

University of New Hampshire

## University of New Hampshire Scholars' Repository

---

Ocean Process Analysis Laboratory

Institute for the Study of Earth, Oceans, and  
Space (EOS)

---

2017

### Caribbean Marine Climate Change Report Card 2017

Michael Taylor

*University of the West Indies*

Kimberly A. Stephenson

*University of the West Indies*

Tannecia Stephenson

*University of the West Indies*

Jhordanne J. Jones

*University of the West Indies*

Melissa Melendez

*University of New Hampshire*

*See next page for additional authors*

Follow this and additional works at: <https://scholars.unh.edu/opal>

---

#### Recommended Citation

Taylor, Michael; Stephenson, Kimberly A.; Stephenson, Tannecia; Jones, Jhordanne J.; Melendez, Melissa; Salisbury, Joseph; Oxenford, Hazel; Monnereau, Iris; and Mahon, Robin, "Caribbean Marine Climate Change Report Card 2017" (2017). *Ocean Process Analysis Laboratory*. 7.  
<https://scholars.unh.edu/opal/7>

This Report is brought to you for free and open access by the Institute for the Study of Earth, Oceans, and Space (EOS) at University of New Hampshire Scholars' Repository. It has been accepted for inclusion in Ocean Process Analysis Laboratory by an authorized administrator of University of New Hampshire Scholars' Repository. For more information, please contact [nicole.hentz@unh.edu](mailto:nicole.hentz@unh.edu).

---

**Authors**

Michael Taylor, Kimberly A. Stephenson, Tannecia Stephenson, Jhordanne J. Jones, Melissa Melendez, Joseph Salisbury, Hazel Oxenford, Iris Monnereau, and Robin Mahon

# Commonwealth Marine Economies Programme



## Caribbean Marine Climate Change Report Card 2017

What you need to know about the impact of climate change on the critical state of coasts and seas in Caribbean Small Island Developing States (SIDS), and what needs to be done.

### Key messages:

Caribbean states are particularly vulnerable to climate change which presents a significant risk to the region's people.

Climate change can have significant negative impacts on the quality of life of Caribbean peoples, if an integrated approach to dealing with its social impacts is not taken.

Much more needs to be done to reduce other human pressures on island systems to make states more resilient to climate change.

The seas, reefs and coasts on which all Caribbean people depend are under threat from coral bleaching, ocean acidification, rising sea temperature, and storms. There needs to be a greater effort to protect these resources.



## Contents

1	Overall key messages
2	Climate change in the Caribbean – why should we worry?
3	Why we need to act now
4-5	What should the Caribbean do about climate change?
6-7	What's driving climate change?
8-9	Climate change impacts at the country level
10-11	Impacts of climate change on marine and coastal biodiversity
12-14	Climate change impacts on people and livelihoods
15	Key recommendations
16	Acknowledgements

“Our efforts to promote sustainable development... are under severe threat from the devastating effects of climate change”

Liliendaal Declaration on Climate Change and Development, 2009

# Climate change in the Caribbean – why should we worry?

Climate change is happening worldwide – no region on Earth has escaped it. But its effects on the Caribbean are already serious and it has the potential to become more severe than in many other parts of the world. In low-lying areas, more intense storms, floods, droughts, rising sea levels, higher temperatures, and ocean acidification are already posing severe threats to people and the marine and coastal ecosystems that support our lifestyles and livelihoods.

Caribbean states are especially vulnerable to these impacts because of:

## Our way of life

Caribbean people's lives and cultures are centred around the sea; we depend more on our coastal and marine environment than do many other regions on Earth.

## Where we live

Most Caribbean people's homes and key institutions – from hospitals to hotels – are located on the coastal fringe. Most people are highly exposed to risks from natural hazards, such as hurricanes which have severe immediate impacts and take a long time to recover from, especially when storms strike quickly again.

## We are island systems

Island land masses are relatively small, which often means there is little distance between inland, coastal and marine environments. Our island systems need an integrated management approach.

## Our dependence on our coasts and seas

The Caribbean is particularly dependent on tourism, which like fishing, depends on the complex web of life in our marine and coastal ecosystems – from mangroves to beaches and reefs, to seas and oceans. Other major economic activities such as farming are typically located in low lying areas.

## Our coastal economy

Caribbean states rely heavily on trade and passenger transport routes (air and sea) that are typically around the coast.

This report card sums up what we know of marine and coastal climate change impacts on Caribbean Small Island Developing States, and explores some of the actions that are needed to respond to these impacts. Case studies are drawn from those SIDS that fulfil the project criteria for the Commonwealth Marine Economies Programme and are eligible to receive international aid (known as Official Development Assistance, or ODA) to highlight examples of climate change impacts at the level of individual SIDS. These Caribbean countries are Antigua and Barbuda, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, and Saint Vincent and the Grenadines.

## Why we need to act now

Given the fact that the Caribbean is highly vulnerable to the impacts of climate change, it is essential that everyone knows what impacts are already being felt in the region and what could happen in the future.

We also need to know what needs to be done to either reduce the impact, adapt to change, or be better able to recover from the toughest shocks from climate change.

Some efforts are already underway to help build a more resilient environment and society. Our report card shows much more work is needed to prepare the Caribbean for climate change. By highlighting the key issues affecting Caribbean systems, this report card, together with the peer-reviewed research behind it, hopes to help people and governments understand the need to step up action to prepare for, and protect against, climate change.

There is a cost, too, of not adapting to climate change – a cost that is expected to grow over time as damage rises substantially, as this table shows for Caribbean islands. This is also why it is important to act now to ensure that Caribbean people are fully prepared to cope with the serious risks of climate change.

The estimates shown here were made in 2008. Given the large number of hurricanes, storms and floods that have occurred in the region since then and the devastating effects they have had, the cost of doing nothing could be even higher.

### Estimated cost of not adapting to climate change for Caribbean islands

Country	Cost of Inaction: % of 2004 GDP			
	2025	2050	2075	2100
Anguilla	10.4	20.7	31.1	41.4
Antigua & Barbuda	12.2	25.8	41.0	58.4
Aruba	5.0	10.1	15.1	20.1
Bahamas	6.6	13.9	22.2	31.7
Barbados	6.9	13.9	20.8	27.7
British Virgin Islands	4.5	9.0	13.5	18.1
Cayman Islands	8.8	20.1	34.7	53.4
Cuba	6.1	12.5	19.4	26.8
Dominica	16.3	34.3	54.4	77.3
Dominican Republic	9.7	19.6	29.8	40.3
Grenada	21.3	46.2	75.8	111.5
Guadeloupe	2.3	4.6	7.0	9.5
Haiti	30.5	61.2	92.1	123.2
Jamaica	13.9	27.9	42.3	56.9
Martinique	1.9	3.8	5.9	8.1
Montserrat	10.2	21.7	34.6	49.5
Netherlands Antilles	7.7	16.1	25.5	36.0
Puerto Rico	1.4	2.8	4.4	6.0
Saint Kitts & Nevis	16.0	35.5	59.5	89.3
Saint Lucia	12.1	24.3	36.6	49.1
Saint Vincent & the Grenadines	11.8	23.6	35.4	47.2
Trinidad & Tobago	4.0	8.0	12.0	16.0
Turks & Caicos	19.0	37.9	56.9	75.9
U.S. Virgin Islands	6.7	14.2	22.6	32.4
<b>TOTAL CARIBBEAN</b>	<b>5.0%</b>	<b>10.3%</b>	<b>15.9%</b>	<b>21.7%</b>

Table adapted from Bueno, R., Herzfeld, C., Stanton, E. A., and Ackerman, F. (2008) The Caribbean and climate change: The Costs of Inaction. Medford, MA, Tufts University Global Development and Environment Institute and Stockholm Environment Institute— US Center.

# What should the Caribbean do about climate change?

Let's consider some key activities that could improve understanding of climate change risks to Caribbean states, and make a region that can bounce back from the hard knocks of climate change.

We'll show some practical steps that are already being taken to demonstrate how national and regional bodies are beginning to tackle the problems of climate change.

## What more needs to be done?

Here are some responses that we could do in the region in the fight against climate change:

- Use climate change and risk information to help plan development of our coasts and seas. For example, examine our vulnerability to extreme sea level and storm surges, as well as increased hurricane intensity across the region. Knowing more about changing extreme events, sea level rise and precipitation patterns across the region would help provide credible state-scale information for improving building standards for infrastructure, particularly transport networks (e.g. roads, bridges and drainage).
- Prepare risk management and disaster preparation plans for hurricanes, storms, droughts and floods.
- Management responses to climate change need to focus on reducing local human stressors, including solutions to reduce degradation of water quality.
- More research on the present and projected impacts of ocean acidification. This would help planners develop adaptive strategies depending on each island's environmental, socioeconomic, and political settings.
- With a broader marine monitoring network, the Caribbean could develop an effective early warning indicator for biodiversity impacts such as bleaching events on the Mesoamerican reef system, or to help with long term marine planning.
- Develop a regional network of marine protected areas designed to future-proof marine biodiversity against climate change.
- Work to stabilize our shorelines and preserve natural barriers such as mangroves, salt marshes, and coral reefs.



## What's already being done?

Here are just a few of the initiatives that can act as a platform for building resilience to climate change across the Caribbean region.

Improving the Outlook for Caribbean Coral Reefs: A Regional Plan of Action 2013-2018. The aim is to identify key actions that can be taken by coral reef managers in collaboration with watershed, coastal zone area, and fisheries managers and local communities to improve the resilience of coral reef ecosystems.



Climate Change Adaptation and Disaster Risk Management in Fisheries and Aquaculture in the CARICOM Region: Strategy and Action Plan.

Caribbean and North Brazil Shelf Large Marine Ecosystems (CLME+) Project addresses fisheries sustainability, habitat degradation, pollution and climate change using an integrated ecosystem approach.

Organisation of Eastern Caribbean States Ocean Governance Programme which aims to maintain the benefits and functions of marine ecosystems for dependent communities.

COAST (Caribbean Ocean Assets Sustainability FaciliTy) which provides an opportunity for countries to buy insurance to help protect their fisheries sector from severe weather.



Pilot Programme for Climate Resilience (PPCR) provides funding to projects for climate change adaptation and resilience building.

Multilateral donor supported resilience building programmes (USAID, KfW, DfiD, TNC, etc.).

Regional Marine Protected Area programmes.

There are national examples of emerging adaptation initiatives, for example the government of Antigua and Barbuda is developing a national climate change adaptation policy and the government of Grenada has recently developed its Strategic Program for Climate Resilience. Belize has a Climate Change Adaptation Policy, which aims to ensure all government agencies consider climate change in their activities and policies.

The Network of Coral Reef Early Warning Systems (CREWS) Stations. These monitor changes in the sea that impact coral reefs in the Caribbean.

The Caribbean Climate Online Risk and Adaptation tool (CCORAL) tool helps countries to make climate-resilient decisions based on data available in their area.

Implementation of the Caribbean Disaster Emergency Management Agency's (CDEMA) Climate Change Disaster Risk Reduction Strategy (2014 to 2024).

## The supporting evidence behind this report card

This report card addresses three themes: climate change drivers; impacts on biological diversity; and society. It is based on twelve specially commissioned scientific papers covering the following **themes** and key topics:

- **Climate change drivers:** Extreme weather events, sea temperature and ocean acidification
- **Biological diversity:** Corals, mangroves, and fish and shellfish
- **Society:** Settlements and infrastructure, tourism and fisheries

The key topics, lead authors and reviewers were identified by Caribbean regional partners to ensure that the issues of greatest concern were addressed, and relevant regional experts were approached to provide the most up-to-date and accurate evidence.

Thirty four authors and reviewers, principally drawn from across the Caribbean region contributed to the key topic and theme papers, which are accessible through the Caribbean Community Climate Change Centre, Caribbean Regional Fisheries Mechanism and CME Programme websites. These comprehensive papers provide more detailed background information to support national and regional level action. They include sections describing our understanding of current and future climate change impacts, our confidence in that understanding, knowledge gaps and social and economic consequences.

# What's driving climate change?

Understanding regional changes in our seas in response to climate (referred to here as 'climate change drivers') is of fundamental importance. These changes ultimately lead to the impacts on biodiversity and society covered later in this card.

The key topics covered in more detail in this section are extreme events, sea temperature and ocean acidification. Extreme events cover a range of issues including major storms and hurricanes, droughts and flooding.

## Extreme events

### What is already happening?

Since the 1990s, there has been an increase in both the number and strength of storms and hurricanes in the North Atlantic. These changes have important consequences for society, given the damage and destruction that hurricanes inflict on lives and infrastructure, as well as the damage done to natural sea defences such as corals and mangroves.

Changing patterns of rainfall are having serious impacts. Prolonged droughts are leading to serious water availability issues for local populations and tourists. Some of the most extreme flooding events in recent years have not been associated with hurricane events; rather, they have been caused by extreme rainfall events.

Sea level in the region has risen by around 20 cm over the past 100 years, increasing the risk of flooding.

### What could happen?

While the overall frequency of Atlantic storms may decrease in the future, the strongest category 4 and 5 storms may increase by 80% in frequency over this century, with higher winds and rainfall rates associated with these storms.

Global mean sea level is projected to rise by a further 26-82 cm (10-32 inches) over the coming century, but higher increases exceeding a metre are possible. In the northern Caribbean, sea level rise could be 25% higher than the global average due to other physical factors affecting land elevation.

This projected rise in sea level and severe storms is likely to increase the risk of storm surge events for Caribbean states, which will further exacerbate risks to biodiversity, settlements and infrastructure across Caribbean states.

In the future, a tendency towards both more dry spells and extreme rainfall events is projected, increasing risks from drought, as well as flooding.

These impacts will necessitate an increased level of planning around water availability and a need to increase the resilience of coastal infrastructure and populations to storm damage and flood risk.

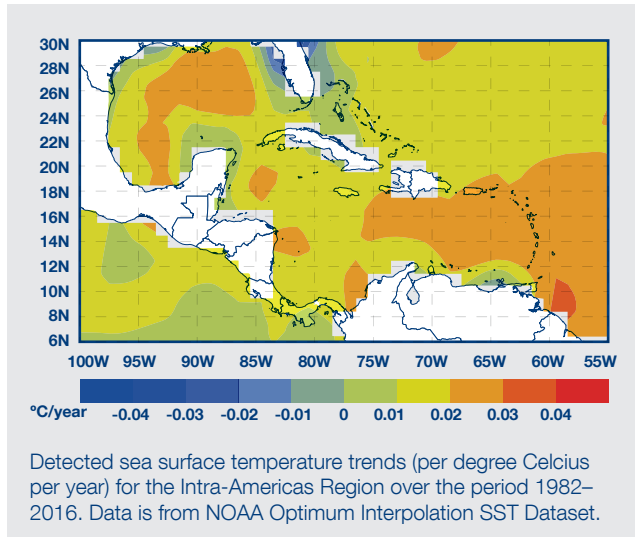




## Sea Temperature

### What is already happening?

As the seasonal variability for sea temperature is low in the Caribbean region, it only takes a small increase in temperature to become distinct from the background trend.



This temperature rise has serious implications for biodiversity in the region (e.g. corals and fish species) that may only be able to cope with a narrow temperature range and are already close to upper temperature tolerances, with consequences for the marine tourism and fishing industries.

Increasing sea temperature has also been linked to changes in severe storm activity and rising sea levels, increasing the risk of wind and flood damage.

### What could happen?

By the 2080s, average sea surface temperatures in the Caribbean region could be 2-3 °C warmer than the period 1976-2005.

Over the coming decades, warming is projected to be greatest in the summer. Later in the century warming is projected to be more uniform across all seasons, with sea surface temperatures exceeding 28 °C across the entire Caribbean all-year round.

As well as further increases in hurricane intensity, bleaching events, and impacts on marine biodiversity, increases in sea surface temperature could affect early season rainfall within the next few decades, leading to more extreme floods and droughts and a need to carefully manage water availability and security. If water availability becomes significantly affected, this would seriously affect quality of life and the development potential of individual states.

## Ocean Acidification

### What is already happening?

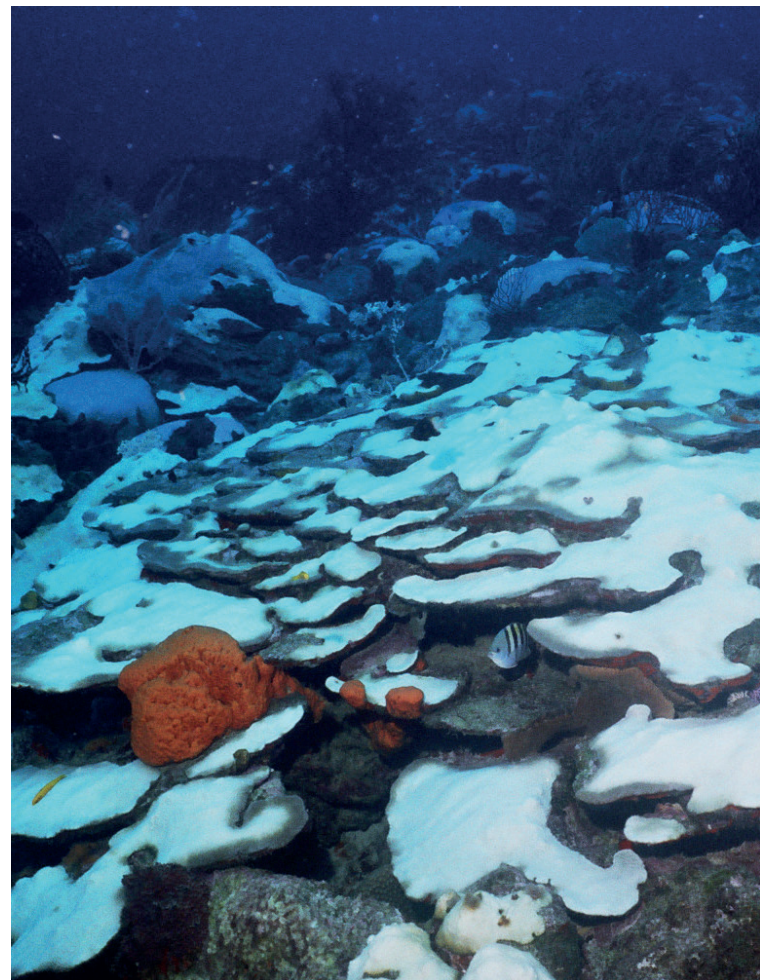
Increases in atmospheric carbon dioxide (CO<sub>2</sub>) concentration since the Industrial Revolution has led to a 26% increase in the acidity of the ocean, as CO<sub>2</sub> is absorbed by seawater to form carbonic acid. This has reduced pH (the unit used to measure acidity) by an average of 0.1 units with serious implications for reef growth and marine biodiversity. For example, coral reefs in the Caribbean may have already been affected by calcification rates dropping by around 15% leading to reef degradation, and also possible effects on some crustaceans (e.g. lobster) and molluscs (e.g. conch). Reducing other pressures on the reefs and sustainably managing our fisheries will be important to build resilience to these impacts.

### What could happen?

If atmospheric CO<sub>2</sub> concentration continues to rise as predicted, by the next century the average pH of oceanic waters could decrease by 0.3 – 0.4 pH units below pre-industrial levels.

Ocean acidification will exacerbate the current global warming effects on coral reefs and is likely to lead to greater degradation of coral reef conditions, with potentially serious consequences for reef building and deep corals, as well as crustaceans (e.g. lobster) and molluscs (e.g. conch).

Throughout the Caribbean, ocean acidification is also likely to adversely affect the physical strength of corals making Caribbean coastal areas more vulnerable to the action of waves and storm surges. This may lead to an increase in damage to coastal infrastructure and adversely affect the tourism and fisheries sectors. Increasing the resilience of the coastal ecosystems will be important to help mitigate these risks.



# Climate change impacts at the country level

**1** In Belize, recent coral bleaching events, associated with elevated temperatures, have been recorded in 1995, 1998, 2005, 2010, 2015 and 2016. The 2005 mass bleaching event coincided with the highest sea surface temperatures ever recorded and led to widespread coral mortality across the region.

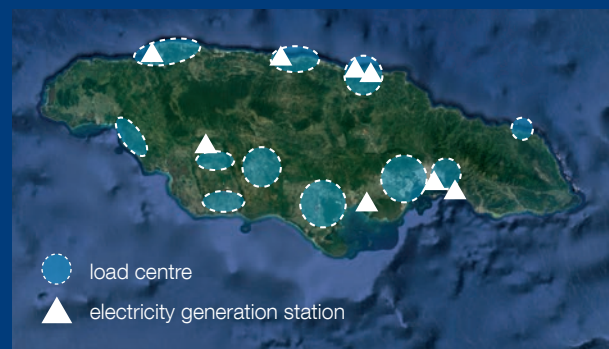
**2**  
**3**  
Belize

**2** Low-lying coastal areas of Belize and offshore cays and atolls are very vulnerable to the projected acceleration in sea-level rise. Wave overtopping and wash-over can be expected to become more frequent, which will degrade fresh groundwater resources.

**3** Permanent fishing camps on low lying offshore cays may be completely submerged by future sea level rise and are particularly vulnerable during extreme-weather events. Examples of these occur in Jamaica (Morant and Pedro Cays), Belize, and St. Vincent and the Grenadines.

**4**  
**3**  
Jamaica

**4** In Jamaica, 7 of 8 electricity generation stations, and all load centres, are located along the coast. With an increase in sea level rise expected, there is the possibility of having to relocate power utilities further inland.



The regional map shown here provides examples of climate change impacts relevant to specific SIDS in the Caribbean to highlight the consequences of local scale impacts. The case studies highlighted are for Caribbean states eligible for the Commonwealth Marine Economies Programme.

**5** In Dominica, the road network and the airports are particularly vulnerable. Ports and port lands are also under threat and at risk of inundation under scenarios of 1 m sea-level rise.

Climate-induced sea surface temperature changes are being linked to the increased occurrence of the micro-algal toxins that accumulate up the food chain to cause ciguatera fish poisoning (CFP) in humans. Although CFP is well known in the northern states of the Caribbean, it could become more frequent in the southern Lesser Antilles.

**6** Grenada and St. Lucia are already experiencing impacts from climate change as seen through the increased occurrence of droughts, lengthier dry seasons (and in turn shorter rainy seasons), increased temperatures and coastal degradation.

**5** Dominica

**6** St Lucia

**3** St Vincent and the Grenadines

**6** Grenada

**7** Georgetown, the capital of Guyana, located at the mouth of the Demerara River is prone to flooding both from the river and sea. It lies on the coast and much of it is below sea level. Up to 80% of the population live in the low-lying coastal areas and these same areas account for 75% of economic activity, including all of the agricultural production.

**8** In Guyana, severe and frequent flooding linked to climate change could destroy fish landing sites and cooperative buildings along the coast. Mangrove forests may become damaged or displaced causing valuable fish resources to be lost. Salt water intrusions are also a risk, as salinisation is likely to affect freshwater aquaculture, as well as large areas of agriculture near the coast.

**8** Guyana

**7**

# Impacts of climate change on marine and coastal biological diversity

The health and biological diversity (biodiversity) of marine and coastal ecosystems around Caribbean states are threatened by the physical changes described under the climate change drivers theme. Changes in temperature, ocean acidity and extreme events are expected to present significant threats to the physical integrity and biological functioning of these ecosystems. Tropical marine species in general are at high risk from ocean warming as they are adapted to a relatively stable thermal regime with a narrow temperature range, and many species already live near their upper thermal tolerances.

In addition to the threats posed to the integrity of these environments and the marine life they support, they also provide important ecosystem services that benefit people. For example, their structures provide physical protection from extreme events and flooding, and they provide an important source of income through tourism and the exploitation of commercial marine species. In view of their importance to local economies, and the services they provide, the key topics covered in more detail here are corals, mangroves, and fish and shellfish.

The resilience of marine and coastal ecosystems to climate change impacts are being compromised by human pressures. These pressures include the degradation of reefs from land based sources of pollution (e.g. garbage and agricultural chemicals), mining of sand from beaches, which exacerbates erosion, overfishing and the destruction of forests and mangroves, impacting on shoreline protection. Reducing these pressures is critical to building resilience to climate change.

## Corals

### What is already happening?

Climate change is already impacting coral reefs through the effects of elevated temperatures leading to coral bleaching and disease outbreaks.

Physical damage to reefs may be increasing due to stronger hurricanes and the net eroding effect of reduced calcification due to ocean acidification.

Combined with local human impacts, such as degraded water quality and overfishing, habitat destruction for tourism and port development, thermal stress could be undermining significant investments in coral reef protection. These impacts are important because long generation times and low genetic diversity means these corals are slow to adapt to climate change, making reducing other human impacts an imperative.

### What could happen?

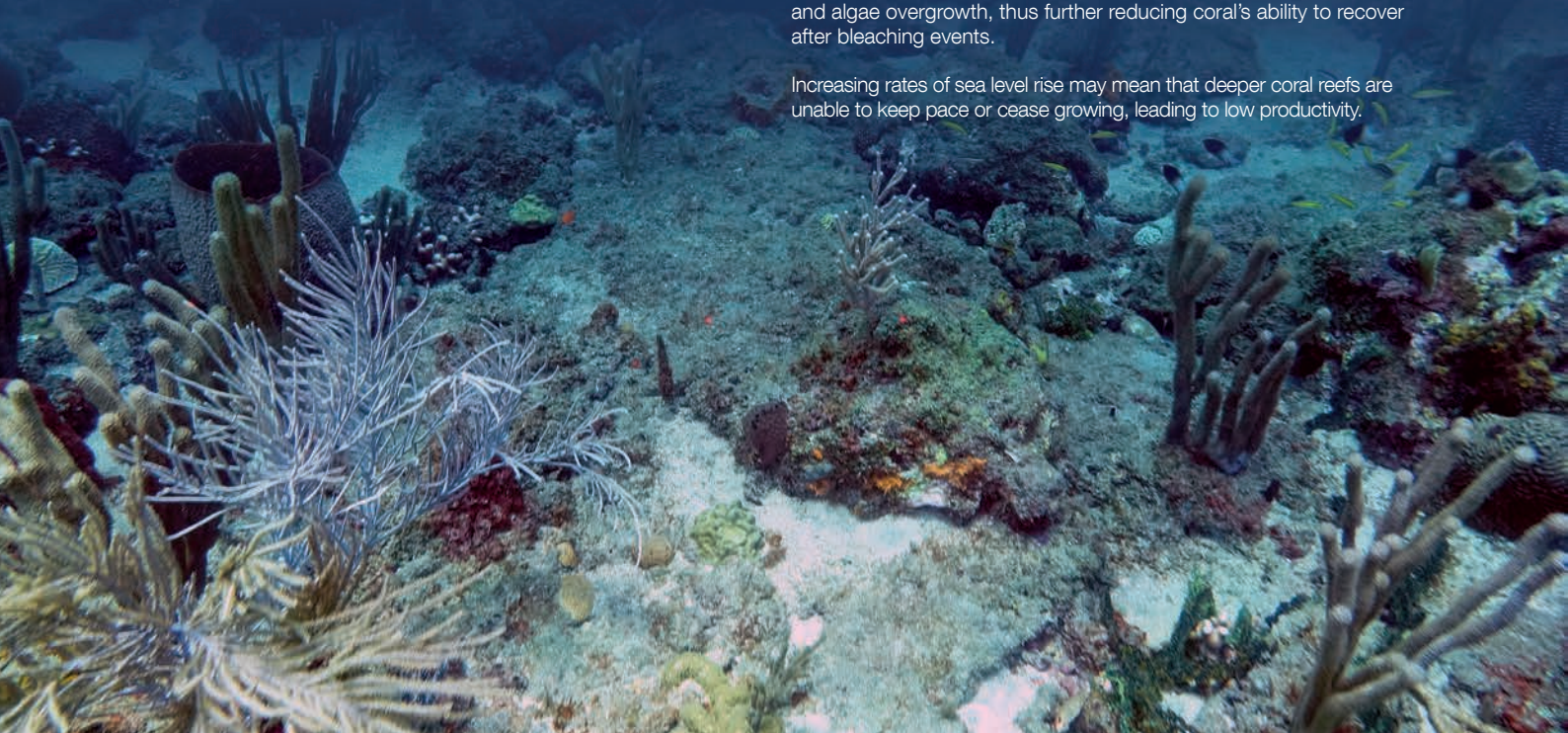
Because corals are currently at, or near, their thermal tolerances increased temperatures that exceed normal summer maxima by only 1 °C are enough to cause coral bleaching, and prolonged high temperatures over large areas could lead to extensive mortality. Future warming will create favourable conditions for coral bleaching that persist well beyond the normal summer months, especially early in the year.

Studies conclude that the majority of the Caribbean will experience coral bleaching annually or bi-annually within the next 30 to 50 years and this will likely become the key driver of reef decline. If extreme sea surface temperatures were to continue, some projections indicate that the Mesoamerican Barrier Reef System could collapse by mid-century.

Increased hurricane intensity is likely to lead to an increase in physical damage to, and loss of, corals especially given the large amount of time needed for recovery in many species and the impacts of other anthropogenic stressors, such as poor water quality and overfishing.

An increase in storm-related flash flood events could cause the poor water quality around nearshore reefs to deteriorate further, which may lead to increased heavy sedimentation, reduced light intensity, and algae overgrowth, thus further reducing coral's ability to recover after bleaching events.

Increasing rates of sea level rise may mean that deeper coral reefs are unable to keep pace or cease growing, leading to low productivity.



## Mangroves

### What is already happening?

Over the last quarter-century, mangrove forests have declined by a quarter across the Caribbean, mostly due to the destruction caused by building and development along the coastal zone. However, the removal or weakening of these natural sea defences by changing land-use is making our coastline more susceptible to climate change impacts.

The most immediate and well-understood climate-related threat to mangroves in Caribbean SIDS is sea level rise — which causes saltwater to seep into fresh water reserves (saline intrusion), erodes our coasts and destroys wildlife habitats.

### What could happen?

The reduction in mangroves forests in the Caribbean region is very likely to be made worse by more extreme temperature and rainfall, sea level rise, and the increased frequency of intense tropical cyclones.

Sea level rise is considered the most important threat for the future sustainability of mangrove ecosystems, especially fringe mangroves. Caribbean SIDS are particularly susceptible to sea level rise owing to limited land space. There is evidence of some benefits of elevated CO<sub>2</sub> in terms of growth and reproduction on a common Caribbean species, *Rhizophora mangle*. Higher levels of CO<sub>2</sub> may strengthen the ability of mangroves to move to higher ground as rising sea levels inundate the primary habitat in the intertidal zone.

Climate change impacts to nearby coral reefs may limit the protection these ecosystems provide from offshore waves and storm surge, and thereby further accelerate the degradation and decline of mangroves.

Increases in surface temperature is expected to affect the geographic range of mangrove species and disrupt the timing of flowering and fruiting.

The cumulative impacts of climate change are expected to cause a significant decline of mangrove ecosystems, and reduce the multitude of ecosystem service values that mangroves provide to people throughout Caribbean SIDS in coming decades.

## Fish and shellfish

### What is already happening?

Fish and shellfish reef habitats have already been degraded because of climate change (most notably coral bleaching and storm damage), and made worse by other human pressures, such as pollution and overfishing. These impacts have threatened the survival of some valuable species, particularly the Caribbean spiny lobster, through loss of their natural habitat and refuge sites.

Decline in live coral cover, caused largely by temperature-induced mass coral bleaching, has already been linked to declines in reef fish in some areas. Declines in herbivorous reef fish biomass across the Caribbean have been attributed to increases in sea temperature.

### What could happen?

As the ocean becomes warmer, less oxygenated, more thermally layered and more acidic, there may be shifts in the distribution of marine fish and shellfish species, leading to changes in their community structure, lower spawning rates, smaller sizes of fish and poorer coral reef health for reef fish.

Climate change impacts on individual fish species could be felt through direct impact on their development and reproduction, as well as indirect effects on habitats, refuges and predator-prey relationships affecting wider abundance and distribution.

For shellfish, the crustacean group (lobsters, shrimps, crabs), which generally build lighter exoskeletons, should fare better under increasing ocean acidification than corals, echinoderms and molluscs (such as conch). The outlook for fish under increasing acidity in the sea is less clear.

The most resilient group, over the short-term, could be the oceanic pelagic species (such as tunas and marlins) that generally show fewer negative responses to climate change stressors.



# Climate change impacts on people and livelihoods

Caribbean culture is largely centred around the sea, with high social dependency on coastal and marine natural resources. Most people live near the coast, and depend very heavily on marine resources for recreation, livelihoods from fishing and tourism. Understanding and responding to the impacts of climate change is particularly important in the Caribbean as weather and climate-related events are more associated with economic damage and loss than other types of natural hazards.

The key topics covered in detail here are settlements and infrastructure, fisheries and tourism. These cover a range of issues including both the economic and social impacts of climate change on the region and its people.

## Fisheries

### What is already happening?

The most immediate impacts have been loss of biodiversity and changes in the composition of fish communities as a result of coral reef death, with coral-dependent fish suffering the most rapid declines. This loss of reef structure has already been shown in the Caribbean to result in significant declines in the biomass of commercially important reef fish and thus the potential sustainable yield that can be taken by the fishery.

Changes to ocean currents and temperatures linked to climate change have recently been associated with unprecedented influxes of pelagic *Sargassum* seaweed into the Caribbean Sea (since 2011), which has hampered fishing in complex ways. While engine propellers become entangled by the weed, the spawning of dolphin fish around clumps of *Sargassum* has made it easier to catch juvenile fish, providing a bounty now but leading to scarcity later as fewer dolphin fish grow to adult size. This complex range of impacts will require an appropriate management solution if it persists in the future.

Caribbean fishing is highly vulnerable to climate change, especially those in the Greater and Lesser Antilles. Caribbean fisheries are under threat due to changes in ocean currents and fish distribution, and loss of marine habitats. Coastal erosion is also compromising important fish landing beach sites and increasing intensity of storms together with increased sea level causes damage to fish habitats, fishery access and assets.

### What could happen?

Any increase to frequency and severity of storms would result in more cases of dangerous storm surges and coastal flooding, leading to injury, ill-health and even death, and resulting in disrupted livelihoods of coastal fishing communities. Fishers are especially vulnerable with potential losses or significant damage to boats and fishing gear, loss of fishing days, and an increased risk of accidents ashore and at sea during rough weather. Impacts on fishing infrastructure such as jetties, slipways, harbours and coastal markets could also be important.

Loss of critical habitats would result in decreased fish production and reduced sustainable fishery yields, particularly of reef-associated fisheries whose target species rely on healthy reefs, mangrove and seagrass habitats, but also on shrimp fisheries and deep slope fisheries because of damage to critical nursery habitats for these species (mangrove estuaries and coral reefs respectively).

The less mobile fish species that live on reefs or near the shore could become more scarce, while the highly migratory oceanic pelagic fishes (e.g. yellowfin tuna, skipjack tuna, swordfish, billfishes) and regional large pelagics (e.g. wahoo, dolphinfish, blackfin tuna and mackerel species) are likely to move northwards in the Atlantic. If regional and international offshore pelagic stocks move northwards in response to increasing sea surface temperatures, catches might be expected to decrease across all species as they move beyond the reach of the small-scale vessels of southerly Caribbean states.

Changes in availability of high-value species (e.g. spiny lobster, conch, shrimp and snapper) will have particular impact on the harvest sector (both small-scale and semi-industrial) and will in turn negatively affect export trade and foreign currency income.

Climate change also challenges the effectiveness of many current fishery management regulations, and will increasingly exacerbate the ongoing decline of fish resources in the region, caused by overfishing and degradation of the marine environment.



## Settlements and infrastructure

### What is already happening?

Since 2000, there has been an apparent increase in the number of hurricanes, especially Category 5 hurricanes, destroying homes, settlements and infrastructure in many Caribbean states.

The risk from coastal flooding in low-lying areas is increasing owing to stronger storm surges and to a lesser extent sea level rise.

More than two-thirds of Caribbean beaches – an estimated 70% – are eroding at rates of 0.25 to 9 metres per year, worsened by sea level rise, wave action and storms.

Rising temperatures, changing rainfall patterns and saltwater intrusions are compromising our fresh water resources which has been linked to public health problems (dehydration, diarrhoea and disease) and mental health issues (domestic violence, anxiety, stress and depression), that have been reported in recent drought events.

Over the past 25 years the intensity of daily and heavy rainfall events has been rising, interrupted by longer dry spells. As water flows down to the sea, it is often the coastal areas that are most severely affected. Health impacts associated with the disruption of water supplies and contaminated water are a concern.

### What could happen?

Climate models project an increase in the frequency of high intensity category 4 and 5 storms over the next century further escalating the threat to already vulnerable coastal communities.

With more high intensity storms, many island nations would face less time to recover between hurricanes before being threatened again. Many post-hurricane countries are already ill-prepared to face a range of public health and social issues – stress and frustration from inadequate or delayed response and relief efforts, looting, violent crime and civil unrest, mental health problems ranging from depression to post-traumatic stress to disorders receiving limited medical treatment owing to the collapse of mental health facilities.

Recovery efforts will therefore require extra financial resources over shorter time periods which in turn means more funding for disaster recovery.

Coastal flooding is expected to increase due to a combination of variation in storm surge extremes superimposed on rising sea levels. This is likely to lead to an acceleration of severe damage to coastal settlements with the accompanying impacts on national economies.

A further example of where changes in extreme events may have serious implications is for energy – many power plants in the Caribbean are located along the coast.

Future annual direct losses in the region due to climate-related disasters have been estimated at USD 2.6 billion due to wind damage, USD 363.1 million from flood damage and USD 3.7 million caused by drought.

Climate studies suggest an increase in the number of dry days experienced in a row but also an increase in rainfall intensity. This would lead to greater run-off and more water would be channelled to low-lying coastal areas. With changes in coastal land use, projected climate change could result in more extensive and frequent flooding and infrastructure damage.

Negative impacts from climate could result in further internal displacement and relocation of sections of the population and also increased outward migration.



## Tourism



### What is already happening?

The attractiveness of water-based tourism in the region is being negatively affected by the increased frequency and magnitude of coral bleaching and disease.

Rainfall has decreased in the Caribbean in the last century. Droughts have become more frequent, leading to severe water shortages, particularly given the increasing demand for water within the tourism industry.

Damage and loss caused by hurricanes has increased and the costs of rebuilding damaged infrastructure along the coasts are disproportionately high for Caribbean SIDS.

### What could happen?

Coastal tourism assets are particularly exposed to direct and indirect climate change effects, including sea level rise, shifting tropical storm patterns, heightened storm surges, and coastal erosion. As a result, coastal tourist resorts could potentially be two-to-three times more exposed to climate change impacts such as extreme events and saltwater intrusion than inland tourist resorts.

Caribbean tourism is particularly vulnerable to climate change due to its concentration in low-lying coastal areas. In a future scenario in which the world is 4 °C hotter and sea levels 0.89–1.4 m higher, tropical cyclones in the Caribbean alone could cost an extra USD22 billion by 2050 (and USD46 billion by 2100) in damage and tourism earnings losses.

By mid-century, Caribbean coral reefs are expected to experience large-scale impacts from coral bleaching, which could not only affect dive tourism significantly but also reduce the coastal protection that reef systems provide. Even modest future declines in the abundance of reef fish, and particularly large fish observed on recreational dives, will result in significant reductions in dive and snorkel tourism spend in the region.

During this century, it is expected that the dry season will be longer in some areas, as rainfall will decrease in the early part of the wet season. This would put more pressure on water supplies for people, given the high level of water consumption of visitors and demands from cruise ships for water.

With greater and more intense tropical storms forecast in the future, there may also be increased port downtime for ships and, therefore, a rise in shipping costs.

As the source countries themselves become warmer (e.g. United Kingdom, Canada and the USA) tourists may be less inclined to come to the Caribbean for a holiday, especially if the heat in the Caribbean becomes unbearable in high season. More unseasonal rainfall may also cause holiday weather to become unreliable, and change tourists' perceptions of Caribbean destinations.



## Key recommendations

In addition to some of the specific recommendations made on page two, and within each paper supporting this Report Card, some key recommendations are made here to support regional and national action.

### Economic and social assessments



Produce an estimate of the cost of climate change impacts on the environmental, social and economic values of marine and coastal habitats across the Caribbean Region such as coral reefs, mangroves, beaches and seagrass beds.

Some studies are beginning to explore how to use “payment for ecosystem service” and “blue carbon” values as a means to better understand the natural and socioeconomic values of mangrove ecosystems, and to encourage protection. Understanding these values can contribute to better public policy and resource management.

Obtain social and economic data on the fisheries sector to understand the consequences of climate induced changes for communities and the region.

### Climate change adaptation actions



Develop adaptation actions that combine human stressors such as fisheries and development with environmental protection. Consider feasibility of mainstreaming coral reef and mangrove restoration, where appropriate and feasible, as an ecosystem-based adaptation strategy to climate change.

Improve the marine protected area network by prioritising areas and considering long-term vulnerabilities to climate warming. Base this on spatial and temporal analysis of historical accounts and projected sea surface temperatures.

### Further research on climate projections and potential impacts



Further research on how climate change might affect ocean currents and storm surges, and by extension, coastal erosion.

Regional modelling to assess climate change impacts on key species in the region.

Consider the combined effects of climate change impacts (direct and indirect) on fish species and ecosystems, together with the synergistic effects of other chronic human pressures in the region.

Further information is needed on the resilience to climate change of heavily exploited and protected reef fish stocks to provide better guidance on appropriate management tools and strategies for climate change adaptation.

Species-specific studies of increasing sea surface temperature and ocean acidification on queen conch and spiny lobster to improve predictions of climate change impacts on two of the region’s most economically valuable fishery species.

### Strategic planning



Develop and implement a centralised and targeted biodiversity surveillance plan to enforce biodiversity surveillance to ensure preservation and ownership of these resources.

Further consider changes needed to fisheries plans, policies and legislation at the national and regional level to address anticipated changes due to climate change.

Legislate for enough space for coastal development setbacks, to reduce vulnerability to sea level rise and coastal erosion.

Develop and keep updated, an inventory of existing sea defences, to allow climate change adaptation to be integrated into development plans, tourism plans and for government insurance policies to take sea level rise into account.

Disaster education and response training are needed for storm preparation and risk mitigation.

This report card is based on an original concept developed by the UK Marine Climate Change Impacts Partnership (MCCIP) [www.mccip.org.uk](http://www.mccip.org.uk)

The delivery of this report card was overseen by the working group:

Ulric Trotz (**Caribbean Community Climate Change Centre (CCCCC)**)

Keith Nichols (**CCCCC**)

Peter A. Murray (**Caribbean Regional Fisheries Mechanism (CRFM)**)

Chantalle Clarke-Samuels (**Belize Coastal Zone Management Authority and Institute**)

Ann Gordon (**National Climate Change Office in Belize**)

Michael Taylor (**University of the West Indies (UWI)**)

Paul Buckley (**Cefas**)

Bryony Townhill (**Cefas**)

Please cite this document as:

**CMEP (2017) Caribbean Marine Climate Change Report Card 2017.** (Eds. Paul Buckley, Bryony Townhill, Ulric Trotz, Keith Nichols, Peter A. Murray, Chantalle Clarke-Samuels, Ann Gordon, Michael Taylor). Commonwealth Marine Economies Programme, 12pp.

## List of contributors

### Authors:

Michael Taylor (**UWI**)

Kimberly A. Stephenson (**UWI**)

Tannecia Stephenson (**UWI**)

Jhordanne J. Jones (**UWI**)

Melissa Melendez (**University of New Hampshire**)

Joseph Salisbury (**University of New Hampshire**)

Hazel Oxenford (**UWI**)

Iris Monnereau (**UWI**)

Robin Mahon (**UWI**)

Melanie McField (**Smithsonian Institution**)

Rich Wilson (**Seatone Consulting**)

Davina Layne (**USAID Caribbean Clean Energy Program**)

Adrian Cashman (**UWI**)

Mohammad R. Nagdee (**UWI**)

Susana Lincoln (**Cefas**)

Silvana Birchenough (**Cefas**)

Stephen Dye (**Cefas**)

John Pinnegar (**Cefas**)

Paul Buckley (**Cefas**)

### Reviewers:

Dwight Gledhill (**NOAA**)

Arnoldo Bezanilla (**INSMET**)

Abel Cantella (**INSMET**)

Owen Day (**Clear Caribbean Ltd.**)

Lisa Carne (**Fragments of Hope**)

Dawn Pierre-Nathaniel (**Department of Sustainable Development, St Lucia**)

Aden Forteau (**The Nature Conservancy**)

Susanna Scott (**Department of Sustainable Development, St Lucia**)

Paulette Bynoe (**University of Guyana**)

Mark Bynoe (**CCCCC**)

Judi Clark (**J F Clarke Consulting Inc**)

Alison King (**King Consulting Inc.**)

Ulric Trotz (**CCCCC**)

Keith Nichols (**CCCCC**)

Peter A. Murray (**CRFM**)

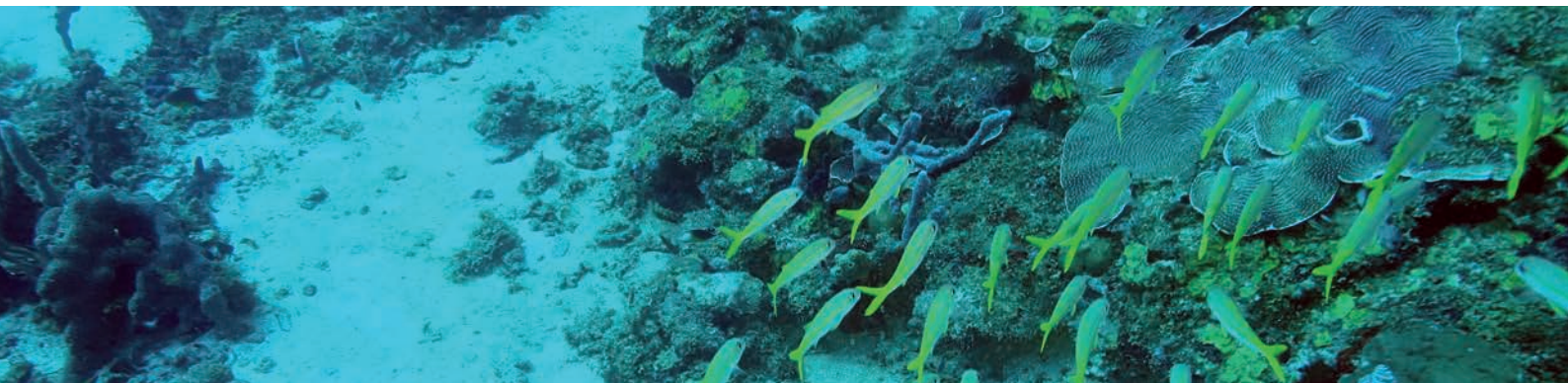
Michael Taylor (**UWI**)

Image credits: Adrian Cashman, Hazel Oxenford, Norman Norris

For more information on the Commonwealth Marine Economies Programme, please contact us via:

[www.gov.uk/guidance/commonwealth-marine-economies-programme](http://www.gov.uk/guidance/commonwealth-marine-economies-programme)

[enquiries@cmeprogramme.org](mailto:enquiries@cmeprogramme.org) | [@CME\\_Prog](https://twitter.com/CME_Prog)   



Centre for Environment  
Fisheries & Aquaculture  
Science



United Kingdom  
Hydrographic Office



National  
Oceanography Centre  
NATURAL ENVIRONMENT RESEARCH COUNCIL

© Crown  
Copyright  
(2017)