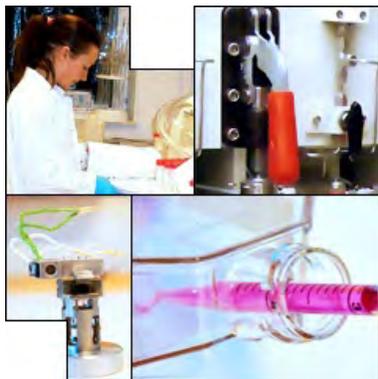


# Studying POPs and plastic debris in ocean gyres



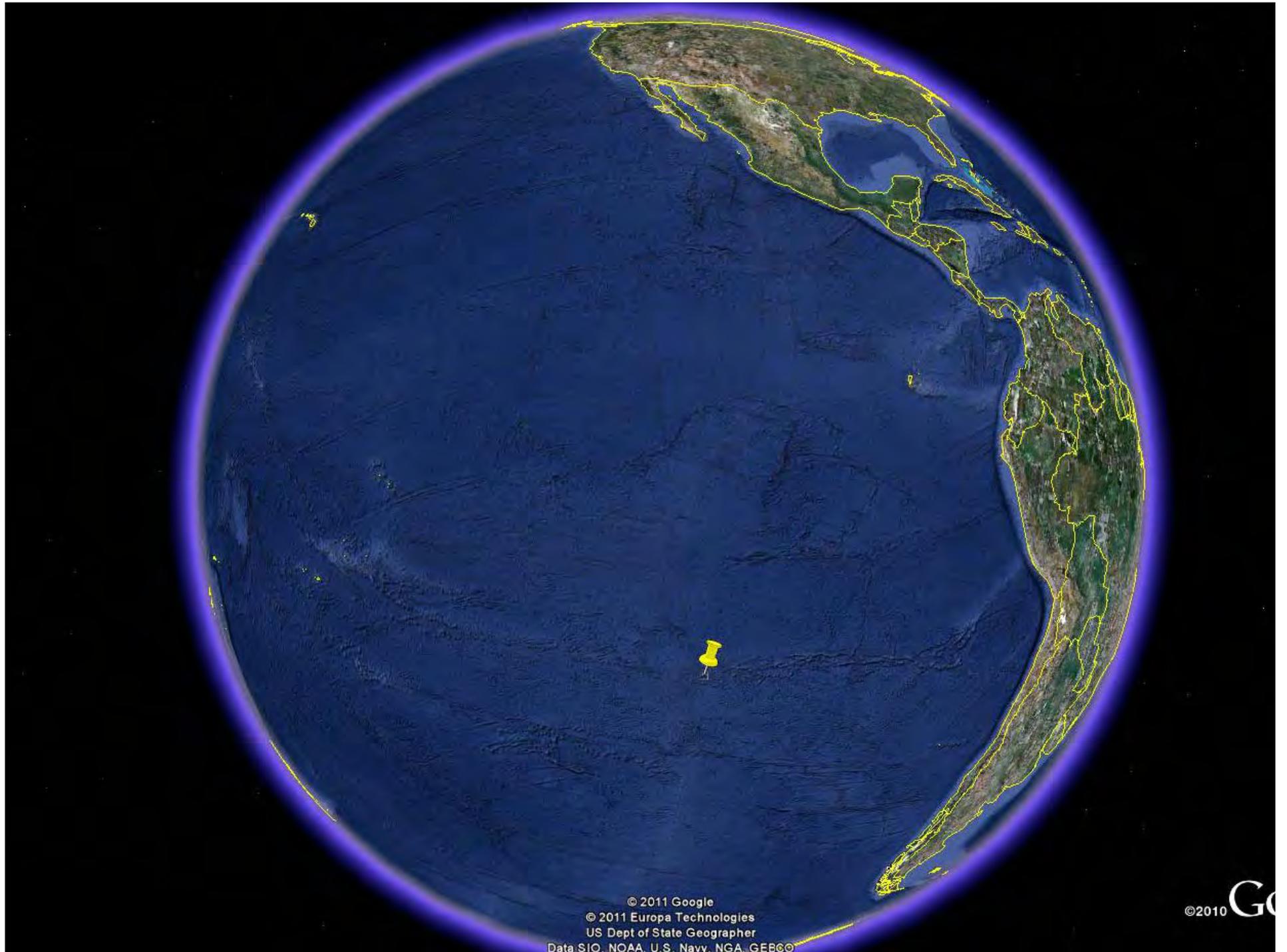
- sailing the Atlantic and South Pacific Oceans -



Anna Rotander and Anna Kärrman

MTM Research Centre  
Örebro University, Sweden





© 2011 Google  
© 2011 Europa Technologies  
US Dept of State Geographer  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

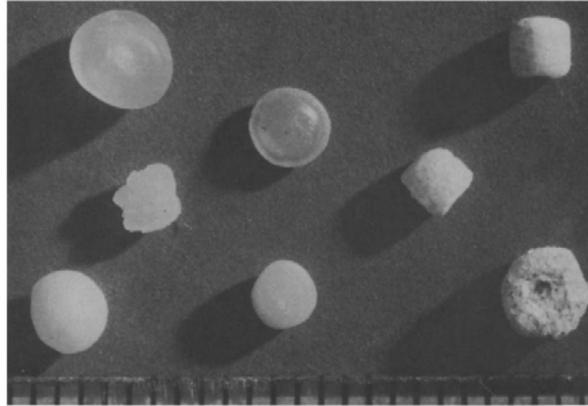
©2010 G



# Outline

- Introduction to plastics and POPs
- MTM involvement
- Movie time
- Challenges
- Preliminary results
- Future work





Plastic debris in the surface waters of the South Atlantic.  
Morris, Marine Pollution Bulletin 1980 11 164-66



# Recycling

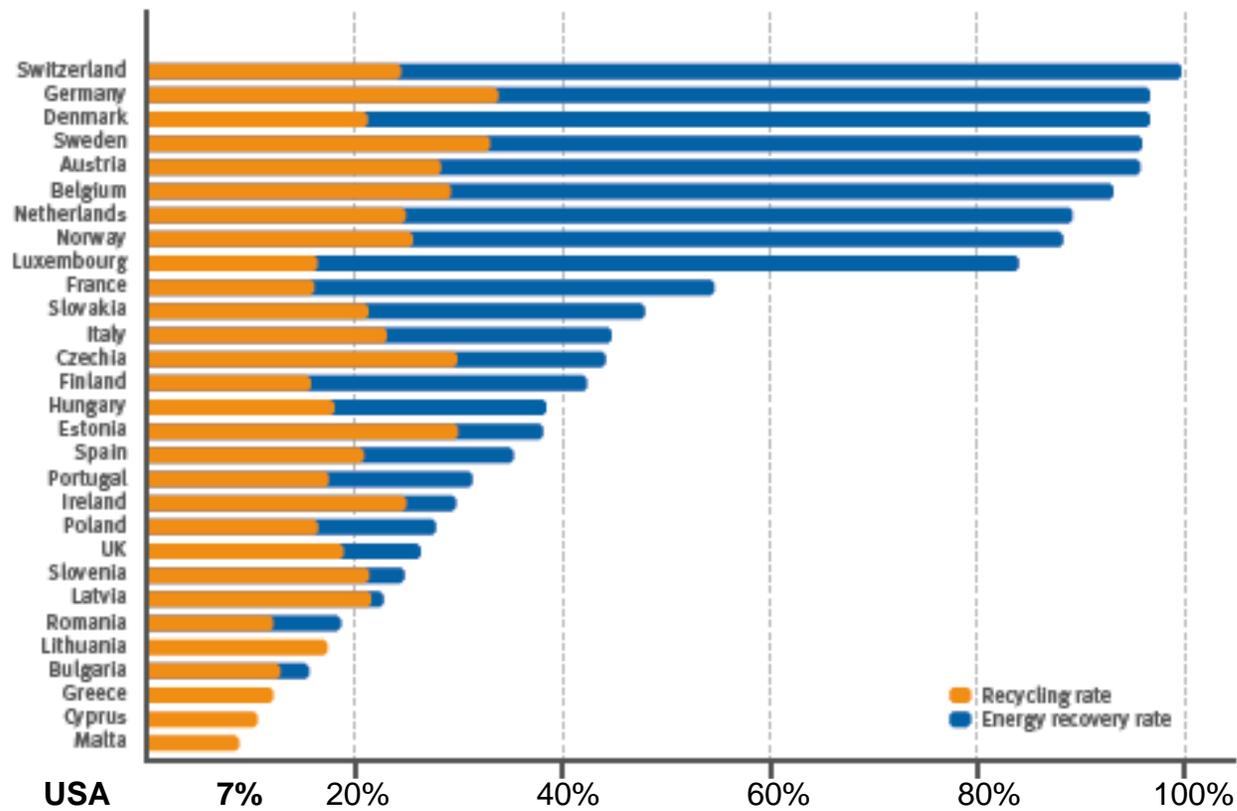
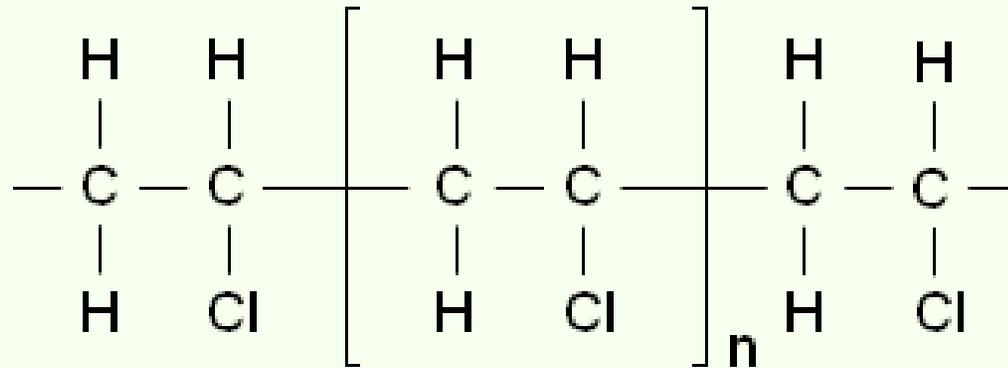


Figure 12. Total Recovery Ratio by Country 2009  
(referred to Post-Consumer Plastic Waste)

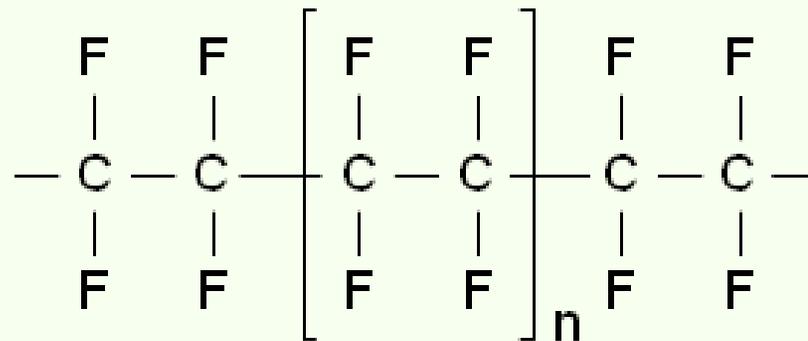
# VINYL PLASTICS

Polyvinyl chloride (PVC)



# FLUOROPOLYMERS

## Teflon



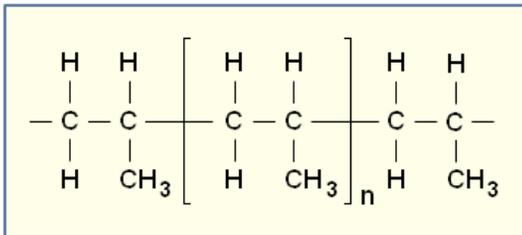
**PTFE (PolyTetraFluorEten)**



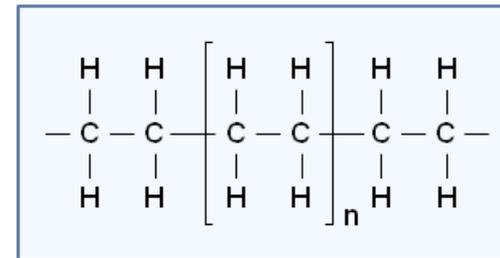
# OLEFIN PLASTICS



**Polypropylene (PP)**

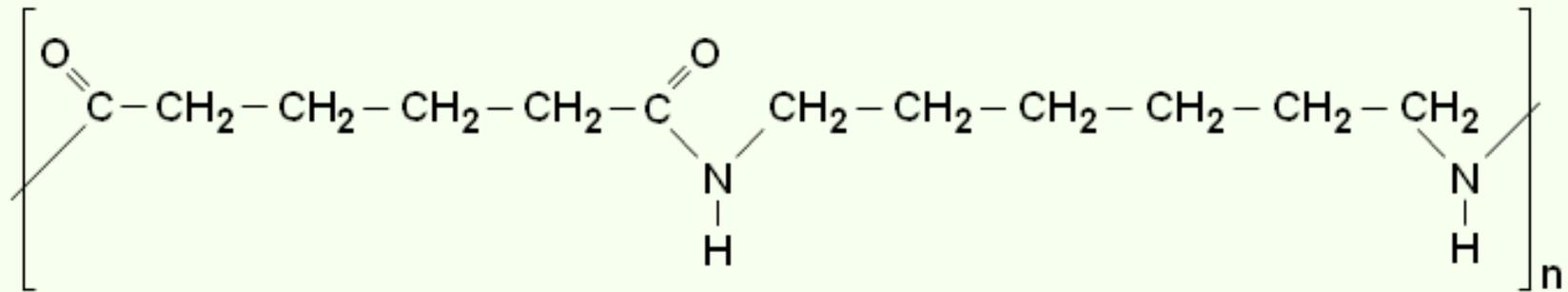


**Polyethene (PE)**

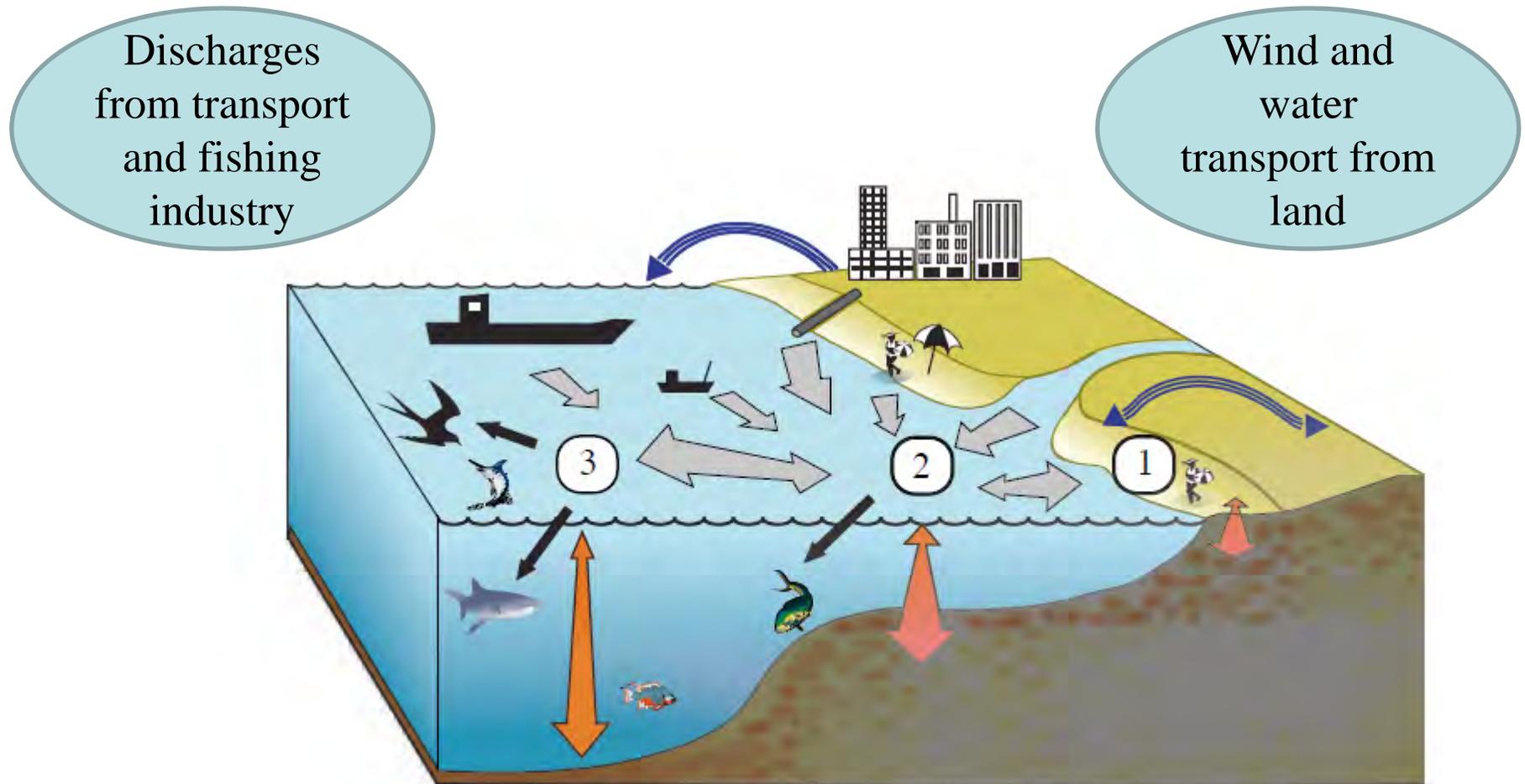


# POLYAMIDE

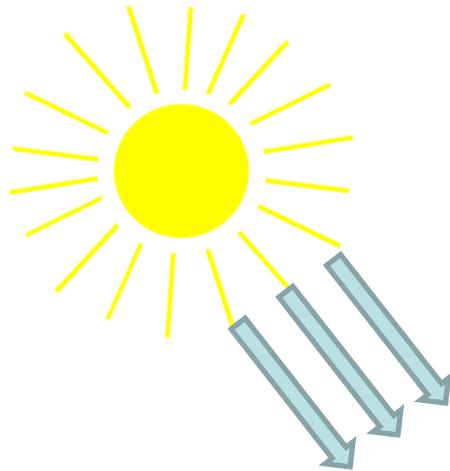
## Nylon



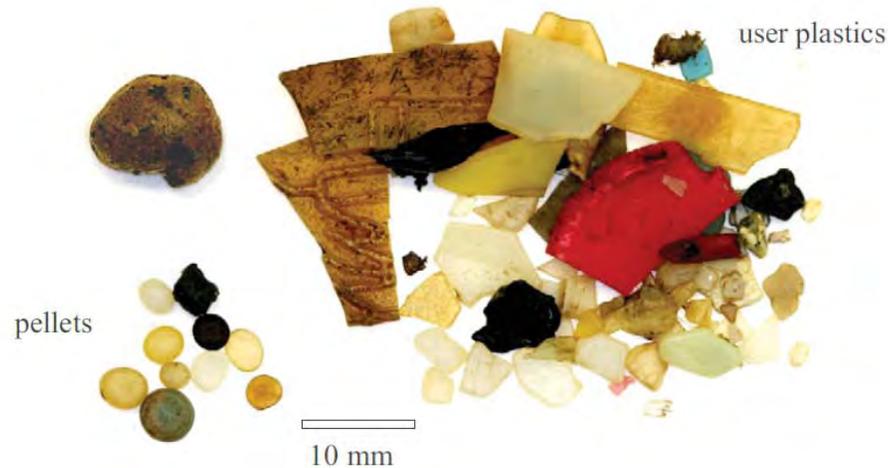
# Sources, routes and distribution



# Plastic debris in the ocean



Mechanical erosion



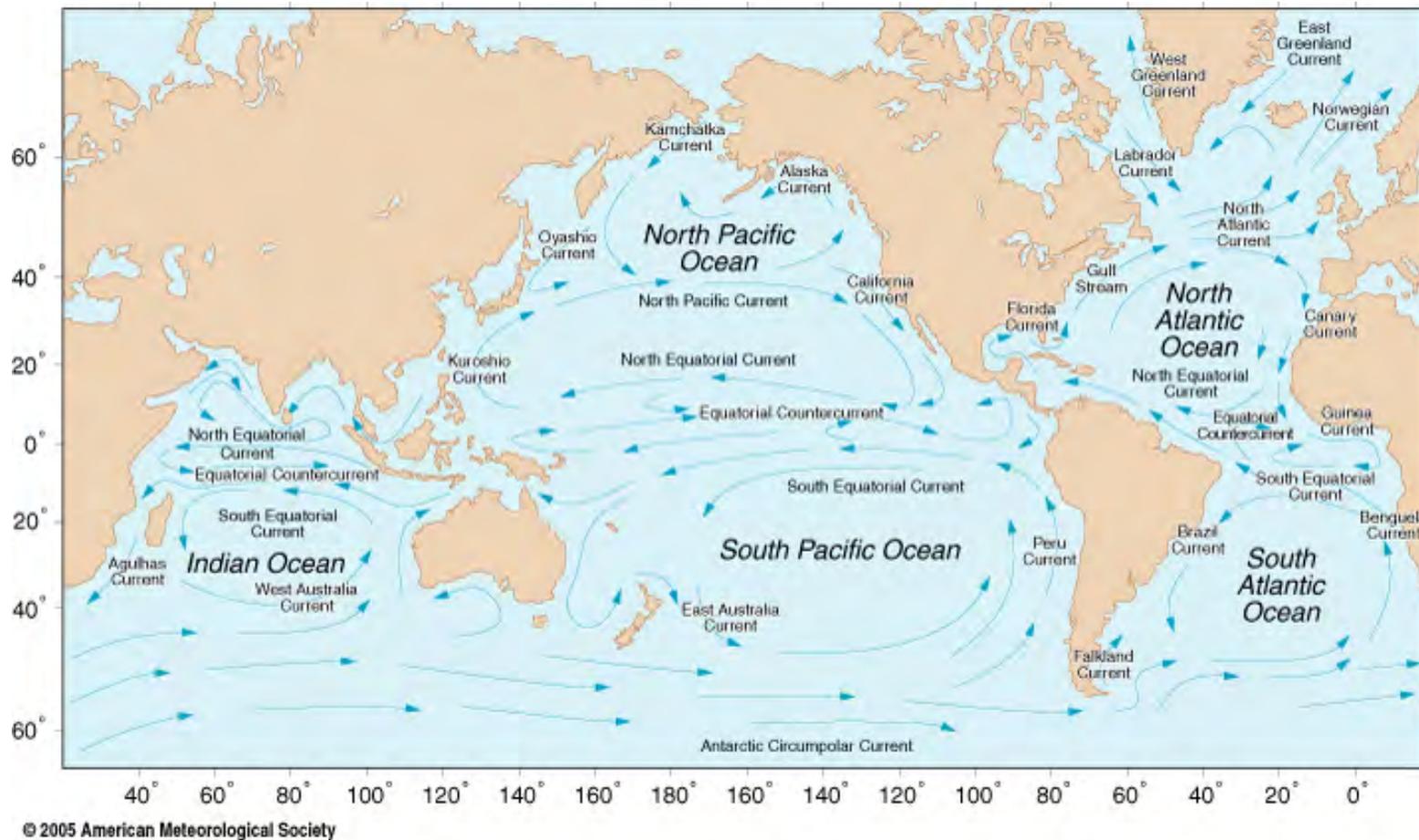
Macro plastic >20mm

Micro plastic <2mm

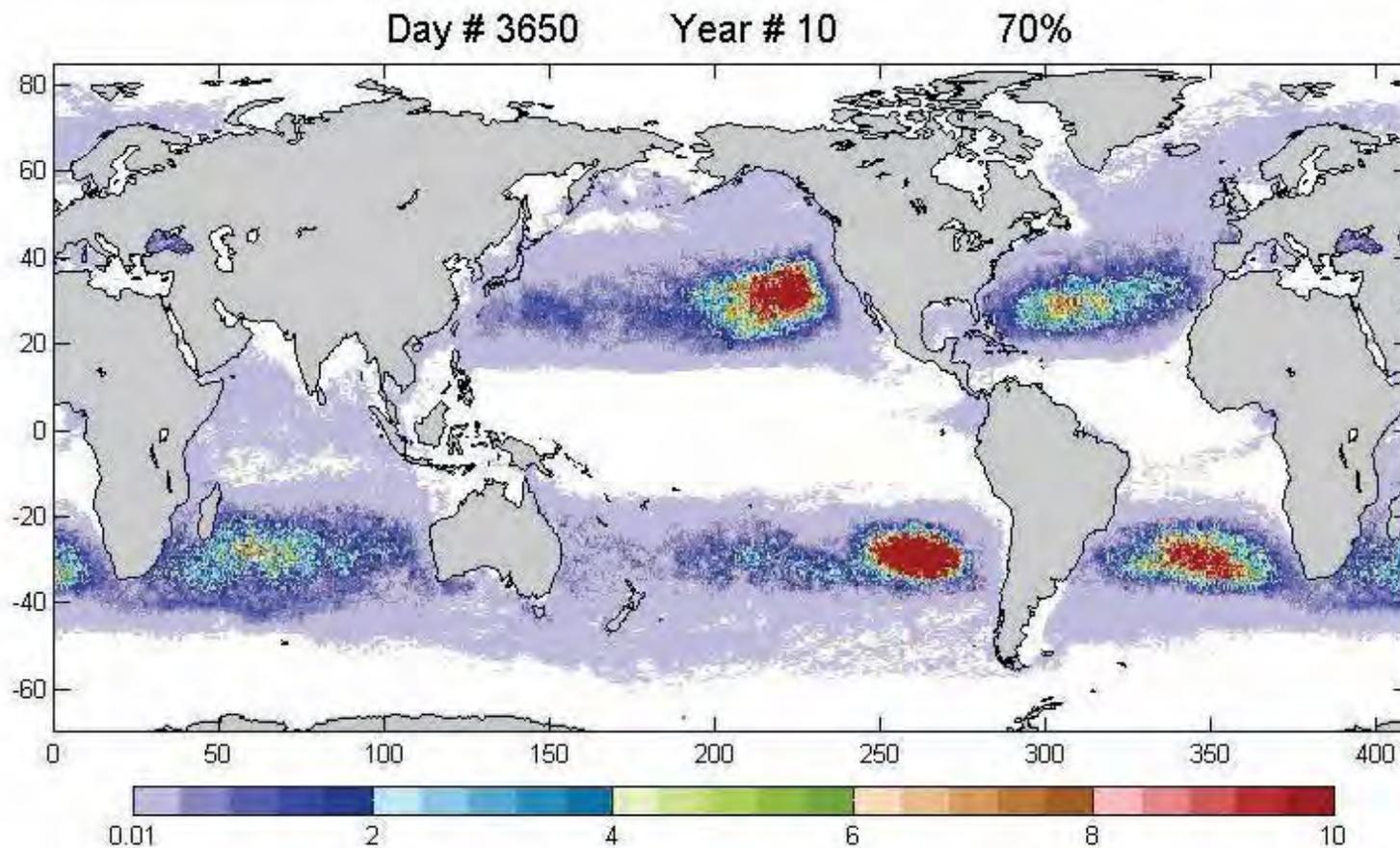
# Floating plastics on Easter island



# Ocean transport and accumulation



# Accumulation zones



Maximenko 2008  
*IPRC Climate* 8(2) 14-16

# Effects on marine wildlife

## Entanglement



Macro plastic  
> 20 mm

## Ingestion



Micro plastic  
< 2 mm

# Persistent organic pollutants, POPs

Persistent

Long-range transport

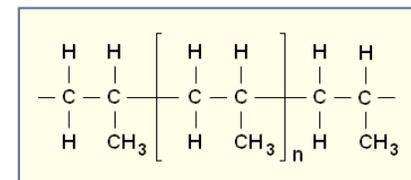
Bioaccumulate

Negative effects, toxic

- Long-lived in the environment
- Global distribution
- Uptake by living organisms
- Threat to humans and the environment

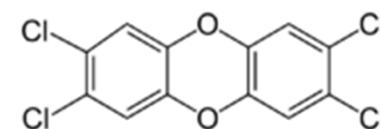


# Indirect effects



1. Plastic can adsorb lipid soluble POPs from the surrounding media

- Pesticides, PCBs, dioxins, etc



2. Plastic can contain chemical additives

- Softeners, flame retardants, "non-stick"-substances, etc

# Additives vs accumulation

## **Additive**

(up to 50weight% in plastics)

- Nonylphenyl
- Phthalates
- Bisphenol A
- Styren monomers
- .....

## **Accumulative substances**

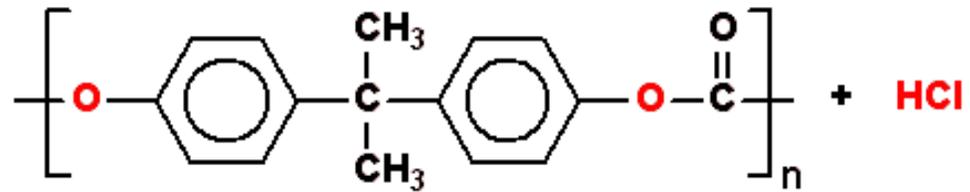
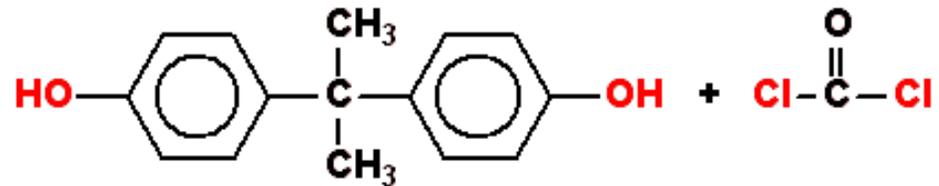
(upp to a million times higher concentration than the surrounding sea water )

- PCB
- PAH
- HCH
- DDT
- .....

# Rest monomers

## Example 1; polycarbonate plastic

Bisphenol A  
Endocrine  
disruptor

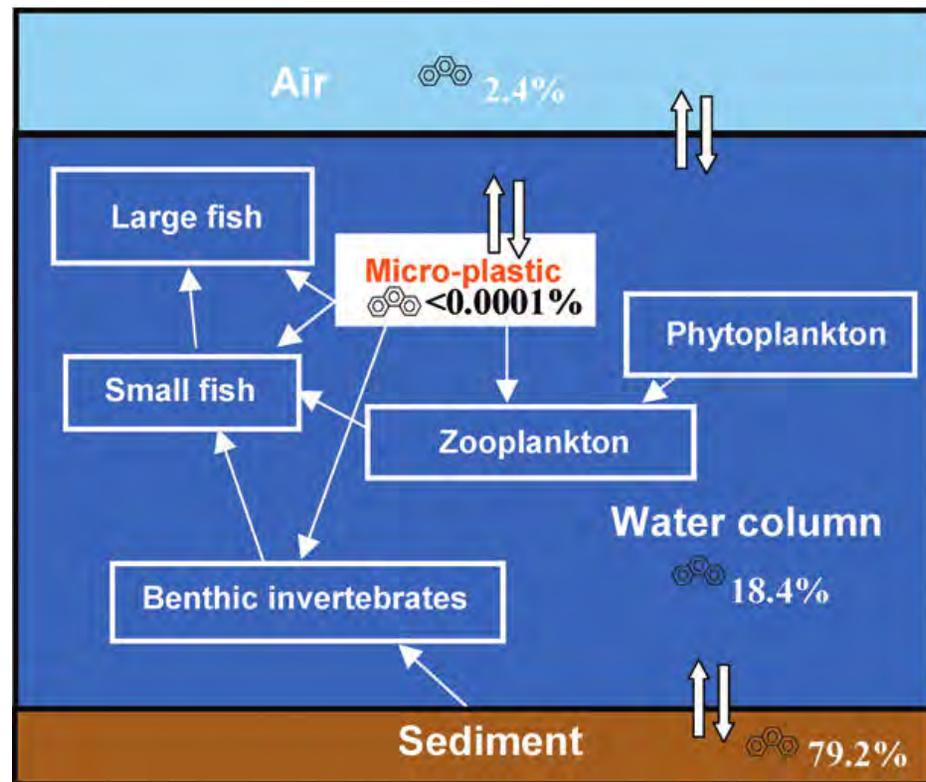




# The importance of plastics as carriers of POPs to marine organisms

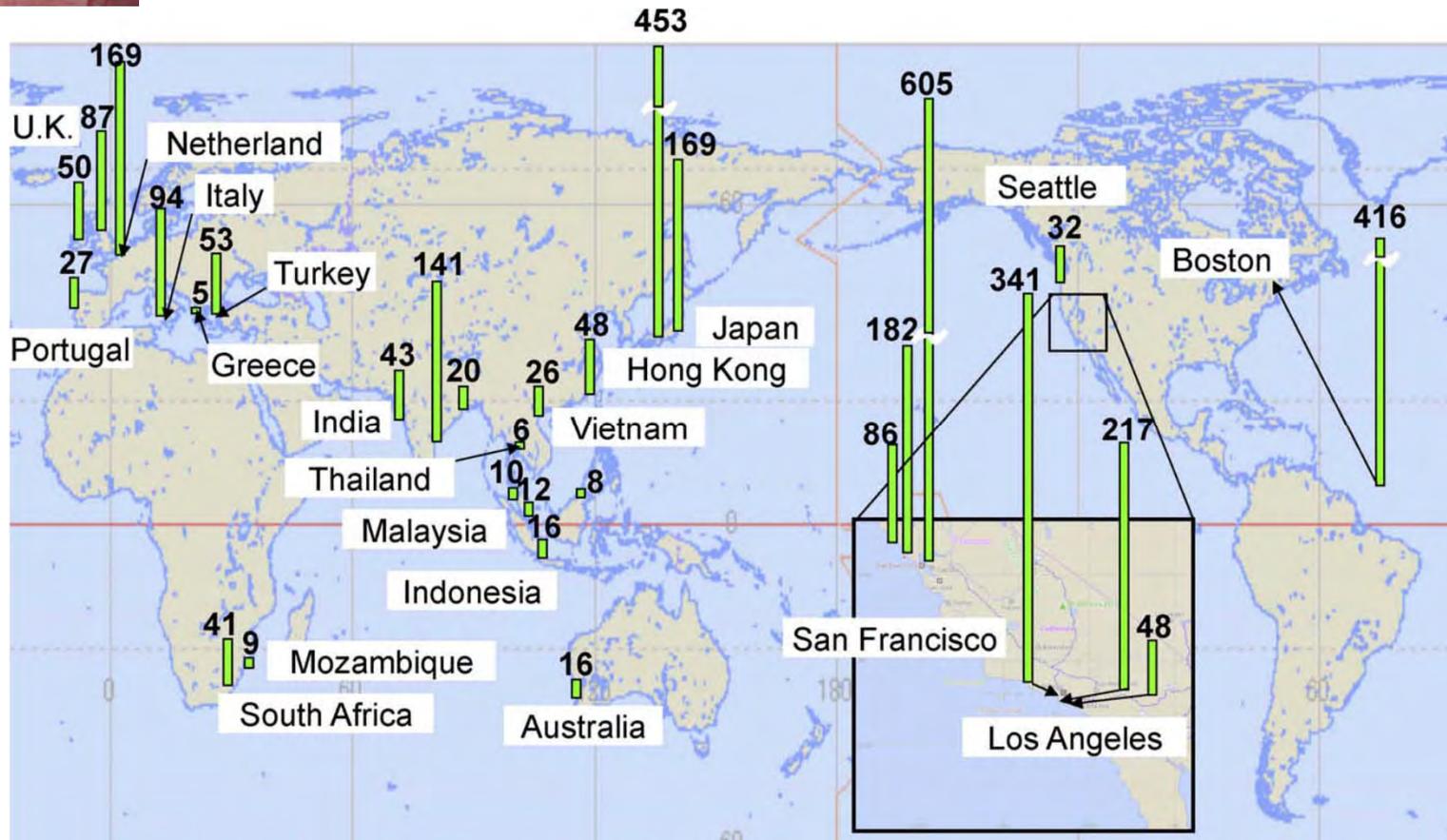
?

- What is the effect of:
  - organic film and its potential to bind chemicals?
  - The shape and plastic structure?
  - The smallest fraction, <0.3 mm?

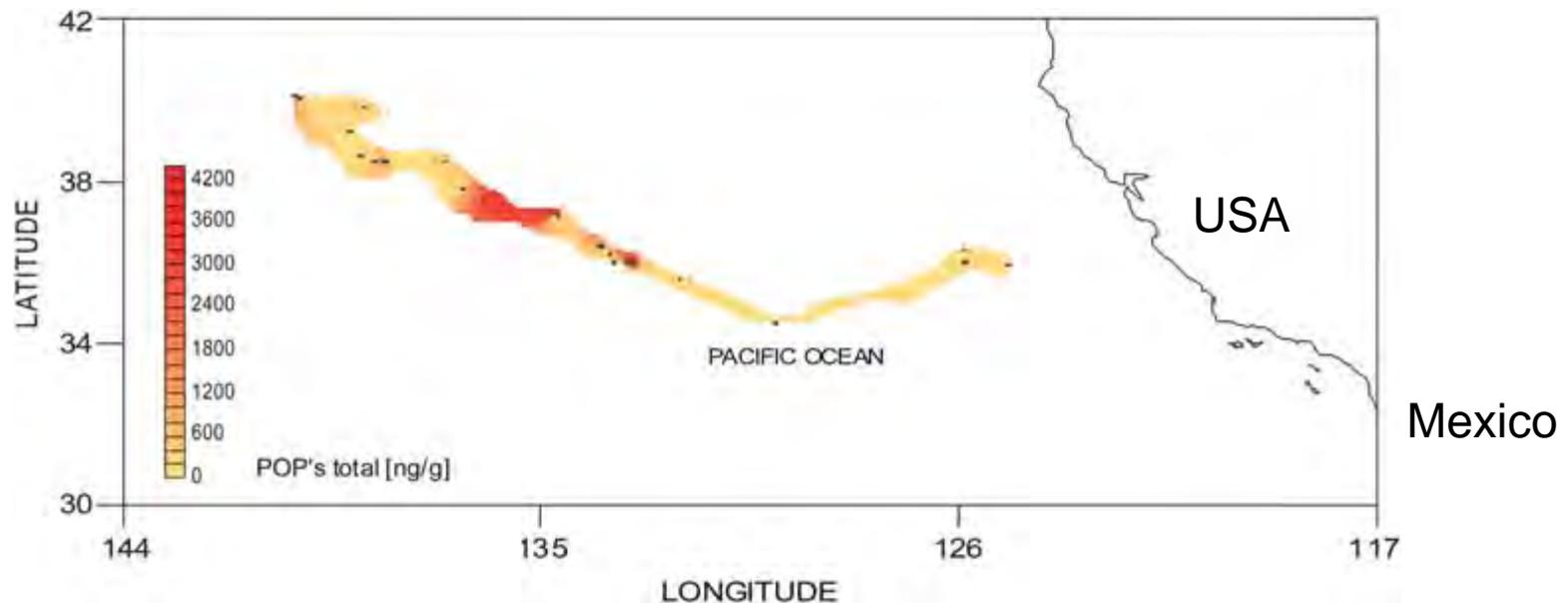




# PCB in PE nurdles (ng/g)



# PCB+PAH+pesticides+aliphatic hydrocarbons on plastic debris from the North Pacific Ocean



37 samples, mainly PE

Conclusion: marine plastic debris behaves like sediments

# How much plastics are there?

Aftonbladet ▶ Klimathotet  
Publicerad: 2008-02-06 5 rekommenderar Textstorlek: 1 2 3



## – Vi åkte genom sopor i flera dagar

Forskare varnar för gigantiska sopberg i Stilla havet

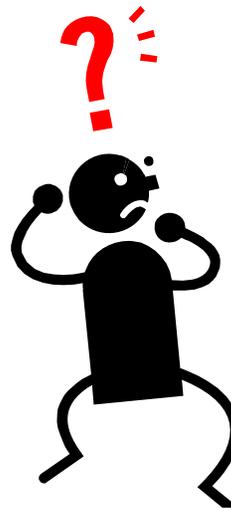
Världens största soptipp finns till havs. I två gigantiska virvlar i Stilla havet har miljoner ton plastskräp samlats till två trögflytande undervattensberg av sopor.

Plastpåsar, leksaker, fotbollar, kilometer av gamla nät – det handlar om ändlösa mängder sopor.

ibland tiotals år gamla. Och de bryts inte ner.

### Fakta

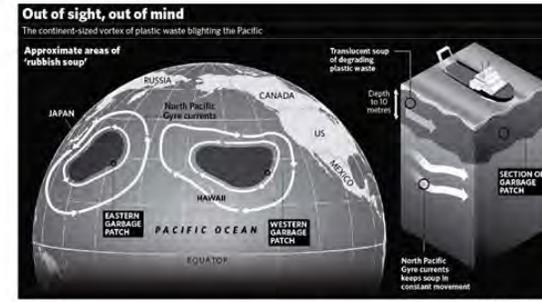
90 procent av soporna till havs tros vara plastskräp. FN:s miljöexperter beräknade 2006 att varje kvadratkilometer hav innehöll i genomsnitt över 100.000 flytande plastföremål.



## Sopberg dubbelt så stort som USA flyter i Stilla Havet

Postat den 2008/02/07 | 34 kommentarer

Nyheten att det finns enorma mängder plast i bla Stilla Havet har de senaste åren återkommit med jämna mellanrum i olika medier. Tillsammans har sopbergen i Stilla Havet ungefär en så stor yta som USA upp till dubbla USA:s yta. (Ytan varierar en hel del beroende på källa) Fenomenet kallas "The Great Pacific Garbage Patch". Till största delen består soporna av plast som inte bryts ner och det flytande sopberget ställer naturligtvis till med massor av problem för det marina djurlivet i området. Eftersom sopkontinenterna flyter en bit under vattenytan är de svåra att se på satellitbilder och problemet har bland annat därför inte fått så mycket uppmärksamhet förrän de senaste åren. Det som inte syns, finns inte som bekant. Hos sjöfarten har områdena dock varit kända länge och många båtar undviker därför dessa områden, detta för att undvika diverse problem.



Minst 100 000 000 ton sopor ska tydligen flyta runt där. Det är naturligtvis länderna runt Stilla havet som i årtionden dumpat sopor i Stilla Havet. Den plast som inte brutits ner i mindre beståndsdelar (vilket ställer till andra problem) har

Mass balance: Production–recycled plastics–plastic waste = 25% "disappeared plastic" (USA)

Floating in the ocean: 200-100000 particles/m<sup>3</sup> water [Swedish west coast]  
Average 1 table spoon plastic/3 football fields [All world's oceans, 5Gyres]

# 5Gyres



- Understanding plastic pollution through exploration, education and action
- Research leaving a small environmental footprint
- studying all five ocean gyres with the questions
  - What is the surface abundance of plastic marine debris?
  - Are surface foraging fish ingesting micro-plastic particles?
- supported by the UNEP Safe Planet campaign



[www.5gyres.org](http://www.5gyres.org)

[www.algalita.org](http://www.algalita.org)





# Sea Dragon

”We must go and see for ourselves” J.Y. Cousteau

- 72 feet sailing vessel
- Former race yacht in the Global Challenge Race
- Owned by Pangaea Exploration and used for missions that
  - ”strengthen the health of marine life”
  - ”inspires new generations of leaders in conservation science”



[www.panexplore.com](http://www.panexplore.com)

# Route February-May 2011



February-March 2011  
Anna Rotander  
Uruguay-Chile

April-May 2011  
Anna Kärrman  
Easter Island-Tahiti



# Getting Sea Dragon ready in Piriápolis, Uruguay Feb 2011





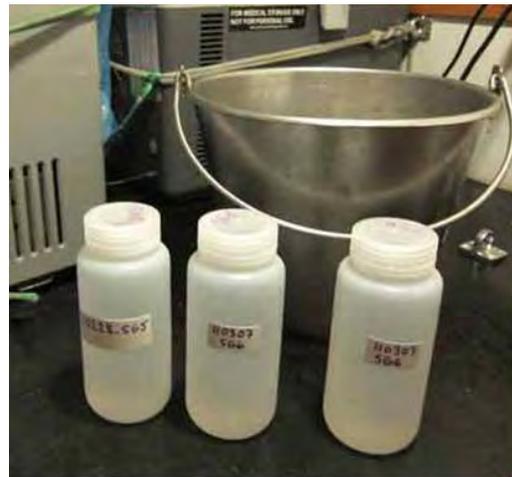
"Re-building" a cabin



- Electrical power
- Strapping down the equipment
- Storage space

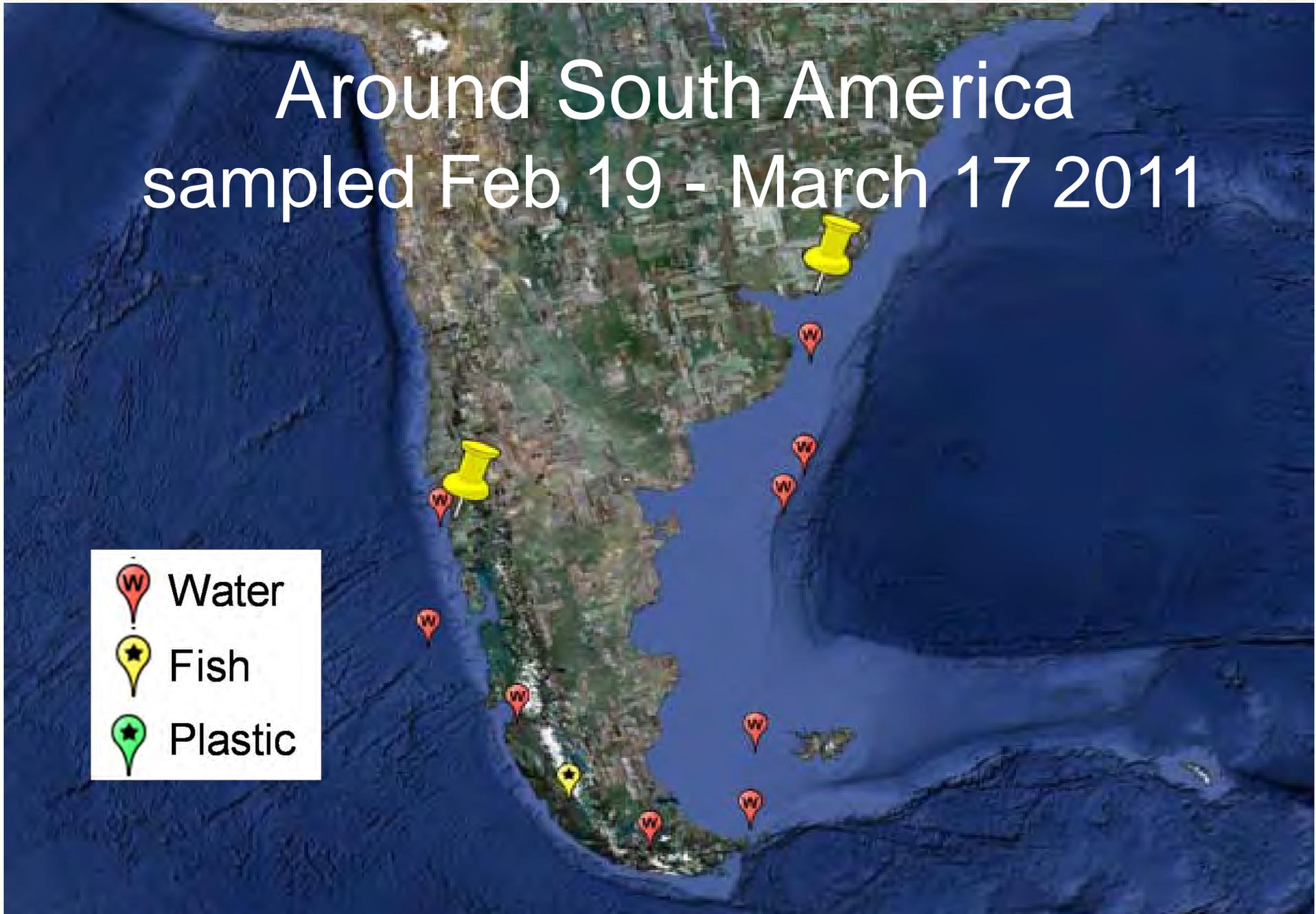
# Sampling/sample prep on a sailing vessel

- Weather conditions
- Movement/leaning over
- 24h watches (cleaning, driving, cooking etc)
- Nausea/sea sickness
- Skipper's last word

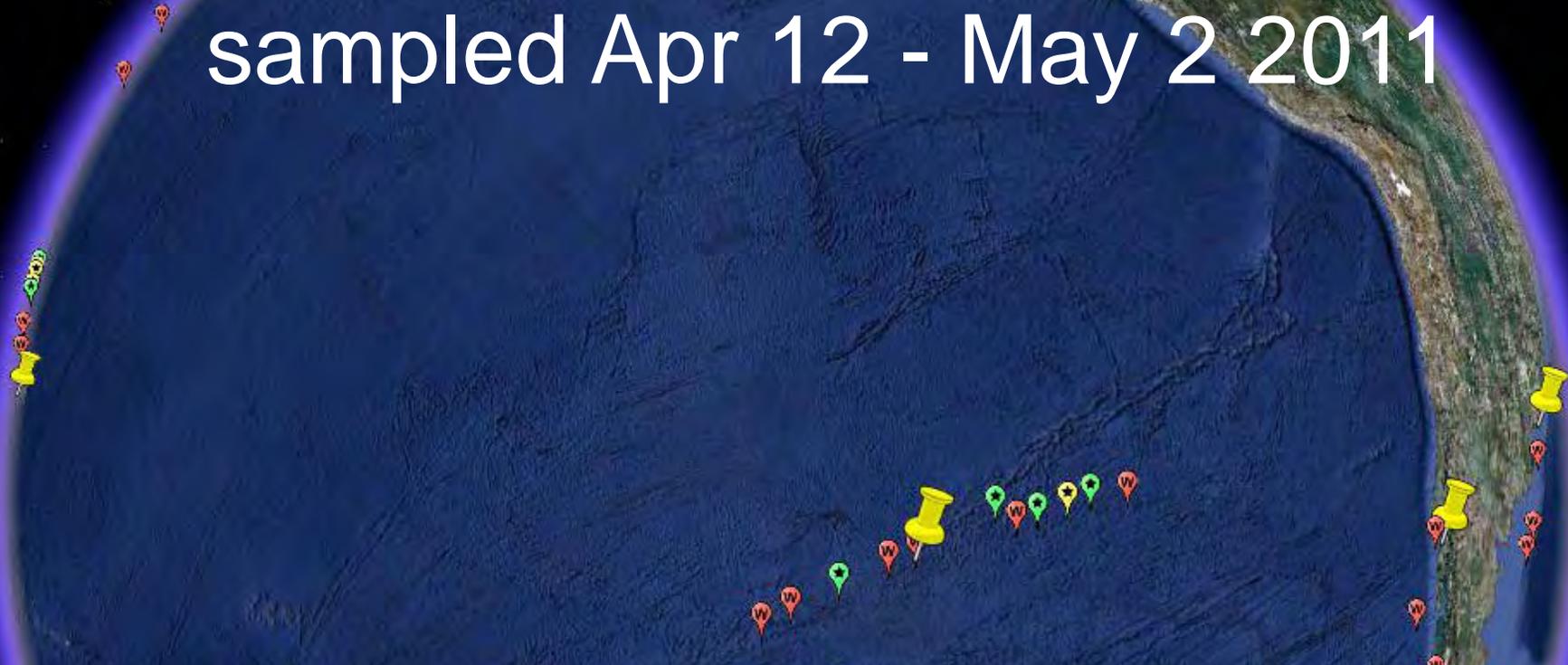


# Around South America sampled Feb 19 - March 17 2011

-  Water
-  Fish
-  Plastic



# South Pacific gyre sampled Apr 12 - May 2 2011



-  Water
-  Fish
-  Plastic

# North Pacific Gyre sampled July 7 - 27 2011



# Methodology PFCs in water

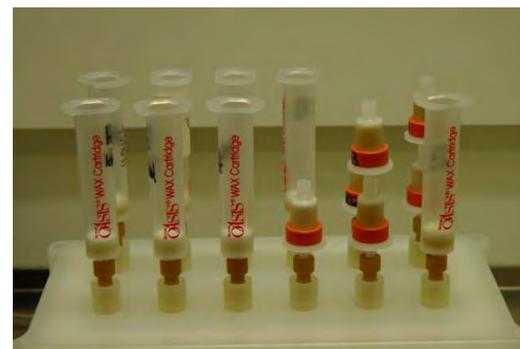
## Preparation

- 1-2L surface water
- 200 $\mu$ L 1.6M Na<sub>2</sub>O<sub>3</sub>S<sub>2</sub>
- Filtration 0.45 $\mu$ m glass fiber membrane filter



## Extraction

- 7 labelled internal standards (Wellington Laboratories)
- Solid phase extraction, Waters Oasis® WAX (Waters Corporation)



## Elution

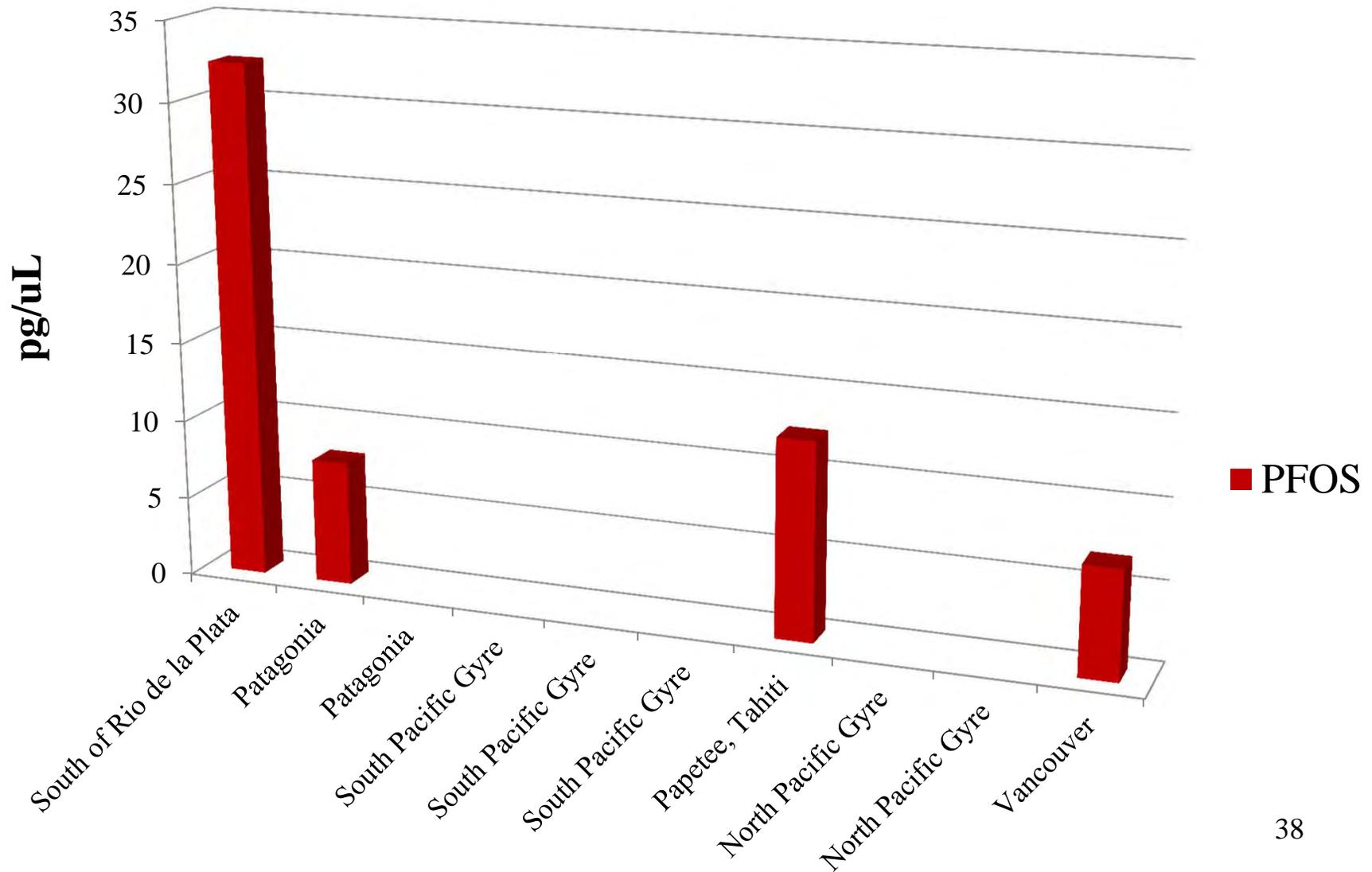
- Wash 4mL 0.025M NaAc buffer, and 4mL methanol
- Elute with 4mL 0.1% NH<sub>4</sub>OH

## Analysis

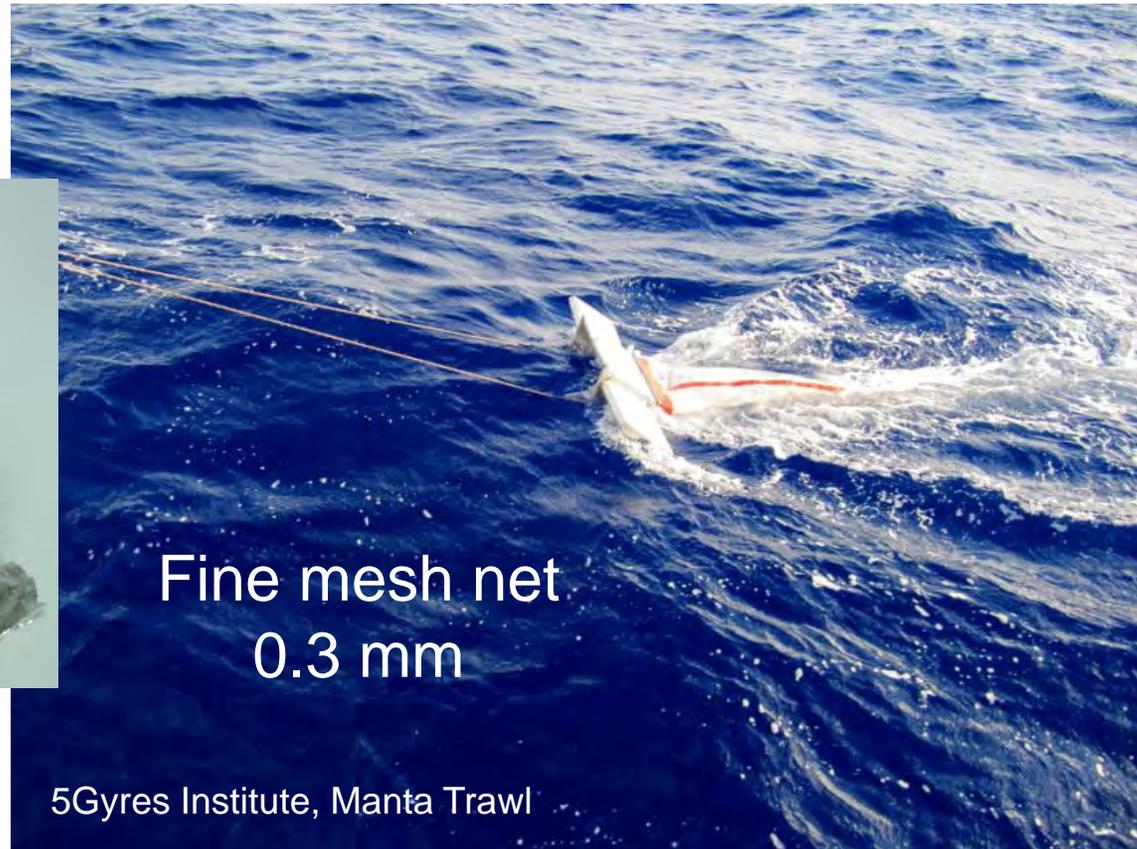
- Acquity UPLC BEH C18 separation
- Quattro Premier XE MS/MS ES(-) detection (Waters Corporation)



# Preliminary results – sea water



# Sampling of ocean surface water



Fine mesh net  
0.3 mm

5Gyres Institute, Manta Trawl

# Trawl sample from the North Pacific gyre





North Pacific  
Gyre

## Future work

South Pacific  
Gyre

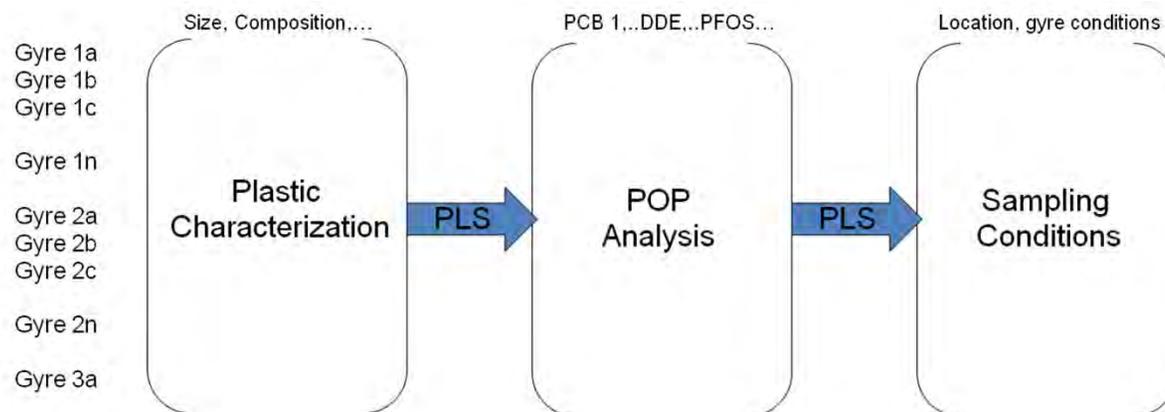
Around South  
America

### Hypothesis

- Macro and micro plastic particles accumulated in ocean gyres will increase accumulation and bioavailability of persistent organic pollutants (POPs).
  - Increased levels of POPs in fish and water from the accumulation zones?
    - Challenges in getting fish samples
    - Challenges with blank levels
    - Trace levels, call for highly sensitive instrumentation
  - Compare the North Pacific, the South Pacific and the supposedly "clean" waters around South America
  - Amount of POPs adsorbed to plastic from the gyres?
  - Focus on "new" POPs (BFRs, PFCs)
    - Challenges in quantification of results
    - Challenges in comparing the results from the different trawls

# Future work

- Study and characterize macro and micro structures of plastic debris by advanced Electron microscopy.
- Develop a high throughput method to determine the concentration and polymer type of micro plastic particles.
  - screening water samples for micro plastics with sizes  $<300 \mu\text{m}$  using membrane technologies .
  - filter particles of smaller sizes than most monitoring programs to date are able to do.



**Thank you for your attention!**

