

Lake Champlain's Lakemounts: Are they Freshwater Biodiversity Hotspots?

How might underwater mountains in Lake Champlain influence biodiversity and lake productivity? Why is this research important for lake management and understanding freshwater ecosystems?

OVERVIEW

This lesson highlights ongoing research in Lake Champlain that explores how lakemounts may influence the lake ecosystem. This lesson draws on the effects seamounts have on deep ocean environments. We explore biological-physical interactions using a physical model (upwelling) and infer how various organisms may be adapted to thrive in various lake environments (nearshore, offshore, or lakemounts). The upwelling demonstration is adapted from the NOAA Explorations “Investigation: Seamounts and Biological Productivity” lesson.

TIME REQUIRED

1 hour, 15 minutes

MATERIALS

- Projector or smart board to display powerpoint, images and/or map
- Printed organism cards
- Hand-written signs or printed habitat cards (Lakemount, Offshore, Nearshore)
- Tape
- Upwelling model demonstration*
 - Ice or very cold water
 - Sink access
 - Liquid food dye (blue preferred but any color will do)
 - Plastic shoe box storage bins with holes in the side (1 per 3-4 students, or 1 for teacher-led demonstration only)
 - White paper
 - Clay
 - Squeeze bottles with nozzles
 - Timer (optional but helpful)
 - Extra buckets or bins (such as trash bins) to catch water and fill up plastic shoe box storage bins
 - Paper towels for clean up

*Can also show video demonstration, or instructor may demo for the entire class (instead of student groups)

PREPARATION

- **Powerpoint lesson:**
 - Review the teaching guide and make any edits to the slides. Decide how much detail you will go into with the scientific concepts and research background.
 - If there are place-based examples that resonate with your students outside of Lake Champlain, add those

AUTHOR

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GRADE LEVEL

9-12

ANCHORING PHENOMENON

Topographical differences in aquatic environments, such as seamounts in oceans, influence the surrounding ecosystem. This results in biological differences compared to deep, open-water environments. In lakes, the effects of underwater mountains on aquatic ecosystems is not yet thoroughly understood.

DRIVING QUESTION

How might underwater mountains in Lake Champlain influence the ecosystem?

IMPORTANT VOCABULARY

- Lakemount
- Seamount
- Biodiversity
- Pelagic
- Benthic
- Biodiversity hotspot
- Productivity
- Upwelling
- Topography
- Bathymetry

STANDARDS

- Upwelling model standards:
 - HS-ESS2-1
 - HS-ESS2-4
- Organism-Habitat card activity
 - HS-LS2-6
 - HS-LS2-8

SUPPLEMENTAL RESOURCES

in!

- **Upwelling demo:**
 - Use a drill to make 1 hole in the side of each plastic shoe storage box for the squeeze bottle nozzle to fit in. Be careful to make the hole slightly smaller than the nozzle so it is snug when inserted. This helps reduce leakage when the bin is full of water.
 - Mark a black line with Sharpie 2-3 inches below the top of the plastic bin (see photos). This indicates how tall each clay lakemount should be. Water will be filled just above this line.
 - Tape a white piece of paper as the background for the demonstration box.
 - Have access to, or prepare containers of cold, ice water (for squeeze bottles) **and** warm water (for plastic bins). You will need more warm water than cold water. Add a few drops of blue food coloring to the ice-cold squeeze bottles.
 - It is important there is a significant temperature difference between the two containers of water so the upwelling demonstration works.
- **Lake Champlain Habitats + Organisms Cards activity:**
 - Print, laminate, and cut out organism cards and habitat signs. You can also use the Canva template to make additional cards that highlight important organisms in your lake.
 - Tape habitat signs on the walls around the room before class starts.

LEARNING GOALS & OBJECTIVES

- Introduce ongoing research on Lake Champlain's lakemounts, providing a deeper connection for students to Lake Champlain's complexities and the current research projects at the University of Vermont
- Understand what lakemounts are, why researchers hypothesize they may influence freshwater ecosystems through upwelling and nutrient dynamics, topographic differences, and habitat/substrate availability
- Explore similarities and differences between lakemounts and seamounts
- Infer and provide reasoning for how organisms may be adapted to various lake zones (*nearshore, offshore, lakemounts*), and consider how these zones may be similar and different from one another
- Discuss how biodiversity hotspots may be understood, monitored, and managed

INTRODUCTION

- Pre-Lesson reading: "Are lakemounts hotspots of productivity and biodiversity?" Dr. Bianca Possamai's article in the Journal of Great Lakes Research HS-LS2-6
 - Have students read and highlight key words, questions, or things they found interesting
- This lesson is based on Seamounts lessons from NOAA Ocean Explorers. Additional resources related to seamounts can be found on their website.
 - Introduction to seamounts <https://oceanexplorer.noaa.gov/facts/seamounts.html>
 - NOAA Ocean Explorers - "Canyon and Seamount Habitats" section <https://oceanexplorer.noaa.gov/explorations/explorations-by-topic.html>
 - Student Investigation: Seamounts and Biological Productivity <https://oceanexplorer.noaa.gov/education/seamounts/lessons/seamounts-biological-productivity.html>
- Lake Champlain Basin Program's website - Learn more about the organisms in Lake Champlain, their habitats, and food webs <https://www.lcbp.org/our-goals/healthy-ecosystems/biodiversity/>

Researchers at the University of Vermont are currently investigating underwater mountains in Lake Champlain, also known as lakemounts, and their potential as **biodiversity hotpots**. Thinking about lakemounts as parallels to oceanic seamounts, scientists at the University of Vermont are curious about how lakemount topography may lead to **nutrient upwelling and increased biodiversity**.

LESSON PROCEDURE

1. Prep materials for model and organism activity ahead of time.
2. Introduce the lesson using the slideshow and notes. The slides should take about 15-20 minutes(or longer depending on level of detail and student interest) before moving into the first activity.
3. **Activity 1: Upwelling Demo -2 options**
 - a. The upwelling demo can be conducted by the teacher for the whole class to observe, or as individual student groups.
 - i. Before each demo have students come up with hypotheses about what might happen to the blue, cold water stream (first without and then with a lakemount present).
 - b. **Teacher led-demonstration (option 1):** Students will first construct their lakemounts in small groups, working together to design and construct them. Requirements:
 1. Must not be taller than the indicator line on plastic bin (see photo). Students can test to see if their lakemounts are tall enough - they should fall just below the indicator line on the plastic bin and be relatively mountain or mound-like shape.
 2. The teacher will randomly choose or use a number generator to test one student groups' lakemounts for the teacher-led demonstration.
 - i. Teacher will set up 2 demonstration bins. The first demo is without a lakemount in the bin. This demo will depict a deep, cold water current (no upwelling).
 1. DEMO 1- Fill the squeeze bottle with blue-dye ice water. Elevate the bin or put it on the edge of the table and **have a helper hold the squeeze bottle in place**, with the nozzle inserted into the plastic bin (see photos).
 2. Pack the edges of the nozzle with clay to minimize leakage and have a bucket or bin and towels nearby in case of a spill.
 3. Fill the plastic demonstration bin with warm water ~½ inch past the black sharpie line.
 4. Gently and slowly squeeze the blue ice water from the wash bottle into the warm water tub.
 5. DEMO 2- Same set up as Demo 1, but add one of the students' lakemounts in the bin. To reset and empty the bins, carefully and slowly dump the plastic bin into another receptacle, the grass, or a sink. Be careful not to release or remove the squeeze bottle nozzle without something to catch the water. The dyed water could stain clothes.

- c. **Student-led demonstrations (option 2):** This option is best-suited to take place outside in grass or inside with extra buckets/receptacles to catch water if it spills, and avoid on carpet. For this option, student groups will have their own demo boxes.
 - i. Students will first construct their lakemounts in small groups, working together to design and construct mini clay lakemounts. Requirements same as option 1.
 - ii. Students will follow the same steps as the teacher-led demonstrations above (steps 1-5) to conduct 2 models.
 - d. Prompt students to observe what happens with the blue stream.
 - i. Following both demonstrations for either option, have students Turn and Talk with another classmate or in their small groups.
 - 1. What did you notice between demo 1 and 2?
 - 2. Between demo 1 and 2, how do you expect nutrient cycling to change? How might that impact other organisms such as plants, plankton, or fish?
 - 3. How do you expect this model to be different from real lakemount dynamics in the lake? What's missing or simplified?
4. Activity 2 - Organism and Habitat Cards - ***Where Would You Live in Lake Champlain?***
- a. Each student will receive an organism card. They now represent an important organism that lives in Lake Champlain!
 - i. Students will read over their cards individually for a few minutes.
 - ii. Students will decide which habitat placed around the room they are best suited to live in - Nearshore, Offshore, or Lakemounts - and go to where that habitat is in the room (taped to the wall).
 - iii. Students will talk to other organisms that arrive at the same habitat and discuss the questions on the habitat card.
 - 1. Teacher may circulate and ask additional probing questions such as "What type of substrate, topography, or other environmental conditions do you need to thrive? Are there any other organisms here that you might eat or be eaten by? Is there another habitat you might be able to live in?"
 - iv. Close this activity by asking all students as a class how they came to these conclusions. Each student could also share their justifications and if they could live in another habitat.
 - 1. Many students that find themselves at Nearshore or Offshore may believe they could also live in a Lakemount. It should also appear that there are more organisms gathered at nearshore or lakemount environments while offshore is less densely populated.
 - 2. Discuss the dynamic nature of aquatic environments, different organism life stages, adaptations, niches, predation strategies, benefits of different topographies and substrates, etc.
5. **Closing questions:**
- a. Why do you think researching lakemounts is important?
 - b. Are there any other under-researched ecosystems you can think of?
 - c. If it turns out that lakemounts are biodiversity hotspots, how do you think this may change the way people interact with them?
 - d. Do you have ideas or suggestions for how to protect biodiversity within a waterbody such as Lake Champlain?

CONCLUSION

Lakemounts are hypothesized to be biodiversity hotspots (like seamounts), and this research is still ongoing. Dr. Possamai has conducted different types of sampling to understand if upwelling is occurring and measure the diversity and abundance of species around the lakemounts in Lake Champlain. Initial data shows strong preliminary evidence that these habitats support diverse life in the offshore lake environment. Additionally, there are many ways in which biological-physical processes impact one another, such as topography influencing nutrient dynamics and potentially increasing biodiversity. It is important to continue asking questions and refining hypotheses to understand vital, freshwater ecosystems for research, conservation, and recreation purposes.

SUPPORTING IMAGES/VIDEOS

NORTHERN PIKE



Esox lucius

- Ambush predator
- Adults can be large in size
- Prefers areas with high structural complexity such as grasses or weeds
- Eats other fish...including baby pike!
- Coolwater fish

CHANNEL CATFISH



Ictalurus punctatus

- Warmwater fish
- Bottom-feeders, use suction to eat
- Flattened heads allow them to dig
- Cavity nesters - lay eggs in crevices or debris
- Adults eat snails, crustaceans, algae, other fish, insects, and more!

PUMPKINSEED



Lepomis gibbosus

- AKA sunfish, sun perch
- Warmwater fish
- Build circular nests in sand or gravel
- Carnivorous, feeding on insects (including mosquito larvae), crustaceans, tadpoles, smaller fish
- Prefer clear water, with shelter to hide

YELLOW PERCH



Perca flavescens

- Coolwater or warmwater fish
- Young perch eat zooplankton and insects, adults eat fish eggs, crustaceans, and other small fish
- Prey for northern pike, sunfish, trout, bass, and birds
- Not nest builders, but their eggs attach to vegetation, gravel, submerged trees

ZEBRA MUSSEL



Dreissena polymorpha

- Originally from lakes of southern Russia and Ukraine
- Filter-feeding organisms that remove particles from water
- Attach to most substrates such as sand, silt, rock, and other living mussel species (which eventually kills them)
- Found down to 180 ft depths

LAKE TROUT



Salvelinus namaycush

- Coldwater fish
- Top predators: adults eat alewife, smelt, and sculpin
- Spread their eggs in wave-swept rocky areas
- By 1900 disappeared from Lake Champlain! As of 2025, restored through fisheries management (success!)
- Parasitism by lamprey

RAINBOW SMELT



Osmerus mordax

- Coldwater fish
- Thrives in clear, deep water
- Eat zooplankton, other small fish, and are aggressive eaters!
- May spawn along tributary streams
- Swim in schools
- Favorite prey for salmon and trout
- Produce an antifreeze protein during winter!

LAKE STURGEON



Acipenser fulvescens

- Coldwater fish
- Longest living and largest fish in Lake Champlain
- Feed on benthic organisms such as leeches, zebra mussels, crustaceans, and some fish
- Spawn in rivers
- IUCN listing: endangered

ALEWIFE



Alosa pseudoharengus

- Shares similar diet with rainbow smelt
- Very sensitive to temperature shifts, ideal range is 16-19°C (61°-66°F)
- Pelagic planktivores
- First appeared in Lake Champlain in 2003
- Populations can increase rapidly when introduced to new waters

SLIMY SCULPIN



Cottus cognatus

- Does not have a swim bladder to control buoyancy like most fish
- seeks shelter under rocks and logs
- Females will lay eggs under rocks or tree roots, males guard eggs
- Eats benthic insects, crustaceans, fish eggs
- Eaten by lake trout, northern pike, salmon

LONGNOSE GAR



Lepisosteus osseus

- Genus may have been present in North America for 100 million years ... considered a "living fossil!"
- Prefers densely vegetated or weedy, shallow habitats
- Opportunistic feeders - eat by stalking smaller fish, frogs, crayfish, and insects
- Adults can reach over 6ft in length

AMERICAN EEL



Anguilla rostrata

- Bottom-dwellers, use burrows, plants, or logs
- Can be found at great depths, on muddy lake bottoms
- Many complex life stages, beginning their lives in the Sargasso Sea
- Spend 10-15 years in freshwater, then journey to the Atlantic Ocean
- IUCN listing: Endangered

COMMON CARP



Cyprinus carpio

- Native to Europe and Asia, introduced everywhere in the world except the N and S poles
- Tolerant of most conditions, prefer slow moving water and vegetation
- Omnivorous bottom-feeders, scavenge for crustaceans, insects, mollusks, fish remains, aquatic plants, seeds, etc

FAUCET SNAIL



Bithynia tentaculata

- Native to Europe, introduced in ballast water from ships
- Grazes on and filters algae in the lake
- Attaches to rocks, gravel, plants, etc. and on shoals up to 5 m depth
- Spreads by attaching to water vessels or plants that are then transported to and from other waterbodies

ATLANTIC SALMON



Salmo salar

- Coldwater fish
- Landlocked Atlantic salmon spend their whole lives in a lake, while others travel out to sea using river networks
- Diet: smaller fish (smelt), insects
- IUCN listing: Near Threatened

SEA LAMPREY



Petromyzon marinus

- Invasive or native status is debated
- Jawless, parasitic fish - latches on to other fish
- Prey on coldwater, soft-scaled fish like salmon and lake trout
- Habitat preferences changes with lifestage - ammocoetes (larval stage) and adults prefer slow streams and sandy bottoms, adults prefer open water

NEARSHORE

1) Why do you think you are best adapted to this habitat?

What about this region of the lake is unique and helpful or vital for your survival?

2) Who else lives in your habitat and does it make sense you would be neighbors?

Why or why not?

3) Could you live in another habitat or region of the lake?

If applicable, explain how you might be adapted for different places and how that might change your diet, behavior, or other aspects of your life in Lake Champlain!

4) Do you have any ideas for how to protect or conserve this habitat?

OFFSHORE

1) Why do you think you are best adapted to the offshore habitat?

Where in the offshore region do you think you might live?

What about the open water of the lake is unique, helpful, or vital for your survival?

2) Who else lives offshore and does it make sense you would be neighbors?

Why or why not?

3) Could you live in another habitat or region of the lake?

If applicable, explain how you might be adapted for different places and how that might change your diet, behavior, or other aspects of your life in Lake Champlain!

4) Do you have any ideas for how to protect or conserve this habitat?

LAKE MOUNT

1) Why do you think you are best adapted to this habitat? Where on a lakemount do you think you might live?

What about the this habitat is unique, helpful, or vital for your survival?

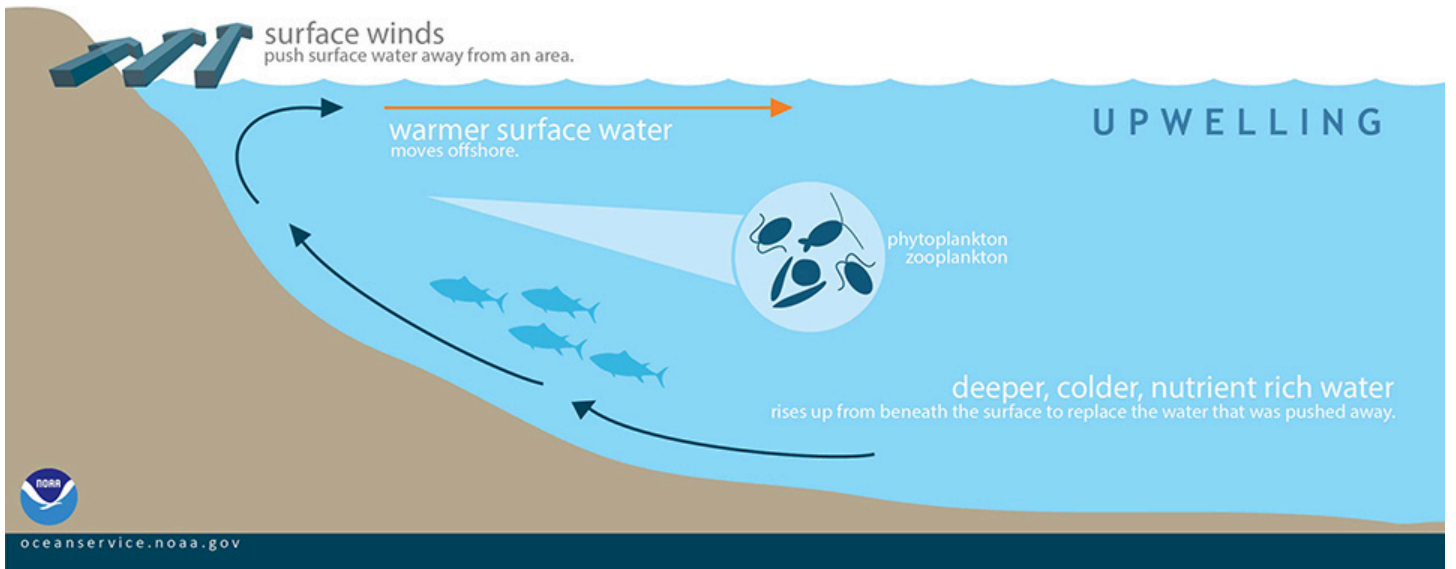
2) Who else lives on or around the lakemounts and does it make sense you would be neighbors?

Why or why not?

3) Could you live in another habitat or region of the lake?

If applicable, explain how you might be adapted for different places and how that might change your diet, behavior, or other aspects of your life in Lake Champlain!

4) Do you have any ideas for how to protect or conserve this habitat?



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Lake Champlain Sea Grant Watershed Alliance