

REEF EDGE

Sponge necrosis in the U.S. Virgin Islands

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Sponges on tropical reefs have long been recognized as critical components of the ecosystem (Reiswig 1973) because they enhance seawater quality through filtration, transfer dissolved organic carbon to higher trophic levels, immobilize rubble, and increase benthic rugosity (Diaz and Rützler 2001; Wulff 2016). However, challenges in identifying and quantifying sponges have led to them being overlooked in many coral reef monitoring programs (Wulff 2001). Scarce historical records of sponge abundance have made it difficult to evaluate long-term population dynamics of sponges on present day reefs (Webster 2007; Edmunds et al. 2020), particularly since dead sponges leave little evidence of their previous existence.

Disease is a leading cause of sponge mortality, and reports of necrotic sponges have become common in the Mediterranean, on the Great Barrier Reef, and throughout the Caribbean (Luter and Webster 2017). While the etiology of most sponge diseases remains poorly understood, perturbed environmental conditions (e.g., rising temperature and high nutrient concentrations) are thought to disrupt sponge-associated microbial communities (Pita et al. 2018). Common signs of disease in sponges are lesions, the rapid “wasting away” of whole organisms, and high rates of infection (Luter and Webster 2017).

The Caribbean sponge fauna is diverse (Diaz and Rützler 2001) and consists of many conspicuous species that produce dense populations on shallow reefs. These include the giant barrel sponges

(*Xestospongia muta*), vase sponges (e.g., *Callyspongia plicifera*), rope sponges (e.g., *Aplysina insularis*), the bell sponges (*Ircinia campana*), the loggerhead sponges (*Spheciospongia vesparium*), and the black ball sponges (*Ircinia strobilina*). Thirty years ago, on the shallow reefs (7–9 m depth) of St. John, U.S. Virgin Islands, the mean density of *I. strobilina* was 0.47 ± 0.14 sponges m^{-2} ($\pm$ SE, $n = 6$ sites), but between 1992 and July 2017 the mean density of this species declined by 53% (Edmunds et al. 2020). By November 2017, two months after two hurricanes impacted the island, the density of *I. strobilina* on the same reefs had declined by a further 74% (relative to July 2017) (Edmunds et al. 2020). Despite these losses, a simple approximation based on sponge density in November 2017 at reef sites (at 7–9 m depth) between White Point and Cabritte Horn, suggested there were ~ 26,400 *I. strobilina* on the shallow reefs extending between these points.

In January 2021 we encountered a high number of necrotic *Ircinia strobilina* (Fig. 1) while conducting scleractinian and octocoral surveys at 13 different sites along the north and south shores of St. John and St. Thomas, US Virgin Islands (as in Edmunds et al., 2016). These surveys were conducted at Cocoloba Cay, Booby Rock, Leduck Island, Haulover Bay, Leinster Bay, Whistling Cay, and six sites between White Point and Cabritte Horn in St. John, and at Magens Bay, Inner Brass Cay, Botany Bay,



Figure 1. Necrotic *Ircinia strobilina* sponge (~ 30 cm in diameter) on a shallow reef (9 m depth) off St. Thomas, US Virgin Islands, in January 2021. Extensive necrosis reveals spongin fibres within the mesohyl (the middle layer of the sponge composing the majority of the biomass).

Fortuna Bay, Flat Cay, and Cow and Calf rocks in St. Thomas. At the six sites off St. Thomas, and three sites off St. John, individual *I. strobilina* were qualitatively inspected for necrosis. At Leduck Island, Booby Rock, Cocoloba Cay, East Tektite, and Little Lameshur on St. John, the number of visually healthy and necrotic *I. strobilina* were quantified in 30×2 m band transects. Additional surveys were completed on the Tektite reef between White Point and Cabritte Horn to assess the effects of depth (5, 7, and 8-m depths) on the abundance of necrotic sponges. When the surveys were completed, seawater temperature was $\sim 26.7^{\circ}\text{C}$, which is close to the mean winter low temperature of 26.0°C that occurs in late February and early March (Edmunds 2021).

Necrotic *Ircinia strobilina* were found at all sites visited around St. Thomas and St. John. Affected individuals had lost portions of their biomass to create lacunae in which spongin fibres were visible (Fig. 2). The size of the lesions was variable and consumed ~ 5 – 100 % of the volume of individual sponges, often leaving only a small patch of living biomass. In severe cases, dead sponges were detached from the benthos leaving a mobile ball of spongin fibres. In partially affected sponges, necroses deeply penetrated each sponge, sometimes creating a void in which juvenile wrasses were seen (e.g., *Thalassoma bifasciatum*), with irregular margins separating the necrosis from apparently healthy sponge biomass. Most of the diseased sponges were 10–20 cm in diameter, and therefore inferred to be between 14 and 28 years old assuming *I. strobilina* grows at 0.7 cm y^{-1} (Hoppe 1988). At the four sites around St. John where quantitative surveys ($n = 4$ band transects) were completed, the mean ($\pm$ SE) density of *I. strobilina* was 0.11 ± 0.06 sponges m^{-2} , of which $74 \pm 11\%$ were necrotic. Surveys of *I. strobilina* on the Tektite reef

suggested the number of necrotic sponges did not vary with depth (4–9 m) ($r = 0.01$, $P = 0.88$).

As the density of *Ircinia strobilina* on shallow reefs along the south shore of St. John overall has declined since 1992 (Edmunds et al. 2020), the high prevalence of necrosis (i.e., $\geq 50\%$ of sponges by site) suggests the population size may decline further. Necrosis with visually similar signs reported here for *I. strobilina* has also been reported on the shallow reefs of Belize (in 2011, Wulff 2011), Curaçao, Panama (in the mid-to-late 1980s, Wulff, 2006), and Puerto Rico (in 2021 J. Wulff pers. comm. to EA Lenz). Without knowing the causes of these cases of sponge necrosis, or the etiology of the condition if it is a disease, it is impossible to project sponge population and community dynamics into the future, especially as current and future environmental conditions rapidly change. Major outbreaks of sponge necrosis have the potential to dramatically alter the structure and function of coral reef communities. There is a risk, however, that these effects will remain under-reported unless coral reef monitoring projects report holistic changes in benthic communities and in abundance of sponges with species resolution.

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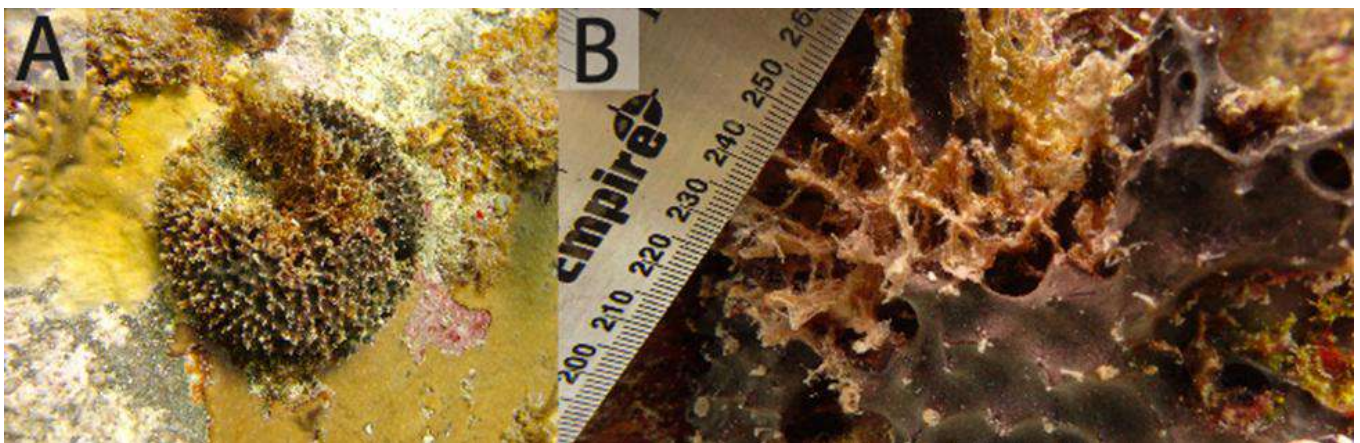


Figure 2. Photographs of necrotic *Ircinia strobilina* at 9 m depth off St. John in January 2021. A) A sponge (~ 20 cm diameter) with a conspicuous lesion extending through the height of the organism to expose the substratum beneath, and B) close-up of a necrotic area showing exposed spongin fibres adjacent to intact sponge biomass.

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Endolithic Tissue Aids Rapid Recovery from Wounds in *Porites cylindrica*: the 'Phoenix Effect' in Action

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Scleractinian corals are frequently fragmented via wave action and animal interactions. For many coral species, including members of the *Acropora*, *Pocillopora* and *Goniopora* genera, these fragments form a natural part of their reproductive strategy. For a handful of massive or sub-massive species, these fragments can remain free-living growing in an almost spheroidal morphology, and have been termed coralliths. However, fragmentation causes wounds, creating three major challenges for the newly fragmented coral. Firstly, energy is diverted away from growth and reproduction in order to heal the wound (Burmester et al., 2017). Secondly, the fracture generates a point of entry for competing or damaging organisms, such as pathogens (Traylor-Knowles, 2016). Finally, the smaller fragment has a reduced available surface area for photosynthesis. The rate at which the coral can recover from the wounds caused by fragmentation will contribute to the fragment's survival.

Three major hypotheses describe wound recovery patterns in corals: localised regeneration, colony integration and the 'Phoenix effect'. The phoenix effect is a phenomenon whereby seemingly dead coral has the ability to regenerate from remnant tissue existing either on the surface or, in more notable cases, deeper within the coral's skeleton (Krupp, 1992, Roff et al., 2014). Some small polyp corals with deep tissue matrices, like *Porites* spp. are known to have sometimes recovered from various stressors, including physical damage, bleaching and grazing, after appearing completely dead. The phoenix effect has been credited with permitting recovery of *Porites* spp. colonies after non-fatal mass bleaching events (Roff et al., 2014), and could aid in their recovery from other forms of stress, such as predation or physical damage following rolling of coralliths by wave action.

To date, the phoenix effect has been observed in very few species, mainly from the genera *Fungia*, *Astrangia* and *Porites*. Using microscopy, we present photographic evidence of *Porites cylindrica* exhibiting endolithic tissue that, post-fragmentation, aids in the healing of the wound along the fracture point and grows out towards this newly exposed surface, allowing for re-sheeting of the newly exposed skeleton.

From corals that were housed in aquaria at the University of Edinburgh, we cut five coral fragments from three larger colonies of *Porites cylindrica*, and, for comparison, five fragments from four colonies of *Platygyra* sp., to a size of approximately 3 cm at their widest point. Corals were then photographed at the same point along