Affects of Temperature on the breathing rate of fish

In every glass of water we drink, some of the water has already passed through fishes, trees, bacteria, worms in the soil, and many other organisms, including people... Living systems cleanse water and make it fit, among other things, for human consumption and for the needs of other species. Trout are even fussier than we are.


Objectives:
1. Describe how a fish breathes, identifying the operculum and the gills work together to derive oxygen for the fish's biological needs.
2. Correlate a fish’s opercular rate (a measure indicating its respiratory rate), with the temperature of its surroundings.
3. Define thermal pollution and identify sources of thermal pollution that threaten fish populations.

Background:
Our atmosphere contains approximately 21% oxygen gas. This source of oxygen is constantly being used and recycled through the reciprocal reactions of photosynthesis and respiration. Terrestrial creatures have adapted lungs and aquatic creatures have gills that can utilize this gas for metabolic needs. The minimum amount of oxygen any organism needs to satisfy its metabolic needs is referred to as its biological oxygen demand or (B.O.D).

The more active an organisms is, the higher its B.O.D becomes. When the B.O.D of an organism is increased, it responds by accelerating its respiratory rate. In the case of terrestrial creatures, the rate at which the diaphragm and lungs contract increases. In aquatic organisms such as fish, the method is slightly different. Fish breathe by forcing water over their gills by contracting two posterior flaps covering the gills called operculum.

Chemically speaking, the amount of dissolved oxygen gas that a given quantity of water can hold is directly proportional to the temperature of the water: the colder the water, the more oxygen it can hold, the warmer the water the less dissolved oxygen it can hold. This is crucial to fish populations that are adapted to living in cold waters. They are used to meeting their B.O.D with a relatively low opercular rate (the rate at which the operculum pass water over the gills for oxygen extraction). If temperatures in their normally cool waters rise significantly, the amount of dissolved oxygen is decreased, forcing the fish to increase their opercular rate to satisfy their B.O.D. If the temperature is too high, the fish can literally “suffocate” regardless of how fast its opercular rate becomes.

This fact becomes a concern when one considers the climatic changes brought about by global warming. People first argued whether global warming was fact or fallacy. Now the consensus is that it is a reality. Currently, people debate the effects of global warming from none at all to extreme effects. Evidence with regard to how global warming has affected aquatic ecosystems has shown:
(1) Freshwater sources that many species of fish depend on for survival are drying up.
(2) The cold water that other species require for breeding is becoming warmer and affecting spawning rates and
(3) Rising sea levels are destroying the coastal estuaries where fish spawn.

These findings should start to make people believe that global warming and its effects is more than the rantings of hippies. Furthermore, thermal pollution in the form of commercial water discharge is threatening fish populations.

Materials:
1. Goldfish
2. 600 ml beaker
3. Thermometer
4. Ice

Procedure:
1. At each lab station, you should have a goldfish swimming in a 600ml beaker. Record the temperature of the water in the data table (initial temperature). Count the number of times the fish breathes in one minute, by counting the number of times the operculum flaps open. Record that number in the data table.

2. Now, add ice chips, several at a time to the beaker. Stir the water frequently in the beaker to ensure an even temperature. NOTE: LOWER THE TEMPERATURE SLOWLY SO THE FISH DO NOT GO INTO SHOCK. As the temperature is dropping, complete #19 and the table associated with it on your fish assignment.
   
   When the temperature has come down to 15 degrees Celcius, count the number of times the fish breathes in one minute, (opercular rate) and record this number in the data table.

   Add more ice, slowly, bringing the temperature down to 10 degrees. Count the opercular rate for one minute and record this data in the table.

3. Pour about half the water out and replace it with warm water from the sink, filling the beaker to the 400 ml mark. You want to bring the temperature back to 20 -23 degrees Celcius.

4. Share your data with your partner, and graph the results of your procedure. Using a line graph, plot the breathing rate you determined for each of the three temperatures. Breathing rate should be placed on the Y axis of your graph paper and the temperature on the X axis. Use the data to help answer the discussion questions.
The Affect of Temperature on the Breathing Rate of Fish: DATA SHEET

<table>
<thead>
<tr>
<th>Temperature (degrees Celsius)</th>
<th>Opercular Rate (breaths per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Temperature:</td>
<td></td>
</tr>
<tr>
<td>15 degrees</td>
<td></td>
</tr>
<tr>
<td>10 degrees</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions:

1. How does temperature affect the overall activity and behavior of the fish? Be descriptive in your response.
2. Look at the graph you made. Explain the relationship between temperature and a fish’s breathing rate?

3. Cold water holds more dissolved oxygen than warmer water. Using this information, and your observations, explain how rising temperatures in a lake or pond would impact fish populations. Be specific.

4. Why do you think we cooled the fish down rather than heat them up? What would have happened to their breathing rate? How would this affect them?

Thermal pollution isn't good for the fish,  
Though they've not voices, there's one thing they wish.  
Whether brook, stream, pond, lake or river,  
They prefer to be cold, and breathe best when they shiver!

~ (N. Dullinger channeling Dr. Seuss)