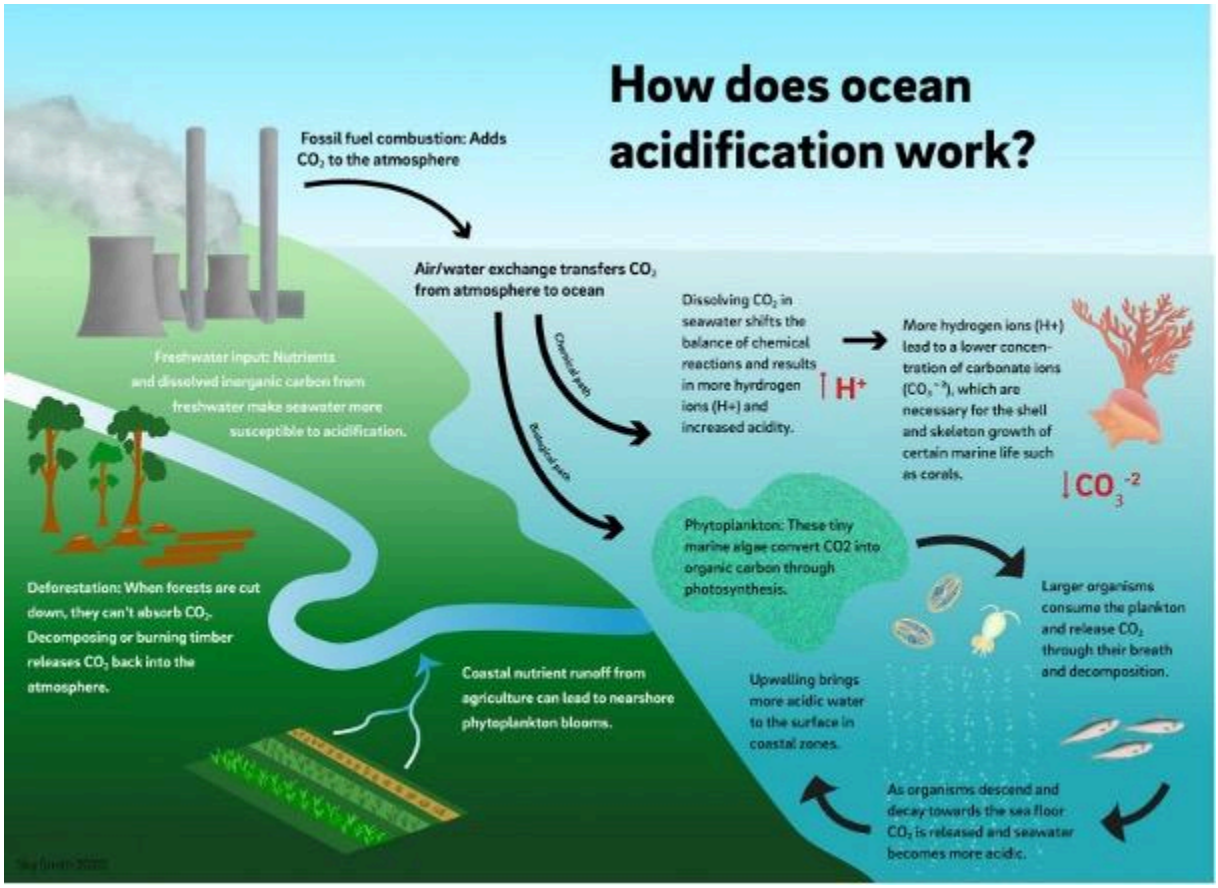
Lesson 2: Ocean Acidification Information

When carbon dioxide (CO2) is released into the air, approximately half remains in the atmosphere, while the other half is absorbed, with plants and oceans each taking about half of the absorbed CO2. Since the industrial revolution, the oceans have absorbed around one-third of all CO2 emitted from fossil fuels, leading to a 30 percent increase in seawater acidity, which is a consequence of human activities.

1. **What is Ocean Acidification?**



Ocean acidification is a process in which seawater becomes more acidic over an extended period of time, caused primarily by the uptake of carbon dioxide (CO2) from the atmosphere. When CO2 is absorbed by seawater, a series of chemical reactions occur resulting in the increased concentration of hydrogen ions. This increase causes the seawater to become more acidic and causes carbonate ions to be relatively less abundant. Carbonate ions are an important building block of structures such as seashells and coral skeletons. Decreases in carbonate ions can make building and maintaining shells and other calcium carbonate structures difficult for calcifying organisms such as oysters, clams, sea urchins, shallow-water corals, deep-sea corals, and calcareous plankton. These changes in ocean chemistry can affect the behavior of non-calcifying organisms as well. Certain fish's ability to detect predators is decreased in more acidic waters. When these organisms are at risk, the entire food web may

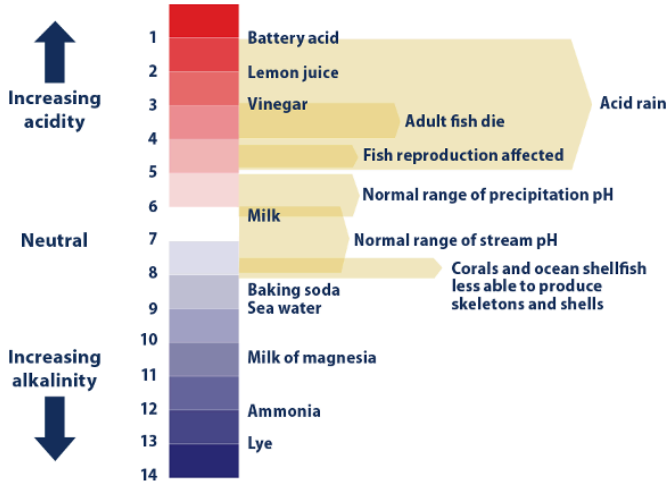
also be at risk. Human activities, such as the burning of fossil fuels and deforestation, have increased the concentration of CO2 in the atmosphere, which is absorbed by the ocean, causing ocean acidification. The average acidity of seawater has increased by 30 percent due to human activities. The pH of the ocean surface has fallen from approximately 8.15 to 8.05 between 1950 and 2020, and atmospheric CO2 levels exceeding 410 ppm (in 2020) are the primary cause of ocean acidification. Ocean acidification is affecting the entire world's oceans, including coastal estuaries and waterways.

2. How is Ocean acidification measured?

Ocean acidification can be measured in a few different ways, including pH, total alkalinity (TA), and dissolved inorganic carbon (DIC):

- **pH:** pH is a measure of how many free hydrogen ions are in the seawater. The more hydrogen ions, the more acidic the water. The pH scale ranges from 0 to 14, with 7 being neutral, below 7 being acidic, and above 7 being basic. The average pH of seawater is around 8.1, but it can vary from about pH 7 to pH 8.5
- **Total alkalinity (TA):** TA is a measure of the ability of seawater to neutralize acid. It is the sum of all the bases in seawater, including bicarbonate, carbonate, and hydroxide ions. As ocean acidification occurs, the TA of seawater decreases
- **Dissolved inorganic carbon (DIC**): DIC is the amount of carbon dioxide (CO2) that is dissolved in seawater. As CO2 is absorbed by seawater, the DIC concentration increases

Scientists use a variety of instruments and methods to measure these parameters, including spectrophotometry, titration, and sensors. These measurements are taken at various depths and locations in the ocean to get a better understanding of how ocean acidification is affecting different regions and ecosystems. Overall, monitoring ocean acidification is crucial for understanding its impacts on marine ecosystems and for developing strategies to mitigate its effects.

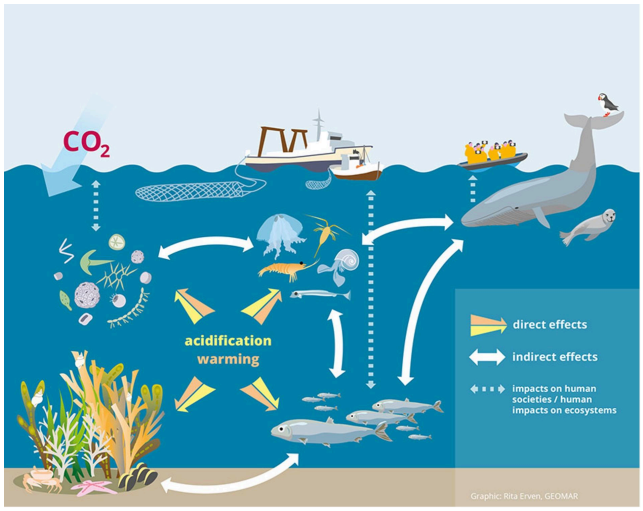


3. Impacts on Ocean Life

Ocean acidification is a significant problem that is affecting marine ecosystems and the people who rely on them. Here are some of the impacts of ocean acidification on the ocean:

- **Reduced calcification**: Ocean acidification reduces the availability of carbonate ions, which are essential for calcifying organisms such as oysters, crabs, sea urchins, lobsters, and coral to build and maintain their shells and skeletons. Studies suggest that marine shells and skeletons may dissolve more easily as pH decreases
- **Weakened coral reefs**: Coral reefs are an important home for many living things, and their health is essential to many ecosystems. Acidic ocean water can cause coral to grow more slowly and weaken coral reefs
- **Disrupted food webs:** Ocean acidification can affect the behavior of non-calcifying organisms as well. Certain fish's ability to detect predators is decreased in more acidic waters. When these organisms are at risk, the entire food web may also be at risk
- **Changes in marine ecosystems:** Ocean acidification will be a driver for substantial changes in ocean ecosystems this century. These changes may be made worse by the combined effect with other emerging climate-related hazards, such as the decrease of ocean oxygen levels
- **Harm to marine life:** Ocean acidification reduces the amount of carbonate, a key building block in seawater. This makes it more difficult for marine organisms, such as coral and some plankton, to form their shells and skeletons, and existing shells may begin to dissolve. The shells and skeletons of animals such as mollusks, corals, and some varieties of plankton may become less dense or strong
- **Threat to human populations:** Ocean acidification threatens marine ecosystems, which also affects populations who rely on the ocean as a source of income and diet. Over three billion people depend on marine and coastal biodiversity for their livelihoods. Acidification also affects other species vital to the marine ecosystem, including reef-building corals and pteropods (tiny snails eaten by numerous species such as fish and whales)

Overall, ocean acidification is a complex problem that requires a global effort to mitigate its effects. Understanding the impacts of ocean acidification is crucial for developing strategies to protect marine ecosystems and the people who rely on them.



4. Impacts on Humans

Ocean acidification is expected to have negative overall effects on many marine species, which could alter marine food chains and food supply to humans. Acidification also affects other species vital to the marine ecosystem, including reef-building corals and pteropods (tiny snails eaten by numerous species such as fish and whales). Here are some of the impacts of ocean acidification on humans:

- **Threat to food supply:** Ocean acidification threatens marine ecosystems, which also affects populations who rely on the ocean as a source of income and diet. Over three billion people depend on marine and coastal biodiversity for their livelihoods. Acidification also affects other species vital to the marine ecosystem, including reef-building corals and pteropods (tiny snails eaten by numerous species such as fish and whales).
- **Harmful algal blooms:** In the laboratory, many harmful algal species produce more toxins and bloom faster in acidified waters. A similar response in the wild could harm people eating contaminated shellfish and sicken fish and marine mammals
- **Malnutrition:** Ocean acidification can cause changes in the quantity and quality of seafood, causing malnutrition. Tropical fisheries will likely be degraded by ocean acidification, with profound consequences for the people that depend upon them.
- **Pollutants accumulate in human tissue**: Ocean acidification can modify the abundance and chemical composition of harmful algal blooms. These algae are food to shellfish, their natural toxins accumulate in shellfish, and this may in turn negatively affect human health.
- **Human health**: Ocean acidification is an emerging human health issue of ‘substantially greater complexity, and possibly scale than currently appreciated’. It has wide-ranging implications including the accessibility and quality of food that we

eat, it will affect the air that we breathe, the medicine we need, and the views that we enjoy.

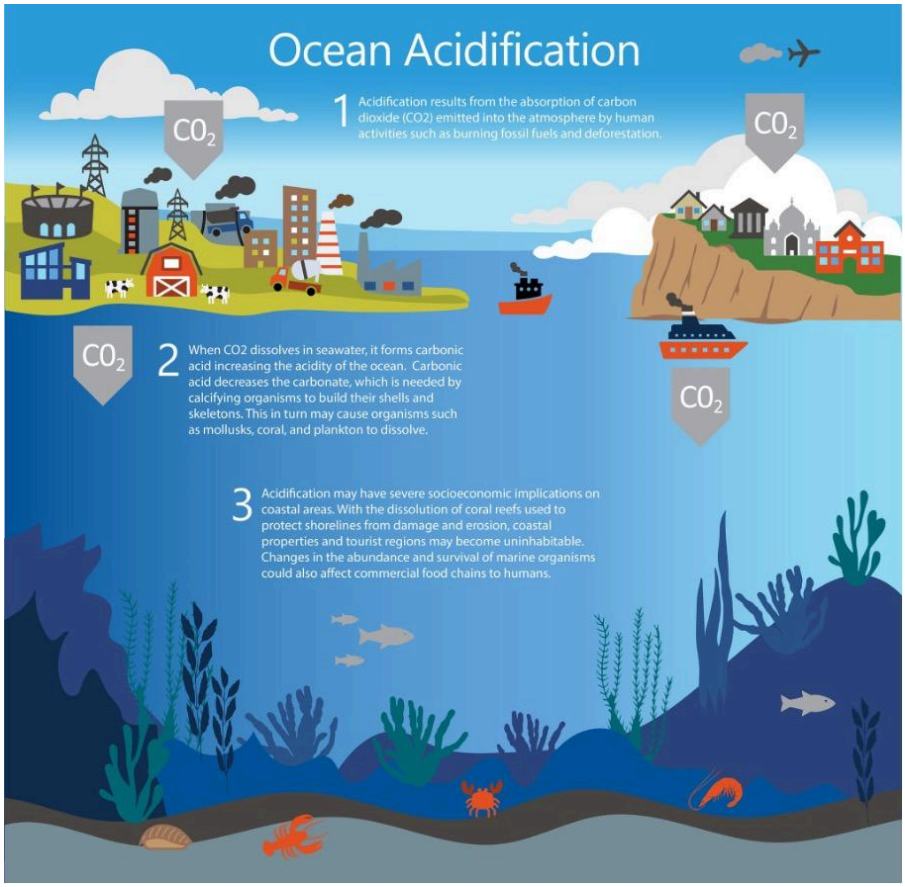
Overall, ocean acidification is a complex problem that requires a global effort to mitigate its effects. Understanding the impacts of ocean acidification is crucial for developing strategies to protect marine ecosystems and the people who rely on them.

5. Solutions

Ocean acidification is a complex problem that requires a global effort to mitigate its effects. Here are some solutions to ocean acidification:

- **Reduce greenhouse gas emissions:** The most obvious and effective way to prevent further ocean acidification is to drastically reduce carbon emissions. This means cutting down on - and ideally eliminating - our reliance on fossil fuels and transitioning to renewable energy sources
- **Strict and relevant regulations**: Governments can implement strict regulations on industries that contribute to ocean acidification, such as the fossil fuel industry, to reduce their carbon emissions
- **Civil education:** Educating the public about the impacts of ocean acidification and how they can reduce their carbon footprint can help raise awareness and encourage individuals to take action
- **Consuming only the "right fish"**: Certain types of fish, such as sardines and anchovies, have a lower impact on the environment and are more sustainable to consume than other types of fish
- **Reducing the consumption of meat**: The meat industry is a significant contributor to greenhouse gas emissions, so reducing meat consumption can help reduce carbon emissions
- **Utilizing nuclear and nuclear-derived techniques:** Scientists can use nuclear and nuclear-derived techniques to develop a science-based understanding of changes in the ocean and to monitor ocean acidification

Overall, addressing ocean acidification requires a multi-faceted approach that involves reducing carbon emissions, implementing regulations, educating the public, and promoting sustainable practices. By taking action now, we can help protect marine ecosystems and the people who rely on them.


Ocean Acidification
1 Acidification results from the absorption of carbon dioxide (CO2) emitted into the atmosphere by human activities such as burning fossil fuels and deforestation.
CO2
CO2
CO2
CO2
2 When CO2 dissolves in seawater, it forms carbonic acid increasing the acidity of the ocean. Carbonic acid decreases the carbonate, which is needed by calcifying organisms to build their shells and skeletons. This in turn may cause organisms such as mollusks, coral, and plankton to dissolve.
3 Acidification may have severe socioeconomic implications on coastal areas. With the dissolution of coral reefs used to protect shorelines from damage and erosion, coastal properties and tourist regions may become uninhabitable. Changes in the abundance and survival of marine organisms could also affect commercial food chains to humans.