Ocean Currents, Marine Debris, and Seabirds

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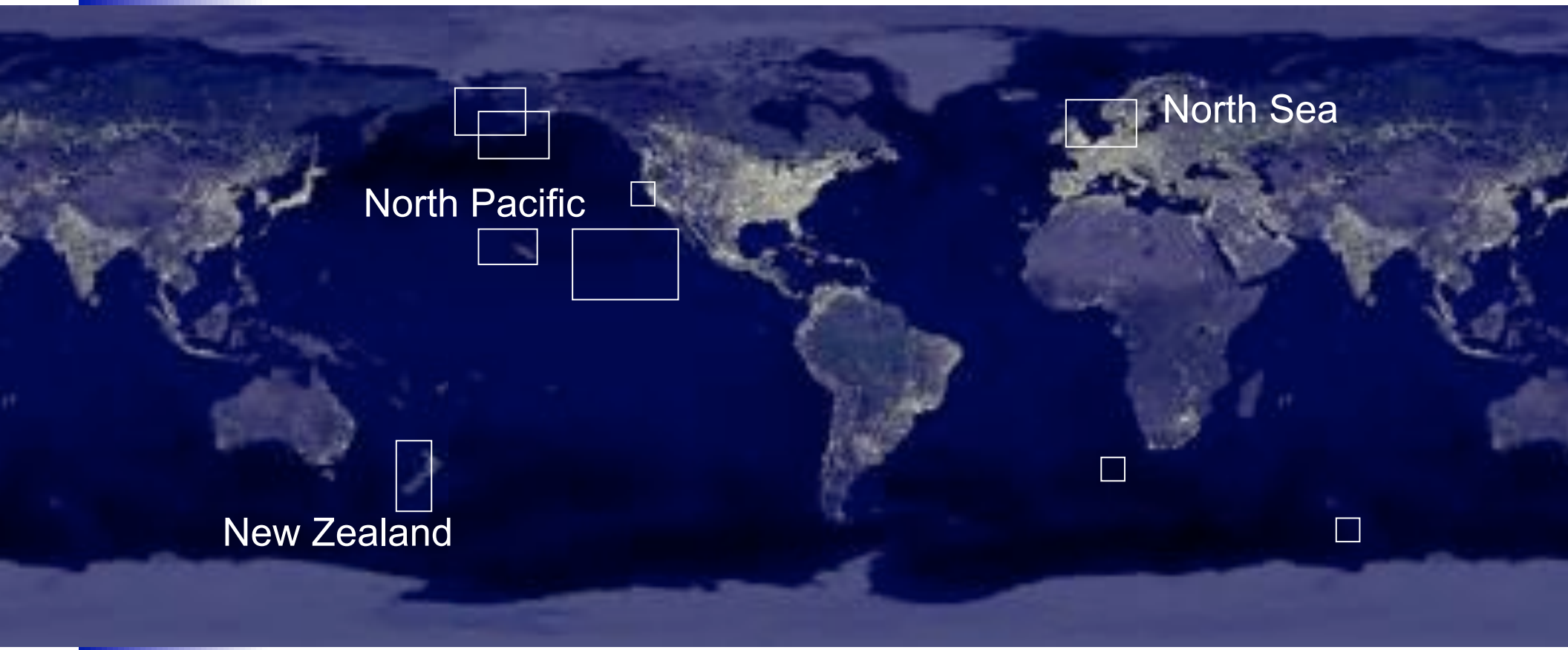
What is “marine debris?”

“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**

United Nations Environment Programme

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**

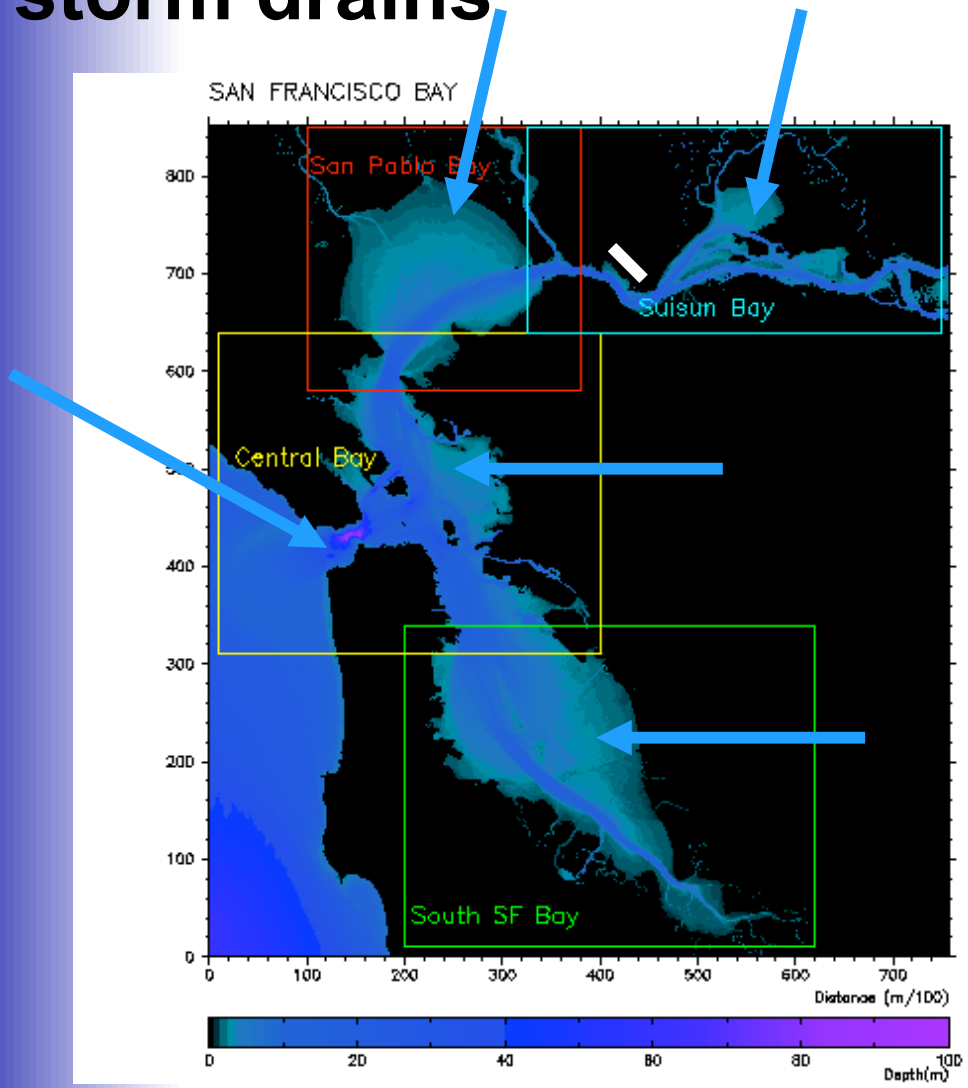
  - Littering, Dumping, Poor waste management

  - Run-off from rivers and storm drains

  - Extreme Storm Events

NOAA ~ Office of Response and Restoration

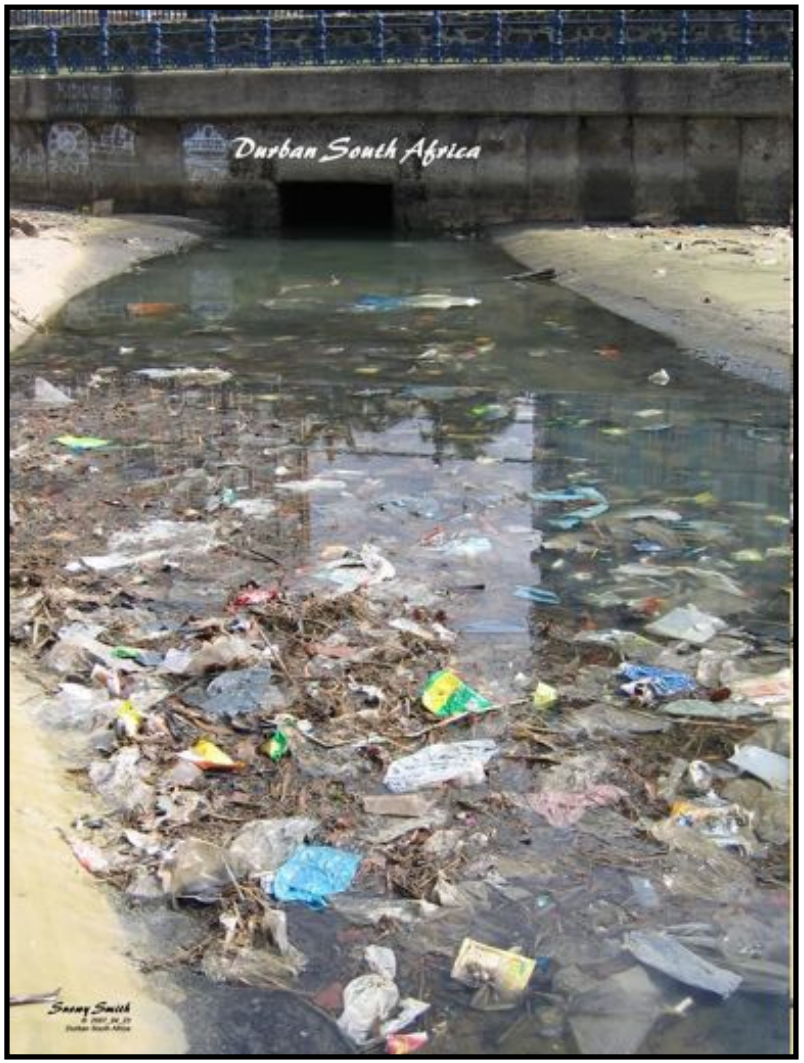
Run-off from rivers and storm drains



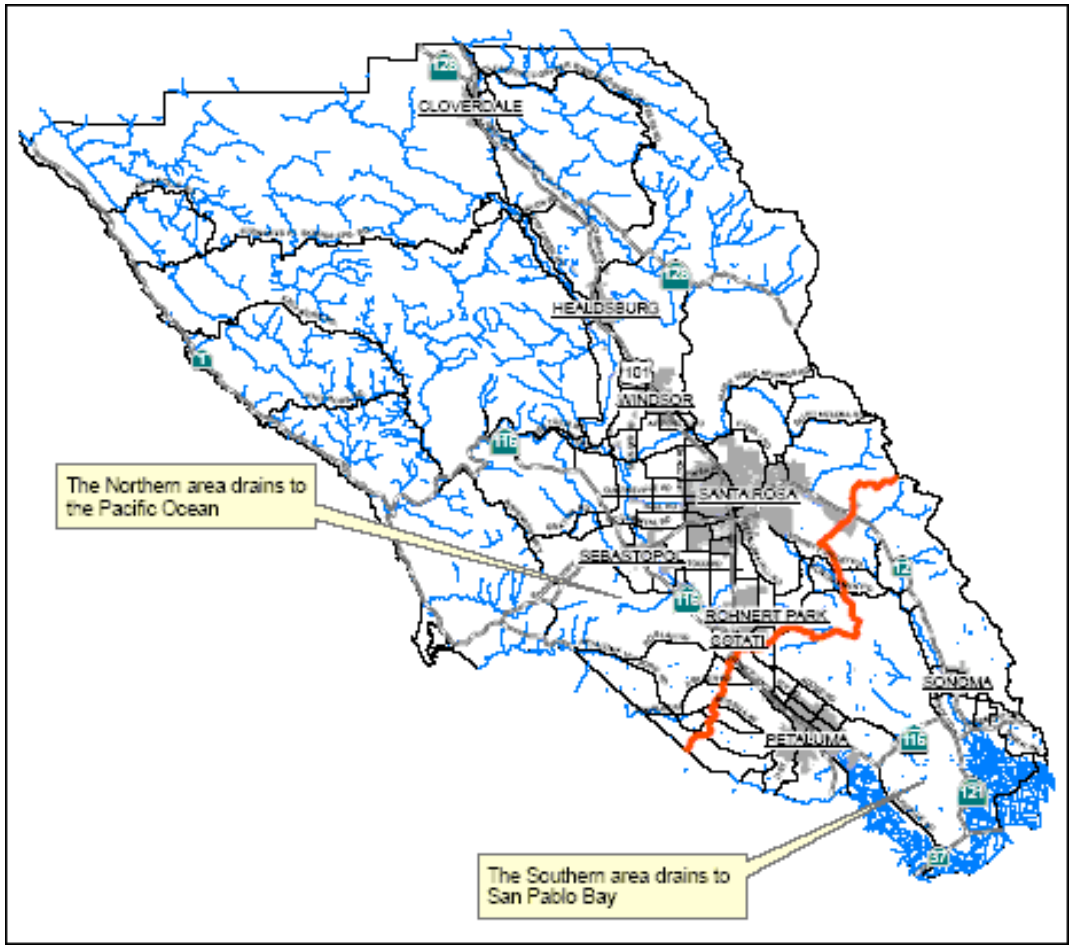
http://geosci.sfsu.edu/courses/geol102/ex6.html

How does plastic get into the sea?

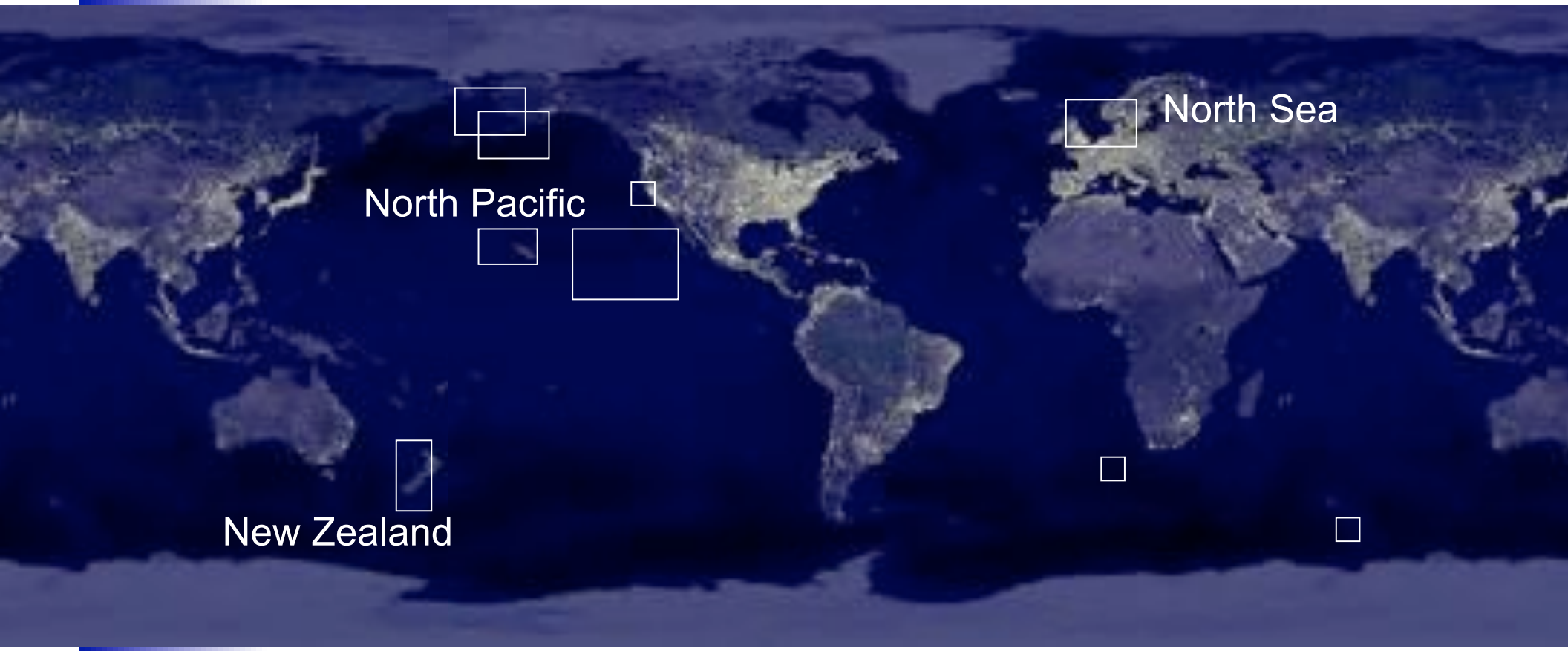
1. Littering by beachgoers.
2. Run-off from rivers and storm drains.
3. Direct dumping into ocean.
4. Accidental loss from ships.



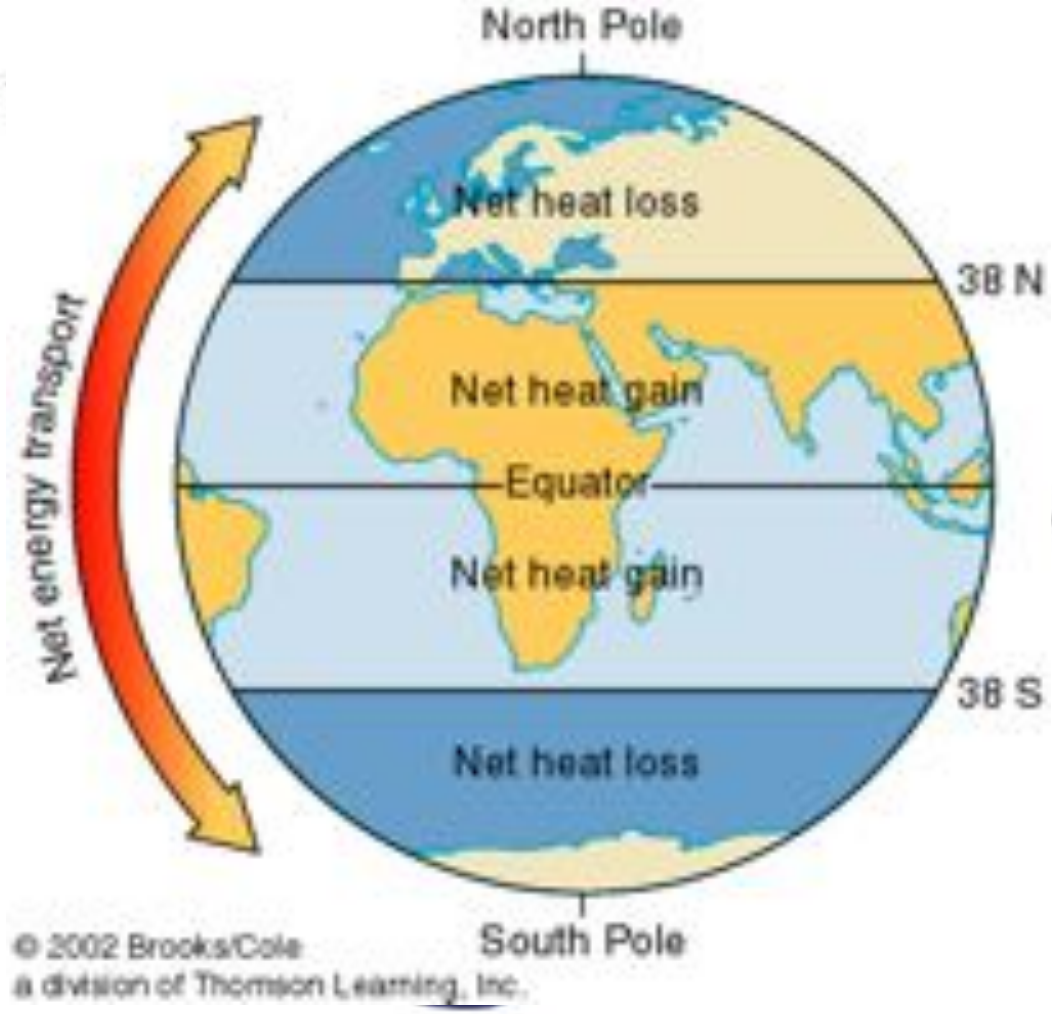
Petaluma “River”



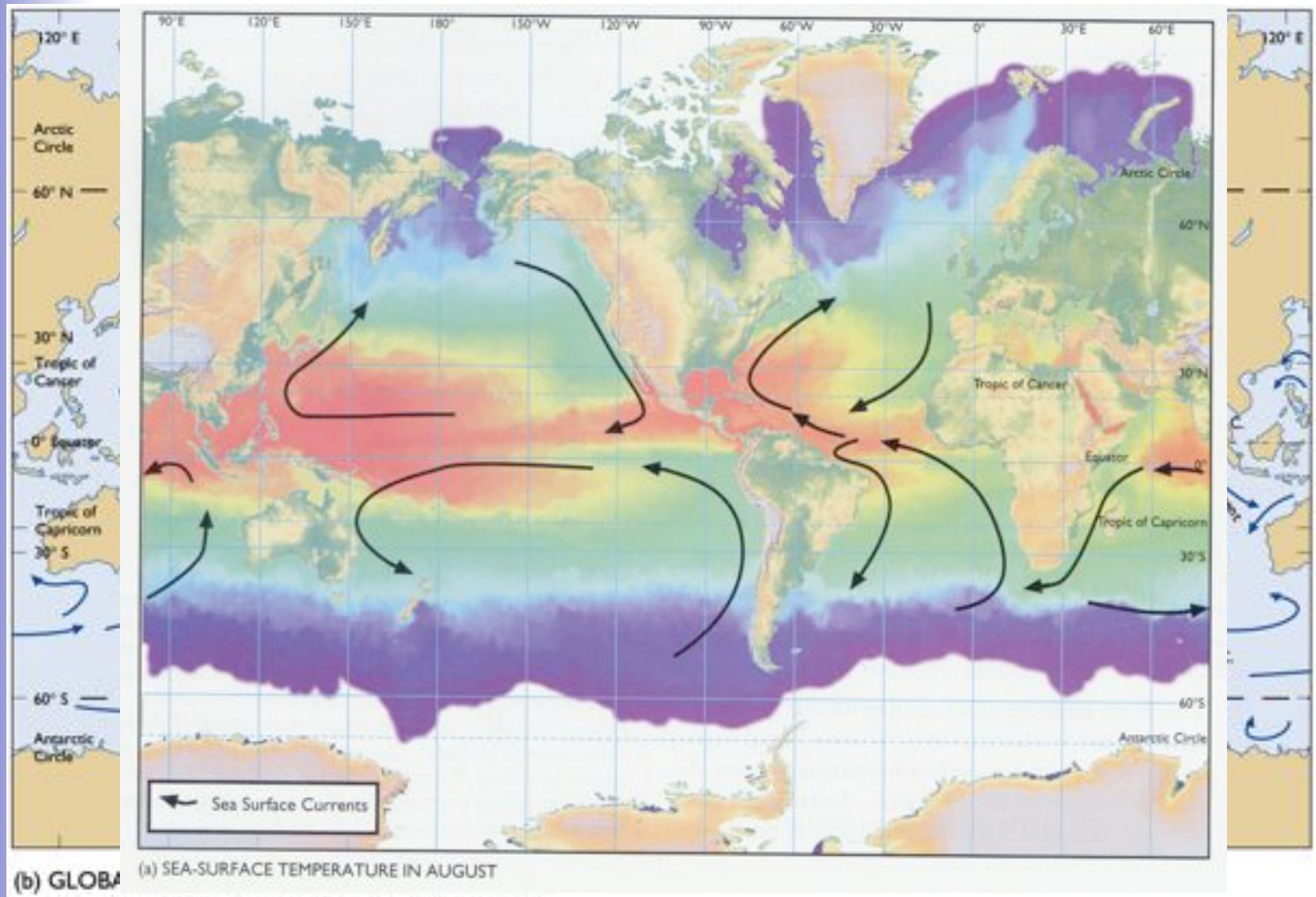
Movement of Marine Debris?



Surface Ocean Currents caused by….WIND!



Surface Ocean Currents



N. Atlantic Gyre

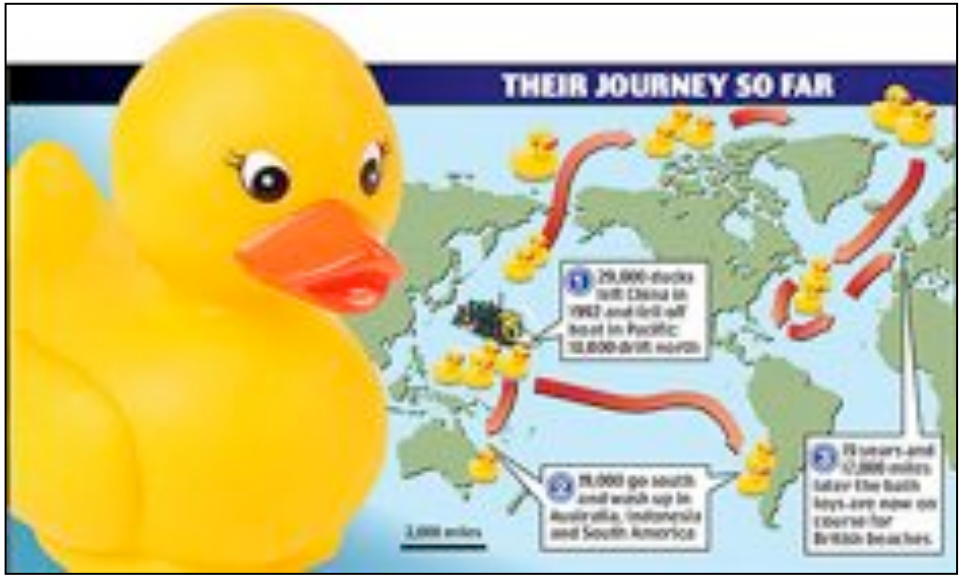
Current Movement observed in… Rubber Duckies !!!

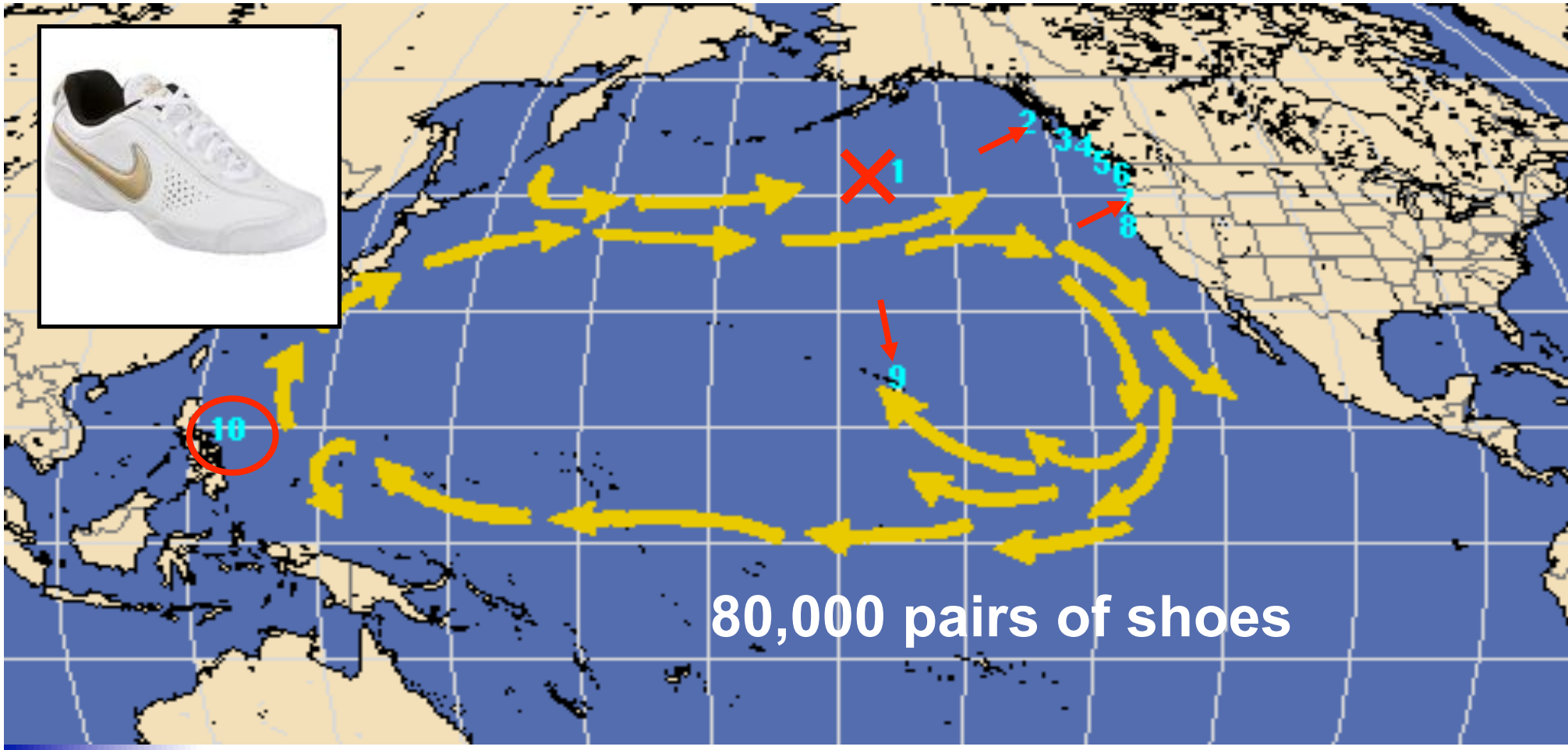
Jan 1992: 29,000 plastic toys spill

Nov 1992: washing up Alaska

2000: washing up in N. Atlantic (Iceland)

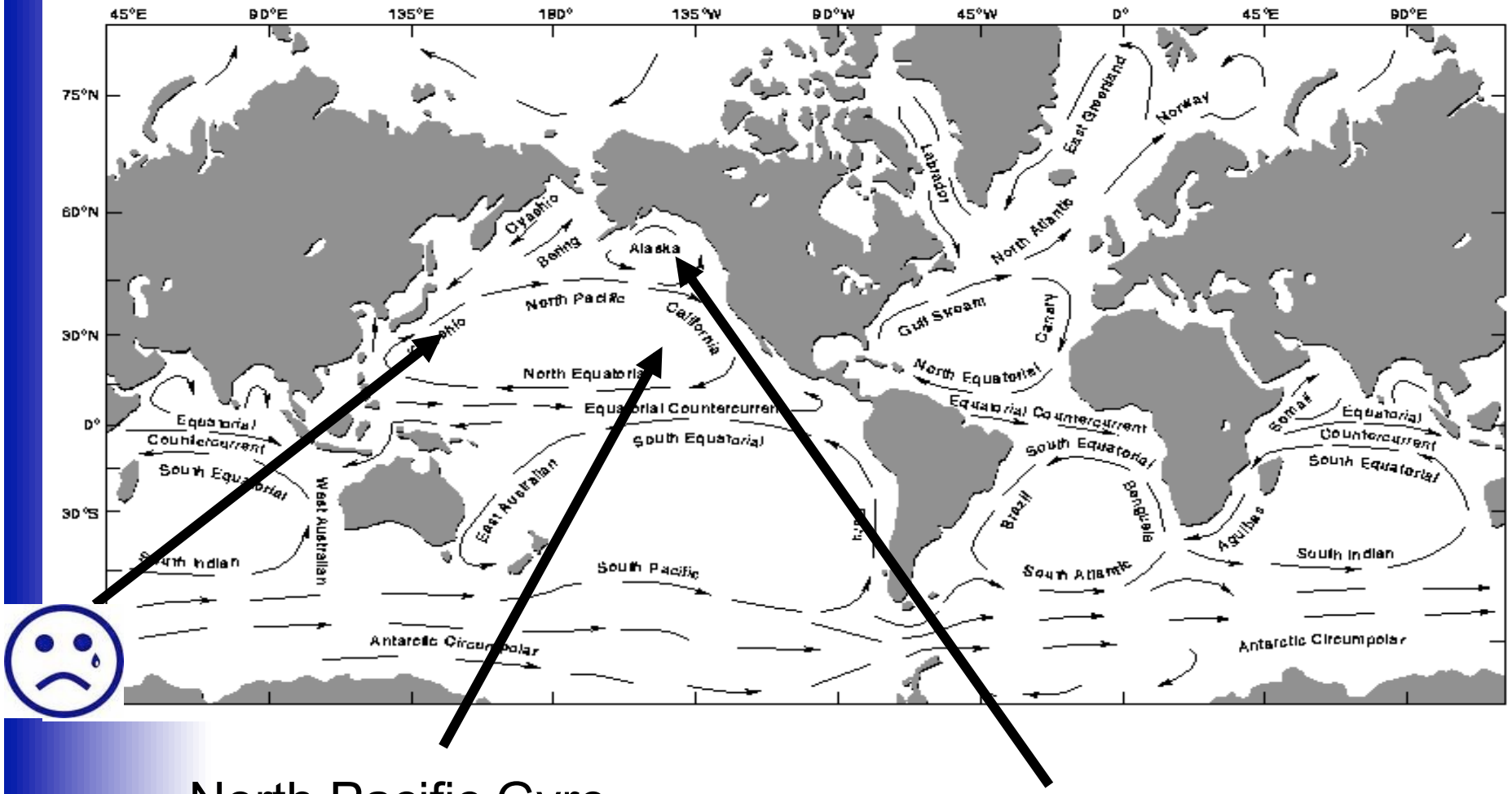
2003: found on shores of Great Britain





1. Shoe Spill May 27, 1990
2. 250 recovered, March 26, 1991
3. 200 recovered, May 18, 1991
4. 100 recovered, Jan-Feb 1991
5. 200 recovered, Nov.-Dec.1991
6. 200 recovered Feb.Mar 1991
7. 150 recovered April 1991
8. 200 recovered May 1991
9. Few recovered Jan-Mar 1993
10. Predicted Jan-July 1994

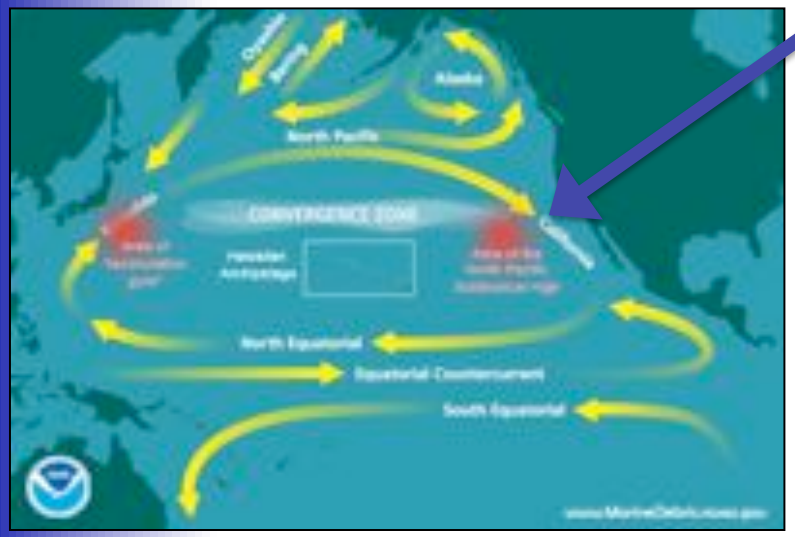
Major ocean surface currents corral trash into “garbage patches”



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

milk carton

styrofoam buoys

paper bag

paper towel

monofilament

plastic bottles

tin can

Aluminum can

cardboard box

newspaper

glass bottles

Trash Timeline

2 wks: paper towel

2 - 4 wks: newspaper

6 wks: paper bag

1 – 2 mths: cardboard box

3 mths: milk carton

50 – 100 yrs: tin can

80 yrs: styrofoam buoys

200 – 400 yrs: Aluminum can

400 yrs: 6-pack ring

450 yrs: plastic bottles

600 yrs: monofilament

Undetermined: glass bottles

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?

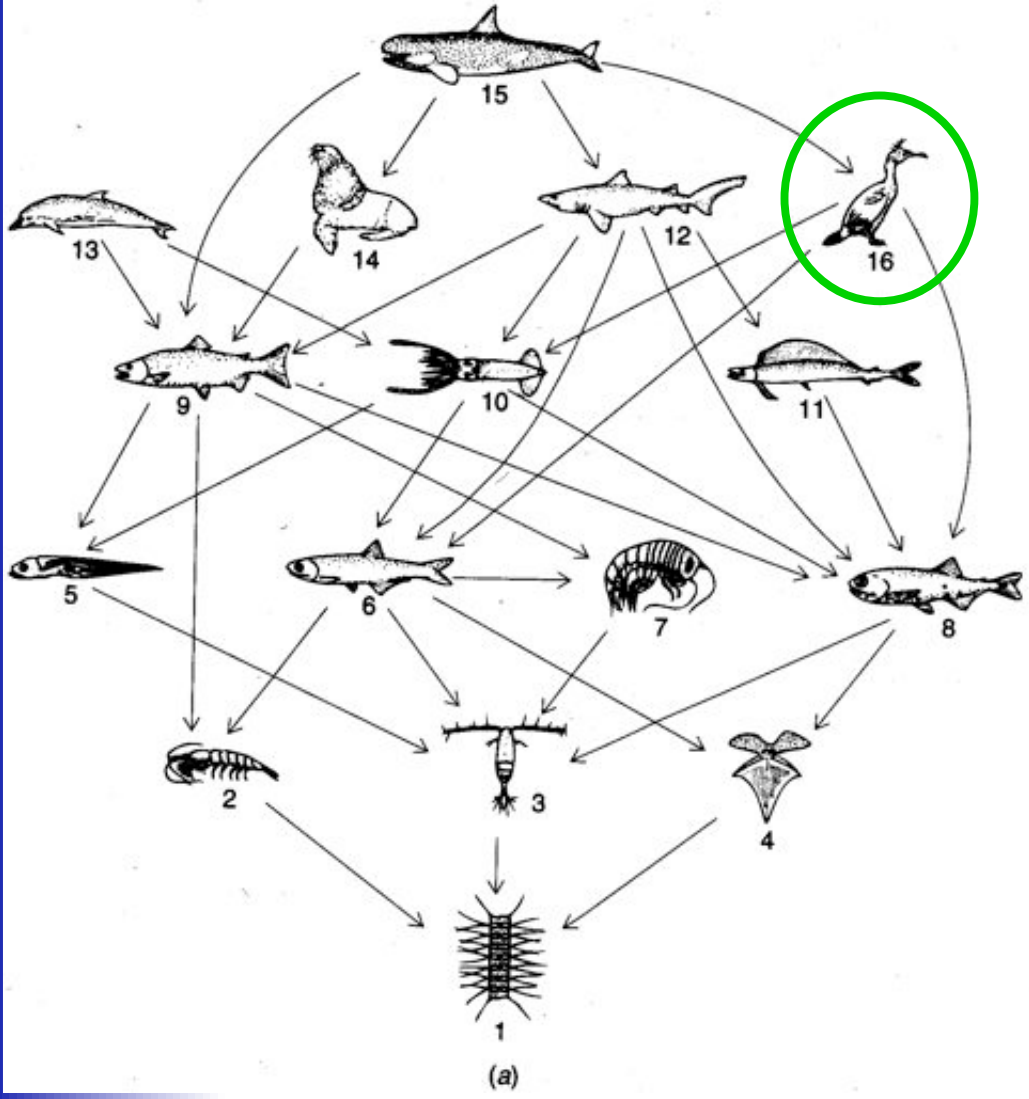
- Spend almost their entire lives in the marine environment.
- Only come to land to breed - often in large colonies on remote islands.
- Return to breed at island where they were hatched.
- Mate for life, each breeding cycle - lay one egg and raise one chick.
- Long-lived (e.g. Albatross >80 yrs, shearwaters >50 years).

Some breeding colonies are not so far away….

de

ation

Seabirds are top-predators in the marine ecosystem



Seabirds, Sharks,
& Marine Mammals

Predatory squid & fishes

Forage fishes &
macro- zooplankton

Zooplankton

Phytoplankton

What threatens seabirds?

Long-line and other fishery interactions

Oiling from oil spills

Marine debris

Threats at colonies: introduced mammals, habitat destruction

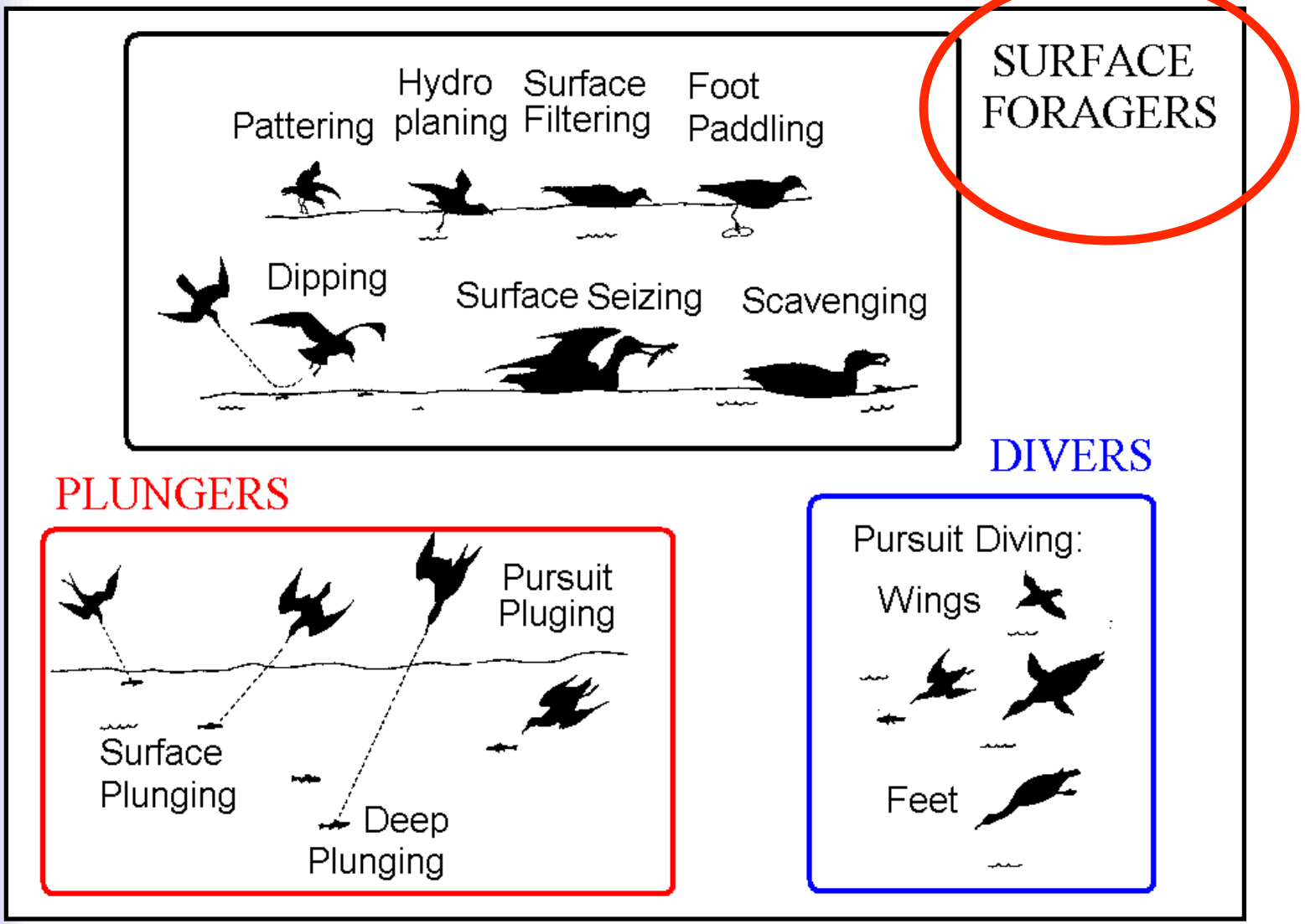
Seabirds are biological indicators of plastic pollution

- 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

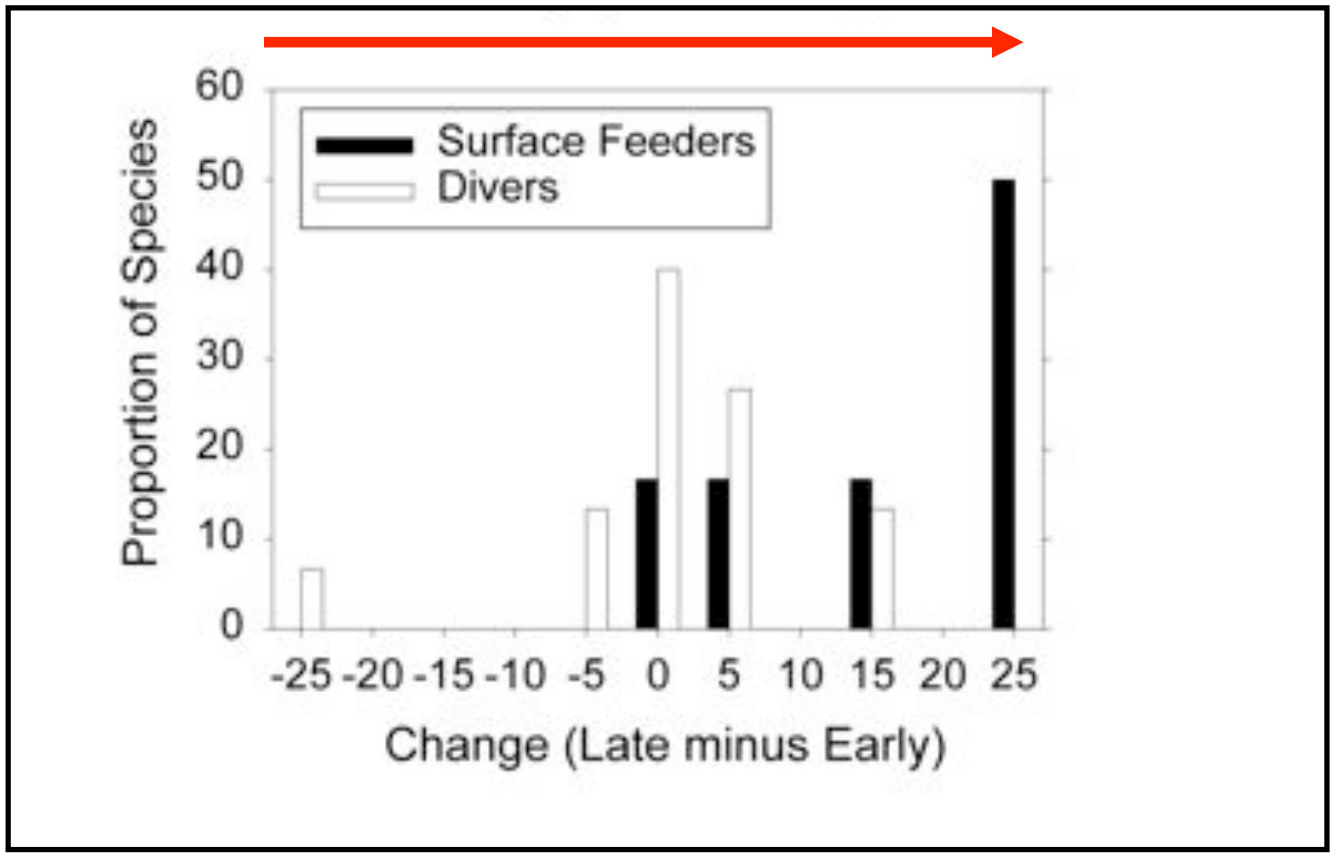
1) Seabird Foraging Modes



(Ashmole 1971)

Surface feeders are more likely to ingest plastics

Increase Plastic Ingestion by Surface Feeders



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

(Robards et al. 1995)

Alaskan Seabirds Increase Plastic Consumption

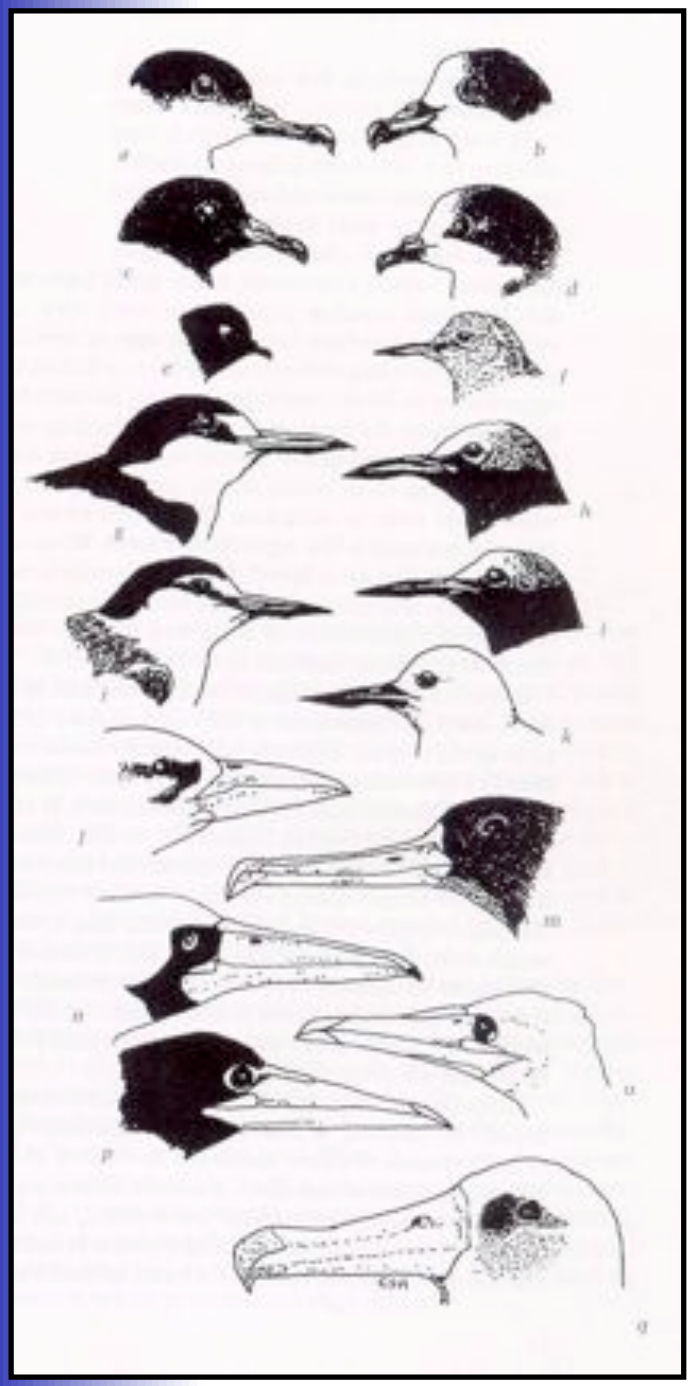



(Robards et al. 1995)

Species	Plastic Incidence 1969-1977	Plastic incidence 1988-1990	Increase
Northern Fulmar	58% n=38	84% n=19	+26%
Tufted Puffin	15% n=348	25% n=489	+10%
Horned Puffin	37% n=148	37% n=120	~no change
Parakeet Auklet	75% n=116	94% n=208	+18%

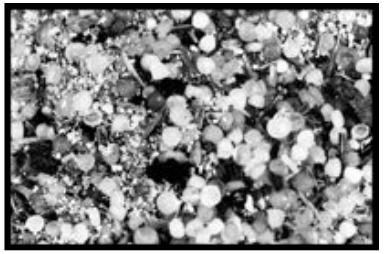
Plastic ingestion is affected by:

1) Foraging mode – *surface feeders*
2) Body Size
3) Habitat Use



2) Body & bill size influence plastic ingestion

20 – 100 mm (Albatrosses)

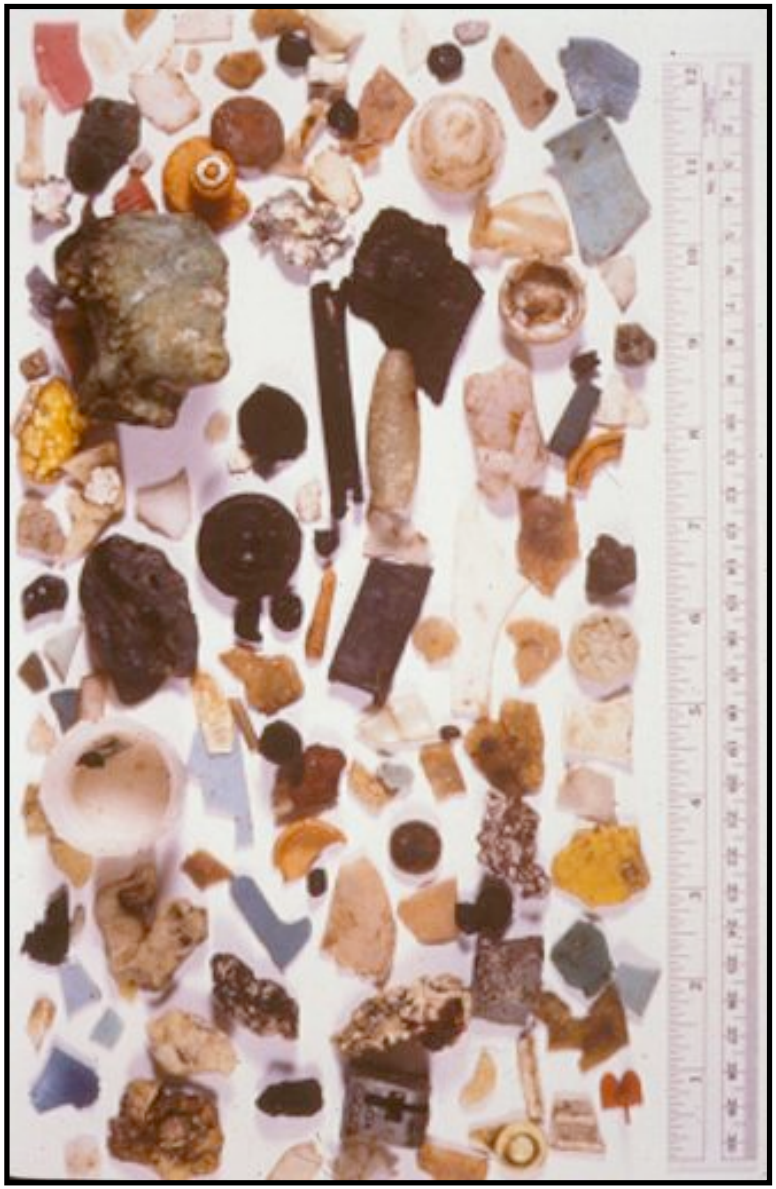


(Fry 1987, Robards et al. 1995, Kinan 2000)

Albatross Bolus Contents

2.5 cm

1 inch



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.

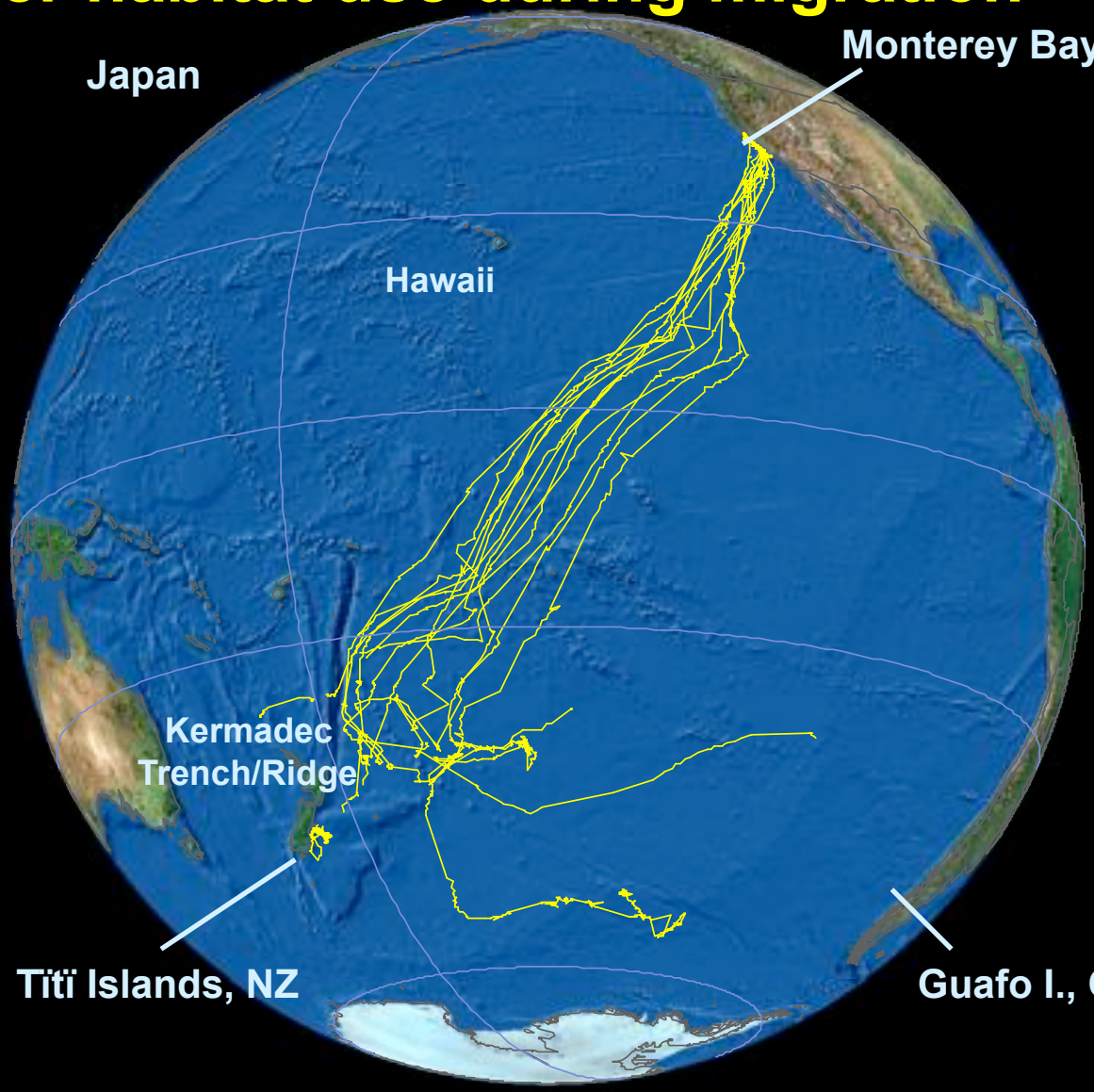
Wilson’s Storm-petrel

Black-footed Albatross

3) Habitat Use: Black-footed albatross from July-Oct 2004

Unpublished data Hyrenbach et al. 2004

Sooty shearwater habitat use during migration



Leach's storm-petrel (*Oceanodroma leucorhoa)*

Adults may live to be 40-50 yrs. old

A chick is hatched after 50-75 days

Description:

- Length: 7.5 inches
- Wingspan: 19 inches
- Feed by pattering feet on surface

Plastic ingestion is high:

- 20% in non-breeding area (tropical Pacific)
- 100% in North Pacific Breeding area

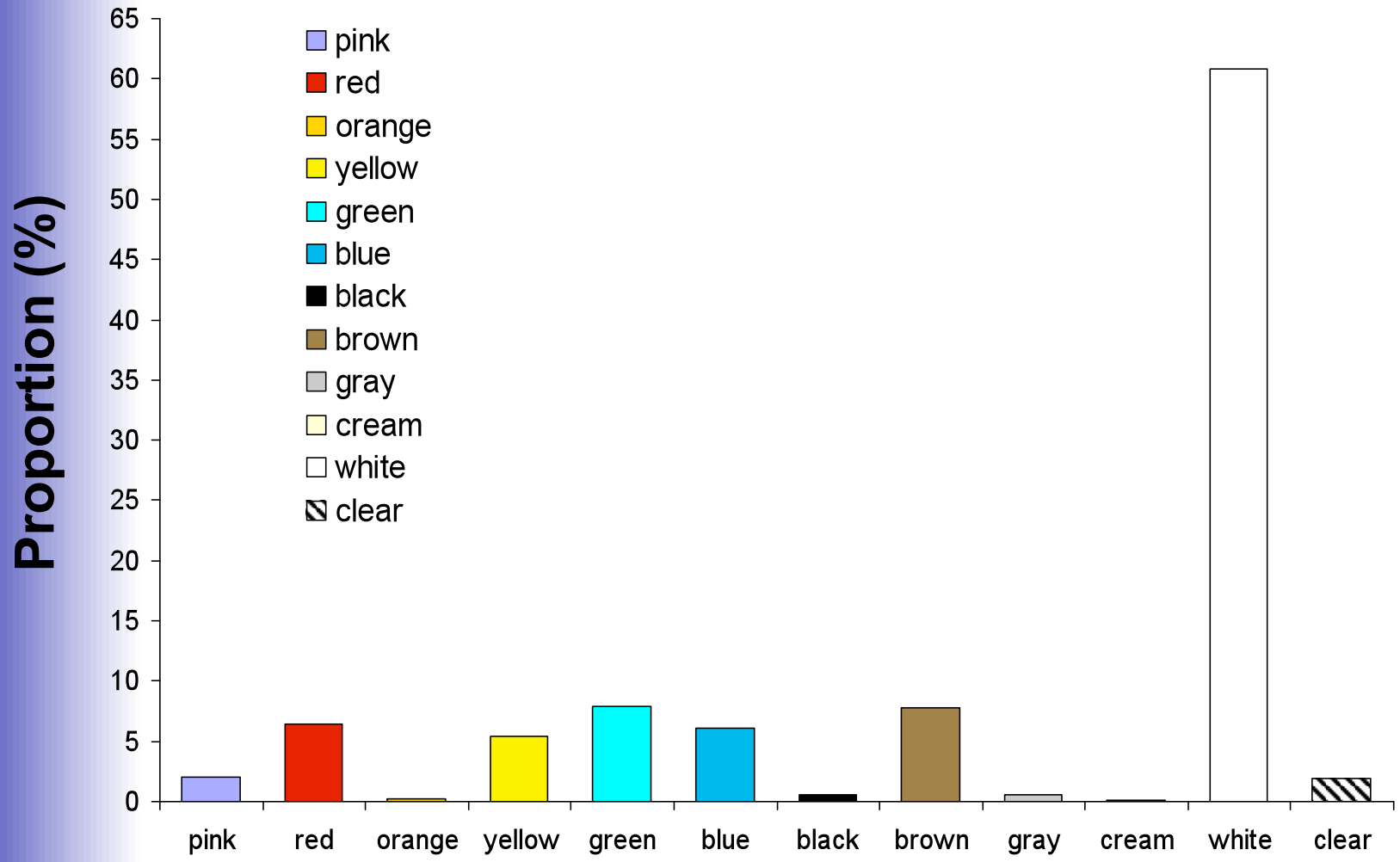
Northern Fulmar *(Fulmaris glacialis)*

- 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

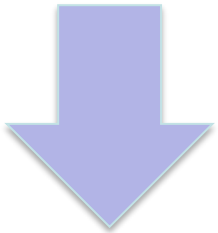


Color of plastic fragments in Northern Fulmar stomachs

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”

Northern Fulmar

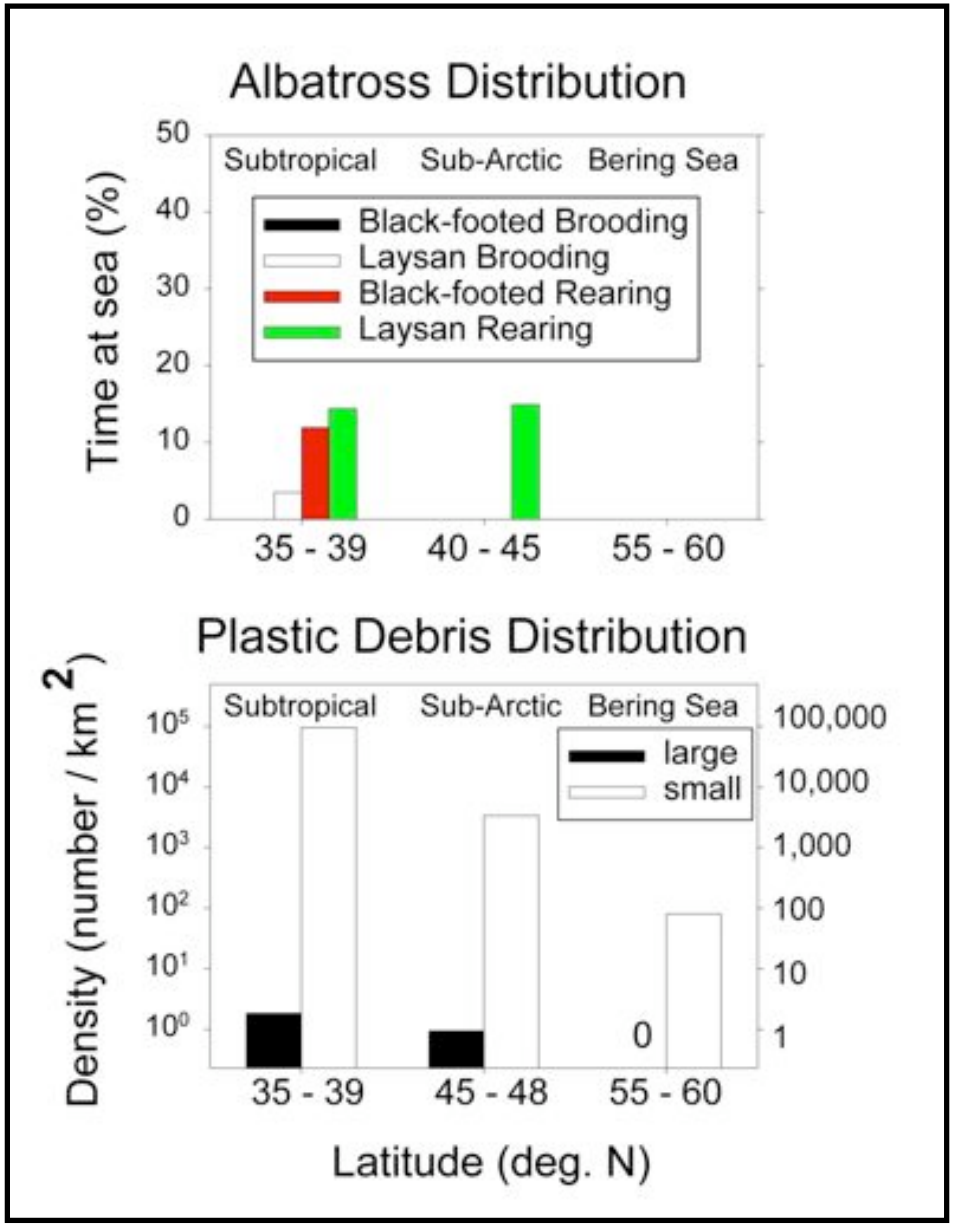
Sooty Shearwater

Laysan Albatross

- 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.

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:

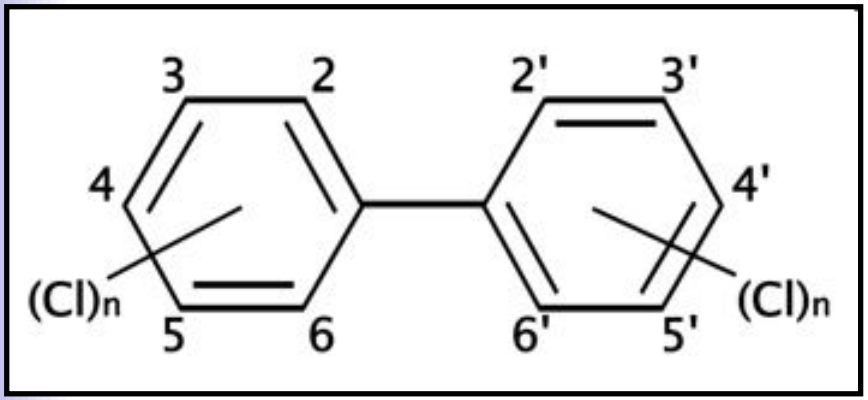
- Cuts / abrasions leading to infection
- Fill up / obstruct the stomach

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

Sievert & Sileo 1993, Dickerman & Goelet 1987, Ryan 1988, Ryan & Jackson 1987

Long-Term Effects



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