

EcoQO on plastic particles in seabird stomachs

Background

The occurrence of plastics (and other man-made types of litter) in the marine environment is due solely to human activity, and can therefore be controlled by human management. Operational and cargo-related wastes from ships are an important source of litter in the marine environment in the entire North Sea. Marine litter, in which plastic has the dominant role, causes huge economic damage (Hall 2000) through costs for coastal clean-ups, reduced tourism, disabled ship propellers and engines, tainted fish-by-catch, and damage to coastal agriculture. Furthermore, marine litter causes ecological damage to a wide range of marine organisms, including at least marine mammals, birds, turtles and fish (Laist 1997; Derraik 2002). Such damage results from: a) entanglement in litter items leading to lethal injury, drowning or starvation, and b) ingestion of plastic and other litter by many species that mistake marine debris for food. Ingested plastics, if not directly lethal, deteriorate body condition by a reduced intake of normal food, negative effects on digestion and elevated body-burdens of toxic chemicals.

The Northern Fulmar is a particularly convenient species to measure plastic pollution by stomach content analysis. Like the whole group of 'tubenosed' seabirds (the albatrosses and petrels), it frequently ingests plastic litter. Fulmars are abundant in the North Sea, forage exclusively at sea, 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. In a pilot study, it was shown that stomach contents of beached emaciated birds have the same amounts of plastics as healthy birds.

Sampling programmes of beached dead fulmars have already been established in a number of locations around the North Sea. Most of these are conducted as a part of existing long-term Beached Bird Surveys. A monitoring programme using litter abundance in stomachs of beached fulmars has been in effect in the Netherlands since 1982. As of 2002, the Dutch fulmar research was expanded to all countries around the North Sea as a project under the Save the North Sea (SNS) programme and has been developed further as an 'Ecological Quality Objective (EcoQO)'.

The EcoQO is formulated as: *“There should be less than 10% of northern fulmars (*Fulmarus glacialis*) having more than 0.1 g plastic particles in the stomach in samples of 50 to 100 beach-washed fulmars found from each of 4 to 5 areas of the North Sea over a period of at least five years.”*

The aim of the EcoQO is not just a healthy fulmar population, but a healthy environment for all species in the ecosystem, the fulmar is a convenient monitoring tool. The 10% target-level was advised to OSPAR as a relaxation to OSPAR's initial proposal of 2%. Compared to levels just out of the North Sea at the Faroe Islands (at that time about 25% birds with > 0.1 g plastic) the 10% target-level seemed ambitious but achievable (ICES 2006). The choice for 10% is thus not directly related to a particular health status of fulmars, but a political choice. Currently 10% levels probably only occur in arctic populations (Van Franeker *et al.* 2008). The 0.1 g level is also not directly related to harm to the fulmar; originally an amount of 10 particles was proposed, this was later changed to the more exact measure of 0.1 g (the average weight of 10 particles). A biologically meaningful level cannot be really established, because a 'no effect' level for fulmars could still be harmful to other ecosystem components. Thus, the EcoQO is an indication of the level of litter in the marine environment, not of harm to the fulmar or to the marine environment.

The main sea-based sources of marine litter are shipping and fisheries. Other sources include coastal tourism and land-based waste dumps that are either located directly at the coast or near rivers that discharge into the sea. In the short term, the most promising measure to reduce litter is a focus on litter from shipping and fisheries through a further refinement of the implementation of the EU Directive on Port Reception Facilities (EU Directive 2000/59/EC). In the longer term, amendments to MARPOL Annex V (simplifying rules to basically 'no discharge') and support to the 'Clean Ship' concept offer potential to reduce marine littering from ships. Specific measures may be needed with regard to discarded and lost fisheries materials including those from mariculture.

Overview of results from recent monitoring

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 6.1) 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.

EcoQO compliance by fulmars in the North Sea and on the Faroe Islands is shown in Figure 6.1: in spite of clear regional differences, the percentage of fulmars with more than 0.1 g 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 g (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 sub-categories 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 g. The geometric mean mass for plastics in fulmars from the Scottish Islands is 0.05 g, 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.

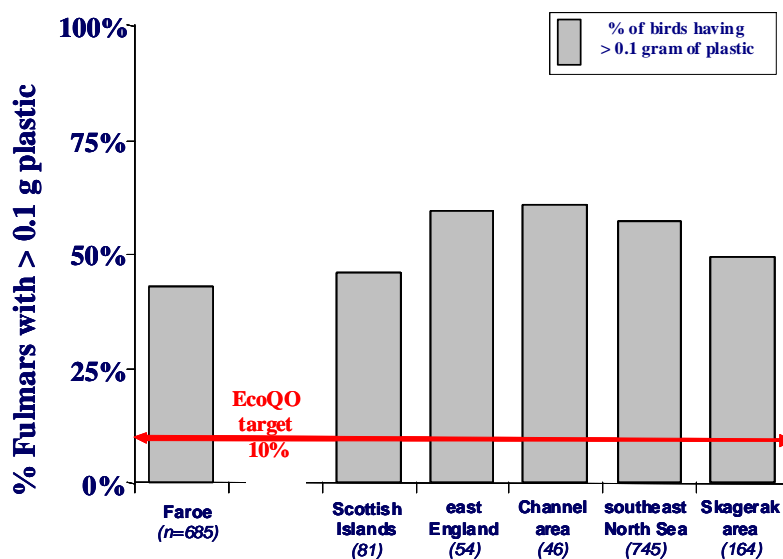


Figure 6.1: The EcoQO performance of Fulmars from study areas around the North Sea and the Faroe Islands over the 5 year period 2002 - 2006: the percentage of beached Fulmars having more than 0.1g plastic in the stomach. All age groups combined.

The 2002 - 2006 study period is too short to properly analyse for temporal trends in separate locations or regions. However, good sample sizes were obtained in the Netherlands, 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: south-eastern North Sea) in Figure 6.2 show a weak general downward trend. In 2006, the German mean went up, as in the Netherlands, but the Belgian mean continued to decrease from 2003 onwards. Linear regressions of the individual data 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 indicates (slow) improvements following implementation of the EU Directive on harbour reception facilities. Over a longer time series 1982 - 2006 Dutch data indicate that peak levels of plastics were observed in the late 1990s and have significantly declined since. Composition of plastic litter has changed since the early 1980s with strong reductions in industrial plastic but increases in garbage type plastics.

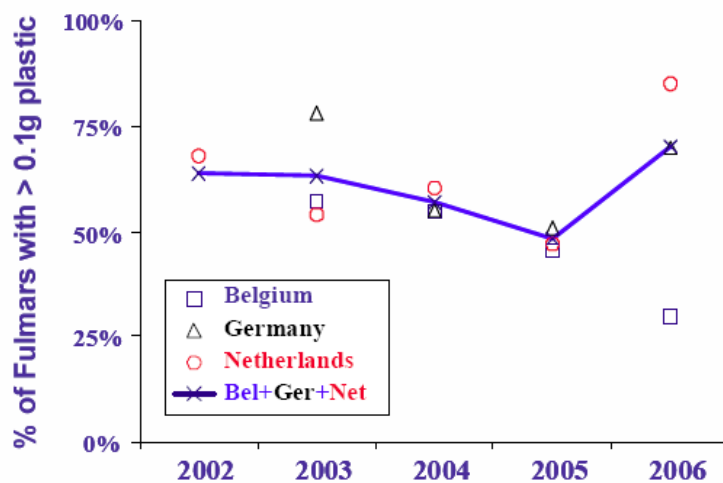


Figure 6.2: EcoQO performance in the south-eastern North Sea 2002 - 2006 – Annual percentages of beached Fulmars having more than 0.1 g plastic in the stomach in Belgium, Netherlands, Germany and the combined region.

Has the EcoQO been met?

As can be seen from Figure 6.2 the EcoQO has not been met in any of the study areas anywhere in the North Sea.

Consequence of failing to meet the EcoQO

The ecological consequences of failing to meet the EcoQO do not only apply to fulmars but also to other species of birds, marine mammals, fish and other elements of the marine ecosystem. Damage results from a) entanglement in litter items leading to lethal injury, drowning or starvation, and b) ingestion of plastic and other litter by many species that mistake marine debris for food (Laist 1997; Derraik 2002). A more recent concern is the issue of microplastics and toxic chemicals built into or adhered to the surface of plastics acting as a booster of bioaccumulation of toxic chemicals in marine organisms eating plastic. Small microscopic size plastic particles become increasingly abundant in the marine environment and are ingested by all filterfeeders (Thompson *et al.* 2004; Teuten *et al.* 2007).

The economic consequences of continued high levels of marine litter include high costs for coastal clean-ups, damage to fisheries and danger for shipping accidents.

From a management point of view, exceeding the level of 10% indicates that the amount of plastic entering the marine environment should be further reduced. In the background document for the EcoQO on plastic particles in stomachs of seabirds (publication number 2008/355) the following priority measures to achieve the EcoQO are mentioned:

- a. Most litter in the North Sea region comes from shipping including fisheries. In the short term, the most promising measure to reduce litter from these sources is a further refinement of the implementation of the EU Directive on Port Reception Facilities (EU Directive 2000/59/EC). The Directive leaves room for national choices, and competition between harbours occurs. Effectiveness of the Directive can be increased by regional agreements on indirect financing and on uniform implementation with a much higher level of service for ship to shore delivery, combined with strict control and enforcement. In the longer-term, amendments to MARPOL Annex V (simplifying rules to basically 'no discharge') and support to the 'Clean Ship' concept offer potential to reduce marine littering from ships. Specific measures may be needed with regard to discarded and lost fisheries materials including those from mariculture.
- b. Potential measures to reduce input from other sources are many, including waste recycling and processing instead of landfill, policy measures to reduce single-use packaging and stimulating awareness among the public and stakeholders.

Suitability of present monitoring and reporting

Over the 2002 - 2006 period, 1090 stomachs of fulmars from around the North Sea have been analysed (see table 6.1) Financial support from the EU Interreg IIIB North Sea programme and the NYK Group Europe Ltd has made this possible and has established a strong international research network. However, EU support has ended, and alternative finances are needed to ensure the network survival and continued data collection for implementation of the Fulmar- Litter-EcoQO.

In the sampling network, the east coast of Britain and the Channel area have been weak links. However, from the SNS project, gradually, a regular Beached Bird Survey is being re-established in North-east England (Dan Turner). In the Channel area, more regular sampling was 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.

Table 6.1: 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 IMAREA Report no. C033/08. Insufficiently sampled locations printed in light italics.

number of stomachs analysed	FAE	BY LOCATION												REGION COMBINATIONS					North Sea
		Scottish Islands		East England		Channel		SE North Sea			Skagerrak area			Scottish Islands	East England	Channel	Southeastern North Sea	Skagerrak area	NORTH SEA
		Shetland	Orkney	<i>North-east-England</i>	South-east England	<i>France Normandy</i>	France Pas de Calais	Belgium	Netherlands	Germany	Denmark Skagen	Norway Lista	<i>Sweden Sotenäs</i>						
2002	38	11	6					1	56	4	1			17	0	0	61	1	79
2003	277	13	10	<i>1</i>				21	39	32	55	7	6	23	1	0	92	68	184
2004	84	17	8	<i>5</i>	40	6	36	97	131	153	51	26		25	45	42	381	77	570
2005	238	5	2	<i>6</i>		4		44	51	69	7	10		7	6	4	164	17	198
2006	48	9	0	<i>2</i>				10	27	10				9	2	0	47	1	59
total 2002-2006	685	55	26	<i>14</i>	40	<i>10</i>	36	173	304	268	114	44	6	81	54	46	745	164	1090
acronyms	FAE	SHE	ORK	<i>NEE</i>	SEE	<i>NMD</i>	FRA	BEL	NET	GER	SKA	LIS	<i>SWE</i>	SCOI	EENG	CHAN	SENS	SKAG	North Sea
summarized plastic abundance:																			
incidence	88%	91%	92%	<i>100%</i>	93%	<i>100%</i>	100%	95%	94%	94%	94%	98%	83%	91%	94%	100%	94%	95%	94%
avg items / bird	13.8	14.9	25.6	<i>24.8</i>	29.8	<i>52.3</i>	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	<i>0.27</i>	0.21	<i>0.31</i>	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	<i>0.205</i>	0.086	<i>0.147</i>	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%	<i>71%</i>	55%	<i>70%</i>	58%	51%	61%	57%	46%	55%	67%	46%	59%	61%	57%	49%	55%

Developments in harmonisation

During the SNS project, three SNS-Fulmar-study workshops have been held at Alterra, Texel, the Netherlands. Each workshop was attended by representatives of nearly every partner in the project. Workshops lasted several days and were used to discuss co-ordination of procedures, analysis of preliminary results, and practical training in the dissection of fulmars. Dissection procedures, methods for measurements, sexing, ageing etc. were thus calibrated among participants. Based on the experiences from these workshops, a manual has been produced describing methods, standard forms and codes used in the dissection of fulmars for the SNS study and future EcoQO monitoring (Van Franeker, 2004).

To ensure full comparability of results in regional comparisons, stomachs from all locations were transported to IMARES on Texel to be analysed by the same team (J.A. van Franeker, A. Meijboom, M.L. de Jong, H. Verdaat). Methods for stomach content analyses were described in Van Franeker & Meijboom (2002) and will be published, in a slightly adjusted format, in the Handbook for the Application of Ecological Quality Objectives in the North Sea (OSPAR 2007/307).

Cost of present monitoring and reporting

Litter EcoQO monitoring in the North Sea has been operational since 2002 by the combination of an existing Dutch monitoring programme of the Netherlands Ministry of VenW, and the international SNS project (EU funded under Interreg IIIB). The Dutch monitoring is anticipated to continue, but EU funding ceased after 2004. Collection of beached fulmars is embedded in existing beached bird surveys or other activities, and requires virtually no additional cost, except for incidental purchases like a freezer. Costs are involved in international co-ordination and mostly laboratory processing of stomach samples. A North Sea wide Fulmar-Litter-EcoQO monitoring programme, on top of the current Dutch effort requires approximately € 10 000 on average per Contracting Party.

Extra cost of harmonisation

Up until now, all stomach analyses in this EcoQO project have been conducted in the Netherlands, with obvious advantages for consistency in methods and maximum comparability of results. Also all database work, calculations and reporting has been integrated in the Netherlands, in association with the Dutch long-term monitoring project for marine litter. Participants in the Save the North Sea Fulmar study group favour the option that project coordination and at least stomach content analysis, database work and reporting continues centrally in the Netherlands. In that case no extra costs of harmonisation are necessary.

Performance of the EcoQO

The technical performance of the EcoQO as provided by ICES, has been summarized in the background document to this EcoQO (OSPAR), some extra information is added here.

ICES criteria	Evaluating comments
Relatively easy to understand by non-scientists and those who will decide on their use.	The message of birds having plastic in the stomach (nearly every Fulmar in the North Sea) is easily conveyed to policy-makers as well as stakeholders and general public, stimulating compliance with measures taken. The Fulmar was the symbol of the successful 'Save the North Sea' campaign, receiving two prestigious awards for the way in which it created awareness on the marine litter issue (Environmental Award from the International PR Association 2005; United Nations Dept of Public Information Grand Award 2005)
Sensitive to a manageable human activity	All plastics in the (marine) environment are due to human activity, mostly intentional disposal, which can be controlled by management intervention
Relatively tightly linked in time to that activity	Persistence of plastic materials could suggest long time-lags in response of the metric to changed activities. However, the EcoQO study (regional differences; changes over time) shows good measurable linkage of the metric to the input-rates of litter in the marine environment within the area under consideration. It is estimated that the amount of plastic in the stomach of a Fulmar is reduced by approximately 75% per month if no new plastics are ingested
Easily and accurately measured, with a low error rate	Easily measured from stomach contents of beached birds. Accuracy and low error amongst other shown by inter-annual consistency and comparability between neighbouring locations
Responsive primarily to a human activity, with low responsiveness to other causes of change	Fully responsive to human activity
Measurable over a large proportion of the area to which the EcoQ metric is to apply	Fulmars are abundant throughout the North Sea area (*), with sufficient spread of locations where beached birds can be collected. (* this species abundant throughout North Atlantic and North Pacific Oceans, with suitable comparable indicator species of tube-nosed seabirds occurring worldwide)
Based on an existing body or time-series of data to allow a realistic setting of objectives	The combination of a long time series of data for the Netherlands (since the 1980s) and the wider 'Save the North Sea' study (since 2002) has already led to modification of earlier wording of the EcoQO to a more realistic one as defined (<i>See ICES 2006 and EcoQO reports cited</i>)

Specific links with the MSFD

The EcoQO on plastic particles in stomachs of seabirds can be used as an indicator for GES Descriptor 10 of Annex 1 of the MSFD: "Properties and quantities of marine litter do not cause harm to the coastal and marine environment."

In the context of the initial assessment under the MSFD, the EcoQO is able to provide an indication of the environmental quality status with regard to the effect of floating litter on the marine environment.

Gaps in knowledge

Some areas do not yet have a Beached Bird survey as complete as might be desirable. As a consequence sample sizes from some areas are small, implying that it will take a longer period before meaningful statistics can be applied. Overall, longer time-series are needed to analyse temporal trends.

Effectiveness of communication

The fulmar was the symbol of the successful 'Save the North Sea' campaign, receiving two prestigious awards for the way in which it created awareness on the marine litter issue (Environmental Award from the International PR Association 2005; United Nations Dept of Public Information Grand Award 2005).

Possible milestones up to the achievement of the objective

Given the limited timeframe in which the measures have been taken and the fact that monitoring in most areas has only recently started, a sensible evaluation of the situation and hence the prediction of milestones, will only become possible at a later date.

Potential applicability of the EcoQO in other OSPAR Regions

The Northern Fulmar is abundant throughout the North Atlantic and North Pacific Oceans. IMARES is currently providing assistance to organisations along the Pacific US coast, which are in the process of establishing a similar litter monitoring programme using fulmars. For seabird based monitoring of plastic in southern OSPAR regions and the Mediterranean, where fulmars do not occur, a pilot study is being conducted using the Cory's Shearwater (*Calonectris* sp). There are suitable comparable indicator species of tube-nosed seabirds (albatrosses and petrels) occurring worldwide.

References

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