

Marine results



Great Barrier Reef Report Card 2016

Reef Water Quality Protection Plan

Marine results

The [Marine Monitoring Program](#) target in the Reef Water Quality Protection Plan 2013 (Australian and Queensland governments, 2013) is to:

- Ensure that by 2020 the quality of water entering the Reef from broad-scale landuse has no detrimental impact on the health and resilience of the Great Barrier Reef.

The objective of the Marine Monitoring Program (Great Barrier Reef Marine Park Authority, 2016a) is to assess trends in ecosystem health and resilience indicators for the Great Barrier Reef in relation to water quality and its linkages to end-of-catchment loads.

The Reef Water Quality Protection Plan (Reef Plan) is now a key component of the Great Barrier Reef 2050 Long-term Sustainability Plan (Commonwealth of Australia, 2015), which provides the overarching framework for the integrated management of the Great Barrier Reef (the Reef) World Heritage Area and its catchments.

A range of pressures affect the health and resilience of the Reef at local and regional scales (Great Barrier Reef Marine Park Authority, 2014a). An ecosystem is considered healthy and resilient if it has the ability to resist a disturbance and recover quickly from any impact without a significant shift in its structure, function, identity and feedback processes (Walker and Meyers 2004; Costanza and Mageau 1999). The Reef ecosystem relies on the integrity of its physical, chemical and ecological processes (Figure 1) which are all interconnected, and the overall health of the ecosystem depends on these processes all functioning.

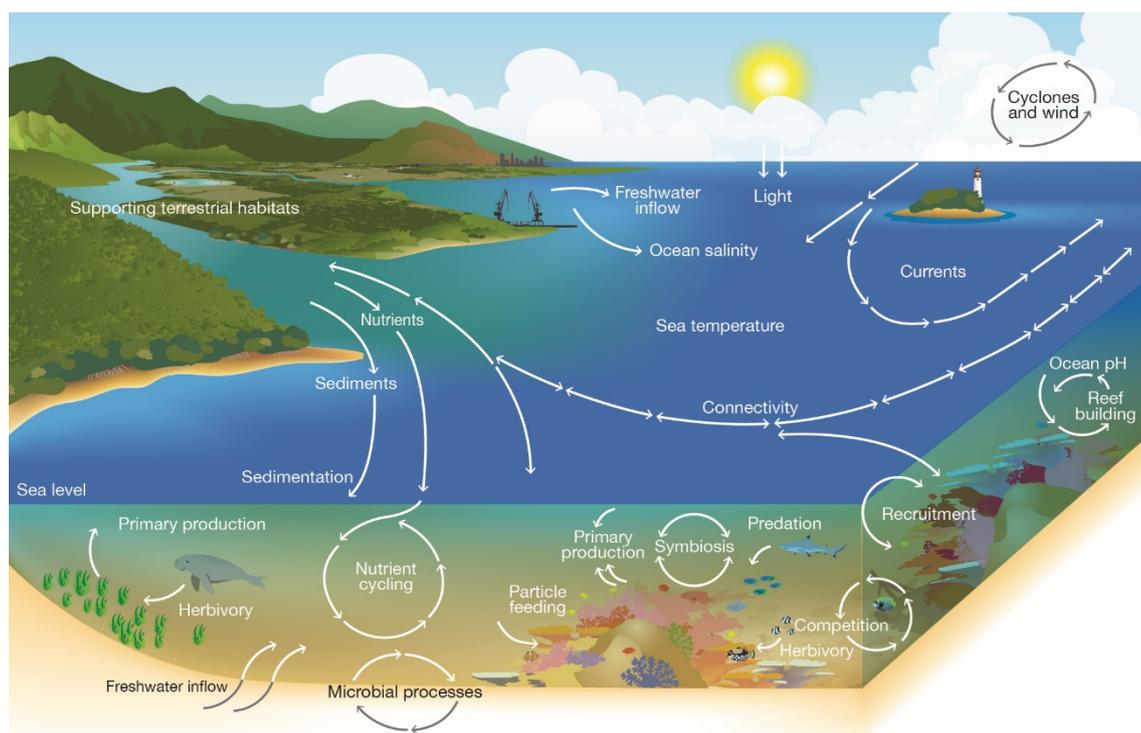


Figure 1: Major physical, chemical and ecological processes. The health of the Great Barrier Reef ecosystem is assessed by considering its physical, chemical and ecological processes as well as the condition of its supporting habitats. Outbreaks of pests and diseases are also considered as a guide to overall health. Reproduced from *Outlook Report 2014* (Great Barrier Reef Marine Park Authority, 2014b).

The Marine Monitoring Program focuses on the Reef's inshore environment, which represents approximately eight per cent of the Marine Park and supports a unique variety of marine communities of high ecological relevance for the overall health of the Reef. This inshore environment is the area most used by recreational visitors, tourism operators and some commercial fisheries (Great Barrier Reef Marine Park

Authority, 2014a), and is also the area most vulnerable to land-based run-off (Great Barrier Reef Marine Park Authority, 2012). The program tracks the condition and trend of inshore seagrass and coral reefs, and synthesises and interprets information on the main pressures affecting the health and resilience of the Reef, such as poor water quality. This report summarises the information collected by the program and provides the basis for the Reef report card marine scores, both Reef-wide and at regional scales.

Pressures and impacts

Catchment run-off contains multiple pollutants (primarily nutrients, pesticides and sediment) that adversely affect the quality of water entering the Reef lagoon. The inshore area is highly influenced by land-based run-off, particularly during the wet season (through increased river discharge), with flow-on effects for ecosystem health (Álvarez-Romero et al., 2013; Schaffelke et al., 2017). Mid-shelf and off-shore areas, on the other hand, are less influenced by catchment run-off (except in extreme events), and water quality is generally good to very good (Schaffelke et al., 2017; Waterhouse et al., 2017a). The condition of the Reef is also strongly influenced by severe weather events, such as tropical cyclones and floods, which have affected all regions over the past decade.

Freshwater inflow

The 2015–16 wet season was declared an El Niño year. Rainfall and, therefore, freshwater discharge was below the long-term median for the Reef catchment, similar to 2014–15 (Figure 2) (Waterhouse et al., 2017b).

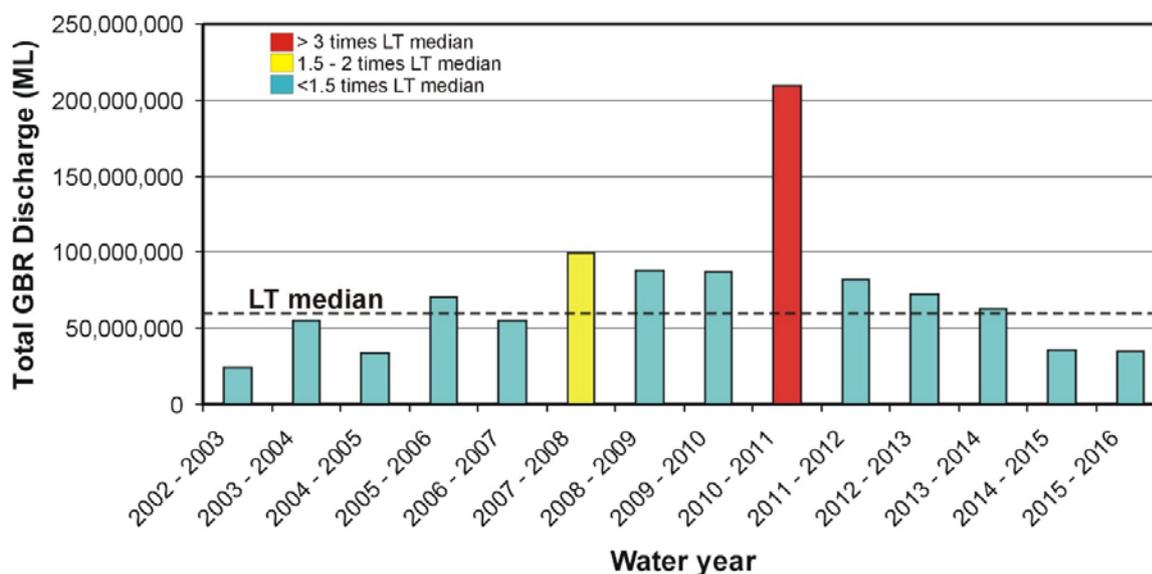


Figure 2: Annual combined discharge (megalitres) from major coastal rivers (35) into the Great Barrier Reef lagoon from 2002 to 2016 (water year: 1 October to 30 September). The long-term (LT) median is from 1986–87 to 2015–16 (Waterhouse et al., 2017b). Source: DNRM, <http://watermonitoring.dnrm.qld.gov.au/host.htm>

Nutrients, sediments and pesticides in catchment run-off

As a consequence of the below-median river discharge in 2015–16, sediment, nutrient and pesticide loads were comparatively low (Figure 3), and load profiles for each region were similar to 2014–15 (Reef Water Quality Protection Plan partners, 2016). In summary, monitored end-of-catchment loads of dissolved inorganic nitrogen were higher in the Wet Tropics compared to all other regions. Loads of total suspended solids (sediment) were highest in the Burdekin and Fitzroy regions, with the Fitzroy also having the highest loads of particulate nitrogen and phosphorus. Overall, toxic-equivalent loads of pesticides were higher in

the Wet Tropics and Mackay Whitsunday regions, where the dominant pesticide detected was diuron, compared to other regions.

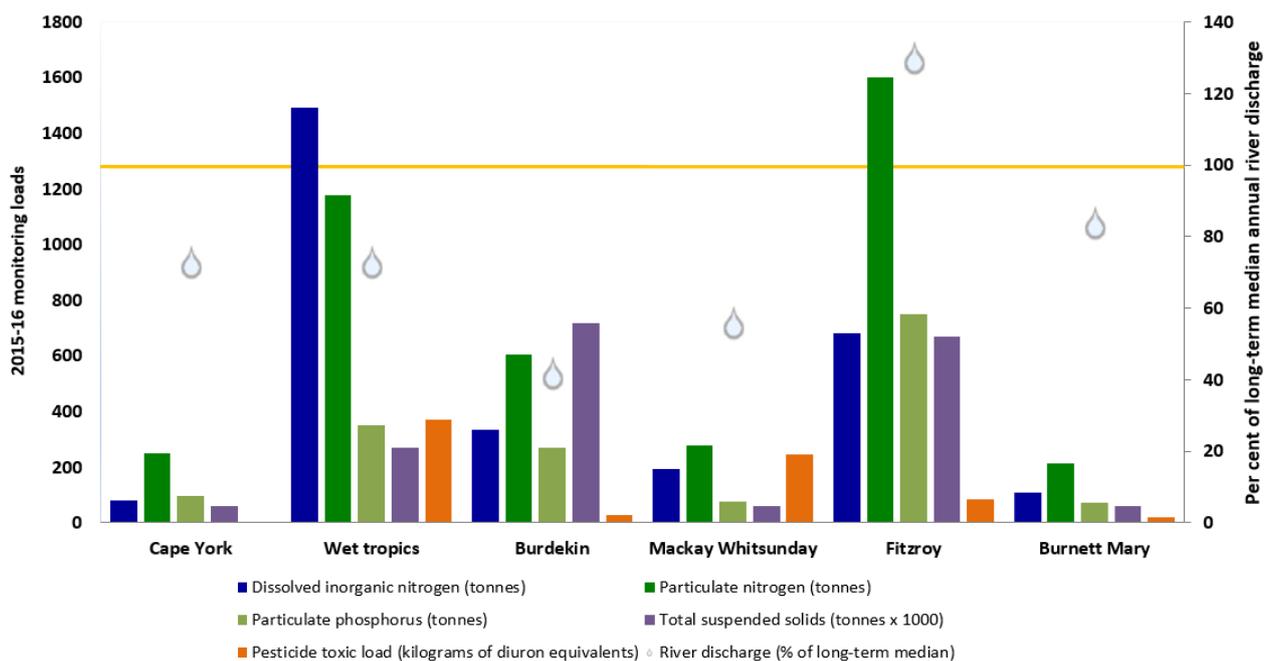


Figure 3: Annual pollutant loads and discharge from major rivers in each natural resource management (NRM) region (1 July 2015 to 30 June 2016). Note: Pesticide loads are not monitored in Cape York. River discharge is presented as a percentage of the long-term (1986–2017) median (yellow line). Source: (Department of Science, Information Technology and Innovation 2016).

A large proportion of dissolved inorganic nitrogen and total suspended solids present in the Reef lagoon is of anthropogenic origin from land-based run-off (Brodie et al., 2012). However, it is recognised that there are also some areas where these concentrations may be naturally elevated (Waterhouse et al., 2017b). The areas with the greatest difference in sediment and nutrient discharge to the marine environment since development of the Reef catchment area, reflect patterns of current agricultural land use (Great Barrier Reef Marine Park Authority, 2012; Waterhouse et al., 2017a). To illustrate which marine areas are influenced by land-based anthropogenic pollutant loads, modelled pre-development loads of dissolved inorganic nitrogen and total suspended solids were compared to current load estimates (Figure 4 and Figure 5, respectively).

The analysis highlighted that, for the 2015–16 water year, the areas with the greatest estimated difference in dissolved inorganic nitrogen concentrations compared to pre-development were in the Wet Tropics region, and to a lesser extent in the Burdekin, Mackay Whitsunday, and Burnett Mary regions (Figure 4). For total suspended solids, the greatest estimated difference was in the Burdekin region and to a lesser extent in the Wet Tropics, Mackay Whitsunday and Burnett Mary regions (Figure 5). These results are consistent with the high priority catchments identified by the pollutant exposure assessment conducted for the 2017 Scientific Consensus Statement update (Waterhouse et al., 2017a).

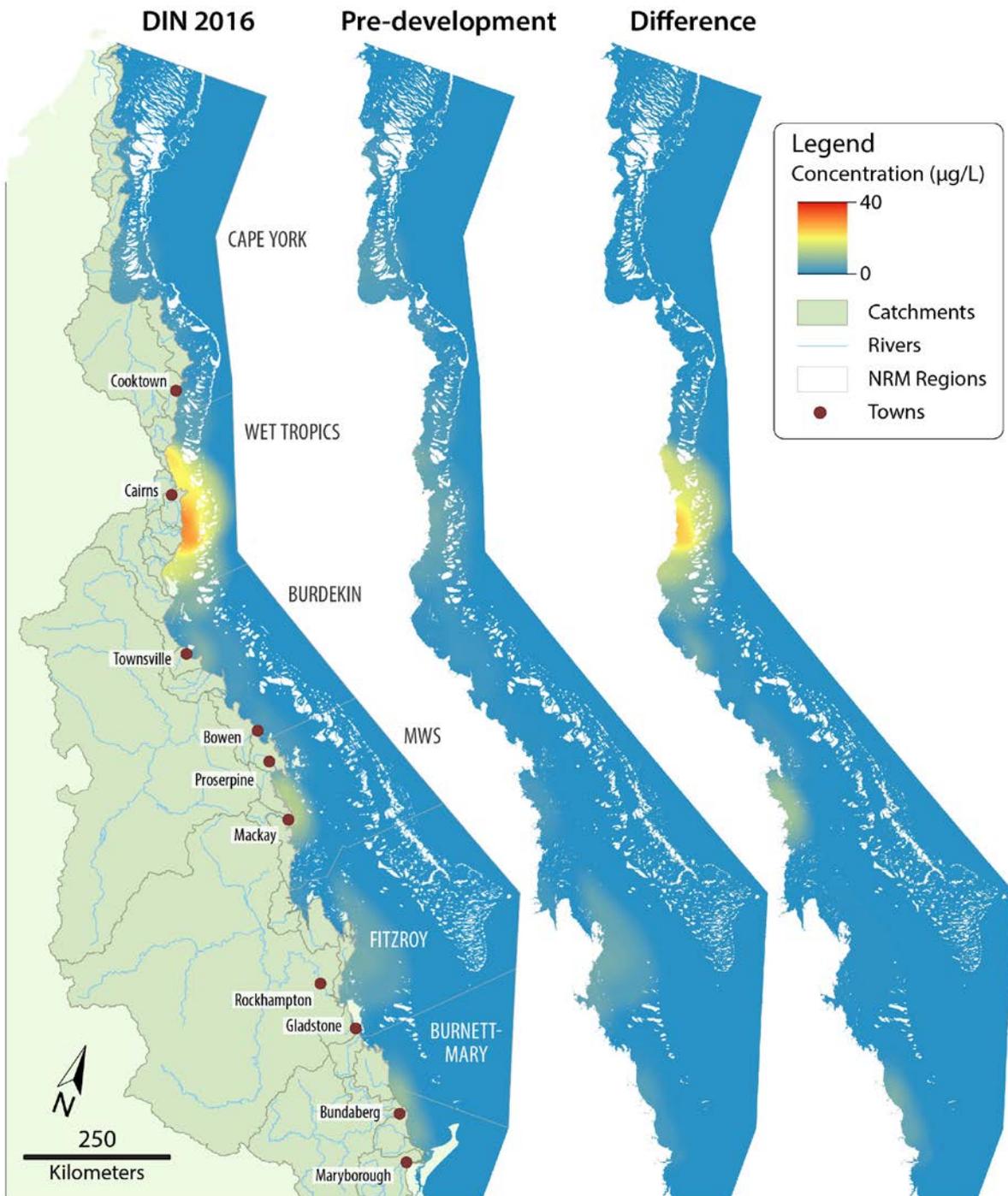


Figure 4: Dissolved inorganic nitrogen concentration (DIN, $\mu\text{g/L}$) modelled from catchment loads transported to the Great Barrier Reef lagoon for the 2015–16 water year (1 October to 30 September). From left to right, DIN concentrations were modelled from the total DIN load (left panel), estimated pre-development loads (centre panel), and the difference between the two (i.e. the anthropogenic load; right panel) (Waterhouse et al. 2017b). To illustrate the 2015–16 modelled DIN concentrations relative to previous years, the colour scale was generated from the modelled maximum DIN concentrations that occurred between 2003 and 2016.

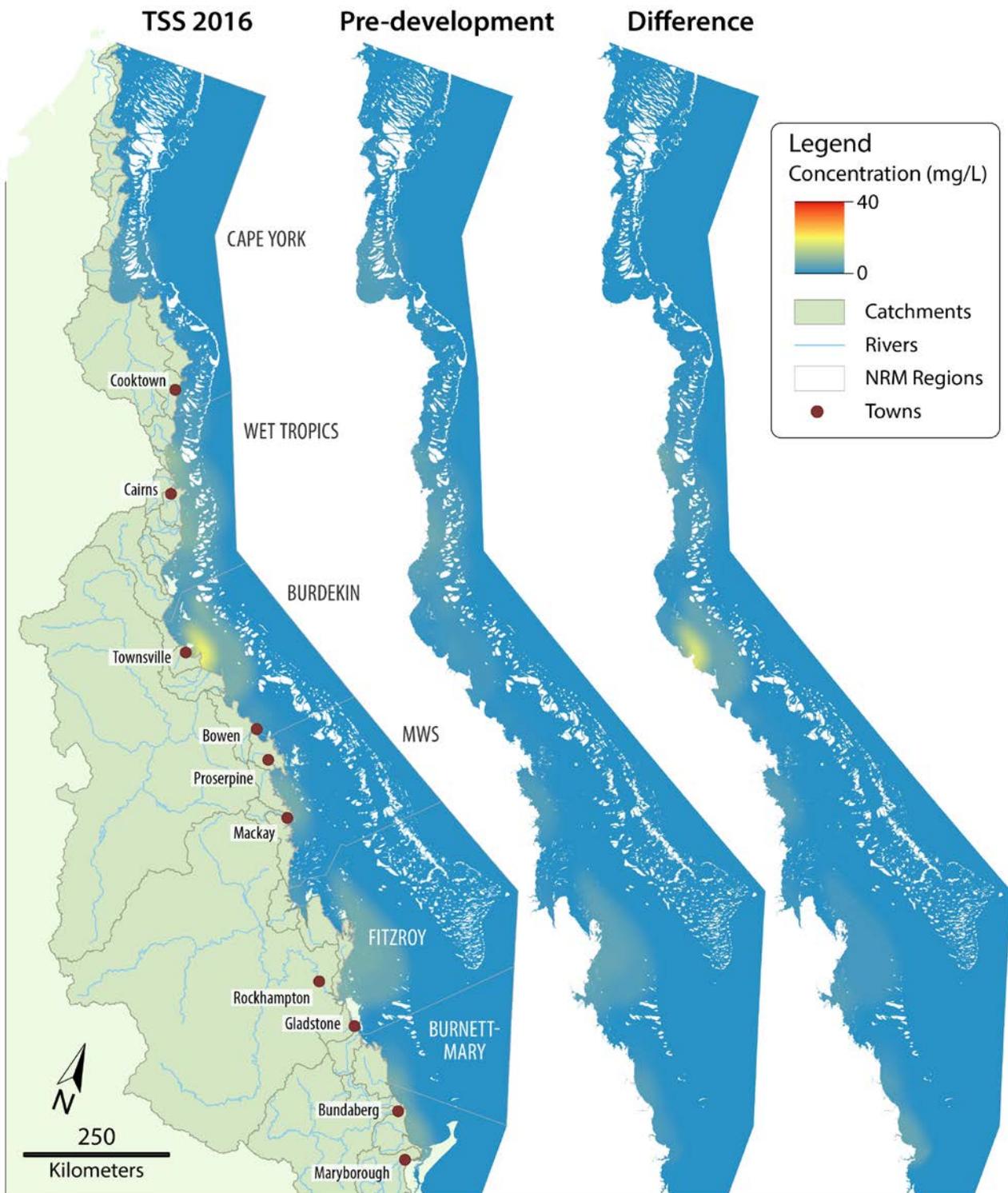


Figure 5: Total suspended solids (TSS, mg/L) modelled from catchment loads transported to the Great Barrier Reef lagoon for the 2015–16 water year (1 October to 30 September). From left to right, TSS concentrations were modelled from the total DIN load (left panel), estimated pre-development loads (centre panel), and the difference between the two (i.e. the anthropogenic load; right panel) (Waterhouse et al., 2017b). To illustrate the 2015–16 modelled TSS concentrations relative to previous years, the colour scale was generated from the modelled maximum TSS concentrations that occurred between 2003 and 2016.

In addition to the decline of marine water quality associated with terrestrial run-off from the adjacent catchments, Reef ecosystems have been severely impacted by a number of recent events, including the progression of the fourth wave (since the 1960s) of crown-of-thorns starfish population outbreaks; tropical cyclones; and prolonged periods of extreme sea-surface temperatures.

Crown-of-thorns starfish

Outbreaks of the coral-eating crown-of-thorns starfish are one of the main direct causes of the decline in coral cover Reef-wide (Osborne et al., 2011). Most outbreaks occur on mid-shelf reefs, beginning along the narrow northern shelf between Cairns and Lizard Island (the 'initiation zone') and then moving to southern reefs as larvae are transported by the East Australian Current. Scientific models indicate that outbreaks are likely to be linked to elevated nutrient levels in lagoon waters serviced by rivers in the Wet Tropics (Furnas et al., 2013; Fabricius et al., 2010; Schaffelke et al., 2017). An active outbreak of crown-of-thorns starfish occurs when the starfish consume coral tissue faster than corals can grow. This is generally estimated to be more than 15 starfish per hectare when coral cover is moderate to high (Moran and De'ath 1992).

In 2015–16, outbreaks of crown-of-thorns starfish were recorded at six per cent of reefs monitored by the [Long-term \(Reef\) Monitoring Program](#) (Australian Institute of Marine Science, 2017) (Figure 6). The current outbreak mostly occurs in the northern part of the Reef, but has recently extended south to Innisfail, on both inshore and mid-shelf reefs (Thompson et al., 2017). In general, crown-of-thorns starfish are not prevalent on inshore reefs; however, Marine Monitoring Program surveys in 2015–16 found an elevated number in the Barron, Daintree, Johnstone and Mulgrave-Russell sub-regions, mirroring the larger populations offshore (Thompson et al., 2017). The proportion of surveyed reefs with outbreaks of crown-of-thorns starfish was less in 2015–16 than the previous year (Figure 6) and the density of crown-of-thorns starfish found on these reefs was lower than the previous year (Figure 7). The proportion of surveyed reefs with outbreaks may appear lower because coral cover on some reefs has been reduced to very low levels, or because the timing of surveys coincided with remedial action undertaken as part of the Australian Government crown-of-thorns starfish management program.

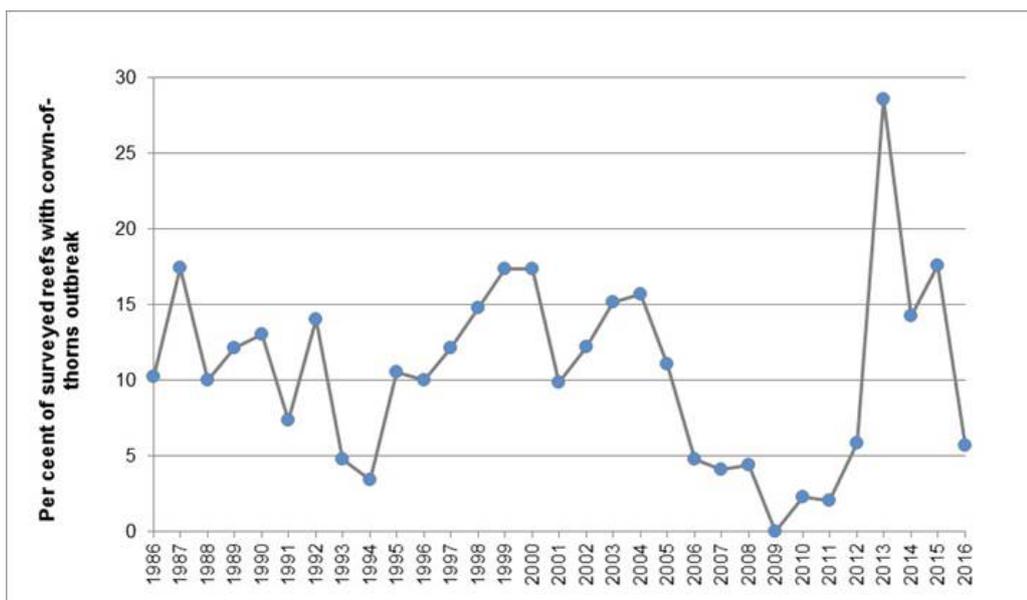


Figure 6: Proportion of surveyed reefs in the Great Barrier Reef with observed outbreaks of crown-of-thorns starfish from 1986 to 2016. Note that the same reefs are not necessarily surveyed every year and some of the outbreaks overlap in time. Source: Australian Institute of Marine Science Long-term Monitoring Program (<http://data.aims.gov.au/waCOTSPage/cotspage.jsp>).

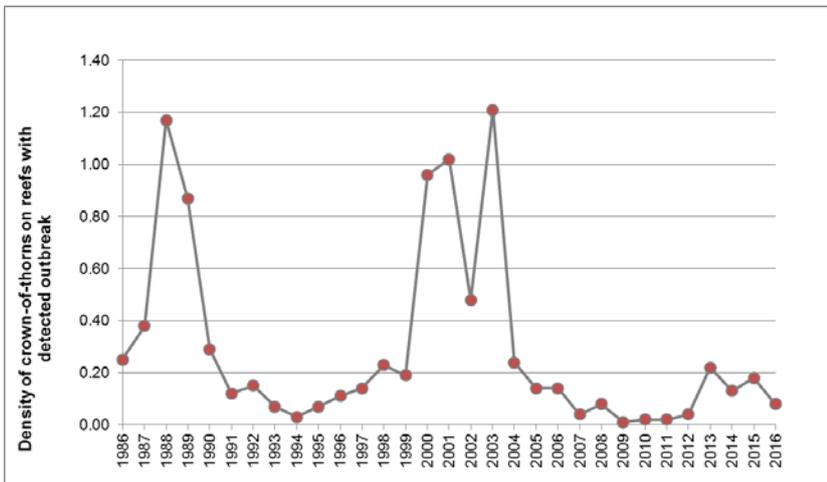


Figure 7: Density of crown-of-thorns outbreaks on reefs with detected outbreaks in the Great Barrier Reef from 1986 to 2016. Density is the number of crown-of-thorns per two-minute manta tow. Note that the same reefs are not necessarily surveyed every year and some of the outbreaks overlap in time. Source: Australian Institute of Marine Science Long-term Monitoring Program (<http://data.aims.gov.au/waCOTSPPage/cotspage.jsp>).

Cyclones

Cyclone damage is one of several factors contributing to major losses of coral and seagrass across the Reef (De'ath et al. 2012; Thompson et al. 2017; McKenzie et al. 2017). All of the Category 5 cyclones that have affected the Reef since 1970 have occurred in the last decade, including Larry (2006), Hamish (2009), Yasi (2011), Ita (2014) and Marcia (2015) (Bureau of Meteorology, 2016; Waterhouse et al., 2017b). The combined paths of severe cyclones since 2005 have exposed more than 80 per cent of the region to gale-force or stronger winds (Figure 9).

During 2015–16, no cyclones affected the Reef (Figure 8), allowing coral and seagrass communities time to recover from the severe weather events of previous years (especially 2007–12). Recovery is still in its early stages—the legacy of impacts from severe tropical cyclones on the Reef may last for decades, and can take many years for diverse seagrass and coral communities to re-establish (Thompson et al., 2017; Mumby et al., 2011; McKenzie et al., 2017).

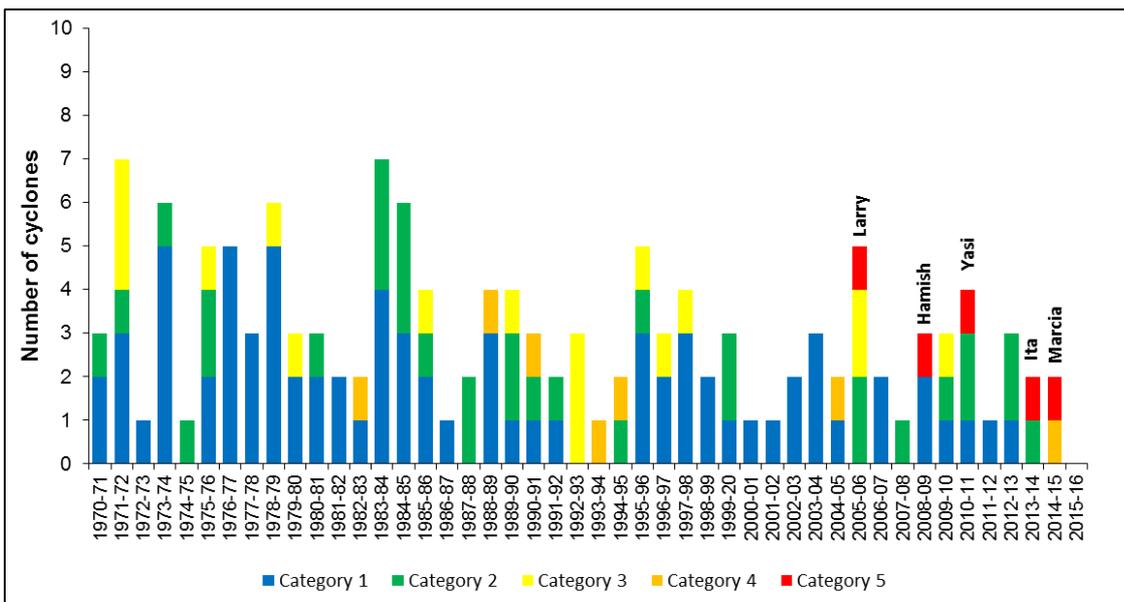


Figure 8: Number and severity of cyclones that have affected the Great Barrier Reef, 1970–2016. Source: (Bureau of Meteorology 2016).

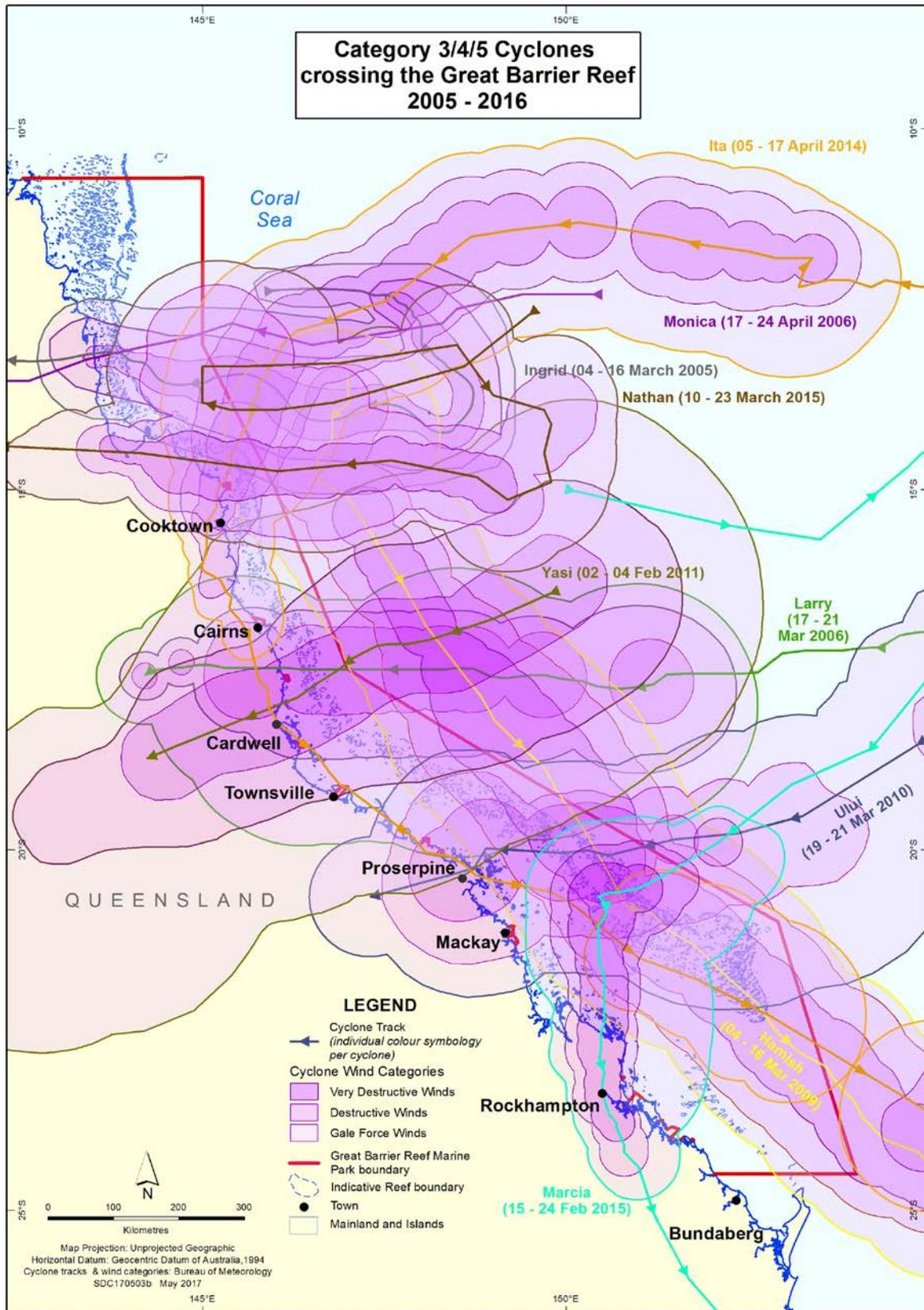


Figure 9: Cyclonic winds associated with category 3, 4 and 5 cyclones, 2005–16. Source: (Bureau of Meteorology 2016).

Elevated sea temperatures

Rising sea-surface temperature is one of the greatest threats to the survival of corals on the Reef (Hoegh-Guldberg et al., 2007, Great Barrier Reef Marine Park Authority, 2014a). In 2016, sea-surface temperatures were the highest since records began in 1900 (Great Barrier Reef Marine Park Authority, 2016b). Coral bleaching commonly occurs when the accumulated temperature stress—measured as the number of ‘degree heating days’ over the summer months—exceeds a threshold of about 60 to 100 degree heating days (Maynard, 2010).

By the end of March 2016, most of the Reef had accumulated between 60 and 80 degree heating days (Figure 10), which triggered the worst mass coral bleaching event ever recorded on the Reef (Figure 11) (Great Barrier Reef Marine Park Authority, 2017). Northern areas of the Reef were the most heat-stressed, with mid-shelf and outer-shelf areas accumulating up to 90 degree heating days and the inshore area in the far north accumulating up to 110 degree heating days (Figure 10).

Coral bleaching

High temperatures combined with an El Niño year triggered the worst coral bleaching event on record in 2016. An estimated 29 per cent of shallow-water coral was lost across the Marine Park (Figure 11) (Great Barrier Reef Marine Park, Authority 2017). The impacts of coral bleaching were highly variable across the Reef, with severity decreasing from north to south:

- The northern region of the Marine Park (Cape York to Port Douglas) was the area most affected by severe bleaching and subsequent loss of coral. However, in comparison, reefs offshore from Cape York to Stanley Island were not as severely affected and coral bleaching was variable (Hughes et al., 2017, Great Barrier Reef Marine Park Authority 2017).
- In the central areas of the Marine Park south of Port Douglas to Mackay, the loss of coral was highly variable and ranged from low to medium (Hughes et al., 2017; Thompson et al., 2017; Great Barrier Reef Marine Park Authority, 2017).
- The southern areas of the Marine Park (Mackay to Bundaberg) had little or no loss of coral (Hughes et al., 2017; Thompson et al., 2017; Great Barrier Reef Marine Park Authority, 2017).
- At inshore reefs south of Snapper Island, coral bleaching was patchy and large sections of the inshore showed only minor impacts (Thompson et al., 2017; Great Barrier Reef Marine Park Authority, 2017).

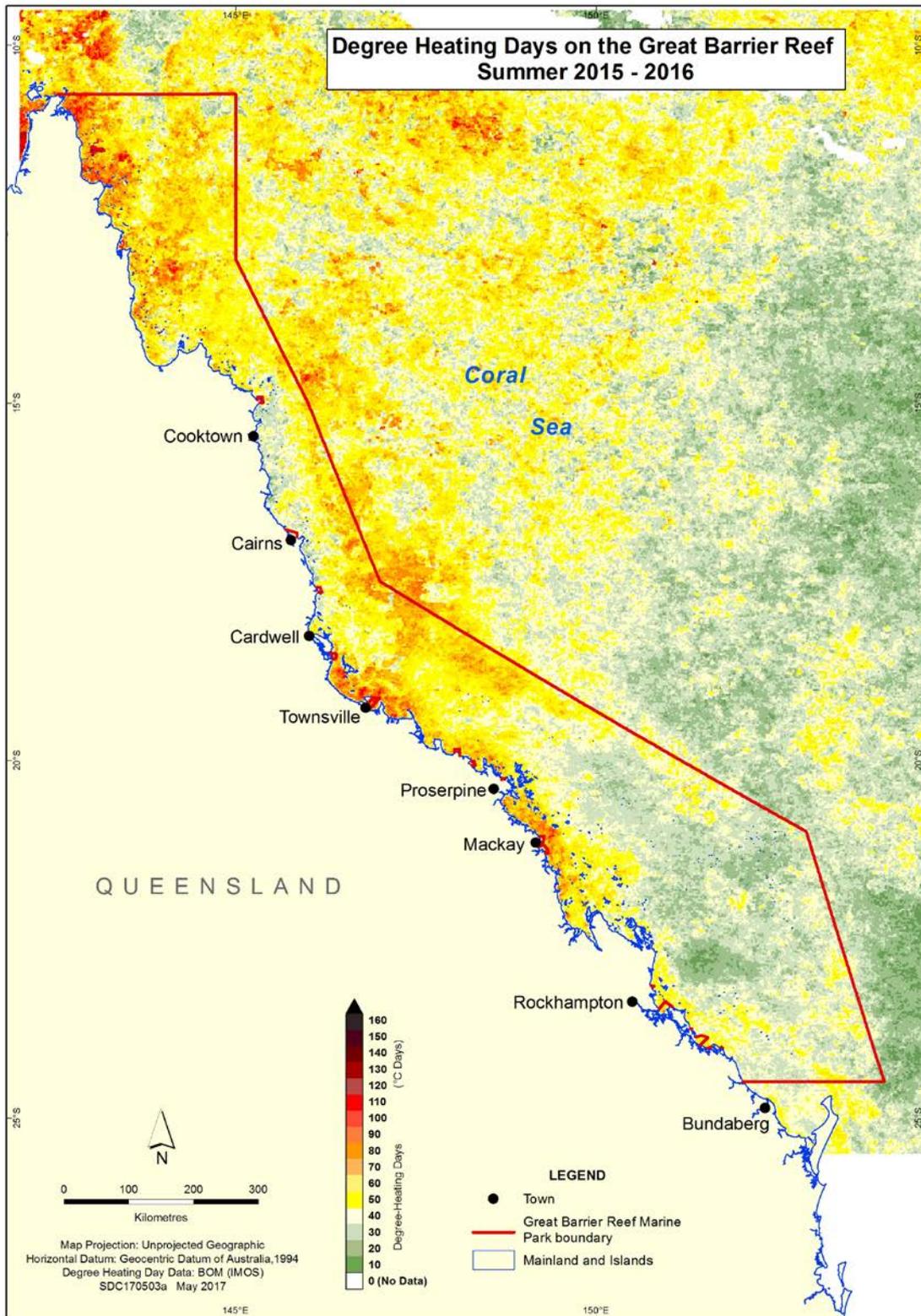


Figure 10: Water temperature, measured as the number of ‘degree heating days’ occurring in 2015–16 (Bureau of Meteorology 2017).

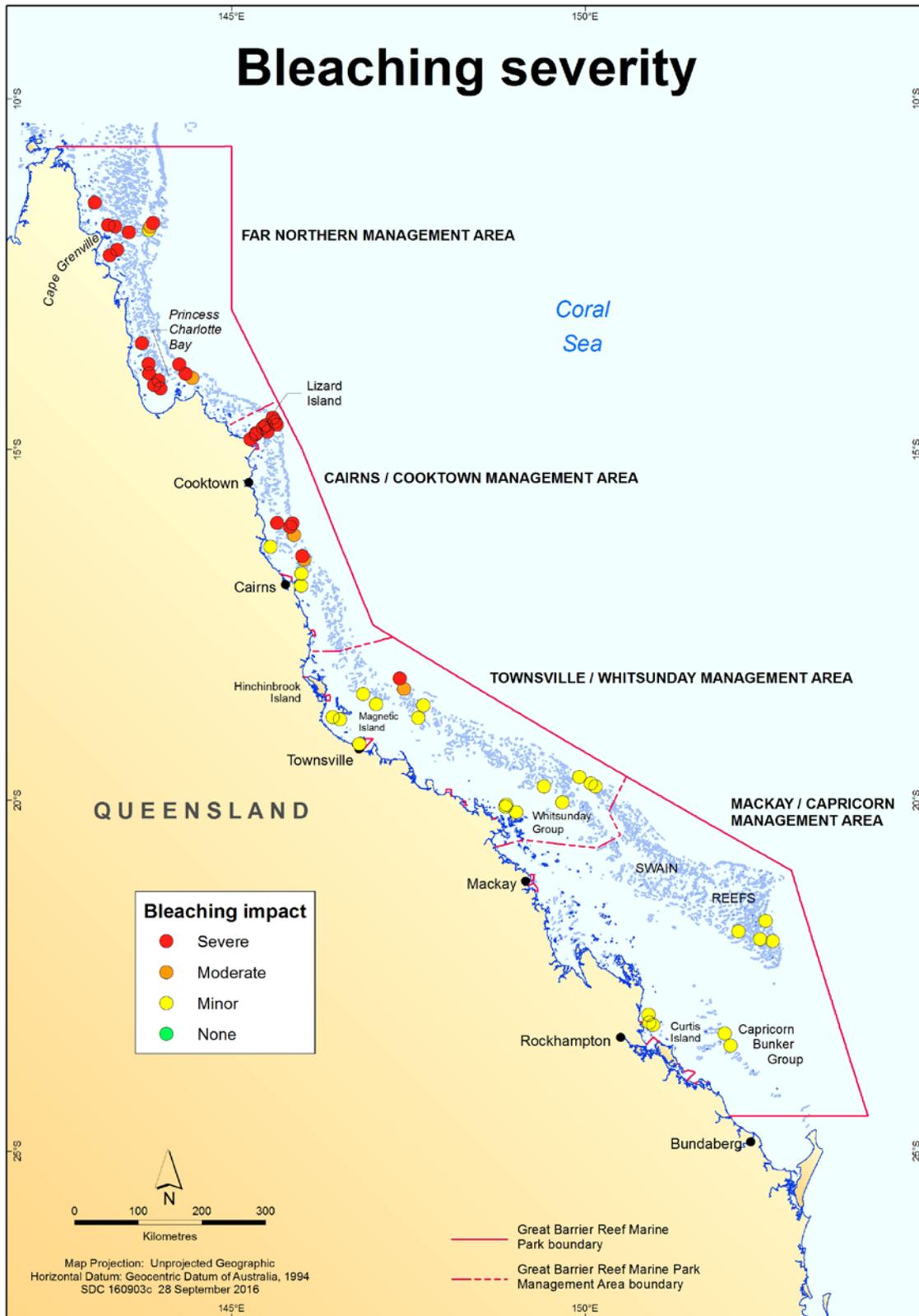


Figure 11: Areas of the Reef where coral bleaching occurred in 2015–16. The mortality level is indicated by the coloured circles.

Outlook for the Great Barrier Reef

Climate change is recognised as the most serious threat to the Reef (Great Barrier Reef Marine Park, Authority 2014b). Climate-change-related threats include increased sea-surface temperature, altered ocean

currents, increased severity of tropical storms, increased run-off from adjacent catchments, ocean acidification and rising sea level. Potential consequences for species, habitats and ecosystems include mass coral mortality, declining growth rates of coral, increased frequency of crown-of-thorns outbreaks, and losses of key habitats and ecosystems (De'ath et al., 2012). The effects, both individually and combined, are likely to have far-reaching consequences for the region's ecosystem and its Outstanding Universal Value as a World Heritage Area (De'ath et al., 2012; Poloczanska et al., 2012; Bustamante et al., 2012; Lough et al., 2012; Jones and Berkelmans, 2014).

These concerns are reiterated in the 2017 Scientific Consensus Statement (Waterhouse et al., 2017a) which concluded that:

Key Great Barrier Reef ecosystems continue to be in poor condition. This is largely due to the collective impact of land run-off associated with past and ongoing catchment development, coastal development activities, extreme weather events and climate change impacts such as the recent coral bleaching events.

Inshore seagrass meadows and coral reefs are continuing to recover from previous losses sustained during major floods and cyclones, but remain in moderate to poor condition overall (McKenzie et al., 2017; Thompson et al., 2017). Continuing recovery of inshore communities during the recent period of low rainfall and run-off (see Results) demonstrates the capacity of these communities to recover from acute disturbances and supports the ongoing efforts to reduce anthropogenic pollutant loads delivered to the Reef. In the past, mid-shelf and outer-shelf reefs in the southern half of the Reef have also shown a capacity to rapidly recover from disturbances (Great Barrier Reef Marine Park Authority, 2014a).

Resilient coral and seagrass communities can have high rates of recruitment and growth, which compensate for the losses resulting from acute disturbances, such as cyclones. However, ongoing chronic pressures—such as poor water quality—can decrease the resilience of coral and seagrass in the Reef by slowing or inhibiting their rates of recovery (Roff et al., 2013; McKenzie et al., 2012; Osborne et al., 2011; Meager and Limpus 2014; Jones and Berkelmans 2014; Folke et al., 2004). Therefore, there is a strong imperative to improve water quality in the Reef, especially given the recent bleaching event, which caused significant coral mortality, especially north of Port Douglas.

Results

Overall condition of the inshore marine area

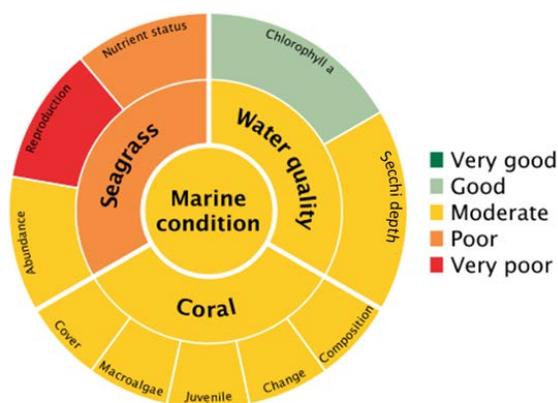


Figure 12: Overall condition of the inshore marine environment for water quality, seagrass and coral in 2015–16.
Note: Corals are assessed only in the Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy regions.

In 2015–16, the overall condition of the Reef’s inshore marine environment was moderate (Figure 12).

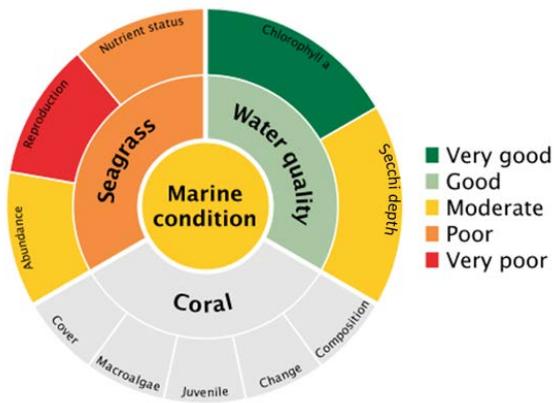
Inshore water quality for the Reef was also moderate (Figure 15).

Inshore seagrass meadows showed slight improvements in condition, but remained in poor condition overall. Indicator scores for seagrass abundance improved in 2015–16 compared to the previous year, but remained in moderate condition. Reproductive effort remained very poor and nutrient status remained in poor condition.

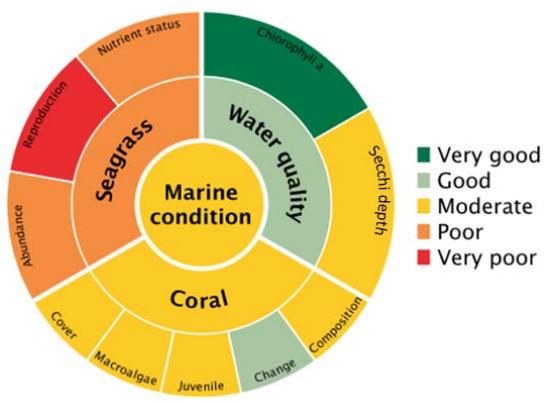
Inshore coral reefs remained in moderate condition overall, despite the 2016 bleaching event. Coral condition has continued to improve since 2011–12 when it was in its worst condition following repeated cyclones and storms. Coral cover, macroalgae cover and juvenile density remained in moderate condition. Coral change and community composition increased from poor to moderate condition.

Regional highlights

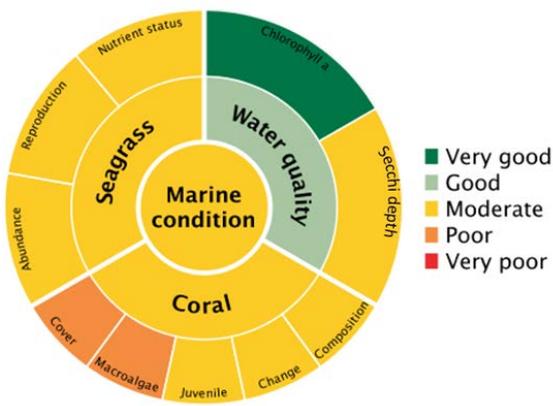
- The inshore marine environment was in moderate condition in all regions except the Fitzroy, where it was in poor condition (Figure 13).
- Sea-surface temperatures were above average along the Reef in 2015–16, but rainfall and discharge were below the long-term average and there were no cyclones.
- Inshore marine water quality was good in Cape York, good in the Wet Tropics, Burdekin and Burnett Mary, and moderate in the Mackay Whitsunday and Fitzroy regions (Figure 15).
- Regionally, the condition of seagrass and coral remained relatively stable in 2015–16 compared to 2014–15. Highlights include improvements in coral condition in the Burdekin (poor to moderate) and Mackay Whitsunday (moderate to good). The condition of seagrass meadows improved from very poor to poor in the Fitzroy region.
- There is no coral monitoring in the inshore waters of Cape York and Burnett Mary region (grey shading) (Figure 13).



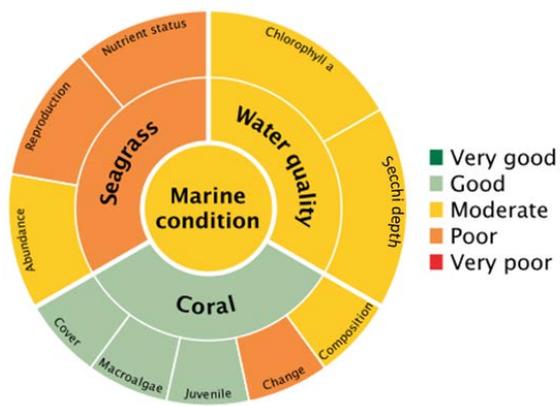
Cape York



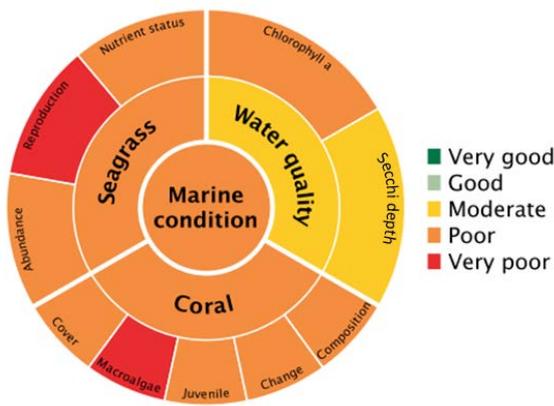
Wet Tropics



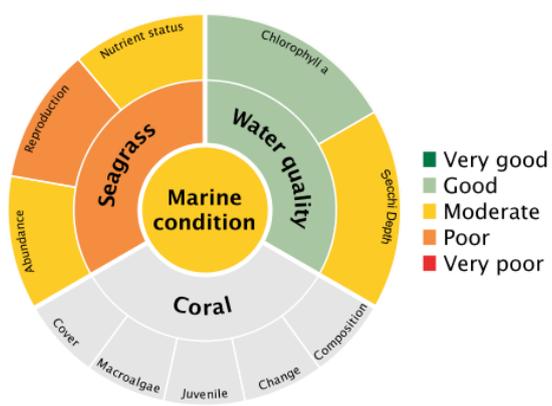
Burdekin



Mackay Whitsunday



Fitzroy



Burnett Mary

Figure 13. Overall condition of the marine environment of the six natural resource management regions for water quality, seagrass and coral in 2015–16. Grey shading indicates that no monitoring occurred.

Trends in the overall condition of the inshore marine environment

The Reef's inshore marine environment has declined markedly from its pre-development condition, especially in inshore areas adjacent to the developed coast (Great Barrier Reef Marine Park Authority, 2014a).

- Reduced pollutant loads, as a result of below average river discharge for the last two years, gave the Reef a chance to recover from the impact of earlier severe weather events such as Tropical Cyclone Yasi in 2011–12.
- The regional differences in condition reflect historical exposure to acute environmental disturbances such as cyclones, as well as differences in long-term cumulative pressures, for example from adjacent land development and marine activities.
- The consistently poor score for the Fitzroy reflects the cumulative effects of multiple severe disturbances since 2006, including major (and in some cases record) floods; cyclones; high levels of macroalgae; bleaching; and outbreaks of coral disease. The small increase in the score for the overall marine condition in 2015–16 represents the first signs of recovery of seagrass and coral communities.

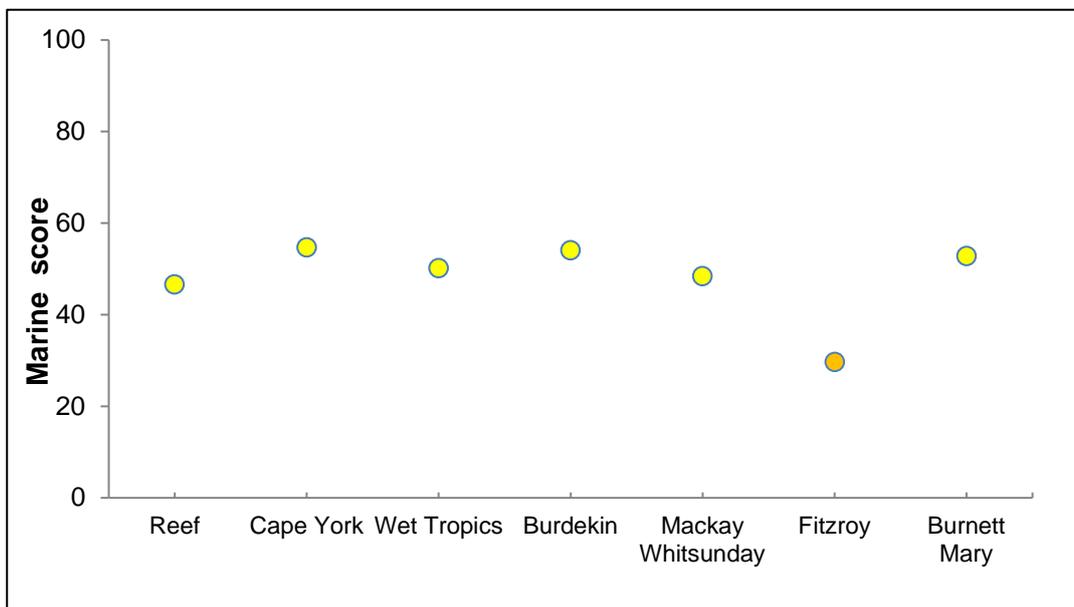


Figure 14: Marine condition for the inshore Great Barrier Reef and NRM regions for 2015–16. Values are indexed scores scaled from 0 to 100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). NB: Scores are unitless.

Water quality

Water quality condition and trend

This summary is adapted from Waterhouse et al., 2017b; Grant et al., 2017; and Robillot et al., 2017.

Revisions to the water quality metric

A revised water quality metric was developed in 2015–16 as an initial step towards integrating multiple streams of data to measure and report water quality condition. The previous metric relied exclusively on satellite data. The new metric is underpinned by the eReefs biogeochemical model integrated with satellite images for improved accuracy in what is commonly referred to as a data assimilation process. All marine water quality results presented in this report were generated using the revised metric (see the Marine Methods report for details). Modelled data was available for three years only and inshore water quality scores are for open coastal waters only.

Note that the revised metric is not directly comparable to the metric used in previous Reef report cards.

The main points for 2015–16 are as follows:

- Inshore water quality across the Reef was assessed as moderate overall using modelled data, with a north-south gradient of declining water quality from Cape York (good) to the Fitzroy (moderate) (Figure 15). For the individual indicators, chlorophyll a was rated as good overall and Secchi depth was rated as moderate overall; however, chlorophyll a was highly variable across the regions and scores ranged from poor to very good (Figure 19).
- In 2015–16, the levels of sediments and nutrients entering the Reef were low (categories I and II) (Figure 16), because runoff was low. Sediment resuspension from wind was higher closer to the coast in some regions (e.g. Burdekin region), which may have affected the amount of light available for seagrass growth.
- Pesticides were detected at relatively low concentrations at most sites in 2015–16 (Figure 17), consistent with the low river discharge. The exception to this was at Round Top Island in the Mackay Whitsunday region, which recorded the highest herbicide-equivalent concentrations (Category 2, which have been shown to inhibit photosynthesis in some species of coral and seagrass) detected at any site since monitoring began in 2014–15 (Grant et al., 2017). Ongoing monitoring is required to ascertain whether high pesticide concentrations are common to this site. In addition, the Reef water quality guideline value for chlorpyrifos, 0.50 ng/L for 99 per cent species protection (Great Barrier Reef Marine Park Authority, 2010), was marginally exceeded during one wet-season sampling period at Round Top Island (0.52 ng/L). More recently, new and revised pesticide guideline values for marine ecosystems have been proposed (King et al., 2017); the proposed 99 per cent species protection values for diuron (430 ng/L) and imidacloprid (33 ng/L) were also exceeded at Round Top Island (462 ng/L and 36 ng/L, respectively).
- Variability between regions was high in the profiles of pesticides detected (type and concentration) (Figure 18). The most frequently detected pesticides in inshore waters (diuron, atrazine, hexazinone and tebuthiuron) were herbicides that inhibit photosynthesis (known as Photosystem II inhibiting (PSII) herbicides). This finding is consistent with pesticide use in adjacent catchments, mainly by the sugarcane, horticulture, grain, cropping and grazing industries.

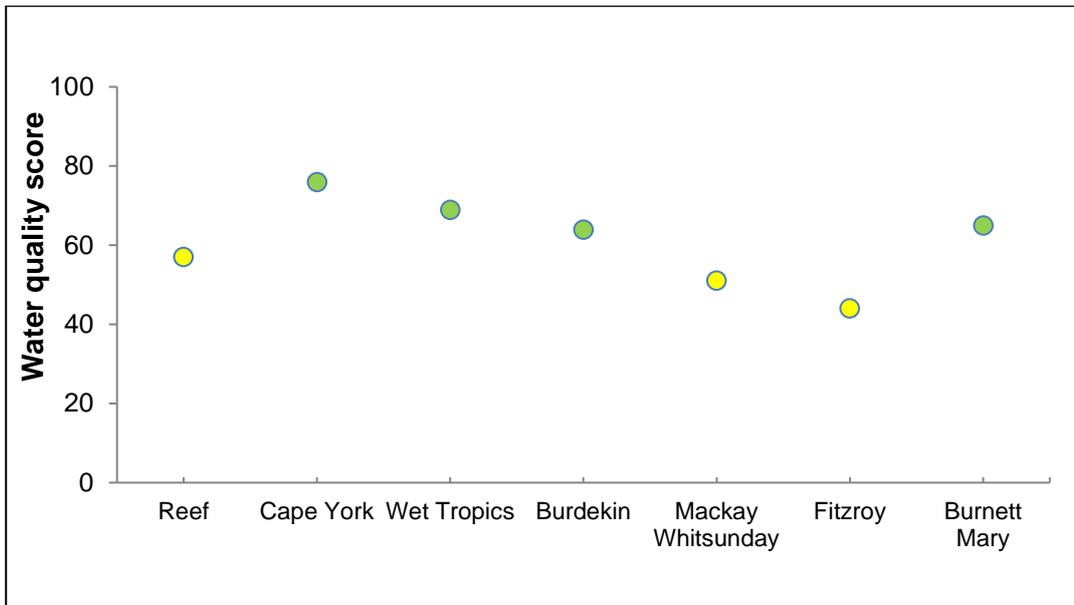


Figure 15: Water quality condition for the inshore Great Barrier Reef and regions for 2015–16. Values are indexed scores scaled from 0 to 100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Note: Inshore water quality scores are for open coastal waters only. For the Burnett Mary region, only the area in the Marine Park was modelled and scored. Modelled data was available for three years only and is not directly comparable to previous report cards.

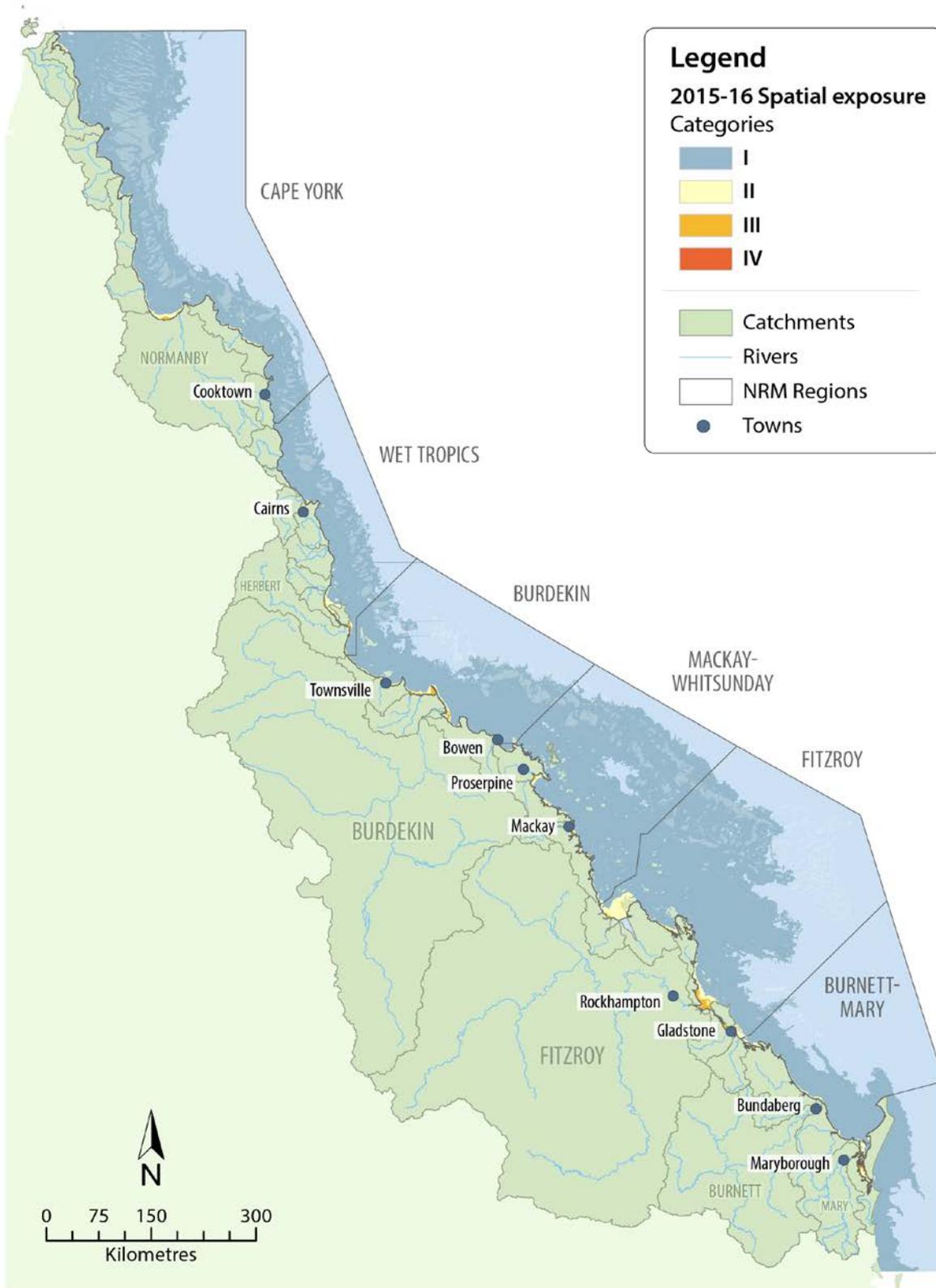


Figure 16: Surface exposure of sediments and nutrients for the Reef in 2015–16 (Waterhouse et al., 2017b). This assessment combined remotely sensed, true-colour imagery with in-situ water quality data. The method takes into account the frequency of exposure to different types of water (characterised by certain water quality conditions), predicted water quality concentrations, and ecological thresholds (see Waterhouse et al., 2016b and Petus et al., 2016).

Maximum PSII Herbicide Equivalent Concentrations

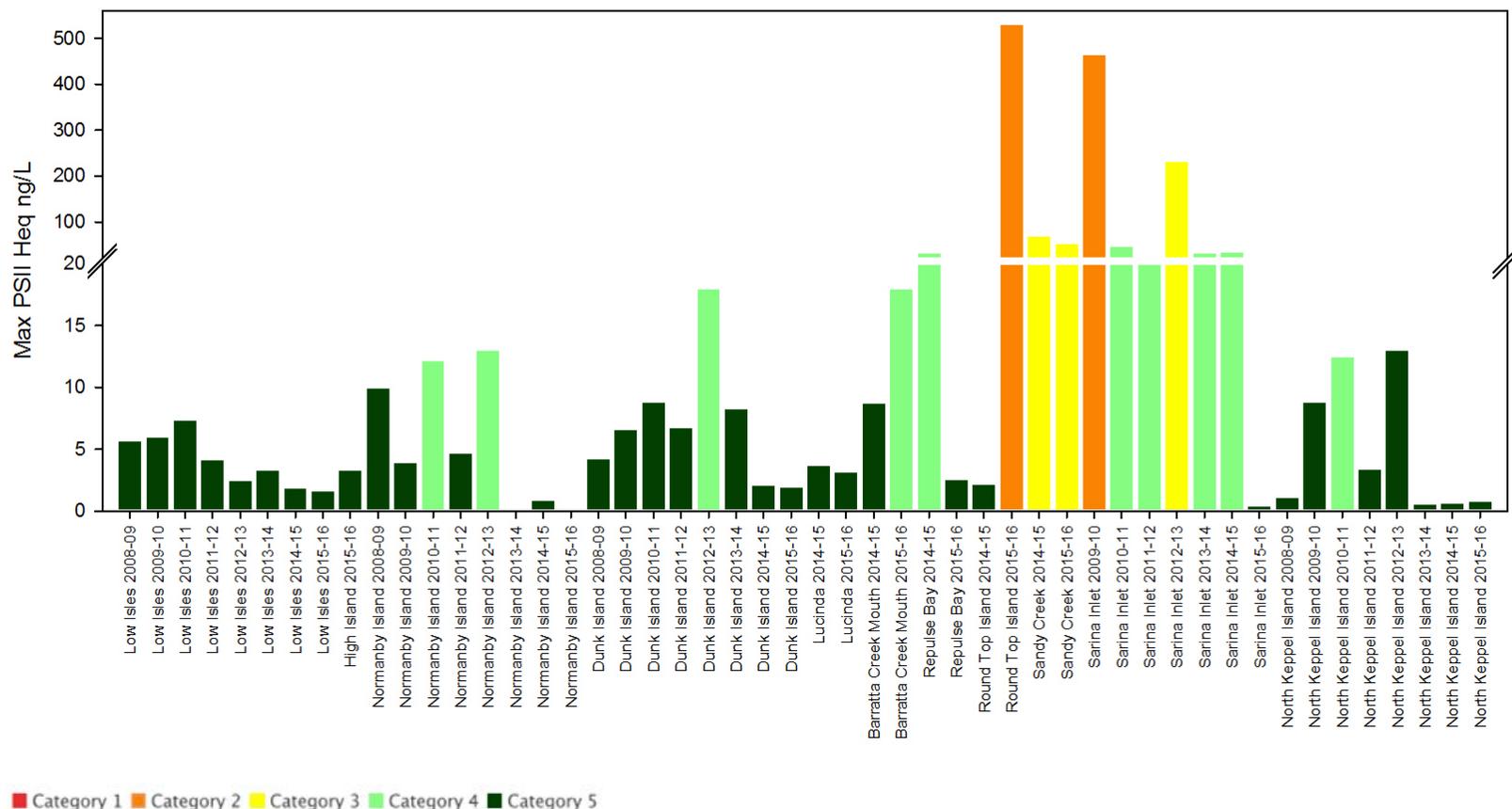


Figure 17: Maximum PSII herbicide equivalent concentrations at all sites monitored in the Great Barrier Reef in 2015–16 compared to previous years. Eleven sites have been included in the monitoring program since 2014–15. These include five long-term monitoring sites: Low Isles, Normanby Island, Dunk Island, Sarina Inlet and North Keppel Island. New sites introduced in 2014–15 were High Island, Lucinda, Barratta Creek, Repulse Bay, Round Top Island and Sandy Creek. The five categories of the index reflect published effects on photosynthesis at levels of pesticides below guideline levels, where Category 5 is no impact and Category 1 is the equivalent to the 99 per cent species protection guideline value for diuron (Great Barrier Reef Marine Park Authority, 2016c) . The PSII herbicide equivalent concentrations include nine PSII herbicides and the two atrazine breakdown products. Source: (Grant et al., 2017).

Maximum concentration of individual herbicides

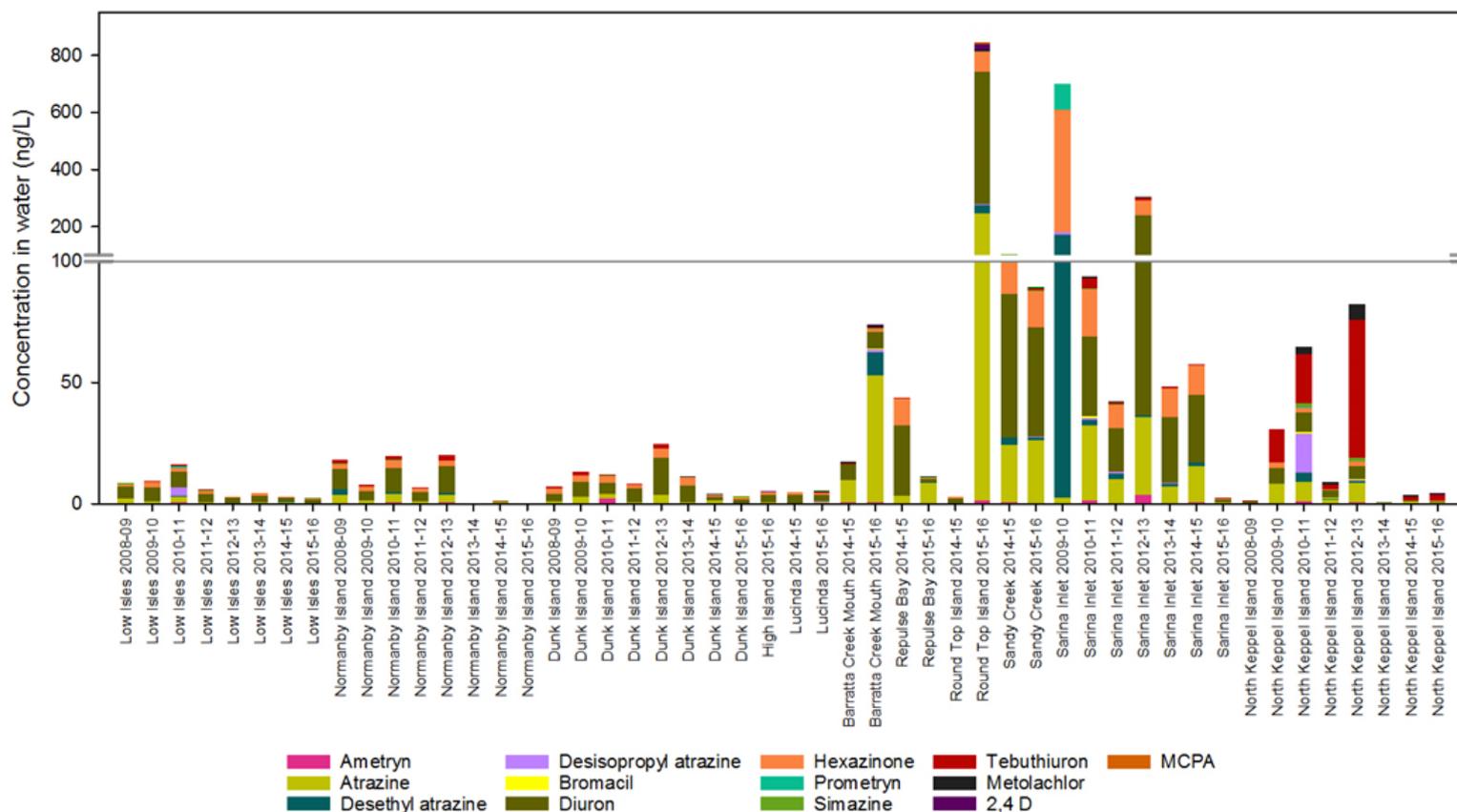


Figure 18: Maximum concentration of the main herbicides detected at all sites monitored across the Great Barrier Reef in 2015–16 compared to previous years. Eleven sites have been included in the monitoring program since 2014–15. These include five long-term monitoring sites: Low Isles, Normanby Island, Dunk Island, Sarina Inlet and North Keppel Island. New sites introduced in 2014–15 were High Island, Lucinda, Barratta Creek, Repulse Bay, Round Top Island and Sandy Creek. Note that this figure shows the concentrations of the main herbicides detected at each site, not just PSII herbicides. Other pesticides detected but which have not been included in this figure include imidacloprid, haloxyfop, fluroxypyr, imazapic, metsulfuron-methyl, chlorpyrifop, pendimethalin and trifluralin. Source: (Grant et al., 2017).

Regional trends in water quality

This summary of regional trends in water quality is adapted from Waterhouse et al., 2017b; Grant et al., 2017; and Robillot et al., 2017.

Cape York

- Inshore water quality in Cape York was good in 2015–16. For the individual indicators, chlorophyll *a* was very good, and Secchi depth was moderate.
- Regular in situ water quality monitoring was not conducted in 2015–16, but commenced in 2016–17.

Wet Tropics

- Inshore water quality in the Wet Tropics region was good in 2015–16. For the individual indicators, chlorophyll *a* was very good and Secchi depth was moderate .
- River discharge was below the long-term median. In the three focus regions (Russell-Mulgrave, Tully, Cairns long-term transect), most water quality parameters fluctuated around guideline values, with some exceedances (Table 1).
- Concentrations of PSII herbicides were similar to the low concentrations detected across all sites in 2014–15 and were below those known to have any observable effect on marine plants and animals (Category 5) (Figure 17 and Figure 18).
- In the wet season, biologically relevant concentrations of herbicides were detected in grab samples collected near the Russell-Mulgrave River mouth (Category 3 or 4), and in the vicinity of the Tully River mouth (Category 3).
- In recent years, other emerging pesticides—including ‘alternatives’ to the traditional five priority PSII herbicides—are being increasingly detected in catchments discharging to the Reef (Department of Science, Information Technology and Innovation, 2016). Other herbicides, insecticides and fungicides detected in 2015–16 included 2,4-D, haloxyfop, MCPA, metolachlor, metribuzin, simazine, imidacloprid, tebuconazole and two atrazine metabolites. The region where the greatest number of alternative pesticides were detected was the Wet Tropics. Note that many of these pesticides are not included in the maximum PSII herbicide equivalent calculation and, therefore, the ecological risk from all pesticides would be higher than that reported here.

Table 1: Wet Tropics sites where mean or median concentrations of chlorophyll α , Secchi depth, nitrate/nitrite, particulate phosphorus and total suspended solids did not meet water quality guidelines (grey shading) (Waterhouse et al., 2017b)

Region	Site	Chlorophyll a	Secchi Depth	Nitrate/nitrite	Particulate phosphorus	Total Suspended Solids
Wet Tropics	Cape Tribulation					
	Port Douglas					
	Double					
	Green					
	Yorkey's Knob					
	Fairlead Buoy					
	Fitzroy West					
	RM3					
	High West					
	Russell Mulgrave Mouth Mooring					
	Franklands West					
	Clump Point East					
	Dunk North					
	Dunk South					
	Between Tam O'Shanter and Timana					
	Bedarra					
	Tully Mouth Mooring					

Burdekin

- Inshore water quality in the Burdekin region was good in 2015–16. For the individual indicators, chlorophyll a was very good and Secchi depth was moderate.
- Rainfall in the Burdekin was below the long-term median in 2015–16. However, several water quality parameters exceeded the guidelines at some sites (Table 2).
- Atrazine had the highest concentrations detected at the Barratta Creek site. In total, 18 pesticides (as well as two atrazine metabolites) were detected including 2,4-D, ametryn, bromacil, diuron, fluroxypyr, haloxyfop, hexazinone, MCPA, metolachlor, metribuzin, metsulfuron-methyl, pendimethalin, propazine, simazine, tebuthiuron, imidacloprid and chlorpyrifos.
- The main rainfall event in early 2016 resulted in a maximum PSII herbicide equivalent concentration in the low Category 4 range (Figure 17) in grab samples collected around the Barratta Creek mouth and within the Burdekin River mouth.

Table 2: Burdekin sites where mean or median concentrations of chlorophyll α , Secchi depth, nitrate/nitrite, particulate phosphorus and total suspended solids did not meet water quality guidelines (grey shading) (Waterhouse et al., 2017b)

Region	Site	Chlorophyll a	Secchi Depth	Nitrate/nitrite	Particulate phosphorus	Total Suspended Solids
Burdekin	Palms West					
	Pandora					
	Magnetic					
	Haughton					
	Yongala					
	Burdekin Mouth Mooring					

Mackay Whitsunday

- Inshore water quality in the Mackay Whitsunday region was moderate in 2015–16. For the individual indicators, chlorophyll a and Secchi depth were rated as moderate.
- The combined discharge from all rivers and loads of pollutants were among the lowest over the past 10 years. However, several water quality parameters exceeded the guidelines at some sites (Table 3).
- Diuron had the highest concentrations detected in the region with the exception of Repulse Bay, which was dominated by atrazine (Figure 14). At two of the four sites monitored in 2015–16, the maximum PSII herbicide equivalent concentrations were below those known to have any observable effect on marine plants and animals (Category 5) (Figure 17). However, at Round Top Island and Sandy Creek the maximum PSII herbicide equivalent concentrations detected could inhibit photosynthesis in coral and seagrass (Category 2 and 3, respectively). Concentrations at Round Top Island during 2015–16 were the highest recorded at any site in the last eight years and were associated with relatively high flow events in the Pioneer River and neighbouring catchments, compared to other regions.
- Other pesticides detected included metolachlor, 2,4-D, haloxyfop, MCPA, fluroxypyr, imazapic, metsulfuron-methyl, pendimethalin, trifluralin, imidacloprid and chlorpyrifos. In total, 19 pesticides were detected, 11 of which were not included in the maximum PSII herbicide equivalent calculation.

Table 3: Mackay Whitsunday sites where mean or median concentrations of chlorophyll α , Secchi depth, nitrate/nitrite, particulate phosphorus and total suspended solids did not meet water quality guidelines (grey shading) (Waterhouse et al., 2017b)

Region	Site	Chlorophyll a	Secchi Depth	Nitrate/nitrite	Particulate phosphorus	Total Suspended Solids
Mackay Whitsunday	Double					
	Pine					
	Seaforth					
	Repulse					
	O'Connell Mouth					

Fitzroy

- Inshore water quality in the Fitzroy region was moderate in 2015–16. For the individual indicators, chlorophyll a was rated poor and Secchi depth was moderate.
- Pesticides were monitored only at North Keppel Island and concentrations of PSII herbicides in 2015–16 were below those known to have any observable effect on marine plants and animals (Category 5) (Figure 17). Consistent with previous years, tebuthiuron was the dominant herbicide detected at North Keppel Island. In total, eight pesticides (plus two atrazine metabolites) were detected, three of which were not included in the maximum PSII herbicide equivalent calculation.

Burnett Mary

- Inshore water quality in the Burnett Mary region was good in 2015–16. For the individual indicators, chlorophyll a was good and Secchi depth was moderate.

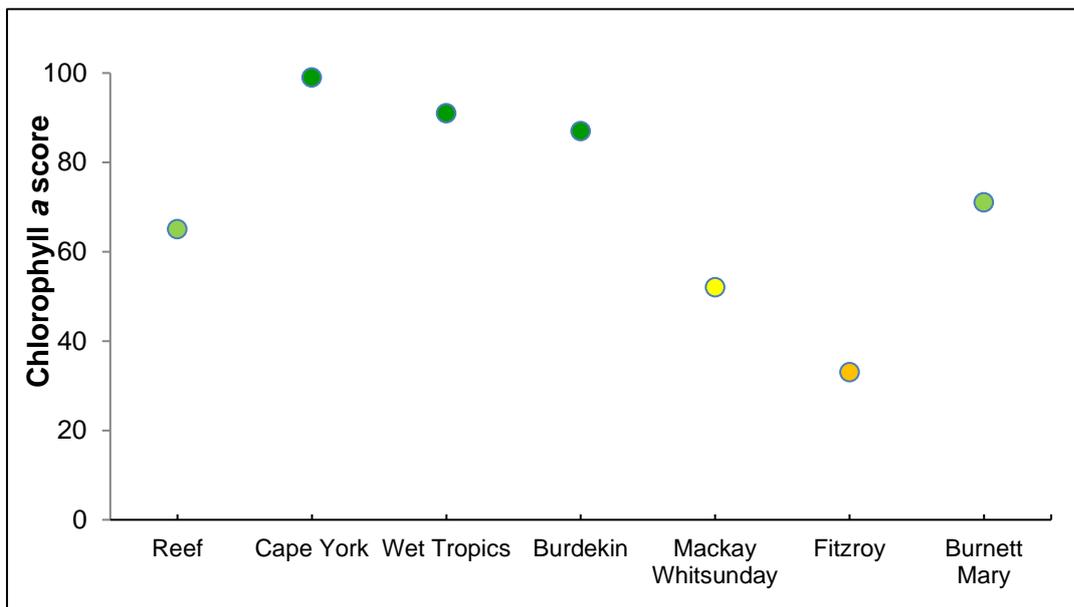
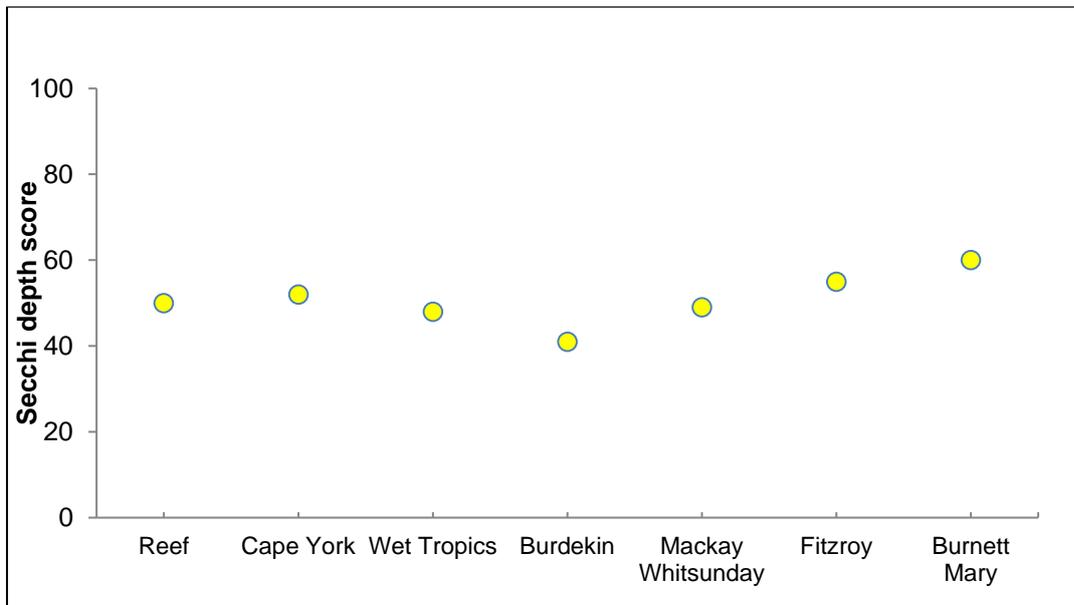


Figure 19: Water quality indicators, Secchi depth (top) and chlorophyll *a* (bottom), for the inshore Great Barrier Reef and NRM regions for 2015–16. Values are indexed scores scaled from 0 to 100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Note: inshore water quality scores are for open coastal waters only. For the Burnett Mary region, only the area in the Marine Park was modelled and scored.

Seagrass

Inshore seagrass condition and trend

This summary is adapted from McKenzie et al., 2017.

The main points for 2015–16 are as follows:

- Overall, the condition of inshore seagrass meadows changed very little. There were small improvements in the Cape York, Mackay Whitsunday, Fitzroy and Burnett Mary regions; however, inshore seagrass condition declined slightly in the Wet Tropics and Burdekin regions (Figure 20).
- Seagrass abundance across the inshore Reef remained moderate, but most regions continued the upward trend in recovery that began in 2013 after widespread losses from multiple years of above-average rainfall, associated flood events and extreme cyclones (Figure 21). Overall, there was a return to more stable foundation communities.
- Reproductive effort declined slightly and remained very poor, fluctuating across regions and habitats (Figure 21). Seed banks showed signs of recovery at some sites, but declined or were variable at others. These results suggest that seagrass resilience has been affected by the multiple floods and cyclones that have occurred since 2009.
- Seagrass leaf tissue nutrients remained poor (C:N reduced), suggesting that insufficient light was available for photosynthesis relative to nutrient availability (Figure 21).
- The overall increase in abundance and the fluctuating scores for other indicators across the Reef indicate a system in a state of recovery, with past climate impacts leaving a legacy of reduced resilience. There are signs that reproductive effort and seed bank density may increase in some regions leading to greater resilience of seagrass meadows, if there are no further disturbances.

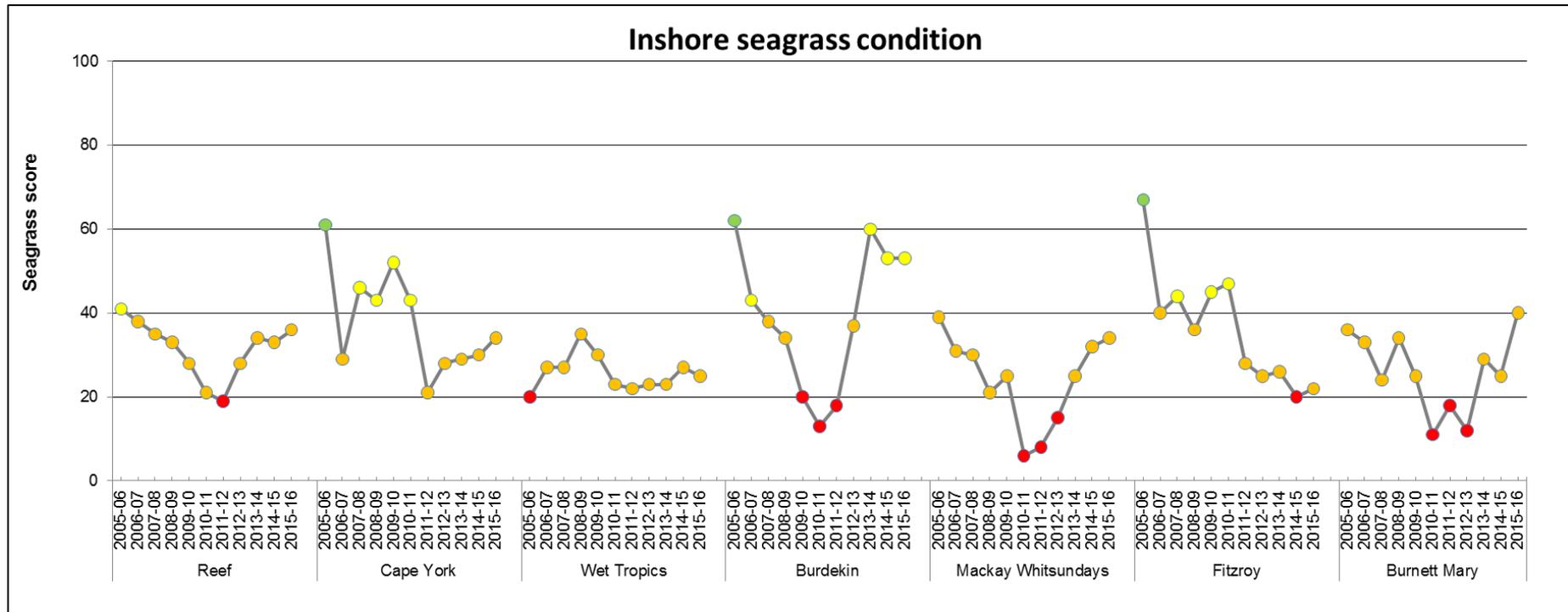


Figure 20: Seagrass condition for the inshore Great Barrier Reef and NRM regions from 2005–06 to 2015–16. The overall score for seagrass condition is the average of the component scores for reproduction, abundance and nutrient status. Values are indexed scores scaled from 0 to 100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Data source: McKenzie et al., 2017

Regional trends in seagrass

This summary is adapted from McKenzie et al., 2017.

Cape York

- Seagrass condition in the Cape York region continued to improve for the fourth year in a row after the low of 2011–12, suggesting seagrass was in a recovery phase. However, the overall condition of seagrass was poor and remained below the 2005–06 Marine Monitoring Program baseline because increases in abundance were offset by the very poor score for reproductive effort and the poor score for nutrient status (Figure 21). Additional seagrass monitoring locations were added in 2012–13, so a more accurate assessment of regional trends will be available in the future (before 2012–13, this region had only one long-term monitored site, Archer Point).
- Seagrass reproductive effort across the region remained very poor in 2015–16, with coastal sites generally having higher seed banks and reproductive effort than reef sites (Figure 21).
- Seagrass leaf tissue nutrients remained largely unchanged (poor) (Figure 21), suggesting seagrass are experiencing sub-optimal light conditions for growth.

Wet Tropics

- Seagrass meadows across the region remained in poor condition and were in a vulnerable state, with limited signs of recovery since the decline in 2010–11 (Figure 21).
- Seagrass abundance increased from very poor to poor in 2015–16 (Figure 21) and was influenced by a complex range of environmental and biological processes.
- Reproductive effort and the number of seed banks remained low at all locations, resulting in a decline in the score for reproductive effort from poor to very poor (Figure 21). The limited capacity for seagrass in this region to recover from seed stock has implications for its resilience to future disturbances—seagrass meadows in the Wet Tropics are considered to be at high risk of further losses.
- Nutrient status remained poor (Figure 21). This indicates that nitrogen potentially exceeds requirements for growth, or that seagrass is limited by low light from high turbidity.

Burdekin

- Seagrass condition remained moderate, which was the highest score for seagrass across all regions in 2015–16 (Figure 21). Seagrass meadows in the Burdekin region have demonstrated high resilience through their capacity to recover from past disturbances. This may reflect a pre-conditioning to disturbance, as seagrass meadows in the region have a high seed-bank density and high species diversity compared to other regions.
- Seagrass abundance remained moderate (Figure 21). Average abundance across all coastal sites was relatively unchanged, while abundance at reef sites declined.
- Reproductive effort increased to moderate in 2015–16 after a poor rating in 2014–15 (Figure 21). The increase in reproductive effort was substantial at coastal sites, leading to an accumulation of seed banks that resulted in the Burdekin region having the highest seedbank density of all regions. Note that reproductive effort is based only on the number of reproductive structures and does not include seed banks.
- Seagrass nutrient status declined to moderate (Figure 21). Exposure from wind-driven sediment resuspension was high close to the coast, which may have affected the amount of light available for seagrass growth.

Mackay Whitsunday

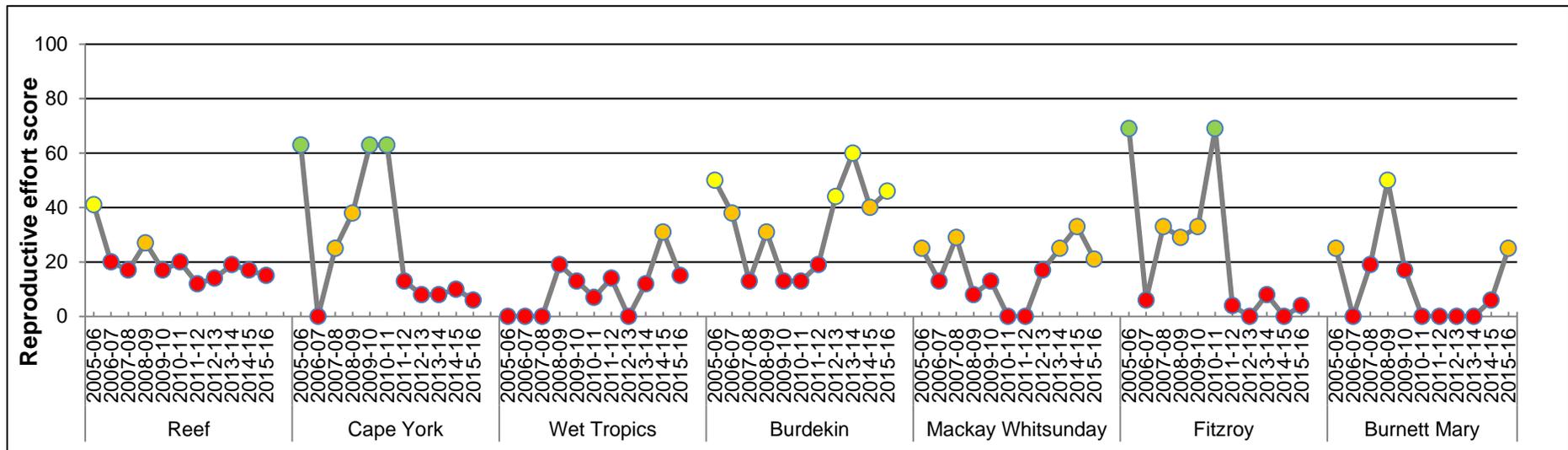
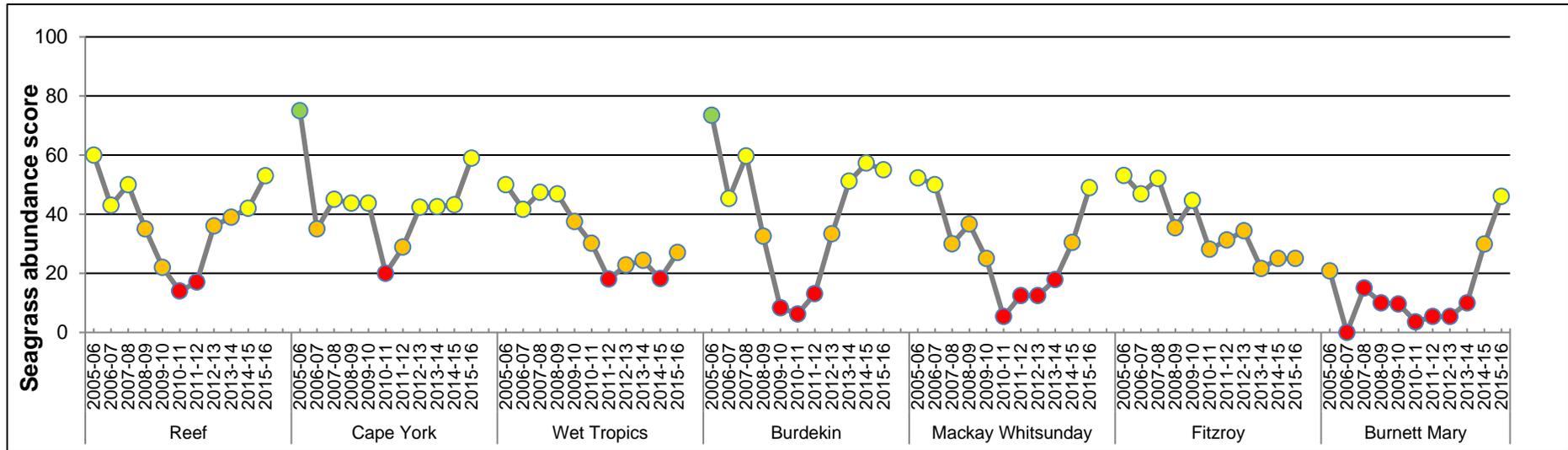
- The overall condition of seagrass continued to improve for the fifth consecutive year, but the index score remained poor (Figure 20). Meadows in the region showed signs of resilience and recovery.
- Seagrass abundance increased at all sites except Hamilton Island (low and stable), resulting in an increase in the score from poor to moderate (Figure 21). This demonstrates rapid recovery over the past two years from very poor abundance in 2013–14.
- Seagrass reproductive effort continued to improve at coastal and estuarine sites, but remained poor overall (Figure 21) due to the low reproductive effort at reef sites. Seed banks also continued to increase at coastal sites and estuarine sites, which may facilitate recovery from future disturbances. Note that reproductive effort is based only on the number of reproductive structures and does not include seed banks.
- Seagrass nutrient status was similar to 2014–15 and remained poor (Figure 21).

Fitzroy

- The condition of seagrass meadows increased from very poor to poor in 2015–16 (Figure 21). Meadows were in the early stages of recovery and remain in a highly vulnerable state following multiple years of climate-related disturbances.
- Seagrass abundance was poor, which was unchanged from 2014–15 (Figure 21).
- Reproductive effort remained very poor, as it has been since 2011–12 (Figure 21). This may indicate that seagrass were using all their resources to maximise vegetative recovery, as seed banks have been stable since 2011.
- Seagrass nutrient status remained poor in 2015–16 (Figure 21), which suggests that light conditions for recovery were sub-optimal.

Burnett Mary

- Seagrass meadows in the Burnett Mary region continued to improve from the very poor condition observed in 2012–13, achieving their best condition in a decade of sampling (Figure 21). However, the overall score remained poor, just below the threshold for moderate.
- Seagrass abundance continued to increase for the second year in a row to moderate, reaching the highest abundance recorded since sampling began (Figure 21). The recent increases in abundance suggest that these meadows are recovering well following many years of poor environmental conditions (cyclones and turbid water).
- Reproductive effort increased from the previous year, improving from very poor to poor (Figure 21). Seed banks remained stable, but low.
- Seagrass nutrient status increased from poor in 2014–15 to moderate in 2015–16 (Figure 21). This, combined with other changes, suggest water quality conditions were improving for seagrass growth.



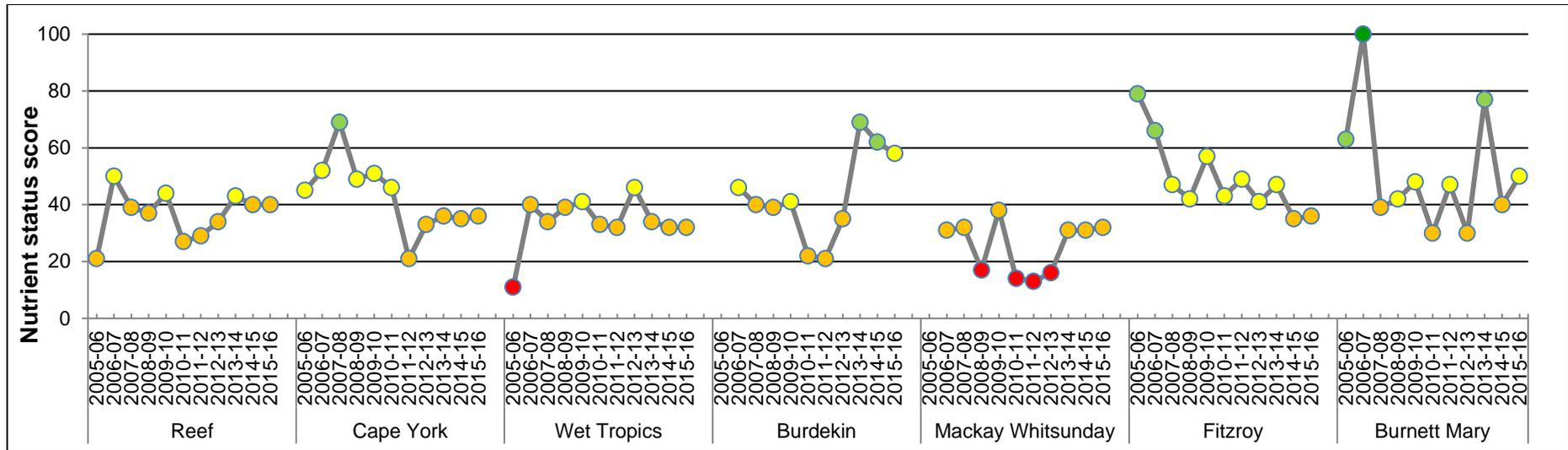


Figure 21: Trends in seagrass indicators, abundance (top), reproduction (middle), nutrient status (bottom), for the inshore Great Barrier Reef and NRM regions from 2005–06 to 2015–16. Values are indexed scores scaled from 0 to 100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Data source: McKenzie et al., 2017

Coral

Inshore coral condition and trend

This summary is adapted from Thompson et al., 2017.

The main points for 2015–16 are as follows:

- Coral condition across the entire inshore Reef was rated as moderate in 2015–16 and continued to improve since the lowest condition score in 2012. The improvement occurred despite the 2016 bleaching event and indicates a degree of resilience in inshore coral communities. Coral condition increased slightly to remain moderate in the Wet Tropics region, and increased from poor to moderate in the Burdekin region (Figure 22). In the Mackay Whitsunday region, coral condition improved from moderate to good, while in the Fitzroy it increased slightly, but remained poor. The scores for coral condition were mainly driven by changes in the indicators for coral cover, coral change and coral community composition.
- Coral cover increased in all regions, but the condition assessments remained the same as in 2014–15 (Figure 23).
- Scores for coral change increased in all regions. In the Wet Tropics, coral change increased from moderate to good; in the Burdekin coral change increased from poor to moderate; and in the Mackay Whitsundays and Fitzroy regions, coral change remained poor (Figure 23).
- Scores for the density of juvenile corals were relatively stable, remaining moderate in the Wet Tropics and Burdekin regions. There was a small increase in scores for juvenile coral density in both the Mackay Whitsunday and Fitzroy regions, which improved from moderate to good and very poor to poor, respectively (Figure 23).
- Macroalgae cover remained relatively stable across all regions and regional scores for 2015–16 were the same as for 2014–15 (Figure 23).
- Coral community composition improved and remained moderate in all regions except Fitzroy where the coral community was characterised by a lack of sensitive species, resulting in a poor score (Figure 23).

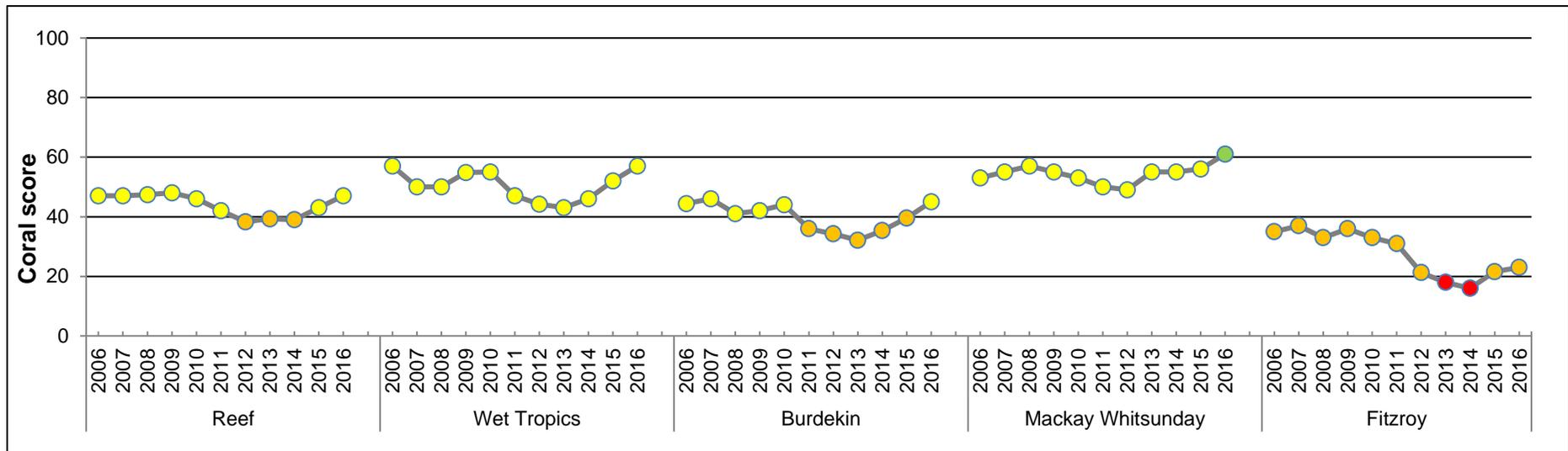


Figure 22: Coral condition scores for the inshore Great Barrier Reef and NRM regions from 2006 to 2016. Values are indexed scores scaled from 0 to 100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Data source: Thompson et al., 2017 Note: The 2015–16 data was collected before the 2017 coral bleaching events and does not represent the condition at time of publication.

Regional trends

This summary is adapted from Thompson et al., 2017.

Wet Tropics

- Coral condition continued to increase for the third consecutive year from the low condition recorded in 2013, and scores were at the upper range of moderate (Figure 22).
- Coral cover increased but remained moderate, while the indicator for coral change increased to good (Figure 23). The steady improvements in coral cover and coral change over the past two years coincided with low river discharge and a lack of acute disturbances.
- Juvenile density remained stable, in moderate condition.
- Regionally, macroalgae remained low and had reduced in some areas.
- Community composition remained moderate.

Burdekin

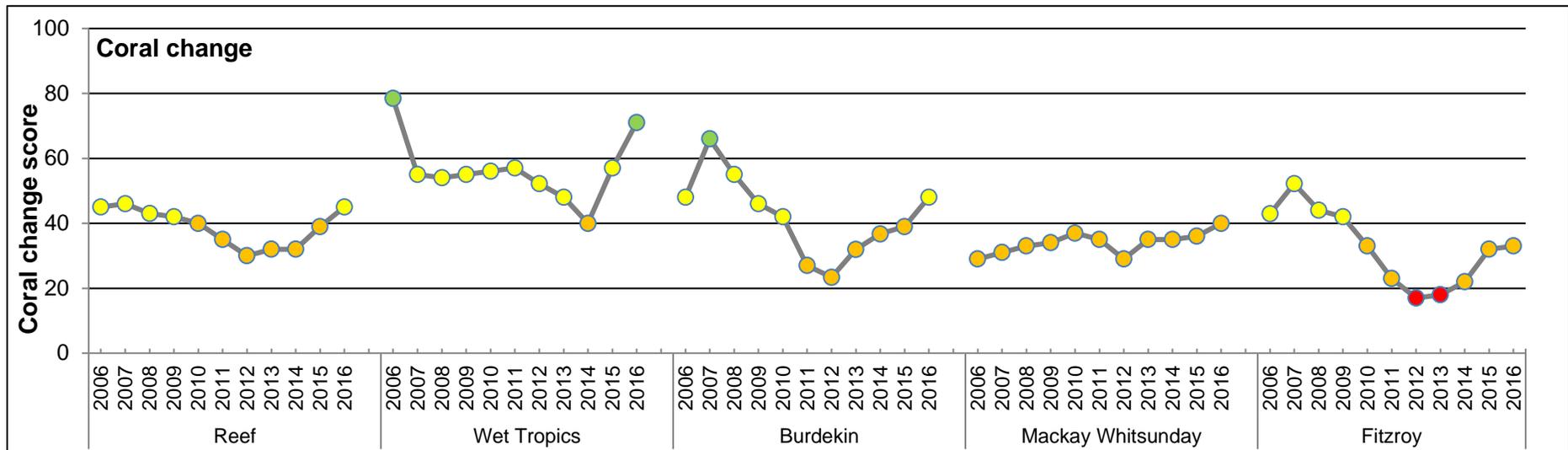
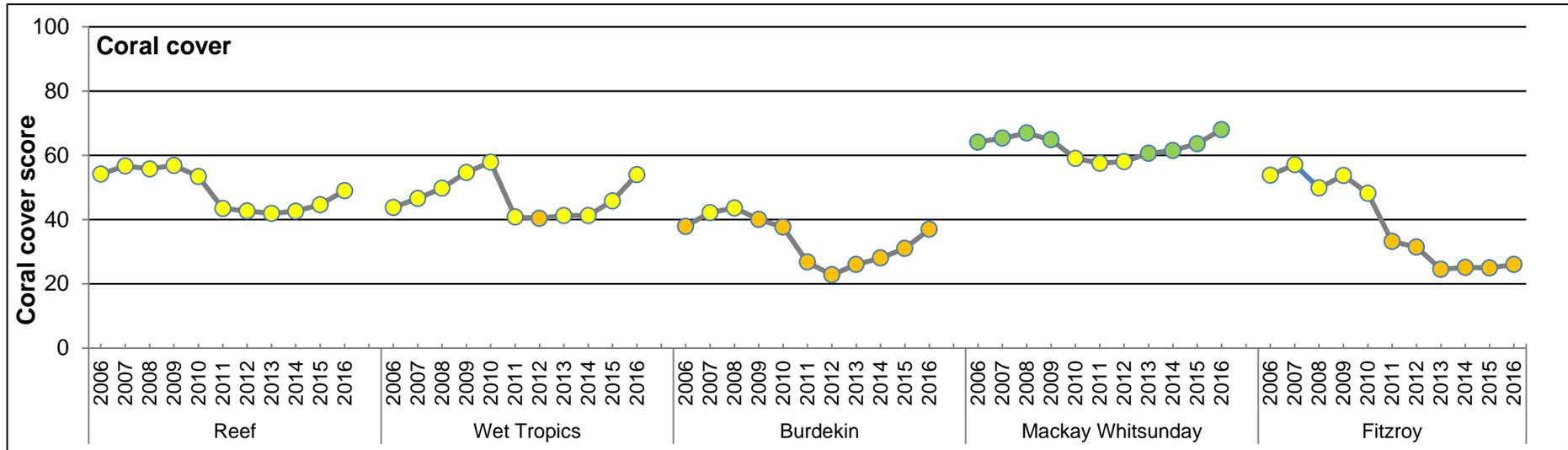
- Coral condition improved from poor to moderate in 2015–16.
- Coral cover and coral change both increased for the fourth consecutive year, with coral cover still in poor condition and coral change increasing to moderate (Figure 23). The steady improvements in coral cover and coral change over the last four years indicate coral communities in this region are inherently resilient.
- There have been slight improvements in the density of juvenile corals, along with a gradual return of sensitive species. Indicators for both juvenile coral density and community composition were at the upper range of moderate (Figure 23).
- The only indicator that did not improve was the proportion of macroalgae. Macroalgae maintained a dominant presence at most locations, indicating the availability of nutrients and light.

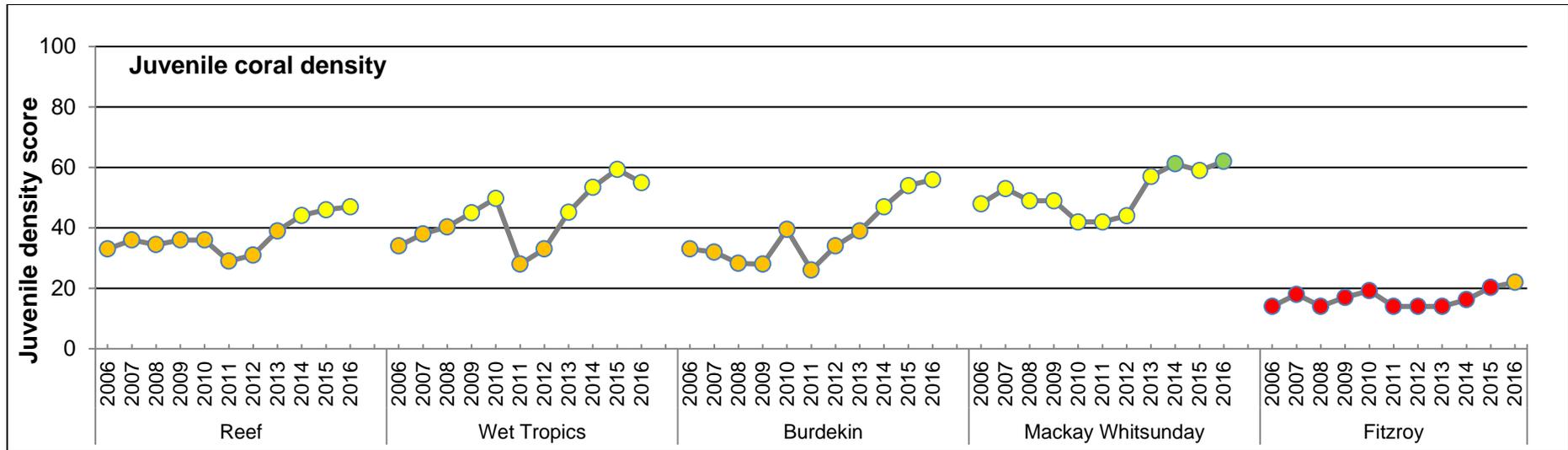
Mackay Whitsunday

- The score for coral condition in the Mackay Whitsunday region was the highest of all regions monitored in the Reef. After being relatively stable for the two preceding years, there was a slight improvement in 2016 from moderate to good, resulting in the highest rating since monitoring began in 2006 (Figure 22).
- The majority of coral health indicators increased in 2015–16. There were moderate to high levels of coral cover, increasing densities of juvenile corals, increasing presence of species sensitive to water quality, and a low, but improving, rate of coral cover change (Figure 23).
- The cover of macroalgae remained consistently low, being absent from most reefs in the region.

Fitzroy

- The score for coral condition in the Fitzroy region remained poor; however, it has improved from very poor in 2014 (Figure 22). A small increase in the rate of change in coral cover demonstrated that the coral communities are beginning to recover following a period multiple disturbances.
- Most indicators of coral condition (coral cover, coral change and coral community composition) remained stable, but in poor condition. Juvenile density showed slight improvements from very poor to poor, and macroalgae remained very poor, showing no sign of decline this year (Figure 23).





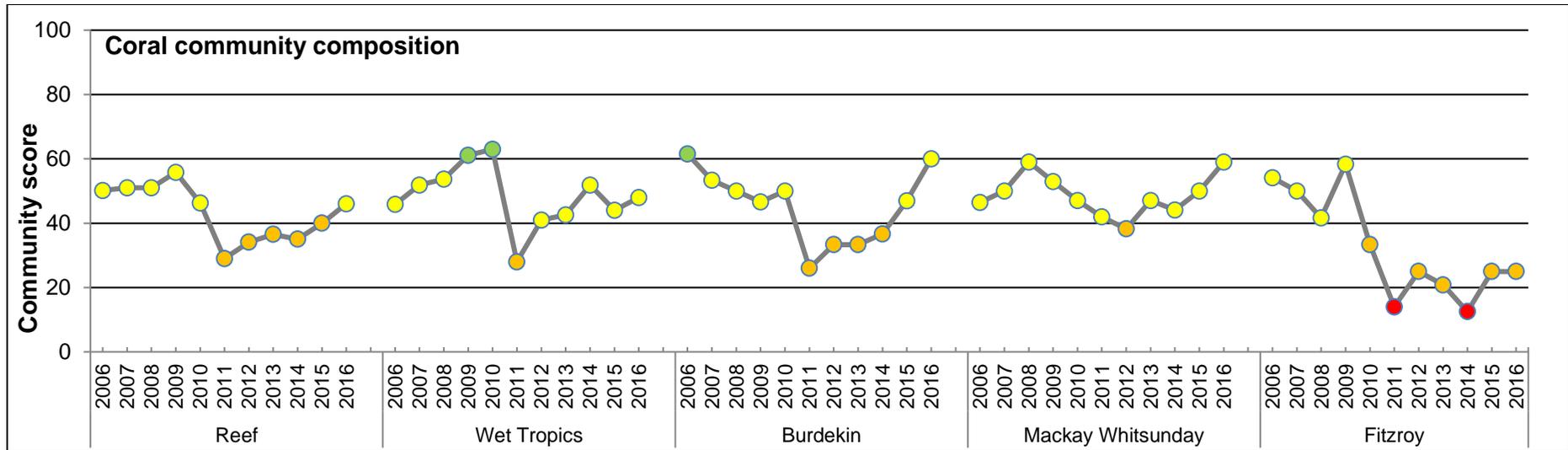


Figure 23: Trends in coral indicators (from top to bottom: coral cover, coral change, juvenile density, macroalgal cover, community composition) for the inshore Great Barrier Reef and NRM regions from 2006 to 2016. The overall score for Great Barrier Reef is the average of the component scores for the Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy regions. Monitoring data from the Marine Monitoring Program and the Australian Institute of Marine Science Long-term Monitoring Program is included. The coral change indicator is calculated as the average rate of increase in coral cover compared to modelled predictions over the preceding four years. Note that the time series for coral has been recalculated and trend graphs in previous Reef report cards are not comparable. Values are indexed scores scaled from 0 to 100; ■ = very good (81–100), ■ = good (61–80), ■ = moderate (41–60), ■ = poor (21–40), ■ = very poor (0–20). Note: Scores are unitless. Data source: Thompson et al., 2017

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