

Appendix: NGSS Standards

This course was designed to align with the **Next Generation Science Standards (NGSS)** for middle school. However, because NGSS is structured as a progression across grade bands, the course also supports younger learners in elementary school and extends into high school standards. The sections below summarize how the course meets or exceeds NGSS expectations at different levels. For detailed crosswalks between individual chapters and NGSS codes, please see the **Visual Matrix (Standards × Chapters)** provided separately.

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Elementary Standards (Grades 1–3, with explicit 5th-grade alignment)

Although this course was written to meet middle school NGSS performance expectations, it provides rich opportunities for younger learners. Many of the core ideas introduced in the primary grades—such as patterns in the natural world, the needs of living things, the flow of energy from the sun, and the ways in which Earth’s systems interact—are revisited here in greater depth. Because NGSS is designed as a progression across grade bands, the lessons and activities in this course naturally meet and often exceed expectations for grades 1–3.

For younger students, the content serves as an **extension and reinforcement of elementary standards**: building on foundational ideas about organisms, environments, and Earth’s systems, while offering real-world, ocean-based contexts that deepen understanding. Parents and teachers can be confident that students in the early grades will not only encounter all of the big concepts expected at their level but will also begin to see how those ideas grow into more complex science thinking. In this way, the course supports mixed-age learning environments and can be used flexibly across the upper elementary through middle school years.

Explicit Standards Met for Elementary (3–5): - **5-ESS2-1:** Sphere interactions → Ch. 1 (P), Ch. 2 (S), Ch. 9 (S).

- **5-PS3-1:** Energy from sun → producers → consumers → decomposers → Ch. 3 (P), Ch. 5 (P), Ch. 8 (P), Ch. 9–14 (P).

Middle School Standards (Grades 4–8)

While NGSS middle school standards are formally defined for Grades 6–8, this course is designed for use across **Grades 4–8**. The content is fully aligned to 6–8 NGSS expectations, with scaffolding and supports that make it accessible to younger learners in Grades 4 and 5.

This course is written first and foremost to meet **middle school NGSS performance expectations** across Life Science, Earth & Space Science, Physical Science, and Engineering Design. The alignment is both **comprehensive and layered**, with recurring themes of energy flow, systems thinking, and human–environment interactions.

Unit-Level Narrative Alignment

Unit 1 (Ch. 1): Introduction to the Ocean

This unit introduces the Earth system spheres (biosphere, hydrosphere, atmosphere, geosphere) and their interactions, anchoring NGSS cross-cutting concepts right at the start. Students learn how water connects Earth’s systems and sets up the themes for geology, chemistry, physics, biology, and human impacts that follow. The focus is on Earth systems (ESS2), the water cycle (ESS2-4), and natural hazards (ESS3-2), with connections to heat and energy transfer (PS3-2). Life science enters through comparative anatomy (whales vs. fish) highlighting structure and function (LS4-2).

Progression: From “Earth as a system” → to “the ocean’s role in connecting those systems.”

Unit 2 (Ch. 2–5): Oceanography

This unit dives into the scientific foundations of ocean study: seafloor geology, chemical properties of water, physical forces (waves, currents, energy transfer), and ocean zones. Together, these chapters weave ESS2 (Earth processes) with PS1 (chemistry), PS3 (energy), and PS4 (waves/light), building the conceptual base students need before tackling ecosystems, abiotic factors, and evolution. Students model tectonic movement (ESS2-2, ESS2-3), explore water’s molecular structure (PS1-1, PS1-2), and study heat and light penetration (PS3-2, PS4-2). Life science connections appear where photosynthesis, respiration, and fossils link chemistry and geology to biology (LS1-6, LS1-7, LS4-1).

Progression: From Earth’s structure and chemistry → to physical ocean processes → to organizing the ocean by light and depth zones.

Unit 3 (Ch. 6–8): Evolution, Adaptations, and Natural Selection

Students explore evolution, natural selection, and the genetic basis of traits at both the species level and across groups of species, then turn to microbes — the foundation of marine life and primary drivers of evolution, shaping Earth’s atmosphere, ecosystems, and biosphere over both geologic and ecological timescales. LS4 (evolution) and LS3 (genetics) form the backbone of this unit, with microbes tying in LS1 (cell structure, photosynthesis, microbiomes) and LS2 (cycling of matter). This unit is unusually rich in fossil record (LS4-1, LS4-3) and Earth systems (ESS2-1) connections, including stromatolites and the Great Oxidation Event — when photosynthetic microbes transformed Earth’s atmosphere.

Progression: Adaptations/evolution → mammalian examples → microbial foundations of Earth’s biosphere.

Unit 4 (Ch. 9–14): Marine Ecosystems

This six-chapter unit is the heart of the NGSS LS2 strand (ecosystems). Each chapter builds an ecosystem case study: coastal, coral reef, kelp forest, open ocean, deep ocean, and polar ecosystems. Students repeatedly model energy flow (LS2-2), interactions (LS2-3), and population shifts (LS2-4) while also linking ESS2/ESS3 (Earth systems & human impact) and PS (chemistry, physics of buoyancy, thermal strategies, pressure). Fossil evidence (LS4-1, LS4-3) and convergent evolution (LS4-2) are reinforced in the deep ocean ecosystem and polar ecosystems chapters.

Progression: Starts with abiotic factors → trophic webs → ecosystem-specific adaptations → challenging environments such as the deep and polar oceans.

Unit 5 (Ch. 15–18): Human Impacts & Stewardship

The final unit explicitly addresses ESS3 (Earth and human activity) and ETS1 (engineering design). Overfishing, climate change, pollution, and conservation provide real-world case studies in how science informs decision-making. Students evaluate human impacts and design solutions, aligning with NGSS’s emphasis on using science to solve problems.

Chapter 18 draws on primary research from a **Nature¹ Magazine article** to emphasize NGSS Science & Engineering Practices such as obtaining, evaluating, and communicating information. By engaging with authentic scientific studies, students practice applying evidence to evaluate conservation strategies, design and engineer a solution, and model the reasoning scientists use and deepening alignment with MS-ESS3 (Earth & Human Activity) and MS-ETS1 (Engineering Design).

Progression: From documenting human impacts → to modeling consequences → to evaluating and designing conservation solutions.

¹ Duarte, Carlos M., et al. “Rebuilding Marine Life.” *Nature Magazine*, 1 April 2020, pp. 39-51.

Alignment Key

- **(P) = Primary:** The chapter directly teaches toward that NGSS performance expectation.
- **(S) = Secondary:** The chapter reinforces or supports that expectation but is not the main instructional focus.

Chapter-by-Chapter Alignment

The following chapter-level breakdown shows how each chapter explicitly aligns with NGSS performance expectations:

Unit 1

Chapter 1: Introduction to the Ocean

Life Science: LS2-2 (S ecosystems), LS4-2 (S whale vs. fish anatomy)

Earth Science: ESS2-4 (P water cycle), ESS2-5 (S water shaping), ESS3-2 (P natural hazards), ESS3-5 (S past climate)

Physical Science: PS1-2 (S properties), PS3-2 (S heat/particles)

Unit 2

Chapter 2: Marine Geology & Plate Tectonics

Life Science: LS4-1 (S fossil evidence)

Earth Science: ESS2-1 (P cycling), ESS2-2 (P processes), ESS2-3 (P tectonic evidence), ESS2-5 (P shaping Earth), ESS3-1 (S resources)

Physical Science: PS1-1 (S modeling), PS1-2 (S chemistry), PS3-2 (S thermal properties)

Chapter 3: Ocean Chemistry & Water Properties

Life Science: LS1-2 (S diffusion), LS1-6 (P photosynthesis), LS2-2 (S cycling)

Earth Science: ESS2-4 (P evaporation/condensation), ESS3-5 (S CO₂/climate)

Physical Science: PS1-1 (P molecule model), PS1-2 (P chemistry), PS1-4 (P acidification), PS3-2 (P heat capacity), PS3-3 (P thermal transfer)

Chapter 4: Physical Oceanography (Waves & Energy)

Life Science: LS2-2 (S energy movement)

Earth Science: ESS2-4 (S convection), ESS2-5 (S water shaping), ESS3-2 (P storm hazards)

Physical Science: PS2-2 (P forces → waves), PS3-2 (P energy/particle motion), PS3-4/5 (S transfer), PS4-2 (P wave behavior)

Chapter 5: Ocean Zones

Life Science: LS1-6 (P photosynthesis), LS1-7 (P cellular respiration), LS2-2 (P energy cycling), LS2-4 (S thermocline barrier), LS4-1 (S fossils)

Earth Science: ESS2-1 (P conveyor belt), ESS2-2 (P trenches), ESS3-1 (P deep sea resources)

Physical Science: PS1-1 (P oxygen molecule), PS1-2 (S chemistry), PS3-2 (P thermal layering), PS4-2 (P light penetration)

Unit 3

Chapter 6: Evolution & Adaptations

Life Science: LS1-2 (S DNA/traits), LS1-4 (P dolphin reproduction), LS3-1 (P DNA → trait), LS3-2 (P genetic variation), LS4-1 (P fossil evidence), LS4-2 (P similarities), LS4-3 (P fossil environments), LS4-4 (P variation survival), LS4-6 (S math models)

Earth Science: ESS2-1 (S change rates), ESS3-5 (S past climate)

Physical Science: PS1-2 (S acidification), PS1-4 (S reactions), PS3-2 (S pressures/heat)

Chapter 7: Marine Mammals

Life Science: LS1-3 (P systems), LS1-5 (P environmental pressures), LS3-1 (P traits), LS3-2 (S reproduction), LS4-1 (P whale fossils), LS4-2 (P similarities), LS4-3 (P fossil environments), LS4-4 (P survival)

Earth Science: ESS3-4 (S human impact)

Physical Science: PS3-2 (S insulation/heat)

Chapter 8: Marine Microbes

Life Science: LS1-1 (P cells), LS1-2 (P functions), LS1-3 (P microbiomes), LS1-4 (P bacterial reproduction), LS1-6 (P cyanobacteria), LS1-7 (P digestion), LS2-2 (P cycling), LS2-3 (P symbiosis), LS3-1 (S mutations), LS4-1 (P stromatolites), LS4-3 (P environments), LS4-4 (P viral shunt), LS4-6 (S models)

Earth Science: ESS2-1 (P coccolithophores), ESS3-5 (S oxygenation record)

Physical Science: PS1-1 (P coccolith model), PS1-2 (P transformations), PS1-4 (S acidification)

Unit 4

Chapter 9: Coastal Ecosystems

Life Science: LS1-3, LS1-5, LS1-6, LS2-1, LS2-2, LS2-3, LS2-4, LS4-4

Earth Science: ESS2-1, ESS2-2, ESS2-5, ESS3-1, ESS3-5

Physical Science: PS1-2 (S osmosis), PS3-2 (S temp stress)

Chapter 10: Coral Reefs

Life Science: LS1-5, LS1-6, LS1-7, LS2-1, LS2-2, LS2-3, LS2-4, LS2-5, LS4-2, LS4-4

Earth Science: ESS2-1, ESS2-5, ESS3-3, ESS3-5

Physical Science: PS1-2, PS1-4, PS3-2

Chapter 11: Kelp Forests

Life Science: LS1-1, LS1-2, LS1-6, LS2-1, LS2-2, LS2-3, LS2-4, LS2-5, LS4-2

Earth Science: ESS2-1 (P carbon sink), ESS2-5 (S coastal shaping), ESS3-3, ESS3-4

Physical Science: PS1-2 (S nutrients), PS3-2 (S upwelling), PS3-4/5

Chapter 12: Open Ocean

Life Science: LS1-2, LS1-3, LS1-6, LS1-7, LS2-1, LS2-2, LS2-3, LS2-4, LS2-5, LS3-1, LS4-2, LS4-4

Earth Science: ESS2-1, ESS2-4, ESS2-5, ESS3-1, ESS3-2, ESS3-5

Physical Science: PS1-2 (S density/buoyancy), PS3-2 (S thermal strategies), PS3-3/4/5 (S currents), PS4-2 (S biomass waves)

Chapter 13: Deep Ocean

Life Science: LS1-1, LS1-2, LS1-3, LS1-7, LS2-2, LS2-3, LS2-4, LS3-1, LS4-1, LS4-2, LS4-3, LS4-4

Earth Science: ESS2-1, ESS2-2, ESS2-3, ESS3-1, ESS3-5

Physical Science: PS1-2, PS1-4, PS2-2 (S squid forces), PS3-2, PS3-3

Chapter 14: Polar Oceans

Life Science: LS1-3, LS1-5, LS1-6, LS2-1, LS2-2, LS2-3, LS2-4, LS2-5, LS3-1, LS4-1, LS4-2, LS4-3, LS4-4

Earth Science: ESS2-1, ESS2-4, ESS2-5, ESS3-1, ESS3-5

Physical Science: PS1-2, PS1-4 (S freezing point), PS3-2 (S thermal adaptations)

Unit 5

Chapter 15: Overfishing & Habitat Loss

Life Science: LS2-1, LS2-4, LS2-5

Earth Science: ESS3-3, ESS3-4, ESS3-1 (P resources)

Engineering: ETS1-3 (S solutions)

Chapter 16: Climate Change & Ocean

Life Science: LS2-4 (S ecosystem stress)

Earth Science: ESS2-1 (P heat content), ESS2-4 (S hurricanes), ESS3-5 (S climate evidence), ESS3-3 (S monitoring)

Physical Science: PS3-2 (S thermal energy), PS3-3 (S hurricane lab)

Chapter 17: Ocean Pollution

Life Science: LS2-2 (S cycling), LS2-4 (S impacts), LS2-5 (S solutions)

Earth Science: ESS3-3 (P monitor human impacts), ESS3-4 (S consumption)

Physical Science: PS1-2 (S oil, eutrophication)

Engineering: ETS1-1 (P problem definition), ETS1-3 (S cleanup tech)

Chapter 18: Conservation & Stewardship

Life Science: LS2-5 (P solutions for biodiversity)

Earth Science: ESS3-3 (P monitoring), ESS3-4 (P population/consumption)

Engineering: ETS1-1 (P design MPA), ETS1-2 (P criteria/constraints), ETS1-3 (P competing solutions)

High School Standards (Grades 9–12)

Although designed for middle school, this course also extends substantially into the **high school NGSS framework**. Core topics such as **evolution and natural selection, genetics and inheritance, ocean chemistry and acidification, climate change, and conservation** are explicitly part of high school standards.

For high school learners, the course offers a **rigorous, real-world science experience** that emphasizes analytical thinking, current research, and global connections between ecosystems and human impacts. It can be used flexibly:

- As a **full-year, lab-based high school science course** in environmental science or marine science.
- As a **semester-long elective or enrichment course** that supplements biology, earth science, or chemistry.
- As a **college-prep elective** for students interested in marine biology, environmental science, or sustainability.

Closing Statement:

Teachers and parents can be confident that learners completing this course will review core middle school expectations and, in some areas, exceed high school NGSS performance expectations in Life Science, Earth & Space Science, and cross-cutting Physical Science concepts. By design, the course emphasizes critical thinking, modeling, and problem-solving, which are central to high school NGSS. As a result, students will be well-prepared for further science study at the secondary level and even introductory college courses.

Explicit Standards Met for High School Extensions:

- **HS-LS4-4:** Natural selection → Ch. 6 (P), Ch. 7 (P), Ch. 12 (S).
- **HS-ESS2-6:** Carbon cycle → Ch. 3 (S), Ch. 5 (S), Ch. 8 (S), Ch. 13 (S), Ch. 14 (P), Ch. 16 (P).
- **HS-ESS3-1:** Human impacts → Ch. 11 (P), Ch. 15–18 (P).

Final Notes

Course Strengths:

- **LS2 (ecosystems):** Covered in depth from multiple angles (limiting factors, trophic webs, keystone species, human impacts).
- **LS3/LS4 (genetics & evolution):** Strong anchors in Ch. 6–14.
- **ESS2/ESS3 (Earth systems & human activity):** Robust coverage of tectonics, currents, sediments, climate change, hazards, and human monitoring.
- **Physical Science:** Strong alignment in PS1-2, PS3-2, PS2-2, PS4-2.
- **ETS1 (engineering design):** Explicitly addressed in Unit 5.

Remaining Gaps (not in scope for Marine Science):

- PS1-3: Synthetic vs. natural materials.
- PS1-5: Conservation of mass.
- PS2-3: Electric/magnetic forces.
- ESS1: Astronomy standards.

Life Science Standards Met by Chapter

NGSS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LS1-1								☑	■		■		■					
LS1-2	■		■			■		☑			☑	☑	■	■				
LS1-3							☑	☑				☑	☑	☑				
LS1-4						☑		☑										
LS1-5						■	☑		☑	☑	■			☑	☑	☑		
LS1-6	■		☑		☑			☑	☑	☑	☑	■		☑				
LS1-7					☑			☑	■	☑	■	☑	☑	■				
LS2-1	■								☑	☑	☑	☑		☑	☑			
LS2-2	■	■	■		☑			☑	☑	☑	☑	☑	☑	☑			☑	
LS2-3								☑	☑	☑	☑	☑	☑	☑				
LS2-4					■				☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
LS2-5										■	■	■		■	☑		☑	☑
LS3-1						☑	☑	■				■	■	☑				
LS3-2						☑	■											
LS4-1		■			■	☑	☑	☑					☑	☑				
LS4-2	☑					☑	☑	■			■	☑	■	☑				
LS4-3						☑	☑	☑					☑	☑				
LS4-4					■	☑	☑	☑	☑	■		☑	■	■	☑	☑	☑	
LS4-5																		
LS4-6						■	■	■				■						

Earth Science Standards Met by Chapter

NGSS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ESS2-1	■	☑	■		☑	■		☑	☑	☑	■	☑	☑	☑		☑		
ESS2-2	■	☑			☑				■				☑					
ESS2-3		☑											☑					
ESS2-4	☑		☑	■	☑				■			☑		■		☑		
ESS2-5	■	☑		■	■				☑	■	■	☑		☑				
ESS3-1	■	■			■			■	■			☑	☑	■	☑			
ESS3-2	☑			☑								■				■		
ESS3-3										■	☑	■		■	☑	☑	☑	☑
ESS3-4							☑				☑				☑		■	☑
ESS3-5	■		■			■	■	■	■	■		☑	☑	☑		☑		

Physical Science Standards Met by Chapter

NGSS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PS1-1		■	☑		☑			☑					■					
PS1-2	■	■	☑		■	■		☑	☑	☑	■	☑	☑	☑			☑	
PS1-3																		
PS1-4			☑		■	■		■		☑			■	■				
PS1-5																		
PS2-2				☑									☑					
PS2-3																		
PS3-2	■	■	☑	☑	☑	■	■	■	■	☑	☑	☑	☑	☑		■		
PS3-3			☑										■			■		
PS3-4/5				■							■	☑						
PS4-2				☑	☑							■						

Engineering Standards Met by Chapter

NGSS	15	16	17	18
ETS1-1			■	☑
ETS1-2				☑
ETS1-3	■		■	☑