

* In this document, "Great Lakes" refers to the Laurentian Great Lakes, a system of large freshwater lakes in North America along the border of the United States and Canada.

- Understands the essential principles and fundamental concepts about the characteristics, functioning, and value of the Great Lakes;
- Can communicate accurately about the Great Lakes' influence on systems and people in and beyond their watershed; and
- Is able to make informed and responsible decisions regarding the Great Lakes and the resources of their watershed.

A Great Lakes Literate Person

and your influence on the Great Lakes.

Great Lakes literacy* is an understanding of the Great Lakes' influences on you

GREAT LAKES LITERACY

This guide presents a vision of a Great Lakes literate society. Providing a framework of knowledge necessary to be considered Great Lakes literate, this document guides coordination, consistency and coherence for Great Lakes sciences education. It is a practical resource that educators and policy makers can use to influence teaching and learning about the Great Lakes throughout schools, museums, aquaria, science centers, parks, and other informal learning environments. The *Essential Principles and Fundamental Concepts for Great Lakes Learning* aid in teaching concepts in the Next Generation Science Standards.

What is Great Lakes Literacy?



The Great Lakes Literacy effort had its origins in Ocean Literacy, a movement by hundreds of scientist and educators who contributed time and expertise to develop a concise framework for conveying the most important ocean science principles and interconnected concepts that all Earth citizens should know. The story of the remarkable journey that led to the Ocean Literacy Essential Principles, a downloadable brochure, and the Ocean Literacy Scope and Sequence for Grades K-12 can be found at oceanliteracy.net. Educators in Centers for Ocean Sciences Education Excellence (COSEE) Great Lakes gratefully acknowledge the groundbreaking work of those who contributed to Ocean Literacy.

Ocean Literacy Origins

Regionalizing: Adding the Freshwater Component

While the Ocean Literacy principles and concepts provided useful guidance for teaching about the marine environment, educators using ocean literacy in the Great Lakes found themselves stretching to say "ocean" while they were teaching on a lake. After aquatic educators in Ohio identified a need for a place-based environmental literacy framework for Lake Erie, they developed the Lake Erie Literacy Principles – based on the Ocean Literacy framework – to guide a unified strategic plan for Lake Erie education and outreach. Concurrent with their development, COSEE California, a guiding force in the Ocean Literacy movement, recognized the need to expand the utility of the Ocean Literacy Principles for the Great Lakes region. With the support of COSEE California, COSEE Great Lakes education leaders in the Great Lakes Sea Grant Network examined the Ocean and Lake Erie literacy principles and drafted a baseline set of principles for Great Lakes literacy in October 2009. These were reviewed and edited by over 80 scientists and educators throughout the eight Great Lakes states. Ohio Sea Grant educators synthesized and organized feedback, ultimately compiling *Great Lakes Literacy Principles and Fundamental Concepts for Great Lakes Learning* as introduced here.

Ocean Literacy Principles

1. The Earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of the Earth.
3. The ocean is a major influence on weather and climate.
4. The ocean made Earth habitable.
5. The ocean supports a great diversity of life and ecosystems.
6. The ocean and humans are inextricably interconnected.
7. The ocean is largely unexplored.

Great Lakes Literacy Principles

1. The Great Lakes, bodies of fresh water with many features, are connected to each other and to the world ocean.
2. Natural forces formed the Great Lakes; the lakes continue to shape the features of their watershed.
3. The Great Lakes influence local and regional weather and climate.
4. Water made Earth habitable; fresh water sustains life on land.
5. The Great Lakes support a broad diversity of life and ecosystems.
6. The Great Lakes and humans in their watersheds are inextricably interconnected.
7. Much remains to be learned about the Great Lakes.
8. The Great Lakes are socially, economically, and environmentally significant to the region, the nation, and the planet.

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Using the Great Lakes Literacy Principles and Concepts

The target audience for the Ocean Literacy principles was teachers of grades K-12. Both formal and informal educators of learners of all ages are the audience for Great Lakes Literacy efforts. Textbooks currently used for biology, Earth and environmental sciences pay scant attention to the Great Lakes, and only a few isolated questions on state tests give evidence that the lakes are part of the science curriculum at all. Likewise, there is a need to redress the lack of ocean content in standard science curricula. Ocean Literacy content has been matched with the National Science Education Standards in brochures and at www.oceanliteracy.net, and COSEE Great Lakes has matched the Great Lakes Literacy concepts with national standards as well.

Ocean educators use the Bridge for Marine Education as a primary online source of content and curriculum information (www.vims.edu/bridge). In the Great Lakes, Ohio Sea Grant hosts a growing Internet resource for Great Lakes Literacy content, curricula, and other resources. We invite your contributions of annotated links and other resources useful for Great Lakes literacy, especially in comparison with oceans.

For a complete list of project contributors, visit www.greatlakesliteracy.net

www.greatlakesliteracy.net



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Established in 2012, the Center for Great Lakes Literacy (CGLL) is a collaborative effort of Sea Grant Educators throughout the Great Lakes watershed. CGLL strives to develop a Great Lakes-literate public capable of effectively contributing to the environmental, economic and social sustainability of the Great Lakes. CGLL promotes informed and responsible decisions that advance basin-wide stewardship by providing hands-on experiences, educational resources, and networking opportunities that promote Great Lakes literacy among an engaged community of educators, scientists, and citizens. Signature opportunities include annual Great Lakes Shipboard Science Workshops that connect educators with scientists aboard the EPA's *R/V Lake Guardian*, webinars and social media postings featuring Great Lakes issues, land-based watershed workshops that facilitate strong community-school partnerships for action-oriented Great Lakes stewardship and restoration activities, and citizen science and other volunteer activities that create opportunities for adults to become involved in watershed restoration. Information on upcoming CGLL professional development and stewardship events can be found at cgllog.org.



GREAT LAKES LITERACY: Essential Principles and Fundamental Concepts for Great Lakes Learning

Each principle is supported by fundamental concepts comparable to those in the Ocean Literacy Principles; consult the Great Lakes Literacy website [www.greatlakesliteracy.net] to view the Principles and their alignment to the National Science Education Standards.

1	THE GREAT LAKES, BODIES OF FRESH WATER WITH MANY FEATURES, ARE CONNECTED TO EACH OTHER AND TO THE WORLD OCEAN.		A. The Great Lakes are a dominant physical feature of North America and form part of the political boundary between the United States and Canada. B. The Great Lakes system includes five Great Lakes (Superior, Huron, Michigan, Erie, and Ontario), Lake St. Clair, and the connecting channels, along with many harbors and bays. Each lake has distinctive basin features, circulation, and ecology. C. The Great Lakes contain nearly 20 percent of the world's fresh surface water and have a coastline longer than the East Coast of the United States. Most of North America's fresh surface water (95 percent) is in the Great Lakes. D. The Great Lakes, their respective watersheds and waterways, and the ocean are all connected. Within the Great Lakes system, water flows from the upper lakes (Lake Superior, Lake Michigan, and Lake Huron) through Lake St. Clair into Lake Erie, over Niagara Falls and into Lake Ontario before flowing through the St. Lawrence River into the ocean. Rivers and streams transport nutrients, dissolved gases, salts and minerals, sediments, and pollutants from watersheds into the Great Lakes.
2	NATURAL FORCES FORMED THE GREAT LAKES; THE LAKES CONTINUE TO SHAPE THE FEATURES OF THEIR WATERSHED.	A. Ancient igneous and metamorphic rocks form portions of the upper Great Lakes basin. Other rocks underlying the present day Great Lakes and surrounding watershed are sedimentary, originating during a time when shallow tropical seas covered the basin. Many of the rocks now exposed on land were deposited and shaped during the advance and retreat of glaciers. B. During the Ice Age, mile-thick sheets of ice covered the Great Lakes region multiple times, depressing the crust with their weight. Ancient beach ridges mark previous lake shorelines. Since glaciers retreated (about 10,000 years ago), Earth's crust has been adjusting upward in a process of isostatic rebound that continues today. C. Lake-level changes influence the physical features of the Great Lakes coast. Lake water levels show changes and patterns that vary over periods of hours to millennia. D. Erosion—the wearing away of rock, soil and other earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the Great Lakes move sediments. E. Sediments are a product of erosion and consist of fragments of animals, plants, rocks, and minerals. Sediments are classified by grain sizes, from silt and clay to sand, cobbles, and boulders. Sediments are seasonally redistributed by waves and coastal currents and help maintain beaches and coastal wetlands.	
3	THE GREAT LAKES INFLUENCE LOCAL AND REGIONAL WEATHER AND CLIMATE.	A. The Great Lakes affect weather and climate by impacting the basin's energy and water cycles. Changes in the Great Lakes' water circulation, water temperatures, and ice cover can produce changes in weather patterns. B. The Great Lakes warm by absorbing solar radiation. Lake temperatures are also affected locally by the temperature of inflowing river waters. The Great Lakes lose heat by evaporation and by the warming of overlying air when the atmosphere is cool. After water vapor is released into the atmosphere, it condenses and forms precipitation, some of which falls within the Great Lakes basin. C. The Great Lakes modify the local weather and climate. Because water temperatures change more slowly than land temperatures, lake waters gain heat in summer and release heat during cooler months. This results in cooler springs, warmer falls, delayed frosts, and lake-effect snow. D. The Great Lakes have a significant influence on regional climate by absorbing, storing, and moving heat and water. Lake-effect precipitation can occur downwind when major weather systems move over the lakes. E. The Great Lakes are influenced by larger climate change patterns affecting North America and the world. Climate patterns in the Great Lakes are changing, with warmer and drier conditions predicted.	
4	WATER MAKES EARTH HABITABLE; FRESH WATER SUSTAINS LIFE ON LAND.	A. Fresh water has unique properties. Its density and electrical conductivity (a measure of salinity) are lower than that of salt water. B. Water is essential for life. All living processes occur in an aqueous environment.	 
5	THE GREAT LAKES SUPPORT A BROAD DIVERSITY OF LIFE AND ECOSYSTEMS.	A. Life in the Great Lakes ranges in size from the smallest blue-green bacteria, such as <i>Microcystis</i>, to the largest animal that still lives in the Great Lakes, lake sturgeon. B. Most life in the Great Lakes exists as microorganisms. Microorganisms, such as phytoplankton and cyanobacteria, are the most important primary producers in the lakes. C. The Great Lakes' watershed supports organisms from every kingdom on Earth. D. Great Lakes biology provides many examples of life cycles, adaptations, and important relationships among organisms, such as symbiosis, predator-prey dynamics, and energy transfer. E. The Great Lakes ecosystem provides habitat for terrestrial and aquatic species. The Great Lakes are three-dimensional, offering vast living space and diverse habitats from the shoreline and surface down through the water column to the lake floor. F. Great Lakes habitats are defined by environmental factors. As a result of interactions involving abiotic factors, such as temperature, clarity, depth, oxygen, pH, light, nutrients, pressure, substrate type, and circulation, life in the Great Lakes is not evenly distributed temporally or spatially. Abiotic factors within the Great Lakes can change daily, seasonally or annually because of natural and human influences. G. Ecosystem processes (abiotic conditions, prey availability, and predation) influence the distribution and diversity of organisms from surface to bottom and nearshore to offshore. H. Wetlands, including coastal marshes and freshwater estuaries, provide important and productive nursery areas for many aquatic and terrestrial species, which rely on these habitats for protective structure, hunting grounds, migration stops, and raising offspring. I. Life cycles, behaviors, habitats, and the abundance of organisms in the Great Lakes have been altered by intentional and unintentional introduction of non-native plant and animal species.	 
6	THE GREAT LAKES AND HUMANS IN THEIR WATERSHEDS ARE INEXTRICABLY INTERCONNECTED.	A. The Great Lakes affect many human lives. They supply fresh water to more than 40 million people. They are a source of drinking water and food, as well as mineral and energy resources. B. One-third of the North American population lives in the Great Lakes' watershed. Some of the most urbanized regions in the United States and Canada can be found around the lakes. C. The Great Lakes are affected directly by the decisions and actions of people throughout its watershed, which includes parts of the states of Illinois, Indiana, Michigan, Minnesota, Ohio, Pennsylvania, New York, and Wisconsin, the Canadian provinces of Ontario and Quebec, and tribal lands. D. Local and national laws, regulations, and resource management affect what is put into and taken out of the Great Lakes. Shoreline development and industrial or commercial activities lead to point and non-point source pollution. Humans have altered the biology of the lakes and the viability of species through harvesting, species introduction, and nutrient loading. E. Coastal regions along the Great Lakes are impacted by land-use decisions and natural hazards. Physical modifications (changes to beaches, shores, and rivers) can exacerbate effects of erosion, storm surges, and lake-level changes. F. To ensure continued availability of Great Lakes assets, people must live in ways that sustain the lakes. Individual and collective actions are needed to effectively conserve and manage Great Lakes resources for the benefit of all.	
7	MUCH REMAINS TO BE LEARNED ABOUT THE GREAT LAKES.	A. Exploration and understanding of Great Lakes interactions and links among diverse ecosystems and people are ongoing. Such exploration offers great opportunities for inquiry and investigation. B. Understanding the Great Lakes is more than a matter of curiosity. Exploration, inquiry, and monitoring promote better understanding and protection of Great Lakes ecosystems, resources, and processes. C. Over time, use of Great Lakes resources has changed significantly. The future sustainability of Great Lakes resources depends on our understanding of those resources and their potential and limitations. D. New technologies and methods of observation are expanding our ability to explore the Great Lakes. Fresh water scientists rely on such tools to monitor conditions in the Great Lakes and provide information to policy makers and leaders in coastal communities. E. Models help us understand the complexity of the Great Lakes. Models process observations, describe interactions among systems, expose information gaps, and forecast change. F. Exploring, understanding, and communicating about the Great Lakes ecosystem are interdisciplinary efforts. They require close collaboration among professionals in science, technology, engineering, and math, as well as public outreach and education.	
8	THE GREAT LAKES ARE SOCIALLY, ECONOMICALLY, AND ENVIRONMENTALLY SIGNIFICANT TO THE REGION, THE NATION, AND THE PLANET.	A. The Great Lakes are a source of inspiration, recreation, rejuvenation, and discovery. They are also an important element in the heritage of many cultures. B. The waters of the Great Lakes have been significant to historical settlement and development. The lakes' names and the names of many cities, counties, and landmarks along their shores have Native American or immigrant origins. This fresh water resource will continue to play a role in future habitation of the area. C. The Great Lakes' moderating effects on climate influence the human culture, activities, agriculture, and health of adjacent coastal areas. D. Waterborne commerce moves millions of tons of cargo annually through the Great Lakes. Shipping is an economically efficient method of transporting raw materials, finished goods, and agricultural products. However, shipping is also a vector for non-native species, several of which may be detrimental to the Great Lakes ecosystem. E. The economy is diverse in the Great Lakes, with major sectors in industry, recreation and tourism, agriculture, commercial and sport fisheries, forestry, and mining. F. The Great Lakes were dramatically degraded and challenged by human endeavors in recent times. Basic ecosystem processes have been restored through individual and collective efforts. Proper foresight and informed decision making will continue to make the Great Lakes a model of environmental protection, restoration, and innovation.	 