Earth's Hydrosphere
ES-5 The student will demonstrate an understanding of Earth's freshwater and ocean systems.

ES-5.7 Explain the effects of the transfer of solar energy and geothermal energy on the oceans of Earth (including the circulation of ocean currents and chemosynthesis).
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Students have not been introduced to the concepts in this indicator in any previous grade.

It is essential for students to know that solar energy penetrating the surface water region of the ocean and geothermal energy from thermal vents deep within the ocean have affects on the movement and chemical reactions that take place in ocean waters.

Ocean currents

Surface currents: As solar energy reaches Earth's oceans most directly in areas near the equator, surface water in that region is warmer.

- The surface ocean water is set into motion by energy from the wind.
- The wind belts determine the direction of the flow, but the Coriolis effect and interaction with continents also help determine surface ocean current direction of movement.
- Warm equatorial surface currents flow and bring warm water to cooler regions.
- Currents coming from areas near the poles where solar energy is less direct are cold currents. As cold currents move toward the equator, they cool the region around them.

Deep currents:

- Water warmed by solar energy near the equator expands, is less dense that cold water, and rises.
- Cold water from the poles is denser, sinks, and moves very slowly beneath warmer ocean water toward the equator.

Chemosynthesis

- Some regions of the ocean are teeming with life due to organisms using solar energy for photosynthesis. The most abundant marine life exists where there are ample nutrients and good sunlight.
- In deep ocean areas where sunlight does not reach, *chemosynthesis* (chemical reactions) supports life near hydrothermal vents, mainly along the oceanic ridge.
    - Microscopic bacteria living in and near the vents perform chemosynthesis and become the bottom of the food web.
    - Through chemosynthesis, the bacteria produce sugars and other foods that enable them and many other organisms to live in this very dark, very unusual environment.

It is not essential for students to know the names of specific warm or cold ocean currents – the explanation here is about solar energy affecting the currents. Students are not responsible for knowing the classification of marine life or the various marine life zones.

Assessment Guidelines:

The objective of this indicator is to *explain* how solar energy and chemosynthesis affect Earth's oceans; therefore, the primary focus of assessment should be to construct cause and effect models of how solar energy affects ocean current movement and life in the ocean, and also how chemosynthesis affects life where solar energy does not reach.

In addition to *explain* appropriate assessments may require students to:

- *compare* surface ocean currents with deep ocean currents;
- *compare* marine life where solar energy reaches with marine life where it is dark;
- *recall* the process of chemosynthesis; or
- *identify* the reason that warm ocean currents exist.