Ocean Currents, Marine Debris, and Seabirds

Adapted From: Hannah Nevins, David Hyrenbach, Carol Keiper, Jenny Stock, Michelle Hester, and Jim Harvey
What is “marine debris?”

“Marine debris is any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes.”

NOAA ~ Office of Response and Restoration
Marine debris is a global problem.
Marine Debris

• Occurs worldwide.

• Found:
  - floating on the water surface
  - mixed throughout the water column and on the seabed
  - as much as 70% sinks to the bottom of the ocean

• Up to 80% of marine debris is plastic
How does debris get into the ocean?

- **Land-Based Sources**
- **Ocean-Based Sources**
Sources of Marine Debris

• Ocean-Based
  - Direct dumping into the ocean
  - Accidental loss from ships, cargo vessels, or stationary platforms
  - Fishing gear
Sources of Marine Debris

• Land-Based
  - Littering, Dumping, Poor waste management
  - Run-off from rivers and storm drains
  - Extreme Storm Events

NOAA ~ Office of Response and Restoration
Run-off from rivers and storm drains

http://geosci.sfsu.edu/courses/geol102/ex6.html
How does plastic get into the sea?

1. Littering by beachgoers.
2. Run-off from rivers and storm drains.
3. Direct dumping into ocean.
4. Accidental loss from ships.
Petaluma “River”

The Northern area drains to the Pacific Ocean

The Southern area drains to San Pablo Bay
Movement of Marine Debris?

- Heard Island
- Inaccessible Island
- North Sea
- North Pacific
- New Zealand
Surface Ocean Currents caused by....WIND!
Surface Ocean Currents
N. Atlantic Gyre
Current Movement observed in... Rubber Duckies !!!

Jan 1992: 29,000 plastic toys spill

Nov 1992: washing up Alaska

2000: washing up in N. Atlantic (Iceland)

2003: found on shores of Great Britain
1. Shoe Spill May 27, 1990
2. 250 recovered, March 26, 1991
3. 200 recovered, May 18, 1991
4. 100 recovered, Jan-Feb 1991
7. 150 recovered April 1991
8. 200 recovered May 1991
10. Predicted Jan-July 1994

80,000 pairs of shoes
Major ocean surface currents corral trash into “garbage patches”

North Pacific Gyre
“Eastern Pacific Garbage Patch”

Alaskan Gyre
“(another small) Garbage Patch”
“Eastern Pacific Garbage Patch”

- **1988**: first predicted the existence of the garbage patch in a NOAA paper - based on research performed on plastics and ocean currents off Alaska

- **1997**: public and scientific importance
  - Charles Moore expedition (Algalita Research Foundation)
  - alerted an oceanographer, Curtis Ebbesmeyer who named the area the ‘EPGP’

- **2009**: SEAPLEX and Project Kaisei
  - assess garbage patch
  - gather insight into future clean up
Eastern Pacific Garbage Patch

- Floats:
  - 1,000 miles west of San Francisco
  - 1,000 miles north of Hawaiian Islands
- Estimated 3 million tons
- Twice the size of Texas

Why can’t we just clean it up?
- Mostly fine particles of plastic
- Translucent in appearance
- Depths vary, spread from 0 to 300 meters
Trash Timeline

6-pack ring  plastic bottles
milk carton  tin can
styrofoam buoys  Aluminum can
paper bag  cardboard box
paper towel  newspaper
monofilament  glass bottles
<table>
<thead>
<tr>
<th>Trash Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 wks: paper towel</td>
</tr>
<tr>
<td>6 wks: paper bag</td>
</tr>
<tr>
<td>3 mths: milk carton</td>
</tr>
<tr>
<td>80 yrs: styrofoam buoys</td>
</tr>
<tr>
<td>400 yrs: 6-pack ring</td>
</tr>
<tr>
<td>600 yrs: monofilament</td>
</tr>
</tbody>
</table>
Biological Indicator Species

A species whose health status can be used to monitor the condition of an ecosystem or the environment.

Monitor for:
- biochemical …
- physiological …
- and behavioral changes.

Examples of biological indicator species:
- fish
- birds (seabirds)
- aquatic invertebrates
What is a seabird?

- Spend almost their entire lives in the marine environment.
- Only come to land to breed - often in large colonies on remote islands.
- Return to breed at island where they were hatched.
- Mate for life, each breeding cycle - lay one egg and raise one chick.
- Long-lived (e.g. Albatross >80 yrs, shearwaters >50 years).
Some breeding colonies are not so far away....

- The Farallones Islands:
  - Located 27-miles outside the Golden Gate
  - Largest breeding population of seabirds in lower 48 (more than 250,000)
Seabirds are top-predators in the marine ecosystem

- Seabirds, Sharks, & Marine Mammals
- Predatory squid & fishes
- Forage fishes & macro- zooplankton
- Zooplankton
- Phytoplankton
What threatens seabirds?

- Oiling from oil spills
- Marine debris
- Long-line and other fishery interactions
- Threats at colonies: introduced mammals, habitat destruction
Seabirds are biological indicators of plastic pollution

- Seabirds eat plastic directly and through their prey.
- They regurgitate plastic to their young.
- Some species ingest plastic more often.
- With time, more species and more individuals are affected.
Plastic ingestion is affected by:

1) Foraging mode
2) Body Size
3) Habitat Use
1) Seabird Foraging Modes

- **Surface Foragers**
  - Hydro Pattering
  - Surface planing
  - Filtering
  - Foot Paddling
  - Dipping
  - Surface Seizing
  - Scavenging

- **Divers**
  - Pursuit Diving:
    - Wings
    - Feet

- **Plungers**
  - Surface Plunging
  - Deep Plunging

(Ashmole 1971)
Surface feeders are more likely to ingest plastics

Increase in proportion of species ingesting plastic from late 1960’s to early 1990’s.

(Robards et al. 1995)
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Northern Fulmar</td>
<td>58%</td>
<td>84%</td>
<td>+26%</td>
</tr>
<tr>
<td></td>
<td>n=38</td>
<td>n=19</td>
<td></td>
</tr>
<tr>
<td>Tufted Puffin</td>
<td>15%</td>
<td>25%</td>
<td>+10%</td>
</tr>
<tr>
<td></td>
<td>n=348</td>
<td>n=489</td>
<td></td>
</tr>
<tr>
<td>Horned Puffin</td>
<td>37%</td>
<td>37%</td>
<td>~no change</td>
</tr>
<tr>
<td></td>
<td>n=148</td>
<td>n=120</td>
<td></td>
</tr>
<tr>
<td>Parakeet Auklet</td>
<td>75%</td>
<td>94%</td>
<td>+18%</td>
</tr>
<tr>
<td></td>
<td>n=116</td>
<td>n=208</td>
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</table>

(Robards et al. 1995)
Plastic ingestion is affected by:

1) Foraging mode – *surface feeders*

2) Body Size

3) Habitat Use
2) Body & bill size influence plastic ingestion

2 – 4 mm (Shearwaters)
3.5 – 4.5 mm (Auklets / Puffins)
11 – 28 mm (Gulls)
20 – 100 mm (Albatrosses)

(Fry 1987, Robards et al. 1995, Kinan 2000)
Albatross Bolus Contents
Plastic ingestion is affected by:

1) Foraging mode – *surface feeders*

2) Body Size – *larger bill sized seabirds*

3) Habitat Use
Many North Pacific seabirds ingest plastics

- **Scientists found:**
  - Tiny scraps of plastic in the chicks of Wilson's storm petrels in the Antarctic.
  - Cigarette lighters, light-sticks, syringes, toys from albatross chicks in Hawaii.
3) Habitat Use: Black-footed albatross from July-Oct 2004

Unpublished data Hyrenbach et al. 2004
Sooty shearwater habitat use during migration

- Hawaii
- Kermadec Trench/Ridge
- Tītī Islands, NZ
- Monterey Bay, CA
- Guafo I., Chile
- Japan

Image of sooty shearwaters.
Leach's storm-petrel
(\textit{Oceanodroma leucorhoa})

\begin{itemize}
  \item Adults may live to be 40-50 yrs. old
  \item A chick is hatched after 50-75 days
\end{itemize}

\textbf{Description:}
\begin{itemize}
  \item Length: 7.5 inches
  \item Wingspan: 19 inches
  \item Feed by pattering feet on surface
\end{itemize}

\textbf{Plastic ingestion is high:}
\begin{itemize}
  \item 20\% in non-breeding area (tropical Pacific)
  \item 100\% in North Pacific Breeding area
\end{itemize}
Northern Fulmar  
*(Fulmaris glacialis)*

- Scientists collected stomach contents of dead fulmars found in California

- 71% of 190 stomachs contained plastic fragments (n = 733)

- 95% of all fulmars washed up dead around the North Sea contained fragments of plastic in their stomachs

Source: H. Nevins BeachCOMBERS
Color of plastic fragments in Northern Fulmar stomachs

COMBERS data
Plastic ingestion is affected by:

1) Foraging mode – *surface feeders*

2) Body Size – *larger bill sized seabirds*

3) Habitat Use – *long distance flyers*

Order Procellariiformes: AKA “Tubenoses”
Order Procellariiformes: AKA “Tubenoses”

- Size ranges from the 200 g (0.44 lb) storm-petrel to the 5 kg (11 lb) albatross.
- **Highly migratory.**
- Mainly *surface pickers* or scavengers, some divers.
- Expend very little energy flying – dynamic soaring, long wings.
- Webbed toes for swimming, taking off from water.
- Carry food for young concentrated in oily slurry.

Northern Fulmar  Sooty Shearwater  Laysan Albatross
19 of 21 albatross species are threatened with extinction

Albatross feed in the same places where debris collects in the ocean

(Day & Shaw 1987)
Analysis of albatross chick stomachs

- Laysan Albatross on Kure Atoll in Hawaii
  - 100% Plastic ingestion
  - 33% of birds contained cigarette lighters
  - Mean mass: 151g (1/3lb) ± 79g (1/6lb)  Maximum: 475 g (1lb)

(Kinan 2000)
Analysis of Albatross Chick • Barf!

- Chicks regurgitate what they cannot digest
- Scientists study their diet by collecting boluses

(Kinan 2000)
The boluses should contain:
- 50% fish
- 32% squid
- 5% crustaceans
- 10% stomach oil

(Kinan 2000)
Albatross Bolus Analysis

Laysan (88 boluses)
average: 33 ± 21 g plastic
- 19% had lighters
- 1% had light-sticks

Black-footed (56 boluses)
78 ± 38 g plastic
- 0 had lighters
- 0 had light sticks

Monofilament line debris
Lighters and plastic bits
Squid beaks and plastic

(Kinan 2000)
**Short-Term Effects**

Large Plastic Items:

- Cuts / abrasions leading to infection
- Fill up / obstruct the stomach

Small Plastic Items:

- Reduce meal size and food consumption
- Reduce the storage volume of the stomach
- Little evidence of impaired digestive efficiency – few cases of physical damage to stomach

Are pollutant levels directly related to plastics?

• Polyethylene pellets lost 1% of their mass after 12 days in the birds' stomachs, suggesting a half-life of one year.

• The mass of ingested plastic was correlated with polychlorinated biphenyls (PCB’s), a group of toxic chemicals found in plastics.

• It is likely that long-lived seabirds assimilate PCBs and other toxic chemicals from ingested plastic particles.

Ryan et al. 1988, Ryan & Jackson 1987
Forming a scientific question…

• ASK A QUESTION......

• You will be:
  – Conducting an analysis of the debris on your campus
  – Analyzing albatross boluses