Introduction to the Ocean Literacy Scope and Sequence for Grades K through 12

The *Ocean Literacy Scope and Sequence for Grades K–12* is a series of 28 conceptual flow diagrams\(^3\) that represent and organize the ideas of the seven Ocean Literacy Principles into four grade bands—K through 2, 3 through 5, 6 through 8, and 9 through 12—effectively showing what students should know at the end of 2nd, 5th, 8th, and 12th grades. This document provides specific guidance to educators, standards committees, curriculum developers, and scientists conducting outreach. It is one part of the Ocean Literacy Framework which comprises four key documents:

- *Ocean Literacy: The Essential Principles of Ocean Sciences for Learners of All Ages*;
- *The Ocean Literacy Scope and Sequence for Grades K–12*;
- *Alignment of Ocean Literacy to the Next Generation Science Standards*; and
- *International Ocean Literacy Survey*.

The scope and sequence was developed iteratively and thoughtfully with significant and substantive participation by hundreds of scientists, science educators, and classroom teachers around the country.\(^4\) Thus, it represents a community consensus regarding the essential ideas in ocean sciences that all students should understand by the end of Grade 12 and a road map for how to get there.

The scope and sequence conceptual flow diagrams provide specific guidance to help educators as they work to grow their learner’s conceptual understanding of essential ocean concepts. Dive into the conceptual flow diagrams on the following pages.

To access online versions of the Framework documents, please visit [www.marine-ed.org/ocean-literacy/overview](http://www.marine-ed.org/ocean-literacy/overview)

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4 A more complete history is provided in the introduction to this handbook.
The Ocean Literacy Scope and Sequence comprises 28 conceptual flow diagrams (hereafter referred to as flows). There is one flow for each principle for each grade band (K through 2, 3 through 5, 6 through 8, and 9 through 12). Each flow is read from top to bottom and left to right and represents one possible way of breaking down and organizing the major concepts and supporting ideas for each principle for a grade band.

The essential principle as well as the grade level are listed at the top of the page. The diagram shows three sets of text boxes (called strands) cascading down the page. Each strand represents a topic related to the essential principle and includes concepts and supporting subconcepts focused on the topic.

Conceptual flow diagrams can be used as a suggested instructional sequence, organizer of ideas, and/or indicator of learning progression.

Figure 1

In this flow for Principle 1, Grades 3 through 5, there are three strands of topics and five levels of ideas. Read the flow from top to bottom and left to right, from Strand A (A1 to A5) to Strand B (B1 to B10) to Strand C (C1 to C5). Some of the concepts cross-reference other concepts in other principles within that same grade band. These cross-references are connections between principles.
Figure 2

Principle 1: Grades 3-5

Strand Topic

Properties of Ocean Water

57% of all water on Earth is salt water in the ocean.

A.1. Only 3% of all water on Earth is fresh water stored in lakes, rivers, underground aquifers, glaciers, and other places.

A.2. Most of all the fresh water in the world is stored in ice caps and glaciers.

A.3. Fresh water melting from glaciers contributes to the ocean and can change its salinity and temperature and cause sea level to rise.

A.4. Salinity and temperature vary throughout the ocean.

A.5. The movement of ocean water as currents is partly driven by these differences in salinity and temperature.

2 ideas that support bigger ideas in this strand

Supporting ideas on properties of ocean water discussed in further detail

For Grades 3-5, concept A2 in Principle 1 is connected to concept B3 in Principle 3

Strand A of conceptual flow diagram of Principle 1 for Grades 3 to 5. Here is a breakdown of the components in a strand. The strand is identified by topic for easy reference. The strand begins with a major concept and then nested below are two levels of ideas that support the bigger idea. Supporting ideas can be examples, but not always.
How to Use the Alternative Form of the Conceptual Flow Diagrams

In addition to the conceptual flow diagrams of the *Ocean Literacy Scope and Sequence for Grades K–12*, we also present the concepts in a tabular format. This helps convey the connections and relationships between concepts, without relying on visual cues.

### Properties of Ocean Water — A

<table>
<thead>
<tr>
<th>Strand</th>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>97% of all water on Earth is salt water in the ocean.</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>Only 3% of all water on Earth is fresh water stored in lakes, rivers, underground aquifers, glaciers, and other places.</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>Most of all the fresh water in the world is stored in ice caps and glaciers.</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>Fresh water melting from glaciers contributes to the ocean and can change saltiness and temperature and cause sea level to rise.</td>
<td></td>
</tr>
</tbody>
</table>

### Ocean Circulation — B

<table>
<thead>
<tr>
<th>Strand</th>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>The ocean, being the largest reservoir of water on Earth, is integral to the water cycle.</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>Water circulates from land to the ocean and back via watersheds and the wind.</td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>Lakes and glaciers are connected to the ocean via watersheds.</td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>Water density-driven currents move ocean water around Earth.</td>
<td></td>
</tr>
<tr>
<td>B5</td>
<td>Tides move ocean water higher and lower, covering and uncovering the shoreline.</td>
<td></td>
</tr>
<tr>
<td>B6</td>
<td>Waves crash on the shore moving and mixing the water.</td>
<td></td>
</tr>
</tbody>
</table>

### Geographic and Geologic Features — C

<table>
<thead>
<tr>
<th>Strand</th>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>The ocean floor has a variety of geological and geographical features comparable to those on land.</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>The ocean floor has many basins. They are called the Pacific, Atlantic, Indian, Arctic, and Southern basins.</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>The ocean floor has other features such as mountains, plains, valleys, volcanoes, canyons, trenches, and ridges.</td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>The ocean floor influences ocean circulation patterns.</td>
<td></td>
</tr>
</tbody>
</table>

### Example

**Strand Topic:** Principle 1: Earth has one big ocean with many features.

#### Major concept of this strand

- Ocean, which covers 70% of Earth's surface, is the defining feature of the planet.

#### 2 ideas that support bigger ideas in this strand

- A1: The ocean, being the largest reservoir of water on Earth, is integral to the water cycle.
- A2: Water circulates from land to the ocean and back via watersheds and the wind.

#### Supporting ideas on properties of ocean water discussed in further detail

- B1: Water circulates from land to the ocean and back via watersheds and the wind.
- B2: Lakes and glaciers are connected to the ocean via watersheds.
- B3: Water density-driven currents move ocean water around Earth.
- B4: Tides move ocean water higher and lower, covering and uncovering the shoreline.
- B5: Waves crash on the shore moving and mixing the water.

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Notes:

- Strands of connected ideas are organized under a topic title and brief description. Instead of using arrows to convey connections between individual concepts, concepts are stacked in columns in the order in which they should be presented (i.e., top to bottom, then left to right). This means some concepts are repeated under each higher level concept to convey the connections among them. As users of assistive technology navigate the tables, the concepts become more and more specific.
Conceptual Flow Diagrams

- Principle 1
- Principle 2
- Principle 3
- Principle 4
- Principle 5
- Principle 6
- Principle 7
**Principle 1: Earth has one big ocean with many features.**

The ocean, which covers 70% of Earth's surface, is the defining feature of the planet.

<table>
<thead>
<tr>
<th>Geologic Features — A</th>
<th>Properties of Ocean Water — B</th>
<th>Ocean Circulation — C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The size and shape of the ocean has changed over geologic time and continues to move and change.</strong></td>
<td><strong>97% of all water on Earth is ocean water, which has unique chemical and physical properties.</strong></td>
<td><strong>The ocean is one interconnected body of water that is integral to the water cycle; and is in constant motion in a global circulation system.</strong></td>
</tr>
<tr>
<td><strong>Motion along the margins of lithospheric plates creates physical features on the ocean floor and land.</strong></td>
<td><strong>Density differences between masses of water can cause currents.</strong></td>
<td><strong>A global ocean circulation system is generated from tides and different types of currents moving the water.</strong></td>
</tr>
<tr>
<td><strong>Many of the physical features on the ocean floor are the result of the constant motion of the lithospheric plates that make up Earth's crust.</strong></td>
<td><strong>The density of ocean water increases as salinity (amount of dissolved salts) increases and as temperature decreases.</strong></td>
<td><strong>Tides are mainly caused by the gravitational interaction between Earth, the moon, and the sun.</strong></td>
</tr>
<tr>
<td><strong>New lithospheric crust is generated at spreading centers while older, denser crust is recycled into the Earth's interior at subduction zones, creating various physical features.</strong></td>
<td><strong>The salinity of ocean water can change due to adding or removing water (e.g., evaporation, melting glaciers, or inflow from rivers, streams, and rainfall).</strong></td>
<td><strong>Ocean circulation is influenced by the position of basins, continents, and other geologic features.</strong></td>
</tr>
<tr>
<td><strong>Plate movement is primarily caused by the convection of hot fluids below Earth's crust.</strong></td>
<td><strong>The temperature of ocean water can change due to warming and cooling (e.g., heat from the sun or contact with ice).</strong></td>
<td><strong>Ocean circulation is influenced by the position of basins, continents, and other geologic features.</strong></td>
</tr>
<tr>
<td><strong>Features on the ocean floor are highly varied, and include trenches, rift valleys, mid-ocean ridges, seamounts, islands, and continental shelves.</strong></td>
<td><strong>Ocean circulation is influenced by the position of basins, continents, and other geologic features.</strong></td>
<td><strong>Ocean circulation is influenced by the position of basins, continents, and other geologic features.</strong></td>
</tr>
<tr>
<td><strong>The continents are still in motion today.</strong></td>
<td><strong>Ocean circulation is influenced by the position of basins, continents, and other geologic features.</strong></td>
<td></td>
</tr>
</tbody>
</table>
**Principle 2**

**The ocean and life in the ocean shape the features of Earth.**

### Geologic Change

- **A.1.** Many landforms are the result of a combination of constructive and destructive forces where the ocean meets the land.
- **A.2.** Weathering is the breaking down of rocks, soils, and minerals through physical, chemical, and biological processes.
- **A.3.** Biological weathering is caused by living organisms (e.g., when sea urchins grind holes in rocks).
- **A.4.** Organisms can release organic acids that can increase chemical weathering.
- **A.5.** Cracks in rock become sites where further weathering is more likely to occur.
- **A.6.** Chemical weathering breaks down and alters the chemical composition of rocks and minerals through hydrolysis, oxidation, and acidification.
- **A.7.** Physical weathering of rocks can be caused by freeze-thaw cycles, salt crystallization, hydraulic action, pressure release, wind abrasion, and/or thermal expansion.
- **A.8.** Erosion and deposition of rocks, sediments, and other particles by wind, rain, waves, ice, gravity, or living organisms can alter coastlines.
- **A.9.** Powerful storms can cause drastic short- and long-term changes to coastlines.
- **A.10.** Beach profiles change seasonally due to different wave action and water flow.
- **A.11.** Powerful winter wave action removes sediment from shorelines. Gentle summer wave action re-builds beaches.
- **A.12.** Sediment deposits from rivers replace sand removed by waves and currents.
- **A.13.** The surface of the land is shaped by sea level changes.
- **A.14.** Sea level is affected by changes in climate and tectonic activity.
- **A.15.** Variations in global climate affect the volume of water in the ocean by changing the size of polar ice caps and glaciers, resulting in relative sea-level changes.
- **A.16.** Changes in sea level can create, destroy, expose, and cover landforms, such as continental shelves, islands, marine terraces, beaches, and inland seas.
- **A.17.** Fossilized marine organisms, ancient coral reefs, and beaches can be found on land, far from current coastlines.
- **A.18.** Tectonic activity causes uplift and subduction, which results in relative sea-level changes.
- **A.19.** Tectonic activity between oceanic and continental plates can result in volcanoes, earthquakes, and mountain formation near the coast.
- **A.20.** Some igneous rocks are formed in the ocean (e.g., at subduction zones).
- **A.21.** Some metamorphic rocks are formed in the ocean from organic sediments.
- **A.22.** Many sedimentary rocks are formed in the ocean from organic sediments.

### Rock Cycle

- **B.1.** Many of the rocks exposed on land were formed in the ocean.
- **B.2.** Many marine organisms form carbonate and silicate skeletal structures, which contribute to the formation of sedimentary rocks, reefs, and stromatolites.
- **B.3.** Some organisms, such as cyanobacteria, coralline algae, and corals construct complex structures (e.g., stromatolites and reefs).
- **B.4.** The skeletal structures formed by some organisms (e.g., mollusk shells, Bryozoa, corals, Radiolaria, and diatom cell walls) sink and are deposited on the ocean floor, eventually forming sedimentary rocks.
- **B.5.** Coral reefs are produced by living organisms that secrete an exoskeleton of calcium carbonate.
- **B.6.** Stromatolites are a major component of the fossil record for the first 3.5 billion years of life on Earth.
- **B.7.** Stromatolites are a major component of the fossil record for the first 3.5 billion years of life on Earth.
**Principle 2: The ocean and life in the ocean shape the features of Earth.**

<table>
<thead>
<tr>
<th>Geologic Change — A</th>
<th>Rock Cycle — B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1</strong></td>
<td><strong>A13</strong></td>
</tr>
<tr>
<td>Many changes in geologic features occur where the ocean meets the land.</td>
<td>The surface of the land is shaped by sea level changes.</td>
</tr>
<tr>
<td><strong>A2</strong></td>
<td><strong>A8</strong></td>
</tr>
<tr>
<td>Weathering is the breaking down of rocks, soils, and minerals through physical, chemical, and biological processes.</td>
<td>Erosion and deposition of rocks, sediments, and other particles by wind, rain, waves, ice, gravity, or living organisms can alter coastlines.</td>
</tr>
<tr>
<td><strong>A3</strong></td>
<td><strong>A6</strong></td>
</tr>
<tr>
<td>Biological weathering is caused by living organisms (e.g., when sea urchins grind holes in rocks).</td>
<td>Chemical weathering breaks down and alters the chemical composition of rocks and minerals through hydrolysis, oxidation, and aacidification.</td>
</tr>
<tr>
<td><strong>A4</strong></td>
<td><strong>A5</strong></td>
</tr>
<tr>
<td>Organisms can release organic acids that can increase chemical weathering.</td>
<td>Cracks in rock become sites where further weathering is more likely to occur.</td>
</tr>
<tr>
<td><strong>A7</strong></td>
<td><strong>A9</strong></td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

GRADES 6 THROUGH 8

**A Handbook for Increasing Ocean Literacy**

oceанин-literacyNMEA.org
**Principle 3: The ocean is a major influence on weather and climate.**

(A. The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth.

B. Changes in the ocean/atmosphere system can result in changes to the climate.

### A.1. Heat exchange between the ocean and the atmosphere drives the water cycle and oceanic and atmospheric circulation.

A.2. The ocean dominates the water cycle.

A.3. Ocean currents move heat throughout the ocean basins.

A.4. The ocean loses heat through evaporation. The lost heat is released back to the atmosphere when the evaporated water vapor condenses and forms rain. The released heat drives atmospheric circulation.

A.5. Most rain that falls on land evaporated from the tropical ocean.

A.6. The weather along coastlines is generally more moderate than inland regions because the ocean absorbs and retains heat more effectively than the land.

A.7. The heat transferred from the tropical ocean provokes the energy that drives atmospheric circulation and weather, including hurricanes, cyclones, and polar storms.

A.8. Increases in sea surface temperature increases atmospheric convection, changing patterns of rainfall and drought.

A.9. El Niño Southern Oscillation (ENSO) is important because it changes where the rain falls in the tropics, which changes atmospheric circulation.

### A.10. Short-term and seasonal changes in ocean temperature can affect rainfall and temperatures on land (i.e., weather). Long-term changes in ocean temperature can affect the climate.

### B.1. The global climate is influenced by the amount of carbon dioxide in the atmosphere. The more carbon dioxide in the atmosphere, the more the climate warms.

B.2. The ocean absorbs about 50% of all carbon dioxide added to the atmosphere.

B.3. Some of the carbon dioxide absorbed by the ocean is used by phytoplankton and other photosynthetic organisms in the process of photosynthesis. About half of the world’s photosynthesis (primary production) occurs in the sunlit layers of the ocean.

B.4. Absorbing carbon dioxide can decrease the ocean’s pH, making the water more acidic. This can have consequences for many organisms in the ocean.

B.5. There have been large abrupt changes in Earth’s climate over geologic time.

B.6. Humans are changing the climate by continuing to release large amounts of carbon dioxide and methane into the atmosphere.

See Principle 1: C
See Principle 2: A9
See Principle 6: C
See Principle 7: A3
See Principle 5: A2
See Principle 6: D13

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**oceanliteracyNMEA.org**
**Principle 3:** The ocean is a major influence on weather and climate.

The interaction of oceanic and atmospheric processes controls weather and climate by dominating Earth’s energy system.

<table>
<thead>
<tr>
<th>Weather and Climate — A</th>
<th>Global Climate Change — B</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth.</td>
<td>Changes in the ocean/atmosphere system can result in changes to the climate.</td>
</tr>
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<td>Heat exchange between the ocean and the atmosphere drives the water cycle, and oceanic and atmospheric circulation.</td>
<td>Short-term and seasonal changes in ocean temperature can affect rainfall and temperatures on land (i.e., weather). Long-term changes in ocean temperature can affect the climate.</td>
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<tr>
<td>The ocean dominates the water cycle.</td>
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<td></td>
</tr>
<tr>
<td>The heat transferred from the tropical ocean provides the energy that drives atmospheric circulation and weather, including hurricanes, cyclones, and polar storms.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increases in sea surface temperature increases atmospheric convection, changing patterns of rainfall and drought. The most important of these changes is called El Niño.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land and ocean weather maps are used to display and identify weather patterns and to help predict future patterns.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>The ocean absorbs about 50% of all carbon dioxide added to the atmosphere.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There have been large abrupt changes in Earth's climate over geologic time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A3</th>
<th>A4</th>
<th>A6</th>
<th>A9</th>
<th>A5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean currents move heat throughout the ocean basins.</td>
<td>The ocean loses heat through evaporation. The lost heat is released back to the atmosphere when the evaporated water vapor condenses and forms rain. The released heat drives atmospheric circulation.</td>
<td>The weather along coastlines is generally more moderate than inland regions because the ocean absorbs and retains heat more effectively than the land.</td>
<td>El Niño Southern Oscillation (ENSO) is important because it changes where the rain falls in the tropics, which changes atmospheric circulation.</td>
<td>Most rain that falls on land evaporated from the tropical ocean.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B3</th>
<th>B4</th>
<th>B6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some of the carbon dioxide absorbed by the ocean is used by phytoplankton and other photosynthetic organisms in the process of photosynthesis. About half of the world's photosynthesis (primary production) occurs in the sunlit layers of the ocean.</td>
<td>Absorbing carbon dioxide can decrease the ocean's pH, making the water more acidic. This can have consequences for many organisms in the ocean.</td>
<td>Humans are changing the climate by continuing to release large amounts of carbon dioxide and methane into the atmosphere.</td>
</tr>
</tbody>
</table>
**Grades 6 through 8**

**Principle 4**

**The Ocean Makes Earth Habitable.**

**Oxygen Production**

**A.**
Originally, all oxygen in the atmosphere came from photosynthetic organisms in the ocean.

**A.1.**
Earth originally had an atmosphere containing gases toxic to most organisms; there was no life on land until oxygen became common in the atmosphere.

**A.2.**
Cyanobacteria (blue-green algae) living in the ocean generated oxygen in Earth’s atmosphere through the process of photosynthesis, over many millions of years.

**A.3.**
The oxygen produced by cyanobacteria through photosynthesis first accumulated in the ocean, and then escaped into the atmosphere, where it formed ozone that blocked much UV radiation from reaching Earth’s surface.

**A.4.**
By 550 million years ago, oxygen and ozone levels in the atmosphere were high enough that terrestrial organisms could develop and survive.

**A.5.**
Most of the oxygen consumed by organisms living on land is produced by photosynthetic organisms in the ocean.

**B.**
Life started in the ocean, and the earliest evidence of life is found in ancient ocean sediments.

**B.1.**
The fossil record of ancient lifeforms provides evidence for the theory of evolution and the important role that the ocean played in the evolution of life on Earth.

**B.2.**
Cyanobacteria (blue-green algae), the ancestors of all plants and algae, are among the oldest fossils currently known on Earth. These 3 billion-year-old organisms evolved in the ocean, and are found in ancient ocean sediments.

**B.3.**
The chloroplast, which plants use to make food for themselves through photosynthesis, is a remnant of cyanobacteria.

**B.4.**
The millions of different species of organisms on Earth today are related by descent from common ancestors that evolved in the ocean and continue to evolve today.

See Principle 2: B7
## Principle 4

### Principle 4: The ocean makes Earth habitable.

<table>
<thead>
<tr>
<th>Ocean Production — A</th>
<th>Origins of Life — B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originally, all oxygen in the atmosphere came from photosynthetic organisms in the ocean.</td>
<td>Life started in the ocean, and the earliest evidence of life is found in ancient ocean sediments.</td>
</tr>
<tr>
<td>A1</td>
<td>B1</td>
</tr>
<tr>
<td>Earth originally had an atmosphere containing gases toxic to most organisms; there was no life on land until oxygen became common in the atmosphere.</td>
<td>The fossil record of ancient lifeforms provides evidence for the theory of evolution and the important role that the ocean played in the evolution of life on Earth.</td>
</tr>
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<td>A2</td>
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</tr>
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<td>Cyanobacteria (blue-green algae) living in the ocean generated oxygen in Earth's atmosphere through the process of photosynthesis, over many millions of years.</td>
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<td>The oxygen produced by cyanobacteria through photosynthesis first accumulated in the ocean, and then escaped into the atmosphere, where it formed ozone that blocked much UV radiation from reaching Earth's surface.</td>
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<tr>
<td>A4</td>
<td>B4</td>
</tr>
<tr>
<td>By 550 million years ago, oxygen and ozone levels in the atmosphere were high enough that terrestrial organisms could develop and survive.</td>
<td>The millions of different species of organisms on Earth today are related by descent from common ancestors that evolved in the ocean and continue to evolve today.</td>
</tr>
</tbody>
</table>
Ocean ecosystems with the greatest abundance of life occur where environmental conditions and/or adaptations allow for high levels of productivity.

**Primary Productivity — A**

- **Most primary productivity in the ocean takes place at the surface where there is plentiful sunlight for photosynthesis.**
- **The diversity of ocean ecosystems allows for many unique lifeforms with many unique adaptations.**

**Diversity of Ecosystem — A**

- **Diversity of Life — B**

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**A2**

Most primary productivity in the ocean takes place at the surface where there is plentiful sunlight for photosynthesis, allowing for high levels of productivity.

**A3**

Some ecosystems function independent of light energy.

**A4**

There are six places in the ocean where the water is warm and there are many nutrients in the water, and yet in some places, they are very low in productivity. These are the coastal upwelling zones.

**A5**

Environments in ecosystems in areas with the greatest abundance of life occur where environmental conditions and/or adaptations allow for high levels of productivity. These are coastal upwelling zones.

**A6**

At the pole, nutrientrich cold water flows from the ocean, bringing nutrients, light energy, and oxygen, resulting in high productivity in subpolar and subantarctic areas for a great many ocean organisms.

**A7**

Ecosystems exist in layers of biota and microhabitats due to environmental conditions and/or adaptations that allow for levels of productivity.

**A8**

Any change in an ecosystem or in the community forces the system to adapt, changing the effect of many other ecosystems.

**A9**

Many major types of organisms, such as plankton (microscopic), crustaceans, and cephalopods, have planktonic life stages that help them to mate and move from one food source to the next, supporting life.

**A10**

Ocean organisms are adapted to live in a relatively stable ocean. They are often adapted to change very specific environmental conditions, such as salinity and temperature range, where some live only within specific temperature ranges, and some live only in very low salinity layers of water with paralitic and salinity conditions.

**A11**

Some marine animals can change sex as they mature, find prey, or escape predators, such as those in seahorses, corals, many fish, and cephalopods.

**A12**

Adaptations that environmental conditions can result in vertical and horizontal distribution patterns. For example, in essential areas, organisms are adapted to coastal waves and the cycle of the tides, while in the open ocean, many organisms are adapted to specific temperature and salinity levels. Different organisms are found in different density layers.

**A13**

Changes in the climate will cause further changes in environmental conditions, which will likely have major impacts on the species living in and around different ocean ecosystems.

---

**B1**

The ocean provides a vast living space and unique ecosystems, from the surface, through the water column, to the sea floor.

**B2**

Some of these life cycles and environments are unique to ocean ecosystems, such as those of oceanic, coral, many fish, and cephalopods.

---

**C1**

In the tropical ocean much diversity can occur. For example, elephant seals spend most of their time diving to the deep ocean. For many others, their migration routes are long, involving plankton, cold nutrient-rich waters from melt, and yet in some places, they are very low in productivity. These are coastal upwelling zones.

**C2**

Ecosystems exist in layers of habitats and microhabitats due to environmental conditions and/or adaptations that allow for levels of productivity.

**C3**

Many major types of organisms, such as plankton, crustaceans, and cephalopods, have planktonic life stages that help them to mate and move from one food source to the next, supporting life.

**C4**

Ocean organisms are adapted to live in a relatively stable ocean. They are often adapted to change very specific environmental conditions, such as salinity and temperature range, where some live only within specific temperature ranges, and some live only in very low salinity layers of water with paralitic and salinity conditions.

**C5**

Some marine animals can change sex as they mature, find prey, or escape predators, such as those in seahorses, corals, many fish, and cephalopods.

**C6**

Adaptations that environmental conditions can result in vertical and horizontal distribution patterns. For example, in essential areas, organisms are adapted to coastal waves and the cycle of the tides, while in the open ocean, many organisms are adapted to specific temperature and salinity levels. Different organisms are found in different density layers.

**C7**

Changes in the climate will cause further changes in environmental conditions, which will likely have major impacts on the species living in and around different ocean ecosystems.

---

**D1**

In the polar regions where there is less sunlight, cold nutrient-rich waters from melt, and yet in some places, they are very low in productivity. These are coastal upwelling zones.

---

**E1**

The diversity of life in the ocean is shaped by the sun, the ocean, which has had millions of years to adapt to the environment, and by the sunlit surface where photosynthesis can occur.

**E2**

Some marine animals can change sex as they mature, find prey, or escape predators, such as those in seahorses, corals, many fish, and cephalopods.

---

**F1**

Many major types of organisms, such as plankton, crustaceans, and cephalopods, have planktonic life stages that help them to mate and move from one food source to the next, supporting life.

**F2**

Ocean organisms are adapted to live in a relatively stable ocean. They are often adapted to change very specific environmental conditions, such as salinity and temperature range, where some live only within specific temperature ranges, and some live only in very low salinity layers of water with paralitic and salinity conditions.

**F3**

Some marine animals can change sex as they mature, find prey, or escape predators, such as those in seahorses, corals, many fish, and cephalopods.

---

**G1**

In the tropical ocean much diversity can occur. For example, elephant seals spend most of their time diving to the deep ocean. For many others, their migration routes are long, involving plankton, cold nutrient-rich waters from melt, and yet in some places, they are very low in productivity. These are coastal upwelling zones.

---

**H1**

Ecosystems exist in layers of habitats and microhabitats due to environmental conditions and/or adaptations that allow for levels of productivity.

**H2**

Many major types of organisms, such as plankton, crustaceans, and cephalopods, have planktonic life stages that help them to mate and move from one food source to the next, supporting life.

**H3**

Ocean organisms are adapted to live in a relatively stable ocean. They are often adapted to change very specific environmental conditions, such as salinity and temperature range, where some live only within specific temperature ranges, and some live only in very low salinity layers of water with paralitic and salinity conditions.

**H4**

Some marine animals can change sex as they mature, find prey, or escape predators, such as those in seahorses, corals, many fish, and cephalopods.

---

**I1**

In the polar regions where there is less sunlight, cold nutrient-rich waters from melt, and yet in some places, they are very low in productivity. These are coastal upwelling zones.

---

**J1**

Ecosystems exist in layers of habitats and microhabitats due to environmental conditions and/or adaptations that allow for levels of productivity.

**J2**

Many major types of organisms, such as plankton, crustaceans, and cephalopods, have planktonic life stages that help them to mate and move from one food source to the next, supporting life.

**J3**

Ocean organisms are adapted to live in a relatively stable ocean. They are often adapted to change very specific environmental conditions, such as salinity and temperature range, where some live only within specific temperature ranges, and some live only in very low salinity layers of water with paralitic and salinity conditions.

**J4**

Some marine animals can change sex as they mature, find prey, or escape predators, such as those in seahorses, corals, many fish, and cephalopods.
### Principle 6: The ocean and humans are inextricably interconnected.

#### Ocean Affects Weather and Climate — A

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>The ocean affects weather and climate by absorbing and releasing heat from the sun, moderating the temperature on Earth so life, including human life, can exist.</td>
</tr>
</tbody>
</table>

#### Human Impact on the Ocean and Atmosphere — D

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Humans use resources such as ocean water and minerals to make products, such as oil, via wind, and for agriculture.</td>
</tr>
<tr>
<td>D2</td>
<td>Humans impact the ocean by releasing unwanted water turbidity, releasing unwanted carbon dioxide, and getting caught in and ingesting marine debris.</td>
</tr>
<tr>
<td>D3</td>
<td>Marine debris from boats, such as fishing nets, and sewage from land development can be impacted by fishing practices and land development, and continued to use the ocean for transportation, historically used, and continue to use the ocean for transportation.</td>
</tr>
<tr>
<td>D4</td>
<td>Excessive amounts of solar heat, which gets caught by greenhouse gases, can lead to increased temperatures and can disrupt ecosystems, leading to changes in ecosystems and loss of many species, thus moderating the temperature on Earth so life, including human life, can exist.</td>
</tr>
<tr>
<td>D5</td>
<td>Increased greenhouse gases can affect the ocean, such as changing water turbidity, acidifying marine organisms, and increasing erosion.</td>
</tr>
</tbody>
</table>

#### Uses of the Ocean — B

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>The vastness of the ocean has provided resources, such as fish, for civilizations; people have settled around it to travel large distances by sea, and continue to use the ocean for transportation, historically used, and continue to use the ocean for transportation.</td>
</tr>
<tr>
<td>B2</td>
<td>The ocean is essential to the existence of human life on Earth.</td>
</tr>
</tbody>
</table>

#### Human Use of the Ocean — C

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Ocean Affects Weather — A1</td>
</tr>
<tr>
<td>C2</td>
<td>Ocean Affects Humans — C3</td>
</tr>
<tr>
<td>C3</td>
<td>Ocean Affects Marine Organisms — C4</td>
</tr>
<tr>
<td>C4</td>
<td>Ocean Affects Marine Organisms’ Ecosystems — C5</td>
</tr>
</tbody>
</table>

#### Responsibility and Advocacy for the Ocean — E

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Everyone can make decisions about the ocean, such as using energy efficient appliances and participating in coastal cleanups.</td>
</tr>
<tr>
<td>E2</td>
<td>Everyone can make decisions about the ocean, such as using energy efficient appliances and participating in coastal cleanups.</td>
</tr>
<tr>
<td>E3</td>
<td>Everyone can make decisions about the ocean, such as using energy efficient appliances and participating in coastal cleanups.</td>
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<tr>
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<td>Everyone can make decisions about the ocean, such as using energy efficient appliances and participating in coastal cleanups.</td>
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<tr>
<td>E5</td>
<td>Everyone can make decisions about the ocean, such as using energy efficient appliances and participating in coastal cleanups.</td>
</tr>
</tbody>
</table>

---

**Note:** The table above summarizes the relationships between the ocean and human activities, highlighting the interconnected nature of these systems.
Principle 7
The ocean is largely unexplored.


There are many opportunities for ocean exploration, which can lead to scientific investigations.

A.4.

Exploration leads to advances in research that will help us better understand changes over time in the climate, the acidity of the ocean, and the health of the ocean.


New methods and technologies are being developed to involve the ocean for mineral and biological resources, and as a source of renewable power, wave power, and ocean thermal energy conversion.

New habitats and species continue to be discovered throughout the ocean.

New discoveries about the ocean can advance our understanding of human health and about our interconnectedness to the ocean.

A.1.

There are many ways that human activities negatively impact the ocean that are not fully understood.

A.2.

There are many ways that human benefit from discoveries about the ocean (e.g., cancer research, new medicines, energy).

A.7.

The current exploration of ocean organisms allows us to make discoveries for human health and about our interconnectedness to the ocean.

A.10.

The communication of accurate and timely information about new discoveries allows the public to make informed decisions that promote sustainability of the ocean.

A.11.

People build their knowledge and skills in different disciplines, so their careers and/or hobbies. These careers can be in science, engineering, or business.

A.12.

Young people can influence and even participate in ocean exploration by learning about science and environmental and community groups, by joining online virtual expeditions, and through communication with government officials.

A.13.

There are many environmental and community groups that play a role in raising awareness about the importance of ocean exploration.

A.14.

The ocean has physical properties, such as depth, pressure, light, temperature, and salinity, that make it difficult to explore. Less than 20% of the ocean is mapped, observed, and explored.

A.15.

Exploration of the ocean requires equipment and instruments that can collect data and operate in environments that are vast, have high density, extreme temperatures, and increased pressure due to depth.

A.16.

Submarines, Remotely Operated Vehicles (ROVs), and Autonomous Underwater Vehicles (AUVs), are tools used for prolonged exploration of the ocean.

A.17.

Acoustic technology, such as sonar, can be used to measure across large distances and to locate unique underwater features.

A.18.

The data from these systems can be accessed over the Internet, which allows for remote, real-time exploration of the ocean.
**Principle 7**

**The ocean is largely unexplored.**

**People Explore the Ocean — A**

<table>
<thead>
<tr>
<th>Exploration leads to a better understanding of systems.</th>
</tr>
</thead>
</table>

| Ocean exploration and the analysis of ocean systems require collaboration and sharing of information on many different levels: local, regional, national, and international. |

| The ocean has physical properties, such as depth, pressure, light, temperature, and salinity, that make it difficult to explore. Less than 20% of the ocean is mapped, observed, and explored. |

**Ocean Exploration Requires Collaboration — B**

| Ocean exploration requires people and organizations in different disciplines of science, technology, engineering, mathematics, and people who carry traditional knowledge, who may be located in different parts of the world, to collaborate and share information. |

| Local, regional, and national governments play a large role in ocean exploration through regulation and funding. |

| There are many environmental and community groups that play a role in raising awareness about the importance of ocean exploration. |

**Ocean Exploration Requires Technological Innovations — C**

| Exploration of the ocean requires equipment and instruments that can collect data and operate in environments that are vast, have high density, high salinity, extreme temperatures, and increased pressure due to depth. |

**Ocean Exploration Requires People and Equipment — D**

| Ocean explorers are discovering geographic areas, both on the surface and under water, as well as new physical, biological, and geochemical features of the ocean. |

| The data from these systems can be accessed over the Internet, which allows for remote, real-time exploration of the ocean. |

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**A Handbook for Increasing Ocean Literacy**

Ocean literacy is the knowledge, understanding, and values that people develop about the ocean and its complex and dynamic relationships with other parts of the Earth system. It involves knowing the processes that shape the ocean, understanding the interactions between the ocean and other parts of the Earth system, and valuing the importance of the ocean for people and the planet. Ocean literacy is essential for informed decision-making and effective stewardship of the ocean.