Australian Government

Great Barrier Reef
Marine Park Authority

Monitoring seagrass within the Reef 2050 Integrated Monitoring and Reporting Program:

Appendices to Final report of the seagrass expert group

8 June 2018

Appendices to - Monitoring seagrass within the Reef 2050 Integrated Monitoring and Reporting Program:

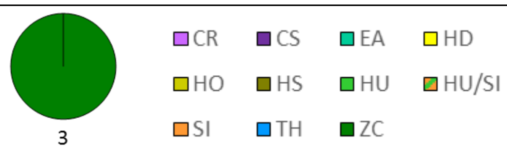
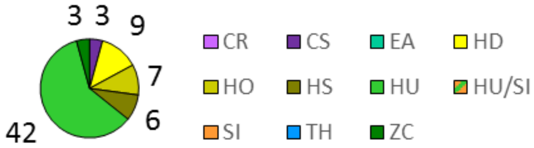
Appendix 1:

Dominant species assemblages that occur within each of the 12 seagrass habitat types on the Great Barrier Reef, within each NRM region.

Dominant meadow community type pie charts were created by: (1) merging all meadows in the Carter et al. 2016 meadow composite, (2) splitting the composite meadow by habitat type and NRM region using the potential seagrass habitat shapefile, and (3) using the Carter et al. 2016 site composite to create a list of all seagrass species present and dominant species within a habitat type/NRM region (Table A1.1). The dominant species is defined at the meadow scale, as the species that occurred most frequently across all sites within a meadow. The frequency with which a species occurs as the dominant species at the meadow scale has been expanded here to determine the dominant species within a habitat type for each of the 6 NRM regions.

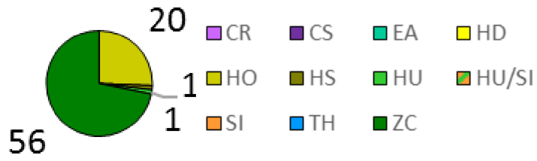
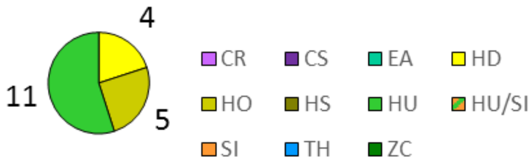
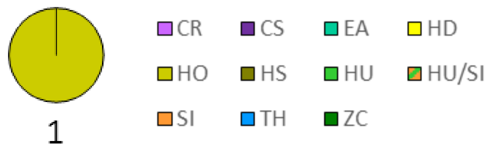
The methods applied to determine dominant meadow community type for intertidal and shallow subtidal meadows could not be applied to deep subtidal seagrass because few meadows have been mapped and most sites fell outside of mapped meadow boundaries. Deep subtidal seagrass species pie charts were created by using the Carter et al. 2016 site composite to create a list of the number of times each seagrass species was present in each of the 12 habitat types within each NRM region, using the potential seagrass habitat shapefile (Table A1.2). The dominant species is defined as the species that occurred most frequently across all sites within a habitat type.

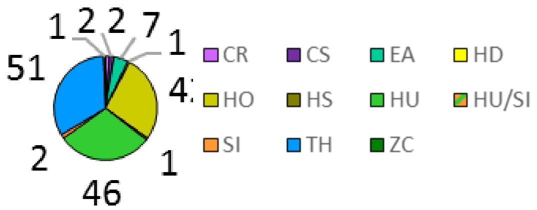
Table A1.1. Intertidal and shallow subtidal meadow species communities across NRM regions and habitat types. CR: *C. rotundata*; CS: *C. serrulata*; EA: *E. acoroides*; TH: *T. hemprichii*; ZC: *Z. capricorni*; HU: *H. uninervis*; SI: *S. isoetifolium*; HS: *H. spinulosa*; HO: *H. ovalis*; HC: *H. capricorni*; HD: *H. decipiens*.

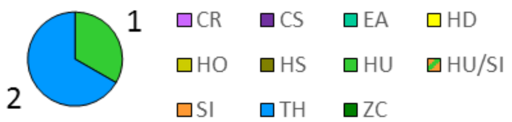
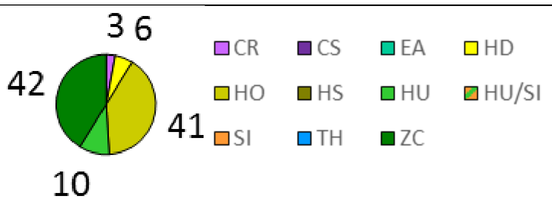
Habitat type	Dominant meadow community types (and number of meadows)	Number of meadows	Seagrass species present (most frequent dominant species underlined)
	Burdekin		
Estuary intertidal		3	<u>ZC</u>
Estuary shallow subtidal	Seagrass absent from all survey sites (n=6)	0	na
Coastal intertidal		52	CR, EA, HD, HO, HS, HU, SI, TH, <u>ZC</u>, CS
Coastal shallow subtidal		70	CR, HD, HO, HS, <u>HU</u>, SI, ZC, CS
Reef intertidal		14	CR, HD, <u>HO</u>, HU, TH, CS

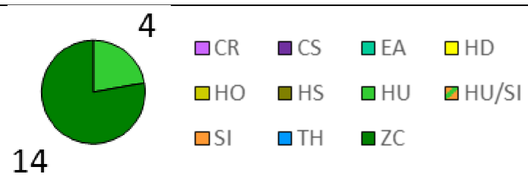
Reef shallow subtidal		5	CR, HD, HO, HS, HU, TH, CS
Offshore intertidal	Habitat not surveyed	na	na
Offshore shallow subtidal	Habitat not surveyed	na	na

Burnett Mary

Estuary intertidal		78	HD, HO, HS, HU, ZC
Estuary shallow subtidal		20	HD, HO, HS, HU, ZC
Coastal intertidal		1	HO, ZC
Coastal shallow subtidal		12	HD, HO, HS, HU, ZC
Reef intertidal	No habitat of this type in habitat layer	na	na
Reef shallow subtidal	Habitat not surveyed	na	na

<table>
<tr><td>Offshore intertidal</td><td>Habitat not surveyed</td><td>na</td><td>na</td></tr>
<tr><td>Offshore shallow subtidal</td><td>Habitat not surveyed</td><td>na</td><td>na</td></tr>
<tr><td colspan="4">Cape York</td></tr>
<tr><td>Estuary intertidal</td><td>
</td><td>3</td><td>HO, HU, TH</td></tr>
<tr><td>Estuary shallow subtidal</td><td>
</td><td>5</td><td>EA, HO, HS, HU, TH, CS</td></tr>
<tr><td>Coastal intertidal</td><td>
</td><td>155</td><td>CR, EA, HD, HO, HS, HU, SI, TH, ZC, CS</td></tr>
<tr><td>Coastal shallow subtidal</td><td>
</td><td>52</td><td>EA, HD, HO, HS, HU, SI, TH, CS</td></tr>
<tr><td>Reef intertidal</td><td>
</td><td>31</td><td>CR, HO, HU, TH</td></tr>
</table>

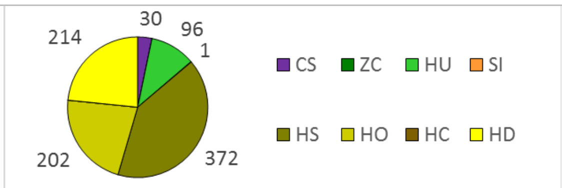
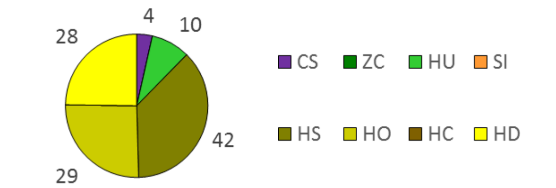
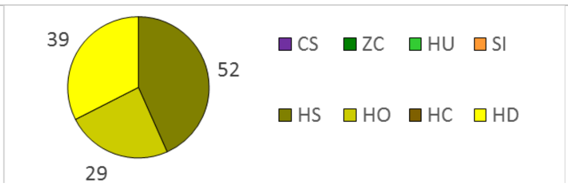
Reef shallow subtidal		1	HD
Offshore intertidal		9	HO, HU, SI, TH
Offshore shallow subtidal		3	HO, HS, HU, SI, TH
	Fitzroy		
Estuary intertidal		102	CR, HD, HO, HS, HU, ZC
Estuary shallow subtidal		30	HD, HO, HS, HU, ZC
Coastal intertidal		110	HD, HO, HS, HU, SI, ZC, CS

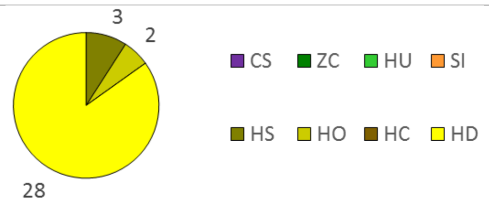
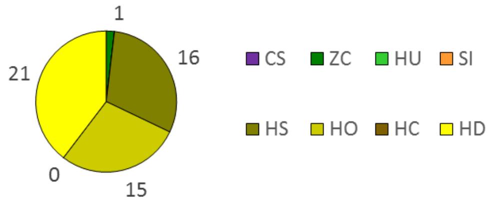
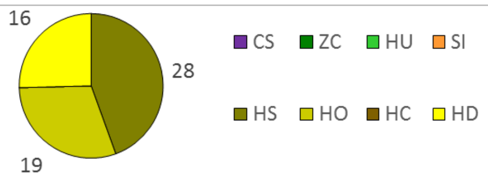
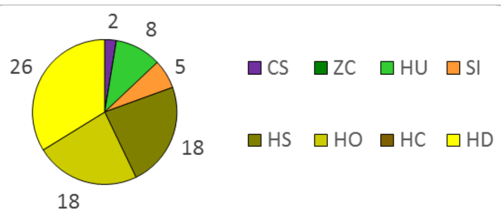
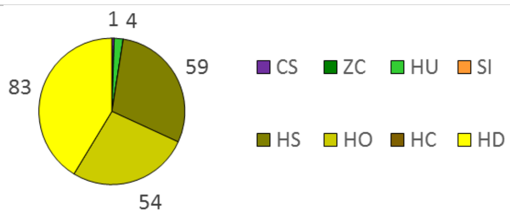
Coastal shallow subtidal		103	HD, HO, HS, HU, SI, ZC, CS
Reef intertidal	Habitat not surveyed	na	na
Reef shallow subtidal	Habitat not surveyed	na	na
Offshore intertidal	Habitat not surveyed	na	na
Offshore shallow subtidal	Habitat not surveyed	na	na
	Mackay-Whitsunday		
Estuary intertidal		18	HD, HO, HU, ZC
Estuary shallow subtidal		8	HO, HU, ZC
Coastal intertidal		112	CR, HD, HO, HS, HU, SI, TH, ZC, CS
Coastal shallow subtidal		152	CR, HD, HO, HS, HU, SI, TH, ZC, CS

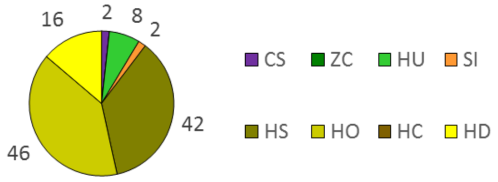
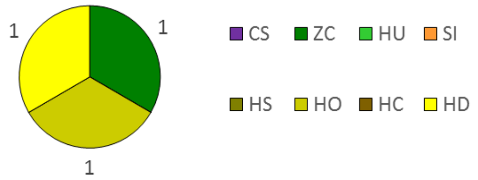
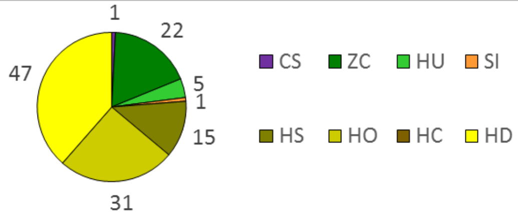
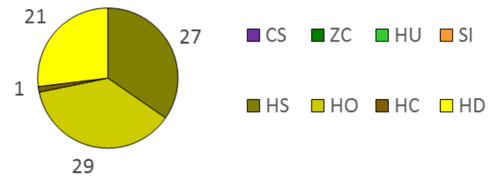
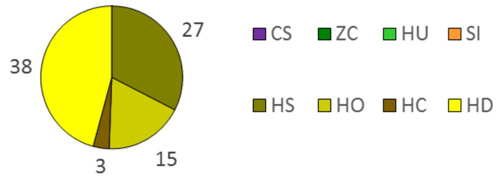
Reef intertidal	No habitat of this type in habitat layer	na	na
Reef shallow subtidal	No habitat of this type in habitat layer	na	na
Offshore intertidal	Seagrass absent from all survey sites (n=432)	0	na
Offshore shallow subtidal	Seagrass absent from all survey sites (n=50)	0	na
	Wet Tropics		
Estuary intertidal		43	EA, HD, HO, HU, ZC
Estuary shallow subtidal		23	EA, HD, HO, HU, ZC, CS
Coastal intertidal		74	CR, EA, HD, HO, HS, HU, SI, TH, ZC, CS
Coastal shallow subtidal		126	CR, HD, HO, HS, HU, SI, TH, ZC, CS
Reef intertidal		10	CR, EA, HO, HU, SI, TH, CS

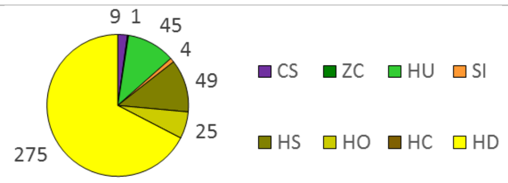
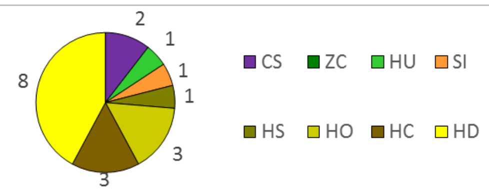
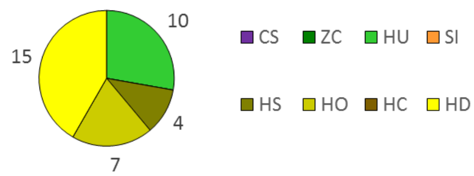
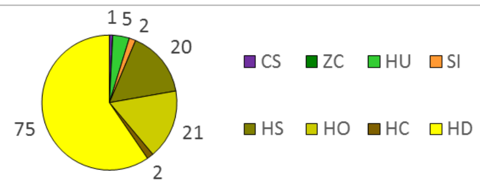
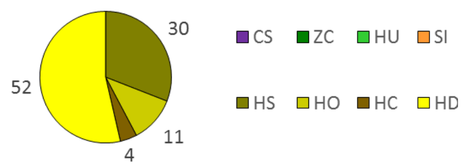
Reef shallow subtidal		19	CR, HD, HO, HU, SI, TH, CS
Offshore intertidal	Habitat not surveyed	na	na
Offshore shallow subtidal	Seagrass absent from all survey sites (n=1)	0	na

Table A1.2. Deep subtidal seagrass species presence and dominance across NRM regions and habitat types. CS: *C. serrulata*; ZC: *Z. capricorni*; HU: *H. uninervis*; SI: *S. isoetifolium*; HS: *H. spinulosa*; HO: *H. ovalis*; HC: *H. capricorni*; HD: *H. decipiens*.

Habitat type	**Dominant meadow community types** (and number of meadows)	**Number of meadows**	**Seagrass species present** (most frequent dominant species underlined)
Burdekin			
Estuary deep subtidal	No habitat of this type in habitat layer	0	na
Coastal deep subtidal		962	CS, HU, SI, HS, HO, HD
Reef deep subtidal		128	CS, HU, HS, HO, HD
Offshore deep subtidal		253	HS, HO, HD
Burnett Mary			
Estuary deep subtidal	Seagrass absent from all survey sites	2	na

Coastal deep subtidal		114	HS, HO, HD
Reef deep subtidal		34	ZC, HS, HO, HD
Offshore deep subtidal		68	HS, HO, HD
Cape York			
Estuary deep subtidal	Habitat not surveyed	na	na
Coastal deep subtidal		165	CS, HU, SI, HS, HO, HD
Reef deep subtidal		393	CS, HU, HS, HO, HD

Offshore deep subtidal		410	CS, HU, SI, HS, HO, HD
	Fitzroy		
Estuary deep subtidal		81	ZC, HO, HD
Coastal deep subtidal		405	CS, ZC, HU, SI, HS, HO, HD
Reef deep subtidal		78	HS, HO, HC, HD
Offshore deep subtidal		333	HS, HO, HC, HD
	Mackay-Whitsunday		
Estuary deep subtidal	Seagrass absent from all survey sites	1	na

Coastal deep subtidal		1317	CS, ZC, HU, SI, HS, HO, <u>HD</u>
Reef deep subtidal	Seagrass absent from all survey sites	22	na
Offshore deep subtidal		232	CS, HU, SI, HS, HO, HC, <u>HD</u>
Wet Tropics			
Estuary deep subtidal	Seagrass absent from all survey sites	32	na
Coastal deep subtidal		183	HU, HS, HO, <u>HD</u>
Reef deep subtidal		229	CS, HU, SI, HS, HO, HC, <u>HD</u>
Offshore deep subtidal		179	HS, HO, HC, <u>HD</u>

Appendix 2:

Adequacy of current seagrass monitoring programs – how is current monitoring effort spread across the 12 seagrass habitat types and NRM regions.

Table 2.1. Habitat classification represented in each NRM region, with total area (km^2) and number of monitoring sites. Site divided between Queensland ports seagrass monitoring program (QPSMP), sporadic data collection and Marine Monitoring Program (MMP) sites. Each MMP site represents a transect block of 33 quadrats visited repeatedly, meadow edge mapping is also conducted adjacent to the sample location. Each QPSMP site represents 3 replicate quadrats sampled in close proximaty. The number of QPSMP sites is the total number of sites visited over the life of the annual monitoring program for that habitat (no repeat measures). *QPSMP monitoring meadow in an adjacent habitat, inadequate data for analysis.

Habitat classification	(area km^2)	QPSMP	Sporadic	MMP
Burdekin Coastal deep subtidal	(3 630)	597	365	
Burdekin Coastal intertidal	(154)	3661	816	7
Burdekin Coastal shallow subtidal	(1 440)	3657	2491	1
Burdekin Estuary deep subtidal		habitat not present		
Burdekin Estuary intertidal	(88)		14	
Burdekin Estuary shallow subtidal	(9.0)		6 (seagrass absent)	
Burdekin Offshore deep subtidal	(22 183)		253	
Burdekin Offshore intertidal	(352)		no data	
Burdekin Offshore shallow subtidal	(347)		no data	
Burdekin Reef deep subtidal	(5 511)		128	
Burdekin Reef intertidal	(34)		108	
Burdekin Reef shallow subtidal	(11)		28	
Burnett Mary Coastal deep subtidal	(743)		114	
Burnett Mary Coastal intertidal	(14)		191	
Burnett Mary Coastal shallow subtidal	(55)		675	
Burnett Mary Estuary deep subtidal	(0.2)		2 (seagrass absent)	
Burnett Mary Estuary intertidal	(75)	951	1395	3
Burnett Mary Estuary shallow subtidal	(55)		385	
Burnett Mary Offshore deep subtidal	(7 556)		68	
Burnett Mary Offshore intertidal	(80)		no data	
Burnett Mary Offshore shallow subtidal	(39)		no data	
Burnett Mary Reef deep subtidal	(2 668)		34	
Burnett Mary Reef intertidal		habitat not present		
Burnett Mary Reef shallow subtidal	(30)		no data	
Cape York Coastal deep subtidal	(3 967)		165	
Cape York Coastal intertidal	(374)		1649	9
Cape York Coastal shallow subtidal	(3 921)		709	6
Cape York Estuary deep subtidal	(0.2)		no data	
Cape York Estuary intertidal	(58)		30	
Cape York Estuary shallow subtidal	(275)		25	
Cape York Offshore deep subtidal	(20 904)		410	
Cape York Offshore intertidal	(900)		259	

Habitat classification		Composite (QPSMP)	Composite (sporadic)	MMP
Cape York Offshore shallow subtidal	(529)		43	
Cape York Reef deep subtidal	(16 375)		393	
Cape York Reef intertidal	(1 339)		1256	2
Cape York Reef shallow subtidal	(1 095)		6	
Fitzroy Coastal deep subtidal	(7 993)		405	
Fitzroy Coastal intertidal	(514)		1207	4
Fitzroy Coastal shallow subtidal	(1 961)		1285	
Fitzroy Estuary deep subtidal	(46)		81	
Fitzroy Estuary intertidal	(406)	7102	9930	2
Fitzroy Estuary shallow subtidal	(275)	776	1779	
Fitzroy Offshore deep subtidal	(51 155)		333	
Fitzroy Offshore intertidal	(1 535)		no data	
Fitzroy Offshore shallow subtidal	(993)		no data	
Fitzroy Reef deep subtidal	(6 139)		78	
Fitzroy Reef intertidal	(9.5)		no data	
Fitzroy Reef shallow subtidal	(12)		no data	
Mackay-Whits. Coastal deep subtidal	(10 089)	609	708	
Mackay-Whits. Coastal intertidal	(113)	5*	1131	10
Mackay-Whits. Coastal shallow subtidal	(1 384)	9*	2623	6
Mackay-Whits. Estuary deep subtidal	(0.3)		1 (seagrass absent)	
Mackay-Whits. Estuary intertidal	(63)		108	
Mackay-Whits. Estuary shallow subtidal	(20)		54	
Mackay-Whits. Offshore deep subtidal	(26 782)		232	
Mackay-Whits. Offshore intertidal	(997)		432 (seagrass absent)	
Mackay-Whits. Offshore shallow subtidal	(490)		50 (seagrass absent)	
Mackay-Whits. Reef deep subtidal	(2 038)		22 (seagrass absent)	
Mackay-Whits. Reef intertidal		habitat not present		
Mackay-Whits. Reef shallow subtidal		habitat not present		
Wet Tropics Coastal deep subtidal	(2 270)	1*	182	
Wet Tropics Coastal intertidal	(113)	1676	1251	7
Wet Tropics Coastal shallow subtidal	(1 384)	1160	3908	3
Wet Tropics Estuary deep subtidal	(1.3)		32 (seagrass absent)	
Wet Tropics Estuary intertidal	(53)	3283	673	
Wet Tropics Estuary shallow subtidal	(25)	1713	504	
Wet Tropics Offshore deep subtidal	(8 931)		179	
Wet Tropics Offshore intertidal	(372)		no data	
Wet Tropics Offshore shallow subtidal	(440)		1 (seagrass absent)	
Wet Tropics Reef deep subtidal	(6 244)		229	
Wet Tropics Reef intertidal	(127)		1163	3
Wet Tropics Reef shallow subtidal	(144)		397	2
TOTAL		**25200**	**40996**	**65**

Appendix 3:

Predicting below ground biomass from above ground biomass – investigating historic data to inform the development of the new monitoring program.

What lies beneath: an assessment of seagrass below-ground biomass in northern Australia

- This has been prepared in a separate document as a draft manuscript to support future estimates of below ground seagrass biomass on the Great Barrier Reef - from above ground observations that will dominate future monitoring activities.

Appendix 4:

Measuring resilience of seagrass on the Great Barrier Reef – background understanding of resilience models to support the selection of resilience indicators.

Incorporating resilience into management frameworks is increasingly recognised as critical to halt the degradation of our coastal ecosystems, and resilient ecosystems are clearly identified as an important component of the Reef 2050 Plan. A framework identifying the important aspects of resilience for seagrass ecosystems has recently been proposed (Unsworth et al 2015). This includes features of a resilient seagrass system such as genetic diversity or continuous habitat, as well as biological (e.g. connectivity) and biophysical (e.g. water quality) features of the supporting ecosystem. Within the seagrass system, the ability of seagrass species to resist or recover from a disturbance varies linked to the different life-history strategies of the species (Kilminster et al 2015, O'Brien et al 2017). So the features necessary to understand resilience have been identified but ideas on how to embed this into monitoring programs is still developing. Globally, no standard approach has been developed to predict or measure resilience in seagrass habitats. Although different approaches have been reported to predict resilience such as using dynamic Bayesian models (Wu et al 2017). Currently monitoring programs in the GBR do not explicitly measure resilience, although seagrass metrics that are currently collected can inform some, but not all aspects of resilience. Here we summarise the information required to measure and predict resilience, and propose how we will embed and assess it as part of the RIMReP seagrass monitoring framework.

Features that confer a resilient seagrass population on the Great Barrier Reef

Seagrass habitat resilience is a consequence of attributes of **recovery** and **resistance,** and a resilient seagrass meadow will have greater ability to persist over time when exposed to a range of pressures and disturbance events (e.g. cyclones, floods, dredging, warming, dugong grazing). The ability of a seagrass meadow to resist and recover is dependent on attributes relating to the seagrass itself including species diversity, population genetic diversity of the species (e.g. clonal diversity, population structure), the condition of the seagrass (particularly sexual and vegetative reproduction)) as well as attributes beyond the seagrass meadow of interest (e.g. connectivity or dispersal of propagules between meadows (Appendix 2 – Fig. 1).

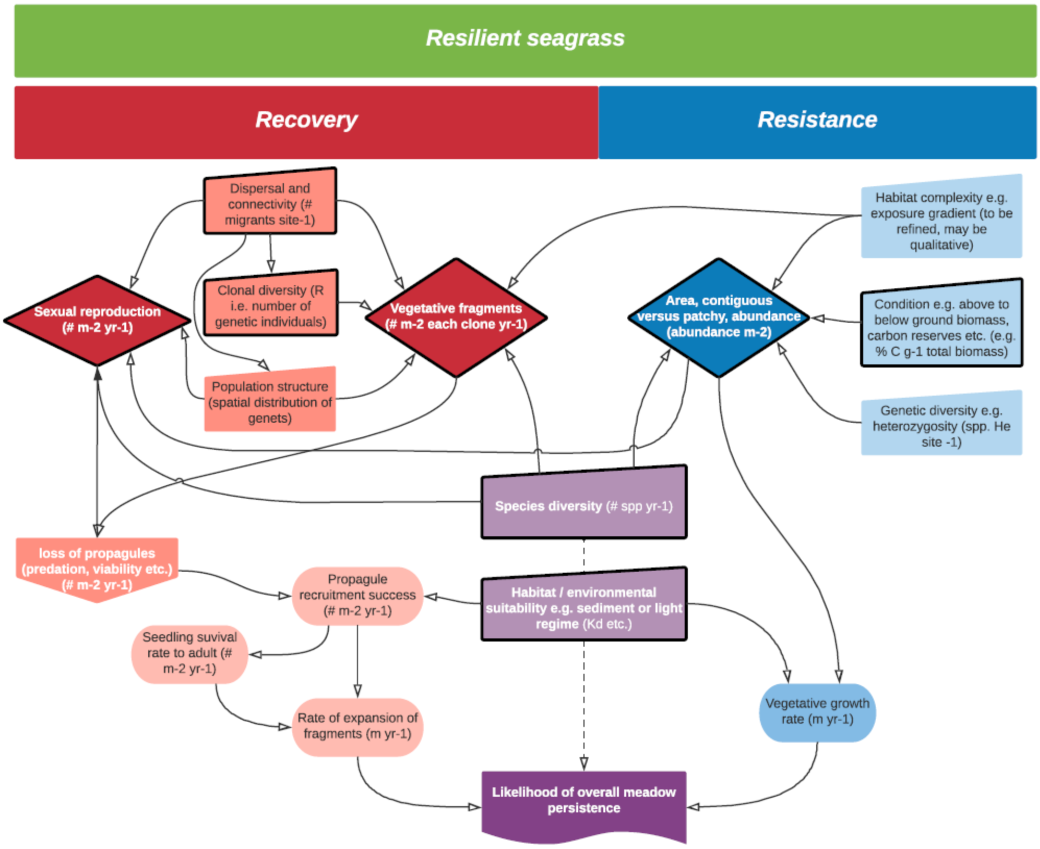
A meadows ability to resist pressures is primarily dependent on the seagrass standing stock, including area, abundance, and the distribution of patches or fragmentation of the meadow. Aspects that modify resistance include species diversity, genetic diversity, habitat complexity, and condition (e.g. carbon resource stores). The rate of vegetative growth and recruitment of new individuals from within or dispersed from other meadows to maintain the existing meadow influence the likelihood of meadow persistence.

Recovery of a meadow following degradation triggered by exposure to a pressure or disturbance event is facilitated by vegetative growth from any remaining seagrass and through the successful recruitment of seeds and or propagules from within or dispersed from other meadows. Survival of these seedlings to adulthood is required for recovery to occur but suitable habitat and environmental conditions are needed for these fragments and seedlings to vegetatively expand. Species diversity alters the likelihood of vegetative fragments and seed banks being present following a disturbance event. The spatial distribution of genets (population structure) within a meadow will also influence the likelihood of successful sexual reproduction *in situ*. If the plants in the meadow are completely removed, then recovery can only be facilitated via seedbanks from within the meadow or propagules dispersed from other meadows. If seedbanks are also completely removed due to the disturbance or pressure, then dispersal of propagules from other meadows is the only remaining pathway for recovery. Connectivity of propagules between meadows is a critical aspect of resilience.

The rates of recovery are dependent on the area, abundance, and distribution of remaining patches and vegetative growth rates. The environmental conditions post-disturbance or related to the continuing pressure will affect these growth rates. Recovery from seed is more likely from species that produce a dormant seed-bank (e.g. *Halophila* spp. and *Halodule* spp.). For those species that do not produce a dormant seedbank (e.g. *Thalassia hemprichii*), the likelihood of recovery depends on the timing of disturbance, coinciding with the release of seeds from remaining plants or dispersal from nearby meadows. The ability of a seagrass meadow to successfully reproduce is modified by clonal diversity and population structure.

There are also 17 recognised feedbacks loops or mechanisms that occur on the Reef that enhance resistance, but if lost will also prevent or slow recovery processes.

Based on these attributes of resilience we propose the following measures be incorporated into RIMRep monitoring at two different tiers, Regional (R), Local (L), as well as specific event-based (E) monitoring designed to evaluate and validate the ability of these measured attributes to predict seagrass resilience in the GBR. These metrics will inform on aspects of resilience, **persistence** (likelihood of persistence) and **recoverability** (likelihood of recovery) following an event. Examples of these metrics are identified in Figure (Resilient Seagrass attributes figure). While an understanding of all of these attributes are important to give a complete picture of resilience, we have identified those we consider a priority to measure in the first instance. We recommend incorporating these measures into the routine Regional- and Local-scale monitoring to enable predictions of resilience. More detailed measures that require seasonal data would be carried out at the Local-scale sites, whereas the more general measures would be carried out at the Regional sites. At this stage the resilience prediction would be based on a relative scoring system like report cards. Event-based monitoring would be used to assess recovery rates where degradation occurs following a disturbance event or a sustained pressure, and refine and validate the resilience measures collected as part of the routine monitoring program (Appendix 2 – Fig. 2). Specifically, we propose that following a disturbance of concern to management, a rapid assessment of resilience will be carried out (e.g. number of fragments, presence of seedbank and/or habitat suitability). This first assessment provides management with information as to whether active intervention may be necessary, or if the meadow is likely to recover by itself. If recovery is considered likely, we propose event based monitoring continue with consideration of kinetic and seasonal aspects to best capture estimates of recovery rates that can be used to both build predictive models and validate the estimates of resilience provided by the routine monitoring at regional and local scales.



Appendix 4 – Fig 1: Demonstrating attributes of resistance and recoverability combine to determine seagrass resilience.

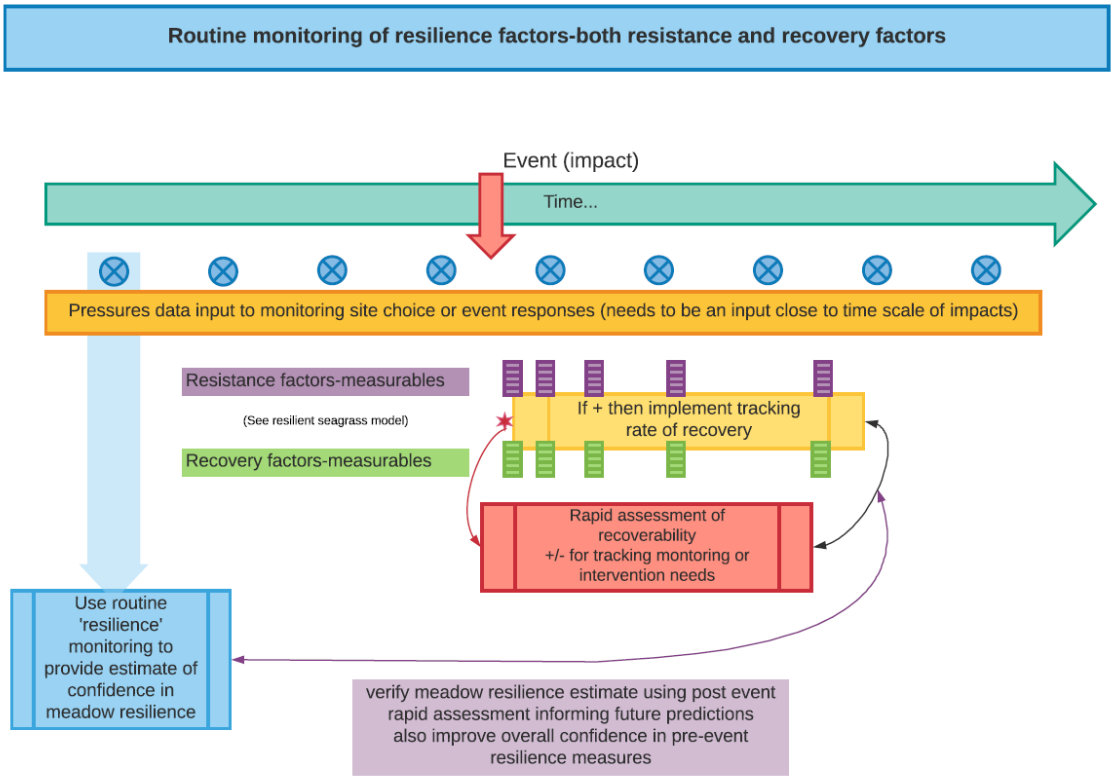
Appendix 4 – Table 1: Resilience attributes of seagrass that can be measured and were considered for possible inclusion as priority indicators in the seagrass monitoring program.* represents and attribute considered to be a priority indicator.

Monitoring type	**Attribute (* priority)**	**Main component of resilience**	**What is it?**	**Direction of influence on resilience**
	CORE ATTRIBUTES OF RESILIENCE			
Health Process - Routine - Post event	Sexual reproduction*	Recovery	How many seeds or seedlings (for species that don't produce seeds) are present in a given area and time.	More seeds or seedlings is positive
Process - Post event	Vegetative fragments*	Recovery	How many fragments (remanent patches following event) are present in a given area and time.	More fragments is positive
Health Process - Routine - Post event	Characteristics of seagrass standing stock*	Resistance & Recovery	Area of seagrass, abundance (density/biomass/cover), how seagrass is distributed over the landscape (continuous versus patchiness, measure of fragmentation)	More area is positive More abundance is positive More fragmentation is negative
	MODIFIERS ON CORE ATTRIBUTES			
Health Process - Routine - Post	Species diversity*	Recovery and Resistance	Number of different species present in a given area	Positive (greater diversity of species will increase

event				resistance potential and likelihood of fragments remaining following event and seedbanks being present)
Process	Habitat complexity	Resistance	Complexity in habitat across the landscape which mean different abiotic pressures (e.g. wave/energy exposure gradient, sediment type) – could be qualitative measure of uniformity of habitat	Positive (where greater habitat complexity is likely to lead to more environmental niches, which will increase potential to resist and likelihood of remnant fragments)
Health Process	Connectivity* (dispersal of propagules between meadows)	Recovery	The ability for external inputs of propagules to the affected area, therefore influences clonal diversity, population structure and genetic diversity	More connectivity to a site better
Process	Clonal diversity*	Resistance & Recovery	Number of individuals (unique genotypes)	More is positive, threshold for too low as sexual reproduction can not occur
Process	Population structure	Recovery	Spatial distribution of individual (genotypes) across seagrass	Positive where individuals are well integrated (mixed as

			landscape	opposed to clumped is better)
Process	Genetic diversity	Resistance	Total expected heterozygosity within the meadow area of interest	Positive (greater genetic diversity of species will increase resistance potential)
Health Process - Routine - Post event	Seagrass condition*	Resistance & Recovery	Seagrass condition or health might be measured by allocation of above/below biomass, carbohydrate reserves …	Positive (Seagrass that is in better condition will have greater resistance)
	MODIFIERS OF SECONDARY ATTRIBUTES			
Health Process - Routine - Post event	Habitat and/or environmental suitability*	Recovery and Resistance	Need to ensure adequate habitat/environmental conditions (e.g. light climate, sediment substrate…) as influences propagule recruitment success and vegetative growth rate	Either suitable or not. If suitable there is a positive gradient contributing to resilience.
	SECONDARY ATTRIBUTES OF RESILIENCE			
Process - Routine - Post event	Propagule recruitment success	Recovery	Success and survival of seedling or fragment establishment, enabling growth	Positive (greater success and survival is better)
Process - Routine - Post event	Vegetative growth rate	Resistance	Resistance and ultimately survival is influenced by expansion, growth	Positive (faster growth rate is better)

			rates, areal productivity..	
Process - Routine - Post event	Seedling survival rate to adult	Recovery	Seedlings need to survive and grow through to adulthood (number of seedlings/area/year)	Positive (greater survival the better)
Process - Routine - Post event	Rate of expansion of fragments	Recovery	Vegetative expansion of seagrass fragments to enable the recovery of meadow	Positive (greater expansion rates the quicker the recovery)
	OVERALL RESILIENCE MEASURE			
	Whole of meadow likelihood of persistence / recovery	Resistance and Recovery	Increased likelihood of meadow survival (resistance attributes) and rapid rate of recovery (recovery attributes) increases overall resilience due to ability to resist/recover from future disturbances.	Positive



Appendix 4 – Fig 2: How different aspects of resilience will be monitored and integrated from post-event monitoring.

Appendix 4 – Table 2: Example of how the resilience score-card could be generated.

Resilience indicators

Likelihood of persistance	Low	Moderate	High
Species diversity based on habitat types	1	2 to 3	>3
Spatial extent	Absent	< 1 ha	> 1 ha
Abundance (may vary depending on habitat type)	Absent	<20% cover	>20% cover
Clonal diversity	0	R<0.5	R>0.5
Likelihood of recovery			
Species diversity (see above)			
Species present that produce seed bank	0	1	>1
Seed banks or seedlings present	Absent		Present
Clonal diversity	<0.25		>0.5
Clonal spatial structure			
Genetic diversity			
Connectivity with other meadows (Species present have seeds that can disperse between meadows)	Absent	Present > 5km	Present with <5km
Species present have seeds that can disperse between meadows	Absent		Present

Appendix 5:

Statistical analysis of reproductive structures and seedbanks – investigating historic data to inform the development of the new monitoring program.

- This will be provided in a separate report by Emma Lawrence under a separate contract with the Authority.