Principle 1:
Grades 6-8

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.

Geologic Features

A.
The size and shape of the ocean has changed over geologic time and continues to move and change.

A.1.
Motion along the margins of lithospheric plates creates physical features on the ocean floor and land.

A.2.
Many of the physical features on the ocean floor are the result of the constant motion of the lithospeheric plates that make up Earth's crust.

A.3.
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.

A.4.
Plate movement is primarily caused by the convection of hot fluids below Earth's crust.

A.5.
Features on the ocean floor are highly varied, and include trenches, rift valleys, mid-ocean ridges, seamounts, islands, and continental shelves.

See Principle 2: A19

A.7.
During various times in Earth's geologic history, all of the continents have been joined into one "super continent." A giant ocean circulated around the supercontinent.

A.8.
The supercontinent broke apart along rift valleys to create new, smaller continents and ocean basins now known as the Pacific Ocean, Atlantic Ocean, etc.

A.9.
The continents are still in motion today.

See Principle 7: A2

Properties of Ocean Water

B.
97% of all water on Earth is ocean water, which has unique chemical and physical properties.

B.1.
Salts enter the ocean via erosion from land, volcanic emissions, reactions at the sea floor, and atmospheric deposition.

B.2.
The freezing point of ocean water decreases as salinity increases; the pH of ocean water is more basic than fresh water.

B.3.
Density differences between masses of water can cause currents.

B.4.
The density of ocean water increases as salinity (amount of dissolved salts) increases and as temperature decreases.

B.5.
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).

B.6.
The temperature of ocean water can change due to warming and cooling (e.g., heat from the sun or contact with ice).

Ocean Circulation

C.
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.

C.1.
A global ocean circulation system is generated from tides and different types of currents moving the water.

C.2.
Deep ocean currents are driven by density differences between masses of ocean water.

C.3.
The wind, combined with Earth's rotation (Coriolis effect), drives surface currents in circular gyres in each ocean basin; clockwise in the Northern Hemisphere and counter-clockwise in the Southern Hemisphere.

C.4.
Tides are mainly caused by the gravitational interaction between Earth, the moon and the sun.

C.5.
Ocean circulation is influenced by the position of basins, continents, and other geologic features.

See Principle 3: A1

C.6.
Currents transport heat, nutrients, and organisms throughout the ocean.

C.7.
Upwelling, which occurs mostly on west coasts, brings nutrients from deep water to the sunlit surface zone where photosynthetic primary producers grow.

See Principle 5: A8

C.8.
Currents are especially important in moving young organisms (larvae and juveniles) to populate new areas.

See Principle 5: B11

C.9.
All major watersheds, from the Amazon River to melting glaciers, mix fresh and salt water when they meet the ocean, which contributes to the density differences that set ocean currents in motion.

C.10.
As water travels through the watersheds, it collects nutrients, salts, sediments and pollutants and carries them into the ocean.

See Principle 6: D17

C.11.
Sea level rises as glaciers melt.

See Principle 2: A15

Principle 2:
Grades 6-8

Principle 2:
The ocean and life in the ocean shape the features of Earth.

Geologic Change

A.
Many changes in geologic features occur where the ocean meets the land.

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.
Chemical weathering breaks down and alters the chemical composition of rocks and minerals through hydrolysis, oxidation, and acidification.

A.6.
Physical weathering of rocks can be caused by freeze-thaw cycles, salt crystallization, hydraulic action, pressure release, wind abrasion, and/or thermal expansion.

A.7.
Cracks in rock become sites where further weathering is more likely to occur.

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.

Plate Tectonics

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.

See Principle 3: A7
See Principle 6: C4
See Principle 1: C11
See Principle 1: A1

Rock Cycle

B.
Many of the rocks exposed on land were formed in the ocean.

B.1.
Some igneous rocks are formed in the ocean in volcanoes, at hot spots, and at mid-ocean ridges.

B.2.
Some metamorphic rocks are formed in the ocean (e.g., at subduction zones).

B.3.
Many sedimentary rocks are formed in the ocean from organic sediments.

B.4.
Many marine organisms form carbonate and silicate skeletal structures, which contribute to the formation of sedimentary rocks, reefs, and stromatolites.

B.5.
Some organisms, such as cyanobacteria, coralline algae, and corals construct complex structures (e.g., stromatolites and reefs).

B.6.
Lime-secreting cyanobacteria trap sediments and form large mounds called stromatolites.

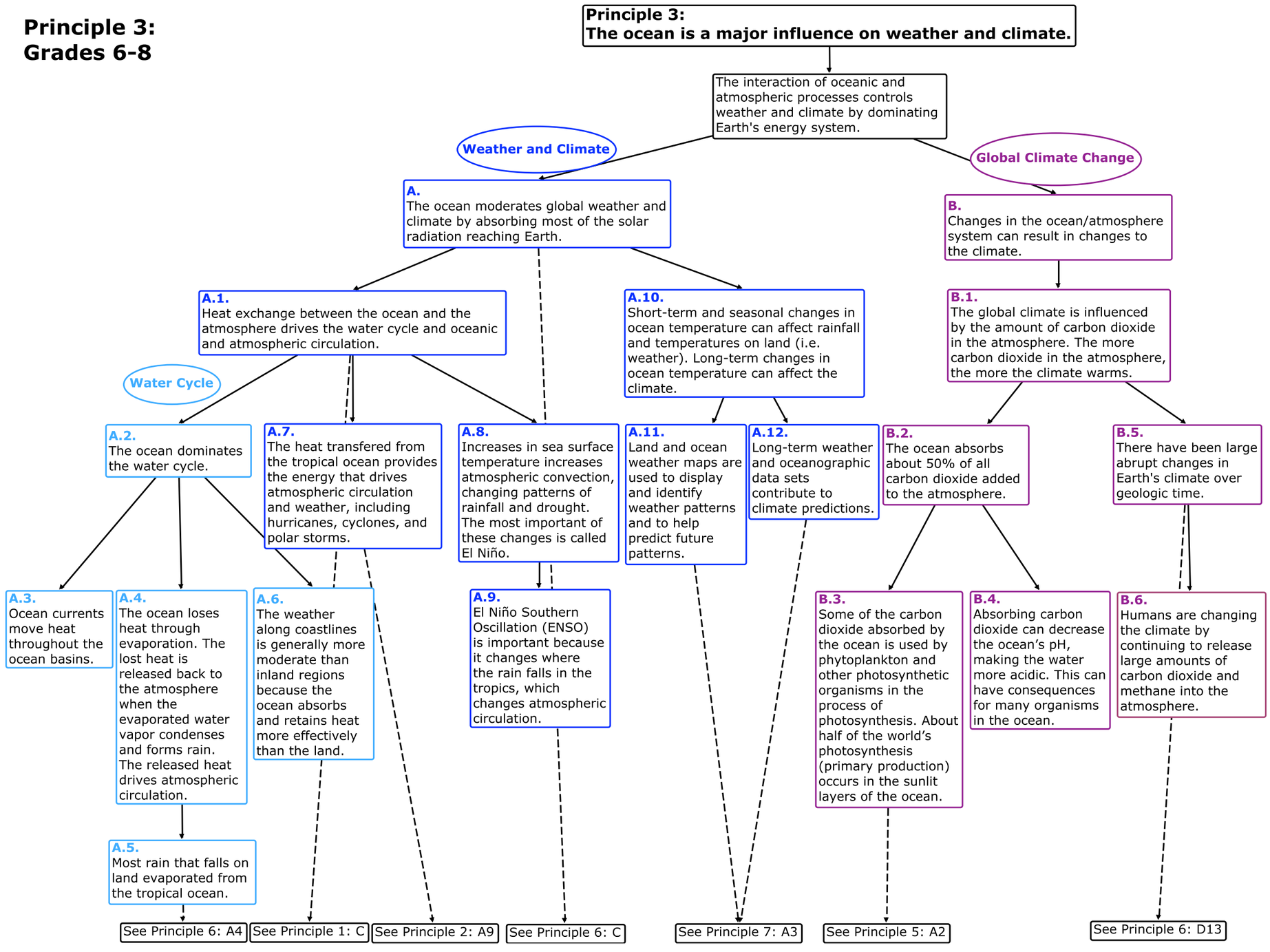
B.7.
Stromatolites are a major component of the fossil record for the first 3.5 billion years of life on Earth.

B.8.
Coral reefs are produced by living organisms that secrete an exoskeleton of calcium carbonate.

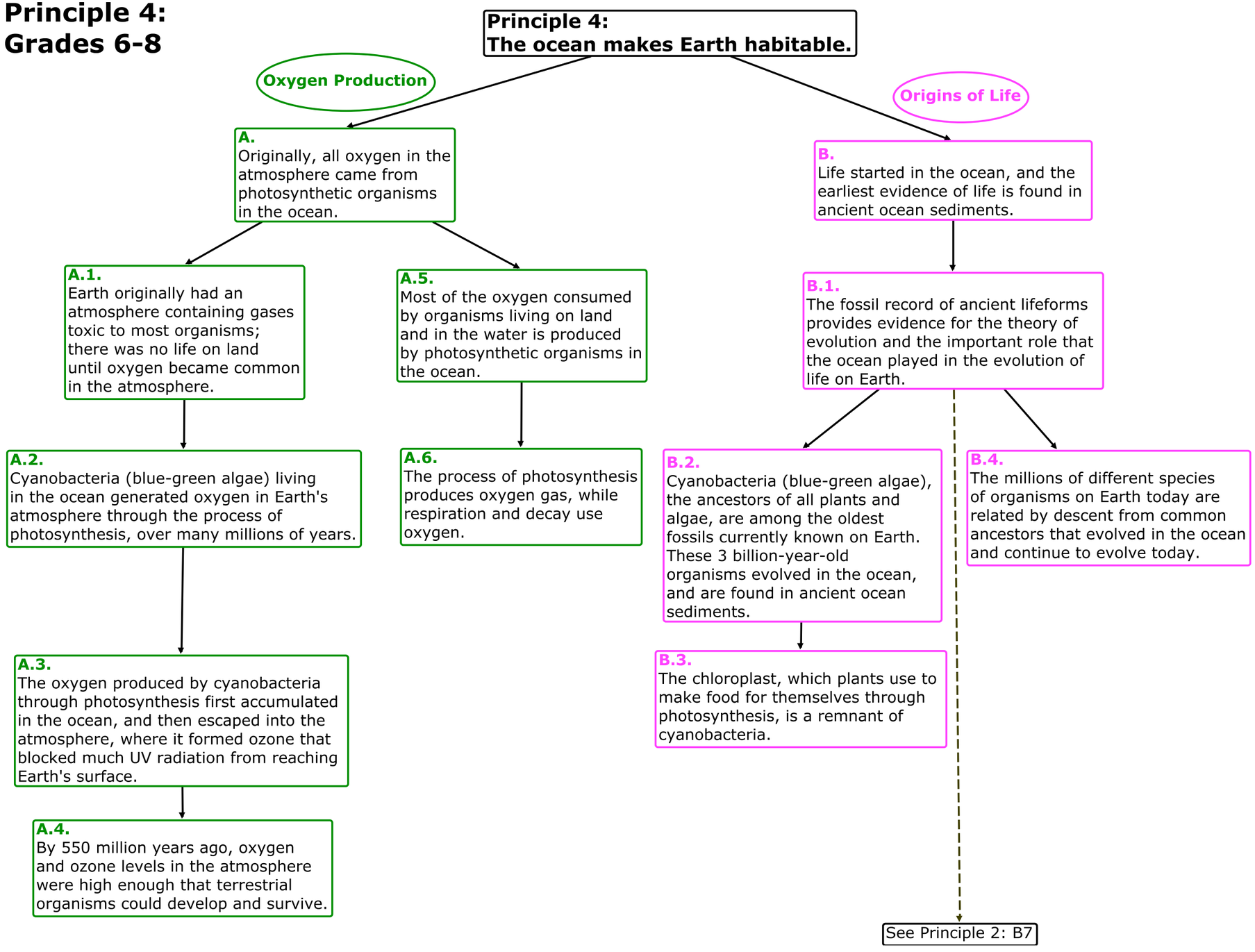
B.9.
The skeletal structures formed by some organisms (e.g., mollusk shells, foraminifera, cocoliths, radiolaria, and diatom cell walls) sink and are deposited on the ocean floor, eventually forming sedimentary rocks.

See Principle 4: B1

Principle 3:
Grades 6-8



Principle 4:
Grades 6-8



Principle 5:
Grades 6-8

Principle 5:
The ocean supports a great diversity of life and ecosystems.

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

Diversity of Ecosystem

A.
Ocean ecosystems vary widely, based on the variety of environmental factors and the community of organisms living there.

Primary Productivity

A.1.
Ocean ecosystems with the greatest abundance of life occur where environmental conditions and/or adaptations allow for high levels of productivity.

A.2.
Most primary productivity in the ocean takes place at the surface where there is plentiful sunlight for photosynthesis and nutrients to support growth.

A.3.
Microbes (photosynthetic algae and bacteria) are important primary producers and support a huge abundance of life.

A.4.
Microbes are the basis of most energy in food webs in the ocean. They are the primary food source for grazers, such as zooplankton and clams. Grazers are in turn the primary food for bigger organisms. such as fish and baleen whales.

See Principle 3: B3

A.5.
Some ecosystems function independent of sunlight energy.

A.6.
Ecosystems, such as deep sea vents and cold water seeps, depend on chemosynthesis—a process similar to photosynthesis, but with a different energy source—for primary productivity.

A.8.
There are six places in the ocean, all on west coasts, with the right environmental conditions to create the most productive areas. These are the coastal upwelling zones.

A.9.
Coastal upwelling occurs when wind and the Coriolis effect push surface water offshore, allowing for cold, nutrient rich water from deeper down to rise to the surface.

A.10.
Kelp forests and other coastal ocean ecosystems in upwelling zones have abundant sunlight, cold water and nutrients, making them some of the most productive ecosystems in the world.

See Principle 1: C7

A.11.
Coral reefs occur where the water is warm and there are not many nutrients in the water, and yet they are very productive ecosystems.

A.12.
A symbiotic relationship between corals and the algae living inside them allows the corals to thrive, even though the environmental conditions do not seem conducive to supporting life.

A.13.
Environmental conditions in estuaries (e.g., shallow, brackish water) and in mangroves (lots of decaying organisms) result in highly productive nursery areas for a great many ocean organisms.

A.14.
At the poles, nutrients flowing into the ocean from melting glaciers, combined with long, sunny days in the summer, result in productivity, and abundance unequaled anywhere else in the world.

A.15.
Differences in light, temperature, pressure, density, and chemical makeup of this fluid environment lead to distinct vertically and horizontally distributed ecosystems.

A.16.
Ecosystems exist in layers of habitats and microhabitats due to gradients in specific environmental factors, such as temperature, salinity and oxygen within the water column.

A.17.
Ocean organisms are adapted to live in a relatively stable ocean. They are often adapted to tolerate very specific environmental conditions. For example, corals can only live within specific temperature ranges, and some larval fish can only live in very narrow layers of water with particular salinity and temperature.

A.18.
Adaptations to specific environmental conditions can result in vertical and horizontal zonation patterns. For example, in intertidal areas, organisms are adapted to crashing waves and the cycle of the tides, while in the open ocean, many organisms are adapted to a specific temperature and salinity level. Different organisms are found in different density layers.

A.19.
Humans have changed environmental conditions in the ocean, which has had a generally negative impact on organisms adapted to the previous conditions.

A.20.
Changes to the climate will cause further changes to environmental conditions, which will likely have major impacts on many different ocean organisms.

A.21.
Ocean ecosystems are connected to each other via a series of food webs.

A.22.
The diversity of phyla and life history strategies of ocean organisms create complex, interconnected food webs, often with many more levels than in terrestrial ecosystems.

A.23.
Any change in an ecosystem or an organism in the community may have an adverse affect on many other ecosystems.

Diversity of Life

B..
The diversity of ocean ecosystems allows for many unique lifeforms with many unique adaptations.

B.1.
The diversity of phyla is greater in the ocean than on land.

B.2.
Many major groups (phyla and classes) of organisms, such as echinoderms, cephalopods, comb jellies, and many types of worms are found exclusively in the ocean.

B.3.
The ocean supports a range of animals from the smallest living thing to the largest animal on Earth.

B.4.
Most of the biomass in the ocean is made up of microscopic microbes.

B5..
Organisms in the ocean exhibit an amazing variety of adaptations to sound, density, pressure, patchy food distribution, and other environmental factors.

B.6.
Different ocean organisms have different life history strategies. Some drift with the currents (plankton), some swim (nekton), and some live on the bottom (benthos).

B.7.
In the tropical ocean where there are fewer nutrients, diversity of life is higher and abundance of life is lower. In the polar regions where there are comparatively more nutrients, there is less diversity of life and more abundance of life.

See Principle 7: C

B.8.
Some ocean organisms, such as phytoplankton, have adaptations (e.g., oil droplets, spines, and a large surface area), which allow them to stay near the sunlit surface where photosynthesize can occur.

B.9.
Many marine animals, from shrimp to whales, rely on sound to communicate, find prey and mates, and sense their environments. Sound travels through the ocean much better than light does.

B.10.
Some ocean organisms have adaptations for living in or diving to the deep ocean. For example, elephant seals spend most of their life diving in the deep ocean to depths at which most mammals could not survive. Other organisms have bioluminescent lures to capture prey, or huge mouths and stomachs to take advantage of the scarce prey in the deep.

B.11.
Organisms in the ocean exhibit an amazing variety of life cycles. Some have planktonic stages that help colonize new areas, some undergo long seasonal migrations to mate and have young, and others change sex as they mature or as the dominance hierarchy in the community changes.

B.12.
Some of these life cycles are unique to ocean organisms, such as those of seahorses, corals, many fish, and kelp.

See Principle 1: C8

Principle 6:
Grades 6-8

Principle 6:
The ocean and humans are inextricably interconnected.

Ocean Affects Weather and Climate

A. The ocean absorbs and releases heat from the sun, as well as distributes heat around the globe, thus moderating the temperature on Earth so life, including human life, can exist.

- **A.1.** During the day, the ocean absorbs heat from the sun and, at night, releases the heat into the atmosphere, resulting in a relatively narrow temperature range suitable for life on Earth.
- **A.2.** The circulation of warmer water from the equator toward the poles distributes heat around Earth.

See Principle 3: A
See Principle 1

Uses of the Ocean

B. The ocean is essential to the existence of human life on Earth.

- **B.1.** Humans obtain food from the ocean through marine fisheries and aquaculture.
  - **B.2.** Some food from the ocean is consumed directly by humans, while others are used as pet food, food additives, animal feed, and fertilizer.
- **B.3.** Humans need fresh water in order to survive.
  - **B.4.** Most of Earth's fresh water is water that has evaporated from the ocean and has returned in the form of rain.
- **B.5.** Photosynthetic organisms in the ocean produce most of the oxygen consumed by humans.
  - **B.6.** Photosynthetic organisms include cyanobacteria, algae, and seagrass.
  - **B.7.** The process of photosynthesis produces oxygen gas, while respiration and decay use oxygen.
- **B.8.** Humans use resources from the ocean.
  - **B.9.** Humans use biotic resources from the ocean to make products, such as medicines and consumer goods.
  - **B.10.** Humans obtain energy from the ocean via wind, wave, oil, and natural gas.
  - **B.11.** Humans extract salt from the ocean.

See Principle 3: A4

Ocean Affects Where People Live

C. The ocean influences the population and population distribution of humans.

- **C.1.** The vastness of the ocean has resulted in the isolation of civilizations; however, people have also used it to travel large distances and settle around the world.
- **C.2.** Humans have historically used, and continue to use, the ocean for transportation, commerce, exploration, recreation, and inspiration.
- **C.3.** Most human population centers developed and thrived due to their access and/or proximity to the ocean.
- **C.4.** The ocean influences many aspects of every coastal culture around the world.
- **C.5.** Hurricanes, typhoons, and tsunamis may adversely affect humans living along or near the coastline.
  - **C.6.** Learning about and preparing for natural hazards can increase survival and minimize the adverse effects of these events.

Human Impact on the Ocean and Atmosphere

D. Human activity contributes to changes in the ocean and atmosphere.

- **D.1.** Fishing and aquaculture affect the ocean.
  - **D.2.** Aquaculture and fisheries can be a positive way to supply growing demands for seafood, if done responsibly.
    - **D.3.** Aquaculture can reduce stress on overfished wild-caught seafood populations.
    - **D.4.** Responsible fishery practices prevent the overfishing of target species, thus sustaining the ecosystem.
  - **D.5.** Aquaculture and fisheries can be destructive to ecosystems, if done improperly.
    - **D.6.** Aquaculture practices can release extra pollutants or non-native organisms into the water, and destroy habitats.
    - **D.7.** Many large-scale fishing practices can disrupt ecosystems, take more fish than can be replaced naturally, and catch unintended organisms (bycatch).
- **D.8.** The introduction of non-native species affects ocean ecosystems.
  - **D.9.** Non-native species can disrupt native food webs, introduce novel diseases, and out-compete native species for resources, leading to changes in ecosystems and loss of native species.
- **D.10.** Human-made modifications to the landscape affect the ocean.
  - **D.11.** Buildidng structures on land can affect the ocean in many ways, such as causing erosion, creating polluted runoff, or altering the flow of waterways.
  - **D.12.** Building structures in the ocean, such as piers, jetties, and marinas, can alter the shape of nearby coastlines and disrupt coastal habitats.
- **D.13.** Human activity can lead to the excess input of greenhouse gases into the atmosphere, which can alter the temperature of Earth's atmosphere and affect the ocean.
  - **D.14.** The excessive input of greenhouse gases traps increased amounts of solar heat, which can raise the temperature of the ocean.
    - **D.15.** Changes in ocean temperature can influence marine organisms by altering physical conditions (i.e. current patterns and temperature ranges) to which they are adapted.
  - **D.16.** Excessive greenhouse gases can lead to increased uptake of carbon dioxide by the ocean, which results in more acidic ocean water.
    - **D.17.** Changes in pH of ocean water can dissolve the shells, tests, and skeletons of many marine organisms.

See Principle 3: B5

- **D.18.** Pollution affects life in the ocean.
  - **D.19.** Pollutants move from the land into the ocean as water flows through watersheds via runoff and rivers.
  - **D.20.** Pollutants move from the atmosphere onto land and into the ocean through rain (e.g., acid rain, acid deposition).
  - **D.21.** Solid waste, such as garbage, fishing nets and sewage, enters the ocean via human activity.
    - **D.22.** Marine organisms may ingest or absorb harmful toxicants, be impacted by water turbidity, and get caught in and ingest marine debris.

See Principle 1: C10

Responsibility and Advocacy for the Ocean

E. Individual and collective actions are necessary for maintaining, conserving, and sustaining a healthy ocean.

- **E.1.** Scientists are still learning about marine organisms and ocean ecosystems. New information is useful for helping guide policy decisions and individual actions.
  - **E.2.** There are national and international efforts that inform and regulate fishing practices and land development, and establish Marine Protected Areas.
    - **E.3.** Sustainable fishing practices maintain fish populations, reduce bycatch, and protect against habitat destruction.
    - **E.4.** Marine Protected Areas are areas that protect marine organisms and habitats.
    - **E.5.** Responsible construction and development practices help to maintain the integrity of coastal environments.

See Principle 7: A4

- **E.6.** It is important for the public to learn about issues regarding the ocean, and to take action.
  - **E.7.** Everyone can make informed decisions that reduce human impact on the ocean.
    - **E.8.** Overfishing and habitat destruction can be reduced by only buying and eating seafood caught through sustainable means.
    - **E.9.** Non-native species can be reduced with actions, such as not releasing unwanted water, plants, or animals collected from different ecosystems, and not dumping ballast water from boats.
  - **E.10.** People can support the regulation of construction to minimize its impact on coastal habitats.
  - **E.11.** Climate change can be reduced with actions, such as using energy efficient appliances, turning off lights, walking, bicyling, or using public transporation.

See Principle 7: B2 & B6

  - **E.12.** Pollution can be reduced in our ocean with actions, such as recycling, using biodegradeable products, and not littering.
  - **E.13.** Everyone can make informed choices about what they purchase and which businesses they support in ways that are environmentally friendly.
  - **E.14.** Everyone can use their knowledge to vote on larger issues that affect the ocean.
  - **E.15.** Everyone can advocate through their actions and by sharing information about the wise use and protection of the ocean.

Principle 7:
Grades 6-8