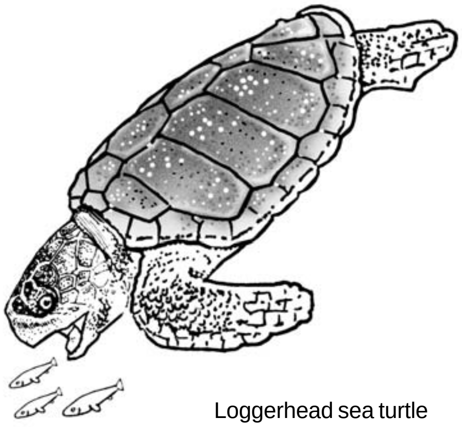
Chapter 8: That Sinking Feeling



Loggerhead sea turtle
Caretta caretta caretta

The properties of water enable life on Earth to survive—water supports biological functions, and its physical properties shape our planet's surface and atmosphere. On land, moving water is the most important agent of erosion, as it works to shape and create our beaches. Salinity influences the density of water, and in the ocean the properties of temperature, density, and salinity interact to create currents that affect global climate. This chapter looks at two of water's physical processes, buoyancy and density, and some of the ways in which our lives are affected by these processes.

Buoyancy is the upward pressure exerted upon an object by the fluid in which it is immersed; this pressure is equivalent to the weight of the fluid that the object displaces. In general, heavy objects sink and light objects float, but much depends upon the shape, size, and density of the objects. Water's buoyant properties allow particles to be transported further than on dry land because the particles can be lifted with less energy, and are subject to less friction in the water.

Density is the mass or amount of matter per unit of bulk or volume. The density of water is so great that many heavy materials are more buoyant in water than on dry land: common rocks have an apparent weight loss of 20 to 40 percent when in water. Whether it's moving a boulder downstream during a flood, floating a plastic six-pack ring down a river and out to sea, or floating a huge oil tanker, water's physical properties affect the world around us every day.

New Words
buoyancy; density; salt water wedge; Plimsoll Mark

One of the ways that water's buoyant properties works against us is in the transport of marine debris, in particular, plastic. Plastic, because of its strength, durability, and buoyancy, makes up the greater part of all debris found in the ocean and is by far the most harmful. More than 90 percent of floating marine debris is plastic—about 650,000 plastic bottles end up in the ocean each day. In the eleven year period between 1990 and 2001, the highest quantity of floating plastic measured in the central North Pacific rose from 316,000 pieces per square kilometer (1990) to nearly 1 million pieces per square kilometer (2001).

California Coastal Commission Areas of Critical Concern: Coastal Processes, Marine Debris

Relevant California Science Content Standards, Grade 8: Buoyancy and Density, 8.a-d.

Marine mammals, birds, turtles, fish, and invertebrates can be harmed by plastic loops, fishing line, nets, strings, and bands, which entangle them, wound them, and/or prevent them from swimming and feeding. Marine animals are also susceptible to ingesting all forms of plastic debris, in particular cigarette filters, small plastic pieces, and pellets (or "nurdles") that form the raw material for plastic products and are frequently found floating at sea.

Grade 8 Activities

These activities demonstrate the power of two of water's physical processes, buoyancy and density, and the ways in which they: 1) determine which objects sink and float, 2) influence the distribution of marine debris and subsequent harm to marine life, and 3) drive the dynamics of salt and fresh water mixing in productive estuaries.

Activity Goals

1. Keep Your Head Above Water

Students will:

1. Predict outcome, and conduct a hands-on lab to compare which things float and which sink.
2. Explore the concept of density and specific gravity.

2. You Are What You Eat: Plastics and Marine Life

Students will:

1. Understand that different types of plastics float, sink, or stay neutrally buoyant.
2. Identify where ten marine species feed in the water column.
3. Make the connection between where a marine organism feeds and the types of pollutants to which it is exposed.

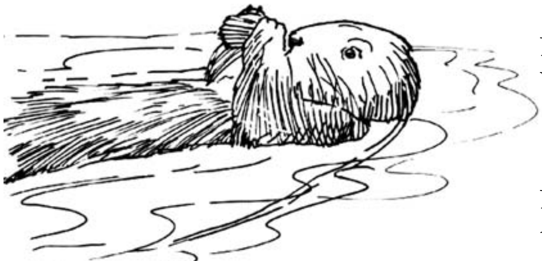
3. The Edge of the Wedge

Students will:

1. Demonstrate why fresh water will stay at the surface while salt water travels up a river along the bottom in a wedge.
2. Describe the water characteristics of an estuary from salty ocean water, to brackish water and fresh water.

Plastic does not biodegrade, and often floats, making it especially attractive to wildlife. Marine animals such as some sea turtles and many seabirds are prone to eating plastic. Sea turtles ingest plastic bags or balloons after mistaking them for jellyfish, a favorite food. Ingestion of plastic can cause intestinal blockages, and can also cause a false sense of satiation, which can lead to starvation.

Grade 8 Activity



Southern sea otter
Enhydra lutris nereis

Science skills

- Observing
- Measuring
- Predicting

Concepts

- Water has physical properties of density and buoyancy

California Science Content Standards

Density and Buoyancy

8. All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept, students know:
8.a. Density is mass per unit volume.
8.b. How to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.
8.c. The buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced.
8.d. How to predict whether an object will float or sink.

Objectives

Students compare the way things float or sink in fresh and salt water.

Time to complete

One class period

Mode of instruction

Teacher directed group work, followed by hands on experiments.

Activity 8.1 Keep Your Head Above Water

Do things that float behave differently in salt and fresh water? What lets them float, and when do they sink?

Background

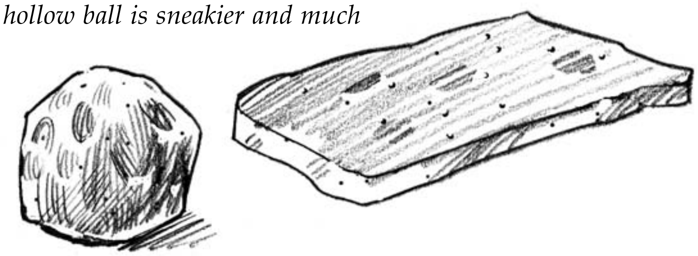
Buoyancy can be a difficult concept to understand. The idea that some things sink and others float is straightforward, but the reasons behind these observations are not so easy to accept. Density is also a challenging concept: the weight per unit volume of objects. This activity uses an experimental approach in which students don't formally identify the concepts, but observe them in action.

Activity

1. Begin a discussion of students' own perceptions of floating and sinking. Have they ever been swimming in salt water? Fresh water? Which was easier to float in? Have they ever been to the Great Salt Lake or seen people floating in it in a picture? How about the Dead Sea (also a salt lake*)? In your class you may be able to find at least one student who has made the observation that it is easier to float in salt water than in fresh water.* Explore students' ideas of what makes things float in water, and why it might be different in salt water.

2. Tell students they will have an opportunity to conduct experiments with buoyancy and density. Hand out "Float or Sink?" worksheet. Begin with a challenge: Can the students design an object that floats in salt water and sinks in fresh water? Let them experiment with film canisters and pennies (13 to 14 pennies in a plastic film canister usually works) in salt and fresh water in measuring cups. To catch spills, place the cups in aluminum pans first. Does a film canister holding the same number of pennies behave differently in two different solutions? How many pennies in a film canister will float in fresh water? How many will salt water support?

3. Does a ball (about 1 inch diameter) of clay sink or float? It sinks. If the student changes its shape, will it still sink? Try it flat or elongated in a bucket of water. It still sinks. Can the students figure out how to make it float? (*Forming it into a boat is the easy answer. Making it into a hollow ball is sneakier and much harder. Clay might be shaped around a ping-pong ball to make a hollow clay ball. It takes a great deal of trapped air to make the clay float*.) Has the weight of the clay changed? Measure it. (*No*.) What has changed? *Its volume. Its weight per unit volume has changed with the addition of air space.*



Materials

For each student or small group

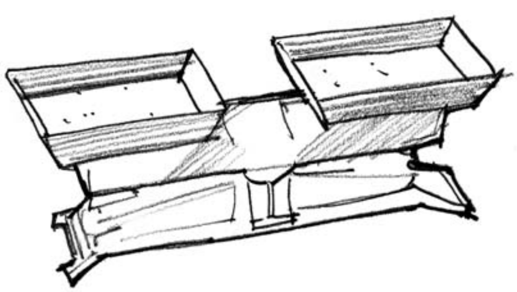
1. “Float or Sink?” worksheet
2. Four 35 mm plastic film canisters
3. 50 pennies
4. Two clear plastic two-cup measuring cups or large drink cups
5. One inch chunk of modeling clay (sold in sticks like butter) per student or group
6. Two pans to catch drips
7. One ping pong ball
8. 250 gm Ohaus spring scale (optional)
9. Rubber bands to hook to the scale
10. Optional: “Shipping in Dangerous Waters—Buoyancy Matters!” handout

For entire class

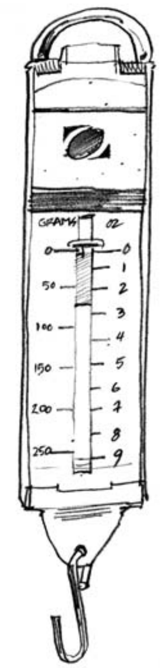
1. Fresh water in gallon plastic milk containers at room temperature (1.5 cups per student or group)
2. Very salty water (6 cups table salt or kosher salt per gallon) in plastic milk containers at room temperature (about 1 1/2 cups per student or group)
3. Bucket of fresh water

For extension activities

1. Graduated cylinders
2. Accurate top-loading balance



4. You may have conducted previous experiments with fresh and salt water where students learned that a volume of salt water weighs more than an equal volume of freshwater; the salt water is more dense than the fresh water. If you have a spring scale, attach the canister holding 13 pennies to the scale with a rubber band and lower it into each kind of water. What happens to the apparent weight in each kind of water? Can the students observe the water supporting the weight of the object? It should be “weightless” on the scale when it floats. If it sinks, it will still weigh less than when measured in air. *The water is supporting the canister. The fact that objects weigh less in water is why water has been used to transport heavy things throughout human history, from logs to oil tankers. Salt water can support heavier objects because it is more dense than fresh water.*

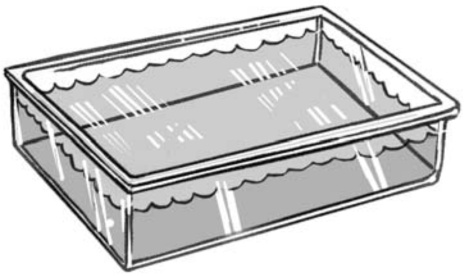


Results and reflection

1. Have students predict what would happen to a very heavily loaded boat as it sails from the ocean up into a river, and write their predictions on their worksheet. *It would sink lower and lower as the water became fresher.* Where harbors and shallow areas have fresh water input, boats have to be partially unloaded out to sea (a process called lightering) to keep them from getting stuck on the bottom as they sail up from the ocean. Have the students noticed marks painted on big ships that tell how low the ships are sitting in the water? *Salt water can float a heavier object of the same size than fresh water.* **Optional:** pass out to students a copy of “Shipping in Dangerous Waters—Buoyancy Matters!”. Students may read this article and hold a classroom discussion on the practical aspects of understanding buoyancy.

2. How do species live that have adapted to live in both fresh water and seawater? *Anadromous species, such as salmon, live the bulk of their lives in the ocean, but are born and give birth in fresh water.* Or species that live in tidal wetlands, where part of the time they are in fresh water, and part of the time in salt water, all within a 12-hour daily cycle? *Species such as pickleweed can excrete excess salt from its tissues.* Have a whole class discussion on this topic.

3. What happens when fresh water hits salt water, as when a river empties into the sea? How might this affect the plants and animals in salt water and fresh water? How might it affect the transport of pollutants carried in the fresh water?



Preparation
Gather materials, photocopy worksheet. Mix salt water the day before, using hot water to dissolve the salt. Let solution sit to room temperature.

Outline
Before class
Mix salt water solution.

During class
1. Have students discuss what they know about floating and sinking.
2. Students use film canisters and pennies to experiment with floating and sinking.
3. Students design something that sinks in freshwater and floats in salt water.
4. Students complete worksheet.
5. Whole class discussion.

Conclusions
Objects weigh less in water than on dry land because of water's buoyant properties. Salt water is more dense than fresh water, and because of this, buoyant properties of salt water are different than fresh water.

Extensions and applications
1. You may introduce the concept of *density* by having the students calculate the weight per unit volume of objects. Density equals mass divided by volume:
   a. Weigh each object on a balance to find the mass.
   b. Find the volume of the objects by filling a larger graduated cylinder part way with water and a bit of detergent to break the surface tension. Record the level. Then sink the object below the surface and record the new volume. Subtract the volume of the water from the volume of the water plus object to find the volume of the object.
   c. Mass divided by volume equals density.
   d. When all the objects' densities have been calculated, arrange them in order on a list.

2. What is the density of the fresh water? The salt water? To find out, weigh a measured volume (again, mass divided by volume equals density, so weigh it first, then divide by the volume, or mls.). Where do fresh water and salt water fit in the list of densities? Can students make a statement about density of an object versus density of a fluid with regard to whether it sinks or floats? *(If the object is less dense than the fluid, it will float. If it is more dense, it will sink.)*

3. Students may calculate the *specific gravity* of each object. Weight depends on gravity. Things weigh less on the moon where the gravity is less than on Earth, but they have the same *mass*. Relative mass can be expressed as specific gravity. Specific gravity generally uses distilled water at 4ºC as a standard and sets it equal to 1. Everything is compared to it. You could use cold tap water without being too far off. Divide the density of an object by the density of the fresh water to get the object's specific gravity. For example, if the object were 2 g/cubic centimeter (milliliter) and water is 1 g/cubic centimeter (milliliter), then the specific gravity of the object will always be 2 although the object's weight will change with gravity.

4. Interested students can investigate the Dead Sea. Why is it called the Dead Sea? Is it really dead? If not, what lives in it? How did it become the way it is now?

Adapted from
Keep Your Head Above Water. In: *Living In Water*, the National Aquarium in Baltimore. 1997. Visit the National Aquarium in Baltimore web site: *www.aqua.org*

Float or Sink?

Object	Salt water: Float or Sink?	Fresh water: Float or Sink?
1. Canister with 13 pennies		
2. Canister with ___ pennies		
3. One inch ball of clay		
4. Clay ball flattened out		
5. Clay ball different shape		
6. Other objects (i.e., clay boat with pennies):		

1. Draw a clay shape that floats successfully in both freshwater and saltwater.

2. **Predict**: Knowing what you know about how things float differently in salt water and fresh water, answer this question: What would happen to a very heavily loaded boat as it sails from the ocean up into a river? Draw a picture of a boat travelling from the ocean as it sails up a river.

Shipping in Dangerous Waters—Buoyancy Matters!

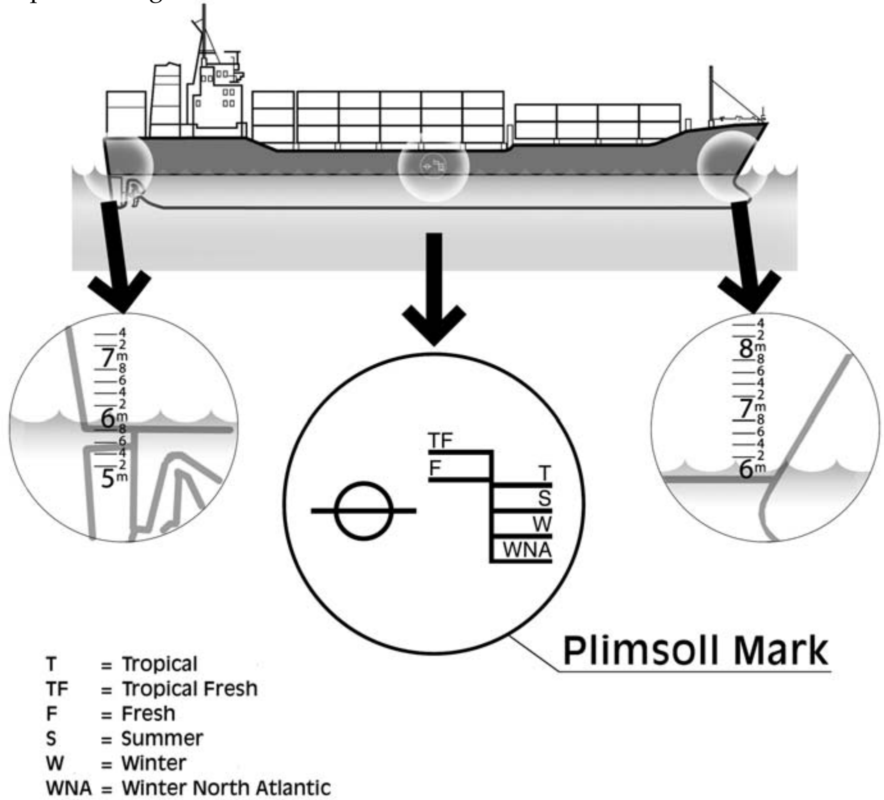
California's bays and harbors can be treacherous places for container ships and oil tankers with heavy loads. Why? These ships go great distances, from the tropics to the arctic, sometimes all in one trip. Due to the expense, harbors and bays are often dredged to just a certain depth to accomodate big ships, and not an inch more. Also, depending on tides, underwater features such as rocks and sand bars become obstacles to avoid. If a ship is loaded in a salt water port, say, in Japan, and then comes across the ocean to unload in a fresh water port, such as the San Joaquin Delta, they could run into serious problems if the ship was loaded too heavily at the beginning. Ships can run aground, spill their cargo, or even worse, break a hole in the hull and leak fuel and oil. How do captains of these ships know when their ships are properly loaded? It has been an issue since the seas were first sailed, and, luckily, someone had a plan.

Samuel Plimsoll (1824-1898) was a member of the British Parliment. Plimsoll was concerned with the loss of ships and crews due to overloading. He called them "coffin ships." To save sailors' lives, he persuaded Parliament to amend the 1871 Merchant Shipping Act to provide for the marking of a line on a ship's sides that would disappear below the water line if the ship was overloaded. Samuel Plimsoll developed the Plimsoll Mark now used by the shipping industry internationally.

The Plimsoll Mark is a reference mark located on the midship of a vessel hull indicating the depth to which it can be loaded, depending upon the destination and the route. The Plimsoll Mark evolved into internationally recognized load lines. Load lines show the maximum draft (in terms of the amount of freeboard, or distance from the waterline to the main deck) to which the vessel may load in different zones and seasons around the world. Draft marks are indicated in meters and are at the forward, midship, and aft of the ship. The Plimsoll Mark is located midship only.

The difference in salinity between loading a ship in fresh water and then proceeding to sea causes an increase in freeboard of about 8.5 inches, called the FWA (fresh water allowance). The ship will rise in the salt water that much or sink that much if proceeding from sea to a fresh water dock. The actual FWA is a little different for each situation, and calculations used by computers on ships are much more exacting. The calculations use the actual water density, displacement of the ship, and other factors that take into account the shape of the vessel.

Next time you see a container ship or an oil tanker, look for the Plimsoll Mark and draft lines. Is the ship in fresh water or salt water? Is it safely loaded? Now you'll know!



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Grade 8 Activity

Activity 8.2
You Are What You Eat: Plastics and Marine Life

Just because you can't see it doesn't mean it isn't there. Whether it sinks or floats, plastics in the sea spell trouble for all the animals in the ocean. Find out the many ways marine life can be affected by plastics in their aquatic home.

Background

Many animals that live in the ocean come into contact with discarded plastic. Because this plastic is not natural to their environment, the animals don't recognize it or know what to do about it. They encounter plastics most often as a result of their feeding behavior. Often they get entangled in it, are cut and injured, or think it's food and try to eat it. The number of marine mammals that die each year due to ingestion and entanglement approaches 100,000 in the North Pacific Ocean alone (Wallace, 1985). Worldwide, 82 of 144 bird species examined contained small debris in their stomachs, and in many species the incidence of ingestion exceeds 80% of the individuals (Ryan 1990).

Plastics and Marine Life

The potential for ingestion of plastic particles by open ocean filter feeders was assessed by the Algalita Marine Research Foundation by measuring the relative abundance (number of pieces) and mass of floating plastic and zooplankton near the central high-pressure area of the North Pacific central gyre. (The gyre is a large recirculating area of water halfway between Los Angeles and Hawaii.) Plankton abundance was approximately five times higher than that of plastic, but the mass of plastic was approximately six times that of plankton. This area is far from land, and many types of marine life feed here.

Plastics don't go away, they just go somewhere else where we can't see them. The effects on marine life can be devastating. Aquatic animals may be harmed by plastic objects in a variety of ways, depending on the shape and buoyancy of the object. These animals may suffer injury or even death from their encounters with plastics. Animals can be harmed through entanglement, laceration, suffocation, and ingestion.

The buoyant properties of water allow some plastics to float, some to sink, and some to stay in the water column. The types of plastics marine animals may come into contact with depend upon where they live and eat: at the water's surface, its bottom, or floating in the water column between the surface and the bottom. All we can see are the plastics on the surface, but there are many different varieties and shapes of plastic objects below the surface. Because we can't see this pollution, we may forget that it exists. Marine animals know by first hand experience the devastating effects of plastics pollution in the ocean, but they aren't talking. As cities grow and more plastics are produced and enter the marine environment, marine species will continue to be affected unless we make wise choices regarding plastic use and disposal.

Science skills

- Predicting
- Analyzing
- Deducting
- Charting

Concepts

- Plastics in the ocean affect animals that live there through entanglement, laceration, suffocation, and ingestion.
- Different plastics have different buoyancies, so where and what a marine organism eats determines the type of plastics to which it will be exposed.

California Science Content Standards

8. All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept, students know:

8.c. The buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced.

8.d. How to predict whether an object will float or sink.

Objectives

Students will:

- Understand that different types of plastics float, sink, or stay neutrally buoyant.
- Learn where ten marine species feed in the water column.
- Make connections between where a marine organism lives and feeds and the types of debris to which it is exposed.

Time to complete

One hour, including video

Mode of instruction

Watch video, then group or individual work with worksheet, chart, and cards, followed by presentation of results and whole class discussion.

Materials

1. Video—*Synthetic Sea: Plastics in the Ocean.* Borrow from California Coastal Commission education web site: *www.coastforyou.org*
2. "You Are What You Eat" worksheet
3. "Marine Animal Feeding Habits and Plastic Risk" chart
4. "Marine Animal Cards"
5. "Plastics and Their Uses" handout

Activity

1. Watch the video *Synthetic Sea: Plastics in the Ocean* with your class. Conduct a whole class discussion on what students think about plastics in the ocean. Does plastic just go away? What types of animals are most affected?

2. Next, conduct a whole class discussion on the many ways we use plastics in our daily lives.

3. Hand out "Plastics and Their Uses" and discuss the different types of plastics. Note that most cities only accept SPI 1 and 2 for recycling; though many of the other types of plastic are labeled as "recyclable," in reality, this does not occur and the majority of plastics end up in landfills.

4. From water bottles to computers, we rely on the convenience and availability of plastics to provide many of today's necessities. List on the board the shapes that plastic can come in, and have students give examples of what they are used for:
One-dimensional objects (line, rope, strapping bands)
Two-dimensional objects (sheets, bags)
Reticulated (netting, six-pack rings)
Hollow-bodied (bottles, fishing floats)
Small particles (Styrofoam, pellets used in making plastic objects)
Angular (boxes, crates)

5. Discuss the marine zones in which animals feed (surface, pelagic, and benthic). Have students brainstorm what types of animals might live and feed in each of these zones.

6. Either divide the class into small groups (3-4 students) or distribute materials to individuals. Distribute copies of the "You Are What You Eat" worksheet, "Marine Animal Feeding Habits and Plastic Risk" chart, and the "Marine Animal Cards" to groups or individuals.

7. Have students complete the worksheet activity. Keep in mind that there are many different possible "right" answers. What is important is that students have a rationale for their choices.

Results and reflection

1. After the groups or individuals have completed the activity, draw the chart on the board. Have each group or student choose one form of plastic (i.e., one-dimensional, two-dimensional, small particles, etc.) and present to the class their results and rationale of what species would be most affected.
2. Allow time to propose different answers, discuss them, and wrestle with different conclusions.
3. Conduct a whole class discussion on how to reduce the amount of plastics in the marine environment. (Refer to activity CA1: Marine Debris, It's Everywhere! for waste reduction ideas.)

Preparation

Order video *Synthetic Seas: Plastics in the Ocean* two to three weeks in advance. Photocopy worksheet, chart, cards, and table, one per student.

Outline

Before class

1. Order video *Synthetic Seas: Plastics in the Ocean* two to three weeks in advance of lesson from California Coastal Commission education web site, *www.coastforyou.org*.
2. Photocopy "You Are What You Eat" worksheet and "Marine Animal Feeding Habits and Plastic Risk" table, one for each student or group.
3. Photocopy and cut out "Marine Animal Cards," one set per student.
4. Photocopy "Plastics and Their Uses," one per student.

During class

1. Lead whole class discussion on characteristics of plastics in the oceans.
2. If working in groups, divide students into groups of 3-4.
3. Hand out worksheets, chart, and cards: students will arrange cards at their own tables.
4. Table groups or individuals present rationales and results to class.

Conclusions

Marine organisms are besieged with plastics in their aquatic home. They can mistake plastic pieces as food and ingest them, or become accidentally trapped by plastic marine debris.

Extensions and applications

1. Have students bring from home different types of plastic trash, or use the trash from their lunches. Conduct buoyancy experiments to see which pieces float and which sink, and which are neutrally buoyant. Group like objects together based on buoyancy. Now check their recycle number on the bottom—the number in the triangle. Do all types of plastic with the same number have the same buoyancy? What might affect the buoyancy besides the type of plastic (e.g. the shape of the object).
2. Get a list from your local refuse agency that indicates what plastics they accept for recycling, and sort your plastic trash from #1 above accordingly. Are the recyclable plastics primarily floaters or sinkers? Do you think that the plastic that is more easily recyclable ends up in the ocean less often than those that are not recyclable in your area? Which ocean animals might recycling plastic help most?

Adapted from

Animals' Feeding Ranges and Plastics, *Plastics Eliminators: Protecting California Shorelines.* California Aquatic Science Education Consortium. CASEC c/o 4-H series, Loran Hoffman, Department of Human and Community Development, UC Davis, 1 Shields Ave., Davis, CA 95616. *www.rain.org/casec*

Further references on ocean pollution:
www.coastal.ca.gov/publiced/marinedebris.html
www.marinedebris.noaa.gov
www.epa.gov/owow/oceans.debris
www.oceanservice.noaa.gov/education/kits/pollution/welcome.html

Answer Key: Marine Animal Feeding Habits and Plastic Risk*

	One dimensional	Two dimensional	Reticulated	Hollow	Small	Angular
Surface Feeders	6	6	9	7	3,7,9	
Pelagic Feeders	4,5	6,8	4, 8	1,2,4,5	10	2
Benthic Feeders	4	6	2	2	10	2

**Note: These are some possible answers. Your students may have additional answers with plausible rationales. This is an area of active scientific investigation; we have yet to learn the extent of devastation caused by plastic marine debris.*

You Are What You Eat

Do different forms of plastic affect animals feeding in different parts of the ocean? Here is some information that will help you answer this question and fill out your Marine Animal Feeding Habits and Plastic Risk chart.

The Three Marine Zones

Scientists divide bodies of water into three basic areas:
1. ***The surface zone:*** the very surface of the water where it meets the air and things float where you can see them.
2. ***The pelagic zone:*** the open water below the surface where neutrally buoyant fish swim and plankton float.
3. ***The benthic zone:*** what lies beneath the bottom of the of water; consists of mud, sand, or rock.

Where Marine Life Eats

Different forms of marine life gather their food in different zones. For example, some birds are surface feeders. They skim along just above the ocean's surface, and scoop up small bits of floating fish. Many fish are pelagic feeders. They swim about, eating smaller animals, plankton, and other food that share the water with them. Many whales, turtles, seals, and diving birds are pelagic feeders. Other kinds of fish, turtles, whales, and sea otters swim along the bottom to scoop up food from the ocean floor. They are called benthic feeders.

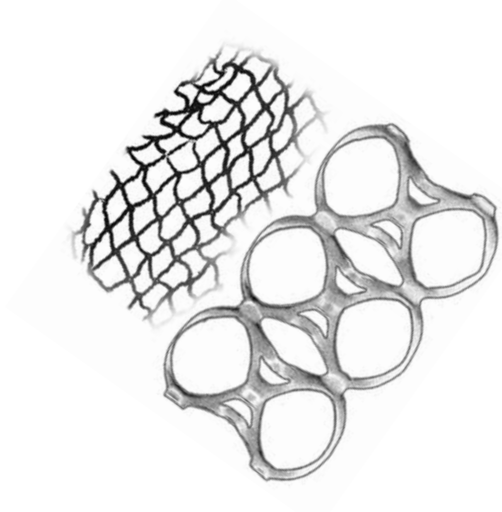
Animals that feed in different areas of the ocean often interact with different forms of plastic. For example, a bird skimming the ocean surface might accidentally scoop up bits of floating plastic pellets thinking they were food, but wouldn't scoop up a large, floating, angular object such as a Styrofoam ice chest, or a hollow object such as a plastic bottle.

Activity Directions

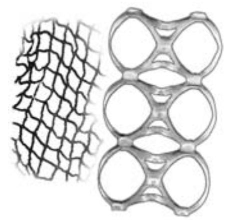
1. Arrange each card in your packet on the chart so that the animals are:
   - located under the form of plastic they will have trouble with and,
   - next to the zone where they feed

2. Then, take the card off of the square and write the animal's name in the square. One animal may be affected by more than one type of plastic, and may feed in more than one habitat, so there will likely be more than one animal name in a square.

3. You will compare charts with other students. Be sure to be able to explain your rationale for placement.



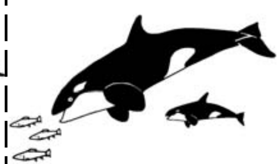
Marine Animal Feeding Habits and Plastic Risk

	One-dimensional Objects 	Two-dimensional Objects 	Reticulated Objects 	Hollow Objects 	Small Particles 	Angular Objects 
Surface Feeders						
Pelagic Feeders						
Benthic Feeders						

You Are What You Eat
Marine Animal Cards

Photocopy and cut along dotted lines.
Each student receives one complete set.

1. Bottlenose dolphin: feeds on surfperch in open water below surface, grabs with teeth.

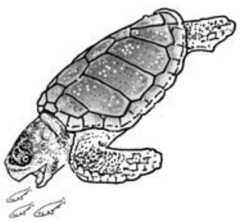


2. Orca: eats fish and marine mammals, grabs with teeth. Feeds in open water below surface.

3. Gull: eats fish, inter-tidal organisms, beach debris. Feeds on shore, top of water, grabs food with beak.

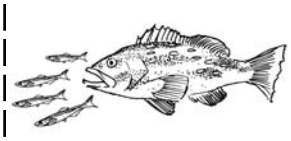
4. Sperm whale: eats squid and fish below surface. Grabs food with long, narrow mouth.

5. Common dolphin: feeds below surface in open water. Grabs small squid, other small fish with teeth.



6. Loggerhead sea turtle: eats jellies, fish, mussels, clams, crabs; grabs them with toothless mouth.

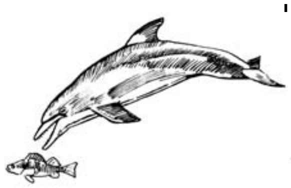
7. Elegant tern: feeds on anchovies and other fish, floats or dives shallowly into the water.



8. Sea bass: feeds below surface in open water, sucks herring, krill, and anchovies into its large mouth.

9. Forster's tern: feeds on various small fish floats along or dive shallowly into water.

10. Sea otter: feeds on benthic urchins and shellfish, bringing them to the surface to eat.



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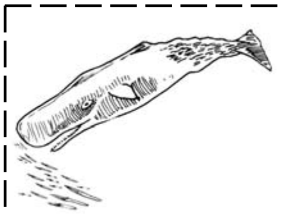

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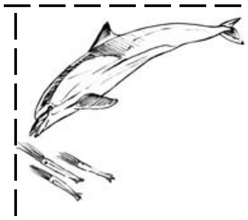

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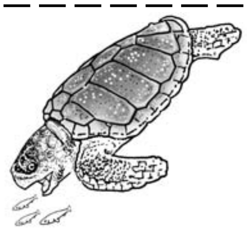

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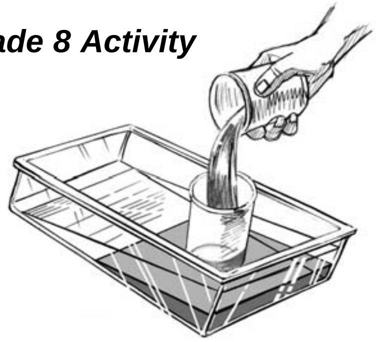
Plastics and Their Uses

Name	SPI Code	Description	Uses
PET (Polyethylene terephthalate)	1	High strength; transparent; barrier to gas and moisture, resistant to heat; **sinks in water**.	Plastic soft drink and water bottles, beer bottles, mouthwash bottles, peanut butter and salad dressing containers, ovenable pre-prepared food trays.
HDPE (High density polyethylene)	2	Tough; chemical and moisture resistant; permeability to gas; translucent or opaque matte finish; **floats in water**.	Milk, water and juice containers, trash and retail bags, liquid detergent bottles, yogurt and margarine tubs, cereal box liners.
PVC (Polyvinyl chloride)	3	Hardy; chemical resistant; resistant to grease/oil; transparent, translucent or opaque; **sinks in water**.	Clear food packaging, shampoo bottles, medical tubing, wire and cable insulation.
LDPE (Low density polyethylene)	4	Tough; lightweight; barrier to moisture; can be nearly transparent or opaque; low to high gloss; **floats in water**.	Bread bags, frozen food bags, squeezable bottles, fiber, tote bags, bottles, clothing, furniture, carpet.
PP (Polypropylene)	5	Hard; resistant to chemicals; resistant to heat; barrier to moisture; resistant to grease/oil; transparent, translucent, or opaque; **floats in water**.	Ketchup bottles, yogurt containers and margarine tubs, medicine bottles
PS (Polystyrene)	6	Stiff; transparent or opaque; smooth surface; **sinks in water.**	Compact disc jackets, aspirin bottles.
EPS (Expanded polystyrene)	6	Lightweight; heat resistant; insulating; opaque; foamed**; floats in water.**	Food service applications, grocery store meat trays, egg cartons, cups, plates.

Grade 8 Activity



Science skills

- Observing
- Experimenting
- Hypothesizing
- Communicating

Concepts

- In tidal estuaries, fresh water behaves differently from salt water due to differences in density of the waters.
- This difference in density is the engine that drives tidal wedges.

California Science Content Standards

8. All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept, students know:

8.a. Density is mass per unit volume.

8.d. How to predict whether an object will float or sink.

Objectives

- Students will demonstrate why fresh water will stay at the surface while salt water will travel up a river along the bottom in a wedge because of density differences.
- Students will describe the characteristics of water in an estuary, from salty ocean water, to brackish, to fresh water.

Time to complete

One-half to one hour

Mode of instruction

Students experiment with a hands-on model and complete a worksheet, followed by a whole class discussion.

Activity 8.3 The Edge of the Wedge

Fresh water out, salt water in—the turn of the tides in coastal estuaries makes for a mixing adventure.

Background

An estuary is a semi enclosed part of the coastal ocean where fresh water from land mixes with seawater. Historically, because of ease of transport by water, cities have been located on rivers and estuaries; seven of the ten largest U.S. cities are on large estuaries. San Francisco Bay is one of the smaller major estuaries at 1,190 square kilometers (459 square miles). The Chesapeake Bay system is the largest in the U.S., covering over 12,000 square kilometers (4,633 square miles). Estuaries are rich in nutrients that support large phytoplankton populations, which in turn provide food for zooplankton, fish, benthic organisms, and birds. Estuaries play a major role in the productivity of the coastal ocean, serving as home, nursery, and breeding ground for many species.

Estuaries act as a two-way street for water movement, where fresh water flows from the river into the estuary and spreads out as a layer over the denser salt water, while the salt water comes in with the tides. Fresh water moves generally seaward in the surface layer, and the two layers are separated by a horizontal pycnocline zone, which is a zone where water density changes noticeably with increasing depth as a result of changes in either salinity or temperature: low density surface water cannot readily move downward through the pycnocline zone. Friction occurs between the seaward-moving surface layer of fresh water and the salt water below it, causing currents that drag salt water from below and incorporate it into the surface layer. Because of the upward movement of salt water into the surface layer, the salinity of the surface layer increases in a seaward direction. The subsurface salt water in an estuary forms a wedge with its thin end pointed upstream. This is an idealized version—depending on the flow of the river and the time of the year, an estuary may be only moderately stratified. In general, the greater the flow of the river, the greater the degree of stratification, such as the lower Mississippi River or the Columbia River during flood stages.

Activity

1. Earlier in the day, prepare or have students prepare a salt water solution: add 35 grams of sea salt (regular salt has additives) to one liter of warm water, or approximately 1.2 ounces (2 scant tablespoons) of salt to 1 quart of warm water. Mix thoroughly until all salt is dissolved. Tint the salt water with food coloring (red makes a dramatic statement). Allow water to come to room temperature. To make a brackish mixture, halve the amount of salt (however, the zonation will not be quite as dramatic).

Materials

Photocopy of "Edge of the Wedge Lab" worksheet, one for each student.

For each group of 3-4 students:

1. Large, clear waterproof box or deep pan, such as a 9" x 13" baking dish
2. Tap water
3. One quart room temperature salt water (see activity description for directions on how to prepare; sea salt and food coloring are needed)
4. White paper
5. Paper cup
6. Small stones or pebbles

Preparation

Collect materials. Photocopy worksheet. Prepare area for a possibly wet model (not neccesarily, but spills may occur). Mix salt water.

Outline

Before class

1. Collect materials for model.
2. Photocopy "Edge of the Wedge Lab" worksheet, one for each student.
3. Mix salt water and food coloring.

During class

1. Student groups build model and conduct experiment.
2. Classroom discussion on experimental results.
3. Classroom discussion relating the experimental results to tidal wedge dynamics in estuaries.

2. Divide class into groups of three or four to a model. Hand out worksheets and model materials to students. Go over the worksheets and answer questions. Be sure they understand the experimental procedure before they begin.

Results and reflection

1. In a whole class discussion, students share their hypotheses, observations, and conclusions with the class.
2. Conduct a whole class discussion on tidal wedges and density differences in salt water and fresh water.
3. Ask students how they could create a control for this experiment. How do we know that the food coloring is not responsible for the result? Have one or more groups replicate the exercise with colored fresh water (instead of colored salt water). Observe the difference in the result when fresh water is added to fresh water instead of salt water being added to fresh water.

Conclusions

Density differences between salt water and fresh water create stratification within the water column.

Extensions and applications

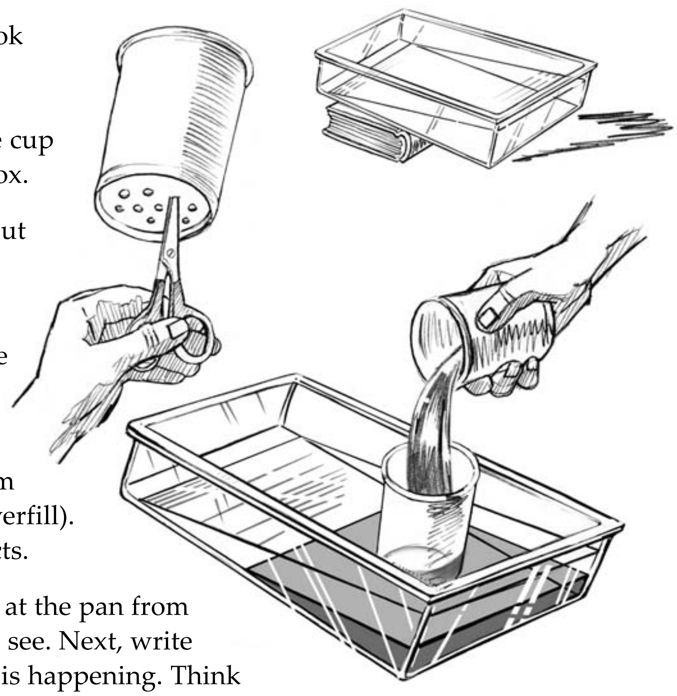
1. How would tides influence the tidal wedge process?
2. Would the tidal influence be stronger in a fast flowing or slow flowing river?
3. Students may conduct research on a large California river that enters into the ocean. Does it have a strong tidal wedge? What types of organisms live there, and how have they adapted to the changing salinities? Have the dynamics changed over the years? What has contributed to the changes?

Adapted from

A Raindrop Journey, by Barbara S. Waters, 1998. *Massachusetts Bays Watershed Stewardship Guide*. Massachusetts Executive Office of Environmental Affairs, Massachusetts Bays Program.

Edge of the Wedge Lab

A. Make the salt water wedge model



1. Place one end of the clear box or pan on a small block or book about 1 inch high.

2. Make several tiny holes in the bottom of the cup. Weight the cup with small stones and place at the lower (deeper) end of the box.

3. Pour room temperature tap water into the box until it is about 1/2 inch from the top of the pan. Wait for about 3 minutes to allow the water to settle.

4. While waiting for the water to settle, take a moment to write a hypothesis about what will happen when you add the colored salt water to the cup.

5. Taking turns in your group, <u>slowly and gently</u> pour the room temperature salt water into the cup a little at a time (do not overfill). Observe. Only use enough water to be able to observe the effects.

6. After you have added the salt water, get down low and look at the pan from the side (instead of from the top). Draw a diagram of what you see. Next, write down a description of what you observe, and conclude why it is happening. Think about what the model represents and where this phenomenon would occur in nature.

B. Experimental Process

1. **Hypothesis**: What will happen when you add the salt water to the cup in the model?

2. **Method**: Describe only **how** you added the salt water to the cup in the model. Include any possible variables (e.g., the rate at which you poured in the water, the angle of the pan, etc.).

3. **Results**: Describe only **what you observed** in the model when you added the salt water to the cup. On the back of this page, draw a diagram to help explain what you saw. Do not write about your hypothesis here; save your ideas for the analysis.

4.**Analysis**: using as few words as possible, **explain your results**. Is your hypothesis proved or disproved by your observed results?

5. **Discussion:** Here is the chance to be more creative. Discuss what you would do differently next time you conduct this experiment. Do you think this was a good model? How could the model be improved? How could the model better show what happens in nature? Use back of page for your answer.

Notes