**Title**
De-Glooming Doom: Fun Ways to Teach About Human Impacts in the Marine Environment



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# De-glooming Doom

## Fun Ways to Teach About Human Impacts in the Marine Environment

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## Contents

# About the Lesson Plans

The goal of these lesson plans is to introduce five of the major anthropogenic impacts on the oceans but to do so that inspires positive action rather than overwhelming students with gloom and doom. Hopefully, this knowledge will influence their decisions and actions for the betterment of our world. The lessons are designed to be short, accurate yet simple and interactive. The target audience is seventh to eighth but the lessons are easily modified to suit older or younger students.

Each topic consists of two sections, *In Brief* and the discovery activity. *In Brief* provides instructors with a basic understanding of the topic. It also includes a list of suggested readings for further information.

The lesson itself contains the information to be presented to the students within the framework of a discovery activity. This type of interactive learning facilitates understanding and information retention' (Wiggins and McTighe).

The discovery activity is divided into several sections. The first portion consists of "Enduring understanding", "Important to know and do", and "Worthwhile knowing". These are based on the three levels of understanding described in Grant Wiggins and Jay McTighe's book on curriculum design, Understanding by Design. These levels are particularly well suited to environmental education. They should help instructors understand the intent of each lesson and allow them to prioritize the information communicated.

- "Enduring understanding" is the big idea or core message that you would like the student to remember years from now.
- "Important to know and do" includes key facts and actions the student could take to avoid contributing to the impact described.
- "Worthwhile knowing" is information that provides a deeper understanding of the issue.

Details of the lesson plan come next, including basic requirements for location and time. A list of materials follows. The materials were designed to be affordable but also reusable with many classes. No expensive laboratory supplies or computer labs are needed.

Green
com.

Procedure describes the steps of the lesson. Game rules are set apart in text boxes as is information to be communicated to the students.

Each topic ends with suggested positive actions to combat the impact. They focus on things that students can do themselves, like turning off the lights. Instructors should end each lesson by focusing on these actions.

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# Ocean Acidification

## Carbonated Oceans

# In Brief

## Introduction

Like global warming, ocean acidification is an effect of increased atmospheric carbon dioxide ($CO_2$). However it is not a result of the greenhouse gas effect and is not related other greenhouse gases. It is a separate outcome of increased $CO_2$.

Anthropogenic sources have been increasing the amount of atmospheric $CO_2$ since the industrial revolution at an ever rising rate (Feely, et al). The concentration of $CO_2$ in the air and in the near surface waters equalizes at the surface (Doney, et al). Approximately 25% of $CO_2$ emissions have been absorbed by the oceans (Hood, ed).

Carbonate ($CO_3$) is an important building material for calcareous marine organisms. ( (Hoegh-Guldberg et al). This includes corals, coralline algae, shellfish, arthropods, echinoderms, and some plankton such as coccolithophores and foraminifera. Through a series of chemical reactions the extra $CO_2$ decreases the concentration of $CO_3$ in the water. The $CO_2$ also increases the acidity (decreasing pH), thus the name "ocean acidification".

## pH

The "H" of pH is hydrogen. The pH scale is a rough measure of the concentration of hydrogen ions ($H^+$). Confusingly, the lower the pH value the more $H^+$ there are (Wikipedia). A lower pH value mean lots of H+ and corresponds to acids. High pH values are low concentrations of H+ and are bases. The scale ranges from 1-14 with pH7 being neutral. Pure water is typically 7. Seawater is nearer pH 7.9, depending on place and time.

$CO_2$ forms carbonic acid which disassociates into bicarbonate ($HCO_3^-$) and $H^+$.

$$CO_2 + H_2O \Rightarrow H_2CO_3 \Rightarrow HCO_3^- + H^+$$

It's these extra $H^+$ that are the real troublemakers. Not only do they decrease the pH but the positively charged ions love to bond with negatively charged $CO_3$, transforming into $HCO_3^-$.

$$H^+ + CO_3^{2-} \Rightarrow HCO_3^-$$

Calcifiers use $CO_3$ to create their calcium carbonate ($CaCO_3$) shells and skeletons.

$$Ca^{2+} + CO_3^{2-} \Rightarrow CaCO_3$$

The bonding of $H^+$ and $CO_3$ uses up the $CO_3$, reducing its concentration in the water thereby reducing its availability to marine calcifiers.

## Trends over time

There have been fluctuations in ocean water acidity in the past. Geological evidence has linked ocean acidification to a mass extinction of calcifiers 65mya (Hood, ed.). Current change is happening quickly and is clearly linked to atmospheric $CO_2$ (Hood, ed.). Ocean acidity has increased 39% since the beginning of the industrial revolution from 280ppm to 384ppm (Doney et al). There is a clear correlation between the rise of $CO_2$ and the decline of pH.

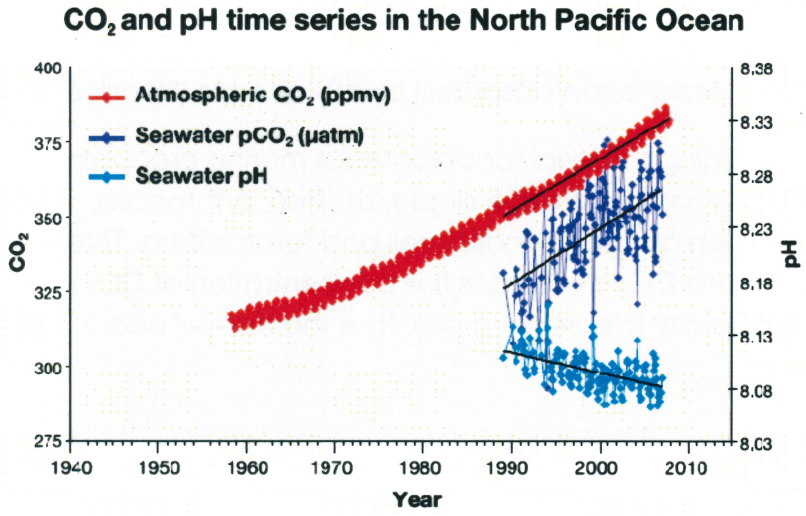


Figure credit: Richard A. Feely, Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration, USA, with atmospheric data from Pieter Tans and seawater data from David Karl. Adapted from Feely (2008) in Levinson and Lawrimore (eds), *Bull. Am. Meteorol. Soc.* 89(7): S58.

If $CO_2$ increases to 800ppm in 2100, as in the IPCC A2 scenario, then pH will decrease by 0.4 from pre-industrial levels. This is a global average drop of 8.2 to 7.9 (Feely et al). By the end of the century ocean acidification will hinder growth of many marine calcifiers (Hood, ed.). $CO_3$ solubility also varies with temperatures. Greater solubility is possible at warmer temperatures. Cold or deep water have lower saturation rates (Doney et al) Polar regions may be acidic enough to be corrosive to calcareous organisms (Hood, ed.).

## Effects

It is certain that ocean acidification is happening and the chemical processes are well known. What is less certain is how marine organisms will react. As explained above increased $CO_2$ means decreased $CO_3$ concentrations; however research shows that at least some calcifiers do better at a lower pH. The reduced pH may also have both positive and negative effects on other invertebrates and fish. Reduced pH also affects physical properties such as acoustics.

Even if you don't care about intrinsic values or non-consumptive uses of marine life, ocean acidification has huge implications for food security. Although we are far away from melting in acid seas ourselves ocean acidification attacks the base of the marine

food web, plankton. Humans, as the top predator of the oceans are greatly affected. Fisheries will be affected resulting in commercial losses and food insecurity for peoples reliant on marine resources. Ocean acidification also affects important reef builders including corals and shellfish, resulting in lost biodiversity and biomass, once again limiting fisheries.

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# Carbonated Oceans

**Enduring understanding:** Our carbon dioxide ($CO_2$) emissions can harm marine life through a process commonly known as "ocean acidification", which reduces the availability of the building material of many marine shells and skeletons.

**Important to know and do:** Energy and fuel conservation reduces $CO_2$ production, thereby helping marine life.

**Worthwhile knowing:** $CO_2$ in the atmosphere is absorbed into the ocean. This extra $CO_2$ changes the properties of the water. This is commonly known as ocean acidification since one change is the water becoming more acidic (a lower pH value). It also limits the amount of carbonate ($CO_3$) available to marine calcifiers for building shells.

**Materials:**

- ✓ Glasses or beakers (2 per student/group)
- ✓ 1 box calcium carbonate chalk
- ✓ seltzer bottle and $CO_2$ cartridge (or bottled soda water)
- ✓ pH test kit or strips
- ✓ water


**Location:** Indoors with tables and a whiteboard.

**Time:** 20-40min

**Procedure:**

This lesson occurs in two parts. The first part shows that adding $CO_2$ to water reduces its pH. The second part shows that calcium carbonate ($CaCO_3$), the building block of most shells, reacts differently in carbonated water than still water.

Part 1: Adding $CO_2$ to water reduces pH

1. Distribute 2 glasses and chalk to each student or group.
2. Fill one glass of those glasses with tap water. Use the test strips or kit to test the pH of the tap water.
3. Pour water into the seltzer bottle and follow manufacturer instructions to carbonate the water. If students are quiet

while the $CO_2$ cartridge is screwed in they'll hear the $CO_2$ releasing into the bottle. Optional: use bottled soda water if a seltzer bottle is not available.

4. Pour the carbonated water into the second glass and test its pH. (It should be around 4.)

Part 2: How increased $CO_2$ affects marine life.

> Conclusion
>
> Thus we have proof that adding $CO_2$ to water lowers the pH. This is because $CO_2$ in water c. The acid decreases the pH. Many of our activities, especially burning fossil fuels, emit $CO_2$. Some, about 25%, of the $CO_2$ is absorbed into the ocean, where it forms carbonic acid and reduces the pH of sea water. This is known as "ocean acidification".

1. How is a stick of chalk like a clam shell? They're both made from calcium carbonate ($CaCO_3$). Marine calcifiers, animals that make $CaCO_3$ shells, include molluscs, bivalves, echinoderms, corals, arthropods, and some plankton. We will be using the chalk, which will react much quicker, to show how $CaCO_3$ reacts to water with extra $CO_2$.
2. Drop a small piece of chalk into each glass and observe the reaction. The chalk in soda water should fizz as the chalk dissolves. The carbonic acid is reacting with the $CO_3$ in the chalk to create water ($H_20$) and $CO_2$, the $CO_2$ bubbles out. The reaction should continue until either the $CO_2$ or the $CO_3$ is used up.

## What can you do?

Reducing your own $CO_2$ emissions is an important part in stopping the increase of $CO_2$

> Conclusion
>
> In seawater, excessive $CO_2$ emissions also use up the $CO_3$. Without plenty of $CO_3$, marine calcifiers can't make their shells. Marine calcifiers are essential elements of the ocean. The tiny plankton calcifiers are the base of the marine food web which we rely on to. Corals and bivalves create reef habitats for fish. Many calcareous invertebrates are important human food sources, like clams and oysters. Without calcifiers the marine ecosystem as we know it would not exist.

in the atmosphere and ocean. A few ways you could reduce your emissions are:

- Use less gas. Walk, bicycle, carpool, or use public transportation.
- Conserve electricity. Much of our electricity is generated by burning fossil fuels which emit $CO_2$.
  - Turn of lights and appliances when not in use.
  - Unplug appliances and chargers.
  - Turn the heat or air conditioning off.
- Reduce, reuse, and recycle.
- What else can you think of?

# Marine Debris

## Not So Sweet Rewards

# In Brief

## Introduction

Trash in the ocean is commonly referred to as marine debris. According to the National Oceanic and Atmospheric Association (NOAA), marine debris is defined as "any persistent solid material that is manufactured or processed and directly or indirectly disposed of or abandoned into the marine environment or Great Lakes. "

In an attempt to educate to public about the serious problem of marine debris many numbers and images are tossed around in public campaigns. While it is indeed a very serious problem many of these numbers are either very rough estimates, misrepresented or outright wrong. (NOAA) The truth is that much regarding the location, quantity, sources, effects, and degradation of marine debris is unknown.

## Where does it come from?

Marine debris includes that which is intentionally disposed of and what might accidentally end up in the ocean. It comes from both terrestrial and marine sources. Remember, many countries do not have organized garbage disposal as in the US.

Marine sources of debris include (UNEP)

- ✓ Commercial shipping,
- ✓ Passenger boats (ferries, cruise ships, recreational)
- ✓ Fishing vessels (includes lost or discarded fishing gear)
- ✓ Military vessels
- ✓ Aquaculture
- ✓ Oil and gas platforms

Terrestrial sources of debris include (UNEP)

- ✓ Landfills near waterways and coasts
- ✓ Sewage and storm water
- ✓ Industry
- ✓ Littering
- ✓ Using the ocean as a dump (not on UNEP list)

## Where does it go?

Some things sink, some things float. Glass and metal tends to sink unless it is containing air. Many plastics float and make up the bulk of debris near the surface. (UNEP) Some garbage is neither floating near the surface nor resting on the seafloor but is suspended in the water column.

It can be moved by wind, waves, and currents. Areas of increased debris density have come to be known as garbage patches, the best known being the Great Garbage Patch in the Pacific Ocean. Much of the debris in garbage patches is not large pieces that are visible by areal or satellite photography.

Rates of complete degradation (breakdown to organic and inorganic compounds) vary depending on material composition, water temperature, light and weathering. Many plastics breakdown into smaller and smaller pieces known as microplastics. (Microplastics are also intentionally created in plastics manufacture and are in beauty products; think about all those exfoliating microbeads swirling down the drain.)

**What effects does it have?**

Marine debris has lethal and sub-lethal affects. Common causes of death include entanglement and ingestion. (UNEP) Entanglement is largely, but not exclusively, a result of loose fishing gear or "ghost nets". Litter also causes entanglement.

Plastics are the most common form of ingested debris. It posited that some animals may confuse trash with food. Plastic bags look like jellyfish or a metallic flash looks like a fish. Plastics might also be inadvertently consumed as it mixes with actual food, or is ingested by smaller food. New research shows that plankton ingest microplastics (pers. from Goldstein). Research also shows that microplastics may be carriers of bacteria and inorganic toxins. Although not yet fully quantified marine debris is a serious problem.

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# Not so sweet rewards

Caution: Not for very young children

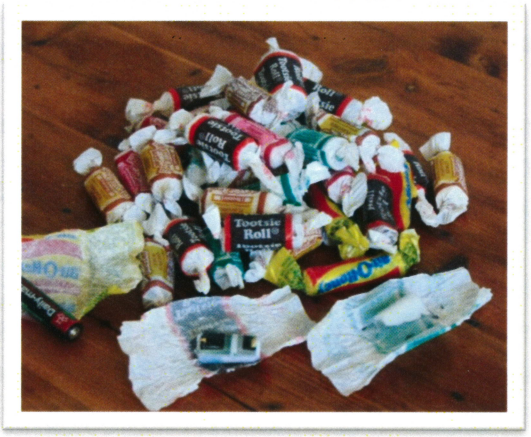
**Enduring understanding**: Trash in the oceans is dangerous to marine life, which may becoming entangled in it or eat it.

**Important to know and do:** By disposing of trash and recycling properly, reducing consumables and using reusable bottles and bags I can save marine life.

**Worthwhile knowing:** Plastic last a very long time. They breakdown into microscopic pieces that are barely visible. Even these small pieces are very harmful.

**Materials:**

- ✓ Candy in individual twisty wrappers (like Tootsie Rolls)
- ✓ Candy sized pieces of trash
- ✓ Container for candy
- ✓ Optional: example of entangling debris




Carefully remove about 1/3 of the candies from their wrappers, without ripping the wrappers. Set aside the candy. Refill the wrappers with the candy sized trash. Small batteries, plastic packaging, magazine pages, and anything else that is obviously not candy, can be used. Set about ½ of the real candies aside. Mix the remaining fake and really candies together in a container.

**Location:** Anywhere

**Time:** 20 minutes

**Procedure:**

1. Using the information provided in the In Brief section discuss;
    a. What is marine debris?
    b. Where does it come from?
    c. What happens to it in the ocean?
2. Do NOT discuss the effects of marine debris on marine life; there is a surprise element to the activity.
3. Ask 2-3 questions about marine debris, rewarding correct answers with the real candy that was set aside. Example questions are;
    a. Who can define marine debris?
    b. Name one source of marine debris.
    c. What type of marine debris floats easily?

4. After a few questions say that the class has done so well that everyone can have candy.
5. Pass around the mixed real and fake candy.
6. The students who get fake candy should react with dismay. If they don't you can prompt them or open your own fake candy. What they thought was a tasty snack was in fact trash. This happens to marine animals too. They can mistake a flash of metallic plastic for a fish, or swallow a plastic bagging floating along like a jellyfish. The plastic can't be digested but can kill them.
7. Give anyone who got fake candy real candy if they want it.
8. Optional: Pull out the optional entangling trash and use it on a volunteer.
9. Another common way in which marine debris harms marine life is by entangling it. This is especially a problem with old fishing gear that has been discarded or lost off a boat.

## What can you do?

Make sure your trash doesn't end up in a turtle or bird's stomach!

- ✓ Reduce
- ✓ Reuse
- ✓ Recycle
- ✓ Don't litter
- ✓ Participate in litter cleanups

# Noise Pollution

## Sounds and Cetaceans

## In Brief

### Intro

Ocean water absorbs light waves relatively quickly but transmits sound waves well. In the dark ocean depths many marine mammals have come to depend on sound rather than sight to envision their world (NRC 2005). Like us they also use sound to communicate (Simmonds).

Prior to mechanized boats the oceans were relatively quiet (NRC 2005). Natural sources of marine sound are limited to physical sources such as tectonic activity, wind, and waves, or biological sources like vocalizations of marine mammals (Simmonds). The development of mechanized boats introduced not only a louder source of power but more boats and greater speeds. We also learned to use sound in ways similar to the marine mammals for navigation, communication, and research (NRC 2005).

### Cetacean sound use

Cetaceans use a wide range of frequencies, 10 Hz to 200 kHz (Wartzok) for a variety of purposes. Toothed whales (odontocetes) including dolphins and porpoise, use high frequency sounds for echolocation. The higher the frequency the greater the resolution (Simmonds). A deaf toothed whale is a blind one. Baleen whales use low frequency sound that can travel hundreds of kilometers (Simmonds) for navigation, an essential tool for many long distance migrators. Sounds are also used to avoid danger (Wartzok), communication between individuals or groups and even to stun prey (Simmonds).

### Anthropogenic noises

Sources of Human-Generated Ocean Noise

- ✓ Transportation: Aircraft, ships and boats, icebreakers, hovercrafts and vehicles on ice.
- ✓ Dredging and Construction: Dredging, tunnel boring, other operations.
- ✓ Oil Drilling and Production: Drilling from islands and caissons, bottom-mounted platforms, and vessels; and offshore oil and gas production.
- ✓ Geophysical Surveys: Air-guns, sleeve exploders, and gas guns.
- ✓ Sonars: Fish finders, depth sounders, and military systems.
- ✓ Explosions
- ✓ Ocean Research: Seismology, acoustic propagation, acoustic tomography, acoustic thermometry.

Richardson et al., 1995

## Effects

An increase in ambient sound can interfere with cetaceans' ability to hear and therefore use sound for communication, navigation, echolocation, or sensing danger. Sharp or distinct sounds can have mild to severe effects. In some cases cetaceans may become habituated to the sounds of increased marine traffic (Wartzok). In other cases sound can cause physical damage and even death. (Simmonds)

Possible impacts of noise on cetaceans

- ✓ Physical
  - Non Auditory
    - Damage to body tissue
    - Induction of the "bends"
  - Auditory
    - Gross damage to ears
    - Permanent hearing threshold shift
    - Temporary hearing threshold shift
- ✓ Perceptual
  - Masking of communication with conspecifics
  - Masking of other biologically important noises
  - Interference with ability to acoustically interpret environment
  - Adaptive shifting of vocalizations (with efficiency and energetic consequences)
- ✓ Behavioral
  - Gross interruption of normal behavior (i.e. behavior acutely changed for a period of time)
  - Behavior modified (i.e. behavior continues but is less effective/efficient)
  - Displacement from area (short or long term)
- ✓ Chronic/Stress
  - Decreased viability of individual
  - Increased vulnerability to disease
  - Increased potential for impacts from negative cumulative effects (e.g. chemical pollution combined with noise-induced stress)
  - Sensitization to noise (or other stresses) – exacerbating other effects
  - Habituation to noise – causing animals to remain close to damaging noise sources
- ✓ Indirect Effects
  - Reduced availability of prey.
  - Increased vulnerability to predation or other hazards, such as collisions with fishing gear, strandings, etc.

(Simmonds and Dolman, 1999)

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Whale recording by Kent Noonan, Whalesong Project, www.whalesong.net

# Sounds and Cetaceans

**Enduring understanding:** Human created (anthropogenic) noise and boat traffic is harmful to marine animals like whales.

**Important to know and do:** The majority of marine traffic is from shipping, by reducing my excess consumption I reduce the number of goods and materials being shipped. Using alternative fuels helps reduce the exploration for and removal of oil.

**Worthwhile knowing:** Cetaceans (whales and dolphins) use sound as a means to communicate, "see", and navigate. Noise pollution from boats (big and small), mining activities, and the military is making this difficult, in some areas, impossible. The sounds can also harm them physically.

Note: The noise pollution aspect is a surprise halfway through the game. Don't give it away during the introduction.

**Materials:**

- ✓ 6 blindfolds of various colors
- ✓ 6 targets to match blindfolds
- ✓ 24 Colored Whale tags
- ✓ Portable music player
- ✓ Large speakers
- ✓ Whale soundtrack
- ✓ Noise soundtrack
- ✓ Whiteboard optional

**Location:** Open space

**Time:** 30-40 min

**Procedure:**

1. Present the information in the How Cetaceans Use Sound box.
2. At this point you can move outside or to game area if needed.
3. Set up the speakers and music player if you haven't done that yet.
4. Following the attached rules, play the game with soft whale soundtrack.
5. Play a second time but play the Marine Traffic soundtrack at high volume. At the same time instructors or 2-3 volunteers should walk around the playing field randomly calling out different colors to confuse the whales.

6. Discuss. What was different about the second round? Was it easier or harder? What does the ocean sound like, the whale soundtrack (1st round) or the noise soundtrack (2nd round)? What creates sounds? How do they affect whales?

How Cetaceans Use Sound

- ✓ Cetaceans: are whales, dolphins, and porpoises. They are not: sharks, seals, or manatees.
  - Toothed whales (Odontoceti) have teeth. For example, dolphins, porpoises, orcas, sperm whale, beaked whales. They mostly eat big things, like fish and seals.
  - Baleen whales (Mysticeti) have baleen instead of teeth. Baleen is a like a filter that collects small bits of food as water is pushed through the baleen.
- ✓ Sound in the ocean
  - Travels far.
  - Sound travels in waves, similar to ocean waves. The speed of the waves is called frequency. Low frequency sounds travel further than high frequency sounds.
  - Note: DO NOT DISCUSS WHAT CREATES SOUNDS
- ✓ Cetaceans use sound to:
  - Communicate: whales "talk" to each other. (Whale from Finding Nemo is a good example.) They communicate about food, family, danger, and their pod members. They can identify themselves. They even use sound to find a mate (chatting up the opposite sex).
  - Navigate: Vocalizations reflect off of the sea floor, ice, and land helping baleen whales find their way on long migrations. These are low frequency sounds that can travel really far.
  - Echolocate: Toothed whales (including dolphins and porpoises) use echolocation to "see". By using the echoes from mid to hi frequency sounds they can form detailed mental images of the world around them. A deaf toothed whale is like a blind human.
  - Hunting: some toothed whales may use sound as a weapon to stun their prey.

Sounds and Cetaceans: The Game

**Object:** Each team must get their whale to its target.

**Roles:** Each team has 1 whale, other team members are echoes.

**Rules:**

1. Whales will be blindfolded. Team members must guide the whale to a target the same color as their blindfold.
1. Echoes will be in a circle around whale. Echoes can't move.
2. When a whale wants to know which way to go it will yell his/her group name. The echo in the best direction responds with the group name. They cannot give directions like right, left, forward, back, etc. Demonstrate with another instructor. For example, if I am a blue whale, and Jane is a blue echo, when I want to know which way to go I yells "blue", if I should walked toward her she yells "blue". If I shouldn't walk towards her she'll stay quiet and another team member, in the right direction will yell "blue".
3. Echoes can only yell in response to another whale. They cannot call out to a whale if the whale does not call first.
4. You will have 5 minutes to get to your target.

**How to Play:**

1. Have the students form a large circle.
2. Hand out the whale tags (colors should be evenly distributed around the circle, not adjacent.)
3. From each color group, select one whale.
4. Blindfold the whales. Lead them somewhere within the circle.
5. Place the targets.
6. When you start the soundtrack the game starts.
    a. Note: 1st round use whale's soundtrack, 2nd round use noise soundtrack.
7. When soundtrack ends, game is over.

What creates sound in the ocean?

- ✓ Natural sounds from physical processes: Waves, wind, earthquakes and volcanoes
- ✓ Natural sounds for biological sources: Marine mammals and other animals.
- ✓ Anthropogenic:
  - o Shipping and large vessels (commercial)
  - o Small boats (private)
  - o Oil and gas
    - ▪ Airguns: used in looking for oil. Sudden loud sounds made by releasing compressed air. The sound is bounced off the seafloor to ….
    - ▪ Drilling and pumping oil: The rigs, drills, and boats.
  - o Ocean research: Like whales people often use sound to help visualize the ocean.
  - o Military and defense: submarine navigation and tracking, monitoring, sonar, vessels, and warfare.

## What can you do?

- ✓ We can decrease shipping by buying reducing excessive consumption and buying local foods.
- ✓ Use alternative fuels to reduce oil exploration and extraction.
- ✓ Follow boating rules and regulations.
- ✓ Support legislation to regulate marine noise.

# Overfishing & Bycatch

## Too much of a good thing...

# In Brief

## Introduction

Overfishing is catching fish faster than they are reproducing. If continued unchecked overfishing can drive a species to extinction. (UNEP) Unlike many other human impacts in the marine environment, overfishing began before the Industrial Revolution. It is the oldest of human impacts on the marine environment. There is evidence of overharvest of marine mammals and fish up to 125,000 B.P. (Jackson).

By 2008, overfishing had expanded to encompass at least 32% of the commercially harvested species tracked by the United Nation's Food and Agricultural Organization. The FAO also reports that 53% of species are fully exploited (FAO 2010). In the US 39 commercially harvested species are classified as being subject to overfishing. Another 43 are overfished (NOAA).

## Contributing factors

Although overfishing has been occurring for millennia, modern technology has significantly exacerbated the problem. For decades technological improvements have been masking declines in fish biomass. Faster larger ships with better storage allow far off locations to be fished. Technology has also increased our ability to find fish, pursue deeper species, and harvest larger quantities and process fish at sea. (UNEP)

Too many boats and too many people pursuing fishing is another problem. Worldwide, most fisheries are open access, meaning they are a commonly held resource open to the "tragedy of the commons". Bycatch, the incidental catch of species, also contributes to overfishing as well as being a problem in its own right (UNEP). Many commercial species are bycatch to other fisheries (UNEP). Bycatch also endangers non-commercial and protected marine species, such as fish, birds, mammals, and turtles. Many of these species are important to ecosystem function and/ or have high non-consumptive value.

## Effects

Besides financial and environmental losses, overfishing and the resultant depletion of species is a serious problem for the over 1billion people who rely on seafood as their main food source. (UNEP) Other environmental issues threatening the health and survival of marine species such as pollution and climate change further increase the risks and likelihood of overfishing.

## Overfished vs. overfishing

In US regulations, a stock is said to be overfished when the population size has been reduced by fishing pressure to a level below that which would result in the maximum

sustainable yield ($B_{msy}$). Overfishing is when harvest rates are faster than reproduction rates.

A stock can be overfished but growing, meaning the population is below $B_{msy}$ but is growing. This is also known as recovering from depletion (FAO). A stock can be overfished and subject to overfishing, meaning the population is below $B_{msy}$ and still being reduced by harvest rates greater than reproduction rates. A stock that is at or above $B_{msy}$ can still be subject to overfishing.

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## Too much of a good thing…

**Enduring understanding:** The ocean is not a bottomless resource. Although fishing itself is not bad, some fishing activities are unsustainable and can drive species near extinction or destroy local ecosystems.

**Important to know and do:** To avoid supporting destructive fishing practices, be aware of how your seafood got from the ocean to your plate and making choices accordingly.

**Worthwhile knowing:** Overfishing occurs when more fish are caught than are being replaced by reproduction and growth. This can lead to collapse of the species and/or local ecosystem. Bycatch is the catching of marine species other than the one you want. It contributes to overfishing as well as killing wonderful and important marine species like sharks, turtles, seabirds, and more.

**Materials:**

- ✓ large tub (≈90 liter)
- ✓ 3 gross orange ping pong balls
- ✓ 5 gross white ping pong balls
- ✓ 5 small buckets
- ✓ various scoops
- ✓ 5-6 large buckets
- ✓ large bag for collecting excess pongfish

**Location:** Open area.

**Time:** 30 min +

**Procedure:**

1. Define the following terms;
    a. Target species- the species that you mean to catch and sell
    b. Bycatch- animals that are caught but are not the target species. Some bycatch are target species for other fisherman. Some bycatch is not

commercially valuable but is nevertheless valuable to the environment and people, for example marine mammals, turtles, sea birds, and sharks.

c. Stock- a sub group of a species that is one geographical/ reproductive unit.
d. Fishery- The stock and everyone who fishes it. Not a physical place or structure. For example the Bering Sea Pollock fishery includes all of the pollock in the Bering Sea and all of the fishers.
e. Recruitment- The number of adult fish joining the stock each year as a result of reproduction. (This is not the number of babies born but more like the number of people turning18)
f. Overfishing- when the removal of the target species is greater than the recruitment.

2. Introduce the Pong Fisheries Game. Using the large tub as the ocean, the ping pong balls as target (white) and bycatch (orange), the small buckets and scoops as gear, and the students as fishermen you will explore the concepts of overfishing and bycatch.
3. Play a 1-3 rounds of the unregulated fishery, mixed gear and bycatch cost.
4. Play 1 or more rounds of a season fishery.
5. Discuss. If you want to fish year after year and not drive the orange pongfish to extinction what should you do? You should maximize catch while making sure that there is enough pongfish left to reproduce and replenish the stock and you should minimize bycatch. Gear restrictions and seasons are one way to do this.

# Pong Fisheries

Universal Rules

- ✓ Do not pick up or tilt the ocean. You are not Poseidon or any sea god.
- ✓ Pongfish on the floor (or anywhere besides table top) cannot be picked up.
- ✓ Boats will be impounded (i.e. team must stop fishing) if they use force.
- ✓ Orange pongfish are bycatch, white pongfish are target fish.
- ✓ Remaining fish stock (population) will double at the end of each season to become next year's stock. (Visual examples, explain this well. Test so if the stock is here at the end of the first round where will it be at the beginning of the second round)
- ✓ The rim of the bucket is the carrying capacity of the habitat. (i.e. if after a fishing round doubling the stock would overfill the ocean bucket, then fill only to the rim)
- ✓ Points will be totaled over all rounds played.
- ✓ Place the ocean tub in the middle of the playing field. Place medium size buckets around the tub about 4 m from the tub.
- ✓ The medium size buckets are the boats. All catch is transported back to the "boat" buckets.
- ✓ At the start of each round all team members must stand behind the "boats"

Unregulated Fishery Rules

- ✓ All members of teams may fish.
- ✓ No time limit. Players decided when to stop.
- ✓ Use hands only for gear.

*Results*: The fishing will be chaotic with a lot of inequality in individual's catches. The stock should be quickly overfished. Lots of fish will fall to the floor and be wasted. Either students will self-regulate or the stock will go extinct. Lots of bycatch will be caught. If they did self-regulate, which form of regulation was their strategy similar to? Total Allowable Catch (limiting quantity) or Season Restrictions (limiting time).

Seasonal Fishery, Limited Entry w/ Mixed Gear Rules

- ✓ Give a different type of gear to each team. One per team.
- ✓ The teams will fish in a relay race. One member goes to the ocean and returns, handing over the fishing gear to the next team member, and so on.
- ✓ There will be a 3 min time limit.

Results: The fishing should be more orderly. If there are not enough fish then the season needs to be shortened, too many fish the season needs to be lengthened. How were the different types of gear in terms of catching white pongfish and avoiding orange pongfish? The gear types can be compared to different fishing methods with buckets representing large-scale fishing such as longlines while smaller more selective gear is more like artisanal fisheries.

Scoring

- ✓ White pongfish = 1
- ✓ Orange pongfish = -2
- ✓ Wasted pongfish (on floor)= 0

How to play

1. When all teams are ready, start the play. End when all players stop fishing.
2. Count both white (target) and orange (bycatch) pongfish. (Extra buckets can be useful for sorting and counting the pongfish.)
3. Total each teams points on board or scorecard.
4. Collect all caught pongfish.
5. Observe how many pongfish are out of the ocean and also not part of the catch. These fish are considered dead but not caught.
6. Collect the dead pongfish in the bag.
7. Double the remaining pongfish in the ocean using pongfish from the bag.
8. What is the status of the fishery? Are there more or less than the previous round?
9. If there is still a significant amount of fish, play another round.

## What can you do?

When buying fish, pay attention what species it is and how it was caught. Avoid buying fish that are already overfished, or are caught with harmful methods. Some helpful tools for doing this are;

- ✓ Seafood selection guides, like the Monterey Bay Aquarium's Seafood Watch
- ✓ Look for certified sustainable seafood (like MSC)
- ✓ Get to know local fisherman and fish mongers.

# Water Pollution

## Pollution Survey

## In Brief

### Summary of NOS Nonpoint Source Pollution Tutorial

Pollution is defined as the contamination of water, land, or air by substances that can adversely impact the environment and human health. Or more elegantly put "something in the wrong place at the wrong time in the wrong quantity". A substance may or may not be a pollutant depending on where, when and how much. Pollution affects water, air and land. Sadly for water pollution in the air and on the land frequently ends up in the water too.

Pollution sources in the United States are divided into two legal categories, point source and non-point source. A point source is defined as "any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship, or smokestack. " Typical point sources include sewage treatment facilities, factories, boats, and large livestock facilities. Since 1972 point sources have been regulated under the Clean Water Act. In most developed areas waste water is collected and treated before being discharged into the water. Treatment systems are not 100% effective.

Non-point sources include anything that is not a point source. Non-point source pollutants are mostly carried into the water system by rain runoff. In cities, pavement and roads accumulate oil and other chemicals which are washed into untreated storm water systems when it rains. Chemical poisons such as insecticides and herbicides are applied in urban, suburban and agricultural areas. Soil itself can be a pollutant when too much enters the water. This frequently happens in areas where human activities have removed vegetation or loosened the dirt (plowing, construction). Fertilizers, pesticides, and plowing all contribute to agriculture's large role in non-point source pollution. Fertilizers create an overload of nutrients known as eutrophication. Severe eutrophication can result in hypoxic "dead zones" like the own near the mouth of the Mississippi. The nutrients fuel algae growth which in turn fuels the growth of zooplankton. When the plankton and algae die they decompose, a process that uses oxygen. The result is an area of low oxygen. Oxygen dependent animals cannot survive. Those that can may move away but sessile or slow creatures frequently die.

### Around your house

Inside your house most water drains into a treated system, either a septic system or a municipal waste water system. This includes water from sinks, toilets, showers, laundry machines, etc. Although usually treated before being discharged some waste water may escape treatment. Some chemicals and compounds are not affected by treatment.

Outside your house, any pollutants that you apply to the land will be washed into the water cycle when it rains. Some pollutants are things you intentionally apply such pesticides and herbicides. Others are incidental such as soap from washing your car, or spilled motor oil.

Also important is the amount of water you use every day. Many pollutants are only harmful when highly concentrated. The concentration is determined by the amount of pollutant but also the amount of water. If less water we remove the better.

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# Pollution Survey

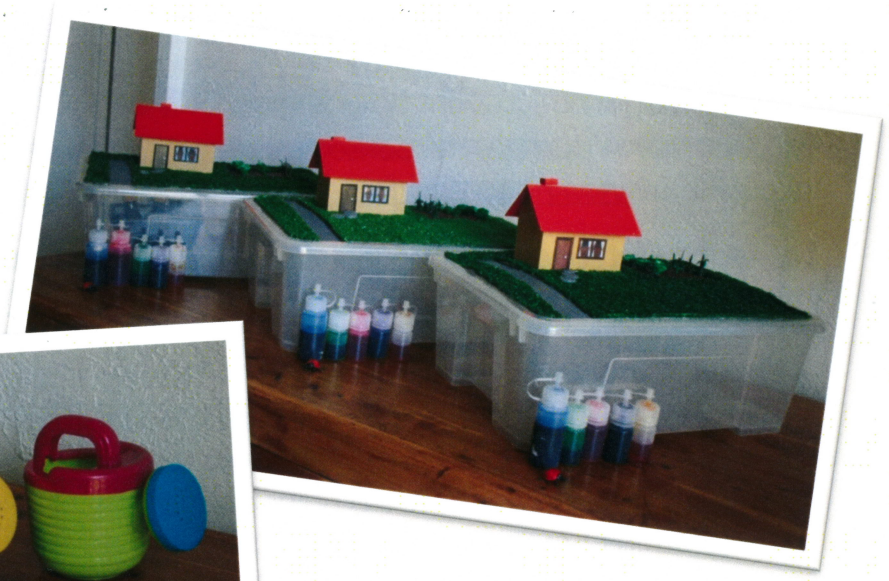
**Enduring understanding:** My actions can affect the ocean even if I never see it.

**Important to know and do:** Many routine human activities, like growing food and plants, painting a house, running a factory or even using the toilet, puts harmful compounds into our water system. These compounds can end up in the ocean, where they potentially harm marine life.

**Worthwhile knowing**: Some pollution acts as poisons killing plants and animals. Other pollution is nutrients but although this sounds like a good thing it is in fact bad and can cause large "dead zones".

**Materials:**

- ✓ 3 house models
- ✓ 15 dropper bottles w/ food coloring
- ✓ Water
- ✓ 3 watering cans
- ✓ Good, Bad, and OK surveys samples



**Location:** Tables are needed.

**Time:** 25 min

**Procedure:**

1. Describe the scenario. The water quality along the beaches and river of Coastville has been declining. To determine the source of the pollution, the city surveyed households about their use of pollutants. After the survey was completed the result were scored by a scientist. Based on the scientists scoring you must re-enact the polluting activities of three homes. *Do **not** explain survey is good, one bad and one ok. They should discover this for themselves.*
2. Divide the students into 3 groups. Each group gets;

a. house model
b. 1 set of 5 products
c. watering can
d. a survey

3. Each group goes through the survey adding products to their model as directed.
4. Compare the water in the boxes.
5. Discuss pollution sources.
6. Discuss how pollution affects the ocean.
7. Optional: Set up an aquarium within an aquarium. Put a fish in the inner aquarium. Place a cover over the lid, but do not completely block air flow. Leave the outer aquarium empty. Once you are done comparing the water in the individual boxes. Pour the contents of each box into the outer aquarium, taking care that no colored water goes into the inner aquarium. Look at your fish from the side. It's now in a polluted ocean, the result of all the combined yards.

## What Can You Do?

- ✓ Use fewer harmful products
  - o use eco-friendly options
  - o cut out unnecessary products
- ✓ Dispose of chemicals properly.
- ✓ Don't pour things into the storm drains or gutter.
- ✓ Clean up spill immediately
- ✓ Plant trees and grass that prevent erosion and filter groundwater

# Acknowledgements

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Art Credit: Timbul Cahyono www.bvllart.com

# Appendix A

## Pollution Survey Documents

# Neighborhood Water Pollution Survey

Dear Residents: In order to determine our contribution to water pollution we are conducting a brief survey of water and pollutant use. Please answer the following questions regarding activities in your home.

1. How long is your normal shower?

2. Do you use environmentally friendly soaps and cleansers in the shower and around your house, including laundry soap, dishwashing detergent, soaps and shampoos?

3. Do you regularly wash your car at home?

4. Do you use fertilizers or compost in your yard?

5. Do you use insecticides?

6. Do you use weed killers (herbicides)?

7. If you spill oil on your driveway how do you clean it up?

8. How do you water your lawn? When?

9. Where do you dispose of old paints?

10. If you have a pet, how do dispose of its waste?

Thank You

# Neighborhood Water Pollution Survey

Dear Residents: In order to determine our community's contribution to water pollution we are conducting a brief survey of pollutant use. Please answer the following questions regarding activities in your home. We will be using your answers to run pollution models in the lab.

1. How long is your normal shower? 1 drop of soapy water

   5 minutes

2. Do you use environmentally friendly soaps and cleansers in the shower and around your house, including laundry soap, dishwashing detergent, soaps and shampoos?

   Yes, always.

3. Do you regularly wash your car at home? 2 drops of soapy water 1 drop of soapy water

   No, we bring it to a car wash.

4. Do you use fertilizers or compost in your yard? 0 drops of fertilizer

   We use compost from our kitchen scraps.

5. Do you use insecticides? 1 drops of poison

   We put insectivorous ladybugs in the garden and use citronella candles.

6. Do you use weed killers (herbicides)?

   No, we just pull weeds out by hand.

7. If you spill oil on your driveway how do you clean it up? 0 drops of poison

   Use paper towels to soak it up. 2 drops of oil

8. Where do you dispose of old paints? 1 drop of poison

   We would take them to the special waste disposal at the dump.

9. If you have a pet, how do dispose of its waste?

   We compost our bunny's feces. 0 drops of sewage

10. Are you concerned about what affect your activities have on the ocean?

    Yes, we love the ocean and are worried about the environment.

Thank You

# Neighborhood Water Pollution Survey

Dear Residents: In order to determine our community's contribution to water pollution we are conducting a brief survey of pollutant use. Please answer the following questions regarding activities in your home. We will be using your answers to run pollution models in the lab.

1. How long is your normal shower?

   10 minutes

   2 drops of soapy water

2. Do you use environmentally friendly soaps and cleansers in the shower and around your house, including laundry soap, dishwashing detergent, soaps and shampoos?

   Sometimes, when they are on sale.

   4 drops of soapy water

3. Do you regularly wash your car at home?

   Once a month.

   1 drop of soapy water

4. Do you use fertilizers or compost in your yard?

   We fertilize at the beginning of spring.

   5 drops of fertilizer

5. Do you use insecticides?

   Sometimes

   8 drops of poison

6. Do you use weed killers (herbicides)?

   Only to get rid of grass growing in the driveway.

   5 drops of poison

7. If you spill oil on your driveway how do you clean it up?

   Use paper towels to soak it up.

   2 drops of oil

8. Where do you dispose of old paints?

   The sink.

   3 drops of poison

9. If you have a pet, how do dispose of its waste?

   We walk our dog outside but always clean up after him.

   2 drops of sewage

10. Are you concerned about what affect your activities have on the ocean?

    Slightly, but being green takes too much time and effort.

Thank You

# Neighborhood Water Pollution Survey

Dear Residents: In order to determine our community's contribution to water pollution we are conducting a brief survey of pollutant use. Please answer the following questions regarding activities in your home. We will be using your answers to run pollution models in the lab.

1. How long is your normal shower?

   15 minutes — 3 drops of soapy water

2. Do you use environmentally friendly soaps and cleansers in the shower and around your house, including laundry soap, dishwashing detergent, soaps and shampoos?

   No. We use common name brands. — 6 drops of soapy water

3. Do you regularly wash your car at home?

   Once a week. — 4 drops of soapy water

4. Do you use fertilizers or compost in your yard?

   We use frequently use fertilizers on our lawn and garden. — 8 drops of fertilizer

5. Do you use insecticides?

   Yes — 12 drops of poison

6. Do you use weed killers (herbicides)?

   Yes, we pride ourselves on our lawn care. — 10 drops of poison

7. If you spill oil on your driveway how do you clean it up?

   Use a hose to rinse it away. — 5 drops of oil

8. Where do you dispose of old paints?

   In the storm drain. — 5 drops of poison

9. If you have a pet, how do dispose of its waste?

   Our dog goes to the bathroom somewhere outside. — 3 drops of sewage

10. Are you concerned about what affect your activities have on the ocean?

    Never thought about it before.

Thank You

# How to Build a House Model

Materials

- plastic box
- water permeable AstroTurf
- plastic sheet (from a hobby or model store) or a small plastic house
- Sculpy clay
- paint
- glue gun
- soldering iron

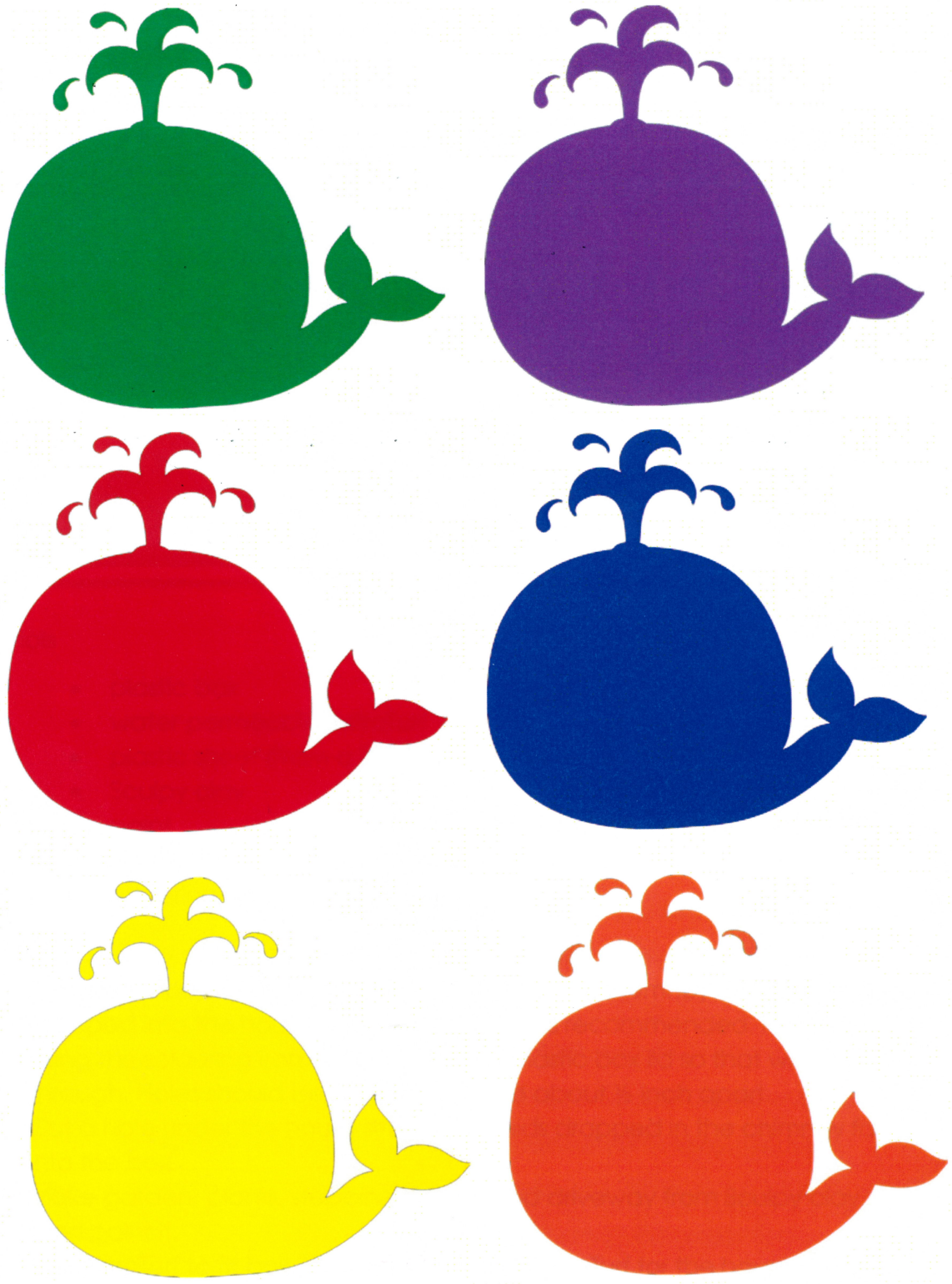
Procedure

1. Build your house from the plastic sheet. Give it a chimney so liquids can be dropped into the house. A removable roof is recommended. Paint it.
2. Using the soldering iron melt holes in the plastic box lid so that what can drain through. Holes should be in a grid spaced about ½ inch apart.
3. Cut a hole under the house site so at liquids dropped in the chimney fall directly into the box.
4. Make garden, plants, stepping stones, and driveway from Sculpy clay. Bake it then paint it.
5. Cut AstroTurf to fit box lid. Cut holes in the AstroTurf for the house, garden, and driveway.
6. Hot glue everything onto the lid. Be careful not to fill drainage holes with glue.

Note: When storing your house model, flip the lid upside down so that the house and garden are protected during storage.

# Appendix B

## Noise Pollution Documents



Print 5 copies. Cut out the whales then laminate them. Cut out the laminated whales leaving a border of plastic. The plastic should be extra wide so you can punch a whole through it. Put each tag on a string. Students hang them around their necks for team identification during the Sounds & Cetaceans game.