Worksheets and post-lab activities for “Floating Fishes”

Possible lesson outlines of this modular activity:

This is the lesson as currently written. It begins with the physics of buoyancy before transitioning to fish biology and how it’s related to fisheries

	Activity	**Time required**
1	Introduction and background	50 min
2	Boat Sinking Lab	50 min
3	Fish Buoyancy	50 min
4	Fishing expedition	50 min

An alternative is to start with the fishing expedition in order to emphasize the ecological aspects.

	Activity	**Time required**
1	Introduction and background	50 min
2	Fishing expedition	50 min
3	Boat Sinking Lab	50 min
4	Fish Buoyancy	50 min

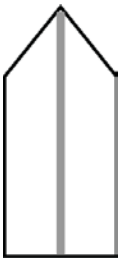
If an instructor is short on time and wishes to emphasize the interaction between biology and physics, they can omit the fisheries background. This could be completed within a 3-hr lab period. To save 50 minutes, one can also omit the boat sinking lab.

	Activity	**Time required**
1	Introduction (omit information about overfishing)	30 min
2	Boat Sinking Lab	50 min
3	Fish Buoyancy	50 min

Sample Worksheet for Day 2: Boat Sinking Lab

1) Add marbles to your boat one by one. What is happening to your boat as you add more marbles?__*Students will find that the marbles all roll to one side* _____

How many marbles did it take to sink your boat? _____ *answers will vary* _____

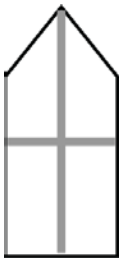


2) Take out the marbles and add the first divider to your boat. Add one marble at a time to just one side of your boat.

How many marbles did it take to sink your boat? _____*answers will vary*_____

3) Now add marbles to both sides of the boat.

How many marbles did it take to sink your boat? ___ *answers will vary* __



4) Put in the second divider. Add marbles into each compartment.

How many marbles did it take to sink your boat? *Students should observe the boat can hold more marbles as the weight is distributed more evenly*

Guided-inquiry Quantitative Worksheet for Day 2: Boat Sinking Lab

1) Before you start adding marbles to your boat, use the following equations to make a prediction. How many grams of marbles will the boat hold before it sinks? __ *answers will vary*_

Density of empty boat = (Mass of carton + mass of air)/volume

Density of boat with marbles = (Mass of boat + mass of air + mass of marbles)/volume

2) Add marbles one by one and weigh them as you go. How many grams of marbles did it take to sink your boat? _____*It will most likely be lower than predicted*_____

Was the result higher, lower or the same as prediction? _____

Repeat the experiment two more times to confirm your result. If the results did not match your prediction, propose an explanation for why.

_____*All of the marbles rolled to one corner so that the mass was not evenly distributed.* ____

_____

3) Use the supplies at your bench to modify your boat so that it can hold the amount of weight that you originally predicted. Draw a sketch of your modified boat.

Provide the strips of cardboard, scissors, tape and any other materials that might be useful for modifying the boat so that the marbles don’t all roll to one corner

4) How many marbles can your modified boat hold without sinking? Was the result higher, lower or the same as prediction?

The result should be closer to their prediction

Sample Post-activity questions for Day 2: Boat Sinking Lab

1) In your own words, what is buoyancy? You can draw a diagram to help explain what you mean.

Possible assessment rubric

	Excellent	**Good**	**Needs work**
Understanding of density	Uses mass and volume to explain density	Uses density to explain floating and sinking, but doesn’t include mass or volume	Describes floating and sinking, but not density
Ability to use vocabulary	Defines positive, negative and neutrally buoyant correctly	Use of terms is vague	No additional vocabulary
Draw conclusions	Explain why the boat with no dividers and the boat with 4 compartments behaved differently	Acknowledges that the boat behaves differently with and without dividers	No mention of the different conditions

2) Are ships usually positively, neutrally, or negatively buoyant? _____ *Positive*_____

3) The SS Minnow was a recreational fishing vessel that had nearly 200 people on board when it sank. What is the main source of mass on such a boat? In terms of how the weight is distributed on a ship, what do you think caused the sinking of the “SS Minnow?”

__*People are the main source of mass. If everyone moved to one side, the ship might sink*

_____

4) We have just learned that a large school of goliath groupers passed by the STERN of the SS Minnow just before it sank. The goliath grouper is a fish desired by ALL fishermen. If you think weight distribution caused the sinking, how could have the weight distribution on the SS Minnow changed so rapidly?

___ *Everyone moved to the stern of the boat to get the groupers.* _____

_____

Sample Worksheet for Day 3: How do fish control buoyancy?

1) Put the bottle with oil and water into the water trough. Is it positively, negatively or neturally buoyant? Why?

__*Neutral. Students should be explaining buoyancy in terms of density, mass and volume.* ____

2) Put the bottle of air into the water trough. Is it positively, negatively or neturally buoyant? Why?

Positive. Students should be explaining buoyancy in terms of density, mass and volume.

3) Fill a bottle with water and put it into the water trough. Is it positively, negatively or neturally buoyant? Why?

Negative. Students should be explaining buoyancy in terms of density, mass and volume.

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4) What can you do to the bottle of water in order to make it neutrally buoyant?

_*Add oil or air. An astute student may generalize and say anything that is less dense than water.*

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5) Take a baggie and fill it with air, but leave a small opening at the top. Pull the baggie down into the water until the top of the baggie is at the surface of the water. What happened to the air in the baggie? Why?

*The water will compress the baggie and push the air out*__

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6) Blow-up a balloon until it is about 1 foot in circumference and tie it off. Use the measuring tape and write down the circumference. ___*answers will vary*___

7) Have one person from your group hold the balloon underwater and then have one person measure the circumference. What is the circumference? ____ *answers will vary* ____

Was the balloon bigger or smaller than before? Why? _____

__ *smaller than before because the water compressed the air*_____

_____

8) Do confined gasses expand or contract when placed underwater? __*contract*_____

9) What would happen if you were able to push your balloon deeper and deeper?_____

_____*it would get smaller and smaller*_____

10) What happens to a fish’s swim bladder when they swim deeper? __*as fishes swim deeper, their swim bladders shrink*___

11) Imagine a fisherman catches two fish: one from shallow water and one from deep water. If both fish started with swimbladders that were the same size, which one will have a bigger swimbladder when it gets to the surface? _____*The fish from deeper water will have the bigger swimbladder at the surface.*_____

12) Use your knowledge of fish and compressed air to answer the following question. Why do fisherman often see a fish’s stomach protruding from its mouth when they catch a fish and pull it up quickly into the boat? Use a diagram to help explain what you mean.

Possible assessment rubric

	Excellent	**Good**	**Needs work**
Understanding of fish physiology	Equates the swim bladder with the balloon. Recognizes that the swim bladder pushes on the stomach	Describes air expanding in the fish, but doesn’t relate it to anatomical structures	Explanation unrelated to air expanding
Understanding of compressed gasses	Compares and contrasts what happens to gas volumes in a sealed container that is being pressurized and depressurized	Views compression and expansion as unrelated phenomena	Struggling to understand the relationship between pressure and gas volume

Guided-inquiry Quantitative Worksheet for Day 3: How do fish control buoyancy?

1) You have three bottles. One is filled with water, one is a combination of oil and water, and one is filled with air. Predict which one will be neutrally bouyant, which one will be positively buoyant and which one will be negatively buoyant when placed in the water trough.

_____

_____ *answers will vary* _____

_____

2) Test your predictions. Did the bottles behave as predicted? If not, why?

_____

_____ *answers will vary* _____

_____

3) The density of water is 1.0 g/cm^3 and the density of oil is 0.9 g/cm^3. If the bottle is 5% oil, what is the density of the bottle?

*Bottle density = (fraction of the bottle that is water * water density) + (fraction of the bottle that is oil * oil density)*

*= (0.95 * 1.0 g/cm^3) + (0.05 * 0.9 g/cm^3) = 0.995 g/cm^3*

3) The density of water is 1.0 g/cm^3 and the density of air is approximately 0.0012 g/cm^3. If the bottle is 5% air, what is the density of the bottle?

*Bottle density = (fraction of the bottle that is water * water density) + (fraction of the bottle that is air * air density)*

*= (0.95 * 1.0 g/cm^3) + (0.05 * 0.0012 g/cm^3) = 0.95006 g/cm^3*

Other possible quantitative questions:

- What is the volume of your bottle? Calculate how much air and water it should have to be neutrally buoyant (or the same density as the bottle of oil and water). Test your prediction.
- What is the average density of a marble? How many marbles do you need to add to a bottle of air in order to make it neutrally buoyant? Test your prediction.
- Sharks have a special oil in their livers called squalene which has a density of 0.858 g/cm^3. If a shark is mostly muscle (density = 1.06 g/cm^3), how much squalene does it need in its liver to be neutrally buoyant? Assume that the volume of the shark is 1 L. (*they’ll find that the shark needs to be approximately 25% oil, which is similar to what scientists have measured in real sharks)*

These two activities could lead to investigations of types of fishing gear, changes in food webs because species reproduce at different rates and by-catch species.

Possible Guided-inquiry for Day 4: Fishing expedition

Start with just one fisher and one fish filler. Time how long it takes to empty the ocean.

Add a second fisher and do the activity again. How long did it take to empty the ocean this time?

Instead of fishing with spoons, switch to fishing with hands. Do the activity again. How long did it take to empty the ocean?

In real life, what types of fishing gear allow fishers to catch more fish in less time? What are some advantages and disadvantages of this?

What would happen if the fish filler was slow? Find some examples of fish that reproduce quickly and fish that reproduce slowly.

Possible Guided-inquiry for Day 4: Fishing and fish reproduction

During each fishing season, each fisher can only take 6 spoonfuls* of fish out of the ocean before they have to stop. After the fishers are done, count the number of fishes left in the ocean. Record the number of fish left.

Assume that the fish can produce an average of two offspring per season**. Multiply the number of fishes left by two and put that many fishes into the ocean. For example, if 10 fish were left, add twenty to the ocean.

Repeat the previous two steps 4 or 5 more times. Make a graph of fish population size over time. Is the fish population increasing or decreasing?

Make a prediction. What would the graph look like if the fishers switched from spoons to hands? Test your prediction.

Make a prediction. What would the graph look like if each fish could only produce one off-spring. Test your prediction.

For an advanced class, you could have your students put their data into a population growth equation from your textbook or an online reference.

*The instructor may have to do a couple of practice runs to figure out the number of spoonfuls per season that would be required to observe a change in population size over time.
** You can have one species reproduce at a fast rate, while the other reproduces at a slow rate and have students graph the change in the ratio of the two species. The slow species could represent a non-target species that is by-catch.

Follow-up Activities

As an extension to this activity it is particularly helpful to discuss bycatch. Bycatch is defined as undesirable species captured in an effort to collect the species of interest. Most fisheries have bycatch rates ranging from 4:1 to 10:1 (i.e. four to 10 non-target animals caught for every one target animal; Evans and Wahju 1996). While this can be a sensitive subject, especially if images are shown of deceased dolphins, turtles, sharks, and other animals entangled in nets, it is a serious problem that if ignored, isn’t going away. Bycatch mortality can happen in a number of ways: physical trauma, suffocation, desiccation, and swim bladder expansion (the focus of the lab). Students easily make the connection between their compressed gasses exercise and what happens as fishes are pulled from depth in nets, and are cognizant that bycatch are killed and thrown back into the ocean and are not returned alive. Following this solemn discussion, one of hope can be shared by discussing “fish cards”, which detail what fisheries are sustainable and safe to eat and also shows those to avoid. Fish cards can be found on many websites, but the fish card from the Monterey Bay Aquarium is especially good, and interactive if viewed online. The URL is: http://www.seafoodwatch.org/seafood-recommendations. Another possibility is to discuss size limits for fisheries and why law does not allow certain sized fishes to be landed. Size limits are often implemented to protect reproductively active size classes of fish species such that the population size can be maintained by allowing for sufficient recruitment.

For seniors in high school, a reading of Roughgarden and Smith (1996) can elucidate the economics of fishing and also provides management suggestions for a sustainable cod fishery in eastern North America. For high school physiology courses, this exercise transitions nicely into a discussion of how fishes fill their swim bladders with oxygen. There are two strategies that fishes use to do this: 1) Physostomous swim bladders (e.g. in goldfish) are attached directly to

the digestive tract and fishes literally gulp air and pass it down the gastrointestinal tract to the swim bladder and inflate their “inner balloon”. 2) Physoclistous swim bladders (e.g. in sea bass) are not attached to the digestive tract, but are innervated with capillary beds (gas gland) from which the fishes pull oxygen and inflate the swim bladder. Sharks do not possess a swim bladder, and instead have an enlarged oily liver. The less-dense oil in the liver allows them to maintain a more neutrally buoyant position in the water column.

NEXT GENERATION SCIENCE STANDARDS

Physical Science Standards

Forces and Interactions MS PS2-2 and HS PS2-3

Earth System Science Standards

Earth and Human Activity HS ESS3-1, HS ESS3-3

Life Science Standards

Matter and Energy in Organisms and Ecosystems MS LS2-4

Interdependent Relationships in Ecosystems MS LS2-2, HS-LS2-6, HS-LS2-7, HS-LS4-6

Common Core Standards

Citations of textual evidence (RST .6-8.1), multistep experiments (RST .6-8.3)

Floating Fishes: an activity investigating overfishing, buoyancy, and gas compressibility.

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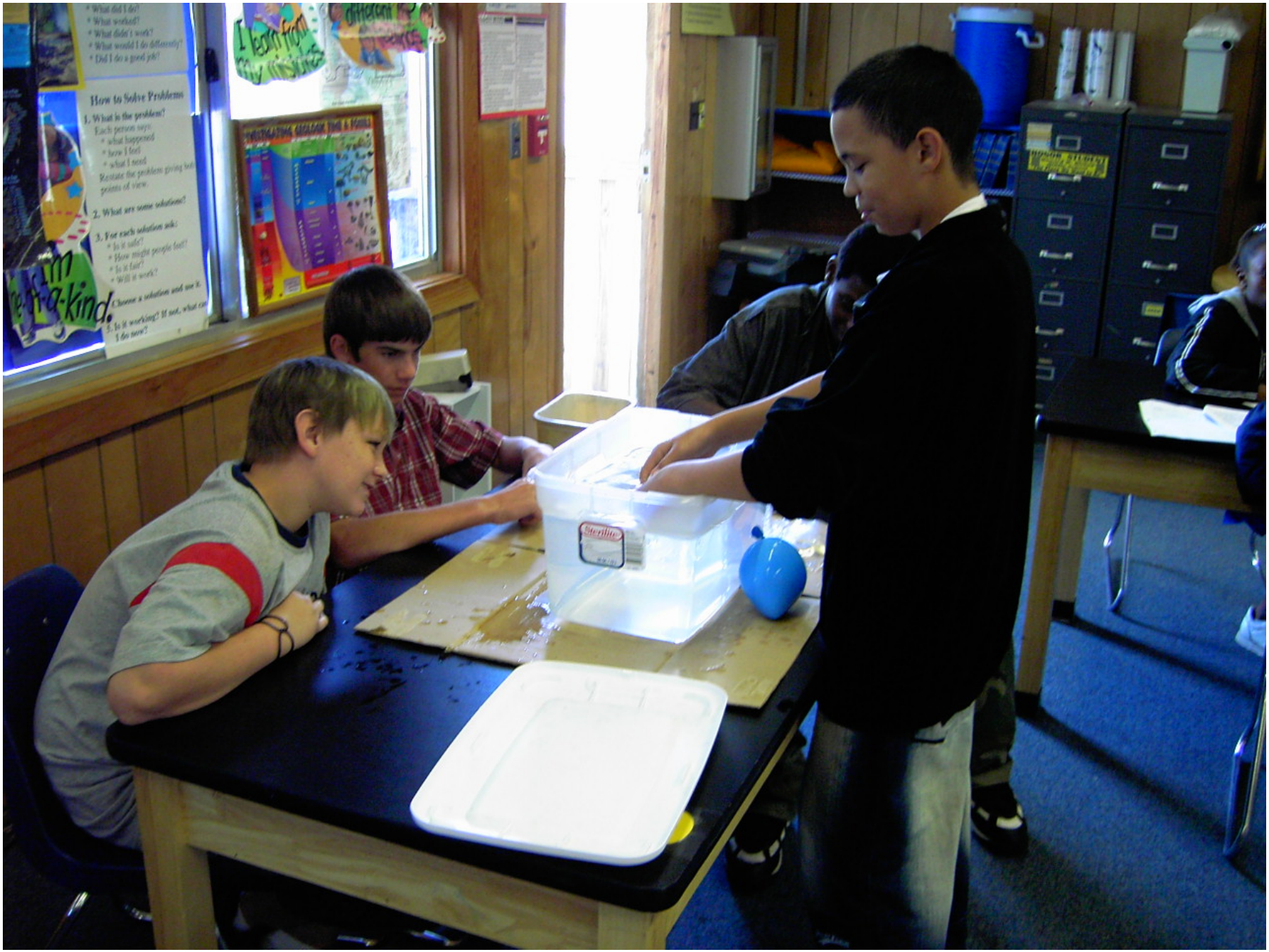
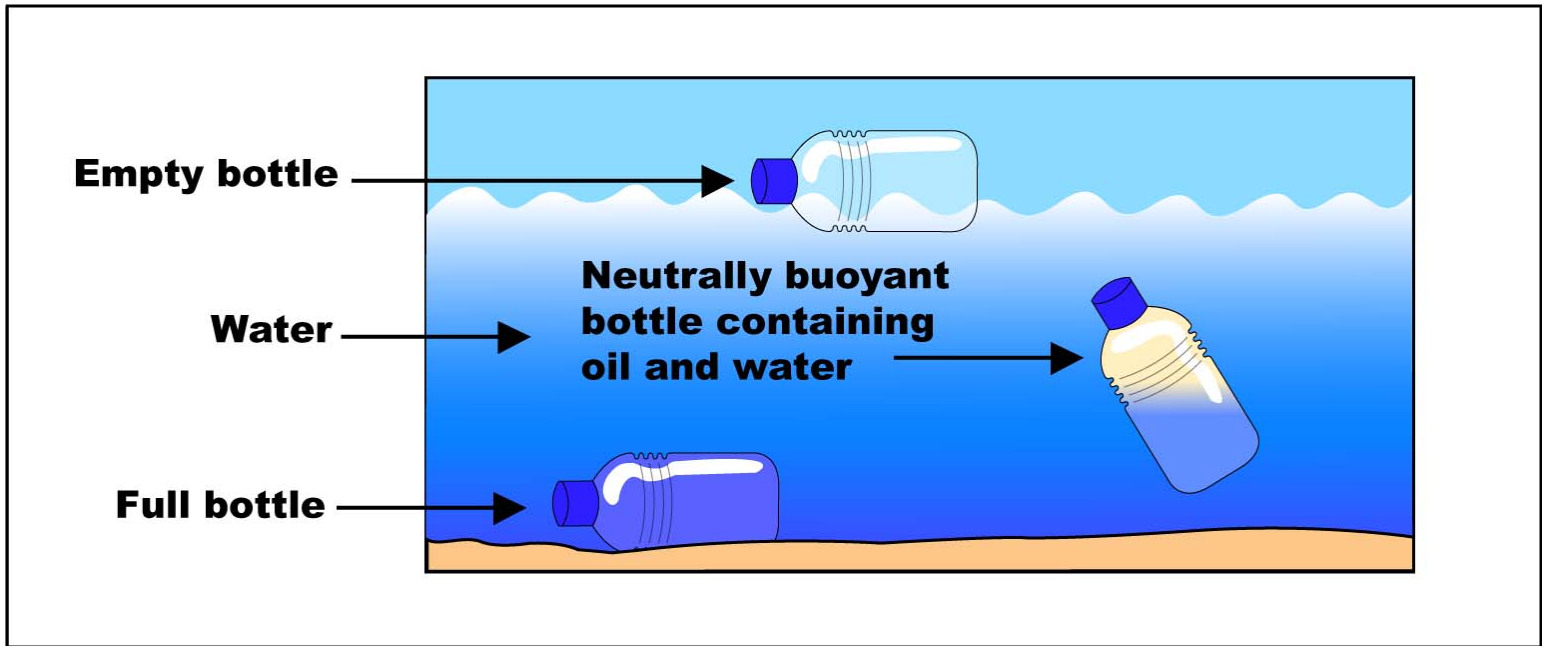
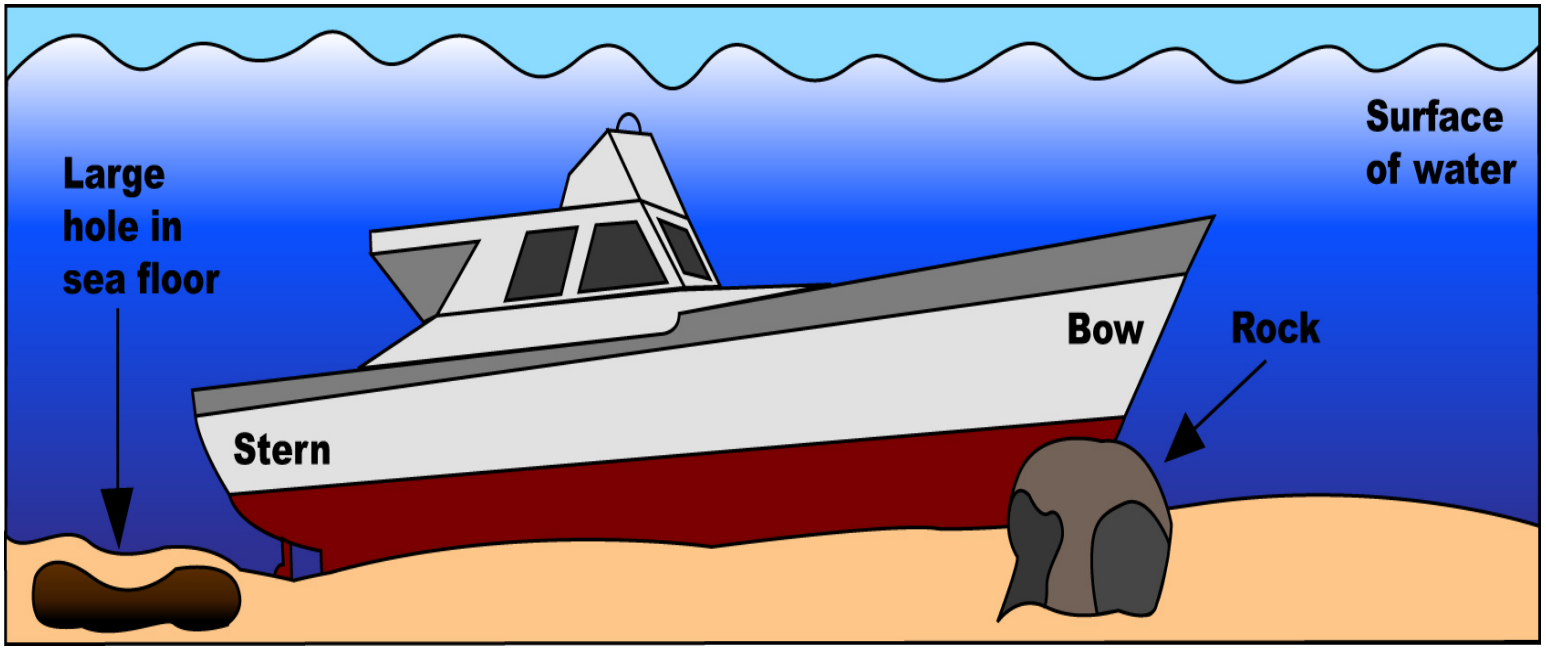
PowerPoint Extras

The next two slides were provided to show the materials and children enjoying the activity.

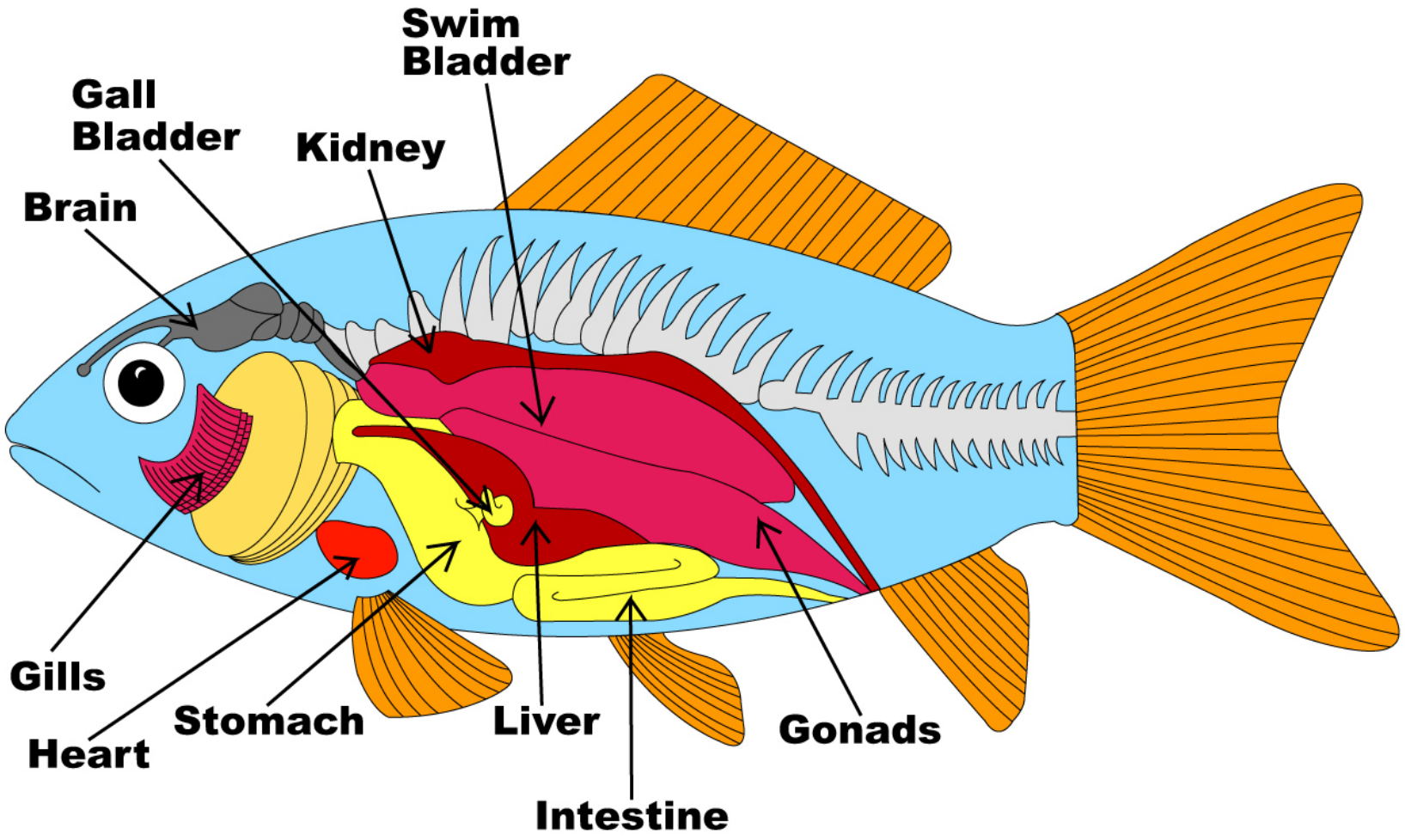

ING
The Human Skeleton
TIME OUT
Classroom Pledge
I pledge to show my respect by listening to others, using my hands for helping, caring about others feelings, and being responsible for what I say and do.
Explore
Inspire
Create.

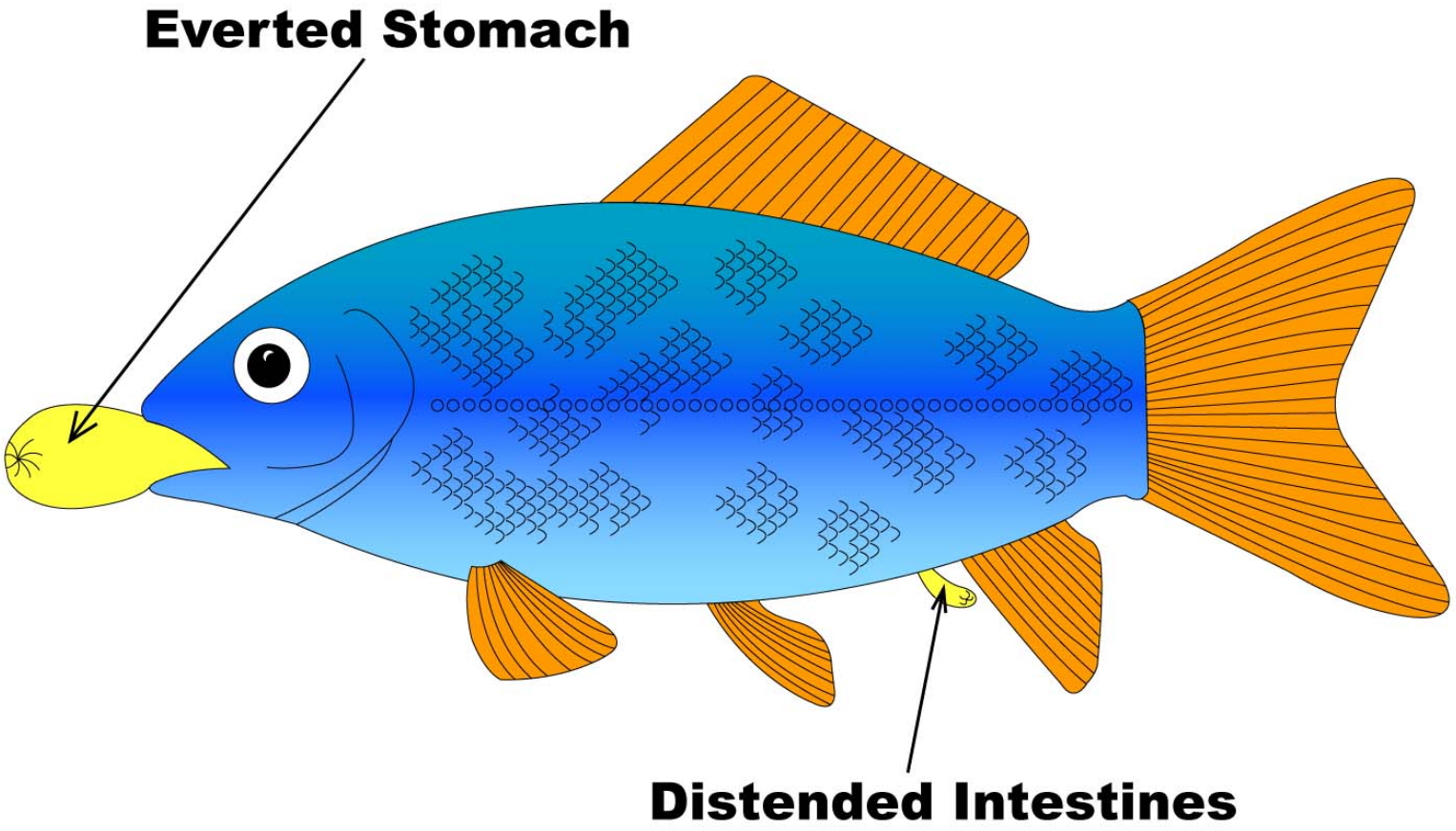

How to Solve Problems
1. What is the problem?
2. What are some solutions?
3. For each solution ask:
Sterilite


Empty bottle
Water
Full bottle
Neutrally buoyant
bottle containing
oil and water

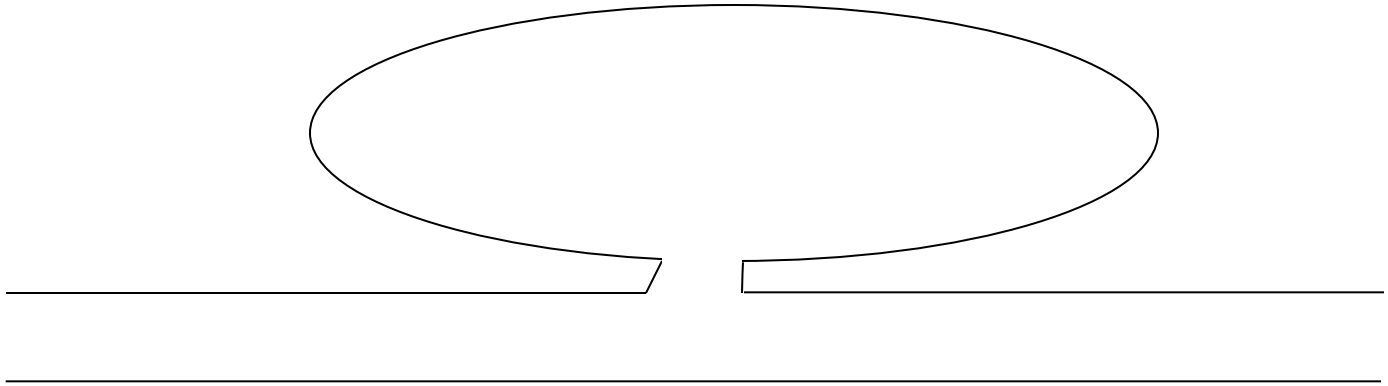

Large
hole in
sea floor
Surface
of water
Bow
Rock
Stern

The next three slides were provided for introductory material into fish anatomy and swim bladder location. Some illustrations of swim bladder expansion are also included.

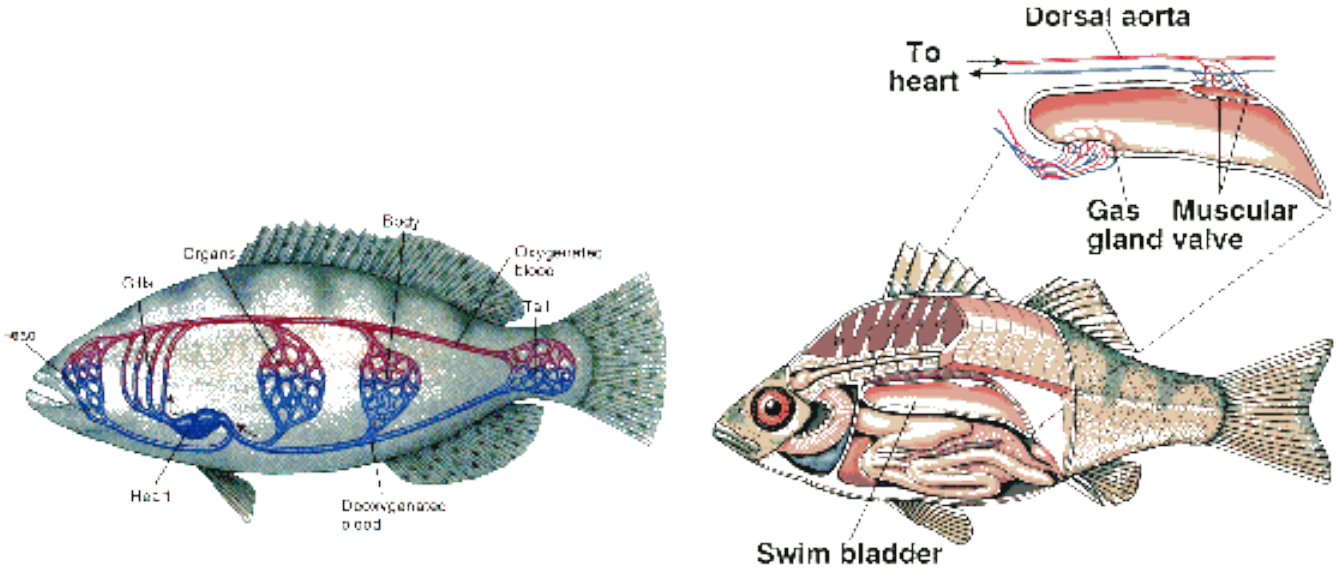

Swim Bladder
Gall Bladder
Kidney
Brain
Gills
Heart
Stomach
Liver
Intestine
Gonads


Everted Stomach
Distended Intestines

Physostmous swim bladder: connects to gut



Physoclistous swim bladder: connects to circulatory system



www.jochemnet.de/.../ BSC1011_17/sld006.htm

The next four slides were provided as evidence of commercial fisheries and the amount of fish they catch at one time. Photos were also included of by-catch to illustrate the graphic nature of commercial fishing. Make note that by-catch levels range from 2:1 (by-catch:target species) to greater than 10:1. Note the diversity of fishes in the last slide of this section.

Bycatch: what is it?

Any “non-target” species that is considered undesirable by the the fisherman.

Can bycatch survive?

They have many routes to mortality: suffocation, desiccation, physical trauma (including damaged swim bladders)

Mammals and sea turtles breath air; they can drown

How many species can you spot in this photo?

Are they all economically valuable?

What happens to the undesirable ones?