Aquatic Ecology Learning Objectives for the NCF-Envirothon

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.
3. Identify the global distribution of water (saltwater, freshwater, ice, et cetera).
4. Describe the major differences between freshwater and saltwater ecosystems.
5. Identify the characteristics of estuaries and explain the importance of brackish water systems.
6. Identify different types of water bodies, how they are formed, and where they are found.
7. Differentiate the types of wetlands, describe their characteristics, and identify common species found in each.

Aquatic Ecosystems

8. Identify the biotic and abiotic components of aquatic ecosystems.

9. Describe the structure of an aquatic ecosystem, including:
    a. Species and communities
    b. Abiotic components
    c. Symbiotic relationships
    d. Carrying capacities
    e. Productivity
10. Define an aquifer and elaborate on how aquifers relate to the local and global water supply.
11. Identify the role of the water table in an ecosystem and how water tables affect human activity and water use.
12. Explain how seasonal changes in temperature, water level, flow rate, nutrient sources, nutrient availability, runoff, and inputs occur in aquatic ecosystems.
13. Describe the natural aging process of lakes and ponds.
14. Diagram an aquatic food web and describe the flow of energy within it.
15. Relate the energy pyramid to different trophic levels and the total amount of energy available to consumers.
16. Determine the order of a stream and describe what the order indicates.
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

Organisms

20. Describe the roles of producers, consumers, and decomposers in various aquatic ecosystems and identify their trophic levels.
21. Categorize different types of aquatic plants based on their adaptations.
22. Identify the major characteristics of fish, amphibians, and other aquatic animals.
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.
25. Describe the unique life cycles of aquatic creatures, including adaptations such as anadromy, catadromy, metamorphosis, et cetera.
26. Identify the ecological niches of aquatic organisms.

27. Explain the distinctions between species designations (such as common, rare, endangered, threatened, endemic, extirpated, and extinct) and provide examples of each type.

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.
30. Identify how major legislation protects water resources.
31. Identify key stakeholders, agencies, and organizations that oversee water resource protection and management (such as local conservation districts or water boards, state/provincial agencies, and national environmental and conservation agencies).
32. Explain why it is important to take the entire watershed/catchment area into account when planning for water quality.
33. Identify state/provincial river basins.
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.
36. Identify ecological and human demands on the water supply and provide recommendations for balancing these demands.
37. Describe water conservation practices and in which situations they are most effectively used.
38. Identify causes of hypoxia and anoxia in aquatic systems, how these conditions impact the functioning of the ecosystem, and best management practices for prevention and treatment.
39. Describe how a disturbance to one trophic level will impact organisms in other trophic levels.
40. Describe cultural eutrophication and how it affects lakes and ponds.
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.

44. Distinguish between point and non-point source pollution and give examples and management strategies for each.
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.
47. Explain the process of ocean acidification and describe its effect on marine ecosystems.
48. Describe how water can be used as a source of renewable energy.
49. Explain the economic, societal, and cultural impacts of water quality and quantity resource issues (such as water scarcity, damming projects, pollution disasters, et cetera).
50. Describe the roles of key leaders in water quality and conservation, both historical and present (such as Marjory Stoneman Douglas, Jacques Cousteau, Amariyanna Copeny, Vanessa Nakate, et cetera).

Field Skills

51. Identify common aquatic animal species including fish, reptiles, amphibians, and mammals.
52. Identify common aquatic macroinvertebrates and their pollution tolerances.
53. Calculate a biotic index and determine water quality for freshwater systems.
54. Identify common aquatic plants and their growth zones.
55. Identify invasive aquatic species.
56. Utilize common water monitoring tools to determine local water quality (such as a secchi disk, Ekman dredge, dip net, pH meter, aquatic sensors, et cetera).
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.
58. Utilize common technologies in water resource management (such as GPS, GIS, aquatic sensors, et cetera).
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.
62. Interpret a hydrograph.