Past progress and future opportunities:

Monitoring microplastic pollution in the North Pacific

Stephanie Avery-Gomm
University of Queensland

#PICES2019

@saverygo

LIFE

Throwaway Living

DISPOSABLE ITEMS CUT DOWN HOUSEHOLD CHORES

"The objects flying through the air in this picture would take 40 hours to clean – except no house-wife need bother.

They are all meant to be thrown away after use."

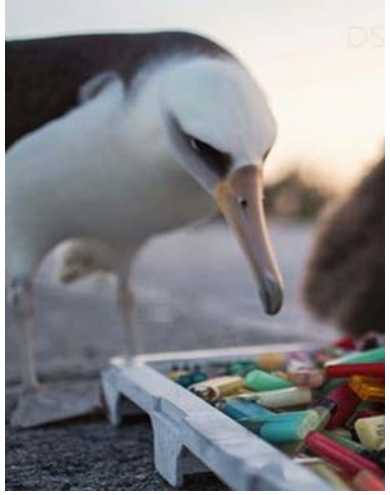
>8 million metric tons of plastic waste enters the ocean each year

Jambeck *et al.*, 2015 *Science*

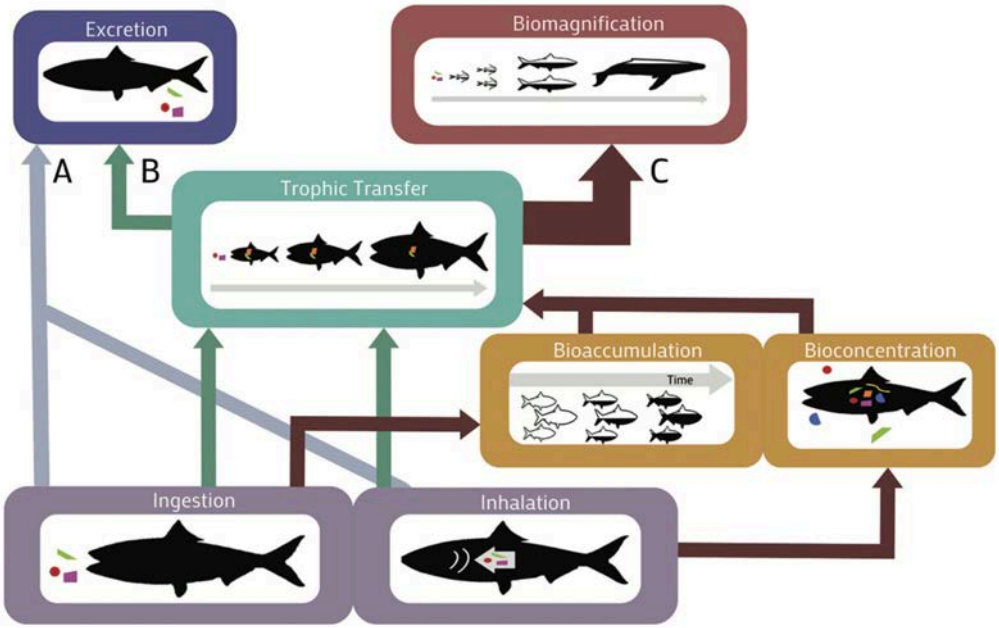
Plastic is everywhere

Water bottle degradation over ~3 years

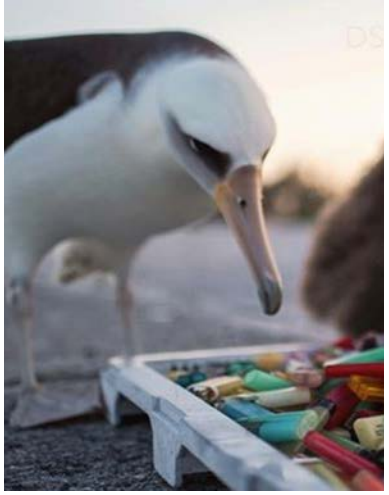
Inaccessible Island ©Peter G. Ryan



Hundreds of species have ingested plastic



Provencher et al., 2018 *Enviro Rev*



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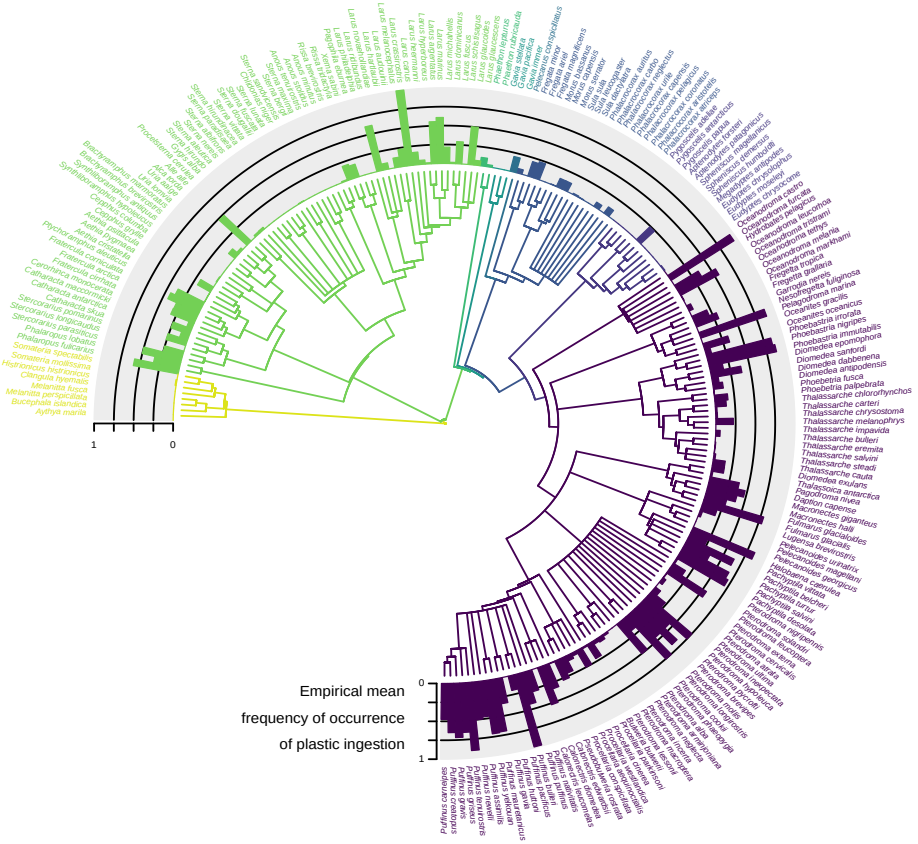
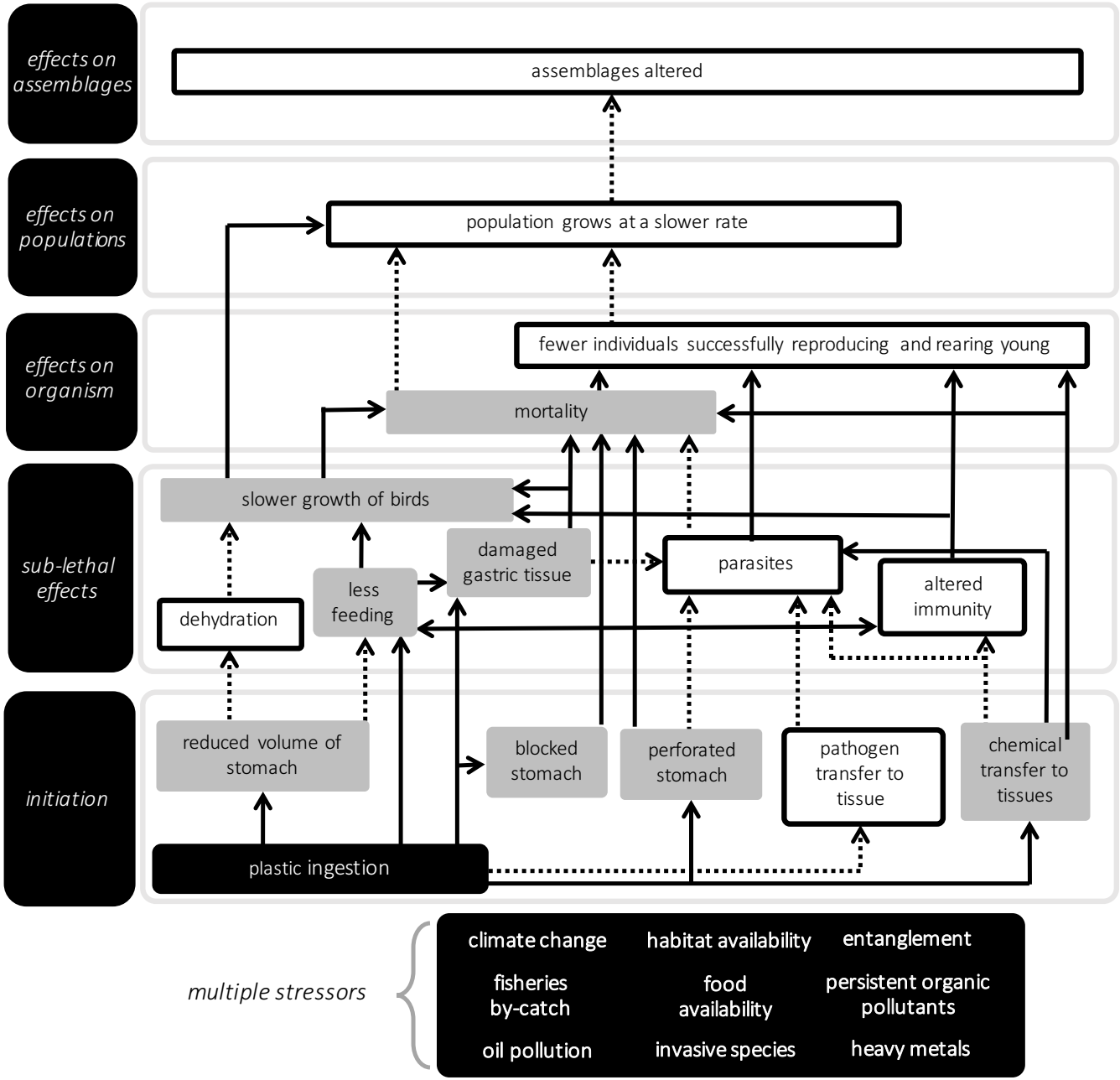


Avery-Gomm et al. *In review*



Browne et al. 2015 *Proc R Soc B*

Plastics are a diverse suite of contaminants

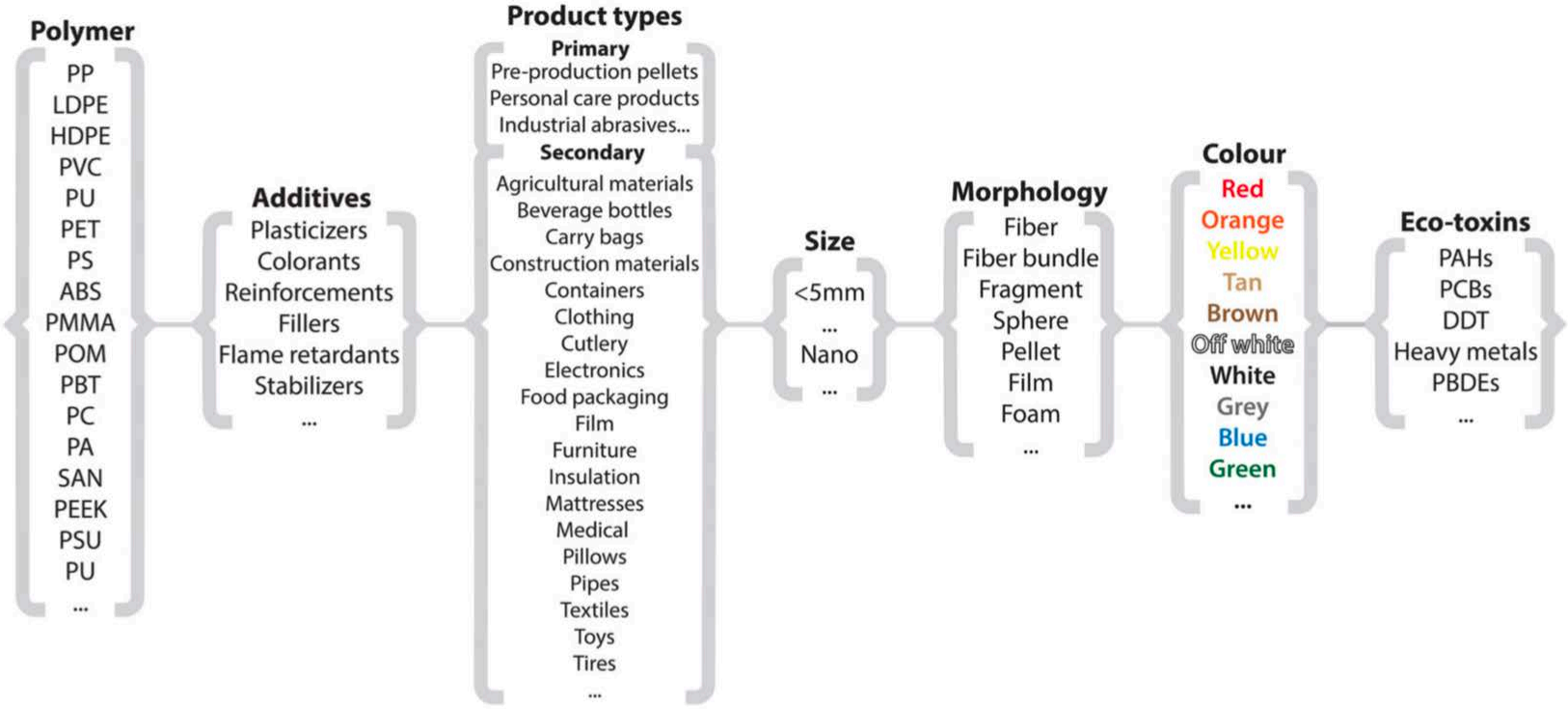
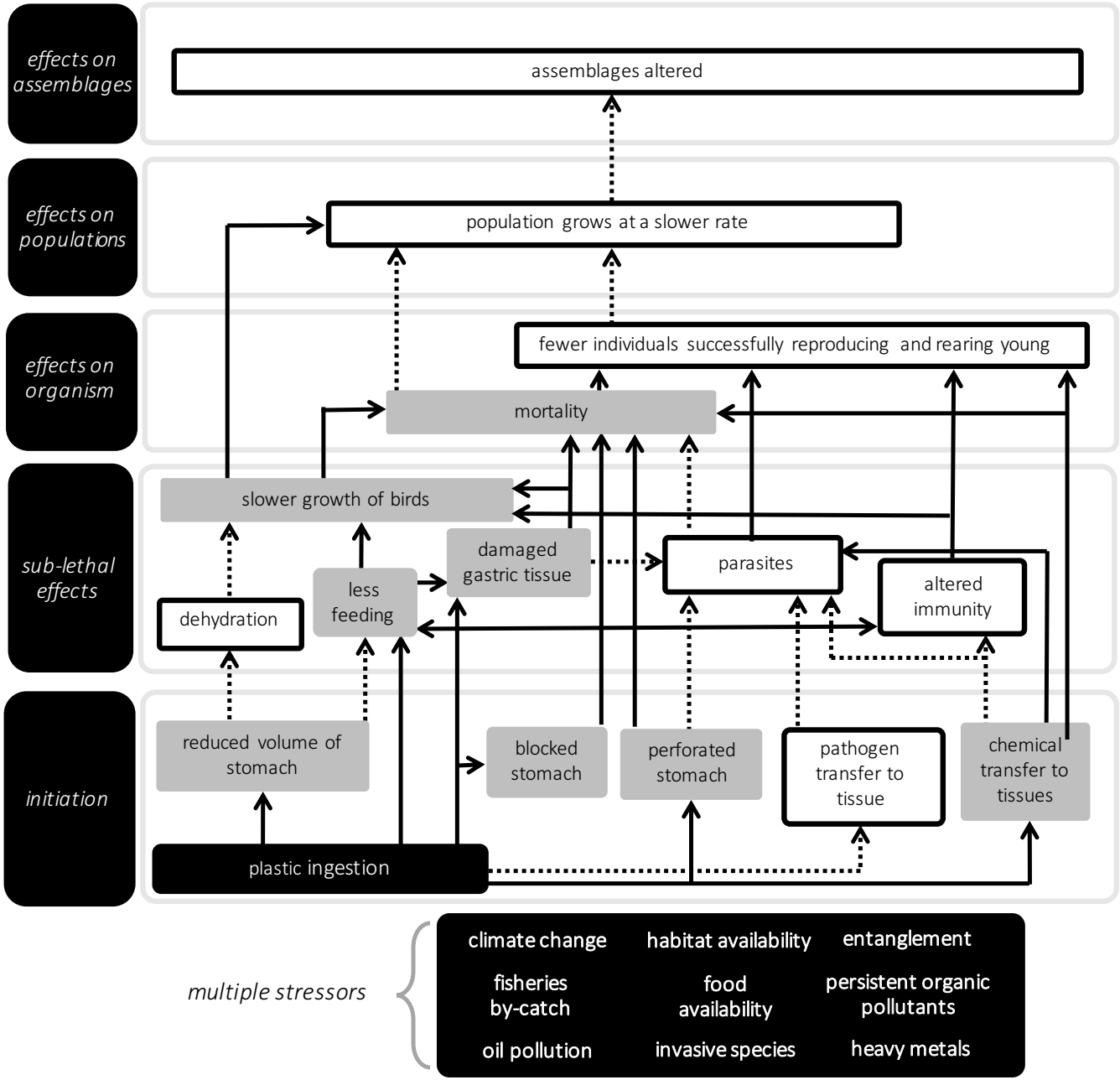


FIGURE 1: Microplastics are made with a variety of polymers, augmented with an array of additives that can be manufactured into a multitude of products. Sources of microplastics can be either primary or secondary, and microplastics may be any size less than 5 mm. Microplastics are described with at least 7 morphologies and are found in many different colors. When in the environment, microplastics can sorb numerous chemical contaminants, including heavy metals and persistent organic pollutants. This is not an exhaustive list. PP = polypropylene; LDPE = low density polyethylene; HDPE = high-density polyethylene; PVC = polyvinyl chloride; PU = polyurethane; PET = polyethylene terephthalate; PS = polystyrene; ABS = acrylonitrile butadiene styrene; PMMA = polymethyl methacrylate; POM = polyoxymethylene; PBT = polybutylene terephthalate; PC = polycarbonate; PA = polyamides; SAN = styrene-acrylonitrile; PEEK = polyether ether ketone; PSU = polyarylsulfone; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; DDT = dichlorodiphenyltrichloroethane; PBDE = polybrominated diphenyl ethers.

Rochman et al. 2019 *Enviro Toxicol Chem*



Browne et al. 2015 *Proc R Soc B*


How do we
get a better picture
of what is going on with
plastic pollution in the
North Pacific?

Can we monitor plastic debris in a **cost-effective** way that detects spatial and temporal trends across an entire ocean?

How will we detect success?

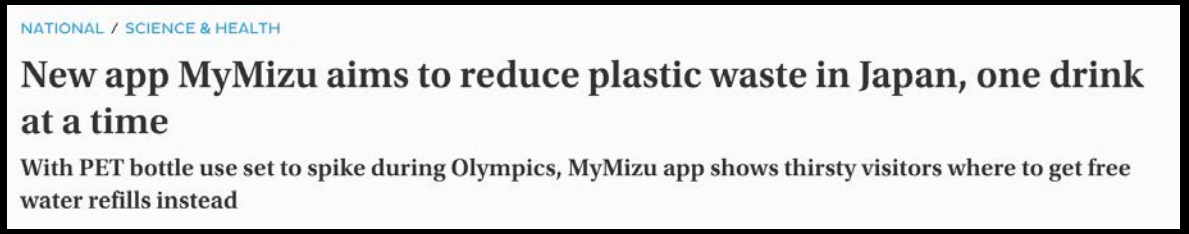

The Moscow Times
INDEPENDENT NEWS FROM RUSSIA

NEWS OPINION BUSINESS MEANWHILE ARTS AND LIFE POD

Russia Moves to Phase Out Plastic Bags in New Draft Law


California bans travel-size plastic shampoo bottles from hotels

Alisha Ebrahimji, CNN • Updated 10th October 2019


NATIONAL / SCIENCE & HEALTH

New app MyMizu aims to reduce plastic waste in Japan, one drink at a time

With PET bottle use set to spike during Olympics, MyMizu app shows thirsty visitors where to get free water refills instead


CNN World + International Edition +

Australia is banning plastic bags. Here's what other countries are doing


Canada to use G7 presidency to push environmental 'zero plastics waste charter'

McKenna wants to stir anti-plastics interest beyond G7 to include G20 countries

Bob Weber · The Canadian Press · Posted: Mar 07, 2018 6:32 PM ET | Last Updated: March 8

Monitoring microplastic pollution

1. Direct sampling of plastic pollution at sea
2. Using biological monitoring
3. Beach surveys

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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

Phil. Trans. R. Soc. B (2009) **364**, 1999–2012
doi:10.1098/rstb.2008.0207

Review

Monitoring the abundance of plastic debris in the marine environment

Peter G. Ryan[1,*], Charles J. Moore[3], Jan A. van Franeker[4] and Coleen L. Moloney[2]

Ryan et al. 2009 *Proc Roy Soc B*

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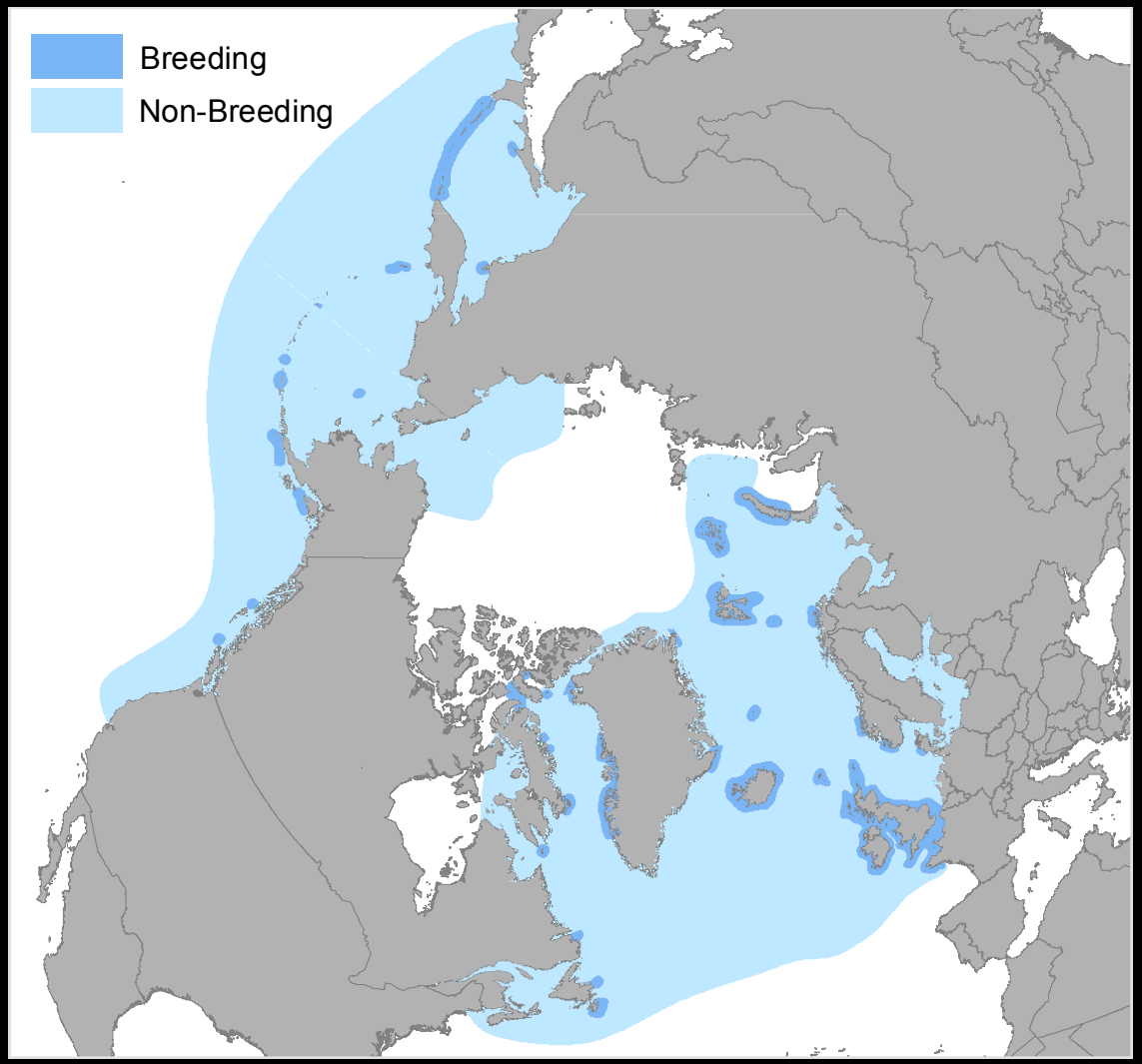
Northern Fulmar (*Fulmarus glacialis)*

Northern Fulmar (*Fulmarus glacialis)* are effective monitors of marine plastic pollution



Northern Fulmar (*Fulmarus glacialis)* are effective monitors of marine plastic pollution

"…because they are fools, they make great tools"

- Stomach content = quantitative data about plastic at sea
- Sources: Beached Bird Surveys, Fisheries Bycatch
- Already vetted as a bio monitor for marine litter

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“Save our North Sea” Program for monitoring marine litter

- 1970s legislative efforts to reduce input of debris
- 2002 North Sea Ministers establish Ecological Quality Objective (EcoQO)
- Northern Fulmar selected as biological monitor for marine litter

Ecological Quality Objective (EcoQO) for marine litter

"There should be less than 10% of Northern Fulmars having 0.1 g or more plastic in the stomach in samples of 50–100 Fulmars from each of 5 different areas of the North Sea over a period of at least 5 years".

Scientist coordinated. Volunteer supported.

Dr. Jan van Franeker

Coordinates Fulmar Marine Litter Monitoring Program

- Beach surveys: volunteer supported
- Bycatch birds: collection from fisheries
- Annual dissection workshops
- Quality control of sample analysis
- Results reported to decision makers
- Lab research refines & improves interpretation of results

WAGENINGEN
UNIVERSITY & RESEARCH

What information about plastic pollution has the North Sea program revealed?

1) Regional differences in microplastic pollution
via comparisons of EcoQO performance

% of birds with > 0.1g plastic

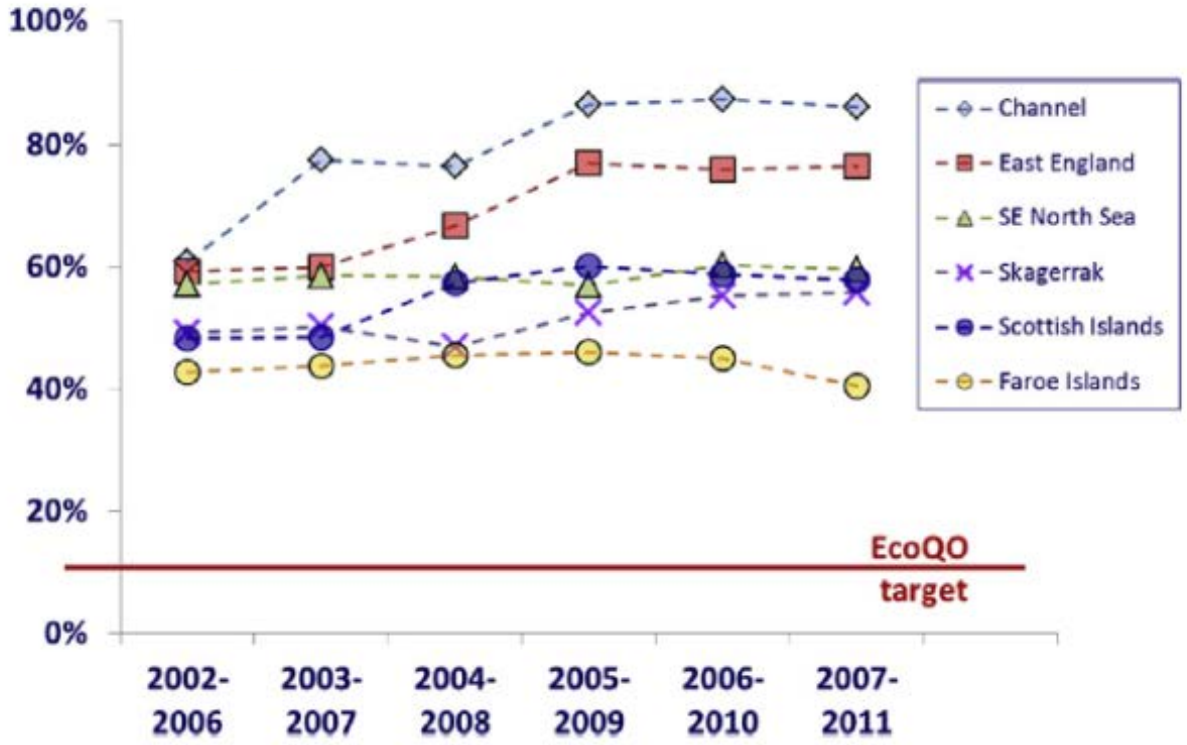

Fig. 3. Regional trends in fulmar EcoQO performance (proportion of fulmars having > 0.1 g plastic in the stomach) over time in North Sea regions and the Faroe Islands (Updated from Van Franeker and the SNS Fulmar Study Group (2013); details in Online Supplement).

van Franeker et al., 2011 *Enviro Poll*

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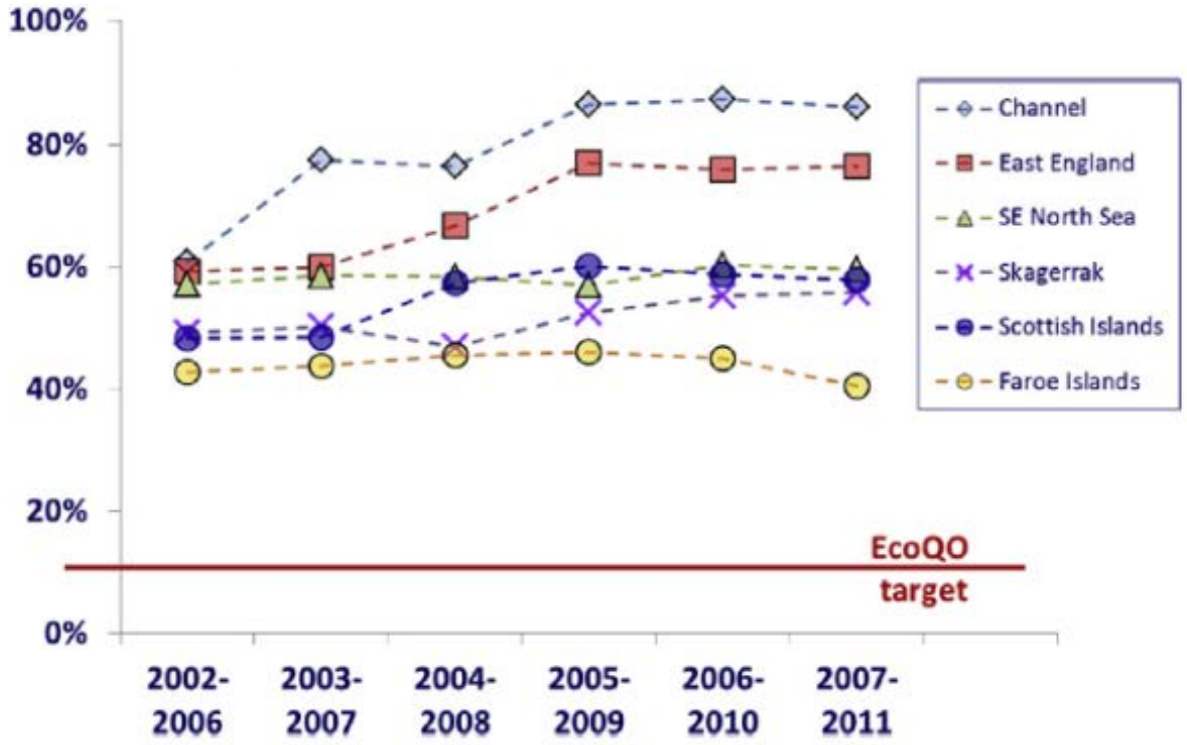

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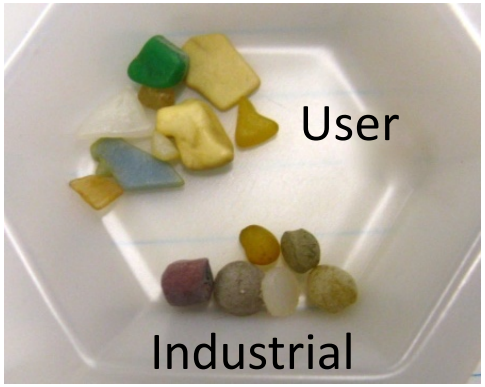
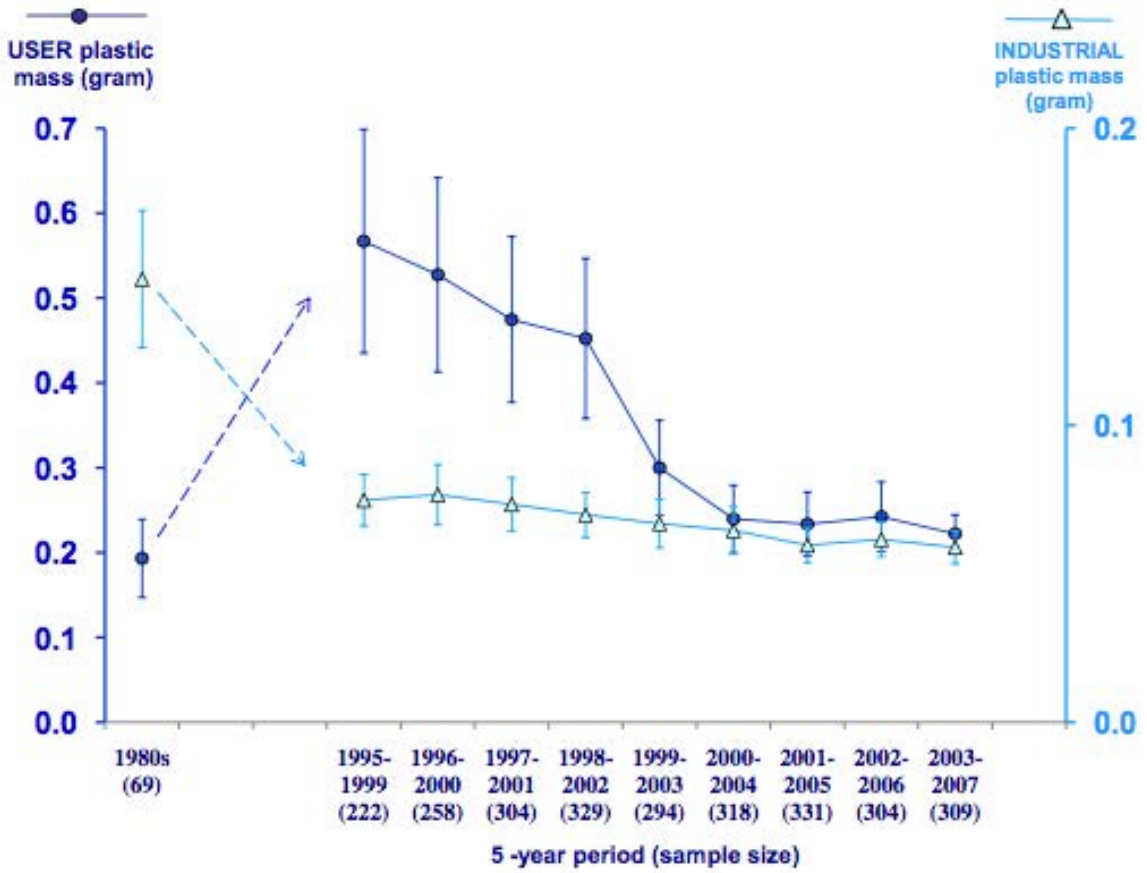
2) Shifts in characteristics of pollution





van Franeker et al. 2011 *Enviro Poll*

3) Consensus between fulmar & at-sea surveys

"Industrial plastic pellets in North Sea fulmars have decreased by ~75%, while user plastics varied without a strong overall change. Similar trends were found in net-collected floating plastic debris in the North Atlantic subtropical gyre, with a ~75% decrease in plastic pellets and no obvious trend in user plastic."

Industrial Plastic

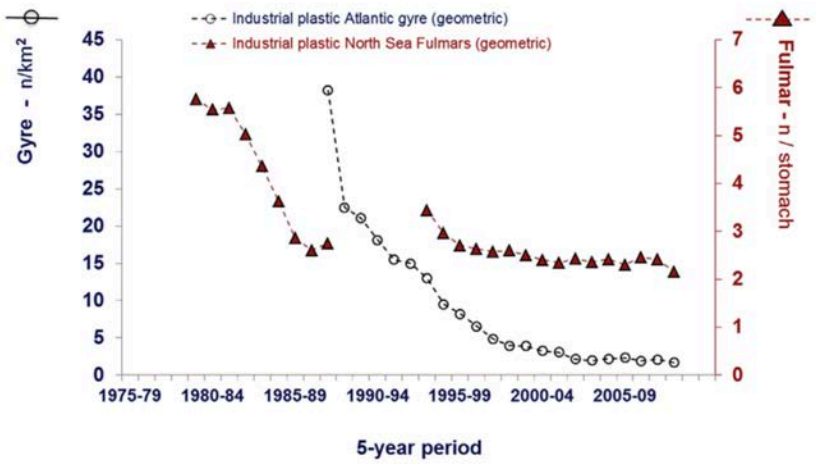


Fig. 9. Comparative trends in numerical abundance of industrial plastics in stomachs of North Sea fulmars and surface densities in the North Atlantic subtropical gyre by running geometric means over 5-year periods.

User Plastic

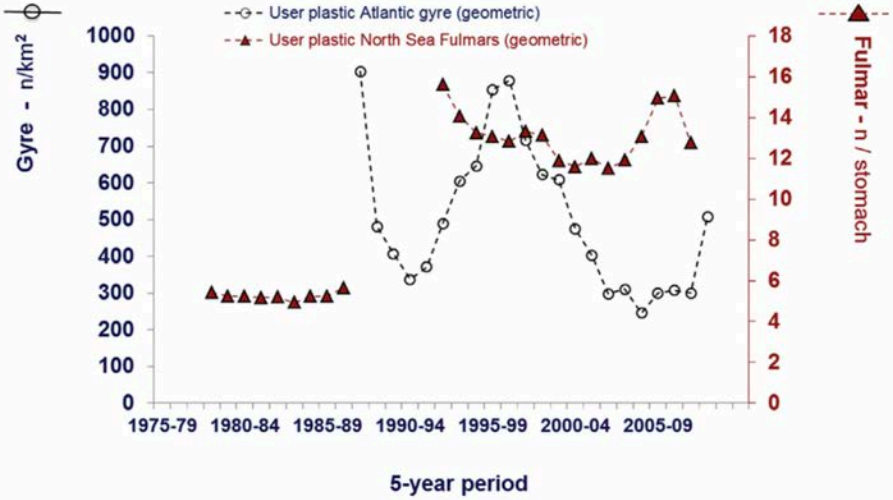
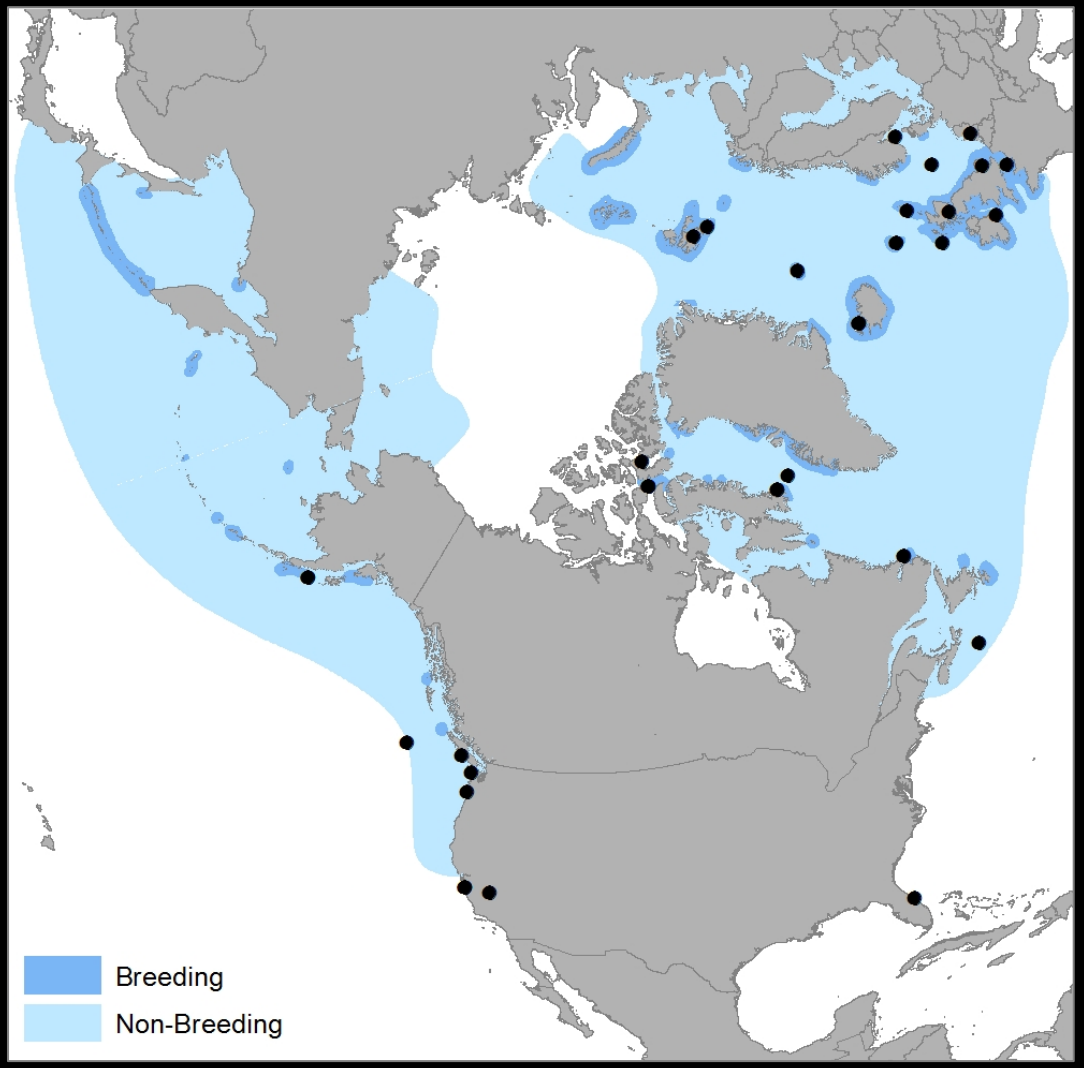


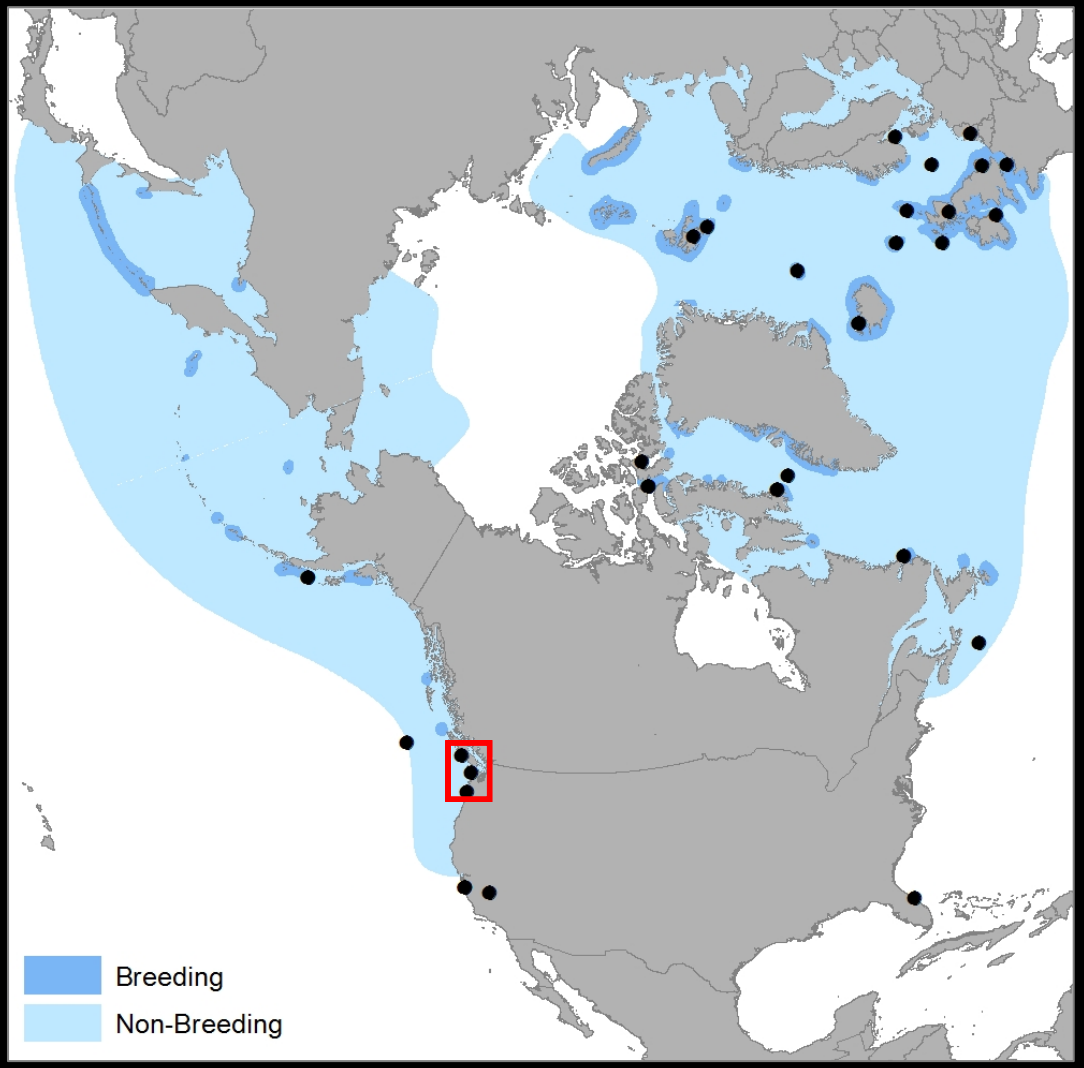
Fig. 10. Comparative trends in numerical abundance of user plastics in stomachs of North Sea fulmars and surface densities in the North Atlantic subtropical gyre by running geometric means over 5-year periods.

van Franeker and Law et al., 2015 *Enviro Poll*

Elsewhere in the world…



In the North Pacific (2009,2010)



Research objectives

1. Establish a quantitative baseline of plastic ingestion for Northern Fulmar in the eastern North Pacific.
2. Investigate how plastic ingestion from this region compares globally.
3. Determine if there is evidence of increased plastic ingestion.

In the North Pacific (2009,2010)

Marine Pollution Bulletin 64 (2012) 1776–1781

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Northern fulmars as biological monitors of trends of plastic pollution in the eastern North Pacific

Stephanie Avery-Gomm [a,*], Patrick D. O'Hara [b], Lydia Kleine [c], Victoria Bowes [d], Laurie K. Wilson [e], Karen L. Barry [f]

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[b] Environment Canada – Canadian Wildlife Service, c/o Institute of Ocean Sciences, P.O. Box 6000, 9860 W Saanich Road, Sidney, BC, Canada V8L 4B2
[c] Slater Museum of Natural History, University of Puget Sound, 1500 N Warner, Tacoma, WA 98416, USA
[d] BC Ministry of Agriculture Animal Health Center, 1767 Angus Campbell Road, Abbotsford, BC, Canada V3G 2M3
[e] Environment Canada – Canadian Wildlife Service, 5421 Robertson Road, Delta, BC, Canada V4K 3N2
[f] Bird Studies Canada, 5421 Robertson Road, Delta, BC, Canada V4K 3N2

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Fulmarus glacialis
Marine plastic pollution
North Pacific
Plastic ingestion
Beached seabirds

ABSTRACT

Marine plastic debris is a global issue, which highlights the need for internationally standardized methods of monitoring plastic pollution. The stomach contents of beached northern fulmar (*Fulmarus glacialis*) have proven a cost-effective biomonitor in Europe. However, recent information on northern fulmar plastic ingestion is lacking in the North Pacific. We quantified the stomach contents of 67 fulmars from beaches in the eastern North Pacific in 2009–2010 and found that 92.5% of fulmars had ingested an average of 36.8 pieces, or 0.385 g of plastic. Plastic ingestion in these fulmars is among the highest recorded globally. Compared to earlier studies in the North Pacific, our findings indicate an increase in plastic ingestion over the past 40 years. This study substantiates the use of northern fulmar as biomonitors of plastic pollution in the North Pacific and suggests that the high levels of plastic pollution in this region warrant further monitoring.

1. Introduction

Since the 1950s, plastic production rates and input of plastic into the marine environment have increased dramatically and plastic is now recognized globally as a major form of marine pollution (Barnes et al., 2009; Moore, 2008; PlasticsEurope, 2010). Marine plastic pollution has significant environmental, economic, cultural, and aesthetic costs (see UNEP, 2009 for review). Of par-

Plastic pollution is so pervasive that it is now found in every ocean of the world, including those formerly thought of as pristine, such as the Arctic Ocean and Southern Ocean (Provencher et al., 2010; Ainley et al., 1990). In 2009, the UNEP challenged the global community to improve methods to monitor trends in plastic pollution (UNEP, 2009). Although many countries have documented plastic debris in the marine environment, no standard technique has been used, and the lack of consistent methodology has made it diffi-

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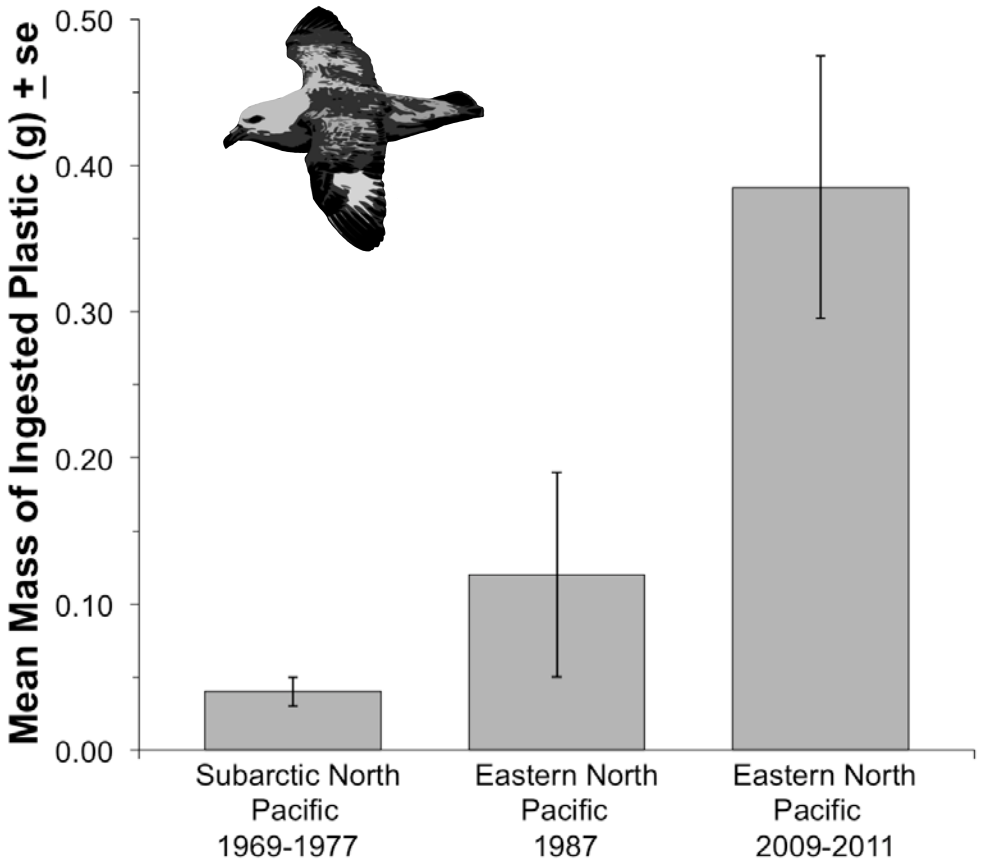
Avery-Gomm et al. 2017 *Mar Poll Bull*

Temporal comparison

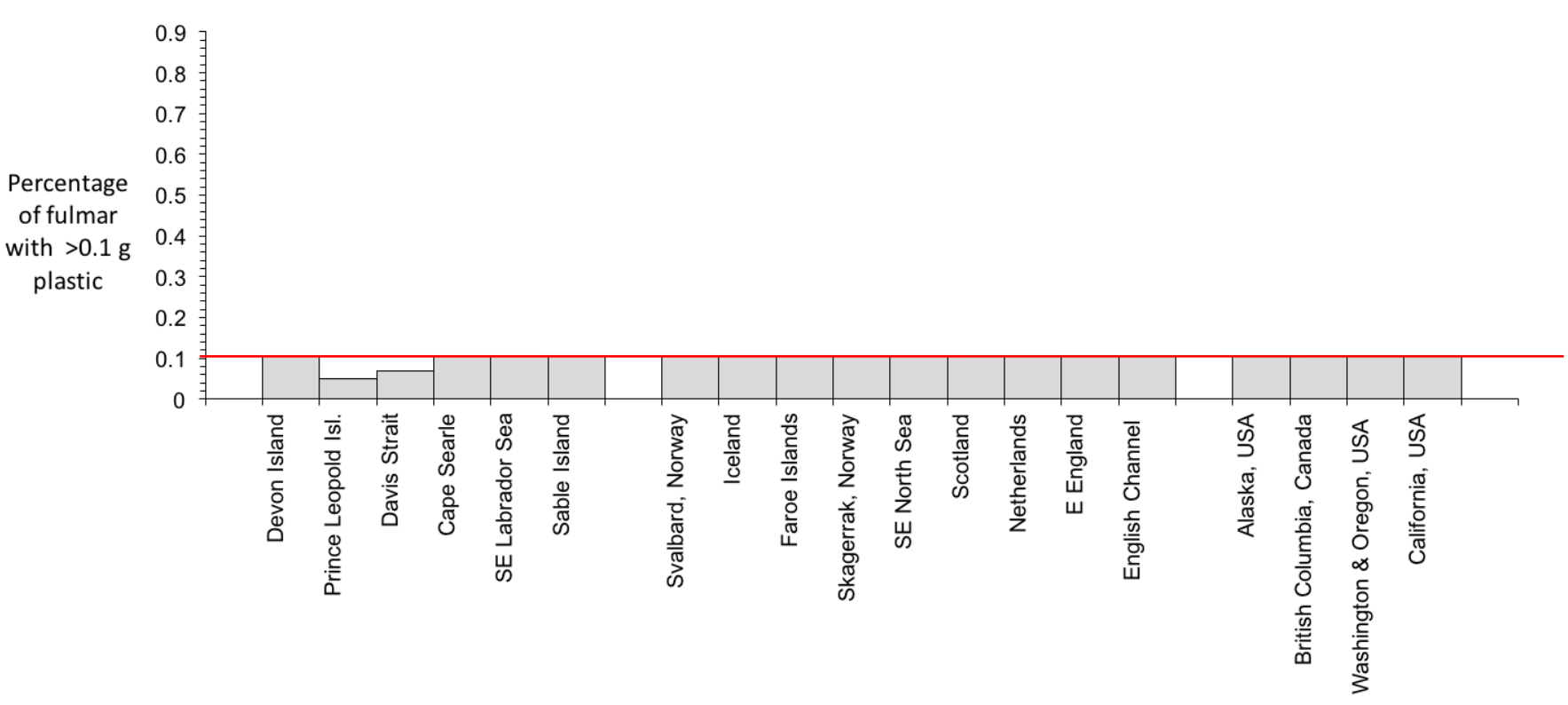


Blight and Burger *unpublished;* Robards *et al.,* 1997; Avery-Gomm *et al.* 2012

Local results. Global comparisons.

Ecological Quality Objective target for marine litter:

"Good Environmental Status is achieved if less than 10% of northern fulmars having 0.1 g or more plastic in the stomachs."



Avery-Gomm et al., 2017

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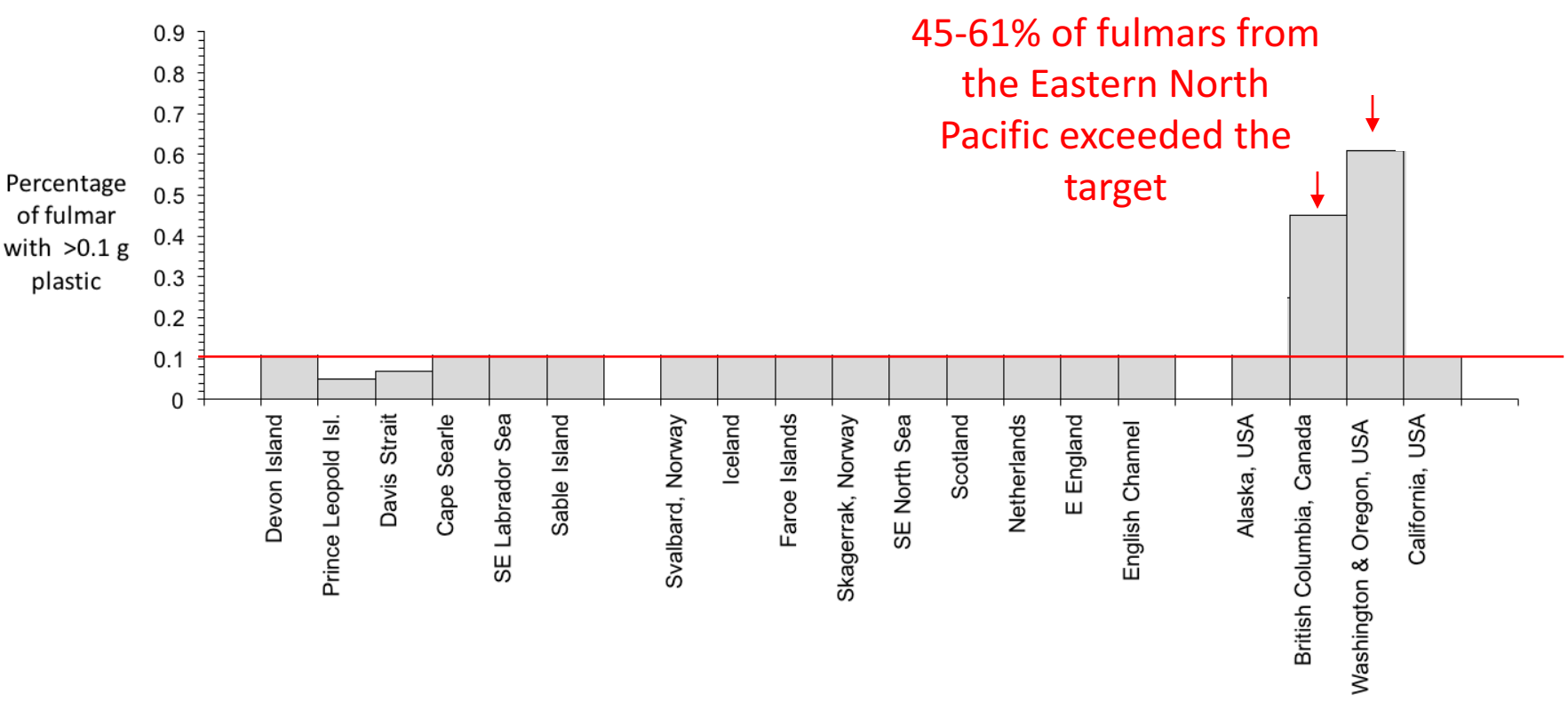

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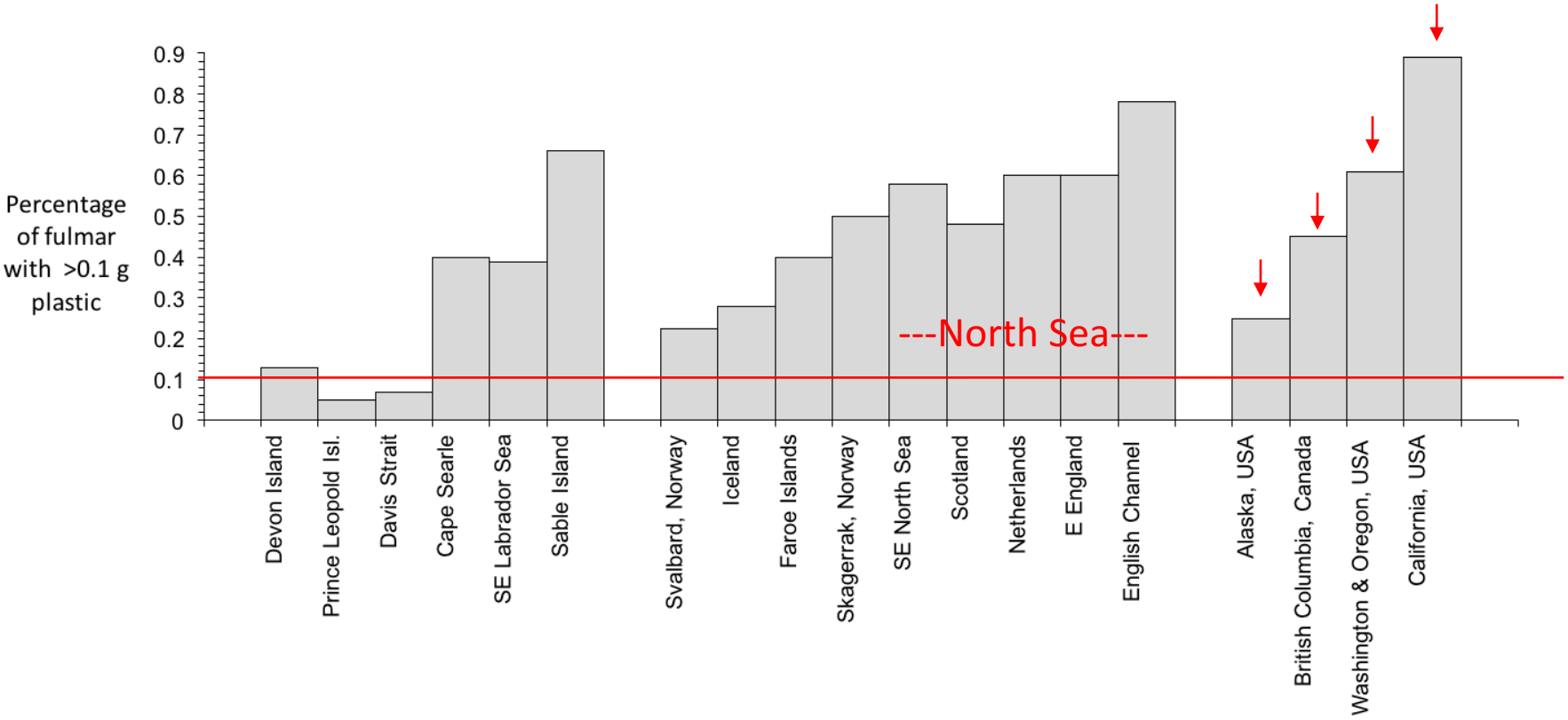


Avery-Gomm et al., 2017

Local results. Global comparisons.

Plastic pollution in the Labrador Sea: An assessment using the seabird northern fulmar *Fulmarus glacialis* as a biological monitoring species

Stephanie Avery-Gomm[a,*], Jenni
Paul A. Smith[e]

Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea

Jan A. van Franeker[a,*], Christine Blaize[b], Johannis Danielsen[c], Keith Fairclough[d], Jane Gollan[e], Nils Guse[f], Poul-Lindhard Hansen[g], Martin Heubeck[h], Jens-Kjeld Jensen[i], Gilles Le Guillou[j], Bergur Olsen[k], Kåre-Olav Olsen[l], John Pedersen[m], Eric W.M. Stienen[n], Daniel M. Turner[o]

Marine plastic debris in n
Nun

Mark L. Mallory [a,*], Gregory J. Roberston [b], Alissa Moenting [c]

ecies in Canadian Arctic seabirds

Florence F. Poon [a,*], Jennifer F. Provencher [b], Mark L. Mallory [c], Birgit M. Braune [d], Paul A. Smith [d]

Size and dynamics of microplastic in gastrointestinal tracts of Northern Fulmars (*Fulmarus glacialis*) and Sooty Shearwaters (*Ardenna grisea*)

Alicia K. Terepocki [a,b], Alex T

Baseline

Plastic ingestion by the northern fulmar (*Fulmarus glacialis*) in Iceland

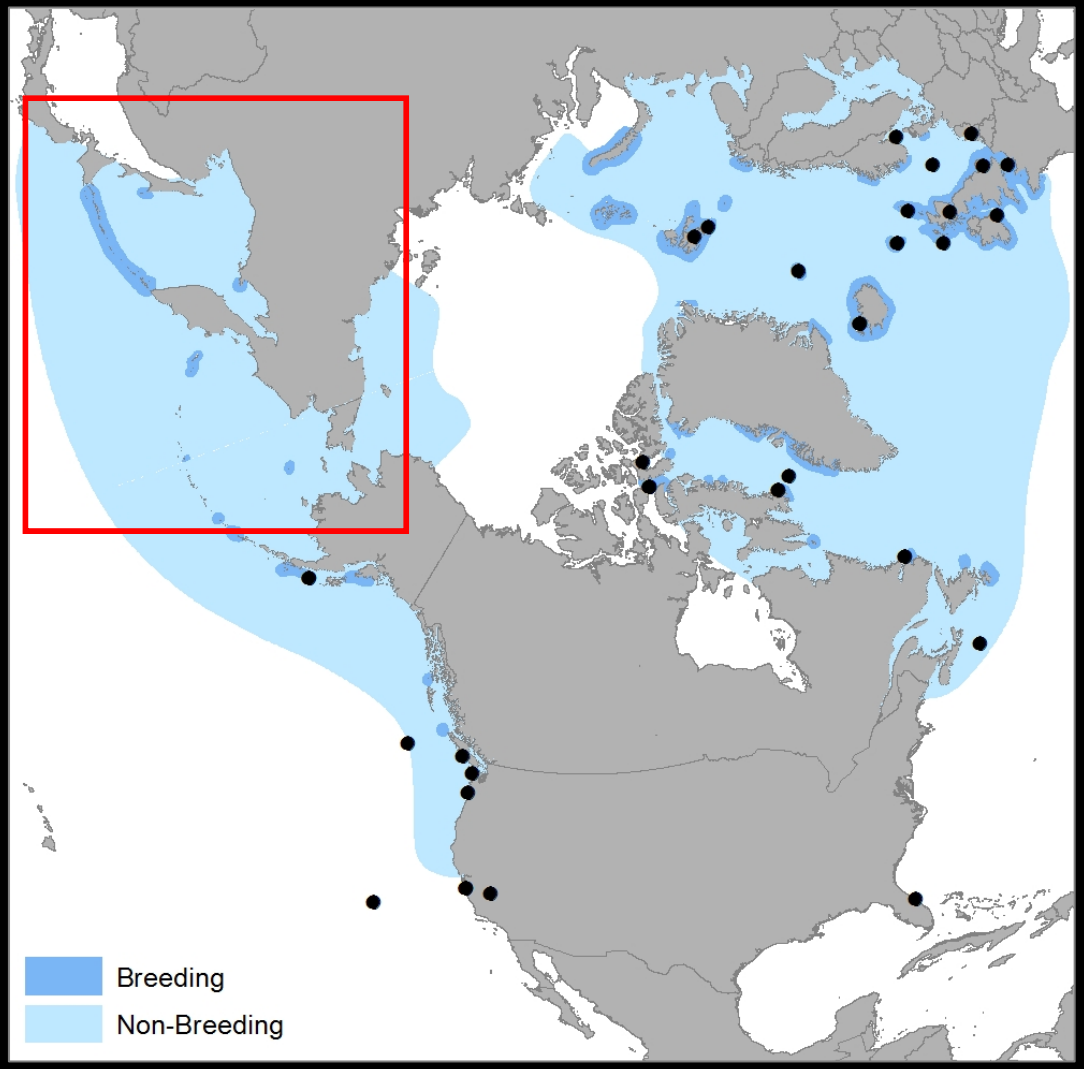
Elevated levels of ingested plastic in a high Arctic seabird, the northern fulmar (*Fulmarus glacialis*)

Alice M. Trevail · Geir W. Gabrielsen · Susanne Kühn · Jan A. Van Franeker

Evidence for increased ingestion of plastics by northern fulmars (*Fulmarus glacialis*) in the Canadian Arctic

Jennifer F. Provencher [a,*], Anthony J. Gaston [b], Mark L. Mallory [c]

We currently have no standardized plastic ingestion data for Northern Fulmar from the Western North Pacific!



Snapshots aren't enough.

Can we **cost-effectively** monitor plastic debris in a way that detects spatial and temporal trends across an entire ocean?

North Pacific Plastic Monitoring Program?

Collect 50-100 fulmar from each region/country each year.

A coordinator could

- Arrange volunteer-supported bird collections in new regions
- Liaise with existing programs in the USA and Canada
- Coordinate dissection workshops & analyse data
- Manage a centralized data repository
- Preform integrative analyses for publishing & reporting

Building on success

LEO Network tracks community reported changes, including wrecking events.

BIOPS Bioindicators of Plastic Pollution program is already working with fisheries in Alaska to monitor plastic ingestion in fulmar.

Beach Surveys have detected ~10,000 fulmar on 450 beaches (USA)

Beached Bird Surveys along the west coast of Vancouver Island also detect fulmars (BC, Canada)

PollutionTracker provides locally sampled plastic pollution data for across the BC coast in a user-friendly interface

What role might PICES play?

Thank You!

Jan van Franeker, Patrick D. O'Hara, Ken Morgan, Jennifer Provencher, Lydia Kleine, Victoria Bowes, Laurie Wilson, Karen Barry, Peter Hodum, Gary Shugart, Sharnelle Fee, Louise Blight, Allen Burger, Peter Clarkson, Robert and Mara Love, Darlene Choquette, Max Liboiron, Florence Poon, Paul Smith, Greg Robertson, Doug Bertram, Hugh Possingham, Richard Fuller, Stephanie Borrelle, Alex Bond, Jennifer Lavers, Craig White, Stephen Portugal, Mark Mallory.

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Canada

NSERC CRSNG

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CANADIAN WILDLIFE SERVICE · SERVICE CANADIEN DE LA FAUNE ·

MEOPAR MARINE ENVIRONMENTAL OBSERVATION PREDICTION & RESPONSE NETWORK