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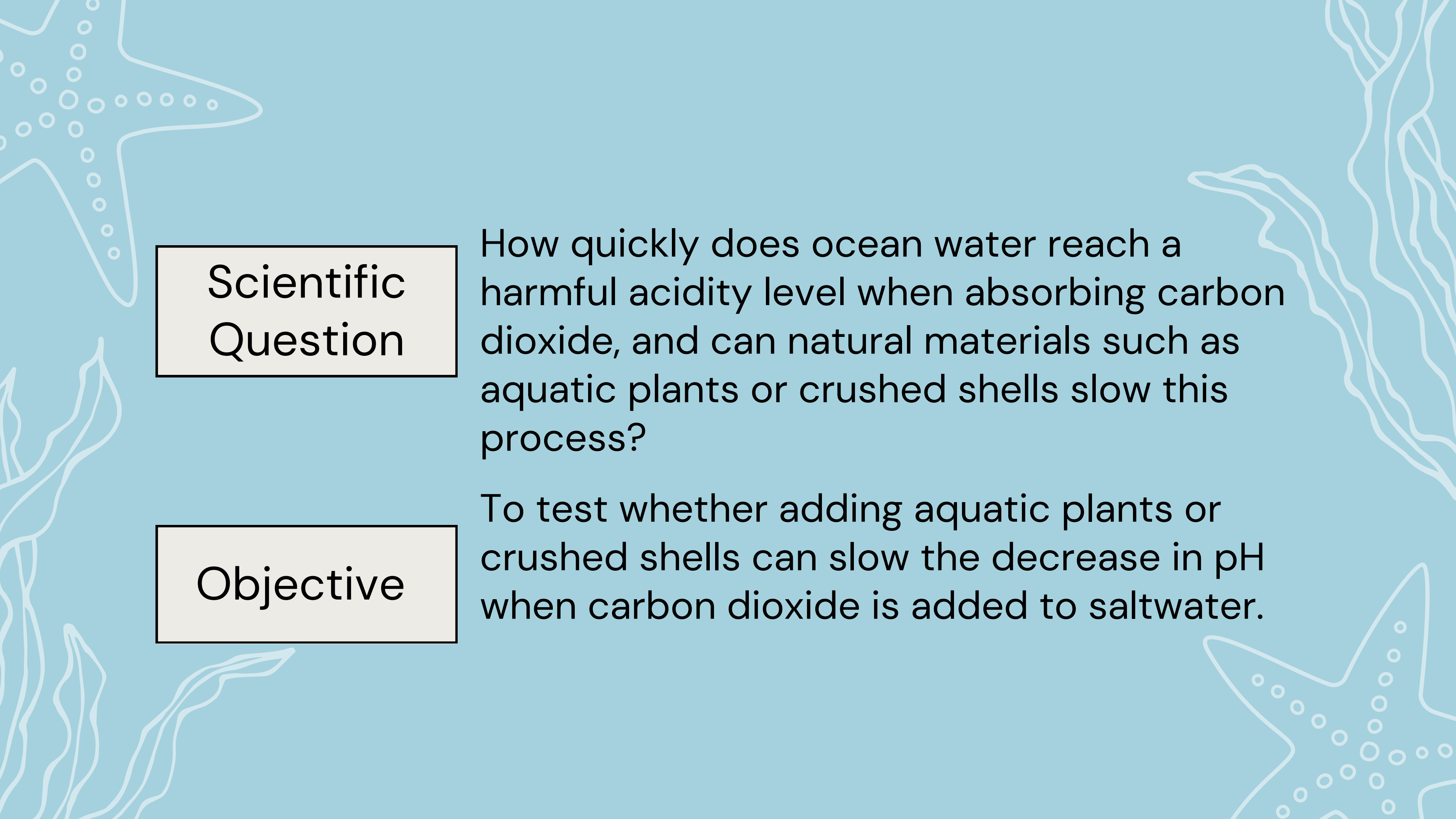
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# Project Contents

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## Scientific Question

How quickly does ocean water reach a harmful acidity level when absorbing carbon dioxide, and can natural materials such as aquatic plants or crushed shells slow this process?

## Objective

To test whether adding aquatic plants or crushed shells can slow the decrease in pH when carbon dioxide is added to saltwater.

# Hypothesis

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If carbon dioxide is added to saltwater with different natural materials, then each container will show a different rate of pH decrease, with crushed shells slowing acidification the most.





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# Prediction

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- Plain saltwater will become acidic the fastest because it has no buffering system.

- The plant container will slow acidification because plants absorb carbon dioxide during photosynthesis.
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- The crushed shell container will slow acidification the most because calcium carbonate acts as a natural buffer.

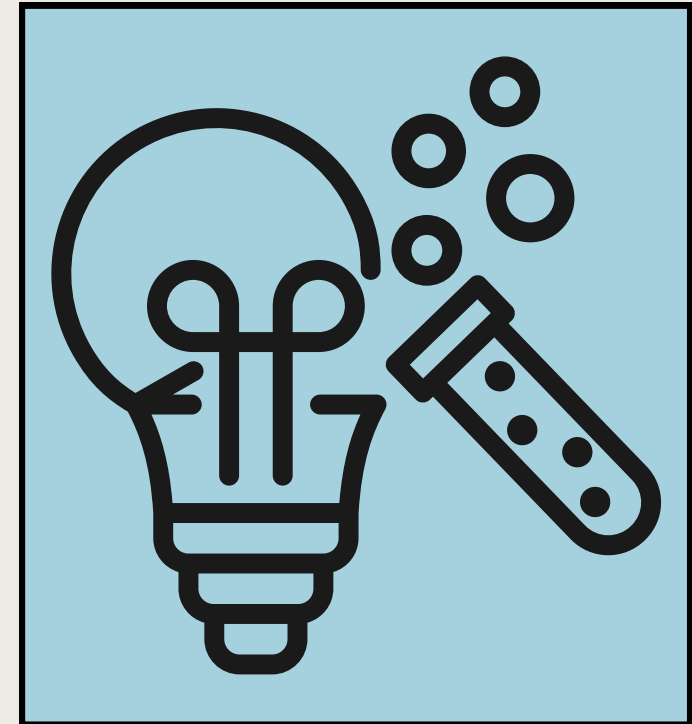
# Research: Part 1

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What is ocean acidification?

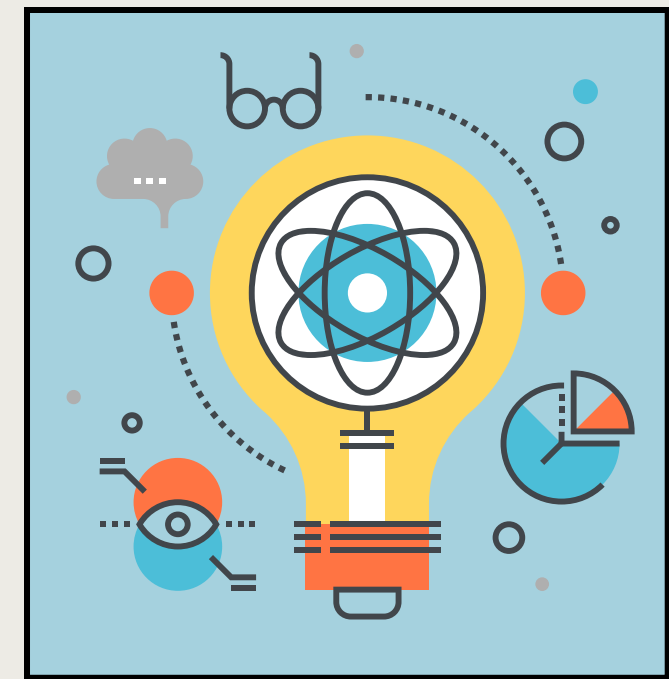
- According to the National Oceanic and Atmospheric Administration, ocean acidification is the ongoing decrease in ocean pH caused by the ocean absorbing carbon dioxide from the atmosphere.
- Over the past 200 years, human activities such as burning fossil fuels have increased carbon dioxide levels. The ocean absorbs about 30% of this carbon dioxide.



# Research: Part 2

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- When carbon dioxide dissolves in seawater, it reacts with water to form carbonic acid:
- $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$
- Carbonic acid increases hydrogen ions ( $\text{H}^+$ ), which lowers pH and makes the ocean more acidic.
- As acidity increases:
- Carbonate ions decrease
- Shell-building organisms struggle to form shells
- Marine food webs may be disrupted



# Research: Part 3

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- Many people depend on ocean life for food and jobs, so ocean acidification can affect human life as well.
- The Process Of Ocean Acidification:
- When carbon dioxide ( $\text{CO}_2$ ) dissolves in saltwater, it reacts with water to form carbonic acid ( $\text{H}_2\text{CO}_3$ ). This reaction lowers the pH of the water, making it more acidic. This chemical process is called ocean acidification.

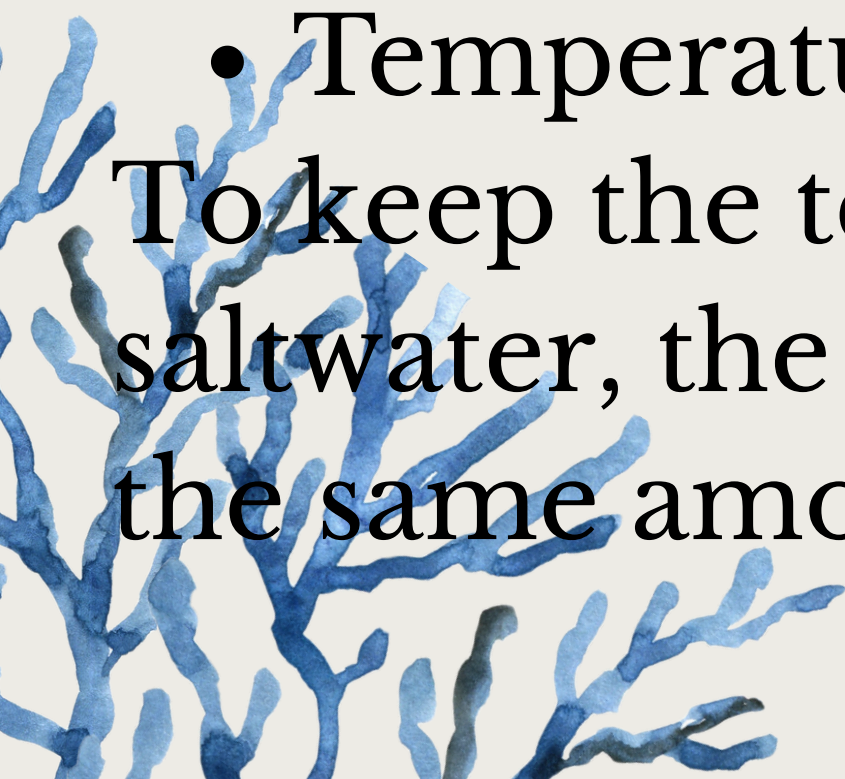




# Variable

## Controlled Variables:

- Amount of saltwater
- Amount of CO<sub>2</sub> (dry ice or reaction amount)
- Time of exposure
- Container size
- Temperature



To keep the test fair and accurate we will use the same amount of saltwater, the same amount of dry ice (CO<sub>2</sub>), and run the test for the same amount of time.



# Variable



Independent Variable:

- Filter

The type of filter in each container (aquatic plants, crushed shells, or nothing).

Dependent Variable:

- pH meter
- The test results
- The pH level of the water over time.

The pH level of the water, which tells us how acidic it is and also the results of the tests



# Materials

3 containers

Salt

Water

Aquatic plants  
(alga seaweed)

Shell

Ph Meter

# Procedure

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1. Prepare three identical containers.
2. Add equal amounts of saltwater to each.
3. Leave one as plain saltwater (control).
4. Add aquatic plants to the second container.
5. Add crushed shells to the third container.
6. Add equal amounts of carbon dioxide to each container.
7. Measure pH at equal time intervals using a calibrated pH meter.
8. Record and compare the rate of pH change.



# Results

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1. The plain saltwater showed the fastest drop in pH
2. The plant container slowed the decrease in pH
3. The crushed shell container showed the smallest change in pH
4. This confirms that calcium carbonate provides the strongest buffering effect.





# Observations



1. The plain saltwater container showed the fastest drop in pH which confirmed that dissolved  $\text{CO}_2$  forms carbonic acid and increases acidity.
  2. The plant container slowed the decrease in pH which was likely because the plants absorbed some of the carbon dioxide during photosynthesis.
  3. The crushed shell container showed the slowest change in pH because the calcium carbonate reacted with excess hydrogen ions reducing the overall acidity this demonstrated buffering capacity.
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Three seashells are arranged vertically on the left side of the slide. They are light-colored with dark, radiating lines. The top shell is slightly open, the middle one is closed, and the bottom one is also closed. The background is a solid light blue color.

# Analysis

## Measurement:

- During the experiment we measured the pH level over time in three containers: plain saltwater, saltwater with plants, and saltwater with crushed shells. All containers received the same amount of  $\text{CO}_2$  and were tested for the same amount of time.
- The plain saltwater showed the fastest drop in pH this demonstrates that when carbon dioxide dissolves in water it forms carbonic acid which increases acidity.

# Ongoing Analysis

## Measurement:

- During the experiment:
- The plant container slowed the pH drop this is likely because plants use carbon dioxide during photosynthesis reducing the amount that forms carbonic acid.
- The crushed shell container showed the slowest change in pH Shells are made of calcium carbonate which reacts with acid and helps neutralize it. This buffering effect made the water more resistant to change.
- Overall the data shows that natural materials can delay acidification but they cannot completely stop it if too much CO<sub>2</sub> is added.



# Analysis – Result

## Results:

- The results support the hypothesis that natural materials can slow ocean acidification.
- The crushed shells were most effective because calcium carbonate chemically reacts with acid, directly reducing hydrogen ion concentration.
- The plant container showed moderate buffering because CO<sub>2</sub> absorption reduced acid formation, but plants cannot remove all dissolved carbon dioxide.
- The control container had no buffering system, so acidity increased rapidly.
- This suggests that while natural systems can delay acidification, they may not prevent it if carbon dioxide levels continue rising.





# Application

According to the Intergovernmental Panel on Climate Change, rising carbon dioxide levels are changing ocean chemistry globally. Coral reefs and shellfish rely on calcium carbonate structures to survive. If carbon dioxide continues to increase, even natural buffering systems may become overwhelmed.

Understanding these buffering systems can help scientists:

- Protect seagrass ecosystems
- Restore oyster reefs
- Reduce carbon emissions

Nature has defense systems — but they have limits.

# Conclusion

This experiment tested how quickly ocean water becomes acidic when carbon dioxide is added and whether natural materials can slow this process. The results showed that plain saltwater became acidic the fastest because it had no protection against the added carbon dioxide. The container with aquatic plants slowed the decrease in pH because plants absorb carbon dioxide during photosynthesis. However, the container with crushed shells maintained the most stable pH level. This is likely because crushed shells contain calcium carbonate, which acts as a natural buffer and helps neutralize acid as it forms





# Ongoing Conclusion

This experiment supports the idea that natural buffering systems can delay ocean acidification. However, it also suggests that there may be a tipping point where too much carbon dioxide overwhelms the ocean's ability to protect itself. This is important because many marine organisms depend on stable pH levels to survive. If ocean acidification continues, it could affect food chains, ecosystems, and even human life.

# Sources Of Error



1. The dry ice may not have released exactly the same amount of carbon dioxide in each container. Even small differences could affect pH results.
2. The pH meter may not have been perfectly calibrated, which could slightly change the recorded values.
3. The aquatic plants may not have absorbed carbon dioxide at the same rate if lighting or plant condition varied.
4. The crushed shells may not have been evenly sized. Smaller pieces react faster because they have more surface area.
5. The experiment was short-term. In the real ocean, acidification happens over many years, so long-term effects were not tested.
6. The containers cannot fully copy ocean currents, pressure, temperature changes, or biological interactions.

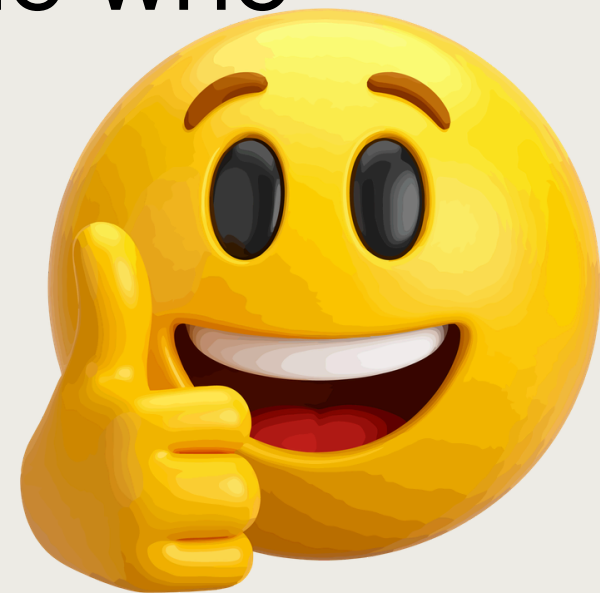


# Acknowledgments



Thank you to our parents for supporting me through this great process.

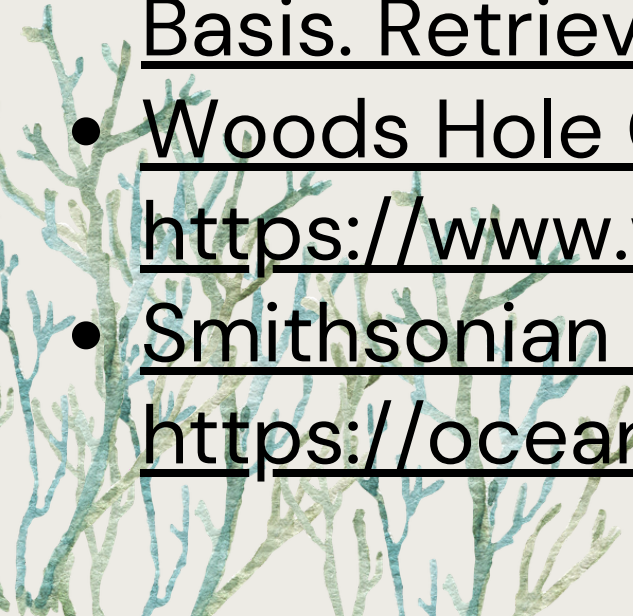
We are grateful to have the support of our science teacher Mr. Maaz Elahi for helping perfect our processes and making our work the best it can be. Thank you to Sara for inspiring us to do the best project we possibly could do. Thank you to Omar bin Al Khattab school and to the CYSF instructor/help in science project, Ms.Hadil El-Cheikh making this possible. Lastly, this was a great experience thanks to everyone who helped develop and make our project come true!



# Citations



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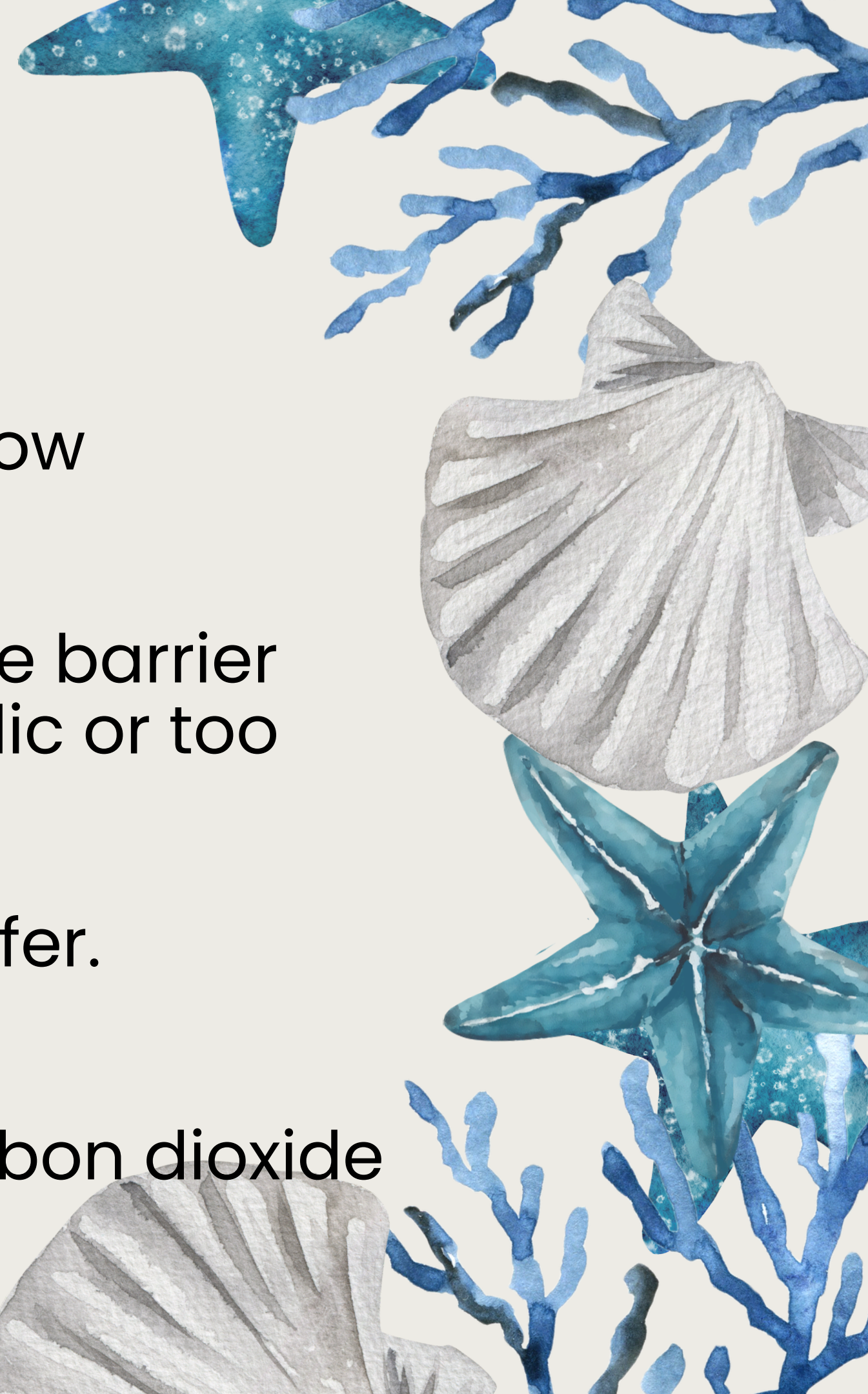
# what is a buffer?

A buffer is a substance that helps resist or slow changes in pH.

In simple terms, a buffer acts like a protective barrier that prevents water from becoming too acidic or too basic too quickly.

- In ocean chemistry:
- Calcium carbonate acts as a natural buffer.
- It reacts with excess hydrogen ions ( $H^+$ ).
- This helps stabilize pH levels.

However, buffers have limits. If too much carbon dioxide is added, the buffering system can become overwhelmed.





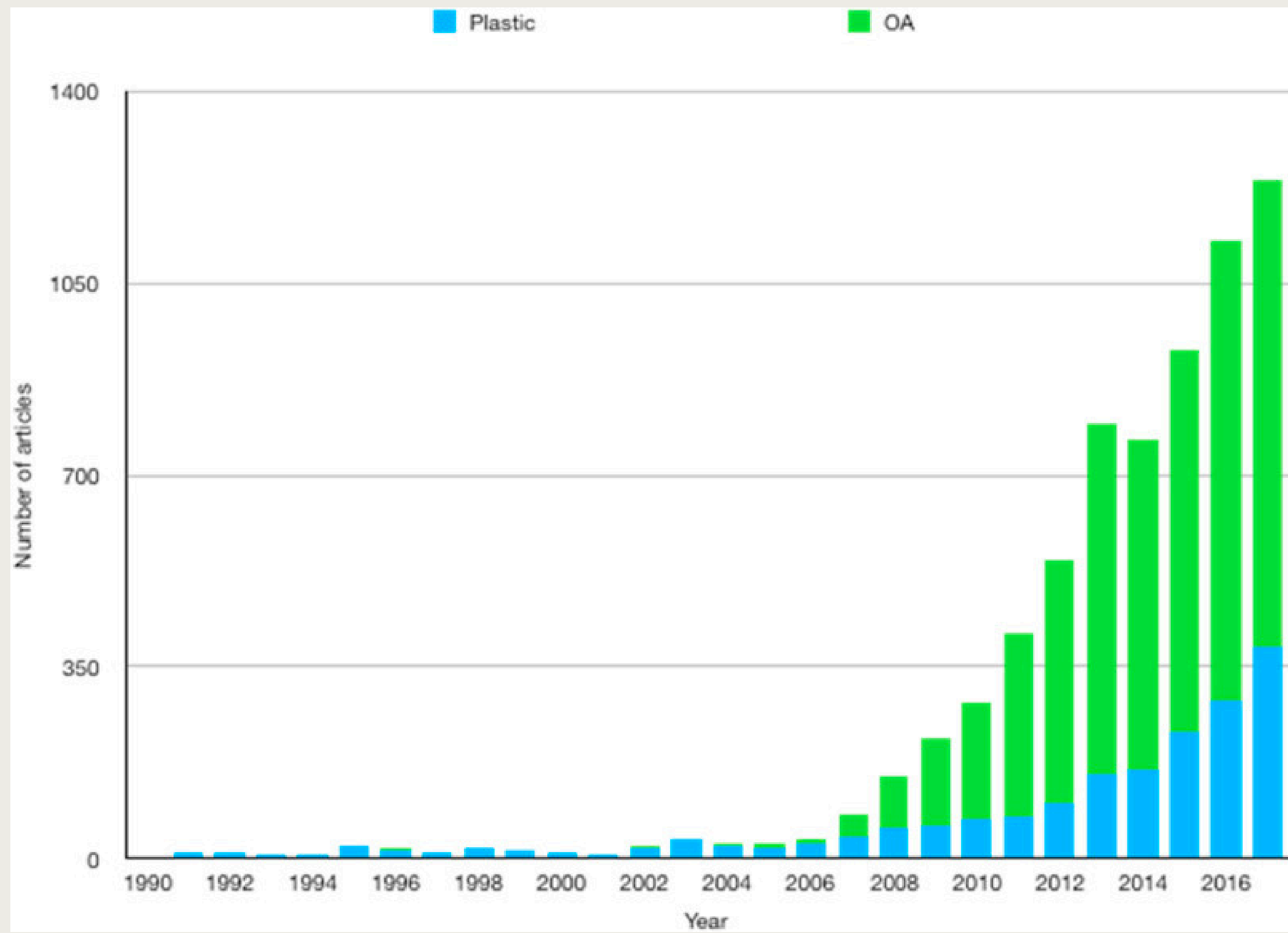
# What is Calcium Carbonate?

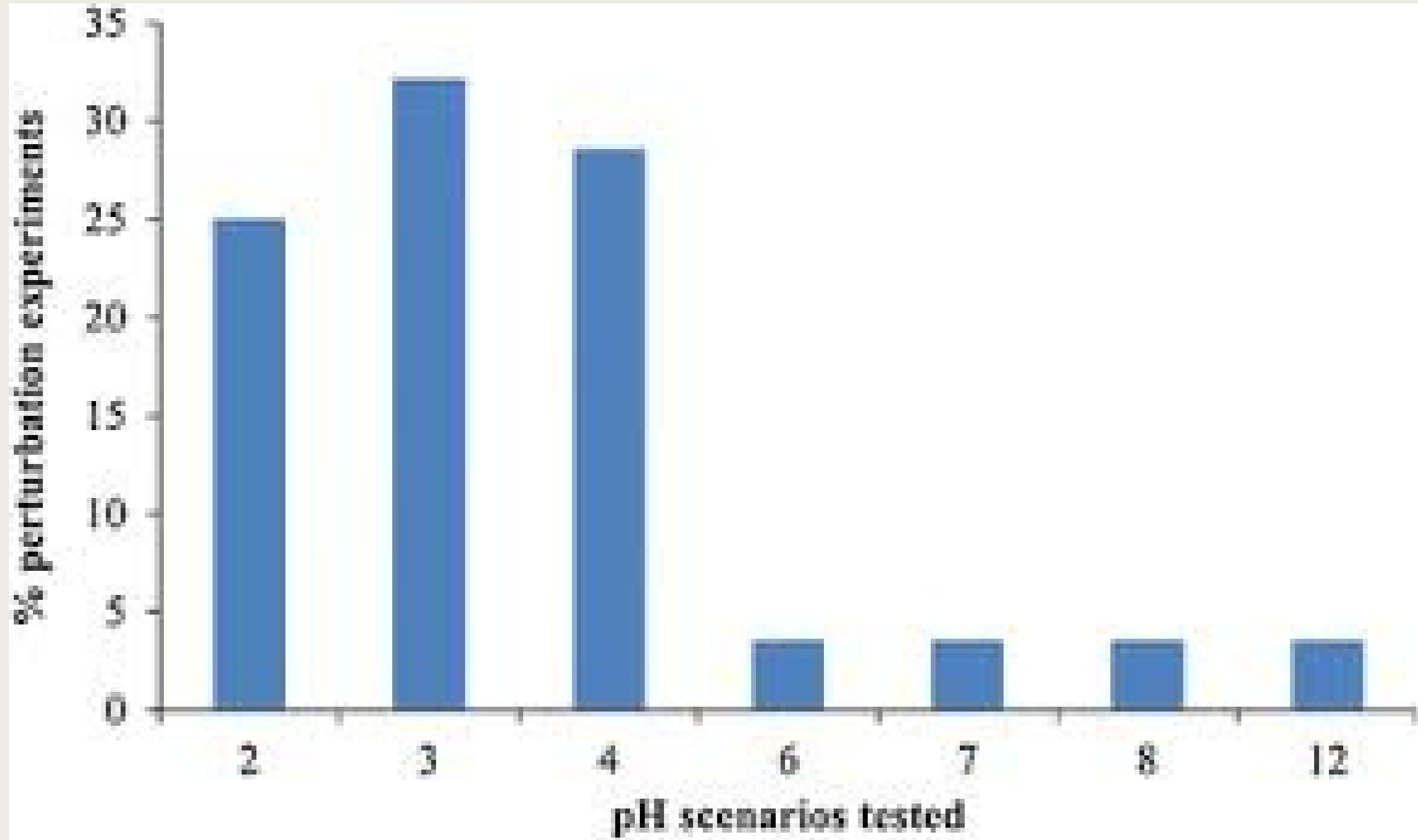
Calcium Carbonate ( $\text{CaCO}_3$ ) is a common, odorless, white chemical compound found naturally around the world.

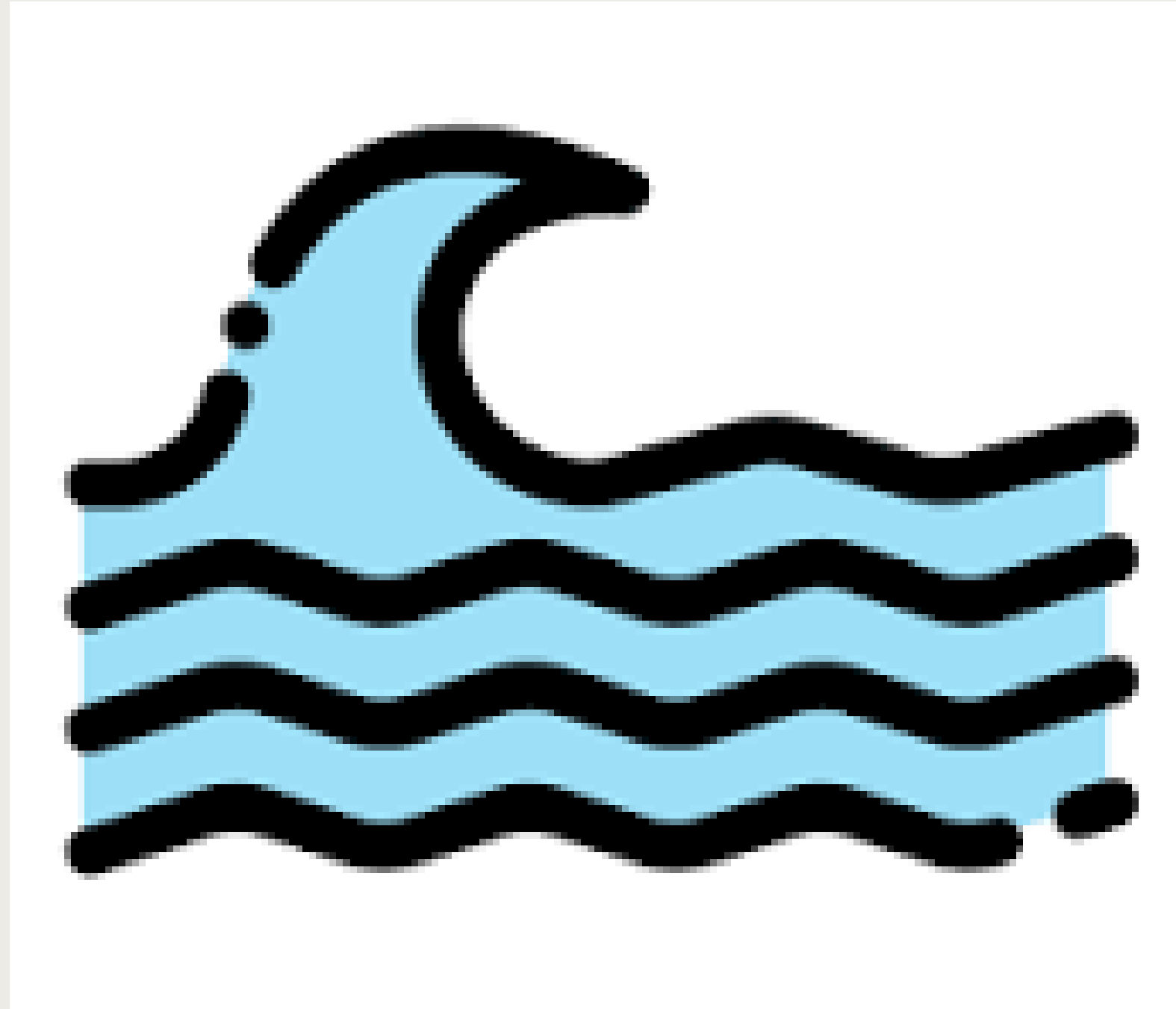
It is found in:

- Limestone
- Chalk
- Marble
- Eggshells
- Seashells

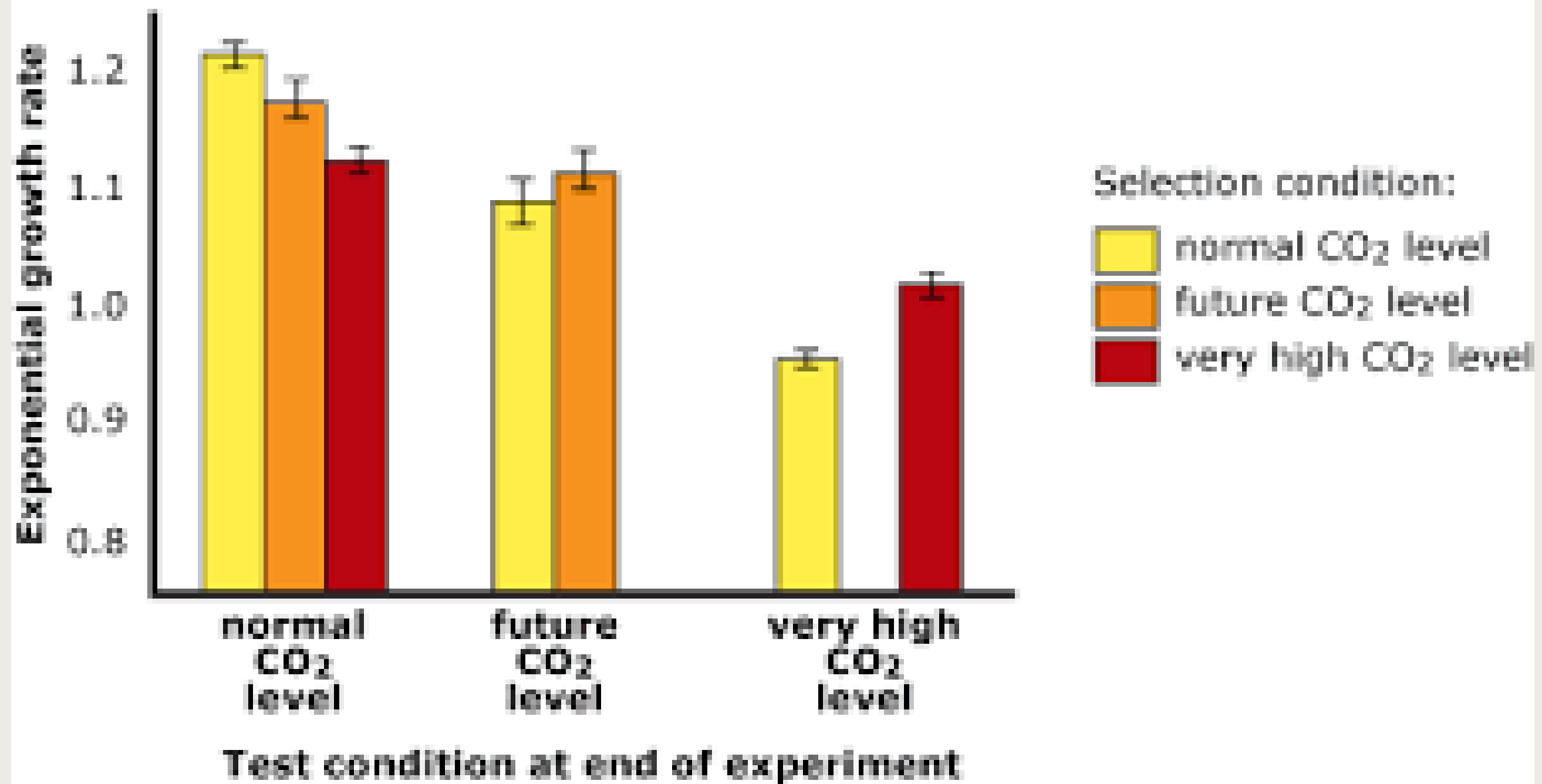
Many marine organisms such as clams, oysters, and corals build their shells and skeletons using calcium carbonate. In our experiment, crushed shells contain calcium carbonate, which helps reduce acidity by reacting with excess hydrogen ions in the water.

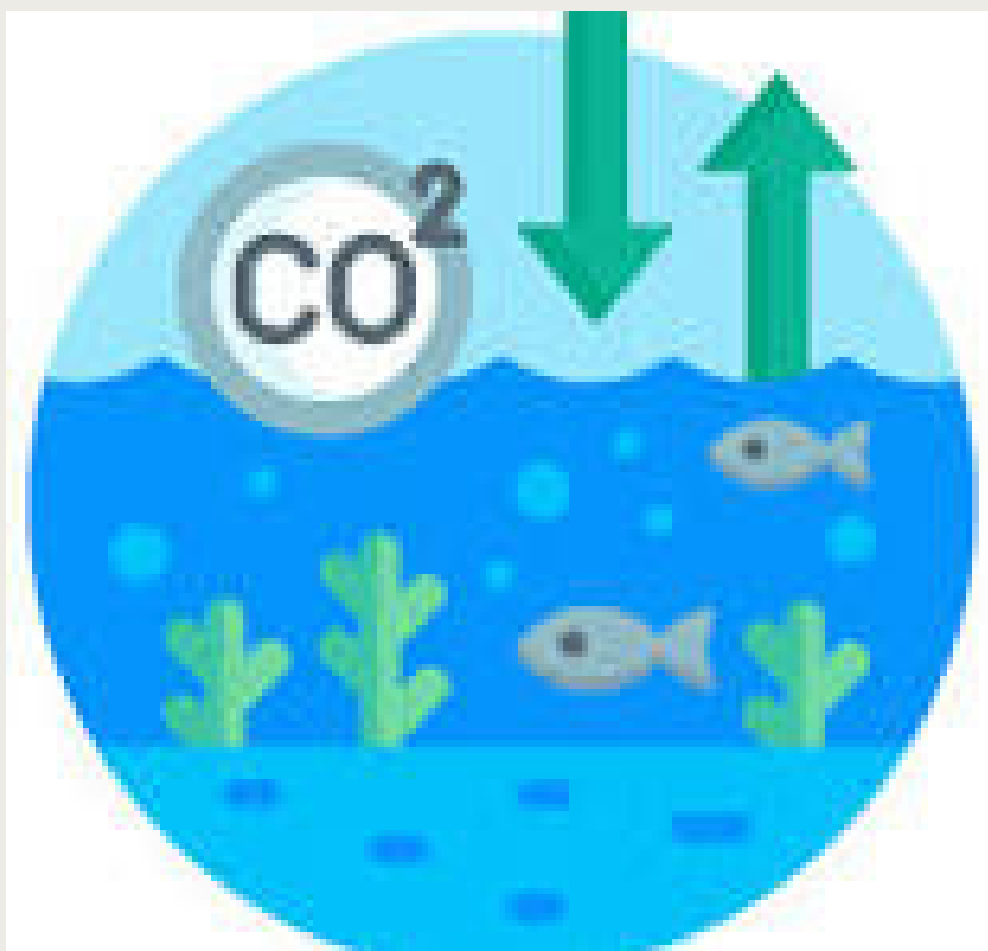
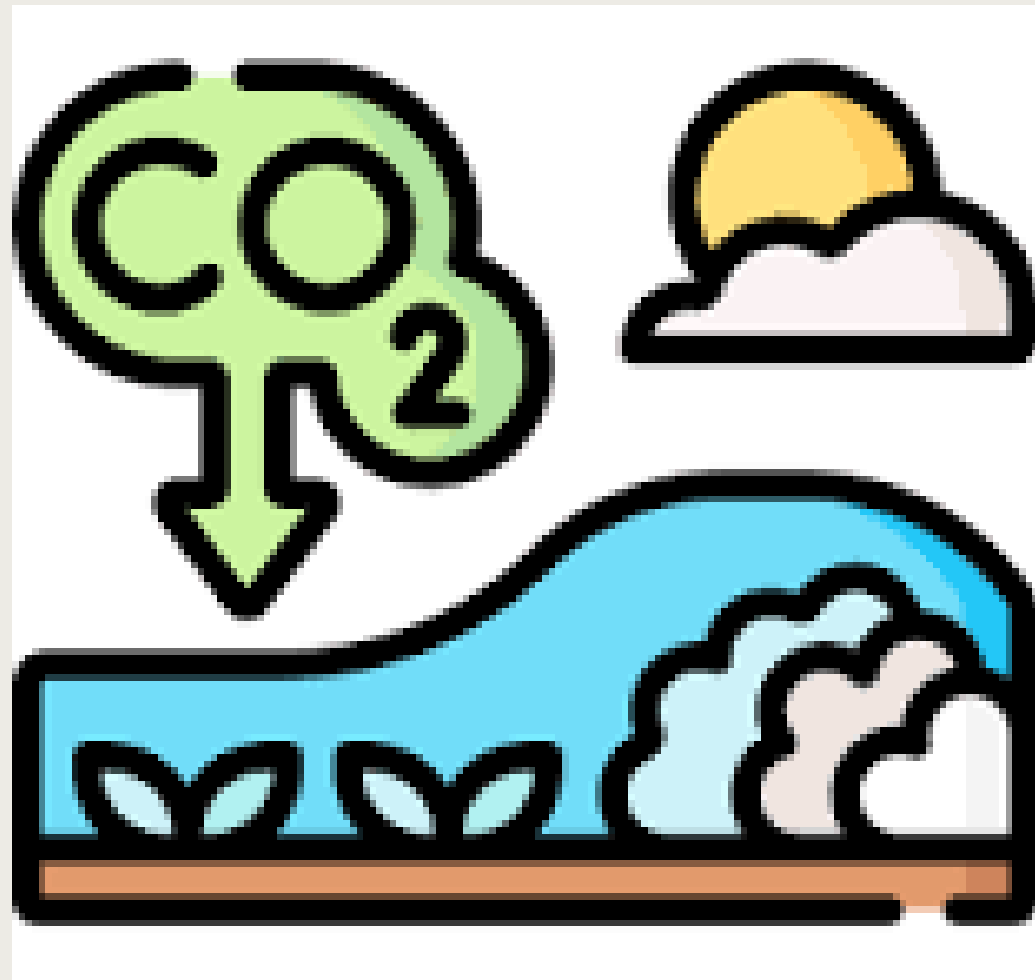




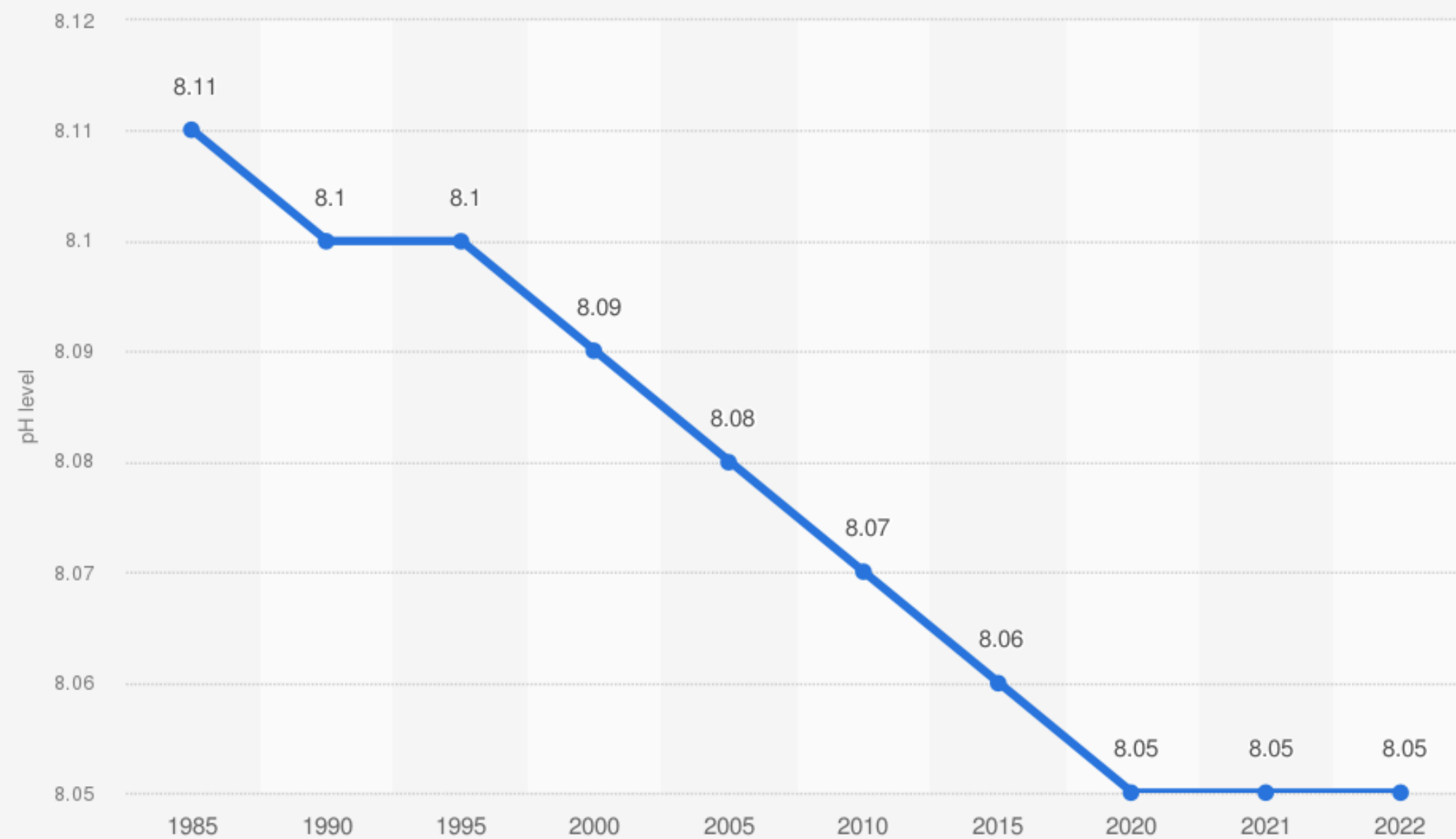


## Results of artificial selection experiment





Average ocean pH level worldwide from 1985 to 2022



Sources  
EEA; Copernicus marine service  
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Additional Information:  
Worldwide; Copernicus marine service; 1985 to 2022

