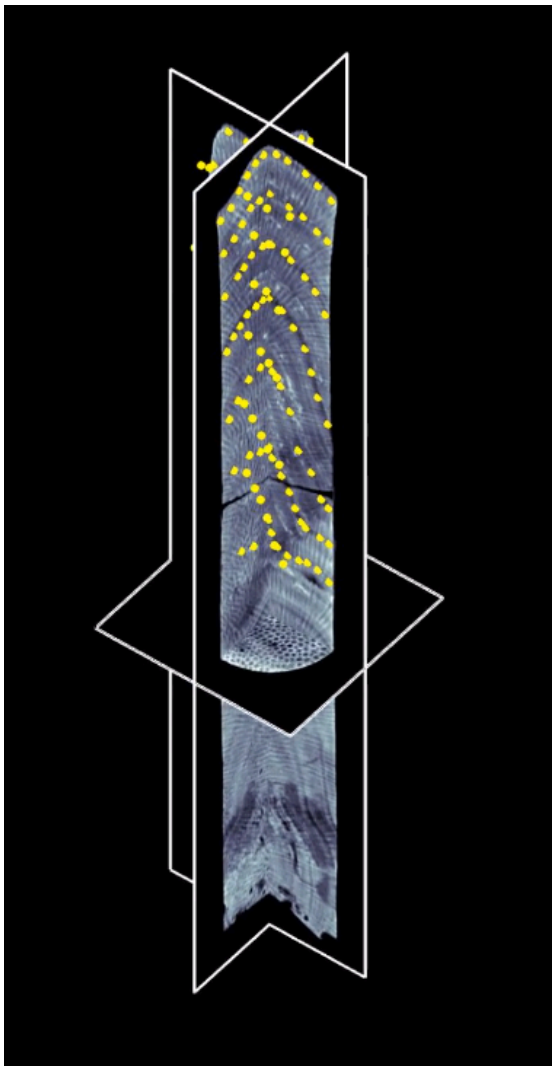


CoralCT High School Lesson Plan

By: The Sclerochronology Lab at Tulane University

Quick Links:

- CoralCT User Guide
- CoralCT Video Tutorials

For questions, contact us at sclerolab@gmail.com

Background

Coral reefs are critical marine ecosystems that provide habitat for numerous animals, support fisheries, and protect the coast from storms. However, corals are struggling due to environmental stressors such as global warming and pollution, causing many to become unhealthy and degrade. Therefore, it's important to assess how healthy coral is and understand how their growth is changing over time due to these stressors so scientists can take action to prevent further damage.

One way coral health can be assessed is through the study of their skeleton. Coral skeletons record information about growth and environmental changes over time in the form of annual density bands. These bands, similarly to tree rings, record how much the coral grows, or calcifies, over the course of one year. Changes in calcification rates offer insights into how environmental factors, such as ocean temperatures, affect coral growth and health.

To study these skeletons, scientists drill into coral skeletons and remove portions called cores. They can CT scan or X-ray the cores to better visualize and analyze these bands. CoralCT is a software tool designed to archive and analyze these X-rays and CT scans, some showing centuries of coral growth. These scans have been uploaded by scientists and organizations from around the world.

Important Vocabulary:

1. **Coral:** A marine animal that lives in colonies and builds hard, rock-like skeletons that form coral reefs.
2. **Calcification:** The process by which corals absorb calcium carbonate from seawater to build their skeletons.
3. **Skeleton:** The hard, calcium-based structure that corals build and live on and forms the framework of coral reefs.
4. **Calcification rate**: How fast the coral is growing. If it's increasing, the coral is growing more. If it's decreasing, the coral is growing less.
5. **Core:** A cylinder-shaped sample that is taken from massive (dome-shaped) coral skeletons and used to study coral health.
6. **Annual Density Bands:** Visible layers in a coral's skeleton, like tree rings, that show how much the coral grew in a single year.
7. **CT Scan/X-ray:** Imaging techniques that help to see the annual density bands of coral cores more clearly, since the bands are often hard to see when looking at the physical core.
8. **Global Warming:** The long-term rise in Earth's average temperature, mainly caused by the trapping of heat in Earth's atmosphere due to greenhouse gases. Greenhouse gases include carbon dioxide (CO_2) and methane. A similar example is when you get into a car in the summer, it's hotter inside the car than outside.
9. **Climate Change:** The long-term change in Earth's average weather patterns, such as precipitation, air temperature, storms, etc., mainly caused by global warming.

10. **Ocean Acidification:** A lowering of the ocean's pH level due to carbon dioxide (CO_2) from the atmosphere dissolving in the water. The dissolved CO_2 causes less carbonate in the water, which corals need to build their calcium carbonate skeletons.

Lesson Plan

Lesson Title: Using the CoralCT App to Study Coral Growth

- **Audience**
  - High school students (Grades 11-12) working in groups of 4-5 in a computer lab.
- **Purpose of Activity**
  - These activities are designed to introduce high school students to marine science and the study of coral reefs. They will use the CoralCT application to map the annual density bands of coral cores and investigate how coral skeletal data can be analyzed to uncover patterns in coral growth over time. In doing so, students will develop skills in data interpretation, graph creation, and scientific reasoning while learning about environmental factors affecting coral reefs.
- **Materials**
  - Computers (one computer per group of 4-5 students)
  - Access to CoralCT via the lab computers with accounts and local working directories set up
  - Excel or another spreadsheet platform for data visualization
  - Recommended coral core samples (see list below)
- **Activities**
  - **Activity 1: Core Selection and First Analysis**
    - Each group selects a coral core from the recommended list.
    - Using CoralCT, students map out the bands of the core. This can be done in turns.
    - Once they have mapped all bands, students will predict if the growth rate is increasing, decreasing, or staying stable. A general key to make this prediction is observing the amount of space between each of their bands, and if this increases or decreases as they move up the core.
    - Once they process their core, students will download their calcification rate data using the "Access Data" page in the CoralCT application. Their data will be downloaded into their local working directory (already created) on their computer (see User Guide for further instructions). They will use these data to create a line graph in Excel with time (years/band numbers) on the x-axis and calcification rate on the y-axis. *Ensure students select the calcification rate (Column G) and not the calcification rate standard deviation (Column H).*
    - For better visualization, have students add a trendline to the graph, which will show how the calcification rate changed over time. *A reminder that band 1 on the x-axis represents the top of the core and the year it was collected (i.e., the closest time to present day).*
    - Students compare their predictions from before with the plotted graph they've created and discuss whether their predictions were accurate.
  - **Activity 2: Regional Comparison**
    - Each group selects a second core of the **same genus** (in parentheses and italicized beside the core ID on the list) from a **different region**.

        - Students map the bands of the second core and make their predictions if the growth rate is increasing, decreasing, or staying stable.
        - Students process the core and go to the Access Data page and download their output data. This will open as a second Excel Sheet.
        - They will select the calcification column and create another line graph, adding a trendline to better visualize if it's increasing, decreasing, or stable.
        - They, as a group, will compare their calcification rate graphs and explain how they are similar (e.g., both are decreasing, both seem to increase at a similar time) or different (e.g., Core 1's calcification rate increased over time, Core 2's calcification rate decreased over time).
        - Students engage in group discussion and research on the two regions their cores are from. This will require outside research on the regions of their cores and the history of weather events, human presence, etc.
        - Students will summarize why they believe these similarities/differences in calcification occurred for each core using the regions' information as their reasoning.
    - **Activity 3: Group Presentations**
        - 1. Each group presents their findings to the class, sharing:
            - Which two cores/regions did they study
            - What their graphs showed for each core
            - How their predictions compared to their findings
        - 2. The class engages in a discussion about the key takeaways from the activity.
- **References and Supplementary Materials**
    - Our published CoralCT manuscript for background scientific information (can be accessed here)
    - CoralCT User Guide and video tutorials (available at www.coralct.org)
    - CoralCT Community Slack (join here)
    - Worksheet (see below)
- **Important notes for the instructor:**
    - Make sure to have the CoralCT application downloaded on 4-5 computers (one for each group) ahead of time, as this process can take 15-20 minutes. The link to download CoralCT for both Windows and Mac can be found at www.coralct.org, and further instructions are in the user guide linked above.
    - **To create an account in CoralCT, you must register with an email address. We recommend that the instructor create one account for the entire class for this lesson. However, students cannot work on the same cores in the same account, as this would override data. Therefore, if the class as a whole uses the class account (registered by the instructor), the instructor must ensure all students work on different cores. See the list of recommended cores below for information on each core.**
    - This lesson, including the activities, will most likely take 2-3 full class periods (30 minutes for introduction/explanation and getting started, one hour for activity 1, one hour for activity 2, 30 minutes for conclusions and class discussion). This depends on how much discussion you'd like to include before they begin, and if you are using the worksheet.

- Recommendations:
    - To keep the students organized, use our example worksheet for them to follow, which includes spaces for them to input their graphs and explanations for their predictions and findings. This can be accessed here and used on their computers or printed out (however, they will need to draw their graphs if printed).
    - Use the list of recommended cores (see below) for these activities rather than choosing a core at random, as some cores have a large file size and will take a long time to open on the computers, or some have less distinct banding patterns and will be difficult for the students to map.
    - It may be beneficial to reiterate that this is a collaborative project and each group member should make sure they are participating in some way, and that every member of the group should be working on the core at some point, and helping the person mapping distinguish bands.
    - For downloading CoralCT and mapping bands, we offer a detailed User Guide with step-by-step instructions and images, as well as video tutorials, all linked on our website www.coralct.org
- **Acknowledgments/Authors**
    - This activity was developed by the Sclerochronology Lab at Tulane University to promote STEM education and awareness of coral reef science.

List of Recommended Cores

- **Region: Red Sea, Subregion: Central Red Sea**
    - K01 (*Porites*)
        - This core is longer, with approximately 51 annual density bands. Its bands can be easily distinguished throughout the entire core. Analyses can be expected to show a very slight decline in calcification over time. Its file size is 188 MB.
    - K03 (*Porites*)
        - This core is medium length with approximately 44 bands and should show a distinct decline in calcification rate over time. Its bands are distinct throughout most of the core, with some areas where the bands are not as straight. Its file size is 118 MB.
    - K12 (*Porites*)
        - This core is very short in length, with approximately 9 bands total. The calcification rate stays completely stable over time. This core would be beneficial to practice mapping bands for its small size and distinct bands rather than conducting analyses. It is 30 MB in file size.
    - K15 (*Porites*)

        - The bands of this core are very distinct all the way through. This is a longer core with approximately 50 bands. Analyses should show a slight decline in calcification rate over time. It is 210 MB in file size.
    - K16 (*Porites*)
        - This core is longer, with approximately 48 bands, and has very distinct bands throughout the entire core. It can be expected to show an increase in calcification rate over time. It is 204 MB in file size.
    - K17 (*Porites*)
        - This core is medium length and has distinct bands throughout, although the bands are not completely straight. It has approximately 30 bands and should show a slight decline in calcification over time. It is 90 MB in file size.
    - K19 (*Porites*)
        - This is a longer core with very distinct bands throughout the entire core. It has approximately 53 bands and is expected to show a decline in calcification over time. It is 216 MB in file size.
    - NRS08 (*Porites*)
        - This core is shorter and has slightly less distinct banding. This will be better for a higher challenge for students to map bands. It is 79 MB in file size.
    - NRS09 (*Porites*)
        - This core is a medium length with approximately 19 bands. It has distinct banding throughout and should show an increase in calcification rate over time. It is 94 MB in file size.
    - NRS10 (*Porites*)
        - This core is short in length, with approximately 25 bands that are very distinct and easy to map. It is expected to show a slight decline in calcification rate over time. It is 83 MB in file size.
- **Region: Red Sea, Subregion: Northern Red Sea**
    - NRS13 (*Porites*)
        - This is a shorter core with very distinct bands that are closer together. It has approximately 36 bands and should show a clear decline in calcification rate over time. It is 79 MB in file size.
- **Region: Red Sea, Subregion: Southern Red Sea**
    - F02 (*Porites*)
        - This core is medium length with bands very close together. The bands do become less straight at the bottom of the core. It has approximately 30 bands, and analyses should be expected to show a clear decline in calcification over time. It is 68 MB in file size.
    - F14 (*Porites*)
        - This core is longer, and the bands are distinct but not as straight and slightly harder to follow. This would be a good core to assign after the student(s) have had practice mapping bands. It has approximately 43 bands and should show a decline in calcification rate over time. It is 118 MB in file size.

    - F28 (*Porites*)
        - This core is very short (approximately 15 bands) and has very distinct bands. This core would be good for students to practice mapping bands. It is 48 MB in file size.
    - F46 (*Porites*)
        - This is a very long core with approximately 88 bands. The bands are distinct throughout most of the core, with some areas of less distinction, especially at the bottom. It should show a clear decline in calcification rate over time. It is 291 MB in file size.
- **Region: Taiwan, Subregion: Dongsha Atoll**
    - T752 (*Porites*)
        - This core is shorter and has distinct banding. It has approximately 10 bands and shows a distinct decline in calcification rate. It is 307 MB in file size.
    - T769 (*Porites*)
        - This core has very distinct banding and is medium length, with approximately 21 bands, and is expected to show a clear decline in calcification rate over time. It is 349 MB in file size.
    - T771 (*Porites*)
        - This core is shorter, with approximately 20 bands, and is expected to show a slight decline in calcification rate over time. The bands are also distinct, and the core is 305 MB in file size.
    - T886 (*Porites*)
        - This core is shorter in length and has slightly less distinct banding in parts of the core. It has approximately 14 bands and shows a clear increase in calcification rate over time. It is 324 MB in file size.
    - T892 (*Porites*)
        - This core is a shorter length and has distinct banding. It has approximately 14 bands and should display an increase in calcification rate over time. It is 339 MB in file size.
- **Region: Taiwan, Subregion: Green Island**
    - T703 (*Porites*)
        - This is a short core with very distinct bands and is good for practicing band mapping. It has approximately 14 bands and should show an increase in calcification rate over time. It is 226 MB in file size.
    - T708 (*Porites*)
        - This is a long core with very distinct banding. It has approximately 31 bands and should display a decline in calcification over time. It is 380 MB in file size.

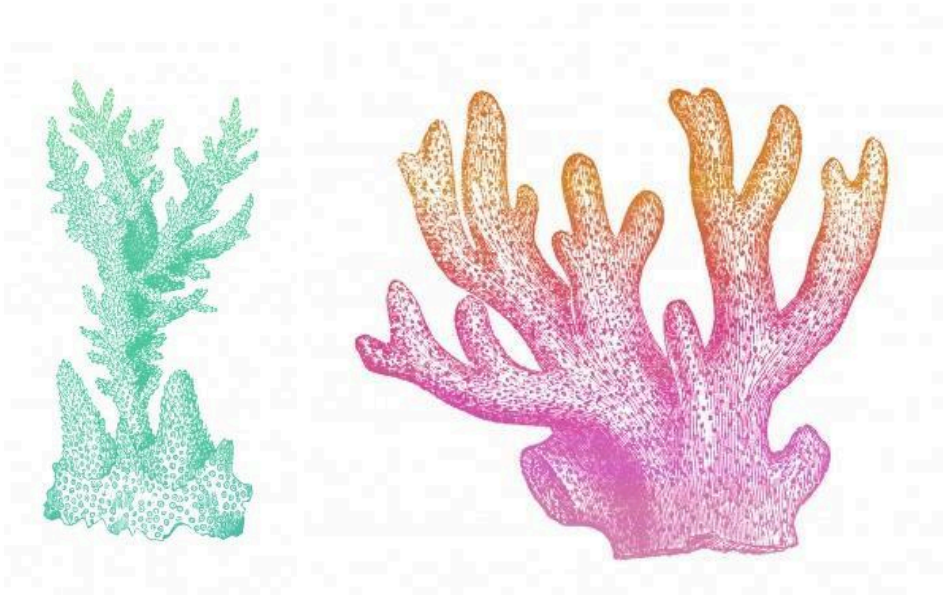
Worksheet

CoralCT Activity

Names: _____

Directions: You should already have CoralCT downloaded on your computer. For more information, please review our User Guide and video tutorials with your teacher.

Important terms to know:
Coral: A marine animal that lives in colonies and builds hard, rock-like skeletons that form coral reefs.
Global Warming: The long-term rise in Earth's average temperature.
Coral growth: The process by which corals build their skeleton and expand. How fast this happens depends on many things, including the type of coral and the health of its environment.
Core: A cylinder-shaped sample that is taken from massive (dome-shaped) coral skeletons and used to study coral health.
Skeleton: The hard, calcium-based structure that corals build and live on and forms the framework of coral reefs.
Calcification: The process by which corals absorb calcium from seawater to build their skeletons.
Calcification rate: How fast the coral is growing. If it's increasing, the coral is growing more. If it's decreasing, the coral is growing less.
Annual Density Bands: Visible layers in a coral's skeleton, like tree rings, that show how much the coral grew in a single year.
CT Scan/X-ray: Imaging tools that help to see the annual density bands of coral cores more clearly, since the bands are often hard to see when looking at the physical core.



Core 1 ID: _____

Region: _____

Subregion: _____

Username: _____

1. How difficult was it to map the bands of this core? Were there any areas of the core where you were unsure of the banding?

2. Do you think the coral is growing more as it gets older? To answer this, look at the spacing between each band (year). As you move up the core (from your last band towards band 1), is the spacing increasing or decreasing between each band?

3. Process your core and go to the Access Data page on the CoralCT main page. Enter the region and subregion of your core, then choose your core. A new menu will appear with everyone's data. Find your username to download your growth rate datasheet onto your computer. Your teacher will demonstrate how to open this in Excel. Once it's open in Excel, select all the numbers in the 'calcification rate' in column G, then create a line graph. Time should be on the bottom, horizontal x-axis, and calcification rate on the vertical y-axis. Add a trendline to the graph (your teacher will demonstrate). Is the growth rate increasing, decreasing, or stable? A reminder that band 1 on the x-axis represents the top of the core.

4. Based on what you know about the environment, why do you think this coral's growth rate is increasing, decreasing, or staying the same?

Core 2 ID: _____

Region: _____

Subregion: _____

Username: _____

5. How difficult was it to map the bands of this core? Were there any areas of the core where you were unsure where the bands were?

6. Make a prediction of the coral's growth rate. Do you think the coral is growing more as it gets older? To answer this, look at the spacing between each band. As you move up the core (from your last band towards band 1), is the spacing increasing or decreasing between each band?

7. Process your core and go to the Access Data page. Enter the region and subregion of your core, then choose your core and find your username to download the growth rate data. Once it's downloaded, open these data on your computer in Excel and find the calcification column. Create a line graph using these data with time on the x-axis and calcification rate on the y-axis. Add a trendline to the graph. Is the calcification rate increasing, decreasing, or stable?

8. Based on what you know about the environment, why do you think its growth rate is increasing, decreasing, or staying the same?

9. Compare your two cores. How are their growth rates similar? How are they different?