Lesson Title: Testing, Testing	Date: February 1, 2008
Author: Ryan Lenz	Topic: Nitrate concentration before and after dilution
Grade level: 8th	Lesson Length: 45 minutes

Overview: Students make estimations on the concentration of nitrate before and after a water change. Students observe or participate in a partial water change. Then three groups of students measure pre-water change water, post-water change water, and the water used for the water change. Predicted values are compared with actual values, and possible explanations are explored. Emphasis on experimental error, such as incomplete mixing, subjectivity of color readings, or lack of precise readings.

Objectives: Students will:

- Understand the necessity of removing accumulated wastes from a closed ecosystem.
- Perform a quantitative analysis of water quality and propose explanations for their observations.
- Predict and compare concentrations of a substance (nitrate) before and after dilution.
- Look for sources and directionality of error in their analysis

Enduring Understandings: Aquariums are closed ecosystems; therefore metabolic byproducts (e.g. nitrate) will accumulate unless removed via dilution or some other means. Waste products (such as nitrate) are toxic at high concentrations and can be diluted to acceptable levels. The concentration of a substance decreases after dilution.

Prior Expectations from Learner: The student should understand that all living organisms digest food and excrete waste. A substance can dissolve in water. Fish waste (urea, fecal pellets) is harmful to the inhabitants of an aquarium.

Assessment: During the discussion on predicted vs. actual results, students should be able to explain the direction of the effect. In other words, if they suggest that the new water that was used to do a water change had nitrates in it, they should understand that the decrease in nitrates would be less than they expected. A brief quiz at the end of the lesson could include questions such as:

Why do we need to test for nitrates? How does a water change affect the concentration of nitrate? What was the first step in the nitrate test?

Materials	Teacher	Student	Notes
	Buckets (for water change) Hose (for water change) Fresh seawater (for water change, testing)	Nitrate test kit (one per group)	

Section/Time	Teacher Activity	Student Activity	Notes
Prep:	Prepare approximately 20 gallons of synthetic saltwater, or collect 20 gallons of natural saltwater. (Note--this is an excellent student activity). Also, collect several cups of water from the aquarium. Calculate the volume of the tank (students can do this)	Calculate volume of tank (previous lesson?)	

Engagement (5 min)	Begin by asking why we need to change water in the aquarium? (Because fish waste, in particular nitrate, builds up in the aquarium. Also, micronutrients such as iodine, calcium and carbonate are depleted by the growth of organisms.) Why does nitrate build up? (Because the bacteria that eat nitrate need low-oxygen environments, and the aquarium is a high-oxygen environment.) Where does the nitrogen come from? (fish food, waste of animals) Introduce the nitrate test kit. Tell the students that this is a tool that is used to measure how much nitrate is in the aquarium. It works by adding a certain chemical to the water that reacts with nitrate to form a colored molecule. The more nitrate, the more intense the color. Remind them that nitrate builds up and becomes toxic when it becomes too concentrated. Students may need a brief explanation of the term concentration (and dilution) Guiding questions: How do we reduce the concentration of nitrate in the aquarium? (Water changes). So if we removed 25% of the water in the aquarium, would we expect to get rid of all the nitrates? (No, you would expect to reduce them by 25%.) How could you test this idea? (Test water before water change, test water after water change)	Listen, respond to questions, observe the parts of the nitrate test kit (especially the color comparator chart)	
Main activity (30 min)	Divide the students into small groups. Present the students with a small amount (1/2 cup is plenty) of "old" aquarium water. Warn students of the possible dangers of these chemicals (they are actually very safe). Allow students ~5 minutes to test the water for nitrate concentration. This is a good opportunity for the students to read the instructions that come with the test. Monitor testing procedures. Tell students you have X gallons of new saltwater, and that you need to calculate what percent you will be changing. To do this, you will need two numbers: the volume of the aquarium, and the volume of water to be changed. Divide volume of water to be changed by volume of aquarium and you have percent change. Depending on time limits and previous student experience, you may either lead the students into the hallway and perform a 25% water change, or you may simply remove 25% of the water you used previously and replace it with clean water. (Note: the more water you change, the more dramatic your results will be) Discuss the dilution with students. Predict the new concentration mathematically (i.e. 50 ppm original X .75 = 37.5 ppm). Allow students to test new concentration. Compare to prediction. If there is some deviation, ask for possible explanations. Ask students to explain the effect they would expect these causes would have on their values. Possible causes of error and effects on final	Students, working in groups, read instructions, test the concentration of nitrates and record their data. Students observe or take part in a water change. Students test new concentration and compare to old. They should see a reduction by whatever percentage of water that was changed. Most likely, the results will be close to their prediction, but not exact. They will	Note: This lesson requires the volume of the tank to be known. Measure the tank in cubic inches and divide by 231 to convert to gallons.

	results are: • New water contains nitrate (very possible if wild-collected--less likely if synthetic). This would lead to less decrease than predicted. • Actual tank volume is less than calculated (most likely due to displacement of water by rocks, filter material, glass walls). This would lead to greater decrease in concentration than predicted. • Lack of precision/accuracy in measurement. Unpredictable effect. • New water wasn't adequately mixed before a sample was taken. Unpredictable effect.	(working in groups or independently) analyze their results and attempt to explain this discrepancy.
Closure (5 min)	Review the importance of monitoring nitrate levels. In the aquarium, these levels are indicators of when a water change is necessary. (Nitrates can also be present in drinking water as a result of agricultural runoff--they are considered a pollutant) When nitrate levels reach a certain level, they must be diluted to avoid harm. Nitrate test kits work by mixing a chemical that changes color when it binds with nitrate.	Students share information they have learned with class.
TAG Differentiation:	Denitrification (conversion of nitrate to nitrogen gas) can occur in the presence of anaerobic bacteria. Challenge students to create a "nitrate reactor", and see if they can reduce nitrate levels. For examples of commercially available nitrate reactors, look through aquarium stores (such as marinedepot.com, drsfostersmith.com, premiumaquatics.com).	

Extensions:

- Keep track of nitrate levels on a large graph posted near the aquarium. Test weekly (or twice weekly) and chart results with a line graph. On the vertical axes, indicate what levels are hazardous (more than 100 ppm), tolerable (between 50 and 100) and ideal (less than 50).
- The test kits also monitor nitrite levels. Nitrite, like ammonia, is extremely toxic to aquariums, even in small amounts. It should be present only when the tank is going through its initial "cycle", or after some kind of (potentially catastrophic) die-off event. When the aquarium is first started, the gradual disappearance of nitrite (it is converted to nitrate--less toxic) is an indicator that the tank is ready for sensitive animals.