# PLASTIC MICRO-DEBRIS

*Scripps Environmental Accumulation of Plastic Expedition* (SEAPLEX)

TEACHER PAGES

Plastic debris is accumulating thousands of miles off the California coast at the center of the Central North Pacific Gyre. SEAPLEX researchers are focusing their studies on answering some critical questions.

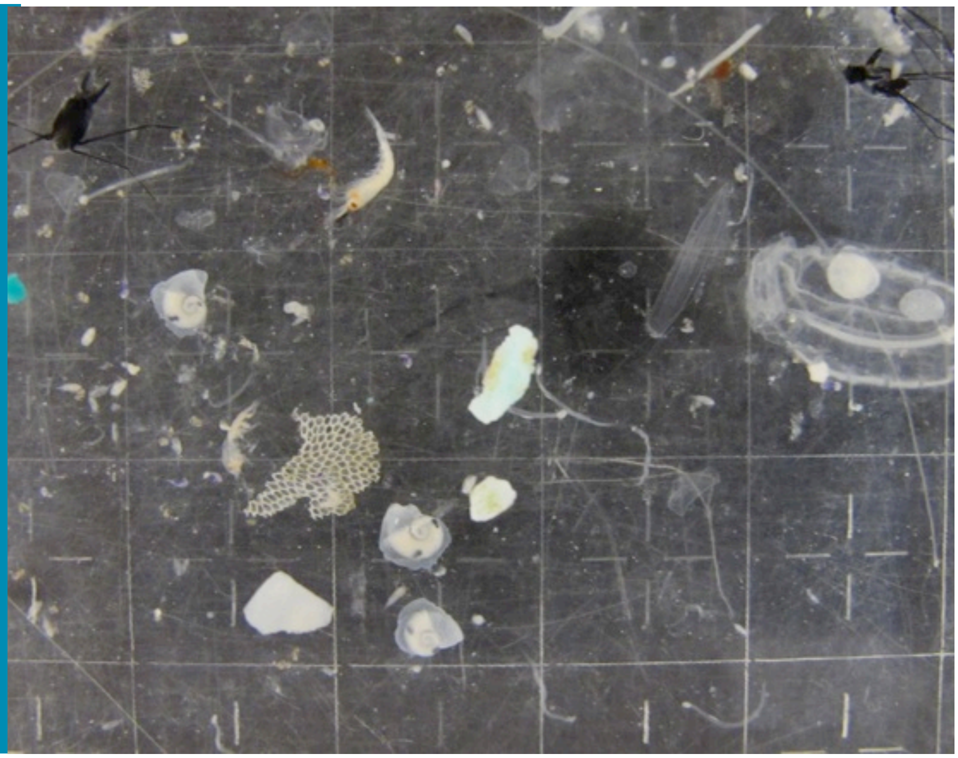

**Figure 1:** Digital image of zooplankton and plastic micro-debris(Courtesy Linsey Sala, UCSD/SIO, 2010.)

## Investigating Plastic Micro-Debris in the Central North Pacific Gyre

By Beth Simmons (CCE LTER Education & Outreach) and William Miller (Patrick Henry High School)

Plastic debris in the Central North Pacific Gyre is a concern at many levels. The introduction and distribution of plastic debris, from both terrestrial and oceanic sources, has recently become of interest to many studies and research expeditions.

Gregory and Ryan (1997) reported that plastics comprise 60-80% of marine debris. It is typically composed of fragments of manufactured plastic products and pre-production plastic pellets that comprise other objects. (McDermid & McMullen 2004).

Most plastics do not biodegrade. Unless they are removed, they remain in the sea for tens to hundreds of years, breaking up into ever-smaller particles (Leahy 2004). The possibility of plastic accumulating in the ocean from countless sources raises many questions; notably because of the lack of effective methods to remove it.

Information about the abundance and occurrence of plastic micro-debris particles, as well as quantitative information on how plastic particles change over time is limited (Gilfillan et. al., 2009). Those scientists that have begun to investigate removal methods have divided marine debris plastic into two class sizes. Those pieces greater than 5mm are characterized as macro debris, and those smaller than 5 mm classified as mircro debris (Arthur et al. 2009).

In 2009, the SEAPLEX research expedition set out on a 3,000 mile cruise track to survey plastic distribution in the Central North Pacific Gyre. They utilized numerous methods from visual observations, manta nets, and trawl nets to pumps and bottles. This lesson is designed to introduce students to the environmental issue of plastic micro-debris in the ocean. It emphasizes that plastic does not just disappear when it enters the ocean, but rather is broken down through processes such as mechanical degradation and photodegradation. Mechanical degradation occurs when plastic breaks down into smaller pieces due to the movement of the ocean waves.

Photodegradation is thought to be one of the driving forces behind plastic breakdown, and occurs when ultraviolet waves of light from the sun break apart the bonds that hold plastic together, causing it to be brittle and more vulnerable to mechanical degradation. Both types of degradation creates microscopic pieces, difficult to see with the naked eye, but continually traveling throughout the Central North Pacific Gyre and having possible long lasting effects.

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**Target Audience**: Grades 9 - 12

**Time/Duration:** 2, 1 hour classes

**Subject:** Earth Science/Ecology/Marine Science

**Learning Objective(s) & Desired Results**:
Student will be able to:

- Collect and analyze micro-debris samples from the Central North Pacific Gyre through a classroom simulation.
- Identify and measure the size and shape of plastic micro-debris.
- Understand the challenges associated with categorizing marine debris.
- Experience how plastic mechanically breaks down and discuss the issue of plastic in the marine environment.

**What prior knowledge is necessary for students to complete this lesson?**

- Students will need to be familiar with the physical aspects of the North Pacific Ocean Gyre
- Mechanical and photo-degradation of plastic in the North Pacific Ocean Gyre

**Correlating National Science Standards**: (9-12)
**NS 9 - 12.1 Science as Inquiry Standards**
- Understanding about scientific inquiry

**NS 9 - 12.5 Science and Technology Standards**
- Understanding about science and technology

**NS 9 - 12.6 Science in Personal and Social Perspectives**
- Science and technology in local, national, and global challenges
- Environmental Quality

**Correlating Ocean Literacy Standards**:
6. The ocean and humans are inextricably interconnected.
A.6: Increased human population, and thus increased demand for resources, as well as improved technology, are having environmental, social and ecological implications on the ocean.

**Essential Questions (E.Q.):**
- Do scientists know what type of plastic exists in the ocean and how long it has been there?
- How does plastic break down in the ocean over a period of time?
- What does plastic look like after it has been in the marine environment for many years?
- How do scientists sample for plastic in the Central North Pacific Gyre?

Figure 2: Research Vessel and Zodiac
New Horizon as it explored the North Pacific Ocean Gyre on August 11th, 2009. A zodiac boat was deployed and encountered a ghost net - a floating mass of lost or discarded fishing gear (Matt Durham and Miriam Goldstein).

**MATERIALS:**

- ✓ Water tubs (one per group of 4 or 5) Rubbermaid: Underbed Clear Box #2221, 26.5 L, 23.0 x 16.75 x 6.0 inches
- ✓ String
- ✓ Duct tape
- ✓ Makers permanent/waterproof
- ✓ Instant Ocean
- ✓ 20 Liters of 3.5% seawater per water tub
- ✓ Blender
- ✓ 2 Dissecting scopes or Magnifying glass
- ✓ 1-600 ml beaker per group
- ✓ 50 ml collection beakers (one for each quadrant in each water tub, 20 are needed for the water tub shown in Fig. 2)
- ✓ 16/18 oz Dixie cups 1 cup shared between 3 groups or soft nylon 3" aquarium net.
- ✓ 3- 6 oz Styrofoam cups
- ✓ Popsicle stick or coffee stir stick
- ✓ Digital Images of Plastic Debris & Organisms from August 09 Manta Tow
- ✓ Parafilm/Aluminum Foil/Saran Wrap
- ✓ Ruler
- ✓ SEAPLEX video (see the extension section on page eleven to expand the lesson)

**TEACHER LAB PREPARATION:** *(optional)*

To expedite this lab inquiry for your students consider having the following items prepared ahead of time. **Depending on class budgets, decide ahead of time if one transect will be used by the entire class or if each small lab group of 4 or 5 students will have a their own transect.*

A. **3.5 % Sea Water**: Prepare 20L of 3.5% sea water by adding 35 grams of salt per one liter of water to make 3.5% solution.

B. **Transect Grid:** (Figure 3.) Construct the sampling grid using a clear rubbermaid underbed storage box with dimensions 23.0 inches - 16.75 inches. Align string to make a grid pattern consisting of roughly twenty (20) equal quadrants total. Use tape to label each quadrant with letters along the vertical edge and numbers across the top.

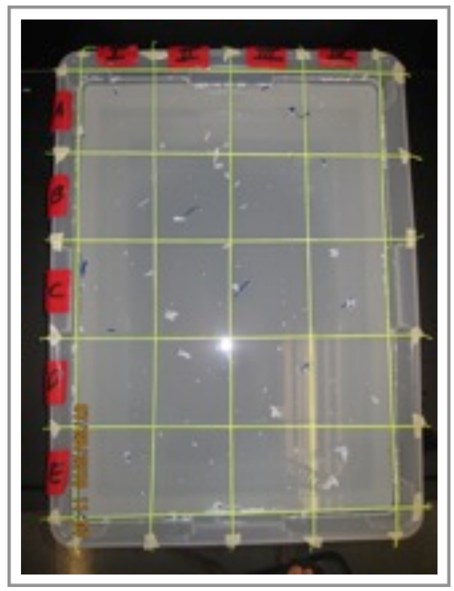

Figure 3. Water tub with transect grid and plastic/styrofoam micro-debris slurry added. Rubbermaid: Under-bed Clear Storage Box (Photo credit: William Miller, 2010).

C. **Labeling Beakers:** Based on a classroom of 4 or 5 groups of students you will need to have twenty 50 ml beakers to correspond with the coordinates of the sampling quadrants. Use tape and a permanent marker to label each of the quadrants as A-1, A-2, A-3, etc.

D. **Sampling Device:** The sampling device is a 3 oz paper Dixie cold cup with a coffee stir stick attached with duct tape. Students may also experiment with a 3" fish nylon aquarium net.

E. **Plastic/Styrofoam Micro-Debris Slurry:** Cut out *two*, 1 x 1 inch squares from a Styrofoam cup and a Dixie plastic cup. Add these plastic pieces to a blender with 500ml of your 3.5% salt water. Cover and blend on "chop" setting for 45 seconds. Pour slurry into a 600ml beaker. Label beaker with class information. Cover with parafilm (or aluminum foil) and let "rest" for one (1) minute.


Figure 4. Collection beaker and sampling device (Photo credit: William Miller, 2010).

**TEACHER PROCEDURE** Day 1

1. Place 4 - 5 students into each group, depending on class size.
2. Have students begin the lesson by reflecting on the following questions and recording their answers on their worksheets or in lab notebooks. Student responses will be shared with the class as the instructor generates a master list.

    1. Do scientists know what type of plastic exists in the ocean and how long it has been there?

    2. Hypothesize how plastic breaks down in the ocean over a period of time.

    3. Consider three different <u>plastic products</u> you might find floating in the ocean. List them on the table. Over the course of floating for 1, 5, and 10 years in the ocean, will plastic bits change over time? You may sketch or describe the changes but you must include a scale of change over time (ex. 1 inch equals 1 cm over X time.)

    4. How do you think scientists sample for plastic in the Central North Pacific Gyre?

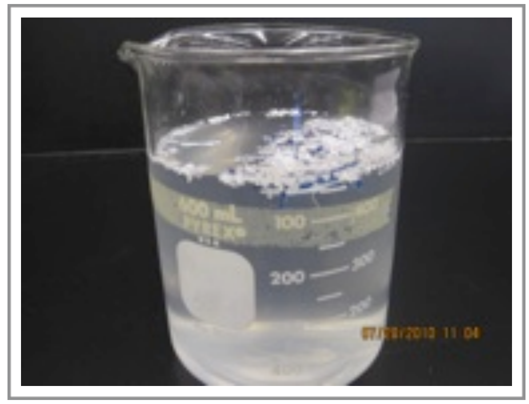

Figure 5: A 500ml Plastic/Styrofoam Micro-Debris Slurry after blending poured in a 600ml beaker (Photo credit: William Miller, 2010).

3. Next, create a "Plastic Micro-Debris Slurry"

*(Teachers Note: In an effort to have the plastic pieces break down well enough for this exercise, students may want to use our suggestions of styrofoam and plastic Dixie cups. It may also be fun to have students experiment with different types of plastic debris to make their own slurry).*

1. Cut out *two*, 1 x 1 inch squares from a Styrofoam cup and a Dixie plastic cup. Add these plastic pieces to a blender with 500ml of your 3.5% salt water. Cover and blend on "chop" setting for 45 seconds. Pour slurry into a 600ml beaker. Label beaker with class. Cover with parafilm a flexible film (or aluminum foil) and let "rest" for one (1) minute.

2. After the slurry has rested students will sketch where the debris can be found in their beaker water column. Including marking their water line and volume demarcations.

3. Students will describe in their own words how plastic in the ocean water column may/may not be similar to their beaker water column recognizing that geography, currents and winds are important factors that concentrate plastic in the Central North Pacific Gyre that are not present in their beakers.

*(Depending on class time and preparation, this may be a good place to stop)*

**TEACHER PROCEDURE** Day 2

4. SAMPLING PROCEDURES

    a. Fill your water tub with 19.5 liters of 3.5% salt water.

    b. Collect your plastic slurry from the previous day and stir it gently for 5 -7 seconds. Immediately pour the slurry into the water tub that already has the 19.5 liters of 3.5% salt water and stir this mixture for 10 seconds. Let this mixture settle while you perform the next step.

    c. After the transect sampling grid and 50ml beakers are ready, sampling can begin. The sampling device may be a 3 oz. paper Dixie cold cup with a coffee stir stick attached with duct tape (Figure 3) or you may have students design their own. Students will need to employ a consistent, slow method to lower the sampling device into each quadrant to ensure that the sampling procedure is the same for each sample taken. The Dixie cold cup should be completely filled each time a sample is taken and then carefully poured into a beaker with the same label as the quadrant from which the sample was taken. (Teachers note: You may want the students to experiment with this section by devising their own sampling tools or, have students compare collection methods between the Dixie cup and a 3" aquarium net, noting the effects of each device. The volume of water within the tub may decrease by 1L or 5% overall after all the samples have been collected. Try to determine ahead of time, based on age level of your students if you will have them sample an entire tub or if quadrants within one tub will be assigned among the class.

**TEACHER PROCEDURE Continued** Day 2:

5. DATA COLLECTION :

a. After the collected sample is poured into the correctly labeled 50ml collection beaker rinse the sampling device before the next sample is taken.**Teachers Note: Preparing two sampling devices might be a good way to speed up the sampling process**

b Students should begin to collect data from their assigned quadrant and complete their data charts. Using a magnifying glass, a dissecting scope and a ruler, collect the following information:

i.) number of plastic pieces
Ii.) number of styrofoam pieces
Iii.) approximate size of each (measured with a ruler)

6. MICRO-DEBRIS ANALYSIS

Once students finish measuring and counting their plastic samples from the assigned quadrant, have them analyze the kinds of plastic and tabulate their totals by creating a chart like the one provided.

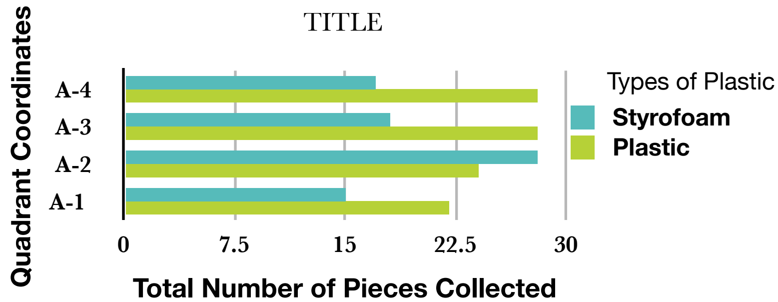


Figure 6. Example analysis graph

7. FINDINGS/DISCUSSION:

Have students watch the SEAPLEX video. http://sio.ucsd.edu/Expeditions/Seaplex/Newsroom/ Then instruct students to write a conclusion summarizing their experience with this inquiry investigation.

They can introduce the topic of plastic micro-debris, identify how they collected, measured and categorized it in their 'water column', and discuss any limitations they may have encountered regarding plastic breaking down in their beaker. They should include explanations for the abundance of plastics in the ocean near them, and anticipate the potential impact of plastic micro-debris to the health of the marine ecosystem.

TEACHER
**DISCUSSION**

Plastic micro-debris is becoming a global issue and has been present in the California Current system for at least 25 years (Gilfillan et. al., 2009). The Central North Pacific Gyre serves as a natural system to concentrate the material. The geographic distribution of plastic and the effects on ocean ecosystems are just recently being uncovered. Students in this investigation were given the opportunity to simulate aspects of the sampling and collection processes from the Scripps Environmental Accumulation of Plastic Expedition (SEAPLEX), investigating the mechanical breakdown of plastic in their 'water column' and then participate in discussions about the issues of plastic in the marine environment.

Plastic micro-debris can be found both offshore and near the coast. Some of this debris may be from land-based sources, and some from items lost at sea. Regardless of its origin, plastic in the ocean remains persistent in the marine environment. Since it is not biodegradable, it may undergo both mechanical degradation and photodegradation, weakening and breaking into many pieces over time. Students should have witnessed this after making their plastic debris slurries.

The potential long term hazards for plastic remaining in the ocean continue to be uncovered. The common misperception is that there are giant patches of large noticeable plastics floating around in the Pacific. Actually, most plastic is not easily visible because it is so small (millimeters to centimeters in size). As plastic remains in the water column it acts as a sponge, absorbing other toxic chemicals (like PCB's and DDT) that cannot dissolve in water. These plastic particles could damage the marine ecosystem by causing harm to animals, such as fish and seabirds, that accidentally eat them.

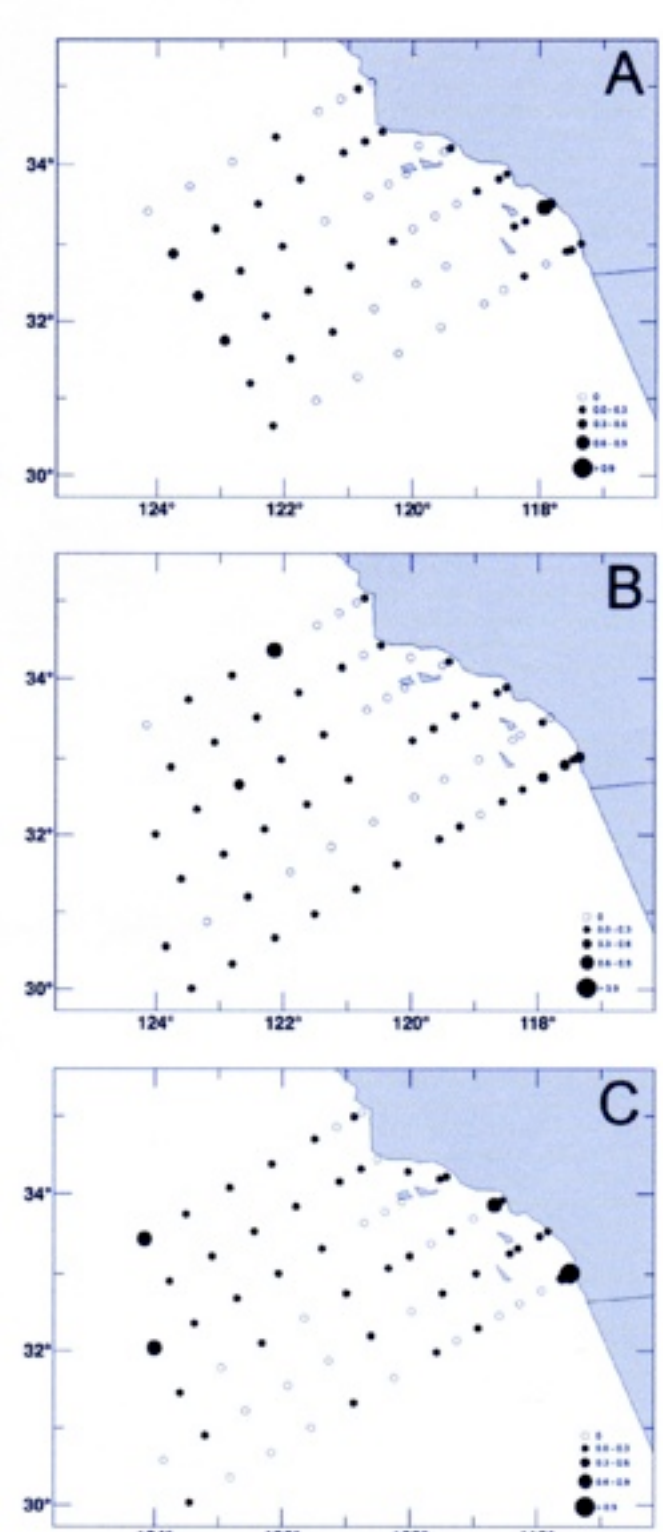


Figure 7: Spatial distribution of plastic micro-debris particles in the CalCOFI Manta net samples from various winter cruises in 1984,1994 and 2007. Open circles indicate no plastic debris detected and filled circles are proportional to particle concentrations (No./m3) (Gilfillan et. al. 2009).

**GLOSSARY**

**CalCOFI** – (California Cooperative Oceanic Fisheries Investigations; www.calcofi.org) A scientific program that studies the marine environment off the coast of California. Formed in 1949 to investigate the collapse of the sardine fishery, CalCOFI is now of the most comprehensive studies of an ocean ecosystem over time.

**Manta Net (Tow)** – A fine meshed net used by scientists to sample plankton and marine debris at the ocean's surface. http://swfsc.noaa.gov/textblock.aspx?Division=FRD&ParentMenuId=213&id=1360

**Mechanical Degradation** - A physical interaction between ocean waves and plastic, in which rubbing, smashing, or grinding against the water and/or other solid objects causes the plastic to break into smaller pieces.

**Photodegradation** – A chemical reaction between sunlight and plastic, which causes the plastic to become brittle or break into smaller pieces.

**SEAPLEX -** A Scripps Institution of Oceanography expedition that explored the problem of plastic in the Central North Pacific Gyre. SEAPLEX stands for the Scripps Environmental Accumulation of Plastic Expedition, and took place from August 2-21, 2009, aboard the research vessel R/V *New Horizon*. http://sio.ucsd.edu/Expeditions/Seaplex/

**Transect Grid** - A path or grid along which a researcher makes a series of observations.

PLASTIC MICRO-DEBRIS

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**EXTENSIONS:**

1. Elementary Level Activity Book: NOAA Understanding Marine Debris Activity Book
2. News Week Article: Tracing the Environmental Impact of the Stuff We Buy
3. The Chemistry of Oceanic Plastic, written by Captain Louis Hoock, further explains the science of plastic in the marine environment. http://www.coastalfootprint.org/Xenobiotic_Education.htm
4. Plastic Piling Up in the Atlantic Ocean
5. Perspectives on Plastic at SEA : a video on plastic in the Atlantic.

**RESOURCES:**

1. NOAA Marine Debris Program online website.
2. SEAPLEX for Teachers: slideshow explaining the accumulation of plastics into the gyre.
3. North Atlantic Expedition 2010: 25 years of plastic pollution research @ SEA.

**CREDITS:** Beth Simmons (CCE LTER Education & Outreach), William Miller, Patrick Henry High School, Linsey Sala (University California, San Diego/ Scripps Institution of Oceanography), Alison Cawood (University California, San Diego/ Scripps Institution of Oceanography), Miriam Goldstein, (University California, San Diego/Scripps Institution of Oceanography), Captain Louis Hoock, (http://www.coastalfootprint.org/Xenobiotic_Education.htm).

Find micro debris stock images in HD and millions of other royalty-free stock photos, illustrations and vectors in the Shutterstock collection. Thousands of new, high-quality pictures added every day.Â  519 micro debris stock photos, vectors, and illustrations are available royalty-free. See micro debris stock video clips. of 6. space debris in Earth orbit, dangerous junk isolated on white background (3d illustration). Plastics have become indispensable in many areas of modern life, used for clothing, storage, transportation, packaging, construction and a host of consumer goods. One of plasticsâ€™ greatest properties, its durability, is also one of the main reasons that plastics present a threat to the marine environment (e.g. Ivar du Sol and & Costa 2014). The risk increases as long as plastic continues to enter the ocean. Most plastic pollution studies focused on micro-, meso-, or macroplastics. Very few of them reported all.Â  Referring to the size ranges, the plastic debris. was termed micro- (â‰¤5 mm), meso- (5 mm to 2.5 cm), or. macroplastic (> 2.5 cm), since they have been adopted. by UNEP (Cheshire et al.