3.c.5. A standard protocol for monitoring marine debris using seabird stomach contents: the Fulmar EcoQO approach from the North Sea.

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Monitoring; Litter; Plastic; Ingestion; *Fulmarus-glacialis*; Ecological-Quality-Objective; OSPAR; Europe

BACKGROUND
The ultimate fate and environmental impact of marine plastic debris is a major policy concern that requires reliable assessments of regional pollution levels and rates of change: such information is critical for efficient decision making and setting the right priorities of measures to be taken. Bio-monitoring can provide such assessments by integrating pollution levels over space and time with an immediate link to ecological impact. It is the ecological impact that generates public awareness of the urgency of the problem and the willingness to accept and support measures to deal with that problem.

METHODOLOGY
Seabirds that regularly ingest marine debris, like many tubenoses, are suitable bio-monitors of litter in the marine environment. In Europe, in the North Sea, regional differences and trends in marine litter are monitored by the abundance of plastics in stomachs of beached Fulmars (*Fulmarus glacialis*). Fulmars forage only out at sea and usually retain poorly digestible particles in their stomach. The accumulated plastics in their stomachs provide an integrated picture of litter abundance in their foraging area over a longer period of time.

In the 2002-2004 'Save the North Sea' campaign (www.savethenorthsea.com), a wide range of persons and organizations joined forces in a program collecting beached Fulmars for marine litter research. This group has been able to continue its work until present. Procedures for dissections, stomach analyses and data processing have been standardized as one of the Ecological Quality Objectives (EcoQO's) for the North Sea by OSPAR *(Convention for the protection of the marine environment of the North-East Atlantic*). The dissection protocol (van Franeker 2004) include details to assess age, sex, condition, origin, cause of death, etc. In a pilot study in the Netherlands (van Franeker & Meijboom 2002) only age was found to have an effect of the amount of litter in the stomach, with younger birds having more plastics. But for robustness of future analysis, records of potentially relevant other variables are maintained.

Contents of the complete stomach, that is the combination of the glandular proventriculus and the muscular gizzard, are rinsed over a 1mm sieve and then sorted under binocular microscope. Remains are categorized into various plastic types (industrial pellets and various user categories), other rubbish types and natural components (see project reports for details). Plastic categories are counted for number of particles and weighed on an electronic mass balance with accuracy to 4th decimal of a gram. The OSPAR EcoQO mainly looks at a simplified overall figure related to the mass of all plastics in the stomachs, but details on sub-categories assist in data interpretation.. The following conventions and definitions apply:

- **'Incidence'** is the percentage of birds in a sample having plastic.
- **'Averages for the numbers or mass of plastics'** refer to 'population averages', so calculated over a sample including the birds that had no plastics at all.
- **'Current Situation'** = the situation over the most recent 5-year period, in which data are calculated from all individuals *(i.e. not from annual averages)*.
- **EcoQO Compliance or Performance** = the percentage of birds in a sample that have 0.1 g or more plastic mass in the stomach
- **EcoQO Target'** = the policy target set by OSPAR for 'acceptable environmental quality' is defined as the situation where less than 10% of beached Fulmars has more than 0.1g of plastic in the stomach over a continuous period of at least five years for all North Sea regions (OSPAR 2008)
- **Temporal Trends** are tested by linear regression fitting ln-transformed plastic mass values for individual birds on the year of collection over the past 10 years (='recent trend') or over a full dataset ('long-term trend'; for the Netherlands first individual 1979). Birds without any plastics are included in the analysis by addition of an imaginary 1 mg plastic to all stomach contents prior to logarithmic transformation.
- **Regional Differences** are evaluated by fitting data from individual birds in a negative binomial generalized linear model and tested by likelihood ratio test.

OUTCOMES

The dataset for the Netherlands starts with a good sample from the first half of the 1980s, then has few birds until about 1995, after which an unbroken series of good annual samples is available. Data on EcoQO performance over the full period are shown in figure 1. Being the defined time-frame for conclusions on environmental status and avoiding short term fluctuations, all data are presented on the basis of 5-year periods. Over the 2005-2009 period in a sample of 226 Northern Fulmars from the Dutch coast, 58% of the individuals had more than 0.1 gram of plastic in the stomach, which is strongly above the policy target of a maximum of 10% of such birds. More specifically, plastic incidence among Dutch Fulmars in this 5 year period was 95% with an average ± se number of 27.3±2.5 pieces per bird, and average mass of 0.28±0.03 gram. Between the 1980s and 1990s industrial plastics showed significant decreases, but user plastics very sharp increases. From the 1990s the trend for user plastics reversed and was significantly downward until 2006, after which the decrease came to a halt. Currently levels seem stable. The analyses do suggest some decrease for both industrial and user plastics but at an extremely low rate and not at a statistically relevant level. Measures like the European Directive on Port Reception facilities (EC 2000) may have assisted in stabilizing pollution levels, but have not reduced the amount of litter.

In the wider North Sea, current levels for EcoQO performance range between roughly 40% to 80% of Fulmars exceeding the 0.1g critical limit of plastic in the stomach. Heaviest pollution is found in the French-English Channel with gradually declining pollution levels when going further north (Figure 2). Shipping and fisheries are considered the main sources of plastics in the North Sea. In the North Atlantic, the OSPAR EcoQO target for acceptable ecological quality is probably only met in its high arctic regions. Fulmars are widely distributed and numerous over much of the North Atlantic and Pacific, making them very suitable for comparative monitoring over a wide area (e.g. Mallory 2008; Provencher et al 2009; Hyrenbach et al. 5IMDC abstract 204) In areas where Fulmars do not occur, feasibility of other species for bio-monitoring of marine litter should be tested. This needs for example to be done for implementation of the European Marine Strategy Framework Directive (EC 2008; Galgani et al. 5IMDCAbstract 20) where Fulmar monitoring can only cover part of the marine areas.

The Fulmar EcoQO approach has shown that monitoring litter abundance through marine animals can provide a reliable scientific tool for policy decisions and at the same time is an powerful instrument to increase awareness among public and stake-holders promoting the understanding for, and willingness to comply with measures.

PRIORITY ACTIONS

- Governments should facilitate long term bio-monitoring of marine litter in order to:
- Obtain reliable information to make the right policy decisions
- Generate awareness and support for their policy decisions
- Obtain reliable information on the effects of policy decisions

FIGURES AND TABLES

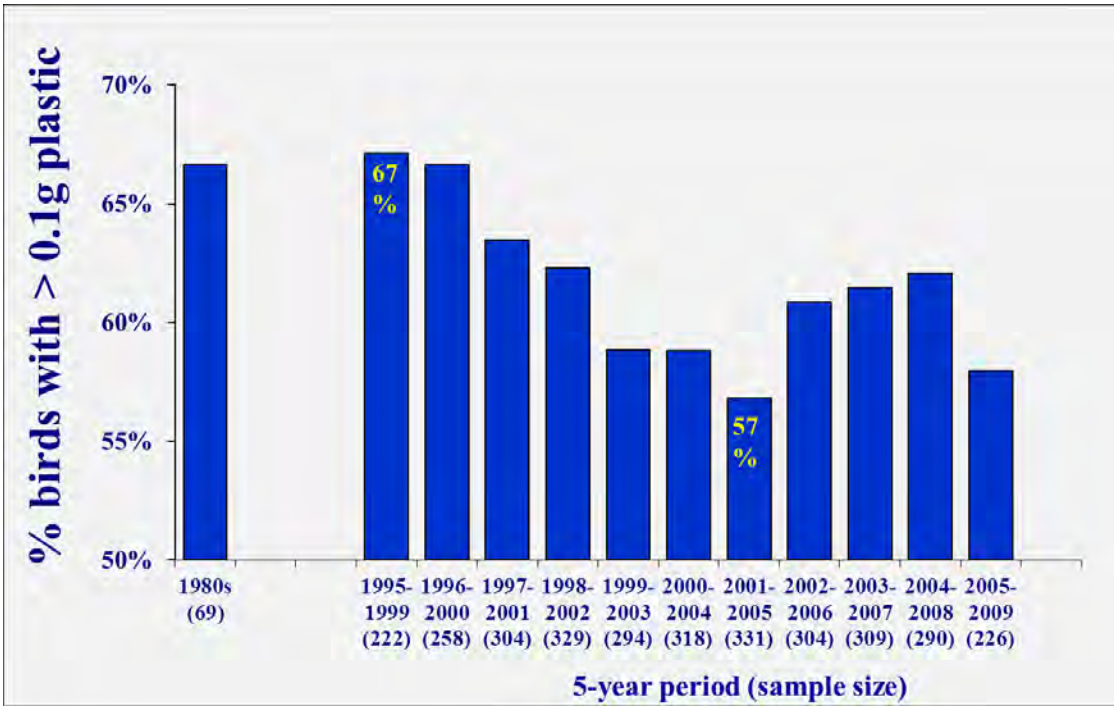

Figure 1. Trend in EcoQO performance in the Netherlands (% of beached fulmars having more than 0.1 gram of plastic in the stomach - *running 5-year arithmetic average for all ages, all plastics; note y-axis starts at 50% in this graph, where reduction target is below 10%).*

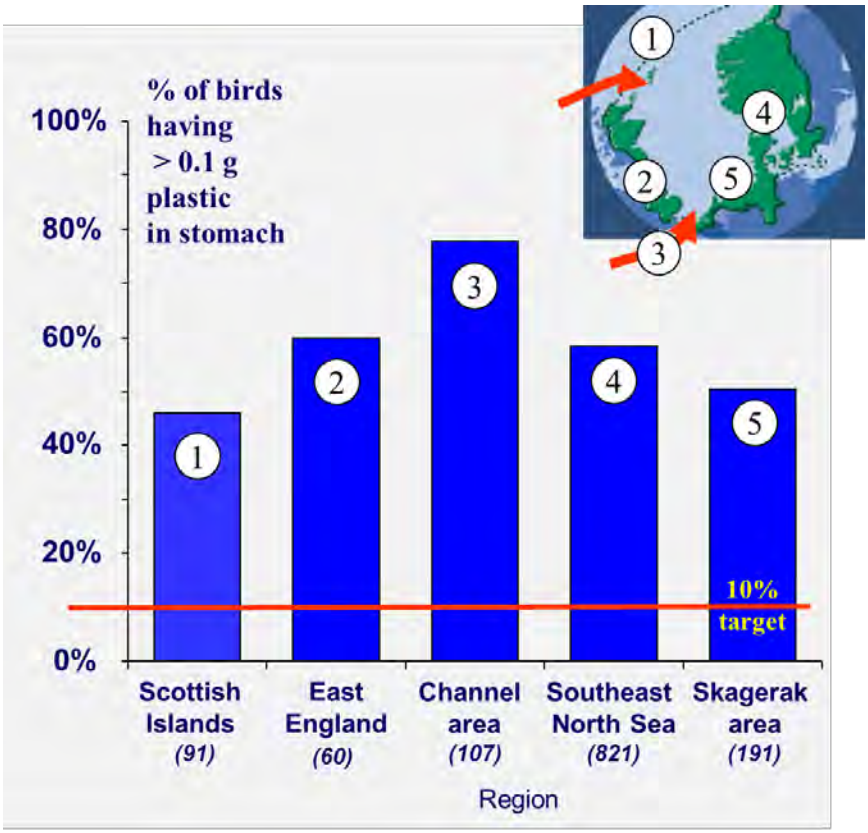

Figure 2. Regional pattern of EcoQO performance in the North Sea (% of beached fulmars having more than 0.1 gram of plastic in the stomach - *5-year arithmetic average 2003-2007 for all ages, all plastics)*

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All Fulmar study project reports on www.zeevogelgroep.nl (click downloads)

Project related info on: www.imares.wur.nl/UK/research/dossiers/plastic/

Fifth International Marine Debris Conference

Waves of Change: Global lessons to inspire local action

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Designing meaningful protocols to monitor debris *presentation 0054*

A standard protocol for monitoring marine debris using seabird stomach contents: **the Fulmar EcoQO approach** from the North Sea

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NYK LINE

NYK LOGISTICS & MEGACARRIER

Chevron

NZG

marine litter = problem

DAMAGE economic

DAMAGE ecological

Dealing with problems requires measurements

Northern Fulmar

Fulmarus glacialis

Havhest
Eissturmvogel
Fulmar boréal
Noordse Stormvogel
Glupysh
Stormfågel

Northern Fulmar – *Fulmarus glacialis*

- sex, age
- condition, health
- cause of death
- origin

etc. size, moult, ...

1 mm mesh

STANDARD METHODS

Number count and mass *by subcategory*

0.0001g

Netherlands

Fulmar-Litter monitoring

1982 – 20…

'North Sea'

Fulmar Study

2002-20....

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Litter categories in Fulmar stomachs

Industrial Plastics

Non plastic rubbish

- *paper & foils*
- *galley waste*
- *other*
- *hooks*

User

- *sheet*
- *thread*
- *foam*
- *fragment*
- *other*

Pollutants

- *slag*
- *tar*
- *chemical ?*
- *preened feathers*

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STANDARD METHODS

conventions and definitions :

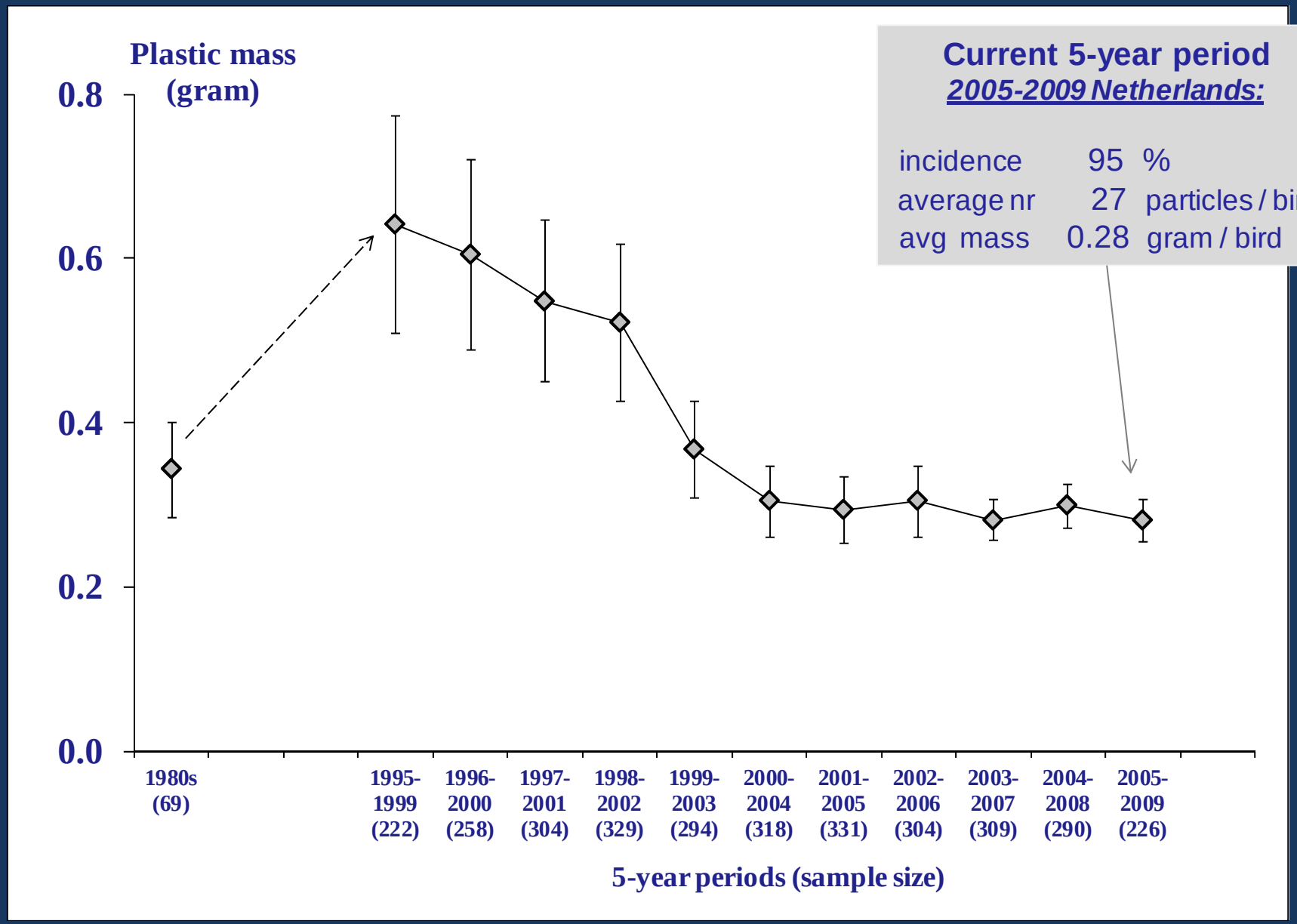
- **‘Current Situation'** = the situation over the most recent 5-year period, in which averages refer to ‘population averages’ calculated over all individuals including the birds that had no plastics.

- **Temporal Trends** are tested by linear regression fitting ln-transformed **plastic mass** + *0.001* g for individual birds on the year of collection over the past 10 years (=‘recent trend') or over a full dataset ('long-term trend‘ *for the Netherlands first individual 1979*)

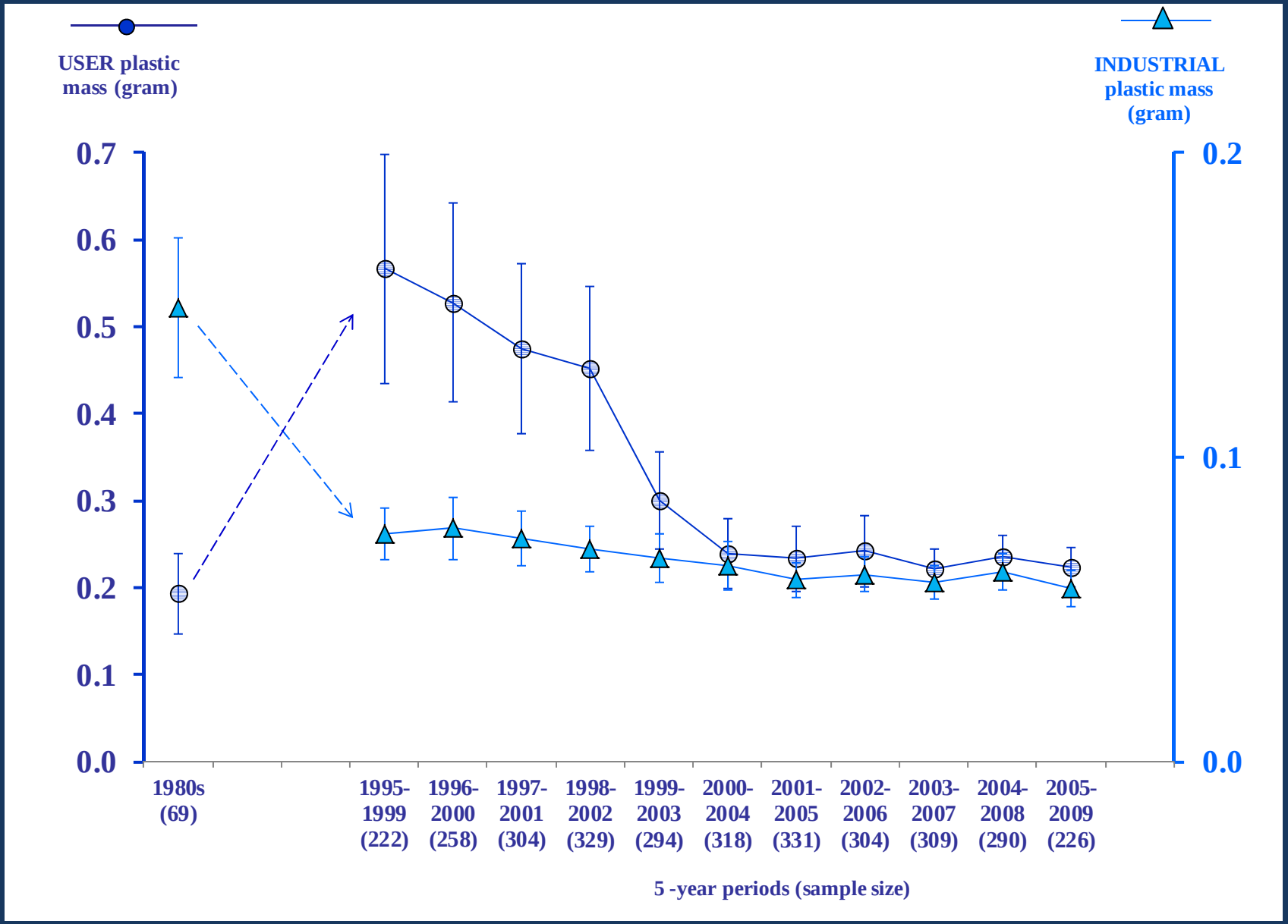
- **Regional Differences** are evaluated by fitting data from individual birds in a negative binomial generalized linear model and tested by likelihood ratio test

Average mass ± se of plastics in stomachs of fulmars in the Netherlands

(running 5-year arithmetic average for all ages, all plastics)



Average mass ± se of industrial and user plastics in stomachs of fulmars in the Netherlands *(running 5-year arithmetic average for all ages)*



OSPAR EcoQOs - *Ecological Quality Objectives*

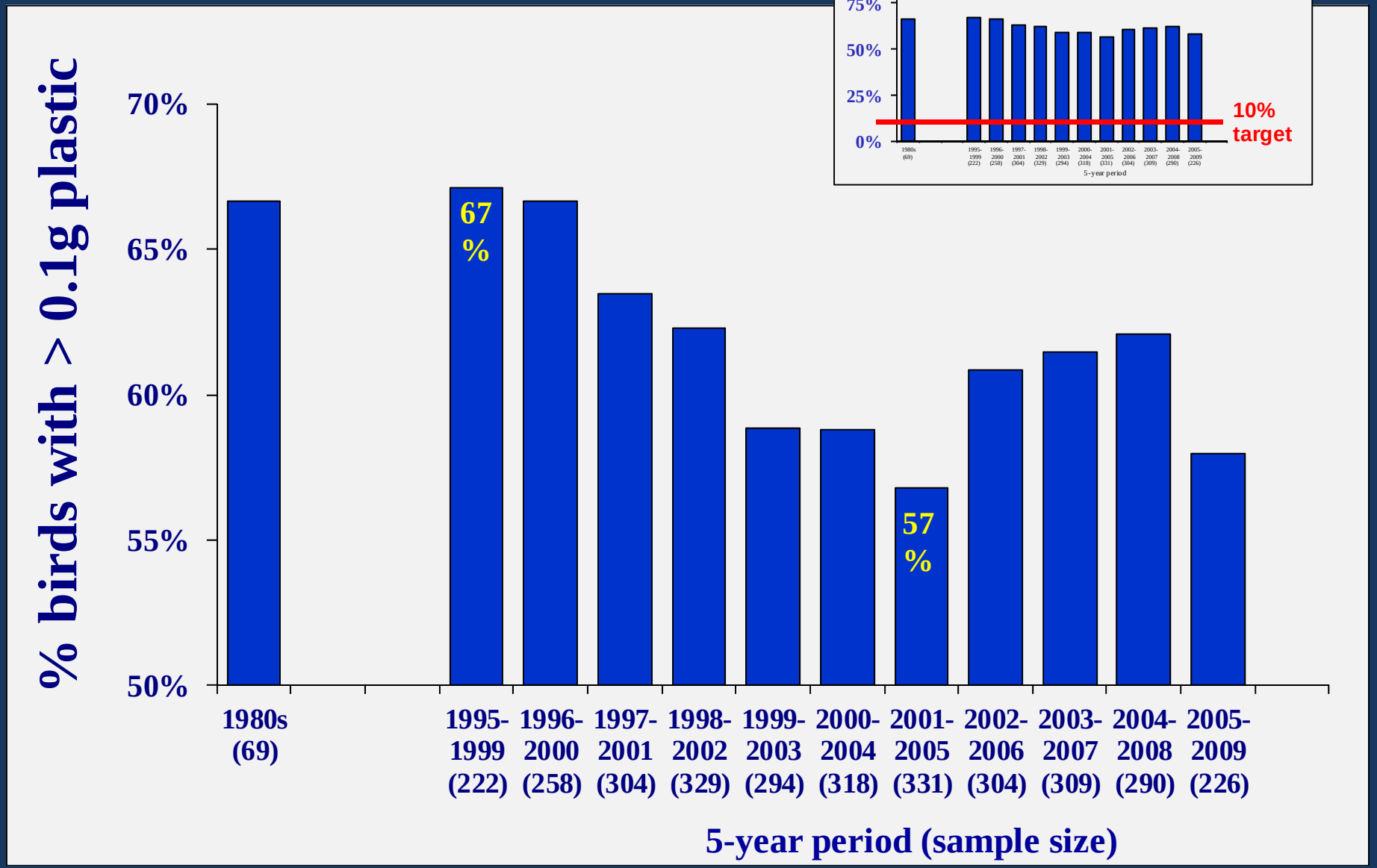
EcoQO on marine litter (plastic) in the North Sea

Quality element
beached Northern Fulmars

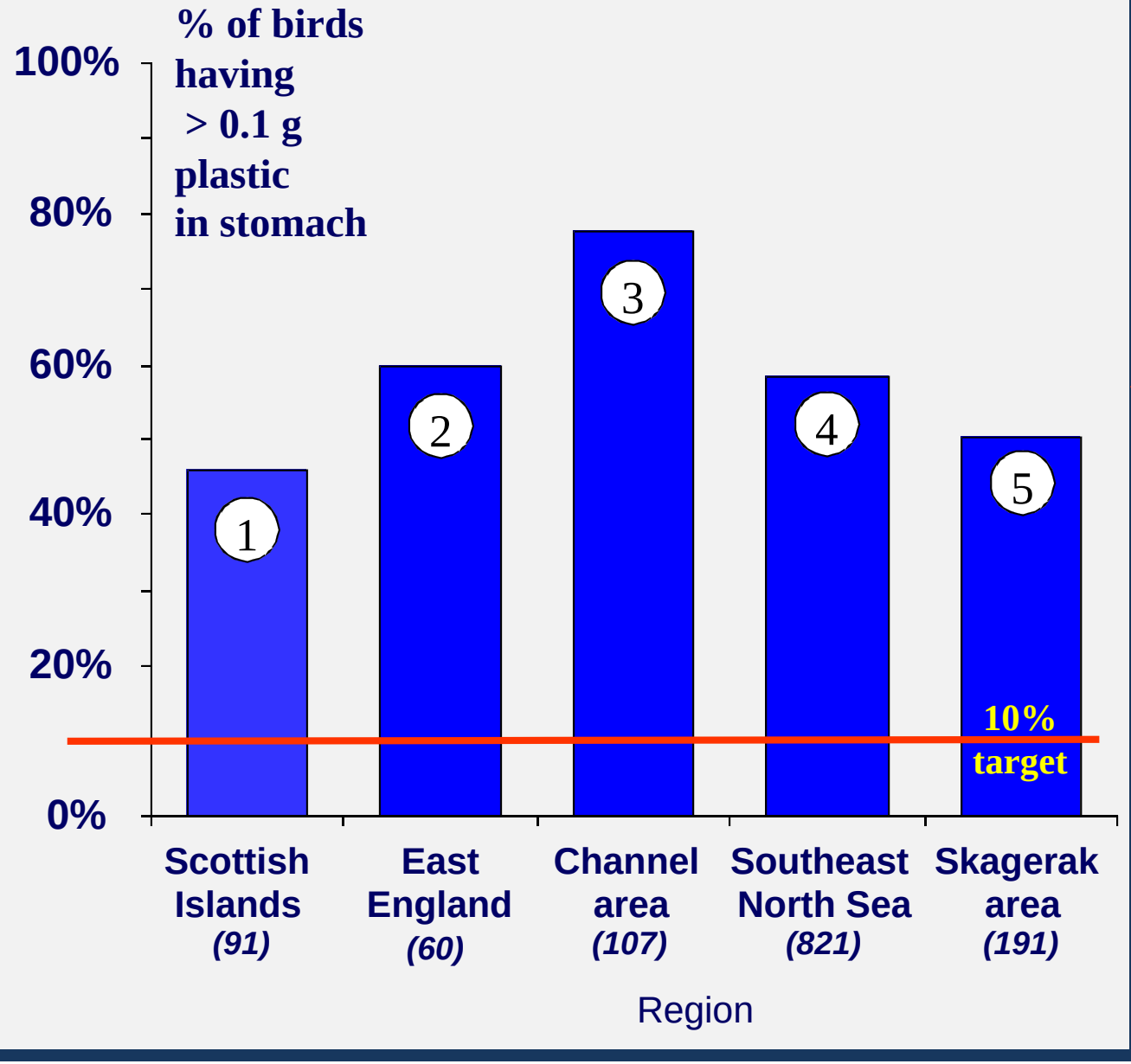
Objective ('target'):
the proportion of Fulmars with more than **0.1g** of plastic in the stomach must be less than 10%
(all regions, for at least 5 years)

EcoQO Compliance or Performance =
the percentage of birds in a sample that have 0.1 g or more plastic mass in the stomach

EcoQO performance Netherlands 1982-2009



North Sea Regional Pattern (EcoQO performance *2003-2007)*



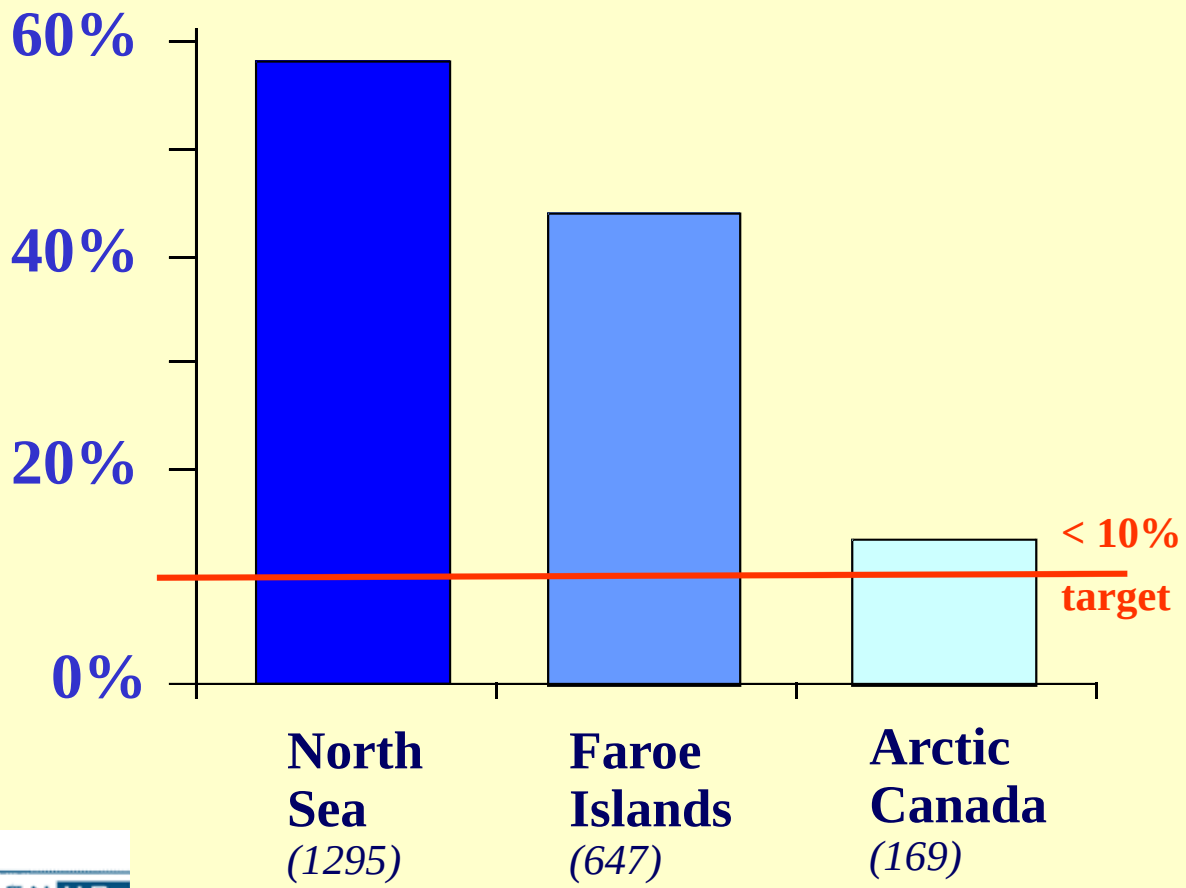
The southern area, in particular Channel, is most heavily polluted: ± twice level of that in Scottish Islands.

The pattern indicates major local pollution sources *(rather than 'background' from e.g. Gulf Stream)*

North Atlantic comparison

EcoQO performance

(% birds with more than 0.1g plastic in stomach)



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Pacific...

Canadian Arctic data from Mallory *et al.* (2006; 2008), Provencher et al 2009 & pers. inf. authors

European Marine Strategy Framework Directive :

in regions where fulmar sampling is not possible other options for bio-monitoring should be surveyed

Other birds ?

Photo: G.Mauger, Groupe d'Étude des Cétacés du Cotentin - GECC

mammals ?

turtles ?

fishes ?

Bio-monitoring is a robust scientific instrument, but also a strong public relations tool !

Both are needed to create the political and public awareness needed for a successful reduction of marine litter

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Priority Actions

Actions to reduce marine debris from 2011-2021.

Governments should initiate and support standardized long term bio-monitoring of marine litter in order to:

1. obtain reliable information to make the right policy decisions
2. generate awareness and support for measures taken
3. obtain reliable information on the effects of their measures

REDUCE – REUSE – RECYCLE

www.imares.wur.nl *Click dossiers .... Plastic.....*

www.zeevogelgroep.nl *Click downloads ... Fulmar study*

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Priority Actions

REDUCE – REUSE – RECYCLE

- **Make deposit & return systems legally required**: high deposit fees for ALL products containing plastic must be standard.
- **Forbid the production of so-called degradable or compostable packaging** for both fossil- or bio-sourced plastic: ***Let plastic be plastic!***

Create value on plastic ‘waste’