Alignment with Next Generation Science Standards

Performance Expectations for

Kindergarten

NGSS	Performance Expectation	TIC match
K-LS1-1	Use observations to describe patterns of what plants and animals (including humans) need to survive.	watching trout in the tank, eating, swimming in water, needing to stay in water, aerating the tank,
K-ESS3-1	Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.	trout need to live in cold water, so they live in streams and lakes
K-ESS3-3	Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.	humans can do some things to prevent runoff into streams, stormwater, litter, water conservation leaves more water in the stream
K-ESS2-1	Use and share observations of local weather conditions to describe patterns over time.	Counting the number of rainy days. Advanced classes could see more water in streams after rain.
K-PS3-1	Make observations to determine the effect of sunlight on Earth's surface.	sunlight heats water and trout need cold water -- shade keeps streams cooler

Alignment with Next Generation Science Standards

Performance Expectations for

1st Grade

NGSS	Performance Expectation	TIC match
1-PS4-1	Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.	Trout have a lateral line with tiny cillia that sense vibrations around them. This is an extra sense for trout. The coffee-can demonstration.
1-LS1-1	Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.	Trout have 8 fins that help them steer and swim very nimbly.
1-LS1-2	Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.	Trout dig redds to lay their eggs in that protect the eggs with a layer of gravel. Salmon die and add to the nutrition of the stream.
1-LS3-1	Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.	Observe the fry in the tank, and compare their shape and features to pictures of adult trout.

Alignment with Next Generation Science Standards

Performance Expectations for

2nd Grade

NGSS	Performance Expectation	TIC match
2-LS4-1	Make observations of plants and animals to compare the diversity of life in different habitats.	Through media or out in the field, observe the number of organisms in a stream or riparian ecosystem. Macroinvertebrate study! Hikes!
2-ESS2-1	Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.	Dams. Also, if they have access to a project site, they can look at stream rebuilding, culverts, riprap, other structures.
2-ESS2-2	Develop a model to represent the shapes and kinds of land and bodies of water in an area.	Build a watershed model, the crumpled paper kind, or out of mud, dig a hole. Build models outside. Also, do the dream stream diorama.
2-ESS2-3	Obtain information to identify where water is found on Earth and that it can be solid or liquid.	Water is in streams. Flows from clouds to lakes/oceans. Also, in spring creek areas or mountain spring areas, can talk about water in ground.

Alignment with Next Generation Science Standards

Performance Expectations for

3rd Grade

NGSS	Performance Expectation	TIC match
3-LS4-1	Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.	Salmon or char fossils?
3-LS4-3	Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.	Trout and salmon live in cold water but cannot live in warm water. Other fish live in warm water.
3-LS4-4	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.	Macroinvertebrates indicate the water quality of a stream, and the types and numbers of organisms change with water quality. Humans impact streams. Stream shape/form can also change.
3-LS1-1	Develop models to describe that organisms have unique and diverse life cycles but all have common birth, growth, reproduction, and death.	Observing trout in the tank and drawing parallels to other organisms' life cycles, such as humans' life. Grow a bean and compare it to an alevin!
3-LS3-1	Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation in these traits exists in a group of similar organisms.	Compare the tank population of fry and observe and note the differing characteristics of the fish. If the opportunity was had to see egg stripping, these traits can be compared to parents' traits.
3-LS3-2	Use evidence to support the explanation that traits can be influenced by the environment.	Fed fish are bigger and healthier. Fish in different parts of the tank or in different tanks grow differently. Also, behaviors? Behavioral traits?
3-LS4-2	Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.	Observe the variations in parr marks and talk about camouflage. Look at spawning colors, especially of males, and compare reproductive behaviors.
3-ESS2-2	Obtain and combine information to describe climates in different regions of the world.	Trout only live in some climates and some parts of the world. Different trout live in different parts of the world. They are suited to their climates.

Alignment with Next Generation Science Standards

Performance Expectations for

4th Grade

NGSS	Performance Expectation	TIC match
4-PS4-1	Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.	Different community members and anglers make vibrations that the trout can feel in their lateral lines, and they can likely tell what is what by the characteristics of the vibrations.
4-PS4-2	Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.	Trout can see around them, with certain limits of their range of vision. The refraction of light at the light/water boundary also changes the perception of the place of objects see by eyes.
4-LS1-1	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.	Trout have so much internal and external anatomy! Unique features include the swim bladder, nares, kype, pyloric caeaca, eggs, gonads, fins, lateral line, etc.
4-LS1-2	Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.	Trout have senses that are somewhat like humans' senses. Eyes, nares, lateral line, mouth, feel. Trout follow smell to their home stream. They sense predator vibrations in lateral line. See prey.
4-ESS2-1	Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.	Stream bank erosion, silt and sand bars in rivers, evidence of floods, canyons, carving of the land by rivers, the shapes of watersheds.
4-ESS2-2	Analyze and interpret data from maps to describe patterns of Earth's features.	Maps show land and water features. Rivers and tributaries. Topographic maps show elevation. Built a 3D topo map? Rivers flow to lakes and oceans. Watersheds have branch shape.
4-ESS3-2	Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.	Human activity has, in some cases, made severe natural events worse for humans, so now we do remediation work to fix that. Especially reshaping streams and replanting riparian areas for flood control.

Alignment with Next Generation Science Standards

Performance Expectations for

5th Grade

NGSS	Performance Expectation	TIC match
5-PS3-1	Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.	Food webs of the stream that connect trees to macroinvertebrates and trout, and to the fish predators.
5-LS2-1	Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.	Food webs of the stream that connect trees to macroinvertebrates and trout, and to the fish predators. Also mention salmon decay and their nutrients in upland ecosystems, forests, scavengers, decomposers.
5-ESS2-1	Develop a model using an example to describe ways the geospere, biosphere, hydrosphere, and/or atmosphere interact.	Water cycle in its entirety, including water travel through all the spheres.
5-ESS2-2	Describe and graph the amounts and percentages of water and fresh in various reservoirs to provide evidence about the distribution of water on Earth.	Water on Earth demonstration. Discuss groundwater, percolation, water cycle, etc.
5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.	Citizen science, macroinvertebrate studies on water quality, stormwater runoff and remediation, rain gardens, rain barrels, pollution, stream shape and guiding, conservation, water conservation, TU's projects, work, efforts.

Alignment with Next Generation Science Standards

Performance Expectations for

Middle School (p. 1)

NGSS	Performance Expectation	TIC match
MS-LS1-3	Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.	Trout anatomy!
MS-LS1-8	Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.	Trout have eyes, nares, lateral line. Anadromous fish smell their way upstream. Trout in a tank respond to stimuli, such as food, light, someone walking by, something foreign in the tank.
MS-LS1-6	Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.	Food webs involving trout, also trout and trees and insects and their connection and cycles.
MS-LS2-1	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.	Trout need food, space, cool water in tank or in stream or lake.
MS-LS2-3	Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	More food webs! Interaction of riparian zone and stream/lake ecosystems.
MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	Altered streams alter trout populations. Lack of water, change in geomorphology.
MS-LS2-2	Construct an explanation that predicts patterns of interaction among organisms across multiple ecosystems.	Trout are parts of many kinds of interactions, especially predator/prey and competitive interactions.

Alignment with Next Generation Science Standards

Performance Expectations for

Middle School (p. 2)

NGSS	Performance Expectation	TIC match
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	Tree-planting in a riparian zone, other types of stream rebuilding, changing stream channels (removal), expaning floodplains, etc.
MS-LS4-2	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.	Deal with the salmonid family. What do they have in common? (adipose fin, 8 fins, spots, scales, torpedo shape, etc.) How do they differ? Deal with geography and earth changes that may have driven these speciations.
MS-LS4-3	Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.	Look at the trout embryos in the tank! Compare to other salmonids, and other fish, and amphibians, etc.
MS-LS4-4	Construct an explanation based on evidence that describes how genetric variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.	Look at variation in the tank. Talk about trout in a hatchery and wild trout, and what different characteristics might be most beneficial in each setting.
MS-LS4-6	Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.	Consider the wild trout in the stream. Remember that out of 1000 eggs, usually 1 reaches reproductive adulthood. (Compare to trout in a cement hatchery.)

TROUT IN THE CLASSROOM

Alignment with Next Generation Science Standards

Performance Expectations for

Middle School (p. 3)

NGSS	Performance Expectation	TIC match
MS-ESS2-1	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.	Water cycle. Also, mineral cycles shape the landscape. Also nitrogen and carbon cycles. Relevant in tank.
MS-ESS2-4	Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	Water cycle.
MS-ESS3-2	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.	high water lines and flood lines and flood water behavior in watersheds and heavily-altered watersheds.
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Monitor watershed, stream, macroinvertebrates, riparian area, stream crossings, tree-plantings, land-use, etc.
MS-ESS3-4	Construct an argument support by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.	Monitor local water, stream, macros. Check against historic data. Water use, water rights.

Alignment with Next Generation Science Standards

Performance Expectations for

High School (p. 1)

NGSS	Performance Expectation	TIC match
HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	It is worth examing the nitrogen cycle that occurs in the tank in this way. Ammonia waste is converted to nitrites, nitrates, and then nitrogen gas by microbes using available reagents, such as oxygen, carbonate, etc.
HS-PS4-2	Evaluate questions about the advantages of using a digital transmission and storage of information.	Relevant here are water-quality probes and data loggers and stream gauges that can collect and store large amounts of data, as well as some interesting disucssions of PIT tags and radio telemetry tags for organisms.
HS-LS-2	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.	Trout systems are worth examing here, and it is interesting that one can see the circulatory system in the trout embroyo inside an egg, as well as in young alevins.
HS-LS-3	Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.	Trout respiration rate, gills responding to dissolved gases, swim bladder in response to water pressure, and anadromous fish physiological changes when moving fresh to salt or vice versa.
HS-LS-4	Use a mathematical representation to support claims for the cycling for matter and flow of energy among organisms in an ecosystem.	Aquatic or marine ecosystem is one example to be used in these studies. One particularly unique ecosystem carbon cycle involves migrating salmon, whose biomass feeds entire forests.
HS-LS2-5	Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	Aquatic or marine ecosystem provides a great example here. Trees-insects-trout-etc. is nice model; salmon participate in a more complex cycle and system.

TROUT IN THE CLASSROOM

Alignment with Next Generation Science Standards

Performance Expectations for

High School (p. 2)

NGSS	Performance Expectation	TIC match
HS-LS2-1	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	Examine water flows, temperature, quality, prey, space available and the impact on salmonid populations.
HS-LS2-2	Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations of different scales.	Examine biodiversity of a stream and the riparian area; consider salmonids keystone species. Find that a stretch of stream with replanted riparian zone reflects an almost immediate increase in biodiversity.
HS-LS2-6	Evaluate the claims , evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.	Consider the changes in water flows due to dams or water removal from streams for human use. Rising stream temperatures with climate change? Consider the increase of resilience through restored streams.
HS-LS2-8	Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.	Schooling salmon in the ocean and on return migration protect the masses by moving in groups.
HS-LS4-6	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.	Improve water flows and flashiness of floods via flow management, culvert modification, or dam removal; replant a riparian area or create a buffer zone on an impacted stream.
HS-LS3-3	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.	Trout or salmon populations can be examined, in the tank, hatchery, or in the wild. Interesting related question--proportions of steelhead to rainbows from the same natal stream!

TROUT IN THE CLASSROOM

Alignment with Next Generation Science Standards

Performance Expectations for

High School (p. 3)

NGSS	Performance Expectation	TIC match
HS-LS4-1	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.	Use the salmonid family and distribution of native species to support this argument, as one example.
HS-LS4-2	Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.	Salmonids make a nice example, here, as they are highly suited to their native ranges and the family has similar traits but varies across the world.
HS-LS4-3	Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.	Look specifically at salmonids that are highly camouflaged (in addition to counter-shading and parr marks), and also compare behaviors and water temperature tolerance across species.
HS-LS4-4	Construct an explanation based on evidence for how natural selection leads to adatation of populations. Discuss how hatchery and non-native fish don't "play by the rules" in streams and can upset a long-evolved balance.	Look specifically at salmonids that are highly camouflaged (in addition to counter-shading and parr marks), and also compare behaviors and water temperature tolerance across species.
HS-LS4-5	Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the exctinction of other species.	Consider impacts of water flow regime changes, climate change, introduction of non-native species of all types. Examine the impact of the last ice age on the speciation of salmonids.

Alignment with Next Generation Science Standards

Performance Expectations for

High School (p. 4)

NGSS	Performance Expectation	TIC match
HS-ESS2-2	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	Watersheds respond to many changes, including changes in glaciers' size, erosion due to vegetation changes, groundwater recharge changes, dams affect things, etc.
HS-ESS2-5	Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.	On field days, examine the impacts of the flowing water on the local landscape. Consider the hydrologic cycle and its impacts locally. Ask why a carbonate-rich rock can be important for trout tanks.
HS-ESS2-6	Develop a qualitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.	Involve trout or salmon in the model.
HS-ESS3-5	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.	And then consider the future range, diversity, and survival of salmonids in the region--trout and salmon are temperature-limited and will lose migratory ability (fresh only or fresh-to-salt) with rising temperatures.
HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, ocurrence of natural hazards, and changes in climate have influenced human activity.	Examine how and where in watersheds humans live. Examine precipitation and water availablity as factors in population density.

Alignment with Next Generation Science Standards

Performance Expectations for

High School (p. 5)

NGSS	Performance Expectation	TIC match
HS-ESS3-2	Evaluate competing design solutions for developing, mananging, and utilizing energy and mineral resources based on cost-benefit ratios.	Focus on water rights and water use. Examine the impacts of resource extraction, especially fracking for natural gas and hard rock mining. Debate the Pebble Mine issue.
HS-ESS3-3	Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	Consider land use, urban planning, agriculture, conservation practices, resource harvest (especially extraction and logging), etc.
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.	Culvert remediation, riparian planting, stream engineering, urban planning, stormwater management, mining/logging/agricultural practices, ecosystem management, organism management, hatcheries?
HS-ETS1-2	Design a solution to a complex, real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	Decreased trout populations, decreased water flows, impaired connectivity of a watershed, human impacts on water quality from land use practices, etc. Remember that environmental engineering is a thing!
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	Dam removal, stream fencing, stormwater management, logging BMPs, resources extraction BMPs, hatchery augmentation programs, moving water across the CO range, any project TU is doing and why.