems, suggest that litter in the North Sea is linked to sea-based activities, in particular shipping, rather than to riverine inputs. A detailed beach study on Texel, the Netherlands in 2005 confirmed that most debris had a North Sea origin and was primarily linked to merchant shipping and fisheries: among plastic wastes, 57% of mass were fishing nets and ropes and the major part of the remainder consisted of jerrycans, fishboxes, and other large items clearly linked to seabased activities. Using various other details of beached items, seabased sources were considered to be responsible for about 90% of the coastal debris found on Texel (Van Franeker 2005; Van Franeker & Meijboom 2006). The implementation of the EU Directive 2000/59/EC on Port Reception Facilities since 2004 has not resulted in significant improvement in Fulmar

EcoQO performance in the Dutch time series or the trends for other North Sea regions. However, considering strong increases in shipping traffic and the ever growing proportion of plastics in waste, the relative stability in ingested quantities of plastics in fulmar stomachs over the last decade (Fig.*v*) indicates that it is likely that the EC Directive on Port Reception Facilities has contributed to stabilizing marine debris input in the North Sea in particular in the southeastern sector.

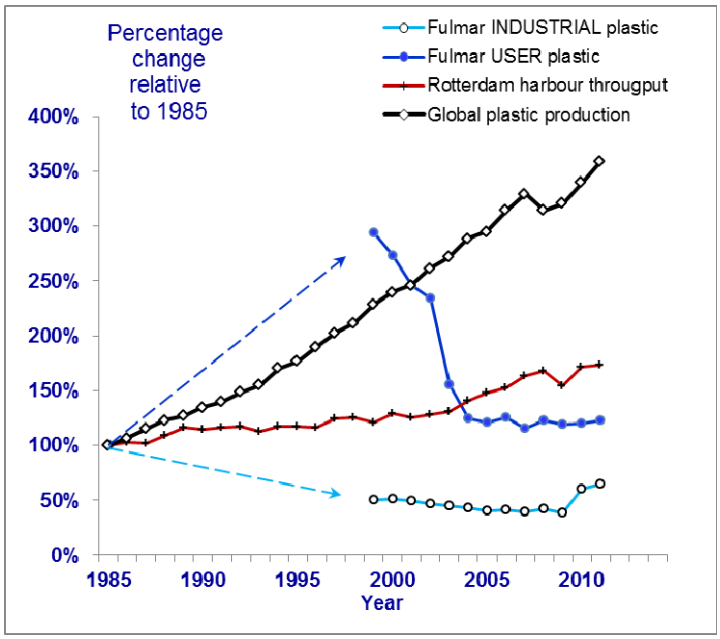

Figure v ***Comparative trends*** *in global plastic production, freight quantities handled by Port of Rotterdam, and mass quantities of industrial and user plastics in stomachs of fulmars (5-year arithmetic averages). Shown are cumulative percentage changes from reference year 1985. (Recent high values for industrial plastic caused by outliers, not significant)*

CONCLUSIONS

1. North Sea governments aim at an Ecological Quality Objective (EcoQO) in which less than 10% of Fulmars exceed a critical level of 0.1 gram plastic in the stomach.
2. In the Netherlands, 60% of Fulmars exceed the 0.1 gram level (*204 fulmars 2007-20011: 95% contained plastic; on average 36 particles per stomach, weighing 0.33 gram).*
3. Long term data for the Netherlands show a sharp increase of marine plastic litter from the early 1980s to the mid-1990s, followed by a similar sharp decline but stabilization and lack of significant improvement during the recent decade.
4. The composition of ingested plastic has changed since the 1980s with a significantly reduced proportion of industrial plastic and increased proportion of consumer waste.
5. Over the whole North Sea, 62% of Fulmars exceed the 0.1g EcoQO level *(796* fulmars *2007-2011: 95% contained plastic; on average 33 particles per stomach, weighing 0.38 gram).*
6. Regional variation in the North Sea is consistent with highest pollution in the Channel (*86% of Fulmars exceed 0.1g EcoQO limit*) and less pollution further north (*to 55%*).
7. Shipping and fisheries continue to be considered the major source for marine litter in the North Sea.
8. In the North Sea, regional trends in amount of plastic in stomachs appear upward in the Channel, east England and the Scottish Islands, and relatively stable in the southeastern North Sea and Skagerrak. Within the southeastern North Sea, Belgian Fulmars suggest decreases, Dutch birds stability, and German Fulmars some increase. None of the trends reaches statistical significance.
9. Policy measures aimed at the shipping sector, such as implementation of the European Directive on Port Reception Facilities (Directive EC 2000/59/EC) probably have contributed to a stabilization in marine litter levels, but not yet to reduction.

Photo:

During a large scale beach litter study at Texel in 2005, 57% of the mass of plastic waste were ropes and nets, clearly related to shipping and fisheries. Much of remaining 43% of plastic mass consisted of jerrycans, fish boxes, crates and other large items clearly linked to seabased sources, rather than to tourism or coastal activity. Further pictures and report (dutch language) are available at : http://zeevogelgroep.nl/SchoonStrandTexel2005/