Alignment of Ocean Literacy Framework to the NGSS for Grades K–2

Standards by Disciplinary Core Idea (DCI)	OLP 1	OLP 2	OLP 3	OLP 4	OLP 5	OLP 6	OLP 7	Specific DCI & Performance Expectations (PE)
K-2-ETS1 Engineering Design						3	3	ETS1.A, B, C
K-ESS2 Earth's Systems			4			2		ESS2.D, E; ESS3.C
K-ESS3 Earth and Human Activity				2	2	1	2	ESS3.A, B, C
K-LS1 From Molecules to Organisms: Structures and Processes					3	3		LS1.C
K-PS2 Motion and Stability: Forces and Interactions		3						PS2.B
K-PS3 Energy			4					PS3.B
1-ESS1 Earth's Place in the Universe								
1-LS1 From Molecules to Organisms: Structures and Processes					3			LS1.A, B, C
1-LS3 Heredity: Inheritance and Variation of Traits					4			LS3.A, B
1-PS4 Waves and Their Applications in Technologies for Information Transfer							3	PS4.C
2-ESS1 Earth's Place in the Universe		3						ESS1.C
2-ESS2 Earth's Systems	1	1						ESS2.A, B, C
2-LS2 Ecosystems: Interactions, Energy, and Dynamics					3			LS2.A
2-LS4 Biological Evolution: Unity and Diversity					1			LS4.D
2-PS1 Matter and Its Interactions	3							PS1.A

RATING SCALE for Alignment of Ocean Literacy Framework to Next Generation Science Standards (NGSS)

1

Verbatim or nearly verbatim language in both OL Framework (Guide or Scope & Sequence) and NGSS

This rating is self-explanatory. The connection and alignment should be obvious and not in need of any explanation.

2

Understanding these Ocean Literacy Principles and/or Fundamental Concepts is essential to helping students to achieve full understanding of these DCIs and/or PEs.

This rating is given for all the DCIs that have a terrestrial bias or ignore the uniqueness of ocean systems, such as: decomposition breaks things down into soil; references to only terrestrial habitats, ecosystems and food webs, etc. This rating says that a learner cannot achieve full understanding of the DCI without understanding the ocean component of the concept, e.g., you don't fully understand primary productivity if you don't understand chemosynthesis; you don't fully understand decomposition if you only understand how it relates to soil, but not to detritus and marine snow in the water column; you don't fully understand food webs and trophic levels unless you understand about microbes in the ocean because they play a very different role than plants do on land. The ocean "examples" are more than just examples; they illustrate different aspects of the concept than the terrestrial examples do.

3

Examples from the Ocean Literacy Framework (not just any ocean examples) are excellent for teaching and understanding these DCIs and/or PEs

This rating is given when an Ocean Literacy Framework example could be used to explain a general science DCI and/or PE, but using that example to explain that concept is not essential to ocean literacy, nor is it essential to understanding DCI, such as, ocean waves, as mentioned in some OLPs, are good examples of the physical properties of waves.

4

These DCIs and/or PEs are building blocks or foundational ideas that help students to understand these Ocean Literacy Principles and/or Fundamental Concepts

This rating is given for general science concepts that help students understand the mechanisms behind OL concepts, such as, force and motion helping to explain currents or phase change, and conservation of matter helping to explain the water cycle.

Examples of a 4:
K-PS2 Motion and Stability: Forces and Interactions.
Ocean Literacy Essential Principle 2: These basic ideas are important conceptual building blocks that help us understand waves, erosion, and landforms of the coast.

1-LS3 Heredity: Inheritance and Variation of Traits.
Ocean Literacy Essential Principle 5: DCI introduces concept of inheritance and variation and provides introduction to the concept of diversity described in OLP 5A & C.

[blank] No substantive or helpful relationship

No rating is given when there does not appear to be any plausible, helpful, or meaningful relationship between the OL Principles and/or Fundamental Concepts and the DCIs and/or PEs.

Example of a 5:
K-PS2 Motion and Stability: Forces and Interactions
Ocean Literacy Essential Principle 5: No relationship

This document was developed by the National Marine Educators Association Ocean Literacy Committee. Special acknowledgement goes to the Lawrence Hall of Science at the University of California, Berkeley for leading the development and supporting the final editing and design. The following individuals made significant contributions:

Lincoln Bergman *(Lawrence Hall of Science),* Scott Carley *(College of Exploration),* Catherine Halversen *(Lawrence Hall of Science),* Kurt Holland *(Seventh Generation Advisors),* Beth Jewell *(West Springfield High School),* Lisa Klofkorn *(Lawrence Hall of Science),* Diana Payne *(Connecticut Sea Grant),* Sarah Pedemonte *(Lawrence Hall of Science),* Sarah Schoedinger *(NOAA),* Craig Strang *(Lawrence Hall of Science),* Lynn Tran *(Lawrence Hall of Science),* Peter Tuddenham *(College of Exploration),* Emily Weiss *(Lawrence Hall of Science),* Jim Wharton *(Seattle Aquarium),* Lynn Whitley *(USC Wrigley Institute for Environmental Studies and Sea Grant)*

Explanation for Ratings

K-2-ETS1 Engineering Design

OLP 6. This is a 3 because humans need to be able to design solutions to both keep the ocean healthy, and to utilize ocean resources to improve our lives. Humans' interconnections with the ocean provide many examples (OLP 6b, d, g; K-2 S&S 6C strand) that illustrate and optimize the need for design solutions (DCI ETS1.A, B, C).

OLP 7. This is a 3 because the ocean provides many examples (OLP 7d, e, f; K-2 S&S B.2, 4) of engineering challenges (DCI ETS1.A, B,C) related to ocean exploration and opportunities ahead.

K-ESS2 Earth's Systems

OLP 3. This is a 4 because students need to understand what weather is and that weather changes (DCI ESS2.D) in order to understand what causes weather (OLP 3a,d; K-2 S&S 3A).

OLP 6. This is a 2 because student understanding of biogeology and human impacts on Earth systems (DCI ESS2.E, ESS3.C) would be incomplete without inclusion of ways humans impact the ocean. People change the environment, e.g., pollution, physical modifications (OLP 6d, f; K-2 S&S 6B, C), as they engage in activities to live comfortably. Everyone can make choices to reduce their impact, and be responsible for caring for the ocean (OLP 6g).

K-ESS3 Earth and Human Activity

OLP 4. This is a 2 because understanding the natural resources that living things need (DCI ESS3.A) is not complete without knowing that life as we know it does not exist without water (K-2 S&S 4A). Almost all the water on Earth is in the ocean (K-2 S&S 4B), and the ocean provided and c

OLP 5. This is a 2 because understanding the natural resources that living things need (DCI ESS3.A) is not complete without considering the ocean as an environment and habitat where organisms live (K-2 S&S 5B).

OLP 6. This is a 1 because human activities to live comfortably (DCI ESS3.B, C) involve use of resources from the ocean (K-2 S&S 6A, B; OLP 6b, c), and thus have an impact on the ocean (K-2 S&S 6C). Everyone can make choices to reduce their impact, and be responsible for caring for the ocean (K-2 S&S 6C; OLP 6g).

OLP 7. This is a 2 because understanding that life on Earth depends on the ocean (OLP 7a; K-2 S&S 7A), and that people explore the ocean (K-2 S&S 7B) are essential to understanding the natural resources that living things need to survive (DCI ESS3.A). Exploring the ocean helps us understand the health of the ocean, and helps us find new medicines, food for humans, and new resources for energy for human activities (K-2 S&S 7B2).

K-LS1 From Molecules to Organisms: Structures and Processes

OLP 5. This is a 3 because the ocean (OLP 5b, d; K-2 S&S 5B.2) provides many important examples of the organization for matter and energy flow in organisms (DCI LS1.C).

OLP 6. This is a 3 because recognizing the ocean as a fundamental source of food and water (OLP 6a, b; K-2 S&S 6A.2-3) is a good example of how all animals need food, and all plants and algae need water and light to live and grow (DCI LS1.C).

K-PS2 Motion and Stability: Forces and Interactions

OLP 2. This is a 3 because water in motion carries Earth materials from one place to another, especially in the coastal zone, leading to erosion and accretion (OLP 2c; K-2 S&S 2A). This is an important example of when objects touch or collide, they push on one another and can change motion (DCI PS2.B).

K-PS3 Energy

OLP 3. This is a 4 because students need to understand that sunlight warms Earth's surface (DCI PS3.B) in order to understand that the ocean absorbs heat energy from the Sun (OLP 3b).

1-ESS1 Earth's Place in the Universe

No alignment between OL and NGSS.

1-LS1 From Molecules to Organisms: Structures and Processes

OLP 5. This is a 3 because there is a greater diversity of organisms in the ocean than are found on land (K-2 S&S 5A; OLP 5a, c, d). The variety of different structures and behaviors that marine organisms have to help them survive (K-2 S&S 5A.4) provide unique and important examples for understanding structure and function (DCI LS1.A), growth and development of organisms (DCI LS1.B), and how organisms process information for growth and survival (DCI LS1.C).

1-LS3 Heredity: Inheritance and Variation of Traits

OLP 5. This is a 4 because inheritance of traits and variation of traits (DCI LS3.A, B) are building blocks for understanding the great diversity of organisms in the ocean (K-2 S&S 5A; OLP 5a, c).

1-PS4 Waves and Their Applications in Technologies for Information Transfer

OLP 7. This is a 3 because existing ocean technology for exploration and communication, including sensors, such as side-scan, multi-beam, and lidar that rely on sound waves for information transfer, are expanding our ability to explore the ocean and provide novel examples of information technologies and instrumentation (DCI PS4.C).

2-ESS1 Earth's Place in the Universe

OLP 2. This is a 3 because the DCI, OLP, and S&S encourage direct examination of evidence to make Earth processes visible. Accretion, erosion, and associated coastline changes (OLP 2c; K-2 S&S 2A) are important examples for illuminating Earth events and timescales (DCI ESS1.C). Observing or experimenting with currents, waves, erosion, and deposition provide natural starting points for understanding these concepts.

2-ESS2 Earth's Systems

OLP 1. This is a 1 because the OLP (1a, e, g) describes and elaborates the concept that water is found in the oceans (sic), rivers, lakes, and ponds (DCI ESS2.C). In order for students to understand that maps show where things are located and that one can map the shapes and kinds of land and water in any area (DCI ESS2.B), they must understand that the ocean is the defining feature on the planet (OLP 1a; K-2 S&S 1B). Geologic features on the ocean floor (plains, valleys, mountains, volcanoes), which are shown on bathymetric maps and are similar to those on land (OLP 1b; K-2 S&S 1D), provide important and unique examples of the shapes and kinds of land and water in any area (DCI ESS2.B).

OLP 2. This is a 1 because the concept that moving water can change the shape of the land is nearly identical in the DCI (ESS2.A), OLP (2c), and S&S (K-2 S&S 2A).

2-LS2 Ecosystems: Interactions, Energy, and Dynamics

OLP 5. This is a 3 because photosynthetic microbes in the ocean (OLP 5b) are examples of primary producers that depend on water and light to grow (DCI LS2.A).

2-LS4 Biological Evolution: Unity and Diversity

OLP 5. This is a 1 because the DCI introduces the concept of many different kinds of organisms living in many different places on land and water (DCI LS4.D), which is essentially the concept represented in Ocean Literacy Framework (OLP 5a-g, i; K-2 S&S 5A, B) related to the diversity of life and ecosystems in the ocean.

2-PS1 Matter and Its Interactions

OLP 1. This is a 3 because understanding the unique structure and properties of seawater (OLP 1e; K-2 S&S 1A) are important and instructive examples of how matter has different observable structure and properties (DCI PS1.A). The freezing point of seawater (OLP 1e) is a good example of how the heating or cooling of a substance may cause changes that can be observed (DCI PS1.B).

Alignment of Ocean Literacy Framework to the NGSS for Grades 3–5

Standards by Disciplinary Core Idea (DCI)	OLP 1	OLP 2	OLP 3	OLP 4	OLP 5	OLP 6	OLP 7	Specific DCI & Performance Expectations (PE)
3-5-ETS1 Engineering Design						3	3	ETS1.A, B, C
3-ESS2 Earth's Systems			3					ESS2.D
3-ESS3 Earth and Human Activity			3			3		ESS3.B
3-LS1 From Molecules to Organisms: Structures and Processes					1			LS1.B
3-LS2 Ecosystems: Interactions, Energy, and Dynamics					3			LS2.D
3-LS3 Heredity: Inheritance and Variation of Traits				4	3			LS3.A, B
3-LS4 Biological Evolution: Unity and Diversity		3		3	4	1	3	LS4.A, B, C, D
3-PS2 Motion and Stability: Forces and Interactions	3	3						PS2.A, B
4-ESS1 Earth's Place in the Universe	3	2						ESS1.C; PE-ESS1-1
4-ESS2 Earth's Systems	1	1						ESS2.A, B
4-ESS3 Earth and Human Activity			3			3		ESS3.A, B
4-LS1 From Molecules to Organisms: Structures and Processes					2			LS1.A, D
4-PS3 Energy			3					PS3.B
4-PS4 Waves and Their Applications in Technologies for Information Transfer						3	3	PS4.C
5-ESS1 Earth's Place in the Universe								
5-ESS2 Earth's Systems	1	2	2		1			ESS2.A, C
5-ESS3 Earth and Human Activity						1	2	ESS3.C
5-LS1 From Molecules to Organisms: Structures and Processes				2	2			LS1.C; PE 5-LS1-1
5-LS2 Ecosystems: Interactions, Energy, and Dynamics		4			2			LS2.B
5-PS1 Matter and Its Interactions								
5-PS2 Motion and Stability: Forces and Interactions	4				4			PS2.B
5-PS3 Energy					2			PS3.D

RATING SCALE for Alignment of Ocean Literacy Framework to Next Generation Science Standards (NGSS)

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Examples of a 4:
K-PS2 Motion and Stability: Forces and Interactions.
Ocean Literacy Essential Principle 2: These basic ideas are important conceptual building blocks that help us understand waves, erosion, and landforms of the coast.

1-LS3 Heredity: Inheritance and Variation of Traits.
Ocean Literacy Essential Principle 5: DCI introduces concept of inheritance and variation and provides introduction to the concept of diversity described in OLP 5A & C.

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Example of a 5:
K-PS2 Motion and Stability: Forces and Interactions
Ocean Literacy Essential Principle 5: No relationship

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Explanation for Ratings

3-5-ETS1 Engineering Design

OLP 6. This is a 3 because human development and activity around the ocean (OLP 6d; 3-5 S&S 6A.4) provide many examples of design solutions to problems (ETS1.A, B, C) that unintentionally led to other problems such as pollution, changes to ocean chemistry and physical modifications.

OLP 7. This is a 3 because technologies for exploring the ocean (OLP 7d; 3-5 S&S 7C) provide good examples of how possible engineering solutions are developed (ETS1.B, C). Similarly, collaboration among interdisciplinary ocean scientists (OLP 7f; 3-5 S&S 7B) is a good example of how communication and sharing of ideas among peers can lead to improved designs (ETS1.B, C)

3-ESS2 Earth's Systems

OLP 3. This is a 3 because the interaction of the ocean and atmosphere (OLP 3a-d; 3-5 S&S 3A.1-2) controls and regulates most of Earth's weather and climate patterns that are recorded by scientists (DCI ESS2.D). Note: this could be rated as a 2 if the instructor's intent is for students to understand causes of weather and climate, rather than only to observe and record weather and climate.

3-ESS3 Earth and Human Activity

OLP 3. This is a 3 because natural hazards related to the ocean, e.g., hurricanes, cyclones, and El Niño (OLP 3c-d; 3-5 S&S 3A.6) are important examples of natural hazards that may impact humans (ESS3.B).

OLP 6. This is a 3 because tsunamis, hurricanes, cyclones, sea level change and storm surges (OLP 6f; 3-5 S&S 6B.4) are important examples of natural hazards that may impact humans (ESS3.B).

3-LS1 From Molecules to Organisms: Structures and Processes

OLP 5. This is a 1 because the DCI (LS1.B), OLP (5b, d, i) and S&S (3-5 S&S 5B.5) all discuss reproduction and unique and diverse life cycles. Understanding life in the ocean is essential to understanding the diversity of life on Earth.

3-LS2 Ecosystems: Interactions, Energy, and Dynamics

OLP 5. This is a 3 because the ocean (OLP 5d) provides unique examples of animals working in groups to obtain food, defend themselves, and cope with changes (DCI LS2.D). For example, schooling behavior can be readily observed in an aquarium in the classroom.

3-LS3 Heredity: Inheritance and Variation of Traits

OLP 4. This is a 4 because knowing the concepts of inheritance and variation (DCI LS3.A, B) can help students understand how millions of different species on Earth are related by descent from common ancestors that evolved in the ocean (OLP 4b).

OLP 5. This is a 3 because the great diversity of major groups of organisms in the ocean (OLP 5a, c) are compelling and illustrative examples of the concepts of inheritance, variation and diversity (DCI LS3.A, B). The concept that the environment can affect an organism's traits (DCI LS3.A, B) is also related to the concept that physical factors influence the distribution of ocean organisms (OLP 5f, h).

3-LS4 Biological Evolution: Unity and Diversity

OLP 2. This is a 3 because marine fossils found on land (OLP 2a; 3-5 S&S 2A.3-4) are excellent examples of fossils that provide evidence of the types of organisms that lived long ago, and of their environments (DCI LS4.A). Additionally, for students to understand the evidence provided by land-based marine fossils, it is useful for them to know that sea level changes over time have contracted continental shelves and destroyed inland seas (OLP 2b).

OLP 4. This is a 3 because students begin to learn about fossils and the environments indicated by those fossils (DCI LS4.A). The ocean provides many excellent examples for such fossil-environment relationships (3-5 S&S 4A, A.1), but is not required in order to understand the DCI.

OLP 5. This is a 4 because understanding adaptation, diverse environments, natural selection, and biodiversity (LS4.B, C, D) build and support understanding that ocean ecosystems are defined by environmental factors and the community of organisms living there, and that the ocean supports a great diversity of ecosystems and adaptations (OLP 5f; S&S 5B.1). The DCI concepts generally support understanding of the ideas in the OLP and S&S.

OLP 6. This is a 1 because the DCI (LS4.D), OLP (6, 6d), and S&S (3-5 S&S 6C.1-4) all discuss how changes to a habitat may affect organisms living there.

OLP 7. This is a 3 because the concept that people are not adapted to survive well in an ocean environment (3-5 S&S 7C.2-3, 5-6) is an excellent example of how some kinds of organisms survive better than others in particular environments (DCI LS4.C).

3-PS2 Motion and Stability: Forces and Interactions

OLP 1. This is a 3 because ocean circulation (OLP 1c; 3-5 S&S 1B, B.1-10) provides a good example of forces and motion (DCI PS2.A). In later grades one would use an understanding of forces and motion to support deep understanding of ocean circulation.

OLP 2. This is a 3 because forces that cause erosion and change the physical structure of coastal landforms (OLP 2c, e; 3-5 S&S 2B) provide good examples of how objects in contact exert forces on one another (DCI PS2.B). Additionally, the concepts that objects can exert force on one another, and that an object's motion can be observed and predicted (DCI PS2.A, B), support an understanding of the forces of waves and other forces that contribute to erosion and the formation of landforms (OLP 2c, e).

4-ESS1 Earth's Place in the Universe

OLP 1. This is a 3 because the presence of marine terraces and other geological marine features (OLP 1b; 3-5 S&S 1C strand) seen on land provide examples of and support an explanation for change over time (DCI ESS1.C; PE-ESS1-1).

OLP 2. This is a 2 because in order to have a complete understanding of how patterns of rock formation reveal changes over time and how fossils can provide indications of the order of the change-causing events (DCI ESS1.C), one needs to understand that ocean life laid down sediments; that dead ocean organisms falling into those sediments often formed fossils; and that marine fossils found on land are evidence that the land was once covered by ocean (OLP 2a; 3-5 S&S 2A.2-4).

4-ESS2 Earth's Systems

OLP 1. This is a 1 because the DCI, OLP, and S&S all list geologic seafloor features (DCI ESS 2.B, OLP 1b; 3-5 S&S 1C strand). Additionally, the OLP and DCI refer to plate movement/movement of Earth's crust as giving rise to many of these features (DCI ESS2.B; OLP 1b). The DCI and OLP also discuss the water cycle/rainfall, and how water breaks down and transports materials (DCI ESS2.A; OLP 1f, g).

OLP 2. This is a 1 because the DCI, OLP, and S&S all describe processes of erosion that act to shape the land/coastline (DCI ESS2.A; OLP 2c-d; 3-5 S&S 2B strand). In addition, the idea that living things affect the physical characteristics of their regions (DCI ESS2.E) is directly supported by the concept that ocean life laid down the vast volume of siliceous and carbonate rocks (OLP 2A; 3-5 S&S 2A.2).

4-ESS3 Earth and Human Activity

OLP 3. This is a 3 because ocean-related natural hazards, such as hurricanes and cyclones (OLP 3d; 3-5 S&S 3A.6), are strong examples of natural hazards that humans cannot eliminate, but humans can take steps to reduce their impact (DCI ESS3.B). The OLP and S&S also discuss the underlying causes of these natural hazards (OLP 3d; 3-5 S&S 3A.3, 5-6). The standard does not call for a complete understanding of all natural hazards or their underlying causes. Therefore, it is not essential to understand ocean-related natural hazards to meet the standard, but ocean-related hazards are among the most prominent and dramatic examples.

OLP 6. This is a 3 because the DCI discusses natural hazards and human response to those hazards (DCI ESS3.B). There are many ocean-related examples of these hazards, as well as information about how humans may be affected because a large proportion of the human population live near the ocean (OLP 6f; 3-5 S&S 6B.4). Additionally, energy resources from the ocean (OLP 6b; 3-5 S&S 6A.4) provide examples of naturally-derived energy and fuels (DCI ESS3.A).

4-LS1 From Molecules to Organisms: Structures and Processes

OLP 5. This is a 2 because students' understanding of structure, function and information processing (DCI LS1.A, D) is not complete unless they are aware of both terrestrial and marine examples (e.g., gills, collapsible lungs for deep diving, fins), since there are many categories of unique organisms that live only in the ocean. Ocean organisms provide many examples of unique life cycles and adaptations (OLP 5d; 3-5 S&S 5B1-3,5). The growth rates and life cycles of ocean microbes (OLP 5b) are also connected, but not as strongly.

4-PS3 Energy

OLP 3. This is a 3 because, wave movement and heat exchange between the ocean and atmosphere (3-5 S&S 3A-A.5) are helpful examples of the transfer, transport, and conversion of energy (DCI PS3.B).

4-PS4 Waves and Their Applications in Technologies for Information Transfer

OLP 6. This is a 3 because the ocean research and communications technology necessary for commerce, resource extraction and resource management (OLP 6b, d, e, g) would make interesting examples of information technologies and instrumentation (PS4.C), but are not essential to understanding them.

OLP 7. This is a 3 because examples of "new ocean technologies, sensors, and tools" (OLP 7d) are dependent on the wave properties of sound and visible light (DCI PS4.C). These real-world examples would add interest for students, but are not essential to understanding the concepts.

5-ESS1 Earth's Place in the Universe

No alignment between OL and NGSS.

5-ESS2 Earth's Systems

OLP 1. This is a 1 because concepts connected to the role of water in Earth's surface processes (ESS2.C) are directly referenced throughout OLP (OLP 1a, e, g). Also, the DCI, OLP, and S&S all directly address ocean system concepts (DCI ESS2.A; OLP 1c; 3-5 S&S 1A, B).

OLP 2. This is a 2 because many of the concepts related to how the movement of water erodes and deposits materials that shape the coastline (3-5 S&S 2B) are essential to fully understanding how the ocean shapes landforms (ESS2.A).

OLP 3. This is a 2 because the concepts about how the ocean and atmosphere interact (3-5 S&S 3) are essential for understanding how Earth's systems interact (ESS2.A).

OLP 5. This is a 1 because the language regarding ocean ecosystems in the DCI (ESS2.A) is nearly the same as several fundamental concepts in the Ocean Literacy Framework (OLP 5e-g, i; 3-5 S&S 5A). The OLP and S&S provide multiple, diverse examples of ocean ecosystems.

5-ESS3 Earth and Human Activity

OLP 6. This is a 1 because the OLP (5d, e, g), and specifically the concepts developed in the S&S (3-5 S&S P5C), provide an overview of how human activity has had and can have major effects on the ocean, as identified in the DCI (ESS3.C).

OLP 7. This is a 2 because in order to fully understand how communities use science ideas to protect the earth (DCI ESS3.C), related ocean science ideas must be considered (3-5 S&S 7). Excluding ocean concepts would result in an incomplete and inaccurate understanding of how to protect Earth's resources and environment.

5-LS1 From Molecules to Organisms: Structures and Processes

OLP 4. This is a 2 because the concept that plants acquire material for growth chiefly from the air and water (DCI LS1.C; PE 5-LS1-1) demonstrates a terrestrial bias. The use of additional ocean examples, such as algae or microbes (3-5 S&S 4B.1) would address this bias and lead to a more complete understanding of primary productivity.

OLP 5. This is a 2 because the concept that "plants" get what they need to live from air and water (DCI LS1.C) represents a terrestrial bias. Understanding primary productivity is incomplete without understanding the huge ecological role played by photosynthetic ocean microbes and algae that do not require "air" (OLP 5b; 3-5 S&S A.6, B.8).

5-LS2 Ecosystems: Interactions, Energy, and Dynamics

OLP 2. This is a 4 because one needs to understand chemical cycling (DCI LS2.B) before being able to understand biogeochemical cycling (OLP 2a). This DCI is a building block for comprehending the concept of chemical cycling that will support discussion of biogeochemical cycling in a later grade.

OLP 5. This is a 2 because a full understanding of food webs (DCI LS2.B) requires examples of species and ecosystems from the ocean, which are fundamentally different from those on land. Ocean food webs begin with microbes, not plants (OLP 5B). There are unique types of energy transfer in the ocean that do not occur on land, including ecosystems that do not depend on light and photosynthesis (OLP 5d, g; 3-5 S&S 5A.2, 9).

5-PS1 Matter and Its Interactions

No alignment between OL and NGSS.

5-PS2 Motion and Stability: Forces and Interactions

OLP 1. This is a 4 because understanding the concept of gravitational force (DCI PS2.B) helps to build an understanding of density-driven currents and tides (3-5 S&S 1B.7, 9).

OLP 5. This is a 4 because the focus on Earth's gravitational force (DCI PS2.B) is a building block to understanding tides. This DCI has a tangential but important relationship to the discussion of tide-influenced vertical zonation in intertidal habitats (OLP 5h).

5-PS3 Energy

OLP 5. This is a 2 because the idea that all ecosystems are driven by the sun's energy and that all energy in food comes from the sun (DCI PS3.D) is inaccurate and represents a terrestrial bias. It is essential that students explicitly understand that there are important ecosystems and organisms supported through chemosynthetic processes (OLP 5d, g).

Alignment of Ocean Literacy Framework to the NGSS for Grades 6–8

Standards by Disciplinary Core Idea (DCI)	OLP 1	OLP 2	OLP 3	OLP 4	OLP 5	OLP 6	OLP 7	Specific DCI & Performance Expectations (PE)
MS-ESS1 Earth's Place in the Universe		4						ESS1.C
MS-ESS2 Earth's Systems	1	1	1	3				ESS1.C; ESS2.A, C, D; PE ESS2-4, 2-6
MS-ESS3 Earth and Human Activity			1			1		ESS3.B, C, D
MS-LS1 From Molecules to Organisms: Structures and Processes			1	4	2			LS1.B, C; PS3.D
MS-LS2 Ecosystems: Interactions, Energy, and Dynamics	4	2	4		2	2		LS2.A, B, C; LS4.D
MS-LS3 Heredity: Inheritance and Variation of Traits								
MS-LS4 Biological Evolution: Unity and Diversity				2	4			LS4.A, C
MS-PS1 Matter and Its Interactions		4	4			4		PS1.A, B; PS3A, B
MS-PS2 Motion and Stability: Forces and Interactions	4							PS2.A, B
MS-PS3 Energy	3		3					PS3.A, B, C
MS-PS4 Waves and Their Applications in Technologies for Information Transfer								
MS-ETS1 Engineering Design						3		ETS1.A, B

RATING SCALE for Alignment of Ocean Literacy Framework to Next Generation Science Standards (NGSS)

1

Verbatim or nearly verbatim language in both OL Framework (Guide or Scope & Sequence) and NGSS

This rating is self-explanatory. The connection and alignment should be obvious and not in need of any explanation.

2

Understanding these Ocean Literacy Principles and/or Fundamental Concepts is essential to helping students to achieve full understanding of these DCIs and/or PEs.

This rating is given for all the DCIs that have a terrestrial bias or ignore the uniqueness of ocean systems, such as: decomposition breaks things down into soil; references to only terrestrial habitats, ecosystems and food webs, etc. This rating says that a learner cannot achieve full understanding of the DCI without understanding the ocean component of the concept, e.g., you don't fully understand primary productivity if you don't understand chemosynthesis; you don't fully understand decomposition if you only understand how it relates to soil, but not to detritus and marine snow in the water column; you don't fully understand food webs and trophic levels unless you understand about microbes in the ocean because they play a very different role than plants do on land. The ocean "examples" are more than just examples; they illustrate different aspects of the concept than the terrestrial examples do.

3

Examples from the Ocean Literacy Framework (not just any ocean examples) are excellent for teaching and understanding these DCIs and/or PEs

This rating is given when an Ocean Literacy Framework example could be used to explain a general science DCI and/or PE, but using that example to explain that concept is not essential to ocean literacy, nor is it essential to understanding DCI, such as, ocean waves, as mentioned in some OLPs, are good examples of the physical properties of waves.

4

These DCIs and/or PEs are building blocks or foundational ideas that help students to understand these Ocean Literacy Principles and/or Fundamental Concepts

This rating is given for general science concepts that help students understand the mechanisms behind OL concepts, such as, force and motion helping to explain currents or phase change, and conservation of matter helping to explain the water cycle.

Examples of a 4:
K-PS2 Motion and Stability: Forces and Interactions.
Ocean Literacy Essential Principle 2: These basic ideas are important conceptual building blocks that help us understand waves, erosion, and landforms of the coast.

1-LS3 Heredity: Inheritance and Variation of Traits.
Ocean Literacy Essential Principle 5: DCI introduces concept of inheritance and variation and provides introduction to the concept of diversity described in OLP 5A & C.

[blank] No substantive or helpful relationship

No rating is given when there does not appear to be any plausible, helpful, or meaningful relationship between the OL Principles and/or Fundamental Concepts and the DCIs and/or PEs.

Example of a 5:
K-PS2 Motion and Stability: Forces and Interactions
Ocean Literacy Essential Principle 5: No relationship

This document was developed by the National Marine Educators Association Ocean Literacy Committee. Special acknowledgement goes to the Lawrence Hall of Science at the University of California, Berkeley for leading the development and supporting the final editing and design. The following individuals made significant contributions:

Lincoln Bergman *(Lawrence Hall of Science),* Scott Carley *(College of Exploration),* Catherine Halversen *(Lawrence Hall of Science),* Kurt Holland *(Seventh Generation Advisors),* Beth Jewell *(West Springfield High School),* Lisa Klofkorn *(Lawrence Hall of Science),* Diana Payne *(Connecticut Sea Grant),* Sarah Pedemonte *(Lawrence Hall of Science),* Sarah Schoedinger *(NOAA),* Craig Strang *(Lawrence Hall of Science),* Lynn Tran *(Lawrence Hall of Science),* Peter Tuddenham *(College of Exploration),* Emily Weiss *(Lawrence Hall of Science),* Jim Wharton *(Seattle Aquarium),* Lynn Whitley *(USC Wrigley Institute for Environmental Studies and Sea Grant)*

Explanation for Ratings

MS-ESS1 Earth's Place in the Universe

OLP 2. This is a 4 because understanding geologic timescales as interpreted through rock strata and fossils (DCI ESS1.C) is a fundamental building block to understanding the geologic changes, plate tectonics, and rock cycle ideas (OLP 2a; S&S 2A.17-19, B strand).

MS-ESS2 Earth's Systems

OLP 1. This is a 1 because the OLP focuses on the global movement of ocean water (OLP 1c; S&S 1C.1), the water cycle (OLP 1f; S&S 1C), and watersheds and coastal ocean (OLP 1g; S&S 1C.9). These concepts are closely aligned with the roles of water in Earth's (and ocean) processes (DCI ESS2.C), cycling of water through Earth's systems (PE ESS2-4), and patterns of ocean and atmospheric circulation (PE ESS2-6). In addition, tectonic processes (DCI ESS1.C) that move Earth's crust form features of the ocean floor (OLP 1b; S&S 1A strand).

OLP 2. This is a 1 because of the strong connections between three DCIs and the Ocean Literacy Framework. The history of planet Earth (DCI ESS1.C) is strongly connected to how ocean processes and plate tectonics influence the structure of the coast (OLP 2e; S&S 2A.18–19). Energy flowing and matter cycling in the planet's systems over various scales have shaped Earth's history (DCI ESS2.A), is strongly connected to Earth's materials and geochemical cycles originating in the ocean (OLP 2a), and to erosion redistributing sediments (OLP 2c). Roles of water in Earth's processes (DCI ESS2.C) is strongly connected to wind, waves, and currents eroding and redistributing earth materials (OLP 2c), as well as to the formation of landforms through a combination of constructive and destructive forces where the ocean meets the land (S&S 2A.1-A.12).

OLP 3. This is a 1 because of the strong connections between three DCIs and the Ocean Literacy Framework. The core ideas that Earth's history has been shaped by water (DCI ESS2.C) and by energy flowing and matter cycling (DCI ESS2.A) is strongly aligned to the concepts of the ocean's role in energy, water and carbon systems (OLP 3a-c; S&S 3A.1-2, 4). The concept that the ocean has a significant influence on climate by moving heat, carbon, and water (OLP 3f; S&S 3A, A.1, 7, 10) is strongly aligned with the ocean absorbing, storing, and moving heat through currents (DCI ESS2.D).

OLP 4. This is a 3 because the concept that oxygen in the atmosphere originally came from organisms in the ocean (OLP 4a; S&S 4A strand) is an excellent example for understanding how interactions between energy flowing and matter cycling in the planet's systems over various scales produces chemical and physical changes in Earth's materials and living organisms, which have shaped Earth's history (DCI ESS2.A).

MS-ESS3 Earth and Human Activity

OLP 3. This is a 1 because the effects of human activities on global climate change (DCI ESS3.D) is strongly aligned with the ideas that CO2 absorbed by the ocean affect the interrelationship between the ocean-atmosphere, which can result in changes to the climate (OLP 3e–g; S&S P3.B, B.1); and that humans are changing the climate by releasing CO2 into the atmosphere (S&S 3B.6). In addition, understanding the use of mapping natural hazards and geologic forces to forecast future events (DCI ESS3.B) requires knowing about ocean weather maps and oceanographic data sets in predicting future weather-related natural hazards, including hurricanes, extreme rainfall, droughts, and El Niño (S&S 3A.7-8, 11-12).

OLP 6. This is a 1 because the DCI focuses on how human activities have altered the biosphere, damaging natural habitats and causing extinctions (DCI ESS3.C), and the effects of human activities on global climate change (DCI ESS3.D). These ideas are strongly connected to the concepts that humans affect the ocean in a variety of ways, including impacting biological diversity and causing extinctions, that most people live near coasts (OLP 6d-f), that human activity leads to excess input of greenhouse gases, and that pollution affects life in the ocean (S&S 6D.13-22).

MS-LS1 From Molecules to Organisms: Structures and Processes

OLP 3. This is a 1 because the process of photosynthesis (DCI LS1.C) occurs in the ocean, with about half the world's photosynthesis taking place in the sunlit layers of the ocean (S&S 3B.3).

OLP 4. This is a 4 because understanding photosynthesis (DCI LS1.C, PS3.D) serves as a building block to and is an integral part of understanding that oxygen in the atmosphere originally came from photosynthetic organisms in the ocean (OLP 4a; S&S 4A.4-6).

OLP 5. This is a 2 because understanding growth and development of organisms (DCI LS1.B) is incomplete without knowing about adaptations for reproduction and growth in ocean organisms (OLP 5d; S&S 5B strand). In addition, to fully understand organization for matter and energy flow in organisms (DCI LS1.C), one needs to understand that there is non-photosynthetic primary productivity in the ocean (OLP 5g; S&S 5A.5-6), and that microorganisms in the ocean produce a huge amount of oxygen on Earth (OLP 5b; S&S 5A.2-4).

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

OLP 1. This is a 4 because an understanding that the basic functions of an ecosystem—interdependent relationships (DCI LS2.A), the cycling of matter and energy transfer (DCI LS2.B), and the dynamic nature of ecosystems (DCI LS2.C)—are integral to understanding ocean circulation (OLP 1c; S&S 1C) and physical and biological systems (OLP 1e).

OLP 2. This is a 2 because students would have an incomplete understanding of the cycling of matter and energy through an ecosystem (DCI LS2.B) without learning about biogeochemical cycles in the ocean (OLP 2a, d; S&S 2B.3).

OLP 3. This is a 4 because cycles of matter and energy transfer in ecosystems (DCI LS2.B) is a building block for understanding the important role of the ocean in the carbon cycle (OLP 3e; S&S 3B.2-3). Additionally, an understanding of ecosystem dynamics, functioning, and resilience (DCI LS2.C) is a building block for comprehending how changes in the ocean-atmosphere system can result in changes to the climate and atmosphere (OLP 3g; S&S 3B.1, 5-6), with regard to disruptions in ecosystems.

OLP 5. This is a 2 because students would have an incomplete understanding of interdependent relationships in ecosystems (DCI LS2.A) and the cycling of matter and energy transfer in ecosystems (DCI LS2.B), if they do not understand how the ocean supports a great diversity of life and ecosystems, including unique adaptations, behaviors, and ecosystems found only in the ocean (OLP 5; S&S 5A, 5B).

OLP 6. This is a 2 because to understand how changes in biodiversity can influence resources and ecosystem services (DCI LS4.D) one must know how humans and the ocean are inextricably interconnected (OLP 6; S&S 6B).

MS-LS3 Heredity: Inheritance and Variation of Traits

No alignment between OL and NGSS.

MS-LS4 Biological Evolution: Unity and Diversity

OLP 4. This is a 2 because in order to achieve a full understanding of the evidence of common ancestry and diversity (DCI LS4.A), one need to learn about origins of life (OLP 4; S&S 4B).

OLP 5. This is a 4 because an understanding of diversity (DCI LS4.A) and adaptations (DCI LS4.C) would be incomplete without learning about the diversity and unique adaptations of the ocean (OLP 5d; S&S 5B).

MS-PS1 Matter and Its Interactions

OLP 2. This is a 4 because an understanding that substances react chemically in characteristic ways and that molecular balance is maintained (DCI PS1.B) is necessary to understand chemical weathering of rocks and minerals (S&S 2A.5).

OLP 3. This is a 4 because an understanding of the structure and properties of matter, and changes of state (DCI PS1.A) and energy (DCI PS3.A), is needed for understanding heat exchange, energy, and the water cycle (OLP 3b); condensation and where rain falls (OLP 3d); and that the ocean moves heat, carbon, and water (OLP 3f, S&S 3A). One must understand energy definitions (DCI PS3.A), heat transfer (DCI PS3.B), and molecular balance (DCI PS1.B) in order to understand how the ocean has such an influence on weather and climate (OLP 3a-b, f; S&S 3A strand).

OLP 6. This is a 4 because understanding the structure and properties of matter (DCI PS1.A), and characteristics and results of chemical reactions (DCI PS1.B), are necessary for understanding how human activities can change ocean temperature and pH (S&S 6D.13-17), which in turn, can affect the survival of some organisms (OLP 6e).

MS-PS2 Motion and Stability: Forces and Interactions

OLP 1. This is a 4 because students need to have a basic understanding of how gravity works (DCI PS2.A, B) in order to understand tides and density-driven thermohaline circulation (OLP 1c). However, the information presented on gravity in these DCIs is not fully supportive of an understanding of thermohaline circulation; it is much more closely tied to understanding tides.

MS-PS3 Energy

OLP 1. This is a 3 because thermohaline circulation in the ocean (OLP 1c; S&S 1C, C.1, 6) provides a helpful example of how energy is transferred out of warmer regions into cooler ones (DCI PS3.B). There is also a connection to understanding that temperature is a measure of the average kinetic energy of particles of matter, and that there is a relationship between temperature and the total energy in a system (DCI PS3.A).

OLP 3. This is a 3 because energy transfer from the ocean to the atmosphere (OLP 3b-d) offers useful examples for understanding energy transfer and related ideas (DCI PS3.A, B, C).

MS-PS4 Waves and their applications

No alignment between OL and NGSS.

MS-ETS1 Engineering Design

OLP 6. This is a 3 because the development of food, medicines, and energy resources (OLP 6b), engaging in discovery (OLP 6e), modifying the ocean environment (OLP 6d), and managing ocean resources (OLP 6g) are all helpful examples of defining problems and developing engineered solutions (DCI ETS1.A, B).

Alignment of Ocean Literacy Framework to the NGSS for Grades 9–12

Standards by Disciplinary Core Idea (DCI)	OLP 1	OLP 2	OLP 3	OLP 4	OLP 5	OLP 6	OLP 7	Specific DCI & Performance Expectations (PE)
HS-ESS1 Earth's Place in the Universe	2	1						ESS1.C; ESS2.B; PE HS-ESS1-5
HS-ESS2 Earth's Systems	1	3	2	2		1		ESS2.A, C, D, E
HS-ESS3 Earth and Human Activity			1			1	2	ESS2.D; ESS3.B; ESS3.C; ESS3.D
HS-LS1 From Molecules to Organisms: Structures and Processes				4				LS1.C
HS-LS2 Ecosystems: Interactions, Energy, and Dynamics	2	1	2	3	2	1	3	LS2.A, B, C; LS4.D; ETS1.B
HS-LS3 Heredity: Inheritance and Variation of Traits								
HS-LS4 Biological Evolution: Unity and Diversity				2	3	1		LS4.A, C, D
HS-PS1 Matter and Its Interactions								
HS-PS2 Motion and Stability: Forces and Interactions	4							PS1A; PS2.A, B
HS-PS3 Energy			3			3		PS3.A, B, C
HS-PS4 Waves and Their Applications in Technologies for Information Transfer	3		4				3	PS4.A, B, C
HS-ETS 1 Engineering Design						3		ETS1.A, B

RATING SCALE for Alignment of Ocean Literacy Framework to Next Generation Science Standards (NGSS)

1

Verbatim or nearly verbatim language in both OL Framework (Guide or Scope & Sequence) and NGSS

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Understanding these Ocean Literacy Principles and/or Fundamental Concepts is essential to helping students to achieve full understanding of these DCIs and/or PEs.

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Examples from the Ocean Literacy Framework (not just any ocean examples) are excellent for teaching and understanding these DCIs and/or PEs

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4

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This rating is given for general science concepts that help students understand the mechanisms behind OL concepts, such as, force and motion helping to explain currents or phase change, and conservation of matter helping to explain the water cycle.

Examples of a 4:
K-PS2 Motion and Stability: Forces and Interactions.
Ocean Literacy Essential Principle 2: These basic ideas are important conceptual building blocks that help us understand waves, erosion, and landforms of the coast.

1-LS3 Heredity: Inheritance and Variation of Traits.
Ocean Literacy Essential Principle 5: DCI introduces concept of inheritance and variation and provides introduction to the concept of diversity described in OLP 5A & C.

[blank] No substantive or helpful relationship

No rating is given when there does not appear to be any plausible, helpful, or meaningful relationship between the OL Principles and/or Fundamental Concepts and the DCIs and/or PEs.

Example of a 5:
K-PS2 Motion and Stability: Forces and Interactions
Ocean Literacy Essential Principle 5: No relationship

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Explanation for Ratings

HS-ESS1 Earth's Place in the Universe

OLP 1. This is a 2 because in order to completely understand plate tectonics as the unifying theory to explain geologic history (DCI ESS2.B; PE HS-ESS1-5), one needs to understand that the lithosphere includes the seafloor and all of its geological features, and that ocean basins vary in size and shape due to movement of Earth's crust (OLP 1b; S&S 1A.3-4).

OLP 2. This is a 1 because there is alignment between the concepts that tectonic activity influences the physical structure and landforms of the coast (OLP 2e; S&S 2 A-A.4), many sedimentary rocks now exposed on land were formed in the ocean (OLP 2a), processes associated with plate tectonics move sediments (OLP 2c), and that plate tectonics is the unifying theory that explains the past and current movement of rocks at earth's surface (DCI ESS2.B; PE HS-ESS1–5).

HS-ESS2 Earth's Systems

OLP 1. This is a 1 because the OLP focuses on the concepts of the ocean is the defining feature of the planet (OLP 1a), the ocean transports energy and matter around Earth (OLP 1c; S&S 1C.7, 11, 12), and the unique properties of water (OLP 1e; S&S 1B). These concepts are closely aligned with the abundance of liquid water on Earth and its unique properties being central to the planet's dynamics (DCI ESS2.C).

OLP 2. This is a 3 because the ocean literacy principles provide important Earth system examples of the core idea that feedbacks between the biosphere and other Earth systems cause the co-evolution of life and Earth's surface (DCI ESS2.E). Examples include biogeochemical cycles and sedimentary rocks found on land originated in the ocean (OLP 2a); and the ocean is the largest reservoir of rapidly cycling carbon on Earth, which is then used by shell and reef building organisms (OLP 2d; S&S 2B strand).

OLP 3. This is a 2 because in order to fully understand the concepts that interactions and feedback effects between Earth's systems cause changes to climate (DCI ESS2.A) and the foundation of the climate system is energy from the sun and interactions with the atmosphere, ocean and land (DCI ESS2.D), one must have an understanding of the concepts of the interaction of oceanic and atmospheric processes controls climate by dominating the Earth's energy, water, and carbon systems (OLP 3a; S&S 3A & B strands), the ocean moderates climate by absorbing most of the solar radiation reaching Earth and heat exchange between the ocean and atmosphere drives oceanic and atmospheric circulation (OLP 3a-b, f; S&S 3A and B strands), and that changes in the ocean-atmosphere system can result in changes to the climate that in turn, cause further changes to the ocean and atmosphere (OLP 3g; S&S 3C strand).

OLP 4. This is a 2 because in order to fully understand the concepts of changes in Earth's atmosphere and feedbacks between Earth's systems, (DCI ESS2.D, E), one must have an understanding of the influence of the ocean on the formation of and changes to Earth's atmosphere and interaction with other systems (OLP 4a, c; S&S 4A & B strands).

OLP 6. This is a 1 because concepts addressing changes in the atmosphere due to human activity are described in both the DCI (ESS2.D) and the S&S (6D.1-2).

HS-ESS3 Earth and Human Activity

OLP 3. This is a 1 because the core ideas of weather and climate models (DCI ESS2.D) are addressed in the Ocean Literacy Framework, which also provides additional examples of the ocean's influence on weather and climate (OLP 3f, g; S&S 3B.1-2,5-6).

OLP 6. This is a 1 because there are strong connections between three DCIs and the Ocean Literacy Framework. The core idea about natural hazards (DCI ESS3.B) is aligned with ideas about human actions increasing the effects of hurricanes and tsunamis (OLP 6f; S&S 6D.4-6). Ideas about resource availability and their effect on human society (DCI ESS3.C) are aligned with concepts about foods, medicines, and mineral and energy resources from the ocean that humans depend on (OLP 6b; S&S 6A strand); ideas about human impacts and management of Earth systems (DCI ESS3.C) are aligned with concepts on ocean resource management (OLP 6e; S&S 6A.2, D.1, E.3-5). Concepts about discovering and modeling Earth's systems (ESS3-D) are aligned with making discoveries about the ocean-atmosphere-biosphere interactions and managing human impacts, including climate change (OLP 6g; S&S 6D.14-15, E.2).

OLP 7. This is a 2 because in order to fully understand the core idea of modeling future climate (DCI ESS2.D), an understanding of ocean exploration and new technologies is needed (OLP 7d-e; S&S 7A.5, C.2-6). In order to fully understand the concepts about global climate change (ESS3.D), an understanding of the complexities and limitations of ocean modeling are needed (S&S 7C.5).

HS-LS1 From Molecules to Organisms: Structures and Processes

OLP 4. This is a 4 because in order to understand oxygen production and the effect of oxygen on life on Earth (OLP 4a; S&S 4A), students will need to know about the process of photosynthesis as described in the DCI (LS1.C).

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

OLP 1. This is a 2 because in order to fully understand cycles of matter and energy transfer in ecosystems and ecosystem dynamics (DCI LS2.B, C), an understanding of how ocean circulation transports (heat) energy and matter and how changes to it affect climate and climate stability are needed (OLP 1c).

OLP 2. This is a 1 because the concepts that many biogeochemical cycles originate in the ocean (OLP 2a), the role that rapidly cycling carbon plays in the ocean (OLP 2d) and the connection of these cycles to the processes of photosynthesis and respiration (S&S 2B strand) are strongly aligned with the cycles of matter and energy transfer, including photosynthesis, respiration and the carbon cycle as described in the DCIs (LS2.B).

OLP 3. This is a 2 because in order to fully understand ecosystem dynamics, functioning and resilience (DCI LS2.C) an understanding of the ocean's influence on climate change and stability is needed (OLP 3e-g; S&S 3B & C strands). Additionally, in order to fully understand cycles of matter and energy transfer in ecosystems (DCI LS2.B), students need to understand the ocean's role in the carbon cycle (OLP 3e; S&S B.1-8).

OLP 4. This is a 3 because the concept of Earth's changing atmosphere (OLP 4c; S&S 4A strand) provides an example of ecosystem dynamics, functioning, and resilience found in the DCI (LS2.C)

OLP 5. This is a 2 because in order to fully understand matter and energy transfer in ecosystems (DCI LS2.B) an understanding of the role that microbes play as primary producers in the ocean ecosystem (OLP 5b; S&S 5A strand) is needed. Understanding the uniqueness and diversity of ocean ecosystems (OLP 5e, g; S&S 5B strand) and the diversity of life and adaptations of ocean organisms (OLP 5c-d, f, h; S&S 5C strand) are essential to comprehending how ecosystems are defined by environmental factors and the community of organisms living there (DCI LS2.A).

OLP 6. This is a 1 because human interactions with the ocean and ocean-atmosphere ecosystems may have negative consequences (OLP 6d-e; S&S 6D strand) is closely aligned to the concept that complex ecosystem interactions are affected by stability vs extreme fluctuations and anthropogenic effects such as pollution, overexploitation and climate change (DCI LS2.C). Also, humans depend on living resources and benefit from biodiversity (DCI LS4.D), which aligns to the concept that humans benefit from the food, medicine, resources, biodiversity and inspiration provided by the ocean (OLP 6a-d; S&S 6A & B strands).

OLP 7. This is a 3 because many examples of different technological advances to explore the ocean are provided, each with strengths and limitations which must be considered (OLP 7c-e; S&S 7C strand) when exploring how human activity impacts ecosystems (DCI LS2.C) and when evaluating solutions (DCI ETS1.B) to sustain biodiversity (DCI LS4.D).

HS-LS4 Biological Evolution: Unity and Diversity

OLP 4. This is a 2 because understanding that the earliest evidence of life is found in the ocean (OLP 4b; S&S 4B strand) is essential to fully understanding evidence of common ancestry and diversity as described in the DCI (LS4.A).

OLP 5. This is a 3 because the ocean provides excellent and diverse examples of adaptations as well as environmental conditions and variations (OLP 5d, g, h; S&S 5B and C strands) introduced in the DCI (LS4.C) which focuses on the process of adaptation and connections to environmental change.

OLP 6. This is a 1 because the concepts that humans are dependent on natural resources and other benefits provided by biodiversity, and on preserving landscapes for recreation and inspiration (DCI LS4.C, D) are strongly aligned with the ocean literacy concepts that although there is a strong interconnection to the environment, humans are having adverse impacts on biodiversity and resources (OLP 6d-e; S&S 6A and D strands).

HS-PS1 Matter and Its Interactions

No alignment between OL and NGSS.

HS-PS2 Motion and Stability: Forces and Interactions

OLP 1. This is a 4 because students need to understand the structure and properties of matter (DCI PS1.A), as well as forces and motion (DCI PS2.A, B) in order to understand thermal expansion and the forces at play in ocean circulation (OLP 1c-d; S&S 1C strand).

HS-PS3 Energy

OLP 3. This is a 3 because the ocean literacy concepts provide important Earth system examples of fundamental physical energy principles including definitions of energy (DCI PS3.A) and conservation of energy and energy transfer (DCI PS3.B, C). Examples include absorption of solar radiation by the ocean, and the energy exchange between the ocean–atmosphere system, which drives Earth's circulation, moderates climate, and provides the energy for hurricanes (OLP 3a-d; S&S 3A, A.1, 4–8, 13).

OLP 6. This is a 3 because the ocean literacy concepts provide examples of energy resources from the ocean (OLP 6b; S&S 6A.5) which help to apply fundamental physical energy principles, including definitions of energy (DCI PS3.A; PE HS-PS3-3).

HS-PS4 Waves and Their Applications in Technologies for Information Transfer

OLP 1. This is a 3 because the core ideas about ocean waves, including how waves transfer energy over a long distance, but with very little horizontal movement (S&S C.15-17), provide strong examples and an application of the concept of wave properties (DCI PS4.A).

OLP 3. This is a 4 because in order to understand solar radiation and heat exchange between the ocean and atmosphere (OLP 3b, c; S&S 3A & B strands) it is helpful to understand electromagnetic radiation, absorption, and conversion to thermal energy (DCI PS4.B).

OLP 7. This is a 3 because the development and use of information technologies in ocean exploration (OLP 7d; S&S 7C strand) is an example of the importance of applying our understanding of waves and their interactions with matter in the use and development of essential tools (DCI PS4.A, C).

HS-ETS1 Engineering Design

OLP 6. This is a 3 because as the human population, climate change and impact on ocean resources increases (OLP 6d; S&S 6A.6, D.1), achieving environmental sustainability in the ocean depends upon action based on scientific research and exploration (S&S 6E), as well as regulations (S&S 6E.2-8,10). These ocean examples of global challenges may be addressed through engineering (DCI ETS1.A). When evaluating these solutions, it is important to take into account social, cultural and environmental impacts (DCI ETS1.B).