Australian Government
Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility (MTSRF) Project Milestone Report, 11 June 2009

Program 1:	Status and Trends of Species and Ecosystems in the Great Barrier Reef
Project 1.1.3:	Condition, trend and risk in coastal habitats: Seagrass indicators, distribution and thresholds of potential concern http://www.rrrc.org.au/mtsrf/theme_1/project_1_1_3.html
Led by:	Dr Len McKenzie, Queensland Primary Industries and Fisheries Dr Michelle Waycott, James Cook University

Report prepared by Dr Len McKenzie, Queensland Primary Industries and Fisheries

Report Summary

All milestone activities have been successfully achieved.

Seagrass-Watch monitoring results over the last twelve months indicate that of inter-tidal seagrass meadows within the Great Barrier Reef World Heritage Area (GBRWHA) appear to be in a relatively fair condition in terms of abundance and composition. Abundance of inter-tidal seagrasses at locations in Cape York and the Wet Tropics are generally stable, however locations from the Dry Tropics to the southern GBRWHA are either variable or have declined over the past six months. For locations which had severe losses in 2006 (e.g. Gladstone and Urangan) the significant increases in abundance in the Late-Dry 2008 were followed by significant declines in the Late-Monsoon 2009. Results of Seagrass-Watch monitoring results are being used to derive regional seagrass abundance guidelines for indicating habitat condition. Results and updates of Seagrass-Watch monitoring have been fed back to participants via newsletters and are available on www.seagrasswatch.org for general public access as well as being circulated widely to a subscriber list.

Temperature experiments were completed in 2008 and results are expected to be submitted for journal publication. Light experiments were conducted twice in 2008 but were unsuccessful due to explosions in the populations of crustaceans, which subsequently ate the seagrass in the experiments. The light experiments have been successfully carried out in 2009 and were being completed at the time of writing this report. The temperature and light experiments will be followed up by experimental investigations into the interaction between light and temperature. Field studies have been ongoing since January 2008 with four sites established between January and November 2008. The field studies will continue until at least the end of Project 1.1.3 (June 2010).

In December 2008, the adequacy of the spatial datasets that delineated the distribution of hazards in the report '*Spatial Risk Assessment for Coastal Seagrass Habitats in the GBRWHA: A case study of the Dry and Wet Tropics*' was reviewed (to download, visit http://www.rrrc.org.au/mtsrf/theme_1/project_1_1_3.html). A working group was convened in February 2009 to assess the applicability of the case study approach to seagrass habitats in the entire GBR. The working group designed a new system of evaluating the risk of coastal seagrass habitats to their threats based on the method of Halpern and others (*Conservation*

Biology, 2008 21: 1301-1315). An online survey was developed that asked survey participants to evaluate the vulnerability of coastal seagrass communities by considering the spatial scale, frequency, and functional impact of each threat identified during the workshop held in May 2008; the resistance of seagrass to disturbance by each threat; the resilience (i.e. recovery time) of seagrass following a disturbance; and the certainty of their estimates. The online survey was sent to 32 experts in seagrass ecology and management. Survey outputs are currently being analysed.

Milestone Reporting Requirements

2008/2009 Outputs **Milestones**	**Date**
Report 3 submission QPIF (with appropriate attribution of MTSRF Funding): • Summary report on findings from Seagrass-Watch monitoring to date at agreed sites (a); and • Final summary describing communication and collaboration activities completed to date (a); Report 3 submission JCU (with appropriate attribution of MTSRF Funding): • Description of results of temperature and light mesocosm experiments (b2); • Summary of outputs from risk assessment working group activities (c3); • Final summary describing communication and collaboration activities completed to date (b and c); and • Proposed work plan for 2009/2010 (a-c).	11 June 2009

Project Results

See the following attachments to this report:

- **Attachment 1:** McKenzie, L. (2009) MTSRF Task 1.1.3(a): Observing change in seagrass habitats of the Great Barrier Reef – Seagrass-Watch monitoring: Report on Year 3 activities;
- **Attachment 2:** Waycott, M. (2009) Understanding the drivers of seagrass change, indicators of seagrass health and thresholds of potential concern;
- **Attachment 3:** Grech, A. and Coles, R. (2009) Risk assessment for coastal seagrass habitats: Values, threats and vulnerabilities;
- Collier, C. and Waycott, M. (2009) Field studies in seagrass meadows of the Great Barrier Reef: An exploration of drivers of change **(Draft Manuscript for Journal Submission – this item is not included with this website download)**; and
- Collier, C., Waycott, M. and Giraldo Ospina, A. (2009) Critical light thresholds and response variables in five seagrass species of the Great Barrier Reef **(Draft Manuscript for Journal Submission – this item is not included with this website download)**.

Communications, major activities and events

During ARP3 (2008/2009)

- Seagrass-Watch monitoring for intertidal seagrass abundance, community structure, and physical parameters was conducted at intertidal Seagrass-Watch sites in Queensland in the Dry (Jul/Aug) 2008, Late-Dry (Sep/Oct) 2008, Monsoon (Jan/Feb) 2009 and Late-monsoon (Mar/Apr) 2009.

- Monitoring of seagrass abundance, community structure and distribution was successfully completed at all agreed intertidal Seagrass-Watch / Reef Rescue Marine Monitoring Program sites in Late-Dry (Sep/Oct) 2008 and Late-monsoon (Mar/Apr) 2009. All sampling (see http://www.seagrasswatch.org/sampling.html).
- Three Seagrass-Watch newsletters (Issues 34, 35 and 36) were produced and distributed in September 2008, December 2008 and March 2009 respectively, updating participants on program developments and results of ongoing monitoring:

  http://www.rrrc.org.au/publications/seagrass_watch_newsletters.html

  http://www.seagrasswatch.org/magazine.html
- Two Seagrass-Watch training workshops for monitoring seagrass habitats in Cape York Peninsula were conducted on 910 and 26-27 March 2009 in Cairns and Cooktown respectively.
- Ongoing discussions and collaboration with AIMS and the Queensland Environmental Protection Agency for the deployment and maintenance of turbidity/chlorophyll loggers. A Project 1.1.3 team member will join the AIMS June 2009 water quality monitoring expedition to learn the deployment protocols for the turbidity/chlorophyll loggers.
- Cath Collier (JCU), Rob Coles (QPIF) and Alana Grech (JCU) presented papers on their respective projects at Third Annual MTSRF Conference in Townsville on 28 and 30 April 2009.
- Informal workshops and/or meetings of the working group (including use of teleconference) were conducted on 11 February 2009, 3-4 March 2009, 29 April 2009 and 10 June 2009 to: (1) review the case study risk assessment model of Grech *et al.* (2008); (2) assess the applicability of the case study approach to seagrass habitat across the GBR; (3) develop an online questionnaire requesting experts to evaluate and rank the vulnerability of coastal seagrass habitats to anthropogenic hazards; and (4) review the model outputs derived from the expert opinion collected via an online survey.
- The online survey was sent to 32 experts on seagrass ecology and biology, marine and terrestrial management, water quality, and spatial information.
- Regular (1-2 per month) E-bulletins are distributed electronically to Seagrass-Watch participants and related international forums/discussion groups on seagrass related news events and Seagrass-Watch activities.
- Len McKenzie and Jane Mellors attended the Eighth International Seagrass Biology Workshop (Bamfield, Canada, 31 August to 6 September 2008) and presented on the Reef Plan Marine Monitoring Program and Seagrass-Watch.
- **Reports:**
  - McKenzie, L. J., Mellors, J. E. and Waycott, M. (2008) Great Barrier Reef Water Quality Protection Plan (Reef Rescue) – Marine Monitoring Program, Intertidal Seagrass for the Sampling Period 1 September 2007 to 31 May 2008 (127pp.)
- **Newsletters: (http://www.rrrc.org.au/publications/seagrass_watch_newsletters.html)**
  - McKenzie, L. J. and Yoshida, R. L. (eds.) (2009) Seagrass-Watch News Issue 37, June 2009 (16pp.).
  - McKenzie, L. J. and Yoshida, R. L. (eds.) (2009) Seagrass-Watch News Issue 36, March 2009 (16pp.).

- McKenzie, L. J. and Yoshida, R. L. (eds.) (2008) Seagrass-Watch News Issue 35, December 2008 (24pp.); and
- McKenzie, L. J. and Yoshida, R. L. (eds.) (2008) Seagrass-Watch News Issue 34, September 2008 (12pp.).

- **Conference Proceedings:**
  - McKenzie, L., Mellors, J., Waycott, M., Yoshida, R. and Smith, N. (2008) *Intertidal seagrass condition, Seagrass-Watch and the Great Barrier Reef Marine Monitoring Program: developing indices of water quality.* In. G. Di Carlo, A. Calladine, M. Waycott and T. Carruthers (eds.) Proceedings of the 8th International Seagrass Biology Workshop, Bamfield, Canada, 31 August to 6 September 2008. World Seagrass Association, Townsville, Australia. p48.
  - Mellors, J., McKenzie, L., Waycott, M., Reid, A., Smith, N. and Yoshida, R. (2008) *Monitoring of inter-tidal seagrass meadows for the GBR Water Quality Protection Plan (ReefPlan).* In. G. Di Carlo, A. Calladine, M. Waycott and T. Carruthers (eds.) Proceedings of the 8th International Seagrass Biology Workshop, Bamfield, Canada, 31 August to 6 September 2008. World Seagrass Association, Townsville, Australia. p50.

- **Workshop Proceedings (http://www.seagrasswatch.org/publications#Training):**
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch: Proceedings of a Workshop for Monitoring Seagrass Habitats in Cape York Peninsula, Queensland, Cairns and Cooktown, 9-10 and 26-27 March 2009 (Seagrass-Watch HQ, Cairns). 56pp.

- **Brochures (http://www.seagrasswatch.org/publications#Brochures):**
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrasses of Dunk Island, 6pp.

- **E-Bulletins (http://www.seagrasswatch.org/publications#Ebulletin):**
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 1 Jun 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 19 May 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 28 Apr 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 21 Apr 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 30 Mar 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 18 Mar 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 02 Mar 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 15 Feb 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 30 Jan 2009
  - McKenzie, L. J. and Yoshida, R. L. (2009) Seagrass-Watch E-Bulletin, 13 Jan 2009
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 24 Dec 2008
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 30 Nov 2008
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 17 Nov 2008
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 31 Oct 2008
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 22 Oct 2008
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 19 Sep 2008
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 28 Aug 2008

  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 14 Aug 2008
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 30 Jul 2008
  - McKenzie, L. J. and Yoshida, R. L. (2008) Seagrass-Watch E-Bulletin, 07 Jul 2008

- **Presentations:**
  - Coles, R. G. (2009) Modelling risk to seagrass meadows in coastal waters of the Great Barrier Reef World Heritage Area. Presentation to Northern Fisheries Centre, 21 April 2009.
  - Coles, R. G. and Grech, A. (2009) Modelling risk to seagrass meadows in coastal waters of the Great Barrier Reef World Heritage Area. Oral presentation. Marine and Tropical Sciences Research Facility (MTSRF) 2009 Annual Conference, Rydges Southbank Hotel, Palmer Street, Townsville, Queensland, 28-30 April 2009.
  - Coles, R. G. (2009) QPIF seagrass monitoring and assessment. Prentation to Bentley Park College, Year 11, Marine Biology class. 20 and 22 May 2009.
  - Collier, C. and Waycott, M. (2009) Temperature and seagrass death. Oral presentation. Marine and Tropical Sciences Research Facility (MTSRF) 2009 Annual Conference, Rydges Southbank Hotel, Palmer Street, Townsville, Queensland, 28-30 April 2009.
  - Grech, A. and Coles, R.G. (2008). Can global assessments of human impacts on marine ecosystems inform local management? School of Earth and Environmental Sciences Postgraduate Conference, Townsville, Queensland, 12 November 2009.
  - McKenzie, L.J. (2009). Seagrass Biology and Identification. Presentation to participants of a workshop for Monitoring Seagrass Habitats in Cape York Peninsula, 9-10 and 26-27 March 2009.
  - McKenzie, L.J. (2009). Seagrass Ecology and Threats. Presentation to participants of a workshop for Monitoring Seagrass Habitats in Cape York Peninsula, 9-10 and 26-27 March 2009.
  - McKenzie, L.J. (2009). Seagrass monitoring. Presentation to participants of a workshop for Monitoring Seagrass Habitats in Cape York Peninsula, 9-10 and 26-27 March 2009.
  - McKenzie, L.J. (2009). Seagrass-Watch: how to sample. Presentation to participants of a workshop for Monitoring Seagrass Habitats in Cape York Peninsula, 9-10 and 26-27 March 2009.
  - McKenzie, L.J. (2009). Seagrass-Watch: 1998-2009 how data is used. Presentation to participants of a workshop for Monitoring Seagrass Habitats in Cape York Peninsula, 9-10 and 26-27 March 2009.
  - Mellors, J. (2008). Seagrass-Watch Field techniques. Belgian Gardens Primary School - July 30.
  - Mellors, J. (2008). How to Seagrass-Watch. Townsville Grammar School – Oct 10.
  - Mellors, J. (2008). Seagrasses and Seagrass-Watch. International Youth Conference assisted with Belgian Gardens – Oct 20.
  - Mellors, J. (2008). Field techniques for monitoring intertidal seagrass meadows Townsville Grammar School – Oct 23.

Communications, major activities and events

During next milestone reporting period

- Seagrass-Watch newsletters Issue 37, 38 and 39.
- E-bulletins distributed electronically to Seagrass-Watch participants and related international forums/discussion groups on seagrass related news events and Seagrass-Watch activities.
- Undertake detailed experiments on the interactive effects of temperature and light on seagrass thresholds and indicators.
- Continue processing samples and data from monitoring.
- Communicate results to date with stakeholders.
- Four manuscripts relating to seagrass distribution and risk are being prepared by the working group:
    - Spatially-explicit model of seagrass distribution for the GBRWHA.
    - Spatial management of a penaeid shrimp trawl fishery in the Great Barrier Reef World Heritage Area, Queensland Australia.
    - A spatial risk assessment approach to quantify the vulnerability of coastal seagrass communities of the Great Barrier Reef World Heritage Area, Queensland Australia.

Proposed objectives / work plan for ARP3 (2009/2010)

Obj.	Targeted Activity	Completion Date
(a)	A 1. Undertake Seagrass-Watch community monitoring for intertidal seagrass abundance, community structure, distribution, physical parameters at agreed regularly monitored sites throughout the GBRMP.	1 Dec 2009
(a)	A 2. Undertake Seagrass-Watch community monitoring for intertidal seagrass abundance, community structure, distribution, physical parameters at agreed regularly monitored sites throughout the GBRMP.	28 May 2010
(a)	A 3. Seagrass-Watch newsletter completed every 4-6 months from 1 July 2008 (min. two for year ending June 2009).	1 ea. at minimum of 30 Nov 09, 31 May 10
(b)	B 1. Test seagrass responses to drivers of seagrass change through field data collection.	1 Dec 2009
(b)	B 2. Conduct mesocosm experiments on temperature and light effects on seagrass growth.	10 Jun 2010
(b)	B 3. Analyse and report *in-situ* light and temperature measurements at seagrass monitoring sites in objective (a).	10 Jun 2010
(c)	C 1. Review the GBRWHA risk assessment model of seagrass habitat.	1 Dec 2009
(c)	C 2. Working group convened to re-assess applicability of the GBR seagrass habitat risk assessment model	1 March 2010
(c)	C 3. Refine model output for the GBRWHA	1 May 2010
(c)	C 4. Provide a final report and manuscript for publication	10 June 2010

Attachment 1:

MTSRF Task 1.1.3(a) Observing change in seagrass habitats of the Great Barrier Reef: Seagrass-Watch monitoring

Report on Year 3 (2008/2009) activities

Dr Len McKenzie, Queensland Primary Industries and Fisheries

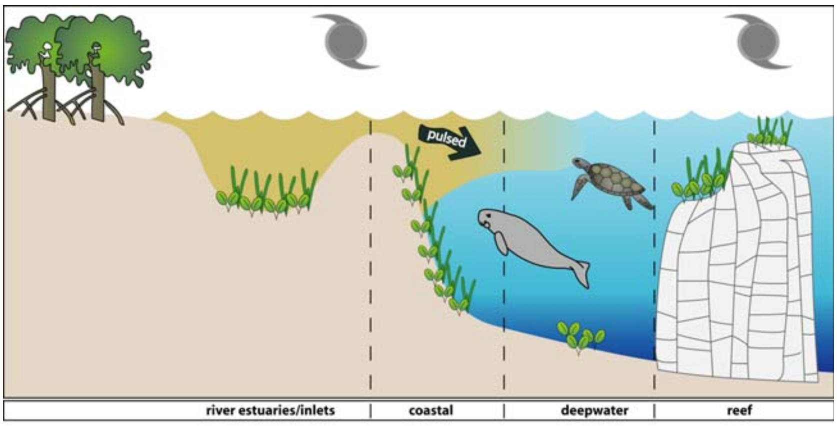
Summary

Seagrass-Watch monitoring results over the last twelve months indicate that of inter-tidal seagrass meadows on the east coast of Queensland appear to be in a relatively fair condition in terms of abundance. Abundance of inter-tidal seagrasses at locations in Cape York and the Wet Tropics are generally stable, however locations from the Dry Tropics to the southern Great Barrier Reef World Heritage Area (GBRWHA) are either variable or have declined over the past six to twelve months. For locations which had severe losses in 2006 (e.g. Gladstone and Urangan) the significant increases in abundance in the Late-Dry 2008 were followed by significant declines in the Late-Monsoon 2009.

There are fifteen species of seagrass in the GBRWHA (Coles *et al*. 2007). The high diversity of seagrass reflects the variety of habitats provided by extensive bays, estuaries, rivers and the 2,600 km of Great Barrier Reef with its reef platforms and inshore lagoon. Seagrasses can be found along coastal sand or muddy shores, on reef platforms and in reef lagoons, and on sandy and muddy bottoms down to sixty metres below MSL. More than 5,000 km^2 of coastal seagrass meadows in eastern Queensland waters are shallower than fifteen metres and it is expected that approximately 40,000km^2 of the seafloor in the GBRWHA deeper than fifteen metres has some seagrass (Coles *et al.* 2003a). This represents about 36% of the total recorded area of seagrass in Australia.

Seagrasses in the GBRWHA can be separated into four major habitat types: estuary/inlet, coastal, reef and deepwater (Carruthers *et al.* 2002) (**Error! Reference source not found.**). All but the outer reef habitats are significantly influenced by seasonal and episodic pulses of sediment-laden, nutrient-rich river flows, resulting from high volume summer rainfall. Cyclones, severe storms, wind and waves as well as macro grazers (fish, dugongs and turtles) influence all habitats in this region to varying degrees. The result is a series of dynamic, spatially and temporally variable seagrass meadows.

Figure 1: General conceptual model of seagrass habitats in northeast Australia (from Carruthers *et al*. 2002).



This assessment of the status of seagrasses in the GBRWHA is based on results of the Seagrass-Watch monitoring program. This approach involves supervised monitoring at predominately intertidal sites (including sites monitored for the Reef Rescue Marine Monitoring Program). Survey methodology follows Seagrass-Watch standard methodology (www.seagrasswatch.org). This program provides information on a range of seagrass variables at a large number of locations throughout the GBRWHA. At each sampling location, sampling includes two or more sites nested in location and three fifty-metre transects nested in each site. A site is defined as a 50m x 50m area within a relatively homogenous section of a representative seagrass community/meadow (McKenzie *et al.* 2000). Sites are monitored for seagrass cover and species composition. Additional information is collected on canopy height, algae cover, epiphyte cover, seagrass reproductive health (*Halodule uninervis* seed bank) and associated macrofaunal abundance. The methods simplicity and relatively low cost allows for sampling to occur more frequently and across a large range of locations, helping to complete the regional picture of trends in seagrass change.

The Seagrass-Watch program has a wide spatial coverage within most of the GBRWHA (monitoring 61 sites) with a high temporal resolution – normally four times per year. This provides an excellent "watch" for changes in percent cover, species composition, local extent and a range of biophysical information. It is focussed on monitoring inter-tidal meadows (including reef platform) and is designed to alert management authorities to changes that may occur in short, less than one year, temporal scales.

Seagrass-Watch monitoring over the 2008/2009 sampling period has occurred at 55 sites across three of the generalised seagrass habitats (deepwater habitats are not monitored), and a summary of results to date are presented below. More detailed information on individual regions or locations can be viewed online at www.seagrasswatch.org.

Estuary / Inlet

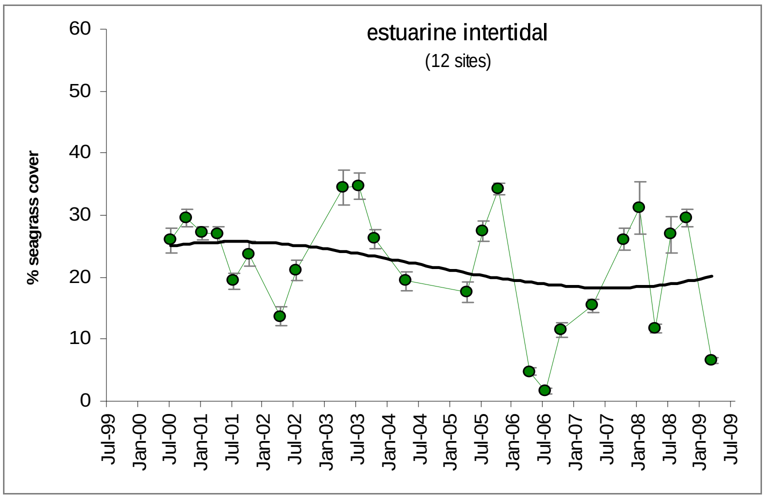
The species composition, growth and distribution of estuary/inlet seagrass meadows are influenced by terrigenous runoff, temperature and salinity fluctuations. Increased river flow in summer causes higher sediment loads and reduced light, creating potential light limitation for seagrass (McKenzie 1994). Associated erosion and unstable sediments make river and inlet habitats a seasonally stressful environment for seagrass growth. These meadows often have high shoot densities but low species diversity (Lee Long *et al.* 1993).

Intertidal estuarine sites were only monitored in the Mackay-Whitsunday, Fitzroy and Burnett-Mary NRM regions over the past twelve months. Seagrass abundance at estuarine monitoring sites fluctuates greatly within and between years (**Error! Reference source not found.**). The dramatic declines appear to correlate with disturbance events such as flooding or storms (e.g. wind and cyclone).

Seed banks however, have continued to decline at estuarine intertidal sites (**Error! Reference source not found.**), indicating a relatively low capacity to recover from any significant losses. Low abundances of germinated seeds suggest that increases in abundance in the 2008 growing season (Aug-Nov) were primarily the result of vegetative growth.

Epiphytes and macro-algae fluctuate greatly at intertidal estuarine habitats and correlate highly with seagrass abundance. Epiphytes are more abundant in the Dry season (Figure 4); however this is also the seagrass senescent season, when plant growth and leaf turnover are low. Overall, there does not appear to be any long-term trend in abundance of either epiphytes or macro-algae.

Figure 2: Mean percentage seagrass cover (all sites pooled) at intertidal estuarine habitats in the GBRWHA (± Standard Error) pooled by season. Note: Polynomial trendline for all sites pooled.



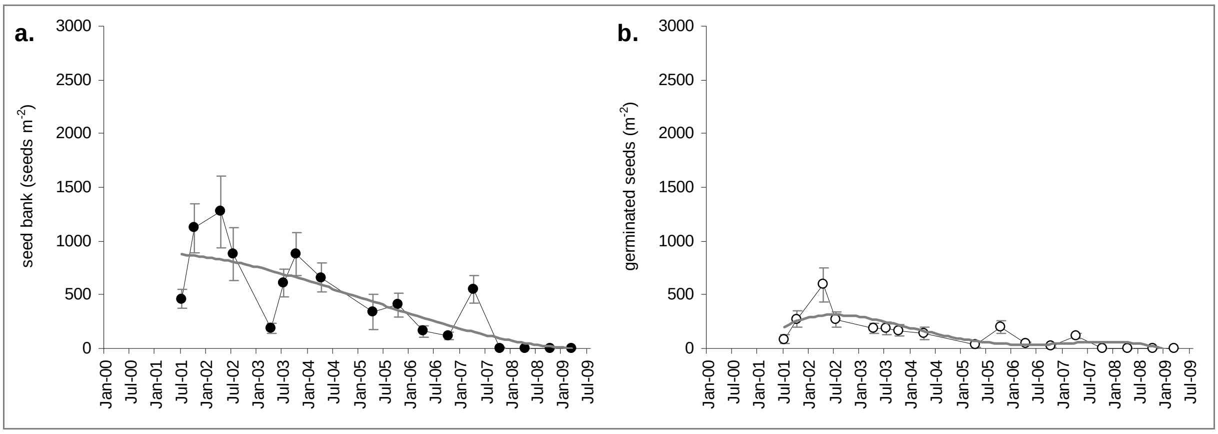


Figure 3: Seed banks (a) and abundance of germinated seeds (b) at intertidal coastal habitats in the GBRWHA (all sites pooled). (Seed bank is represented as the total number of whole seeds per square metre of sediment surface. Germinated seed abundance is represented as the total number of half seeds per square metre of sediment surface.)

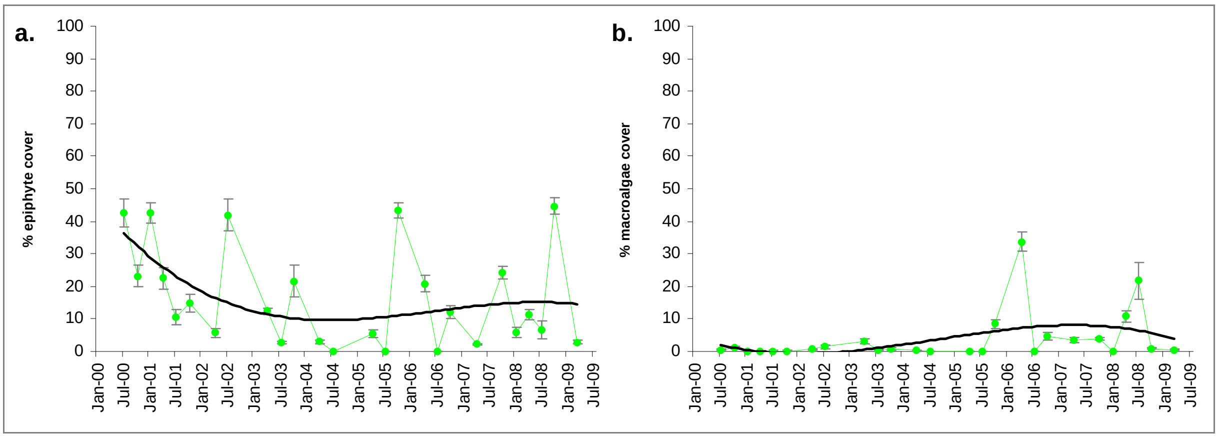


Figure 4: Epiphyte (a) and macro-algae abundance (b) at intertidal estuarine habitats in the GBRWHA (all sites pooled).

Coastal

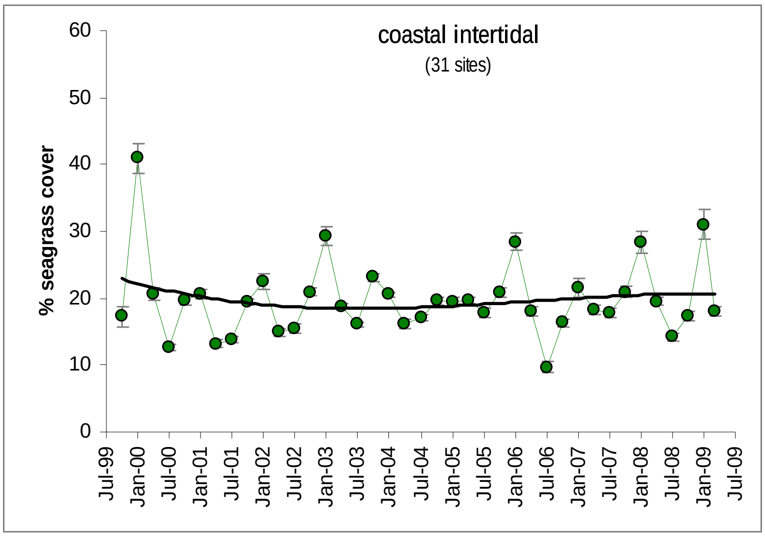
Coastal seagrass habitats have extensive inter-tidal and sub-tidal seagrasses. Inter-tidal environments are impacted by sediment deposition, erosion, tidal fluctuations, desiccation, fluctuating and sometimes very high temperature, variable salinity resulting from rainfall and impacts from strong winds and storms. Tidal range can be in excess of six metres. These communities are affected rapidly by increased runoff with heavy rain or cyclone events. A large and variable seed bank can facilitate recovery following disturbance (Inglis 2000). Inshore seagrass communities are found in varying extents all along the eastern Queensland coastline where these are protected to some degree from the prevalent south east winds by the Great Barrier Reef. Along the southern coast of the GBRWHA, the Great Barrier Reef offers little protection and coastal seagrass meadows are restricted to sheltered bays, behind headlands and in the lee of islands.

Coastal seagrass meadows are the more predominate and consequently more sites are monitored. Intertidal coastal sites were monitored in the Wet Tropics, Burdekin Dry Tropics, Mackay-Whitsunday and Fitzroy NRM regions over the past twelve months. Seagrass abundance at coastal intertidal seagrass meadows has remained relatively stable over the years of monitoring (**Error! Reference source not found.**).

Seed banks continued to decline in 2008 until Late-Monsoon 2009. The decline in 2008 of the seed bank also corresponds with the increase in germinated seeds and consequently seagrass abundance (**Error! Reference source not found.**).

Epiphytes and macro-algae fluctuate greatly at intertidal coastal habitats and appear more abundant in the Dry season (Figure 7). Overall, there appears to be an increase in epiphytes over the last two to three years.

Figure 5: Mean percentage of seagrass cover (all sites pooled) at intertidal coastal habitats in the GBRWHA (± Standard Error) pooled by season. Note: Polynomial trendline for all sites pooled.



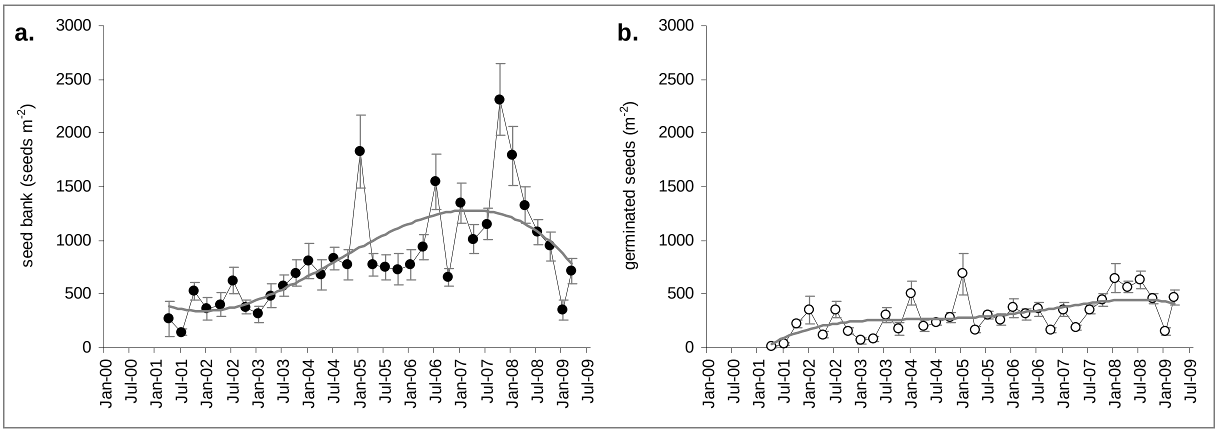


Figure 6: Seed banks (a) and abundance of germinated seeds (b) at intertidal coastal habitats in the GBRWHA (all sites pooled). (Seed bank is represented as the total number of whole seeds per square metres of sediment surface. Gerrminated seed abundance represented as the total number of half seeds per square metre of sediment surface).

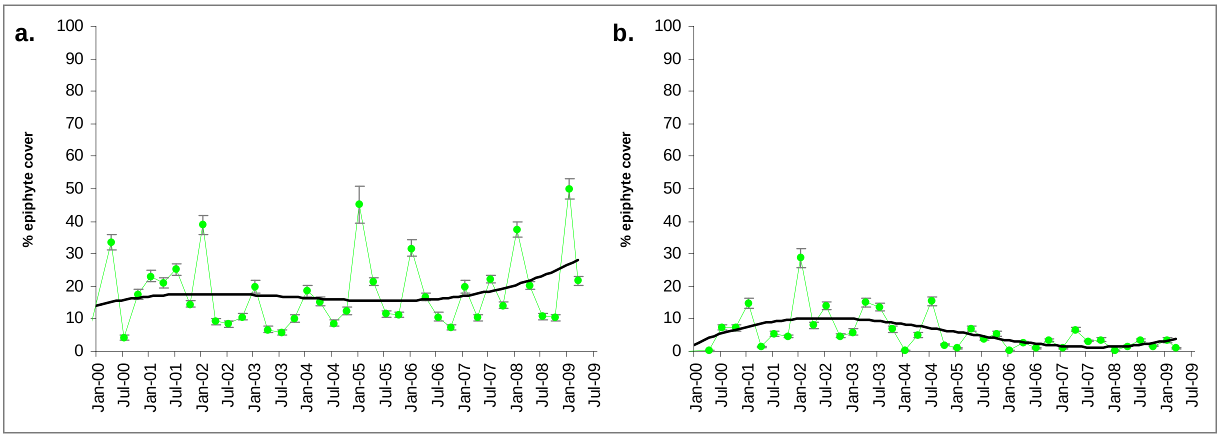


Figure 7: Epiphyte (a) and macro-algae abundance (b) at intertidal coastal habitats in the GBRWHA (all sites pooled).

Reef

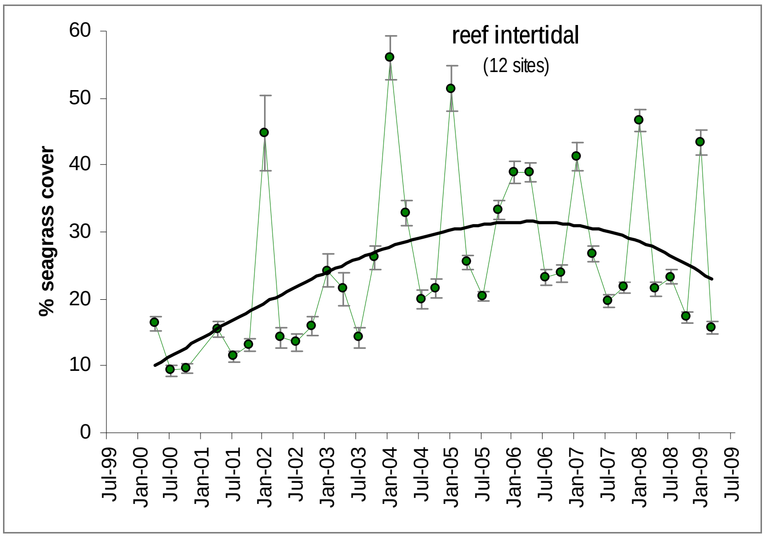
Reef platform seagrass communities support a high biodiversity and can be extensive and highly productive. Shallow unstable sediment and fluctuating temperature characterise these habitats. Low nutrient availability is a feature of reef habitats as seagrasses are nitrogen limited in carbonate sediments. Seagrasses are more likely to be present on reefs with vegetated cays than on reefs with highly mobile sand. Increasing distance from the coast decreases the sediment impacts from pulsed terrigenous runoff, however intermittent sources of nutrients can reach the reef (Udy *et al.* 1999). The more successful seagrass species in reef habitats of the Great Barrier Reef include *Thalassia hemprichii*, *Cymodocea rotundata, Syringodium isoetifolium*, the colonising species *Halophila ovalis* and *Halodule uninervis*.

Twelve sites are monitored by the Seagrass-Watch program within the GBRWHA in the Cape York, Wet Tropics, Burdekin Dry Tropics and Mackay-Whitsunday NRM regions over the past twelve months. Although a few sites are near-shore, most are located on offshore reef-platforms. Seagrass abundance has decrease at intertidal reef-platform seagrass meadows in the past twelve to eighteen months; however abundances are still higher than was observed in 2000-2001 (**Error! Reference source not found.**). Within years, seagrass abundance fluctuates greatly between seasons.

Seed banks are very low at reef habitats compared to both estuarine and coastal intertidal habitats (**Error! Reference source not found.**). Seed abundance also appears to fluctuate greatly both within and between years, which is possibly a consequence of the species diversity with relatively low occurrence of *Halodule uninervis*.

Although epiphyte abundance fluctuates within and between years, it has continued to increase at intertidal reef habitats over the past nine years (Figure 10). Macro-algae abundance however has remained low and relatively stable.

Figure 8: Mean percentage of seagrass cover (all sites pooled) at intertidal reef habitats in the GBRWHA (± Standard Error) pooled by season. Note: Polynomial trendline for all sites pooled.



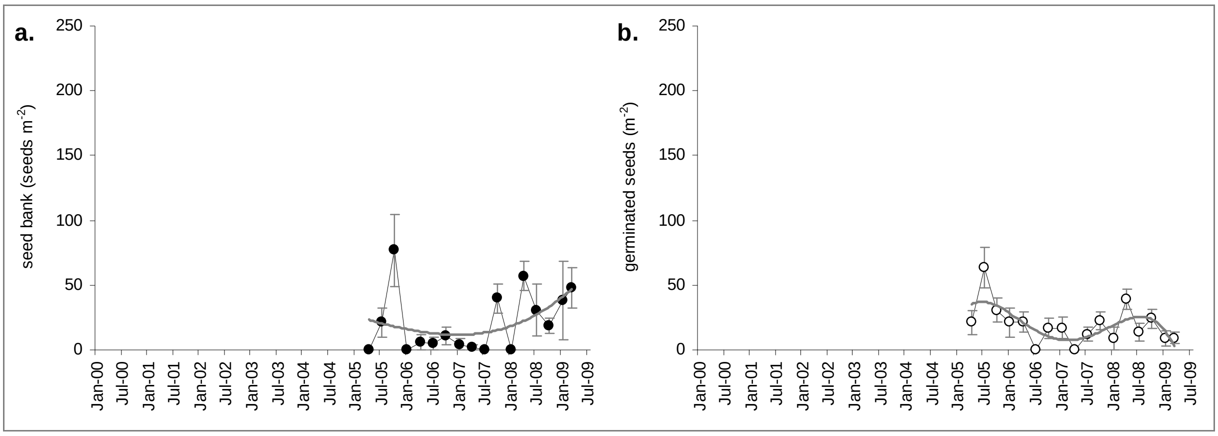


Figure 9: Seed banks (a) and abundance of germinated seeds (b) at intertidal reef habitats in the GBRWHA (all sites pooled). (Seed bank is represented as the total number of whole seeds per square metre of sediment surface. Germinated seed abundance represented as the total number of half seeds per square metre of sediment surface).

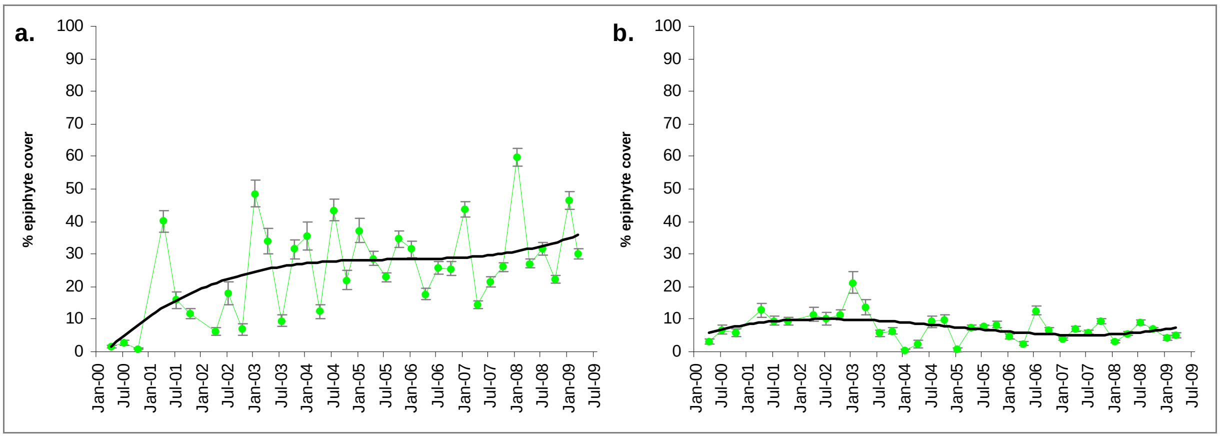


Figure 10: Epiphyte (a) and macro-algae abundance (b) at intertidal reef habitats in the GBRWHA (all sites pooled).

Delivering seagrass abundance indicators for regional habitat guidelines

Currently the only published guidelines for seagrass ecosystems in Queensland are based on the Seagrass Depth Limit used in Moreton Bay and Pumicestone Passage (EHMP). The 50th percentile value is used for condition and applies to high ecological value waters and to waters that are slightly to moderately disturbed (Queensland Water Quality Guidelines, 2007).

Currently, assessment of seagrass habitat condition is subjective to some extent. Although based on qualitative measures (Campbell and McKenzie 2001), the interpretation of the data relies heavy on expert opinion depending on seagrass habitat and community composition. The goal is to develop more transparent and impartial guidelines.

As the Seagrass-Watch program has been collecting data state-wide on a number of seagrass ecosystems measures for nearly a decade at some locations, it is timely to use these measures to assist with the development of more appropriate guidelines.

What is suggested is that abundance data collected from reference sites could be used to estimate percentile values, which in turn could be used to derive guidelines. It was decided to use the 20th and 50th percentiles as these are recommended for water quality guidelines. To be confident in such guidelines we need to be sure they are based on percentile estimates that reflect the true population values.

Indicator values at reference sites vary naturally (seasonal). To reduce errors, it was decided to choose replicate sites within a location. As both Green Island and Yule Point are long term datasets (nine years) and are within the same region (Wet-Tropics), it was decided to use these locations for the case study. The locations also represent reef and coastal seagrass habitats respectively.

Like most statistical measures, errors in percentile estimates reduce with increasing sample size (Figures 11 and 12). The figures show how percentile estimates move towards the true value (the true value is based on the total data set, usually more than thirty samples) with increasing sample size. Results are shown for two different percentile values. For the 50th and 20th percentiles, error values tend to level off at around fifteen to twenty samples, suggesting this number of samples is sufficient to provide a reasonable estimate of the true percentile value. This sample size is reasonably close to the ANZECC 2000 Guidelines recommendation of 24 data values.

The analysis also shows that use of a smaller number of data values results in percentile estimates that mostly lie inside the true percentile values. Thus, in practice, percentiles based on small numbers of samples would give rise to more stringent guidelines. Note, however, that sample sizes less than about six tend to give rise to very inaccurate results.

Based on these analyses it is recommended that estimates of the 20th percentile at a reference site should be based on a minimum of eighteen samples collected over at least three years. For the 50th percentile a smaller minimum number of samples (~10-12) would be adequate but in most situations it would be necessary to collect sufficient data for the 20th percentile anyway. For seagrass habitats with high variability, primarily the result of seasonal fluctuations, a more appropriate guideline may however be the 10th percentile (similar to highly disturbed systems).

Another source of percentile variability is that even within the same habitat type, different reference sites give slightly different percentile estimates. At least some of this variation is due to natural variability between sites. To allow for this source of variability it is recommended that at least two (preferably more) reference sites are used to derive guidelines for each habitat type. If the minimum two sites give obviously different results then further reference sites need to be included. In the event that three or more reference sites give widely varying results (which is not highly likely if reference sites are carefully selected) it may be necessary to assume this is a natural effect. Guideline values would have to be tailored to take account of the wide range of natural variability. However, such assumptions should only be arrived at after a careful review of the suitability of the selected reference sites. Where at least two reference sites are being sampled and are giving consistent results the data can be pooled to give a percentile estimate. In this situation it is reasonable to reduce the minimum number of samples at each site to twelve.

The subregional guidelines when developed could be used to verify if the seagrass meadows at a location are in a poor (*median below 20th or 10th percentile*), fair (*median below 50th and above 20th percentile*) or good (*median above 50th percentile*) state. For example, if the median seagrass abundance for Yule Point is plotted against the 20th and 50th percentiles for coastal habitats in the wet tropics (Figure 13), it would indicate that the meadows were in a poor condition in mid 2000, mid 2001 and mid 2006 (based on abundance). Current abundances at Yule Point would indicate the meadows are in a good condition.

Similarly, if the median seagrass abundance for Green Island is plotted against the 20th and 50th percentiles for intertidal reef habitats in the Wet Tropics (Figure 14), it would indicate that the meadows were in a poor condition in the middle of most years (based on abundance). However, the poor rating is most likely a consequence of seasonal lows in abundance. Therefore, in this instance, it would possibly be more appropriate to set the guideline at the 10th rather than the 20th percentile.

Using this approach, it is planned to continue developing regional guidelines for each seagrass habitat types where possible. These guidelines would contribute to an assessment toolbox which is planned to include a selection of measures.

Figure 11: Relationship between sample size and the error in estimation of percentile values for seagrass abundance (percentage cover) in coastal habitat in the Wet Tropics NRM region.

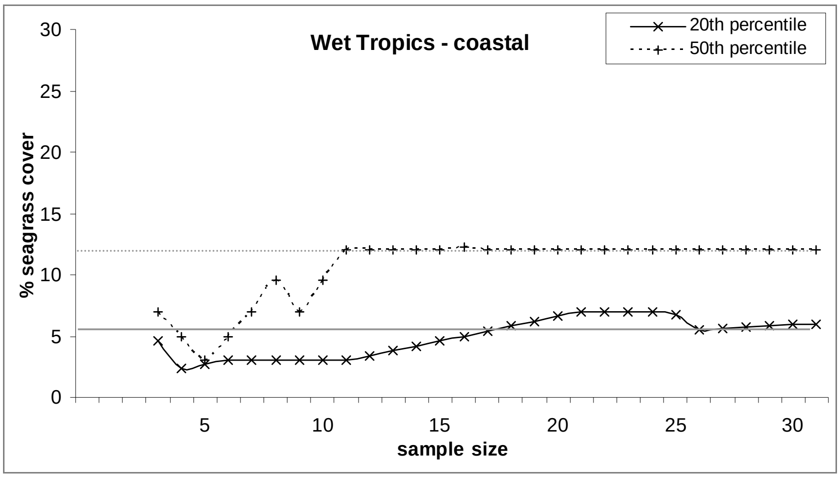


Figure 12: Relationship between sample size and the error in estimation of percentile values for seagrass abundance (percentage cover) in reef seagrass habitat in the Wet Tropics NRM region.

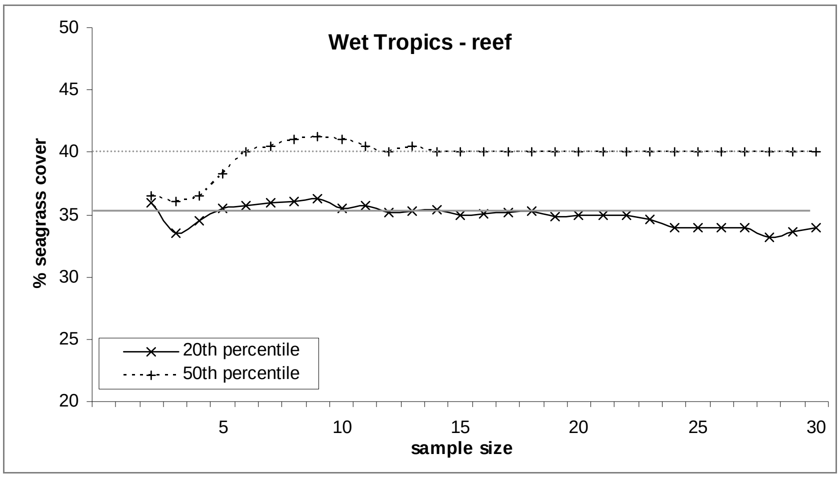


Figure 13: Median seagrass abundance (percentage cover) at Yule Point plotted against the 50th and 20th percentiles for coastal seagrass habitat in the Wet Tropics.

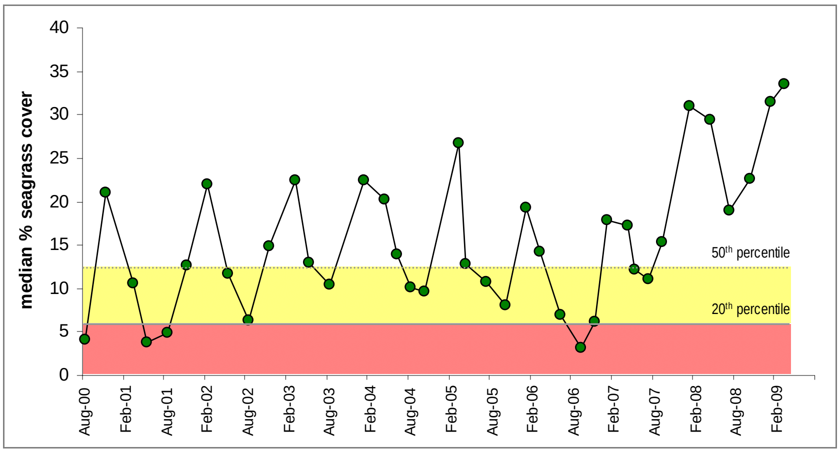
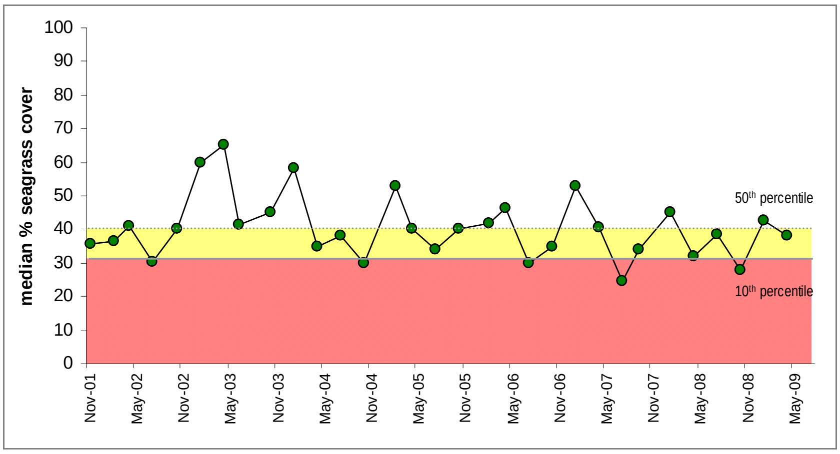


Figure 14: Median seagrass abundance (percentage cover) at Green Island plotted against the 50th and 20th percentiles for intertidal reef seagrass habitat in the Wet Tropics.



Conclusions

The average seagrass percent covers (over the past ten years) at each of the intertidal seagrass habitats within the GBRWHA are relatively similar: 20% for estuarine habitats, 19% cover for coastal habitats and 24% for reef habitats.

Results from the Seagrass-Watch (this summary) indicate that at the scale of the GBRWHA, seagrass meadows were in a “fair” state. Seagrasses have fluctuated greatly in estuarine habitats; most often as a response to climate (e.g. rainfall, temperature and desiccation) and at smaller localised scales there have been some acute event related changes. These fluctuations do not appear to represent long term trends in a particular direction – but rather simply fluctuations.

Unfortunately, there is no indication of the status of deepwater seagrass habitats as they are currently not monitored as part of the Seagrass-Watch program. Also, there is currently little information available on the status of seagrasses in the Cape York NRM region as only one location (Archer Point) is monitored. It would be desirable if at least annual monitoring of seagrasses at selected sites in these habitats and remote locations was considered.

The Seagrass-Watch monitoring program within the GBRWHA has been successful in monitoring seagrass condition at a variety of locations and habitats. It is one of the most comprehensive seagrass programs outside the east coast of North America. Some regions however are less well monitored than others and this needs to be addressed.

References

Campbell, S.J. and McKenzie, L.J. (2001). Community-based monitoring of intertidal seagrass meadows in Hervey Bay and Whitsunday, 1998-2001. DPI Information Series QI01090 (DPI, Cairns) 32 pp.

Carruthers TJB, Dennison WC, Longstaff BJ, Waycott M, Abal E, McKenzie LJ and Lee Long WJ (2002). Seagrass habitats of northeast Australia: Models of key processes and controls. Bulletin of Marine Science 71 (3): 1153-1169.

Coles, R. G., McKenzie, L. J., Rasheed, M. A., Mellors, J. E., Taylor, H., Dew, K. McKenna, S., Sankey. T. L., Carter A. B. and Grech A. (2007). Status and Trends of seagrass in the Great Barrier Reef World Heritage Area: Results of monitoring in MTSRF Prroject 1.1.3. Marine and Tropical Sciences Research Facility, Cairns. 104 pp.

Coles RG, McKenzie LJ and Campbell SJ (2003). The seagrasses of eastern Australia. In: Green EP, Short FT, Spalding MD (eds.) The World Atlas of Seagrasses: present status and future conservation University of California Press, Chpt 11 pp. 131-147.

EPA (2006). Queensland Water Quality Guidelines 2006 (minor updates March 2007). 121pp.

Inglis GJ (2000a). Variation in the recruitment behaviour of seagrass seeds: implications for population dynamics and resource management. Pacific Conservation Biology 5: 251-259.

Lee Long WJ, Mellors JE and Coles RG (1993). Seagrasses between Cape York and Hervey Bay, Queensland, Australia. Australian Journal of Marine and Freshwater Research 44: 19-31.

McKenzie LJ, Lee Long WJ, Coles RG and Roder CA (2000). Seagrass-Watch: Community based monitoring of seagrass resources. Biologia Marina Mediterranea 7(2): 393-396.

McKenzie LJ (1994). Seasonal changes in biomass and shoot characteristic of a Zostera capricorni (Aschers.) dominant meadows in Cairns Harbour, Northern Queensland. Australian Journal of Marine and Freshwater Research 45: 1337-1352.

Udy JW, Dennison WC, Lee Long WJ and McKenzie LJ (1999). Responses of seagrass to nutrients in the Great Barrier Reef, Australia. Marine Ecology Progress Series 185: 257-271.

Attachment 2:

MTSRF Task 1.1.3(b) Thresholds of survival and drivers of change

Report on Year 3 (2008/2009) activities

Associate Professor Michelle Waycott, James Cook University

Project Overview

MTSRF Project 1.1.3(b) *Drivers of change in seagrasses of the Great Barrier Reef* is a research project investigating the role of light and water temperature in determining the growth, physiology and physical characteristics of seagrasses. The objectives of this work are to:

- Quantify thresholds in light and water temperature that lead to changes in coastal tropical seagrass;
- Test proposed response variables in relation to changes in light and water temperature; and
- Contribute to the development of the Reef Rescue Marine Monitoring Program seagrass indicators.

There are three approaches to this project:

1. A review of the literature highlighted gaps in knowledge (Collier and Waycott, 2009);
2. Experimental tests of changes in water temperature and light. Experimental tests of their interaction are yet to be completed; and
3. Field investigations into light and temperature variability occurring in intertidal and subtidal seagrass meadows coupled with measurement of changes in seagrass response variables.

Summary of Findings

- Seagrasses (four coastal tropical species) were exposed to short-term pulses of elevated water temperature to simulate midday low tide conditions. Seagrass species differ in their tolerance to water temperature above 35°C: *H. ovalis*, a broadly distributed species in tropical and temperate environments, is the most sensitive; *C. rotundata*, the most ‘tropical’ species investigated, was the most resilient to high water temperatures (Figure 1) and survived the longest at lethal temperatures (43°C). The seagrasses survived for six days at 35°C and 40°C, but repeated exposure to 40°C impacted seagrass growth and physiology. Short-term exposure to temperatures at 43°C are lethal and are beyond the capacity for the seagrass plants to adapt. An interactive effect between incoming light and short-term increases in water temperature was observed incidentally and requires further investigation.
- Much lower temperatures (27°C and 30°C) can affect seagrasses if sustained over the long-term (Figure 1). Over a seven week experimental period where water temperature was increased from ambient (23.5°C) to 27°C and 30°C, growth rates were initially stimulated at higher temperatures. This did not translate into an increase in shoot density and shoot size (leaf length, leaf width, leaves per shoot). This suggests that increases in metabolic rates, including respiration, inhibit the development of larger, denser meadows after extended periods at higher water temperatures.

- Light thresholds and light response variables were tested at high (66%), moderate (31%), low (14%) and very low (1%) light treatments for 74 days in aquaria. There were multiple light thresholds in four out of five of the seagrass species: only *H. ovalis* exhibited only one threshold within this range of treatments (Figure 2). *Zostera muellerii* responded strongly at moderate to low treatments and again in the very low treatment. *Halophila ovalis* responded strongly to the very low treatment. The other species (*Thalassia hemprichii*, *Halodule uninervis* and *Cymodocea serrulata*) responded at moderate and low treatments. All seagrass variables responded to reductions in light; however, they responded at different thresholds (Figure 2). Rapidly responding variables included the number of leaves per seagrass shoot and growth rate, while shoot density was much slower to respond.
- Field sites were established between January and November 2008 at Magnetic Island, Dunk Island, Green Island and Low Isles where light and temperature are continuously monitored by *in situ* loggers and seagrass response variables are measured approximately every three months (Attachment A, this report). The most comprehensive data set available is for Magnetic Island which was established as a site in January 2008. Seagrasses in intertidal meadows receive much higher light levels than subtidal sites. At most locations, this corresponds to higher percent cover and growth rates in intertidal meadows. Seagrasses in subtidal meadows receive lower light than intertidal meadows and at Magnetic Island, changes in light appears to be acting as a driver of change in percent cover (Figure 3). Seagrass leaf growth rates at Magnetic Island reflect annual changes in water temperature with maximum growth occurring in spring and summer and the lowest during autumn and winter (Figure 4).

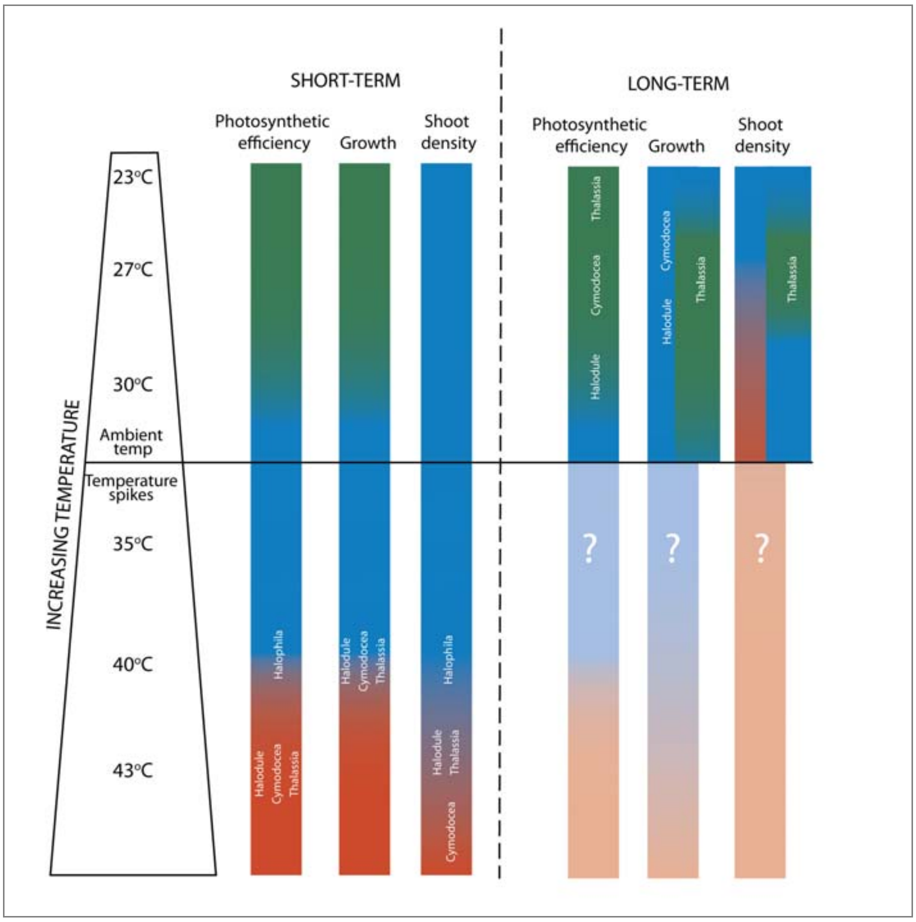


Figure 1: Summary of seagrass response to elevated temperature, including response to short-term (2.5 hours) spikes and long-term temperature responses (seven weeks).

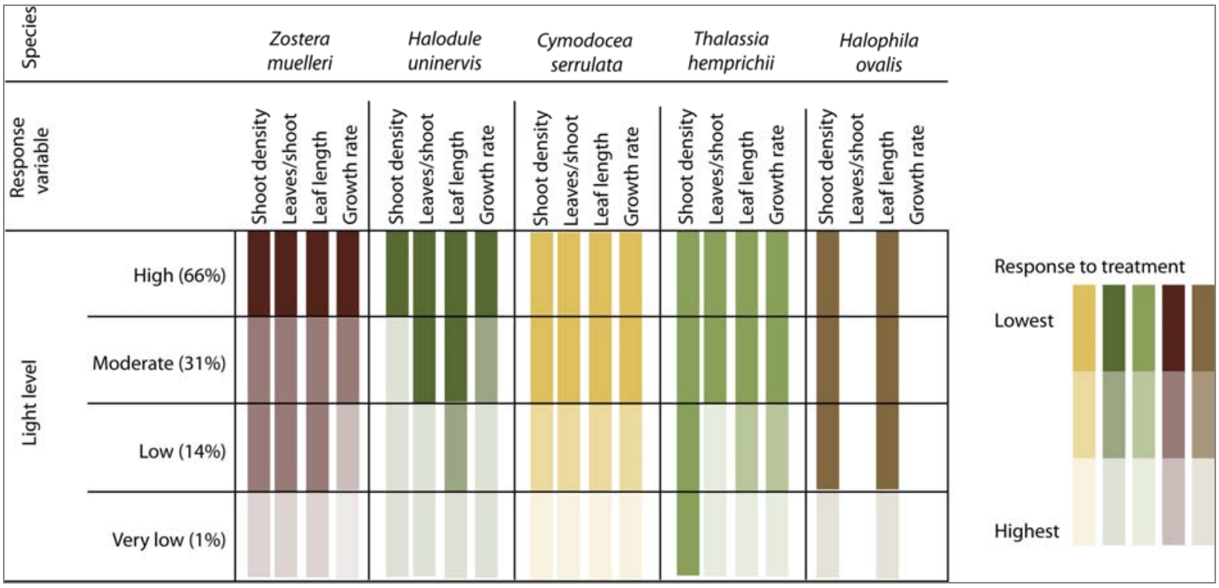


Figure 2: Summary of light thresholds and response variables from light experiments.

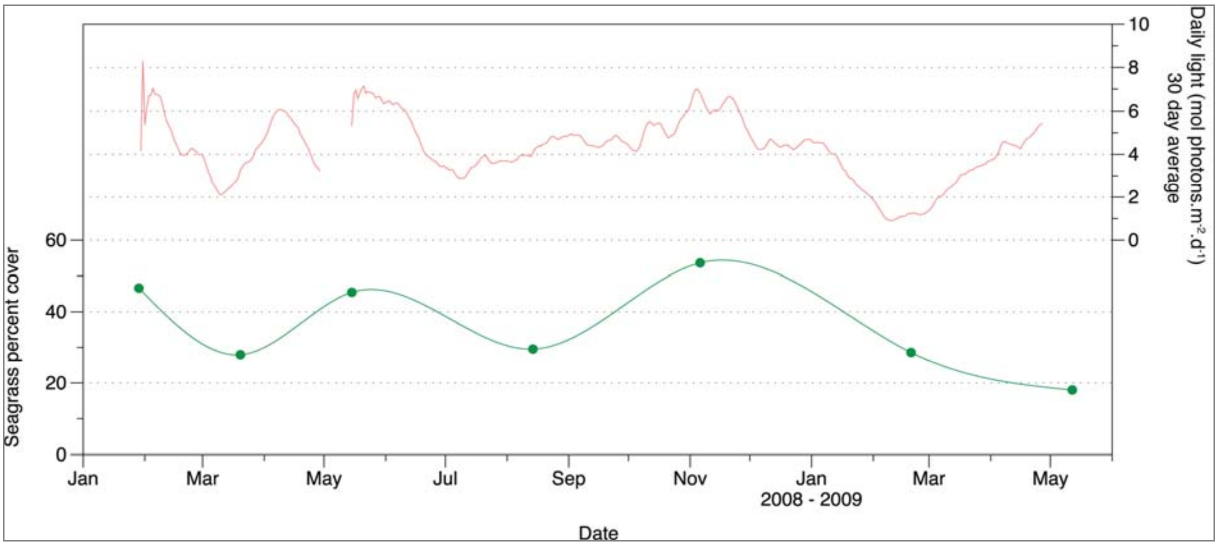


Figure 3: Light (total daily photosynthetic photon flux density, thirty day average; top graph) and seagrass percent cover (lower graph) in the subtidal meadow at Magnetic Island since January 2008.

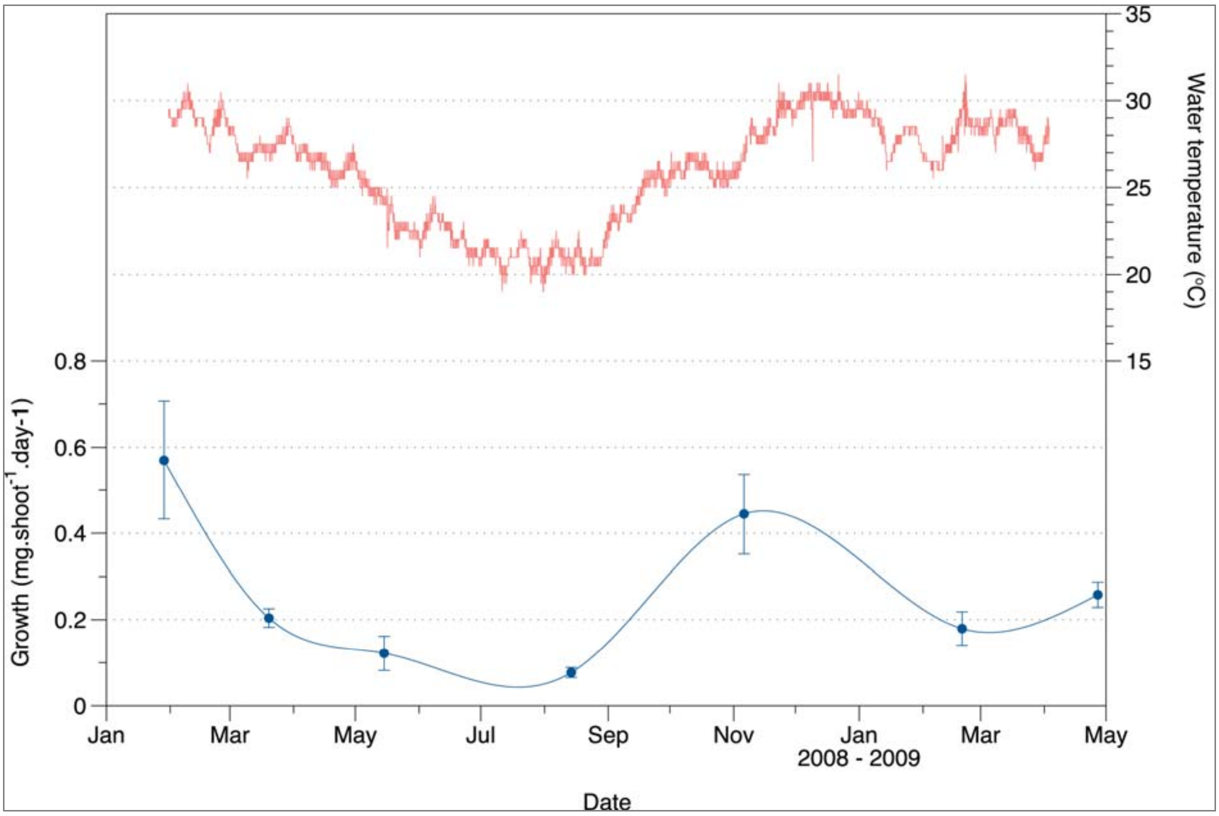


Figure 4: Water temperature (top graph) and *Halodule uninervis* leaf growth (lower graph) in the subtidal meadow at Magnetic Island since January 2008.

With the remaining time that project 1.1.3 Drivers of change is funded, the following will be undertaken:

- Investigations into the interactive effect of increased water temperature and light intensity on seagrasses. This work will test the hypothesis that higher light intensities (which would be associated with good water quality and/or shallow meadows) should enable seagrasses to survive for a longer duration at high water temperatures.
- Ongoing field studies to capture seasonal variation in light and temperature as well as episodic events. By the end of Project 1.1.3 the sites will have been studied for 1.5 to 2.3 years (up to April 2010). This is the minimum required to account for seasonal and interannual variability. If the project were extended this will allow ongoing field studies beyond April 2010 and a much more comprehensive analysis of the role that changes in light and temperature have on seagrass meadows.
- Analysis of field samples including morphology and physiology will continue.
- Detailed statistical analyses will be undertaken and the outcomes from the experimental and field studies will be compared.
- Discussions and communication of findings with stakeholders.

References

Collier, C. and Waycott, M. (2009) *Drivers of change to seagrass distributions and communities on the Great Barrier Reef: Literature review and gaps analysis*. Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns

Attachment 3:

MTSRF Task 1.1.3(c) Risk assessment for coastal seagrass habitats: Values, threats and vulnerabilities

Report on Year 3 (2008/2009) activities

Alana Grech, James Cook University and
Dr Rob Coles, Queensland Primary Industries and Fisheries

Summary and Results

A working group was convened in February 2009 to assess the applicability of the 2007/2008 case study approach to assessing risk to seagrass habitats in the Dry and Wet Tropics. During the May 2008 workshop concerns were raised by workshop members on the adequateness of a simple rank and weight system to quantify the vulnerability of coastal seagrass habitats to their various hazards. The system does not explicitly allow for issues such as scale and resilience to be included within hazard weights, and was considered incomplete. In light of this, the working group designed a new system of evaluating the risk of coastal seagrass habitats to their threats based on the method of Halpern *et al.* (*Conservation Biology*, 2008 21(5): 1301-1315).

The working group developed an online survey using 'Survey Monkey' that asked survey participants to evaluate the vulnerability of coastal seagrass communities by considering the spatial scale, frequency, and functional impact of each threat identified during the workshop held in May 2008; the resistance of seagrass to disturbance by each threat; the resilience (i.e. recovery time) of seagrass following a disturbance; and the certainty of their estimates. The survey is still online and can be accessed at: http://www.surveymonkey.com/s.aspx?sm=4ylw9EDUuVEHD5rvGO0_2b7Q_3d_3d. In May 2009, the online survey was sent to 32 experts on seagrass ecology and biology, marine and terrestrial management, water quality, and spatial information. The response rate of the survey was 31%.

In May and June 2009 the working group compiled the survey results. Using the method of Halpern and others, we combined the five vulnerability measures into a single weight-average vulnerability score that provides a relative estimate of how vulnerable coastal seagrass communities are to a given threat. The greatest relative threat to coastal seagrass communities identified using this method was (1) dredging, followed by: (2) urban/port infrastructure development, (3) agricultural runoff, (4) urban and industrial runoff, (4) shipping accidents, (5) trawling, (6) increase in severity of tropical cyclones, (7) changes in sea surface temperature, (7) boat damage (commercial), (8) boat damage (recreational), (8) sea level rise, (8) changes in air temperature, (9) fishing (other than trawling), and (10) elevated CO_2 and ocean acidification.

We delineated the spatial distribution of anthropogenic threats using spatial layers described in Grech *et al.* (2008). We imported the weight-average vulnerability score for each threat derived from the online survey into their descriptive GIS layers. All of the various threat layers were intersected to create composite hazard coverage (Figure 1). Areas with a high composite hazard score pose the greatest relative threat to coastal seagrass communities in the GBR. Regions of the greatest composite hazard score include the coastal waters adjacent to Gladstone, Mackay, and between Bowling Green Bay and Port Douglas. Areas with a low composite hazard score include the waters north of Cooktown, south of Gladstone and Shoalwater Bay and Broad Sound.

We evaluated, spatially, the relative risk of seagrass communities by combining the composite impact coverage with our probabilistic model of seagrass presence and distribution (Figure 2), resulting in a hazard/consequence matrix (Figure 3). A risk/consequence grid that has a high score will have both a high composite hazard score and a high probability of seagrass presence; a grid that receives a low score can have a high composite hazard score and a low probability of seagrass presence or a low composite hazard score and a high probability of seagrass presence. The areas of highest risk/consequence score include Cleveland Bay, coastal waters adjacent to Gladstone and Mackay, the Hinchinbrook Island region and Trinity Inlet.

The risk assessment models are currently limited by: (1) the spatial datasets that delineate the distribution of threats; (2) the low survey response rate (31%). During the next year the working group will refine some of these datasets to improve the output risk assessment models, and will improve the survey response rate by collecting information from those experts that did not complete the original survey.

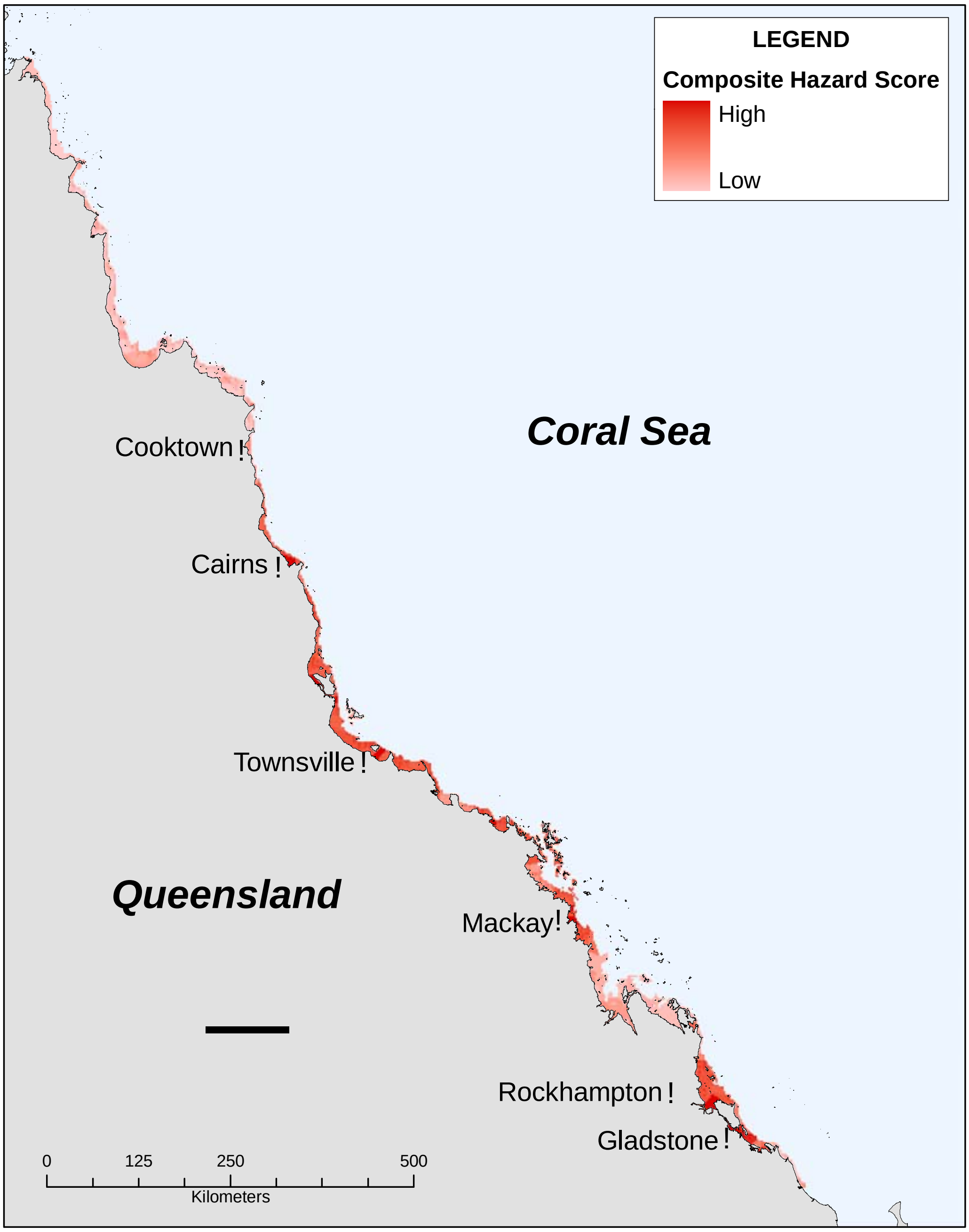


Figure 1: Composite hazard score for the coastal (<15m) region of the Great Barrier Reef World Heritage Area derived from spatial information on the distribution of hazards and the relative hazard scores developed by experts via an online survey.

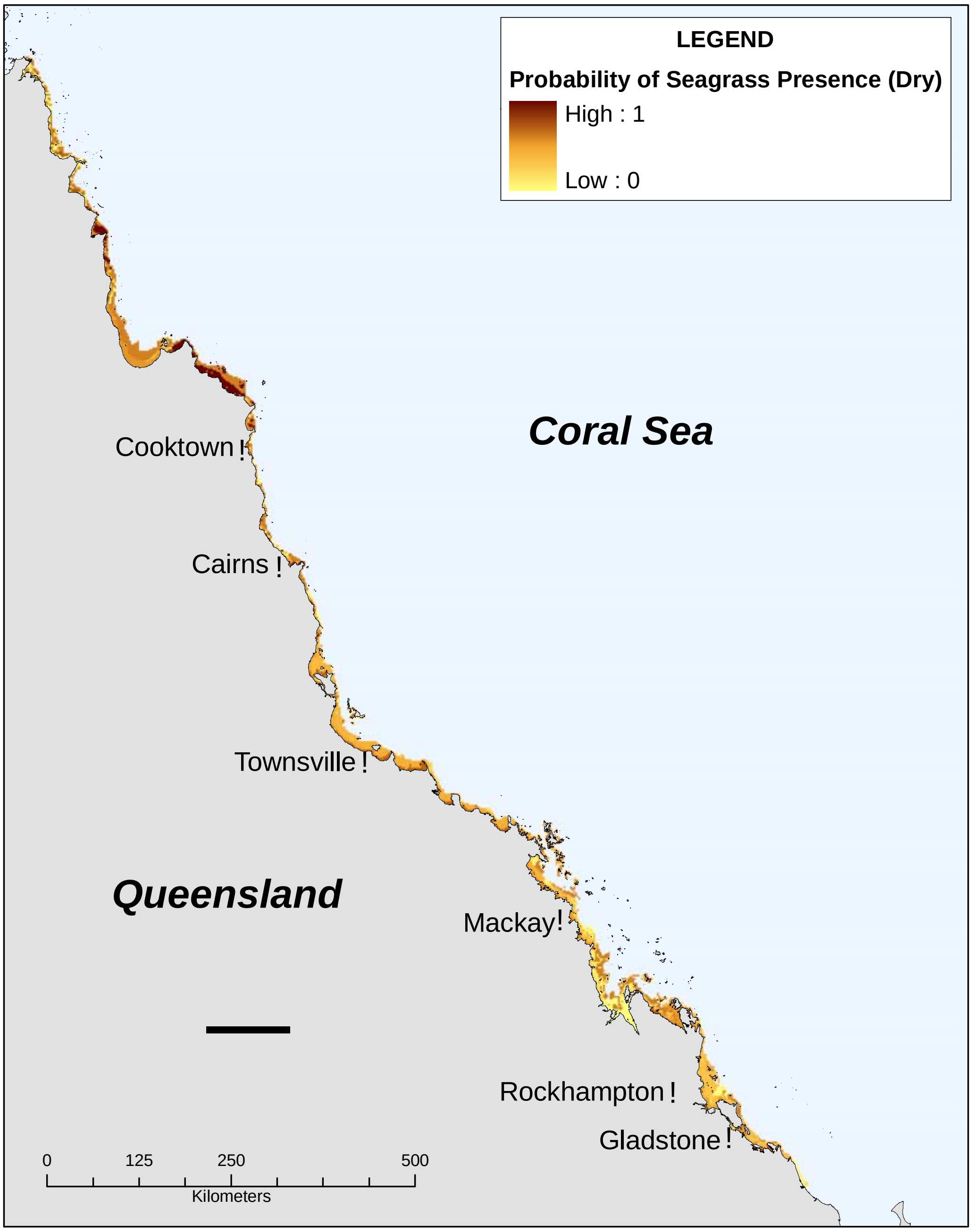


Figure 2: Probability model of coastal (<15m) seagrass presence in the Great Barrier Reef World Heritage Area.

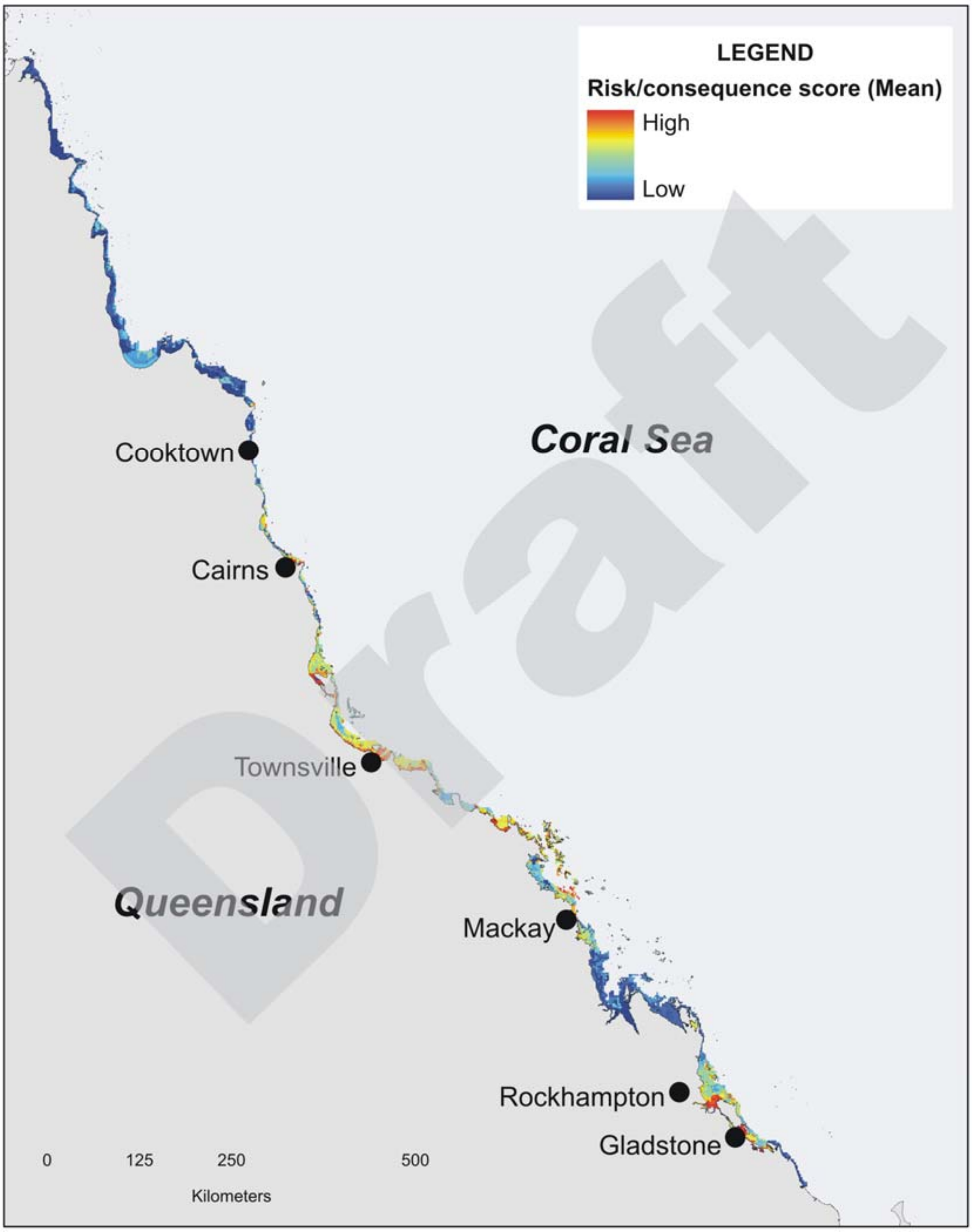


Figure 3: Risk/consequence matrix for the coastal (<15m) region of the Great Barrier Reef World Heritage Area. A risk/consequence grid that has a high score will have both a high composite hazard score and a high probability of seagrass presence; a grid that receives a low score can have a high composite hazard score and a low probability of seagrass presence or a low composite hazard score and a high probability of seagrass presence.