

How the keepers of the ocean's crown jewels are dealing with planetary warming

What to do about the warming of the planet remains a subject for debate, but the fact of climate change is now a scientifically measurable phenomenon that threatens not just coastal areas, but all types of ecosystems around the planet. World Heritage marine sites are esoecially vulner

World Heritage marine sites are especially vulnerable to climate change, since so many of them shelter coral reefs, estuaries, beaches and other habitats at or near sea level. The Unesco World Heritage Centre's Marine Program, which counts 46 sites around the world, stresses that extra care is essential for these "crown jewels of the oceans." The most obvious threat is a rise in sea level, proj-

Ine most obvious threat is a rise in sea level, projected to reach as much as three feet, or about a meter, worldwide by the year 2100, according to several recent studies. But climate change generates other, weather-related, events that can be just as catastrophic for coastal areas, including drought, flooding, glacial melting and more powerful storms.

"As a scientist, one has to be careful about attributing any specific event or change in ecosystem health specifically to climate change," says Paul Marshall, the founding director of the climate-change program at the Great Barrier Reef Marine Park Authority and program leader of the Australia-Caribbean Coral Reef Collaboration. "This is because climate change is not the only factor that affects these large and complex systems. What we do know for sure is that the climate is changing, and that this is significantly increasing risks."

Among the areas most at risk.

According to a climate-change vulnerability index recently published by Maplecroft, a British consultancy, are the Everglades in Florida, the Sundarbans in India, much of the Indonesian and Philippines archipelagos, and the of the w

Caribbean coast of Central America, all of which boast marine World Heritage sites. Chris Bates, representative in the United Kingdom of Tristan da Cunha, where the World Heritage marine

of Tristan da Cunha, where the World Heritage marine site Gough and Inaccessible Islands is located, indicates that rising sea temperatures make it easier for invasive species there to multiply, and that continued warming will exacerbate the problem. Eradicating invasive species is one of the site's main challenges. The Phoenix Islands Protected Area, in Kiribati, is one of the largest marine protected areas and in a very remote location. Tukabu Teroroko, director of the Phoenix Islands Protected Area, says that the World Heritage site could serve as a great marine laboratory where scientists study more closely the effects of climate change.

change cantly g risks' of the ware stay there longer before they start their migration and thus are more mature when they begin their migrature to the start of the stagoons, newborn gray whales stay there longer before they start their migration and thus are more mature when they begin their

journey north. Site monitoring is crucial, says Frauke Fleischer-Dogley, chief executive officer of the Seychelles Islands Foundation. Coral bleaching has been seen at Aldabra Atoll in the Seychelles since 1998. The remoteness of the site makes it more resilient to bleaching, since there are few other pressures, but it also makes it very costly to carry out research and monitor the site.

Heard Island in the southern Indian Ocean, Wrangel Island off the northern coast of Siberia, the massive Kluane/Wrangell-St. Elias/Glacier Bay/ Tatshenshini-Alsek reserves in Canada and Alaska, and other World Heritage sites in or near the polar regions face a possibly severe impact from glacier melt or sea-ice degradation.

Although climate change is a worldwide phenomenon — and the solutions require global effort — managers from the World Heritage marine sites are doing what they can to limit the local impact and share best practices and other information with their colleagues throughout their network.

Says María M. Chavarria Diaz of the Guanacaste Conservation Area, a World Heritage site in Costa Rica: "I think there is not much we can do to influence climate change as a global problem because we are a small country, but we should at least try to be an example of how to deal with the problem, to be alert and look for options or alternatives, understand the impacts and find solutions. It is vital to be able to react. Programs around the world have impacts that will affect areas locally and beyond. We need to educate ourselves, and we are all working against the clock."

Marshall agrees: "The strong interaction between global climate change and local stresses creates a potent cocktail of risk. But it also creates opportunities for local action that can make a difference. There is abundant science to support the premise that local actions can make a difference. But this same body of science also says that even the most effective local actions will be overwhelmed if climate change reaches the worst scenarios."

The World Heritage model offers the conservation community valuable experience. Says Fleischer-Dogley of the Seychelles Islands Foundation: "I'm convinced that World Heritage marine sites should serve collectively as laboratories showcasing climate change. They are perfectly placed to instigate the much-needed wind of change on the global scene." J.Y.

ECOSYSTEMS | Coral reefs Seawater acidification and storms are among threats

A ustralia's Great Barrier Reef has suffered less from climate change. But even the world's largest reef system with conservation practices and a management regime widely regarded as worldleading — has not been immune to the effects of meteorological upheaval.

fects of meteorological upheaval. Global increases in temperatures create conditions that drive sea temperatures above thresholds that coral can tolerate. Unusually warm conditions cause coral to "bleach" — a sign of stress that indicates the coral has lost the microscopic algae living within its tissues.

Globally, bleaching has effectively destroyed 18 percent of the world's reefs. Two major bleaching events, in 1998 and 2002, each damaged approximately 5 percent of the Great Barrier Reef. Those who manage the Unesco World Heritage site fear more impact in years to come.

"The frequency and severity of coral bleaching events is projected to increase as global temperatures rise," says Paul Marshall, founding director of the climatechange program at the Great Barrier Reef Marine Park Authority and program leader of the Australia-Caribbean Coral Reef Collaboration. "The alarming worldwide increase in coral-bleaching events over the last three to four decades shows that climate change is already putting unsustainable pressure on coral reefs, and that coral reef managers need to prepare for a future of increasing risk for reefs."

Arvid Hogstrom, district manager for the

Imagination and technology for extreme conditions

Breakthroughs occur when individuals seek new ways of solving old problems. For example, mechanical devices — such as movements in timepieces as well as other machinery — require lubricants to ensure the smooth operation of moving parts. Over time, the efficacy of these lubricants deteriorates and the performance of the parts suffers unless the lubricant is replaced. The holy grail for watches has

The holy grail for watches has long been a lubricant-free movement. In 2002, Jaeger-LeCoultre introduced lubricant-free ceramic ball bearings. Later, the research team at the manufacture in Le Sentier went further, making a mechanical movement that runs without any lubricant whatsoever, the Jaeger-LeCoultre Calibre 988C — the first mechanical movement in watchmaking history to operate accurately and reliably without

To develop its Master Compresson Extreme LAB with the 988C movement, the manufacture turned

lubricants.

Exmouth Department of Environment and Conservation, Western Australia, says that Ningaloo Coast has seen significant coral bleaching. But he points out that the site's ecosystems are very resilient and recover quite quickly, thanks to good site management, together with its remote location. He adds, however, that it remains to be seen how continued events like coral bleaching and warming waters will interact in the long term with other types of pressures, such as cyclones and other extreme weather events.

Over the last decade, Belize has been ravaged by six major hurricanes, storms that inflicted major damage on agriculture, transportation, housing, forestry resources and

the Belize Barrier Reef Reserve System. Amanda Acosta, executive director of the Belize Audubon Society, says that the Belize Barrier Reef has seen coral bleaching, algal blooms and rising water temperatures in recent years, particularly in the shallow atolls.

"This World Heritage site is being threatened by higher sea temperatures and ocean acidification caused by increasing levels of carbon dioxide in the ocean," said Lisel Alamilla, Belize's minister of forestry, fisheries and sustainable development, at the meeting of the United Nations Framework Convention on Climate Change in Warsaw in November.

Alamilla went on to say that financing is urgently needed to move Belize toward sustainable development and a climate-resilient and low-carbon future. "The time for action is now," she said. "However, we cannot do it alone, and we cannot do it without significant

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Naomi Oreskes, a Harvard professor and a leading authority on climate change, says: "Climate change threatens to undo a great deal of good work that has been done. And it's important to note that when we talk about coral reefs, we are not just talking about survival in their current state. We are talking about survival, full stop."

In addition to rising sea temperatures, climate change also increases the likelihood of severe storms, and increased absorption of carbon dioxide is making the oceans more acidic.

"Whether related to climate change or not, the Great Barrier Reef has experienced an unprecedented run of severe cyclones," says Marshall. "More Category 5 cyclones have crossed the Great Barrier Reef so far this century than in the entire 20th century. These storms have caused massive damage to some sections of the reef."

Scientists say that ocean acidification is an even greater long-term threat than coral bleaching and increased storm severity. Calcifying organisms find it harder to make their calcareous skeletons and shells under conditions of higher acidity.

The Great Barrier Reef Marine Park Authority is fighting back via several means, including a coral-bleaching response program, a water-quality protection project, continued scientific monitoring and assessment, and an action plan for building ecosystem resilience and adaptive capacity. The authority is sharing this information with World Heritage and other protected marine areas around the world. Through support from the Australian Agency for International Development, the park has also begun to actively collaborate with reef managers in the Caribbean, in particular World Heritage sites in Belize and St. Lucia, to share experiences and transfer knowledge.

The park has also collaborated with the International Union for Conservation of Nature, the National Oceanic and Atmospheric Administration of the United States and others to produce the "Reef Managers Guide to Coral Bleaching," a publication that has become the de facto textbook for a sustained program of capacity-building for coral reef managers around the world.

"Over 11,000 people have benefited from the reef-resilience training program led by the Nature Conservarcy in conjunction with partners," says Marshall, "and it has been very rewarding to have worked with them for over a decade to share the experience of the Great Barrier Reef Marine Park Authority." J.Y.

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