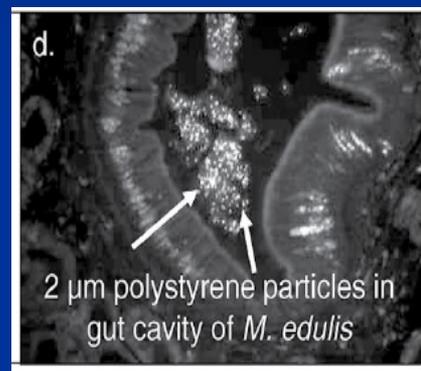


# Microplastics: Is smaller bigger?



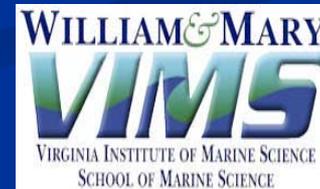
Rob Hale, Professor

Department of Environmental & Aquatic Animal Health

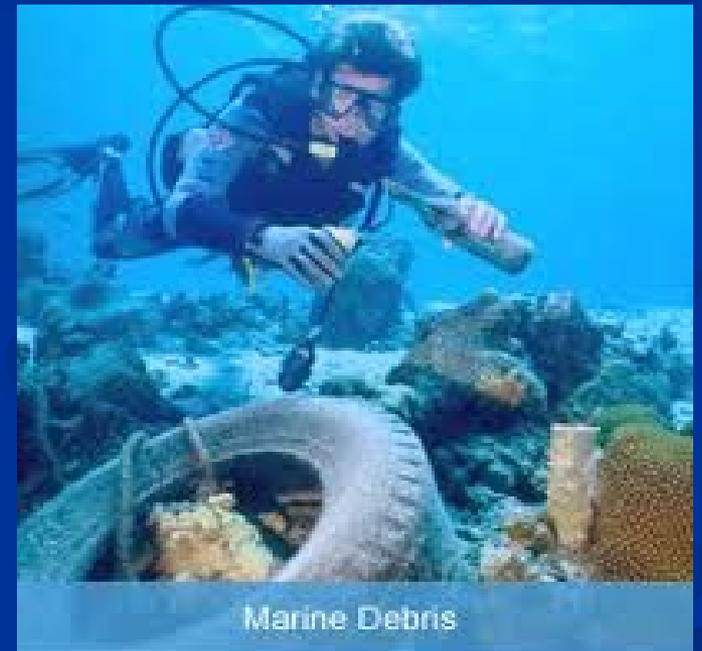
Virginia Institute of Marine Science

[hale@vims.edu](mailto:hale@vims.edu)

Virginia Marine Debris Summit 2013



# Obvious Impacts in Environment



## ■ Wildlife Entanglement

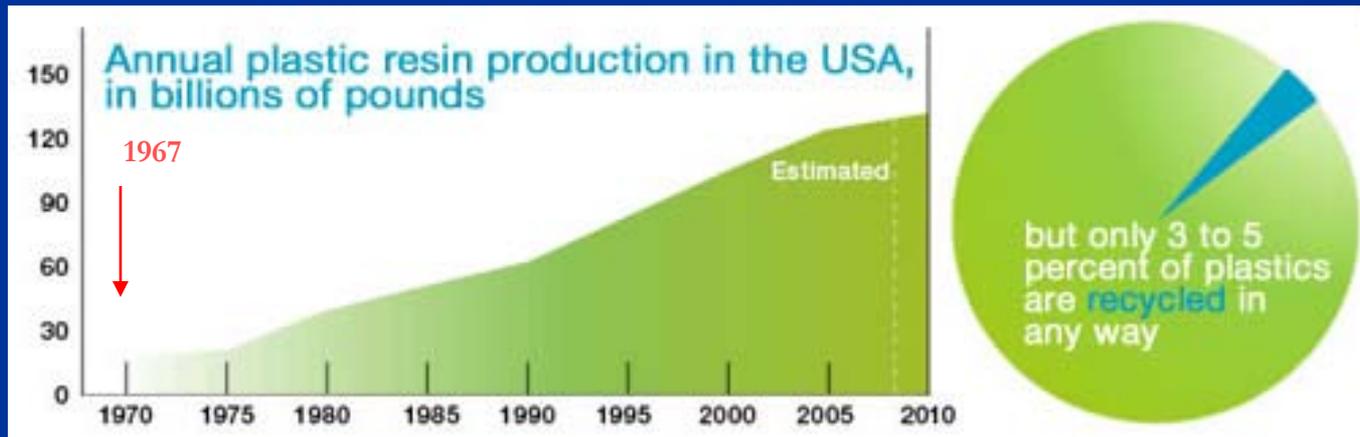


## ■ Macro-plastic ingestion



# Advice for the future in *The Graduate*:

“...I just want to say one word to you  
Just one word. ...*plastics*.”



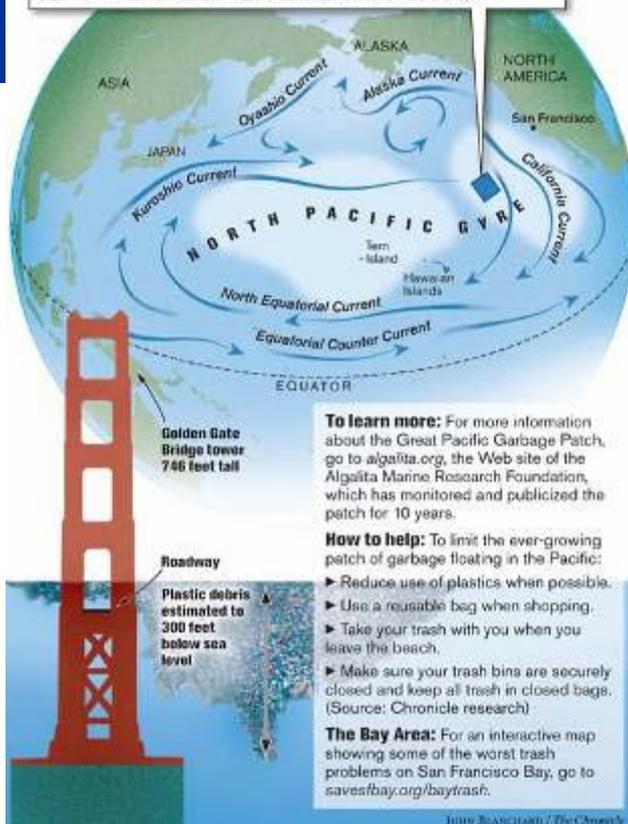
Global plastic production grew 500% over 30 years

# Plastics in Environment



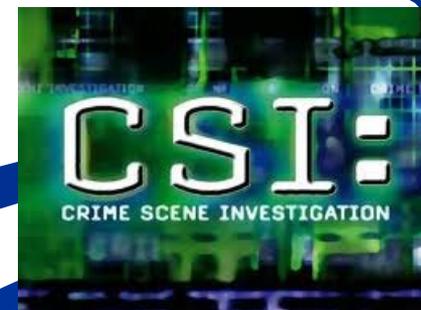
## A mammoth garbage pit in the Pacific

The Great Pacific Garbage Patch swirls around an area of the Pacific Ocean about 1,000 miles west of California and the same distance north of the Hawaiian Islands – a week's journey by boat from the nearest port. Scientists disagree about its size, but a marine researcher in Long Beach says it's twice as big as Texas and weighs 3 million tons. Most agree that the mass of garbage is hurting marine life such as fish.



## Mystery of the Missing Ocean Plastic

We're throwing away more and more plastic. If it's not ending up in the open Atlantic, where is it going?



# Could it be our measurement of plastics?



## ■ What is found depends on:

- Where we look
  - Beaches & water surface
- What we look for
  - Most for  $>1$  mm



Submicroscopic particles of PVC (shown via electron microscope)  
CREDIT: Courtesy of Emma Teuten, University of Plymouth, UK

Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification. *Environ. Sci. Technol.* 2012, 46, 3060–3075.

# Plastics degrade & fragment over time

- form “microplastics”



- Half-lives

- Years-decades
- Varies by polymer & environment
  - Factors: UV, microbial, chemical...
  - Do fragments accumulate in some locales
    - sediments?

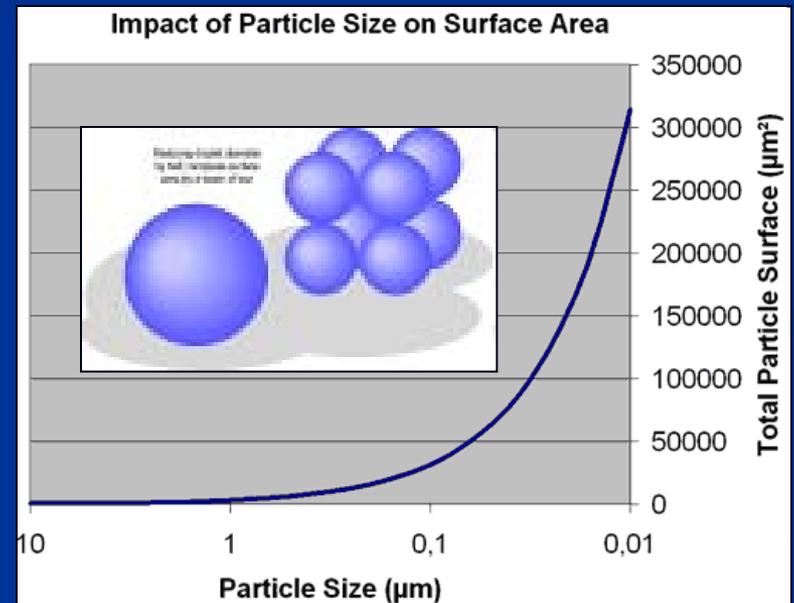


FIGURE 3. Fragmented, atomized plastic fibers extracted from a 2-mg fraction of MSW compost.

# Size matters!

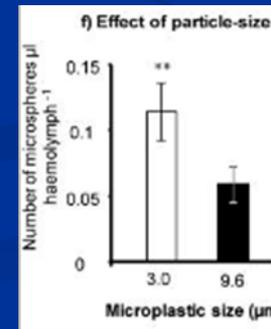
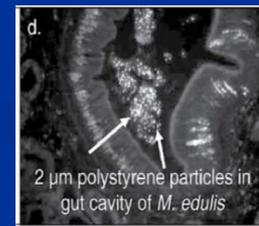
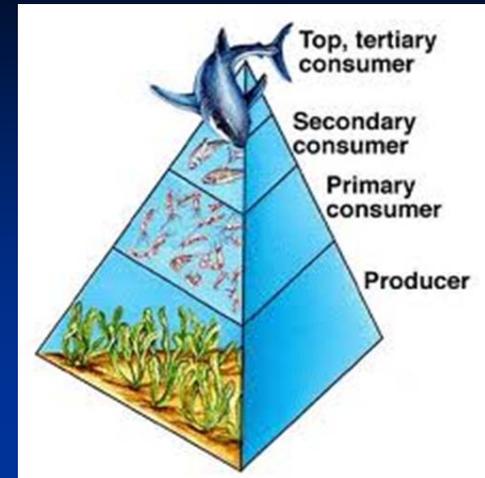
- **Small particles**

- Macro-plastic deterioration
- Engineered micro- & nano-particles

- More abundant
- More transportable
- More surface area
  - Leaching/Sorption
- More critters can eat & transfer up the chain!



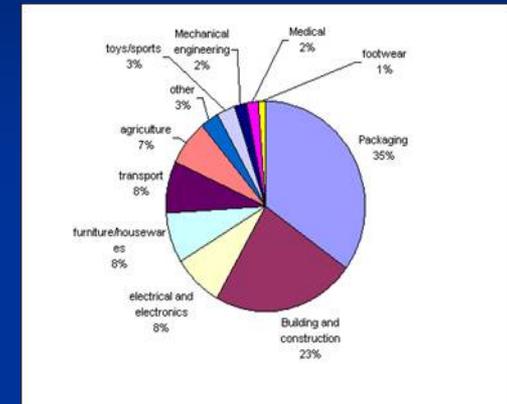
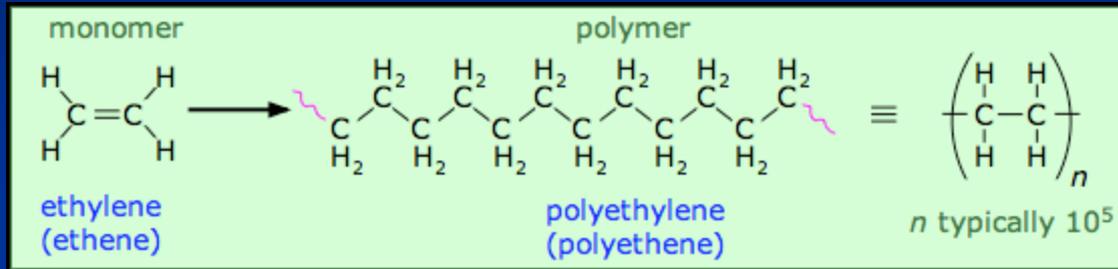
Ecosystem importance



Environ. Sci. Technol.,  
2008, 42  
5026–5031

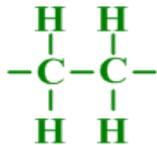
# What is Plastic?

## Polymeric chemicals

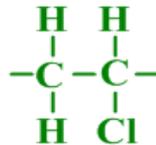


### Monomer structures of different polymers

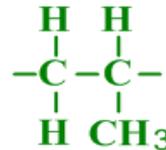
Polyethylene (PE)



Polyvinyl chloride (PVC)



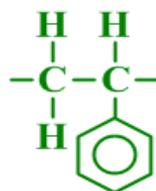
Polypropylene (PP)



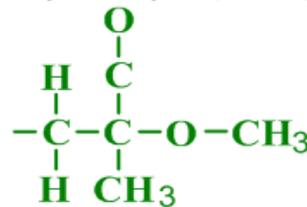
Polytetrafluoroethylene (PTFE)



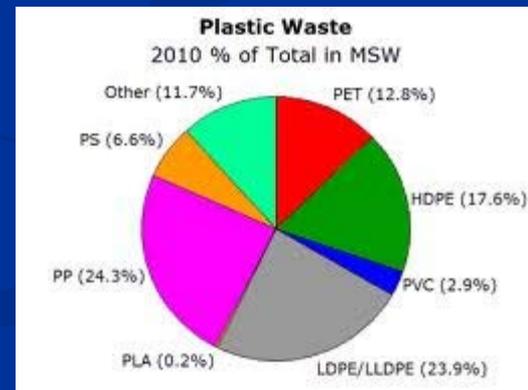
Polystyrene (PS)



Polymethyl methacrylate (PMMA)

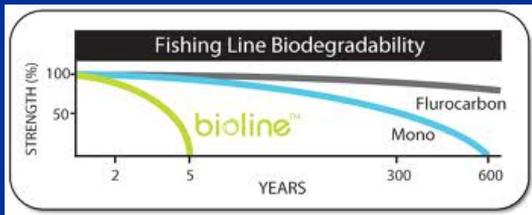
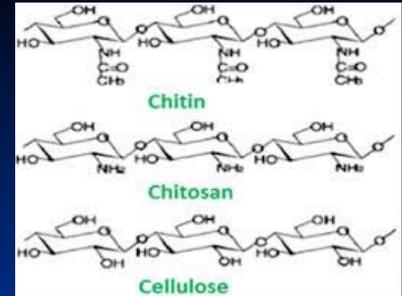


[www.substech.com](http://www.substech.com)



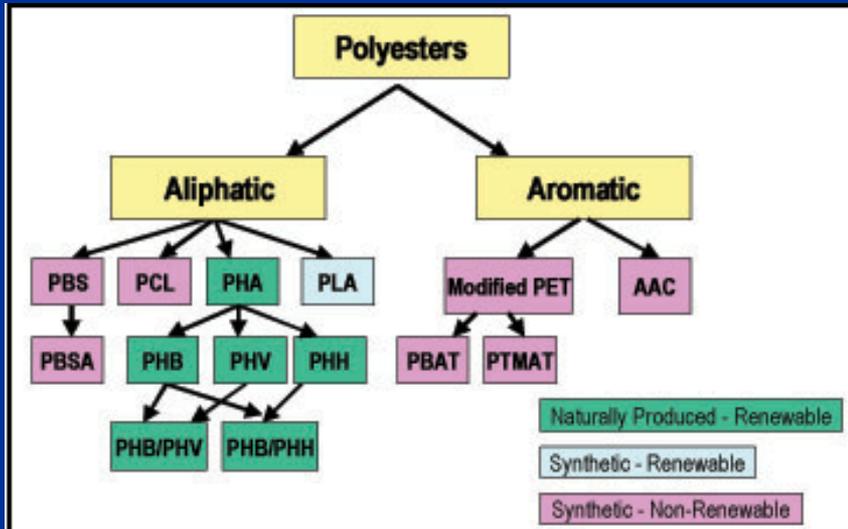
# Biodegradable Polymers

- Use natural polymer components (e.g. starch, chitin) or mimic their structures



December 7, 2012

Biodegradable Materials May Take the Scare Out of Ghost Fishing



Arrow points to the biodegradable escape hatch design by scientists at the VIMS. Photograph by David Stanhope.

# Synthetic polymer additives

## Many % levels in plastics!!!

Antimicrobials / Biostabilisers

Antioxidants

Antistatic Agents

Biodegradable Plasticisers

Blowing Agents

External Lubricants

Fillers/Extenders

Flame Retardants

Fragrances

Heat Stabilisers

Impact Modifiers

Internal Lubricants

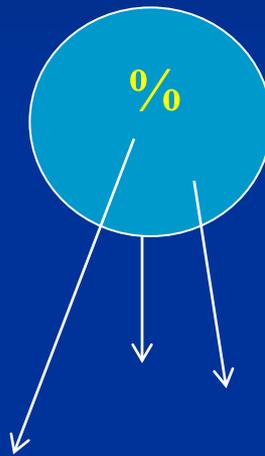
Light Stabilisers

Pigments

Plasticisers

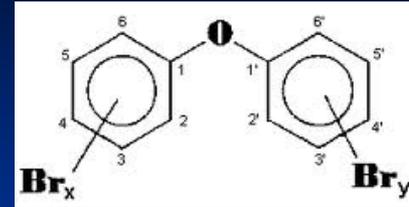
Process Aids

Reinforcements

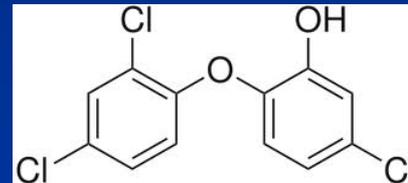


Particle size?

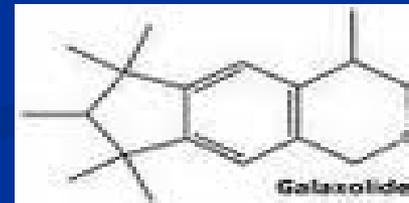
Additives &  
monomers escape



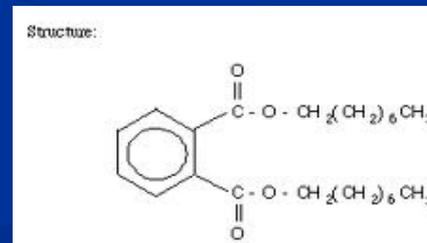
PBDE



triclosan



musk



phthalate



“We don’t make the plastic...we make it toxic”

# Once upon a time...

## We assumed additives locked in plastics

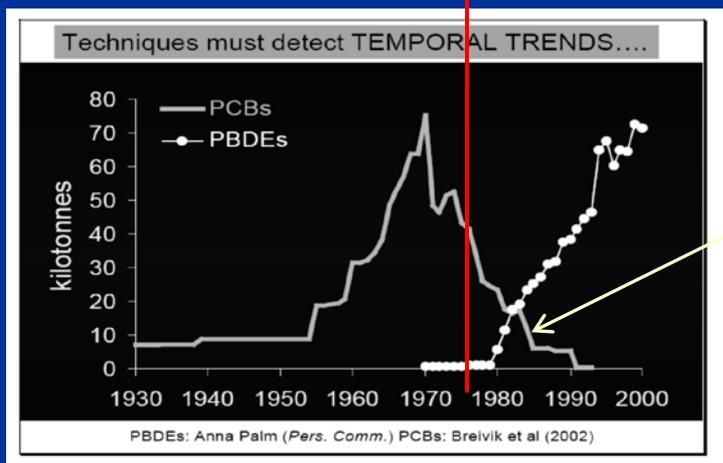
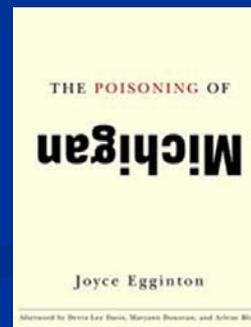
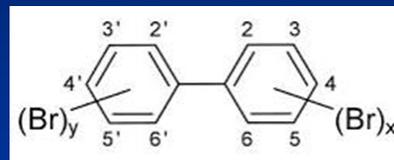


### Polybrominated Biphenyls (PBBs)

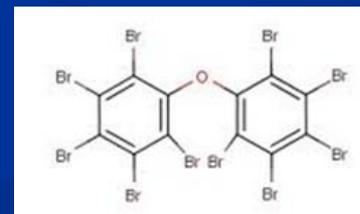
PBBs used in “nondispersive” flame retardant applications 1970-1975

Thermoplastics, electronics housings & polyurethane foam

Accidentally mixed into cattle feed at a MI farm cooperative- PBBs pulled from market 1976



Put PBDEs  
on the  
market





# Indoor dust: plastics fragment

Webster et al.  
2009. Identifying  
Transfer  
Mechanisms and  
Sources of  
Decabromodiph  
enyl Ether (BDE  
209) in Indoor  
Environments  
Using  
Environmental  
Forensic  
Microscopy.  
*Environ. Sci.  
Technol* 43:3067–  
3072

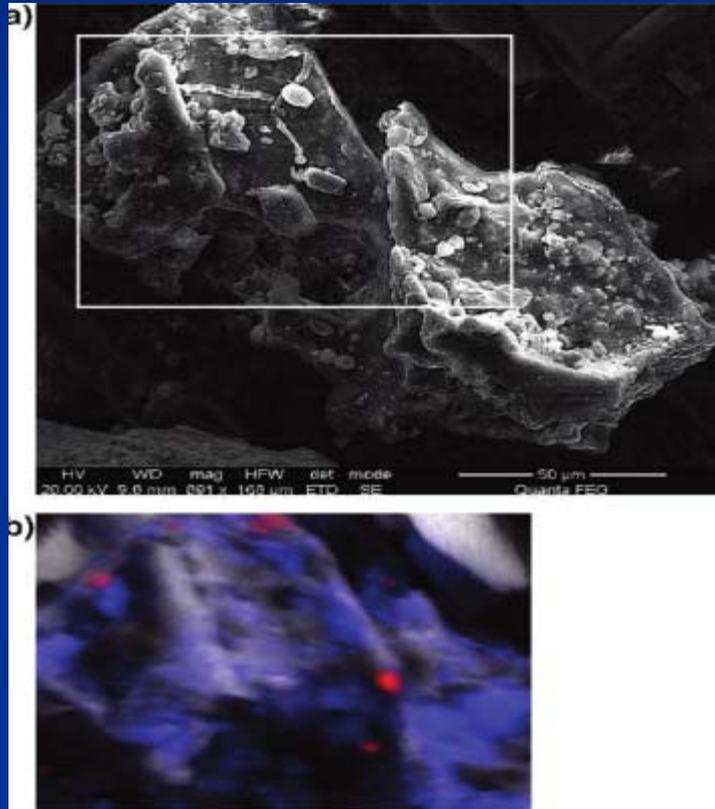


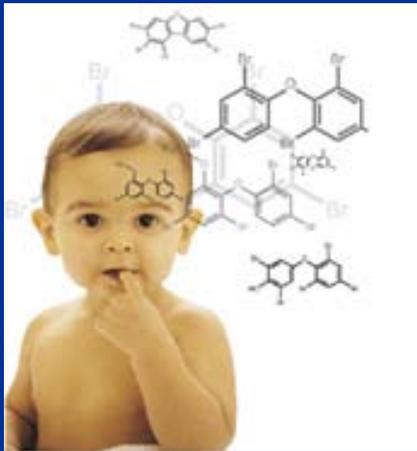
FIGURE 5. (a). Close-up secondary electron image of a bromine-containing dust particle. (b) Elemental map constructed using EDS of the boxed area in 5a (white = carbon, blue = calcium, red = bromine).



ingestion

# In the News: Additive Toxicity

**May 16, 2011** Plastic products leach toxic substances. Many plastic products contain hazardous chemicals that can leach to the surroundings. In studies conducted at the University of Gothenburg, a third of the tested plastic products released toxic substances, including 5 out of 13 products intended for children.



**Feb. 4, 2008**

Science News

Plastic Bottles Release Potentially Harmful Chemicals (Bisphenol A) After Contact With Hot Liquids







Upping the ante...



## Classify plastic waste as hazardous

Policies for managing plastic debris are outdated and threaten the health of people and wildlife, say **Chelsea M. Rochman, Mark Anthony Browne** and colleagues.

14 FEBRUARY 2013 | VOL 494 | NATURE |

Are plastics PBT chemicals?

