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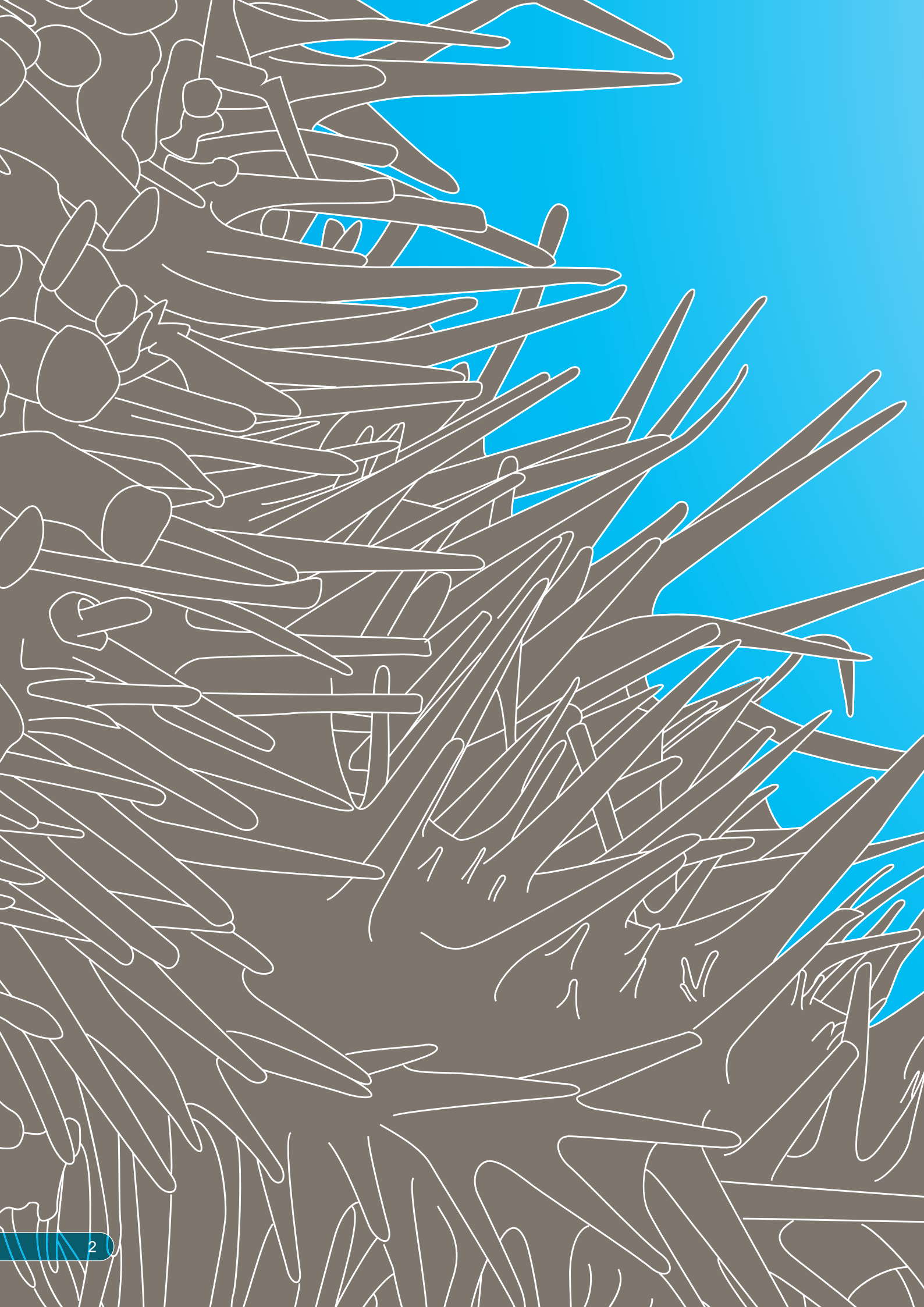
REPORT

2015

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THE STARFISH THAT EAT THE REEF

HOW TO SAVE THE GREAT BARRIER REEF BY STOPPING THE POLLUTION THAT
FUELS CROWN-OF-THORNS STARFISH OUTBREAKS



GOVERNMENTS HAVE COMMITTED TO ACHIEVE THE POLLUTION CUTS NEEDED TO STOP STARFISH OUTBREAKS BUT HAVEN'T COMMITTED THE FUNDING

In the last three decades we have lost half the Great Barrier Reef's coral cover – with coral-eating crown-of-thorns starfish responsible for over 40% of this loss. The current outbreak, which has been building for five years, will further damage the Reef's coral.

Crown-of-thorns starfish are a natural part of the marine ecosystem. However, nitrogen run-off from farms leads to algal blooms in Reef waters, which starfish larvae feed on, allowing them to survive in unnatural abundance and eat vast areas of coral.

The current outbreak, if it follows previous patterns, will likely become the biggest on record with starfish numbers potentially reaching 60 million.

We can stop this happening. Scientists estimate that the next crown-of-thorns starfish outbreak will happen in about a decade. If we want to stop this, the critical action to take now is to reduce farm nitrogen pollution running off onto the Reef.

Governments have committed to achieve the pollution cuts needed to stop starfish outbreaks by 2025. However, they have not yet established the programs nor the investment needed to deliver on this commitment. Governments must step up to strengthen laws and funding to ensure the Great Barrier Reef has the clean water it needs to restore its health.

WWF commissioned Dr Glen Holmes to summarise the state of knowledge of the impact of crown-of-thorns starfish on the Great Barrier Reef and the solutions that would reduce the frequency and impact of starfish outbreaks. We hope you enjoy reading this report.

Dr Gilly Llewellyn
Conservation Director
WWF-Australia

THE CROWN-OF-THORNS STARFISH

The crown-of-thorns starfish (*Acanthaster planci* or COTS) eats coral. It prefers fast growing hard corals such as plate and staghorn corals but when these aren't available it will eat all species. Large densities of COTS – sometimes in excess of 1,500 starfish per hectare – can remove virtually 100% of live hard coral from a reef.

Although COTS occur naturally on the Great Barrier Reef, their numbers sometimes reach plague proportions. When this happens they inflict extensive damage on coral, in a similar way to locusts devastating vegetation.

Researchers believe that outbreaks would naturally occur rarely, perhaps only once a century. Recently, however, the frequency of outbreaks has increased such that we are now seeing an outbreak every 14 to 17 years.

While outbreaks tend to occur a couple of years after large flood events, they are likely the result of a combination of factors, water quality being the most widely accepted. However, the consequence of a large outbreak is well understood – the decimation of the coral reefs in its path.

Action is required now to reduce the frequency of COTS outbreaks to natural levels and recent research has given us the tools to do so.

THE CONSEQUENCE
OF A LARGE
OUTBREAK IS WELL
UNDERSTOOD –
THE
DECIMATION
OF THE CORAL
REEFS IN ITS PATH



© WWF/James Morgan

Crown-of-thorns starfish eat coral by extruding their stomach out of their body and onto the coral, and slowly digesting it

THE CURRENT OUTBREAK

The current outbreak of crown-of-thorns starfish has now been underway for five years. In 2013, estimates based on survey data calculated that between three and ten million starfish were on reefs north of Cairns, compared to a fifth of that on reefs over an equivalent area further south.

If, as expected, this outbreak follows the previous pattern of feeding secondary outbreaks, these numbers are expected to increase six-fold over the next five years, potentially reaching 60 million.

Of more concern is the number of reefs that are experiencing an outbreak. About 20% of surveyed reefs had an outbreak over the last three years, which is double the number of the hugely destructive 1988 outbreak. This means that reefs of the central and southern GBR may well be reduced to coral cover levels well below an average of 10%. If this outbreak follows previous patterns it will likely be the biggest on record.

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A researcher investigating crown-of-thorns starfish amongst dead *Acropora* coral branches

DECLINE IN CORAL ON THE GREAT BARRIER REEF

In 2012 the Australian Institute of Marine Science (AIMS) published a report on the decline of the Great Barrier Reef over the 27 years that they had been monitoring the Reef. Focused on mid-shelf and offshore reefs, it showed that on average, the GBR experienced a major decline in live coral cover over that period, dropping from 28.0% to 13.8%. This represents a loss of over 50%

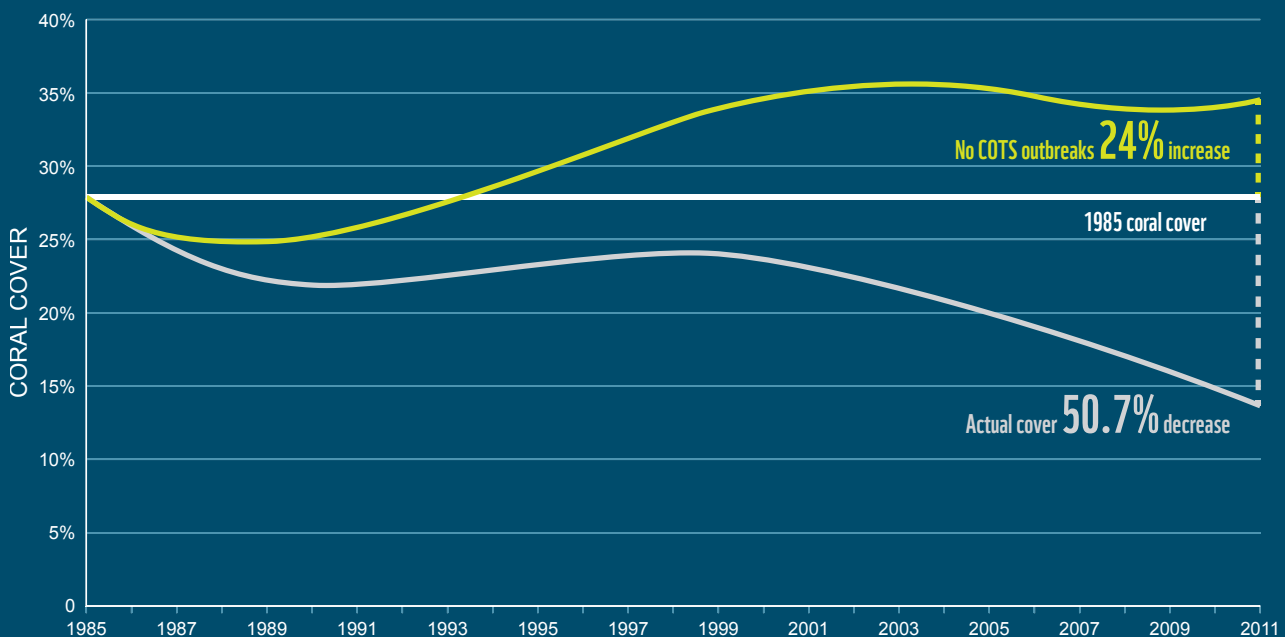
The dominant driver of this decline was attributed to intense tropical storms, with crown-of-thorns starfish a very close second, responsible for 42% of the coral loss. This loss of coral on the GBR is even more stark within specific regions. The northern section of the reef includes about 42% of all coral and has remained relatively stable, evening out the impact when the GBR is considered as a whole. In the central section of the GBR (from 15°S to 20.5°S) coral cover declined by 47%, dominated by damage from COTS. In the southern section, coral cover declined by a massive 78%, with just under half the damage a result of COTS. It has been calculated that, when considered together, the central and southern sections of the GBR have lost over 60,000 hectares of live coral cover, solely because of COTS.

Outbreaks on the GBR take years to play out and usually follow a pattern. Primary outbreaks tend to occur between Cairns and Lizard Island and then migrate south, feeding secondary outbreaks on well-connected reefs.

IN THE SOUTHERN
GREAT BARRIER
REEF CORAL COVER
DECLINED BY A
MASSIVE

78%

FIGURE 1 A MODELLED SCENARIO SHOWS THAT CORAL COVER WOULD HAVE INCREASED WITH NO COTS OUTBREAKS



Source: Unpublished data De'ath *et al.*

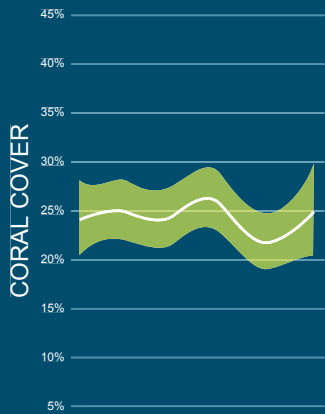
FIGURE 2 MOVEMENT AND IMPACT OF CROWN-OF-THORNS STARFISH OUTBREAKS

DOMINANT CAUSES

- COTS
- CYCLONES
- BLEACHING

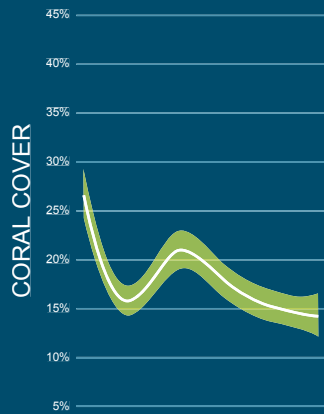
NORTHERN REGION

ECOSYSTEM STABLE



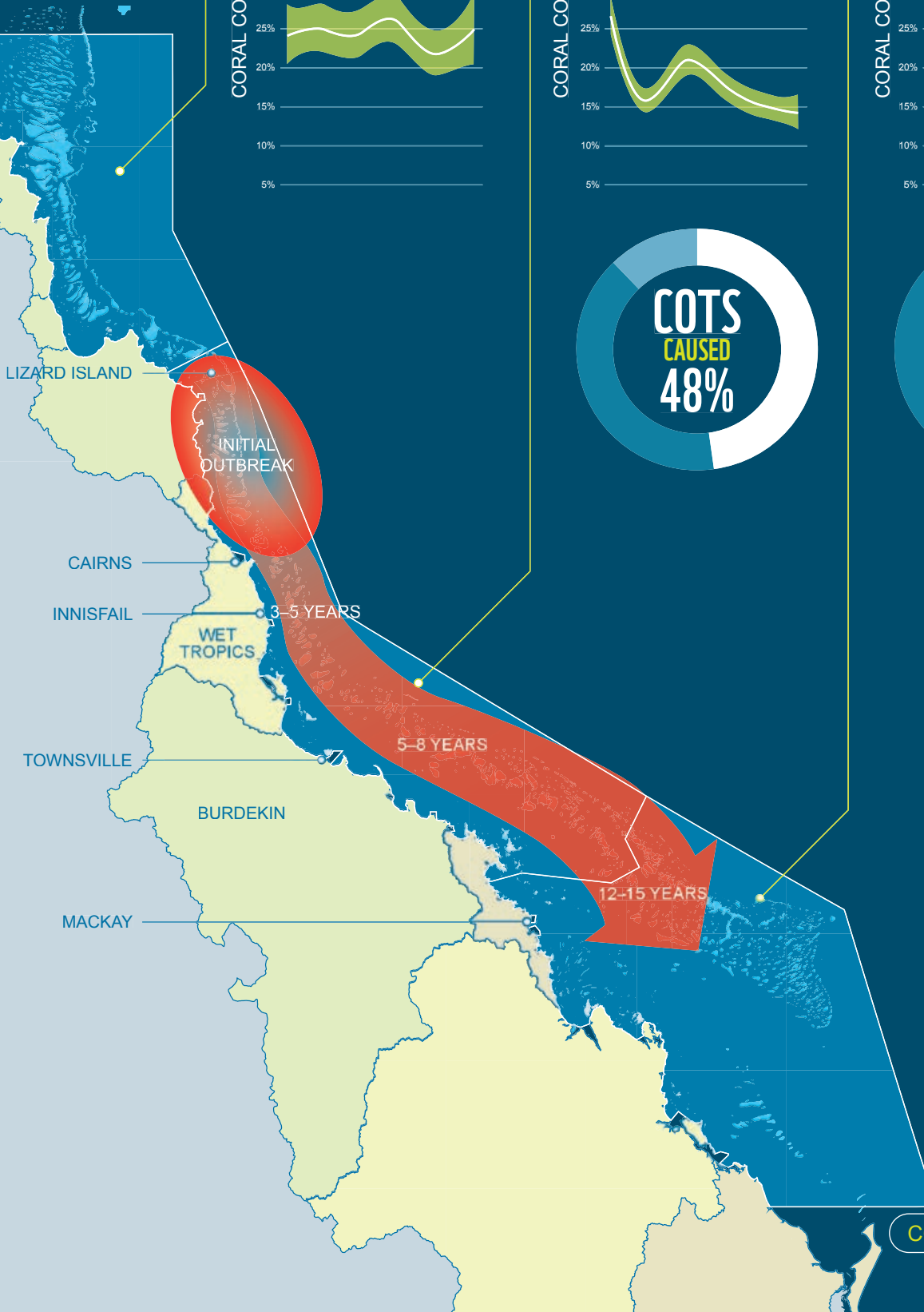
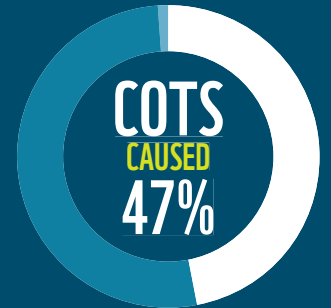
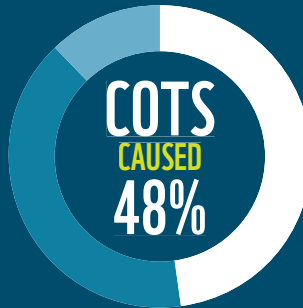
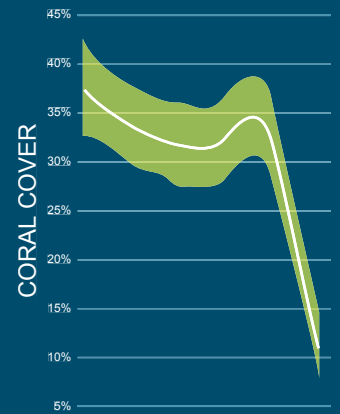
CENTRAL REGION

OVERALL DECLINE 47%



SOUTHERN REGION

OVERALL DECLINE 78%



CAUSES OF OUTBREAKS

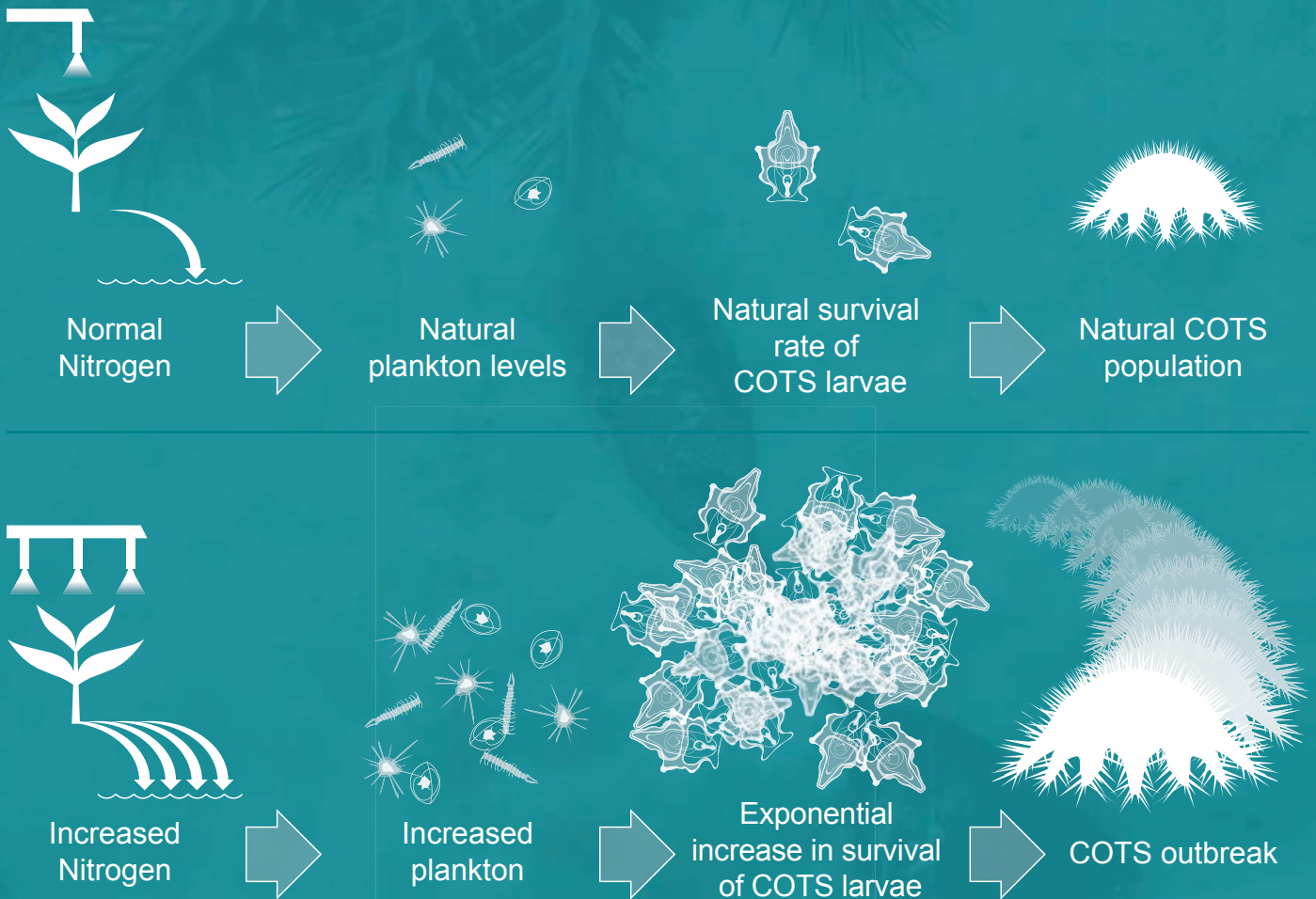
Large female starfish are able to produce up to 65 million eggs and COTS are much more efficient than similar animals at fertilising their eggs. These millions of larvae spend about the next 10–20 days in the water column feeding on plankton.

It is at this stage that the most widely accepted driver of outbreaks occurs. Plankton feeds on nutrients, including dissolved inorganic nitrogen (DIN). When levels of these nutrients increase – largely from agricultural fertiliser run-off and erosion – the abundance of plankton increases. Research has shown that an increase in plankton results in many more larvae surviving. In fact, for every doubling of plankton there is an up to eight-fold increase in COTS larval survival. The link between nutrients and survivorship has been confirmed by multiple independent studies.

COTS larvae are also less palatable to predators than other food (including coral larvae), resulting in higher than natural numbers becoming juveniles and subsequently, coral-eating starfish.

EACH DOUBLING IN
FOOD LEADS TO AN
8-FOLD
INCREASE IN
SURVIVAL OF
COTS LARVAE

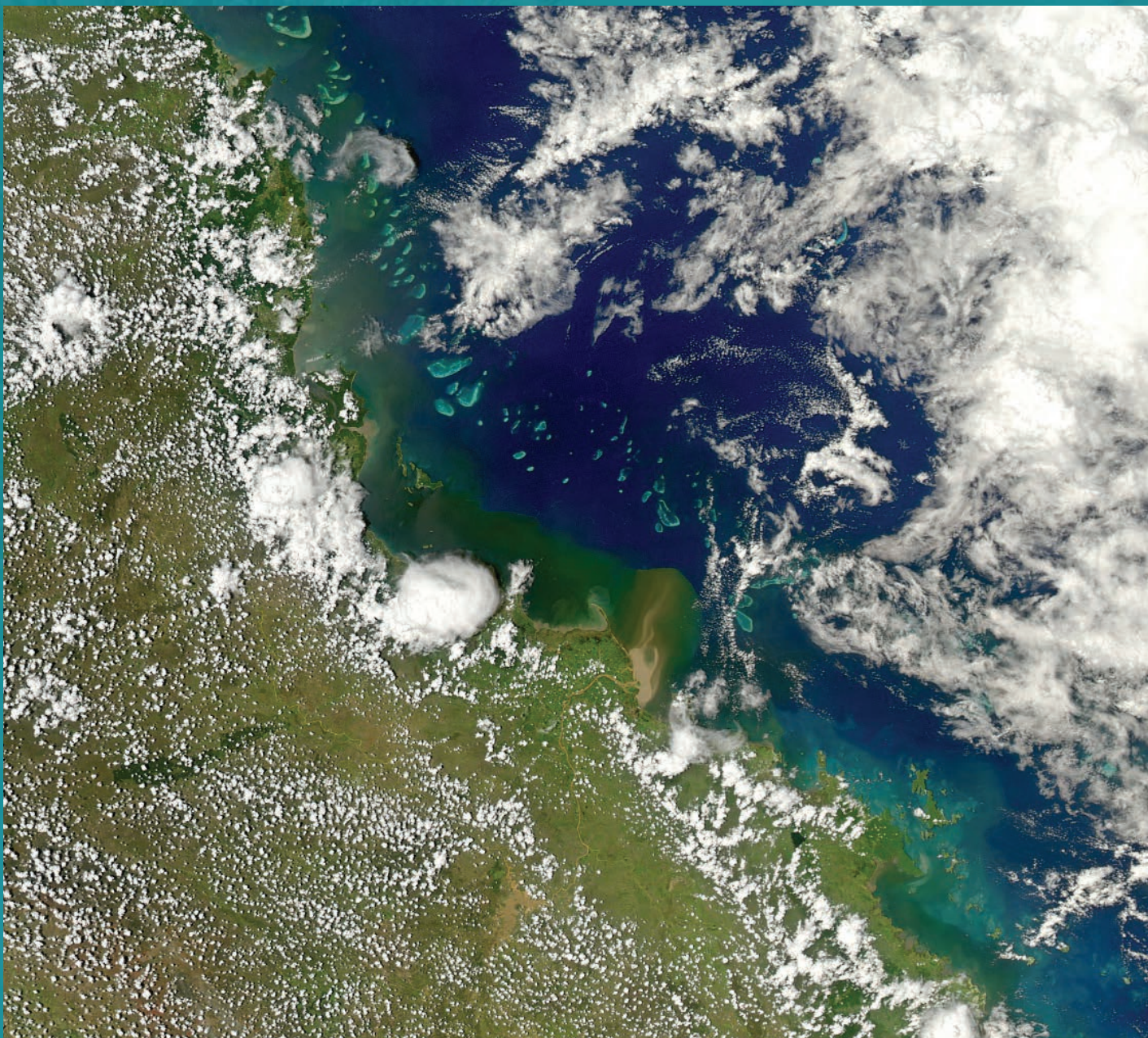
FIGURE 3 IMPACT OF NITROGEN RUN-OFF ON COTS SURVIVAL RATES



Other potential contributors to outbreaks include the connectivity between reefs, fishing pressures removing predators and increased temperature from climate change (acting together with nutrient enrichment). There is also a link to the timing of large floods which push excess nutrients into the Great Barrier Reef lagoon. Recently released research has demonstrated that a combination of nutrient-rich flood waters and amenable currents act in concert to produce ideal conditions for an outbreak.

It is also possible that outbreaks are now continually on the brink of occurring due to the chronic loading of nutrients and that these other factors can then come together to cause an explosion of COTS on the Reef.

Image: NASA



Sediment loaded with nutrient run-off flows north from the Burdekin River towards the outbreak initiation zone in 2011

DIRECT CONTROL

Controlling crown-of-thorns starfish directly can help protect small areas.

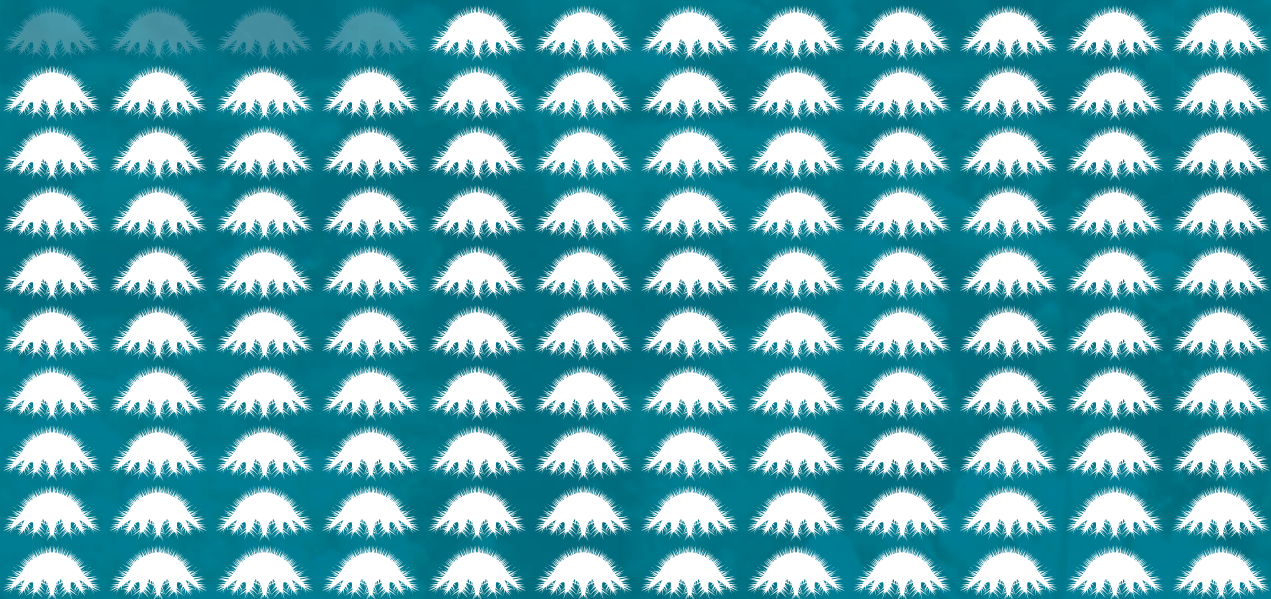
Several direct control options have been tested. Cutting up starfish has proven not to be effective due to their rejuvenating ability. Removing them from the water is too labour intensive. Injection with a variety of toxins has been refined so that a single 10ml shot is effective, but even this is time and labour intensive.

All of these options involve eliminating COTS one-by-one. Given the scale of an outbreak, their successes have been localised and the effort required to protect even moderate reef areas is beyond the most well-resourced programs. The largest eradication program to date was in Japan where approximately 13 million were removed over 13 years, yet COTS killed more than 90% of corals over vast areas of fringing reef.

The current direct control program on the GBR has removed more than 400,000 starfish since 2012. Even on heavily targeted reefs it has struggled to contain an active outbreak. For example, over three important tourist reefs off Cairns, around 13,000 starfish were removed between 2012 and 2014, yet surveys in late 2014 estimated that there were still more than 70,000 starfish across the three reefs.

While direct control will remain an important means to protect high value reefs, such as those in key tourism areas, it does not provide a means to protect the Great Barrier Reef.

FIGURE 4 PROPORTION OF COTS REMOVED BY DIRECT CONTROL ON THE GBR SINCE 2012



Direct control can protect key areas but not the whole reef. Control methods on the GBR since 2012 have removed 400,000 of the up to 12 million COTS.

**REDUCING THE
NITROGEN
FLOWING INTO
THE REEF CAN
SIGNIFICANTLY
REDUCE
THE RISK
OF FUTURE
OUTBREAKS**

FARM POLLUTION REDUCTION TO ARREST OUTBREAKS

Indirect control actions are likely to be far more effective at reducing outbreaks of crown-of-thorns starfish.

There are some management actions that have the potential for widespread positive outcomes. The most effective of these is the limiting of nutrients that flow into the Reef, largely from farm fertiliser run-off, and feed plankton.

Research suggests that reducing nitrogen inputs by up to 80% from catchments near the COTS initiation area will significantly reduce the risk of future outbreaks. Improving water quality in this way will also enhance the resilience of coral systems to another dominant threat, climate change – providing a 2°C to 2.5°C buffering to thermal bleaching.

Other indirect management actions that can be adopted include a reduction of fishing pressure and increased protection areas to bolster natural predators such as the titan triggerfish and the triton trumpet. This will have the additional benefit of increasing ecosystem resilience although the effect on COTS populations may be small.

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Crown-of-thorns starfish outbreaks normally spread south along inter-connected reefs

Our best chance of returning outbreaks to their natural cycle is to reduce the nutrients flowing onto the Reef from farms. To do this we need to reduce the nitrogen surplus.

The nitrogen surplus is the amount of nitrogen fertiliser applied to crops that isn't taken up by those crops, but instead released into the water and the air. Currently, around 50,000 tonnes of fertiliser is applied to sugar cane farms in Queensland, of which around 30,000 tonnes become surplus. Much of this surplus eventually finds its way to the ocean and the Reef.

It's estimated that up to 80% of the surplus reactive nitrogen that flows onto the Reef in key northern catchments needs to be removed in order to return COTS to their natural cycles and to boost ecosystem resilience. However, reducing the surplus to that extent does not mean simply applying less fertiliser, nor having a smaller crop. In fact, recent developments have shown that innovative practice can mean an increased crop with less fertiliser and, importantly, much less nitrogen surplus.

Traditional approaches to applying fertiliser have involved spreading it evenly over both high-yield and low-yield paddocks, or even adding more to the low-yield areas in an attempt to improve them. Research has shown us that most of this excess isn't taken up by crops, but simply adds to the nitrogen surplus. Critically for farmers, it also results in degraded soils and reduced yield.

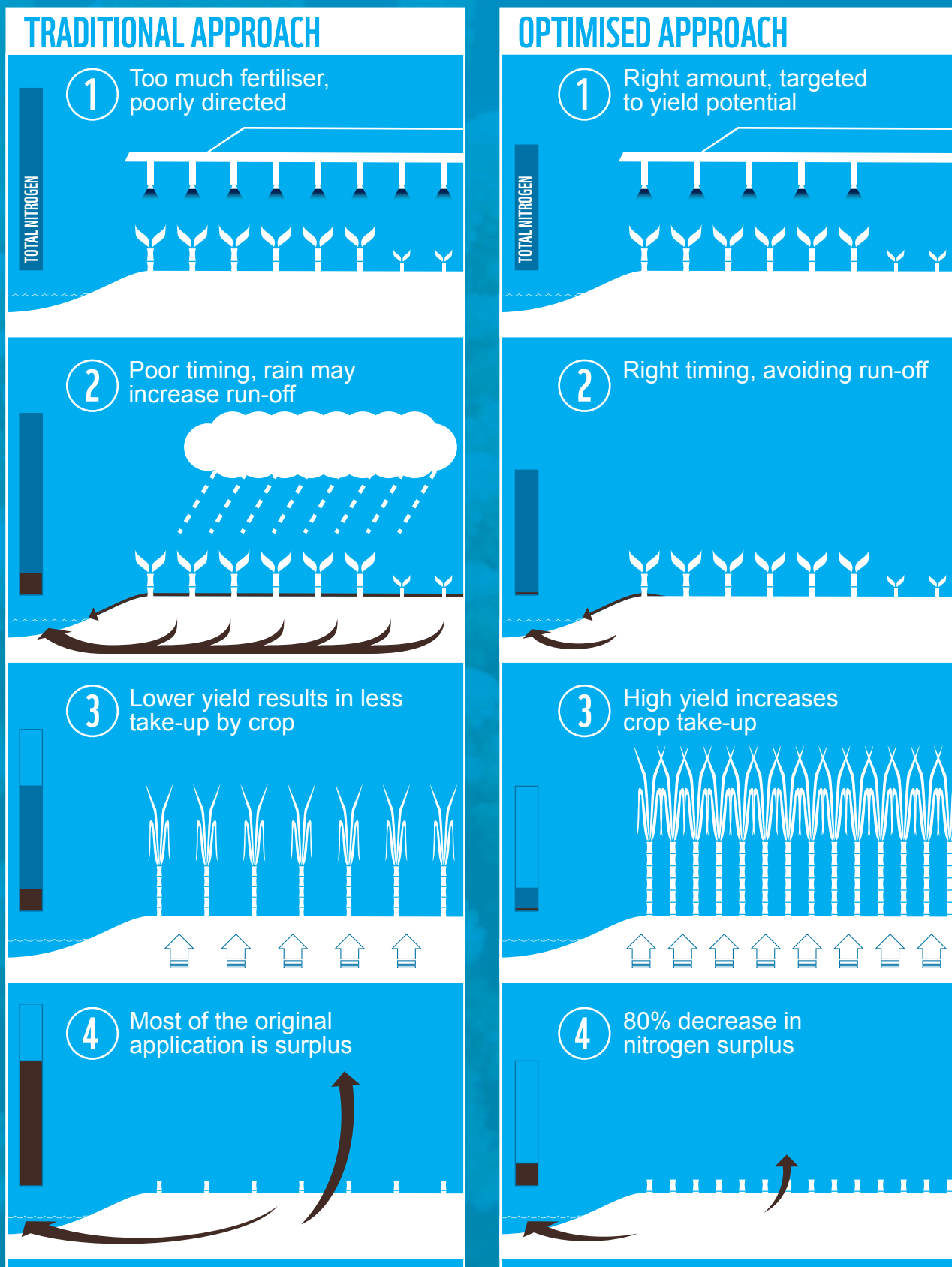
In long-term studies where low-yield areas have been given little or no fertiliser, or else been used in alternative ways, yield has increased and nitrogen surplus greatly reduced.

Further, fertiliser is typically applied early in the growing season, when crops are too small to take up much of it. If heavy rains come, this fertiliser can be washed into the river system and onto the Reef before the crops have even had a chance at take-up.

Reducing the nitrogen surplus benefits farmers as well as rivers and the Reef, in the form of better soils, higher yields and lower costs.

**REACTIVE
NITROGEN
FLOWING TO THE
REEF NEEDS TO BE
REDUCED BY
UP TO 80%
IN ORDER TO
RETURN COTS TO
THEIR NATURAL
CYCLES**

FIGURE 5 AN 80% DECREASE IN NITROGEN LOAD DOES NOT NEED AN 80% DECREASE IN FERTILISER APPLIED



WWF: ACTIONS TO STOP CROWN-OF-THORNS STARFISH EATING THE REEF

Right now the Great Barrier Reef is being eaten alive by a crown-of-thorns starfish outbreak. However, on-ground actions can give the Reef the clean water it needs to rebuild its coral gardens.

Implementing innovative agricultural practices which reduce fertiliser run-off will result in significant nitrogen reductions in Reef waters – removing the food source for COTS larvae and stopping outbreaks before they start.

In 2015 the World Heritage Committee welcomed the Australian and Queensland governments' Reef 2050 Plan, and welcomed “in particular the establishment of an 80% reduction in pollution run-off in the property by 2025”.

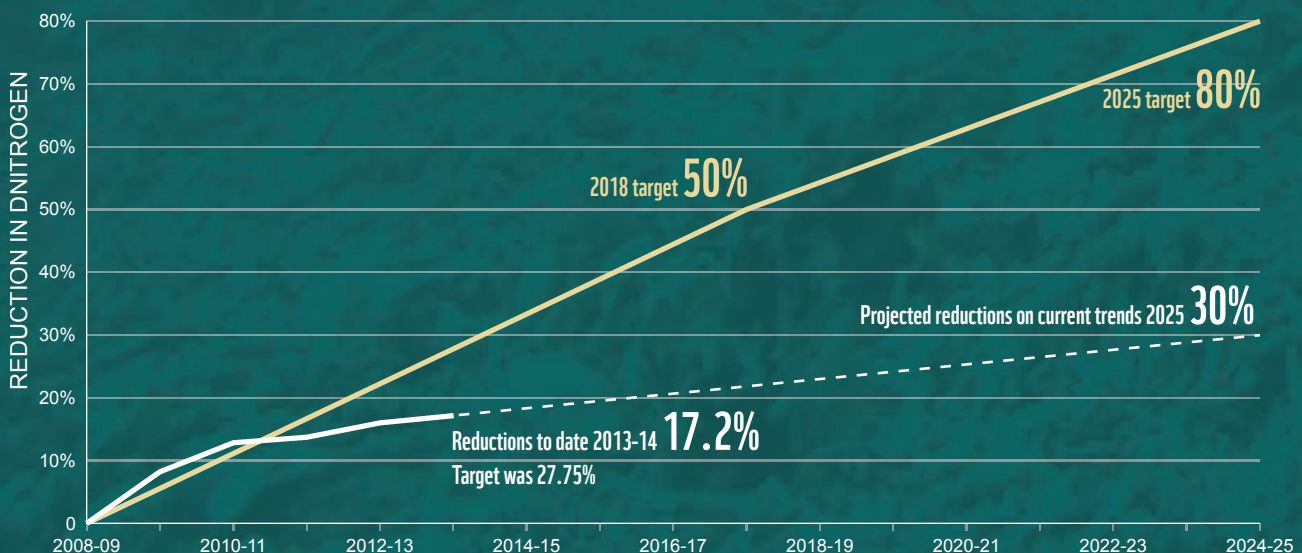
Current programs and investment are insufficient to achieve the promised pollution targets. The Reef Taskforce, established by the Queensland Government, has stated that achieving the new targets is “well beyond the funds currently allocated by the government” and that “transformational change is required to deliver substantial water quality improvement”.

To achieve the 2025 clean water targets WWF is calling on governments to take the following critical actions:

- Place a cap on pollution to ensure new development does not result in more dirty water flowing to the Reef.
- Support farmers to implement the latest practices which increase productivity and cut pollution.
- Enforce laws for businesses who continue to pollute the Reef.
- Invest to secure the farm practice and land use changes needed to deliver significant cuts to pollution.
- Co-invest with industry in innovation to deliver the next wave of profitable pollution cutting practices.

ACHIEVING THE TARGETS IS “WELL BEYOND THE FUNDS CURRENTLY ALLOCATED BY THE GOVERNMENT”

FIGURE 6 THE REEF WATER QUALITY PROTECTION PLAN SHOWS EFFORTS TO REDUCE THE LEVELS OF DISSOLVED INORGANIC NITROGEN ON THE REEF ARE FALLING WELL BELOW TARGETS



Source: Queensland Government Reef Water Quality Protection Plan – Report Card 2014

Governments are currently deciding how to fulfil their promises to give the Reef clean water.. They must show real leadership and deliver the programs and funding to achieve Reef safe water quality by 2025.

Recent studies have estimated this may cost more than \$2 billion. This is a small amount compared to the more than \$10 billion that has been invested to protect the Murray-Darling Basin. Most Australians would consider the Great Barrier Reef just as important to protect, not only for its beauty but also for its economic value.

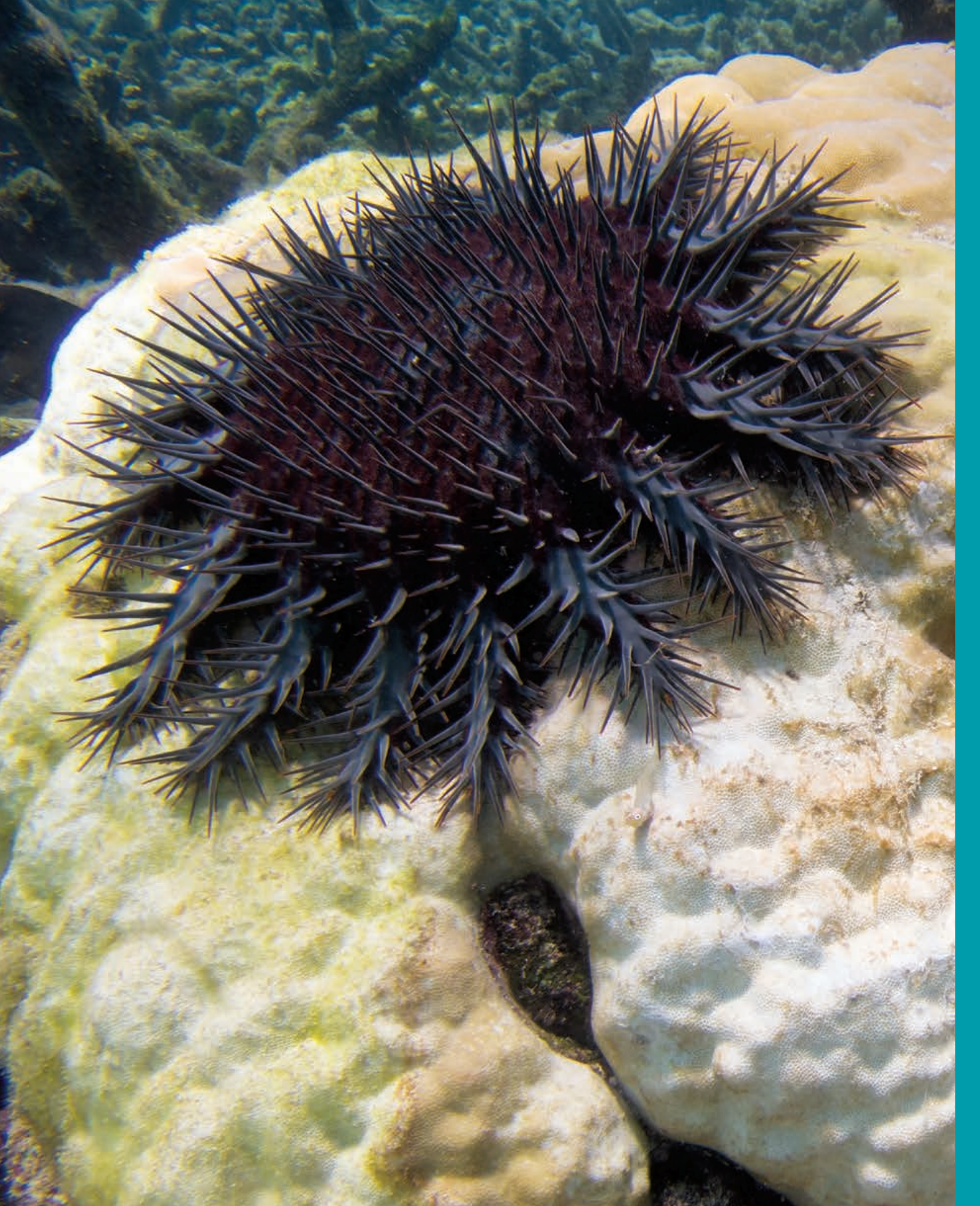
In the next ten years to 2025 the Reef will provide over \$60 billion to the economy and tens of thousands of jobs through tourism, fishing and other Reef-dependent industries. The Reef is critical economic infrastructure and should be invested in so that it continues to deliver jobs and revenue.

WWF is committed to working in partnership with governments, farmers and the community to deliver the solutions to meet the 2025 pollution targets.

If governments and business act now to cut farm pollution, we can provide the Reef the clean water it needs to stop the next crown-of-thorns starfish outbreak.

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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