



INTERNATIONAL ALLIANCE TO  
COMBAT OCEAN ACIDIFICATION

# CONNECTING ACIDIFICATION AND WATER QUALITY MANAGEMENT

[www.oaalliance.org](http://www.oaalliance.org) |   

# Ocean vs. Coastal Acidification: What is the Difference?

## Ocean Acidification

Ocean acidification (OA) is a direct result of human-caused carbon dioxide (CO<sub>2</sub>) emissions and is altering the chemical balance of seawater that marine life depends upon for proper functioning and survival.

When CO<sub>2</sub> combines with seawater, it sets off a chemical reaction that lowers the pH of seawater, making it more acidified. We call this process “ocean acidification” or OA. The chemical changes of ocean acidification also decrease the availability of carbonate ions, which many species like shellfish, finfish and coral need to grow, reproduce, and thrive.

Direct impacts of acidification are already evident in some regions of the United States, particularly in the disruption of vulnerable shellfish aquaculture operations. Researchers anticipate broader ecological impacts as acidification intensifies.

## Coastal Acidification

While ocean acidification is primarily driven by climate change and carbon emissions, coastal acidification often results from the same factors that drive eutrophication and hypoxia, including local sources of human-caused land-based nutrient pollution (excess nitrogen and phosphorus) that enter the ocean through wastewater, stormwater, and agricultural runoff.

## Eutrophication

Eutrophication is the accelerated enrichment of nutrients in a body of water, leading to an overgrowth of algae and organic matter. In coastal ecosystems, this excessive algae growth results in enhanced biological respiration of organic carbon, which lowers the pH and contributes to coastal acidification.

In addition to coastal acidification, eutrophication also raises the risk of hypoxia (low oxygen) and toxic harmful algal blooms (HABs).

Additionally, natural processes such as upwelling in nearshore environments can be a major contributor to coastal eutrophication. These processes are also susceptible to changing ocean and climatic conditions, which can exacerbate their contribution to eutrophication in the nearshore.

The relative importance of this global vs. local driver of acidification and eutrophication varies along any given coastline, depending on several site-specific factors.

# UNDERSTANDING CAUSES OF OCEAN & COASTAL ACIDIFICATION

The ocean absorbs approximately:

**30%**  
CARBON  
DIOXIDE

**90%**  
EXCESS  
HEAT

## COASTAL ACIDIFICATION

Caused by **land-based pollution**. Excess nutrients (including nitrates) enter the ocean through wastewater, stormwater, and agricultural run-off.

## OCEAN ACIDIFICATION

Caused by atmospheric carbon dioxide emissions ( $\text{CO}_2$ ) from the burning of fossil fuels.

The addition of  $\text{CO}_2$  to the ocean is increasing seawater acidity; we call this process "ocean acidification."

In nearshore and coastal environments, these factors contribute to **EUTROPHICATION**, which can **ACCELERATE COASTAL ACIDIFICATION** in the water column and amplify negative conditions for marine organisms and habitats.

All these sources of excess  
**CARBON &  
POLLUTION**  
CAUSE ACIDIFICATION.

Combined with other stressors like **ocean warming and oxygen loss**, acidification makes it harder for marine life to grow, reproduce and thrive.

Potentially vulnerable species:



Coral



Lobster,  
Shrimp



Fish



Oyster,  
Clam

## UPWELLING

**Carbon stored in deep cold water** being pushed to the surface amplifies acidification in coastal areas.

Upwelling occurs **SEASONALLY** when wind-driven ocean currents push **DEEPER COLDER WATER** up to the surface.

Deeper colder water contains more dissolved inorganic carbon, nutrients and has a lower pH with less calcium carbonate minerals available for marine life.

# What actions are available to Governments?



## Reduce land-based pollution and support necessary infrastructure.

- Actions that prevent or minimize land-based pollution like wastewater and agricultural runoff improve coastal ecosystem functioning and increase species resilience to coastal acidification and eutrophication.



## Protect and restore blue carbon and coastal habitats.

- Healthy and intact coastal wetlands improve coastal ecosystem functioning, sequester and store carbon, and increase resilience in the context of climate change, acidification, and eutrophication.



## Support communications and recognize the need to identify local trends and options to minimize coastal acidification.

- Many states include ocean and coastal acidification as part of their state-led responses to climate change, coastal resilience and/or water quality programs.
- Communications materials about coastal acidification help state agencies, state legislatures, and constituents understand the causes, drivers, and risks to local and state resources when coastal acidification is not measured and adequately addressed.
- Additionally, coastal acidification awareness may increase political or financial support for co-beneficial actions, science needs, or projects.



Invest in monitoring and research to document status, trends, and locally specific drivers of acidification, hypoxia, and harmful algal blooms and investigate the potential for tailored local solutions.

- Support long-term monitoring of the chemical and biological effects of acidification and align assets to extend to hypoxia and HABs.
- Document impacts on coastal economies and livelihoods, and identify ways to mitigate these impacts.
- Invest in research and numerical modeling to determine if and where local inputs of human nutrient sources and hydrological/habitat modification are exacerbating these problems.



Update policies and procedures.

- Update existing policies and procedures to address the water quality challenges caused by acidification and opportunities to confront coastal acidification, hypoxia, and related harmful algal blooms.
- Further update policies and procedures to streamline mitigation measures to support coastal industries impacted by coastal acidification, hypoxia, and HABs.
- Clarify policies and procedures to companies seeking to permit marine carbon dioxide removal technologies in coastal waters, including regenerative aquaculture.

## What role can Water Quality Managers play?

Water quality programs are concerned with physical, chemical, and biological conditions.

For a better assessment of the land-based local drivers of coastal acidification and eutrophication, OA parameters including pH and TA or aragonite saturation, DIC, and DOC can be incorporated into state-led or state-utilized water quality monitoring programs.

State ambient water quality programs can monitor for chemical and biological measures of acidification, hypoxia, and HABs, which will help build a baseline and better quantify the impact of local pollution and nutrient loading to coastal waters.

This will make it easier to measure the relationship between coastal acidification and local inputs of nutrients/organic matter in your area, and to further study how that might impact overall health and productivity of the marine ecosystem.



# OCEAN ACIDIFICATION MONITORING

INTERNATIONAL ALLIANCE TO COMBAT OCEAN ACIDIFICATION

Monitoring for OA can tell us how the ocean is changing in response to climate change and how this may impact marine life, coastal communities, and local economies.

Some areas will experience more rapid change than others. Governments can increase local climate change knowledge and preparedness by incorporating ocean and coastal acidification monitoring into marine management strategies.

**THE MORE WE KNOW, THE BETTER WE CAN RESPOND.**

THE FOLLOWING FOUR PARAMETERS ARE INTERLINKED IN THEIR CHEMISTRY. IF WE MONITOR ANY TWO OF THEM TOGETHER WITH TEMPERATURE AND SALINITY, WE CAN GET AN UNDERSTANDING OF ACIDIFICATION.

## PARTIAL PRESSURE OF CARBON DIOXIDE (pCO<sub>2</sub>)

pCO<sub>2</sub> describes the carbon dioxide (CO<sub>2</sub>) that has absorbed into a liquid, such as seawater. As anthropogenic CO<sub>2</sub> in our atmosphere increases, due to fossil fuel combustion, so does pCO<sub>2</sub> in our seawater.

## POTENTIAL OF HYDROGEN (pH)

pH is the measure of hydrogen ions in a substance, in this case seawater. pH ranges from 0 - 14 and values are logarithmic. As hydrogen ion concentrations increase (as a result of chemical reactions between water and CO<sub>2</sub>) seawater pH decreases.

HOW DO YOU MEASURE OA?

## DISSOLVED INORGANIC CARBON (DIC)

DIC is the total of 4 different substances (carbon dioxide, carbonic acid, bicarbonate ions and carbonate ion) that are dissolved in seawater. They are in a chemical equilibrium, which can go out of balance if too much of one substance is added too quickly. For example, when increased CO<sub>2</sub> emissions are absorbed by the ocean, it forces a chemical reaction which decreases the carbonate ions available for marine life and results in an increase in hydrogen ions.

## TOTAL ALKALINITY (TA)

Alkalinity measures all the negatively charged ions and molecules available in seawater to 'soak up' or bond to the positively charged hydrogen ions. Two components of alkalinity are carbonate ions and bicarbonate ions. Alkalinity is important because it measures the ocean's ability to buffer acidification.

ADDITIONAL MEASURES CAN HELP US BETTER UNDERSTAND MULTIPLE STRESSORS OF CLIMATE-OCEAN CHANGE:



OCEAN TEMPERATURE



SALINITY

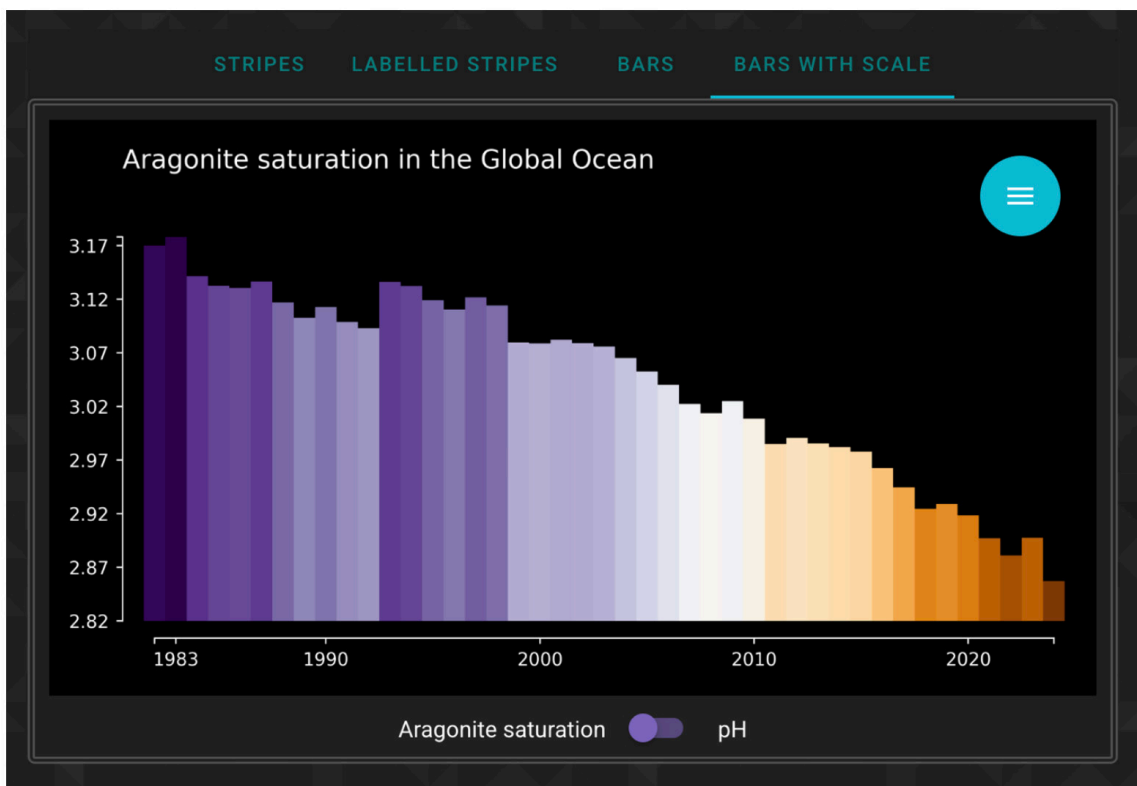


DISSOLVED OXYGEN

## Aragonite Saturation

**Aragonite** is a crystalline form of calcium carbonate that many marine animals use to build their skeletons and shells.

**Aragonite Saturation State** is a measure of how easily aragonite can dissolve in the water. In the context of OA, *saturation state* is an assumed measure of the solubility of a specific organism or species under different availabilities of calcium carbonate. Coral and most shell-forming species like oysters, clams, and mussels need high saturation states to keep from dissolving. OA changes the availability of calcium carbonate and therefore lowers the saturation state of seawater.



The image above shows the declining aragonite saturation of the global ocean. Organisms will start to show signs of distress at aragonite saturation states under 3, and some may even start to dissolve at aragonite saturation states under 1. (Source: [OA Stripes Project](#)).

# Use What You Have: Taking Inventory of Relevant Tools

---

Water quality managers can comprehensively review and strategize how to use state-granted and federally-granted authorities, policies, and procedures to accelerate local solutions to coastal acidification, hypoxia events, and harmful algal blooms.

In the short term, there may be many non-regulatory responses available such as:

- Reviewing existing permitting conditions and determining if incorporating nutrient and organic matter limits in wastewater, stormwater, or agricultural permitted discharges would be useful. This should be informed by local science that documents where that action would be most beneficial.
- Utilizing programs such as agriculture programs and policies to address nutrient and organic matter runoff.
- Applying best management practices, such as enhancing restoration and conservation of blue carbon and coastal habitats.

In the longer term, there may be a desire to:

- Integrate acidification assessments into impaired waters listings.
- Update water quality standards and total maximum daily load implementation.
- Make investments in infrastructure upgrades, utilizing state and federal grant or loan programs.

## Water Quality Assessments, Indicators, and Methodologies

---

Water quality assessments and related indicators (thresholds and criteria) serve as targets for regulating the amount of pollution that any given water body can tolerate. Assessments and indicators also help in planning for mitigation and resilience projects, inside or outside of a regulatory framework.

Including coastal acidification measurements as part of narrative criteria in a water quality program will promote awareness of the issue and the need to begin characterizing and reducing impacts.

Developing assessment methodologies is important in allowing the state to assess designated uses in coastal waters due to acidification, hypoxia, and HABs.

Developing indicators means creating a basis for assessing water body conditions relative to acidification, which will aid in decisions in designating a water body as impaired. Indicators for acidification could be biological or chemical changes from a baseline, which indicate an impact in species abundance or changes the availability of tolerable habitat. This process could lead to updated coastal water quality standards for pH, oxygen content and/or harmful algal blooms.