STAGHORN CORALS AND CLIMATE CHANGE

Better to burn out than to fade away?

Summary

• As well as being the most biodiverse ecosystems in the marine realm, coral reefs provide protein, livelihoods and services to tens of millions of people worldwide.

• Staghorn corals, the collective name for some 160 species representing approximately one-fifth of earth’s extant reef-building corals, are critical to the processes of reef-building and provision of habitat for the remarkable array of associated reef life globally.

• These corals are extremely sensitive to high sea temperatures. They ‘bleach’ when warming forces them to expel the pigmented algae on which they rely for energy. Too much warming and they die, en masse.

• In addition, ocean acidification is causing weakening of coral skeletons, slower growth rates and, if unchecked, will contribute to the erosion of coral reefs in general.

• Corals are already threatened by human activities and disease; climate change interacts synergistically with these threats, reducing their chance of recovery. 33 percent of coral species are already listed as threatened on the IUCN Red List.

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- Staghorn corals highlight the impacts of rising sea temperatures and increasing ocean acidification due to climate change. These changes directly or indirectly affect most species in the marine biome.

Coral reefs are the most biodiverse ecosystems in the marine realm. They are home to more than a third of all known marine species and are sometimes referred to as ‘undersea cities’ or ‘oases’.

Staghorn corals are hard or ‘stony’ corals belonging to the genus *Acropora* and are so named for the antler-like colony forms of characteristic species. Other typical forms include intricate tables, expansive bushes and delicate ‘bottle-brushes’, among a bewildering variety of growth architectures. There are approximately 160 species of staghorn corals worldwide. Staghorn corals are thought to have evolved in the late Paleocene some 55-65 million years ago, and have dominated many reefs for the past 500,000 years.

Staghorn corals play crucial roles in reef-building, and in providing food, shelter and other services to the remarkable array of associated species, a number of which are important to humans.

More than 100 countries have coastlines fringed by reefs, and almost 500 million people (about eight percent of world’s population) live within 100km of a coral reef. Consequently, tens of millions of people depend on coral reefs for their protein. They also provide many important services to human societies. These include shielding thousands of kilometres of coastline from wave erosion, and protecting lagoons and mangroves, which are vital habitats for a range of commercial and non-commercial species.

Many medically active compounds are also created by or from corals and associated reef species. Reefs are also popular locations for snorkelling and SCUBA diving and as such have much value for ecotourism. Although valuation of all the goods and services provided by reefs is difficult, estimates range from $172 billion to $375 billion per year.

What do we know about staghorn corals?

Staghorn corals can be broadly divided into Atlantic and Indo-Pacific groups, and are generally located between 25°N and 25°S. The Atlantic group is by far the smaller of the two, being composed of only two extant species and a common hybrid, found along the Caribbean coasts of Central and South America, south-western Gulf of Mexico and the Bahaman archipelago. The Indo-Pacific group is distributed across the tropics in suitable habitat all the way from the west coast of Central America to the Red Sea and East Africa, with the centre of diversity in the ‘Coral Triangle’ region of the Solomon Islands, Papua New Guinea, Indonesia, East Timor, Philippines and Malaysia. Undisturbed staghorn corals normally form a distinct “staghorn zone” in shallow waters between 5 to 15m depth, though they do also occur in shallower and deeper water.

As with other stony corals, staghorn corals have a symbiotic relationship with photosynthetic single-celled algae called zooxanthellae. Staghorn corals are highly dependent on the oxygen and nutrients provided by these algae and the algae, in turn, receive carbon dioxide, nitrogen and other substances they need from the coral. Zooxanthellae are presently divided into six major clades and numerous sub-clades and different coral-zooxanthella combinations result in different coral physiology and colouration.

Staghorn corals reproduce both sexually (being hermaphrodites) and asexually (via budding and colony fragmentation). Sexual reproduction begins when, triggered by various environmental cues, including sea temperature, solar irradiance and lunar cycles, corals release vast numbers of sperm and eggs into the sea. In some regions hundreds of species do this simultaneously, (known as mass spawning). Eggs are fertilised in the open ocean and develop into free-living planktonic larvae that are carried by water currents. Larvae may drift on ocean currents for periods lasting several days to up to three months and may travel for up to hundreds of kilometres during this time. Upon maturing, they settle on a reef and undergo metamorphosis to transform into a single polyp.

Each staghorn polyp is approximately one to several millimetres in size and its body structure consists of a mouth and a sac-like cavity called the coelenteron. The coral polyp secretes a calcium carbonate skeleton that serves as a home and helps to protects it from harm.

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Polyps divide asexually by budding to make the colonies of thousands of polyps that form the antler-, bush- and table-like structures we recognise as staghorn corals. In addition to the energy provided by the zooxanthellae, polyps are also carnivorous and feed nightly on plankton by extending their tentacles, equipped with stinging cells called nematocysts, to capture prey. When coral polyps are threatened, they simply retract into their skeletons.

When pieces of a staghorn corals break off, they are often able to grow and form a new coral colony. This process of asexual reproduction is called fragmentation and is a common form of coral reproduction, particularly following severe storms.

How is climate change affecting staghorn corals?

Climate change has a wide range of impacts on corals and the reefs they build, the most important of which are bleaching, acid erosion and increased disease susceptibility.

Bleaching:

Bleaching occurs when corals experience environmental stress. Corals and their symbiotic zooxanthellae usually live only 1 to 2°C below their upper temperature tolerance, and climate change is expected to cause seawater temperature to rise above this limit with greater frequency. Large-scale or ‘mass’ coral bleaching is a new phenomenon dating back to the 1980s; and is now the main cause of coral mortality and reef deterioration globally.

When water temperature increases, the algal symbionts photosynthesise more quickly. This increases the amount of oxygen they produce which can increase to toxic levels within the corals’ tissues. To survive, corals expel most, if not all, of the algae from their tissues, thereby losing their source of energy. Corals appear white or ‘bleached’ because when the pigmented algae are gone, the white calcareous skeleton becomes visible through the transparent coral tissues.

Coral survival is contingent on a complex variety of factors that are both species- and colony-specific, including the type of zooxanthellae present. If seawater temperature returns to normal within a few weeks, the bleached corals sometimes regain their zooxanthellae populations and recover. Even so, these colonies still suffer from increased disease susceptibility, reduced growth rates and reproductive capability.

If high water temperatures persist for several weeks then bleaching causes coral tissues to die; bleaching mortality
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tends to be proportional to the intensity and length of unusually high temperature conditions. Once dead, coral skeletons break down over a period of years into grey ‘rubble’, which destroys the complex three-dimensional structure and supports few other species. These reefs look eerily like flattened cities abandoned after a nuclear explosion. When high proportions of colonies on reefs bleach and die, this can lead to changes in the community structure of the entire coral reef ecosystem, severely impacting reef-dependent organisms and reducing overall biodiversity.

Coral vulnerability to bleaching varies between species, and staghorn corals are thought to be one of the most vulnerable groups. Temperature-induced mass coral bleaching has caused widespread mortality of staghorns and other corals worldwide, including the well-protected Great Barrier Reef in Australia. Globally, 20 percent of coral reefs are already damaged beyond recovery.

Ocean acidification:
Carbon dioxide (CO₂) emitted into the atmosphere by human activities is being absorbed by the oceans, making them more acidic. Because acidification affects the process of calcification, this directly impacts marine animals like corals and molluscs which have calcareous shells or plates. Ocean acidification causes weakening of coral skeletons, slower growth rates and, if unchecked, erosion of coral reefs in general. Recent studies have shown that if atmospheric CO₂ concentrations reach 560 ppm, coral calcification and growth will be reduced by 40 percent.

Disease:
Increasing water temperatures and acidification cause physiological stress, increasing corals’ susceptibility to diseases. In addition, rising sea temperatures often present more suitable conditions for the pathogens themselves, and this also worsens outbreaks of coral diseases. The rapid, large-scale devastating loss of staghorn corals in the Caribbean is due to an unprecedented rise in coral diseases and this climate change-related effect poses a very real threat to coral biodiversity.

Other threats:
Climate change introduces a host of other impacts which may act synergistically with bleaching, acidification and disease to threaten staghorns and other corals. These include sea level rise, changes to ocean circulation patterns, damage from increased storm intensity and frequency, and loss of light from increased river sediment loads.

Will corals adapt to climate change?
Corals’ susceptibility to bleaching varies substantially between geographic locations, even for the same species. This is partly because some clades of symbiont algae photosynthesise at slower rates than others, thereby preventing oxygen levels in coral tissues from reaching toxic levels. Corals containing these algae are able to tolerate greater heat stress, though at the cost of slower growth rate during normal conditions. In some coral-zooxanthella symbioses, several types of zooxanthellae can be present and ‘shuffle’ to better suit changing environmental conditions, and in some cases, switch completely between different algal clades or subclades. These mechanisms may provide an added, although not infinite, degree of flexibility and environmental tolerance to the association, and hence a small, if rapidly closing, window of opportunity to address climate change.

It has also been suggested that corals may be able to adapt to climate change by gradually evolving greater tolerance to higher oxygen levels in their tissues and hence to higher temperatures. In general, however, such adaptation is very slow and unlikely to be able to keep up with the current rates of climatic change.

Other threats
Of the 704 species of corals that were assessed in the IUCN Red List Assessment (2008), 33 percent are listed as threatened. Declines in their abundance are associated with bleaching and diseases driven by elevated sea surface temperatures, with extinction risk further exacerbated by local-scale anthropogenic disturbances. The proportion of corals threatened with extinction has increased dramatically in recent decades and exceeds that of most terrestrial groups.

Direct human impacts such as coastal developments can completely remove an entire reef, altering the flow dynamics and causing changes to nearby ecosystems. Dynamite fishing, vessel ground and anchoring, and tourism can also cause damage and scouring of corals. Corals are also threatened indirectly by urban and agricultural runoff, and deforestation, which reduce water quality and increase sediment loads. This degrades habitat quality and exposes corals to further stress. Collection and removal of herbivorous fishes also result in corals becoming overgrown by macroalgae, preventing resettlement of new corals in damaged reefs.

“Both staghorn corals and coral reefs as a whole are canaries in the coal mine for human impacts from the local your local coastline, to the global scale of climate change. They serve up a lesson for what will happen to other less sensitive species and ecosystems. We must have consensus to reduce climate change to minimal levels to have a chance of having healthy coral reef ecosystems as long as we are on the planet.”
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The Coral Reef Crisis

• Temperature-induced mass coral bleaching is causing widespread mortality on the Great Barrier Reef and many other reefs of the world which started when atmospheric CO₂ exceeded 320 ppm.

• At today’s level of 387 ppm CO₂, reefs are seriously declining and time-lagged effects will result in their continued demise with parallel impacts on other marine and coastal ecosystems.

• If CO₂ levels are allowed to reach 450 ppm (due to occur by 2030–2040 at the current rates of increase), reefs will be in rapid and terminal decline world-wide from multiple synergies arising from mass bleaching, ocean acidification, and other environmental impacts.

The full statement can be accessed at: http://www.coralreefresearch.org/misc/Workshop%20statement%20and%20scientific%20justification.pdf

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