# Bahamas
# Coral Reef Report Card

## Volume 1: 2011–2013

Andros, Cay Sal Bank, Little Bahama Bank, New Providence & Rose Island, Southern Bahamas

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## On the Cover

*Initial phase Queen Parrotfish on a reef.*

Photo © Craig Dahlgren

*Parrotfish promote reef health by removing seaweed.*

*Coral reefs support key fisheries.*



# Executive Summary

***Coral Reefs are vital components of the ecology, economy, and culture of The Bahamas.*** From 2011 to 2013 a total of 214 reefs were assessed throughout The Bahamas, including sites on Cay Sal Bank, Andros, the Southern Bahamas, New Providence and Rose Island, the Little Bahama Bank, and partial surveys in The Exuma Cays and Berry Islands. The health of these reefs was determined by examining the status of six key indicators. For each indicator, reef health was scored as being Good, Fair, Impaired, or Poor, and an overall Bahamian Reef Health Index (BRHI) was calculated by averaging scores of individual indicators.

***Bahamian reefs were classified as Impaired overall***, but there was much variability among areas and reef zones. Other key findings include:

- Live coral cover was lower on Bahamian reefs than reefs in the rest of the Caribbean and macroalgae coverage was relatively high.
- Reef structure was rated as Fair for most areas surveyed and greatest for New Providence.
- Coral Recruitment was low throughout The Bahamas, particularly Cay Sal Bank, but similar to elsewhere in the Caribbean on average.
- Parrotfish populations were scored as Fair in most areas and were 2–4 times greater than the rest of the Caribbean.
- Grouper populations were healthiest in The Exuma Cays where the Exuma Cays Land and Sea Park provides protection.
- Large groupers were fairly common on Bahamian reefs but were practically absent from the rest of the Caribbean.

Results also point to the impacts of specific threats and call for several actions. Key threats affecting specific areas include:

- **Coastal development**
- **Illegal fishing**
- **Legal but unsustainable fishing**
- **Climate change**

To combat these threats, specific strategies can be implemented to put Bahamian reefs back on the path to being vibrant ecosystems teeming with marine life and supporting the lives of Bahamians. Key strategies include:

- **Creating island development plans** to prevent degradation of sensitive habitats.
- **Improving fisheries management** through better enforcement and revising regulations so they are based on the best available science.
- **Implementing a network of marine protected areas** encompassing at least 20% of nearshore waters and designed based on science and stakeholder input.
- **Rehabilitating critical ecosystems** and facilitating recovery of key species.


*Healthy coral reefs support a diversity of sea life.*

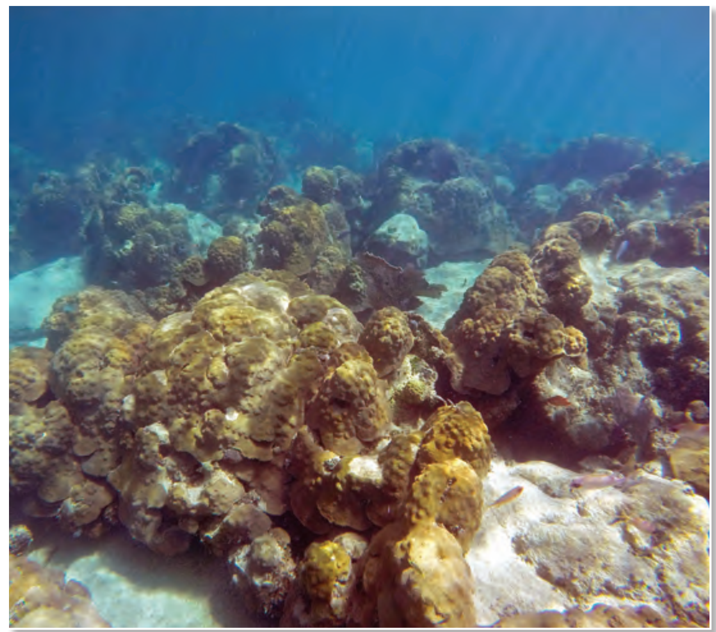
## Coral Reefs of The Bahamas

As a nation of over 700 islands and cays bathed in crystal-clear blue waters, the marine environment is critical to the ecology, economy, and culture of The Bahamas. This is particularly true of coral reefs, which harbour the greatest diversity of life in The Bahamas, support fisheries that feed its people, are vital to the Bahamian economy, and are woven into the fabric of Bahamian culture. ***The Bahamas has more coral reef area than any other nation in the region and boasts one of the world's largest contiguous coral reefs, the Andros Barrier Reef.***

## Reef Types

Bahamian coral reefs are as varied as the islands they surround, based on their location and the environmental conditions they face. Along the east side of Andros, for example, a barrier reef parallels the shore, separated from the island by a lagoon. In other areas, reefs fringe the shoreline, such as in The Exuma Cays, Berry Islands, and parts of the southeast Bahamas. Reefs also form on the edge of banks where there are no large islands, such as Cay Sal Bank, or along the eastern edge of the Tongue of the Ocean, southwest of New Providence.

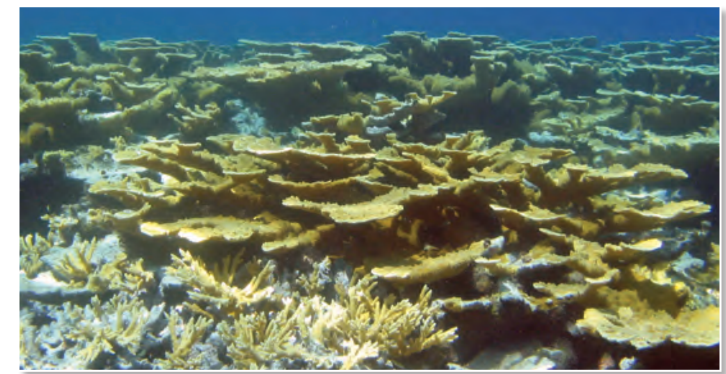
How reefs develop depends on their environment, including exposure to wind and waves. Tidal flows off shallow banks can further expose corals to sediments and large fluctuations in temperatures. As a result, the composition and growth of coral species on reefs can vary, along with the structure they provide as habitat for fish and other reef creatures, leading to different species assemblages on different reefs.



*Scattered nearshore patch reefs off Abaco.*

## Reef Zones

***In The Bahamas there are three major reef zones—reef crest, patch reef, and fore reef—each with its own set of species.*** The reef crest is where waves may be seen breaking offshore (barrier reefs) or near rocky shorelines (fringing reefs). This zone can be formed by large stands of branching elkhorn coral. In lagoons sheltered by reef crests are patch reefs, small reefs that rise above the surrounding seafloor. Patch reefs also form on shallow banks leeward of islands (e.g., Rose Island) or in channels between islands (Exuma Cays Land and Sea Park). Offshore from the reef crest is the fore reef, which extends out to the drop-off and is often dominated by large mounding corals.

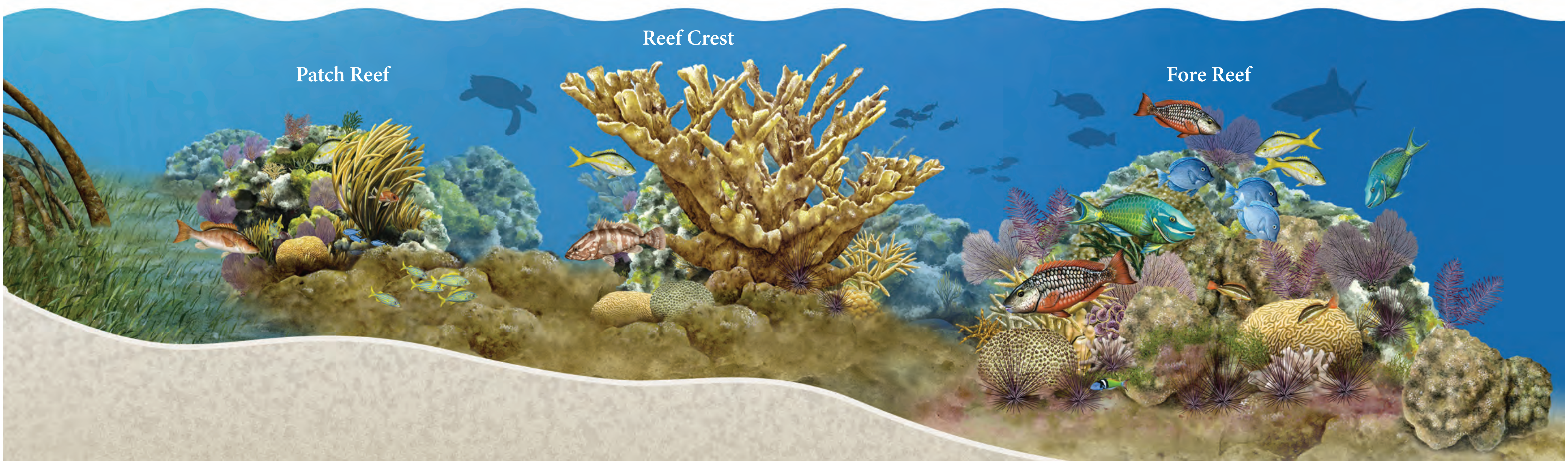


*Elkhorn coral along a reef crest in The Exuma Cays.*

## Natural Variability vs. Human Impacts

Human impacts can affect reefs by altering their environments, potentially reducing diversity and limiting the ecological services and benefits that coral reefs provide. In this report card we examine both natural variability and human impacts and how they affect key aspects of reef health.

*Mounding corals in the fore reef zone.*



# Introduction to Indicators

## Measures of Coral Reef Health

Reef health was evaluated by examining the condition of several indicators on reefs throughout The Bahamas. The indicators take into account the current status of corals and other key species responsible for maintaining reef health. These indicators show how reefs are affected by various threats and have important implications for the management of reefs throughout The Bahamas. Based on the status of individual indicators, a Bahamian Reef Health Index (BRHI) was developed to grade overall reef health.

All reef surveys from 2011–2013 used Atlantic and Gulf Rapid Reef Assessment (AGRRA v5) methods to assess corals and other organisms living on reefs, including populations of key fish species. Because these surveys were part of individual research and monitoring projects in different parts of The Bahamas, with different goals and objectives, as opposed to a national monitoring program, these assessments should be considered as representative of reefs only in those areas surveyed.

### Benthic Index

The amount of a reef covered by live coral and other organisms that promote reef growth versus the amount that is covered by organisms that overgrow or displace corals is compared in the Benthic Index. Higher scoring sites have more live corals and other reef builders.

### Coral Condition Index

When a coral suffers natural stresses or human impacts, parts of the colony may die, or the entire colony may die. This index compares the average percentage of live coral on colonies greater than 25 cm at each site because corals of this size would have been exposed to multiple threats and stresses.

### Reef Structure Index

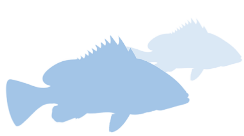
Reefs are constantly being built by corals and destroyed by storms and organisms that erode the reef structure. This index provides an assessment of the net structure that a reef provides by averaging the maximum vertical relief measured at spaced intervals along transects. Sites with higher scores have more reef structure and more hiding places for fish and reef creatures.

### Coral Recruitment Index

Recruitment is measured as the number of new corals on a reef. While coral size varies among species, recruits are considered as any coral less than 4 cm in diameter for this index. Reef sites need to be periodically replenished with new coral recruits to replace corals that die off.

### Large Parrotfish Index

In The Bahamas, large parrotfish play a key role in reducing the amount of seaweed that can overgrow corals, particularly new recruits. This index examines the density of large parrotfish (> 30 cm) on reefs at each site.



### Grouper Index

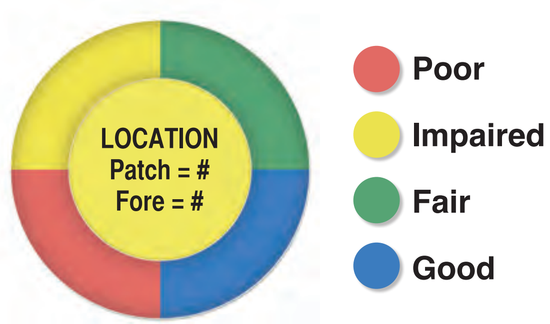
Large grouper species are among the most important fishery species on reefs and play an important ecological role as predators, controlling populations of species that harm corals. Healthy grouper populations include fish across all size ranges, but they must have large adults (> 40 cm) that reproduce. This index examines grouper abundance at sites, with greater values assigned to larger fish.

### Bahamian Reef Health Index (BRHI)

The scores from the other indicators are combined to calculate the BRHI by assigning the grades of the other indicators a numeric score of 1–4 (Poor to Good) and averaging the score. This index was only calculated for sites with at least 5 of the other 6 indicators calculated.

## Reef Scores

For each geographic area of The Bahamas that was surveyed, scores for each index are displayed on maps using a color-coded circular graph showing the proportion of fore reefs and patch reefs (summed together) receiving each score (see facing page for details). The average score for the area is shown in the center of the circle, along with the number of reef sites surveyed in each zone. Summary scores across all reef sites in all areas are shown for each reef zone using the same format in the upper right margin of each map.





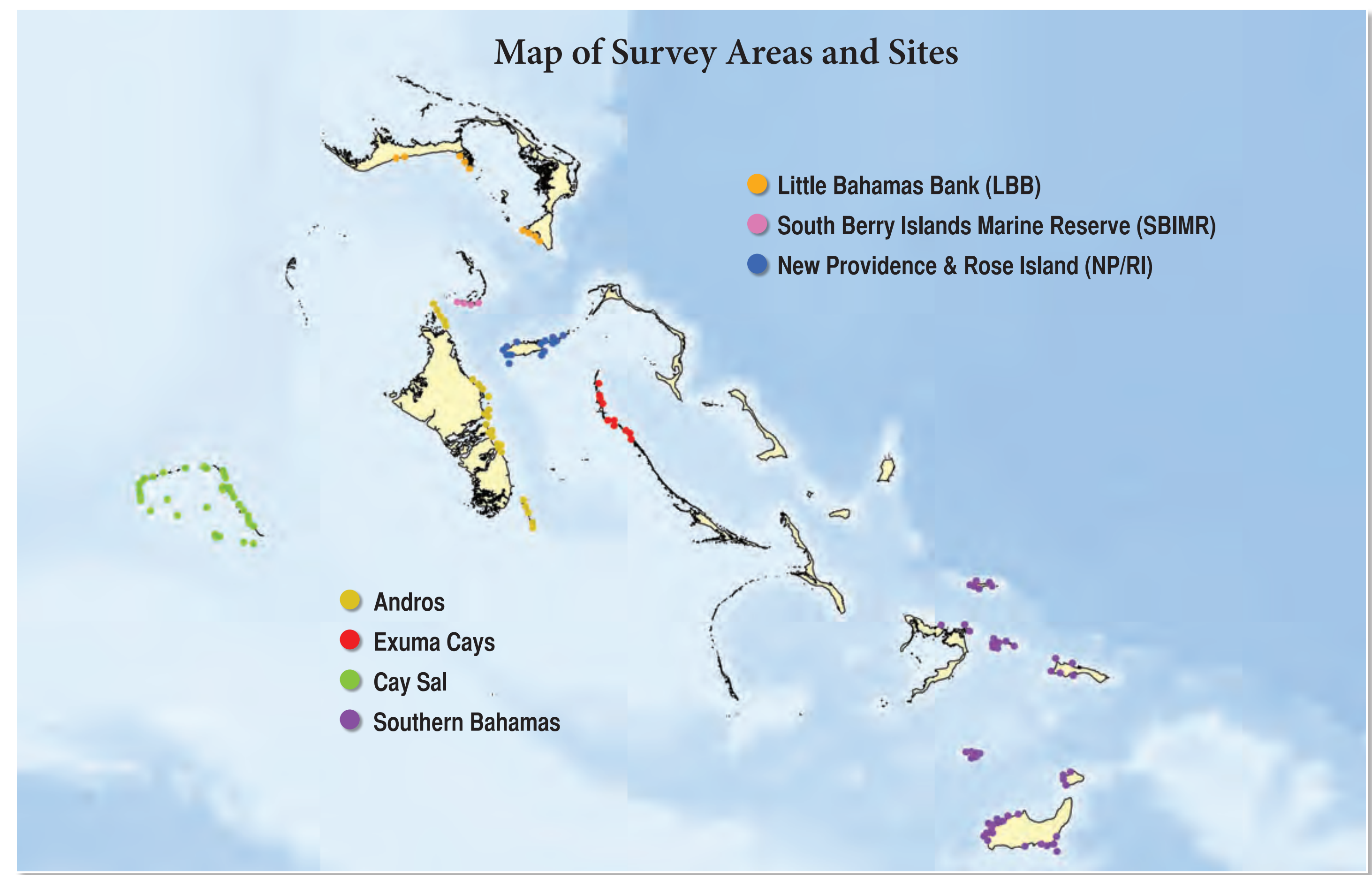

# Evaluating Reef Health

## Grading Scale

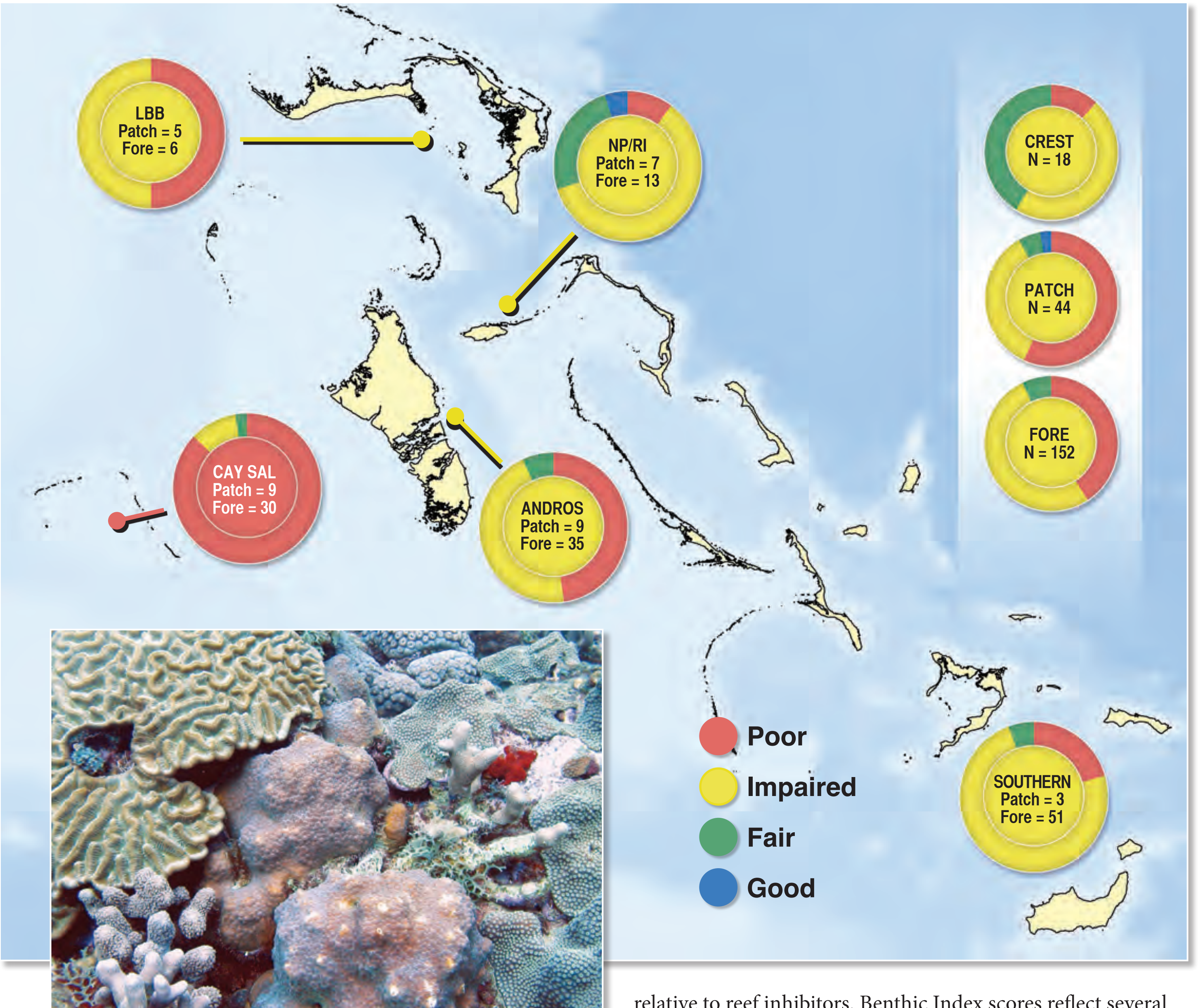
Individual reef sites were scored on their condition for each indicator, with grades of Poor, Impaired, Fair, and Good. The grading scale was developed based on information about the healthy status of each indicator from historic accounts, comparisons of reefs that are exposed to minimal stresses or human impacts, or from studies of coral reef ecology. The condition of an indicator on any reef may reflect both environmental conditions and human impacts. For example, a reef may be Poor due to natural limiting conditions, or it may have degraded from various human threats.

| INDICATOR | POOR | IMPAIRED | FAIR | GOOD |
|---|---|---|---|---|
| Benthic Index* | 1.0–1.5 | 2.0–2.5 | 3.0–3.5 | 4 |
| Coral Condition (% alive) | < 40 | 40–59 | 60–79 | 80–100 |
| Reef Structure (cm) | < 33 | 33–66 | 67–100 | > 100 |
| Recruit Density (no./$m^2$) | < 4.0 | 4.0–7.9 | 8.0–11.9 | 12+ |
| Large Parrotfish Density (no./100$m^2$) | 0 | 0.1–0.5 | 0.6–1.0 | > 1.0 |
| Grouper Index* | 0–0.5 | 0.51–1.0 | 1.1–2.0 | > 2 |
| Bahamian Reef Health Index* (BRHI) | 1.0–1.75 | 1.76–2.5 | 2.51–3.25 | 3.26–4.0 |

* These indices do not have units. A description of how they are calculated is available at **www.blueprojectatlantis.org.**



# Benthic Index




*High cover of reef-building coral on a fore reef.*

## Building Reefs

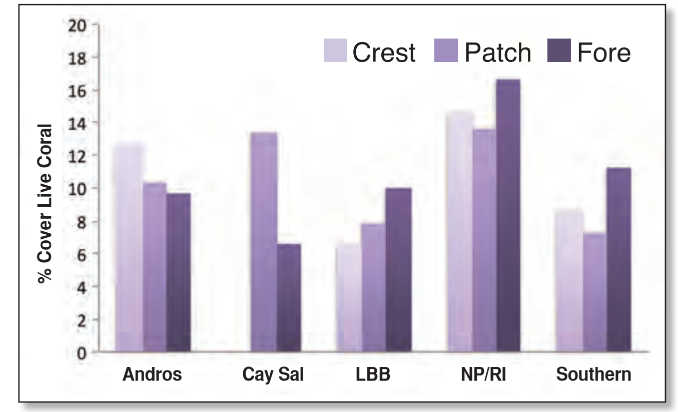
Corals with their stony skeletons are the primary architects of reefs, with pink crustose coralline algae acting like cement to bind pieces of the reef together and providing new surfaces for coral larvae to settle and grow. Other organisms like macroalgae (seaweeds) and some sponges and tunicates inhibit larval settlement or kill corals, thereby preventing reef growth. Similarly, small turf algae may bind sediment and smother corals. The balance between organisms that promote reef growth and those that inhibit reef growth currently is tipped in favor of reef inhibitors across all reef zones and regions of The Bahamas, with reefs around Cay Sal Bank having the lowest overall Benthic Index scores. Only one patch reef off New Providence Island had a high score indicating high amounts of reef promoters relative to reef inhibitors. Benthic Index scores reflect several factors that have resulted in the loss of coral on Bahamian reefs. These losses may be reversed, however, through several key strategies discussed in the Recommendations section.

## Coral Cover

In the 1970s and early 1980s, corals covered an average of approximately 35% of the seafloor on Caribbean reefs. Since then many corals have died from temperature stress during particularly hot periods, disease outbreaks, pollution, sedimentation, and other factors. This has resulted in the loss of more than half of the live coral cover on reefs. ***At present, live corals only cover an average of 10–12% across all Bahamian reefs*** surveyed, with some areas like New Providence and Rose Island having live coral cover up to 17% on average. Major source of coral loss in The Bahamas have been mass bleaching events and subsequent disease outbreaks.

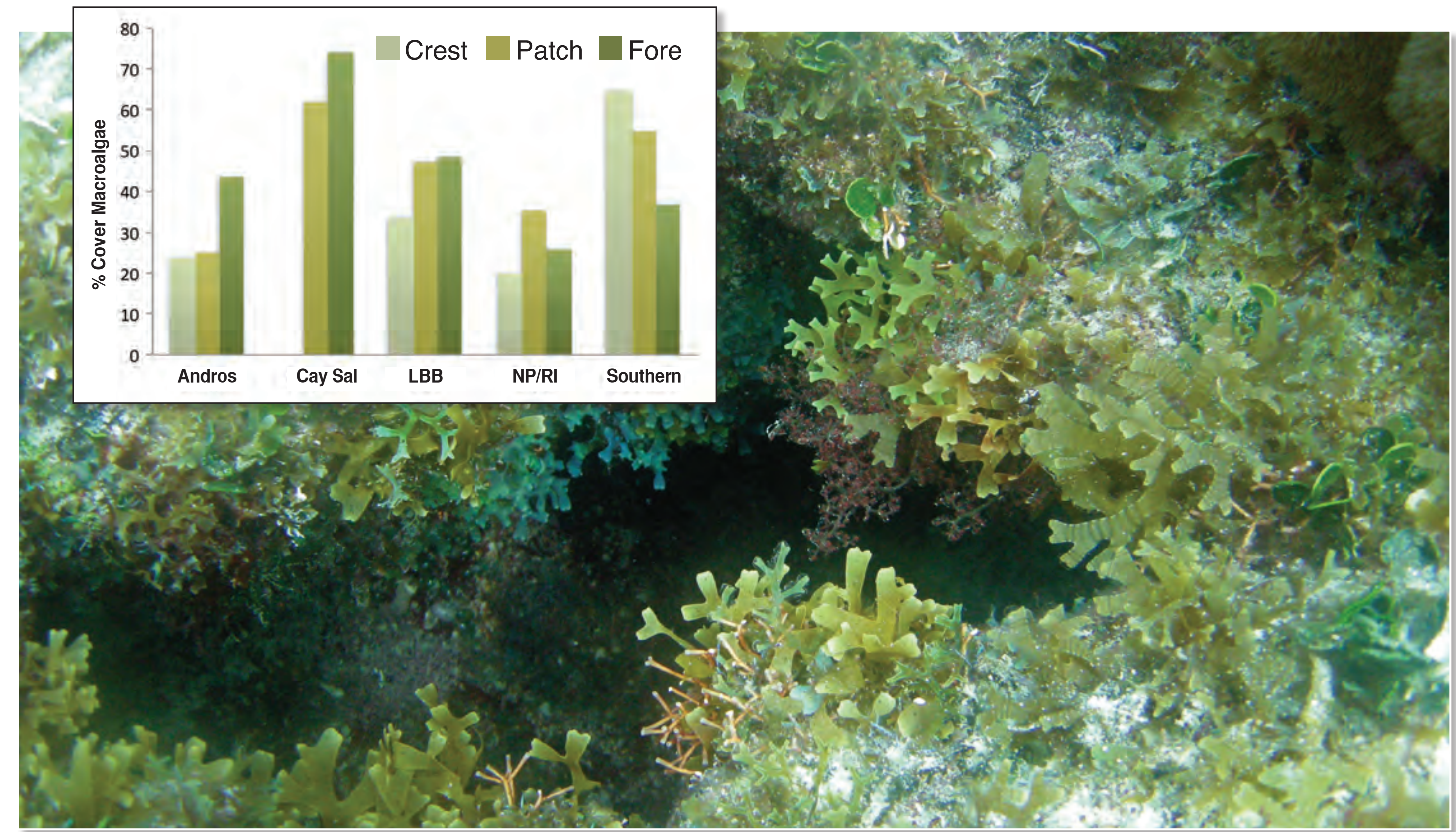


# *Reef Builders vs. Competitors*




## Macroalgae

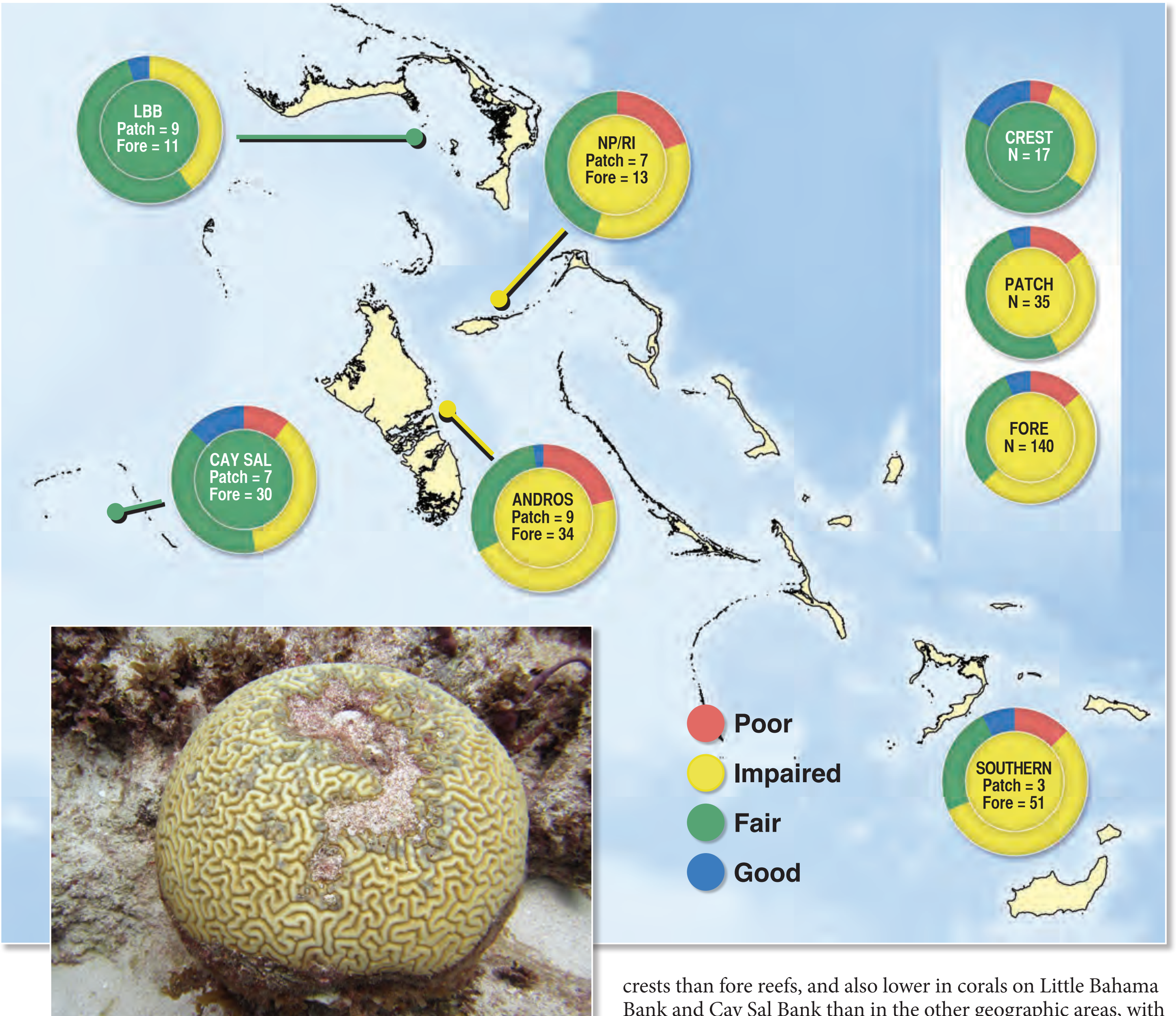
Macroalgae, or seaweeds, can overgrow or outcompete corals if nutrients are high or there are not enough herbivorous grazing animals to keep them in check. While we commonly refer to reefs in The Bahamas as coral reefs, currently there is a higher cover of macroalgae than corals on most reefs. The actual amount varies by reef zone and location, with macroalgae covering an average of 50–75% of many reefs on Cay Sal Bank and in the Southern Bahamas. Their coverage is lower (20–25%) in some reef zones on Andros and New Providence, yet even here macroalgae still cover more of the reef surface than corals on most reefs. Note the vast difference in scale between the amount of macroalgae and corals in the graphs to the left.




*Macroalgae cover is high on Bahamian reefs.*

## Coral Bleaching

Bleaching occurs when corals are stressed and lose the tiny, yellowish-brown algae that ordinarily live within their tissues and provide them with energy from photosynthesis. Mass bleaching is usually a response to warm water temperatures—either extremely high temperatures or temperatures slightly elevated above normal conditions over an extended period of time. Although different species or even different colonies of the same species often vary in their response to warm waters, severe bleaching events affect the majority of corals on a reef. Corals can recover from bleaching but their growth and reproduction may be affected. Parts or all of a severely affected coral colony may die either when bleached or from the effects of coral diseases that outbreak after severe bleaching events. Delayed effects of the 1998 mass-bleaching event eventually destroyed up to half of all corals in many central Bahamian reefs. The loss of large reef-building corals is still evident 15 years later as populations of these species are slow to recover. Since 1998, late summer bleaching has recurred several times, most notably in 2015, when the vast majority of corals were bleached on many reefs in The Bahamas. Severe bleaching and post-bleaching mortality pose great threats to coral reefs and are expected to worsen as our climate continues to change. ***Improving coral reef management to lessen impacts of bleaching and promoting recovery after bleaching events is critical.***



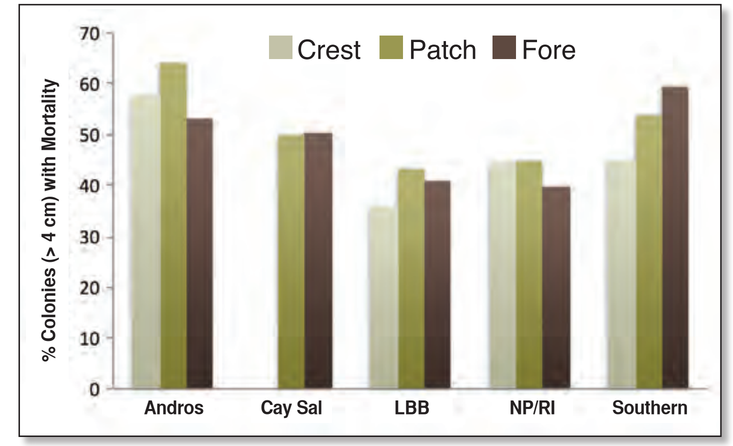

*Coral displaying partial mortality.*

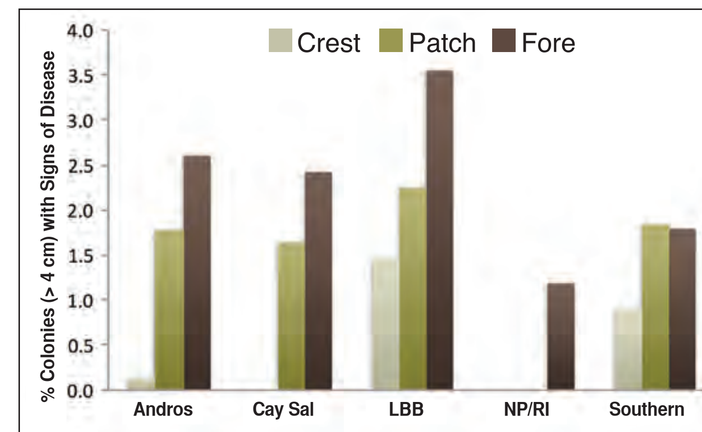
## Coral Colony Partial Mortality

Corals are subject to a wide range of potentially lethal threats. Most reef-building corals are colonial: when affected by diseases, predators or other stressors, parts of the colony may die while unaffected areas continue to grow and thrive. This is called partial colony mortality. Small dead areas, such as fish bites, may rapidly heal as living coral tissue overgrows the exposed skeleton. Areas of extensive mortality due to disease or bleaching, however, don't recover quickly and are often colonized by other organisms. As corals that survive stresssors get older and larger, they are likely to accumulate some dead areas. The average amount of partial mortality on large colonies (over 25 cm in maximum length) was lower within Bahamian reef crests than fore reefs, and also lower in corals on Little Bahama Bank and Cay Sal Bank than in the other geographic areas, with these areas getting an average score of Fair and other reef types and areas getting a score of Impaired. Minimizing threats to corals and building resilience of coral reef ecosystems can help corals heal and reduce partial mortality.

## How Common is Partial Mortality?

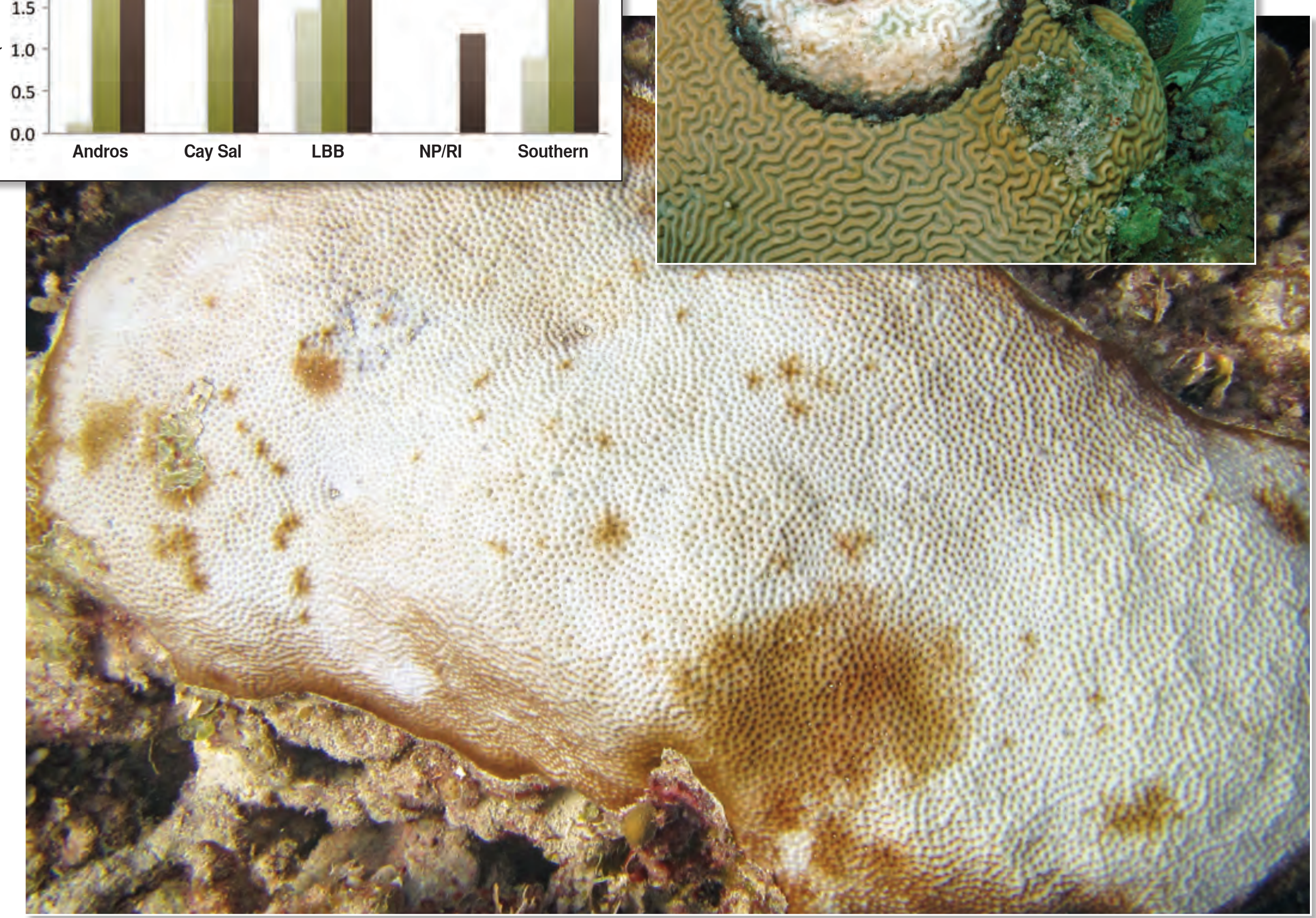
***In The Bahamas, anywhere from 35% to over 60% of all corals (> 4 cm) had some amount of partial mortality,*** with reefs on the Little Bahama Bank and the New Providence area having fewer corals showing signs of partial mortality than other sites. This may be due to the greater prevalence of smaller and perhaps younger corals in these areas (see Reef Structure Index) that would not have experienced as many periods of stress, such as the 1998 bleaching event, which caused widespread mortality in The Bahamas.



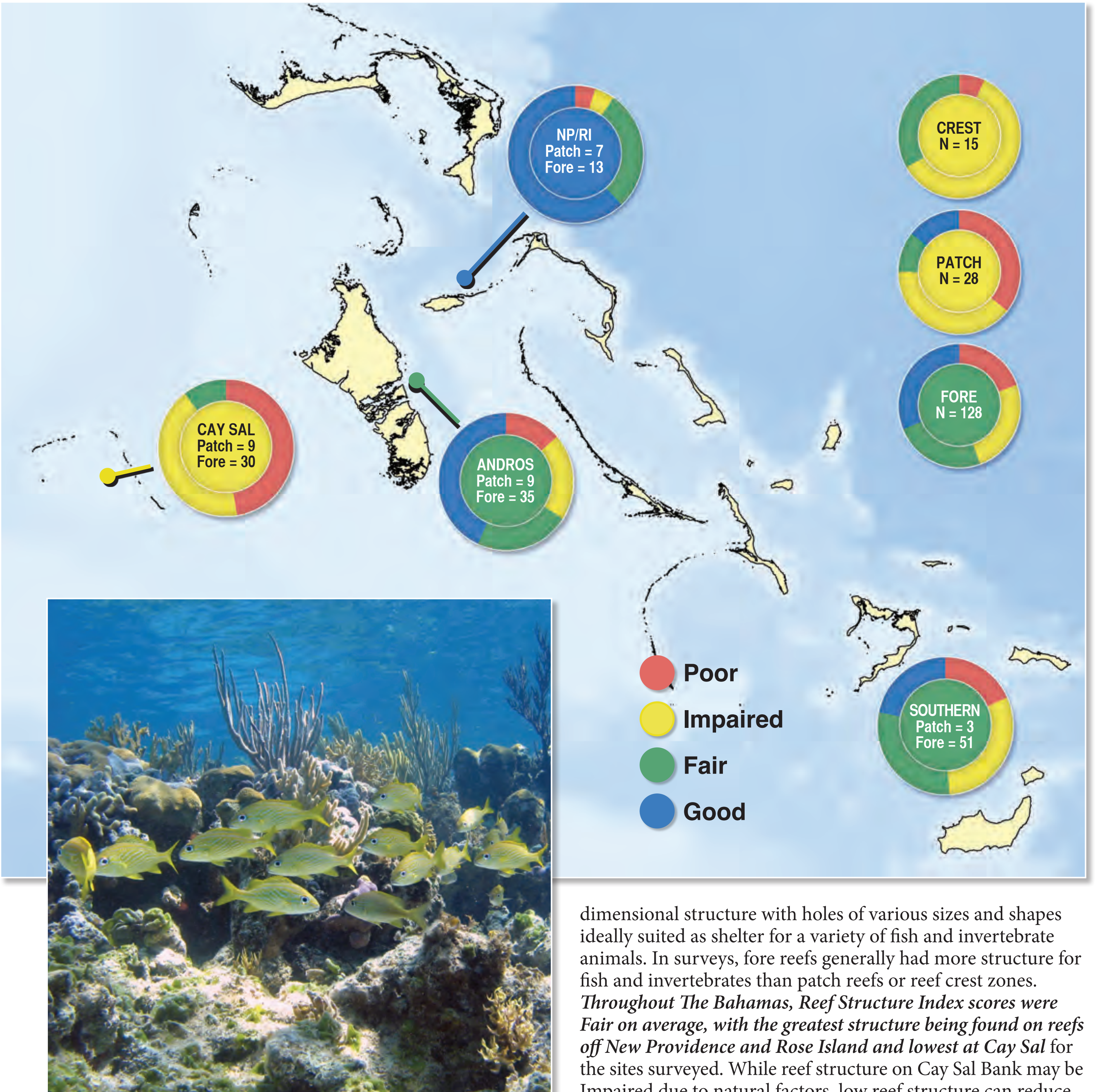




## Coral Disease

An important source of partial mortality is disease. There are approximately a dozen signs of disease that affect corals in the Caribbean, with some affecting only a few species and others a wide range of species. Diseases also vary in how aggressively they kill coral colonies. During our surveys, ***the prevalence of disease varied among areas, with some having only 1% or fewer corals infected and others having up to 4% of all corals infected.*** Coral bleaching can also cause partial mortality in affected areas and make corals more vulnerable to disease. Because bleaching is a periodic event primarily occuring during particularly warm summers, the importance of bleaching for determining coral condition may be underrepresented in our surveys, which were conducted during different months between April 2011 and September 2013.



*Coral showing signs of bleaching. Partial mortality resulting from coral with Black Band Disease (inset).*




*Grunts use reef structure for shelter.*

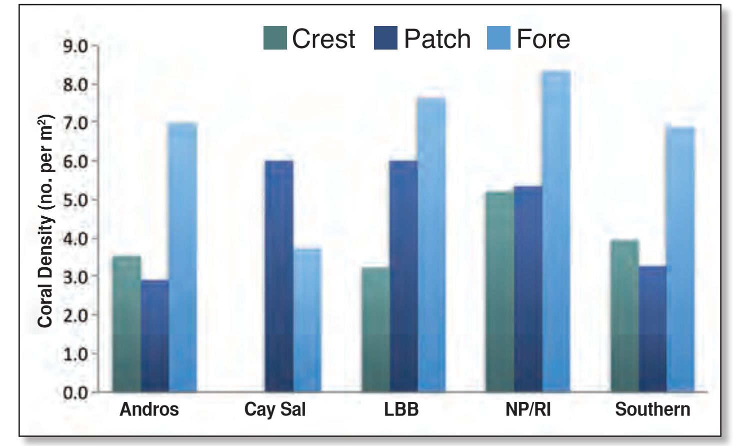
## Corals Create Habitat

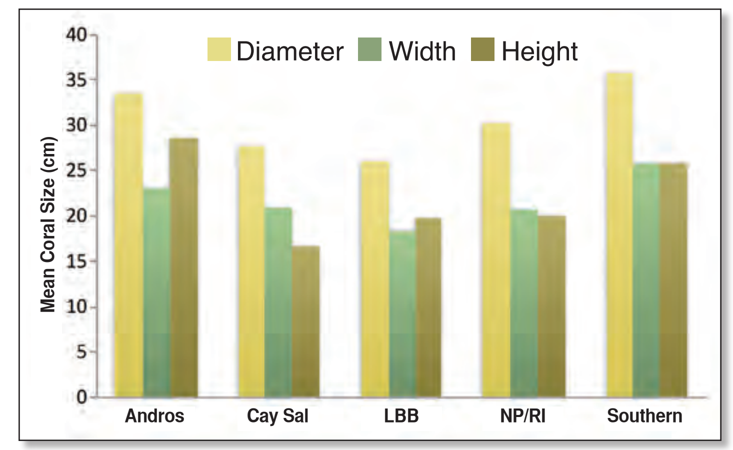
Reef structure created by stony corals is the key to supporting the remarkable abundance and diversity of life on coral reefs. Shelter created by corals provides homes for fishes and other reef creatures. The unique plating, mounding, or branching growth forms of different corals provide a complex three-dimensional structure with holes of various sizes and shapes ideally suited as shelter for a variety of fish and invertebrate animals. In surveys, fore reefs generally had more structure for fish and invertebrates than patch reefs or reef crest zones. ***Throughout The Bahamas, Reef Structure Index scores were Fair on average, with the greatest structure being found on reefs off New Providence and Rose Island and lowest at Cay Sal*** for the sites surveyed. While reef structure on Cay Sal Bank may be Impaired due to natural factors, low reef structure can reduce habitat for some species and limit their populations there.

## Coral Abundance and Size

One factor that contributes to the structure of a reef is the density of its corals. The more colonies on a reef, the more hiding places for fish and invertebrates of all sizes. ***Areas with the greatest number of corals had some of the greatest reef structure.*** The size of corals also plays an important role, with larger corals providing greater reef structure.





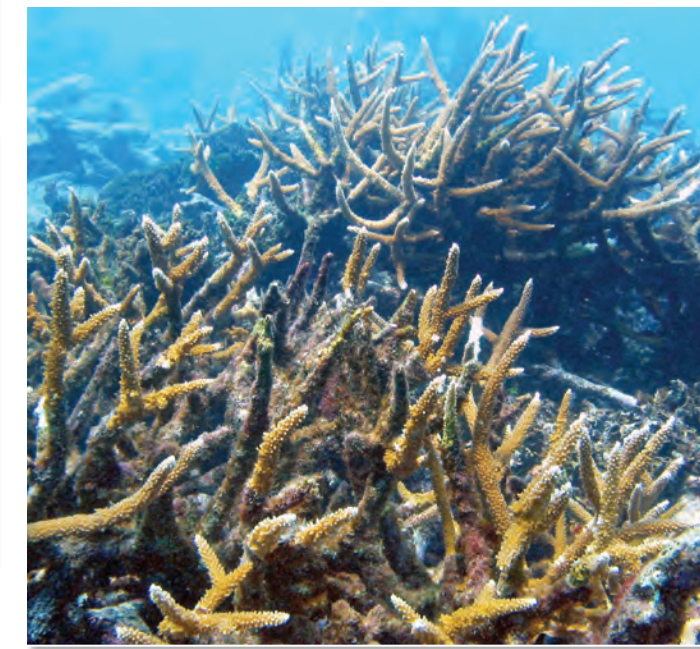




## Coral Growth vs. Bioerosion

As colonial corals grow, their skeletons provide habitat for fish and other creatures. Some species can live for hundreds of years while continuing to grow and they may reach huge sizes, exceeding several meters in diameter or height. All corals do eventually die, however, and their skeletons become available for other bottom-dwelling organisms, including larval corals, to colonize. Some of these organisms bore into the dead coral structure, weakening it. At the same time, even while they are alive, some organisms may scrape or break off pieces of coral, or excavate cavities in their skeletons. This is called bioerosion, and it can directly reduce or weaken the coral skeletons, allowing fragmentation during storms. ***Coral growth must be able to outpace bioerosion for a reef's structure to remain intact.*** As thermal stress, diseases, pollution, and other factors cause widespread coral death, continued bioerosion further decreases the three-dimensional structure of reefs. Over time, this leads to decreases in the ability of reefs to provide habitats for other creatures. ***Loss of structure also has economic impacts as ecological services ordinarily provided by reefs, such as buffering against storm damage or supporting key fisheries, are reduced.***

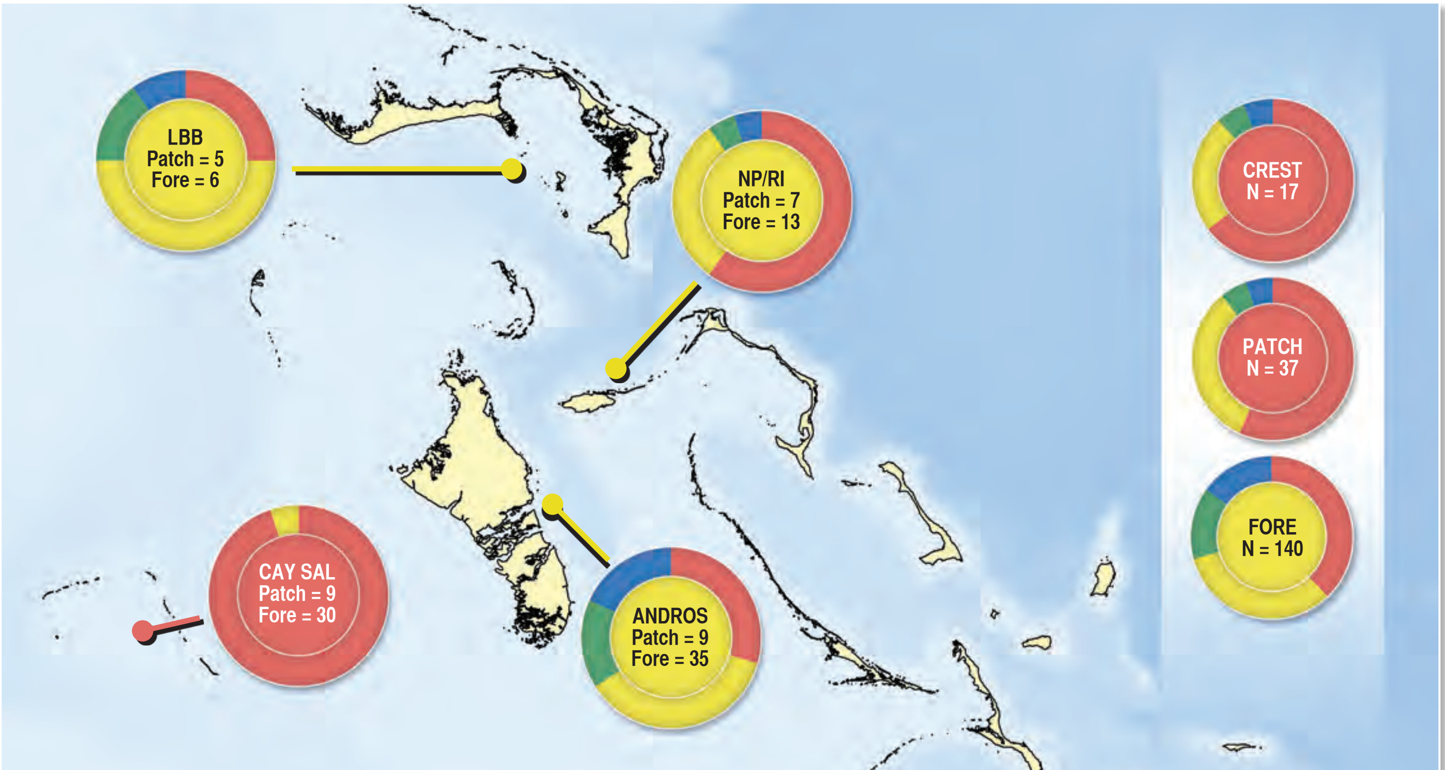
## Factors Influencing Coral Growth

Some reefs may have naturally low structural relief. In environments where corals are frequently stressed or suitable settlement substrate is low, growth may be inhibited and reef structure low. This may be the case for reefs with fluctuations in temperature, salinity or high amounts of sediment. Human impacts can also limit reef structure. In areas with increased nutrients from runoff or poor sewage treatment that promote growth of algae, or high sedimentation rates due to inappropriate coastal development, coral growth may be limited.



*Living staghorn coral creates habitat.*

*Dead staghorn coral rubble has little habitat value.*




*High coral recruitment leads to high coral cover.*

## Recruitment and Reef Recovery

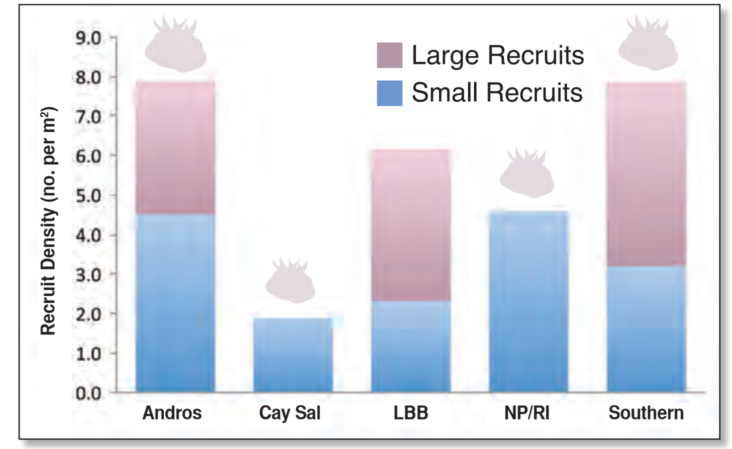
Recruitment is the addition of new corals to a reef when larvae successfully settle and grow into small corals. Reefs are dependent on new recruits to recover from the natural stresses and human impacts that kill corals. Without the addition of new corals, reefs will slowly die and degrade to the point that they cannot support the fishes and invertebrates that depend on the habitat structure their growth creates. Assessments of small (< 2 cm) and large (2–4 cm) recruits indicate that *recruitment of corals is low throughout The Bahamas,* across all reef zones, with only a few fore reef sites showing significant recruitment. Andros and the Southern Bahamas had more recruits than the other areas, but even here recruit densities were low.

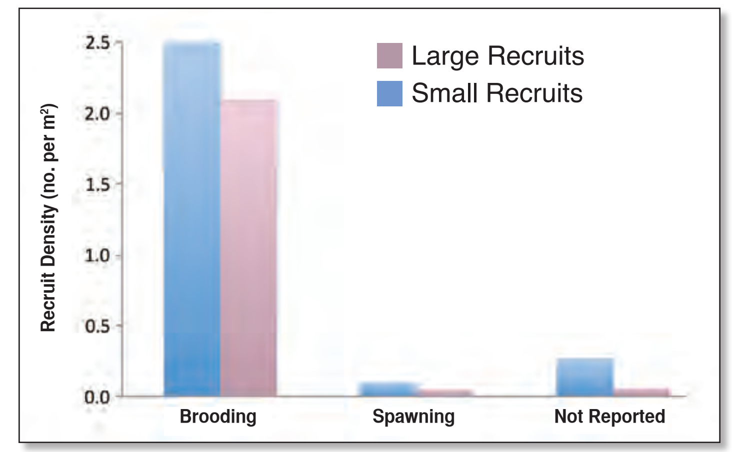
## Fewer Corals Limit Recruitment

Broadcasting corals only spawn over a few nights each summer, with all colonies of any given species releasing their gametes (eggs and sperm) within a few minutes of each other in a highly synchronized event. Successful fertilization of the eggs depends in part on how close corals are to each other. ***Higher coral density means more gametes are produced and eggs are more likely to be fertilized*** than if there are fewer corals producing gametes. For some species, reproductive output may be enhanced locally through propagation efforts to assist species recovery.







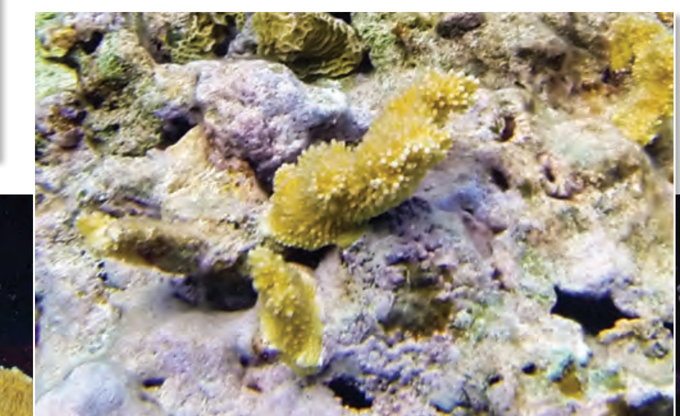



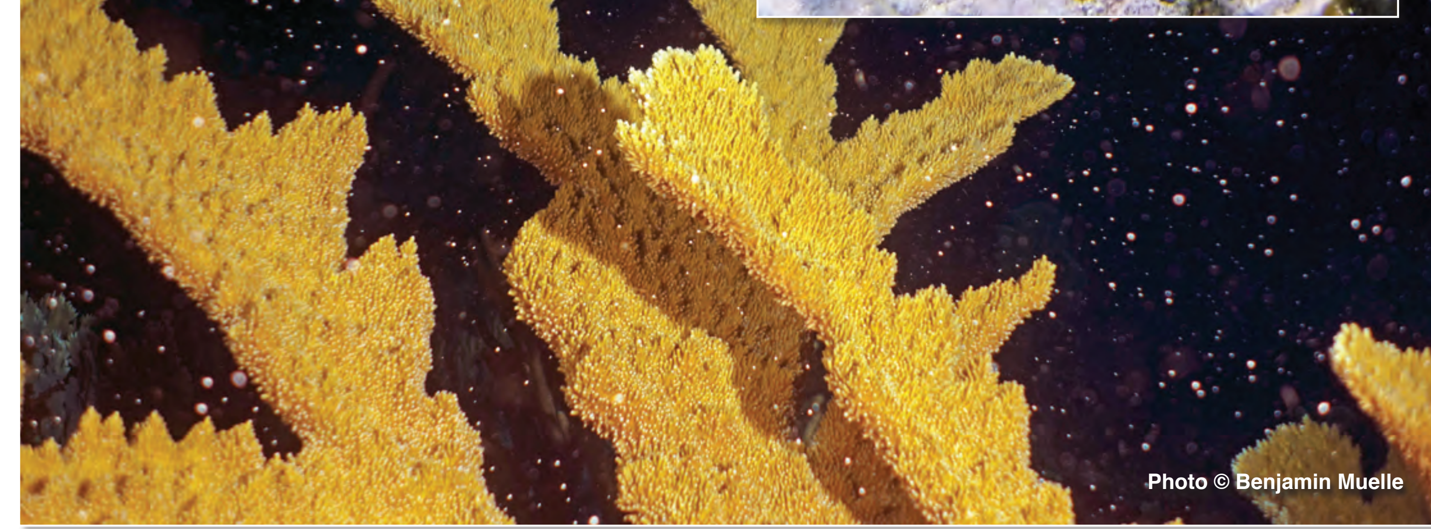

## Broadcasters and Brooders

Corals of different species use one of two reproductive modes. The first mode is broadcast spawning in which gametes are released into the water and eggs are fertilized as they drift. Most major reef-building species are broadcast spawners. For other species, only the male gametes are shed to fertilize eggs that are retained within coral polyps where the larvae develop to an advanced stage before they are released. These species that brood fertilized eggs tend to be smaller "weedy" species. Despite most major reef-building corals being broadcast spawners, a greater number of recruits from brooding species are reported in our surveys. ***Increased success of broadcast spawners will be needed for Bahamian reefs to be resilient.***

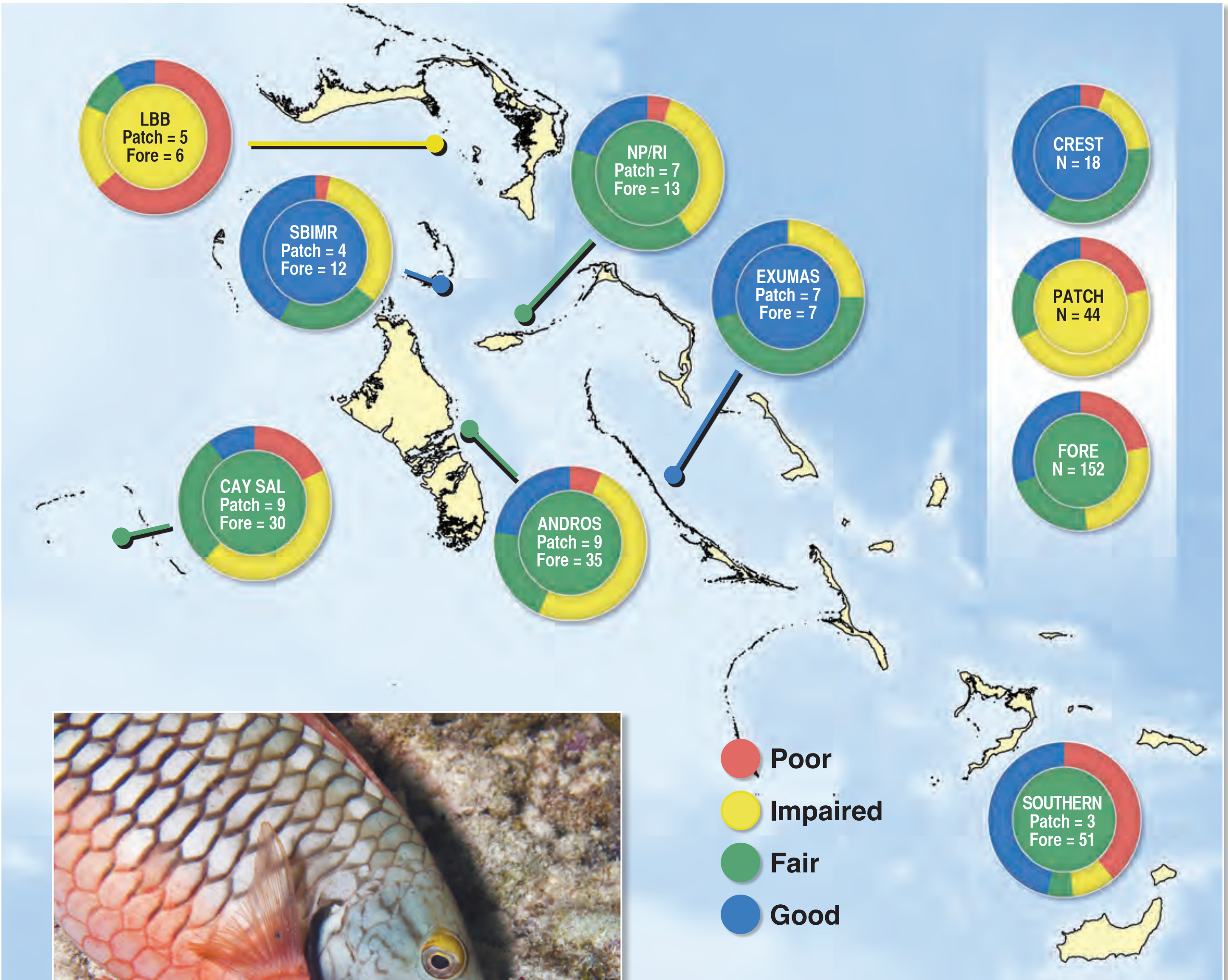
## Poor Settlement Habitat Affects Recruitment

Fertilized eggs develop into larvae that are carried by ocean currents for hours (some brooders) to days or weeks before they are ready to settle to the bottom. Coral larvae cannot attach themselves to reef areas overgrown with macroalgae or encrusted with sponges or other invertebrates. They prefer areas with crustose coralline algae. Even when they do find a place to settle, they are vulnerable to being overgrown and killed by macroalgae or animals that aggressively colonize the seafloor. Well-grazed reefs are better suited to support new coral recruits.






*Elkhorn coral spawning. Elkhorn coral recruits on pink crustose coralline algae (inset).*

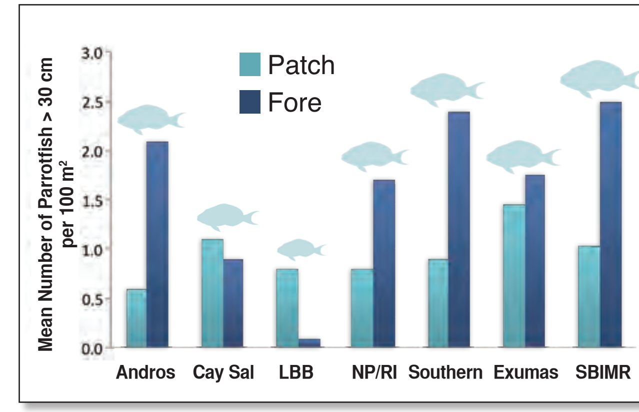



*Stoplight parrotfish and other large parrotfish remove macroalgae from reefs.*

## Large Parrotfish are Important Grazers

When corals die, the space on the reef they leave behind is often occupied by seaweeds called macroalgae. Removal of macroalgae by grazing is needed to clear space for coral larvae to settle and to prevent new recruits and small corals from getting overgrown and killed. Several fish and invertebrate species are important grazers on reefs. At present, the dominant grazers on most Bahamian reefs are adult parrotfish of species that grow greater than 30 cm in length, like the stoplight, queen, yellowtail, blue, midnight, and rainbow parrotfishes.

Although populations of these large parrotfish species are relatively healthy throughout The Bahamas, these species are commonly taken as bycatch in fish pots. Invasive lionfish can further reduce parrotfish populations as well as those of other native species. In recent years, a parrotfish fishery has also developed and grown in some parts of The Bahamas. As a result, the healthiest parrotfish populations are in The Exuma Cays and southern Berry Islands where marine protected areas protect them from fishing. ***Where parrotfish populations thrive, there may be less macroalgae and more coral recruits.***

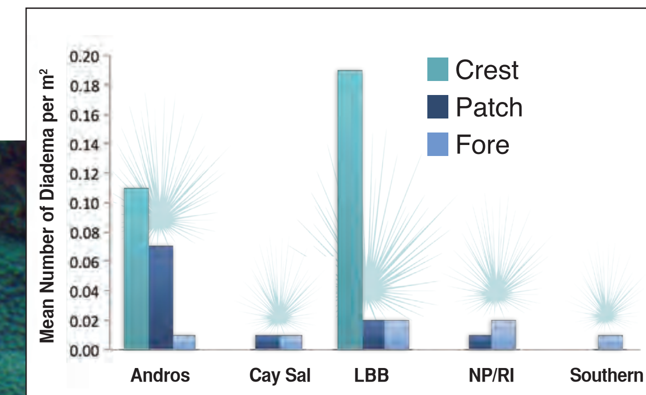


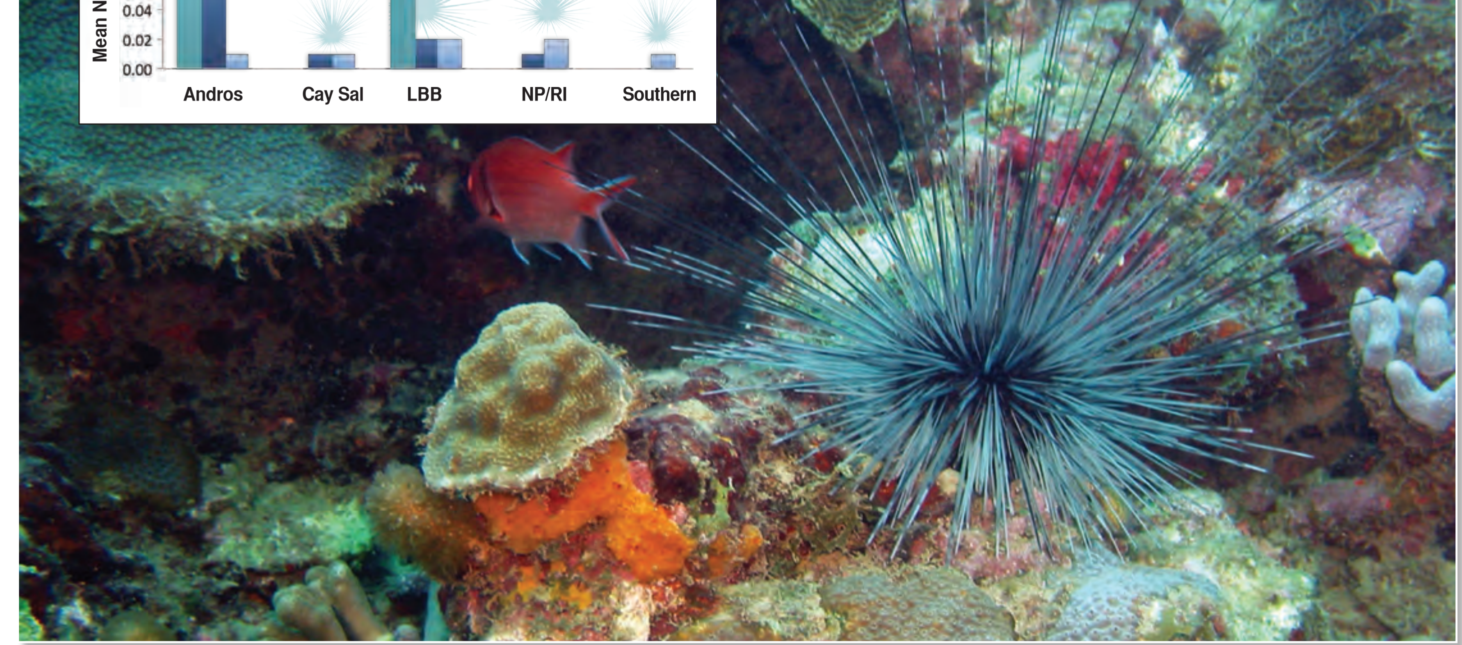

## Protecting Parrotfish

In several parts of the wider Caribbean, like Belize, Bermuda, and Bonaire, it is illegal to harvest parrotfish. In these places the ban has resulted in a shift from decreasing parrotfish numbers to an increase since the ban was put in place. Protecting nursery areas, like seagrasses and mangroves, is also important for healthy fish populations, including parrotfish.

## Other Herbivores

Many fish and invertebrates are herbivores on reefs. The smaller species of parrotfish, and juveniles of the large species, consume turf algae and can graze on macroalgae, but their smaller size limits their grazing ability. Blue tang, surgeonfish, doctorfish, chubs, and some damselfish also graze algae, as do several crustacean and urchin species.

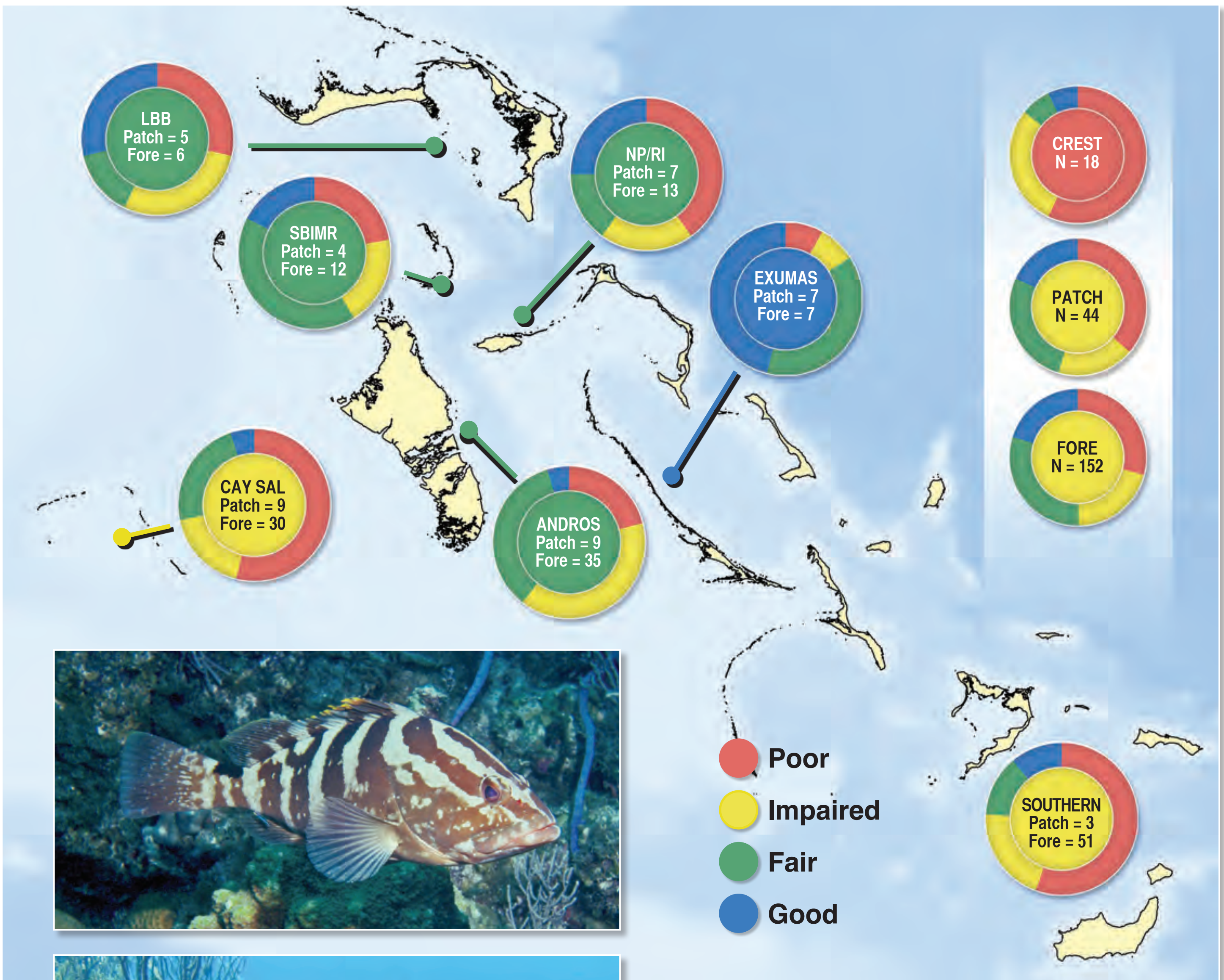


*Long-spined sea urchins,* Diadema antillarum, *are effective grazers.*

## Long-spined Urchins

The long-spined urchin *Diadema antillarum* was once the most effective and important grazer on reefs throughout the Caribbean. These urchins are capable of clearing large areas of macroalgae and keeping it clear for coral larvae to settle and grow. However, in 1983, an unknown pathogen nearly wiped out the entire population of long-spined urchins in the Caribbean region. Over the past 30+ years, their populations have begun to recover in some parts of the Caribbean, but populations have yet to see widespread recovery in The Bahamas, with densities typically reaching only 0.02 per m$^2$ or less. These densities are not high enough to keep reefs clean of macroalgae and are also below reproductive thresholds, further preventing their recovery. At present, research is being conducted to see where populations are recovering, why they are recovering in these limited areas, and if we can increase the rate of recovery for long-spined urchins on reefs throughout The Bahamas.




*Nassau grouper (top) and black grouper, known locally as rock-fish (bottom), are important predators on reefs.*

## People and Reefs Depend on Healthy Grouper Populations

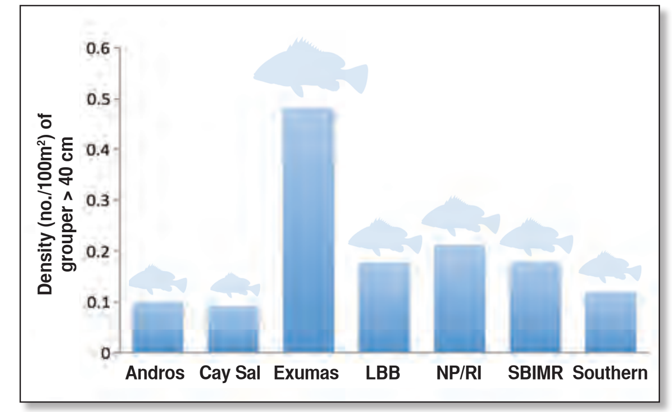
Healthy populations of predatory species like large groupers are important for maintaining reef ecosystems by controlling populations of fish and invertebrates that harm corals. They also support valuable commercial and subsistence fisheries. Of the sites surveyed in The Bahamas, populations of large grouper species, such as Nassau grouper, red hind ("strawberry grouper"), tiger grouper, and black grouper ("rockfish"), were healthiest in The Exuma Cays Land and Sea Park, where abundances where higher and sizes larger than other areas. Fewer fish and smaller sizes, such as reported for Cay Sal Bank and the Southern Bahamas, may indicate unsustainable fishing.

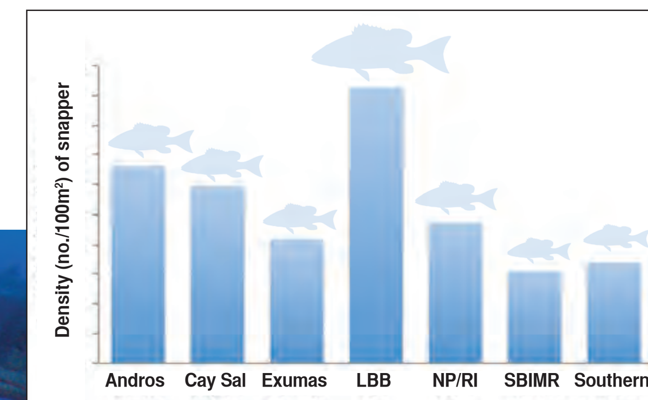
## The Nassau Grouper Is Endangered

While once common on Bahamian reefs, *Nassau groupers were found in a less than 1/3 of the surveys* in The Bahamas from 2011–2014. Minimum size limits and a seasonal closure to protect spawning Nassau groupers are important steps towards ensuring sustainable populations of this species, but stronger protection and increased compliance with regulations by fishers and consumers is also needed to improve recovery of the species.







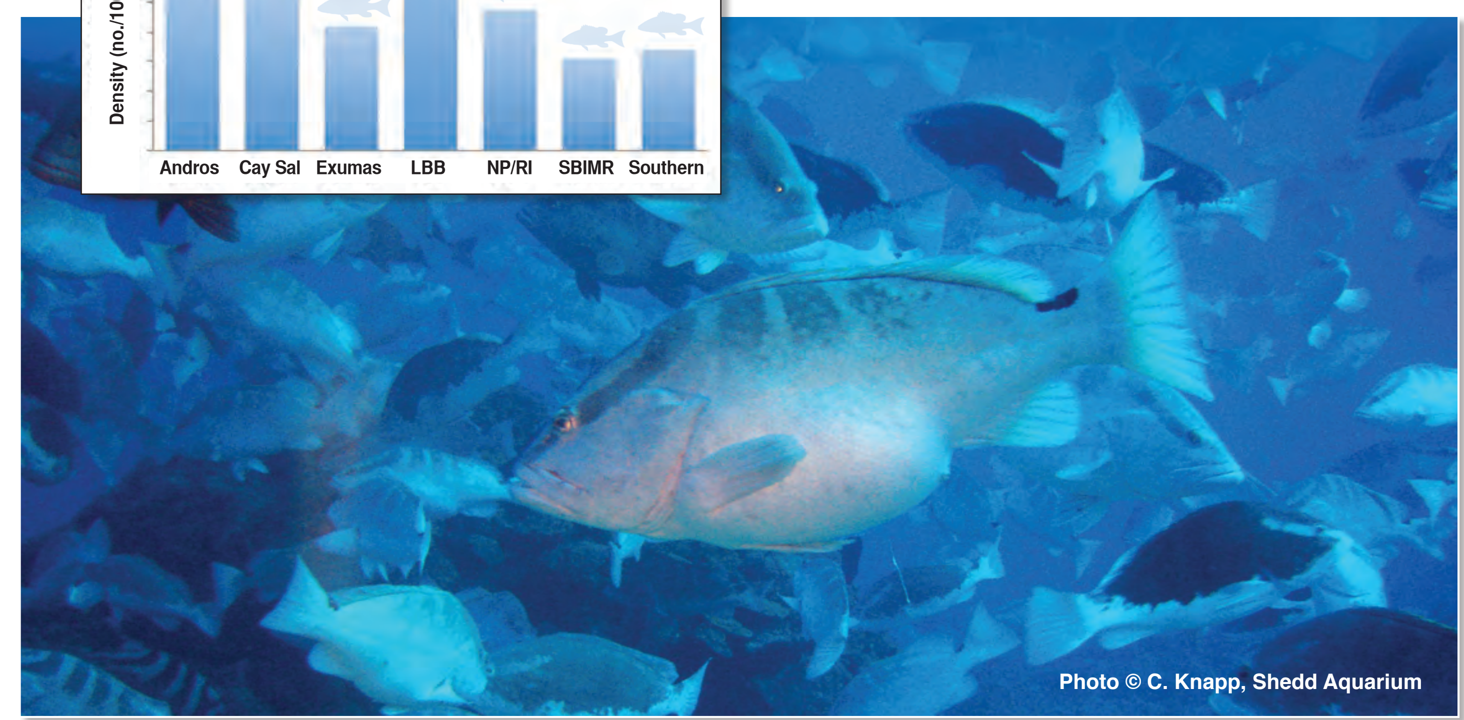




## Habitat Is Important

Many species of grouper use multiple habitats throughout their life, moving from nearshore habitats to offshore reefs as they grow. Higher abundances of large groupers were reported for fore reef and patch reefs than for reef crest habitats, with larger fish in fore reef than patch reef habitats.

## Snapper Populations Are Affected by Fishing and Habitat

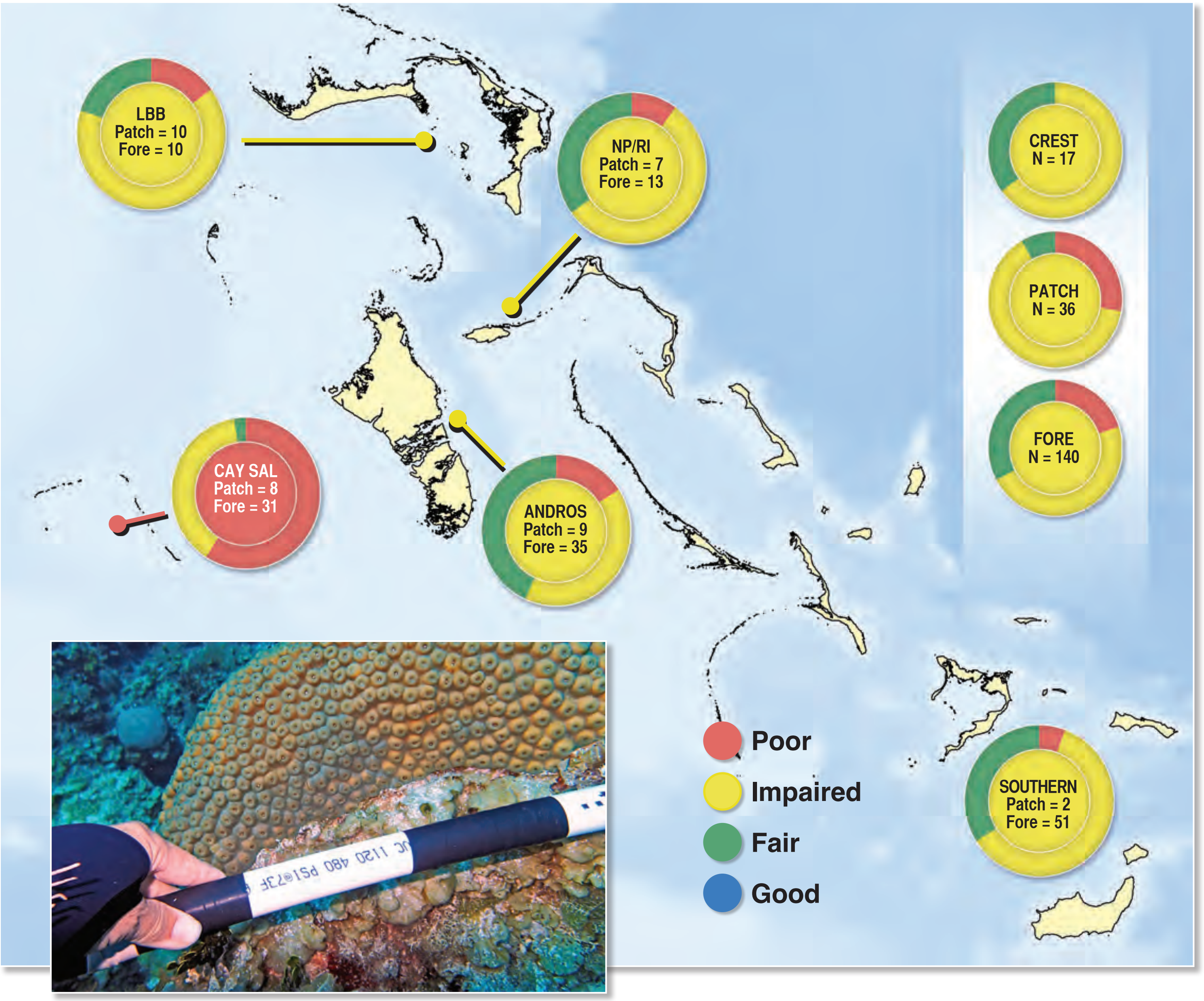
Snappers are also important commercial fish species for The Bahamas. Like some grouper species, snappers use several habitats as they grow, settling as larvae into seagrass and mangrove nurseries, where they live as juveniles, and then moving to patch reefs, reef crest, and fore reef habitats as they mature. Snapper populations are affected by the availability of habitats and the extent to which they are fished. Snapper abundance throughout The Bahamas reflects both factors, with sites close to large seagrass and mangrove areas, like those on the Little Bahama Bank and Andros, having greater density than areas with fewer mangroves, like the small islands in The Exuma Cays.




*Nassau grouper spawning aggregation, showing gravid females and fish in spawning coloration.*

## Spawning Aggregations

Large grouper and snapper species form spawning aggregations where all reproduction occurs for the entire year at specific sites and times. Nassau groupers spawn around the December, January or February full moon, while many snapper species spawn around the full moon in the late spring or summer. At spawning aggregations, hundreds to tens of thousands of fish that travel up to hundreds of miles gather to spawn over a few days. Because so many fish from a large area are present at spawning sites during these times, they are extremely vulnerable to fishing. Catching fish before they have a chance to spawn will also limit reproduction from the site and reduce future generations. At present there is a closed season for Nassau groupers during their spawning times from December 1 to February 28 annually. Nevertheless, illegal fishing is still common. ***There is a need for better compliance and enforcement of the closed season, and consumers need to stop buying Nassau groupers at this time.*** Other snappers and groupers would benefit from similar closed seasons.




*Measuring coral size—large corals create habitat.*

## Overall Reef Health

The Bahamian Reef Health Index (BRHI) provides a comprehensive summary of the health of each patch reef or fore reef by averaging the scores of the other indicators for all sites in which at least 5 indicators were measured. ***None of the surveyed reefs were categorized as being in Good health overall.*** Most sites were in Impaired or Fair condition. There were some differences in reef health across sites and reef zones, with the reefs of Cay Sal Bank having the poorest condition, with an average score of Poor.

Average reef health index scores were Impaired for all reef zones surveyed, but reef crests had no sites that were scored as Poor and patch reefs had the greatest proportion of Poor and Impaired sites. It is important to note, however, that relatively few reef crests were surveyed, and none were conducted on Cay Sal Bank where scores were generally lower for the other two zones.

## Andros

| Benthic Index | Coral Condition | Reef Structure | Recruitment | Large Parrotfish | Grouper |
|---|---|---|---|---|---|
| | | | | | |

The reefs on Andros reflect average conditions in The Bahamas as a whole, with scores of Impaired for 3 indicators and Fair for 3 indicators. The overall BRHI score for most reefs was either Impaired (43%) or Fair (41%). On a positive note, while long-spined urchin and coral recruit densities were low throughout The Bahamas, some of the highest densities were reported from Andros. It is also worth noting that 13 of the reef crest sites surveyed were along the Andros barrier reef, and although not included in BRHI values for Andros, they were a major component in the BRHI score for the reef crest zone.

## Cay Sal

| Benthic Index | Coral Condition | Reef Structure | Recruitment | Large Parrotfish | Grouper |
|---|---|---|---|---|---|
| | | | | | |

Nearly 60% of Cay Sal's reefs were considered to be in Poor health and only 3% had BRHI scores of Fair. These reefs had the lowest average scores for Benthic, Coral Recruitment, Reef Structure, and Grouper Indices, leading to a BRHI score of Poor. They also had the highest cover of macroalgae and lowest average densities of key grazers—large parrotfish and long-spined urchins.

## Little Bahama Bank

| Benthic Index | Coral Condition | Reef Structure | Recruitment | Large Parrotfish | Grouper |
|---|---|---|---|---|---|
| | | No Data | | | |

Reefs on the Little Bahama Bank had an overall BRHI score of Impaired. They had the lowest average density of large parrotfish, were among the lowest in average coral cover, and had the highest prevalence of disease. Nevertheless, these reefs showed positive signs of having a relatively high abundance of long-spined urchins on shallow reef crests and low levels of partial coral mortality.

## New Providence & Rose Island

| Benthic Index | Coral Condition | Reef Structure | Recruitment | Large Parrotfish | Grouper |
|---|---|---|---|---|---|
| | | | | | |

The condition of reefs off New Providence and Rose Island varied considerably based on their proximity to Nassau.[1] New Providence reefs had a relatively high percentage of sites with large groupers, surpassed only by The Exumas. What set these reefs apart was the high amount of structure, creating habitat for fish. However, coral recruitment rates were low, with no large coral recruits reported, and their overall BRHI score was Impaired.

## Southern Bahamas

| Benthic Index | Coral Condition | Reef Structure | Recruitment | Large Parrotfish | Grouper |
|---|---|---|---|---|---|
| | | | | | |

Reefs in the Southern Bahamas ranked as Impaired for 4 of the 6 indicators, giving a BRHI score of Impaired. They had low average densities of snappers and groupers and high frequencies of corals showing partial mortality. On the positive side, the reefs had large average coral sizes and high average densities for large parrotfish, but there was considerable variability among individual reefs. For example, 54% of the reefs were scored as Good for the Large Parrotfish Index and 39% as Poor. Although recruitment rates were high compared to most of The Bahamas, they were still considered to be Impaired.

[1]Dahlgren, C., P.R. Kramer, J. Lang, & K, Sherman. 2014. New Providence and Rose Island, Bahamas 2014 Coral Reef Report Card. Available from www.blueprojectatlantis.org

*Coral being overgrown by cyanobacteria.*


*Diver surveying a reef to determine Benthic Index.*

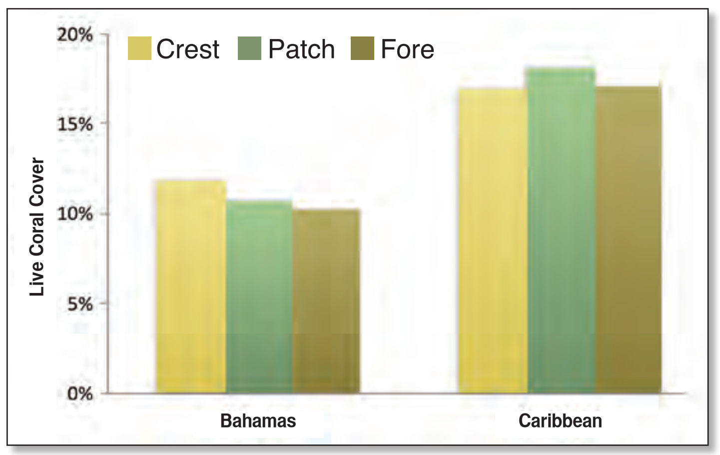
# Comparing The Bahamas to the Caribbean

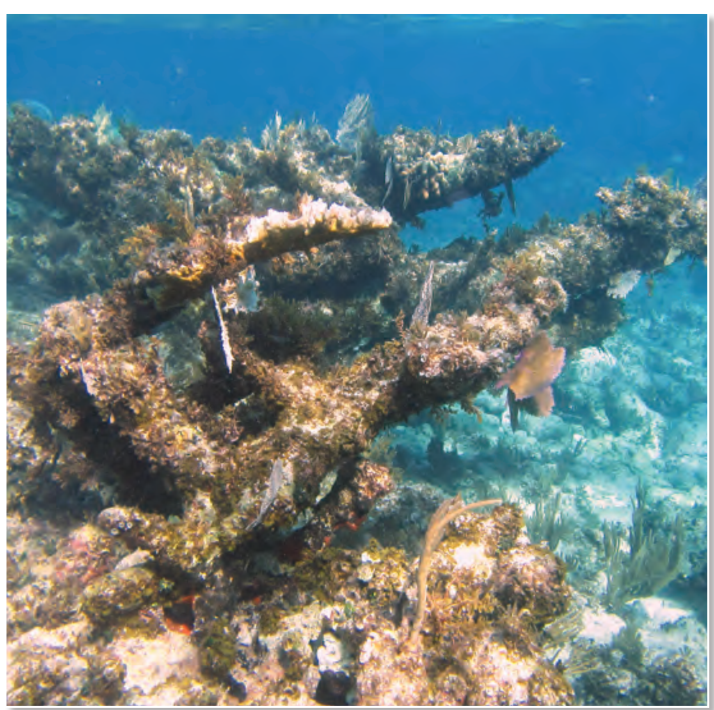
## Caribbean Context

The main focus of this report card has been comparisons of key indicators of reef health within The Bahamas, but how do Bahamian reefs compare to those of its Caribbean neighbors? Here we compare a few components of reef health in The Bahamas to comparable surveys conducted throughout the Caribbean over the same time period.

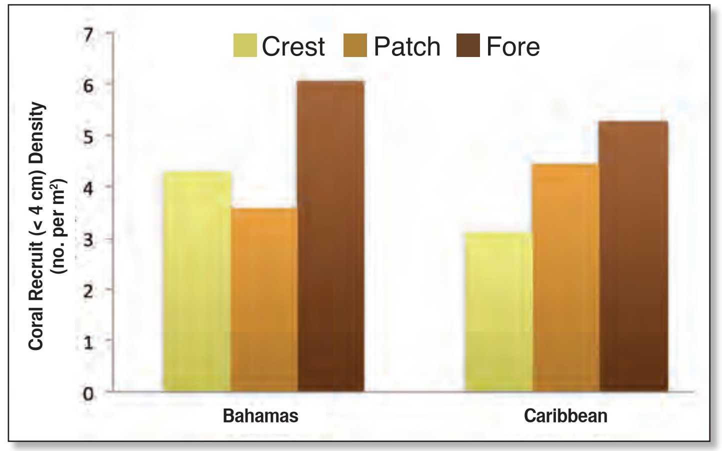
## Corals

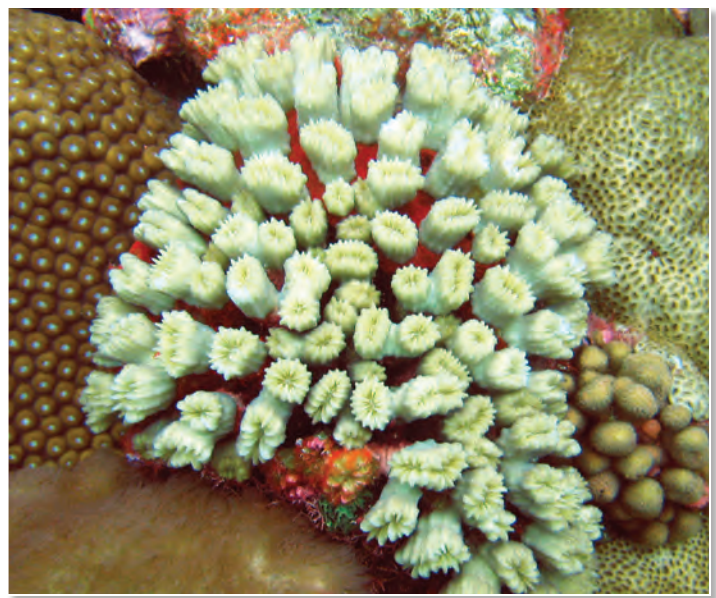
***Bahamian reefs and Caribbean reefs both averaged scores of Impaired on the Benthic Index, but Bahamian reefs had less live coral cover*** on average than reefs in other parts of the Caribbean across all reef zones. This may be due to greater impacts of thermal stress in The Bahamas than in other parts of the Caribbean. Coral recruitment rates were also Impaired on average for both The Bahamas and other parts of the Caribbean.



*Dead elkhorn coral skeleton being overgrown by macroalgae.*



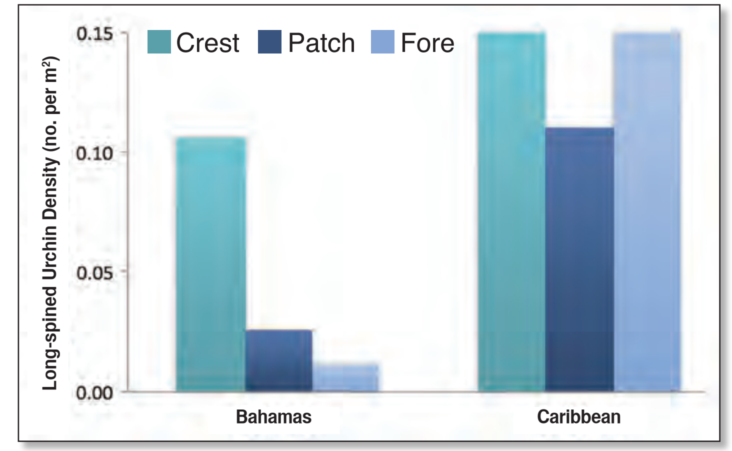
*Healthy reefs have high cover of live coral.*

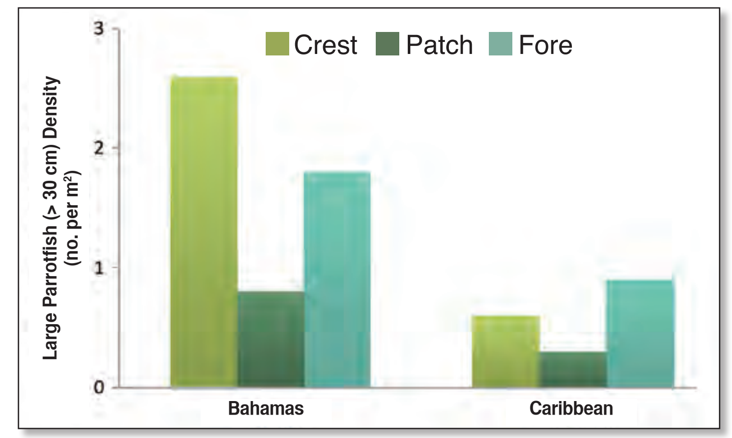
## Grazers

Two major grazers of macroalgae were compared between Bahamian reefs and reefs elsewhere in the Caribbean. ***Long-spined sea urchins are the most effective grazers, but their densities remain fairly low throughout the region.*** Densities in The Bahamas averaged 4–10 times lower on patch reefs and fore reefs than in the Caribbean. Densities in the shallow reef crest zone were similar to other parts of the Caribbean, however, indicating that populations may be showing initial signs of recovery.

In contrast, large parrotfish (> 30 cm total length) densities are 2–4 times greater in The Bahamas on average than in the rest of the Caribbean across all reef zones. While ***large parrotfish may not be as effective grazers as long-spined urchins, healthy populations in The Bahamas are critical for reducing macroalgae*** while urchin populations recover. Higher density in The Bahamas is likely due to less fishing of these species here than elsewhere. However, the recent development of a parrotfish fishery may threaten Bahamian populations.

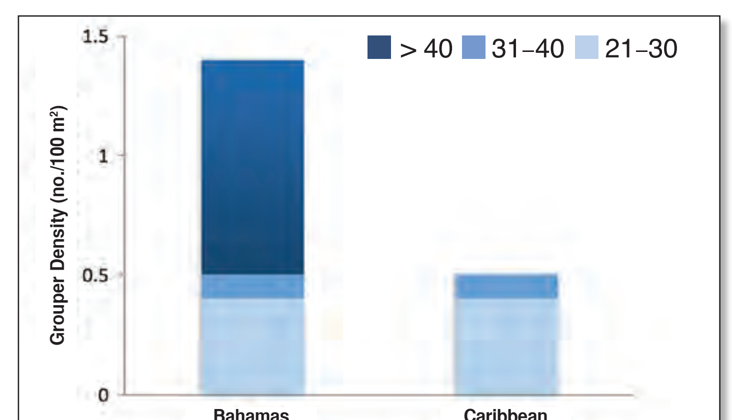


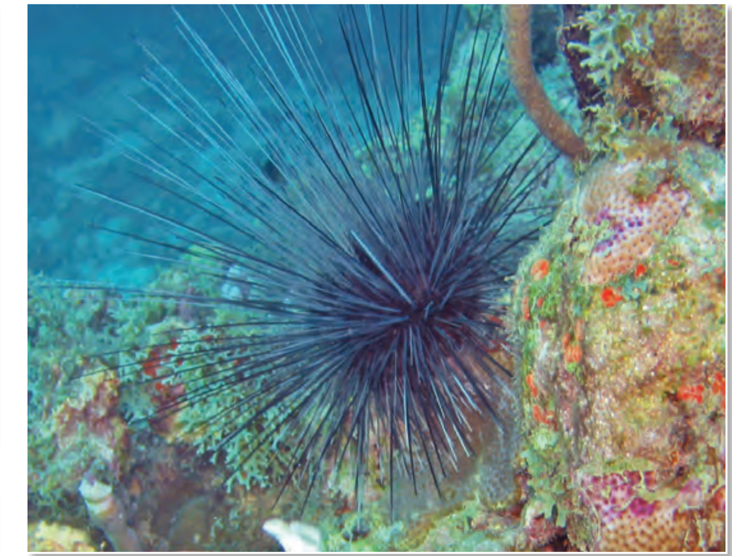



## Grouper

Smaller grouper (< 40 cm total length) had similar average densities for The Bahamas and the rest of the Caribbean in the fore reef zone. Larger, adult-sized fish (> 40 cm), however, comprised nearly two thirds of groupers on Bahamian fore reefs, but they were essentially absent from Caribbean reefs. This is likely the result of overfishing large groupers in much of the Caribbean, with some species like Nassau grouper fished out in many areas. ***While grouper populations are comparatively healthy in The Bahamas, recent findings of declines in Nassau grouper densities, and the loss of some spawning aggregations, is of great concern.***



*Long-spined urchin populations are slow to recover in The Bahamas.*

## The Power of Protected Areas

One reason why The Bahamas compares favorably to the rest of the Caribbean for size and abundance of key fish species is The Exuma Cays Land and Sea Park (ECLSP), the oldest and one of the largest Marine Protected Areas (MPA) in The Bahamas. The ECLSP is effectively managed as a no-take area, leading to numerous benefits to key species. Within the ECLSP, Nassau grouper abundance and biomass is 2–3 times greater than any other area in The Bahamas. Lobster and conch abundances in the ECLSP are also greater than other areas of The Bahamas, and there is evidence that healthy populations of these species there support fisheries outside the MPA by replenishing these areas with larvae.[1] Large parrotfish abundance and biomass in the ECLSP is also greater than surrounding parts of The Exuma Cays. While no AGRRA data on benthic communities and corals were collected for the ECLSP, other studies there provide insights into how the ECLSP benefits coral reef ecosystems. Increased parrotfish biomass within the ECLSP doubled grazing intensity there and reduced macroalgae cover by 60%.[2] This resulted in a two-fold increase in coral recruits in the ECLSP.[3]

The example of the ECLSP shows how well-managed MPAs can protect key species, support fisheries, and improve reef health. Many of the areas surveyed in this report card are within newly designated MPAs. Similar benefits to key species, fisheries, and reef health can be expected in all of these areas following the implementation of effective management of these new MPAs.

[1]Reviewed in: Dahlgren, C. 2004. Bahamian Marine Reserves—Past experience and future plans. Pages 268-286 in Sobel, J. and C. Dahlgren (eds.). *Marine Reserves: A Guide to Science, Design and Use.* Island Press.

[2]Mumby, P. J., C.P. Dahlgren, A.R. Harborne, C.V. kappel, F. Micheli, D.R. Brumbaugh, K.E. Holmes, J.M. Mendes, K. Broad, J.N. Sanchirico, K. Buch, S. Box, R.W. Stoffle, and A.B. Gill. 2006. Fishing, Trophic Cascades, and the Process of Grazing on Coral Reefs. *Science* 311: 98-101.

[3]Mumby, P.J., A.R. Harborne, J. Williams, C.V. Kappel, D.R. Brumbaugh, F. Micheli, K.E. Holmes, C.P. Dahlgren, C.B. Paris, and P.G. Blackwell. 2007. Trophic cascades facilitate coral recruitment in a marine reserve. *PNAS* 104: 8362–8367.

# Threats to Bahamian Coral Reefs

## *Causes of Reef Decline*

Bahamian coral reefs have declined to their current condition because of local, regional, and global threats. Specific hazards may vary among locations, but most sites are faced with multiple threats. This section addresses some of the most serious threats facing Bahamian reefs.

### Climate Change

Climate change is a global issue facing reefs worldwide. One of the greatest impacts of climate change on corals is an increase in the frequency, duration, and intensity of periods of elevated sea temperature. Warming can lead to mass mortality from bleaching or outbreaks of disease. These impacts have already reduced coral cover on reefs throughout much of The Bahamas, as evident in Impaired Benthic Index and Coral Condition Index scores in most areas. Reduced coral populations and high cover of macroalgae also contribute to Impaired Coral Recruitment Index scores throughout The Bahamas. Shallow banks like Cay Sal Bank, which had the lowest scores for both the Benthic Index and Coral Recruitment Index, are among the most vulnerable areas for thermal stress, as they heat up rapidly during the summer. ***Key strategies for facilitating the ability of reefs to survive climate change include reducing carbon emissions and building reef resilience by minimizing the impacts of other stressors.*** Many of the strategies outlined in this section play an important part in reducing local threats to reefs and thereby should help to promote their recovery.


*Dredging and other coastal development threaten corals.*

### Coastal Development

Coastal development alters shorelines, increases sediments, nutrients or other pollution, and decreases the amount of nearshore habitat for key species like some parrotfish, groupers and snappers. This can have a strong local effect on reefs, reducing their scores for most, if not all, indicators. While most of the areas surveyed had minimal coastal impacts, unsustainable coastal development was evident around New Providence. For example, sites along the developed north and eastern parts of New Providence have Poor or Impaired scores for the Benthic Index, whereas reefs to the southwest of New Providence have Fair to Good scores.

### Illegal Fishing

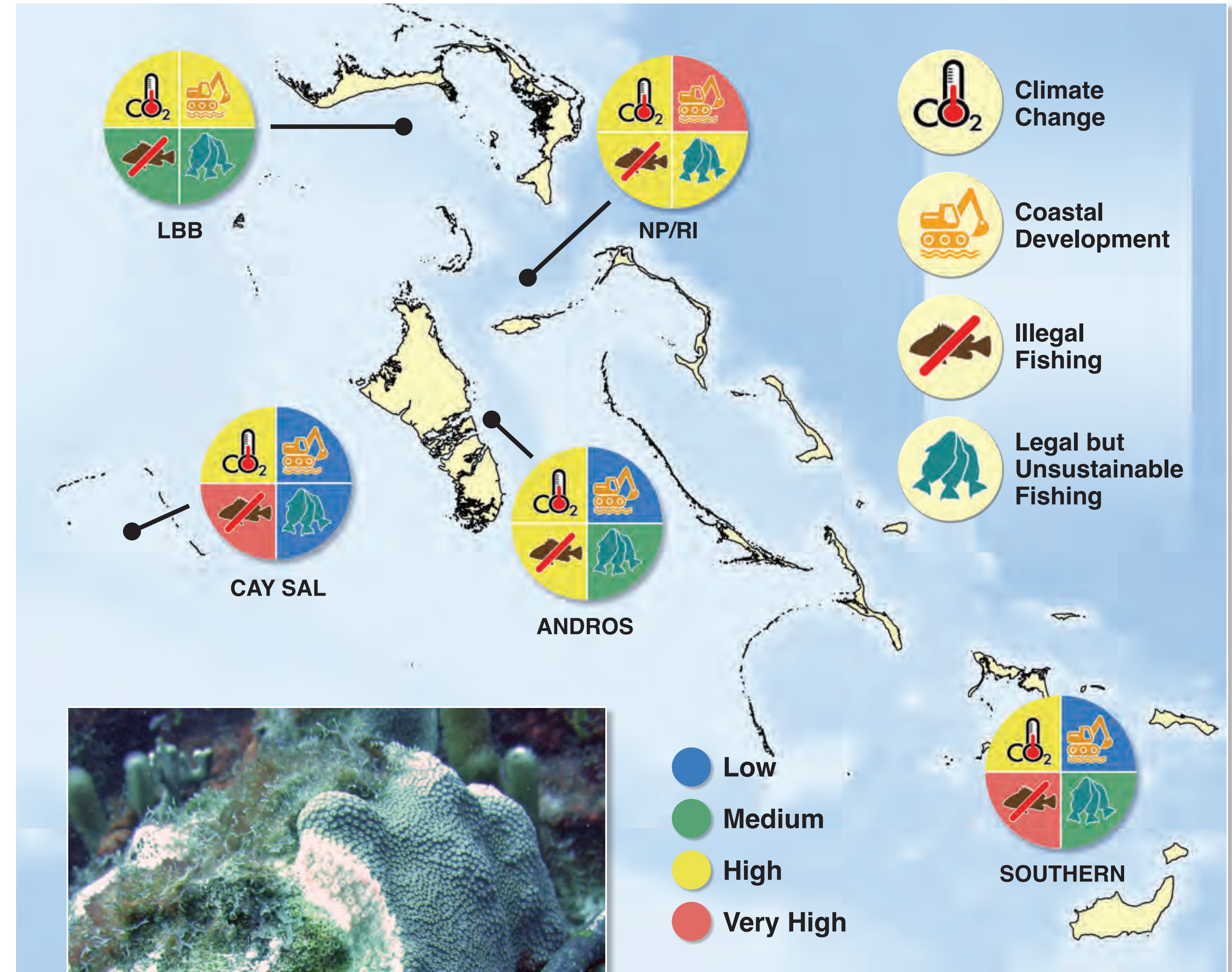
Fishing that is not sustainable can drive stocks to collapse, with severe economic and ecological consequences. Unsustainable fishing includes illegal fishing, such as fishing during closed seasons, use of restricted fishing gear, or minimum size violations. Commercial fishing by foreigners is also illegal. Illegal fishing threatens stocks of grouper, conch, and crawfish. The small size and low densities of groupers on Cay Sal Bank and the Southern Bahamas may reflect illegal fishing, given reports of high levels of foreign fishing vessels in these areas. ***Reductions in Nassau grouper stocks in other parts of The Bahamas are likely the result of illegal fishing during the closed season, with up to 1/3 of fish at spawning aggregations being captured illegally.***

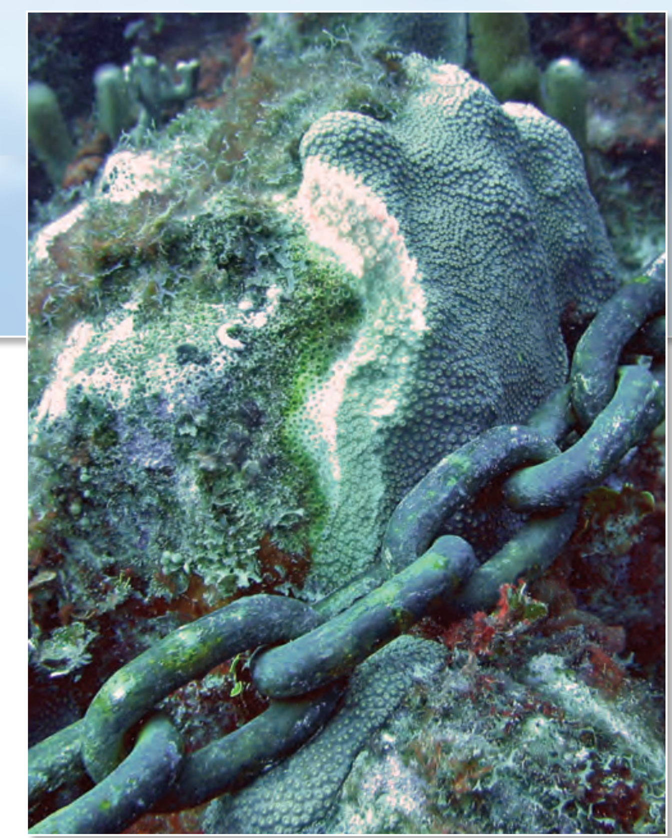

*Illegal fishing of Nassau groupers in the closed spawning season can wipe out populations.*

### Legal but Unsustainable Fishing

Unsustainable fishing can also occur when regulations do not exist or do not effectively manage stocks. At present, fishing for parrotfish is unregulated in The Bahamas, but studies show that fishing for large parrotfish may cause their populations to decline, resulting in less coral recruitment. ***Low scores for the Large Parrotfish Index from the Little Bahama Bank, and the absence of large parrotfish from nearly 40% of sites in the Southern Bahamas, reflect unsustainable fishing as a target species or as bycatch.***


*A parrotfish fishery has developed in The Bahamas.*



*Anchor damage and vessel groundings can have a local effect on reefs.*

### Threat Ratings

Threats of Climate Change, Coastal Development, Illegal Fishing, and Legal but Unsustainable Fishing were rated for each area and given a color-coded threat rating of Low, Medium, High, or Very High. Threat ratings were determined based on AGRRA data in this report card and a 2015 workshop where marine resource managers, NGO representatives, and scientists with working knowledge of specific areas rated threats based on specific criteria. Threat ratings determined during the workshop took into account the scope of the threat or the percent of resources in the area to be affected, and severity of the threat or how the threat would contribute to degradation of resources over 10 years. Each threat was considered for key conservation targets related to the indicators in this report card, including reef-building corals, parrotfish, and groupers. Additional threats such as anchor damage or vessel groundings were also evaluated and may present significant threats locally but were not among the top threats presented here.

Despite the Impaired state of many reefs surveyed, and the ongoing threats to these reefs, we can take action to reverse the decline of Bahamian coral reefs. By implementing several key strategies we can put Bahamian reefs back on the path to being vibrant ecosystems, teaming with marine life and supporting the lives of Bahamians.

## Island Development Plans

Coastal development is increasing around New Providence and other parts of The Bahamas. In areas where further development of the coastal zone is likely, impacts should be minimized by creating island development plans that identify critical nearshore areas and account for the ecosystem services provided by coral reefs and other marine habitats, such as supporting fisheries and buffering against storm surges. Such ***plans can guide coastal development to reduce its impact on coral reefs,*** particularly for Islands like Andros, the Southern Bahamas or less populated areas of southern Abaco and eastern Grand Bahama.

## Improved Fishery Management

More effective fisheries management is needed to reverse the decline of many fish and mobile invertebrate species before their collapse, as they have done elsewhere in the Caribbean. To this end, building compliance with existing fisheries regulations is a priority. This should include better communication of the reason for the regulations to fishers, seafood buyers, and the general public to ***build compliance with regulations.*** It must also include ***stronger enforcement of regulations*** throughout the country for Bahamians (e.g., enforcing legal size limits and closed seasons) and the elimination of illegal foreign fishing, particularly in remote areas of the Southern Bahamas and Cay Sal Bank.

For some species, ***improved management also requires an updating of regulations based on current science*** to better manage stocks of key species throughout The Bahamas. For other species, no regulations exist, and restrictions on the fishery are needed to protect stocks. For example, ***minimum sizes*** and ***protection of fish at spawning*** times will improve sustainability of fishery for many species (e.g., snappers). Establishing a ***ban on parrotfish fishing*** is also needed before this fishery develops further, to preserve species that are critical to coral reef health.

## Implementing Network of Protected Areas

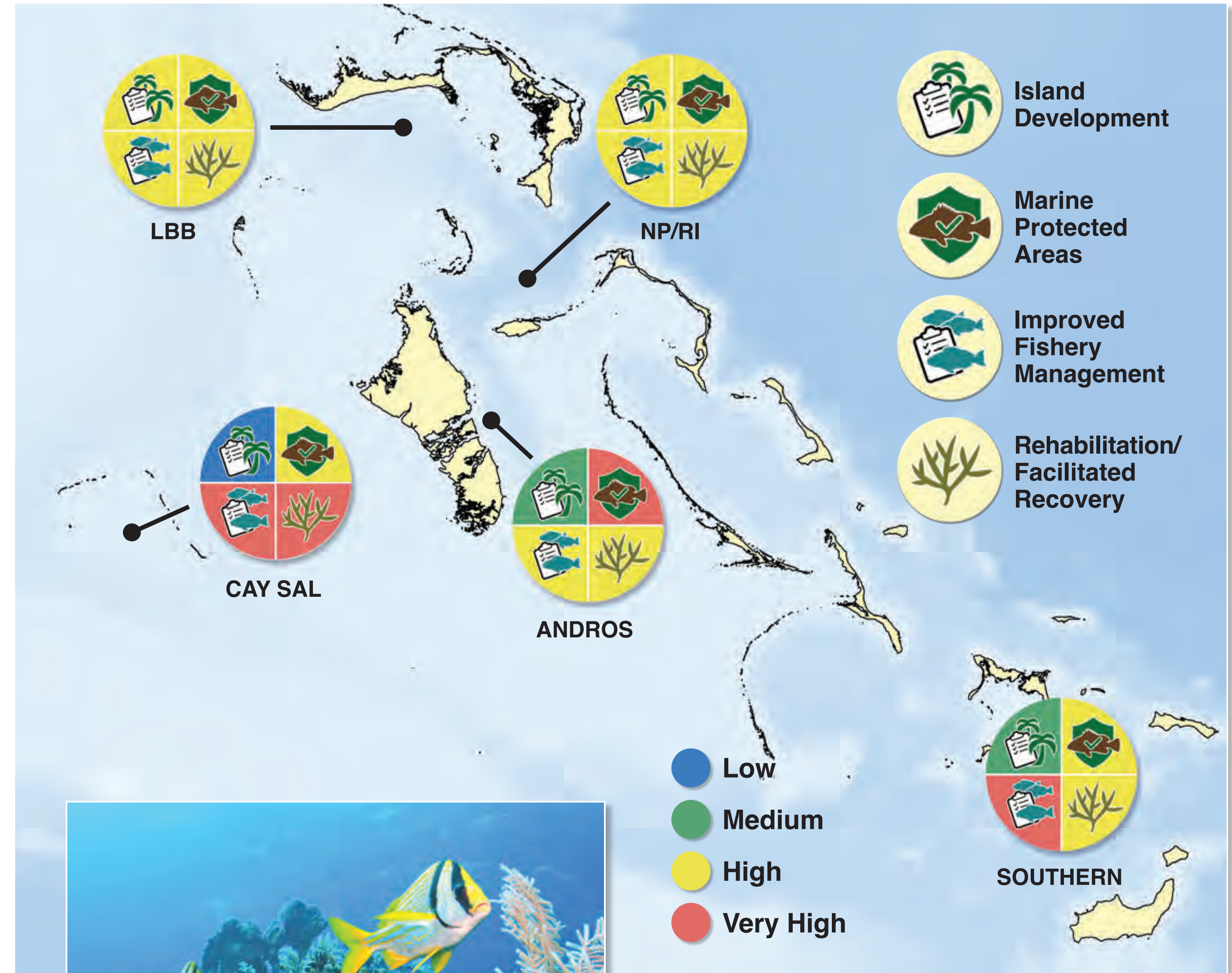
Another strategy to reduce unsustainable fishing and coastal development is the use of protected areas. It is no accident that fish surveys throughout The Bahamas show the healthiest populations in The Exuma Cays Land and Sea Park (ECLSP), a large Marine Protected Area (MPA). ***MPAs like ECLSP provide critical protection to key species that support coral reef health.*** The success of the ECLSP can be attributed to its size, diversity of habitats included within its boundaries, and the fact that it has been effectively managed as a no-take area for 30 years.

The surveys in this report contributed to the declaration of MPAs in Cay Sal Bank, Southwest New Providence, the Joulter Cays, Cross Harbour Abaco, East Grand Bahama, and an expansion of Lucaya National Park. Designation of MPAs in these areas is not enough, however: effective ***management plans need to be developed*** in each of these areas with both scientific and stakeholder input, followed by the ***implementation of effective management.*** Furthermore, MPAs function most effectively if they are networked together in such a way that they can contribute propagules, like coral larvae, to replenish each other and the waters around them. The Bahamas is a little over half way towards its goal of ***protecting 20% of its nearshore areas by 2020.*** The creation of new MPAs that are linked by ocean currents, contain habitats used by key species and are sized based on the movements of these species will promote reef health, conserve biodiversity and support fisheries.


*Staghorn coral grown in nurseries can help repopulate reefs.*

## Rehabilitation: Facilitating Recovery of Species and Ecosystems

In some cases where key species or ecosystems are impaired because of past threats and recruitment is low, recovery may need some additional help. ***A reef, mangrove or seagrass bed that has been altered by human impacts may be rehabilitated by removing ongoing threats and reintroducing key components of the ecosystem.*** For species whose populations have collapsed, like some corals or long-spined urchins, with little to no recruitment evident, such assistance may speed up recovery. For example, in-water propagation is possible for elkhorn and staghorn corals, which may be reintroduced to reefs where natural recruitment rates are low. New advances in genetics may also allow for selection of colonies best adapted or able to acclimate to climate change and other threats to improve long-term survival. ***Further research is also needed to facilitate recovery of long-spined urchins and other coral species.***




## Recommendations

Strategies of Island Development Plans, Marine Protected Areas (MPA), Improved Fishery Management, and Ecosystem Rehabilitation/Species Recovery, were prioritized for each area and rated as Low, Medium, High, or Very High. Priority ratings were based on the current threats faced by each area and recent activities related to recommendations in each area. For example, MPAs have recently been designated in many study areas of this report card, but management plans have not been developed and implemented yet, earning these areas a High priority rating. The absence of MPAs for the vast majority of the Andros Barrier Reef and the lack of management plans for the two small existing MPAs earned a priority rating of Very High for Andros. Most of the recommended strategies are complementary and need to be applied throughout The Bahamas, not just in specific locations or limited to the areas discussed in this report card.

*Marine Protected Areas increase fish populations and reef health.*

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Graphic Design: Dawn Witherington. Photos © Craig Dalgren unless noted.

## Citation

**Dahlgren, C., K. Sherman, J. Lang, P.R. Kramer, & K. Marks. 2016.**
**Bahamas Coral Reef Report Card Volume 1: 2011–2013.**

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## Support Provided by