The Science behind Ocean "Garbage Patches"

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“Great Pacific Garbage Patch”
“Great Pacific Garbage Patch”

Water covers more than 70 percent of the planet's surface, making our rivers, lakes and oceans the lifeblood of our planet. Many of these bodies of water may be out of sight and out of mind, but our health may depend on their protection.

Currently, scientists believe the world's largest garbage dump isn't on land...it's in the Pacific Ocean. The Great Pacific Garbage Patch stretches from the coast of California to Japan, and it's estimated to be twice the size of Texas. "This is the most shocking thing I have seen," Oprah says.

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The Great Pacific Garbage Patch covers more than 70 percent of the planet’s surface, choking our rivers, lakes and oceans the lifeblood of our planet. Many of these bodies of water may be out of sight and out of mind, but our health depends on their health.

Current scientists believe the world’s biggest garbage dump isn’t in India. It’s in the Pacific Ocean. The Great Pacific Garbage Patch stretches from the coast of Japan, and it’s estimated to be twice the size of Texas. “This is the most shocking thing I have seen,” Oprah says.

juiceonline.com
Sargasso Sea

Images from Sea Education Association
Sargasso Sea

Images from Sea Education Association
Outline

• What is marine debris?
• SEA’s plastic debris data set (Atlantic)
• Geographical distribution of floating plastic debris
• 22-year trends in floating plastic debris
• Outstanding research questions
Marine Debris - Beaches

Kamilo Beach, Hawaii
Properties of Plastic

- Lightweight
- Strong
- Durable
- Inexpensive

- Buoyant in seawater
- Difficult to break apart
- Resists biodegradation
- “Disposable”

PERSISTENT in the environment

Plastic resin pellets

Photo: H. Takada
Plastic Marine Debris
Known Environmental Impacts

Entanglement
Plastic Marine Debris
Known Environmental Impacts

Entanglement

Ingestion

Irene Kinan (Oikonos.org)

www.wildcoast.blog.com
Plastic Marine Debris
Known Environmental Impacts

www.chrisjordan.com
Plastic Marine Debris
Known Environmental Impacts

Entanglement

Ingestion

Organic pollutants

DDT
PCBs
PAHs
Others
Plastic Marine Debris
Known Environmental Impacts

Entanglement

Ingestion

Organic pollutants

Micro-ecosystems
Plastic Marine Debris
Environmental Impacts??

Microbial biofilms
Bioaccumulation of toxins
Chemical impacts of degradation
Plastic Marine Debris
Environmental Impacts

It is illegal for any vessel to dump plastic trash anywhere in the ocean or navigable waters of the United States. Annex V of the MARPOL Treaty is an international law for a cleaner, safer marine environment. Violation of these requirements may result in civil penalty up to $25,000, fine and imprisonment.

U.S. Lakes, Rivers, Bays, Sounds and 3 miles from shore: ILLEGAL TO DUMP Plastic & Garbage
- Paper
- Metal
- Rags
- Crockery
- Glass
- Dunnage
- Food

3 to 12 miles: ILLEGAL TO DUMP Plastic
- Dunnage, lining & packing materials that float, also if not ground to less than one inch:
  - Paper
  - Crockery
  - Rags
  - Metal
  - Glass
  - Food

12 to 25 miles: ILLEGAL TO DUMP Plastic
- Dunnage, lining & packing materials that float

Outside 25 miles: ILLEGAL TO DUMP Plastic

State and local regulations may further restrict the disposal of garbage.

www.nmma.org

International Regulation
MARPOL Annex V (1988)
SEA Semester
Undergraduate research cruises

SSV Corwith Cramer

SSV Robert C. Seamans
Cruise Tracks
Atlantic Ocean & Caribbean Sea

- Six-week long SEA Semester cruises
- Annually-repeated cruise tracks
- Data collected by > 7000 undergraduates
Surface Plankton Net Tows

- Net mouth: 1 m x 0.5 m
- Net mesh: 335 μm
- Tow length: 1.8 km (1 nm)
- Ship speed: 2 knots
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Typical Samples

Samples collected by Sea Education Association
Physical Characteristics of Debris

It’s small:
- 88% < 10 mm
- 95% < 0.05 g

It floats:
- 99% less dense than seawater
- HDPE, LDPE, PP

6100+ Surface Net Tows
Collected from 1986-2008
Distribution in Latitude

83% collected between 22°N and 38°N
Major Ocean Surface Currents

http://www.windows2universe.org/earth/Water/ocean_currents.html
Surface Circulation
10-year average from ocean measurements

Maximenko et al., J.Atm.Ocean.Tech., 2009
Surface Circulation
10-year average from ocean measurements

Plastic Debris and Circulation
23,237 pieces!
Expedition Summary
June 10-July 14, 2010

Number of plastic pieces counted: 48,571
Number of plankton net tows: 128
Distance traveled: 3817 nautical miles
Fuel consumed: 2032 gallons
Days at sea: 34
People on board: 33

www.sea.edu/plastics
Subtropical accumulation zones
Numerical model predictions

Dohan and Maximenko, *Oceanography*, 2010
Trend in Plastic Concentration
In accumulation zone, 1986-2008

![Graph showing trend in plastic concentration from 1985 to 2010](image)
Trend in Plastic Concentration
In accumulation zone, 1986-2008

Trend: -20 ± 217 pieces km^{-2} year^{-1} (r^2 = 0.0, P > 0.01)
Quantifying the Source

- **Plastic Waste Generation**
- **Plastic Waste Discards**

Source: Environmental Protection Agency

1960 - 2008
Investigating the Trend
Floating Plastic Debris

- Sampling Bias
- Variability in surface ocean currents
- Change in source: material composition
Plastic Resins in Municipal Solid Waste

![Graph showing the distribution of plastic resins in municipal solid waste between 1992 and 2008. The graph shows separate lines for HDPE + LLDPE/LDPE + PP, PET + PVC + PS, and Other resins. Buoyant and dense resins are indicated.]
Investigating the Trend
Floating Plastic Debris

- Sampling Bias
- Variability in surface ocean currents
- Change in source: material composition
- Removal Mechanisms:
  - Fragmentation
  - Shore deposition
  - Sedimentation
  - Ingestion
Trend in Resin Pellets
Entire region, 1986-2008

Trend: $-32 \pm 4$ pellets km$^{-2}$ year$^{-1}$

($r^2 = 0.79, P < 0.01$)
Outstanding Questions

• How much plastic is in the ocean?
• Where is it located?
• What is the fate of plastic marine debris?
• What are the biological implications?
• What are the chemical implications?
Scientific Summary

- SEA’s 22-year plastic marine debris data set is the longest and most extensive record of plastic marine debris in any ocean.

- These data provide an important baseline.

- Plastic debris accumulates in the subtropical convergence of the western North Atlantic.

- Despite a likely increase in source input, a robust increasing trend in floating plastic debris has not been observed in the North Atlantic accumulation zone.
Are “Garbage Patches” a problem?

• Let’s just clean it up!

• Won’t new “biopolymers” prevent the problem from getting worse?

The solution:

CONTROL at the SOURCE
Reduce, Reuse, Recycle
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www.sea.edu