Grade Level: 6-8
Time Estimate: 3-5 days

OCEAN ZONES / INSTRUCTOR INFO

Summary

This lesson includes vocabulary, content, examples, and activities to help students learn and understand how the oceans are divided into different zones. Students will learn how the divisions were established as well as what environmental conditions are associated with each division like light intensity, temperature, and pressure. Students will also learn which organisms inhabit each zone and the morphological variations and adaptations these organisms possess in order to survive there.

Part 1. Intertidal Zone
Part 2. Continental Shelf, Slope, and Rise
Part 3. Pelagic Zones
Part 4. What Changes with Ocean Depth
Part 5. Sharks in Different Zones
Activity 1. Oral Presentation
Activity 2. Ocean Zones Card Game
Activity 3. Design Your Own Shark!

Goals & Objectives

The students will learn:

- the different divisions of the intertidal zone;
- the different divisions of the continental shelf;
- the different divisions of the pelagic zones;
- how temperature decreases with depth;
- how pressure increases with depth;
- how light intensity changes with depth;
- what types of shark are found in each depth zone;
- how the morphology and adaptations of sharks differ depending on what zone they live in.

// STANDARDS

This lesson aligns with the following TEKS:

6th Grade Science: 2A, 2B, 2C, 2E, 3A, 4A
7th Grade Science: 2A, 2B, 2C, 2E, 3A, 4A, 11B
8th Grade Science: 2A, 2B, 2C, 2E, 3A, 4A

This lesson aligns with the following Next Generation Science Standards:

Framework

1. Asking questions and defining problems
3. Planning and carrying out investigations
6. Constructing explanations
8. Obtaining, evaluating, and communicating information

MS. Interdependent Relationships in Ecosystems – MS-LS2-2; MS-LS2-5

Science and Engineering Practices

- Construct an explanation that includes qualitative and quantitative relationships between variables that predict phenomena. (MS-LS2-2)

Crosscutting Concepts

Stability and Change

1. Small changes in one part of a system might cause large changes in another part. (MS-LS2-5)

Helpful Tips

1) The content in this lesson is based on the conservation work of OCEARCH™ and the Global Shark Tracker™. Spend a few minutes getting familiar with the website and the tracker if you have not done so already. The Global Shark Tracker™ is also available as an app for iPhone and Android.
2) This lesson plan is designed to be adaptable to suit your specific needs. Use the entire lesson plan or just parts of it. This material can be expanded to be an entire unit or condensed for just one day in the classroom.
3) Vocabulary words will be underlined as they first appear in the lesson plan. A complete list of vocabulary words is included as well.
4) Answers to questions and prompts for discussions will appear in *italics*.
5) Optional activities and content (side notes) will appear in a box. Use these to enhance your lesson and adapt it to suit your needs!
6) Have questions for OCEARCH Expedition Leader, Chris Fischer? Email info@OCEARCH.org to schedule a Skype session and let your students/child talk directly to Chris and the OCEARCH crew!
7) Email all questions about this lesson to info@OCEARCH.org.

Vocabulary

Abyssopelagic Zone – The abyssopelagic zone is below the bathypelagic zone and ranges from 4,000 m to 6,000 m (13,124-19,686 ft). There is no light in the *abyss* and the temperature of the water is near freezing.
Bathypelagic Zone – The bathypelagic zone is below the mesopelagic zone and is also known as the *midnight zone*. The bathypelagic zone extends from 1,000 m to 4,000 m (3,281 ft-13,124 ft) and no light reaches these depths.
Bioluminescence – An organism's ability to produce light through chemical reactions.
Continental Shelf – Shallow extension of the landmass extending outward to the continental slope. It contains the highest amount of benthic (bottom) life.
Continental Slope – Descent from the continental shelf to the bottom of the ocean.
Continental Rise – An incline from the bottom of the ocean to the continental slope. The rise can be hundreds of miles wide and consists of mud, sand, and silt.
Detrivore – Organism that feeds on dead and decaying organic matter and returns nutrients back to the environment.
Diurnal – Refers to a daily pattern. For example, organisms in the mesopelagic zone undergo diurnal behaviors when they travel up into the epipelagic zone at night and migrate back into the mesopelagic during the day.
Epipelagic Zone – The uppermost zone in the pelagic ocean. It is often referred to as the sunlight or euphotic zone. The epipelagic zone ranges from the surface to 200 m (0 ft-656 ft). Temperatures range from 104ºF to 27ºF, and there is enough light for photosynthesis to occur.

Hadalpelagic Zone – The hadalpelagic zone extends from 6,000 m to the bottom of the deepest parts of the oceans. The hadalpelagic zone includes deep water trenches and canyons.
High Tide – The high tide zone is covered by water only during a high tide. As the tide recedes (or goes back to sea), pools of seawater are left to evaporate in the hot sun. High tide is also called the upper mid-littoral zone.
Hydrothermal Vents – Hydrothermal vents form when seawater moves down into the cracks of the Earth's crust near subduction zones (areas of Earth's crust where tectonic plates move toward or away from each other). The seawater reacts with hot magma and reemerges to form these vents.
Intertidal Zone – Area between high and low tide and is subject to harsh environmental conditions. The intertidal zone is also called the littoral zone and is divided into four zones: spray zone, high tide zone, middle tide zone, and low tide zone.
Littoral – Zone between low and high tide. Also called intertidal zone.
Mesopelagic Zone – The mesopelagic zone is directly below the epipelagic zone and is often referred to as the twilight zone. This zone ranges from 200 m to 1,000 m (656 ft-3,281 ft). While some light reaches this zone, there is not enough light for photosynthesis to occur.
Photosynthesis – Process by which plants convert sunlight and carbon dioxide into glucose and oxygen.
Spray Zone – The spray zone is a section of the intertidal zone far up on the beach and does not include the high tide zone. This zone will occasionally be sprayed by incoming waves. This zone is covered by water only during unusually high tides or storms.

Grade Level: 6-8

Time Estimate: 5-15 mins

OCEAN ZONES / PRE-LESSON ASSESSMENT

Use the following true/false and multiple choice questions as an introduction/warm-up to the lesson topics. You can do this in a verbal or written format, as a game, individually, or as a whole class! A handout is provided if you wish to hand the questions out in a quiz format.

The questions do not need to be graded. They are intended to give the students an idea of what they will be learning and to see what they already know.

1) True or False The bathypelagic zone is located between the mesopelagic and abyssopelagic zone.

Answer: *True*

2) True or False The abyssopelagic zone, which extends from 6,000 m to the bottom of the deepest parts of the ocean, includes trenches.

Answer: *False*

3) True or False There are 3 pelagic zones in the open ocean.

Answer: *False*

4) Which zone contains the highest amount of benthic life, such as plants and animals?

a. intertidal zone
b. epipelagic zone
c. continental shelf
d. mesopelagic zone
e. abyssopelagic zone

Answer: *c*

5) The thermocline is located in which pelagic zone?

a. abyssopelagic zone
b. mesopelagic zone
c. epipelagic zone
d. bathypelagic zone
e. hadalpelagic zone

Answer: *b*

6) Which color of the visible spectrum penetrates best in water?

a. red
b. orange
c. yellow
d. blue
e. green

Answer: *d*

Name: _____ Date: _____

Ocean Zones

Select the correct answer(s) to each of the following questions.

1) True or False The bathypelagic zone is located between the mesopelagic and abyssopelagic zone.

2) True or False The abyssopelagic zone, which extends from 6,000 m to the bottom of the deepest parts of the ocean, includes trenches.

3) True or False There are 3 pelagic zones in the open ocean.

4) Which zone contains the highest amount of benthic life, such as plants and animals?
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   b. epipleagic zone
   c. continental shelf
   d. mesopelagic zone
   e. abyssopelagic zone

5) The thermocline is located in which pelagic zone?
   a. abyssopelagic zone
   b. mesopelagic zone
   c. epipelagic zone
   d. bathypelagic zone
   e. hadalpelagic zone

6) Which color of the visible spectrum penetrates best in water?
   a. red
   b. orange
   c. yellow
   d. blue
   e. green

Grade Level: 6-8

OCEAN ZONES / LESSON PLAN

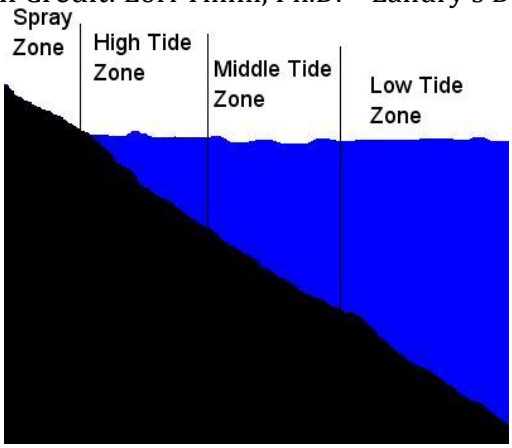
There are three broad oceanic habitats: the intertidal zone, continental shelf, and pelagic zone. Scientists have divided the pelagic zone (open ocean) into five zones, or layers which extend from the surface to extreme depths. As you transition zones and position in the water column, many factors change, along with the animals you find there! For example, as the zones get deeper, temperature and pressure rapidly change. Most of the oceanic life is near the surface, where there is sunlight. However, the deeper zones, where no light penetrates, are home to some of the most bizarre-looking creatures on earth!

Part 1. Intertidal Zone (10 – 20 minutes)

The intertidal zone is located between low and high tide. Scientists also refer to this zone as the littoral zone. The intertidal zone is divided into four separate zones: spray zone, high tide zone, middle tide zone, and low tide zone (Figure 1).

Figure 1. Intertidal Zones

Illustration Credit: Lori Timm, Ph.D. – Landry's Downtown Aquarium



The spray zone is far up on the beach and does not include the high tide zone. This zone will occasionally be sprayed by incoming waves and is covered by water only during unusually high tides or storms. Although there is not a lot of wildlife in this area, you can find gastropods such as limpets and periwinkles!

The next zone down is called the high tide zone. This zone is covered by water only during a high tide. As the tide recedes (or goes back to sea), pools of seawater are left to evaporate

in the hot sun. As seawater evaporates, it leaves behind salt. Therefore, this zone is very salty! Barnacles, periwinkles, limpets, mussels, sea stars, crabs, and anemones are found in the high tide zone.

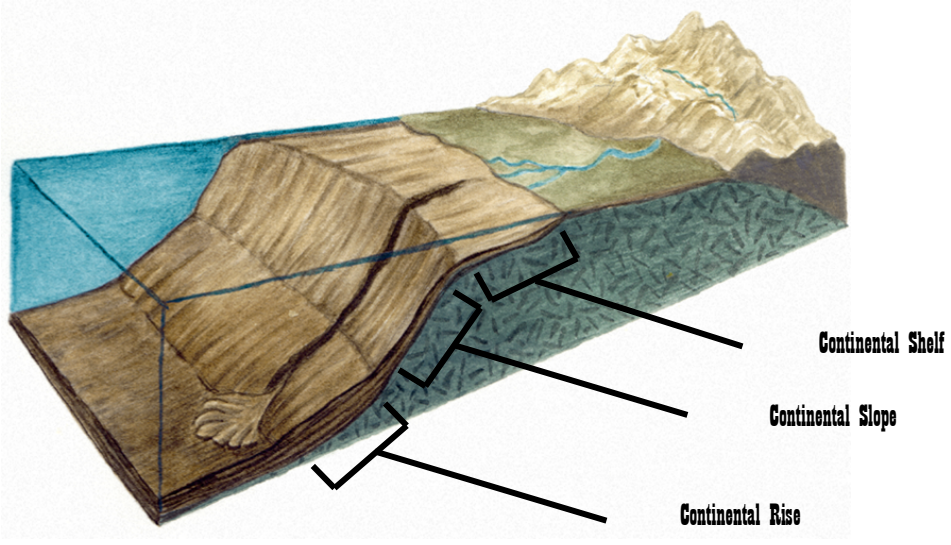
The zone below the high tide zone is called the middle tide zone. The middle tide zone spends half of its time under water and the other half above the water. This zone receives the heaviest wave action. Organisms in this zone are usually larger in size than those found in the high tide zone. Seaweed, mussels, chitons, limpets, hermit crabs, sea stars, and barnacles are some of the wildlife you can find in the middle tide zone.

The lowest intertidal zone is called the low tide zone. This zone remains underwater most of the time. Organisms in this zone grow even larger than the ones in the higher tide zones because more food and light is available. The low tide zone has a more stable environment, with few fluctuations of dry and wet times. At low tide, this area becomes dry and it is a perfect place to look for wildlife, such as sea anemones, sea stars, small fishes, and seaweeds! This intertidal zone possesses great biodiversity and is home to most of the marine vegetation such as seaweeds.

Part 2. Continental Shelf, Slope, and Rise (5 minutes)

The continental shelf is a shallow extension of the intertidal zone extending outward to the continental slope. The shelf contains the highest amount of benthic life, such as plants and animals. The continental slope connects the shelf to the ocean floor. As currents move from the continental shelf to the slope, sediments get pushed further and further down where it accumulates and forms a continental rise (Figure 2).

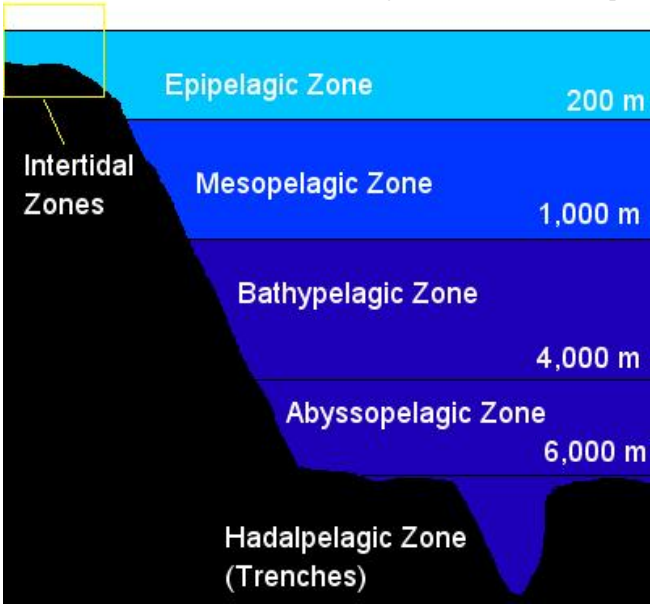
Figure 2. Continental Shelf, Slope, and Rise



Part 3. Pelagic Zones (20-30 minutes)

The pelagic zone is divided into five vertical ecological zones (Figure 3). The zones differ in temperature, water pressure, light, and availability of nutrients. Marine organisms have different adaptations for living in each of these zones. Some animals are capable of living in multiple pelagic zones, undergoing vertical migrations from the mesopelagic zone to the epipelagic zone. Sperm whales are capable of living in the epipelagic, mesopelagic, and as deep as the bathypelagic zone where they hunt their favorite food, giant squid! Great white sharks also venture into the mesopelagic zone. Perhaps they are also preying on giant squid!

Figure 3. Vertical ecological zones in the pelagic zone.
Lori Timm, Ph.D. – Landry's Downtown Aquarium



Epipelagic Zone

The uppermost division of the pelagic zone is called the epipelagic zone (sunlight or euphotic zone), and ranges from the surface to 200 m (0 ft. – 656 ft.). There is enough light in this zone for photosynthesis to occur, therefore plants and phytoplankton (photosynthetic plankton) are abundant. Plants and phytoplankton are called primary producers because they use light from the sun to produce food. Primary producers in the ocean produce the same amount of oxygen as all the land plants combined! Due to the fact that primary producers are the first link in the ocean's food web, most of the ocean's wildlife lives in this zone. Examples of primary producers in the epipelagic zone are red algae, green algae, brown algae, phytoplankton, seagrasses, and mangroves. Examples of animals found in the epipelagic zone include most fish (e.g., sharks and reef fishes), jellyfish, sea turtles, corals, seals, whales, dolphins, and zooplankton.

Mesopelagic Zone

The zone directly below the epipelagic zone is called the mesopelagic zone (twilight zone). This zone ranges from 201 m to 1,000 m (657 ft. – 3,281 ft.). While some sunlight reaches this zone, there is not enough light for photosynthesis to occur. Only about 20% of food made in the epipelagic zone makes it to the mesopelagic zone, thus fewer animals live in this zone. Because there is not a lot of food in the mesopelagic zone, most mesopelagic organisms (shrimp, krill, copepods, and fishes) undergo a vertical migration into the epipelagic zone at night to feed on the more diverse and abundant prey. By feeding at night, these organisms can avoid being detected by large predators and during the day they have protection in the deeper, darker waters.

Several strange and bizarre looking creatures live in this zone. Animals in the mesopelagic zone are adapted to live in darkness, increased water pressure, and cold water. Most fishes are generalists (meaning they eat many different things) with large mouths and teeth. Some animals have extremely large eyes to help them see in low light, while others produce their own light through a process called bioluminescence.

Bioluminescence is the production of light as a result of a chemical reaction where chemical energy is converted to light energy. Bioluminescence is used by organisms to attract prey and/or to avoid predators. For example, cookiecutter sharks use bioluminescence to camouflage its underside. The bright underside and dark tail make the shark appear smaller, attracting large predatory fish like tuna. When the fish approaches the shark, the shark attacks and removes a piece of flesh. Animals that live in the mesopelagic zone include squid, octopus, krill, copepods, cuttlefish, and fishes such as bristle mouths, lantern fishes, angler fish, hatchet fish, and lancet fish. Sperm whales frequently dive into this zone to prey on giant squid. Great white sharks are also known to dive to these depths!

Bathypelagic Zone

Below the mesopelagic zone is the bathypelagic zone (midnight zone), which extends from 1,001 m to 4,000 m (3,282 ft. – 13,124 ft.). No light reaches the bathypelagic zone and the abundance and diversity of marine life decreases with depth. Due to the lack of light, the bathypelagic zone lacks photosynthetic plants and primary productivity. Unlike the mesopelagic zone, there is little to no vertical migration into the bioproductive epipelagic zone. Animals in the midnight zone have amazing adaptations to survive in this dark, cold environment, such as bioluminescence. Animals in this zone are slow swimmers due to the reduced visibility and low predator density.

The water pressure at these depths is greater than 5,800 psi (pounds per square inch). The average pressure at sea level is only 14.7 psi! However, animals at this depth have adaptations to tolerate these pressures. For example, larger animals have significant fat

stores to achieve neutral buoyancy under such high water pressures. And most fishes in this zone actually lack swim bladders!

Animals in this zone are limited to detrivores (feed on decaying organisms), resident carnivores, and resident scavengers.

Abyssopelagic Zone

The next deepest layer is called the abyssopelagic zone (abyss) and it ranges from 4,001 m to 6,000 m (13,125 ft. – 19,686 ft.). There is no light in the abyss and the temperature of the water is near freezing. Very few organisms can live in these depths. The abyssal zone is known for its high oxygen content and lack of nutrients. Animals in the abyss are adapted to a life with no diurnal or seasonal changes, high pressures, complete darkness, and cold temperatures. Organisms tend to be translucent or red in color. Crustaceans may be blind, as no light reaches these depths. Carnivores and scavengers become less abundant and animals that feed on suspended matter (e.g., bacteria, microalgae, zooplankton, and dead remains) become more abundant. Organisms that live in the abyss include shrimp, deep-sea anglerfish, and bacteria near hydrothermal vents.

Hadalpelagic Zone

The last pelagic zone is the hadalpelagic zone (trenches), which extends from 6,001 m to the bottom of the deepest parts of the ocean. The hadalpelagic zone includes deep water trenches and canyons. The deepest point in the ocean is called the Mariana Trench, located in the Pacific Ocean. The Mariana Trench reaches a depth of 10,911 m (35,797 ft.). That's deeper than the height of Mount Everest at 29, 035 ft.!

Hydrothermal vents are located in the hadalpelagic zone in areas where tectonic plates are moving apart, near ocean basins, and hotspots. Relative to the rest of the ocean floor, hydrothermal vents are biologically more productive. Organisms that can survive here include sea stars, clams, giant tube worms, and chemosynthetic bacteria (bacteria that produce their own energy!).

Although very few fish can survive here, spook fish and deep-sea anglerfish can be found in these deep waters. Due to the complete darkness in the hadalpelagic zone, fish in this zone lack color pigments and have wide eyes for detecting bioluminescence from other organisms.

Part 4. What Changes with Ocean Depth

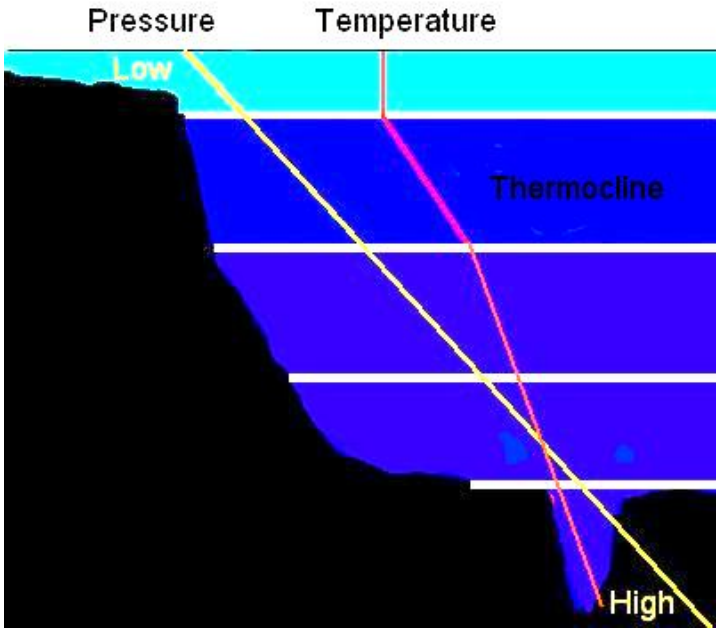
Temperature and Pressure (5 – 10 minutes)

Most of the visible light is found in the epipelagic zone. Here the sun warms the surface of the water. Wind and waves keeps the epipelagic zone mixed and allows the heated surface water to mix vertically into deeper waters. The bottom of the mixing layer is called the thermocline, which is a layer of water where the temperature decreases rapidly with increasing depth (Figure 4). The thermocline is located in the mesopelagic zone.

In contrast to the rapid temperature drop in the mesopelagic zone, the temperature in the bathypelagic zone remains constant (Figure 4). Temperature is approximately 39 ºF (4 ºC). The water pressure in this zone is over 5,850 psi. At sea level, we are only experiencing 14.7 psi!

The water temperature in the abyssopelagic zone and hadalpelagic zone remain constantly freezing (Figure 4). Although the temperature of these two zones is the same, the water pressure in the hadalpelagic zone at is about 8 tons psi. This is comparable to the weight of 48 Boeing 747 jets. Not many organisms can withstand such pressures.

Figure 4. Temperature and Pressure Change as Depth Increases
Illustration Credit: Lori Timm, Ph.D. – Landry's Downtown Aquarium

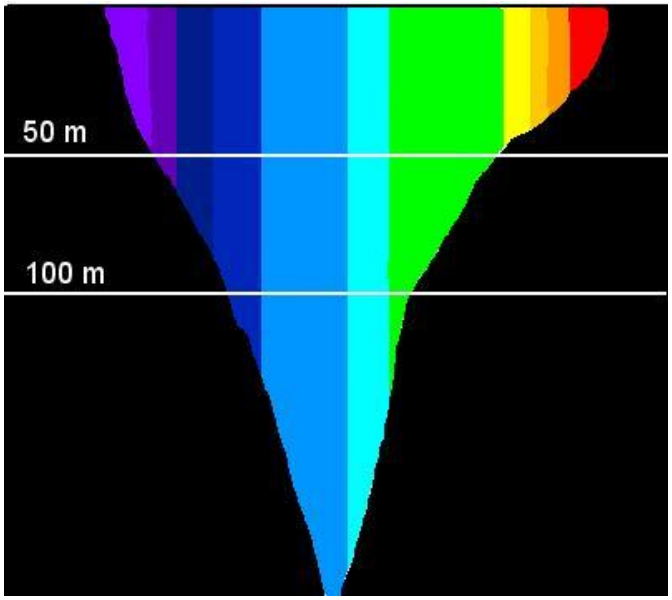


Light (10 minutes)

As depth increases, the quantity and quality of light decreases. Sunlight contains all colors of the visible spectrum: red, orange, yellow, green, blue, and violet (Figure 5). Energy increases and wavelength decreases as you move from red to violet light across the spectrum in this order: red, orange, yellow, green, blue, and violet. Blue light penetrates

best in water, thus the ocean appears blue (Figure 5). Green light is second, yellow is third, orange is fourth, followed by red light. All objects reflect or absorb all light that hits them. White objects appear white because they reflect all colors of the visible spectrum. In contrast, black objects appear black because they absorb all colors of the visible spectrum.

Figure 5. Visible light.
Illustration Credit: Lori Timm, Ph.D. – Landry's Downtown Aquarium



What happens to light as you travel deeper in the ocean?

A red fish appears red because it reflects red light and absorbs all other colors. If a red fish was at the surface, where red light can penetrate, the fish appears red. However, red light does not reach the ocean depths; therefore, red animals appear black and are not visible to predators and prey. This is a great way to avoid being detected by a predator or to easily sneak up on prey.

Most animals in the twilight zone are black or red. Black animals absorb all colors of light available and red animals appear black because there is no red light to reflect off the bodies. All available light is absorbed and the animal appears black.

Part 5. Sharks in Different Zones (10-15 minutes)

Sharks have different body shapes (morphology) depending on where they live in the water column.

Benthic Sharks

Most benthic sharks (sharks that live on the seafloor) have flat, less streamlined bodies. This enables the sharks to lie on the bottom and blend in with the sediments. Most benthic

species have external connections between the olfactory system (nose) and respiratory system (mouth) such as enlarged nasal flaps or external grooves. This would suggest that active respiration has a major role in pulling water through the nostrils to detect odor (smell). Some benthic sharks have modifications of the nasal flap into a barbel, similar to that of a catfish. Barbels are associated with benthic habitats and are used as tactile sensors for finding benthic prey. Possession of barbels is common in species inhabiting murky waters where sight is limited.

Pelagic and Coastal Sharks

In contrast, most pelagic (open ocean) or coastal (coastline) sharks have long, slender, streamlined bodies which enable them to swim through the water with the least amount of friction. This allows the sharks to swim very quickly! Fast swimming sharks (e.g., great white sharks, mako sharks, blue sharks) have symmetrical lobes (equal sized lobes) on their caudal fin (tail fin), which helps to swim faster. Slower moving sharks have asymmetrical lobes (not equal). Asymmetrical lobes are more consistent with slower movements. Pelagic sharks inhabiting deeper water tend to be slower moving than species living in shallower pelagic zones, and therefore tend to have asymmetrical lobes.

Below are examples of different sharks that inhabit each of the ocean zones, including the continental shelf! Remember some sharks will travel in and out of different zones. For example, some sharks will travel from the epipelagic zone into the mesopelagic zone, and back. These sharks utilize both zones in search of food! Make note of adaptations necessary for each ocean zone.

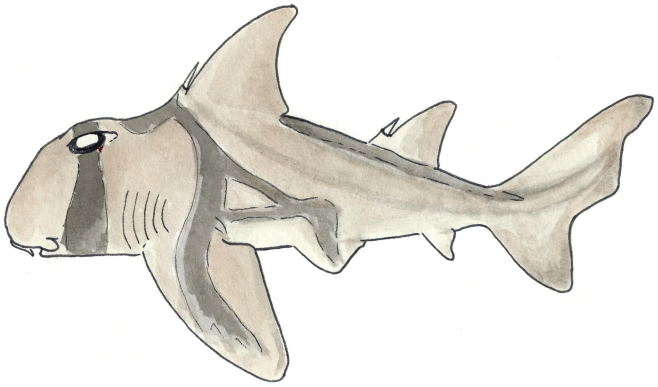
Continental Shelf (5 – 10 minutes)

Chain catsharks are bottom-dwelling (benthic) sharks typically found on the outer continental shelf and upper slope near rocky bottoms (Figure 6). The two caudal fin lobes are asymmetrical, which means the chain catshark is a slower moving species. Like most benthic species, chain catsharks have bold and descriptive body patterns to act as camouflage. Chain catsharks can be found in depths ranging from 75 m to 550 m.

Figure 6. Chain Catshark
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium

Port Jackson sharks are common to the continental shelves and range from the intertidal zone to 275 m (Figure 7). These sharks have broad, flat heads and possess barbels. Port Jackson sharks are nocturnal and prefer to hide in caves during the day! They feed on benthic invertebrates, mollusks (oysters and snails), crustaceans (crabs), echinoderms (sea stars), and small fish.

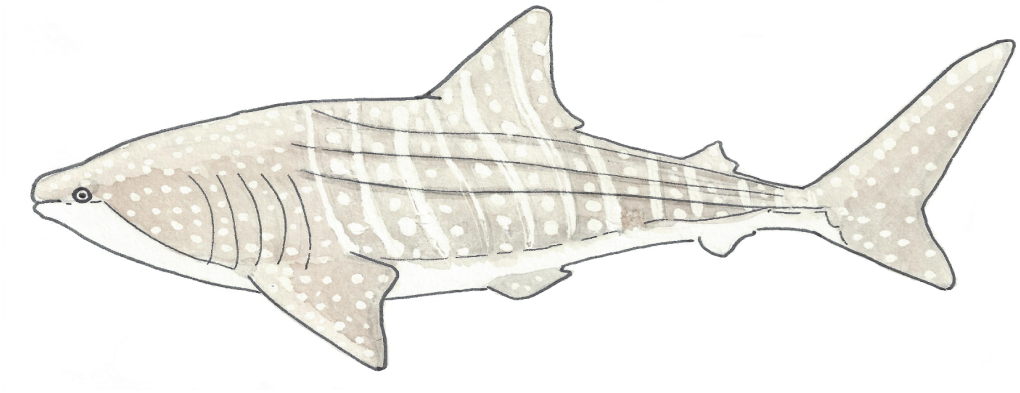
Figure 7. Port Jackson Shark
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium



Epipelagic Zone (10 – 15 minutes)

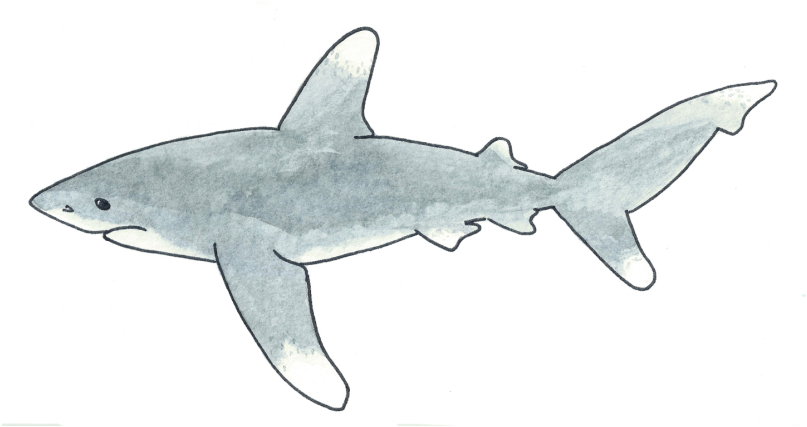
Many sharks live in the epipelagic zone! One of the most popular is the whale shark (Figure 8)! These sharks can reach a length of 12 m (40 ft). Whale sharks are gray with white spots on the dorsal side and all white on the ventral side (Figure 8). The spot pattern may be a way for the sharks to "recognize" each other, or may be an adaptation for shielding radiation from the sun. Whale sharks are filter feeders and must spend a significant amount of time at the surface where they are exposed to high levels of radiation from the sun. The white ventral side enables the shark to blend in if a predator from below is looking up. Remember, this is the euphotic zone, where light shines! What better way to blend into their surroundings?!

Figure 8. Whale Shark
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium



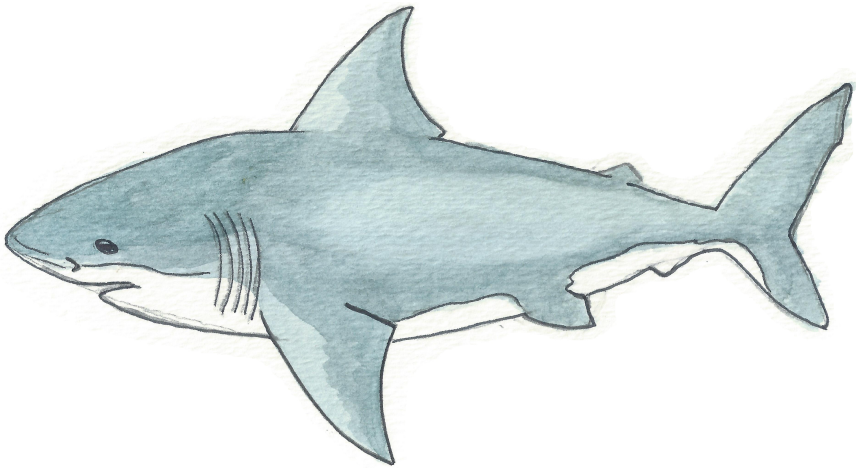
Oceanic whitetip sharks are found from the surface to depths of about 150 m (Figure 9). These sharks have white markings on the tip of the dorsal fins, pectoral fins, and caudal fins. These sharks are often associated with pilot whales, especially in waters around the Hawaiian Islands. This association is unclear; however, these sharks will follow pilot whales to greater depths possibly looking for squid!

Figure 9. Oceanic Whitetip Shark
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium



Great white sharks are primarily an epipelagic species, spending the majority of their time at the surface (Figure 10). This species spends most of its time patrolling the coastlines where pinniped (seals and sea lions) populations flourish and along offshore reefs where large fish live. However, great white sharks have been known to dive over 250 m into the mesopelagic zone. Some of the deepest dives recorded in the Pacific have been over 600 m! Great white sharks are streamlined with near-symmetrical caudal fin lobes, which mean these sharks are built for speed! Great whites are also camouflaged on both the dorsal and ventral sides: dark above and light below (Figure 10). This makes it difficult for prey to see great whites swimming from below. Remember that it gets darker as you go deeper in the water.

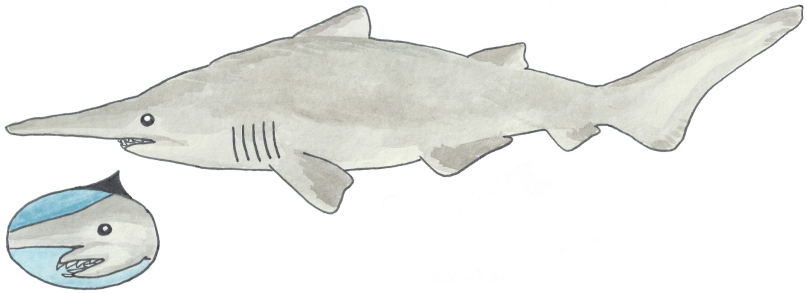
Figure 10. Great White Shark
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium



Mesopelagic Zone (10 minutes)

The goblin shark is a bottom-dwelling shark found along the outer continental shelves, upper slopes, and seamounts (Figure 11). Most goblin sharks have been found off continental slopes between 270 m and 960 m. These bizarre creatures are rarely observed at the surface! The goblin sharks have long jaws with sharp, narrow teeth. It is difficult to find food at such great depths, so when the goblin shark finds prey it doesn't want to lose it! The caudal fin is long and lacks a ventral (lower) lobe, which is characteristic of a slower moving shark.

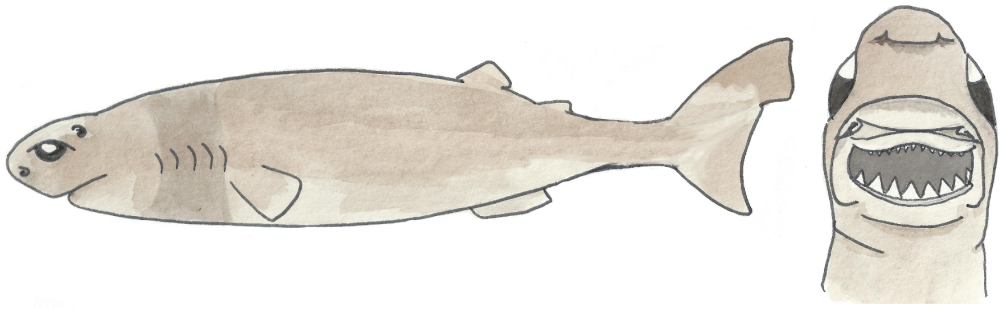
Figure 11. Goblin Shark
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium



Cookiecutter sharks are found in depths below 1,000 m (3,281 ft) during the day, and migrate into the epipelagic zone at night (Figure 12). Cookiecutter sharks primarily feed on mesopelagic fishes, crustaceans, and bite large chunks of flesh from large sharks, whales, and dolphins. Like other mesopelagic sharks, cookiecutter sharks have elongated bodies with a large liver. As in other sharks, the liver makes up 35% of the shark's body weight! The liver has low-density oil that keeps the shark neutrally buoyant in the water column over a wide range of depths; therefore the shark does not have to continuously swim to stay afloat. Cookiecutter sharks are ambush predators with very large eyes to search for prey in the dark! These sharks have short, broad caudal fins for rapid bursts of speed over short distances, perfect for ambush predators. Like other sharks in the

mesopelagic zone, cookiecutter sharks use bioluminescence to attract prey and avoid predators. These sharks use photophores (light producing organs) to eliminate their shadow from below. What's really interesting is that these photophores are absent only between the gills under the throat! This could be a means to lure a would-be predator to the mouth of the cookiecutter shark! As the potential predator is swimming below and looks up, it would see the shadow, or dark spot under the throat, and would go investigate. The cookiecutter shark can then strike at the predator for a quick and easy meal!

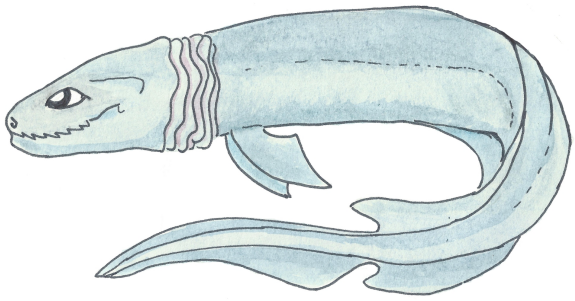
Figure 12. Cookiecutter Shark
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium



Bathypelagic Zone (10 minutes)

Frilled sharks are one of the most primitive shark species living today and possess 6 gills, instead of the typical 5 gills (Figure 13)! Frilled sharks are eel-like creatures that reach lengths up to 2 m! They are usually found between 120 m and 1,280 m and primarily prey on other sharks, squid, and bony fishes. These sharks are highly specialized for life at this depth. They have especially large livers with low-density oil to maintain neutral buoyancy. Frilled sharks are one of the only shark species with an "open lateral line" that exposes the hair cells (cells that respond to displacement of water caused by motion) directly to the seawater! This may increase their sensitivity to tiny movements of prey. What a great adaptation for sharks living in complete darkness!

Figure 13. Frilled Shark
Illustration Credit: Sarah Rich –Landry's Downtown Aquarium



Portuguese dogfish are the deepest living shark species known to date (Figure 14)! They live approximately 3,700 m deep! Portuguese dogfish have short and stout bodies with blunt snouts. The upper caudal fin lobe is significantly longer than the lower lobe, meaning this shark is a slow swimmer. These sharks are black or brown without any obvious markings. Camouflage is not necessary in these dark depths. Portuguese dogfish primarily feed on fish and squid.

Figure 14. Portuguese Dogfish
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium

Ocean Zones

ACTIVITY 1. Oral Presentation

(1 week)

Introduction

The ocean is divided into many different zones, from the intertidal zone and continental shelf, to the 5 pelagic zones in the open ocean. Each zone contains organisms with different adaptations to the changing temperature, water pressure, and light availability. This is a great opportunity to have the students create oral presentations about their favorite oceanic zone! Students can present their reports using Microsoft PowerPoint or poster boards.

Materials

- Microsoft PowerPoint (optional)
- Poster board
- Markers, pencils, pens
- Internet

Instructions

1. Students can do these presentations individually or in groups.
2. Have the students choose a single zone (intertidal, continental shelf, or 1 of the 5 pelagic zones.
3. Students should have adequate time to conduct their research on their chosen zone. This can be done at the library or on the internet. The available PowerPoint can also be used as a source.
4. The students will put together a presentation on the zone, including light availability, temperature, water pressure, and types of organism that live in the chosen zone.
5. The students will then organize the information into a powerpoint slideshow or on poster board. Allow the students to have fun and be creative with this project!
6. Lastly, the students will present the information to the class.

See Student Handout to get started.

Helpful Hints

Below are questions the students can ask while doing their research

1. What does the temperature, light availability, and water pressure look like?
2. What animals live in this zone?
3. Do the animals undergo vertical migrations into the epipelagic zone?
4. Is there enough light availability in this zone for photosynthesis to occur?
5. Animals that live in different zones have different adaptations to survive in these zones. What are the adaptations and why?
6. How do scientists explore the zones past the mesopelagic zone? Have the students investigate different methods to explore these worlds (e.g., deep-sea submersible).
7. What about horizontal migrations? Do some animals in the chosen zone migrate between oceans? If so, why? Certain whales and fishes (great white sharks) travel hundreds of miles to warmer water where their breeding grounds are located. Others follow prey. One idea would be to choose a shark on the OCEARCH Global Shark Tracker™ and track its migrations.

Activity 1. Oral Presentation

Name: _____

Date: _____

Instructions

The ocean is divided into many different zones, from the intertidal zone and continental shelf, to the 5 pelagic zones in the open ocean. Each zone contains organisms with different adaptations to the changing temperature, water pressure, and light availability. For this activity, you will choose your favorite zone and present information about this zone to the class.

Before you start your presentation:

1. What zone will you be presenting?

2. What are the environmental factors of this zone? For example, what is the temperature, pressure, sunlight level, and what visible light is detected?

3. What animals live in this zone? Does photosynthesis occur in this zone?

4. What adaptations are necessary for living in this zone? Give examples.

Ocean Zones

ACTIVITY 2. Ocean Zones Card Game

(45 minutes – 60 minutes)

Introduction

The Ocean Zones Card Game is a fun way to get the students involved! It is an interactive game to test the students' knowledge about each pelagic zone. There are five fun facts to match with each of the five pelagic zones!

Materials

- Printer
- Tape
- Scissors

Instructions

1. Print out the available cards below. This can be a team effort, so print out 1 copy of cards per group. Every team gets the same cards.
2. Cut out the cards with scissors and give to the students with the cards mixed up.
3. Divide the students into teams. Have the students choose the name of their team.
4. Have the students place folded tape on the back of each card.
5. The first cards to be placed on the board should be the pelagic zones, followed by the fun fact cards. One student per team should place only one card on the board at a time. Once the student is back to their group, the next student can go to the board with their one card. Remember this is a race to see which team can organize the cards correctly in the shortest amount of time.
6. Whichever teams gets all of the fun facts into the correct ocean zones the fastest wins.

Epipelagic Zone
Mesopelagic Zone
Bathypelagic Zone
Abyssopelagic Zone
Hadalpelagic Zone

Photosynthesis

Alga
coral

97ºF

Twilight Zone

200 m to 1,000 m

Squid, krill, octopus, cuttlefish, vertical migrations

Thermocline

5,850 psi

Midnight Zone

1,000 m to 4,000 m

Detrivores, scavengers, resident carnivores, deep-sea anglerfish, giant squid

Fish lack swim bladders

39ºF (4ºC)

4,000 m to 6,000 m

Lack of nutrients, high oxygen content, and hydrothermal vents

35ºF (2ºC) to 37 ºF (3ºC)

No diurnal or seasonal changes, high pressures, complete darkness, and cold

Organisms tend to be translucent or red in color

6,000 m to bottom

Mariana Trench

8 tons psi

Tube worms, spook fish

Organisms lack color pigments and have wide eyes

ACTIVITY 2. Ocean Zones Card Game – Answer Key

Epipelagic Zone

- Photosynthesis
- Euphotic zone
- Surface to 200 m
- Algae, seagrass, jellyfish, corals, great white sharks
- 97ºF (36ºC) to 28ºF (-2ºC)

Mesopelagic Zone

- Twilight zone
- 200 m to 1,000 m
- Squid, krill, octopus, cuttlefish, vertical migrations
- Thermocline
- 5,850 psi

Bathypelagic Zone

- Midnight zone
- 1,000 m to 4,000 m
- Detrivores, scavengers, resident carnivores, deep sea angler fish, giant squid
- Fish lack swim bladders
- 39ºF (4ºC)

Abyssopelagic Zone

- 4,000 m to 6,000 m
- Lack of nutrients. high oxygen content, and hydrothermal vents
- 35º F (2ºC) to 37ºF (3ºC)
- No diurnal or seasonal changes, high pressures, complete darkness, and cold temperatures
- Organisms tend to be translucent or red in color

Hadalpelagic Zone

- 6,000 m to bottom
- Mariana Trench
- 8 tons psi
- Tube worms, spook fish
- Organisms lack color pigments and have wide eyes

Ocean Zones

ACTIVITY 3. Design Your Own Shark!

(30 minutes – 45 minutes or take home)

Introduction

This activity is designed for the students to be creative! The students are to imagine they are scientists on a mission to find a new species of shark! As they begin their descent into the ocean (scuba diving, snorkeling, or deep-sea submersible), they stumble across what appears to be an unrecognizable shark swimming by them. The first thing a scientist would do in this scenario is to examine the new specimen and give it a name! The students are first to explain which oceanic zone the new species was discovered. They can then go into detail about the adaptations they observe and the environmental conditions in which the new species lives. Body coloration and adaptations should be accurate to the oceanic zone chosen by the student.

Materials

- Handout provided
- Internet (optional)
- Coloring utensils (crayons, markers, coloring pencils)
- Pencils or pens

Instructions

1. Have individual students or groups of students pick an ocean zone (continental shelf, epipelagic zone, mesopelagic zone, etc.)
2. Each student or group needs to make a list of adaptations that a shark would need to live in this specific zone, including a color pattern.
3. Students can then create their own shark. Allow the students to be creative and have fun, but adaptations should be accurate to the chosen zone. Remember that some sharks rely heavily on camouflage, so the coloring pattern of these imaginative sharks should be conducive to the environment in which it lives.
4. In addition to drawing their new species, students should then explain 3-5 adaptations the shark possesses in order to survive in environmental conditions of the chosen ocean zone (e.g., light availability, color intensity, pressure).
5. Lastly, the student(s) can present their new shark species to the class, explaining all the shark's adaptations.

Activity 3. Design Your Own Shark

Name: _____

Date: _____

Instructions

Create a new species of shark inhabiting either the continental shelf or one of the five pelagic zones in the space provided. Below, explain 3-5 adaptations needed to survive in this zone and explain the environmental conditions that this shark experiences (e.g., light availability, body coloration, temperature, pressure). How did you find this new species? Did you need a deepwater submersible, or did you find this new species in shallower water or deep inside a cave? Did you find your new species while snorkeling or scuba diving? Explain your reasoning.

	Adaptations and environmental conditions: