NGSS Connections

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Illuminating Indicators
High School

Performance Expectations: Students' ability to complete the following performance expectation(s) will be supported by participation in this activity.

HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. (Note: We currently use quantitative data.)

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 new ecosystems.

HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. (Note: We currently use quantitative data.)

HS-ESS3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (Note: We currently use quantitative data.)

Dimension	**NGSS Code or citation**	**Corresponding student task in activity**
Disciplinary Core Idea	LS2.C Ecosystem Dynamics, Functioning, and Resilience • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however can challenge the functioning of ecosystems in terms of resources and habitat availability.	Students test various chemical pollutants and see how those pollutants impact the ability of a model microorganism (*Photobacterium phosphoreum*) to survive in the changed ecosystem.

	• Moreover, anthropogenic changes (induced by human activity) in the environment – including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change – can disrupt an ecosystem and threaten the survival of some species.	Students design a test to determine how water quality impacts organisms using the model organism, *Photobacteria phosphoreum,* when human activity puts pollutants in the environment.
	ESS3.C Human Impacts on Earth Systems • The sustainability of human societies and the biodiversity that supports them require responsible management of natural resources.	Human pollution is entering the Chesapeake Bay and killing bacteria, which impacts other populations in the ecosystems. In the class, we discuss how we (the students and people in general) can make a difference.
	ESS3.D Global Climate Change • Though the magnitude of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activity.	Human pollution is killing organisms and disrupting ecosystems. Humans can and have taken action to save ecosystems. This activity focuses on an indicator organism that can be used to monitor water quality to support management of the system for now and for the future. The class is also asked to identify ways they can help protect the ecosystem. The beginning video talks about how bioluminescent bacteria are under investigation and how scientists are still learning why organisms bioluminescence.
Practice	Planning and Carrying Out Investigations • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models,	Students develop the protocol to test the bacteria's sensitivity to various environmental contaminants. The purpose of the activity is to begin the testing and development of a bioassay for a fictional company.

	supporting explanations for phenomena, or testing solutions to problems. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data and refine the data accordingly.	Students are introduced to both fluorescence and bioluminescence and asked to identify which process would be the most suitable for development into a bioassay. They then design an investigation to test the reaction of bioluminescent bacteria to exposure of pollutants. They must consider the data they will collect, what it will inform regarding development of a bioassay, and possible limits.
	Analyzing and Interpreting Data • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.	Students consider the limitations on the model bacteria we use. For example, *P. phosphoreum* is one marine organism, and may have different sensitivities to pollutants compared to other microbes, and it may not function in fresh water.
	Constructing an explanation • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	Students use the data collected during the lab to explain the impacts of the pollutants on the bacteria. For example, if exposure to tea tree oil (independent variable) results in bacteria not glowing (dependent variable), then the tea tree oil killed the bacteria. Students explain how bacteria's sensitivity to environmental contaminants can make them useful as indicator organisms, and also identify the next steps necessary to fully develop a bioassay (i.e., testing this strain with multiple pollutants, testing the strain's sensitivity at different concentrations of pollutants,

		possibly considering sensitivities in differences in types of water – fresh vs. brackish vs. marine).
Crosscutting Concept	Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable.	Ecosystem was stable, but an introduced disturbance (pollution) is changing the environment, the ecosystem populations. Some populations are more sensitive to the pollution than others; changes in these can serve as indicators of ecological health.
	Cause and Effect • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	Populations in aquatic environments that have pollutants commonly have changes in the populations. Students design an investigation to determine the impacts of specific pollutants on a population (bioluminescent bacteria). They link the cause (each pollutant) with the effect (i.e., death of the bacteria).

Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes the universe is a vast single system in which basic laws are consistent.

Scientific Investigations Use a Variety of Methods

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Scientists often use hypotheses to develop and test theories and explanations.

Connections to Common Core State Standards

English Language Arts/Literacy	RST.11-12.4
RST.9-10.4	RST.11-12.7
RST.9-10.7	RST.11-12.8
RST.9-10.8	
RST.11-12.2	