Crown-of-thorns starfish

"We can't stop the storms, but maybe we can stop the starfish"

Storms, spikes in sea temperature and crown-of-thorns starfish outbreaks are the major direct contributors to the decline in coral cover.

The Great Barrier Reef lost half its coral cover between 1985 and 2012. The known causes of this decline in coral cover since 1985 were storm damage (48%), crown-of-thorns starfish (42%), and bleaching (10%) caused by extended periods of unusually warm summer sea temperature.

We can't stop the storms, and ocean warming—the primary cause of coral bleaching—is one of the critical impacts of global climate change. We can, however, act to reduce the impact of crown-of-thorns starfish.

If we can, then the Reef will have more opportunity to adapt to the challenges of rising sea temperatures and ocean acidification,

Studies by AIMS, the Australian Institute of Marine Science, show that in the absence of the starfish, coral cover would increase at 0.89% per year so, even with losses due to cyclones and bleaching, there would be slow recovery.

The impact of crown-of-thorns begs the question: what causes these starfish outbreaks? Water quality is the number one suspect but there is still much we need to learn about crown-of-thorns and how to control them. AIMS researchers are working with colleagues in Australia and around the world to learn more about the causes of outbreaks and to develop better ways of controlling the starfish.

"Without crown-of-thorns starfish outbreaks over the past 30 years, coral cover on the Great Barrier Reef would have slowly recovered from damage caused by storms and bleaching."

Meet a crown-of-thorns starfish

She's got up to 21 arms, more than 600 ovaries, and hundreds of 4 cm-long toxin-tipped thorns. She grows to 80 cm across, eats 10 square metres of coral a year and can produce up to 50 million eggs a year. An adult female crown-of-thorns is a formidable predator.

She belongs on the Reef. She's not an introduced pest. Crown-of-thorns starfish are natural predators of the coral on the Great Barrier Reef and on coral reefs from the Red Sea to the west coast of the Americas.

Her larvae spend between 14-30 days as plankton before they settle and change into five-armed juvenile starfish. Over the next six months to a year they change again into the adult form and begin consuming corals. Within two years they can be sexually mature.

Adult starfish have few natural predators and little is known about the impact of these predators on outbreaks. Predators of adult crown-of-thorns starfish include the giant triton snail, the humphead Maori wrasse, starry pufferfish and titan trigger fish. Predators of juvenile starfish include shrimp, crabs and polychaete worms. They may also be targets for small generalist-feeding reef fish. There are fewer starfish outbreaks on reefs in marine protected areas, perhaps because more of the juveniles get eaten.

A new outbreak - more than five million adult crown-of-thorns between Cooktown and Cairns

Periodically the population of starfish booms and destroys large areas of reef. There have been three outbreaks since the 1960s, each starting around Cairns and taking about a decade to spread south along the Reef. They can kill up to 90 per cent of the corals onaffected reefs.

A new outbreak is underway in 2015. There are currently more than five million crown-of-thorns starfish on the reefs between Cooktown and Cairns, and over the coming years similar numbers will appear further south as the outbreak spreads south along the Reef. Five million adult crown-of-thorns starfish can eat about fifty square kilometres of coral every year.

This animation generated by e-Atlas illustrates the pattern of outbreaks over the past thirty years:

http://eatlas.org.au/content/crown-thorns-starfish-outbreaks-animation

Crown-of-thorns starfish

Water quality is the number one suspect for causing crown-of thorns starfish outbreaks

Crown-of-thorns starfish have lived on the Great Barrier Reef for at least 8,000 years and outbreaks are likely to have occurred many times. However, the overall rate of disturbances has now shifted. The evidence suggests that climate change is not only exacerbating existing impacts like cyclones, but also may be introducing new threats to coral reefs including more severe storms and floods, coral bleaching, increased susceptibility to disease and reduced calcification rates. The combined effect of these disturbances means that reefs get less time to recover from a crown-of-thorns outbreak.

We don't know precisely what causes the periodic crown-of-thorns outbreaks but water quality is the number one suspect. The outbreak waves on the Reef since the 1960s all followed extreme floods of the Burdekin River and the rivers along the Wet Tropics coast.

The larvae feed on plankton which may also undergo a population boom when increased nutrients are available when, for example, storms floods sediment and nutrients into the ocean. Field data and population models suggest that river floods and regional differences in plankton availability are strongly related to patterns of starfish outbreaks on the Reef.

However, some outbreaks also occur on remote reefs, perhaps just because a large number of larvae are washed in by currents or because of natural sources of nutrients.

How are we controlling crown-of-thorns starfish today?

High profile individual reefs such as those used by the tourism industry have been protected by divers injecting starfish with poisons. New techniques and chemicals have been developed and applied that have improved this process almost ten-fold in the last two years.

About 500,000 starfish have been killed by injections by divers. However, we also need a more systemic approach for long-term protection of the whole of the Great Barrier Reef. Ideally this would involve identifying and controlling the conditions that lead to outbreaks, and developing effective means for early detection and control.

A new research strategy to understand and tackle crown-of-thorns

Tackling the crown-of-thorns problem on the Great Barrier Reef requires an approach different from the one that has clearly failed the Reef over the last 50 years. So AIMS has developed a new research strategy. To fully understand the crown-of-thorns outbreak phenomenon and to identify how best to intervene we need to consider:

(a) How an outbreak starts - the proximate drivers leading to the initiation of a primary outbreak – i.e. larval nutrition, survival, dispersal and recruitment,

(b) Demography and predator-prey relationship for juvenile and adult starfish in the outbreak region,

(c) Stock-recruitment relationships of the local outbreak populations,

(d) Larval connectivity to reefs downstream

(e) How these factors work across the large network of reefs downstream from an initial outbreak.

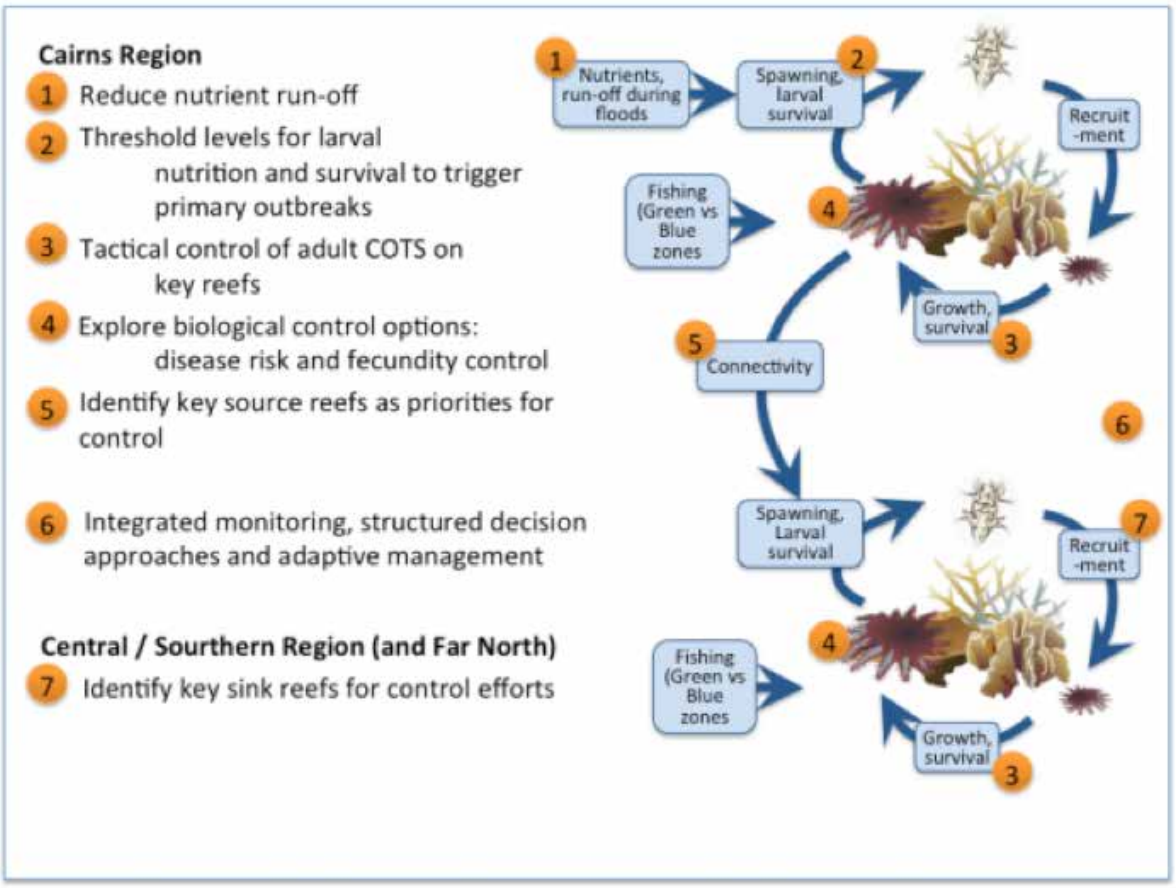
The key elements of the research strategy are:

What causes and drives outbreaks

- Improving long-term monitoring of starfish and their larvae so we have more detailed awareness of the development of outbreaks
- Developing ways to rapidly identify the presence of crown-of-thorns larvae
- Experiments in SeaSim to understand the factors that lead to more larvae surviving – is it simply more food?
- Studying how flood plumes contribute to outbreaks.

Better control

- Surveys, analysis and modelling to allow us to track outbreaks and determine and refine the effectiveness of manual control
- Developing ways to measure crown of thorns densities in water too deep for sustained diving
- Exploring the biology of crown of thorns and its genome; what it secretes into the ocean; and its behaviour, all with the aim of developing better attractants and repellents to help in control
- Biological control – exploring potential disease agents and predators.



Processes controlling crown-of-thorns populations and projects targeting stages in the life cycle of the starfish.

Crown-of-thorns research at SeaSim

AIMS' new research strategy into the crown-of-thorns starfish is underpinned by access to SeaSim, the national sea simulator. This set of smart aquaria opened in 2013. It gives our researchers the ability to imitate conditions in the ocean very closely and to see how these affect crown-of-thorns starfish and larvae in ways that have not been possible before.

A recent AIMS study in SeaSim showed that warmer sea surface temperatures, as well as high nutrients, are contributing to the survival rate of the starfish. A two-degree increase in sea temperature can increase the probability of survival of the starfish larvae by 240% if there are sufficient nutrients for crown-of-thorns larvae to feed on.

Working with Japanese researchers

Crown-of-thorns starfish are found on reefs throughout the Pacific and Indian Oceans. Researchers from the Okinawa Institute of Science and Technology are working with their colleagues at AIMS on various aspects of the starfish. They are working at every level from the underlying genetics of the starfish, the ecology and behaviour of its larval stages.

Further reading

About COTS http://www.aims.gov.au/tr/docs/research/biodiversity-ecology/threats/cots.html

Monitoring crown-of-thorns starfish on the Great Barrier Reef, http://data.aims.gov.au/waCOTSPage/cotspage.jsp

Crown-of-thorns starfish (COTS) outbreaks on the Great Barrier Reef [animation], http://eatlas.org.au/content/crown-thorns-starfish-outbreaks-animation

Crown-of-thorns starfish and the Great Barrier Reef, http://eatlas.org.au/gbr/cots-acanthaster

Crown-of-thorns starfish research strategy, July 2015, http://www.aims.gov.au/documents/30301/23464/AIMS+CoTS+research+strategy/0c23a1d9-56fa-4706-9948-2c0b2ea87e09

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Further references in the crown-of-thorns starfish research strategy; http://www.aims.gov.au/documents/30301/23464/AIMS+CoTS+research+strategy/0c23a1d9-56fa-4706-9948-2c0b2ea87e09