SEEING FEAR FROM SPACE

The beauty of the Great Barrier Reef from the air is in part due to seaweed patterns caused by where algae-eating fish and urchins feel safest from predators. *Photo: Sharon Wormleaton*

Marine biologist **Elizabeth Madin** investigates the meaning of grazing halos on coral reefs.

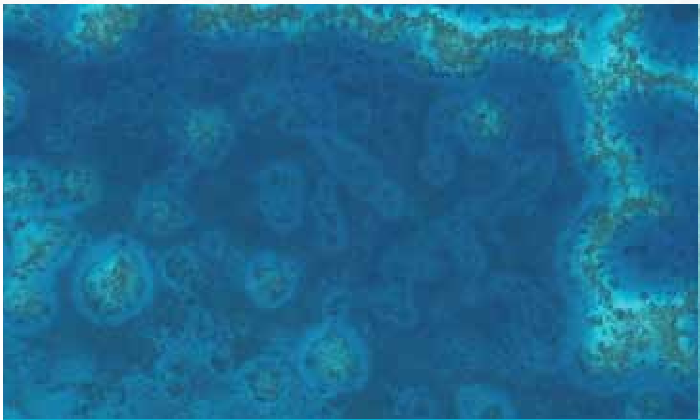
One hallmark of an excellent abstract painting is that it compels attention. The more you stare, the more it yields. Satellite photos of coral reefs can be like that. Artistry and biology combined, they are not only mesmerisingly beautiful but have much to reveal about reef life.

You can see this for yourself. On Google Earth (or 'satellite view' on Google Maps), take a look at Heron Island on the Great Barrier Reef and zoom in on the lagoon. As the view is magnified, the dark smudges are revealed as reefs surrounded by seaweed. As a marine biologist, I have spent a lot of time studying such photos, and I often wondered about the halo – the clear ring – around each reef. Why does the seaweed not grow right to the edge of the reef? Presumably, as reported for reefs elsewhere and in other marine systems, it was being grazed by fish or urchins.

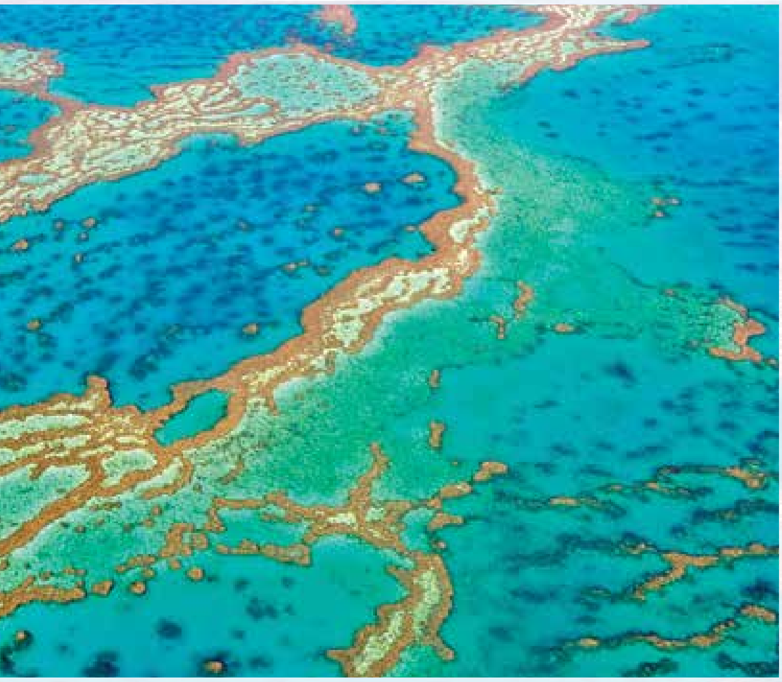
A few years ago, I decided to get to the bottom of this pattern by conducting a grazing survey around reefs in the Heron Island lagoon. My colleague Joshua Madin and I scanned satellite photos for grazing halos, keyed their coordinates into GPS units, and then waded through waist- to chest-deep water, towing gear and dodging stingrays, to reach them. Around the reef patches, we saw precisely the pattern we expected from the photos, but were amazed at how marked it was – swimming away from a reef was like flying over a desert that abruptly turns into a miniature forest.

The main vegetation visible from space is a filamentous algae (primarily a H*incksia* species) that attaches to the sand and grows up to about 9 centimetres high. Measuring the height of this algal canopy every 3 metres in lines radiating out from the reef edges, we found bare sand out to about 6–9 metres – after which point the algae suddenly became obvious. Its density and height increased dramatically with distance from the reef edges.

We confirmed it was being grazed by attaching 5.5 centimetre lengths of the algae to high-tech 'grazing assay units' – otherwise known as clothes pegs attached to lead weights – every 3 metres out from the reef edges. After three days, they had been heavily grazed up to about 6 metres from the reef's edge, but hardly at all beyond this point. Far from the reef, the algae was ungrazed and lush.



The pale rings or contours around each reef patch (top, near Heron Island) represents the distance from reef shelters to which algae-eating fish and urchins dare venture to graze on seaweed. For most species here, this distance is 6 to 9 metres. The contrasting lack of grazing halos around Panggang Island in Indonesia (bottom) suggests that heavy fishing has wiped out most predators (or herbivores or both). There is power in being able to see so clearly the effect of predators. These surveys showed the potential value of Google Earth for monitoring grazing patterns resulting from predator loss or recovery over space and, potentially, also time. Using satellite imagery may allow monitoring of aspects of coral reef health at very low cost and over thousands of kilometres at once. This will be particularly valuable at the world's most remote and inaccessible reefs. *Photos: DigitalGlobe*



Surveying grazing patterns in the Heron Island lagoon proved to be arduous. Each day we walked out from Heron Island (visible in the background), towing our gear in a plastic box, and tapping a stick to make sure we didn't step on any stingrays. *Photo: Joshua Madin*

One of the many fish predators on the Great Barrier Reef that influences seaweed growth is the coral trout. *Photo: Andy Thirlwell*

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The seaweed edge shows how far plant-eating fish or urchins are prepared to venture from the safety of their reef shelters to graze. Their fear of coral trout, trevally, sharks and other predators are shaping vegetation patterns on a scale clearly visible from space.

On land, vegetation patterns resulting from herbivores' fear of predators are called 'landscapes of fear'. Our Heron Island study showed similar processes shape what we call 'seascapes of fear'. Since then we have seen grazing haloes around reefs in several other regions around the world, including the Red Sea, the Caribbean, the Indo-Pacific, and the Indian Ocean.

The Heron Island reefs have predators aplenty, for they have experienced only limited fishing pressure in recent years. About half of the island's reef area is within a no-take marine reserve, and the other half is within a zone that allows limited fishing (such as spearfishing on snorkel only and fishing with a single hook and line).

If predators were scarce or absent, there would be little for grazers to fear, and they would be able to forage further from shelter with impunity. We would expect, and are now confirming with a larger Great Barrier Reef study, that the halos become less obvious as predators are lost. You can see this on heavily fished reefs as well as those in which fewer predators naturally occur. Check it out for yourself on Google Earth by comparing the reefs in the Heron Island lagoon with those around Panggang Island in Indonesia's Thousand Islands (Kepulauan Seribu), which are heavily fished and lack apparent grazing halos. This is not an image I would want hanging on my walls, for it appears to have lost both ecological integrity and beauty. ■

READING: Madin EMP, Madin JS, Booth DJ. 2011. Landscape of fear visible from space. *Scientific Reports* 1(14):1–4

DR. ELIZABETH MADIN is an Australian Research Council DECRA Fellow at Macquarie University investigating how human impacts on animal behaviour can lead to cascading effects through food webs. Growing from her doctoral work on the behavioural ecology of coral reefs, her current focus is understanding how predator-prey interactions can scale up to generate large-scale footprints on coral reef landscapes. She is leading a project to assess whether this concept can be developed into a conservation tool for assessing marine reserve effectiveness.