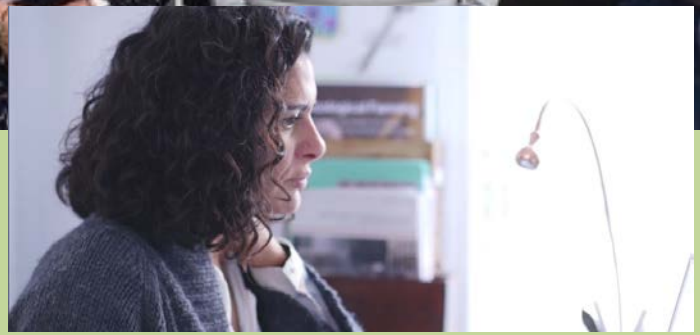
Infrared and green:
Applying the Spotlight 400 FT-IR system to microplastics research within an environmental NGO

Dr David Santillo

Greenpeace Research Laboratories

University of Exeter

Greenpeace Research Laboratories (or Greenpeace Science Unit)



Greenpeace Research Laboratories (Science Unit) Mission Statement

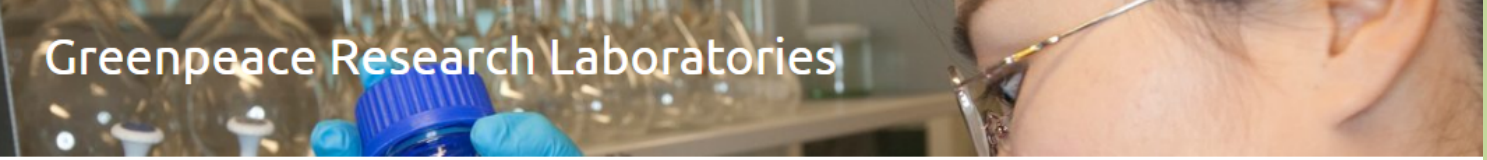
- provide scientific advice, research and analytical support
- oversee best scientific practice, quality control and scientific communications
- to engage with the wider scientific community
- to help identify and respond to new and emerging issues/risks
- to represent Greenpeace at the science-policy interface

To conduct scientific research to inform Greenpeace's campaigns…

…*'bearing witness' through science*

Science Unit: analytical capabilities

- GC-MS (persistent organic pollutants)
- LC-MS (POPs and pesticides)
- ICP-MS (toxic metals)
- FT-IR (plastics)
- Field equipment
- Radiation protection equipment and advice
- Working relationships with many leading laboratories



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- Reflecting sun's rays would cause crops to fail, scientists warn https://t.co/EqwxsipGV9
- Prohibited activities | Standard Chartered Bank https://t.co/oZYAszKYK0
- We found 29 pesticides mixed together in a river in Devon https://t.co/TRfVQS0AkO #pesticides #greenpeacescience
- Our poster at ISEAC-40 in Santiago de Compostela last week https://t.co/ssw4yc3S3G #microplastics https://t.co/M4E49vGuxg
- Even in the remote waters of the Hebrides (NW Scotland), microplastics and their chemical burdens are now

Greenpeace Research Laboratories (Exeter, UK)

The Greenpeace Research Laboratories form the Science Unit of Greenpeace International. Based at the University of Exeter in the UK, the laboratories provide scientific advice and analytical support to Greenpeace offices worldwide, over a range of disciplines. The laboratories are equipped with hardware for the analysis of heavy metal and organic contaminants in a range of environmental samples. An extensive database of scientific literature has been built up since 1986 and serves as a core information resource.

The expertise of the group encompasses a number of c
including toxicology, organic and inorganic analytical c
biochemistry and terrestrial and marine ecology.

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Recent Posts

- Characterisation of sea-surface microplastics collected from coast and inland waters of Scotland
- Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures
- Multi-residue analysis of pesticides in surface water by liquid chromatography quadrupole-Orbitrap high resolution tandem ma spectrometry

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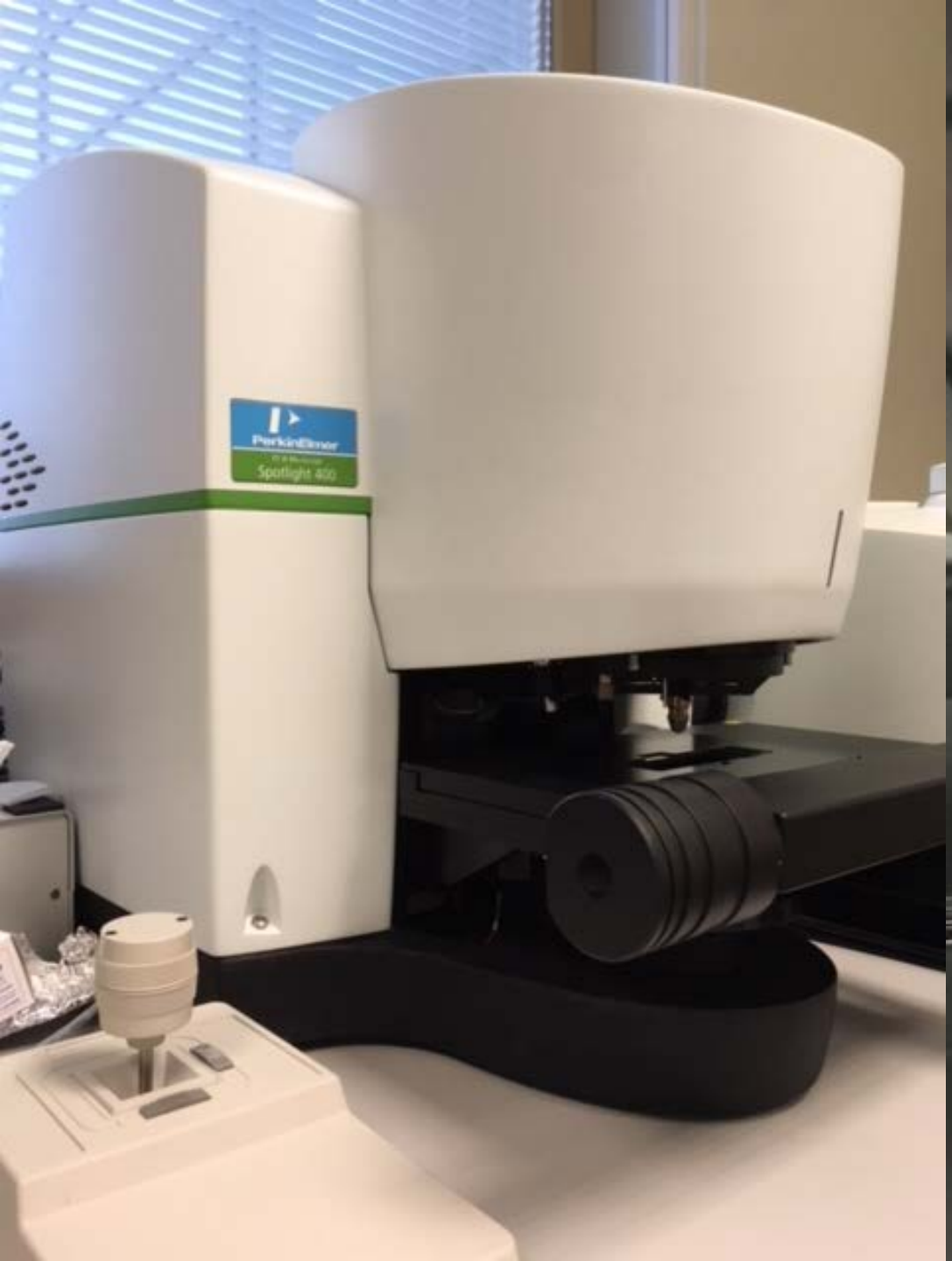
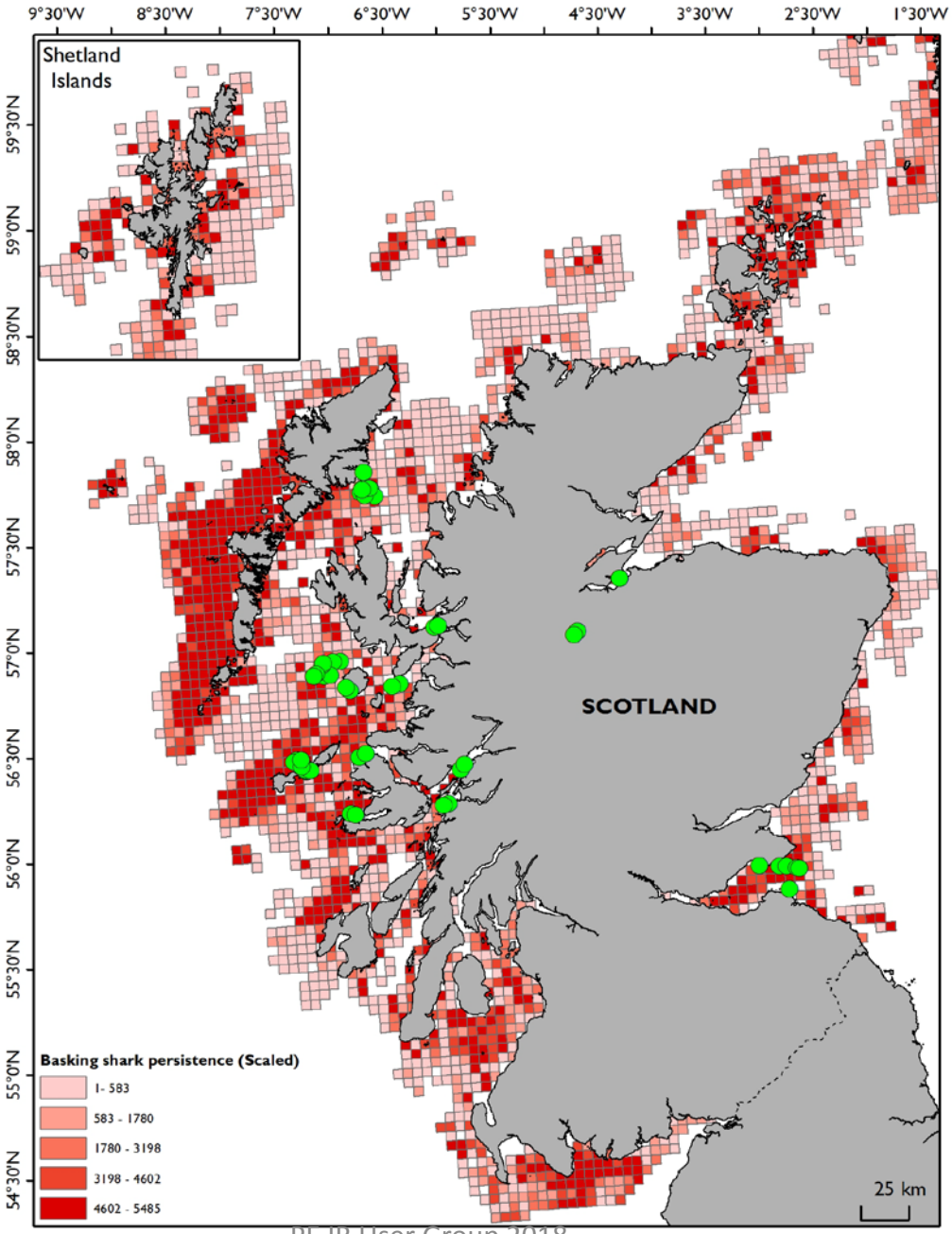
Plastics – a global problem


2.5
3


PerkinElmer
Spotlight 400


CRYSTAL S/N 30
HEIGHT 14090


TESTING
THE WATERS
MICROPLASTICS
IN SCOTTISH SEAS
GREENPEACE


9°30'W
8°30'W
7°30'W
6°30'W
5°30'W
4°30'W
3°30'W
2°30'W
1°30'W
59°30'N
59°0'N
58°30'N
58°0'N
57°30'N
57°0'N
56°30'N
56°0'N
55°30'N
55°0'N
54°30'N
Shetland Islands
SCOTLAND
Basking shark persistence (Scaled)
1- 583
583 - 1780
1780 - 3198
3198 - 4602
4602 - 5485
25 km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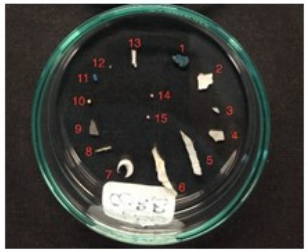
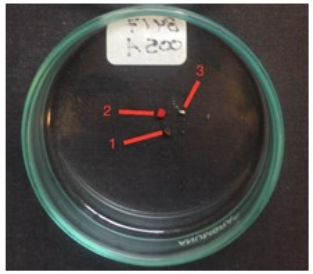
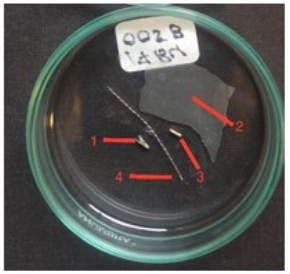


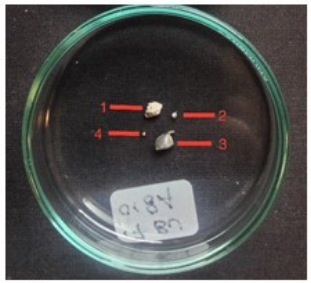
(a) 17BU003A:
Firth of Forth

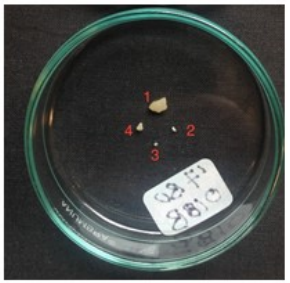




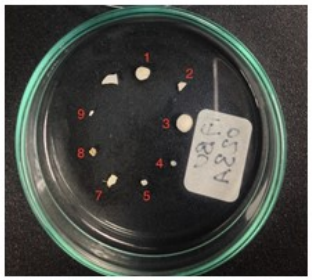
(b) 17BU005A & B:
Firth of Inverness

(c) 17BU011A & B:
Gunna Sound, Tiree



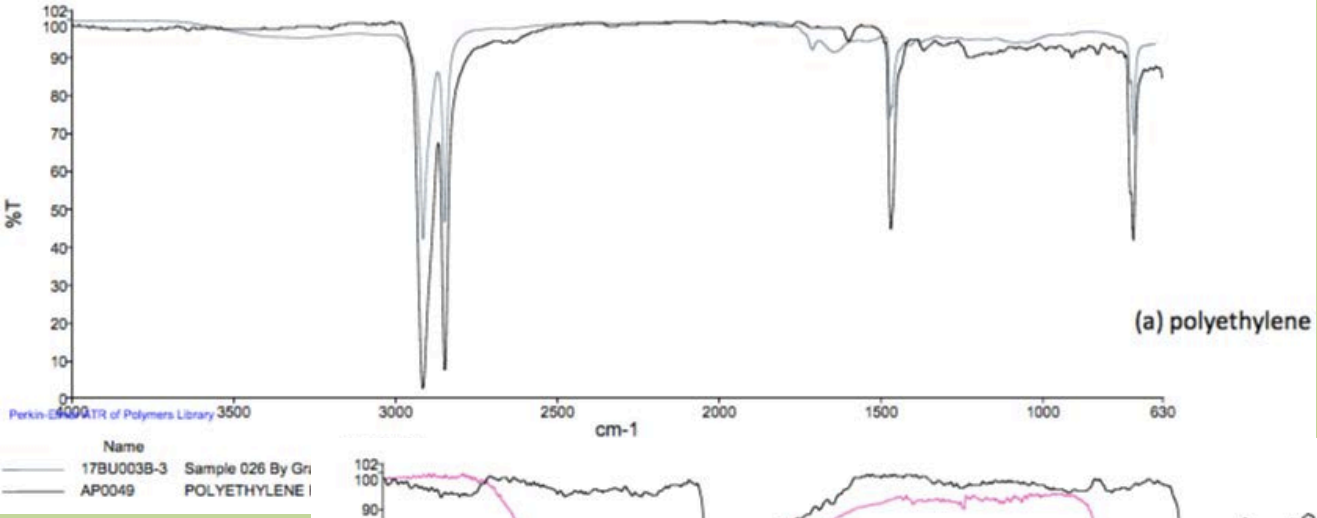


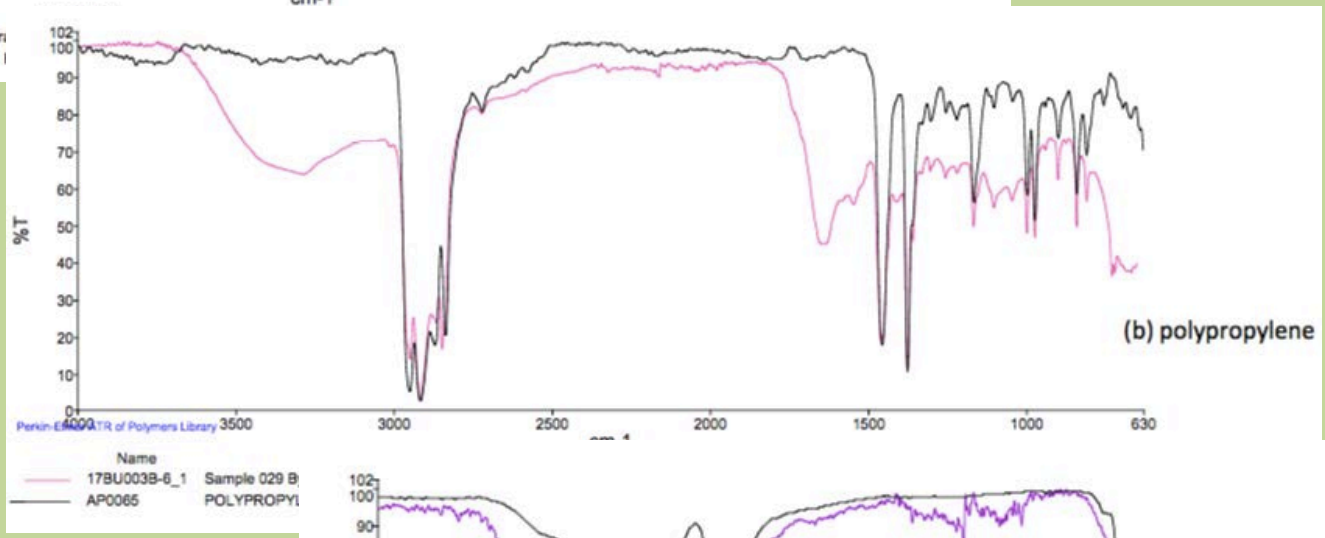
(d) 17BU018A & B:
Canna Island

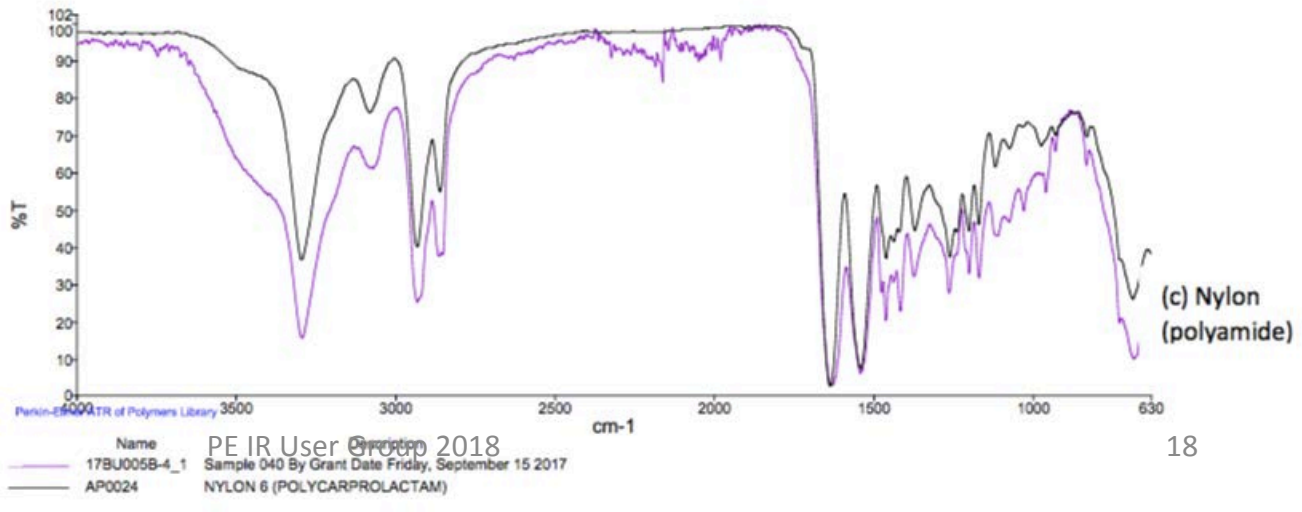


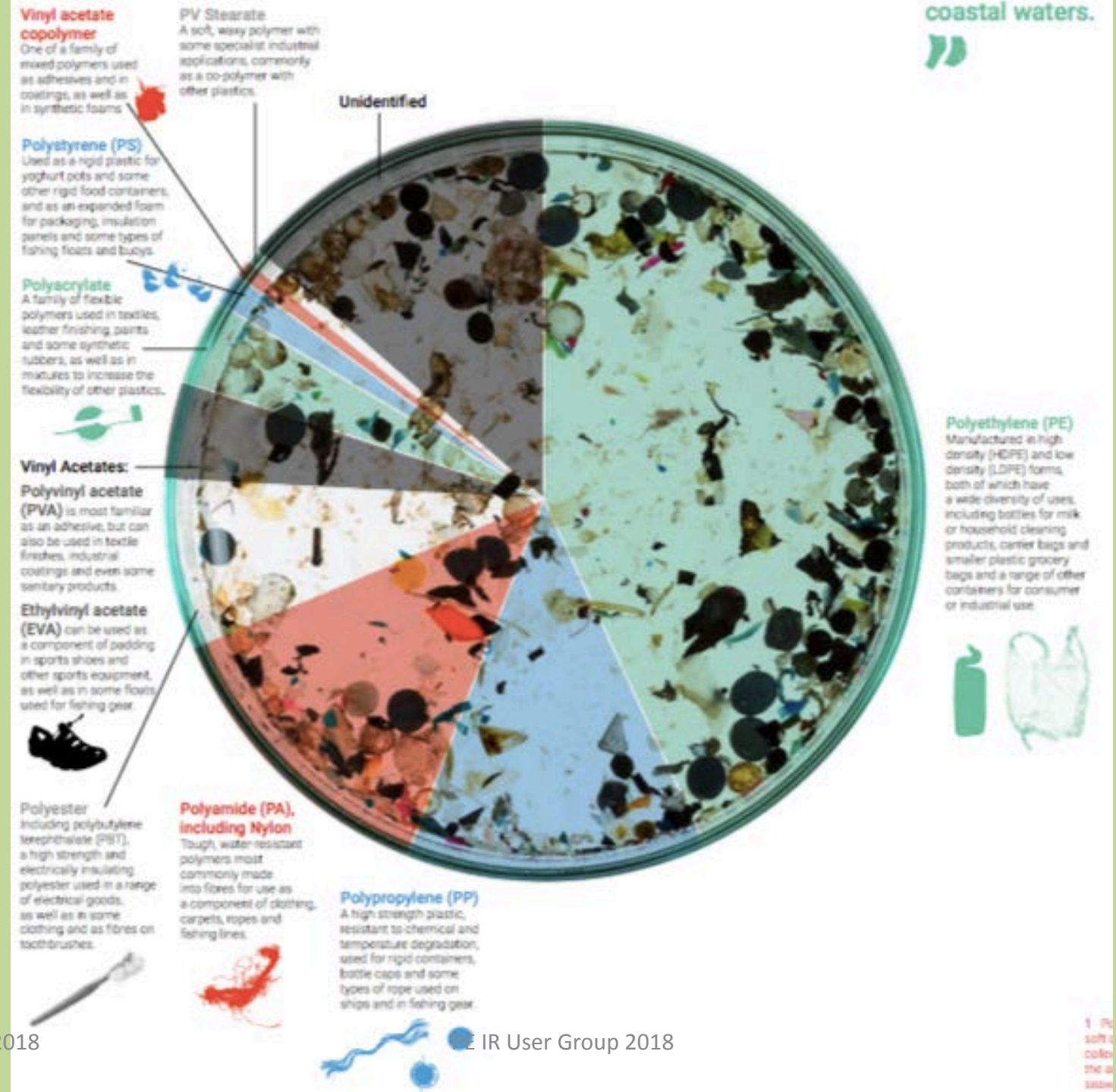
(e) 17BU023A & B:
Shiant Islands

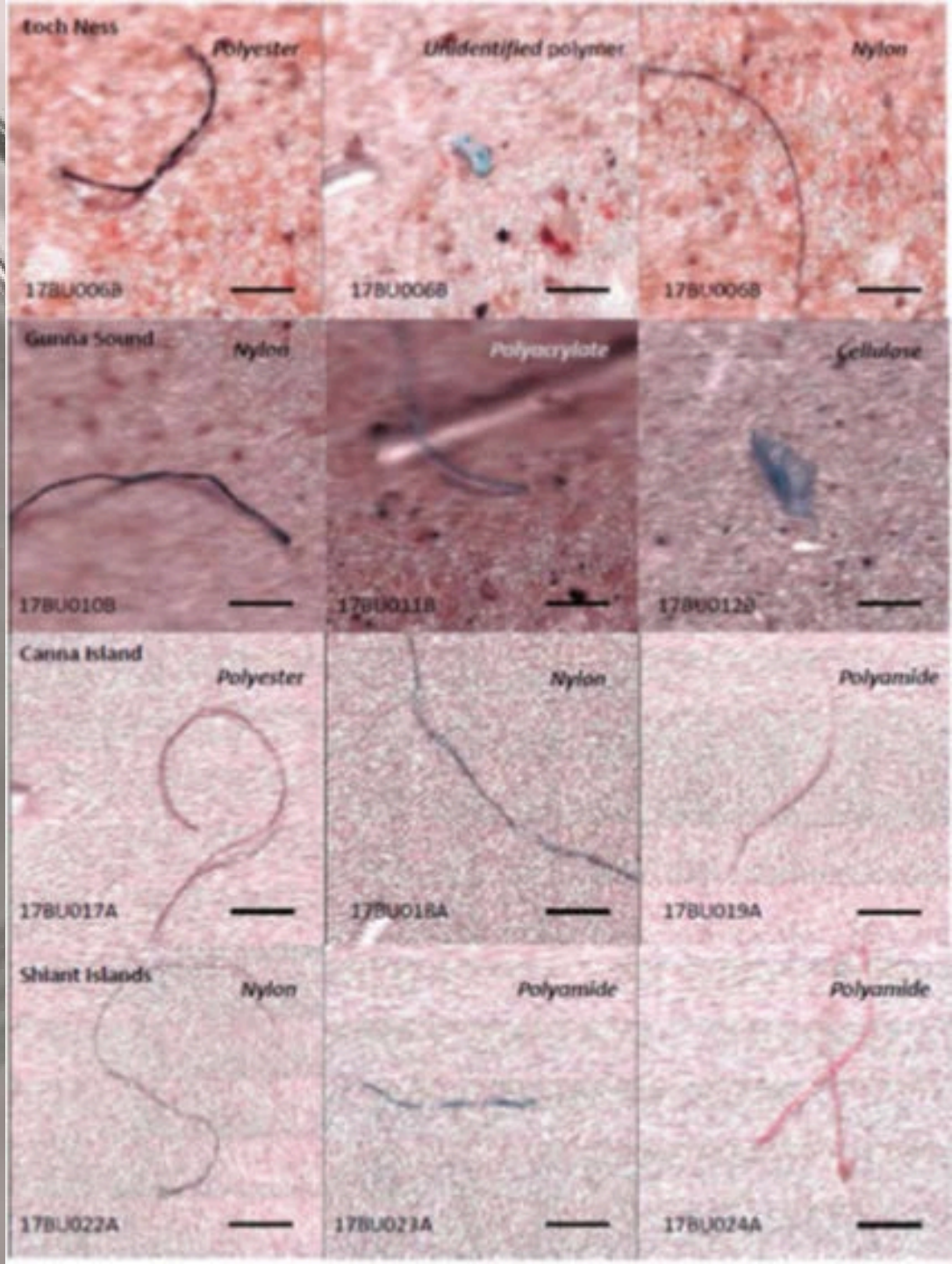
Typical infra-red spectra for plastics most commonly found in the samples








Vinyl acetate copolymer
One of a family of mixed polymers used as adhesives and in coatings, as well as in synthetic foams.
PV Stearate
A soft, waxy polymer with some specialist industrial applications, commonly as a co-polymer with other plastics.
Unidentified
Polystyrene (PS)
Used as a rigid plastic for yoghurt pots and some other rigid food containers, and as an expanded foam for packaging, insulation panels and some types of fishing floats and buoys.
Polyacrylate
A family of flexible polymers used in textiles, leather finishing, paints and some synthetic rubbers, as well as in mixtures to increase the flexibility of other plastics.
Vinyl Acetates:
Polyvinyl acetate (PVA) is most familiar as an adhesive, but can also be used in textile finishes, industrial coatings and even some sanitary products.
Ethylvinyl acetate (EVA) can be used as a component of padding in sports shoes and other sports equipment, as well as in some floats used for fishing gear.
Polyester
including polybutylene terephthalate (PBT), a high strength and electrically insulating polyester used in a range of electrical goods, as well as in some clothing and as fibres on toothbrushes.
Polyamide (PA), including Nylon
Tough, water-resistant polymers most commonly made into fibres for use as a component of clothing, carpets, ropes and fishing lines.
Polypropylene (PP)
A high strength plastic, resistant to chemical and temperature degradation, used for rigid containers, bottle caps and some types of rope used on ships and in fishing gear.
Polyethylene (PE)
Manufactured in high density (HDPE) and low density (LDPE) forms, both of which have a wide diversity of uses, including bottles for milk or household cleaning products, carrier bags and smaller plastic grocery bags and a range of other containers for consumer or industrial use.
coastal waters.


Loch Ness
Polyester
178U006B
Unidentified polymer
178U006B
Nylon
178U006B
Gunña Sound
Nylon
178U010B
Polyacrylate
178U011B
Cellulose
178U012B
Canna Island
Polyester
178U017A
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Polyamide
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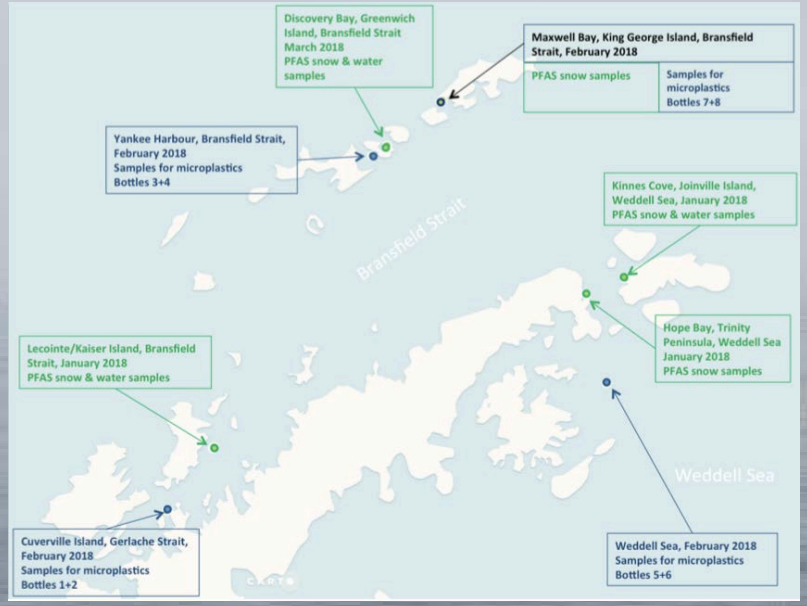
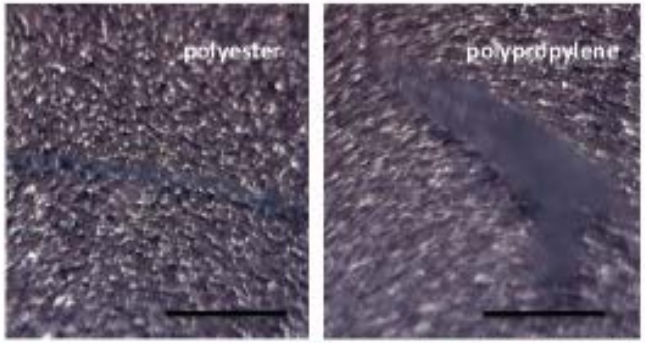
Nylon
178U022A
Polyamide
178U023A
Polyamide
178U024A

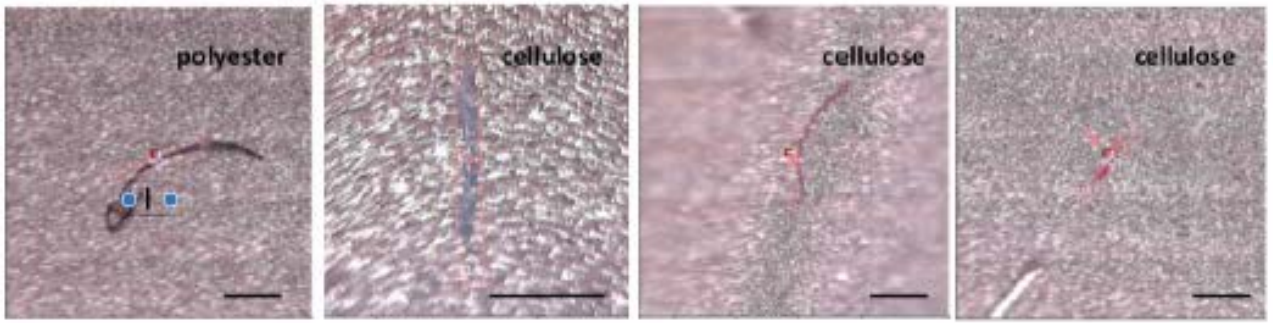


Microplastic sampling in Antarctic waters from aboard the Arctic Sunrise
© Christian Åslund / Greenpeace

Sample ANT18001-2

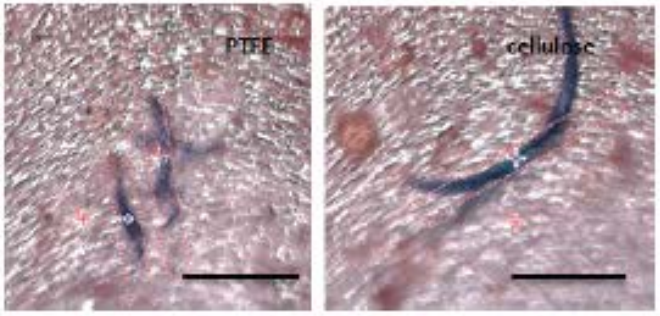
Position: 64°38.496 S;
062°36.910 W
Date: 15/02/18
Time of sampling: 1839hrs GMT
Finding: ANT18001 2.0 fibres/litre;
ANT18002 3.6 fibres/litre





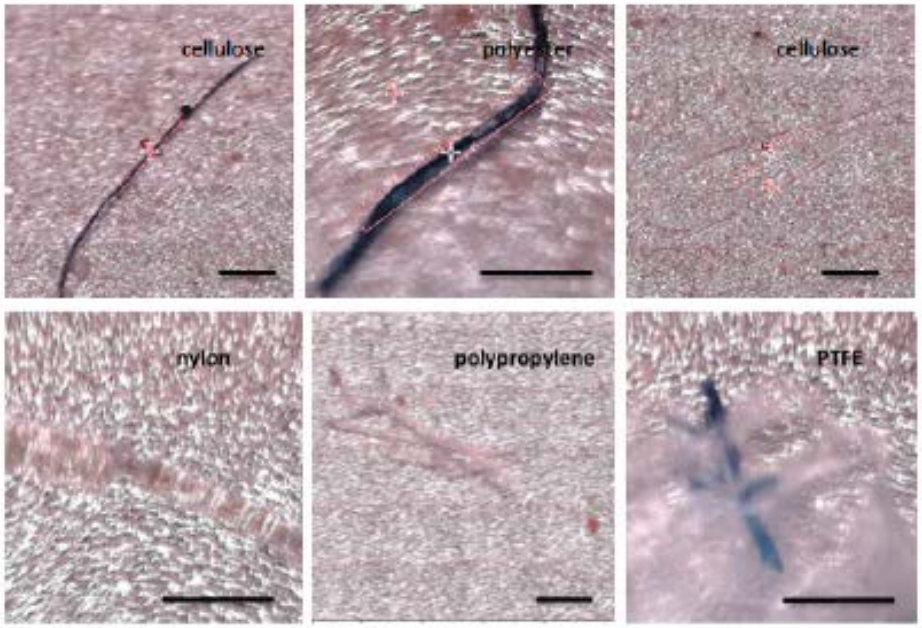
Sample ANT18003-4

Position: 62°32.073 S;
059°51.377 W (Yankee Harbour)
Date: 18/02/18
Time of sampling: 1412hrs GMT
Finding: ANT18003 4.0 fibres/
litre; ANT18004 0.8 fibres/litre



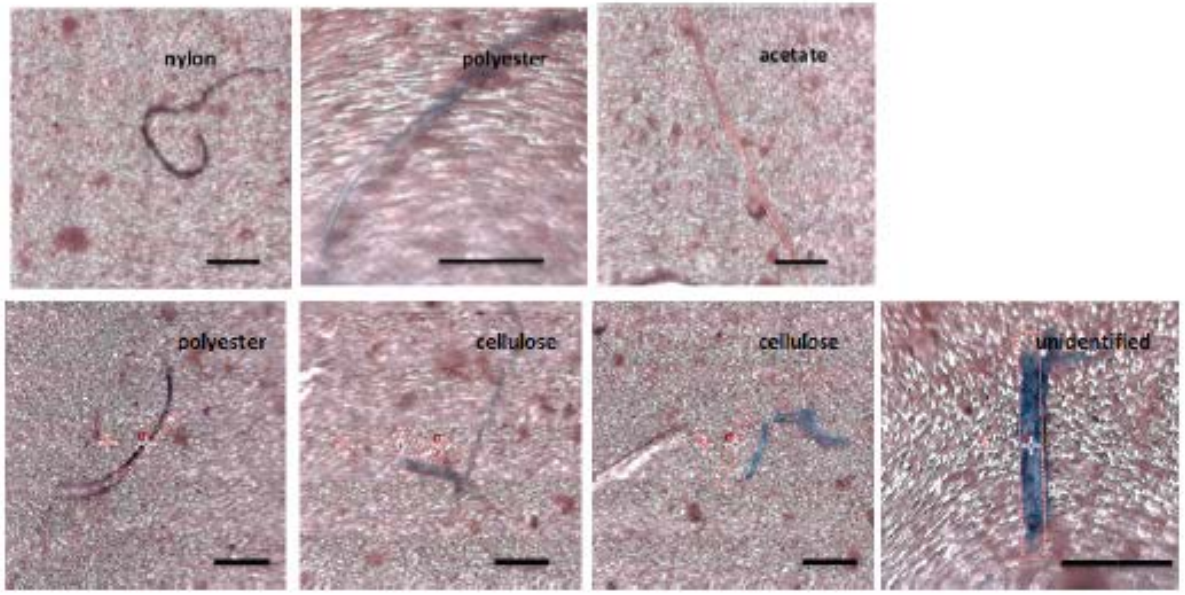
Sample ANT18005-6

Position: 63°54.053 S;
056°42.496 W (Weddell Sea)
Date: 22/02/18
Time of sampling: 2215hrs GMT
Finding: ANT18005 2.8 fibres/
litre; ANT18006 3.2 fibres/litre

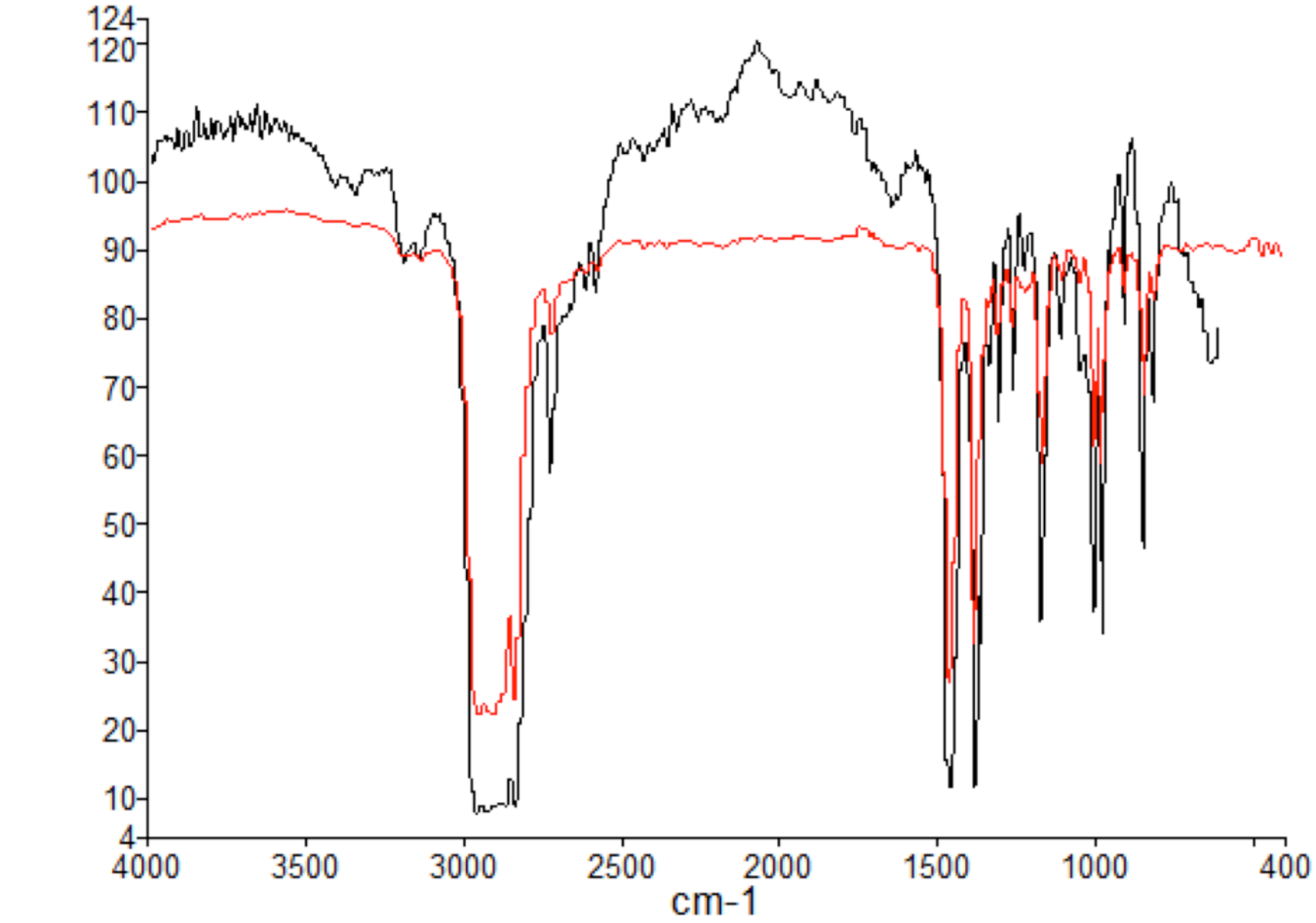


Sample ANT18007-8

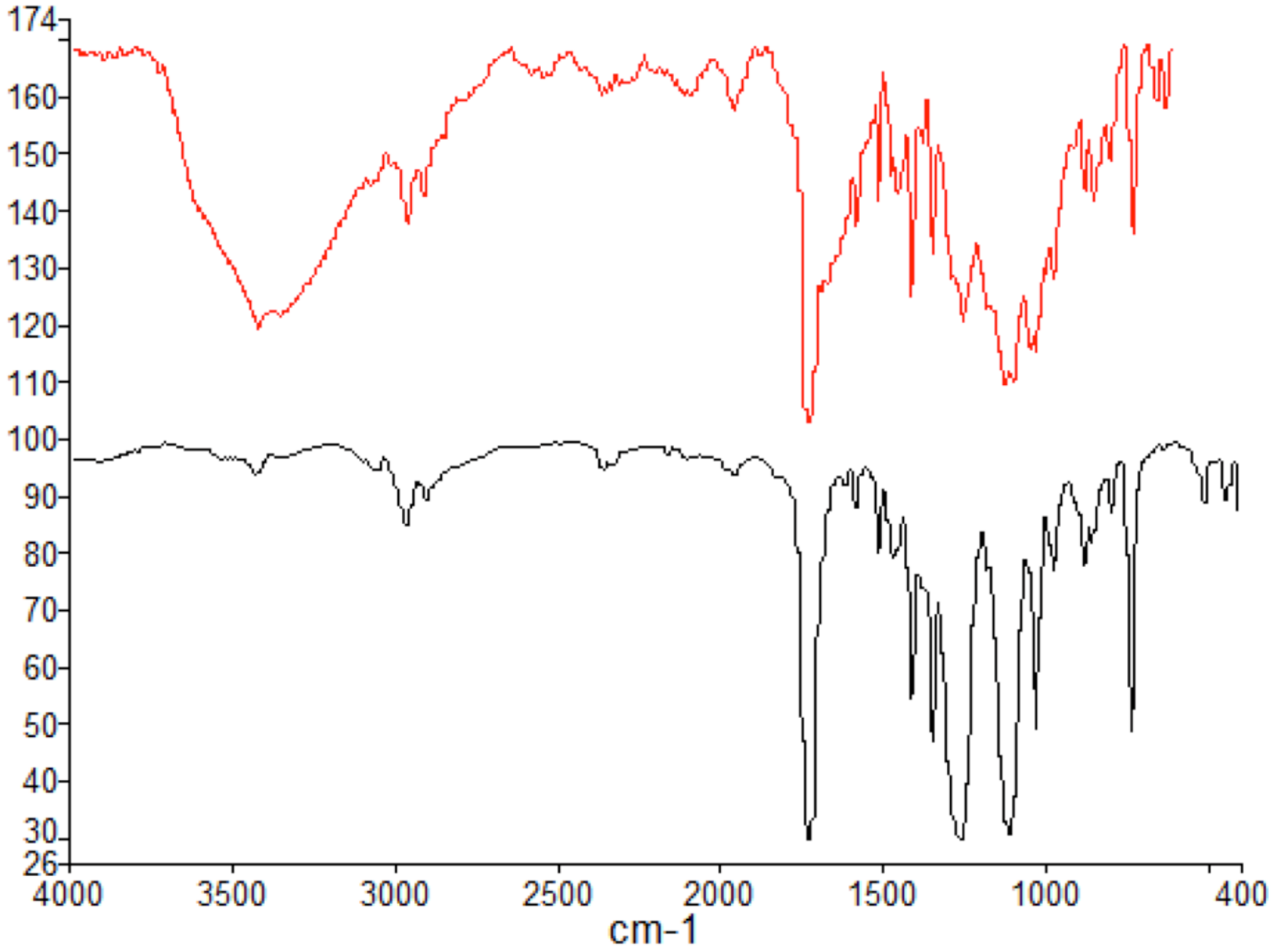
Position: 62°12.145 S;
058°56.488 W (King George Island)
Date: 26/02/18
Time of sampling: 1856hrs GMT
Finding: ANT18007 5.6 fibres/litre;
ANT18008 2.8 fibres/litre



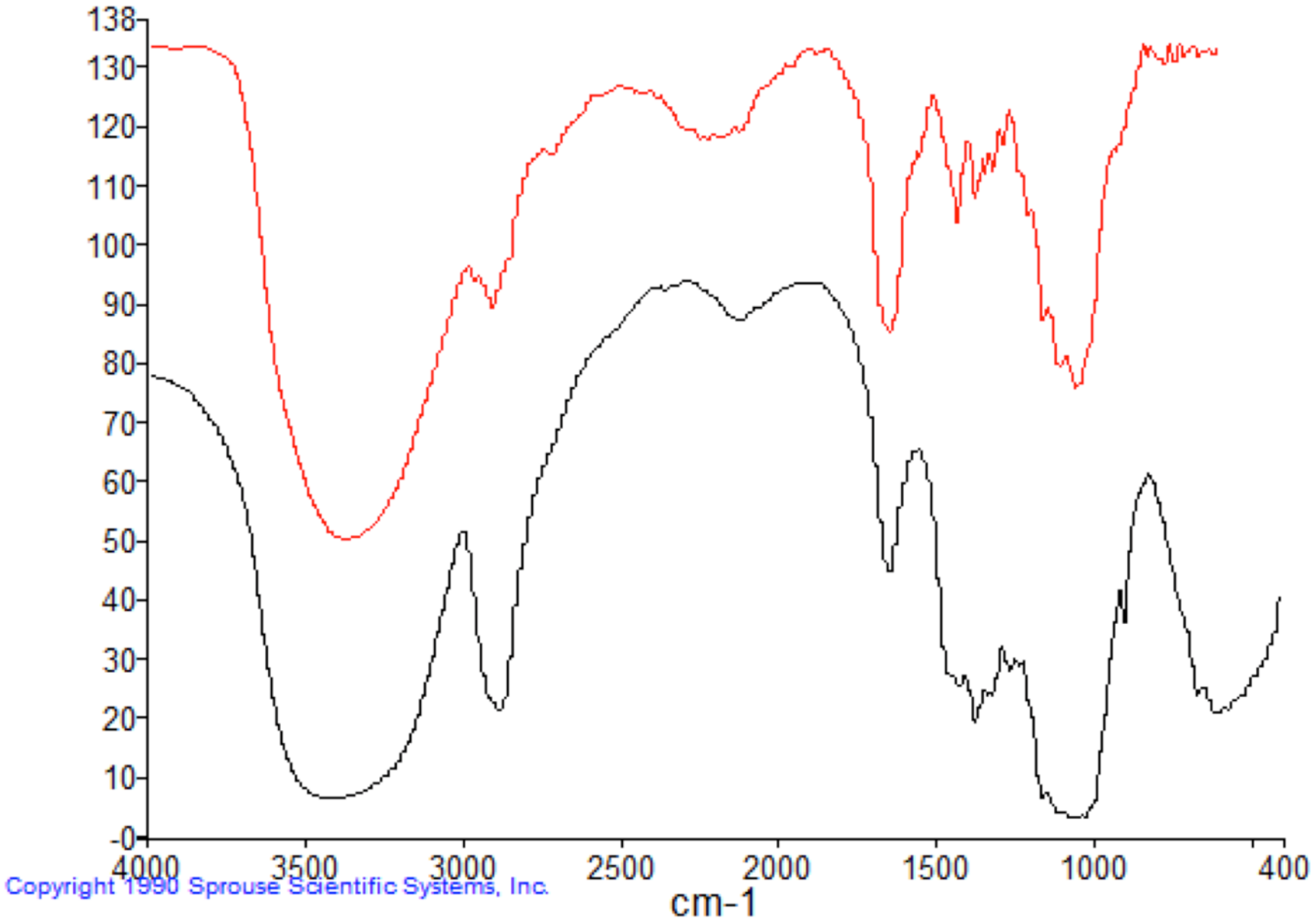
All bars are 0.2 mm or 200 µm



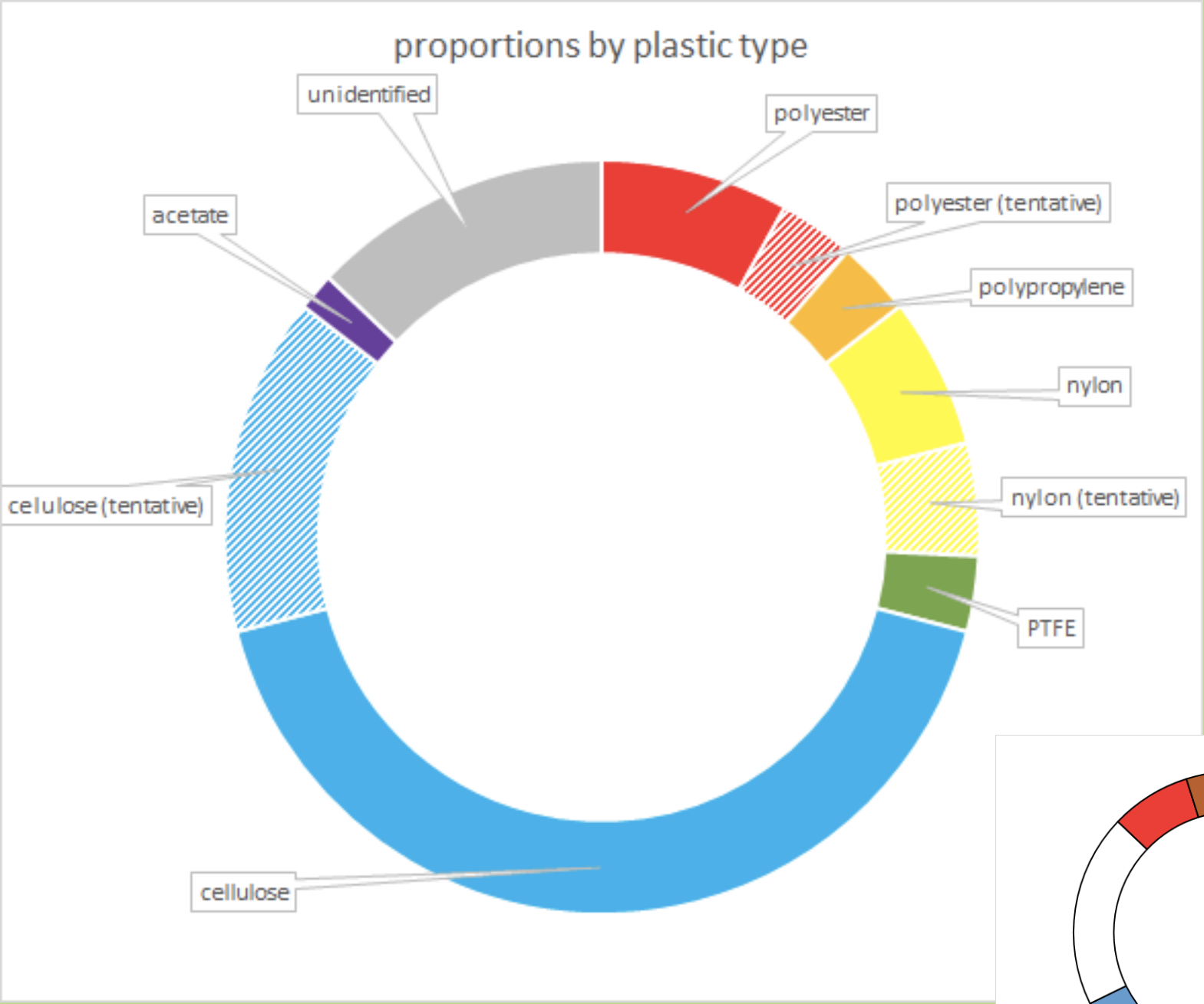
Name	Description
ANT18002 blue fragment #1	Sample 284 By Administrator Date Friday, April 27 2018
FI0042	CTA 87 E0398 OLEFIN (POLYPROPYLENE)

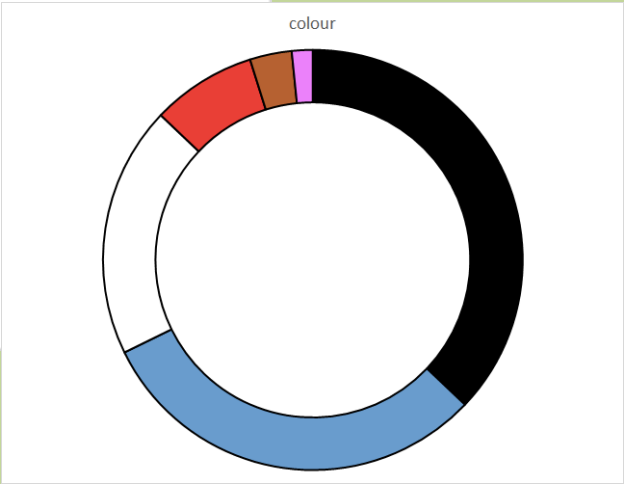


Name	Description
ANT18007 transparent fibre #1	Sample 130 By Administrator Date Friday, May 25 2018
FI0106	CTA 87 A0336 POLYESTER (KODEL)



Name	Description
ANT18008 black fragment #1_1	Sample 119 By Administrator Date Wednesday, May 23 2
PT0121	CELLULOSE, ECTEOLA MODIFIED

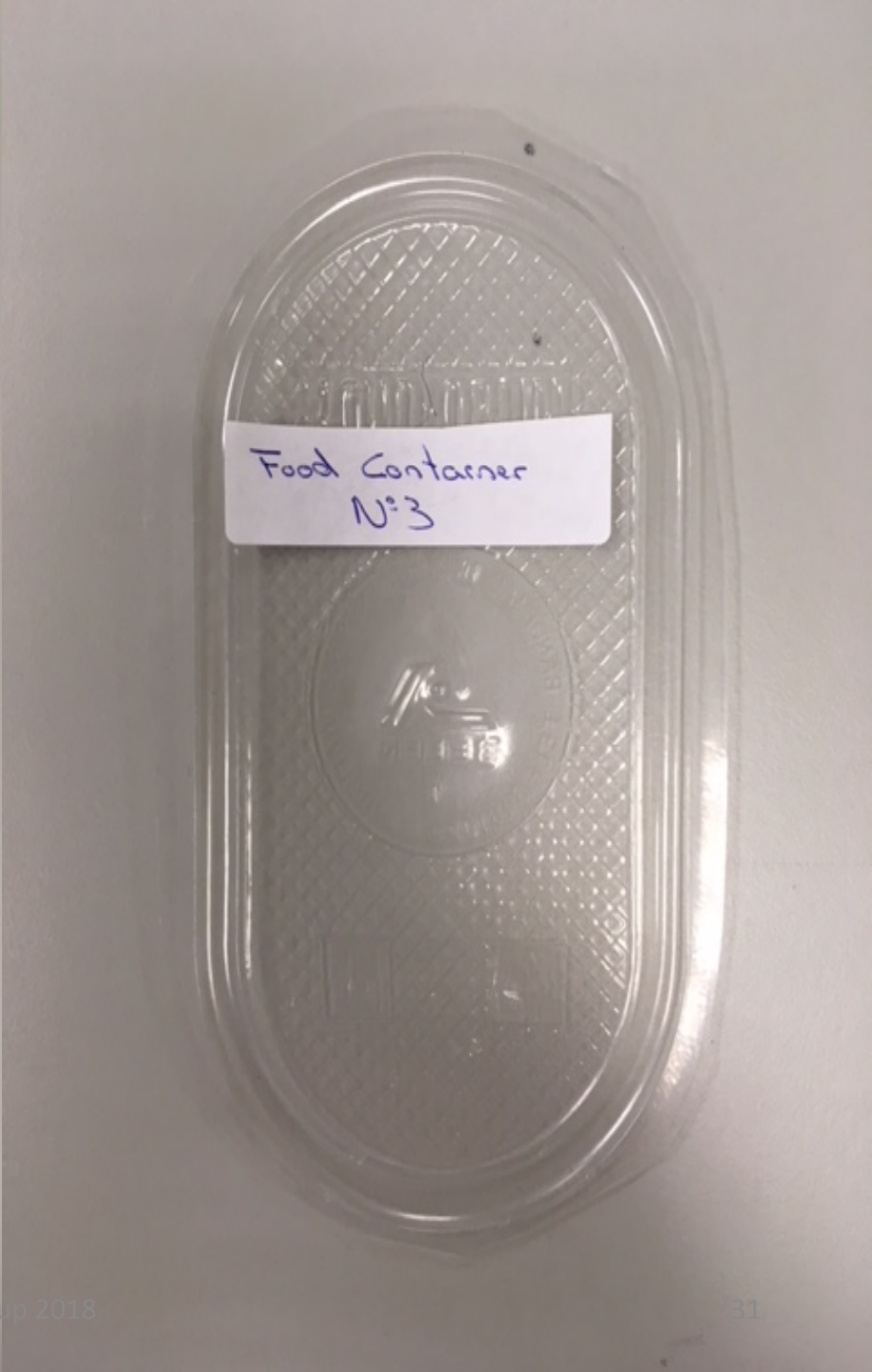

proportions by plastic type
unidentified
polyester
polyester (tentative)
polypropylene
nylon
nylon (tentative)
PTFE
cellulose
celulose (tentative)
acetate

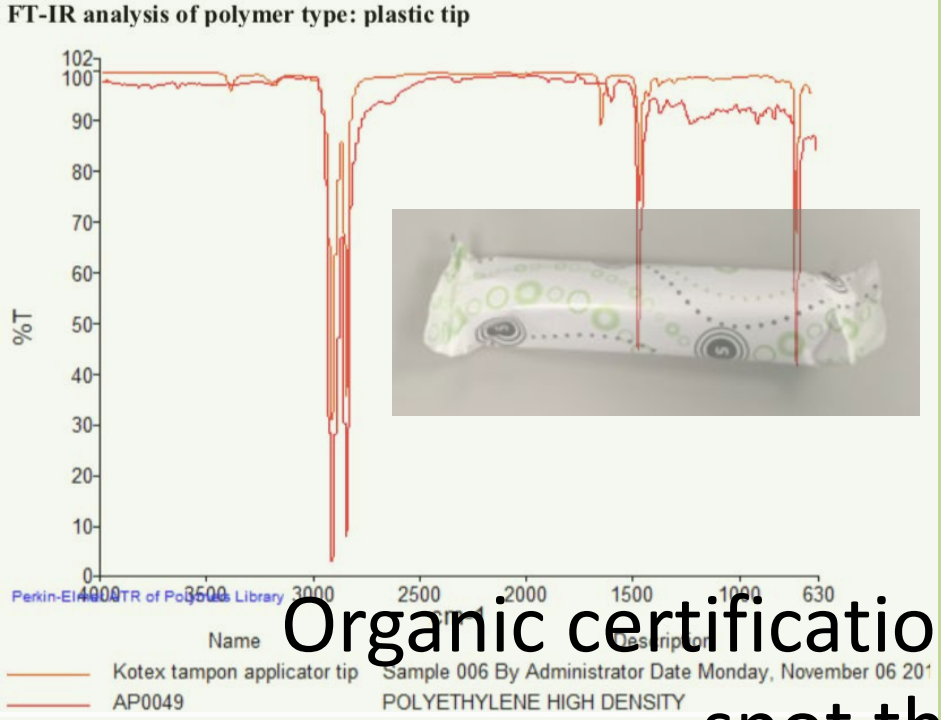

colour


Surveys of microplastics on
Mediterranean beaches


All other fragments identified as polyethylene
Unidentified – possible paraffin wax
Unidentified – possibly PVC
polypropylene

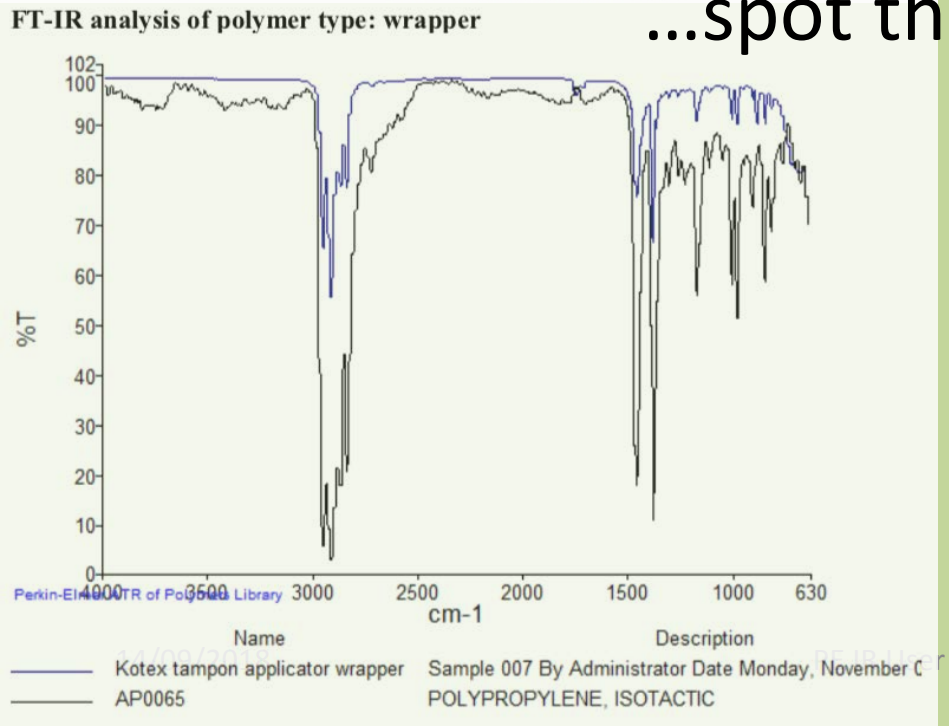
‘Degradable’ plastics…?

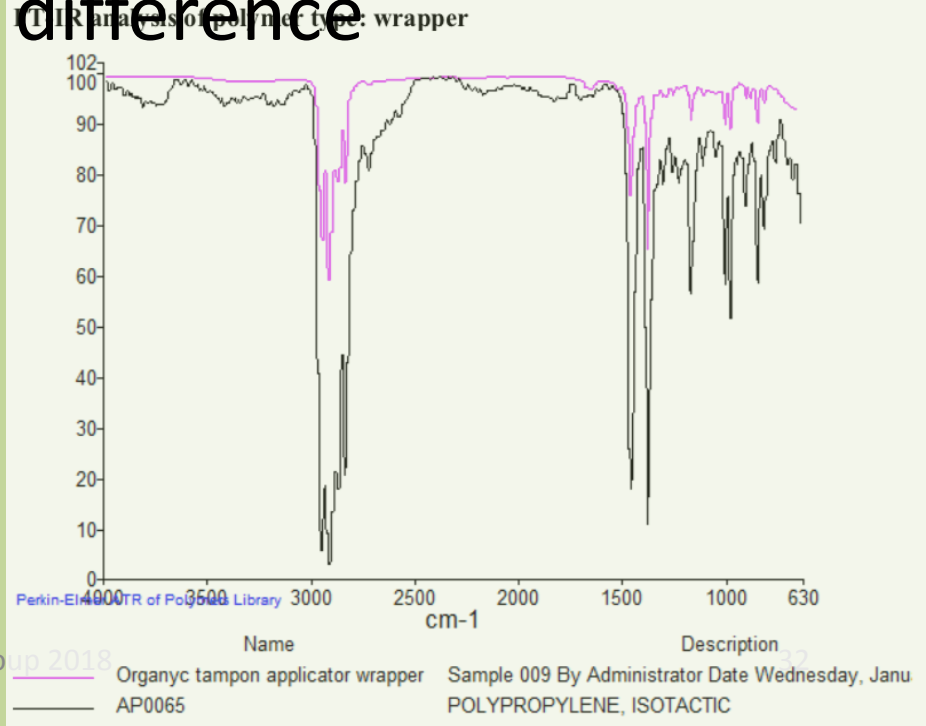




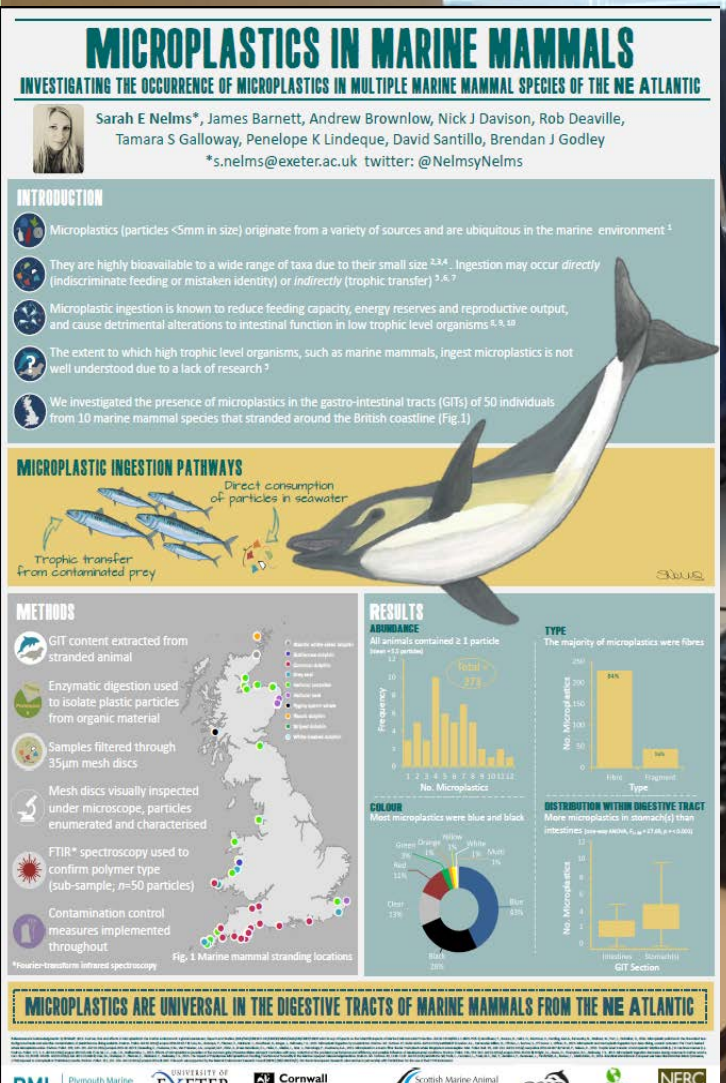
Organic certification for sanitary products

...spot the difference





Collaborative research: Microplastics in marine mammals from the North-East Atlantic (with PML)



MICROPLASTICS IN MARINE MAMMALS

INVESTIGATING THE OCCURRENCE OF MICROPLASTICS IN MULTIPLE MARINE MAMMAL SPECIES OF THE NE ATLANTIC

Sarah E Nelms*, James Barnett, Andrew Brownlow, Nick J Davison, Rob Deaville, Tamara S Galloway, Penelope K Lindeque, David Santillo, Brendan J Godley

*s.nelms@exeter.ac.uk twitter: @NelmsyNelms

INTRODUCTION

- Microplastics (particles <5mm in size) originate from a variety of sources and are ubiquitous in the marine environment [1]
- They are highly bioavailable to a wide range of taxa due to their small size [2,3,4]. Ingestion may occur *directly* (indiscriminate feeding or mistaken identity) or *indirectly* (trophic transfer) [5,6,7]
- Microplastic ingestion is known to reduce feeding capacity, energy reserves and reproductive output, and cause detrimental alterations to intestinal function in low trophic level organisms [8,9,10]
- The extent to which high trophic level organisms, such as marine mammals, ingest microplastics is not well understood due to a lack of research [3]
- We investigated the presence of microplastics in the gastro-intestinal tracts (GITs) of 50 individuals from 10 marine mammal species that stranded around the British coastline (Fig.1)

MICROPLASTIC INGESTION PATHWAYS

Direct consumption of particles in seawater

Trophic transfer from contaminated prey

METHODS

- GIT content extracted from stranded animal
- Enzymatic digestion used to isolate plastic particles from organic material
- Samples filtered through 35µm mesh discs
- Mesh discs visually inspected under microscope, particles enumerated and characterised
- FTIR* spectroscopy used to confirm polymer type (sub-sample; *n*=50 particles)
- Contamination control measures implemented throughout

*Fourier-transform infrared spectroscopy

Fig. 1 Marine mammal stranding locations

RESULTS

ABUNDANCE
All animals contained ≥ 1 particle

Frequency

No. Microplastics

TYPE
The majority of microplastics were fibres

No. Microplastics

Fibre

Fragment

Type

COLOUR
Most microplastics were blue and black

Green 3%, Orange 1%, Yellow 1%, White 1%, Multi 1%, Red 11%, Clear 13%, Blue 83%, Black 26%

DISTRIBUTION WITHIN DIGESTIVE TRACT
More microplastics in stomach(s) than intestines

No. Microplastics

Intestines

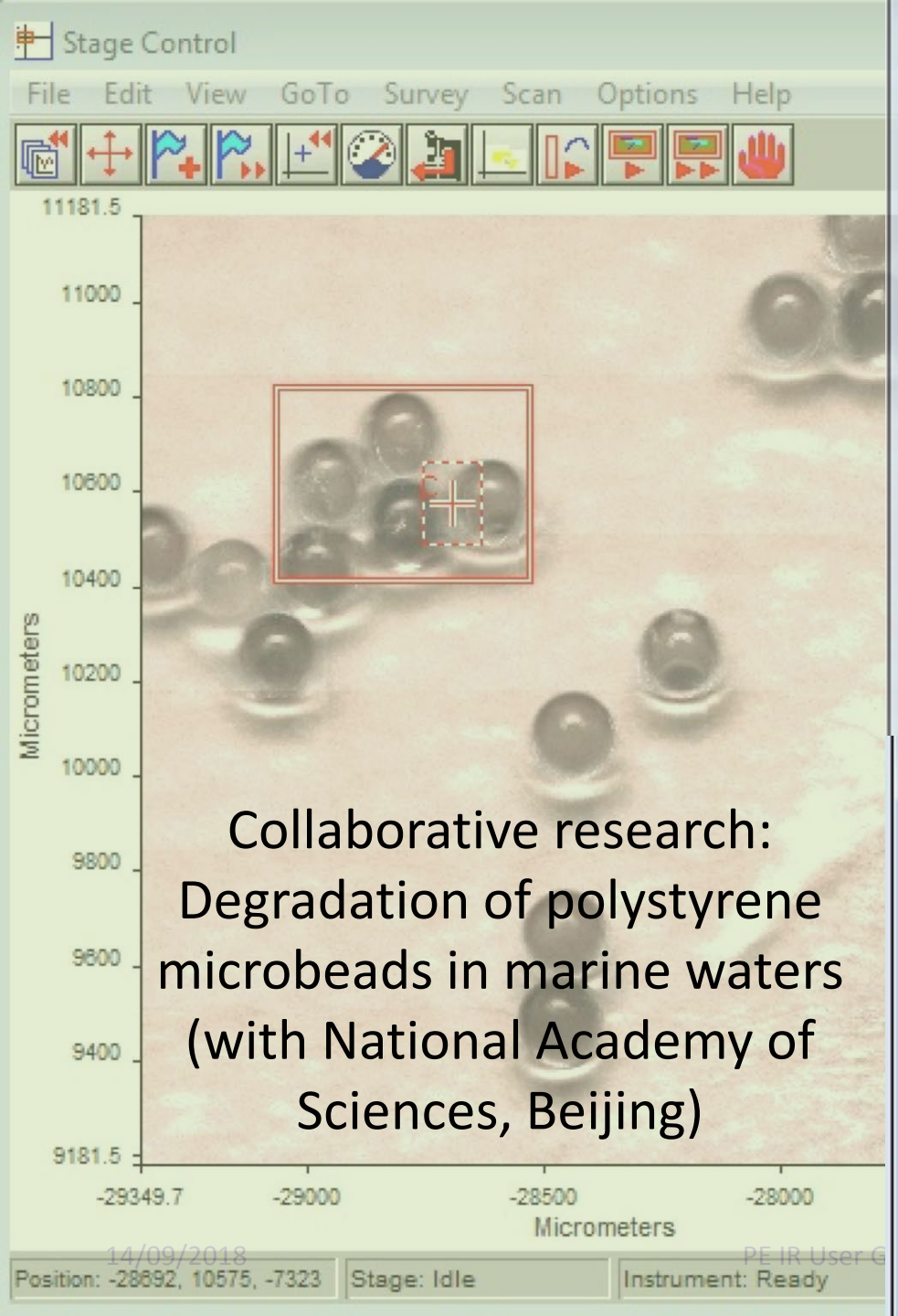
Stomach(s)

GIT Section

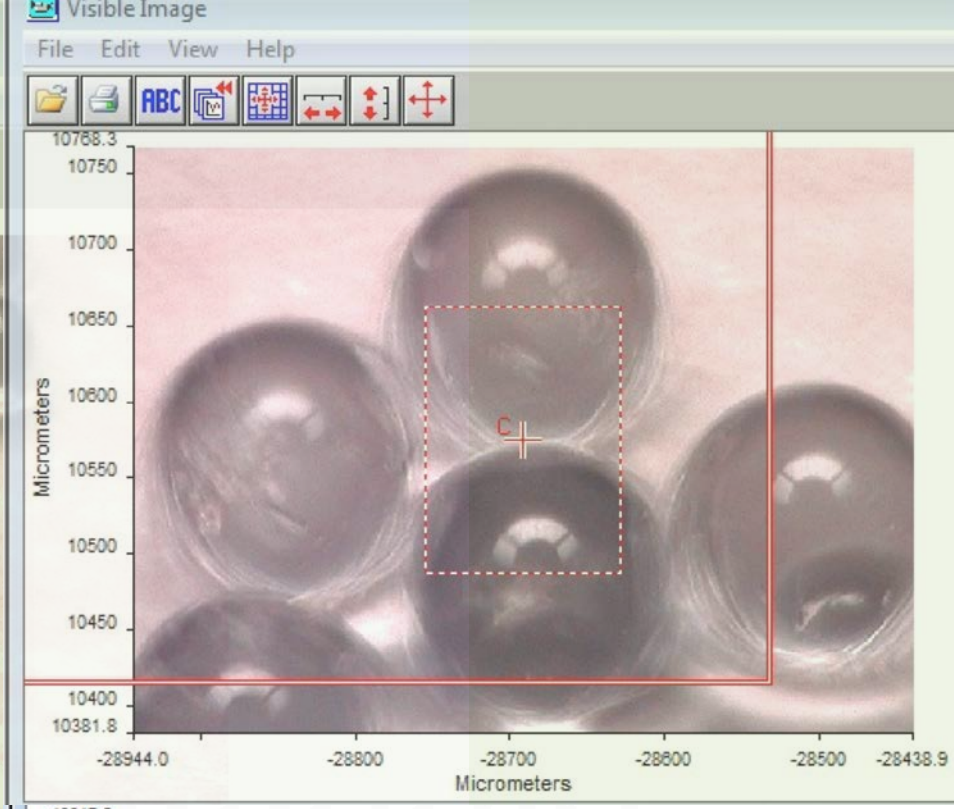
MICROPLASTICS ARE UNIVERSAL IN THE DIGESTIVE TRACTS OF MARINE MAMMALS FROM THE NE ATLANTIC

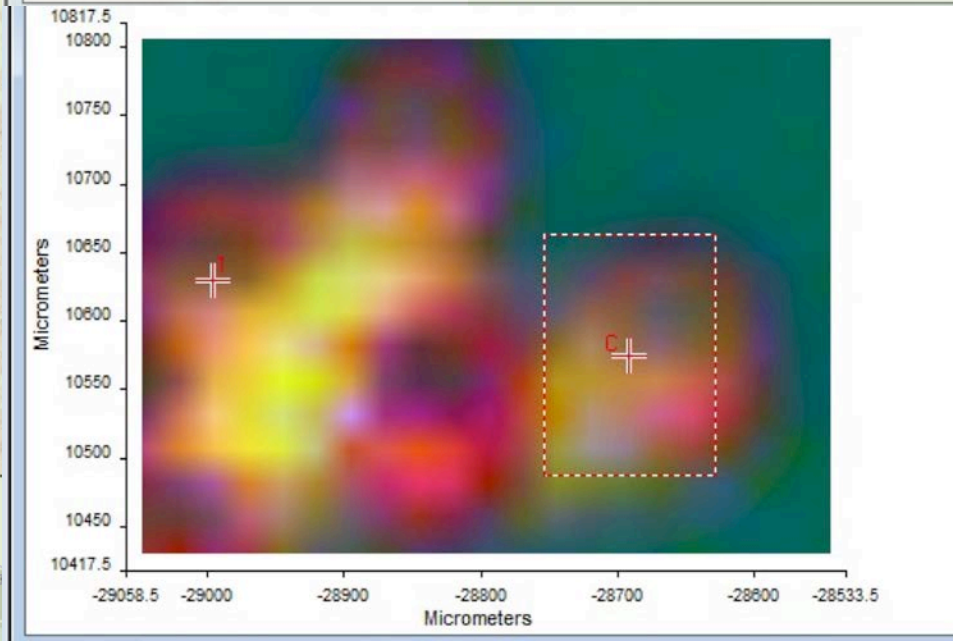
PML Plymouth Marine | University of Exeter | Cornwall | Scottish Marine Animal | NERC

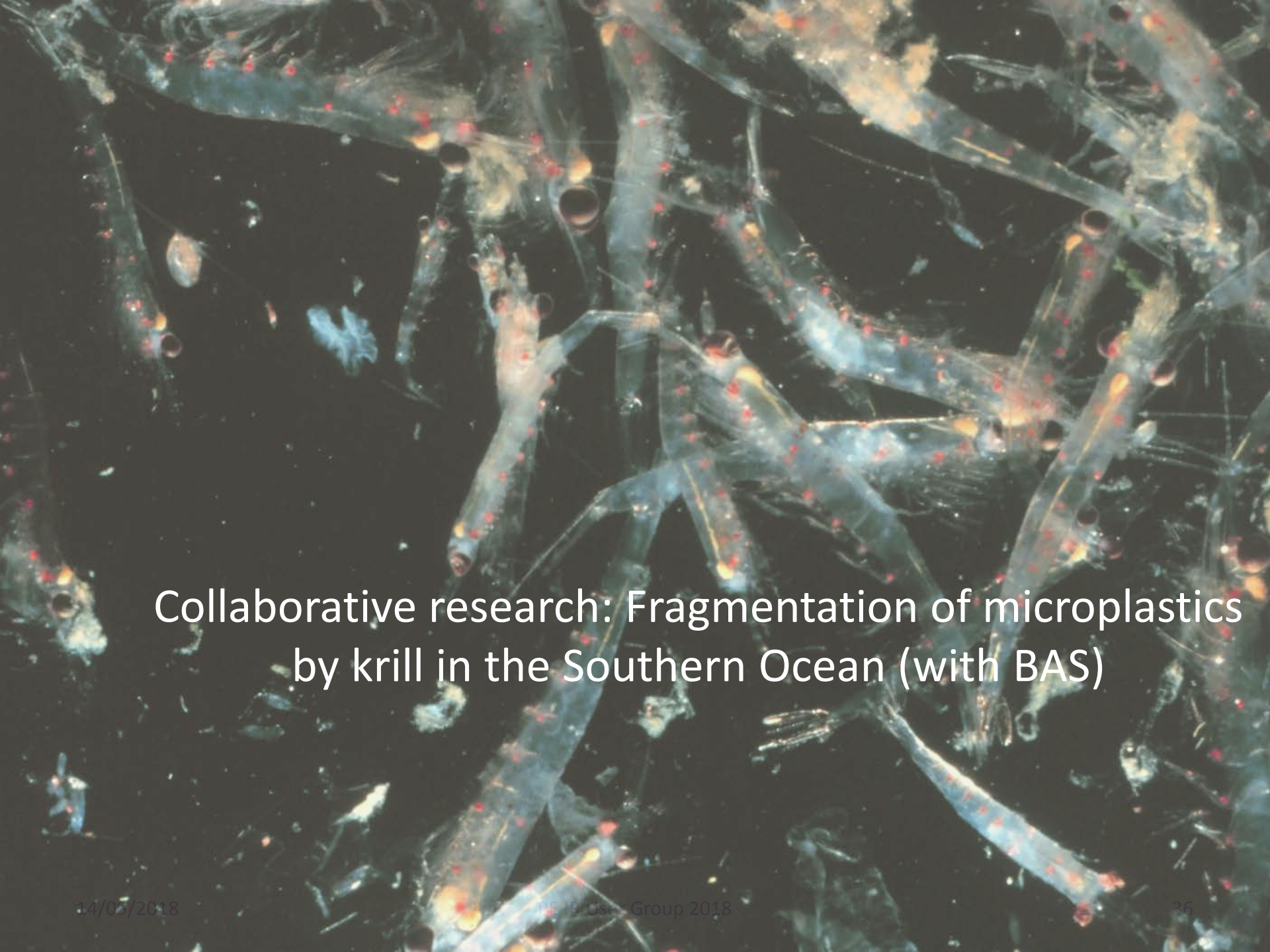
Collaborative research: Microplastics in turtles from th
Atlantic, Pacific and Indian Oceans (with UoE)

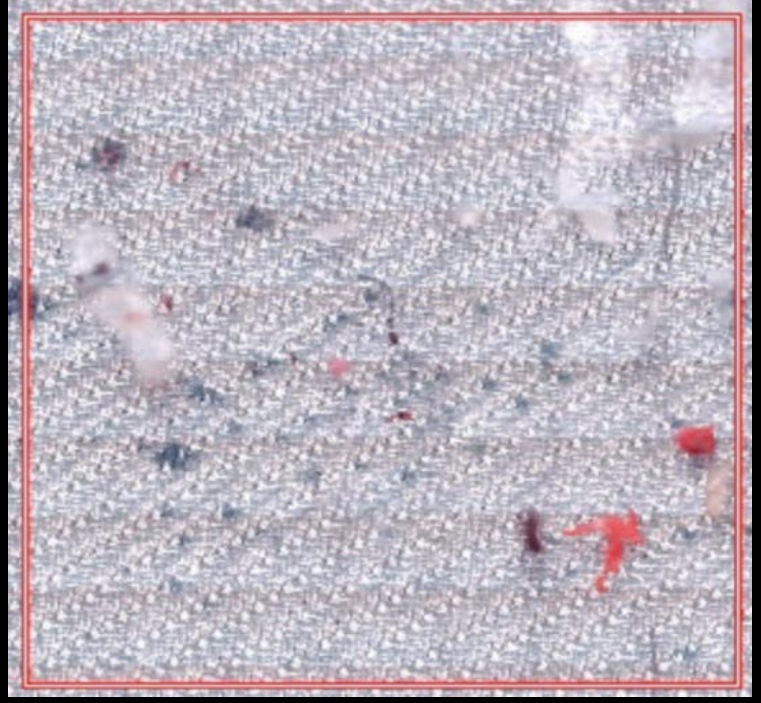


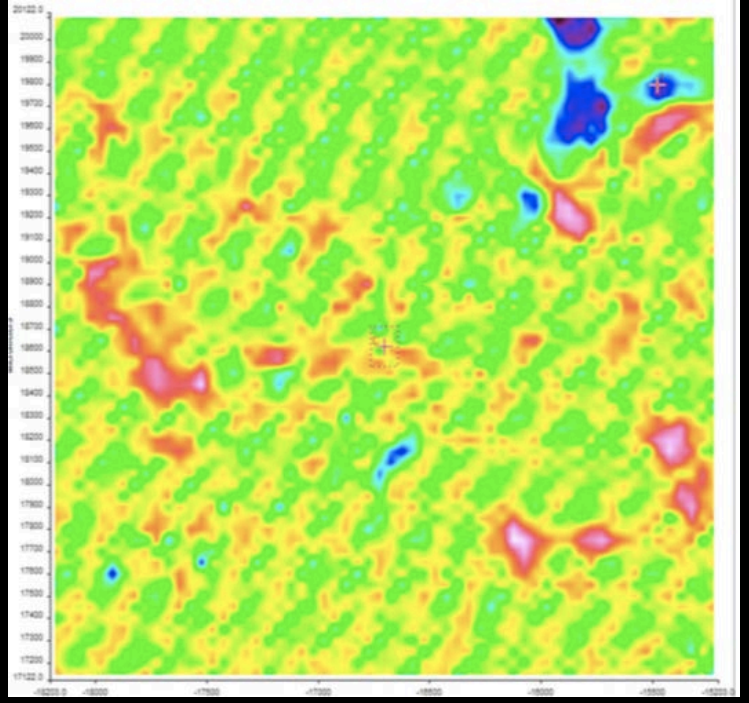
Collaborative research: Degradation of polystyrene microbeads in marine waters (with National Academy of Sciences, Beijing)

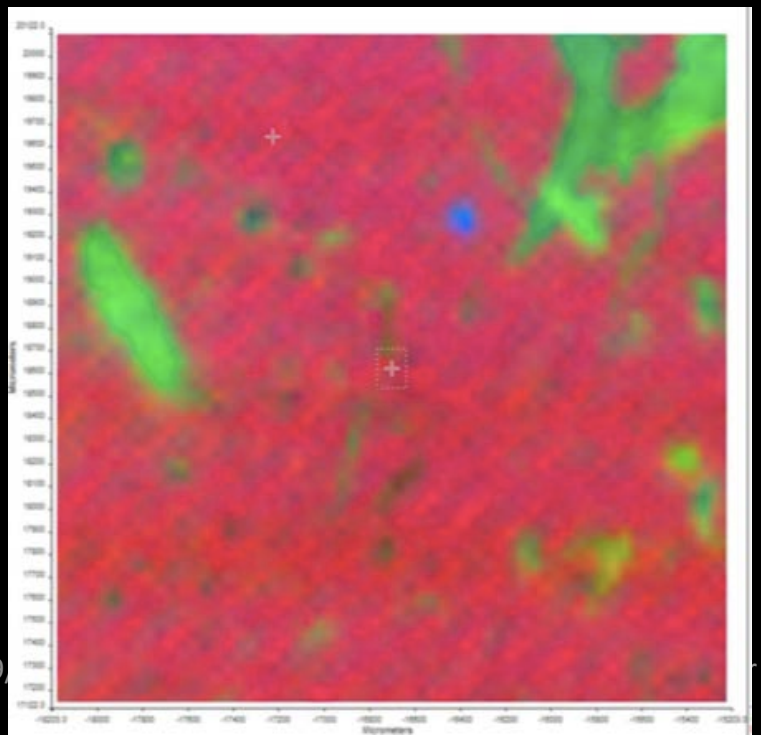


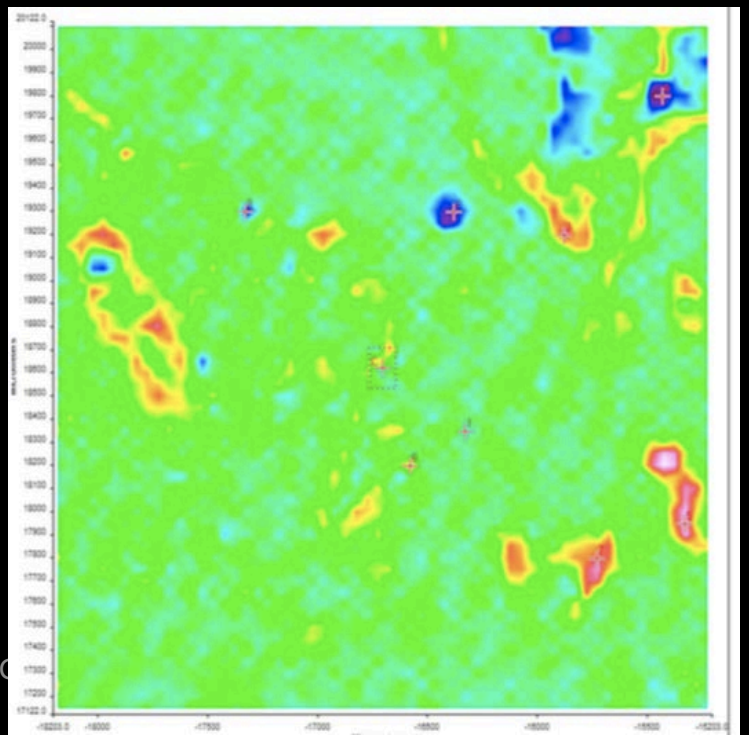


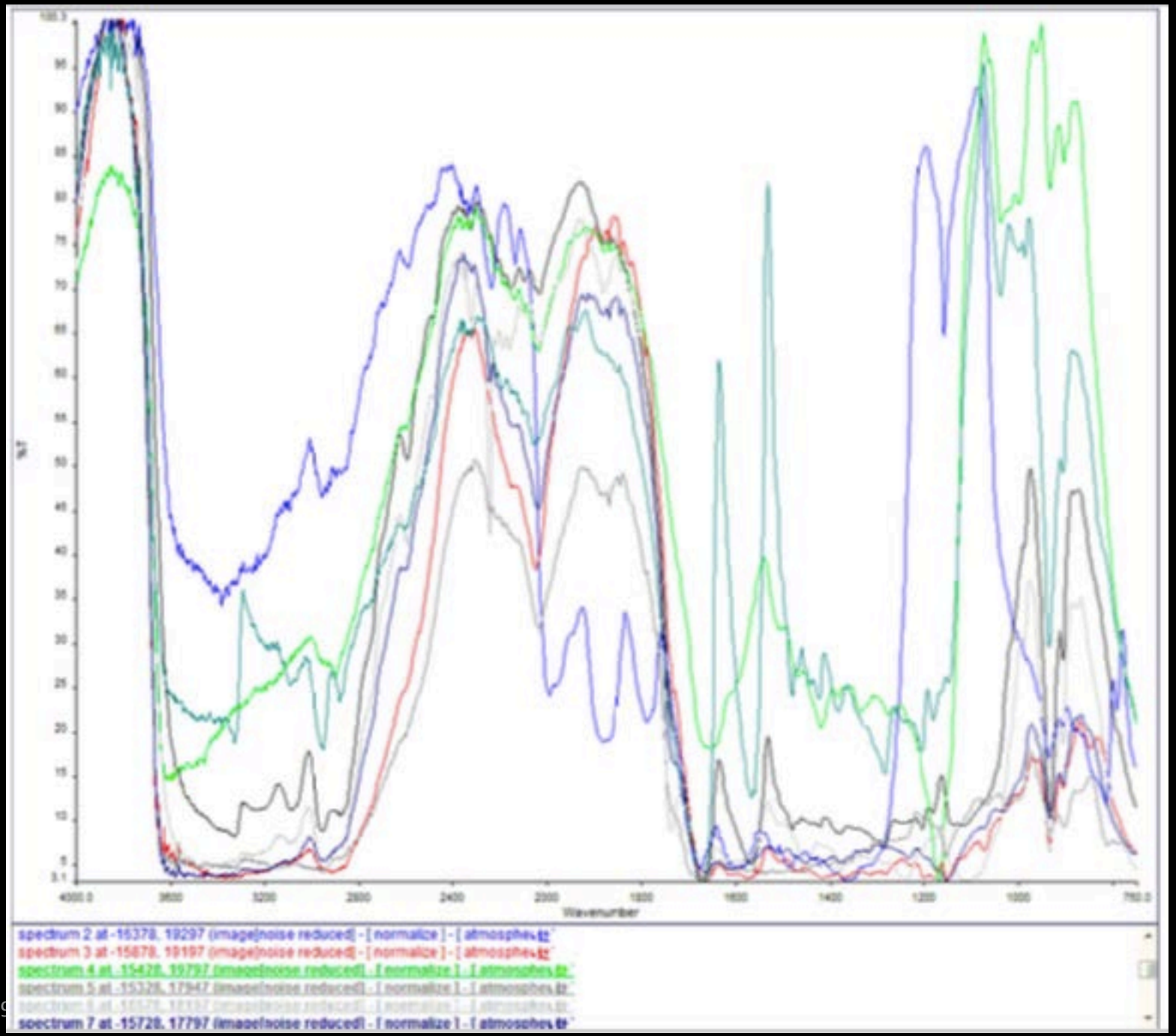

Collaborative research: Fragmentation of microplastics by krill in the Southern Ocean (with BAS)







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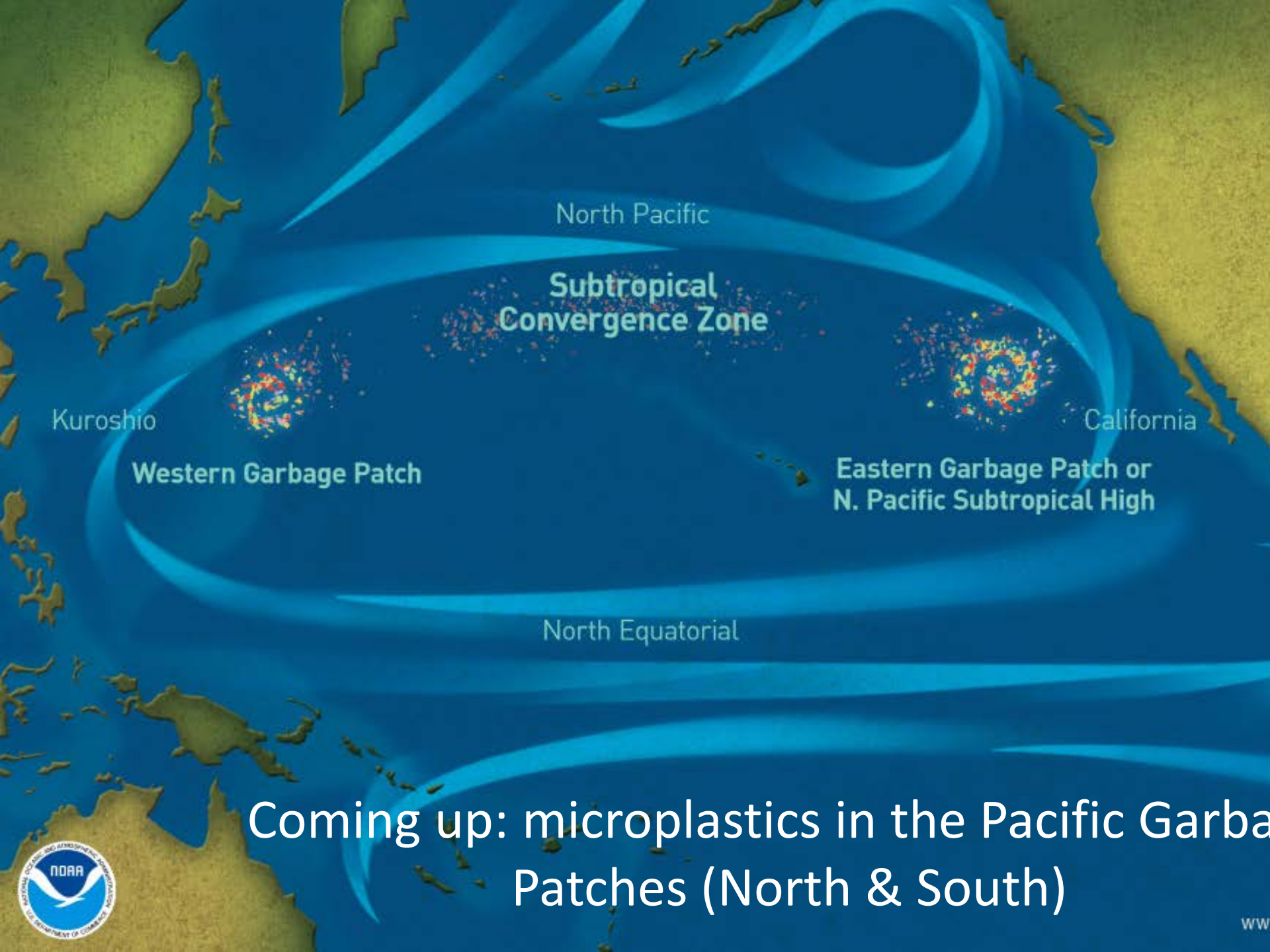
spectrum 4 at -15428, 19797 (image)noise reduced] - [normalize] - [atmosphe
spectrum 5 at -15328, 17947 (image)noise reduced] - [normalize] - [atmosphe
spectrum 7 at -15728, 17797 (image)noise reduced] - [normalize] - [atmosphe


Coming up: microplastics in coastal waters of the Baltic (Poland, Germany and Denmark)

Coming up: microplastics in the Vltava and Elbe Rivers, Czech Republic



Coming up: microplastics in the Pacific Garba
Patches (North & South)

Some key challenges in FT-IR analysis of environmental samples #1

- Representative sample collection
- Difficulty in replication and sub-sampling (every sample is discrete and non-homogenous)
- Separation of plastics from other materials (biological matter and sediments)
- Interference from surface biofouling

Some key challenges in FT-IR analysis of environmental samples #2

- Variable extent of polymer degradation
- Presence of pigments and other additives
- Sample contamination during collection, storage and analysis (especially fibres and paint fragments)
- Contamination of sampling equipment (…even before we start!)