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PACIFIC YEAR OF THE CORAL REEF
HEALTHY REEF, HEALTHY PEOPLE

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Our vision: *A resilient Pacific environment sustaining our livelihoods and natural heritage in harmony with our cultures.*

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# What Is Ocean Acidification?

Our global ocean has absorbed approximately 30% of the carbon dioxide ($CO_2$) released into the atmosphere. This $CO_2$ combines with seawater to produce carbonic acid, acidifying the seawater and depleting it of carbonate that many forms of sea life need to build their shells. $CO_2$ is an acid gas, so the addition of $CO_2$ to the ocean from burning fossil fuels is making seawater more acidified; we call this process "ocean acidification" or OA.

As the ocean absorbs $CO_2$, the $CO_2$ combines with seawater forming carbonic acid. The carbonic acid quickly dissociates into hydrogen ions and bicarbonate ions. Some of the hydrogen ions then combine with naturally occurring carbonate ions to form more bicarbonate. This reduces the concentration of carbonate in the seawater (Gattuso et al., 2015).

**Ocean acidification is a direct result of carbon dioxide emissions and is altering the chemical balance of seawater that marine life depends upon for survival.**

A reduction in carbonate concentration is bad because carbonate is an important building block for sea life including calcifying plankton and algae, shellfish, sea urchins, and corals that need calcium carbonate to build their shells and skeletons.

This chemical reaction also results in decreasing the seawater's pH. pH is a measure of the concentration of free hydrogen ions in seawater, also known as acidity; the lower the pH, the higher the concentration of hydrogen ions, and the more acidic the water.

## $CO_2$ emissions lead to ocean acidification

195 countries including thirteen Pacific Islands signed the Paris Agreement committing to meaningful and timely action to reduce greenhouse gas emissions to limit global average temperature rise to 1.5 degrees Celsius. While reducing emissions of any combination of greenhouse gasses can address the goal of limiting temperature rise, for ocean acidification, $CO_2$ is particularly important. Reducing methane emissions, for example, can limit temperature rise, but it will not help address ocean acidification. Only by reducing $CO_2$ emissions can we directly mitigate ocean acidification.

Future changes to our ocean due to acidification will largely depend on how much $CO_2$ the global population continues to release. The IPCC Special Report on Ocean and Cryosphere will also provide significant scientific evidence about the hastening rate of ocean acidification and potential impacts.

## Ocean acidification is happening now

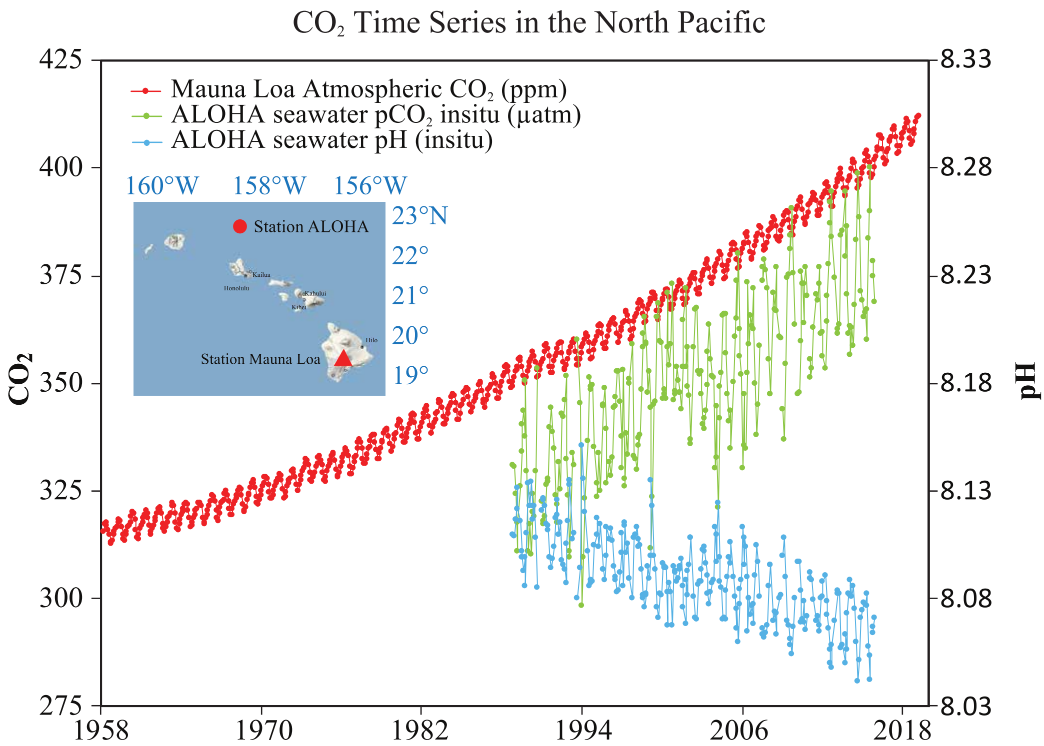
For the last 20 million years, the pH of the surface ocean has remained relatively stable between approximately 8.1 and 8.2. Over the last 200 years, as humans have accelerated the burning of fossil fuels, the ocean's average surface pH has decreased by 0.11, representing a 28% increase in acidification since the start of the industrial revolution. Hence, ocean acidification is not a problem expected to only occur in the future, ocean acidification is already happening and being observed now (Figure 1).

**Ocean acidification is not merely a problem for the future, ocean acidification is already happening and being observed now.**

Projections for the end of this century indicate that our oceans' surface waters could be 150 times more acidified than pre-industrial revolution. This would result in an ocean that is more acidified than at any time over the last 20 million years. It would also mean that the pH will change 100 times faster than at any time in the past (Orr et al., 2005).

Increasing acidification, combined with other climate related changing ocean conditions including warmer temperatures and reduced oxygen levels, is already having significant, adverse impacts on fisheries, aquaculture, and marine ecosystems and these impacts will worsen in the future without urgent action.

1 Since the pH scale is logarithmic, a 0.1 pH decrease change represents approximately a 28% increase in acidity.

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Ref: J.E. Dore et al, 2009. Physical and biogeochemical modulation of ocean acidification in the central North Pacific. *Proc Natl Acad Sci USA* **106**:12235-12240.

**FIGURE 1**: Time series showing increasing atmospheric $CO_2$ (red), increasing seawater $pCO_2$ (green), and decreasing seawater pH (blue).

# Why is Ocean Acidification a Problem?

## OA reduces the ocean's concentration of dissolved carbonate

Ocean acidification threatens our biodiversity. With decreasing seawater concentration of carbonate ions, marine life, including calcifying plankton and algae, shellfish, sea urchins, and corals, will find it more difficult to build their skeletons and shells. This will lead to a reduction in growth for many of these species and ecosystems.

Molluscs and crustaceans (pearl oysters, shrimp, and marine ornamentals) are predicted to be vulnerable to ocean acidification, potentially slowing or reducing their ability to form shells at early life stages (Johnson, 2016; Kroeker, 2013).

One study projects that by 2050, coral reefs will dissolve faster than they can build their skeletons (Eyre, 2018). Loss of coral reefs will mean loss of critical habitat for important seafood species and would result in increased rates of coastal erosion. Modelling suggests that by 2050, only 15% of coral reefs around the world will be in areas that are adequate for sustainable coral growth (Johnson, 2016).

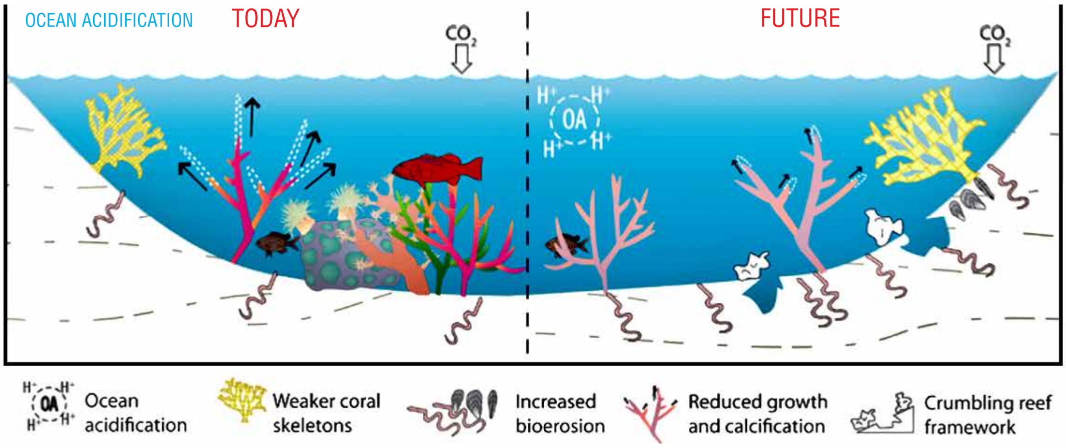


**FIGURE 2**: Effects of projected ocean acidification on coral reefs. Reduced calcification of reef-building corals and calcareous algae as ocean pH declines is expected to change the balance of reef processes from net construction to net erosion, leading to loss of corals and reef frameworks (Hoegh-Guldberg, 2011).

This will have a huge impact on ocean and coastal ecosystems, including coral reef ecosystems, shellfish, and plankton – the basis of the food web. Eventually this will affect livelihoods, food security, and coastal indigenous cultural practices and traditions.

## Many species of fish could experience reduced productivity and growth rates

A study that looked at ocean acidification effects on yellowfin tuna found that larvae reared at decreasing pH levels (pH 8.1, 7.6, 7.3 and 6.9) showed increasing organ damage in the kidney, liver, pancreas, eye and muscle, which correlated with decreased growth and survival (Frommel, 2016). Another recent study examined adaptive potential in the early life stages of yellowtail kingfish to ocean warming and acidification (Munday PL, 2019).

A loss of fisheries productivity would threaten national economies that are highly dependent on fisheries resources, particularly Pacific islands. Fish is a cornerstone of food security for the people of the Pacific – fish provide 50–90% of animal protein in the diet of coastal communities across a broad spectrum of Pacific islands, and national fish consumption per person in many Pacific islands is more than 3–4 times the global average (Bell JD, 2011).

Scientific studies have indicated that ocean acidification also has the potential to impact phytoplankton that form the base of ocean food webs, and could have impacts on fish behavior affecting their sensory ability to detect and avoid predators (Munday & K.B., 2009) though more studies are needed.

## OA adds to other stresses coral reefs face, like ocean warming and coral bleaching

Ocean acidification can be considered a “stress multiplier” for coral reefs, as it combines with other stresses that corals are currently facing, i.e., rising sea surface temperatures, increasing frequency and duration of bleaching events, increasing intensity of tropical cyclones, overfishing, destructive fishing methods, and land-based sources of pollution (Figure 3).

Loss of coral reefs would mean loss of critical habitats for important seafood species and could result in increased rates of coastal erosion and a threat to the tourism industry. Coral reefs also play a role in dissipating 97% of the wave energy that would otherwise impact shorelines (Ferrario et al., 2014).

Ocean acidification combines with the impacts of other stressors, e.g., ocean warming and reduced oxygen levels, increasing the stress on marine species and ecosystems.

This means that local actions to reduce these exacerbating stressors can increase the resilience of our marine species and ecosystems. Local actions to reduce impacts of OA also have multiple beneficial outcomes.

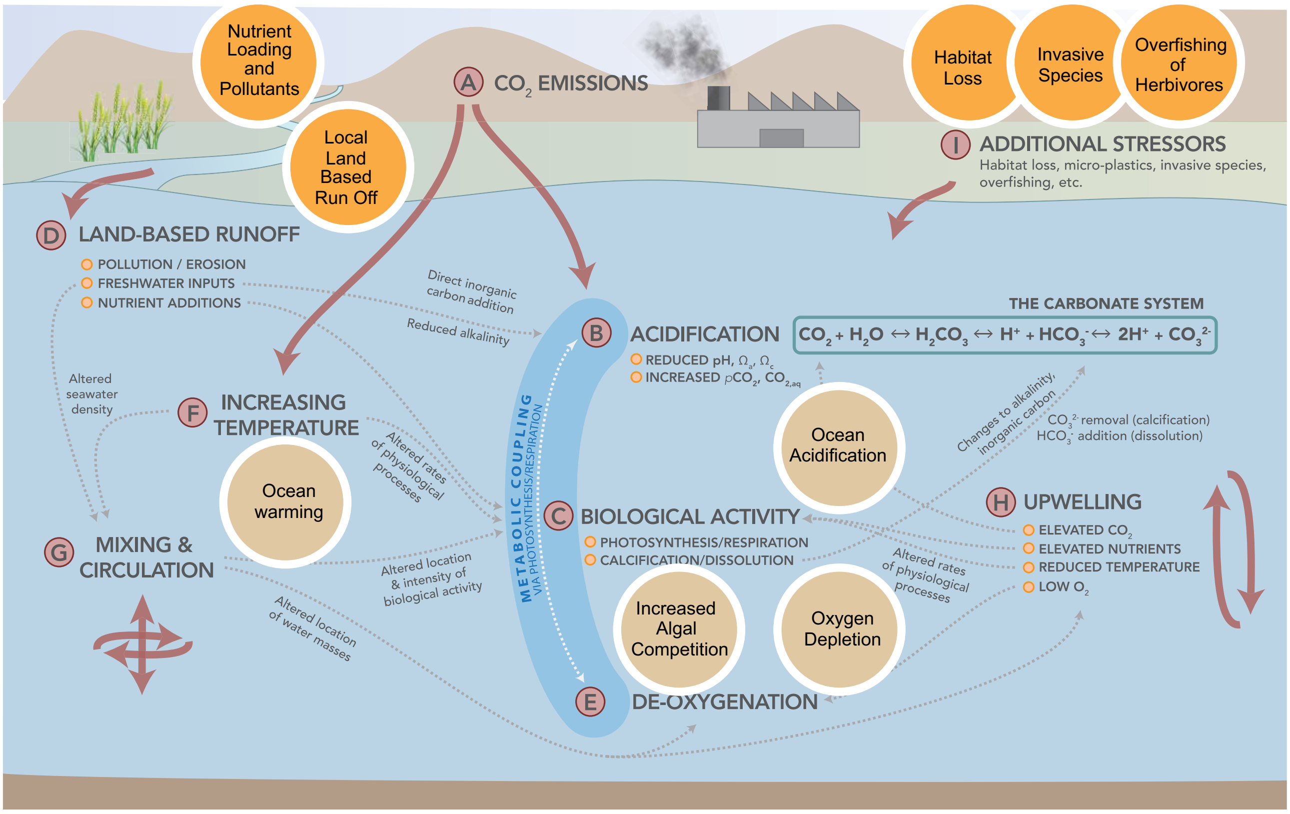


**FIGURE 3**: Adapted from The West Coast Ocean Acidification and Hypoxia Science Panel, “Multiple stressor considerations: Ocean Acidification in a deoxygenizing ocean and warming climate.” Provides an overview of the major driving processes (and associated linkages among them) in coastal oceans. (A) Atmospheric $CO_2$-driven (B) acidification occurs against a backdrop of additional drivers of change in ocean conditions, including (D) land-based runoff, (E) deoxygenation, (F) warming, (G) mixing and circulation, (H) upwelling, and (I) other additional stressors. Processes can be accentuated in bodies of water with low circulation and mixing, for example tidal flushed bays and estuaries, as well as tidepools. Note: Location of processes relative to one another does not denote actual location in the water column (Hales, 2016).

**In addition to reducing emissions of $CO_2$, governments must manage coral reefs and other vulnerable ecosystems and species to maximize their ability to cope with future changes.**

To best maximize resilience strategies and buffer against the worst impacts of ocean acidification, more scientific research examining adaptative capacity of key species and ecosystems under increased acidification and ocean warming is needed.

# Assessing Ocean and Coastal Vulnerability in the Pacific Region

Several publications including, “Pacific Islands Ocean Acidification Vulnerability Assessment” (Johnson, 2016), “Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change” (Bell JD, 2011), “Status and Trends of Coral Reefs of the Pacific” (Moritz C, 2018), and the “Pacific Marine Climate Change Report Card” (CMEP 2018) (Figure 4) have explored Pacific vulnerability to ocean acidification and have identified priority areas and resources at risk (Figure 5).


**FIGURE 4:** Examples of recent Pacific island regional marine vulnerability assessments. (Bell JD, 2011; Johnson, 2016; Moritz C, 2018; CMEP, 2018).

| Asset | Regional Importance | Vulnerability | |
|---|---|---|---|
| Coral Reefs | High | Very High | |
| Reef Fish | High | High | Moderate |
| Aquaculture | Moderate-High | Species Dependent | |
| Oceanic Habitats | Moderate | Uncertain | |
| Tuna | Very High | Uncertain | |
| Food Security | Very High | Very High | |
| Livelihoods | Very High | High | Moderate |
| Reef-dependent Communities | Varies by Country | High | Moderate |
| Economic Development and Revenue | Very High | Moderate | Uncertain |

**FIGURE 5:** Pacific island natural assets at risk to OA. Based on data from Johnson, 2016.

## Recommendations for Pacific Islands

1. Improve monitoring and observations of OA in the region and evaluate impacts to key species and ecosystems.
2. Incorporate OA into ecosystem-based and coastal zone management plans.
3. Implement and evaluate adaptation measures that improve resilience.
4. Raise awareness and understanding about report findings, conclusions and recommendations.
5. Collaborate across international, regional and national policies and frameworks.

# Mainstreaming OA Into National Policies

To further support and advance implementation of the regional recommendations listed above, Pacific island countries and territories (PICTs) can take any number of tangible actions across the following themes. Because ocean acidification is a multi-sectoral issue, it is important that governments coordinate this work across appropriate Ministries and departments (environment, fisheries, climate), across multiple sectors, and in coordination and collaboration with other governments, chiefs, local experts and traditional knowledge holders, local academic institutions and regional and international ocean acidification networks.

## MONITORING OCEAN ACIDIFICATION

| **Expand and sustain OA monitoring and observations, leverage existing partnerships and networks.** |
| --- |
| Establish baseline monitoring necessary to capture natural variability in ocean carbon chemistry and understand long-term trends. |
| Ensure coherence and data compatibility in monitoring across the Pacific Region, through the development and adoption of common monitoring indicators and data formats and in keeping with the methodology developed for UN Sustainable Development Goal 14.3. |
| Encourage OA scientists and experts to participate in regional and international networks like the Global Ocean Acidification Observing Network (GOA-ON) and Ocean Acidification International Coordination Centre (OA-ICC) and to share OA observations and best practices. |
| Continue to support and expand the Pacific Region's ocean acidification monitoring network (PI-TOA) and increase monitoring sites established through the New Zealand Pacific Partnership on OA. |
| Support partnerships with local experts, fisheries, industry, traditional leaders, chiefs, universities and NGOs to participate in inclusive and sustained data collection. Develop and participate in a sustained national or regional citizen science program that includes water sampling, pH monitoring and observations. This should include long term support for education, technical training and equipment. |

| **Commission research to understand local OA impacts, vulnerability and risks.** |
| --- |
| Commission additional regional and national vulnerability assessments with a focus on species and social vulnerability. |
| Inventory existing case studies that examine ecological or biological vulnerability thresholds and responses to OA. Identify studies that must be prioritized and commission reports.<br>Examples:<br>▪ Impacts to coral accretion rates under decreased carbonate ion concentrations.<br>▪ Impacts of warming, ocean acidification and coral bleaching on specific reef fisheries.<br>▪ Impacts on Tuna (Skipjack and Yellowfin) and food web impacts that support Tuna. |
| Develop sustainable budget and funding mechanisms (existing or new) to support or expand OA research and sustained monitoring and observations nationally and regionally. This will help ensure baseline data is available to better inform adaptation and policy decisions at a local level. |
| Where possible, streamline data management as well as access to data and data products, through the development of a regional data repository. |

## INCORPORATE OA INTO ECOSYSTEM-BASED AND COASTAL ZONE MANAGEMENT PLANS

| **Reduce local contributions to OA by using existing regulations and developing new regulations where appropriate.** |
|---|
| Implement strategies to limit the flow of nutrients and sediments from rivers and coastal catchments onto coral reefs. |
| Support implementation of effective nutrient and solid waste reduction programs and determine whether existing water quality criteria are appropriate for tracking OA impacts or interactions with other stressors. Where pollution sources are identified, amend allowed land or water uses, update wastewater and storm water treatment requirements, and regulate land use actions to prevent and reduce run off and water quality issues exacerbating coastal acidification. |
| Ensure coastal development plans and land-use changes are managed in a way that considers local hydrology changes to water movement that could further exacerbate impacts of coastal acidification. |
| Support testing and implementation of local OA mitigation strategies including the potential for submerged aquatic vegetation like mangroves and seagrass to absorb $CO_2$ in the water column. Mitigation actions could also include shell recycling, co-culture of shellfish and aquatic vegetation, water chemistry amendments or wave simulations |
| Eliminate destructive fishing activities, mining of coral rock, unregulated sand and gravel mining from streams and coasts and damage from boating and tourist operations. |

## IMPLEMENT AND EVALUATE ADAPTATION MEASURES THAT IMPROVE RESILIENCE

| **Increase adaptation capacity and enhance ecosystem, biological and economic resilience.** |
|---|
| Build local capacity to preserve, protect, and restore submerged aquatic vegetation like mangroves and seagrass. Develop vegetation-based remediation systems for use in upland habitats and in vulnerable areas. |
| Manage resources and human activities to reduce co-occurring stressors that exacerbate ecosystem vulnerability This could include precautionary fisheries policies or establishing Locally Managed Marine Areas. |
| Support fisheries stock assessments designed to alert managers of climate related changing ocean conditions and resulting impacts. As applicable, transfer some fishing effort from coral reefs to oceanic species by installing fish aggregating devices close to the coast that will increase access for some communities. |
| Develop methods to incorporate OA and ocean warming into existing short- and long-term resource management plans and adaptive management actions for species at varying scales. |
| Diversify catches of coastal demersal fisheries to match changes in species composition due to a) local increases in abundance due to changes in distribution; b) increase in herbivorous species. |
| Maintain and enhance genetic diversity of native species including conservation hatchery techniques or selective breeding for tolerance. |
| Develop hatchery and grow-out systems of freshwater pond aquaculture. |
| Pursue and support projects for coastal environment management and restoration in partnership with traditional leaders, chiefs, NGOs, local universities and other researchers. |
| Develop alternative income options for fishing and other ocean resource dependent jobs and provide direct support for affected industries and communities. Establish funding sources and regional networks of financial aid for this purpose. |
| Continue to invest in and expand coordinated efforts like the New Zealand Pacific Partnership on OA that aims to support community adaptation planning for OA in communities and villages across the Pacific Region. |

## EXPAND PUBLIC AWARENESS AND UNDERSTANDING

| Increase visibility of OA as an issue and facilitate understanding of potential impacts and actions. |
|---|
| Support regulatory bodies in publicizing and communicating local ocean acidification impacts and potential responses. Leverage existing education and outreach networks and forums to disseminate key information and build support for priority actions both within government and within local communities and villages. |
| Facilitate community and village conversations and include facts and summaries of the issue. Share information with potentially vulnerable fisheries and industries through convening specialists and scientists within the region. |
| Appoint positions within appropriate departments/ agencies/ ministries/heads of state to focus on ocean acidification and ocean changes from a resource management and climate mitigation, adaptation and resilience perspective. Identify key findings and talking points for use by heads of state and other officials who will act as ambassadors on ocean acidification. |
| Leverage relationships with local academic institutions, traditional leaders, chiefs, city leaders, and NGOs within the region to provide a platform and inclusive approach to learning more about the impacts of ocean acidification on local water bodies. |
| Help educators develop and implement curricula on OA and associated climate issues for primary, secondary and higher education. Aid formal and informal OA education programs and teacher trainings. |

## BUILD NATIONAL, REGIONAL AND INTERNATIONAL COLLABORATION

| Enhance collaboration and coordination of OA efforts among PICTs and other nations focused on ocean, climate and coastal issues. |
|---|
| Join and actively engage with international knowledge-exchange networks focused on OA, including Global Ocean Acidification Observing Network (GOA-ON), the International Ocean Acidification Coordinating Centre (OA-ICC), the OA Information Exchange (OAIE) and the International Alliance to Combat Ocean Acidification (OA Alliance.) |
| Integrate OA into National Ocean Policies, National Action Plans and Joint National Action Plans by incorporating the most current science, vulnerability assessments and actions that support mitigation, adaptation and resilience planning. |
| Convene stakeholders, decision makers and other target audiences to promote understanding of OA causes and consequences at regional and international symposiums, conferences, workshops and other events. Ensure that OA is a permanent agenda item at regional meetings. |
| Request and support inclusion of OA and other ocean health indicators and action plans through frameworks like the UNFCCC's NDCs, UN Sustainable Development Goals and CBD Aichi Targets. Ocean acidification adaptation goals, policies, actions and priorities can also be elevated and communicated though adaptation communications. |
| Establish a clearing house for OA information and data in the Pacific Region that can be accessed by governments with the goal of informing local decision making and actions. |
| Leverage funding opportunities through framework conventions like CBD, UNFCCC and through programs such as UNEP to assist with implementation of measures related to science, monitoring, mitigation, adaptation and resilience building as relevant to OA impacts. |

# Governance Frameworks for Addressing OA in the Pacific Region

OA can be mainstreamed by integrating any of the above-mentioned actions, where appropriate, into existing policy frameworks, e.g.:

## United Nations Sustainable Development Goal 14.3

As part of the 2030 Agenda for Sustainable Development framework, Sustainable Development Goal 14 aims to conserve and sustainably use the oceans, seas and marine resources. Nations can directly contribute to measuring progress towards SDG 14 by implementing actions within this publication that will strengthen national capacity and improve local knowledge of ocean acidification trends and impacts.

**SDG 14.3: Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.**

Desired outcomes of SDG 14.3 include:

- Developing international standards through the development of a universal indicator; adoption and compliance of standards at national level.
- Collecting data from countries and regional organizations; calculate global and regional aggregates.

Additionally, efforts to address OA cut across many other Sustainable Development Goals including SDG 13 (Climate), SDG 11 (Sustainable Cities); SDG 7 (Clean Energy); SDG 4 (Education); and SDG 2 (Zero Hunger.)

Progress towards SDG 14.3 will be measured with the following indicator:

**INDICATOR 14.3.1**: **Average marine acidity (pH) measured at agreed suite of representative sampling stations.**

This indicator is based on observations that constrain the carbon system, which are required to capture the variability in ocean acidity at locations providing ocean services. The carbon system in this context refers mainly to the four measurable parameters: pH (the concentration of hydrogen ions on a logarithmic scale), CT (total dissolved inorganic carbon), $pCO_2$ (carbon dioxide partial pressure), and TA (total alkalinity).

An agreed suite of representative sampling stations are sites that: 1) have a measurement frequency adequate to describe variability and trends in carbonate chemistry to deliver critical information on the exposure of and impacts on marine systems to ocean acidification, and 2) provide data of sufficient quality and with comprehensive metadata information to enable integration with data from other sites in the country.

Monitoring OA is essential to understand natural variability and distinguish long term trends.

## National Ocean Policies

Some PICTs have begun the development of National Ocean Policies (NOPs) that will serve as a strategic roadmap for integrated ocean management and governance and will also:

- Support local traditional and inclusive marine resources management practices.
- Fill policy gaps and call for deeper integration across sectoral ministries on ocean issues.
- Harmonize existing legislation or inform new legislation that will implement key policy outcomes.
- Implement commitments under Sustainable Development Goal 14 and other applicable frameworks.

Ocean acidification should be included across the socio-economic development, food security, climate change resilience and adaptation, environmental protection and conservation of biodiversity goals referenced within a NOP.

Solomon Islands National Ocean Policy (SINOP) acknowledges the importance of incorporating emerging changes such as climate change and ocean acidification within their NOP and outlines strategies to establish and strengthen integrated efforts to minimize or mitigate risks and threats.

Vanuatu's National Ocean Policy builds upon important sectoral-level management plans, policies and strategies and aims to assist departments, Ministries, users and communities to better work together to build resilience in its marine ecosystems to climate change.

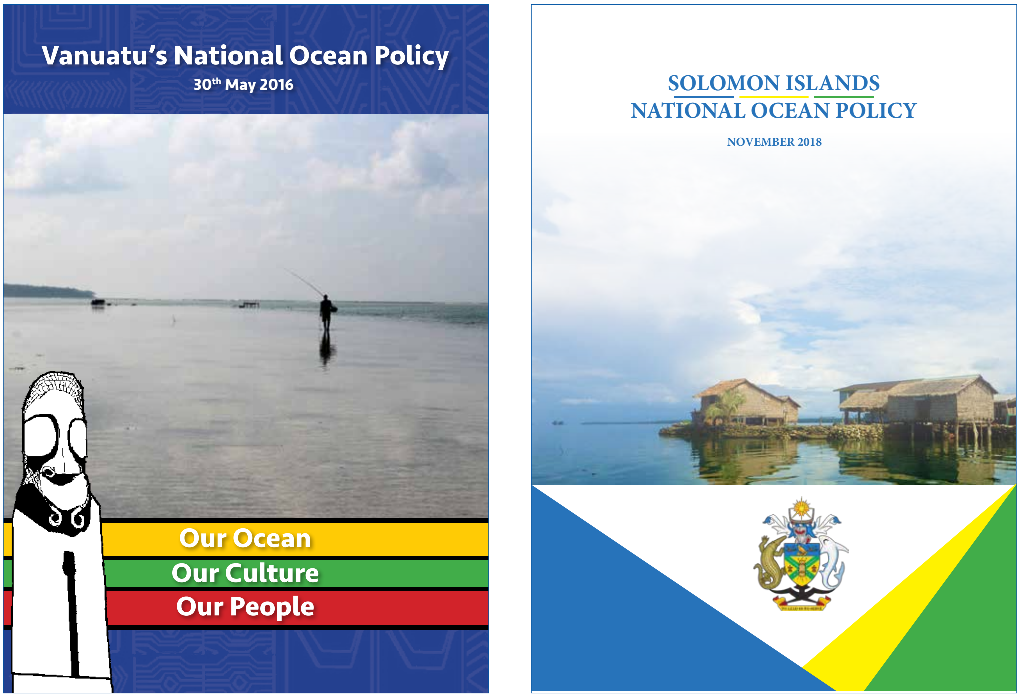


**FIGURE 6:** Vanuatu's National Ocean Policy, 2016; Solomon Islands National Ocean Policy, 2019.

## National Action Plans

PICTs have developed National Action Plans (NAPs), National Adaptation Plans of Action (NAPAs) and Joint National Action Plans on Climate Change and Disaster Risk Reduction (JNAPs) to meet their obligations under multilateral environmental agreements.

NAP/NAPA/ JNAP offer a concrete framework for systematically addressing environmental issues, mitigating the risk of climate-related disasters, and adapting and building resilience.

PICTs should identify opportunities to incorporate OA actions across multiple sectors such as the Economic Sector (Agriculture, Fisheries and Biodiversity); Social Sector (Health, Jobs and Food Security) as well as incorporate the ongoing need for ocean acidification research and monitoring that will better inform decision making, adaptation strategies and resilience building objects.

Nations should prioritize mitigation, science and adaptation priorities with a focus on linkages with other national, regional and international frameworks.

Republic of Fiji National Adaptation Plan was published in 2018 and includes the following references and integration of ocean acidification:

> The greatest current threats to Fiji's biodiversity and natural environment remain human activities such as habitat loss, over- exploitation as well as urban, agricultural and industrial pollution. Climate change combines with these threats to exacerbate the problems faced (SPREP, 2016). Increases to sea level rise, sea surface temperature, and acidification associated with climate change may have detrimental impacts, potentially altering entire coastal and marine ecosystems (IGCI, 2000.)
>
> Overwhelming evidence indicates the inability of many coral species to adapt to ocean warming and acidification, and their negative impact on growth rate and calcification22 (IGCI, 2000). Increased storms and cyclone intensity can also cause local breakage of corals on shallow reef tops.

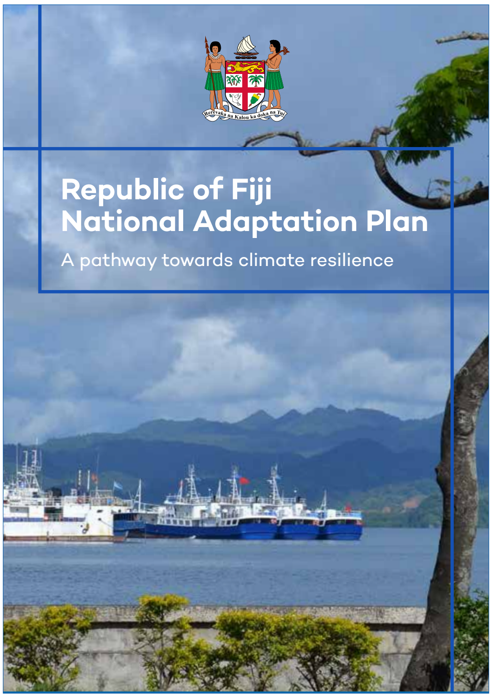


**FIGURE 7**: Republic of Fiji National Adaptation Plan: A pathway towards climate resilience 2018.

## Nationally Determined Contributions

Nationally Determined Contributions (NDCs) are required under the Paris Agreement. Each country's NDC outlines its efforts to reduce national emissions (including $CO_2$) and adapt to the impacts of climate change.

The Paris Agreement (Article 4, paragraph 2) requires each Party to prepare, communicate and maintain successive NDCs. Each NDC reflects the country's ambition for reducing emissions, considering its domestic circumstances and capabilities.

Using NDCs as platforms to enhance ocean-climate ambition will help to highlight the ocean's role in combatting the impacts of climate change and will also allow countries to better measure vulnerability and potential resource loss. While global warming can be mitigated by the reduction of any combination of greenhouse gases, OA can only be mitigated through a reduction in $CO_2$ emissions, since OA is a direct result of the ocean's uptake of atmospheric $CO_2$. Therefore, it is important that OA gains explicit mention in NDCs.

While global warming can be mitigated by the reduction of any combination of greenhouse gases, OA can only be mitigated through a reduction in $CO_2$ emissions, since OA is a direct result of the ocean's uptake of atmospheric $CO_2$.

Countries have an opportunity to support adaptation and build resilience to the impacts of OA within their Nationally Determined Contributions pursuant to the Paris Agreement. Incorporation of OA in an NDC is particularly relevant for those countries that choose to communicate information on plans for adaptation in NDCs.

Of the 161 NDCs submitted, 70% mention or include oceans and only 14 NDCs make reference to ocean acidification (Natalya D. Gallo, 2017). Large gaps remain across NDCs to recognize climate change threats like ocean deoxygenation and ocean acidification.

The "Because the Ocean Initiative" has hosted several regional workshops, including in Fiji in 2019, aimed at further exploring options to incorporate oceans and ocean acidification into NDCs.

Resources from the workshops can be found here: https://www.becausetheocean.org/resources/

## Framework Convention on Biological Diversity, Aichi Targets

Because maintaining marine biodiversity is crucial to building resilience to ocean acidification, PICTs should consider leveraging funding opportunities and legally binding protocols from the CBD to support actions that preserve marine biodiversity. Additionally, parties to the CBD should address ocean acidification as a threat to biodiversity in their National Biodiversity Strategies and Action Plans (NBSAPs). The following targets are those that include action measures that can help coastal communities to adapt ocean acidification.

- **Target 8:** "By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity."
- **Target 10:** "By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning."
- **Target 11:** "By 2020, at least 17 percent of terrestrial and inland water, and 10 percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into wider landscapes and seascapes."

**Because ocean acidification is a multi-sectoral issue and is relevant to climate mitigation and adaptation, ocean and land management, food security, reef resilience, aquaculture and fisheries, it is essential that there is a high-level of national coordination between ocean and climate experts, negotiators and policy implementers.**

**By explicitly referencing OA across policy frameworks, PICTs will have an increased ability to:**

- **Develop a more comprehensive stock take of regional vulnerabilities and risks associated with climate and ocean acidification related impacts.**
- **Understand local variability and trends in ocean and coastal and chemistry.**
- **Prioritize studies to examine adaptive capacity of critical species and resources.**
- **Strengthen capacity to improve local management of trends and impacts.**
- **Strengthen funding opportunities for OA-related mitigation, science, adaptation and resilience building projects.**

# Regional Information and Resource Hubs

## New Zealand Pacific Partnership on OA (PPOA)

The Secretariat of the Pacific Regional Environment Programme (SPREP) is coordinating the Pacific Partnership on Ocean Acidification (PPOA) in collaboration with the University of the South Pacific (USP), and the Pacific Community (SPC) to build resilience to ocean acidification in Pacific island communities and ecosystems with financial support from the New Zealand Ministry of Foreign Affairs and Trade and the government of the Principality of Monaco.

This partnership is tackling ocean acidification in the Pacific by supporting research and monitoring, building Pacific scientific capacity, raising awareness, and implementing practical adaptation actions at pilot sites in Fiji, Kiribati, and Tokelau. Work is underway to increase resilience to ocean acidification through practical adaptation activities such as planting mangroves to locally buffer pH; restoring coral to enhance reef resilience; and establishing locally managed marine areas to reduce secondary reef stresses.

PPOA is also working with international partners like the Ocean Foundation and the Global Ocean Acidification Observation Network to build local capacity to monitor and report ocean acidification data.

**PPOA website:** https://www.sprep.org/project/new-zealand-pacific-partnership-on-ocean-acidification

## Pacific Islands and Territories Ocean Acidification Network (PI-TOA)

PI-TOA is a regional hub of the Global Ocean Acidification Observing Network (GOA-ON). GOA-ON is a collaborative international network to document the status and progress of ocean acidification in open-ocean, coastal, and estuarine environments, to understand the drivers and impacts of ocean acidification on marine ecosystems, and to provide spatially and temporally resolved biogeochemical data necessary to optimize modelling for ocean acidification. To date, PPOA, in partnership with the Ocean Foundation, has sponsored ocean acidification trainings and distributed "GOA-ON in a Box" OA monitoring kits for 11 Pacific scientists from 8 Pacific island countries. As capacity for ocean acidification monitoring increases in the region, there is an increasing need for collaboration and communication among the various islands and territories, for which PI-TOA provides a platform. GOA-ON also facilitates a mentoring programme for OA scientists.

**PI-TOA website**: http://goa-on.org/regional_hubs/index.php

## Pacific Community Center for Ocean Science (PCCOS)

PCCOS is a regional science information and data virtual hub developed through Pacific Community to support and strengthen ocean science/observations, management and governance with an emphasis on fisheries and climate change science, including ocean acidification. There is also scientific work being undertaken by the FAME division on OA and fisheries.

**PCCOS website**: https://www.spc.int/pccos

## Additional Resources

- Pacific Community
- University of the South Pacific
- World Meteorological Organization and PICT Met Services
- Global Ocean Acidification Observing Network (GOA-ON) and the OA Information Exchange
- Pacific Environment Portal
- PacIOOS and NOAA's Pacific Islands Fisheries Science Center
- Pacific Islands Global Ocean Observing System (PI-GOOS)
- SPREP Climate Change Center

## International Alliance to Combat Ocean Acidification

The OA Alliance was established in 2016 as an outgrowth of regional collaboration by subnational governments responding to the observed impacts of ocean acidification in the mid-2000's to oyster hatchery production across the North American West Coast. Today, over 80 members from across the globe have joined forces to act on ocean acidification through the OA Alliance including nations, states and provinces, tribes and first nations, indigenous and sovereign, cities, and a wide array of affected industries, academic and research institutions, and NGOs.

Members of the OA Alliance commit to take individual actions that address the environmental, cultural and economic threat posed by ocean acidification within their region by creating an OA Action Plan.

OA Action Plans describe tangible actions members will take to respond to the threat of ocean acidification. OA Action Plans help governments identify key species at risk in their region (e.g. those of economic, cultural, or ecological importance) and develop strategies to protect them, including those focused on using living natural systems. Not all OA Action plans will have the same framework or structure, as there is no "one-size fits all" approach for governments thinking through how they will uniquely experience and respond to this issue.

For example, New Zealand is working to protect critical aquaculture industries like the Green Shelled Mussel through strategies that help to mitigate OA impacts on mussel farms through waste shell dissolution, aeration techniques, and identifying resilient families and using stocks from selective breeding. New Zealand is also working to improve management of land-based activities in locations where economically significant marine species are most vulnerable.

Washington State released a series of 42 recommendations for actions, including reducing carbon emissions and local land-based contributions to ocean acidification, investing in adaptive measures in partnership with local shellfish companies, and developing predictive forecasting models.

The City of Vancouver in British Columbia, Canada launched a Blue Carbon pilot project that aims to explore how blue carbon projects can be better incorporated in city carbon accounting, conservation, development and restoration efforts and have discovered many co-benefits of the pilot project along the way.

The Alliance invites government and affiliate members at all stages of learning about and responding to ocean acidification and is available to help governments connect with each other and share information.

The OA Alliance has an OA Action Plan Toolkit available on the website in addition to more guidance about how to get started. You can also download completed OA Action Plans from subnational state governments including California, Oregon, and Washington.

**OA Alliance website**: https://www.oaalliance.org OA ALLIANCE International Alliance to Combat Ocean Acidification

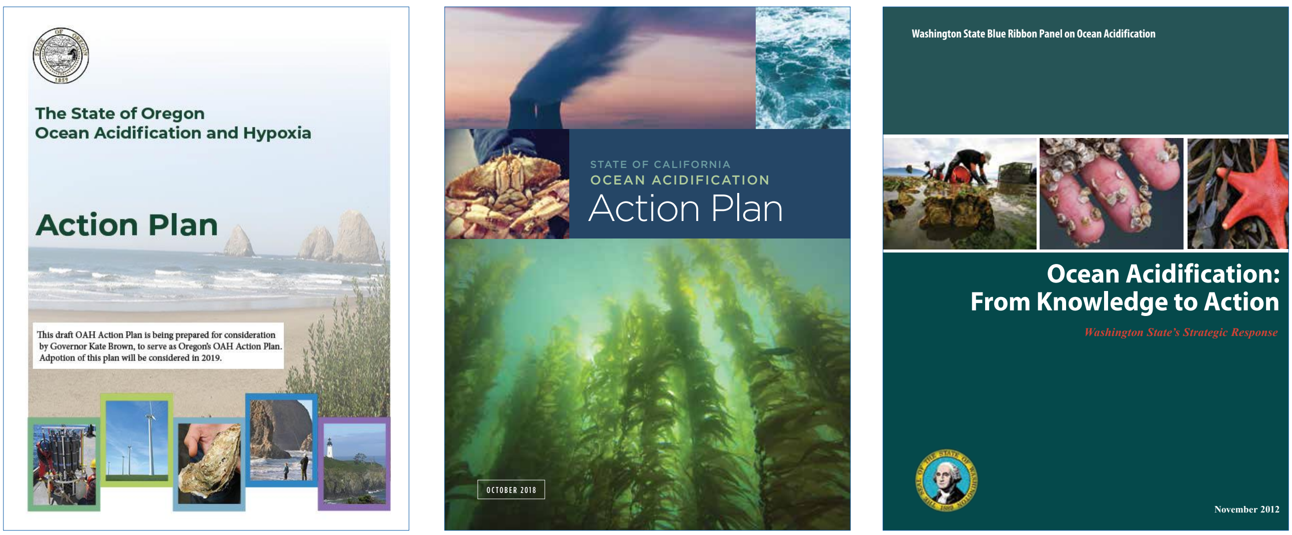


**FIGURE 8:** The State of Oregon Ocean Acidification and Hypoxia Action Plan, 2019; Ocean Acidification from Knowledge to Action: State of California Ocean Acidification Action Plan, 2018; Washington State Blue Ribbon Panel on Ocean Acidification 2012.

# Key Takeaways

Reducing global $CO_2$ emissions is fundamental to mitigating ocean acidification. However, this booklet outlines examples of actions that governments can take now to increase the resilience of their people and ecosystems to OA.

To protect marine species, ecosystems, and the coastal communities, cultures, traditions and economies that rely on a healthy ocean we must:

1. Dramatically increase ambition to reduce $CO_2$ emissions.
2. Enhance monitoring throughout the Pacific island region to better understand natural variability of OA and to distinguish long term OA trends.
3. Drive implementation of local and regional actions that can reduce exacerbators of OA impacts locally.
4. Support and advocate for practical adaptation actions to enhance the resilience of Pacific communities and ecosystems to OA.
5. Advocate for increased support to address OA in the Pacific islands region.

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