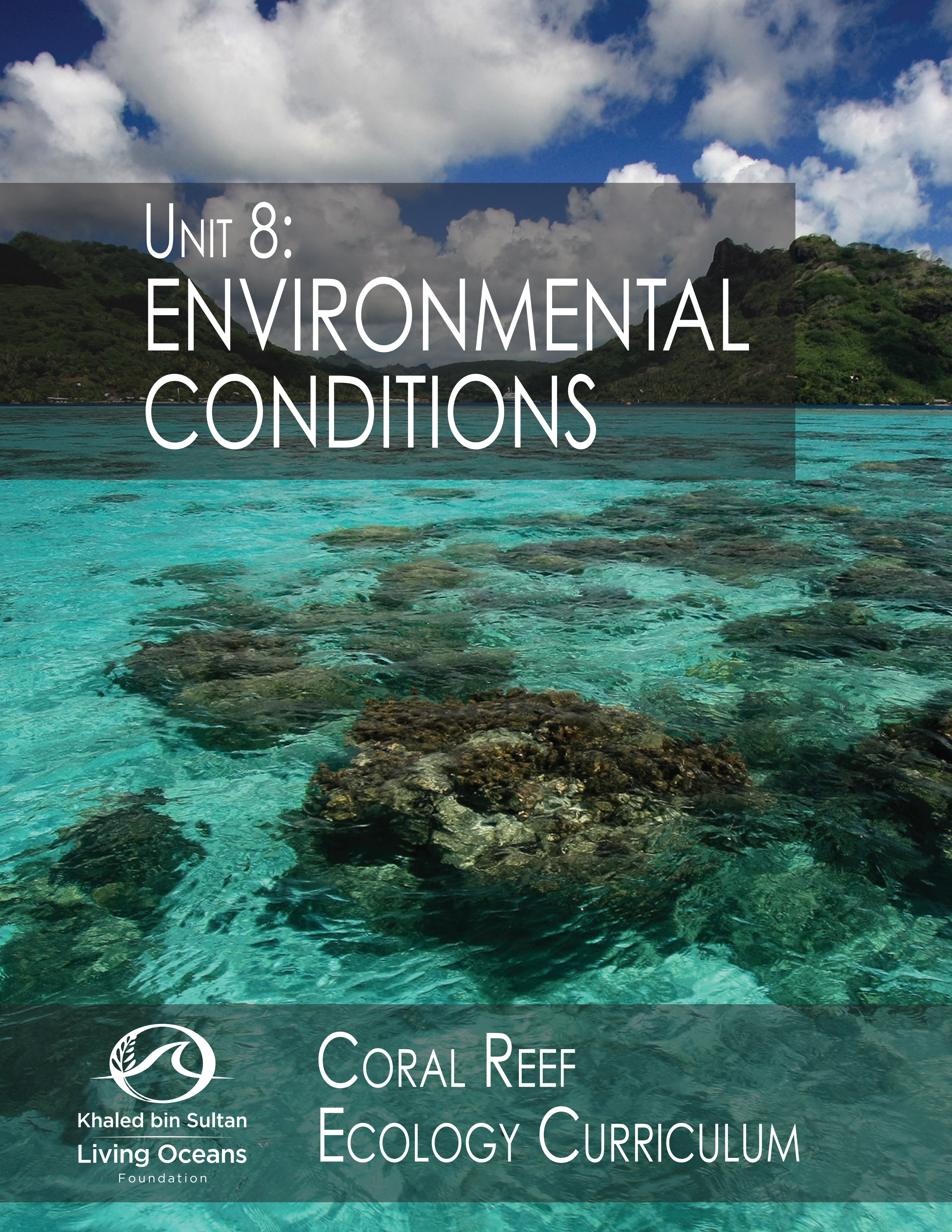
Unit 8: Environmental Conditions



Khaled bin Sultan Living Oceans Foundation

Coral Reef Ecology Curriculum

Khaled bin Sultan

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This unit is part of the *Coral Reef Ecology Curriculum* that was developed by the Education Department of the Khaled bin Sultan Living Oceans Foundation. It has been designed for secondary school students, but can be adapted for other uses. The entire curriculum can be found online at lof.org/CoralReefCurriculum.

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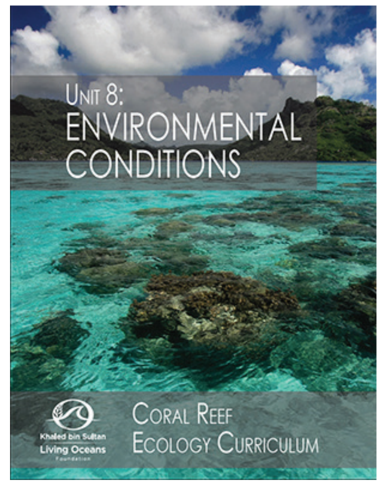
ENVIRONMENTAL CONDITIONS

This lesson is a part of the *Environmental Conditions* unit, which explains the abiotic factors that corals need to thrive. Below is a summary of what is included in the entire unit.

UNIT CONTENTS



A. Background Information
   - Environmental Conditions
   - Abiotic Factors

B. Lessons

Conditional Corals
- A lab to evaluate the water quality at potential sites for a new coral reef colony

Deep Conditions
- A lesson to research deep-water corals and compare them to shallow-water corals

Read it! Shivering for Science
- A worksheet to accompany the *Shivering for Science* field blog

STANDARDS

- **CCSS**: RST.9-10.1, 3, 4, 5, 7, 8, 9, 10; RST.11-12.1, 3, 4, 8, 9, 10; W.9-10.4, 7, 8; W.11-12.4, 7, 8; SL.9-10.1, 3, 6; SL.11-12.1, 3, 6
- **NGSS**: ESS 2.D, HS-LS2-6
- **OLP**: 1.B, 1.B.3, 5.A.2, 5.B.1, 5.B.2, 5.B.5, 5.C.25, 5.C.33, 5.C.34

ONLINE CONTENTS

- Environmental Conditions Quiz

BACKGROUND INFORMATION

Corals have certain environmental conditions that they need in order to survive. These factors limit where corals can live. In this unit, we will learn about the abiotic factors that corals need to thrive.

These environmental conditions are referred to as biotic and abiotic factors. Remember, we can break down the word abiotic:

a	***biotic***
without	life

Therefore, abiotic means without life. **Abiotic factors** are non-living components of an organism's environment. Do you remember what biotic means? It means life. **Biotic factors** are living or once living components of a community.

Coral reefs are complex **ecosystems**. There are many different biotic factors that affect coral reefs. They will be discussed throughout different units. For now, we will focus on the abiotic factors that affect corals.

Can you think of any abiotic factors that may affect coral reef ecosystems?

Abiotic Factors
Water
Light
Wind
Sediment
pH
Temperature
Pressure
Salinity
Humidity
Weather
Waves
Current
Ocean depth
Substrate
Turbidity
Inorganic nutrients (phosphorus, nitrogen, etc.)
Dissolved gases – oxygen (O_2), nitrogen (N_2), carbon dioxide (CO_2), etc.
Aragonite and calcium carbonate saturation (we will discuss more about this in later units)

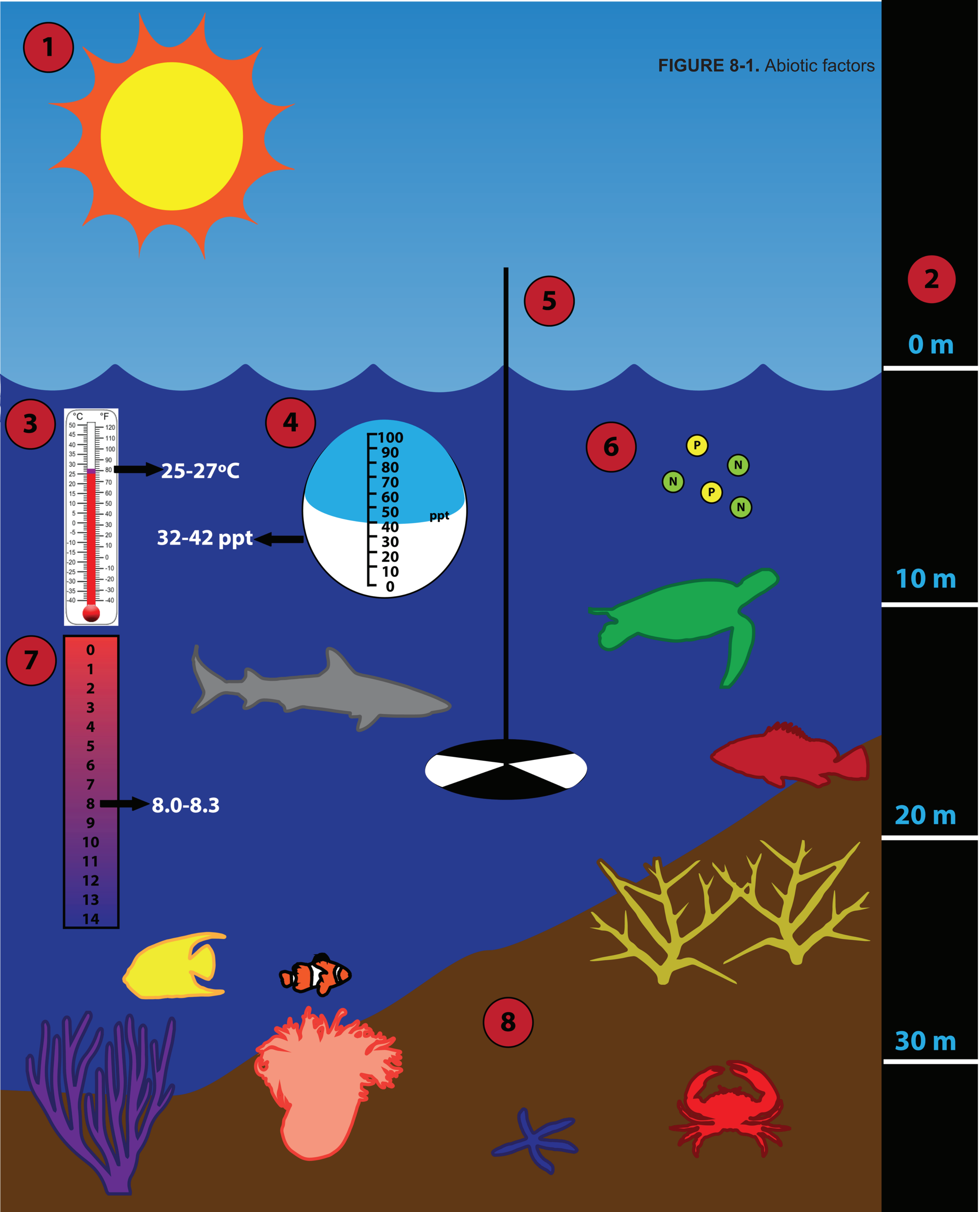


FIGURE 8-1. Abiotic factors

There are multiple abiotic factors that affect coral reefs. See figure 8-1 on the previous page. The numbers in the diagram correspond to the numbered descriptions below. Here are the optimal parameters for corals to live in:

1. Light: Corals need a moderate amount of sunlight in order to survive. Light is rapidly absorbed by seawater and does not penetrate to great depths. If there is too little light, then the zooxanthellae will not be able to photosynthesize and produce food for corals. Too much light, especially ultraviolet (UV), may cause corals to expel zooxanthellae, causing them to bleach. In later units, we will learn more about coral bleaching.

2. Depth: Reef building corals must live where there are moderate amounts of light. Recall that corals have a symbiotic relationship with **zooxanthellae** living inside their tissues. These algae photosynthesize in order to create food and nutrients for corals. See *Unit 4: Coral Feeding* for more information. Corals can live in depths less than 230 feet (70 meters), but are typically found at approximately 98 feet (30 meters).

3. Water temperature: Remember that corals thrive in the warm waters of the tropics. They prefer a water **temperature** range of 60.8–93.9°F (16–34.4°C). This range varies for corals depending on the temperature to which they have adapted (Dubinsky & Falkowski 2011).

4. Salinity: **Salinity** is usually measured in parts per thousand (ppt). Corals can tolerate a salinity range of 23–42 ppt. The average ocean salinity is 35 ppt. Let's think of salinity like this, if we have 1,000 buckets of seawater, 35 of those buckets will be filled with salt and the other 965 will contain freshwater. For more about salinity, see *Unit 7: Distribution*.

   Salinity can be measured by using a hand-held **refractometer** (figure 8-2). When using this tool, a small drop of seawater is placed between a measuring prism and a cover plate. Light passes through the sample and the light is refracted through the prism to the scale. By looking through the eyepiece, the salinity can be read. There are other tools, such as hydrometers and conductivity meters, that are also used to measure salinity.

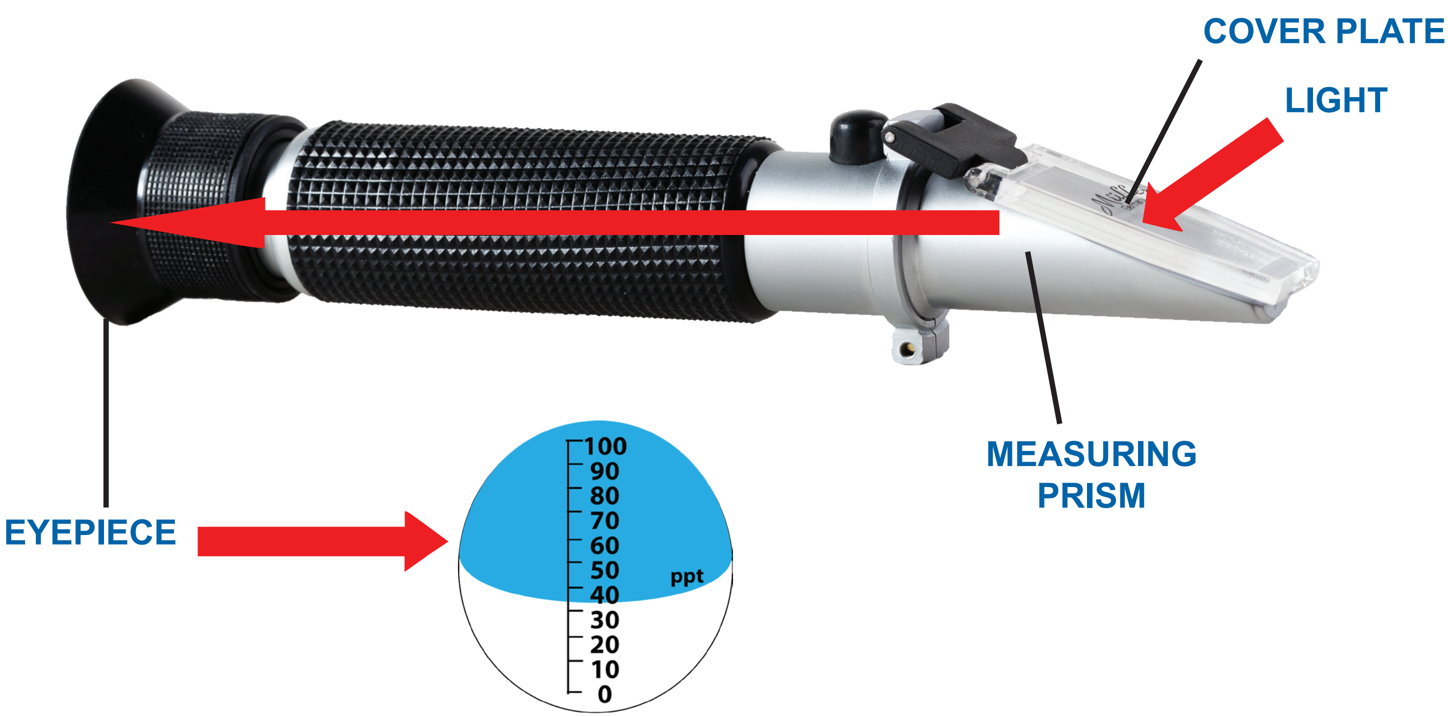


FIGURE 8-2. The light (red arrow) bends through a refractometer giving a salinity reading, which is seen through the eyepiece.

5. Turbidity**: Turbidity** is the measure of the clarity of water. When there are particles in the water, this inhibits light from penetrating through the water column. Turbidity can be caused by phytoplankton, sediments, runoff, pollution, etc.

   Corals need clear water (water with low turbidity) so that the light can penetrate through the water column, allowing the zooxanthellae to photosynthesize. When there is high turbidity, light can't penetrate through the suspended particles. Additionally, corals can be smothered by sediments or particles that settle on top of the corals. Eventually, this could lead to the coral dying.

   One way to measure turbidity is to use a **Secchi disk**. A Secchi disk is often an 8 inch (20.3 centimeter) round disk that has alternating black and white quadrants (figure 8-3).

   Secchi disks are lowered into the water with a rope. Light reflects off of the top of the Secchi disk. When the Secchi disk is no longer able to be seen, the person stops lowering the rope. Then they record the depth that is marked on the rope. Using the Secchi depth, scientists can calculate the turbidity of the water.

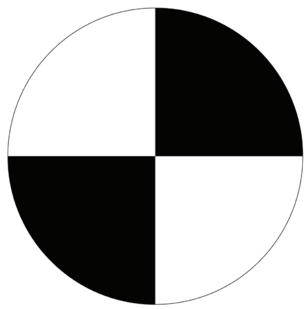


FIGURE 8-3. Secchi disk pattern

6. Nutrients: Corals prefer low nutrient water. Nutrients include phosphorus (P) and nitrogen (N). When there are lots of nutrients, this may cause algae and phytoplankton to grow. This process can block out the light that zooxanthellae need to survive. Also, algae can overgrow coral while competing for space. If the coral cannot get light, then it will die.

7. pH: Whether a solution is an acid or a base is the measurement of its **pH**. The pH scale ranges from zero to fourteen (figure 8-4). Seven is neutral, which is the pH of pure water. A pH of less than seven is acidic (like vinegar) and a pH greater than seven is basic (like bleach).

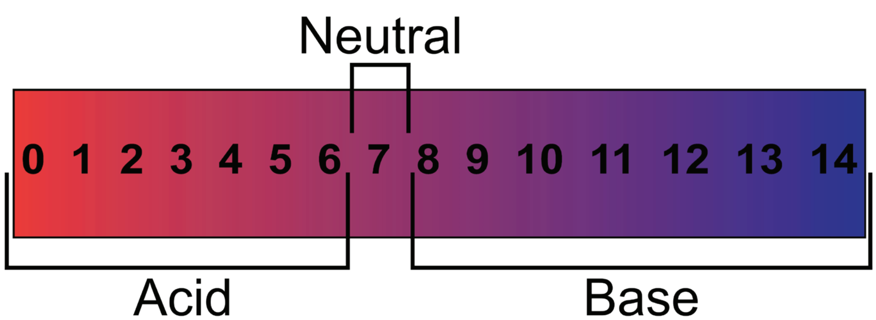


FIGURE 8-4. pH scale

   Corals prefer seawater to have a pH level between 8.0–8.3, which is the standard pH of saltwater. It is very difficult for corals to grow in acidic conditions. We will learn more about this topic and how it is related to ocean acidification in later units.

8. Substrate: A surface where an organism can attach and/or grow is called a **substrate**. Corals need to attach to a hard surface. Recall that most corals are **sessile** meaning that they do not move once mature.

Remember that these are general parameters and that there are corals that have adapted to different conditions. For example, *Siderastrea radians*, the lesser starlet coral, has adapted to living in very stressful conditions in Florida Bay (Lirman *et al.* 2002). This large body of water is an estuarine area where seawater mixes with freshwater. The average depth in Florida Bay is 5 feet (152.4 centimeters), which is one of the reasons that environmental conditions fluctuate greatly. During the dry season, when there is little to no rain and evaporation rates are high, salinity levels can reach **hypersaline** conditions (greater than 40 ppt). It has also been documented that certain basins in Florida Bay reach over 70 ppt. This would be a very difficult place to live if you were a coral. Remember that most corals can tolerate 23–42 ppt.

In another example, American Samoa corals have adapted to high temperatures that can easily exceed 89.6°F (32°C) for multiples hours and days at a time (Craig *et al.* 2001). This gives us hope that some corals will adapt to climate change and warming seas.

There are other abiotic factors that affect coral reefs. We have already learned how currents can affect distribution of coral reefs in *Unit 7: Distribution*. There are other abiotic factors that we will learn more about in later units (see *Unit 9: Coral Growth*). We will also learn about the biotic factors that affect coral reefs too (see *Unit 16: Food Webs*).

ATTRIBUTIONS

Figure 8-1. Sun. 2014 via Clipart Panda. http://www.clipartpanda.com/clipart_images/sun-clipart-medium-5602503.

Figure 8-1. Thermometer. n.d. via Teacher's Files. http://www.teacherfiles.com/clip_art_thermometers.htm.

Figure 8-2. Refractometer adapted from CEphoto, Uwe Aranas [CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], 29 Oct 2013 via Wikimedia Commons. http://commons.wikimedia.org/wiki/File%3APortable-Refractometer-03.jpg.

Figure 8-3. By User: Mysid (Own work) [Public domain], 1 Nov 2005 via Wikimedia Commons. http://upload.wikimedia.org/wikipedia/commons/0/0b/Secchi_disk_pattern.svg.

CITATIONS

Craig, P., Birkeland, C., & Belliveau, S. (2001). High temperatures tolerated by a diverse assemblage of shallow-water corals in American Samoa. *Coral Reefs* 20: 185-189.

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Coral Reef Ecology Curriculum

The Coral Reef Ecology Curriculum is a comprehensive educational resource designed to educate people about life on coral reefs.

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The Khaled bin Sultan Living Oceans Foundation is a US-based nonprofit environmental science organization. The Foundation was established to protect and restore the world's oceans through scientific research, outreach, and education.