

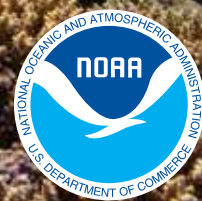
Coral reef condition:
A status report for

GUAM

2018



NOAA
CORAL REEF
CONSERVATION PROGRAM



CORAL REEFS ARE IMPORTANT

Healthy coral reefs are among the most biologically diverse ecosystems on Earth, with high cultural and economic significance. They provide billions of dollars in **food, jobs, recreational opportunities, coastal protection**, and other important goods and services to people around the world. Guam's coral reefs are an integral part of the culture, livelihoods, and aesthetics of the island.

Food

Fishing provides Guam residents with an accessible and healthy source of protein. Nearshore coral reef habitats are important to both subsistence and commercial fishing. Survey data indicate that 30% of residents fish or gather marine resources and 94% of residents who do fish, do so to feed themselves or their family (NOAA National Centers for Coastal Ocean Science 2018). Traditionally, a large catch was shared by many people, providing a much needed food resource. Traditional marine management was conducted at the village level. Under modern management at the island-scale, enforcement of marine preserve regulations is an ongoing challenge on Guam.

Biodiversity

Coral reef ecosystems are renowned for the stunning diversity of life they support. Although they occupy less than 1% of the seafloor globally, it is estimated that more than 25% of all marine species can be found on coral reefs (Burke et al. 2011). On Guam, there are over 5,000 species of coral reef organisms (Paulay 2003). Protecting this impressive biodiversity through management and conservation is important for sustaining healthy reefs and the human communities dependent on them.

Tourism

Coral reef-related tourism contributes \$323 million per year to Guam's economy (Spalding et al. 2016). The tourism industry supports over 21,000 jobs annually, representing 34% of total employment (Guam Visitors Bureau 2018). Each year, Guam's reefs host over 300,000 tourist snorkelers and 100,000 tourist scuba divers (QMark Research 2016a, 2016b). In addition, over 30% of visitors cite the marine environment as a top reason for visiting Guam (Guam Visitors Bureau 2018).

Shoreline Protection

The coral reefs found in the nearshore areas and lagoons of Guam provide many benefits to the island's shorelines. Coral reefs form a natural breakwater, protecting the shoreline by absorbing and reducing wave energy by 97% on average (Ferrario et al. 2014). This prevents erosion and beach loss, which can lead to economic hardship. Shoreline protection is important for Guam, which is subjected to typhoons that may increase in severity due to climate change.



Ryan Harvey



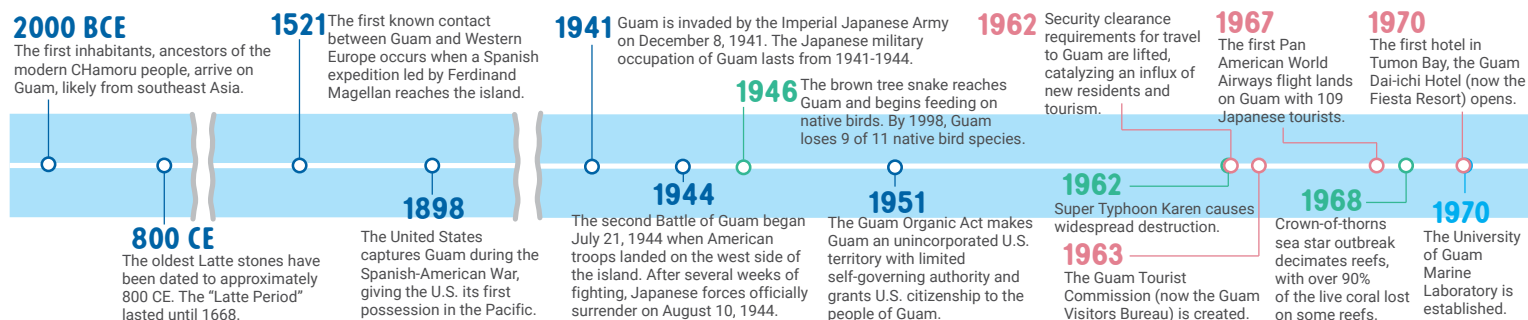
David Burdick



Josie Moyer



Robert D. Raio



REEFS ARE UNDER THREAT

Coral reefs are declining globally, which has significant ecological, social, cultural, and economic impacts on people and communities. Guam's coral reefs are threatened by overfishing, climate change, pollution, and overuse.

Overfishing

Catch data over the last two decades on Guam show the gradual replacement of large-bodied species with smaller species across several fisheries sectors: SCUBA, freedive, and bottom (Houk et al 2018). Fish declines impact fishermen's profits, ecosystem health, and local diets. Improving Guam's nearshore fisheries is a difficult ongoing process that requires trusted partnerships between scientists, fishermen, managers, and other stakeholders.

Climate Change

Ocean warming is the most pressing climate change impact facing Guam's reefs, which experienced coral bleaching in 2013, 2014, 2016, and 2017. Bleaching-induced mortality has reduced coral cover and decreased available habitat for fishes and other reef-associated species. Ocean acidification is a growing threat to Guam's reefs. Local resource managers aim to address climate change impacts by reducing local stressors and protecting resilient coral populations.

Land-based sources of pollution

Pollution threatens Guam's reefs, with much of the pollution stemming from activities on land. Unsustainable coastal development, driven by population growth and increasing tourism, leads to runoff of pollutants and sediments to the reefs. This can smother corals and impact fish and other organisms. Nutrient pollution may lead to outbreaks of the crown-of-thorns sea star, a coral predator that has had major impacts on Guam's reefs.

Misuse and overuse

Guam's reefs are threatened by recreational misuse and overuse, and lack of regulations aiming to protect reefs from impacts such as vessel groundings. Reef users can impact coral reef health by breaking corals, feeding fish, harassing marine life, or introducing harmful chemicals into the water with sunscreen use. Guam needs stronger laws and regulations to protect coral reefs from impacts caused by recreational use and vessel groundings.

WHAT YOU CAN DO TO HELP

There are many threats to coral reefs. Here are a few actions YOU can take to help conserve coral reefs:



Be responsible for the fishing nets and other gear you use.



Only catch enough fish for you and your family and obey all marine preserve regulations.



Do not drop your anchor in reef areas, instead use mooring buoys or sandy bottom areas.



Reduce energy use and your carbon footprint.



Pick up your own trash and carry away the trash that others have left behind.



Support initiatives to preserve and protect coral reefs.



Plant native vegetation to prevent sediment and pollutants from reaching the reef.



Don't burn trash. Don't burn for hunting as it causes erosion that damages reefs.



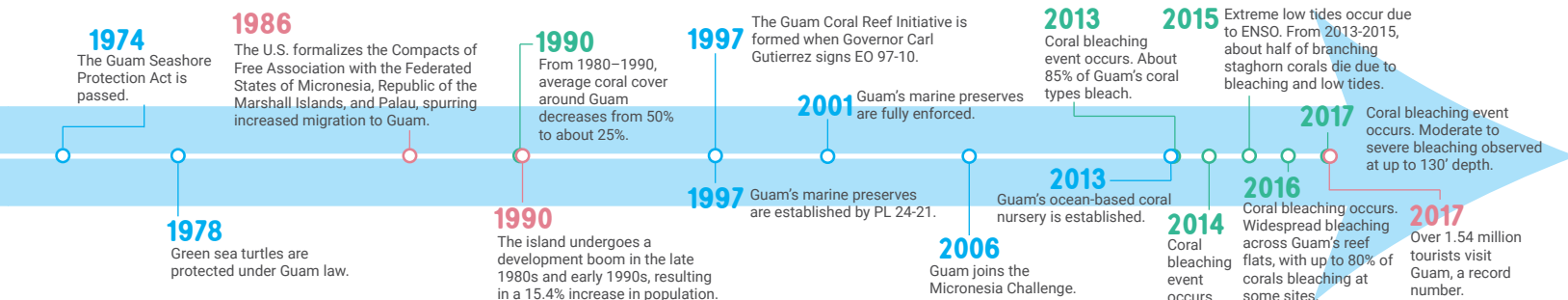
Help protect mangroves and wetlands from filling and construction activities.



Don't stand on or touch live coral. Don't take pieces of corals home with you.



Educate yourself about coral reefs and the creatures they support.



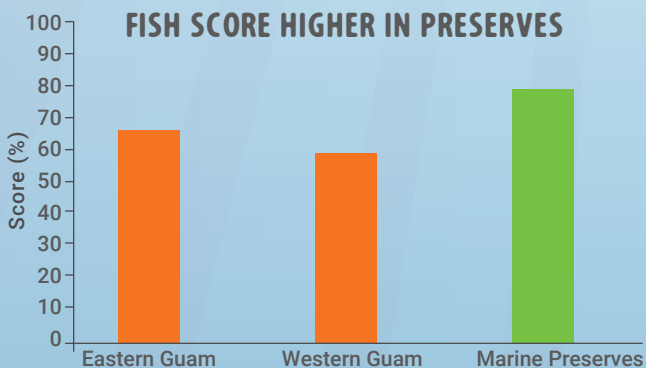
MARINE PRESERVES HELP FISHERIES

Guam has established five marine preserves to protect, preserve, manage, and conserve aquatic life, habitats, and marine communities and ecosystems. The five preserves are Piti Bomb Holes, Achang Reef Flat, Pati Point, Sasa Bay, and Tumon Bay.

Guam's network of marine preserves was created in 1997 to restore declining fish stocks. The preserves have been enforced since 2001. Although protection of these areas is difficult due to insufficient enforcement of regulations, there are signs of improvement. Studies have confirmed that limiting fishing in these areas has had a positive effect on species density and diversity (The Territory of Guam and NOAA Coral Reef Conservation Program 2010). The increased number, size, and diversity of fish within the protected areas has allowed residents and visitors to recognize the value of Guam's marine preserves.



The size of reef fish has increased in and around the Piti Bomb Holes Marine Preserve. Photo: Dave Burdick.



Fish indicators scored better within the Marine Preserves.

COMMUNITY-BASED MONITORING ON GUAM

Community involvement in marine resource management enables critical conversations about and actions around coral reef protection. The Guam Community Coral Reef Monitoring Program was launched in 2012 to create more opportunities for Guam residents to engage in coral reef management through experiential learning about Guam's coral reefs and first-hand observation of the challenges facing them.



Members monitoring in Piti. Photo: NOAA.

Local community members are trained to survey the condition of corals, algae, and macroinvertebrates, all of which are important indicators of habitat health. Trained program members complete monitoring surveys on reef flats around Guam. Community-collected data is shared at member meetings and with local reef managers for informed updates on Guam's reef flat health at monitoring sites. The Guam Community Coral Reef Monitoring Program encourages community members to be stewards of Guam's natural resources so that their cultural, social, and economic value can be preserved for the people of Guam.

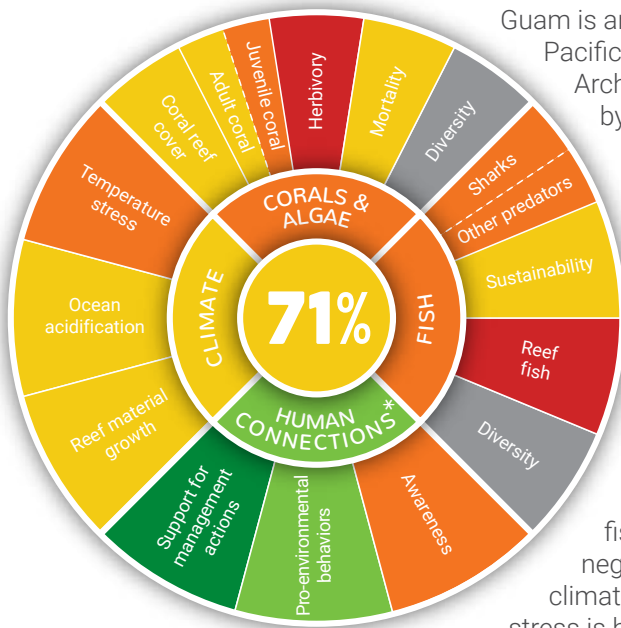


A group of volunteers preparing to go monitor the reef. Photo: NOAA.

GUAM CORAL REEFS ARE IN FAIR CONDITION



GUAM

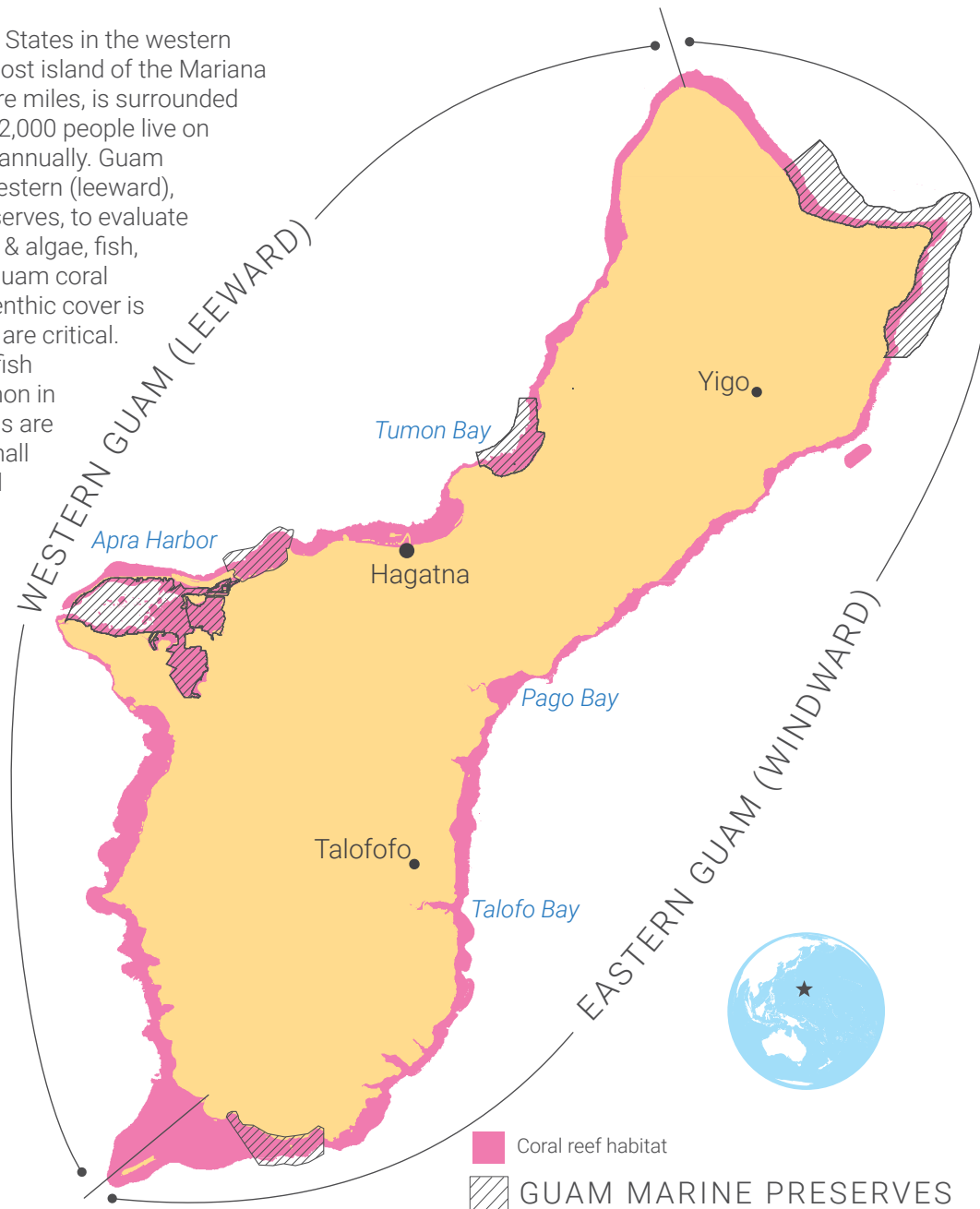
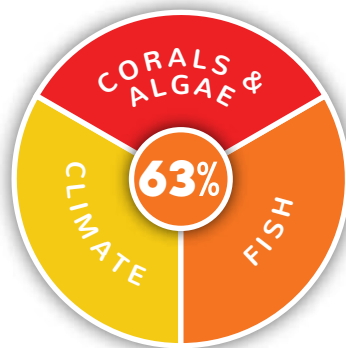


Guam is an unincorporated territory of the United States in the western Pacific Ocean. It is the largest and southernmost island of the Mariana Archipelago. The island, which is 210 square miles, is surrounded by fringing coral reefs. Approximately 162,000 people live on Guam, with 1.5 million tourists visiting annually. Guam was divided into three sub-regions, western (leeward), eastern (windward), and marine preserves, to evaluate condition of four categories—corals & algae, fish, climate, and human connections. Guam coral reefs are in fair condition overall. Benthic cover is very impacted, and herbivory levels are critical. Fish are very impacted and overall fish indicators are impaired. As is common in populated areas, reef fish populations are depleted, as indicated by relatively small sizes of fishery species and low overall fish biomass. Climate is also a factor negatively affecting coral reefs. Overall climate conditions are fair. Temperature stress is having an impact on coral reefs.

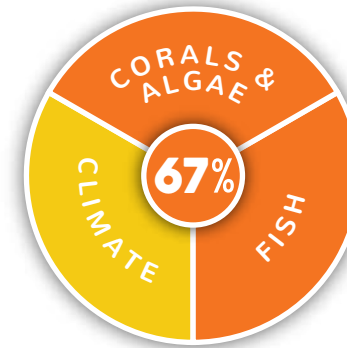
Human connections are good, which means communities support management actions and engage in behaviors that protect reef ecosystems. These conditions show that Guam's coral reefs are moderately impacted, and overall conditions are fair. Guam's reefs are struggling against threats such as pollution, overfishing, and climate change.

WESTERN GUAM (LEEWARD)

Western Guam extends from Ritidian Point in the north, to Tumon Bay and Apra Harbor in the west, to Cocos Point in the south. Western Guam's coral reefs are in an impaired condition. This was the lowest score of all three regions. This region also had the lowest score for corals & algae, a critical score. Climate conditions were fair, and fish indicators were very impacted, leading to an impaired condition.

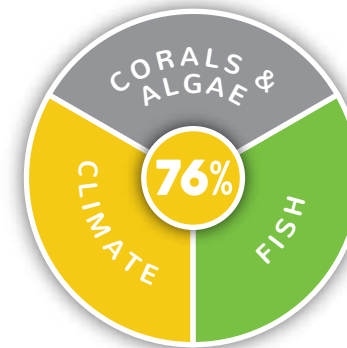


EASTERN GUAM (WINDWARD)



Eastern Guam extends from Ritidian Point in the north through Pati Point, to Pago Bay and Talofo Bay on the eastern side, to Cocos Point in the south. Eastern Guam's coral reefs are in impaired condition. This region had the highest score for climate, a fair score. Corals & algae were very impacted with an impaired score. Fish indicators were very impacted, leading to an impaired condition.

GUAM MARINE PRESERVES



Guam has five marine preserves, encompassing 11% of the island's coast. They are Pati Point, Achang Reef Flat, Sasa Bay, Piti Bomb Holes, and Tumon Bay. The coral reefs in Guam's marine preserves are in fair condition. This was the highest score of all three regions. This region also had the highest score for fish, a good score. Corals & algae are not scored due to insufficient monitoring data within the marine preserves.

While these scores reflect data collected through summer 2017, very recent data suggest coral reef bleaching has resulted in severe impacts. It is unclear what the impact of the latest bleaching event will be on all reefs of the Mariana Islands, but preliminary information suggests widespread loss across the archipelago.

Biodiversity is a measure of the variety of living organisms. High biodiversity of corals, fish, and other organisms helps keep the ecosystem in balance and makes it resilient to environmental impacts. Although we measure biodiversity, the science is not yet mature enough to score biodiversity in an area. As the science and analysis progress, we will look to include biodiversity scores in future status reports.

What do the scores mean?

90–100% Very good	80–89% Good	70–79% Fair	60–69% Impaired	0–59% Critical
All or almost all indicators meet reference values. Conditions in these locations are unimpacted, or minimally impacted or have not declined. *Human connections are very high.	Most indicators meet reference values. Conditions in these locations are lightly impacted or have lightly declined. *Human connections are high.	Some indicators meet reference values. Conditions in these locations are moderately impacted or have declined moderately. *Human connections are moderate.	Few indicators meet reference values. Conditions in these locations are very impacted or have declined considerably. *Human connections are lacking.	Very few or no indicators meet reference values. Conditions in these locations are severely impacted or have declined substantially. *Human connections are severely lacking.

*Human connections data are only collected at the overall Guam level, not the sub-region level.

Insufficient data, not scored

REEF RESTORATION

On Guam, reef restoration is recognized as an important approach to restoring the health of degraded reefs. Natural resource managers are extremely interested in reef restoration as a tool to recover degraded reefs. In 2018, stakeholders formed the new Guam Reef Restoration and Intervention Partnership (GRRIP), to develop an island-wide strategy for restoration.

An ocean-based coral nursery was installed in the Piti Bomb Holes Marine Preserve during workshops in 2013 and 2014. The University of Guam and Underwater World Guam co-organized the workshops, in which field training taught participants how to use sexual coral reproduction for restoration efforts. In 2015, a mass spawning occurred and more than 1000 larvae settled on tiles in the floating nursery. Spawning work continued in 2016 with support from the Aquarium of the Pacific.



The mid-water coral nursery in Guam. Photo: Whitney Hoot.

The nursery also contains over 1,000 fragments of five species of staghorn *Acropora* corals, which are a vital component of Guam's coral reef communities. Local scientists and resource managers have already experimentally outplanted some of these corals and plan to scale-up efforts to restore degraded reefs. Local stakeholders plan to install a second nursery in 2019.

In addition to the coral nursery and sexual propagation, Guam is experimenting with micro-fragmentation and various outplant methods to increase restoration success. Restoration of other coastal systems, such as seagrasses and mangroves, is also being considered.

KEY THEMES & INDICATORS



CORALS & ALGAE

Corals & algae make up the base of the coral reef ecosystem, providing food and shelter for fish, shellfish, and marine mammals. The five indicators for corals & algae are:

- **Coral reef cover**, which includes corals, algae, and crustose coralline algae.
- **Coral populations**, a measure of the population's ability to reproduce and sustain itself.
- **Herbivory**, a measure of the level of grazing pressure by fish on corals and algae.
- **Mortality**, which measures the amount of recently dead coral.
- **Diversity**, a measure of the number of different species of coral present.



FISH

Coral reefs serve as habitat and food for fish species. Fish are important to the ecology of the reef, the economy, and the livelihoods of local communities. The four indicators chosen for fish are:

- **Reef fish**, a measure of the amount of fish present.
- **Sustainability**, which is indicative of whether fishery stocks still have abundant large breeding-sized fishes.
- **Sharks and other predators**, a measure of the amount of fish that eat other fish.
- **Diversity**, a measure of the number of different species of fish present.



CLIMATE

Climate affects all components of a reef system. Climate change and ocean acidification influence reefs across the globe, but conditions vary at the regional and local level. The three climate indicators are:

- **Temperature stress**, which evaluates the frequency and severity of high temperature events.
- **Ocean acidification**, indicating if the water chemistry is suitable for the growth of corals and other calcifiers.
- **Reef material growth**, which directly measures the increase in reef skeletal material in a particular place.



HUMAN CONNECTIONS

Coral reef management agencies protect reef resources through management plans, public education, and involving communities in managing their resources. The three indicators for human connections are:

- **Awareness**, an indicator of residents' familiarity with threats to and the importance of reefs.
- **Support for management actions**, an indicator of support for reef management activities.
- **Pro-environmental behavior**, an indicator of residents' participation in activities to protect the environment.

CHALLENGES FOR CORAL REEF MANAGEMENT ON GUAM

Local natural resources managers are striving to protect and restore Guam's coral reefs through an integrated, collaborative ridge-to-reef approach. Managers are taking actions to identify challenges identified by stakeholders.

Lack of awareness of coral reef health and impacts among community members	Increased public outreach and education efforts using a citizen science approach
Lack of local legislation to protect coral reef resources	Additional legal and technical expertise within local agencies
Insufficient enforcement of Guam's marine preserve regulations	Funding to build capacity for Guam's conservation officers to enforce preserves
Conflict between coral reef user groups and natural resource managers	Proactive, consistent engagement with community leaders and groups to bring stakeholders to the table
Uncertainty surrounding future climate change impacts	Adaptive management of coral reef resources



Coral reef bleaching is caused by temperature stress due to climate change. Adaptive management can help make coral reefs more resilient to climate impacts. Photo: David Burdick.

WHY A STATUS REPORT?

Effective coral reef conservation cannot be accomplished without an informed and engaged public. This status report is part of an ongoing series of documents to track the status and trends of coral reefs across the U.S. and its territories.

The Guam coral status report is part of a larger effort to provide the public and decision-makers with information about managing and conserving coral reef ecosystems.

This status report provides a geographically specific assessment of Guam coral reef condition for the period 2012–2017. Guam was divided into three sub-regions based on data resolution, geographical features, and impacts to the ecosystem. Data were collected by NOAA's National Coral Reef Monitoring Program. For more detailed information on methodologies, indicators, thresholds, and grading, visit <http://www.coris.noaa.gov> (keyword: status reports).

Status report working group

Rusty Brainard, Val Brown, Dave Burdick, Jesse Cruz, Peter Edwards, Hilary Goodwin, Andrea Hershberger, Whitney Hoot, Peter Houk, Justine Kimball, Adrienne Loerzel, Dana Okano, Marybelle Quinata, Anna Simeon, Brent Tibbatts, Bernardo Vargas-Angel, & Ivor Williams.

About this status report

This status report is a joint product of NOAA's Coral Reef Conservation Program (CRCP) and the University of Maryland Center for Environmental Science. Science communication, design, and layout by Alexandra Fries, Caroline Donovan, & Heath Kelsey. November 2018.

Cover photo by David Burdick.

Acknowledgements

The CRCP supports effective management and sound science to preserve, sustain, and restore valuable coral reef ecosystems for future generations.

For more information, visit coralreef.noaa.gov.

References

Burke L, K Reyter, M Spalding, and A Perry (eds). 2011. Reefs at risk revisited. World Resources Institute.

Ferrario F, M Beck, C Storlazzi, F Micheli, C Shepard, and L Airoidi. 2014. The Effectiveness of Coral Reefs for Coastal Hazard Risk Reduction and Adaptation. Nature Communications 5. Article number 3894. doi:10.1038/ncomms4794.

Guam Visitors Bureau. 2018. I Estoria. 2017 Annual Report. Tumon, Guam.

Houk P, J Cuetos-Bueno, B Tibbatts, and J Gutierrez. 2018. Variable density dependence and the restructuring of coral-reef fisheries across 25 years of exploitation. Nature Scientific Reports 8:5725.

Paulay G. 2003. Marine biodiversity of Guam and the Marianas: overview. Micronesica 35-36: 3-25.

NOAA National Centers for Coastal Ocean Science (2018). National Coral Reef Monitoring Program: Socioeconomic surveys of human use, knowledge, attitudes, and perceptions in Guam. NOAA National Centers for Environmental Information. Dataset. 09.12.2018.

QMark Research. 2016a. Guam Visitors Bureau: Japan visitor tracker exit profile, FY2016 data aggregation. Prepared for the Guam Visitors Bureau. 106pp.

QMark Research. 2016b. Guam Visitors Bureau: Korean visitor tracker exit profile, FY2016 data aggregation. Prepared for the Guam Visitors Bureau. 104pp.

Spalding MD, RD Brumbaugh, and E Landis. 2016. Atlas of Ocean Wealth. The Nature Conservancy. Arlington, Virginia.

The Territory of Guam and NOAA Coral Reef Conservation Program. 2010. Guam's Coral Reef Management Priorities. Silver Spring, MD: NOAA. 36pp.



The status report working group during the workshop in Guam, January 2017.



University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE