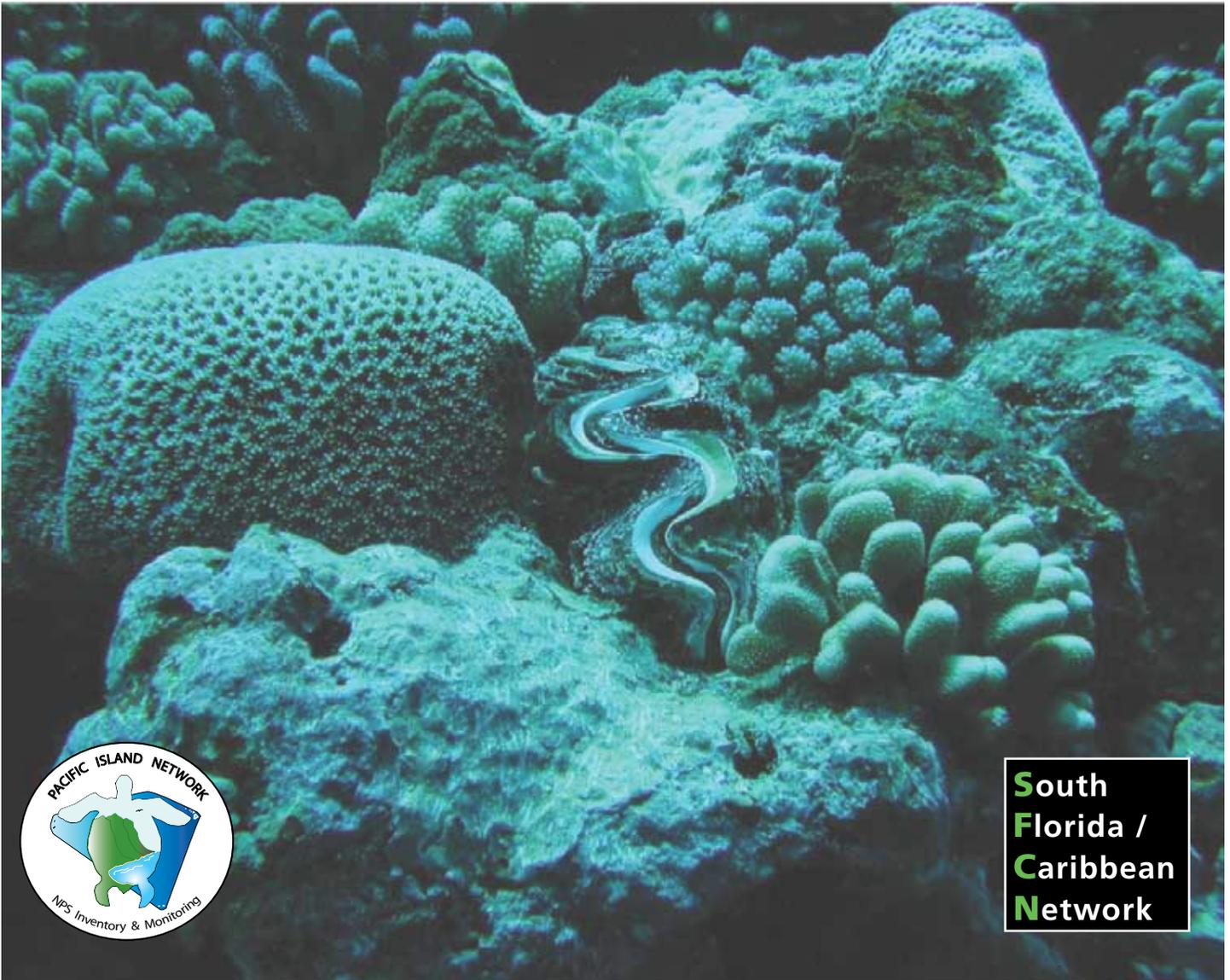




Coral Reefs in U.S. National Parks

A Snapshot of Status and Trends in Eight Parks

Natural Resource Report NPS/NRPC/NRR—2009/091



South
Florida /
Caribbean
Network

Coral Reefs in U.S. National Parks

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April 2009

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

ON THE COVER

A diverse coral reef community

Photo by: L.V. Basch

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

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Please cite this publication as:

National Park Service. 2009. Coral Reefs in U.S. National Parks: A Snapshot of Status and Trends in Eight Parks. Natural Resource Report 2009. National Park Service, Fort Collins, Colorado.

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Acknowledgements

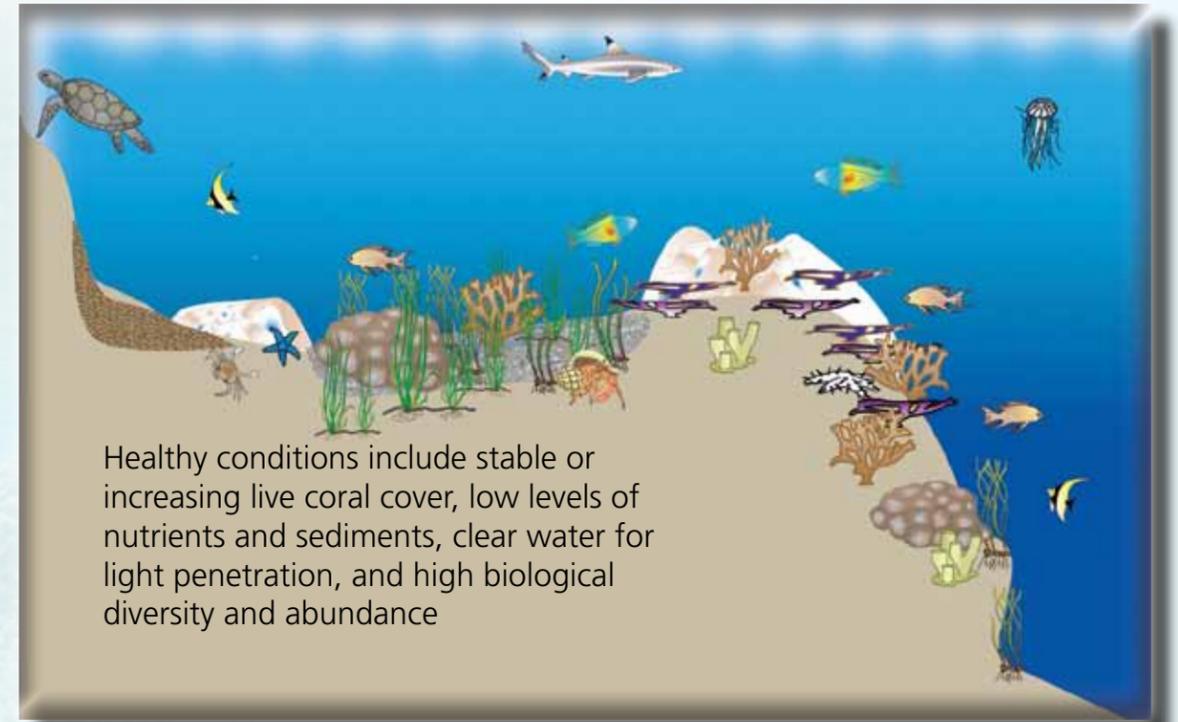
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The National Park Service (NPS) is entrusted with preserving and protecting the biodiversity, health, heritage, and social and economic value of U.S. coral reef ecosystems and the marine environment by coral reef mapping and monitoring, research, conservation, mitigation, and restoration in park units with significant coral reef development (Executive Order 13089). This publication provides a snapshot of the state of selected coral reefs in eight marine parks. The coral reefs in these parks are monitored by the parks and two networks in the National Park Service Inventory and Monitoring Program (I&M): the South Florida/Caribbean Network (SFCN)  and the Pacific Island Network (PACN) . These two I&M networks share many of the same reef monitoring goals, encounter similar challenges, and the coral reefs they study face many of the same threats.

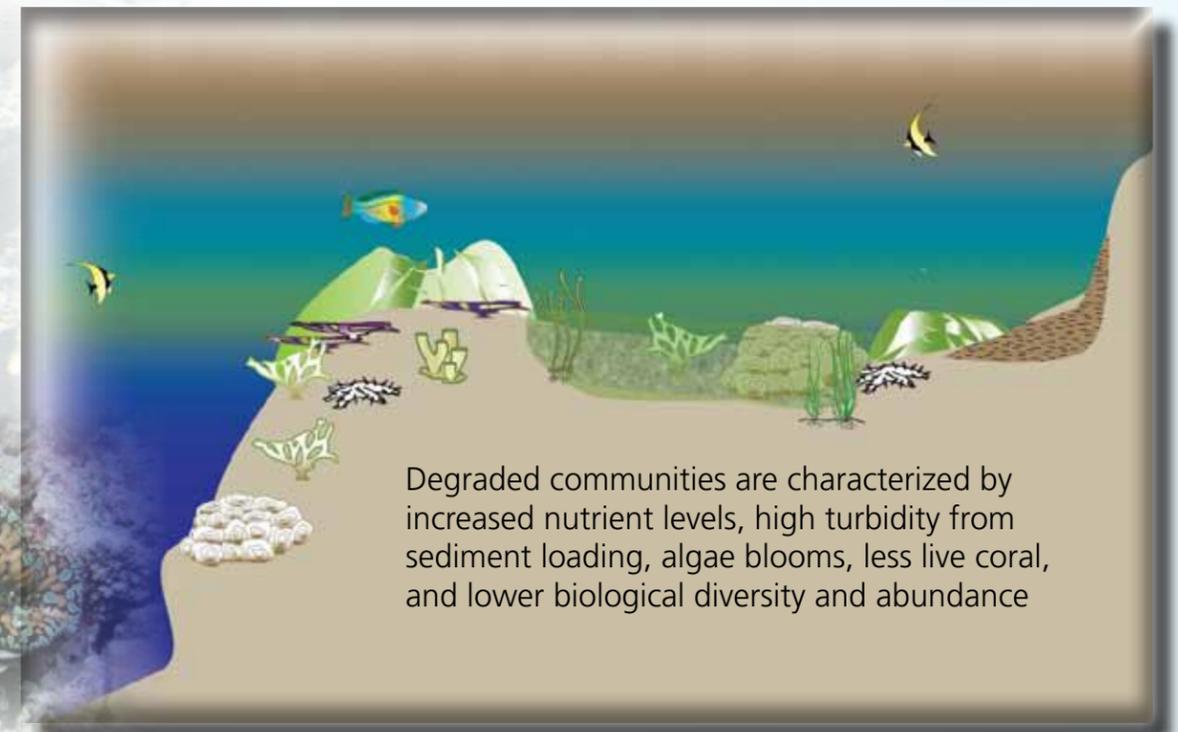


Introduction

The coral reef communities in U.S. national parks in the tropical and subtropical Atlantic and Pacific Oceans contain some of the most diverse ecosystems in the United States, forming critical habitats for thousands of species of algae, fishes, corals, and other marine organisms. In addition, coral reefs support recreational and commercial fisheries, protect coastlines from storm damage, serve as beautiful natural areas for recreation, and function as rich storehouses for genetic and species diversity. Coral reefs are fragile ecosystems that are impacted by natural and human-based threats worldwide.



Conceptual comparison of a 'healthy' coral reef community (top) and a 'degraded' coral reef community (bottom)



Coral Reefs Under Threat

There are many factors that threaten the health of coral reefs. Threats are man-made and natural, direct and indirect, and both local and global. It is the combination of these stressors, often acting together, that threaten reefs and challenge resource managers.

Coral bleaching usually occurs in response to high water temperatures or other stressors and can kill coral. Bleaching occurs when corals lose the symbiotic microscopic algae (which provide up to 95% of the coral's nutrition) from their tissues causing them to look white or "bleached."

Coral diseases cause both severe and chronic coral mortality on reefs.



Black band disease



Bleached coral

Overfishing, invasive species, and coral predator outbreaks disrupt the ecological balance on reefs.



A fisherman poaches undersized lobsters

The Crown-of-Thorns sea star is a voracious coral predator; when population outbreaks occur they destroy large areas of reef



Nutrient enrichment, pollution, and sedimentation are generally land-based impacts to reefs. Excess nutrients promote algal overgrowth of corals and prevent juvenile corals from establishing. Pollution and sedimentation impair or smother reefs, making corals more vulnerable to other stressors.



Sediment runoff from land carries soil, excess nutrients and other pollutants onto reefs



Sedimentation from run-off can harm corals

Physical damage from anchors, boat groundings, marine debris, careless snorkelers/divers, fishing gear, and severe storms can kill coral and destroy the physical structure of a reef.

Snorkelers and divers sometimes step on and unknowingly damage or kill coral



Severe damage to a coral head from a boat grounding

Hurricanes can wreak havoc on coral reef communities

Changing climate, ocean warming, sea level rise, and ocean acidification act at regional and global scales and can reduce the ability of corals and coral reefs to cope with or recover from other threats and disturbances.

Monitoring to Protect Reefs

National Park Service scientists collect a variety of inventory and monitoring data for coral reef management.

Percent cover is the amount of reef area occupied by live coral and is one of the most common measures of reef health or condition. Growing corals create the structure upon which other reef-associated plants and animals depend. Changes in percent cover of live coral over time helps to give managers an indication of whether reef health is improving or declining.

Rugosity is a measure of a coral reef's three-dimensional structure. Higher complexity reefs tend to contain higher biodiversity and greater abundance of many marine organisms. Changes in rugosity can occur over long time scales (i.e., decades) or after brief but extreme events, such as hurricanes, and influence how a coral reef ecosystem functions.

Coral bleaching and coral disease have severe and rapid negative effects on reefs, causing substantial changes in percent coral cover and reef condition. The amount of coral that is bleached or diseased is an important measure of these stresses.

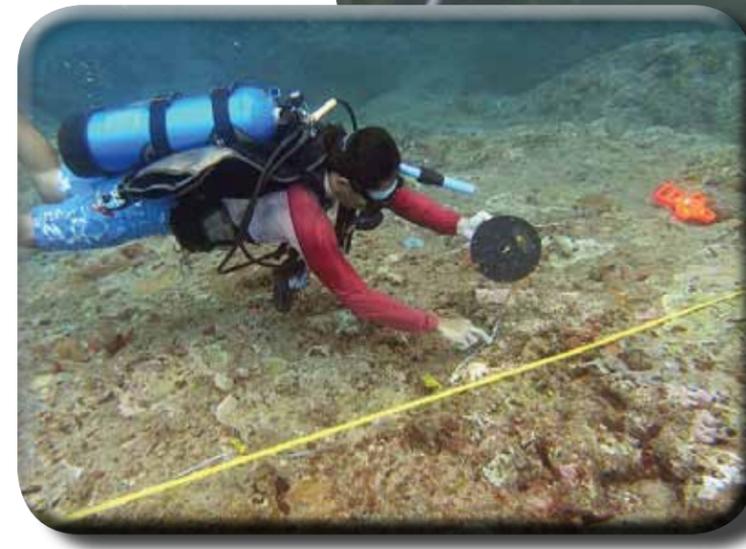
Coral recruitment is a measure of the number of juvenile corals settling on a reef. Recruitment of juveniles is essential for a reef to persist.

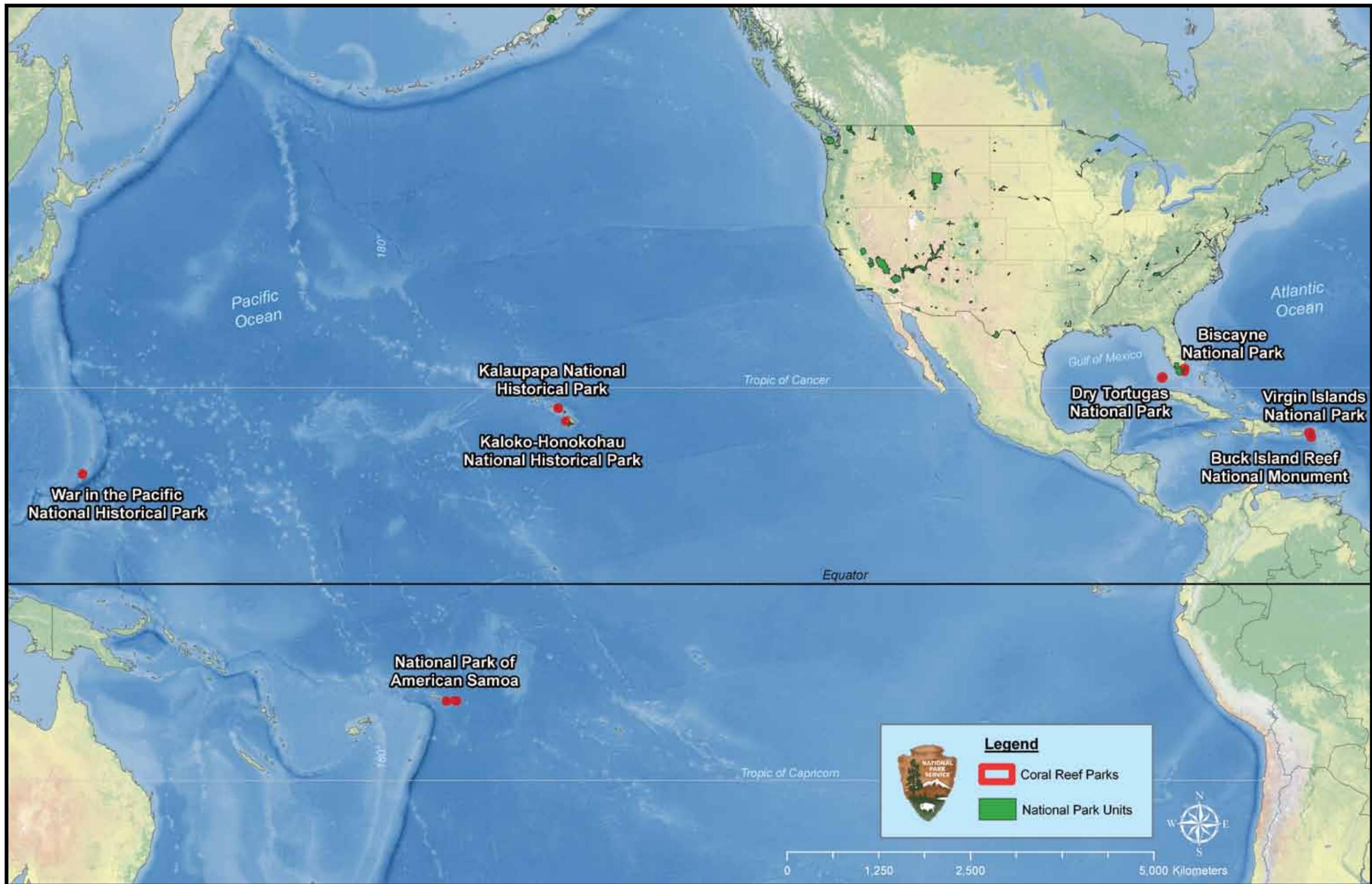
Coral reef fish density, biomass, and species composition play important roles in reef ecosystems. Coral reef fishes are ecologically important and commercially valuable members of reef communities, both as fishery targets and as visitor attractions. Many reef fishes are over-harvested, and reef fish monitoring data can indicate whether management actions are necessary and effective (e.g. area closures, changing fishing regulations).



Monitoring coral reefs requires a high level of consistency in a challenging environment

The NPS uses sonar equipment, transect lines, photo and video equipment, and other field methods





Virgin Islands National Park

Virgin Islands National Park, which covers the majority of the island of St. John, was created in 1956. Coral reefs and hard bottom communities occupy 8.2 km² (34%) of the waters of the park, are a key resource for local communities, and are one of the main attractions for visitors to the park. NPS staff began monitoring selected reefs in 1999.

- Major Threats**

 - Coral bleaching and disease
 - Overfishing
 - Sedimentation from land-based sources

Bleaching and disease strike rapidly on Tektite Reef



Bleaching
September 2005



Disease outbreak
November 2005



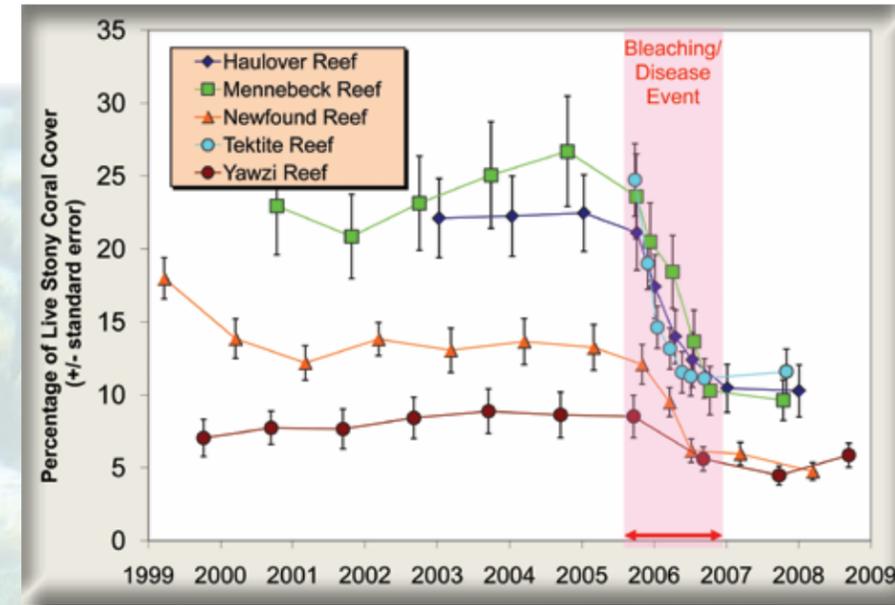
Catastrophic mortality
January 2006

Status and Trends: Coral cover at five permanent monitoring sites was moderately high (7-25% live coral) until 2005-2006, when a severe coral bleaching event followed by a massive disease outbreak affected much of the Virgin Islands. By early 2007, these reefs had experienced declines in live coral of 32-64%. Much of the coral death was caused by disease as corals began recovering from bleaching. Disease levels returned to pre-2005 levels by 2008. Monitoring data has detected one positive sign: crustose coralline algae, a critical substrate for juvenile corals, has increased at all sites.

Action: Coral monitoring continues, and NPS will have 10 years of data from some sites in 2009. In partnership with the National Oceanic and Atmospheric Administration, the National Park Service will continue to monitor fish communities and create a higher-resolution sea floor habitat map in 2009 showing coral reefs, seagrass beds, and other features on the sea floor. This map will help managers and scientists better understand the distribution of submerged natural resources, provide a baseline for future studies, and help focus future monitoring efforts.

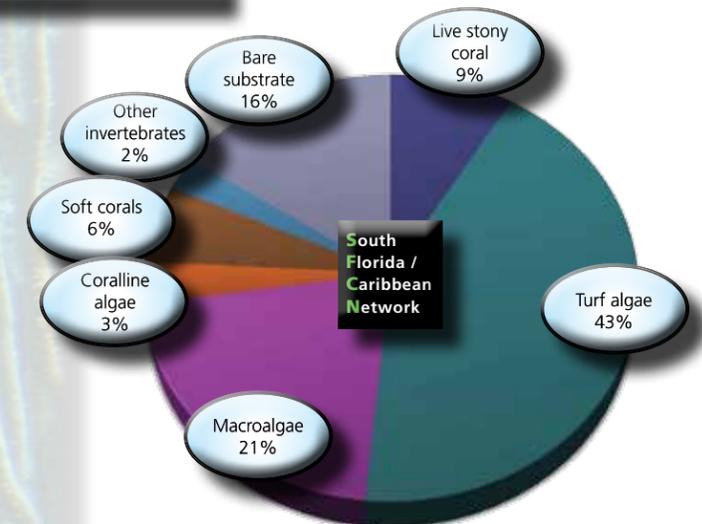


Blue tangs swim over Mennebeck Reef



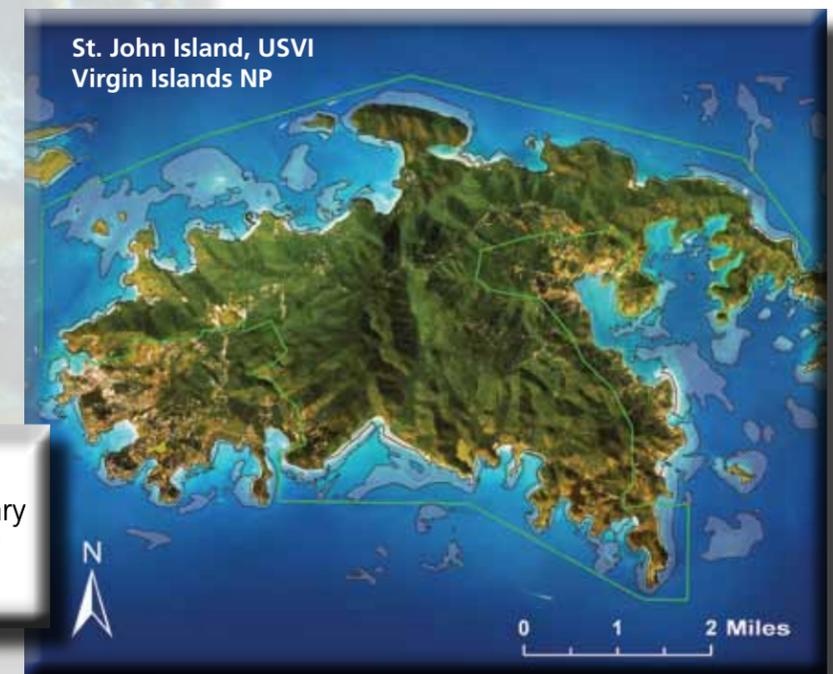
Stony coral cover at five sites showing declines of 32-64% during the coral bleaching / disease event of 2005-2006 (Standard error bars show the variability around the average at each time interval)

Composition of selected coral reefs in Virgin Islands National Park



- Fast Facts**

 - Coral bleaching and coral disease reduced coral cover by 32-64% at monitored reefs in 2005-2007
 - Coralline algae, important habitat for juvenile corals, have increased



Map legend

- Park boundary (authorized)
- Coral reef

Buck Island Reef National Monument

Buck Island Reef National Monument was created in 1961 and expanded in 2001 to preserve “one of the finest marine gardens in the Caribbean Sea.” The elkhorn coral barrier reef and surrounding coral formations occupy approximately 19 km² (26%) of the park waters, and are one of the main attractions for visitors to the park. The monument covers approximately 77 km² and is one of the few fully protected marine reserves in the National Park Service. Buck Island Reef contained some of the finest examples of elkhorn coral ‘haystacks’ in the Caribbean and harbors an incredible diversity of fishes, corals, sea turtles, and other marine organisms. The park educates 50,000 visitors each year along its coral reef underwater trail.

Major Threats

- Coral bleaching and disease
- Overfishing
- Damage from storms and oil spills

Status and Trends: Coral cover at two monitoring sites at Buck Island Reef was fairly stable until the bleaching event and disease outbreak of 2005-2006. Percent live coral cover declined from 6% and 17% to 3% and 5%, respectively, in just over a year as a result of coral death caused by bleaching and disease. Crustose coralline algae have been increasing in the last few years, which may facilitate the reestablishment of juvenile corals.



Large stands of protected elkhorn coral bleached in 2005 and mortality from disease ranged from 36-66%

Action: NPS plans to expand coral monitoring to include additional randomly selected sites throughout Buck Island Reef National Monument in 2010-2011. NPS is also collaborating with the National Oceanic and Atmospheric Administration Biogeography Team to monitor fish communities and habitat inside and outside protected areas.



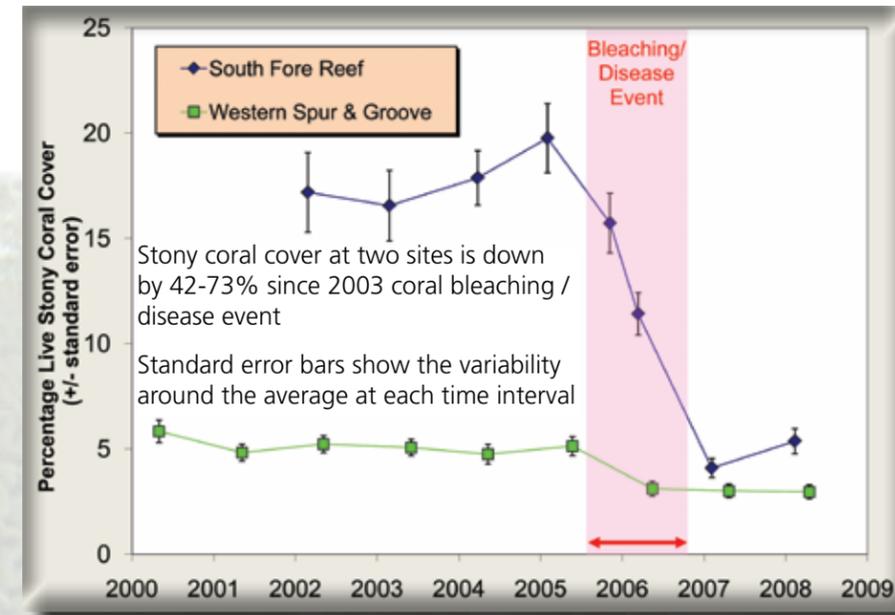
South Fore Reef with high live coral cover



South Fore Reef, bleached



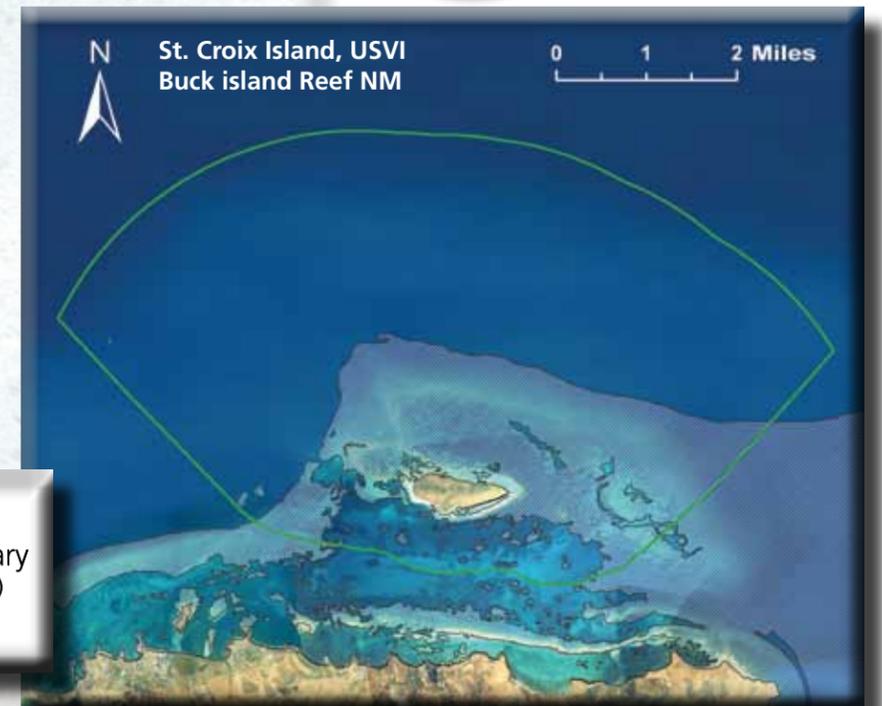
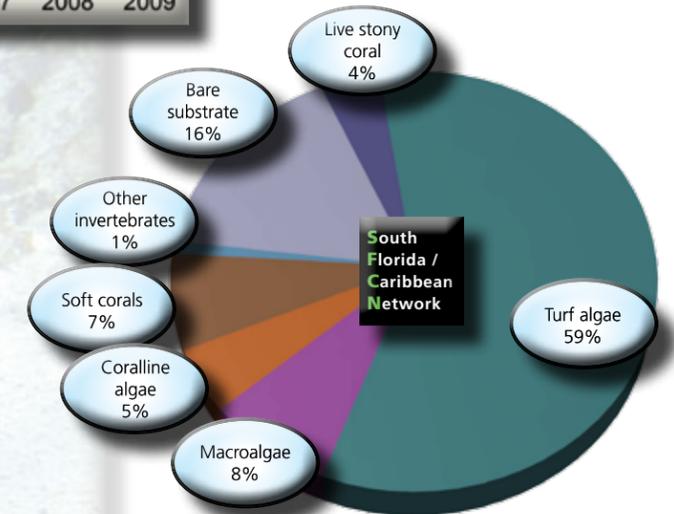
South Fore Reef, mostly dead



Fast Facts

- Coral bleaching and coral disease reduced coral cover by 42-73% at monitored reefs between 2005-2008
- Coralline algae, important habitat for juvenile corals, have increased
- Future work will expand the coral monitoring program

Composition of selected coral reefs in Buck Island Reef National Monument



Map legend

- Park boundary (authorized)
- Coral reef

Biscayne National Park

Biscayne National Park was created as a national monument in 1968 and was expanded to become a national park in 1980. The park covers approximately 700 km² and includes the northernmost 42 islands of the Florida Keys, the shallow waters of Biscayne Bay, and over 5000 patch reefs in the offshore portion of the park. The NPS has been conducting coral monitoring annually since 2004.



Abandoned lobster trap lodged in the reef

Major Threats

- Overfishing
- Run-off and pollution from urbanization
- Physical damage from boat groundings and marine debris

Status and Trends: Stony coral cover at two selected sites in Biscayne is generally low, averaging 5-8% during the first four years of monitoring. However, in contrast to the Virgin Islands, Biscayne National Park was unaffected by the bleaching and disease event of 2005-2006, and suffered no obvious decline in live coral cover, despite direct hits from two hurricanes.

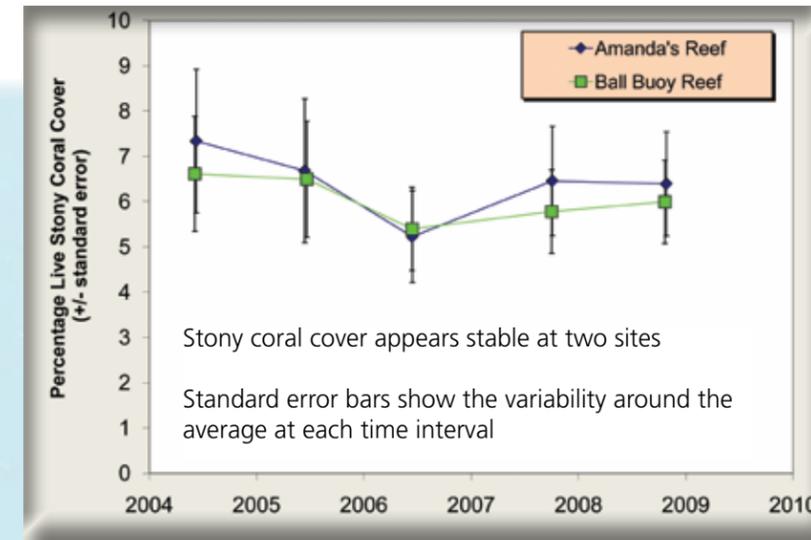


Live corals in the shallow waters of Amanda's Reef



Complex reef structures like this sea arch provide habitat for fish and invertebrates

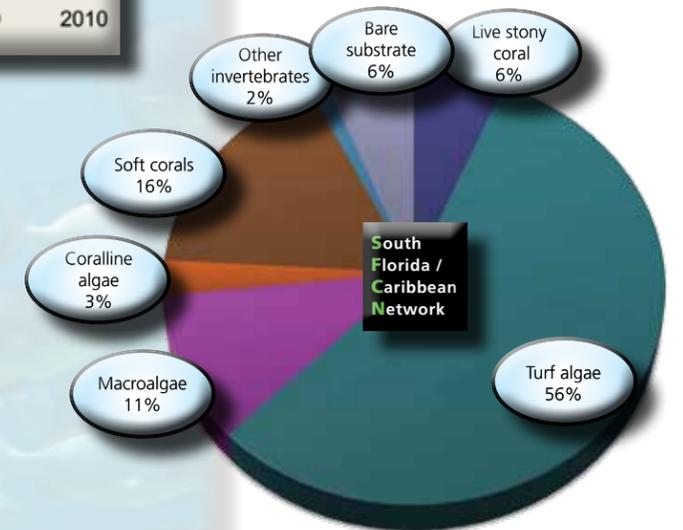
Action: In 2008, a consortium of state, federal and private partners created a detailed sea floor habitat map of the seaward portion of Biscayne National Park, which outlines many underwater park features for the first time, including coral reefs and seagrass meadows. NPS is conducting an accuracy assessment of this map in the field, and will use it to expand coral monitoring to additional randomly selected sites throughout the park in 2009. The NPS is also collaborating with state, federal, and academic partners to monitor park fish communities and create a new fisheries management plan.



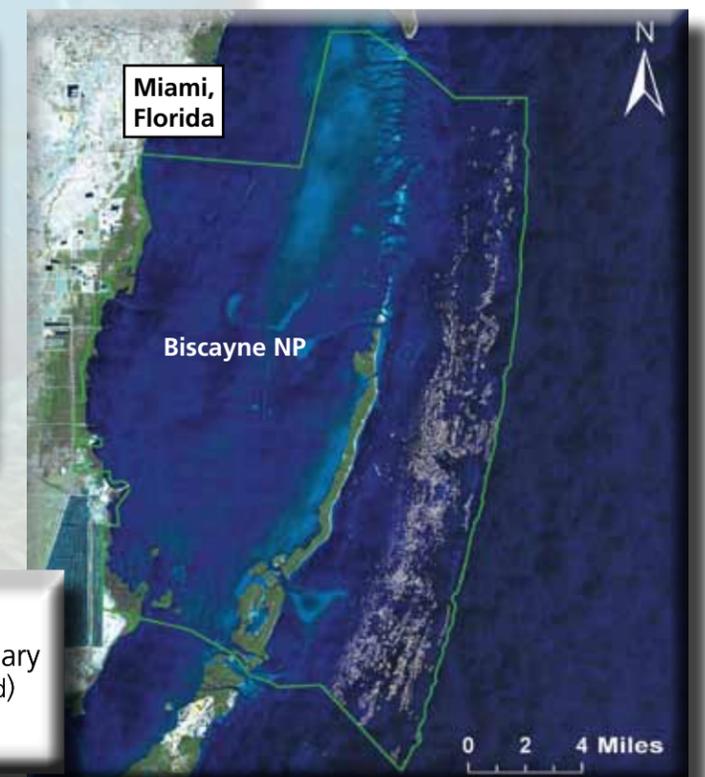
Fast Facts

- Coral cover is low (5-8%) but stable in the park
- The coral monitoring program will expand, using a new sea floor habitat map to randomly select additional sites

Composition of selected coral reefs in Biscayne National Park



A school of bait fish interests both a diver and reef fish predators



Map legend

- Park boundary (authorized)
- Coral reef

Dry Tortugas National Park

Dry Tortugas National Park was created as a national monument in 1935, and was designated a national park in 1992. Located over 110 km west of Key West, the park covers 262 km² (99% of which is submerged) and has some of the highest coral cover reefs in Florida. Coral reefs cover 96 km² (37%) of the waters of the park, and are one of the main attractions for park visitors. In 2007, a no-take marine reserve (called a Research Natural Area) was created. It occupies 46% of the park, and the NPS expanded the coral monitoring program to include 18 randomly selected sites, half of which are inside and half outside the reserve.



A coral disease outbreak was detected in June 2008

Major Threats

- Coral disease and bleaching
- Global climate change and ocean acidification
- Overfishing

Status and Trends: Live coral cover declined slightly at one of two permanent monitoring sites in the Dry Tortugas from 2004-2008, from 13.2% to 10.5%. NPS staff also detected a rapid and severe coral disease outbreak on one of the highest coral cover reefs in the park during June 2008. A rapid response team with coral disease experts from the U.S. Coral Disease and Health Consortium and George Mason University returned to reevaluate the affected area in July and gather samples of diseased coral tissue to determine the causes of the disease. Fortunately, the outbreak had ceased.

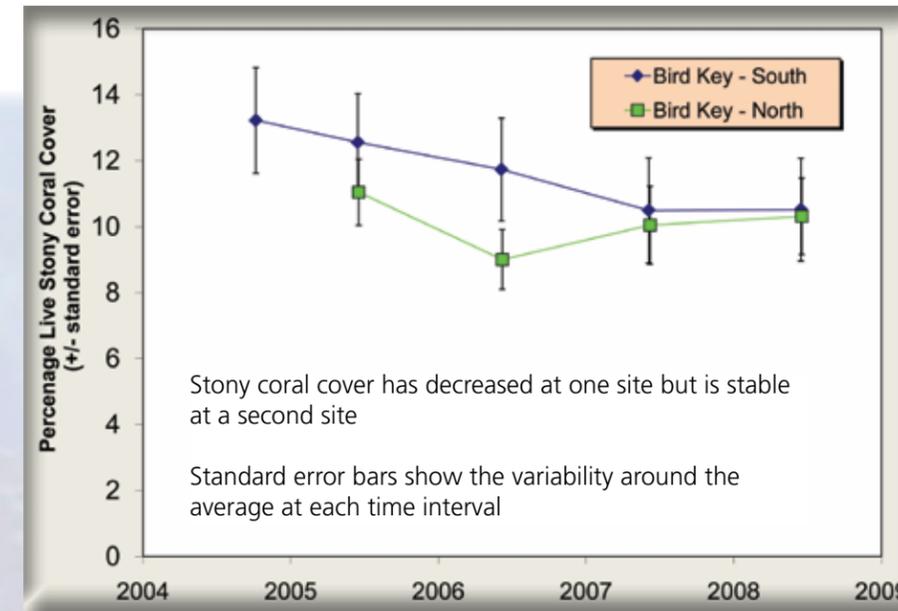


Some corals come in unusual colors, like this orange variant of the great star coral

Corals use tentacles to feed on plankton but get most of their nutrition from symbiotic algae living in their tissues



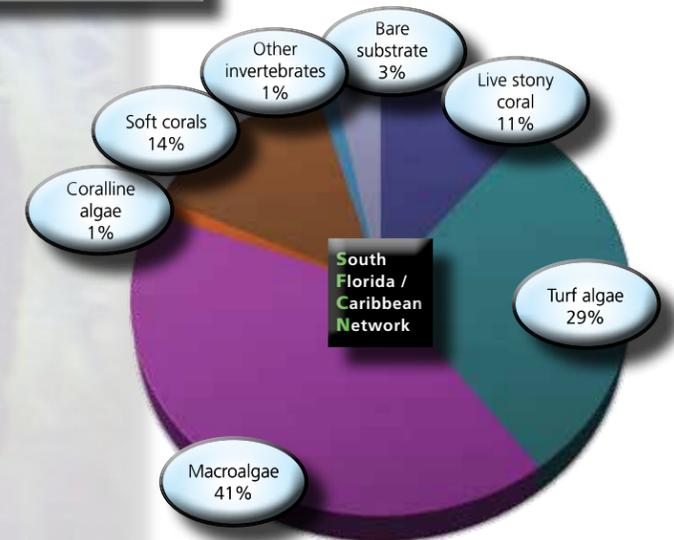
Action: Data from the new park-wide monitoring sites are being analyzed, which will give park managers a much broader picture of reef condition throughout the park. Work on the June 2008 disease outbreak continues. The NPS is also collaborating with state, federal, and academic partners to monitor fish communities inside and outside the protected Research Natural Area.



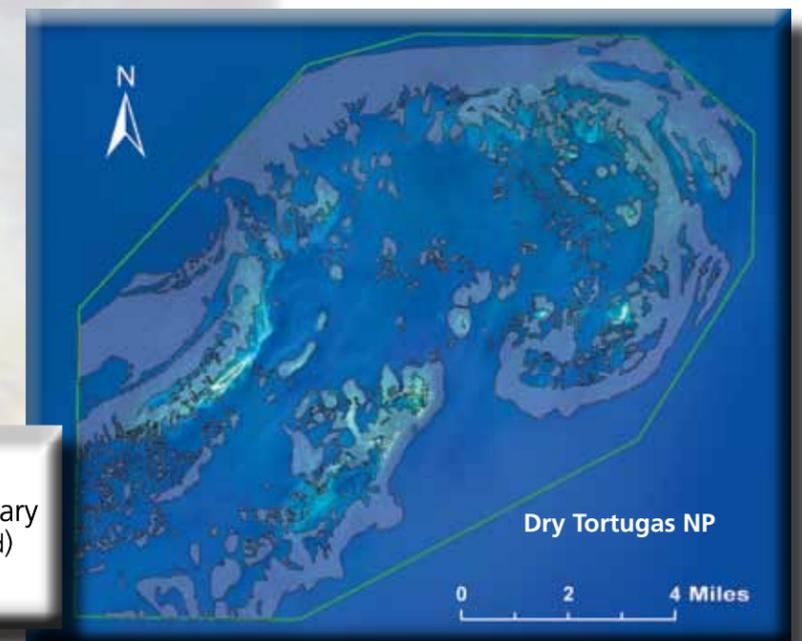
Composition of selected coral reefs in Dry Tortugas National Park

Fast Facts

- Coral cover is declining slowly at one of two sites, and is about 10% at both
- A severe coral disease outbreak occurred in June 2008, but ceased within a month
- The coral monitoring program recently expanded



A protected hawksbill sea turtle ('tortuga' in Spanish), from which the park takes its name



Kaloko-Honokohau National Historical Park

The coral reefs of Kaloko-Honokohau National Historical Park are an integral part of an ancient Hawaiian coastal settlement that includes over 250 archeological sites and three large fishponds traditionally used for fish aquaculture. Park waters receive significant groundwater inputs that deliver excessive nutrients to the coral reef, but also provide lower salinity nursery habitat for several culturally important fish species.

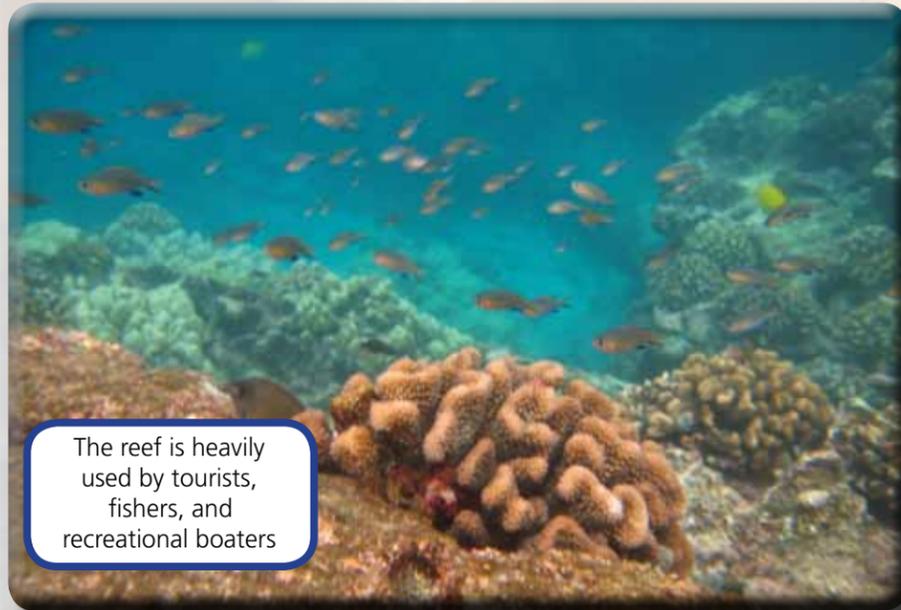
Major Threats

- Overfishing
- Urbanization / non-point source pollution
- Physical damage from overuse

The park is surrounded on three sides by heavy urban development



Status and Trends: Coral reef monitoring began in 2001. Coral cover at 30 monitoring sites was moderately high (32%) with low levels of coral disease in 2007. The rate of coral recruitment (arrival of juveniles) has been extremely low in the last few years, and is a concern. Relatively low cover (10%) of macroalgae suggest that herbivorous fish, invertebrates, and marine turtles may be helping to control algal overgrowth of corals.

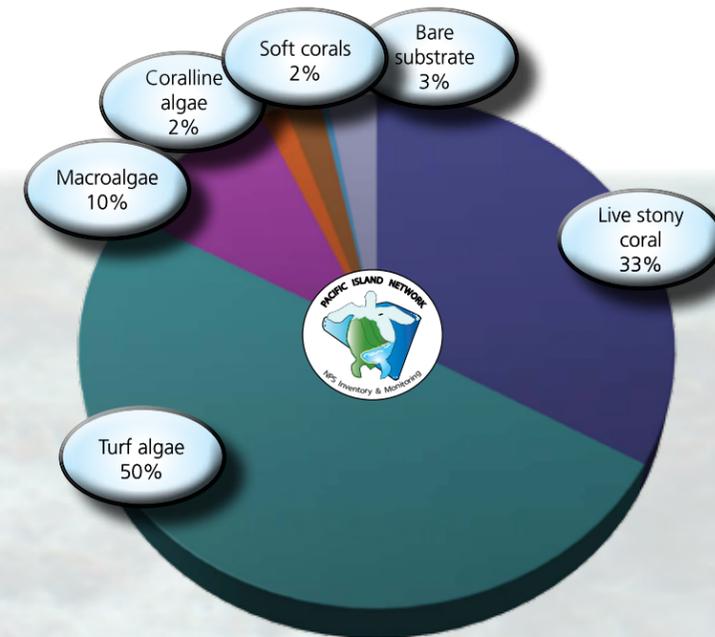


The reef is heavily used by tourists, fishers, and recreational boaters



Many species, such as this blenny, use corals for shelter

Action: The state of Hawaii manages fisheries within the park. Fishing for the aquarium-fish trade is banned and lay-gill nets must be handmade of local fibers. All other fishing is allowed, consistent with state regulations. Data on fisheries harvest are needed. Protection of ground water from excess nutrient and urban contaminant inputs is a primary focus of park management. Two alien marine species, an alga and a jellyfish, have invaded Kaloko fishpond but have not yet been found on the adjacent reef. Monitoring and control of these species is ongoing.



Composition of selected coral reefs in Kaloko-Honokohau National Historical Park

This Hawaiian fishpond is testament to the fact that humans have been altering the near shore marine environment for generations

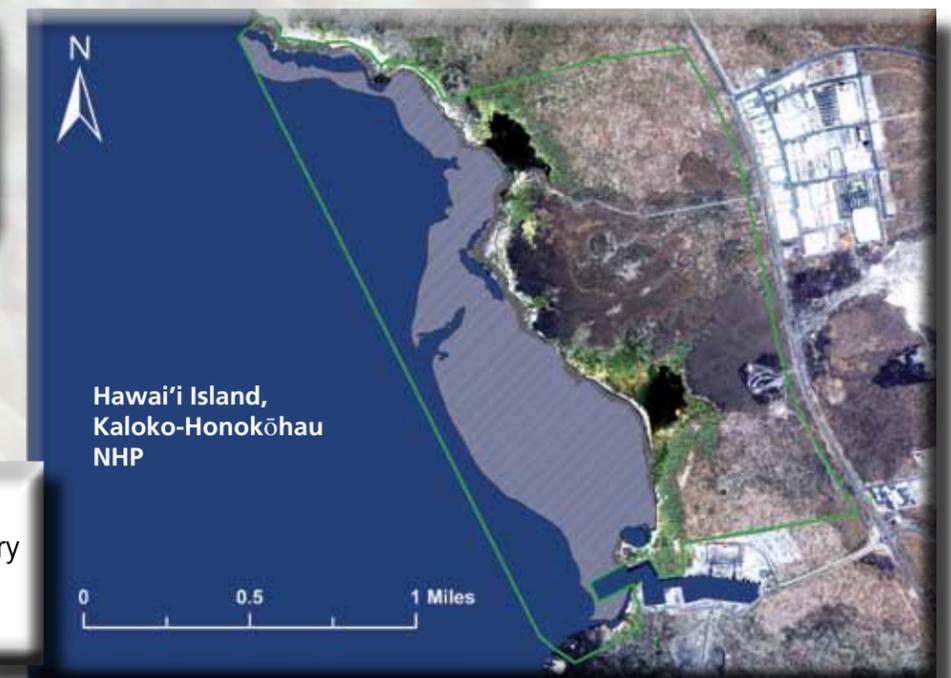


Fast Facts

- Adult corals are relatively healthy, but natural replenishment of juvenile corals has been low for several years
- There is a resident population of threatened juvenile green sea turtles
- Urban development impacts ground-water quality and coral reefs in the park



Once harvested throughout the Pacific, the green sea turtle is now fairly common on park reefs



Map legend

- Park boundary (authorized)
- Coral reef

Kalaupapa National Historical Park

Kalaupapa National Historical Park established in 1980, tells the story of the isolated Hansen's disease (leprosy) community by preserving and interpreting its settings and values. Kalaupapa peninsula is isolated from the outside world by sheer cliffs of over 600 meters. The 25 km of coastline and offshore islands surrounding the park hold a rich and abundant fish assemblage that is among the most diverse in the main Hawaiian Islands. Encounters with rare fish and unique coral species not commonly observed in the main Hawaiian Islands can occur in the shallow waters of this windswept north coast.



Underwater oceanographic observatories measure currents, waves, temperature, and water clarity at several parks in the Pacific

Major Threats

- Overfishing
- Climate change
- Tsunami

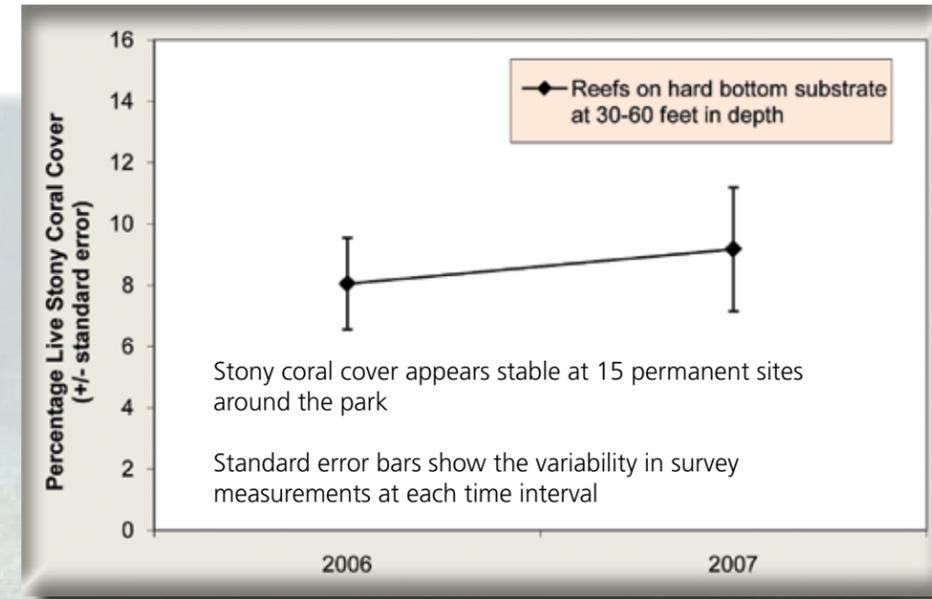
Status and Trends: Coral reef monitoring was implemented in 2006. Coral cover at 30 monitoring sites is relatively low (10%) but appears stable at the 15 permanent sites. This is not surprising since coral habitat along the north shore of Moloka'i Island is subjected to extremely high wave action each winter, causing damage to existing coral colonies and limiting the number of coral species that can thrive under these conditions. There has been a very low incidence (<2%) of coral bleaching or disease. Coral recruitment (arrival of juveniles) is low compared to other north shore environments in the state of Hawaii. Monitoring data have detected a low (4%) cover of crustose coralline algae, a critical settlement surface for juvenile corals and many other reef organisms and important for maintaining reef structure. Low macroalgal cover of 12%, however, suggests that the abundant herbivorous fish populations may be helping to keep algae in check. Fishing activity in the park is limited to local residents and occasional fishing vessels.



These corals are adapted to survive, grow and reproduce in areas exposed to extreme forces from winter storm waves



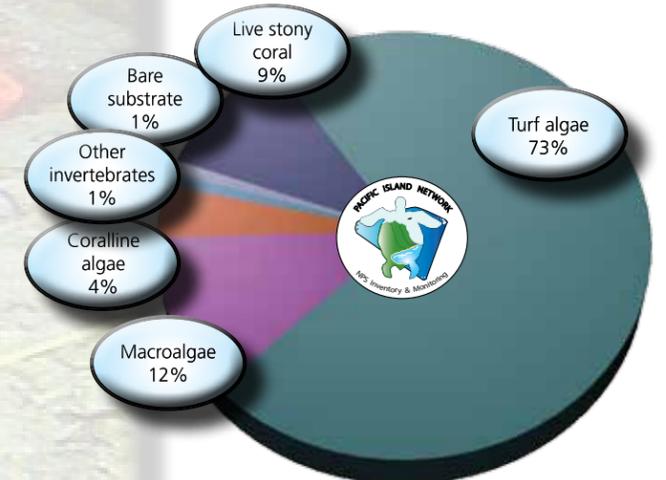
Action: Marine algae, invertebrate, and fish inventories have yielded new scientific records and identified unique habitats within the park. Monitoring and research on targeted fisheries are providing valuable information for park and state-wide fisheries management. Park staff and cooperators are continuing to monitor sea floor communities and reef fish assemblages along with natural coral replenishment. Physical parameters such as currents, tides, temperature, and water quality are also being monitored within the park to provide information to resource managers.



Composition of selected coral reefs in Kalaupapa National Historical Park

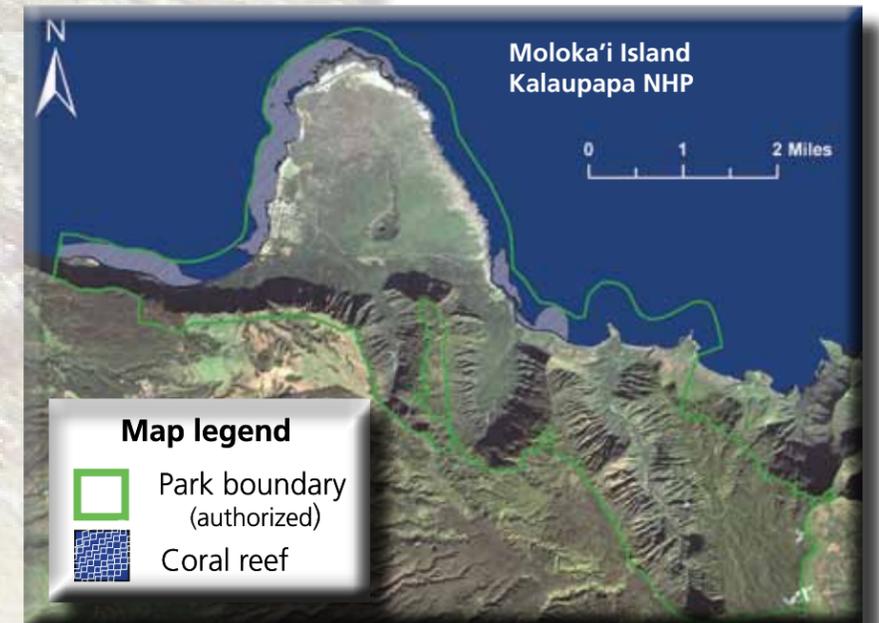


Endangered Hawaiian monk seals use the beaches at Kalaupapa to pup their young and rest



Fast Facts

- Large boulder habitat provides an ideal environment for fish populations
- Fishing pressure from outside sources is a local concern
- The park is engaged with the local community in marine resources management
- Kalaupapa is a primary pupping area for the Hawaiian monk seal in the main Hawaiian Islands



National Park of American Samoa

The National Park of American Samoa has some of the greatest marine biodiversity of any U.S. park with over 975 fish and 250 coral species. Large table corals (*Acropora sp.*) over three meters in diameter, and mound corals (*Porites sp.*) standing up to seven meters tall and 25 meters long can be found in nearshore marine waters. The marine boundaries of the park contain nearly 20% of American Samoa's nearshore waters. The park was created on three islands to preserve and protect the cultural and natural resources of American Samoa.

Major Threats

- Overfishing
- Sedimentation and habitat degradation
- Climate change



Modern fishing techniques have replaced many traditional methods, and have resulted in unsustainably high fish yields

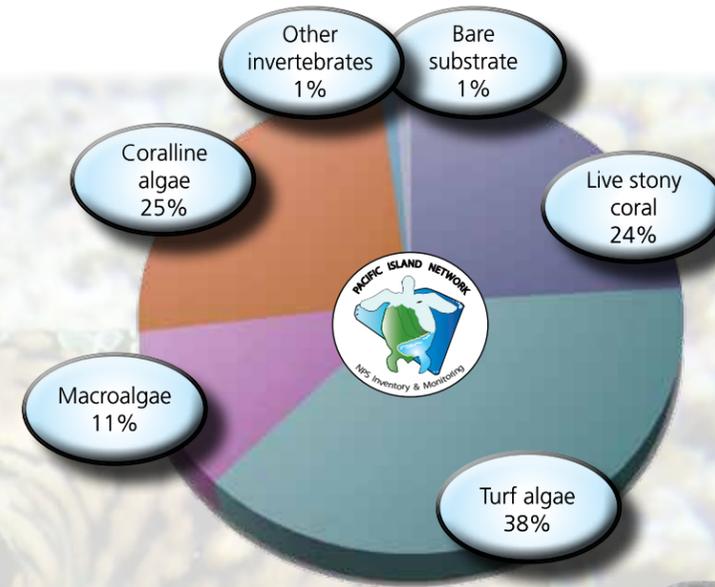
Status and Trends: Coral reef monitoring was implemented in 2007. Coral cover at 30 monitoring sites was moderately high (22% live coral) in 2008. This likely reflects high coral biodiversity, relatively fast coral growth rates and large areas of suitable shallow habitat for corals. Bleaching events occurred in 1994, 2002, and 2003, which affected both shallow and deep corals. There has also been minor bleaching in back reef pools and lagoons for the past three years. Monitoring data have shown a 19% cover of crustose coralline algae, a critical settlement substrate for juvenile corals and many other reef organisms, and important for maintaining reef structure. Eleven percent cover of macroalgae suggests that herbivorous fish populations are maintaining low levels of algal abundance. Overall fish biomass is roughly 1/3 the levels occurring on unfished reefs in the tropical Pacific, and large fish are extremely rare.



Plate corals and these algae have calcium-based skeletons threatened by ocean acidification



Reefs are important nursery habitats for juvenile fish

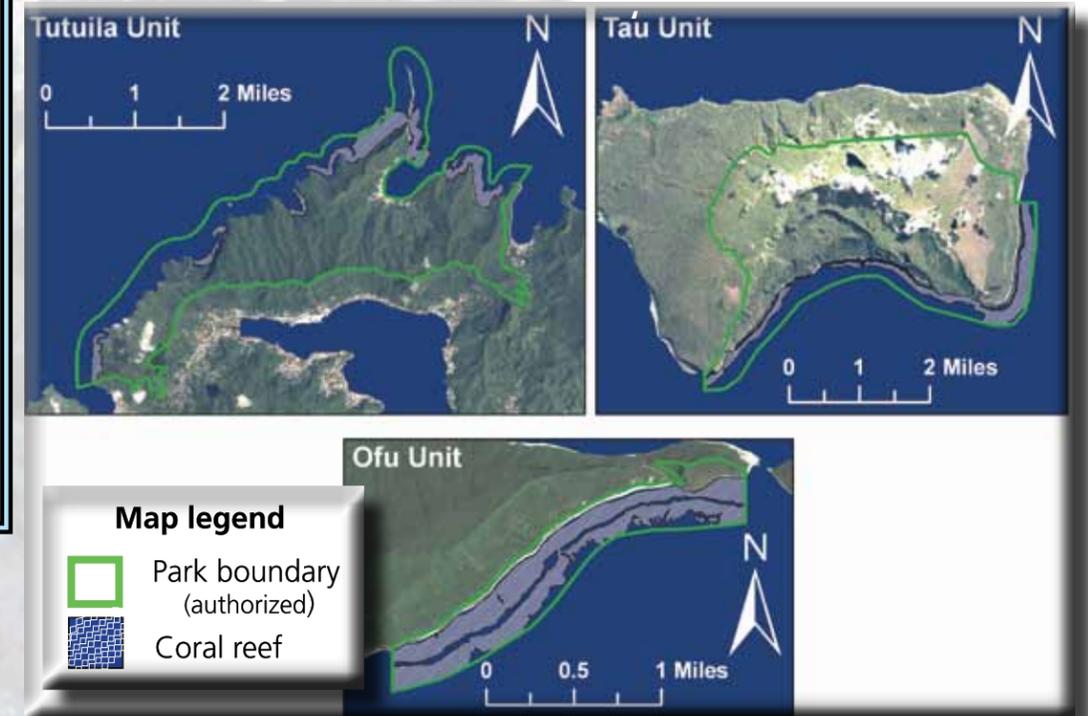


Composition of selected coral reefs in National Park of American Samoa

Fast Facts

- The park contains over 250 species of corals, and a very high diversity of other marine invertebrates, fishes, and plants
- Some of the most immense coral colonies in the world live here
- Some coral populations in park waters seem resilient to high ocean temperatures and may serve as 'refuge populations'

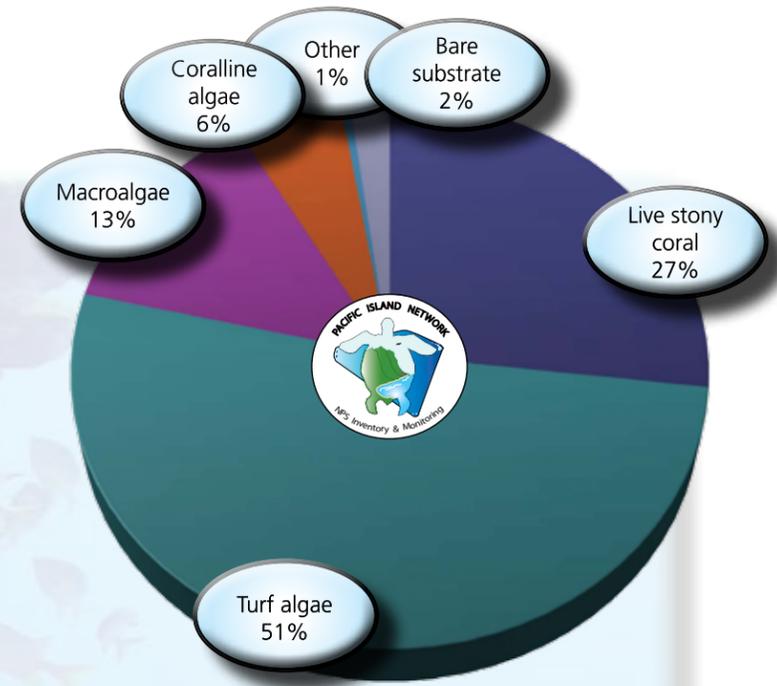
These soft corals, common on Tutuila Island, can withstand conditions of high sedimentation and poor water quality



Action: Research in the park by the NPS and many partners has made important contributions to understanding and managing coral reefs during climate change. Coral reef and reef fish monitoring have been implemented by NPS and cooperators including a nearshore fisheries study.

War in the Pacific National Historical Park

War in the Pacific National Historical Park has one of the highest levels of species diversity within the national park system, including one of the most diverse coral reefs. The park was established to commemorate the men and women who fought and served in the battlegrounds of Guam during World War II. Bomb holes that once scarred the sea floor are now covered with coral and algae, and serve as habitat for a diversity of fishes and marine invertebrates. Unexploded ordnance and empty shell casings rest silently on the sea floor to remind divers of the fierce battles that took place during World War II.



Composition of selected coral reefs in War in the Pacific National Historical Park

- Major Threats**
- Overfishing
 - Sedimentation
 - Watershed development



An NPS scientist taking measurements of an eroded landscape which has led to massive sedimentation on the reefs



Corals are becoming increasingly rare due to impacts from land-based sources

Status and Trends: Coral reef monitoring began in 2008. Live coral cover at 30 monitoring sites was moderately high (27%). Sedimentation and its impacts on coral reefs is a continuing major concern. Coral recruitment (arrival of juveniles) in the park has been extremely low over the last several years. Monitoring data have shown six percent cover of crustose coralline algae, a critical settlement surface for juvenile corals and many other reef organisms, and important for maintaining reef structure. Twelve percent cover of macroalgae suggests that at least some herbivorous fish or invertebrate populations need protection in order to help prevent algae overgrowth on coral.

- Fast Facts**
- Fire and subsequent erosion in the uplands causes severe sedimentation impacts on coral reefs
 - Coral recruitment (arrival of juveniles) is extremely low
 - Harbor expansion adjacent to the park presents serious threats to coral reef resources



A stingray makes its home along the reef in Agat Bay



This feather plume worm sweeps up small particles and helps to keep reefs clean

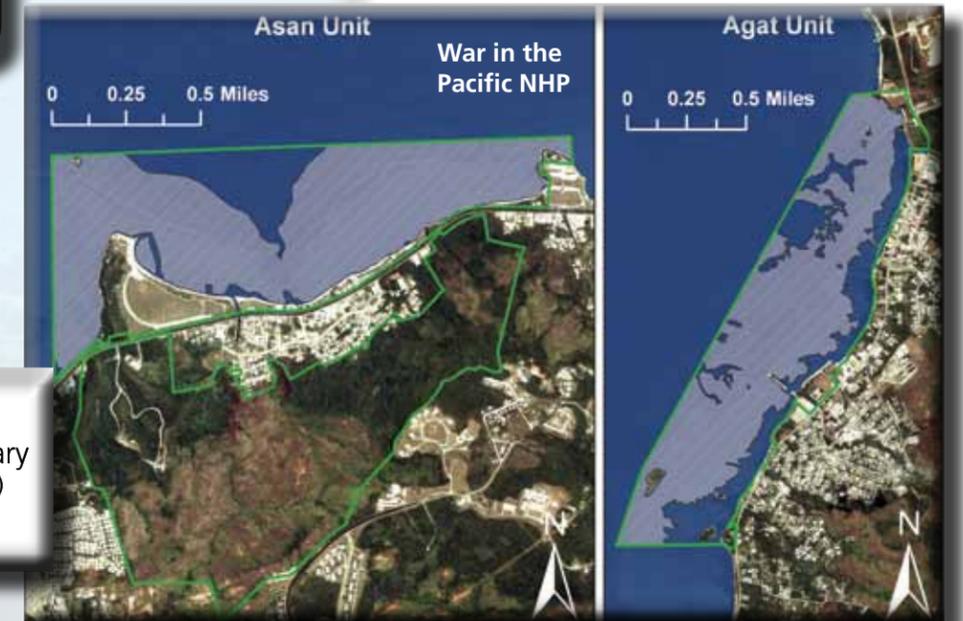


An anemone fish rests in the tentacles of its host anemone, where it is safe from potential predators

Action: A subsistence fisheries harvest study has been done in the park. Coral reef and reef fish monitoring has been implemented by NPS and cooperators as has the monitoring of currents, tides, temperature, sedimentation, water quality, and coral recruitment. The park is experimenting with several methods for restoring eroded upland areas to reduce sediment loads on coral reefs along with monitoring off-road vehicle use in park watersheds which is associated with erosion.

Map legend

- Park boundary (authorized)
- Coral reef



The Future

The coral reefs in U.S. national parks are irreplaceable global treasures. They span thousands of kilometers across two oceans and are home to many thousands of species of fishes, corals, and other marine organisms. The health and condition of these reefs varies dramatically and the reefs face many threats. The NPS coral reef program tracks ecological indicators that measure reef health. Diverse threats including climate change, coral disease, and changes in land use can degrade or destroy coral reefs in and around national parks. Some immediate needs include:

Coral disease research

For most coral diseases the pathogens are still unknown and increased research funding on the causal agents and contributing factors of coral disease is critical. The NPS assists with field logistics for qualified university or agency researchers.

Coral reef habitat maps

Good maps of shallow sea floor coral reef environments will improve both monitoring programs and management. These have been developed for reefs in some parks.

Expansion of programs to deeper reefs

Little is known about the status and trends of deeper coral reefs (>20 m). Deeper reefs may be less susceptible to some stressors and may serve as important refuges for components of shallower coral reef ecosystems.

Participation in watershed and land use planning

National park units are affected by external land uses and activities. Participation with government agencies and stakeholders on watershed planning and conservation measures to protect these resources will continue to be pursued.

Increasing enforcement activities

Several parks are considering joint enforcement agreements with state and territory management agencies to enable law enforcement rangers to patrol coastal waters within park boundaries.

The Inventory and Monitoring Program of the National Park Service is documenting the status of coral reefs and how they are changing in national parks. This information will help alert resource managers to problems and assist them with developing and evaluating different management actions to better protect these fragile resources for future generations.



The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

Natural Resource Report NPS/NRPC/NRR—2009/091

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