Title: Antarcti-Freeze

Grade Level: Middle School (6-8)

Subject: Adaptations to Polar Marine Environment

Connection to ICEFISH Cruise: Scientists participating in the ICEFISH Cruise are interested in the adaptations that fish have to living in an extremely cold environment. On previous cruises in the Antarctic, scientists discovered a chemical in the blood of icefish that keep their blood from freezing. During this cruise, scientists will be looking for the presence of this chemical in fish that live in water that in not as cold.

Background
We all know that fish live in fresh and salt water. They have all evolved adaptations to living in these environments. We also know that all animals have salt in their bodies and that salt is necessary for a variety of physiological functions to occur. However, too much salt in the body can be bad and too little salt can also be bad, particularly for fish. So, fish that live in salt water have adapted over time to control the amount of salt in their bodies. One important thing that salt does when it is added to water is that it reduces the temperature at which the solution will freeze. For fish that live in more temperate or tropical waters, this is not a major concern. But fish that live in polar environments must balance the amount salt in their bodies and still have a way to keep from freezing (remember, too much salt is bad). Fish in polar environments have evolved to produce a chemical that acts as “antifreeze”. It is called a Glycoprotein. The presence of this extra chemical prevents the water inside their bodies from freezing. This is important because, even though the water inside the fish is salty, it is not salty enough to keep from freezing in the cold, cold waters of the Antarctic.

Objective
It is an easy activity to conduct either as a demonstration or an entire class experiment. For this exercise, the added “antifreeze” agent is rubbing alcohol (Isopropyl alcohol). By the end of the activity, students should be able to explain why certain salt solutions freeze or partially freeze in very cold environments. They should also be able to explain the value of high salt concentrations and “anti-freeze” agents as an adaptation to polar environments.

Time
1.5 - 2 45-minute periods

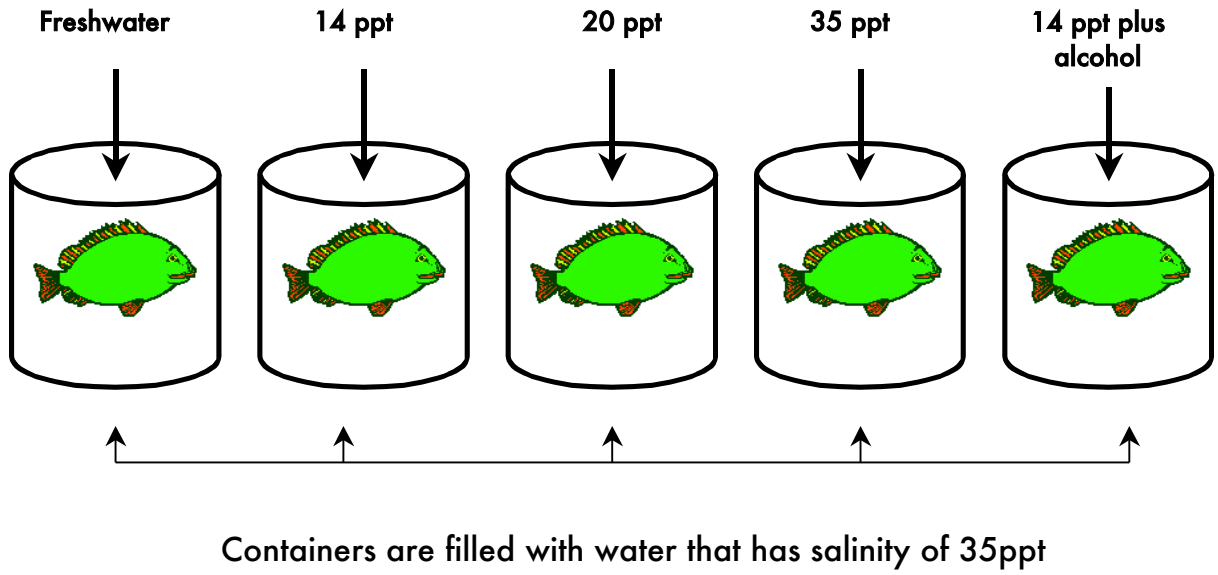
Materials
For each team:
Several small balloons (the fingers of a rubber or nitrile glove will work too)
At least 4 containers of equal size, preferably transparent (~300ml)
Table salt
Rubbing Alcohol (Isopropyl)
Graduated Cylinders
Tap water
Balance or electronic scale for measuring salt
Permanent markers and labeling tape

Advanced Preparation
We suggest the following concentrations 0, 14, 20, and 35 parts per thousand. You can create these solutions by using a standard formula that uses the weight of common table salt in a fixed volume of water (e.g. 1000ml). For example, to create a 20 parts per thousand solution, weigh out 20 grams of salt, add to a graduated cylinder and fill with tap water to the 1000ml mark. For the Alcohol solution, add 14 grams of salt to a graduated cylinder, then add 200ml of Rubbing Alcohol, and fill the rest with tap water to the 1000ml mark. Lastly, create a large volume of 35ppt salt solution, enough to fill all the containers for each team (~6-8L). The containers are filled with a solution of 35 ppt because that is the average salinity of the world's oceans.

Activity
Break the class up into teams of three or four students. Teachers can have the students gain experience with weighing and measuring mass and volumes by having each team be responsible for creating on of the concentrations (except the rubbing alcohol solution, teachers should make this one!).

Fill each balloon with a different concentration of salt, tie up the end and draw some fins, gills and eyes (so it looks like a fish!). Fill halfway, each teams' containers with 35ppt salt solution (to simulate the ocean). Make predictions about which one(s) will freeze or partially freeze. Place the balloons in the containers of "saltwater" and place them in the freezer. Make sure you label each container with the concentration of the "balloon fish". Make sure you have a thermometer in the freezer and record the temperature.

The diagram below illustrates the correct setup of the experiment



Synthesis
The next day, remove the containers and observe the "balloon fish". Have any or all of them frozen. Have students interpret the results of this experiment verbally, or on paper. Have a discussion with your students about how this knowledge of temperature/salinity/and blood can be applied to human medicine.

Extended Investigations
Teachers can lead discussion about various methods for measuring salinity of a solution such as freezing point depressions, refractometry, conductivity and hydrometry. Teachers can also lead a discussion about how antifreeze gene can be used in biotech/biomedical applications