Great Barrier Reef

Report Card 2011

Reef Water Quality Protection Plan

Marine results

Australian Government

Queensland Government

Disturbances affecting the reef

The health and resilience of the reef is affected by a range of short-term and long-term disturbances including:

- floods
- cyclones
- elevated sea surface temperatures
- crown-of-thorns starfish outbreaks
- pollutant loads.

The impact of disturbances on the reef depends on their frequency, duration and severity as well as the state of the ecosystem (Fabricius 2005; Osborne et al., 2011). Multiple disturbances may have a combined negative effect on reef resilience that is greater than the effect of each disturbance in isolation. Between 2009 and 2011, repeated floods and cyclones had a considerable impact on the water quality and ecosystem status of the inshore area of the Great Barrier Reef.

Floods

The summer of 2010-2011 was the second wettest on record in Australia. This extreme weather caused flooding in several catchments and much higher than normal discharge from most rivers. A large expanse of the inshore reef south of Mackay was exposed to persistent flood plumes from the Fitzroy, Burnett and Mary Rivers.

Catchment runoff entering the Great Barrier Reef lagoon, north of Mossman. Photo: courtesy Queensland Government Department of Agriculture, Fisheries and Forestry.

La Niña caused significant rainfall events across Queensland during 2010-2011 which led to greater overall freshwater discharge to the reef. This was primarily due to high flows from the Burdekin, Fitzroy, Burnett and Mary Rivers and all rivers in the Mackay Whitsunday region. Discharges from most rivers in the Wet Tropics and Cape York regions were also at least 1.5 times their annual median flow. This is the fifth consecutive year where the overall freshwater discharge from all rivers has been greater than the long-term annual median. For example, in the 2010-2011 wet season, flows from the Fitzroy and Proserpine Rivers were the largest on record and discharge from the Herbert River was comparable to the record flood in 1994.

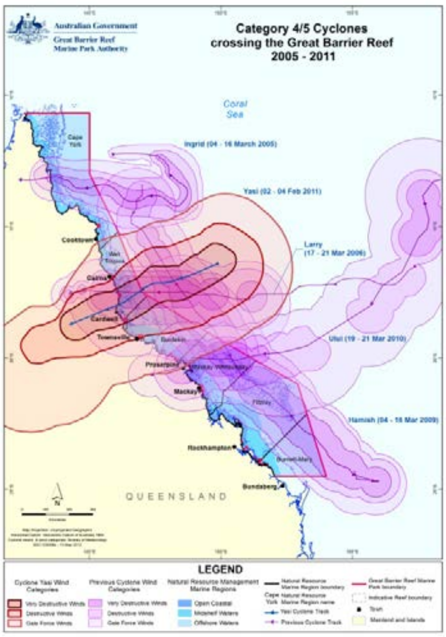
The influence of flood plumes on the marine environment depends on the volume and duration of river flows, the influence of wind direction and velocity, local currents and tidal regimes. Flood plumes had an impact on inshore areas along the Queensland coast. The southern section of the Great Barrier Reef Marine Park in particular was exposed to large volumes of low salinity flood waters for an extended period which is likely to have contributed to localised coral bleaching on shallow, inshore reefs in the area (refer to coral bleaching section).

In addition to large volumes of freshwater, wet season floods deliver the majority of annual loads of nutrients, sediments and herbicides to the reef lagoon. In 2010-2011, concentrations of herbicides in flood plumes sometimes exceeded those known to have a negative effect on coral and seagrass (Haynes et al., 2000b, Jones and Kerswell, 2003, Magnusson et al., 2010). Regions with a high probability of exposure to elevated concentrations of dissolved inorganic nitrogen and suspended solids were the Wet Tropics, Burdekin and Mackay Whitsunday regions, respectively.

Cyclones

Three tropical cyclones had an impact on the reef in 2010-2011. Cyclone Tasha (category 1) crossed the coast near Innisfail and caused large-scale flooding in the Burnett, Fitzroy and Burdekin Rivers. Cyclone Anthony (category 2) passed through the Burdekin region and was closely followed by Cyclone Yasi (category 5) which crossed the coast near Cardwell in early February 2011. About 13 per cent of the reef, from Cairns to Townsville, was exposed to Yasi's destructive or very destructive winds. The affected area represents a 300 km stretch of the 2400 km-long Reef, however the influence of Yasi extended beyond the destructive wind band with damage also occurring south of Townsville. Cyclones may cause extreme physical damage to reef structure.

Since 2005, many areas of the Reef, including the inshore area, have been affected by category 4 or 5 cyclones. The combined paths of these cyclones have exposed 3889 reefs (80 per cent of the Great Barrier Reef Marine Park) to gale force winds or above. Most of the affected reefs were outside the inshore area, which is a relatively small proportion of the whole Great Barrier Reef Marine Park (7.8 per cent). Recent estimates attribute 34% of total coral mortality recorded between 1995 and 2009 to cyclones and storms (Osborne et al., 2011).



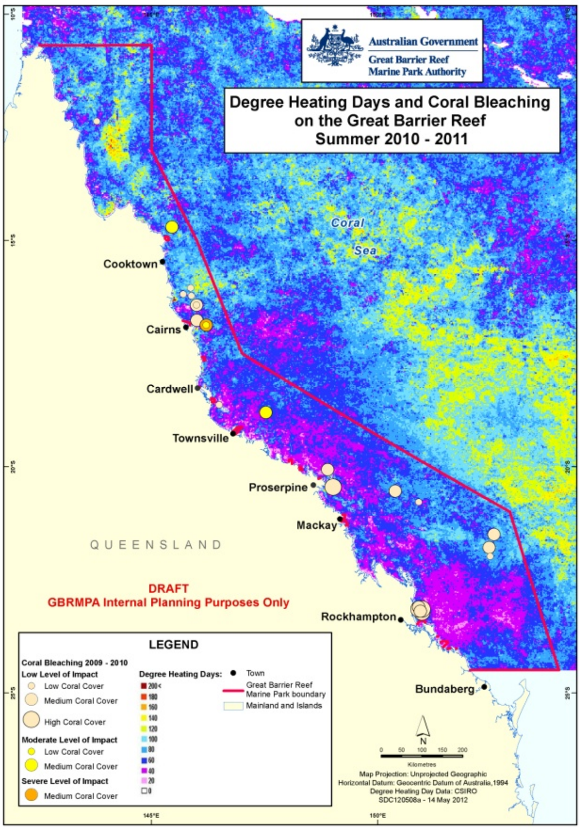
Extent of the Great Barrier Reef impacted by Category 4 or 5 cyclones in the six year period 2005-2011. Map: courtesy of the Spatial Data Centre, Great Barrier Reef Marine Park Authority.

Elevated sea surface temperatures

Coral bleaching commonly occurs when accumulated temperature stress, measured as degree heating days over the summer months, exceeds a threshold of about 60 to 100 degree heating days (Maynard, J.A. 2009). An increase in the long-term average temperature of reef waters is narrowing the gap between a regular summer and a coral bleaching season. For example, the frequency of mass bleaching events has increased over the last two decades, corresponding to higher seawater temperatures. Major coral bleaching events caused by unusually warm water temperatures were not recorded in the Great Barrier Reef Marine Park before a major episode in 1998 that was part of a global event. Similar conditions returned in 2002 and to a lesser extent in 2006. Prolonged exposure to elevated seawater temperatures may increase the susceptibility of corals to disease (Bruno, J.F. 2007).

Degree heating days are a measure of only one potential stress. Coral bleaching may also occur in response to other stressors, such as water that is too cold or too fresh as occurs after floods, poor water quality and exposure to certain chemicals.

In 2010-2011, sea surface temperatures around Australia were the highest on record (Bureau of Meteorology 2010). However, summer conditions on the reef were influenced by a series of extreme weather events including monsoonal cloud cover, rainfall and cyclonic activity which collectively minimised the build-up of heat stress. Coral bleaching across the reef was low to moderate. Most of the bleached areas were in the central and southern sections of the Great Barrier Reef Marine Park following Cyclone Yasi and exposure to large volumes of freshwater, respectively.

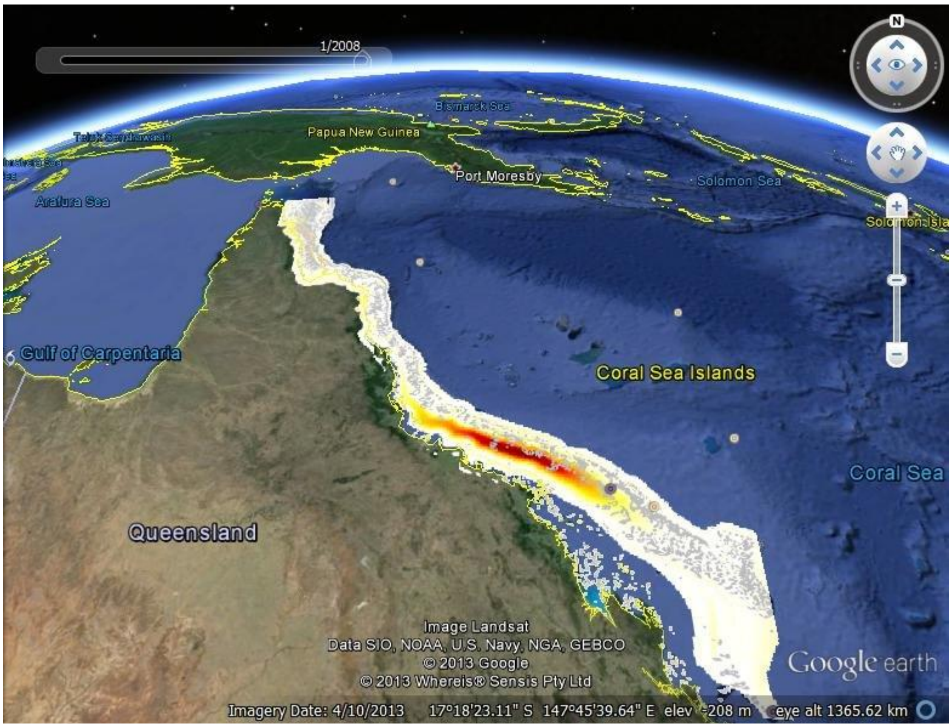


Water temperature as degree heating days and areas where coral bleaching occurred.

Crown-of-thorns starfish

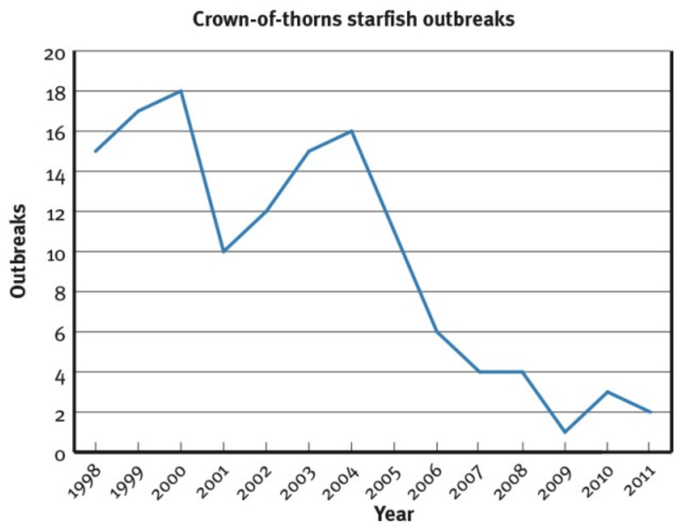
Most of the crown-of-thorns starfish monitoring in the reef is conducted by the Australian Institute of Marine Science as part of the Long Term (Reef) Monitoring Program. An active outbreak of crown-of-thorns starfish is when densities are such that the starfish consume coral tissue faster than the corals can grow. This is generally considered to be densities greater than about 30 starfish per hectare (Engelhardt et al., 1997; Sweatman et al., 2008).

Most outbreaks occur on midshelf reefs, beginning along the narrow northern shelf between Cairns and Lizard Island and then moving to southern reefs as larvae are transported by the East Australian Current. The Swains Reefs in the Fitzroy region have had low-level chronic infestations throughout most of the past three decades explained by the high density of reefs in this region and the regional oceanography.



Google Earth shows recent crown-of-thorns starfish densities
(http://e-atlas.org.au/sites/default/files/datasetdetails/large-scale-manta-tow-surveys-densities-crown-thorns-starfish-and-benthic-cover-aims-ltmp-100/cots-outbreaks.kmz).

In 2010-2011, few outbreaks of crown-of-thorns starfish were detected on the northern reefs despite evidence of feeding scars on some reefs. This is because young starfish hide in the reef interior for the first two years emerging only to feed at night. The situation in 2010-2011 is consistent with a new cycle of crown-of-thorns starfish outbreaks on the Great Barrier Reef caused by severe floods in 2009.



Crown-of-thorns starfish have had a major impact on the reef with a recent analysis of long-term monitoring data showing the starfish has been responsible for more than 40 per cent of the decline in coral cover since 1985. The increasing incidence of crown-of-thorns starfish in recent decades may be linked to enhanced survival of larvae from nutrient-rich flood waters and increased availability of phytoplankton as a food source (Brodie, J. 2005; Fabricius, K.E. 2011). However, a reduction in predator populations has also been suggested as outbreaks are lower in zones closed to fishing (Osborne, K. 2011). The high discharges from most rivers draining into the Great Barrier Reef lagoon in 2010-2011 created conditions likely to trigger additional outbreaks to the ones started by the 2009 floods.

Influence of climate change

The frequency and intensity of disturbances to the reef is set to increase under future climate change scenarios (Hoegh-Gulberg et al., 2007). The average annual seawater temperature on the reef is likely to rise by one to three degrees Celsius by 2100 (Intergovernmental Panel on Climate Change 2007; Garnaut 2008). It is also predicted that reef waters will become more acidic, sea levels will continue to rise, patterns of ocean circulation will change and weather events will become more extreme (Intergovernmental Panel on Climate Change 2007). The Outlook Report (GBRMPA 2009a) assessed the overall outlook for the reef to be 'poor' and reported that "catastrophic damage to the ecosystem may not be averted".

The extent and persistence of damage to the reef will largely depend on the rate and magnitude of change in the world's climate and on the resilience of the reef ecosystem (GBRMPA 2009a). The future is not easily forecast, but there is strong evidence that halting and reversing the decline of water quality in the Great Barrier Reef lagoon will increase the natural resilience of Great Barrier Reef ecosystems to future challenges.

Pollutant loads

The reef receives runoff from 35 major catchments which drain 424,000 square kilometres of coastal Queensland. The reef region is relatively sparsely populated; however, there have been extensive changes in land-use since European settlement driven by increased urban, agricultural and industrial development particularly in areas adjacent to the coast (Furnas, M. 2003; Hutchings, P. 2005). Unfortunately, the combination of expanding catchment development and modification of land-use has resulted in a significant decline in the quality of water flowing into the reef lagoon over the past 150 years (Moss, A.J. 1992; Neil, D.T. 2002; Furnas, M. 2003; McCulloch, M. 2003). Flood events in the wet season deliver low salinity waters and loads of nutrients, sediments and pesticides from the adjacent catchments into the reef lagoon that are well above natural levels and many times higher than in non-flood waters (Department of the Premier and Cabinet 2009). Pesticides, which are manufactured chemicals with no natural level, are now widespread in Great Barrier Reef waters.

Numerous studies have shown that nutrient enrichment, turbidity, sedimentation and pesticides all affect the resilience of the reef ecosystem, degrading coral reefs and seagrass meadows at local and regional scales (Department of the Premier and Cabinet 2008; Waycott, M. 2010; Fabricius, K.E. 2011). Pollutants may also interact to have a combined negative effect on reef resilience that is greater than the effect of each pollutant in isolation. For example, the reduced light and excess nutrients found in turbid flood plumes combine to increase the level of stress on seagrasses, and differences in tolerance between species of adult coral to nutrient enrichment and sedimentation can lead to changes in community composition (Collier, C. 2009; van Dam, J.W. 2012; Fabricius, K.E. 2005; Fabricius, K.E. 2011).

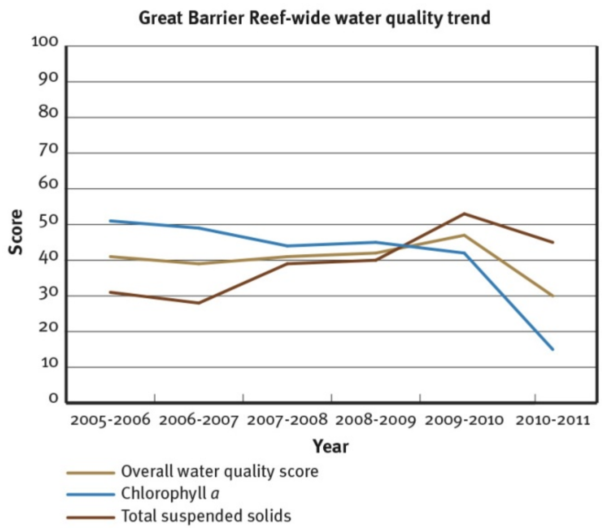
Generally, reef ecosystems decline in species richness and diversity along a gradient from outer reefs distant from terrestrial inputs to near-shore coastal reefs more frequently exposed to flood waters (Cooper, T. 2007; Fabricius, K.E. 2011). The area at highest risk from degraded water quality is the inshore area which makes up approximately eight per cent of the Great Barrier Reef Marine Park within 20 kilometres of the shore. The inshore area supports significant ecological communities and is also the area of the reef most utilised by recreational visitors, commercial tourism operators and commercial fishers.

Great Barrier Reef-wide

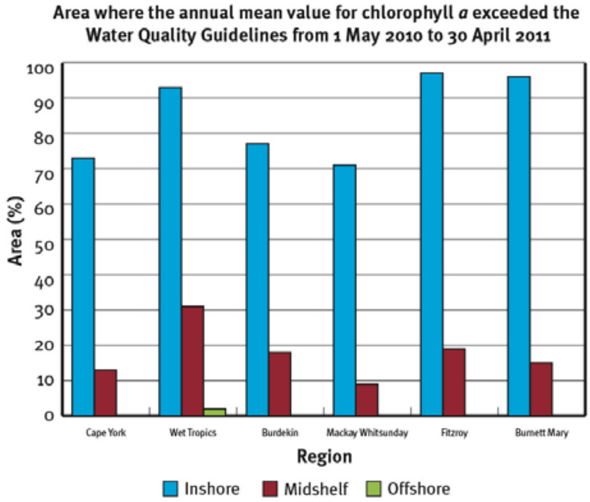
The overall condition of the reef in 2010-2011 declined from moderate to poor. Inshore water quality was poor overall and varied from moderate to poor depending on the region. Inshore seagrass was in very poor condition overall, and its condition has continued to decline since 2006-2007. Inshore coral reefs were in poor condition overall with some sites in the Wet Tropics and Mackay Whitsundays in moderate condition. The primary reason for this was the extreme weather which occurred during 2010-2011. Herbicides were detected at all inshore sites in the Great Barrier Reef in 2010-2011 with pronounced variation between regions and seasons.

Water quality

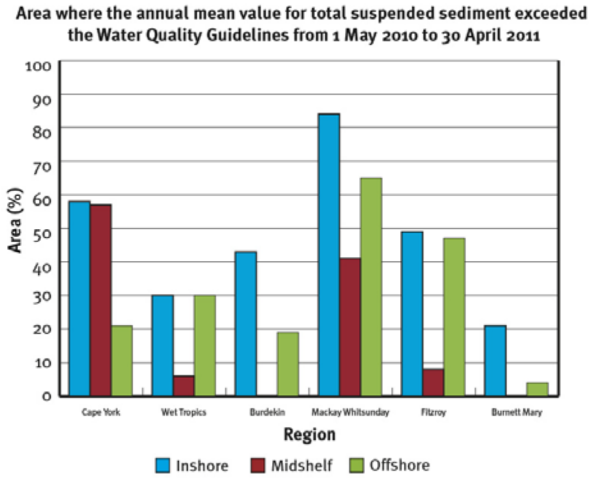
Inshore water quality declined from moderate to poor overall which reflects freshwater discharge that was more than five times the annual median flow for the reef. The decline in water quality is a departure from the trend for most years since 2005-2006. Concentrations of chlorophyll *a* and total suspended solids were very poor and moderate overall.



In 2010-2011, remote sensing of water quality showed a clear gradient of declining water quality from offshore areas to inshore areas more frequently exposed to flood waters. The inshore area of all regions had annual mean chlorophyll *a* concentrations that exceeded the Great Barrier Reef Water Quality Guidelines with some areas approaching close to 100 per cent exceedance (Great Barrier Reef Marine Park Authority 2010). While some exceedance of the guidelines is expected in the wet season, water quality was at its lowest level since monitoring began in 2005. In Cape York and Mackay Whitsunday, water quality was influenced by a high annual mean concentration of total suspended sediment that exceeded the guidelines (Great Barrier Reef Marine Park Authority 2010). The relatively high concentrations of total suspended sediment in most areas of Mackay Whitsunday may be a result of elevated river discharge since 2007 and continued re-suspension of finer sediment particles by wind and wave action. Regions where the guidelines (Great Barrier Reef Marine Park Authority 2010) were exceeded had water quality scores that ranged from moderate to poor.



Relative area (%) of the inshore and midshelf water bodies where the annual mean value for chlorophyll a exceeded the Water Quality Guidelines from 1 May 2010 to 30 April 2011.



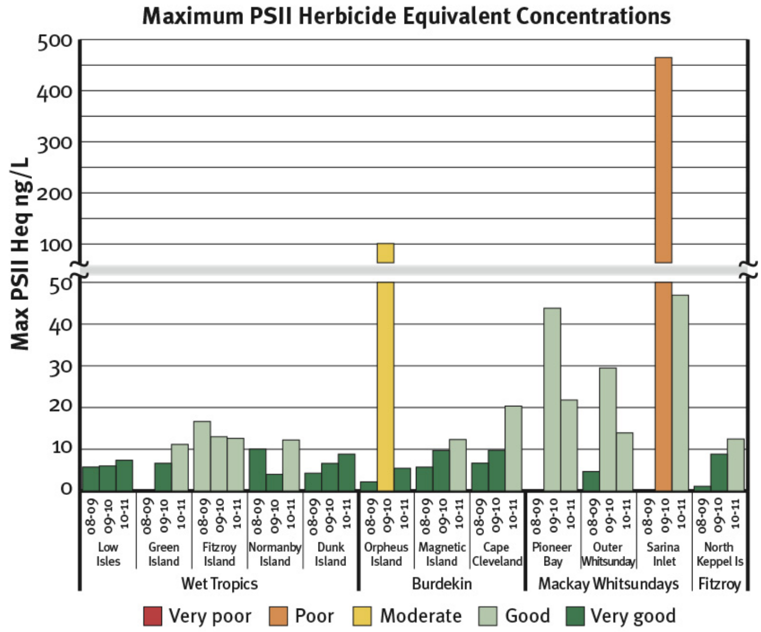
Relative area (%) of the inshore, midshelf and offshore water bodies where the annual mean value for total suspended sediment exceeded the Water Quality Guidelines from 1 May 2010 to 30 April 2011.

Pesticides

Herbicides were detected at all sites in 2010-2011 with high variability between regions and seasons. High photosystem II inhibiting (PSII) herbicide equivalent concentrations generally coincided with periods of high flow from the major rivers in the wet season. Biologically relevant concentrations of PSII herbicides (Category 4) were present at most sites in the Wet Tropics, Burdekin, Mackay Whitsundays and Fitzroy regions.

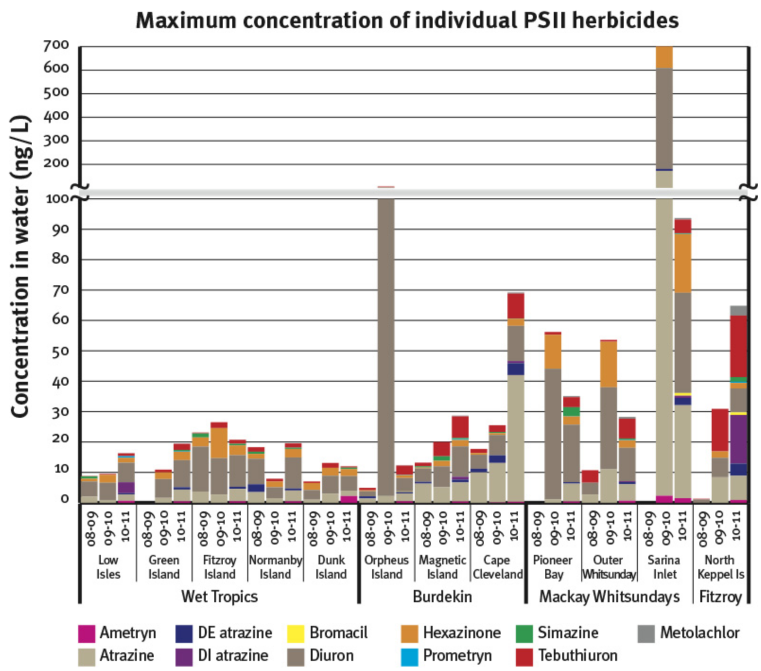
The PSII herbicide equivalent concentration incorporates both the relative potency and relative abundance of individual PSII herbicides compared to a reference PSII herbicide, diuron. The highest PSII herbicide equivalent concentrations detected in 2010-2011 were in the Mackay Whitsunday region in areas with seagrass meadows and inshore coral reefs nearby.

There is evidence of an increasing trend in PSII herbicide equivalent concentrations since monitoring began in 2005, with Category 4 or greater levels detected at the majority of routine monitoring sites in 2010-2011.



Maximum PSII herbicide equivalent concentrations at all sites monitored in the reef in 2010-2011.

Herbicide equivalent concentrations provide a single reporting parameter for PSII herbicides with a similar mode of action; however, they may obscure differences in the abundance of individual herbicides detected in different regions because herbicide equivalent concentrations also consider the potency of each herbicide. The type of pesticides detected in each region is often related to the land management activities in adjacent catchments. The most prevalent herbicide detected across the reef was diuron which dominated the PSII herbicide equivalent index. Atrazine, tebuthiuron and hexazinone were also frequently detected (Kennedy, K. 2012) and tebuthiuron was the only PSII herbicide that exceeded the Great Barrier Reef Water Quality Guidelines at a routine monitoring site at North Keppel Island in the Fitzroy region.

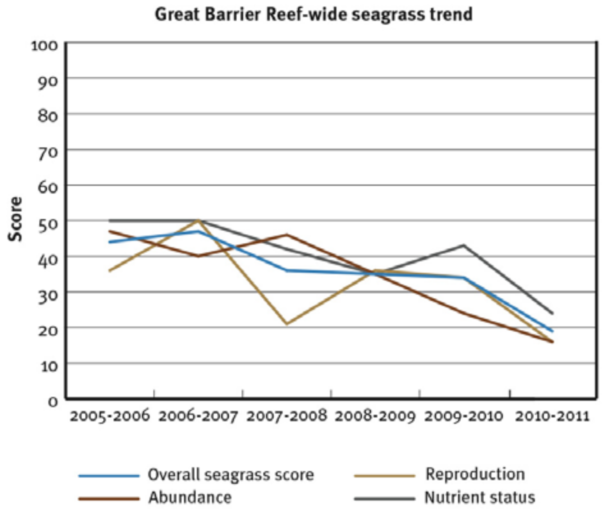


Maximum concentration of individual PSII herbicides at all sites monitored across the reef in 2010-2011 compared to the previous two years.

Samples collected in flood plumes had levels of tebuthiuron and metolachlor that met or exceeded the Great Barrier Reef Water Quality Guidelines and the ANZECC and ARMCANZ Interim Working Level for marine waters, respectively, at multiple sites in the Burdekin and the Fitzroy regions. A range of other pesticides were present including the insecticide imidacloprid which was detected in flood waters in the Fitzroy and Wet Tropics regions.

Seagrass

The overall condition of inshore seagrass meadows in 2010-2011 declined from poor to very poor and has been declining since 2006-2007. Seagrass abundance and reproductive effort were very poor, while nutrient status was poor. However, there are differences between habitats and regions over time (refer to regional sections).

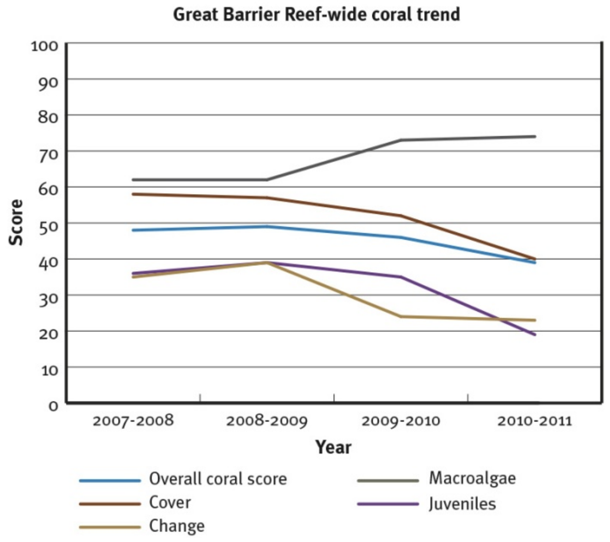


In 2010-2011, the abundance of intertidal seagrasses declined to very poor at most locations from Cairns to the southern reef. However, abundance was moderate at some sites in the northern Wet Tropics and Fitzroy regions. The impact of the flooding reversed any signs of recovery in abundance noted in 2009-2010. The regions of greatest concern for seagrass are the Burdekin, Mackay Whitsunday and Burnett Mary where a decline in abundance was accompanied by very poor reproductive effort, which may result in reduced capacity of local meadows to recover from environmental disturbances.

Seagrass abundance differed according to habitat type. The greatest fluctuations occurred in estuarine habitats, most often in response to prevailing climatic conditions but also with localised weather events such as pulses of nutrient-rich, sediment-laden flood waters and cyclonic activity. Seagrass abundance in coastal habitats has been relatively stable over the past decade however, there are signs of a continual decline since 2009. Abundance at inshore reef habitats appears to have been in a constant state of decline since monitoring began in 2005-2006. Increases in the nutrient content of seagrass tissue across all habitats reflected local declines in water quality. Further information on seagrass abundance is presented in the regional sections.

Coral

Inshore coral reefs declined to poor condition overall in 2010-2011 and the level of cover from competing macroalgae was good. The density of hard coral juveniles and the rate of change in coral cover were poor overall. However, there are differences between regions over time (refer to regional sections).



Results for the cover of hard corals, macroalgae and density of hard coral juveniles are shown in the relevant regional section.

Coral cover declined in all regions to the lowest point since surveys began in 2005 due to a combination of impacts associated with tropical cyclones and broad-scale flooding. In all regions, the incidence of coral disease increased proportionally with the discharge of local rivers. The associated increase in turbidity and the proportion of fine-grained sediments is likely to have had a negative impact on coral growth and recruitment by smothering and limiting the amount of available light.

The density of juveniles declined from 2005 to 2011 in all regions except the Fitzroy where densities remained stable. Overall, Cyclone Yasi had a negative impact on juvenile densities with the largest declines on reefs in the Wet Tropics where juvenile density in 2010-2011 was 65 per cent lower on average. In the Burdekin and Mackay Whitsunday regions, declines in juvenile densities co-occurred with high turbidity from above-median river discharge.

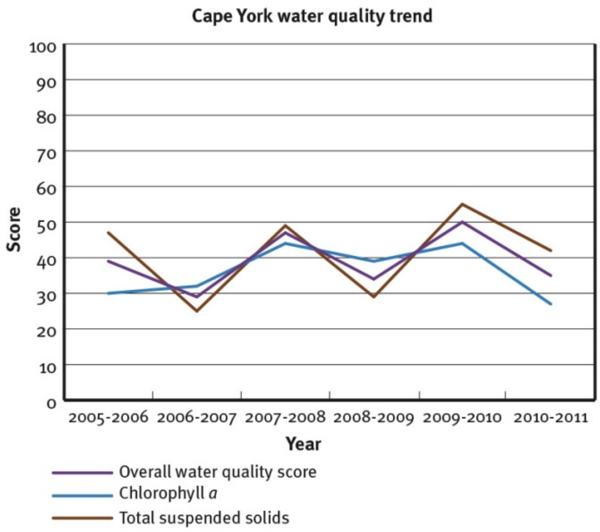
The relatively low cover of hard coral coupled with a decline in the density of juvenile colonies may indicate a lack of resilience of coral communities at many inshore reefs. Acute disturbances in combination with periods of elevated stress from poor water quality are driving changes in the composition and condition of inshore coral reefs.

Cape York

The marine condition in Cape York was poor. Inshore water quality was poor and the one southern seagrass bed monitored was in moderate condition. No coral monitoring occurs in the Cape York region under the Marine Monitoring Program; however some sites are monitored in the southern section by the Australian Institute of Marine Science as part of the Long Term (Reef) Monitoring Program. No herbicides were detected in 2010-2011.

Water quality

Inshore water quality in Cape York is poor overall and has varied from poor to moderate since 2005-2006 showing no clear correlation with high freshwater discharges. The two water quality indicators, chlorophyll *a* and suspended solids, have also varied similarly over time and were poor and moderate, respectively, in 2010-2011.



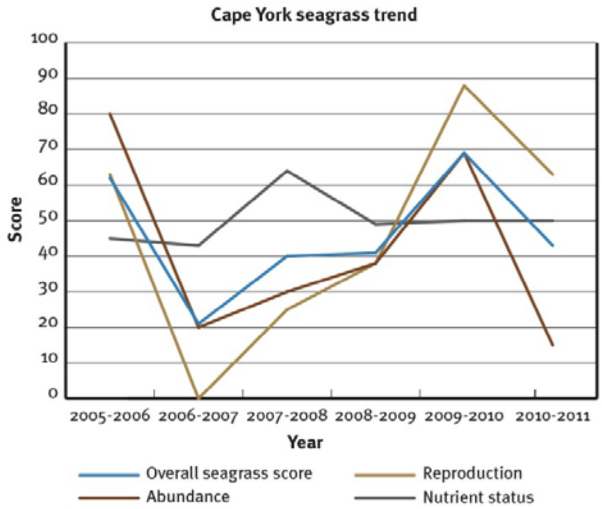
Chlorophyll *a* exceeded the Great Barrier Reef Marine Park Water Quality Guidelines for 95 per cent of the inshore area in the dry season. However, in the wet season, the guidelines were exceeded for 45 per cent of the inshore area, mainly around river mouths and bays. Total suspended solids exceeded the guidelines for 76 and 20 per cent of the inshore area, in the dry and wet seasons, respectively.

There is no comprehensive, ongoing *in situ* water quality monitoring in the Cape York region. Estimates of chlorophyll *a* and total suspended solids are derived from remote sensing only which requires further field validation and, hence, estimates have relatively low reliability compared to those for other regions. As such, Cape York water quality data was not used in overall assessments of Great Barrier Reef water quality and reef health.

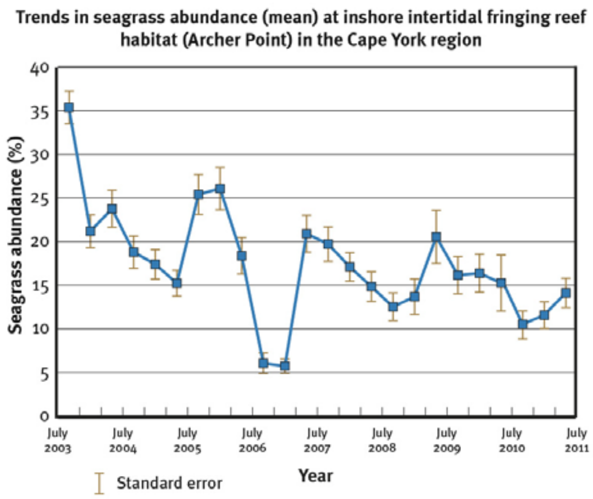
The marine environment in the Cape York region is relatively pristine compared to other regions. However, increasing pressure from development and the associated impacts on water quality in the region mean that Cape York is a high priority for intensifying monitoring efforts.

Seagrass

The condition of inshore seagrass in the Cape York region declined to moderate overall and has been highly variable since 2005-2006. This is due to a complex and highly variable environment and the impacts of recent significant rain events and cyclones on seagrass abundance and reproductive effort. The lack of seagrass monitoring sites in Cape York does not adequately capture the spatial variability of the region. As such, Cape York seagrass data was not used in the Great Barrier Reef-wide assessment of seagrass condition.



Seagrass is monitored at one fringing reef location in the southern part of the Cape York region, Archer Point, which supports a diverse range of species. The environment is characterised by fluctuating temperature and salinity, and the growth of seagrass is primarily influenced by physical disturbance from waves and swell and associated sediment movement. Seagrass abundance in 2010-2011 declined to very poor while reproductive effort was good, indicating communities may have a relatively high potential for recovery from environmental disturbances compared to seagrass in other regions. Nutrient ratios of seagrass tissue were again rated as moderate, reflecting local water quality conditions.



Wet Tropics

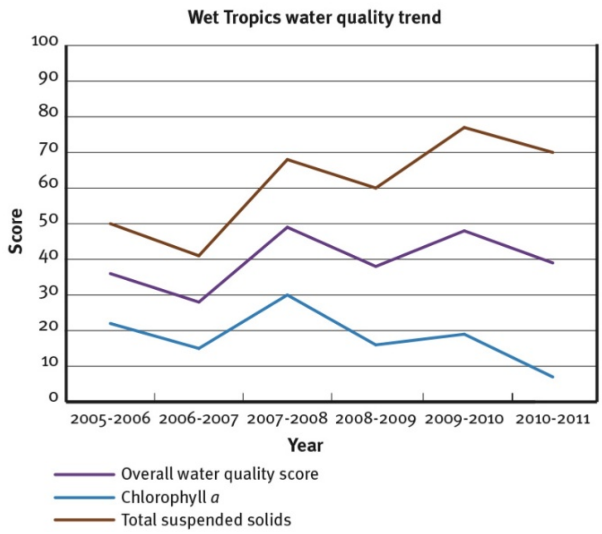
The Wet Tropics' marine condition declined from moderate to poor. Inshore water quality and seagrass meadows declined from moderate to poor and coral reefs have declined from good to moderate condition.

Water quality

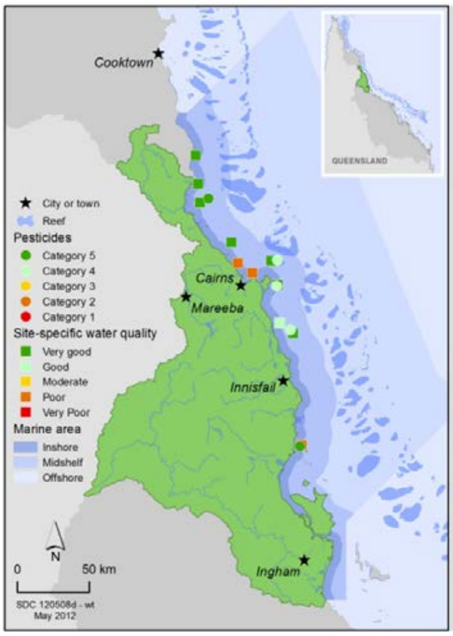
Inshore water quality in the Wet Tropics region is poor overall and has varied from poor to moderate since 2005-2006, largely driven by total suspended sediment. Scores for chlorophyll *a* were consistently worse than suspended sediment in all monitoring years.

In 2010-2011, chlorophyll *a* was rated as very poor with concentrations exceeding the Great Barrier Reef Marine Park Water Quality Guideline for 99 and 63 per cent of the inshore area, in the dry and wet season, respectively. Total suspended solids were rated as good; however, concentrations exceeded the guidelines for 59 and 16 per cent of the inshore area, in the dry and wet seasons, respectively.

Remote sensing of water quality across the region showed a clear gradient of improving water quality from inshore areas more frequently exposed to flood waters to offshore areas.



Site-specific water quality was rated as either good or very good at eight out of 11 sites in the region, three of which are located in the midshelf water body. However, water quality at the three sites close to river mouths draining from highly developed catchments was rated as poor due to high concentrations of particulate phosphorus, chlorophyll and turbidity that exceeded the Great Barrier Reef Marine Park Water Quality Guidelines in 2010-2011. The water quality scores are a long-term integrative assessment based on four indicators of water quality relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2009b).



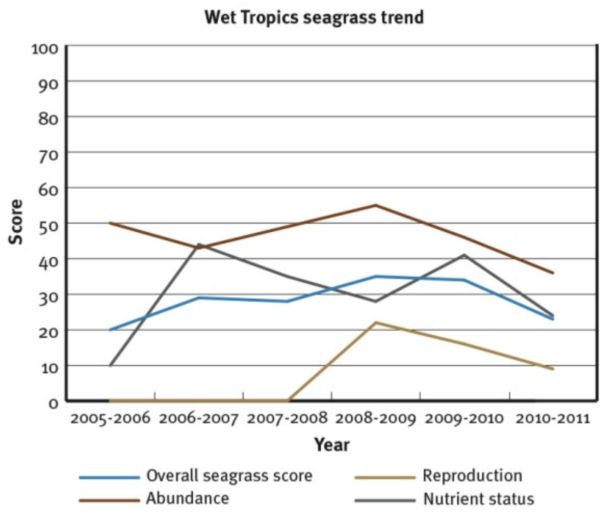
Water quality and pesticide scores for PSII herbicides at fixed monitoring sites in the Wet Tropics region.

A range of herbicides were detected in the Wet Tropics region including diuron, atrazine and its breakdown products hexazinone, simazine and tebuthiuron. Diuron was present at the highest concentrations. Concentrations of photosystem II (PSII) herbicides were above those known to affect photosynthesis in diatoms (Category 4) at Green, Fitzroy and Normanby Islands. The highest PSII herbicide equivalent concentration in flood waters (Category 3) was detected in grab samples collected near the Tully River mouth and around Bedarra Island following a flow event.

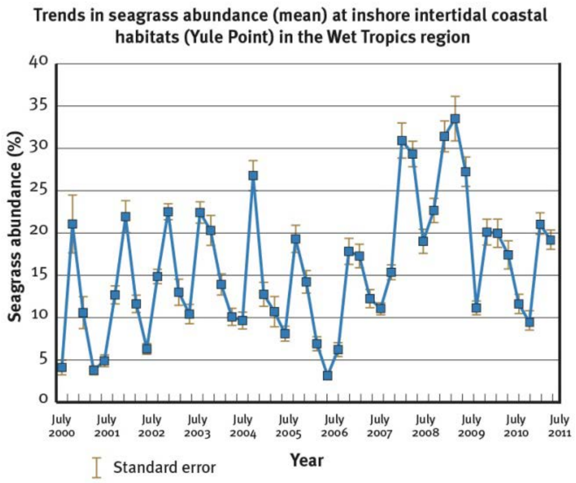
Long-term monitoring of pesticides shows evidence of an increasing trend in the detection of herbicides at some sites in the Wet Tropics since 2005. In 2010-2011, the higher concentrations typical of the wet season were sustained for longer periods of time as evidenced by an increase in average PSII herbicide concentrations by 1.5 to 3.4 times.

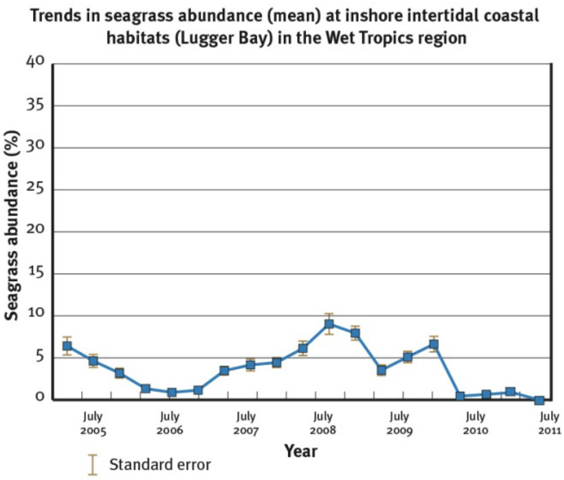
Seagrass

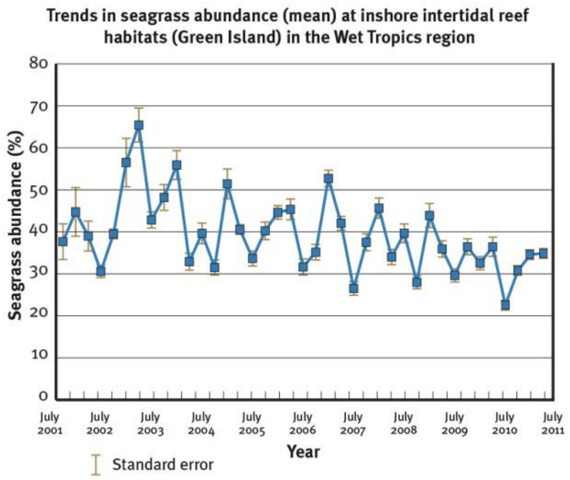
The overall condition of inshore seagrass in the Wet Tropics region is poor and has been poor since 2005-2006. This is due to complex interactions between the three indicators of seagrass condition: abundance, reproductive effort and nutrient status which are highly variable between years and habitats. Cyclone Yasi had an impact on the south of the region with abundance and meadow extent declining until only a few isolated shoots remained.

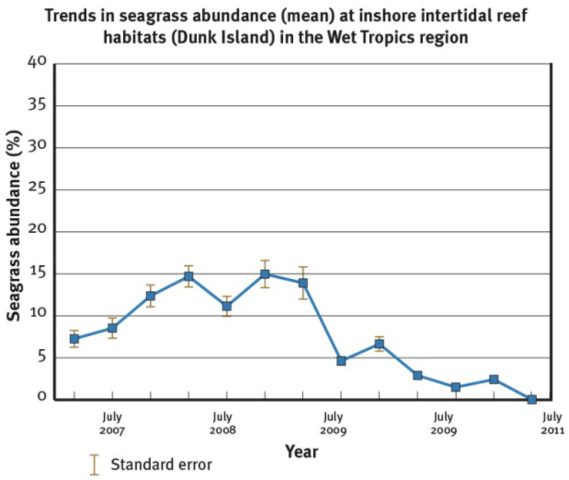


Inshore seagrass were monitored in coastal and reef habitats in the Wet Tropics and were in very poor or poor condition, respectively. Dominant influences on seagrass communities in the region include elevated temperatures, seasonal run-off and disturbance from wave action and associated sediment movement. In 2010-2011, seagrass meadows at Yule Point and Green Island in the north remained relatively stable. However, the effects of Cyclone Yasi were apparent in the south, and seagrass meadows at Lugger Bay and Dunk Island were either completely lost or reduced to scattered isolated shoots by the physical disturbance and deposition of sediments. The reproductive effort of inshore seagrass in the Wet Tropics was very poor in five of the six monitoring years which may indicate a low potential of meadows to recover from disturbances. Leaf tissue nutrient ratios were rated poor overall with a site in the north showing signs of light limitation and poor water quality.



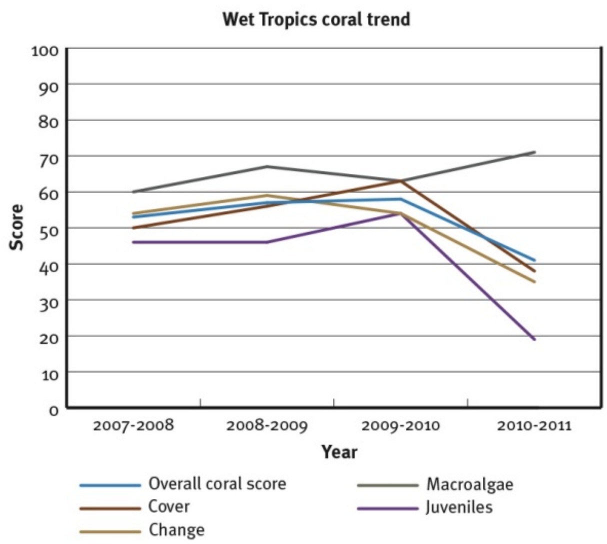




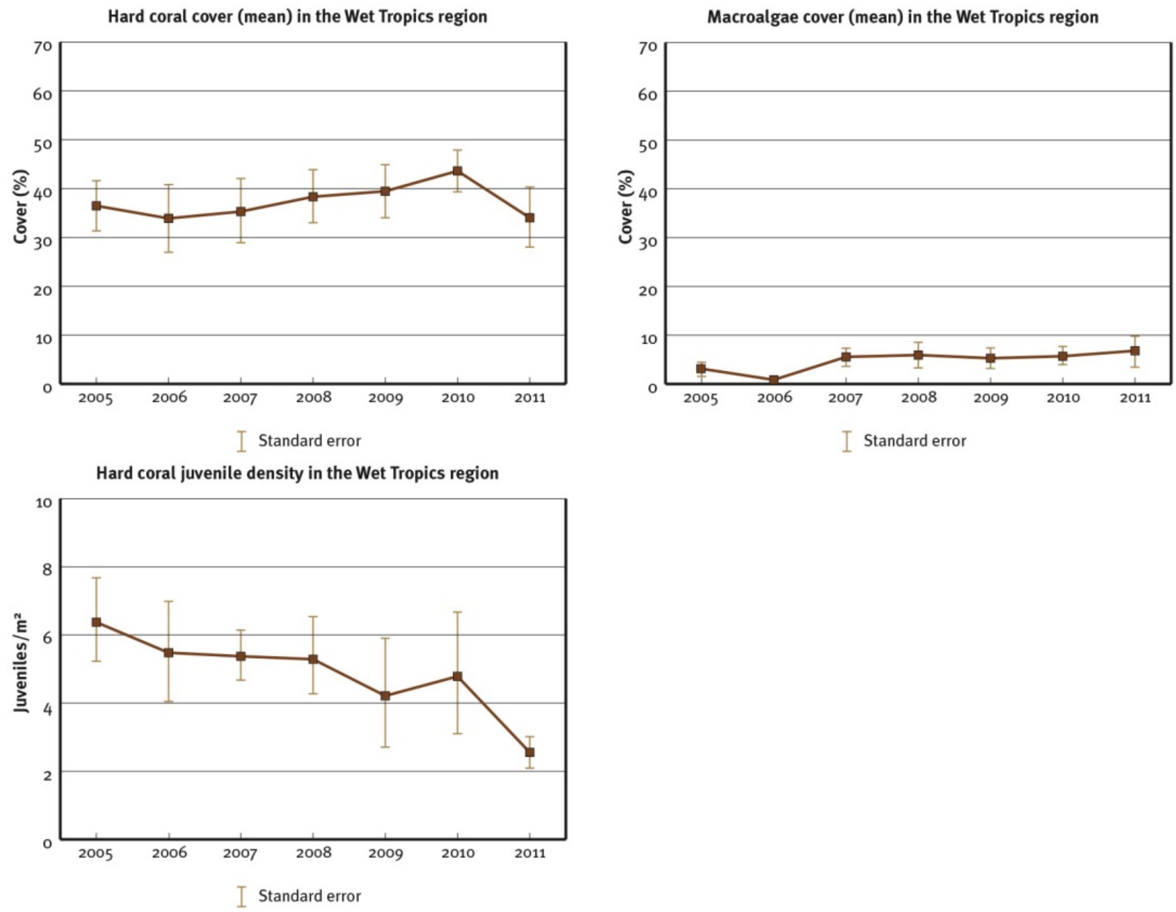


Coral

The overall condition of inshore coral reefs in the Wet Tropics remained moderate; however, there were differences between northern and southern parts of the region and the underlying scores decreased markedly from 2010. Coral reef communities in the Barron Daintree and Johnstone Russell-Mulgrave areas in the northern Wet Tropics were downgraded from good to moderate condition, while those in the more southerly Herbert Tully area were in poor condition.



Coral cover of inshore reefs in the Wet Tropics varied with reefs in the north in better condition than those in the south. Prior to 2010-2011, coral communities were recovering from the impact of past disturbances; however, Cyclones Tasha and Yasi had a negative impact on coral cover and the density of juvenile corals across the region.



Average cover of hard corals, cover of macroalgae and density of hard coral juveniles in the Wet Tropics region from 2005 to 2011.

Coral cover at sites in the Barron to Daintree area remained very good. However, coral cover at reefs in the Johnstone Russell-Mulgrave area declined to moderate condition as a result of acute disturbances from cyclones Tasha and Yasi. Macroalgae cover was higher at some locations in 2010-2011 and the density of coral juveniles declined to very poor. Coral disease also contributed to declines in coral cover and the moderate condition assessment of reefs in the northern Wet Tropics.

In contrast, coral cover in the Herbert Tully area was still very poor, reflecting the severity of Cyclone Larry in 2006 and Cyclone Yasi in 2011 and the subsequent negative impacts on the density of juvenile corals. As well as reducing coral cover, Cyclone Yasi also reduced the cover of macroalgae resulting in a good score overall for the Wet Tropics region. However, macroalgae cover is likely to increase rapidly as occurred following Cyclone Larry. Reefs in the region were recovering at a moderate rate prior to the extreme weather of 2010-2011, which may indicate some resilience to disturbance and a capacity for recovery.

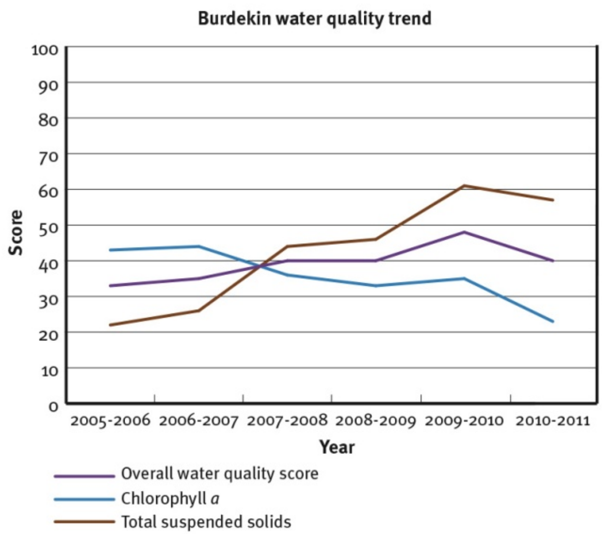
Burdekin

The Burdekin's marine condition remained poor. Inshore water quality was moderate overall, while inshore seagrass meadows declined from poor to very poor and coral reefs remained in poor condition.

Water quality

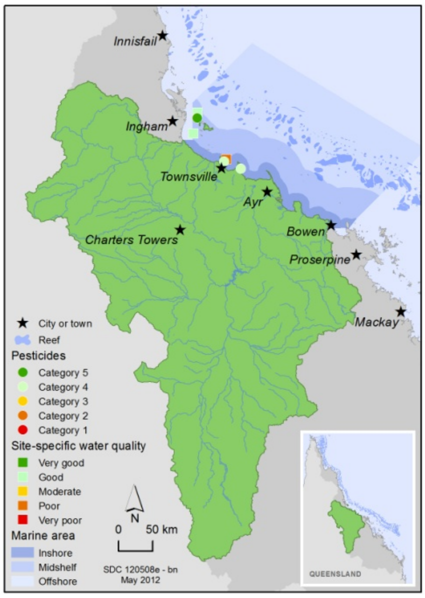
Inshore water quality in the Burdekin region remained moderate in 2010-2011, although there were declines in the underlying scores for the two water quality indicators chlorophyll *a* and suspended solids. Scores for these two indicators have varied since 2005 with the initial pattern of higher scores for chlorophyll *a* and lower scores for suspended solids reversing in later monitoring years.

In 2010-2011, chlorophyll *a* was again rated as poor with concentrations exceeding the Great Barrier Reef Marine Park Water Quality Guideline for 98 and 69 per cent of the inshore area, in the dry and wet season, respectively. Total suspended solids were rated as moderate; however, concentrations exceeded the guidelines for 62 and 34 per cent of the inshore area, in the dry and wet seasons, respectively.



Remote sensing of water quality across the region showed a clear gradient of declining water quality from offshore areas to inshore areas more frequently exposed to flood waters. This onshore-offshore gradient was supported by long-term assessments of water quality at specific sites with variability between sites reflecting local hydrodynamic conditions and biophysical processes.

Site-specific water quality was good at the two mid-shelf sites and poor at Magnetic Island in the inshore region The Great Barrier Reef Marine Park Water Quality Guideline values for turbidity and concentrations of particulate phosphorus were exceeded at Magnetic Island in 2010-2011. The water quality scores are a long-term integrative assessment based on four indicators of water quality relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2009b).



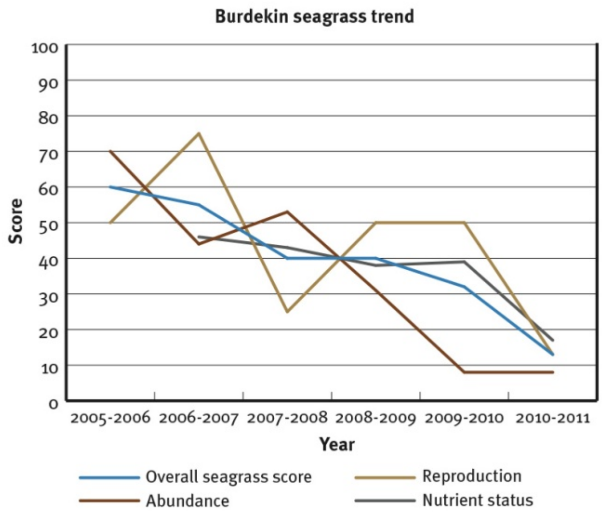
Water quality and pesticide scores for PSII herbicides at fixed monitoring sites in the Burdekin region.

A range of herbicides was detected in the Burdekin region including atrazine and its breakdown products diuron, hexazinone, simazine and tebuthiuron. The Burdekin River had a large flood event in the 2010-2011 wet season and tebuthiuron was detected in flood waters at concentrations that exceeded Great Barrier Reef Water Quality Guideline values. Routine monitoring showed spatial variability in the abundance of herbicides, and atrazine concentrations typically exceeded diuron concentrations at Cape Cleveland and Magnetic Island while at Orpheus Island, closer to the Wet Tropics, diuron was present at higher concentrations. In 2010-2011, concentrations of photosystem II (PSII) herbicides were above those known to affect photosynthesis in diatoms (Category 4) at Cape Cleveland and Magnetic Island.

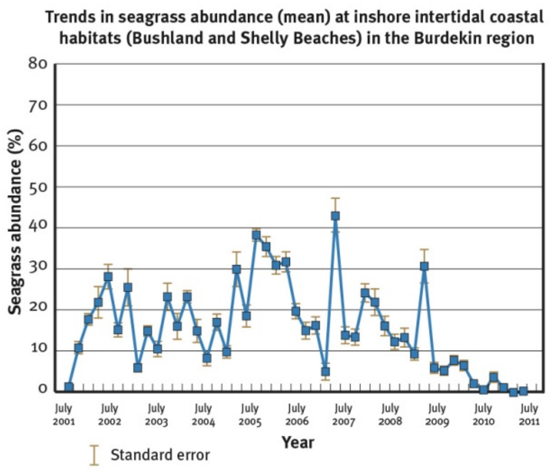
Long-term monitoring of pesticides shows evidence of an increasing trend in the detection of herbicides at some sites in the Burdekin since 2005. In 2010-2011, higher concentrations typical of the wet season were sustained for longer periods of time, as evidenced by a doubling in average PSII herbicide concentrations.

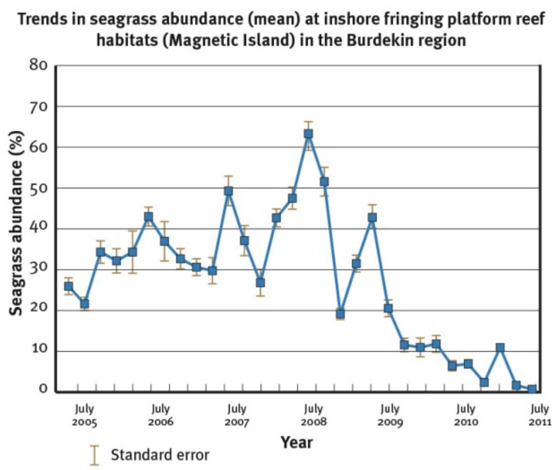
Seagrass

The overall condition of inshore seagrass in the Burdekin region has progressively declined from good in 2005-2006 to very poor in 2010-2011. The very poor assessment is driven by large declines in abundance and reproductive effort and increased nutrient enrichment of seagrass tissue. Cyclone Yasi had an impact on the region with abundance and meadow extent declining across the region until only a few isolated shoots remained at the monitored sites.



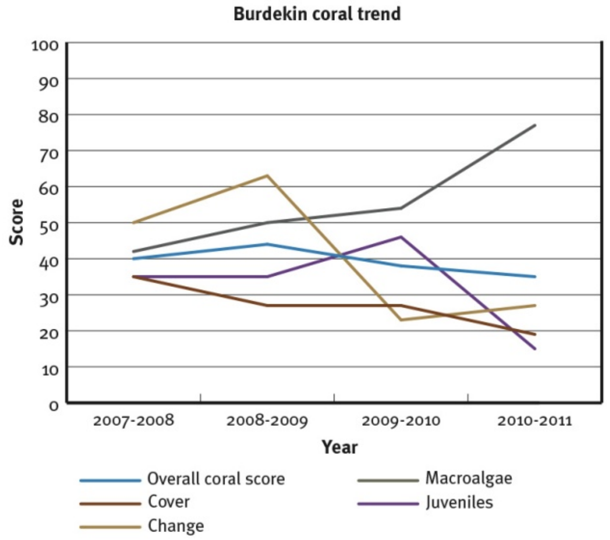
Seagrass monitoring was conducted in coastal and reef habitats primarily influenced by wind-driven turbidity and pulsed delivery of nutrients and sediment, and seagrass abundance remained very poor across the region. There was a decline in the reproductive effort of seagrass meadows at reef locations (Picnic Bay and Cockle Bay on Magnetic Island) and coastal locations (Bushland Beach and Shelly Bay) to poor and very poor, respectively. Low reproductive effort may indicate reduced capacity for recovery from environmental disturbances. The nutrient content of seagrass tissue was either very poor or poor and indicated nutrient enrichment in coastal and reef habitats, which reflected local water quality conditions.



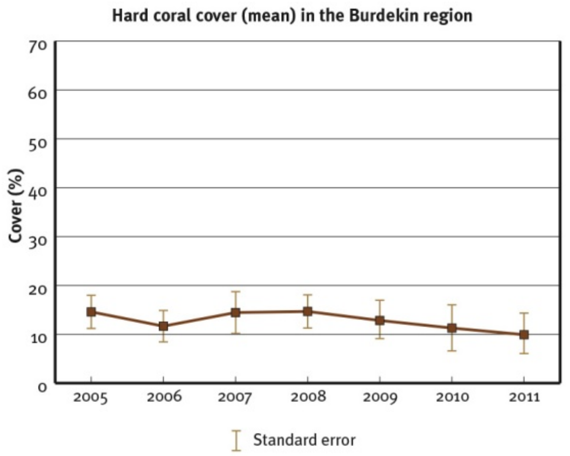


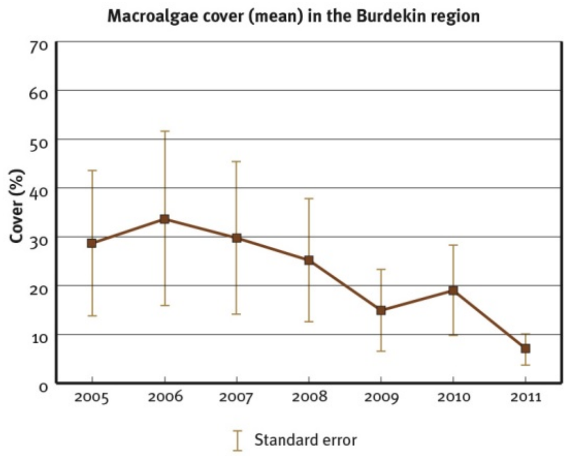
Coral

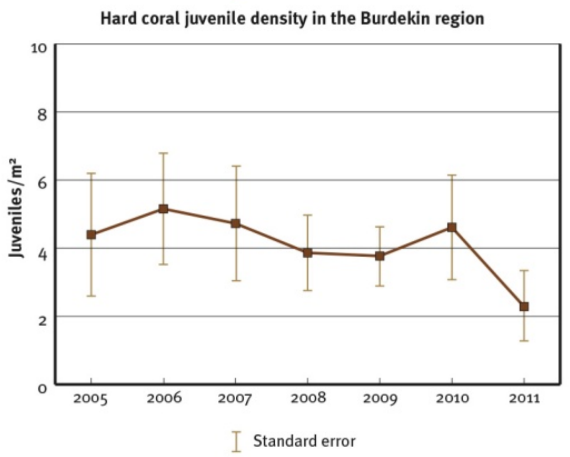
The overall condition of inshore coral reefs in the Burdekin remained poor and has declined from moderate since 2007-2008.



Coral cover across the Burdekin region has not recovered from the impact of coral bleaching in 1998 and 2002, and declined further following Cyclone Yasi to very poor in 2010-2011. Some reefs had high larval settlement in 2010; however, Cyclone Yasi hit shortly after settlement and will most likely have a negative impact on the development of larvae into juvenile and then adult colonies.







Average cover of hard corals, cover of macroalgae and density of hard coral juveniles in the Burdekin region from 2005 to 2011.

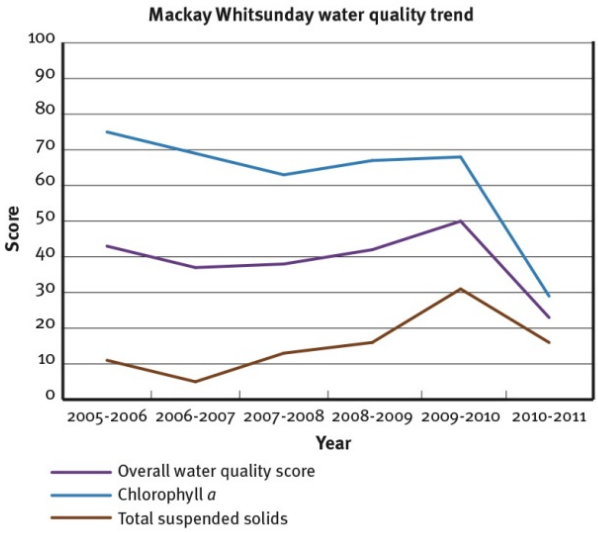
There was also a reduction in the density of juvenile corals from moderate to very poor levels that are likely to compound the low rates of increase in coral cover during periods free from acute disturbance. Reductions in the cover of macroalgae due to Cyclone Yasi are expected to be temporary due to the high availability of conditions that favour the persistence of macroalgae. The factors underlying the poor condition assessment suggest a lack of resilience of reef communities in the Burdekin region.

Mackay Whitsunday

The Mackay Whitsunday's marine condition declined from moderate to poor. Inshore water quality also declined from moderate to poor, inshore seagrass meadows declined from poor to very poor and coral reefs remained in moderate condition.

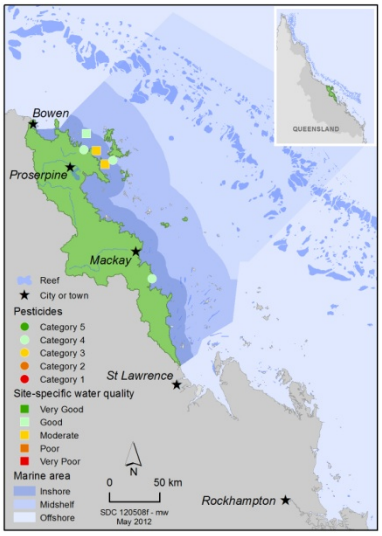
Water quality

In 2010-2011, chlorophyll *a* was rated as poor with concentrations exceeding the Great Barrier Reef Marine Park Water Quality Guideline for 99 and 44 per cent of the inshore area, in the dry and wet season, respectively. Total suspended solids was rated as very poor with concentrations exceeding the guidelines for 59 and 69 per cent of the inshore area, in the dry and wet season, respectively.



Remote sensing of water quality across the region showed a clear gradient of declining water quality from offshore areas to inshore areas more frequently exposed to flood waters. This gradient was supported by long-term assessments of water quality at specific sites with variability between sites reflecting local hydrodynamic conditions and biophysical processes.

Site-specific water quality remained moderate at Daydream and Pine Islands, and good at Double Cone Island. Annual mean turbidity levels at Pine and Daydream Islands exceeded the Great Barrier Reef Marine Park Water Quality Guidelines in 2010-2011. The water quality scores are a long-term integrative assessment based on four indicators of water quality relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2009b).



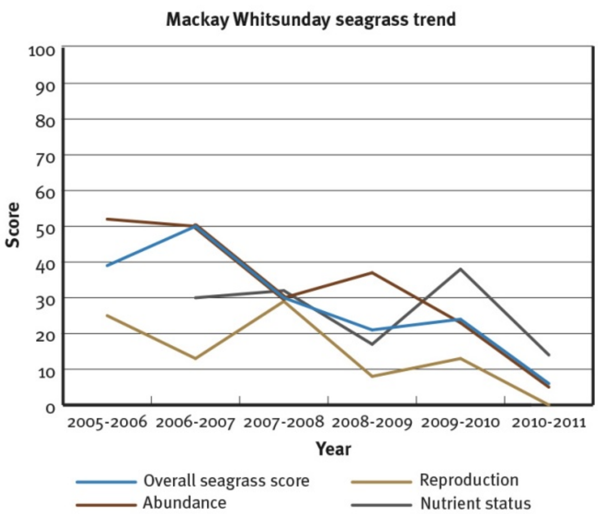
Water quality and pesticide scores for PSII herbicides at fixed monitoring sites in the Mackay Whitsunday region.

A range of herbicides was detected in the Mackay Whitsunday region including atrazine and its breakdown products, diuron, hexazinone, simazine and tebuthiuron. There were multiple, high flow events in all rivers of the Mackay Whitsunday region in 2010-2011 and concentrations of photosystem II (PSII) herbicides were above those known to affect photosynthesis in diatoms (Category 4) at all routine monitoring sites.

Long-term monitoring of pesticides shows evidence of an increasing trend in the detection of herbicides at some sites in the Mackay Whitsundays since 2005. Sarina Inlet generally had the highest concentrations of most PSII herbicides compared to all other sites in the GBR, which reflected the proximity of the site to flows from Plane Creek (Rhode et al., 2008).

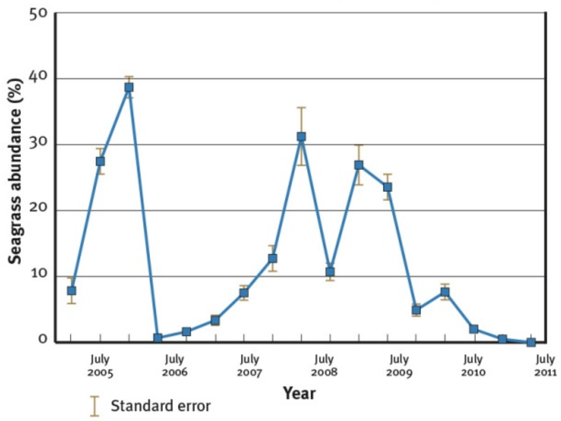
Seagrass

The overall condition of inshore seagrass in the Mackay Whitsunday region was very poor and has progressively declined since 2005-2006 to the lowest levels reported since 1999. The decline in seagrass condition reflects very poor abundance, very poor reproductive effort and increased nutrient enrichment of seagrass tissue.

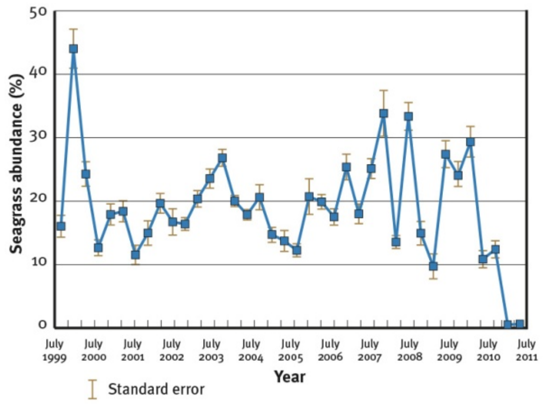


Seagrass meadows were monitored at coastal, estuarine and fringing reef locations in the Mackay Whitsunday region (Pioneer Bay, Sarina Inlet and Hamilton Island, respectively). Key environmental drivers of seagrass communities in this region include exposure at low tides and variable catchment run-off. Seagrass abundance declined in all habitats throughout the region over the monitoring period. By late monsoon 2010, all sites were in very poor condition. Reproductive effort declined at both reef and coastal sites, raising concerns about the ability of local seagrass meadows to recover from environmental disturbances. The nutrient status of seagrass tissue was rated as poor in reef habitats and very poor in coastal and estuarine habitats, which reflected local water quality conditions following record flood events.

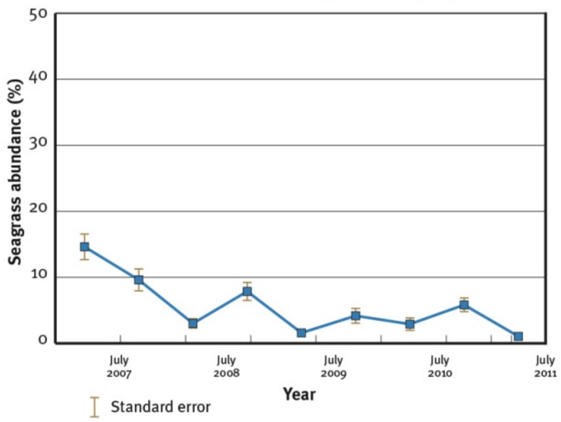
Trends in seagrass abundance (mean) at inshore intertidal estuarine habitats (Sarina Inlet) in the Mackay Whitsunday region



Trends in seagrass abundance (mean) at inshore intertidal coastal habitats (Pioneer Bay) in the Mackay Whitsunday region

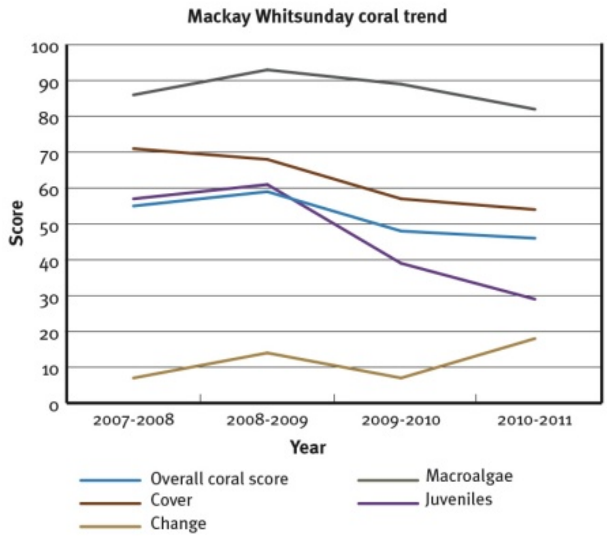


Trends in seagrass abundance (mean) at inshore fringing reef habitats (Hamilton Island) in the Mackay Whitsunday region

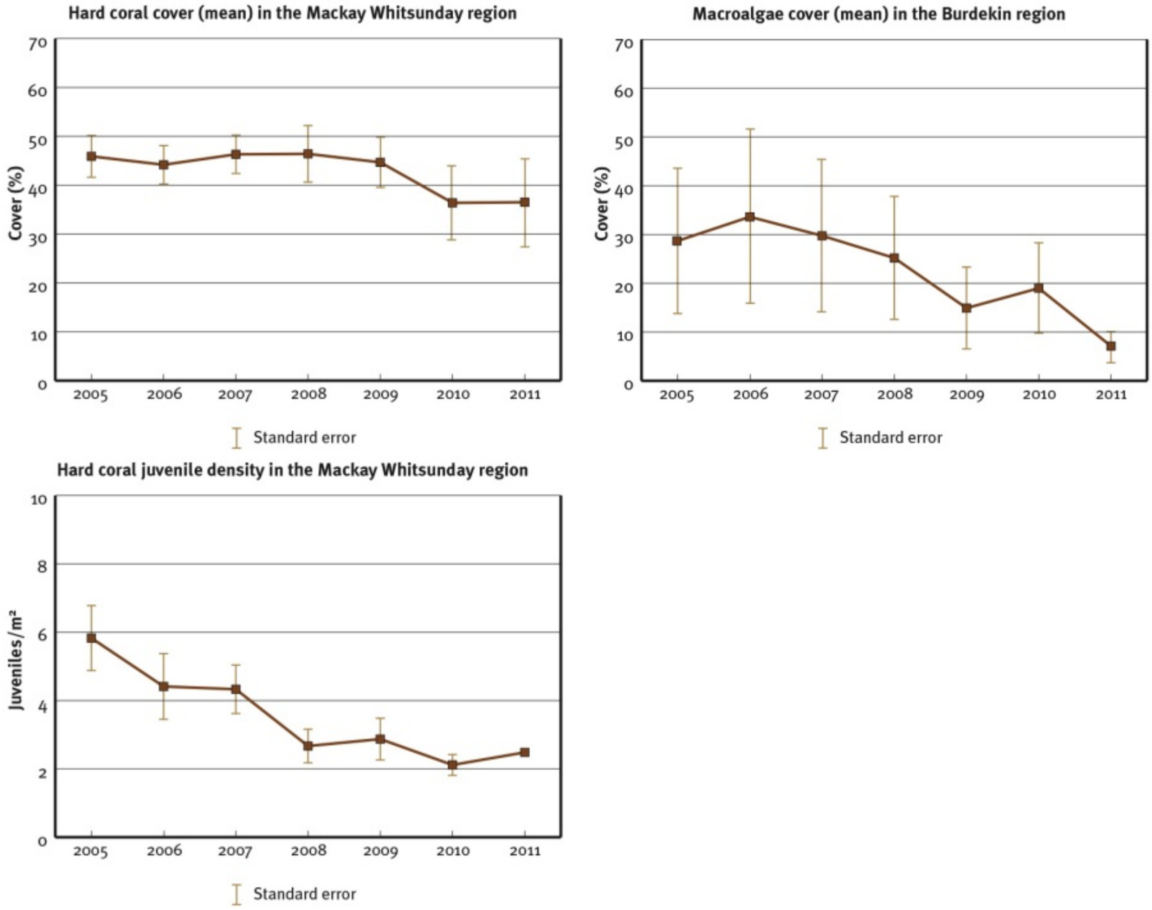


Coral

The overall condition of inshore coral reefs in the Mackay Whitsunday region has remained moderate since 2007-2008. Similarly to the Burdekin region, reefs in the Mackay Whitsunday region have had very slow rates of increase in coral cover since Cyclone Ului passed through the region in 2010. The largest change in coral cover from 2005 to 2011 occurred in the Fitzroy region with an average decline of 53 per cent, primarily due to coral bleaching in 2006 and record flooding in 2011.



Coral cover remained moderate in 2010-2011 with the exception of one site at Double Cone Island where cover increased due to the survival of and growth of coral fragments produced during Cyclone Ului early in 2010. The rate of increase in coral cover during periods free from acute disturbances was very poor and, when combined with the continual decline in the density of juvenile colonies to poor, may have implications for the long-term resilience of local coral communities in the region. There were also outbreaks of coral disease in the region that occurred along with conditions known to be stressful to some corals, such as elevated turbidity and a high proportion of fine grained sediments from above-median river discharge. The very low cover of macroalgae offset the poor or very poor ranking of other coral community attributes, resulting in the overall condition assessment of moderate. Macroalgae cover has remained low following Cyclone Ului, despite an increase in available space for colonisation.



Average cover of hard corals, cover of macroalgae and density of hard coral juveniles in the Mackay Whitsunday region from 2005 to 2011.

Fitzroy

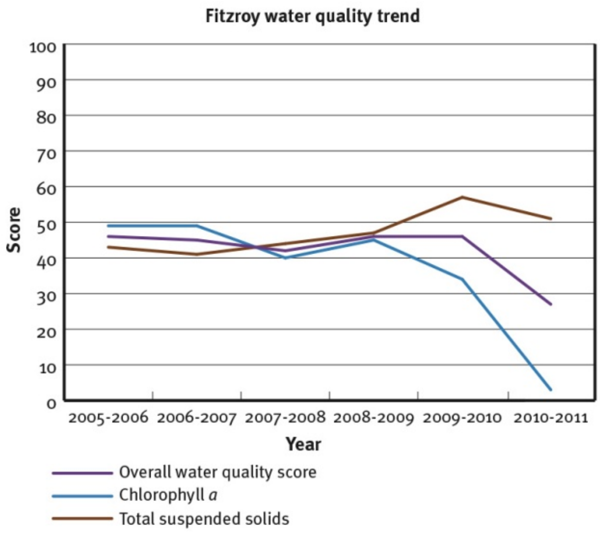
The Fitzroy's marine condition declined from moderate to poor. Inshore water quality and inshore seagrass meadows also declined from moderate to poor and coral reefs remained in poor condition.

Water quality

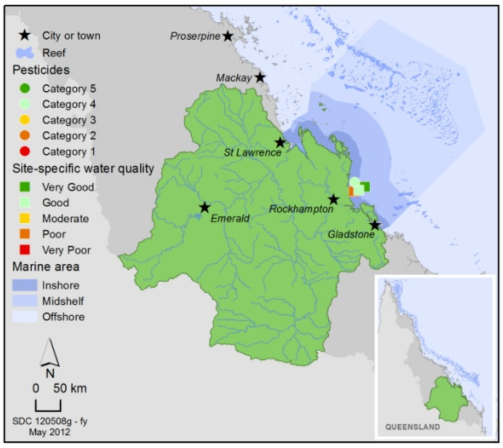
Inshore water quality in the Fitzroy region declined from moderate to poor overall, representing a departure from the relatively stable water quality since 2005-2006. The divergence in the scores for the two water quality indicators chlorophyll *a* and suspended solids became more pronounced following the floods in 2010-2011.

In 2010-2011, chlorophyll *a* declined sharply to very poor with concentrations exceeding the Great Barrier Reef Marine Park Water Quality Guideline for 99 per cent and 89 per cent of the inshore area, in the dry and wet season, respectively. Total suspended solids were again rated as moderate; however, concentrations exceeded the guidelines for 55 per cent and 47 per cent of the inshore area, in the dry and wet season, respectively.

Remote sensing of water quality across the region showed a clear gradient of declining water quality from offshore areas to inshore areas more frequently exposed to flood waters. This gradient was supported by long-term assessments of water quality at specific sites, with variability between sites reflecting local hydrodynamic conditions and biophysical processes.



Site-specific water quality was poor at Pelican Island, moderate at Humpy Island and very good at Barren Island, respectively, reflecting increasing distance away from river influence. At Pelican Island, the Great Barrier Reef Marine Park Water Quality Guidelines were exceeded for chlorophyll *a*, turbidity and concentrations of particulate nitrogen and phosphorus in 2010-2011. The water quality scores are a long-term integrative assessment based on four indicators of water quality relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2009b).



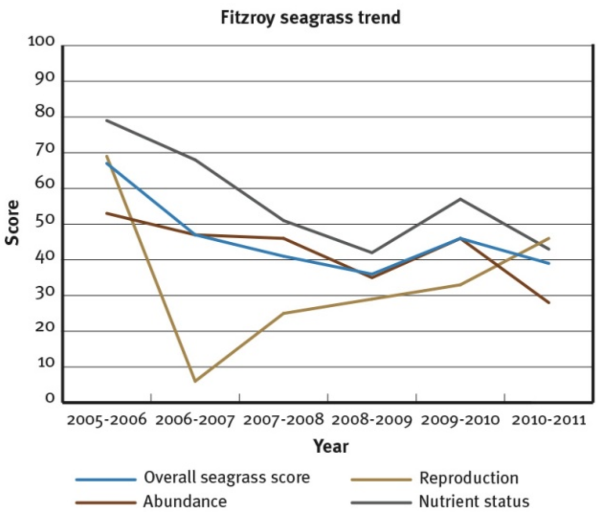
Water quality and pesticide scores for PS-II herbicides at fixed monitoring sites in the Fitzroy region.

A range of herbicides was detected in the Fitzroy region including atrazine and its breakdown products, diuron, hexazinone, simazine and tebuthiuron. The Fitzroy River had large flow events in the 2010-2011 wet season and tebuthiuron and metolachlor were detected in flood waters at concentrations that met or exceeded the Great Barrier Reef Water Quality Guidelines and the ANZECC and ARMCANZ Interim Working Level for marine waters, respectively. Tebuthiuron was also detected at concentrations that exceeded the guidelines at the routine monitoring site at North Keppel Island. However, on average, concentrations of photosystem II (PSII) herbicides were rated as Category 4 at North Keppel Island.

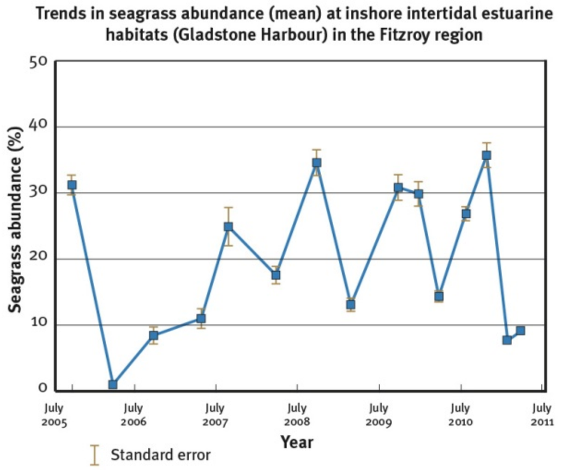
Long-term monitoring of pesticides shows evidence of an increasing trend in the detection of herbicides in the Fitzroy since 2005. In 2010-2011, the higher concentrations typical of the wet season were sustained for longer periods of time.

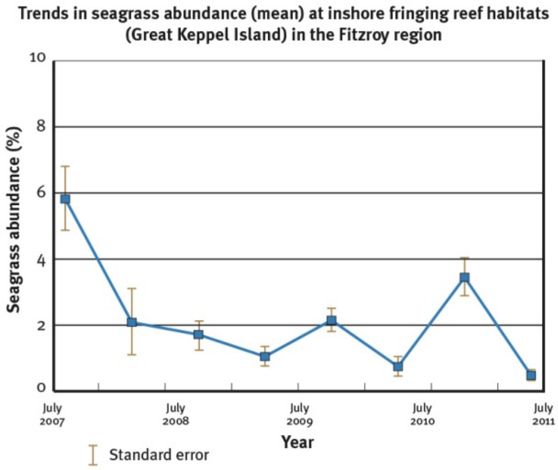
Seagrass

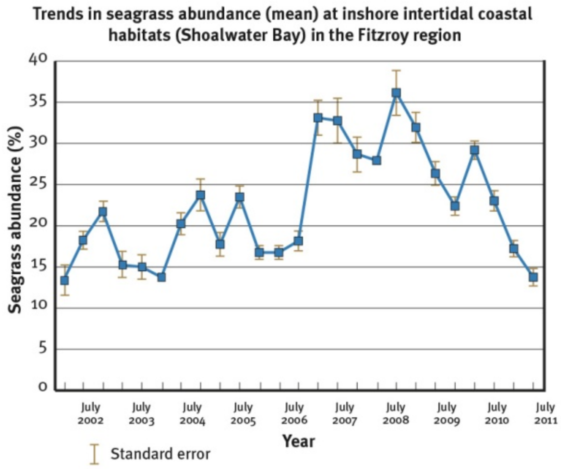
The overall condition of inshore seagrass in the Fitzroy region declined to poor, driven largely by poor seagrass abundance. Reproductive effort and nutrient content were not measured every year. Hence the capacity to assess trends in these two indicators, which were both rated as moderate in 2010-2011, is limited.



Seagrass meadows were monitored at coastal, estuarine and fringing reef locations in the Fitzroy region. Key environmental drivers in the region include exposure at low tide and high turbidity. Seagrass abundance at both the coastal Shoalwater Bay and estuarine Gladstone Harbour sites declined to poor during 2010-2011, which represented a reversal of previous trends. Similarly, seagrass meadows at the Great Keppel reef site, which continued to decrease in size and abundance, remained very poor. Relatively high reproductive effort at the reef and estuarine sites indicate these seagrass meadows may have a higher capacity to recover from disturbances compared to seagrass in coastal habitats. The nutrient status of seagrass tissue was moderate overall, reflecting high concentrations of nutrients at the reef site and moderate to good tissue nutrient status at the coastal and estuarine sites, respectively. High concentrations of nutrients in seagrass tissue are indicative of poor water quality in this area following record flood events.

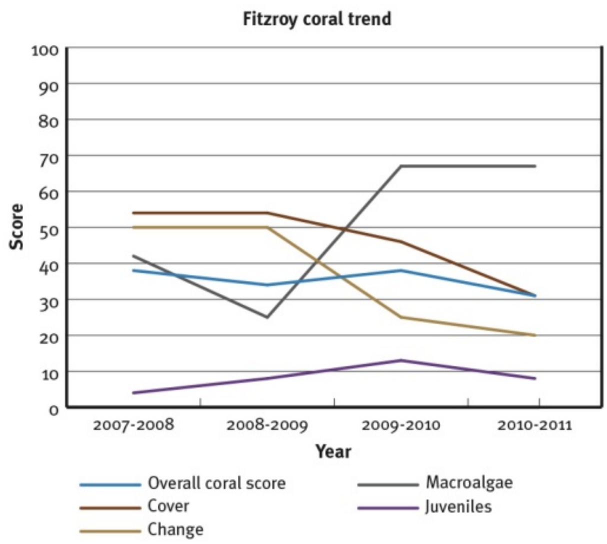




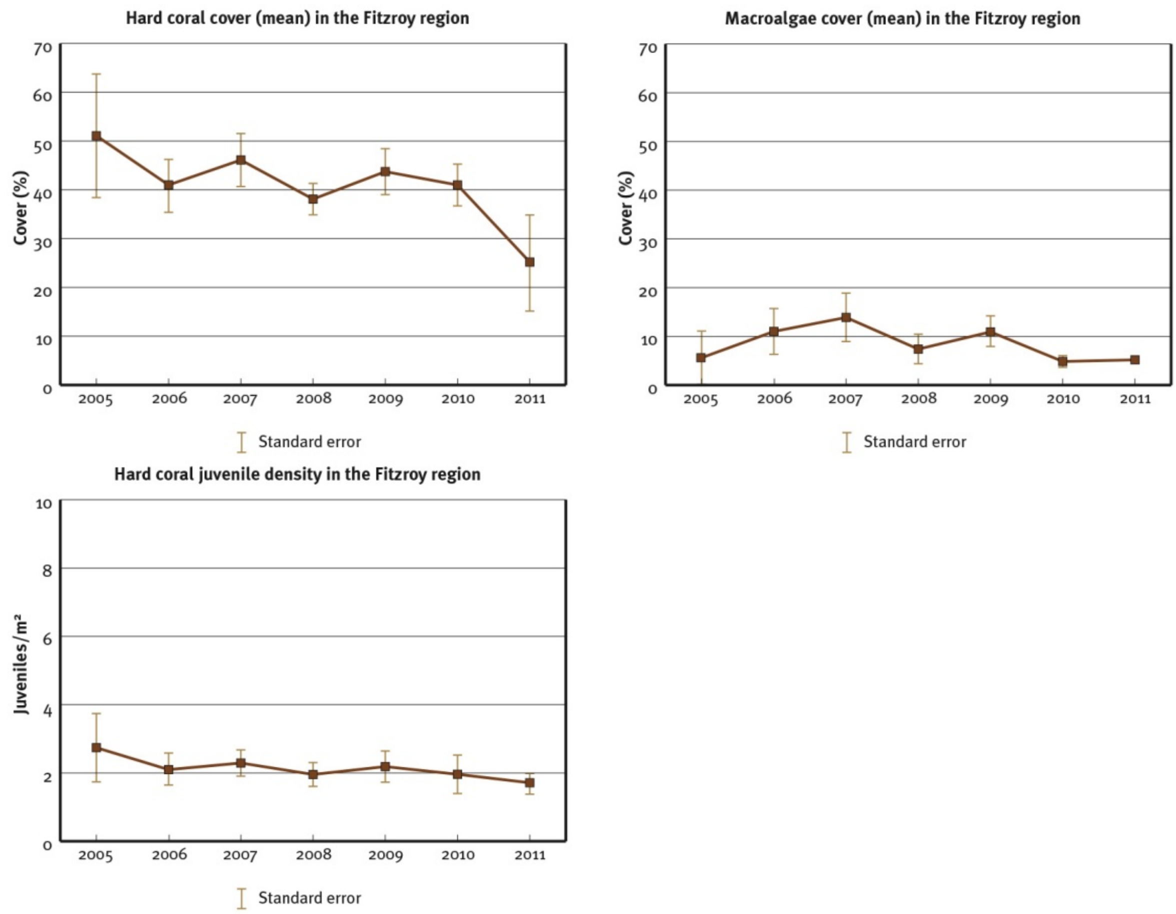


Coral

The overall condition of inshore coral reefs in the Fitzroy region has remained poor since 2007-2008.

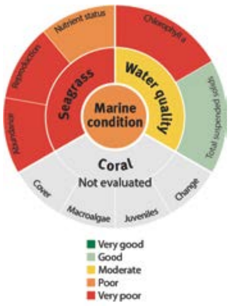


Coral cover declined to poor across the Fitzroy region and the density of juveniles was very poor. There was a marked reduction in coral cover and juvenile densities to depths of at least two metres on reefs inshore of Great Keppel Island, consistent with exposure to low salinity waters in the Fitzroy River flood plume. The prevalence of coral disease in the region appears to be related to the annual discharge from the Fitzroy River. Changes in the community composition of several reefs in the region may be a consequence of a shift in selective pressures. The rate of increase in coral cover was poor and is likely to reflect chronic stress associated with poor water quality and attributable to repeated flooding of the Fitzroy River in 2008, 2010 and 2011. The cover of macroalgae, however, was low and therefore good for the reef.



Average cover of hard corals, cover of macroalgae and density of hard coral juveniles in the Fitzroy region from 2005 to 2011.

Burnett Mary

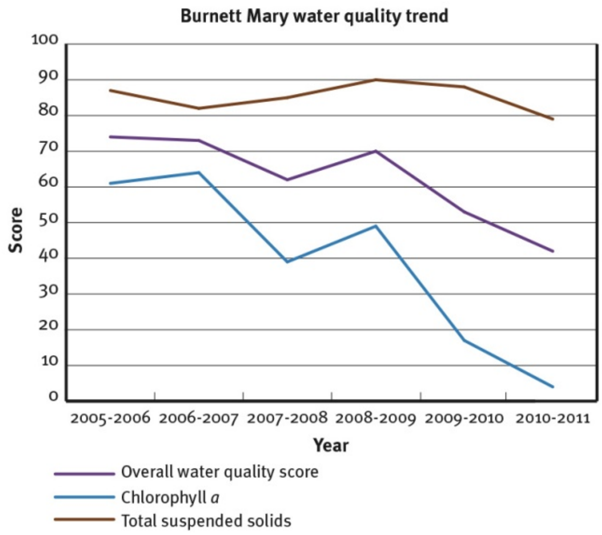


The Burnett Mary's marine condition remained poor. Inshore water quality remained moderate and the condition of seagrass declined from poor to very poor. No coral monitoring occurs in the Burnett Mary region under the Marine Monitoring Program.

Water quality

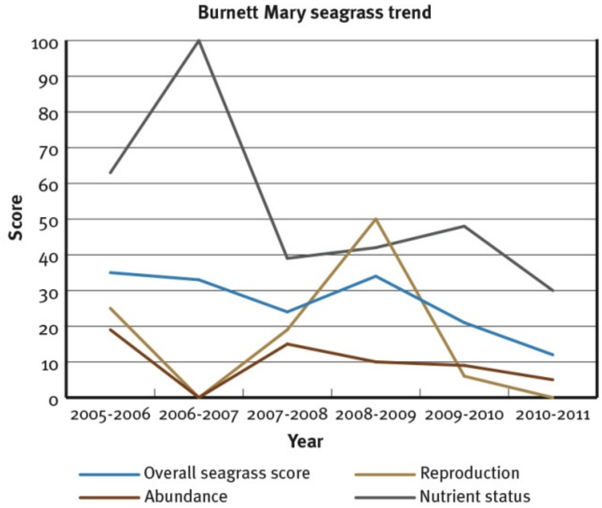
Inshore water quality in the Burnett Mary region continued to decline and was moderate in 2010-2011. The decline was driven by relatively large changes in chlorophyll *a*, while total suspended solids remained stable.

In 2010-2011, chlorophyll *a* was very poor with concentrations exceeding the Great Barrier Reef Marine Park Water Quality Guideline for 97 per cent and 96 per cent of the inshore area, in the dry and wet season, respectively. Total suspended solids were rated as good; however, concentrations exceeded the guidelines for 15 per cent and 26 per cent of the inshore area, in the dry and wet season, respectively.

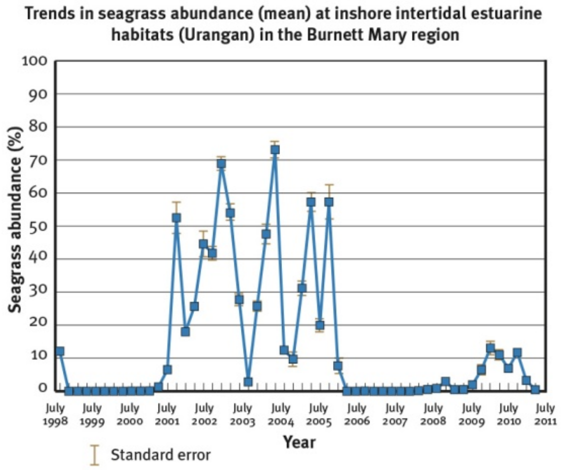


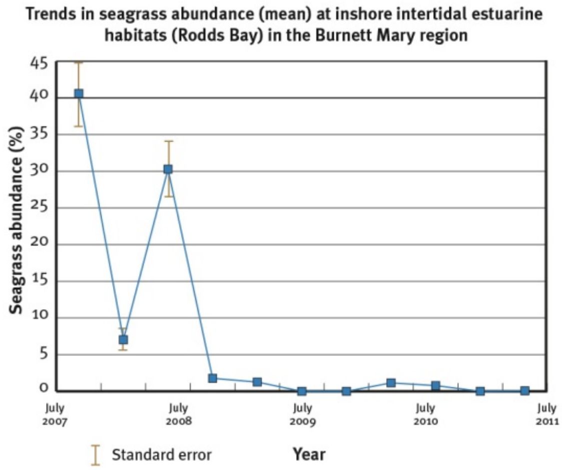
Seagrass

The overall condition of inshore seagrass in the Burnett Mary region declined from poor to very poor, reflecting very poor abundance and reproductive effort of seagrass meadows and poor tissue nutrient status. Seagrass condition has generally been declining since 2005-2006; however, the indicators driving the condition assessment were highly variable over the monitoring period.



Seagrass is monitored at estuarine sites at Rodds Bay and Urangan, in the north and south of the Burnett Mary region, respectively. The primary environmental drivers of community composition at these sites are fluctuating temperatures, catchment run-off and high turbidity. Seagrass abundance was very poor throughout the region. The meadow in the south showed signs of recovery in 2010 from previous years of flooding; however, following the extreme weather events, abundance declined to pre-2008 levels. Reproductive effort declined across the region to a very poor state, which may result in reduced capacity of local meadows to recover from environmental disturbances. The nutrient concentrations of seagrass tissue were high, which is indicative of poor water quality following large flood events in the region.





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