Teaching with the Great Lakes Observing System (GLOS) Dead Zone Enrichment Unit

Lesson 3: Interpreting graphs of water temperature vs. depth

Activity: Investigate seasonal cycles by interpreting Great Lakes Coastal Forecasting System graphs of water temperature vs. depth

Grade levels: 5-8
Subjects: Science
Setting: Classroom
Duration: 45 minutes
Key terms: density, epilimnion, hypolimnion, metalimnion, thermocline

Objectives

Following this lesson, students will be able to:

- Explain how unique properties of water contribute to seasonal cycles
- Describe the Great Lakes seasonal cycle
- Explain water temperature vs. depth graphs

Summary

Many lakes within the Great Lakes region undergo seasonal cycles that are caused, in part, by unique properties of water.

In summer and winter lake water becomes stratified, preventing surface and bottom water from mixing. Bottom water is cut off from new supplies of oxygen from the air. The lakes 'turnover' in the spring and fall distributing oxygen within the lakes.

Background

Many lakes within the Great Lakes region undergo seasonal cycles which are caused, in part, by unique properties of water. As water cools its density increases and it sinks. Therefore, warmer waters are always found on top of cooler waters in lakes. During the summer and winter, the typical water profile of a lake is stratified into layers of water with differing densities.

Water is one of the few substances that is less dense as solid than as liquid. As temperature approaches 0^{o}C, ice forms. The density of ice is almost ten times lighter than liquid water and floats on top of the lake. In winter, ice floats on top of warmer waters. In the spring and the fall lakes 'turnover', distributing oxygen within the lakes.

- **Summer:** Sun warms the lake, heating the lake from the surface down. Warm water is less dense, creating a layer of warm water floating over cold water. Lake waters form layers (thermal stratification).
    - Epilimnion: Warm water at the surface
    - Hypolimnion: Cold water at depth
    - Metalimnion: Layer of water in between

  During the summer, stratification prevents complete mixing. Water is only mixed in the epilimnion. Warm water, sunlight and nutrients in the epilimnion are ideal for algae growth
- **Autumn:** Epilimnion shrinks as temperatures decrease. Eventually, as the lake loses stratification, lake temperatures become uniform. Surface water in contact with cold air cools faster than the water below and cold, dense water sinks mixing the lake. Wind can also mix lake waters again. This turnover replenishes oxygen and nutrients throughout the lake.
- **Winter:** Surface water cools below 4^{0}C and water no longer sinks. As surface water temperatures reach 0^{o}C, ice begins to cover the lake. A layer of low density water colder than 4^{0}C, but warmer than 0^{o}C forms just below the ice. Below this water, the remainder of the lake water is usually near 4^{0}C. Ice cover prevents wind from mixing the lake.
- **Spring:** Ice melts. Lake water is generally the same temperature from the surface to the bottom. Spring turnover occurs as wind circulation allows mixing, surface water is pushed to the bottom and bottom waters rise to the surface. Turnover allows relatively large amounts of oxygen to reach the bottom of the lake.

Activity: Investigate seasonal cycles by interpreting Great Lakes Coastal Forecasting System graphs of water temperature vs. depth

Materials and Preparation

- Computer with internet access (not necessary to complete lesson, as an alternative use example images)
- Download:
  - Temperature vs. depth graphs - Select temperature profiles at http://www.glerl.noaa.gov/res/glcfs/
  - Buoy data - Select eastern or western Great Lakes at http://www.ndbc.noaa.gov/rmd.shtml

Go to examples page for: Surface temperature image examples

Procedure

Use Great Lakes Coastal Forecasting System graphs to investigate water temperature vs. depth

1. Find water temperature vs. depth graphs. Go to http://www.glerl.noaa.gov/res/glcfs/ and select 'temp profile' for the Great Lake nearest you (see example slides # 1 & #2)
2. Find location of graphs. To find where the water temperature vs. depth graphs are located, look up the National Data Buoy Center (NDBC) number on the bottom of the graph ---
   a. Find the National Data Buoy Center (NDBC) number on the bottom of the graph
   b. Look up the location of the buoy at http://www.ndbc.noaa.gov/rmd.shtml (select the eastern or western Great Lakes image) (see example slides #3 & #4)
3. Interpreting water temperature vs. depth graphs. Each water temperature vs. depth graph displays depth in meters (y-axis) and water temperature (F^o) (x-axis). The date and time are listed near the top of the page
4. Look up other graphs. The most recent water temperature profile graphs are displayed, but water temperature vs. depth graphs from up to 48 hours previous are also available

a. Links to profiles are across the top of the page (-01 = one hour previous)

5. Print graphs. Use printed graphs to answer questions on the data sheet

Source

WOW - Studying Temperature Variation in Lakes
http://waterontheweb.org/curricula/bs/student/diel/study.html

Assessment

This assessment chart was designed for teachers to create their own assessment. The recommended points show the relative difficulty of student performance. In creating assessments, the total point value depends on the number and type of performances selected.

Learning Objective	**Student Performance**	**Recmnd # Points**
Describe unique properties of water which contribute to seasonal cycles	**Describe** a property of water which contributes to seasonal cycles	
Describe the Great Lakes seasonal cycle	**Describe** the Great Lakes seasonal cycle	
Explain graphs	**Explain** water temperature vs. depth data/graphs	

Standards

Michigan

State of Michigan – Grade Level Content Expectations 5th-7th grade			
Discipline 1: Science processes	Discipline 2: Physical science	Discipline 3: Life science	Discipline 4: Earth science
Inquiry, analysis & communication (IA) S.IA.05-07.11 – Analyze information from graphs to answer scientific questions *Reflection & social implications (RS)* S.RS.M.1 Reflecting on knowledge S.RS.05-07.15 – Demonstrate scientific concepts through various models & activities	*Properties of matter (PM)* P.PM.M.2 Elements & compounds P.PM.07.24 – List examples of physical & chemical properties of elements & compounds		*Earth systems (ES)* E.ES.M.1 Solar energy E.ES.07.12 – Describe the relationship between the warming of the atmosphere of the Earth by the sun & convection within the atmosphere & oceans

National

NSES	Ocean Literacy
Middle	Middle / High
A1.3 A1.5 B1.1 B3.2 D3.4	4a 5e 5f 6e

Notes:
State of Michigan = Michigan Dept of ED - Grade level content expectations
NSES = National science education standards
Ocean Literacy = Essential principles of ocean sciences, an ocean-oriented approach to teaching the National Science Education Standards

National Science Education Standards

Middle

A1.3 – use appropriate tools & techniques to gather, analyze & interpret data
A1.5 – think critically & logically to make the relationships between evidence & explanations
B1.1 – a substance has characteristic properties, such as density, a boiling point & solubility, all of which are independent of the amount of the sample
B3.2 – heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature
D3.4 – the sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents & the water cycle

Ocean literacy standards

4a – most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean
5e – the ocean is three-dimensional, offering vast living space & diverse habitats from the surface through the water column to the seafloor
5f – ocean habitats are defined by environmental factors
6e – humans affect the ocean in a variety of ways

Glossary

Density: Mass of a substance per unit volume. Density is the measure of the relative 'heaviness' of objects with a constant volume. For example, a rock is obviously more dense than a crumpled piece of paper of the same size. A styrofoam cup is less dense than a ceramic cup.

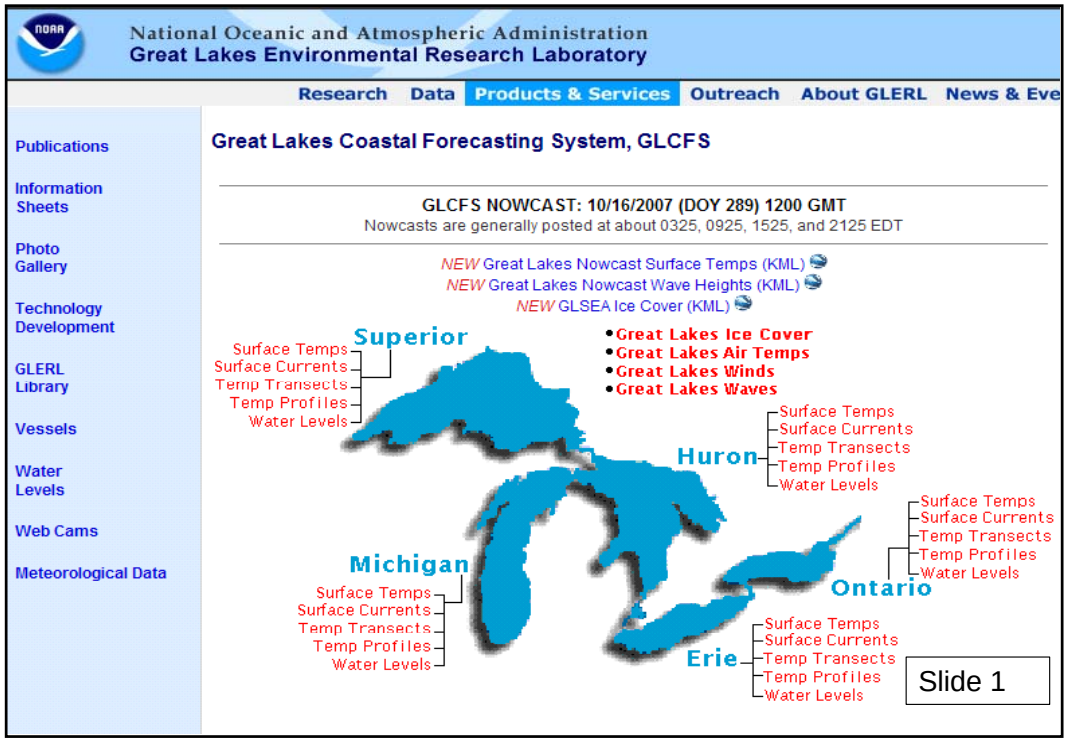
Epilimnion: (ep-uh-lim-nee-on)
The surface water in a lake or ocean into which light penetrates
(epi = upon; limnio = lake, marsh)
Audio pronunciation: http://biology.clc.uc.edu/scripts/glossary.pl

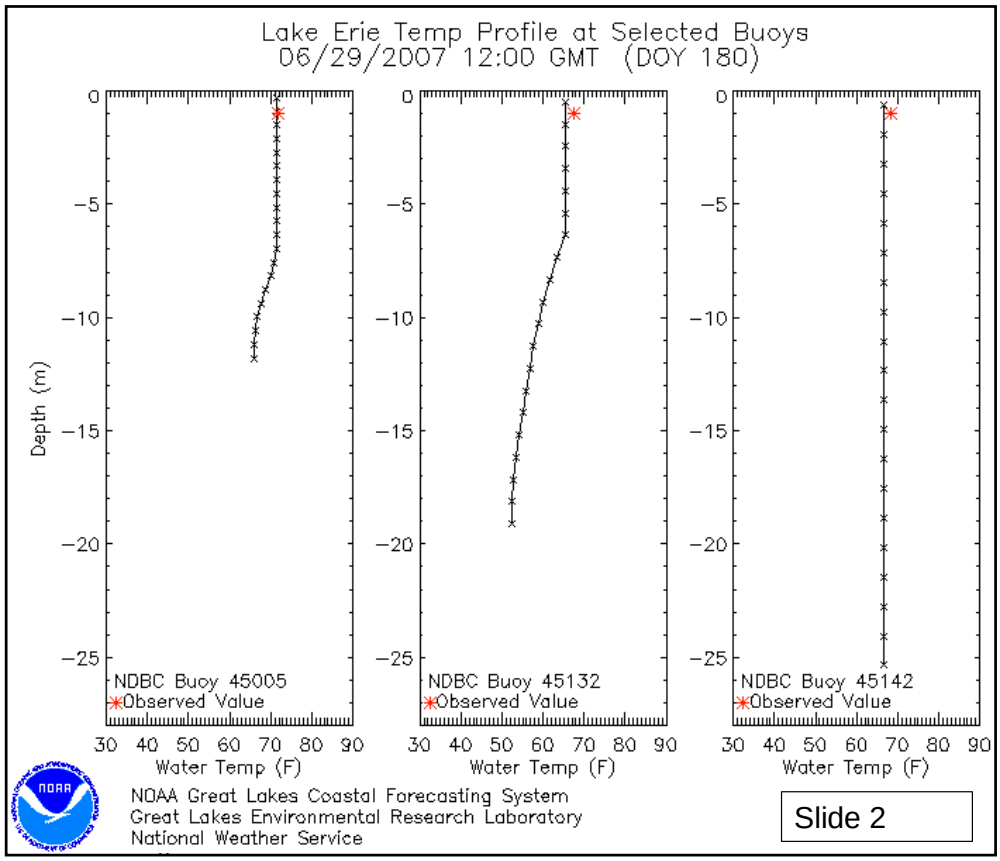
Hypolimnion: (hahy-puh-lim-nee-on)
The deep, bottom layer of water in a lake or an ocean
(hypo = beneath; limnio = lake, marsh)
(Audio pronunciation: http://biology.clc.uc.edu/scripts/glossary.pl)

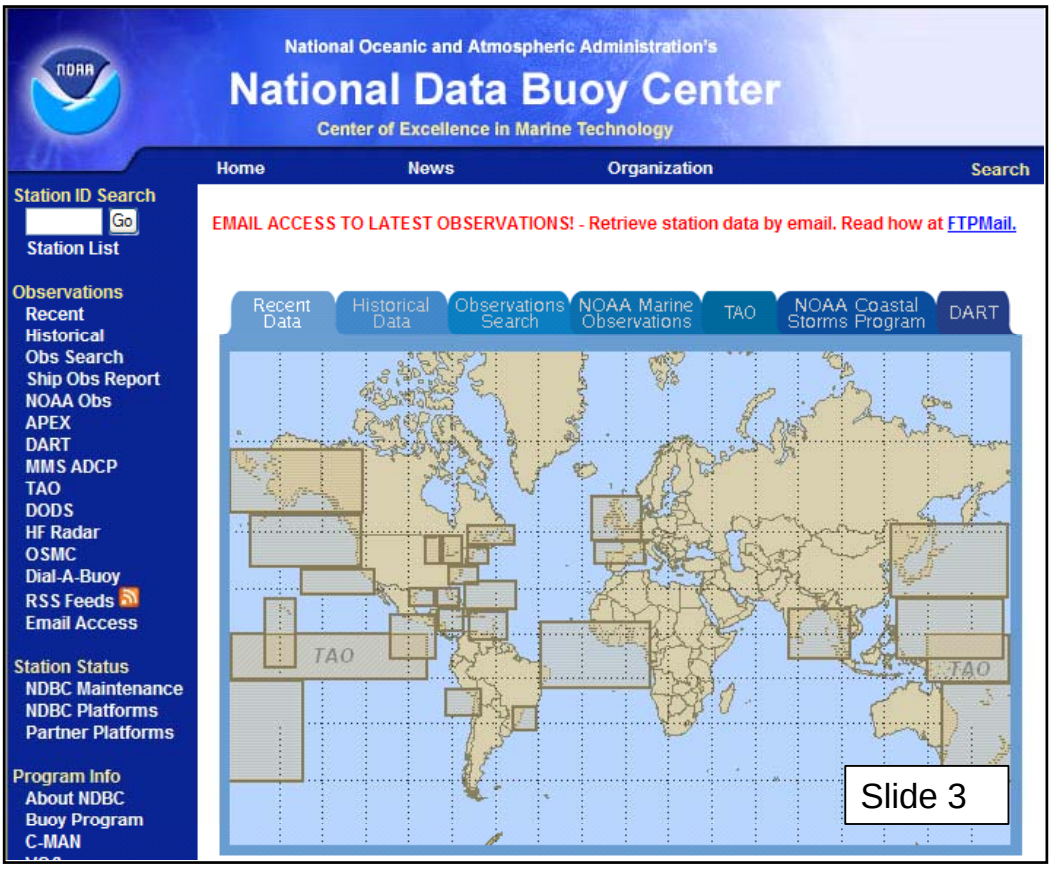
Metalimnion: (meta-lim-nee-on)
Layer of water in between the epilimnion and hypolimnion that sharply separates regions differing in temperature, may also be called a thermocline
(meta = between; limnio = lake, marsh)
(Audio pronunciation: http://biology.clc.uc.edu/scripts/glossary.pl)

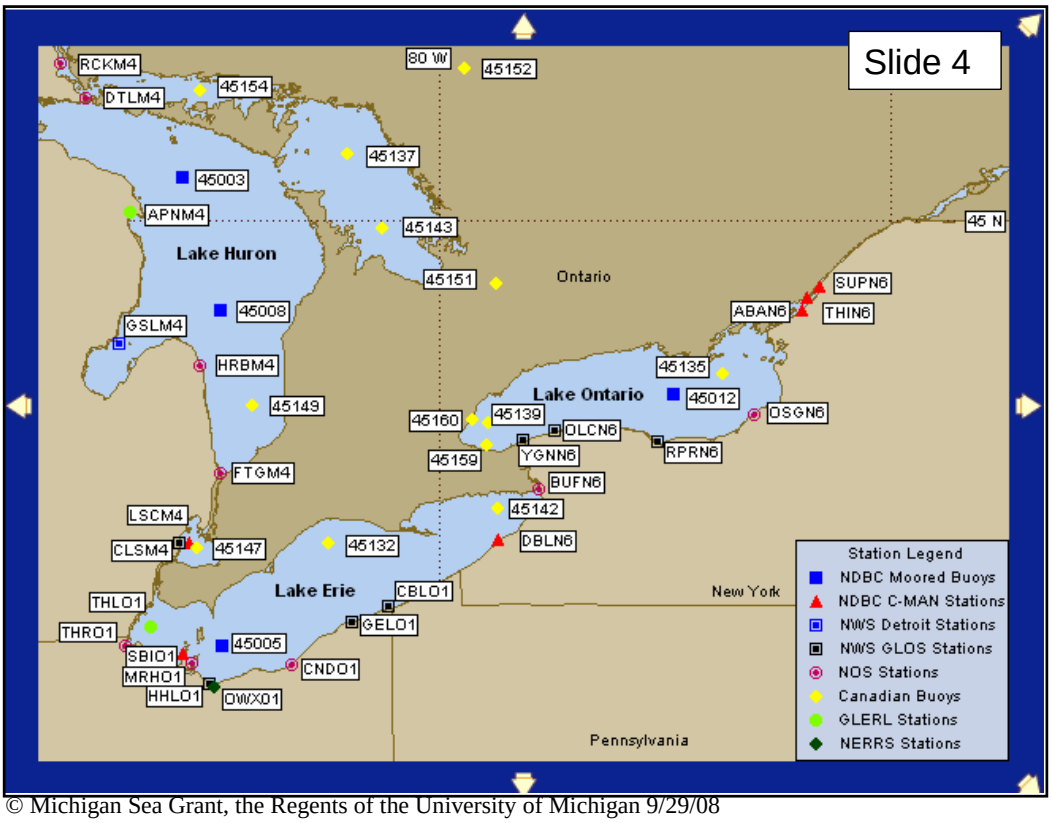
Thermocline: A layer in the water column in a body of water, such as a lake or in the ocean that abruptly separates water masses differing in temperature.

Examples









Data sheet

Use water temperature vs. depth graphs to answer these questions

1. Do any of the graphs show stratification?

2. Is this what you expected based on the seasonal water cycle? Why?

3. If present, label the epilimnion and hypolimnion of each graph

4. Do the graphs differ?

5. What variables do you think affect temperature stratification in lakes?

Data sheet (Key – based on example graphs from 6/29/2007)

Use water temperature vs. depth graphs to answer these questions

1. Do any of the graphs show stratification?

   Yes, graph 45005 & graph 45132

2. Is this what you expected based on the seasonal water cycle?

   Yes, it is typically for lakes to become stratified during the summer

3. If present, label the epilimnion and hypolimnion of each graphs

   Epilimnion is the vertical portion at the top of the graph (from the surface to approx. 8 m below the surface). Hypolimnion is the portion from the approx. 8 m to the bottom

4. Do the graphs differ?

   Yes, (1) graph 45142 is not stratified. Temperature appears to be uniform in graph 45142. (2) Depths differ in each graph

5. What variables do you think affect temperature stratification in lakes?

   Water depth, orientation of the lake, wind speed, wind direction