

# PLASTIC POLLUTION OF THE MARINE ENVIRONMENT

A PROBLEM THAT IS  
RAPIDLY WORSENING  
AND HAS NO SIMPLE  
SOLUTION

CAPTAIN CHARLES  
MOORE



ALGALITA MARINE RESEARCH FOUNDATION

[www.algalita.org](http://www.algalita.org)

# The Age of Plastic

AN EXCITING TIME FOR BOTH  
MEN AND WOMEN



# Popular Science

SEPTEMBER 1982 \$1.50

The **What's New** magazine

Here at last:  
low-cost  
**DIY SOLAR  
HEATERS**

Checking out a  
**FEEDBACK  
CARBURETOR**

Ford's impossible  
**plastic  
engine**

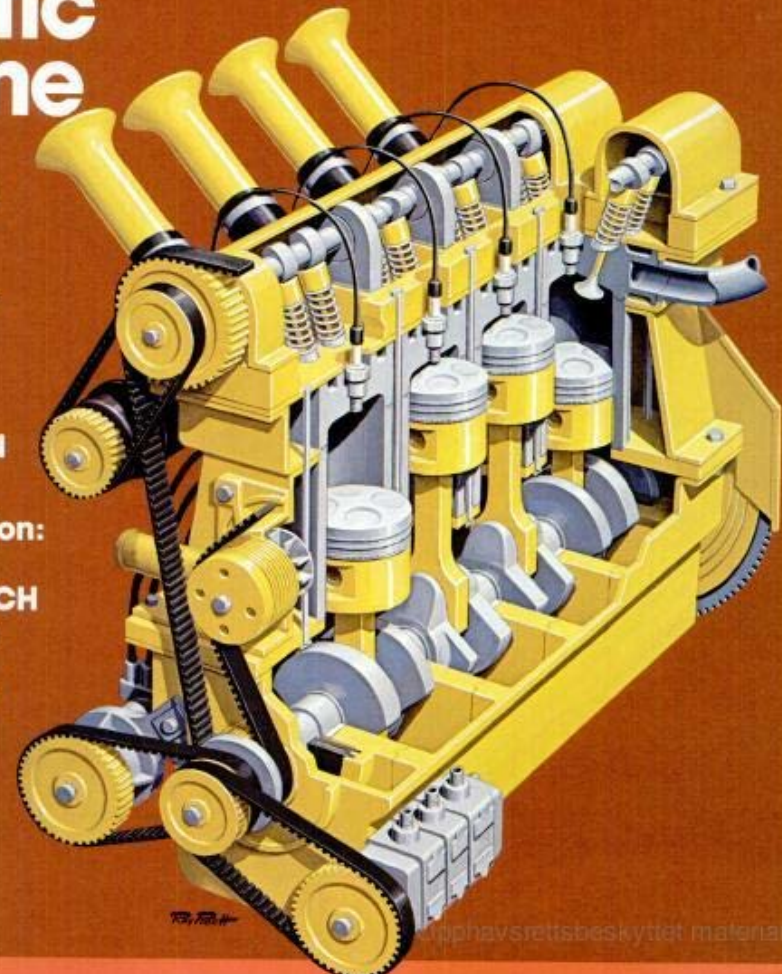
TALKING  
APPLIANCES

THE GLASS-  
WIRED  
COMMUNITY

Now: 96%  
efficient  
PULSE-  
COMBUSTION  
FURNACE

Special section:  
STORAGE  
FROM SCRATCH

- Living-dining divider
- Storage wall
- Wine cellar
- Swing-out shelves

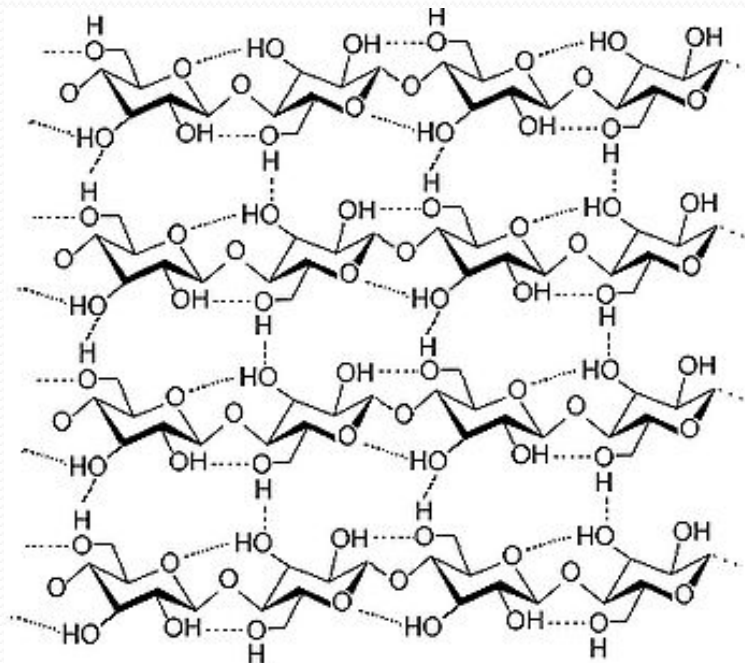


uphavssrettsbeskyttet materiale

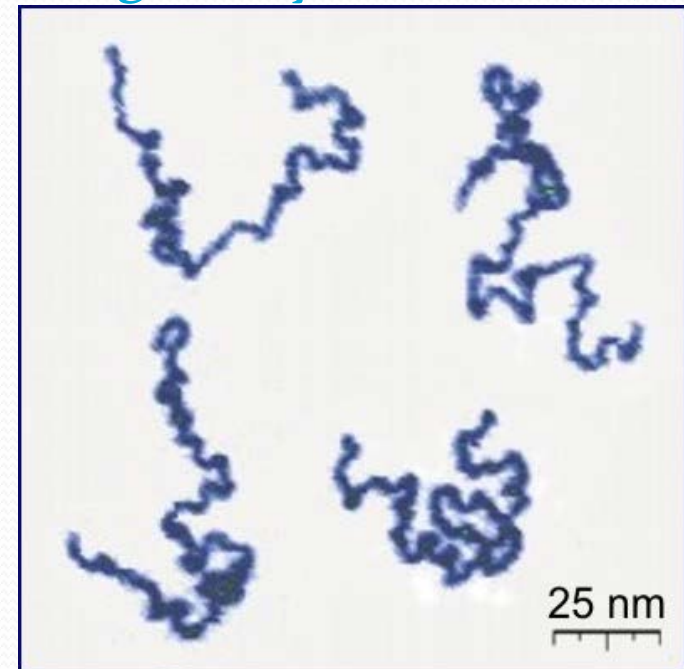


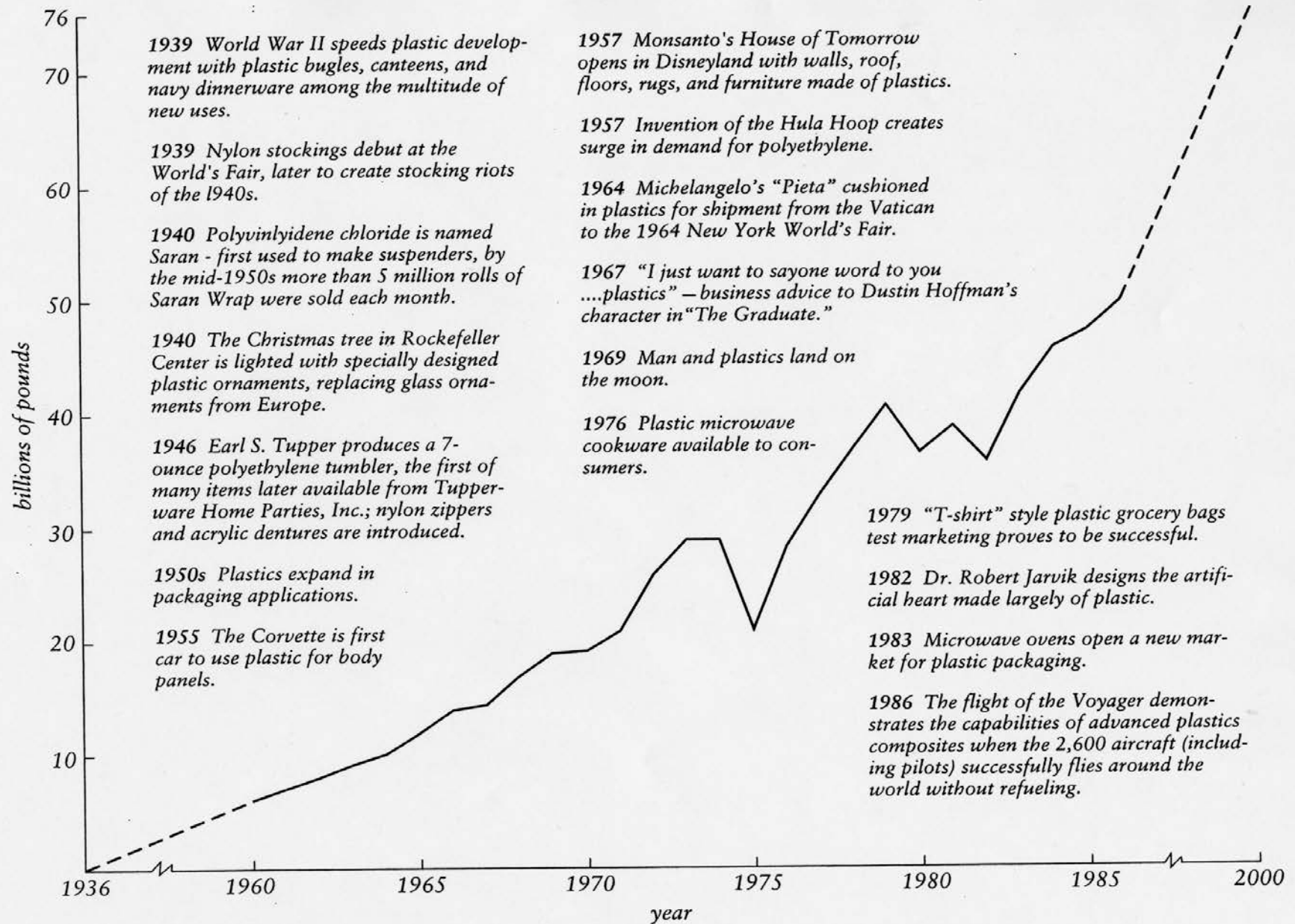
# Introduction and Definitions

- Polymer
  - Is a large molecule of repeating structural units, most typically connected by covalent bonds
  - Not just synthetic... can be natural. Rubber, amber, nucleic acids, cellulose



Single Polymer Chains (AFM)





19.21 Growth of plastics production in the United States. (Source: Center for Environmental Education)



# Introducing...the one-way, throwaway can...late 1940's



**DRINK RIGHT FROM THE CAN:  
NO EMPTIES TO RETURN**

Source: Can and Bottle Bills - CalPIRG,  
Original Source Unknown

A FEW YEARS  
EARLIER,  
DURING WWII,  
THIS BEHAVIOR  
WOULD HAVE BEEN  
UNTHINKABLE—  
AND PROBABLY  
ILLEGAL

LIFE

MAGAZINE

“Throwaway Living”

OH  
JOY!!

OH  
BLISS!!

1

9

5

5





# Throw Away Products Are Now Mostly Plastic



# Plastic Resin Families:

## **Thermoplastics**

- 79% of all plastics sold in US
- Targeted for recycling because can be re-melted & molded again
- Can be recycled in existing technologies
- Most widely used for everyday items
- Over 55% are packaging & throwaways
- Make up 70-80% of waste stream plastics.



## Other Resin Families:

- **Thermosets (7%)**  
(7,893 mm lbs)
  - Once molded, can't be re-melted/recycled
  - Ex: heat resistant items.
- **Specialty Plastics (14%)**  
(15,231 mm lbs)
  - Engineering & durable resins
  - Ex: high performance auto/ aircraft parts, construction materials.



# Buoyancy in Sea Water

- Polyethylene 0.79-0.97
- Polypropylene 0.90-0.92
- Polyethylene/Polypropylene ~ 1
  
- Polyamid resin or Nylon 6/10 (Unfilled) 1.09
- Polyamid resin or Nylon 6/6 (Unfilled) 1.13 - 1.15
- Polyamid resin or Nylon 6/12 1.06-1.08
  
- Polyethylene terephthalate (PET) 1.34-1.39
- Polystyrene (unexpanded) 1.04-1.09
- Polystyrene (Foam) < 1
- PVC Flexible (Filled) 1.30 - 1.70
  
- Cellulose acetate 1.35-1.42
- Polyester urethane 1.1-1.25



## Why isn't plastics recycling simple?

- Low melting point
  - Aluminum = 1,500 °F
  - Glass = 2,800 °F
  - Steel = 3,000 °F
  - Plastic = 210 - 480 °F
- Some scorch if heated = thermosets
- So many different types of plastic

# What happens if you Mix Plastic??

- ✘ Most olefins *could* be recycled together...
- ✘ But how would you keep the material properties consistent on the large manufacturing scale??
  - + Each plastic has slightly different properties due to its molecular structure
  - + When you make alloys the properties are slightly to greatly lowered because you have lowered the crystallinity
  - + If you have inconsistent composition, you will have inconsistent properties.
  - + Mixed plastics have less opportunity to be recycled again for this same reason...

Tova Sardot slides



HAWAII 5 FEB 2006









Kahalu'u Beach Park 2-5-06





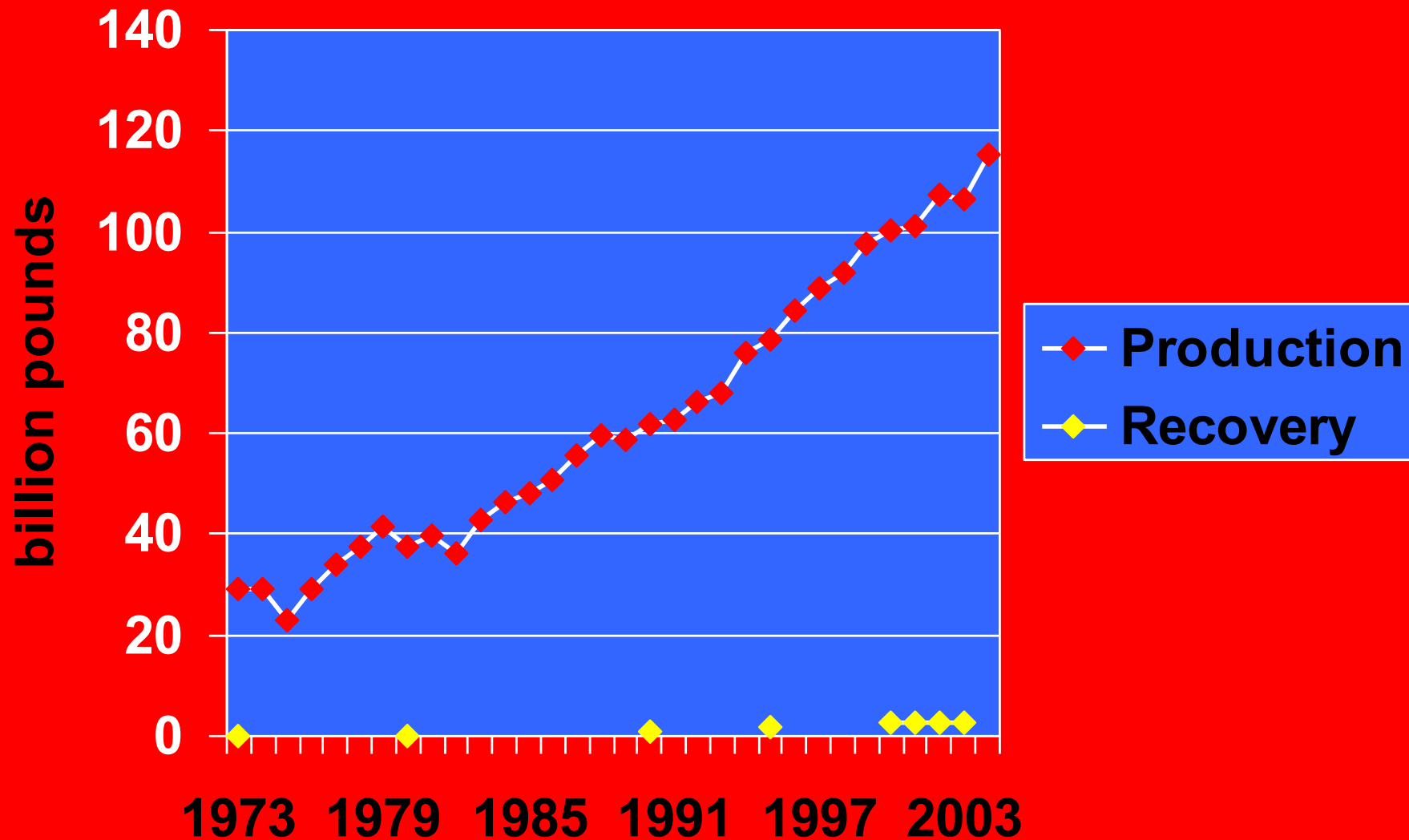




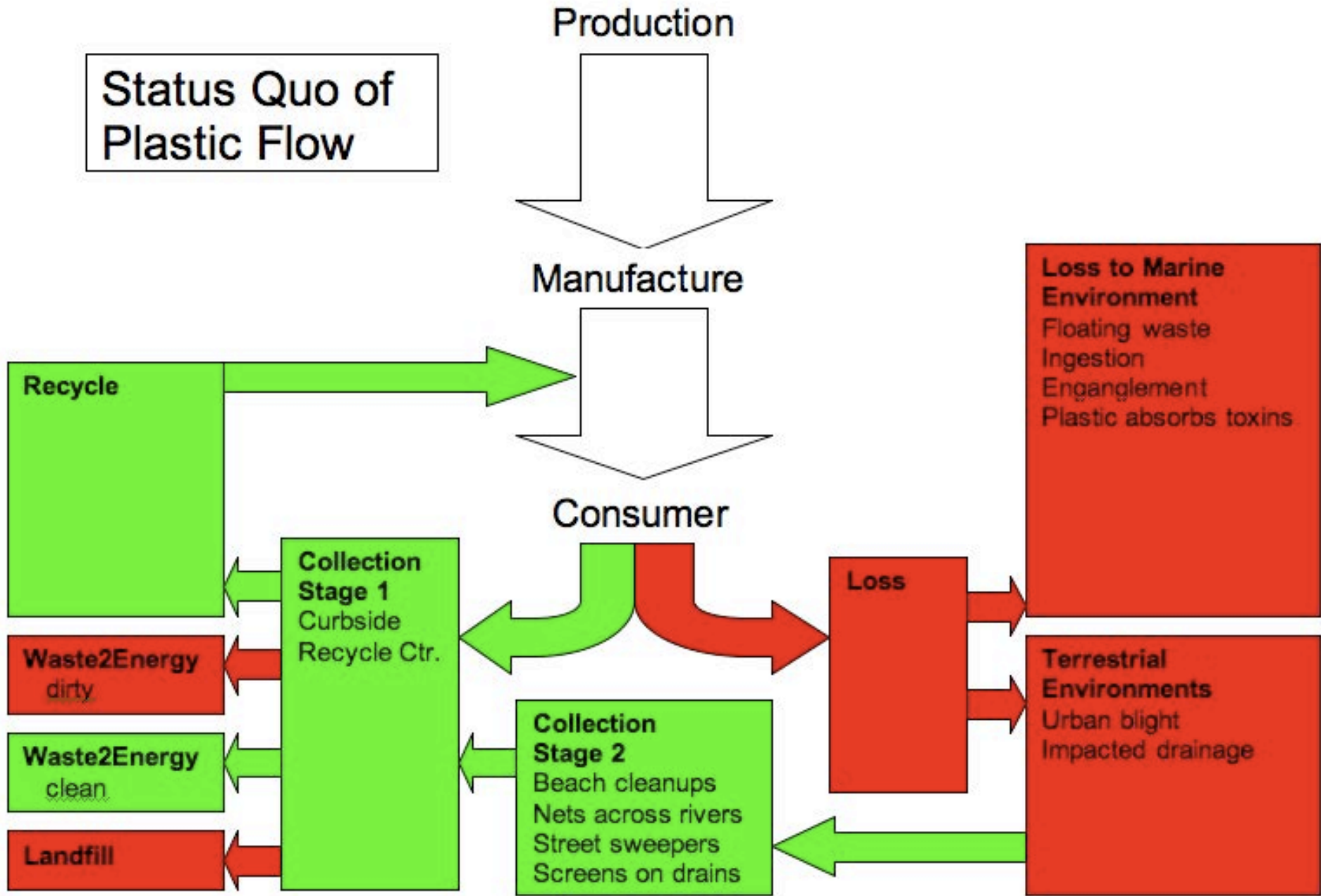




# Annual US Plastic Resin Production & Recovery

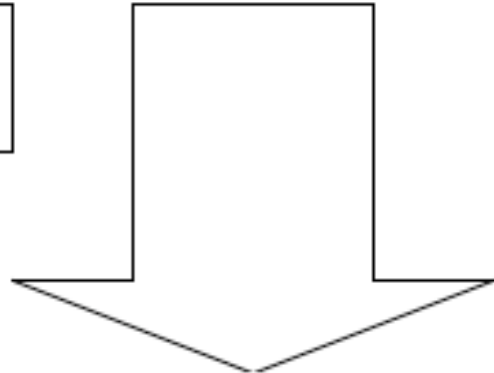


# Status Quo of Plastic Flow

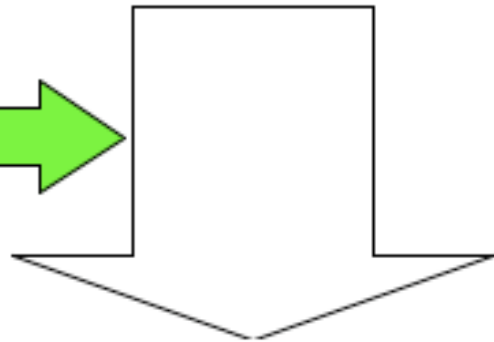


**Ideal System**

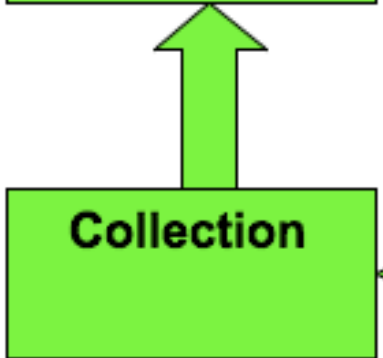
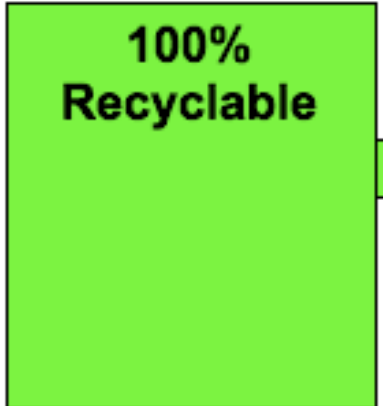
**Production**



**Manufacture**




**Consumer**





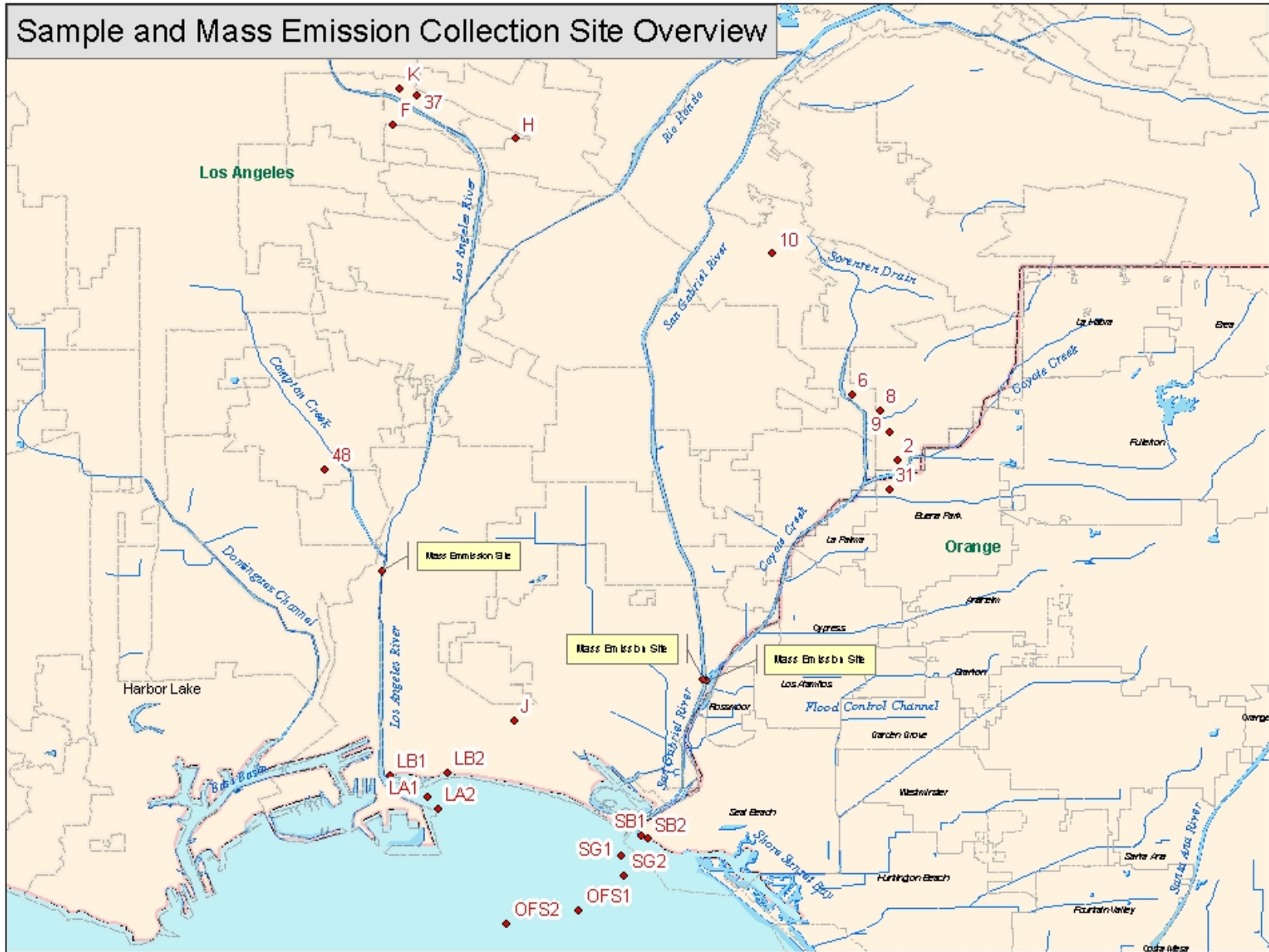
URBAN THROWAWAYS ON THEIR WAY  
TO “**AWAY**” >>> NAMELY; THE **OCEAN**  
**LONG BEACH, CALIFORNIA, 2005**





**HOW MUCH TOTAL PLASTICS ARE  
TRANSPORTED BY THE TWO  
MAJOR RIVERS DRAINING RUNOFF  
FROM LOS ANGELES TO  
SAN PEDRO BAY?**

# Sample and Mass Emission Collection Site Overview



SWRCB Number 03-084-554-0  
 Site Location Source: Algalita Marine Research Foundation  
 Features Data Source: TIGER Census 2000







DRY CONDITIONS









HEAVY RAIN CONDITIONS



# THREE DAY TOTAL

TOTAL PLASTICS FROM THE TWO MAIN LA RIVERS  
TO THE OCEAN IN TWO WET AND ONE DRY  
DAY\*\*\*\*\* 2.3 Billion

- WEIGHT OF PLASTIC PARTICLES AND WHOLE  
PLASTIC OBJECTS \*\*\*\*\*30 Metric Tons

*Debris boom on Ballona Creek,  
which carries Los Angeles' runoff*





# CITARUM RIVER, INDONESIA









# LAGOS, NIGERIA





RF

# MUMBAI, INDIA





New Delhi, India



Marcus Eriksen, Photo



Yamuna River, New Dehli,  
India  
Marcus Eriksen, Photo





# Yamuna River, New Delhi, India

Photo: Manan Vastayana





HAKODATE 9 MARCH 2007





ROTTERDAM April 23, 2009





# Pirate Camp, Somalia





**KAMILO BEACH  
BIG ISLAND**





KAMILO DELIVERED ANCIENT HAWAIIANS  
EXOTIC TREES FROM THE PACIFIC  
NORTHWEST, SOME OF WHICH THEY  
CRAFTED INTO VOYAGING CANOES

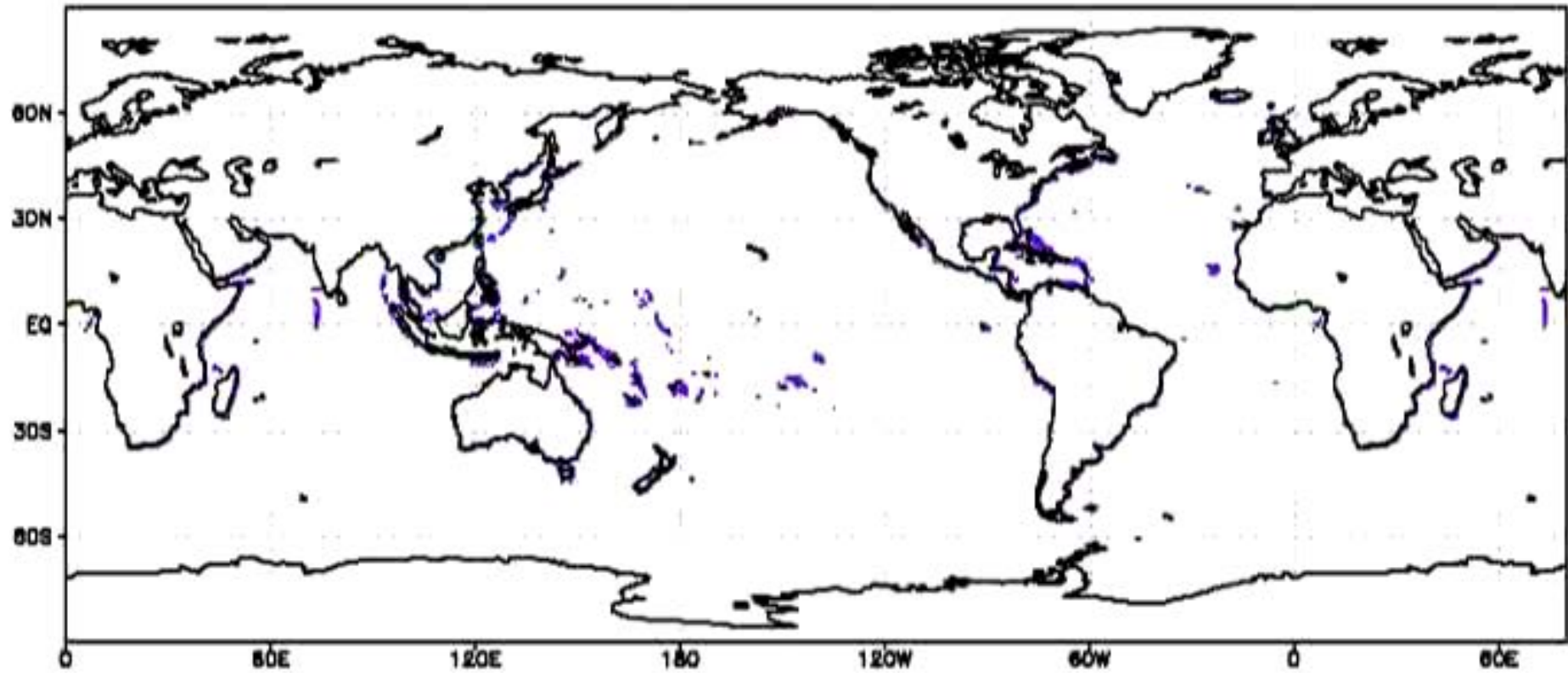








1999-08-01

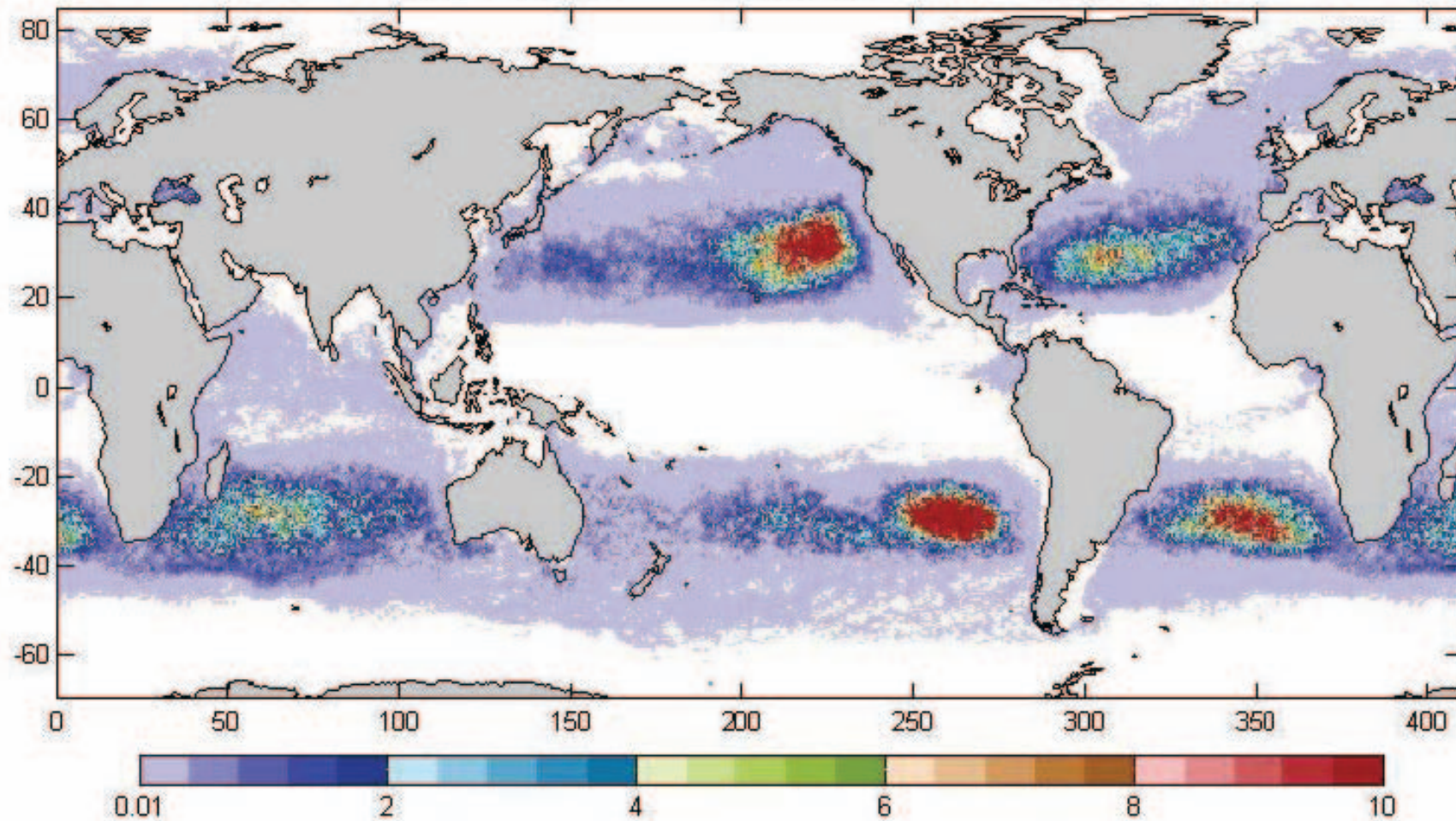




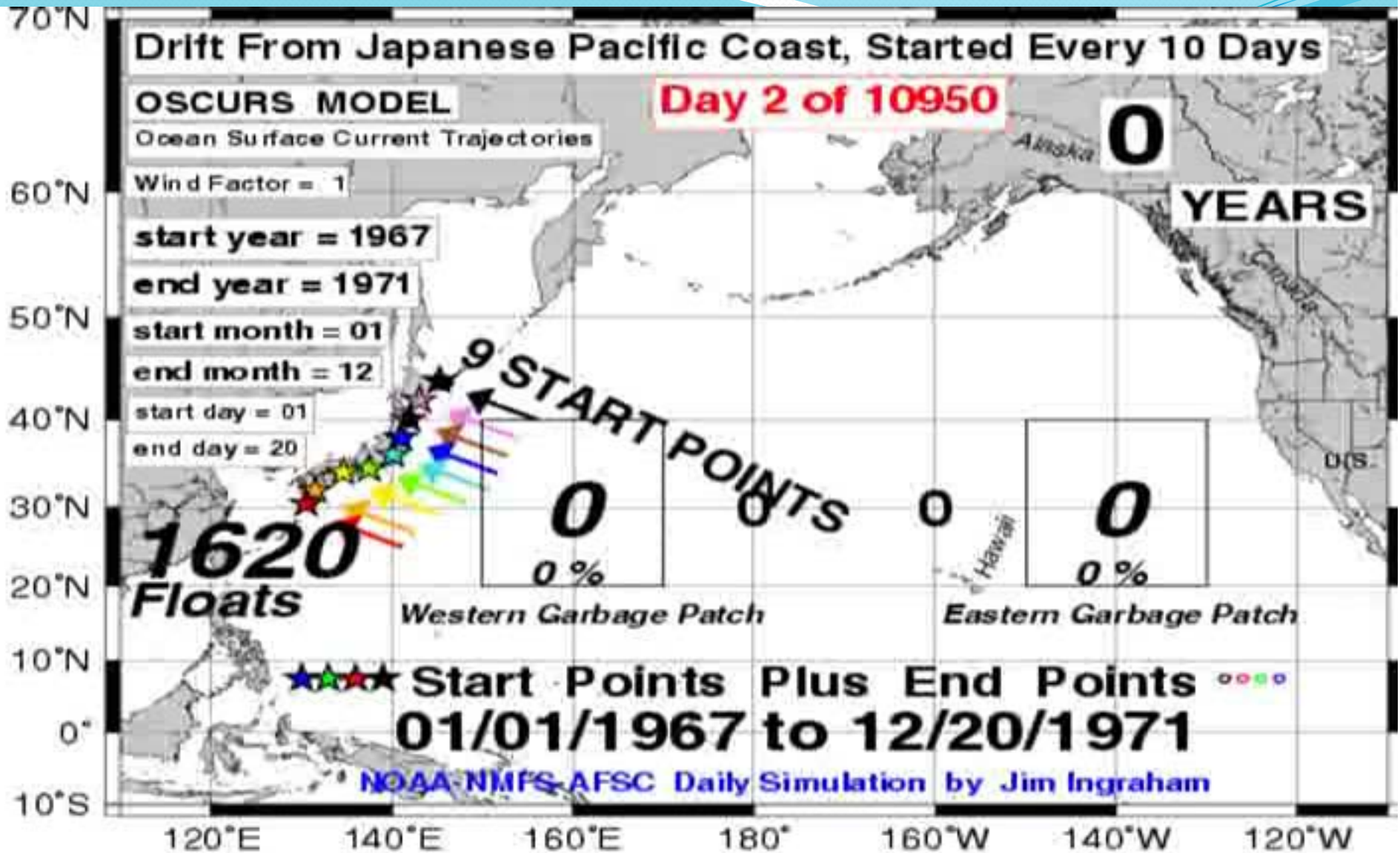
Day # 3650

Year # 10

70%



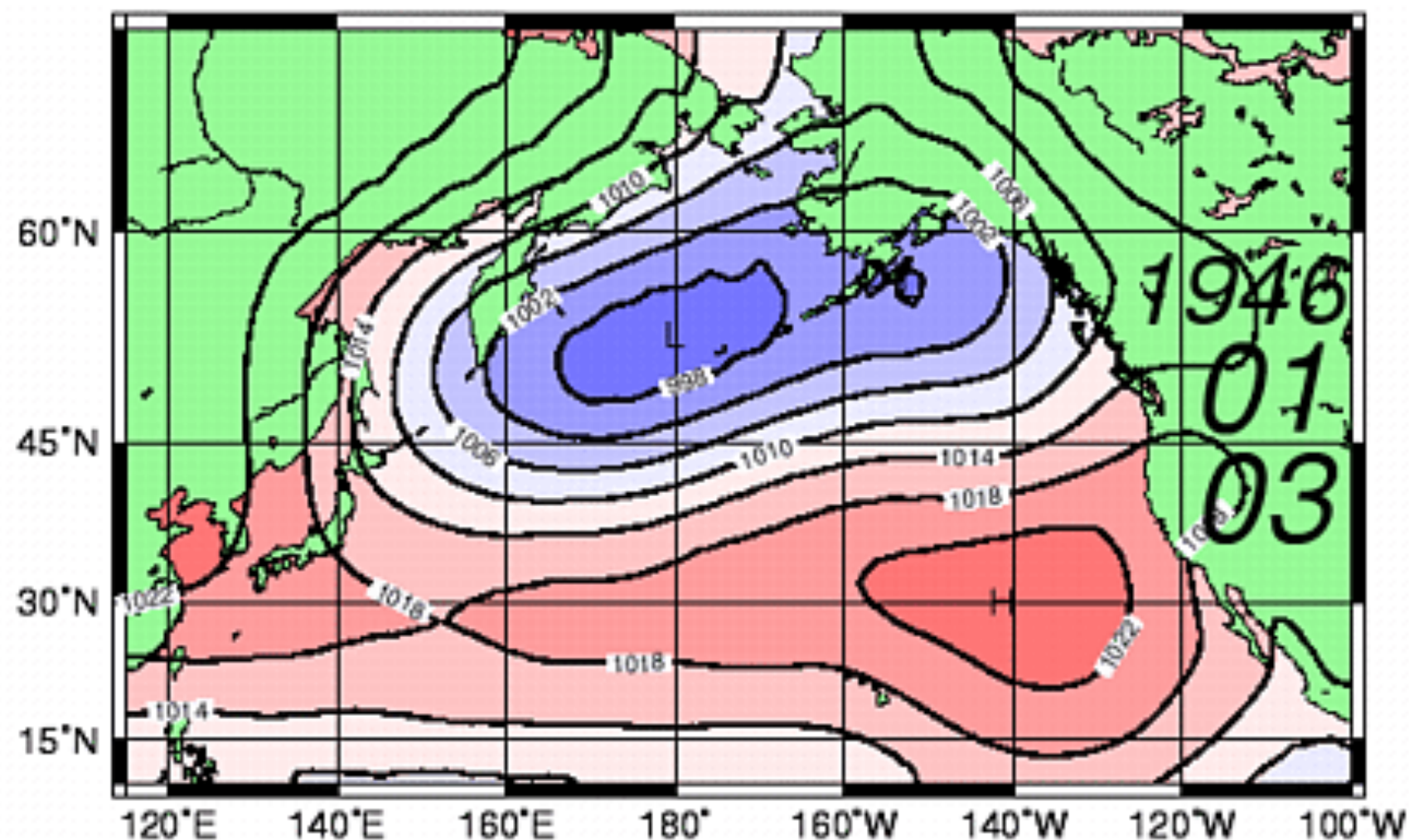




JAPANESE TSUNAMI OCCURRED ON MARCH 11, 2011

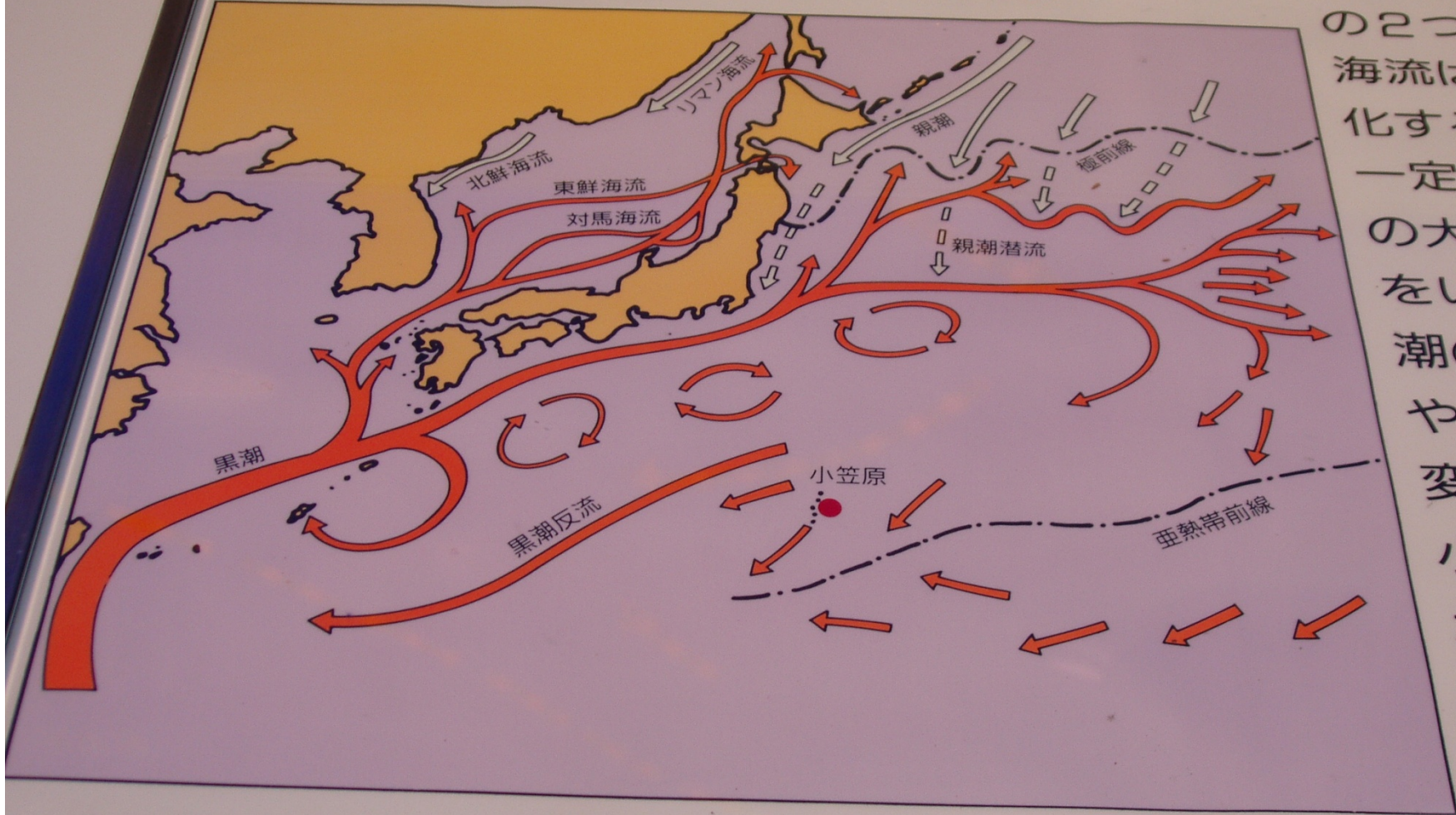


*3-Month Running Mean Sea Level Pressure (mb):  
1946 MONTHS 01 to 03*



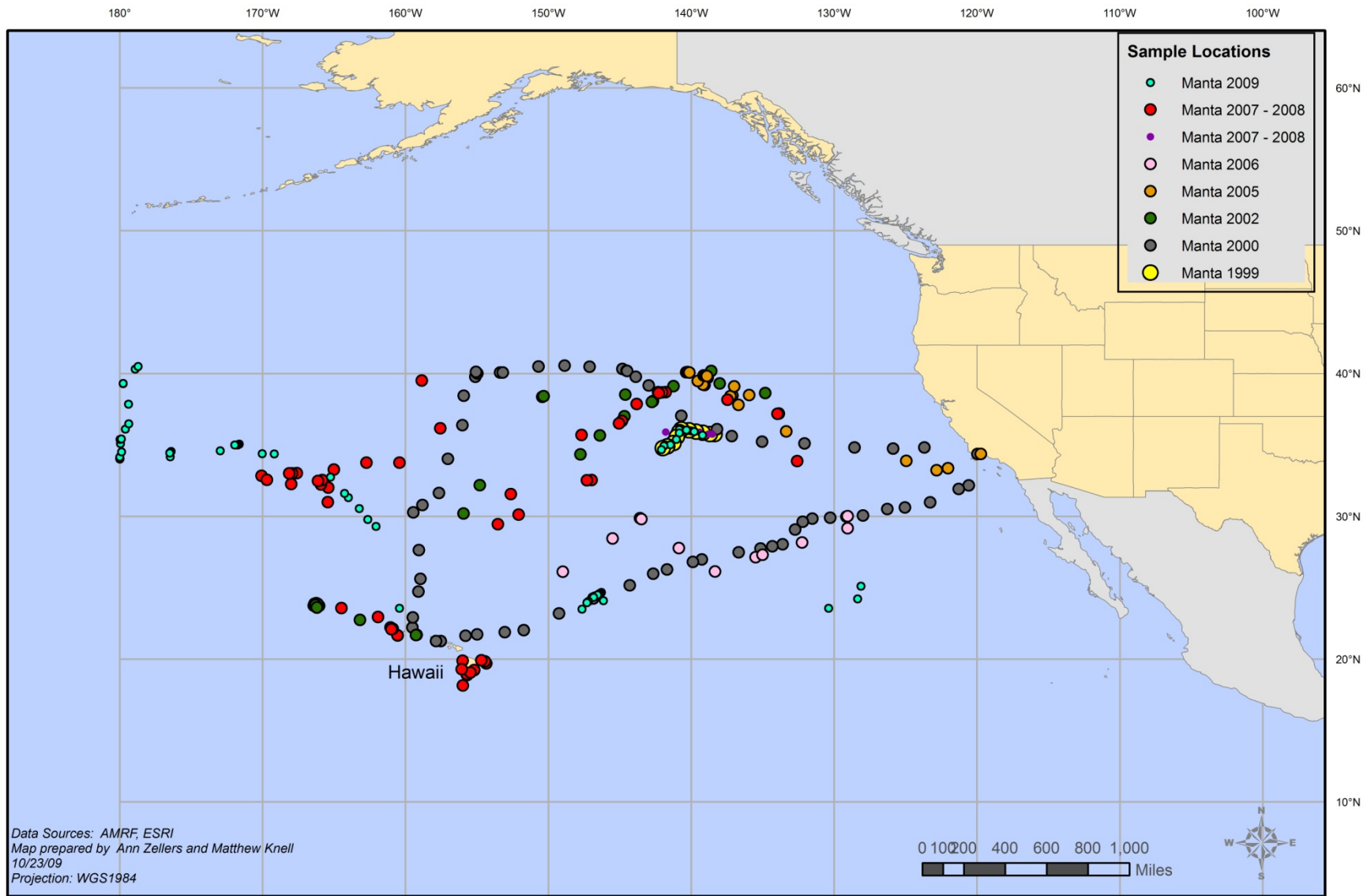


# 小笠原周辺の海流



海の流れは、  
 の2つに大き  
 海流は流れ  
 化するもの  
 一定方向に  
 の大河に何  
 をいいま  
 潮の満ち  
 や速さ  
 変化さ  
 小笠原  
 な大き  
 流が  
 辺に





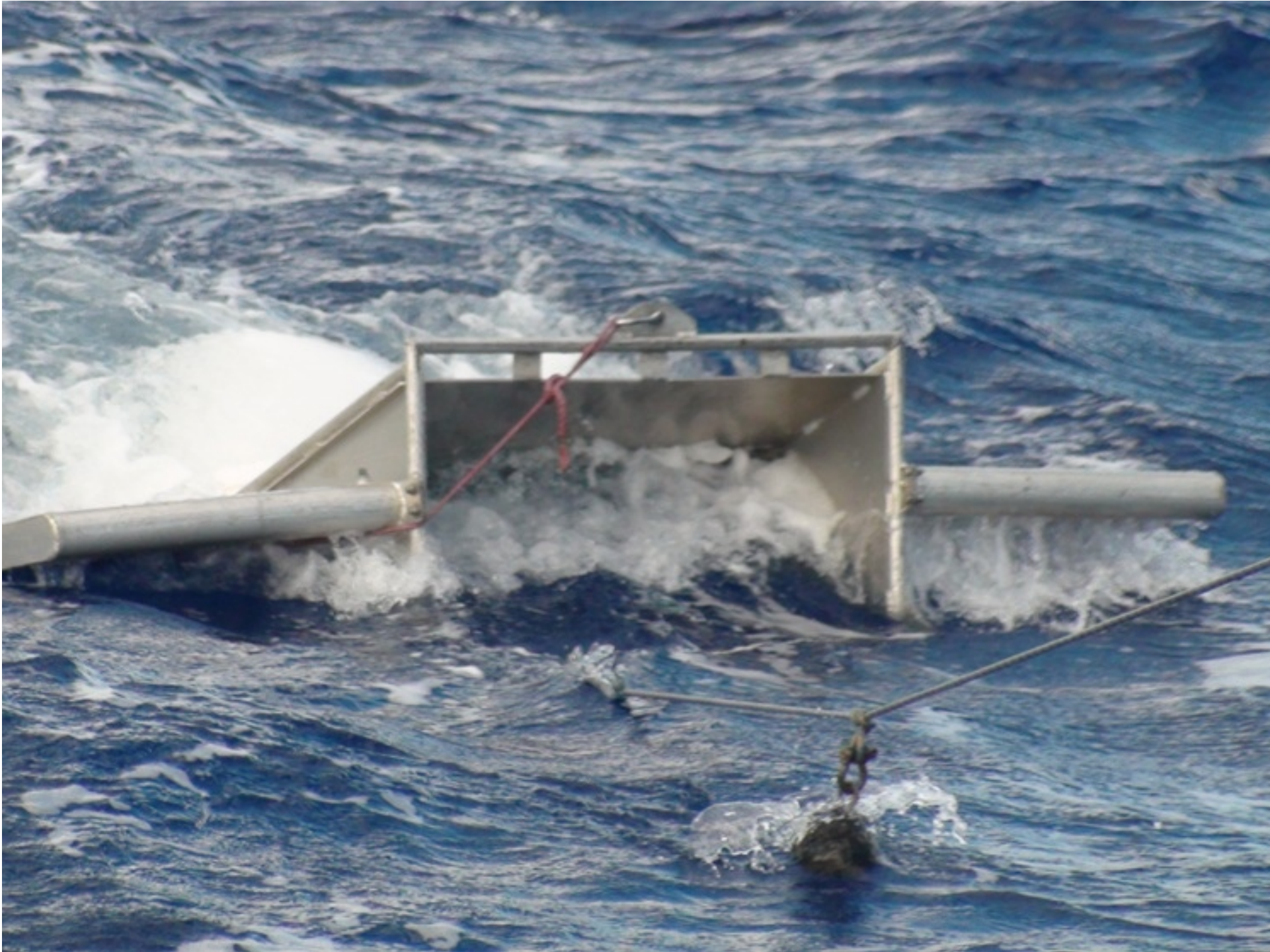
## Plastic Marine Debris Surface Sample Locations North Pacific Gyre 1999 - 2009













What enters the manta trawl is collected in the cod end of the sampling net.









1 mile  
Zooplankton  
Trawl  
Core

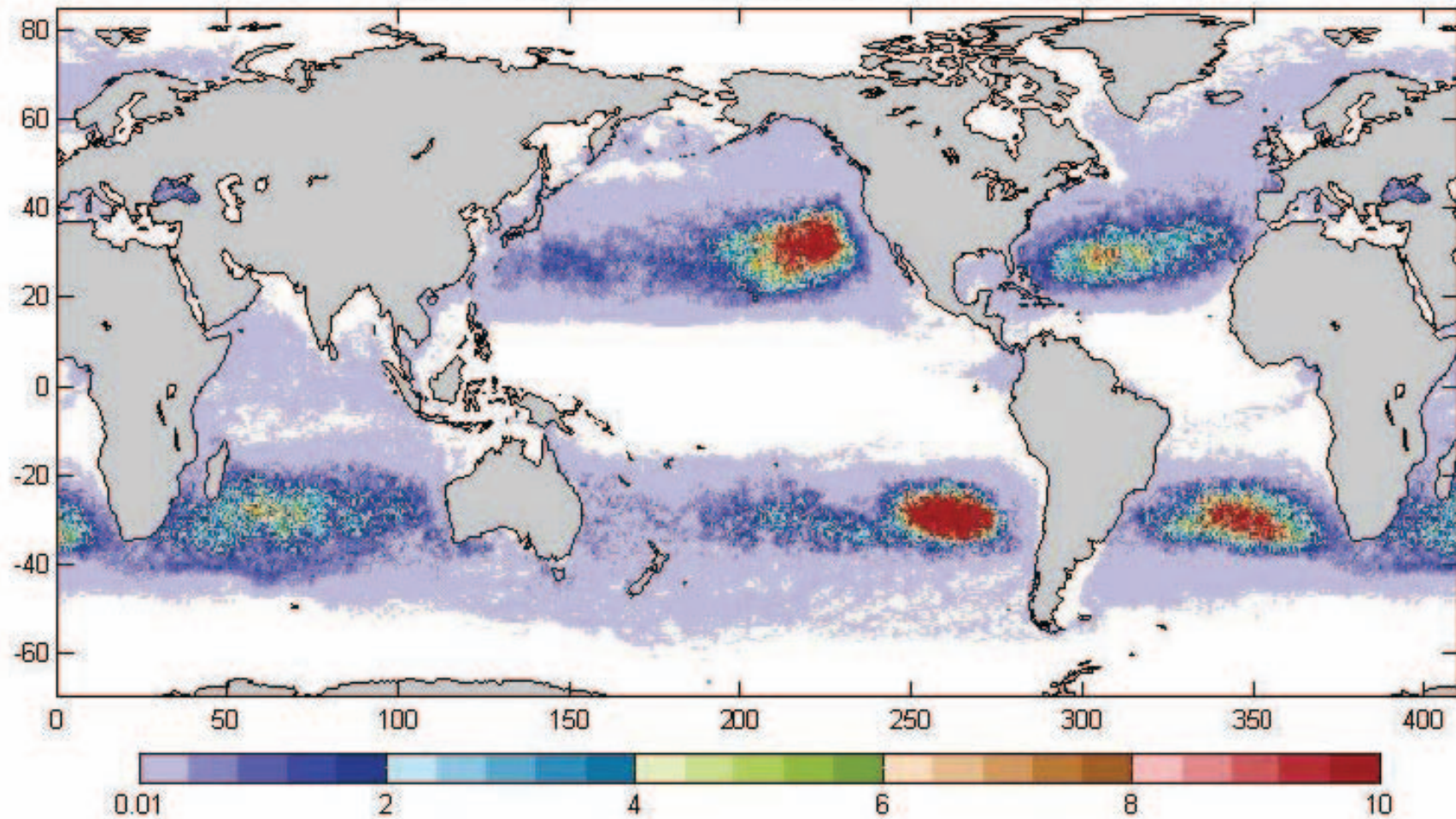




Day # 3650

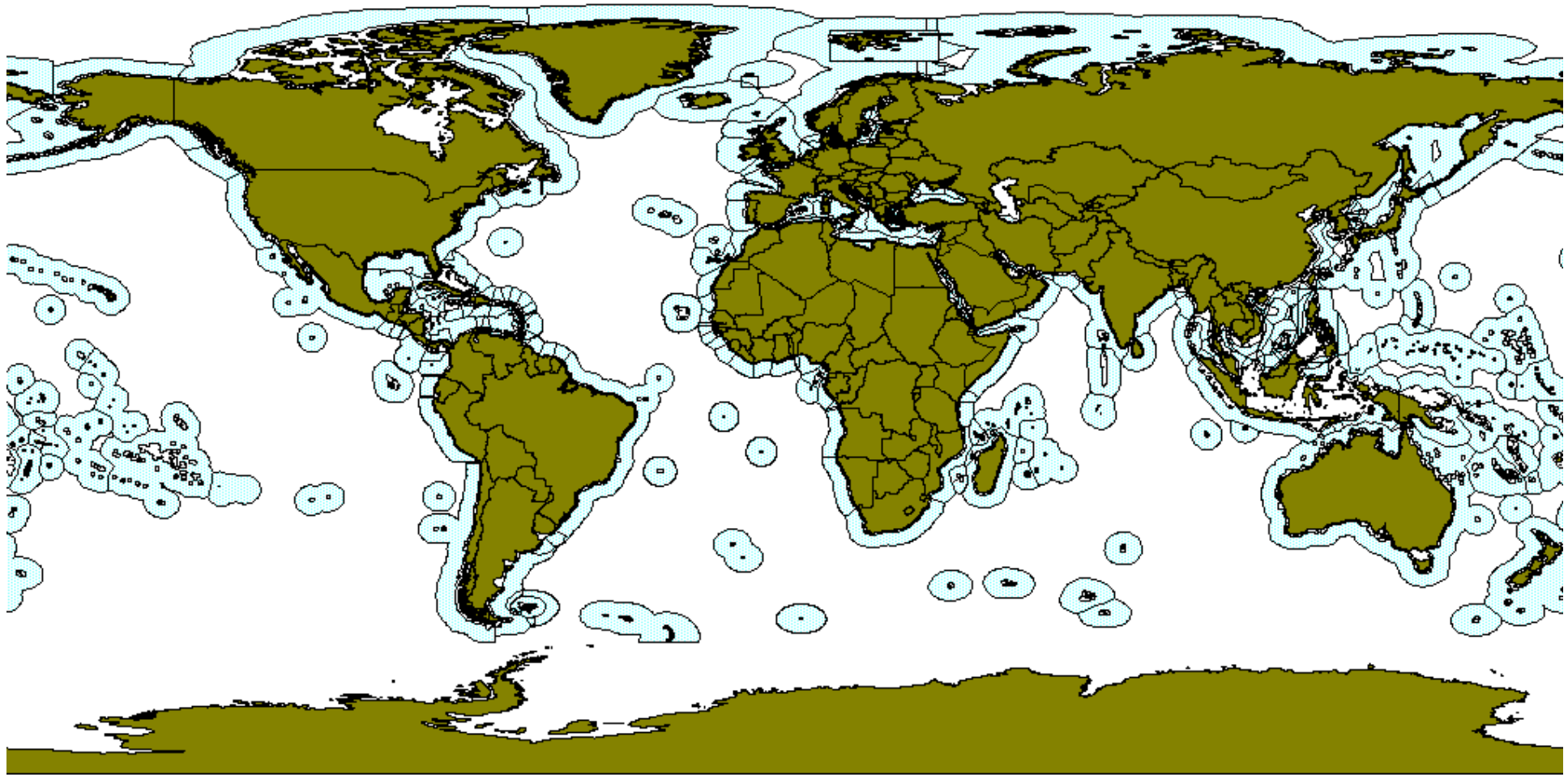
Year # 10

70%





# 200 mi Exclusive Economic Zones of the World





# NORTH PACIFIC GYRE-July 2011





# SOUTH PACIFIC GYRE April 2011





# Indian Ocean Gyre April 2010





# North Atlantic Near Azores



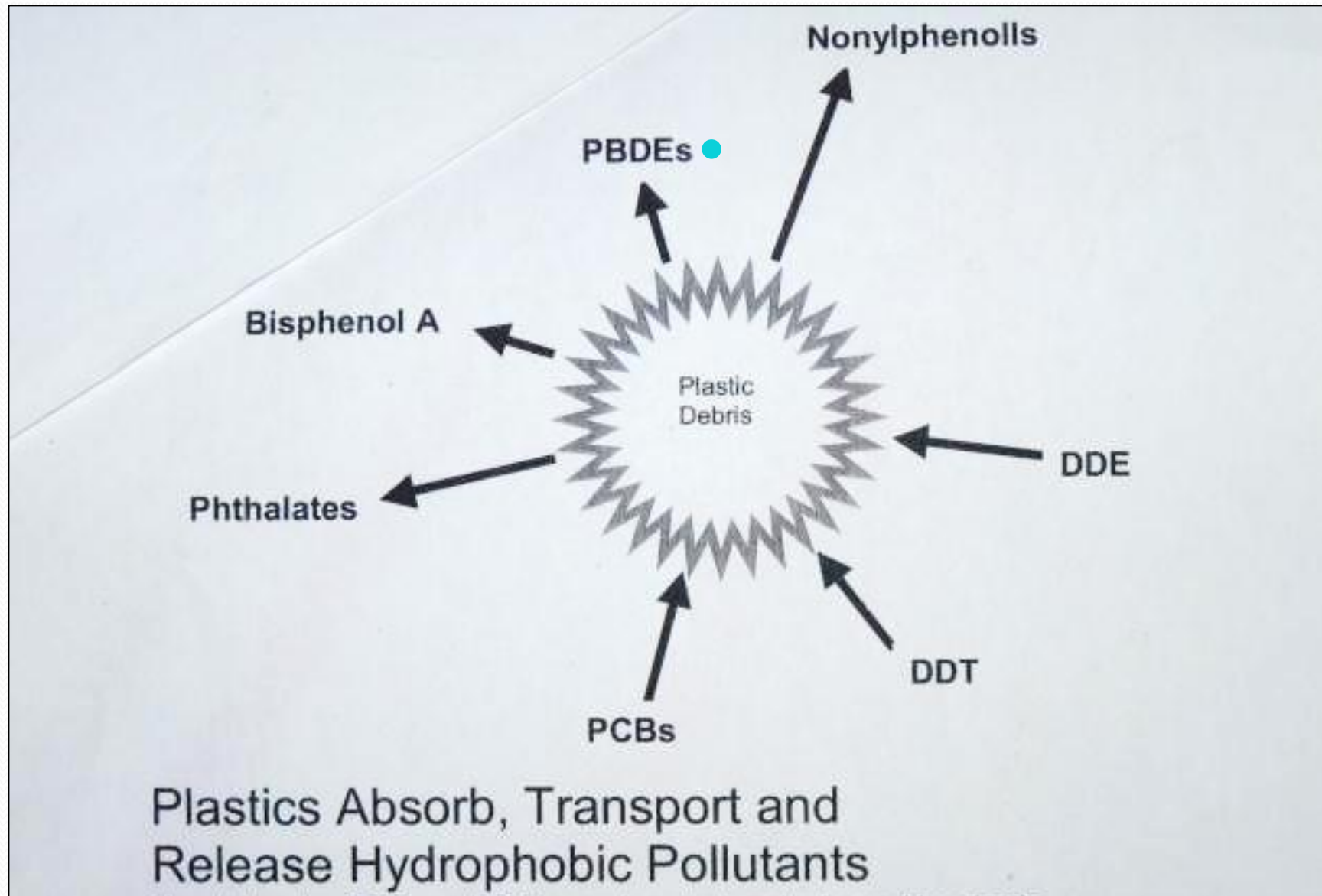


SOUTH ATLANTIC GYRE, AUGUST 2010



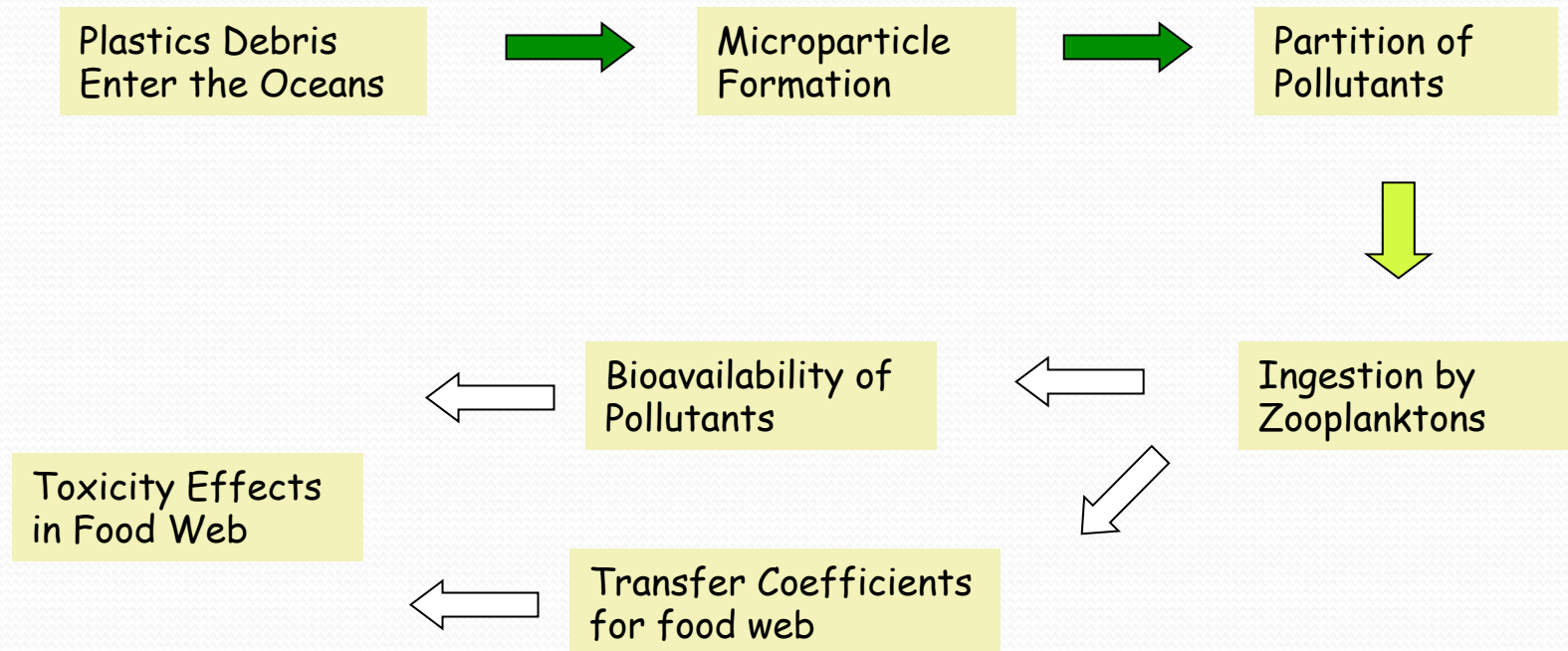


# WHAT HAPPENS TO THE PLASTICS IN THE OCEANS? – LEACHING & ABSORPTION





# Cause for Concern



SLIDE BY ANTHONY ANDRADY  
RESEARCH TRIANGLE INSTITUTE



# Plastics Absorb Persistent Organic Pollutants (POPs) in high concentrations



One plastic pellet can have up to 1 million times higher concentration of POPs than an equal volume of seawater. (Takada, 2001)







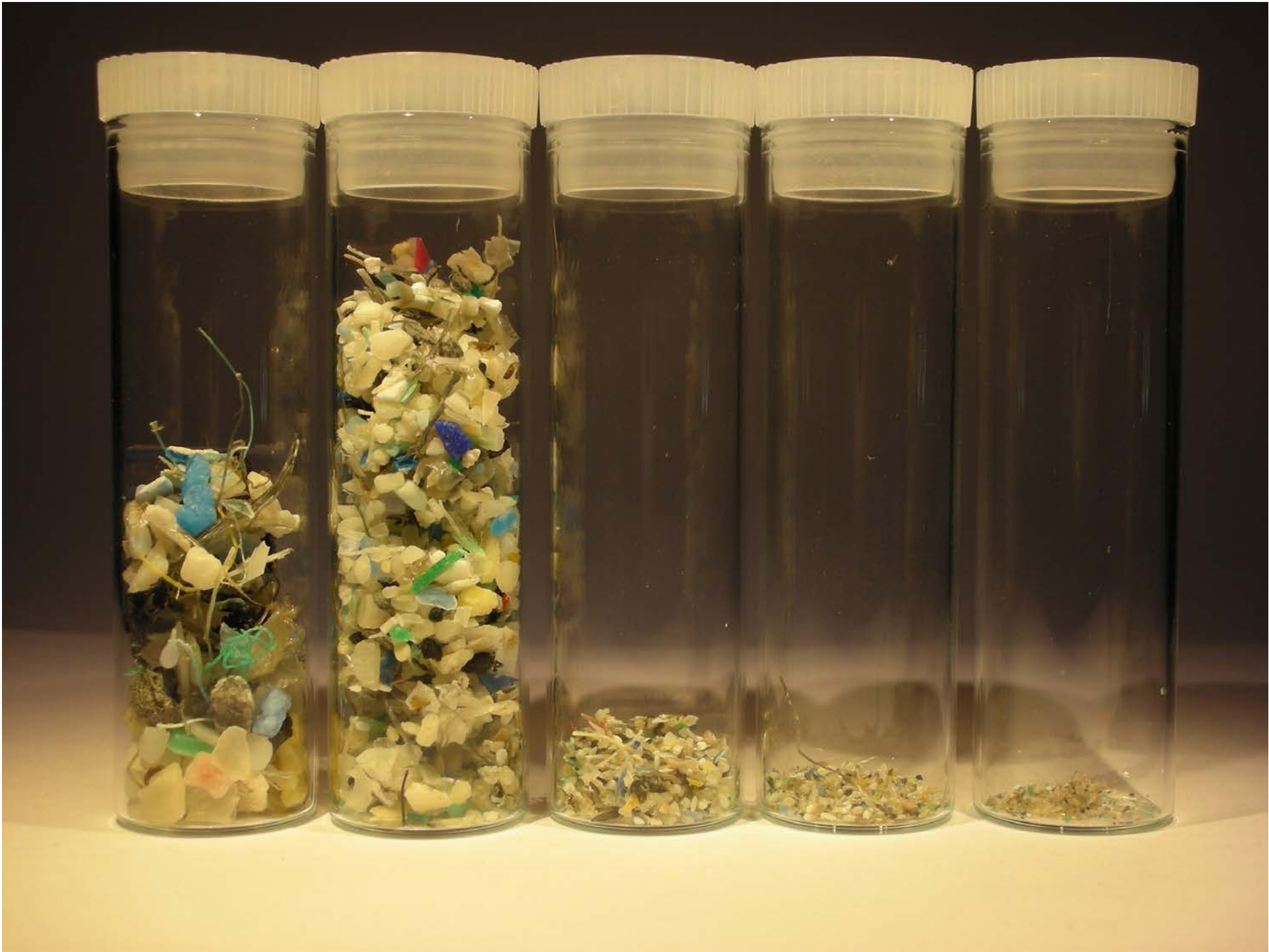
The samples are sorted by hand in the Algalita Marine Research Foundation Lab with a dissecting microscope.



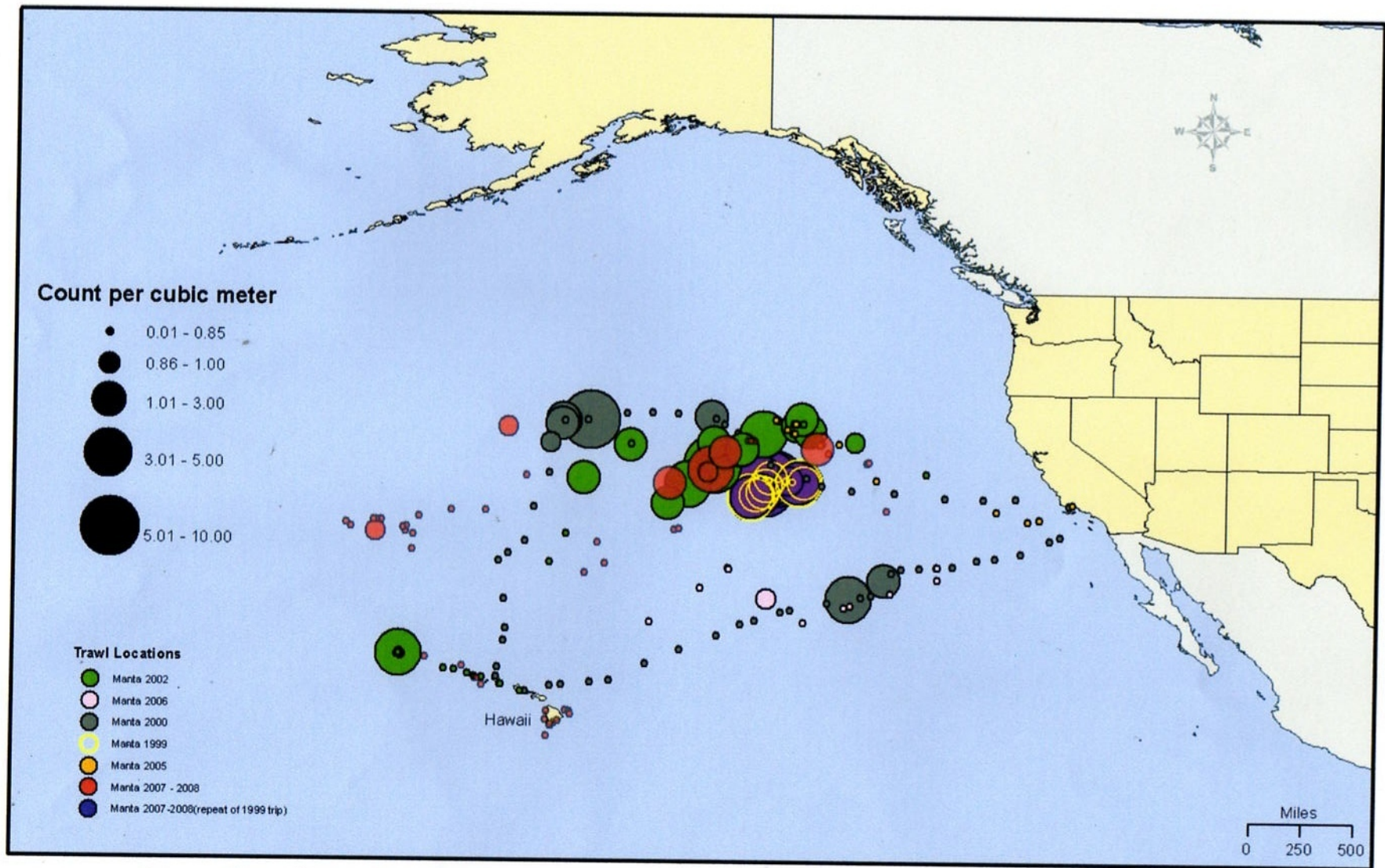












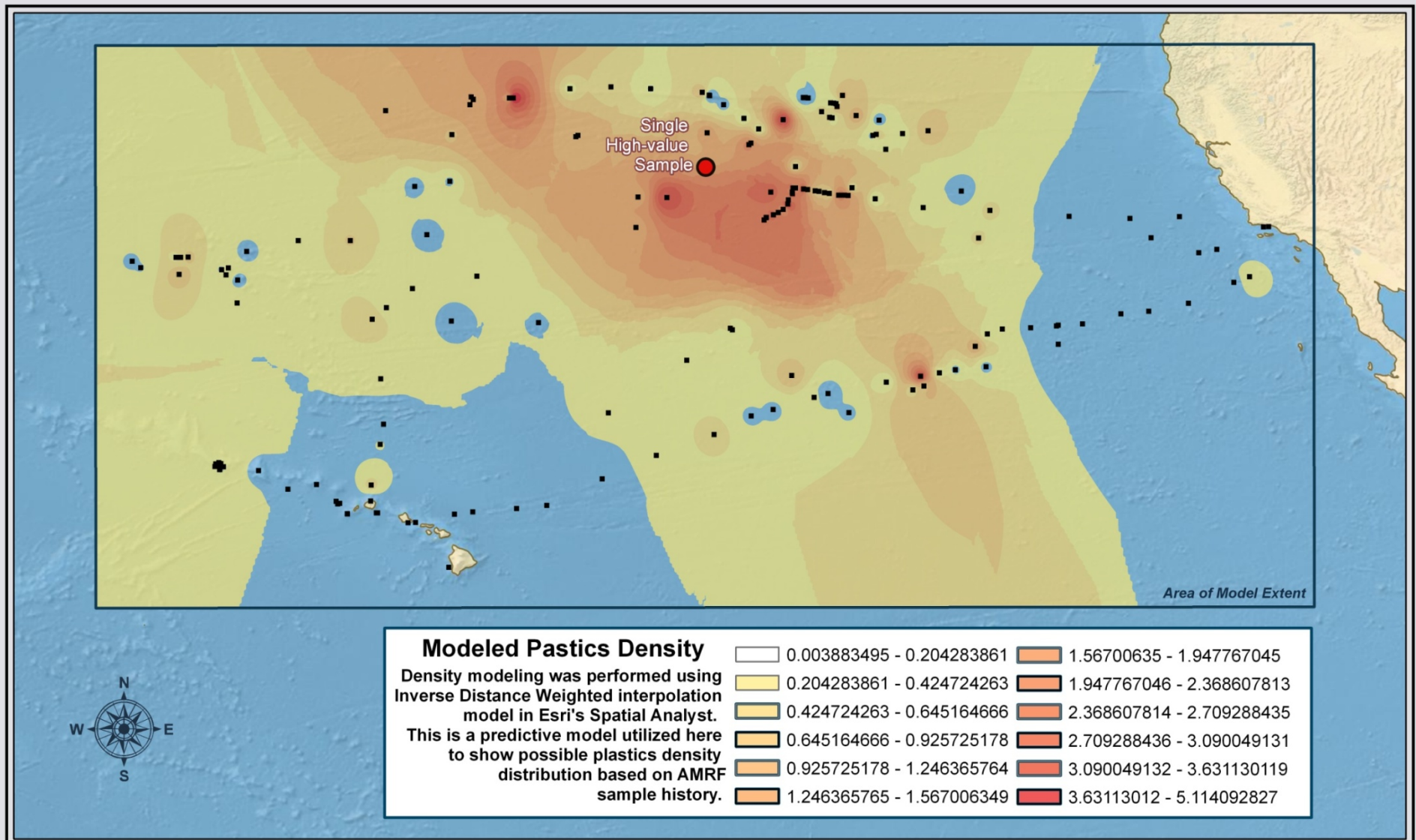
## North Central Pacific Gyre Plastic Pollution Study Manta(surface) Trawls 1999 - 2008

Data Sources: AMRF, ESRI  
Map prepared by Ann Zellers and Matthew Knell  
2/3/09  
Projection: WGS1984





# PLASTICS DENSITY PROJECTION













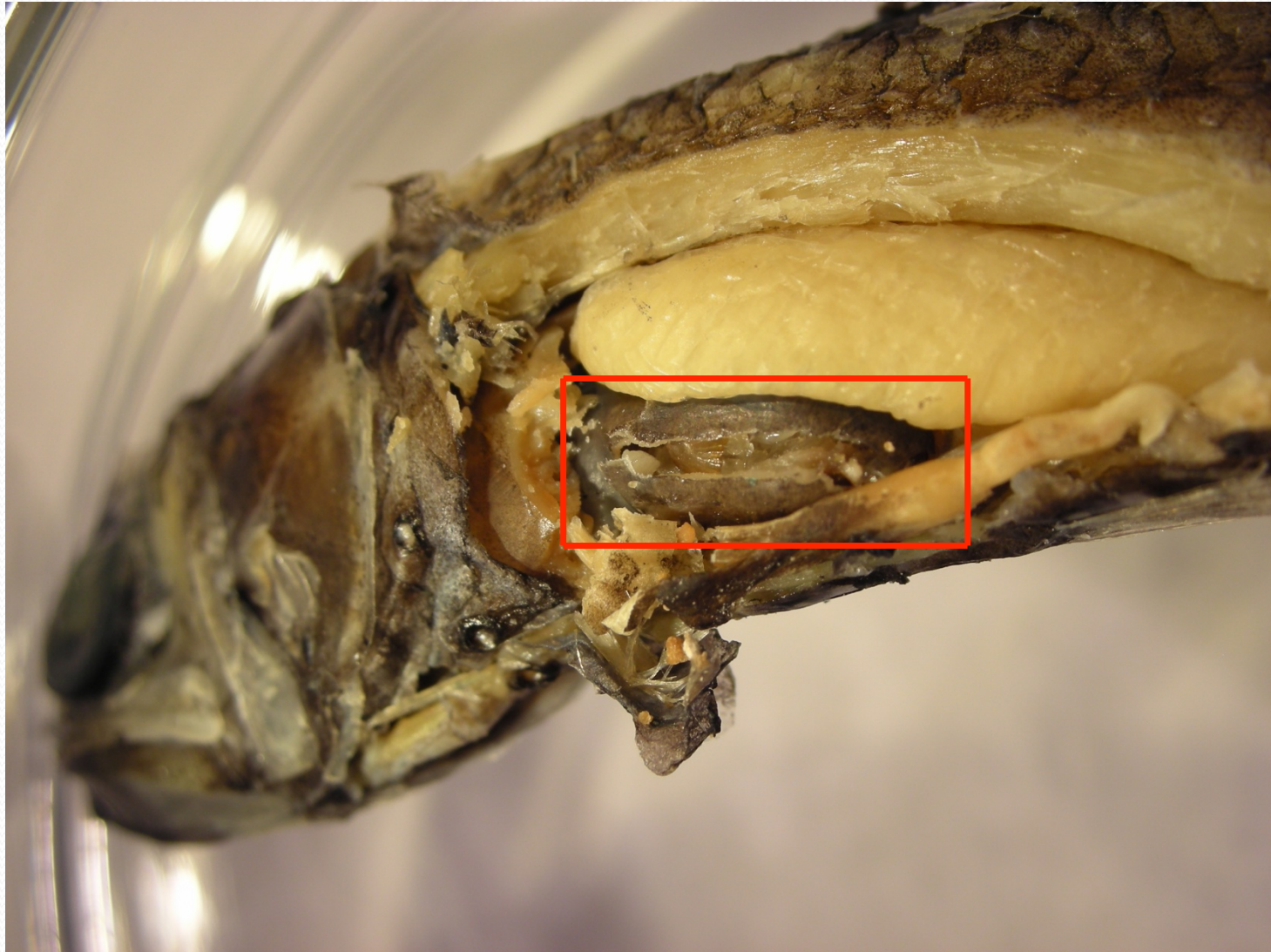








# Stomach Removal





# Consumption of Plastic



PLASTIC

PLANKTON









7



# Results

Total Fish = 671 (46% immature)

**35% had plastic in the stomachs 1391 pcs**

## 6 Species:

	Count	% with Ingested Plastic
<i>Astronesthes indopacifica</i>	6	16
<i>Cololabis saira</i>	51	16
<i>Hygophum reinhardii</i>	43	23
<i>Loweina interrupta</i>	26	8
<i>Myctophum aurolanternatum</i>	460	37
<i>Symbolophorus californiensis</i>	74	56



# Endocrine Disrupting BPA in Seafood

**Bisphenol-A  
found in  
coastal  
waters and  
all seafood  
sampled  
from  
Singapore  
markets**



(Basheer et al., 2004)







# Black Footed Albatross

Bill Cooper photo





# 4 Month old Laysan Albatross Stomach Contents from Kure Atoll





# INGESTION









# 100% of Carcasses have evidence of Plastic ingestion















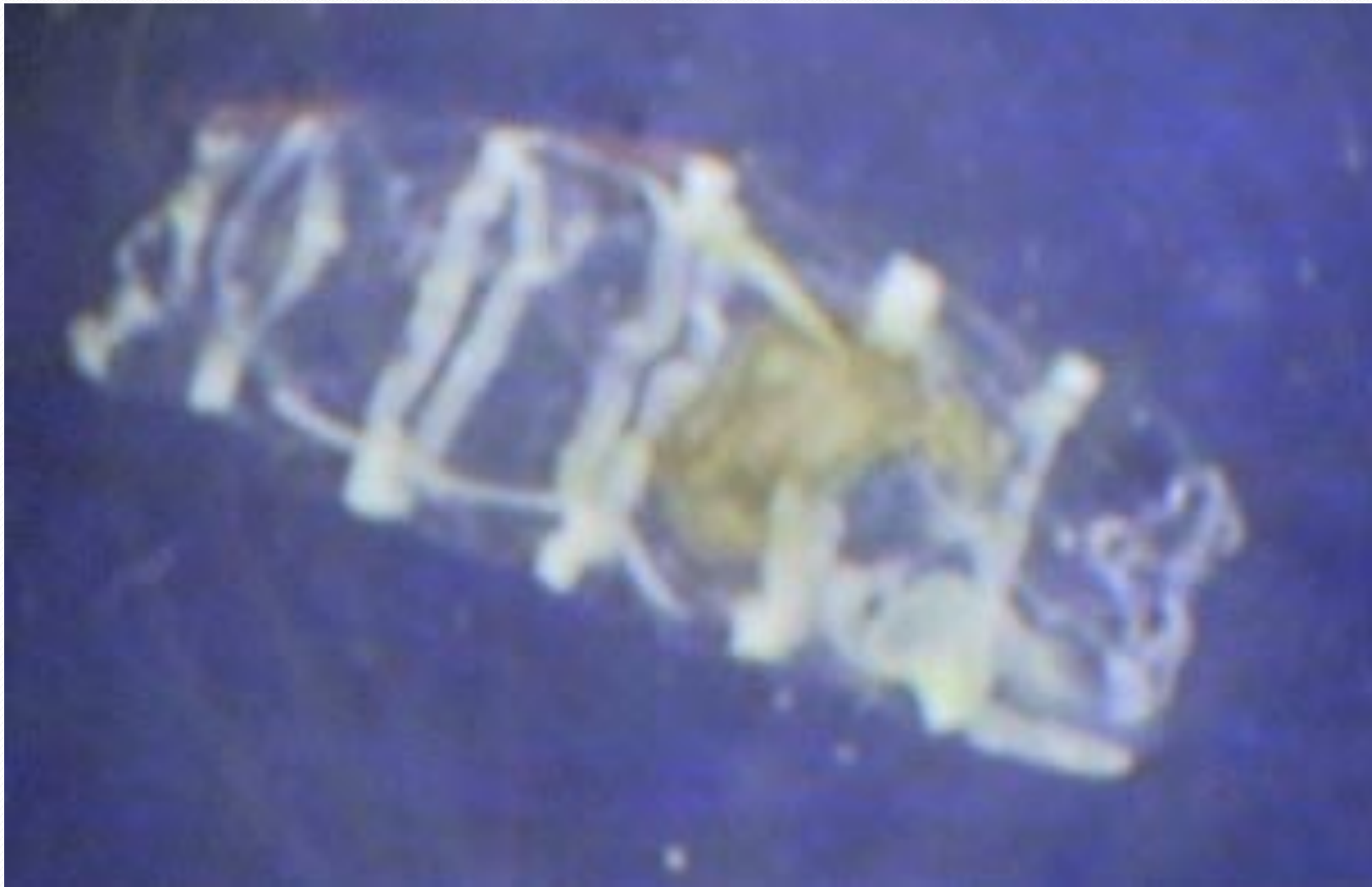


# Three Salps--Two appear to have ingested Styrofoam

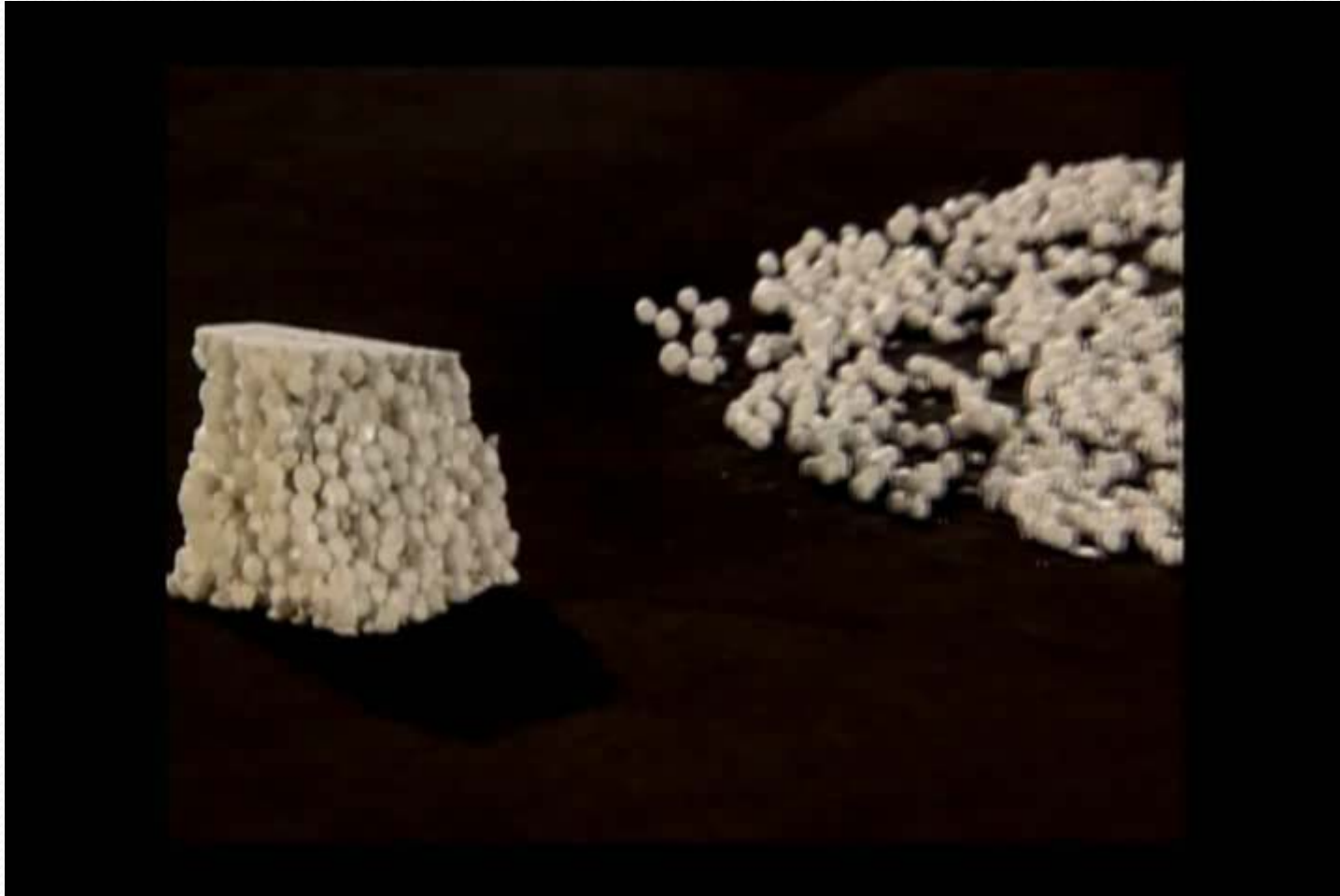




Ingested plastic particle appears to be near maximum possible size













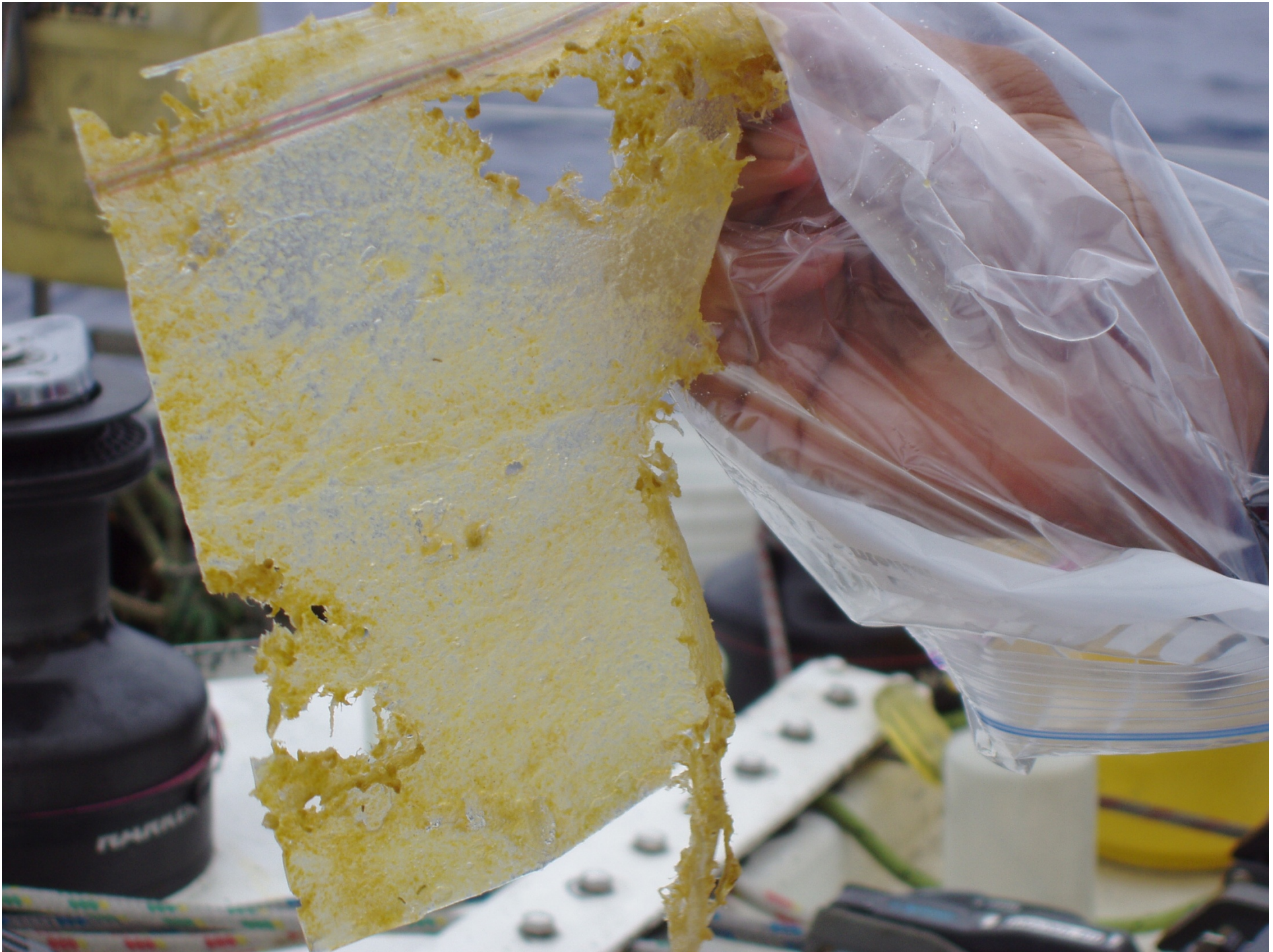
Hatchling turtle, with two pieces of plastic measuring approximately 3mm in diameter. The darker piece of plastic was lodged in the pylorus (the bottom of the stomach) like a plug, preventing the turtle from digesting food. Credit: Australian Seabird Rescue, Australia

















# Swordfish Impaled Bottle Top





# Whale Entanglement Common

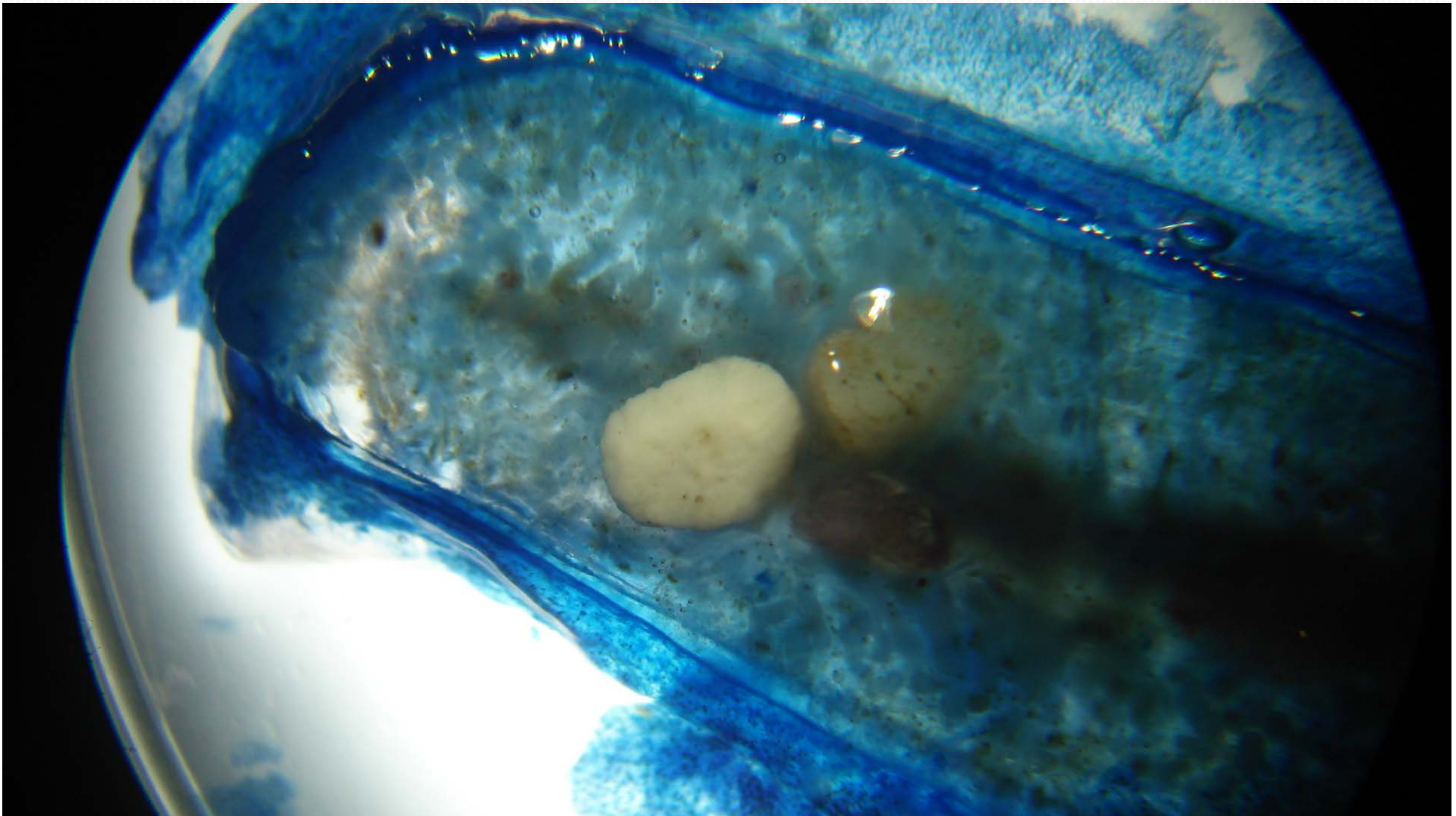






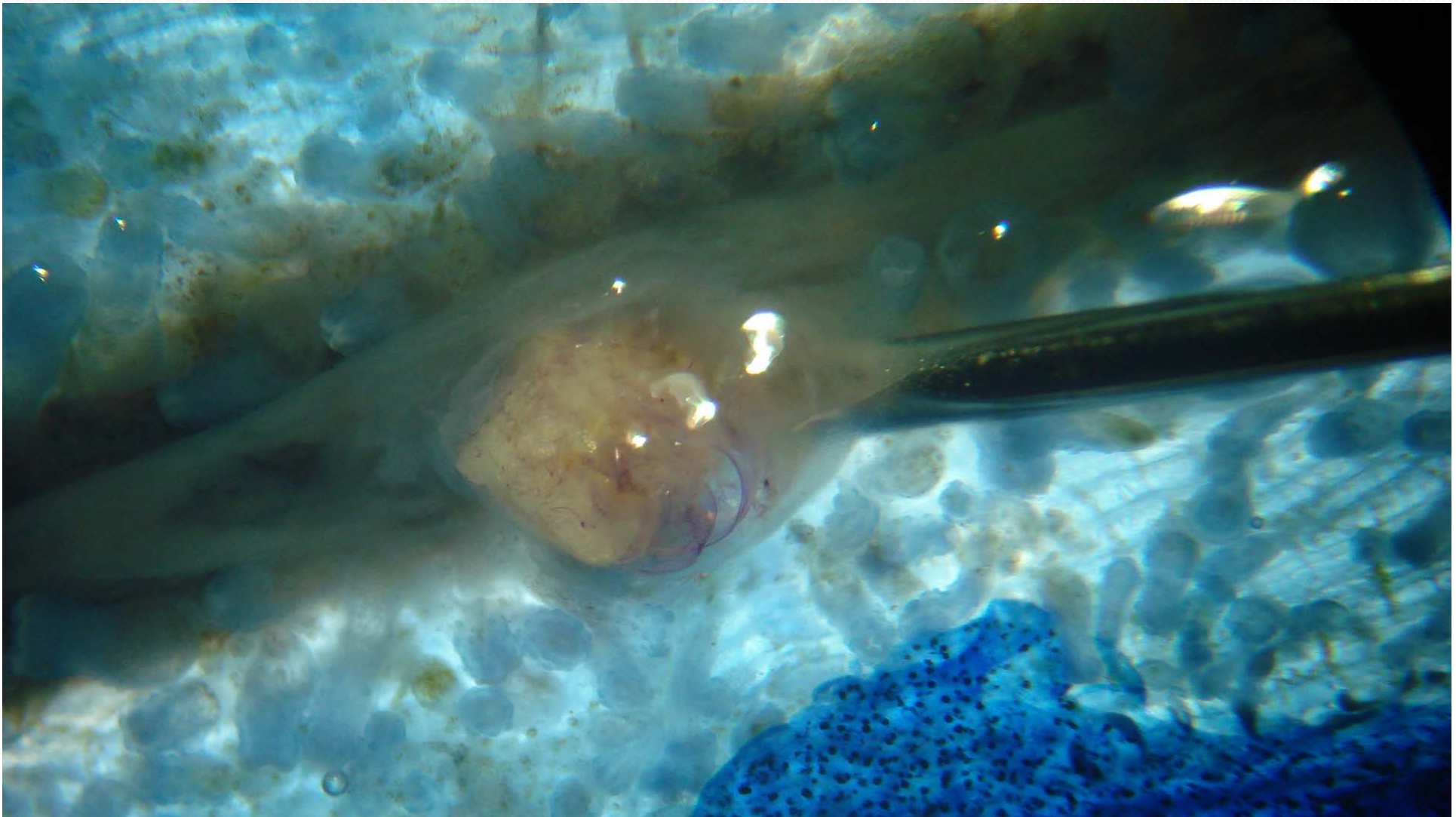


Valella Valella with several plastic particles / Angel White of C-MORE/OSU





Valella Valella with Plastic Particle embedded / Angel White of C-MORE/OSU

































# Korean Beach

















# Hawaiian Sergeant Mamo





SCRAWLED OR SCRIBBLED FILE FISH FOUND ON TROPICAL REEFS TO 120 Meters





# FROGFISH IN THE DEEP OCEAN?





Frogfish can change colors  
They are “lie and wait” predators

















# EXPANDED POLYSTYRENE BIT COLONIZED BY GOOSENECK BARNACLES







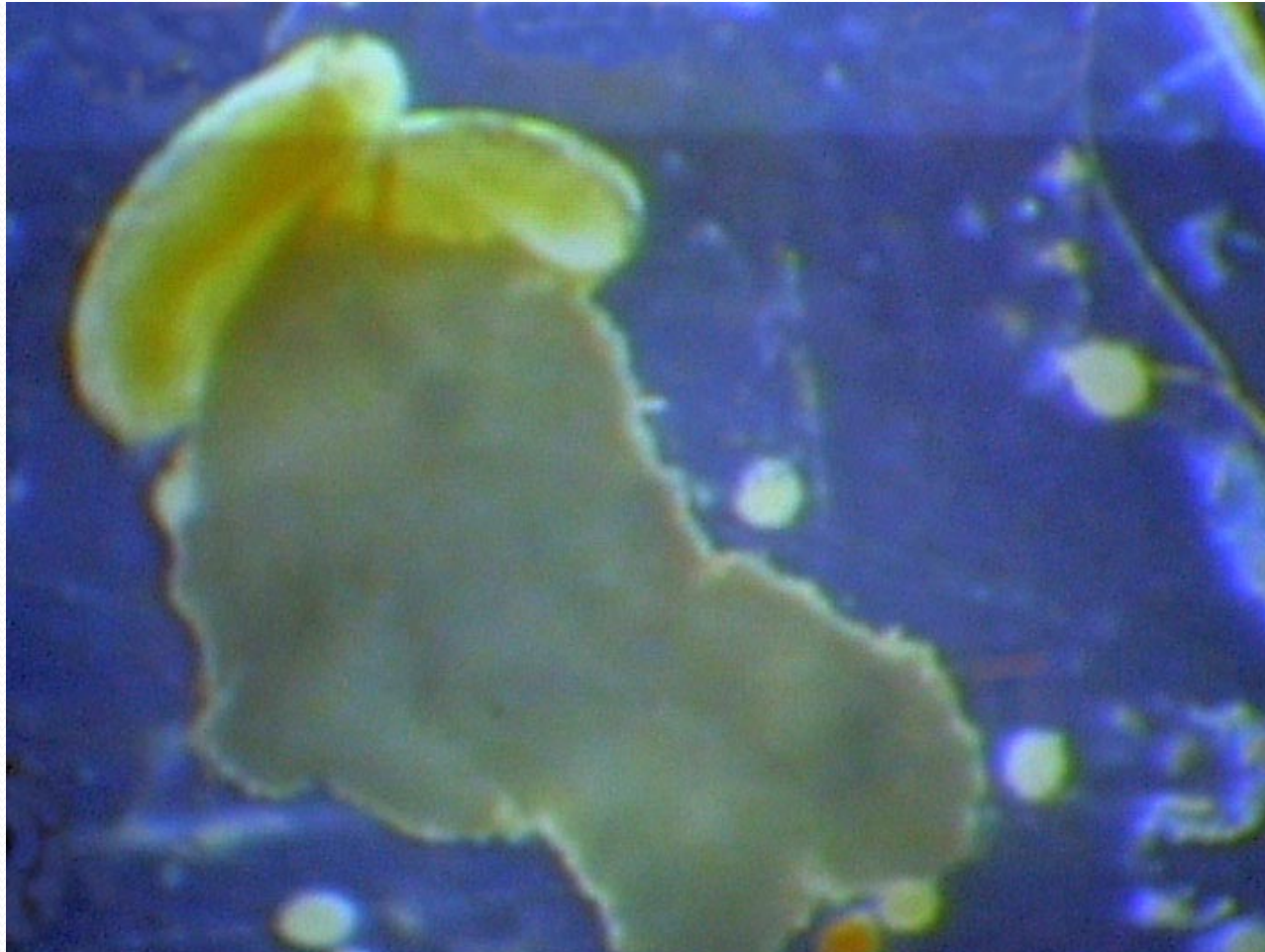
Styrofoam Packing Peanut







# Colonized Plastic Particle attracts and transports food



Plastic Facilitates Biotic Mixing Through Slow Transportation of Organisms.  
Estimated 47% Marine Species Lost if Total Biotic Mixing Occurs



# In the Mediterranean Trash Cannot Escape





# Deep sea litter



Depth 992m, 20 km offshore, Mediterranean coast, 3255 feet



# Buoyancy in Sea Water

- Polyethylene 0.79-0.97
- Polypropylene 0.90-0.92
- Polyethylene/Polypropylene ~ 1
  
- Polyamid resin or Nylon 6/10 (Unfilled) 1.09
- Polyamid resin or Nylon 6/6 (Unfilled) 1.13 - 1.15
- Polyamid resin or Nylon 6/12 1.06-1.08
  
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- Polystyrene (Foam) < 1
- PVC Flexible (Filled) 1.30 - 1.70
  
- Cellulose acetate 1.35-1.42
- Polyester urethane 1.1-1.25



VIDEO COURTESY FRANCOIS GALGANI, *IFREMER* (A FRENCH NOAA)











## **Stomach Contents:**

- **Pair of Sweat Pants**
- **Golf Ball**
- **20 Plastic Bags**
- **Small Towels**
- **Duct Tape**
- **Surgical Gloves**

**Deceased Gray Whale on West Seattle Beach (2010)**



MANILA HARBOR, PHILLIPINES

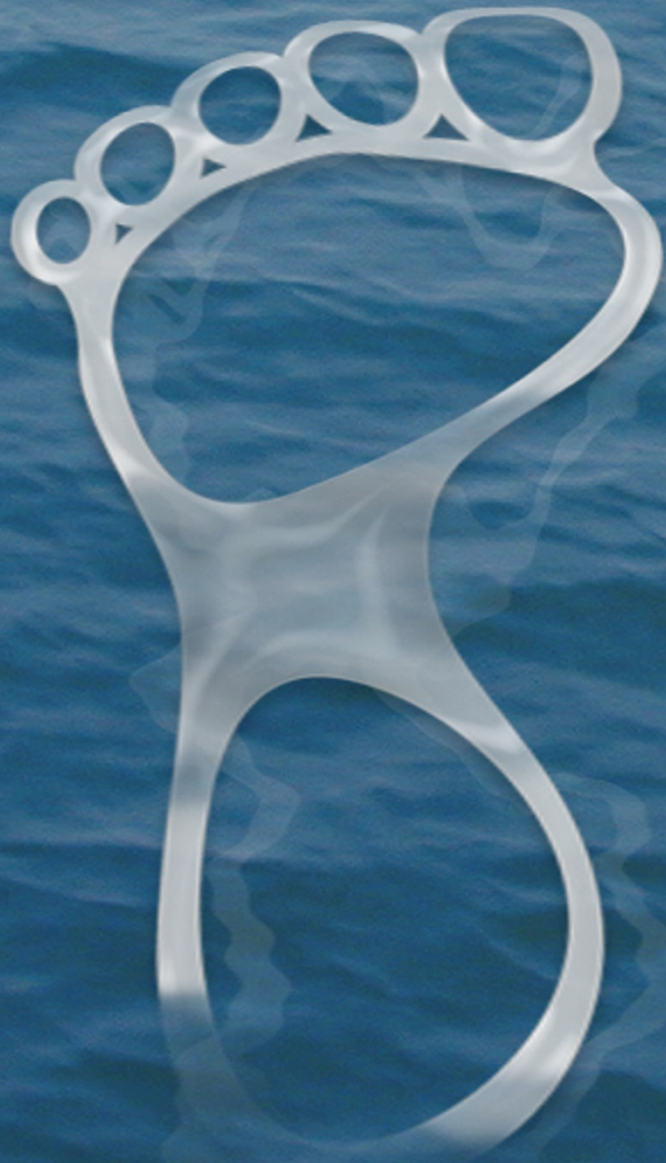




# Our Legacy?







*How **BIG**  
is your  
plastic  
footprint?*

*Algalita Marine Research Foundation  
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