Chariho Regional School District - Science Curriculum
September, 2016

OCEANOGRAPHY CURRICULUM

Unit 1: Introduction to Oceanography

OVERVIEW

Summary

In this unit students will be introduced to the field of oceanography. They will explore the technologies that have helped make ocean exploration and ocean science more accurate over time. They will begin by reviewing a brief history of the exploration of the oceans, including some of the notable discoveries made during those travels. They will briefly gain common understanding of the dimensions of the oceans, as well as latitude and longitude, so that all students have the same foundational understanding as they explore the later topics in detail. Finally, students will focus on various navigation techniques and the advancements in technology that have improved those techniques. This brief introductory unit will provide perspective as to why it is important to study the oceans.

Content to Be Learned

- Define oceanography.
- Explore historical and recent technologies that support the field of oceanography.
- Describe notable discoveries in, on, or under the ocean.
- Discuss the advancement of navigation techniques.
- Identify the dimensions of the ocean, including distribution of water at various latitudes, volume, area, and depth of various oceans.
- Identification of uses of the grid system referred to as latitude and longitude.

Practices

- Obtaining, evaluating and communicating information.
- Developing and using models.
- Analyzing and interpreting data.

Crosscutting Concepts

- Systems and system models.
- Scale, proportion, and quantity.

Essential Questions

- Historically, how has the field of oceanography changed due to advances in technology?
- How can the position of an object on Earth be identified using latitude and longitude?
- What are the reasons for the increased interest in resources of the sea?

Next Generation Science Standards

No Standards Applicable.

Unit 2: Geologic Oceanography

OVERVIEW

Summary

Students will begin this unit learning about plate tectonics and a review of the Earth's layers. They will then investigate the relationship between the age of crustal rock and the past and current movements of the crustal plates. They will review plate boundaries and the geologic events that occur at each. Students will apply this knowledge to explaining how various features of the seafloor are created. Students will identify the major features of seafloor bathymetry and will investigate the technologies used to identify those structures. They will also look at the influence of plate tectonics on the creation of hydrothermal vents and will further investigate the unique environments that are created due to the warming of the water in these areas. Next, they will look at the various types of seafloor sediments, their distribution and the rates of sedimentation. They will compare lithogenous and biogenous sediments. Students will learn how scientists collect sediment cores and how the layering of sediments can be useful to scientist in their study of geologic oceanography. Students will also identify seafloor resources, and their uses. Finally, students will make connections between the drilling for natural resources, and the human impact that has resulted. They will focus on why humans drill, and the results of drilling on the environment and biodiversity. (A case study of an example of drilling that has gone wrong, such as the Deepwater Horizon oil spill of 2010 may be used.)

Content to Be Learned

- Review the layers of the Earth, as defined by composition as well as by physical properties.
- Explain the influence of the mantle on the movement of the crustal plates.
- Discuss the movement of the plates of the crust, as it pertains to continental drift.
- Identify the three types of boundaries and the events that occur at each.
- Identify evidence for seafloor spreading.
- Identify locations and characteristics of the unique environment known as hydrothermal vents.
- Discuss major features of the bathymetry of the seafloor, how they are discovered, and how they formed.
- Discuss types of sediments found on the seafloor, their distribution, and rates of sedimentation.
- Explain the differences in sources and chemistry of various seafloor sediments.
- Explain how sediment cores are collected, and how the layering of sediments can be studied with these cores.
- Discuss human uses of seafloor resources, including sand and gravel, minerals, and fossil fuels.

Practices

- Constructing explanations and designing solutions.
- Engaging in argument from evidence.
- Developing and using models.

Crosscutting Concepts

- Stability and change.
- Patterns.

Essential Questions

- How can the age of the seafloor be explained, using evidence from the theory of plate tectonics and oceanic plate movement?
- How have both the drilling for oil, as well as the errors that have occurred, impacted the environment and biodiversity?
- How are seafloor features a result of both constructive forces as well as destructive mechanisms?
- What are the reasons that scientists study the sea floor? What techniques do they use to collect data?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • 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. **LS4.D: Biodiversity and Humans** • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)* • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)* **ETS1.B: Developing Possible Solutions** • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; HS.ESS2.E ; HS.ESS3.A ; HS.ESS3.C

Articulation of DCIs across grade-bands:
MS.LS2.C ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:
ELA/Literacy -

RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. *(HS-LS2-7)*
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-7)*
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)

Mathematics -

MP.2	Reason abstractly and quantitatively. *(HS-LS2-7)*
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-LS2-7)*
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-7)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-LS2-7)*

HS-ESS1-5 Earth's Place in the Universe

Students who demonstrate understanding can:

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core (a result of past plate interactions).]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth

- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. *(ESS2.B Grade 8 GBE) (secondary)*

PS1.C: Nuclear Processes

- Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. *(secondary)*

Crosscutting Concepts

Patterns

- Empirical evidence is needed to identify patterns.

Connections to other DCIs in this grade-band:
HS.PS3.B ; HS.ESS2.A

Articulation of DCIs across grade-bands:
MS.ESS1.C ; MS.ESS2.A ; MS.ESS2.B

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS1-5)*
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-5)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-ESS1-5)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS1-5)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-5)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS1-5)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-5)

HS-ESS2-1 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [*Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

ESS2.B: Plate Tectonics and Large-Scale System Interactions
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)*

Crosscutting Concepts

Stability and Change
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Connections to other DCIs in this grade-band:
HS.PS2.B
Articulation of DCIs across grade-bands:
MS.PS2.B ; MS.LS2.B ; MS.ESS1.C ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS2.D
Common Core State Standards Connections:
ELA/Literacy -

SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-ESS2-1)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-1)
MP.4	Model with mathematics. (HS-ESS2-1)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-1)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-1)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-1)

Unit 3: Coastal Geology

OVERVIEW

Summary

In this unit students will transition to focusing on the geology of the coasts. Students will begin by observing the diversity of coasts that exist on the planet and the geomorphology that created and influences them. They will identify beach anatomy and observe the cyclic changes that occur to these structures. They will analyze geoscience data for evidence of sea level rise, and will discuss the impact of sea level rise on both a local and global scale. They will look at connections between climate change and sea level rise. Students will look at the movement of Earth materials through the processes of erosion and sediment transport, and explain how beach dynamics represent the gross movement of materials on and off a beach. Finally, students will identify human influence on the coasts and how the structures built by man cause changes to the natural processes of the area. (A case study of an area, such as the erosion of Matunuck Beach, is suggested.)

Content to Be Learned

- Identify reasons for sea level rise and effects of sea level rise on the coasts.

- Discuss the influence of climate change on sea level rise.
- Analyze geoscience data for evidence of sea level changes.
- Explain how Earth materials are transported using erosion and sediment transport.
- Identify features of beach anatomy and explain how they are influenced by seasonal environmental changes.
- Analyze the influence of storm events on the processes that affect coastal structures, and on the structures themselves.
- Identify modifications made by humans to the coasts, and discuss the impact those structures have on the geography of the surrounding areas.
- Discuss human influence on the natural coastlines, both as a function of the reasons for the influences, as well as results of the change.

Practices

- Using mathematics and computational thinking.
- Constructing explanations and designing solutions.
- Planning and carrying out investigations.

Crosscutting Concepts

- Cause and effect.
- Structure and function.
- Stability and change.

Essential Questions

- How does beach anatomy exhibit both stability and change?
- How has climate change affected the volume of the oceans, and how has the change in volume affected the coasts?
- How do storm events disrupt the natural cycle of changes that occur to a coast of beach? How does a beach rebound after a storm event?
- Going forward, what is something that can be done to reduce the impact of human activities on the coastal environment and the unique biodiversity that exists in this ecosystem?
- How does water influence the anatomy of a beach?
- How have changes in climate influenced the activities of humans along the coasts?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • 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. **LS4.D: Biodiversity and Humans** • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)* • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)* **ETS1.B: Developing Possible Solutions** • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; HS.ESS2.E ; HS.ESS3.A ; HS.ESS3.C

Articulation of DCIs across grade-bands:
MS.LS2.C ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

ELA/Literacy -

RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. *(HS-LS2-7)*
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-7)*
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)

Mathematics -

MP.2	Reason abstractly and quantitatively. *(HS-LS2-7)*
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-LS2-7)*
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-7)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-LS2-7)*

Students who demonstrate understanding can:

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Create or revise a simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas

LS4.C: Adaptation

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.

LS4.D: Biodiversity and Humans

- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)*

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. *(secondary)*

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; **HS.ESS2.E** ; **HS.ESS3.A** ; **HS.ESS3.C** ; **HS.ESS3.D**

Articulation of DCIs across grade-bands:
MS.LS2.C ; **HS.ESS3.C**

Common Core State Standards Connections:
ELA/Literacy -

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. *(HS-LS4-6)*

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-LS4-6)*

HS-ESS2-5 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- 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 (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Disciplinary Core Ideas

ESS2.C: The Roles of Water in Earth's Surface Processes

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

Crosscutting Concepts

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Connections to other DCIs in this grade-band:
HS.PS1.A ; HS.PS1.B ; HS.PS3.B ; HS.ESS3.C

Articulation of DCIs across grade-bands:
MS.PS1.A ; MS.PS4.B ; MS.ESS2.A ; MS.ESS2.C ; MS.ESS2.D

Common Core State Standards Connections:

ELA/Literacy -

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)

Mathematics -

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-5)

HS-ESS3-1 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS3.A: Natural Resources** • Resource availability has guided the development of human society. **ESS3.B: Natural Hazards** • Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. - - - - - - - - - - - - - - - - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Modern civilization depends on major technological systems.

Connections to other DCIs in this grade-band: N/A

Articulation of DCIs across grade-bands:

MS.LS2.A ; MS.LS4.D ; MS.ESS2.A ; MS.ESS3.A ; MS.ESS3.B

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS3-1)*
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)

Mathematics -

MP.2	Reason abstractly and quantitatively. *(HS-ESS3-1)*
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-ESS3-1)*
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-1)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-ESS3-1)*

Unit 4: Chemical Oceanography

OVERVIEW

Summary

This unit will focus on the chemistry of seawater. Students will begin by describing the chemical and physical properties of water and will focus on hydrogen bonding and its influence on the other properties. They will have opportunities to demonstrate these properties in various laboratory experiences. They will then look at the pH and salinity of seawater. They will discuss the pH scale and hydrogen and hydroxide ions influence the pH of a substance. They will learn the chemical formula that represents the stable pH of seawater and will discuss how buffers are used to keep the water in a relatively stable state, regardless of outside influences. Students will then focus on sources of seawater salts and look at factors, on both a global and local scale, that cause salinity to fluctuate. Next they will identify dissolved gases that are abundant in seawater, focusing primarily on carbon dioxide and oxygen. They will review the carbon cycle and discuss how photosynthetic organisms are able to influence the concentrations of both gases in seawater. Finally, students will focus on pollution and its influence on both seawater chemistry and the resulting effect on ocean biology. (A case study, perhaps focusing on one type of pollution, is suggested.)

Content to Be Learned

- Describe the properties of water at the atomic level, including, but not limited to:
    - Bonding.
    - Polarity.
    - Adhesion, cohesion, surface tension.
    - Light transparency.
    - Density.
    - Heat capacity.
    - Heat of fusion and heat of vaporization.
- Describe the pH scale.
- Explain how a substance becomes more acidic or basic.
- Describe the role of buffers in the reaction that maintains a constant pH in seawater.
- Identify the salinity of the major ocean basins.
- Discuss the relationship between latitude and salinity.
- Identify sources of salt that contribute to the salinity of seawater.
- Identify abundant gases in the ocean and their source and uses.
- Explain how the process of photosynthesis affects the concentrations of dissolved gasses in the ocean.
- Explain the carbon cycle as it appears in the oceans.
- Identify and describe chemical resources that can be gleaned from the oceans.
- Explain how resources, like salt, or fresh water, can be extracted from seawater.
- Analyze available data to describe the impact of carbon dioxide emissions on seawater.
- Describe the types of waste found in the oceans and explain how they affect water quality.
- Research and describe what we are doing now to mitigate the damage done to the past with regards to ocean pollution.

Practices

- Constructing explanations and designing solutions.
- Analyzing and interpreting data.
- Developing and using models.
- Using mathematics and computational thinking.

Crosscutting Concepts

- Cause and effect.
- Systems and system models.
- Energy and matter.
- Stability and change.

Essential Questions

- How does the arrangement of water molecules change as water moves from a solid to a liquid to a gas?
- How does hydrogen bonding influence the rest of the properties of water?
- What roles do photosynthesis and cellular respiration play in the cycling of carbon?

- Using data and information on global climate change, how do meteorologists create a forecast for the rate of temperature change in the oceans on a global scale?
- How does the concentration of carbon dioxide in the atmosphere influence ocean temperature?
- Using data to support your answer, in your opinion, are humans doing more or less damage to the oceans now as compared to one hundred years ago?

<u>Next Generation Science Standards</u>

Students who demonstrate understanding can:

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.** [Clarification Statement: Examples of models could include simulations and mathematical models.] [*Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show how relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or components of a system.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • <u>Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.</u> **PS3.D: Energy in Chemical Processes** • The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary)*	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Connections to other DCIs in this grade-band:
HS.PS1.B ; HS.ESS2.D

Articulation of DCIs across grade-bands:
MS.PS3.D ; MS.LS1.C ; MS.LS2.B ; MS.ESS2.A

Common Core State Standards Connections: N/A

Students who demonstrate understanding can:

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- 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.

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)*
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)*

ETS1.B: Developing Possible Solutions

- When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*

Crosscutting Concepts

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; HS.ESS2.E ; HS.ESS3.A ; HS.ESS3.C

Articulation of DCIs across grade-bands:
MS.LS2.C ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

ELA/Literacy -

RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. *(HS-LS2-7)*
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-7)*
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)

Mathematics -

MP.2	Reason abstractly and quantitatively. *(HS-LS2-7)*
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-LS2-7)*
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-7)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-LS2-7)*

Students who demonstrate understanding can:

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Create or revise a simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas

LS4.C: Adaptation

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.

LS4.D: Biodiversity and Humans

- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)*

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. *(secondary)*

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; HS.ESS2.E ; HS.ESS3.A ; HS.ESS3.C ; HS.ESS3.D

Articulation of DCIs across grade-bands:
MS.LS2.C ; HS.ESS3.C

Common Core State Standards Connections:
ELA/Literacy -

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. *(HS-LS4-6)*

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-LS4-6)*

HS-ESS2-6 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.D: Weather and Climate** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved.

Connections to other DCIs in this grade-band:
HS.PS1.A ; HS.PS1.B ; HS.PS3.D ; HS.LS1.C ; HS.LS2.B ; HS.ESS3.C ; HS.ESS3.D

Articulation of DCIs across grade-bands:
MS.PS1.A ; MS.PS3.D ; MS.PS4.B ; MS.LS2.B ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-6)
MP.4	Model with mathematics. (HS-ESS2-6)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-6)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-6)

HS-ESS3-5 Earth and Human Activity

Students who demonstrate understanding can:

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. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using computational models in order to make valid and reliable scientific claims.

Connections to Nature of Science

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.
- New technologies advance scientific knowledge.

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence.
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Disciplinary Core Ideas

ESS3.D: Global Climate Change

- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

Crosscutting Concepts

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Connections to other DCIs in this grade-band:
HS.PS3.B ; HS.PS3.D ; HS.LS1.C ; HS.ESS2.D

Articulation of DCIs across grade-bands:
MS.PS3.B ; MS.PS3.D ; MS.ESS2.A ; MS.ESS2.D ; MS.ESS3.B ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-5)
RST.11-12.2	Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. *(HS-ESS3-5)*
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-ESS3-5)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS3-5)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS3-5)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-5)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-5)

HS-ESS3-6 Earth and Human Activity

Students who demonstrate understanding can:

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.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)*

ESS3.D: Global Climate Change

- 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 activities.

Crosscutting Concepts

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Connections to other DCIs in this grade-band:
HS.LS2.B ; **HS.LS2.C** ; **HS.LS4.D** ; **HS.ESS2.A**
Articulation of DCIs across grade-bands:
MS.LS2.C ; **MS.ESS2.A** ; **MS.ESS2.C** ; **MS.ESS3.C** ; **MS.ESS3.D**
Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS3-6)
MP.4	Model with mathematics. (HS-ESS3-6)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS3-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-6)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-6)

Unit 5: Physical Oceanography

OVERVIEW

Summary

During this unit, students will focus on the physical nature of the oceans. They will learn about the movement of water on many scales, from global ocean currents, to waves crashing on the shores. They will look at the energy that comes from moving water and how humans can and are using the moving water as an energy source. Students will compare surface and deep water currents, and look at the influence of wind and temperature on the current patterns in the major ocean basins. They will briefly review the anatomy of a wave, and then look at wave motion in the open ocean and along the shores. Finally, they will study how the sun and moon influence the bulging of water on Earth and how the movement of those celestial objects create high and low tides, as well as spring and neap tides. Finally, students will look at how human waste, specifically plastics, have collected at the centers of most major ocean basins, due to the movement of water. (A case study, perhaps on the Great Pacific Garbage Patch, is suggested.)

Content to Be Learned

- Describe the pattern of water movement in the oceans.
- Compare surface transport with density-driven transport.
- Describe upwelling and downwelling zones.
- Research and discuss how ocean engineers harness the power of ocean circulation.
- Describe the process of Ekman transport.
- Explain how surface currents, combined with Ekman transport create the gyres in the ocean basins.
- Explain the influence of wind patterns in the movement of surface currents.
- Describe the process of Western Intensification.
- Review the anatomy of a wave and discuss wave motion in the open water and as it reaches shore.
- Differentiate between deep-water waves and shallow-water waves.
- Explain how waves exhibit refraction, reflection and diffraction.
- Research how humans can harness energy of waves.
- Differentiate between the three tidal patterns.
- Explain how the interaction between the sun, moon and earth creates high and low tides, spring and neap tides.
- Research how plastics are swept out to sea and form “islands” due to ocean current patterns.

Practices

- Using mathematics and computational thinking.
- Constructing explanations and designing solutions.
- Analyzing and interpreting data.
- Developing and using models.

Crosscutting Concepts

- Stability and change.
- Cause and effect.

Essential Questions

- How does temperature influence the movement of water?
- If Ekman transport is driving water towards the center of a gyre, why does the current not flow toward the center, but rather in a clockwise pattern around the gyre?
- How do refraction, reflection, and diffraction affect a wave?
- If you were sailing at night in the trade-wind belt, how could you use the waves to keep you on a course of constant direction?
- Why do the three different tidal patterns exist? What conditions are needed for each one?
- What would happen if there were no force counteracting the Sun’s gravitational force on the center of mass of the Earth-Moon system?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ▪ Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** ▪ 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. **LS4.D: Biodiversity and Humans** ▪ Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)* ▪ Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)* **ETS1.B: Developing Possible Solutions** ▪ When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*	**Stability and Change** ▪ Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; HS.ESS2.E ; HS.ESS3.A ; HS.ESS3.C

Articulation of DCIs across grade-bands:
MS.LS2.C ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

ELA/Literacy -

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. *(HS-LS2-7)*

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-7)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)

Mathematics -

MP.2 Reason abstractly and quantitatively. *(HS-LS2-7)*

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-LS2-7)*

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-7)*

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-LS2-7)*

HS-ESS2-2 Earth's Systems

Students who demonstrate understanding can:

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. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.

Crosscutting Concepts

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system.

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Connections to other DCIs in this grade-band:
HS.PS3.B ; **HS.PS4.B** ; **HS.LS2.B** ; **HS.LS2.C** ; **HS.LS4.D** ; **HS.ESS3.C** ; **HS.ESS3.D**

Articulation of DCIs across grade-bands:
MS.PS3.D ; **MS.PS4.B** ; **MS.LS2.B** ; **MS.LS2.C** ; **MS.LS4.C** ; **MS.ESS2.A** ; **MS.ESS2.B** ; **MS.ESS2.C** ; **MS.ESS2.D** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS2-2)*
RST.11-12.2	Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. *(HS-ESS2-2)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-2)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2)

HS-ESS2-4 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-4. **Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Use a model to provide mechanistic accounts of phenomena.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary)*

ESS2.A: Earth Materials and Systems

- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.PS3.A ; HS.PS3.B ; HS.LS2.C ; HS.ESS1.C ; HS.ESS3.C ; HS.ESS3.D

Articulation of DCIs across grade-bands:
MS.PS3.A ; MS.PS3.B ; MS.PS3.D ; MS.PS4.B ; MS.LS1.C ; MS.LS2.B ; MS.LS2.C ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS2.D ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

ELA/Literacy -

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-ESS2-4)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS2-4)

MP.4 Model with mathematics. (HS-ESS2-4)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-4)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-4)

Students who demonstrate understanding can:

HS-PS4-1. **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] *[Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]*

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.ESS2.A

Articulation of DCIs across grade-bands:
MS.PS4.A ; **MS.PS4.B**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-PS4-1)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-PS4-1)
MP.4	Model with mathematics. (HS-PS4-1)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1)
HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. *(HS-PS4-1)*
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *(HS-PS4-1)*

Unit 6: Biological Oceanography

OVERVIEW

Summary

In this unit, students will focus on life in the oceans. They will begin with a brief overview of the diversity that exists in the oceans, and discuss how and why certain features can exist in organisms that live in water while those same features do not exist on land. They will also discuss the constraints that exist on organisms that live in the oceans. Students will learn about the level of organizations and about ocean-specific food webs. They will focus on ocean producers, mainly phytoplankton, and their essential role in maintaining the food webs of the oceans. They will have opportunities to measure primary productivity in a lab setting and will discuss influences on productivity. Finally, students will research the adverse affects, on both a local and global scale, of commercial fishing. Students should look at the situation from multiple perspectives, including how fishing impacts the food webs of the oceans. (A case study, on the impacts of commercial fishing of a particular species, is suggested.)

Content to Be Learned

- Describe the diversity of habitats available in the oceans.
- Discuss the need for organisms to be able to survive in the oceans, and how they are able to deal with physical parameters, including buoyancy, salinity, temperature, pressure, gas concentrations, nutrient availability, light availability, and circulation patterns.

- Identify organisms at each taxonomic level, both in a food chain and a food web.
- Discuss the importance of primary producers in maintaining the ocean food web.
- Review the process of photosynthesis and discuss primary productivity in terms of carbon dioxide intake and oxygen output.

Practices
- Using mathematics and computational thinking.
- Constructing explanations and designing solutions.
- Analyzing and interpreting data.
- Developing and using models.

Crosscutting Concepts
- Stability and change.
- Cause and effect.

Essential Questions
- Using examples, how do organisms cope with the constraints of living in the ocean?
- How do humans impact the diversity of the ocean?
- How is global climate change impacting primary productivity?
- What is the role of primary producers in maintaining balance in the ocean food web?
- How do organisms interact with each other to create communities in the ocean?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-LS1-5. **Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Connections to other DCIs in this grade-band:
HS.PS1.B ; HS.PS3.B

Articulation of DCIs across grade-bands:
MS.PS1.B ; MS.PS3.D ; MS.LS1.C ; MS.LS2.B

Common Core State Standards Connections:
ELA/Literacy -
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-LS1-5)*

Students who demonstrate understanding can:

HS-LS1-7. **Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.** [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [*Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	**Energy and Matter** • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.

Connections to other DCIs in this grade-band:
HS.PS1.B ; **HS.PS2.B** ; **HS.PS3.B**

Articulation of DCIs across grade-bands:
MS.PS1.B ; **MS.PS3.D** ; **MS.LS1.C** ; **MS.LS2.B**

Common Core State Standards Connections:
ELA/Literacy -
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-LS1-7)*

Students who demonstrate understanding can:

HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	**LS2.A: Interdependent Relationships in Ecosystems** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Connections to other DCIs in this grade-band: N/A

Articulation of DCIs across grade-bands:
MS.LS2.A ; **MS.LS2.C**; **MS.ESS3.A** ; **MS.ESS3.C**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-LS2-1)*

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-LS2-1)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-LS2-1)

MP.4 Model with mathematics. *(HS-LS2-1)*

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-1)*

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-1)

Students who demonstrate understanding can:

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.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

- Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

Disciplinary Core Ideas

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.

Crosscutting Concepts

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.ESS2.E

Articulation of DCIs across grade-bands:
MS.LS2.A ; **MS.LS2.C** ; **MS.ESS2.E** ; **MS.ESS3.C**

Common Core State Standards Connections:

ELA/Literacy -

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS2-6)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-6)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-LS2-6)

HSS-ID.A.1 Represent data with plots on the real number line. *(HS-LS2-6)*

HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population. *(HS-LS2-6)*

HSS-IC.B.6 Evaluate reports based on data. (HS-LS2-6)

Students who demonstrate understanding can:

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- 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.

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)*
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)*

ETS1.B: Developing Possible Solutions

- When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*

Crosscutting Concepts

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; **HS.ESS2.E** ; **HS.ESS3.A** ; **HS.ESS3.C**

Articulation of DCIs across grade-bands:
MS.LS2.C ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:

ELA/Literacy -

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. *(HS-LS2-7)*

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-7)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)

Mathematics -

MP.2 Reason abstractly and quantitatively. *(HS-LS2-7)*

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-LS2-7)*

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-7)*

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-LS2-7)*

Students who demonstrate understanding can:

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 extinction of other species.** [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science. • Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**LS4.C: Adaptation** • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. • Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.LS2.A ; **HS.LS2.D** ; **HS.LS3.B** ; **HS.ESS2.E** ; **HS.ESS3.A**

Articulation of DCIs across grade-bands:
MS.LS2.A ; **MS.LS2.C** ; **MS.LS4.C** ; **HS.ESS3.C**

Common Core State Standards Connections:
ELA/Literacy -
RST-11.12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS4-5)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS4-5)
Mathematics -
MP.2 Reason abstractly and quantitatively. *(HS-LS4-5)*

Students who demonstrate understanding can:

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create or revise a simulation of a phenomenon, designed device, process, or system.	**LS4.C: Adaptation** • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. **LS4.D: Biodiversity and Humans** • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)* **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)* • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. *(secondary)*	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; **HS.ESS2.E** ; **HS.ESS3.A** ; **HS.ESS3.C** ; **HS.ESS3.D**

Articulation of DCIs across grade-bands:
MS.LS2.C ; **HS.ESS3.C**

Common Core State Standards Connections:
ELA/Literacy -

WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. *(HS-LS4-6)*
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-LS4-6)*

Narragansett Bay and Rhode Island Coasts Capstone Project

It is the recommendation of the curriculum writing team that the Oceanography course pay particular attention to the local region, as a vast and awesome resource for students to learn, in detail, about their own community. There are partnership opportunities to be had with the University of Rhode Island's School of Oceanography. There is also large amounts of research and data that has been collected on Narragansett Bay and there are many opportunities to apply the knowledge learned in this course to the local areas. It is our recommendation that the instructors of this course culminate the semester with a Capstone Project, focusing on how the disciplines of Oceanography (geological, physical, chemical, biological) are intertwined and interdependent. While learning about Oceanography on a global scale has much value, it is the sincere hope of the curriculum writers, that the instructors take advantage of the unique opportunities that living in southern Rhode Island offers.