



CO₂ LEARNING CENTER

Sleep Well Series Lesson Plan

Foxy the Fruit Bat Sleeps Well



This lesson plan was produced by the CO₂ Learning Center, a project of the CO₂ Coalition, and meets the Next Generation Science Standards for Grades K, 2, 3, 4, 6, 7, and 8.

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A note about our lesson plans:

Our CO₂ Learning Center lesson plans all have the same format, which includes learning standards from the Next Generation Science Standards (NGSS), student learning objectives, background information on the science concepts covered in the book or video, suggested activities including labs to enrich the lesson and reinforce use of the scientific method, and formative and summative questions.

The NGSS are the standards on which most public-school systems have based their curriculum. We do not necessarily endorse the NGSS but have included the relevant standards for circumstances in which a teacher is required to use them. The lesson plans contain everything that a teacher might be required to submit in a formal lesson plan to a school administrator or science department head. Our lesson plans emphasize the use of the scientific method and critical thinking skills.

This lesson plan was created for the CO₂ Coalition’s CO₂ Learning Center by Sharon Camp, Ph.D. Analytical Chemistry; B.S., Geology, using Next Generation Science Standards (NGSS).

Understanding NGSS:

LS: Life Science PS: Physical Science ES: Earth Science

1-5 indicates the standard for grade level (1-first grade, 2-second grade, 3-third grade, 4-fourth grade, 5-fifth grade)
K indicates the standard for kindergarten

MS: Middle School (6, 7, 8)

Please note that only the parts of the outline that are relevant to this lesson have been included. If LS1.C or PS3.D (examples from this lesson plan) are shown, these NGSS segments were included as relevant to this lesson for Life Science and Physical Science.



Lesson Plan: Foxy the Fruit Bat Sleeps Well

Grades K, 2, 3, 4, 6-8

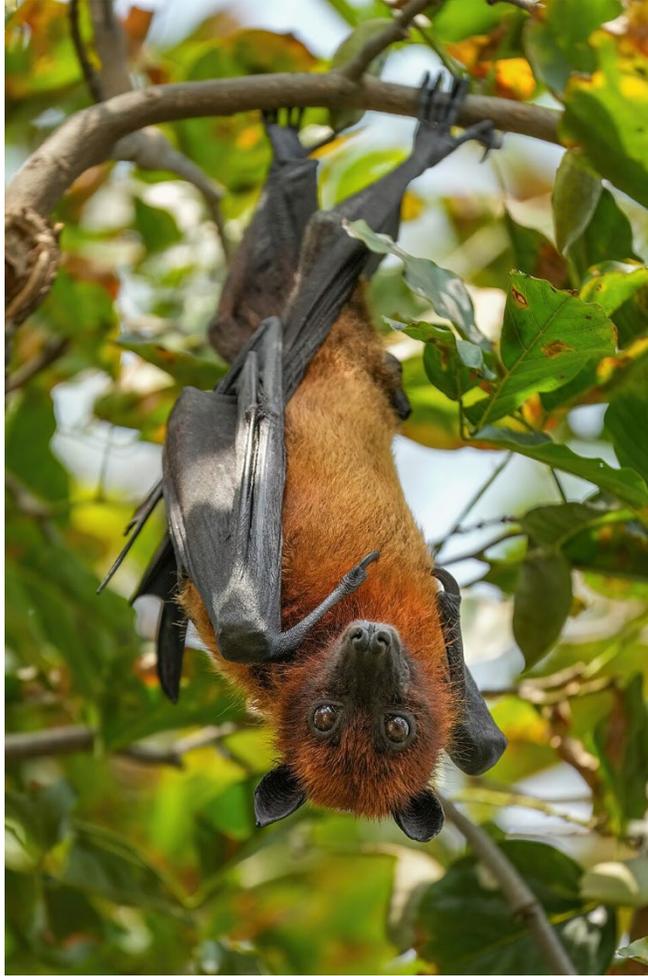
Student Learning Goals

After reading the book, students will be able to:

1. Explain what a Flying Fox is, where it lives, and why it is important to its local ecosystem.
2. Describe an Oriental Garden Lizard, where it lives, and what it eats.
3. Describe a Common House Gecko, where it lives, and what it eats.
4. Describe a coral atoll and explain how it forms.
5. Explain what a parrotfish is and why it is important for the formation of sand on coral atolls.
6. Explain the process by which coral atolls can grow as the sea level rises.
7. Explain why most coral atolls will not be submerged by the sea.

Background Information

Flying foxes, also known as fruit bats, are tropical bats that are found in many parts of the world. The fruit bats found in the Maldives are a type of Old World fruit bat, which is one of more than 180 species of large-eyed fruit-eating or flower-feeding bats that are widely distributed from Africa to Southeast Asia and Australia.¹ Specifically, Foxy is an Indian Flying Fox (*Pteropus giganteus*). These bats live in colonies of up to 1000 individuals who roost upside down in trees during the day and leave their roosts at night searching for figs, mangoes, and blooming flowers.² They have a wingspan of 5 to 6 feet and are the largest bats in the world. (There is a fun video on the Cincinnati Zoo website on this specific type of bat at <https://cincinnatizoo.org/animals-archive/giant-fruit-bat-indian-flying-fox/>.) Unlike many bats, they rely on their sense of smell to find food. Because they eat agricultural crops, they are considered to be pests in many countries. There are about 1400 different species of bats worldwide.³



Indian flying fox in Keoladeo National Park Photo by Giles Laurent. Giles Laurent, CC BY-SA 4.0
<<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:045_Indian_flying_fox_in_Keoladeo_National_Park_Photo_by_Giles_Laurent.jpg

About 530 plant species are dependent on bats for pollination.³ Plants that are pollinated by bats include mangoes, bananas and guavas, and like other plants whose flowers are pollinated by bats, they are open at night; large, white or a light color; fragrant; and have lots of nectar.⁴ A good description of pollination can be found at the US Forest Service's website at [What is Pollination? | US Forest Service](#).



Grey-headed Flying Fox (*Pteropus poliocephalus*) eating flower nectar. The face and fur of this bat being covered with yellow pollen provides a good visual example of the role that bats have in pollinating Australian trees and bushlands. Brisbane, Queensland, Australia. Andrew Mercer (www.baldwhiteguy.co.nz), CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons. [https://commons.wikimedia.org/wiki/File:Grey-headed Flying Fox \(IMG0527\).jpg](https://commons.wikimedia.org/wiki/File:Grey-headed_Flying_Fox_(IMG0527).jpg)

The Oriental Garden Lizard, also known as the Changeable Lizard (*Calotes versicolor*), is native to the Maldives. It is quite common and can be found among low shrubs and bushes hunting for insects.⁵ It can be easily found in parks and gardens.



[Calotes versicolor](https://commons.wikimedia.org/wiki/File:Calotes_versicolor_(Oriental_garden_lizard)_2.jpg) (Oriental garden lizard) on a wooden step in Don Det, Si Phan Don, Laos. Basile Morin, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons. [https://commons.wikimedia.org/wiki/File:Calotes versicolor \(Oriental garden lizard\) 2.jpg](https://commons.wikimedia.org/wiki/File:Calotes_versicolor_(Oriental_garden_lizard)_2.jpg)

They are called changeable because during the breeding season, males develop an orange head with a black blotch over the cheeks.⁶ Including its tail, it can reach up to 14.5 inches in length.



Oriental Garden Lizard. Sifat Shaker, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons. <https://commons.wikimedia.org/wiki/File:OGL.jpg>

These lizards like to live in the undergrowth in forests, gardens, and agricultural areas. They eat mostly insects but will also eat small animals such as geckos. These lizards will outcompete native lizards when introduced into a new environment.

Common House Geckos (*Hemidactylus frenatus*) are native to countries all over Southeast Asia but have spread worldwide due to recent introductions.⁷ They are frequently found in and around houses, on walls and ceilings, and near bright lights. Their diet consists of insects, which they catch mostly in the morning and early evening. In areas where they have been introduced, they can outcompete the native lizards and geckos. Males can reach just over 5 inches in length while females are somewhat smaller.



Hemidactylus frenatus. Vengolis, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Hemidactylus_frenatus_9701.jpg

Geckos have amazing pads on their feet that allow them to climb windows, walls, and other vertical surfaces. Their feet use the tiny attractions between their foot hairs and the molecules of the vertical surface in a phenomenon known as Van der Waal's forces.⁸



Close-up of the underside of a gecko's foot as it walks on a glass wall. Van der Waals force interactions between the finely divided setae (hairs on the toes) and the glass enables the gecko to stay in place and walk on the seemingly smooth glass. Source: Bjørn Christian Tørrissen, CC BY-SA 3.0 <<https://creativecommons.org/licenses/by-sa/3.0/>>, via Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Gecko_foot_on_glass.JPG

The primary theme of the book *Foxy the Fruit Bat* is the fact that the islands in the Maldives, along with other coral atolls around the world, are not in danger of being submersed by rising sea levels as has been claimed by the Intergovernmental Panel on Climate Change (IPCC) and others. The IPCC is an international scientific and political group that was established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) in 1988.⁹ For over 30 years, the IPCC has held international conferences and released both scientific and policy reports, although the quality of the science is questionable. It first predicted that islands would be submersed by rising sea levels in their First Assessment Report, published in 1990. This report predicted that sea level would rise an average of 20 cm by 2030 (7.9 inches or 0.2 inches per year), primarily due to thermal expansion of the oceans.¹⁰ It also highlighted small islands' vulnerability, noting that some low-lying atolls and coral islands would be especially vulnerable to sea-level rise due to accelerated inundation, erosion, and saltwater intrusion.¹⁰ In 1995, they revised their predictions and stated that by 2100 there would be an associated increase in sea level of about 15–95 cm, or a rise of 0.56 to 3.56 inches per decade.¹¹ In 2023, they again revised the measured rate to 0.15 inches per year.¹² It also forecast partial submersion (especially of *reef islands*), reduced habitability, and serious habitat destruction on many small islands.¹³

The purpose of the IPCC is to convince more developed countries that their continued use of fossil fuels will cause catastrophic warming of Earth's climate, with predictions of dire environmental and social consequences, and that fossil fuels should be removed as an energy source as soon as possible.

Fortunately, in the three decades since the alarming predictions of the IPCC were first made, there is no support for those dire predictions to be found in observational data, and no evidence of any significant harms from fossil fuel use and global warming.

The islands of the Maldives are a type of island called a coral atoll. An atoll is an island that has formed on top of the remains of a submerged volcanic island.¹⁴



Nissan Atoll, Green Islands, Papua New Guinea. Source: NASA, Public domain, via Wikimedia Commons.
https://commons.wikimedia.org/wiki/File:Nissan_Atoll_Landsat.jpg

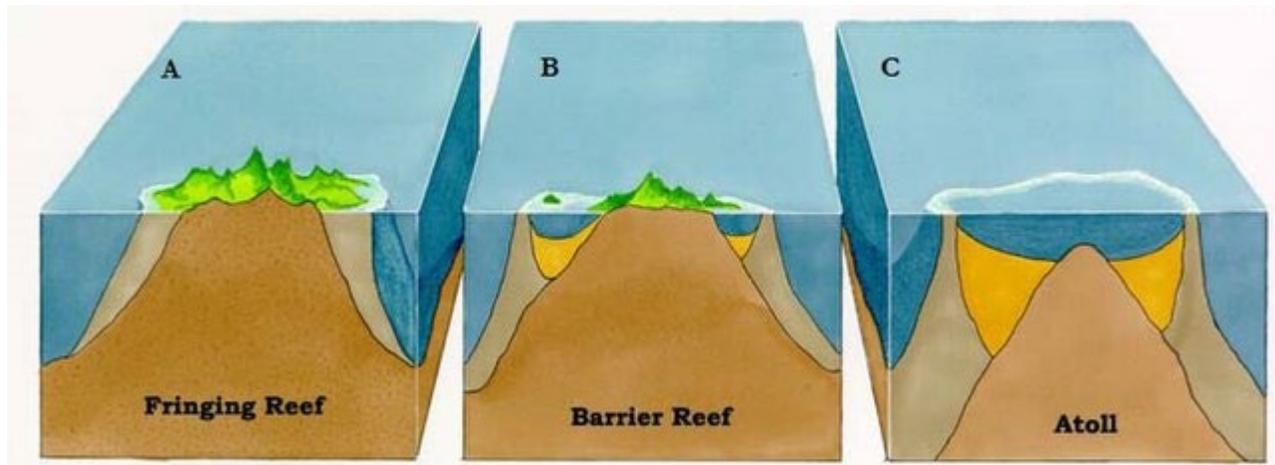
First, the volcano erupts on the sea floor and gradually grows to where its top is above sea level. At this point, the volcano has become an island. Hard corals will grow along the side of the volcano forming a fringing reef. Hard corals form colonies of animals that live in a home that is made of calcium carbonate.

(For a more complete discussion of corals, please see the background information in the lesson plan for our book *Chloe the Clownfish Sleeps Well* at <https://co2learningcenter.com/lesson-plans/>.)

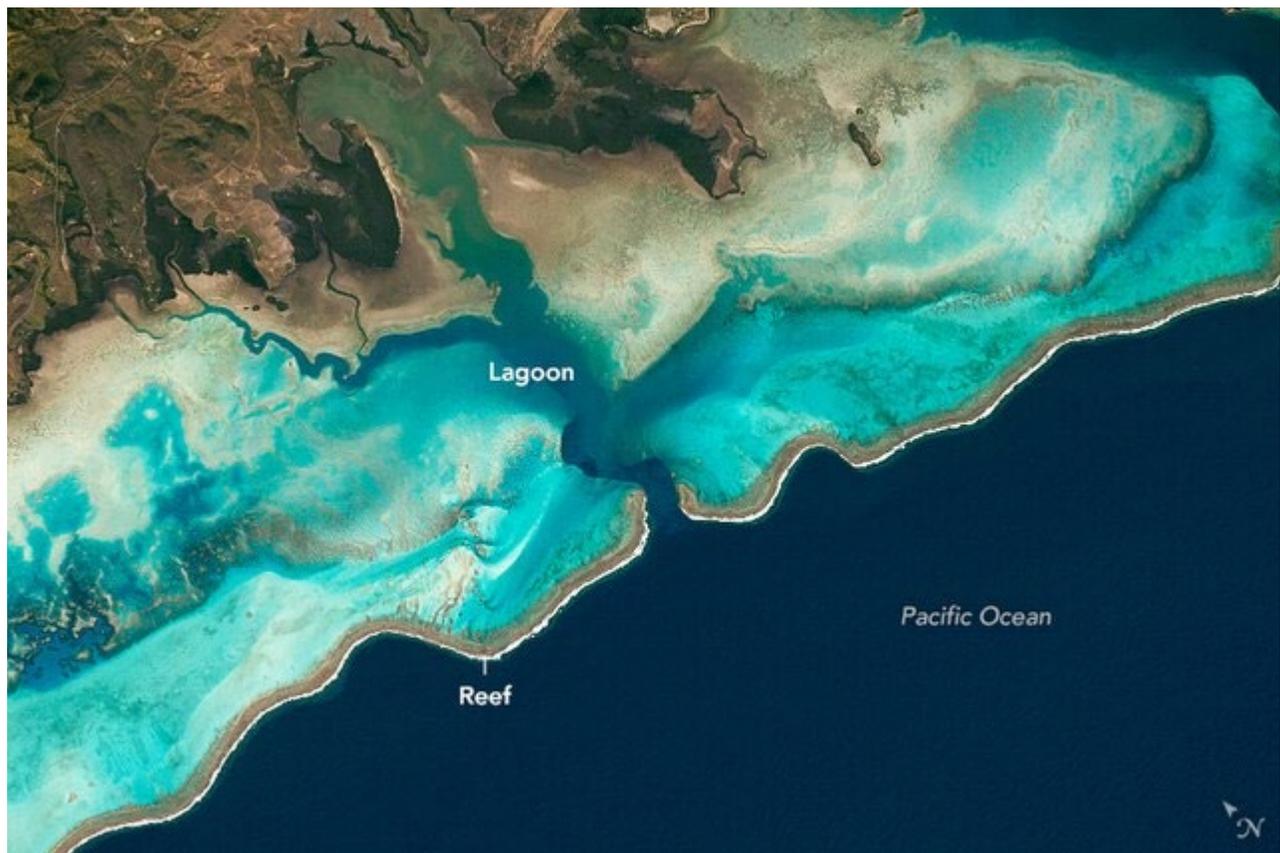


Example of a hard coral. Coral (*Danafungia scruposa*), Red Sea, Egypt. They are around 9.8 in. Its polyps have diameters of up to 9.4 in and are oval or circular. *D. scruposa* is found in the eastern and western Indian Ocean, the eastern central, northwestern and western central Pacific Ocean, Japan, the East China Sea, the Red Sea, and eastern Australia. It's found at depths between 3 ft 3 in and 88 ft 7 in on the slopes of reefs. Source: Diego Delso, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons. [https://commons.wikimedia.org/wiki/File:Coral_plato_\(Danafungia_scruposa\),_mar_Rojo,_Egipto,_2023-04-15,_DD_49.jpg](https://commons.wikimedia.org/wiki/File:Coral_plato_(Danafungia_scruposa),_mar_Rojo,_Egipto,_2023-04-15,_DD_49.jpg)

As long as the volcano continues to erupt, it will stay above the surface of the water. But once the volcano becomes extinct (stops erupting forever) the action of the wind and the waves of the sea will erode the island until it is below sea level, which allows corals to grow. The erosion process typically takes millions of years. The barrier reef forms as the island erodes away. The reef will then become an atoll (or a group of atolls) as all remnants of the volcano disappear beneath the coral. The coral protects the lagoon that has formed in what used to be the crater of the volcano.



Different types of coral reefs: (a) Fringing, (b) Barrier, and (c) Atoll. Source: coral reef, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons. <https://commons.wikimedia.org/wiki/File:Tipos-recifes-de-coral.jpg>



Reefs of New Caledonia from ISS. While orbiting over the southwestern Pacific Ocean, an astronaut onboard the International Space Station (ISS) photographed this fringing coral reef on the south coast of New Caledonia. The reef separates the light blue shallows of the lagoon from the darker, deeper Pacific Ocean. Tan hues tinge the lagoon where sediment flows in from uplands to the north-northeast. Source: NASA Earth Observatory, Public domain, via Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Reefs_of_New_Caledonia_from_ISS,_September_9,_2020.jpg



Maupiti island Airport in French Polynesia. The airport is built on the barrier reef that surrounds the island.
Source: Kyprianos Biris, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons.
https://commons.wikimedia.org/wiki/File:Aerial_view_of_Maupiti_Airport.jpg



Part of the Majuro atoll in the Marshall Islands. Source: Mark Uriona, CC BY-SA 4.0
<<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons.
[https://commons.wikimedia.org/wiki/File:Majuro - Main Atoll of the RMI.jpg](https://commons.wikimedia.org/wiki/File:Majuro_-_Main_Atoll_of_the_RMI.jpg)

A coral reef is composed of living corals, their exoskeletons, and coral sand and mud that combine in a complex group of features.¹⁵ The exoskeletons of coral are made of calcium carbonate, which is a hard material of which seashells and limestone are composed. The reef is made of a large variety of corals that grow together in intricate patterns that include many spaces. Mud and coral sand fill the spaces and harden, along with any plants or algal mats that may be growing in the sand. Sometimes storms will break up pieces of coral and add them as sand to the beach. The process by which all these extra materials are added to the reef is called accretion, and it is because of accretion that coral reefs will grow and maintain their size as water levels change. In fact, there have been many studies recently by scientists in the tropical waters within the coral triangle that have measured changes in the size of coral atolls. These studies have revealed that most of the islands in this area have either maintained their size or have grown.^{16, 17, 18} Most of the growth on the Maldives has occurred by human land reclamation,¹⁷ but in other places, most of the growth occurred by natural accretion.¹⁸ Reef islands also change in response to environmental changes, such as major typhoons or hurricanes.¹⁸

Another organism that is crucial in creating the sand on coral atolls is the parrotfish. There are about 100 species of parrotfish, and they live in and around corals reefs.¹⁹ One common parrotfish that lives in the Indian Ocean is the Ember Parrotfish, shown below. It is important in maintaining reef health and in beach formation, as its poop contains tiny fragments of the coral that it ate. Its massive teeth bite off chunks of coral or scrape algae off the reef, and the hard coral skeleton is broken down so that it can pass easily through the fish's digestive system. The sand then forms the beaches on the tropical islands.²⁰



Scarus rubroviolaceus, Hanauma Bay Beach Park, Honolulu, Hawaii. Also known as the Ember Parrotfish and the Redlip Parrotfish. Source: (c) Don Loarie, some rights reserved (CC BY), CC BY 4.0 <<https://creativecommons.org/licenses/by/4.0/>>, via Wikimedia Commons.

[https://commons.wikimedia.org/wiki/File:Scarus_rubroviolaceus, Hanauma Bay Beach Park, Honolulu, Hawaii, United States imported from iNaturalist photo 29805110.jpg](https://commons.wikimedia.org/wiki/File:Scarus_rubroviolaceus,_Hanauma_Bay_Beach_Park,_Honolulu,_Hawaii,_United_States_imported_from_iNaturalist_photo_29805110.jpg)

Where the previous articles by Kench, et.al, Holdaway, et.al., and Duvat, et.al. address changes in the sizes of coral atolls, none of them address the larger issue of sea level itself. Sea level is a complicated thing to measure. If it is measured by satellite altimetry, the satellite measures the distance between the height of the ocean and the center of the Earth. A drawback of using satellite measurements of sea level is that they only began in 1978, so long term trends are not available. Sea-level data for the open ocean from satellite altimetry also does not measure relative changes along the coast where people live. The best long-term sea-level measurements are from tide gauges. These measure sea level by measuring water level relative to the surrounding land.²¹ (That's called "relative sea level.")

Tide gauges are at many harbors and channels around the world, where sea levels have been carefully and methodically measured for over one hundred years. The earliest ones consisted of a simple open-top vertical pipe called a "stilling well," with one end immersed in the sea, the other end above the water, and a "tide stick" to measure the water level in the pipe. Later came automated float sensors, data recorders, and other improvements, but the basic principles of a tide gauge's operation remain the same to this day.

Here's a diagram of an old-style tide gauge with a strip-chart recorder:

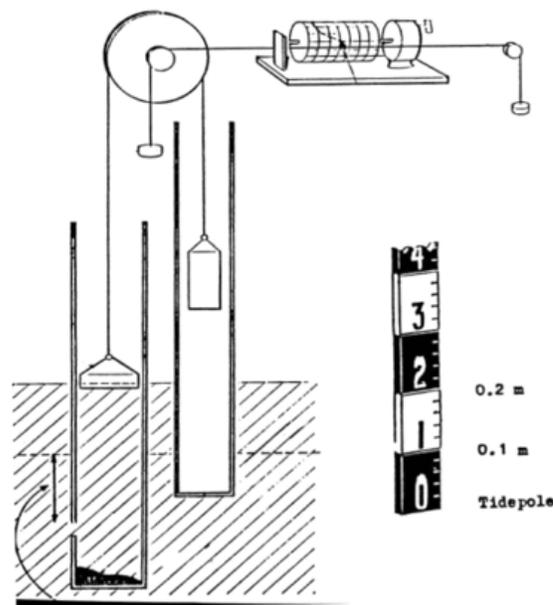


Figure 1. Float Activated Tide Gauge (Hydrographer of the Navy, 1969)

Source: http://www.fg.net/resources/metro/_articles/2000/05/uk_200005uk_2000_hannah.pdf

Source: https://sealevel.info/tide_gauge_schematic.html

Tide gauges may also move vertically with vertical changes in the land surface, which complicates determining how much change is due to "global" (average) sea level rise.²² For this reason, some tide gauges are coupled with a Continuously Operating Reference Station (CORS). These stations provide real-time GPS positioning for a specific area and allow researchers to distinguish changes in sea level from changes in land position.²³ Some tide gauges are also collocated with weather stations that

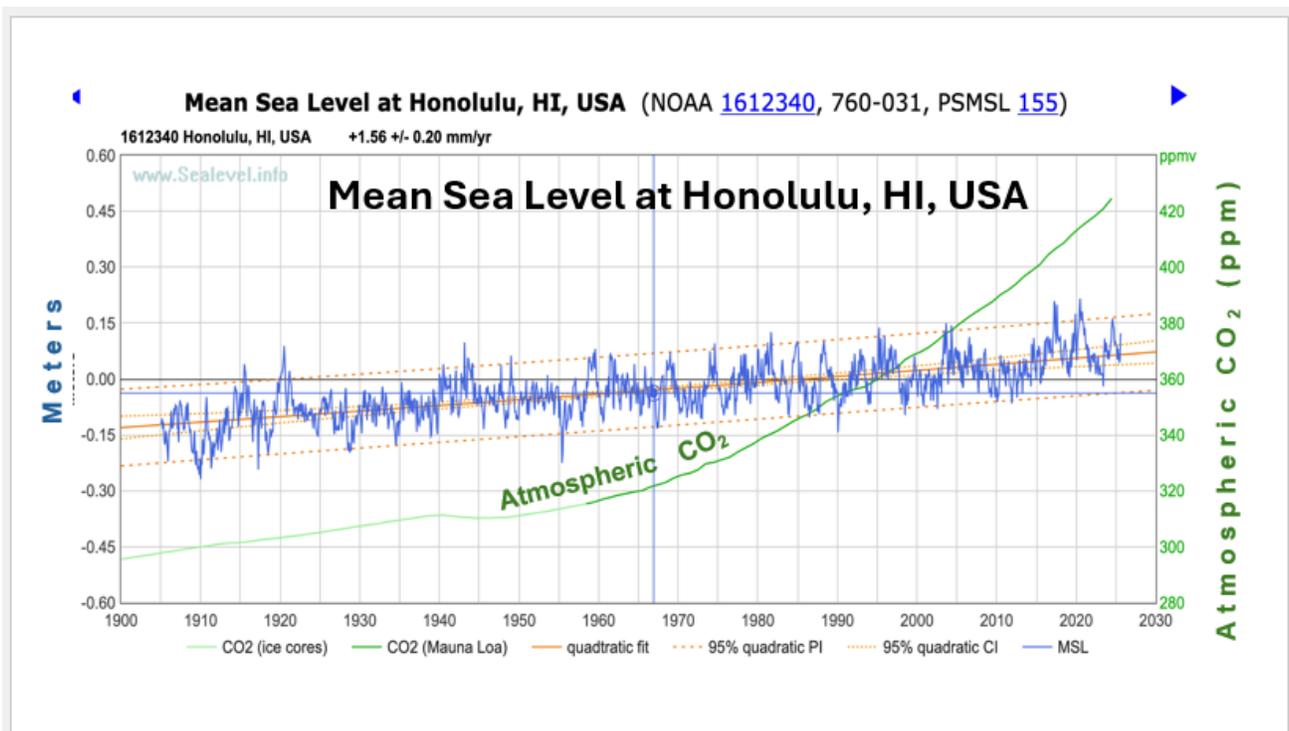
monitor meteorological factors that affect sea levels, such as barometric pressure and wind speed. A comprehensive list of tide gauge data can be found at [PSMSL](https://sealevel.info/) or <https://sealevel.info/>.

The measurements show that global (average) sea level trends are so slight and slow that in many locations they are dwarfed by local factors, like erosion, sedimentation and vertical land motion. In fact, in quite a few places sea level is falling, rather than rising, because the land is rising faster than the ocean. Places where the relative sea level has dropped include measurement sites in Scandinavia, in Iceland, Alaska, and Canada. In some other places, sea level is rising much faster than the global trend, not because of global sea level change, but because the ground there is sinking. Places where the land is sinking include the Louisiana bayous, Miami, most of the eastern coast of the United States and Sri Lanka.

Most measurement records show little or no sign of acceleration. Over periods of a few decades or less, the ocean may slosh up or down, but at most sites the long-term sea-level trends today are still similar to what they were at the same locations fifty or a hundred years ago.

One of the best tide gauge measurement records is from Honolulu. Honolulu is near the middle of the world's largest ocean, on a tectonically stable island with near-zero vertical land motion, small tides, and little ENSO distortion, and it has a 100% complete 120 year-long measurement record with a very typical trend: 7.3 inches of sea level rise in 120 years. That is equal to 0.061 inches per year, which is about half the rate of both the IPCC and the satellite altimetry measurements (0.13 inches per year^{11, 24}).

The measurement record for Honolulu is almost perfectly linear, with no detectable effect from rising CO₂ levels:



Source: https://sealevel.info/MSL_graph.php?id=Honolulu&quadratic=1&quad_ci=1&quad_pi=1&lin_ci=0&linear=0

The IPCC's "AR6" assessment report warns that the rate of sea-level rise is accelerating. But according to the best long measurement records from tide gauges, like the one in Honolulu, the rate of acceleration is negligible. At many sites (including Honolulu) there's been no detectable acceleration at all. Some studies^{25,26} of tide gauge data from many sites have reported a tiny average acceleration of about 0.0004 inches/year², which is inconsequential. If that rate of acceleration were to continue for 150 years, it would only add about 4.4 inches to average coastal sea levels. For a primer on what acceleration is, see https://sealevel.info/acceleration_primer.html.

Bottom line, there is no good evidence to support the predictions of the IPCC that the Maldives will suffer severe habitat loss or be underwater any time soon. After all, earlier predictions held that they would be underwater by now. New predictions hold that they will be underwater by 2050. It is unlikely that those predictions will be accurate either.

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Suggested Activities

1. **There are many different bats that are called flying foxes.** Research to find the common and scientific names of ten different flying foxes and record the following: a physical description

of each bat with pictures, where it lives, what it eats specifically (flowers, bananas, etc.), what habitat it can be found in, how long it lives, how many pups the females will give birth to per year, why it is important to the local ecosystem (what are its ecosystem services). Put your findings in a presentation, which could include a notebook, a written report, or an oral and visual presentation.

2. **Oriental Garden Lizards are found throughout southeast Asia.** Research exactly where the lizards can be found, what they eat, what habitat they can be found in, how long they live, how many eggs a female will lay at a time and how often, why they are important to the local ecosystem. Why are they sometimes considered to be invasive and what harm do they do to the local ecosystem? Put your findings in a presentation, which could include a notebook, a written report, or an oral and visual presentation.
3. **Common House Geckos are found throughout southeast Asia.** Research where they can be found, what they eat, what habitat they can be found in, how long they live, how many eggs a female will lay at a time and how often, why they are important to the local ecosystem. Why are they sometimes considered to be invasive and what harm do they do to the local ecosystem? How have they spread to many places around the world? Put your findings in a presentation, which could include a notebook, a written report, or an oral and visual presentation. *Extra activity: What are some pros and cons of the exotic pet trade? Do you think shipping exotic pets around the world is a good or bad idea? Support your opinion with sources and facts and present your argument to an audience.*
4. **Find out what bats live in your area.** Bats can be found almost anywhere. Use the Internet to discover what bats live around you. Make a notebook that includes the common and scientific names of each bat, what they eat, where they live, how long they live and how many pups they have in a litter. Find out what the best time of day is to observe them and try to identify each one you see based on the information you have recorded.
5. **Find out what lizards live in your area.** Do the same activity as in #4 but research lizards instead. If you are very interested in lizards and/or bats, you can record your sightings on the iNaturalist app. There you can upload any pictures you have taken and also see what lizards or bats other people who live around you have seen. You can also participate in the nationwide citizen science project called HerpMapper, where you can record your findings.
6. **What is a volcano and why do some of them permanently stop erupting?** Volcanoes are alternately fascinating and terrifying. Some volcanoes, such as on the big island of Hawaii, are actively and quietly erupting while others, such as the volcano that makes up the island of Kauai, have stopped erupting forever. The Maldives are a group of coral atolls that formed over an ocean ridge called the Chagos-Laccadive Ridge in the Indian Ocean. Research the history of the ridge to determine why it formed and why the volcanoes in the Maldives are no longer active. Put your findings in a presentation, which could include a notebook, a written report, or an oral and visual presentation.

- 7. What do bats, lizards, and geckos have in common?** Bats are mammals while lizards and geckos are reptiles. Yet they all three have these things in common: birth, growth, and reproduction. Use a table or a Venn Diagram to illustrate what these three animals have in common as far as birth, growth, and reproduction, and how they are different.
- 8. Pick three major coral atolls anywhere in the world.** Using world maps, locate three atolls and compare their satellite images (Google Earth is a good resource). Then answer the following questions:
- Where is each island chain located?
 - How many islands are in each archipelago?
 - How many of the islands are true atolls and how many are islands made of barrier reefs? How do you know?
 - Research the types of corals that are in each island chain. Are they the same or different from island to island? Why?

Combine your information into a report, either oral or written, and give a presentation.

- 9. Compare the rate of change in sea levels for different places around the country.** Go to <https://sealevel.info/data.php#top> and check the sea level changes for the following cities:
- Juneau, AK
 - Seattle, WA
 - Lewisetta, VA

Record in a notebook the rate of sea level change for each of these locations, then answer the following questions:

- Form a hypothesis. Before you begin, record in your notebook whether you expect the rates of sea level change for each location to be the same or different. Possible hypotheses include (but are not limited to) a) they will all have rising sea levels b) they will all have falling sea levels c) they will have different rates of sea level change.
- Look up the data for all three locations. At which locations (if any) did the sea level fall? At which locations (if any) did the sea level rise? Were the values for the change in rate the same or different?
- What are some reasons why tide gauge data might be different from place to place and not the same everywhere?
- Why would it not be accurate to average the tide gauge data from all over the world to get one number as the value of the rate of change of sea-level rise? Why would it not be accurate to combine tide gauge data with satellite altimetry data to get one number as the value of the rate of sea-level rise?
- In the places where the sea level is falling, can you find a geologic or oceanographic reason?
- In the places where the sea level is rising, can you find a geologic or oceanographic reason?

- g. Pick a state that has a coastline (such as Alaska or California) and make a table of the values from all the tide gauges in the state. Do they all show the same trend in sea-level changes? If so, why do you think they do? If not, why?

Prepare a presentation to share your results. Be sure to include your hypothesis, whether it was supported and why. Include in your presentation the charts of sea level change for each location. Also include any information you found about the geology of the area or any other factor that might explain your observations. Be sure your report includes a discussion of what you did, what you discovered, and a conclusion.

Formative and Summative Assessment

1. Describe a Flying Fox. Where does it live and why is it important to its local ecosystem?
2. Describe an Oriental Garden Lizard. Where does it live and what does it eat?
3. Describe a Common House Gecko. Where does it live and what does it eat?
4. What is a coral atoll? Describe how it forms.
5. Describe a parrotfish. Why is it important for the formation of sand on coral atolls?
6. Why do coral atolls grow as the sea level rises?
7. Why will most coral atolls not be submerged by the sea?

Next Generation Science Standards (NGSS) Learning Objectives

Please note that the standards that cover the material in this lesson plan are only found in kindergarten, 2nd, 3rd, and 4th grades and middle school curricula. The standards here are written exactly as they are written in the NGSS.

K-ESS3-1 Earth and Human Activity. Students who demonstrate understanding can:

K-ESS3-1. Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. [Clarification Statement: Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.] This standard includes the following Disciplinary Core Ideas:

ESS3.A: Natural Resources

- Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.

2-LS2-2 Ecosystems: Interactions, Energy, and Dynamics. Students who demonstrate understanding can:

2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants. This standard includes the following Disciplinary Core Ideas:

LS2.A: Interdependent Relationships in Ecosystems

- Plants depend on animals for pollination or to move their seeds around.

3-LS1-1 From molecules to Organisms: Structures and Processes. Students who demonstrate understanding can:

3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. [Clarification Statement: Changes organisms go through during their life form a pattern.] [Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.] This standard includes the following Disciplinary Core Ideas:

LS1.B: Growth and Development of Organisms

- Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.

3-LS2-1 Ecosystems: Interactions, Energy, and Dynamics. Students who demonstrate understanding can:

3-LS2-1. Construct an argument that some animals form groups that help members survive. This standard includes the following Disciplinary Core Ideas:

LS2.D: Social Interactions and Group Behavior

- Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.

4-ESS1-1 Earth's Place in the Universe. Students who demonstrate understanding can:

4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. [Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.] [Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.] This standard includes the following Disciplinary Core Ideas:

ESS1.C: The History of Planet Earth

- Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.

4-ESS2-2 Earth's Systems. Students who demonstrate understanding can:

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.

[Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.] This standard includes the following Disciplinary Core Ideas:

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth.

MS-ESS2-2 Earth's Systems. Students who demonstrate understanding can:

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.] This standard includes the following Disciplinary Core Ideas:

ESS2.A: Earth's Materials and Systems

- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

ESS2.C: The Roles of Water in Earth's Surface Processes

- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.



What is the CO₂ Coalition?

The CO₂ Coalition was established in 2015 as a 501(c)(3) for the purpose of educating thought leaders, policymakers, and the public about the important contribution made by carbon dioxide to our lives and the economy.

The CO₂ Coalition is a group of top scientists, engineers and energy experts who study and report on the important contribution made by carbon dioxide to our lives and the economy.

Learn more at CO2Coalition.org and CO2LearningCenter.com.