Worldwide Plastic Debris in a Changing Climate

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Plastic waste and rubbish on Kuta Beach, Bali, Indonesia
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Jenna Jambeck
Assistant Professor of Environmental Engineering, College of Engineering, UGA
Marine Debris as a Pollution Issue

• Marine debris has been recognized as a pollution issue for over 50 years
• Oceans are “ultimate” sinks for many forms of pollution
• Beaches and coastlines are desirable places to live
  – Coastline population grows faster than U.S. average and may reach 165 million by 2015 (U.S. population 298 million 2006 est.)
• Debris is everywhere – found in both populated and unpopulated & remote areas
• International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V limits garbage inputs and prohibits plastic disposal in the ocean (1988)
Complex Issue, Not Well Understood

• Perception is that it is an issue on par with global warming
  – “They are equally large and serious problems; they are imminent; they threaten people on islands and coasts quite directly; they require not only massive governmental action from international and national bodies but individual actions—both require us to change ourselves and our society.”

• Interdisciplinary, worldwide problem with unknown human consequences
• Not very coordinated science to date (quantities, trends, etc.)
• National Center for Ecological Analysis and Synthesis (NCEAS) Scientific Working Group
  – Marine Biologists, Physical Oceanographers, Chemical Oceanographers, Ecologists, Microbiologists, Environmental Chemists, Marine Sciences, Environmental Engineers (solid waste), Economist, etc.
Sources

- Acute
  - Natural/Manmade Disaster

- Chronic
  - Land
    - Sewer overflows and sewerage treatment plants
    - Storm drains
    - Manufacturing plants
    - Beach visitors
    - Littering
    - Inadvertent littering
    - Mismanaged waste (lack of waste management infrastructure)
  - Ocean and inland waterways
    - Recreational boating
    - Recreational fishing
    - Commercial fishing
    - Merchant/Military/Research vessels
    - Off-shore oil drilling platforms
Modeled Movement of the Marine Debris Generated by the March 2011 Japan Tsunami

On March 11, 2011, an estimated 5 million tons of debris washed out by the tsunami. Estimated 30% floated away and dispersed. Estimated 70% sank near Japan.

- Japan Ministry of the Environment estimates that 5 million tons of debris washed into the ocean.
- They further estimated that 70% of that debris sank near the coast of Japan soon after the event.
- Model Results: High windage items may have reached the Pacific Northwest coast as early as winter 2011-2012.
- Majority of modeled particles are still dispersed north and east of the Hawaiian Archipelago.
- NOAA expects widely scattered debris may show up intermittently along shorelines for a long period of time, over the next year, or longer.

Expected Distribution of Computer Simulated Particles Through Wednesday, 08/01/12

NOAA used a computer model to simulate the movement of tsunami debris from March 11, 2011, to the present day. This GNOME model (General NOAA Operational Modeling Environment) simulation is based on ocean surface currents from the US Navy (the Hybrid Coordinate Ocean Model) and winds from NOAA (the NOAA blended wind product). The computer model simultaneously released 1,000 simulated particles from each of 8 locations on the Japan coastline where tsunami wave heights were 3.5 meters or greater. Particles were randomly assigned windage values from 1-5%, meaning that they were moved not only by ocean currents, but were also moved by 1-5% of wind speed in the downwind direction. The dotted black line contains 95% of all simulated particles. The cross-hatched area indicates the region of the highest concentration of simulated debris with 1% windage at the end of the simulation. For more details on this model, please visit marindepderis.noaa.gov. Have you seen tsunami debris? Report it to: DisasterDebris@noaa.gov

Tsunami Debris

Image showing debris accumulated near the coast of Yamada, Japan following the tsunami. The debris has dispersed since this image was taken (Credit: U.S. Navy Pacific fleet).
Chronic Debris

NOAA

Chris Jordan

NOAA
Plastic to Microplastic

This

Becomes


http://marinedebris.noaa.gov/info/plastic.html

Microfibers/Cleansing Beads

Browne et al., 2011
Convergence Zones/Gyres

[Diagram of ocean currents and convergence zones]

Microplastics skimmed from the North Pacific Ocean. Photo courtesy of J. Foley, C-MORE.

http://marinedebris.noaa.gov/info/plastic.html
Debris Impacts

• Well documented for more than 20 years to have impacted Sea Turtles, Manatees and multitudes of birds
• Fish/shellfish caught in derelict fishing gear
• Invasive species/bacteria transport/plastsisphere
• Economic impacts from a drop-off in tourism, and increased beach cleanup maintenance (e.g., NY medical waste)
• Fishing industry impacted by derelict fishing gear
• Navigable waters impacted by debris
Debris Impacts... Human Health and the Environment

• Pollution source and transport, esp. plastic
  – PCBs, DDE (Dichlorodiphenyldichloroethylene) and nonylphenols were detected in polypropylene pellets off the coast of Japan (Mato et al., 2001)
• Plastic abrasion – microscopic pieces of plastic ubiquitous
  – Thompson et al., 2004 – Science
• Contribute to contamination from catastrophic events
• Uncontrolled pollution source
  – Hinder cleanup (e.g., oil spills with debris)

http://vimeo.com/45564559
Debris sizes and potential Impacts

*Figure 5.* Schematic diagram illustrating various sizes of plastic debris and marine organisms together with the potential impacts both physical and chemical. It should be noted that our understanding of impacts of microscopic and nano-sized particles is at present very limited.

What is found?

Figure 2. Combined data showing total number of items of marine debris from 100m sections of selected reference beaches in Europe examined between 2001 and 2006. Note the prevalence of plastic items as the major components of the debris recorded. These trends are broadly consistent across regions and at a global scale. The analysis was based on data from 609 surveys made in eight countries – Belgium, Denmark, Germany, The Netherlands, Portugal, Spain, Sweden and the United Kingdom (51 regular reference beaches altogether). (OSPAR 2007).

International Coastal Cleanup (Citizens)

- 561,633 volunteers
- 10,149,988 pounds of trash
- 17,719 miles

**TOP 10 ITEMS FOUND**

1. 2,117,931 cigarettes / cigarette filters
2. 1,140,222 food wrappers / containers
3. 1,065,171 beverage bottles (plastic)
4. 1,019,902 bags (plastic)
5. 958,893 caps, lids
6. 692,767 cups, plates, forks, knives, spoons
7. 611,048 straws, stirrers
8. 521,730 beverage bottles (glass)
9. 339,875 beverage cans
10. 298,332 bags (paper)
Bergmann and Kalges (2012) found the amount of trash, primarily plastics, on the Arctic seafloor has more than doubled in the past decade. [Marine Pollution Bulletin]

Norwegian blogger (above the arctic circle):
http://marinelitterpictures.posterous.com/
How “big” is this issue?

• The last time waste quantification into the ocean was completed was 1975
  – Before MARPOL
  – All ocean-based waste
• The first time land-based global input has been estimated
• Primarily focusing on plastic
Global Waste

• Estimates are that currently 1.3 Billion Tonnes of waste is generated each year by urban citizens
• In the past century waste production has risen tenfold. By 2025 it will nearly double again to 2.2 billion tonnes.
• Unless there are significant changes, we will not hit “peak waste” in this century.
• Of 95 countries, 85% have an estimate of solid waste collection for the total country, the other 15% have an estimate for collection in urban centers only.
• Only 29% (28 countries) are estimated to have 100% coverage of solid waste collection
• Of the 300 urban centers examined, 46% are said to be using an “open dump” for solid waste management, with another 7% using water courses for waste
Figure 9. Relative contribution of material groups to environmental problems (EU27+Turkey) (Source: UNEP, 2010).

**Figure 6.** Global and European production of plastics (millions tonnes per annum) from 1950 to 2007. Data include thermoplastics, polyurethanes, thermosets, elastomers, adhesives, coatings and sealants and polypropylene fibers. Not included are polyethylene terephthalate-, polyacrylate- and polyacrylic-fibers (Source: PlasticsEurope, 2008).

Percent that Enters the Ocean

• Not collected by street sweeping
• Not collected by stormwater catchments
• Not picked up in litter removal or cleanup
• = Available as input to the ocean
  – Blown
  – Washed in by storms
  – Washed in by tides
Results

• 2010 annual input
• Predictions through 2100 – increasing in business as usual scenarios
• High, Mid, Low estimates
• Vary greatly by waste management infrastructure
  – Our plastic consumption is out-pacing our improvements to waste management infrastructure
  – Cultural issues: industrial v. developing countries
• Climate change impacts, e.g., more variable and intense storms, sea level rise will exacerbate the issue
Lebanon

Damage to Lebanon caused by the Israel war with the Hezbollah in Summer, 2006.
Discarded Electronics Mismanagement

The United Nations Environment Program (UNEP) estimates 50 million metric tonnes of e-waste per year globally.

Basel Action Network
www.ban.org
Solutions?

- California/Alaska/Maryland (Anacostia River)
  - Total Maximum Daily Loads = ZERO
- How?
  1. Source reduction, product redesign
  2. Improve waste management infrastructure
  3. Street sweeping, stormwater catchment, litter removal, cleanups
  4. Education and outreach
Los Angeles River Watershed Trash Abatement Progress
Southeast Atlantic Marine Debris Initiative

• Southeast Atlantic Marine Debris Initiative (SEA-MDI) funded by NOAA (3 year partnership)
  – Georgia, North Carolina, South Carolina
  – Website: [http://sea-mdi.engr.uga.edu/](http://sea-mdi.engr.uga.edu/)
SEA-MDI Mini-Grants & Projects

1. Reading Between the Lines: Marine Debris Education for Children in Georgia, Georgia Marine Extension Service and Georgia Sea Grant College Program
2. Clean Marine: Debris Free Waterways in Beaufort County, SC, South Carolina Sea Grant Consortium & Extension Program
3. Fort Pulaski Marine Debris Initiative, Clean Coast and the National Park Service
4. Georgia Sea Turtle Center Marine Debris Citizen Science and Education Program, Georgia Sea Turtle Center (GSTC)
5. Plastic Debris on the Georgia Coast, Skidaway Institute of Oceanography and UGA Marine Extension Service
6. Tracking Monofilament Line Recycling to Make a Difference for Our Wildlife, North Carolina Big Sweep Statewide Headquarters
Marine Debris Tracker
Tool for Data Collection

• Less error without paper & pen
• GPS coordinate for every debris item
• Real time data gathering/upload
• Easy download (Excel) and mapping
• Used by researchers, citizens or citizen scientists

Website: http://www.marinedebris.engr.uga.edu/
Methodology - The List

- The categories and marine debris item list (37 items) - NOAA Marine Debris Division
  - plastic (blue)
  - glass (brown)
  - metal (red)
  - fishing gear (purple)
  - processed lumber (yellow)
  - rubber (black)
  - cloth (orange)
Marine Debris Tracker – How To

• One you download the app and accept the Terms, you will be taken to the start page with the logo. Click Track Debris to begin.
**Marine Debris Tracker – How To**

- Next, simply click on the drop-down list to find the item you want to track. Be sure your GPS is showing valid coordinates and then click **Add to Log**.

- Then, you can either add more items (simply find them and click **Add to Log**) or you can **View and Submit** or **Show Map** (shows only your data collected at this point on a map).
Marine Debris Tracker – How To

• At the **View and Submit page**, you can click on items in your list, then choose to delete them or submit them to the database.

• This feature allows you to track and log items anywhere – you don’t need to be connected to a network to log and all your items will be stored until you submit.
Marine Debris Tracker – How To

• The first time you use Marine Debris Tracker, you will need to choose a username and password. This will allow you to view and download your data from the website (anonymous data is public).
Marine Debris Tracker – How To

- Once you have registered once, your username and password is all you need to submit all your tracked data each tracking session (and can be stored in the phone so you don’t have to enter it each time you submit).
View and Get Data

Item: Bottle or container caps (plastic)
Quantity: 1

Latest Items Tracked:
- Plastic or styrofoam fragments
- Straws
- Building materials (describe)
- Straws
- Paper and cardboard containers or pieces
- Food wrappers (plastic)
- Plastic or styrofoam fragments
- Food wrappers (plastic)
- Toys (plastic)
- Food wrappers (paper)
- Plastic or styrofoam fragments
- Food wrappers
I would make this only www.marinedebris.engr.uga.edu and leave out the http, etc. Since we can't actually go to the website during the presentation...

dac.admin, 3/9/2011
App Stats

- Android and iPhone
  - 10,000 downloads

29,762 entries; 322,777 items logged
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dac.admin, 3/9/2011
More solid waste and Climate Change

• Recycling
  – WeRecycle App
  – WeRecycle Bin (Climate Change Conveying Realities EcoArtLab)

• Mobile Apps & Smart Technology
  – “App Store for the Planet”
  – Sustainable Technology and App Research (STAR)
• jjambeck@uga.edu

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  – https://www.facebook.com/JennaJambeck