Aquatic Ecology Learning Objectives Adapted from the NCF-Envirothon Learning Objectives

From vast oceans and tiny streams to irrigation systems and kitchen sinks, water touches every aspect of our lives. This essential compound makes life on Earth possible, and to continue to sustain this life, we must protect our water resources. Aquatic ecosystems are diverse, as are the creatures that inhabit them. All water on Earth, whether it is flowing in a river or deep underground in an aquifer, is connected through the water cycle. As a result, human impacts on our water resources can have far reaching effects, and careful consideration must be taken when making management decisions.

Just like the ecosystems we study, human society and culture are incredibly diverse. In the same way that biodiversity makes ecosystems more resilient, these differences in human perspective and experience make us stronger as a global community. Every person's story and relationship with the environment is important, and we must work together to ensure that everyone's stories are heard, including the historically marginalized and economically disadvantaged. We invite you to seek out stories from your own communities – to discover the unsung conservation heroes, to learn the histories that aren't typically taught in classrooms, to highlight local environmental issues, and to explore what types of natural resource conservation are occurring in your local community, state/province, and nation.

Students should be able to:

- Provide an informed opinion about current issues in water quality and water resources.
- Think critically about solutions to current water quality and water resource issues.
- Work collaboratively in a team to synthesize and apply knowledge.
- Make connections between the concepts in Aquatic Ecology and the subjects of Soils and Land Use, Forestry, Wildlife, and the Current Issue.

Students will be able to:

Hydrosphere

1. Describe the physical and chemical properties of water that affect aquatic ecosystems and how they do so.
2. Diagram the water cycle and describe each component in detail.
7. Differentiate the types of wetlands, describe their characteristics, and identify common species found in each.

Hydrosphere Resources

- Physical & Chemical Properties of Water | ChemTalk
- The Water Cycle | U.S. Geological Survey
- Water Basics Information by Topic | U.S. Geological Survey
- Classification and Types of Wetlands | US EPA

Aquatic Ecosystems

8. Identify the biotic and abiotic components of aquatic ecosystem.
9. Describe the structure of an aquatic ecosystem, including:
    a. Species and communities
    b. Abiotic components
    c. Symbiotic relationships
    d. Carrying capacities
    e. Productivity
12. Explain how seasonal changes in temperature, water level, flow rate, nutrient sources, nutrient availability, runoff, and inputs occur in aquatic ecosystems.
17. Describe the importance, functions, and characteristics of watersheds/catchment areas.
18. Explain the role of aquatic ecosystems in biogeochemical cycles, such as the carbon, nitrogen, and phosphorus cycles.
19. Describe the basics of hydrology, including:
    a. Stream/River geomorphology (Catchment area/Drainage basin, Channel, Bank, Meander, Riffle, Water Table, Thalweg, Hyporheic Zone, et cetera)
    b. Groundwater flow
    c. Interactions between surface water and groundwater
    d. Impact of landscape factors on water movement
    e. Stratification in freshwater and saltwater systems
    f. Discharge and recharge for aquatic systems
    g. Runoff

Aquatic Ecosystems Resources

- Introduction to Watershed Ecology | Watershed Academy Web | US EPA (21 slide module that covers much of this section)
- 8.2: The structure of aquatic ecosystems - Geosciences LibreTexts
- (PDF) Forest-Stream Interactions in Eastern Old-Growth Forests (Focus on Figure 9-3 pg 173 understanding the significance of interactions within the chart).
- https://www.youtube.com/watch?v=yyvT0wOuS2c (video on sediment and streamflow)
- 2c48e6_1c1d81f8c071425fa60e75fee794c60f.pdf (link to training day resources. page 1 has info related to these learning objectives)
- Hydrology Education: Hydrographs (understand the basics of how to read/comprehend what a hydrograph shows).

Organisms

20. Describe the roles of producers, consumers, and decomposers in various aquatic ecosystems and identify their trophic levels.
23. Analyze physical and behavioral adaptations to aquatic environments that are common among many types of organisms, such as streamlined body shape, eye placement, countershading, et cetera.
24. Describe the role of cyanobacteria in aquatic ecosystems and their role in harmful algal blooms.

Organisms Resources

- Producers, Consumers, and Decomposers - Examples, Types and Definition | CK-12 Foundation
- Living in Water - Texas Aquatic Science - Rudy Rosen
- Cyanobacteria Harmful Algal Blooms | NH Department of Environmental Services
- Beaver: Nature's ecosystem engineers - PMC (focus on section 2-beaver impact on environment)

Aquatics and Society

Native and Indigenous peoples have cultures and traditions that include close relationships with the environment. Native and Indigenous communities are unique, and each group has its own history, culture, Indigenous systems of science, traditional ecological knowledge, and conservation practices. The NCF-Envirothon encourages each state, province, and partner nation to consult with your local Native and Indigenous communities to highlight their unique environmental perspective in your Envirothon learning objectives, study materials, and competitions.

The following Learning Objectives should be applied on a local, state/provincial, national and/or worldwide (international) scale as appropriate to each objective and the unique parameters under consideration.

28. Describe the basics of water quality and water quality improvement.
29. Explain the history of human impact on water quality and water resources.
32. Explain why it is important to take the entire watershed/catchment area into account when planning for water quality.
34. Explain how human activities upstream impact downstream water quality, and why investing in conservation upstream is important.
35. Identify biotic and abiotic factors that impact water quality.
41. Describe natural and human impacts on river and stream health, flow, structure, and velocity.
42. Recommend best management practices for improving water quality and enhancing aquatic habitat, such as riparian buffers.
43. Identify threats to aquatic ecosystems, such as pollution, biomagnification of toxins, erosion, development, invasive species, excess nutrients, thermal shock, et cetera.
45. Describe the impact of changes in climate on water quality and water resources.
46. Describe action that can be taken to mitigate adverse human impacts on aquatic systems.

Aquatics and Society Resources

- Basic Information and Answers to Frequent Questions | US EPA
- A Brief History of Water and Health from Ancient Civilizations to Modern Times | IWA Publishing
- Good Forestry in the Granite State (2010) how forest management can impact various aquatic ecosystems, focusing on the aquatics portions.
- The effects of forest management on water quality - ScienceDirect
- Water Quality and Forestry Activities
- Threats on Aquatic Ecosystem- Mitigation and Conservation Strategies
- Water and Climate Change | UN-Water
- NASA Satellites Reveal Abrupt Drop in Global Freshwater Levels | NASA Jet Propulsion Laboratory (JPL) (technology used to study aquatic systems, climate change impact on freshwater)
- Climate Change Impacts on Freshwater Resources | US EPA

Field Skills

52. Identify common aquatic macroinvertebrates and their pollution tolerances.
57. Interpret results of water quality monitoring measures (such as dissolved oxygen, turbidity, *E. coli* counts, pH, nutrient levels, et cetera) and provide recommendations for best management practices.
59. Delineate a watershed using a topographic map.
60. Calculate relevant hydrological measures such as base flow, water volume, runoff, water balance, et cetera.
61. Calculate a water budget, including precipitation, evapotranspiration, storage, stream flow, discharge, and recharge.

Field Skill Resources

- "An Image-Based Key To Stream Insects" , University of New Hampshire Center for Freshwater Biology": http://cfb.unh.edu/StreamKey/html/index.html
- Macroinvertebrate ID Resources – Virginia Save Our Streams (vasos.org) (specifically the macroinvertebrate pollution sensitivities)
- Interpreting VRAP Water Quality Monitoring Chemical Parameters
- Slide 1 (wordpress.com) (how to delineate watersheds and understand topographic maps)
- How to Read a Topographic Map and Delineate a Watershed (state.mn.us) (how to determine stream flow from a topographic map)
- Water Budgets: Foundations for effective water-resource and environmental management.
- How Streamflow is Measured | U.S. Geological Survey

Connections to Current Issue

Below are the Key Topics from the 2025 NCG-Envirothon Current Issue Part A Study Resources that are likely to be imbedded within the Aquatics Exam. These topics will be woven into the learning objectives listed on the previous pages. Familiarize yourself with the concepts on pages 1-5 and be able to connect them to the Key Topics below.

1. **Key Topic #1: Climate Change Projections**
    - **I.** Explain the impacts of climate change on the environment, as well as social and economic impacts both locally and globally. Focused on aquatics.
2. **Key Topic #2: Forest Health in a Changing Climate**
    - **I.** Describe how wildfire impacts the hydrology, wildlife, and soils of forest communities.
    - **II.** Describe the conditions of drought as it relates to forest ecosystems, and identify how increasing drought severity and frequency impacts global forests.
3. **Key Topics #6: The Boreal Forest**
    - **I.** Differentiate the types of wetlands found in the boreal forest, explain their importance, and describe the anticipated effects from a changing climate on these ecosystems