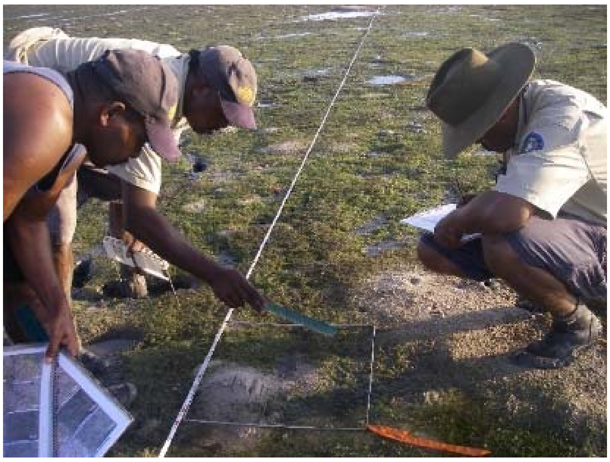

TORRES STRAIT SEAGRASS 2018 REPORT CARD

Carter AB, Mellors JE and Rasheed MA

Report No. 18/25

June 2018

TORRES STRAIT SEAGRASS

2018 REPORT CARD

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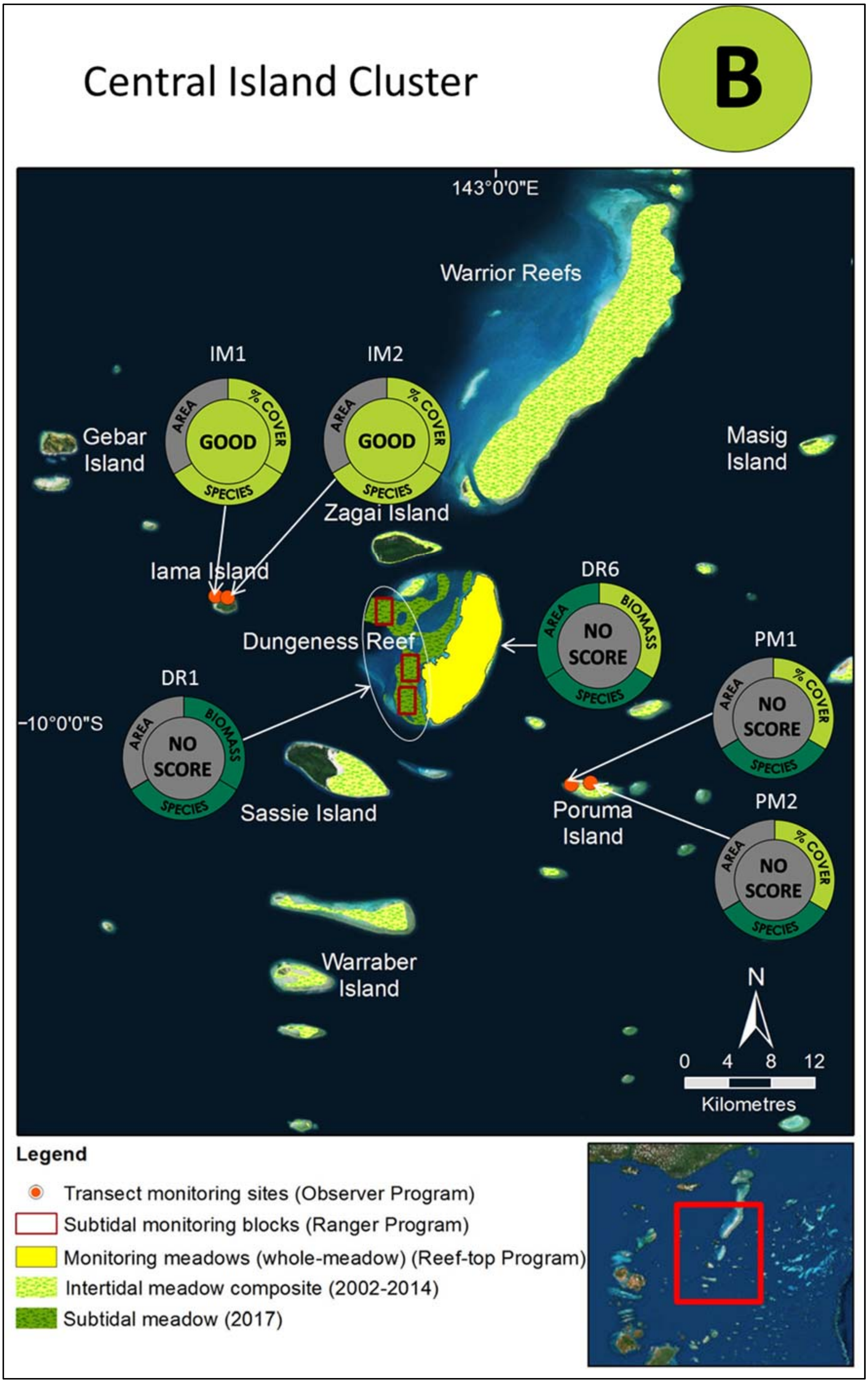
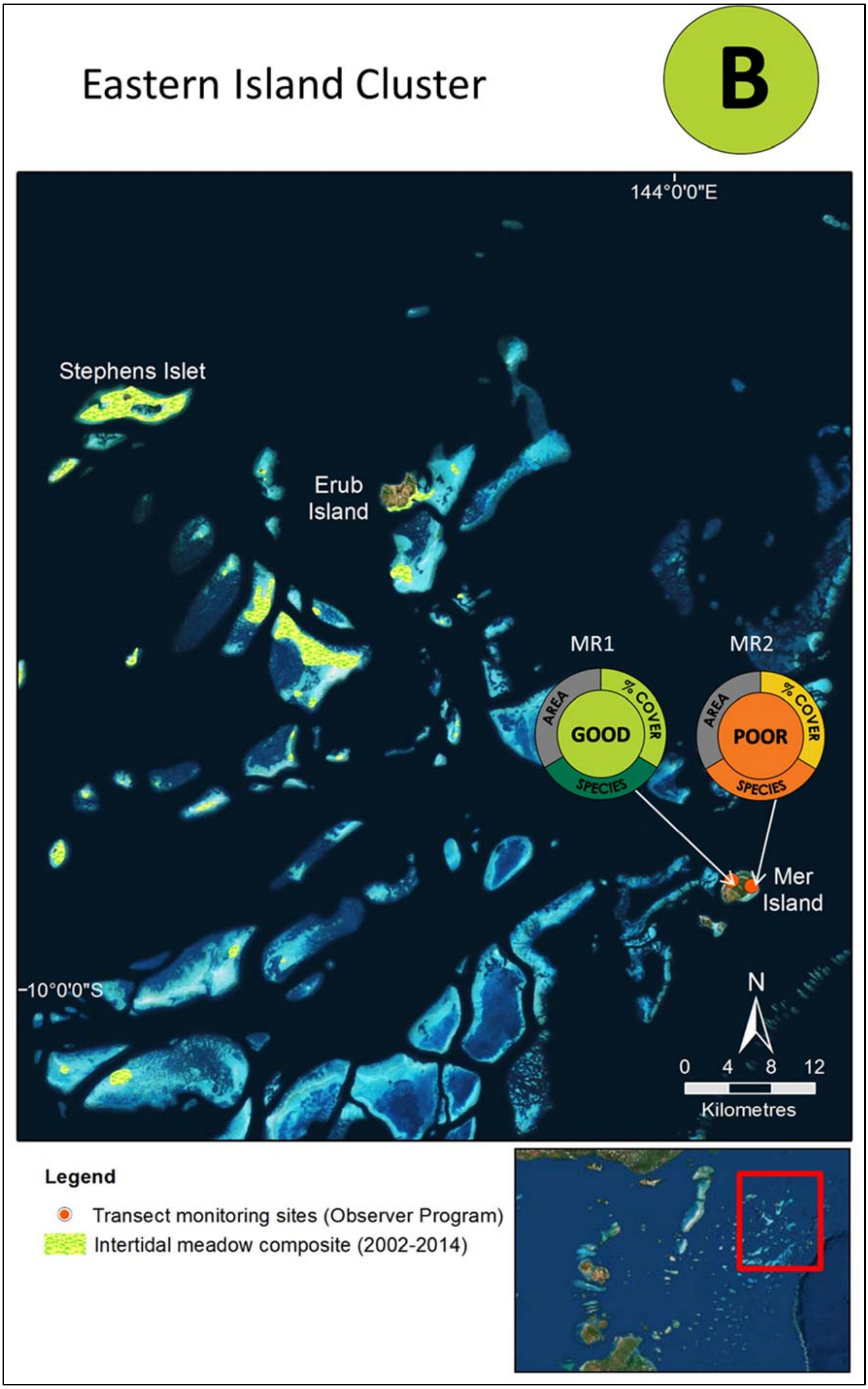
EXECUTIVE SUMMARY

- Seagrass meadows show measurable responses to changes in environmental condition, so are ideal sensitive receptors for monitoring marine environmental health.
- Torres Strait contains some of the most extensive seagrass meadows of northern Australia. Torres Strait Island communities rely on coastal marine habitats for subsistence, and have strong cultural and spiritual links to these environments.
- This report provides the first integrated condition assessment of Torres Strait seagrass using a report card approach. Seagrass was graded from A (very good) to E (very poor) relative to baseline conditions, and scored on a 0–1 scale.
- Data used in this report card comes from the Torres Strait Seagrass Monitoring Program (TSSMP), which incorporates the Torres Strait Seagrass Observers Program, Ranger Subtidal Monitoring Program, Queensland Ports Seagrass Monitoring Program, and Reef-top Monitoring Program.
- Thirty-one sites/meadows were classified for this report card across four Torres Strait Island Clusters. Seagrass condition in all clusters was good (Maps 1-4).
- The majority of individual sites/meadows were in good condition. Only one monitoring site in the entire Torres Strait monitoring network received a poor score in 2018, site MR2 (Lei) at Mer Island, which was likely a reflection of a localised change in condition at that particular site. No condition indicators or overall grades were very poor in 2018 (Maps 1-4).
- The program will be substantially improved as it matures and more sites/meadows build 10 years of baseline information.
- We recommend: (1) establishing monitoring in the Top-Western Cluster where no monitoring currently occurs, (2) expanding meadow-scale monitoring and subtidal block monitoring to include examples in all island clusters, (3) establishing additional intertidal transect monitoring in the central island cluster, and (4) establishing monitoring meadows in the inner cluster away from anthropogenic impacts at Thursday Island. These additions would vastly improve the mix of information and provide a more reliable assessment of seagrass condition and change in the region.

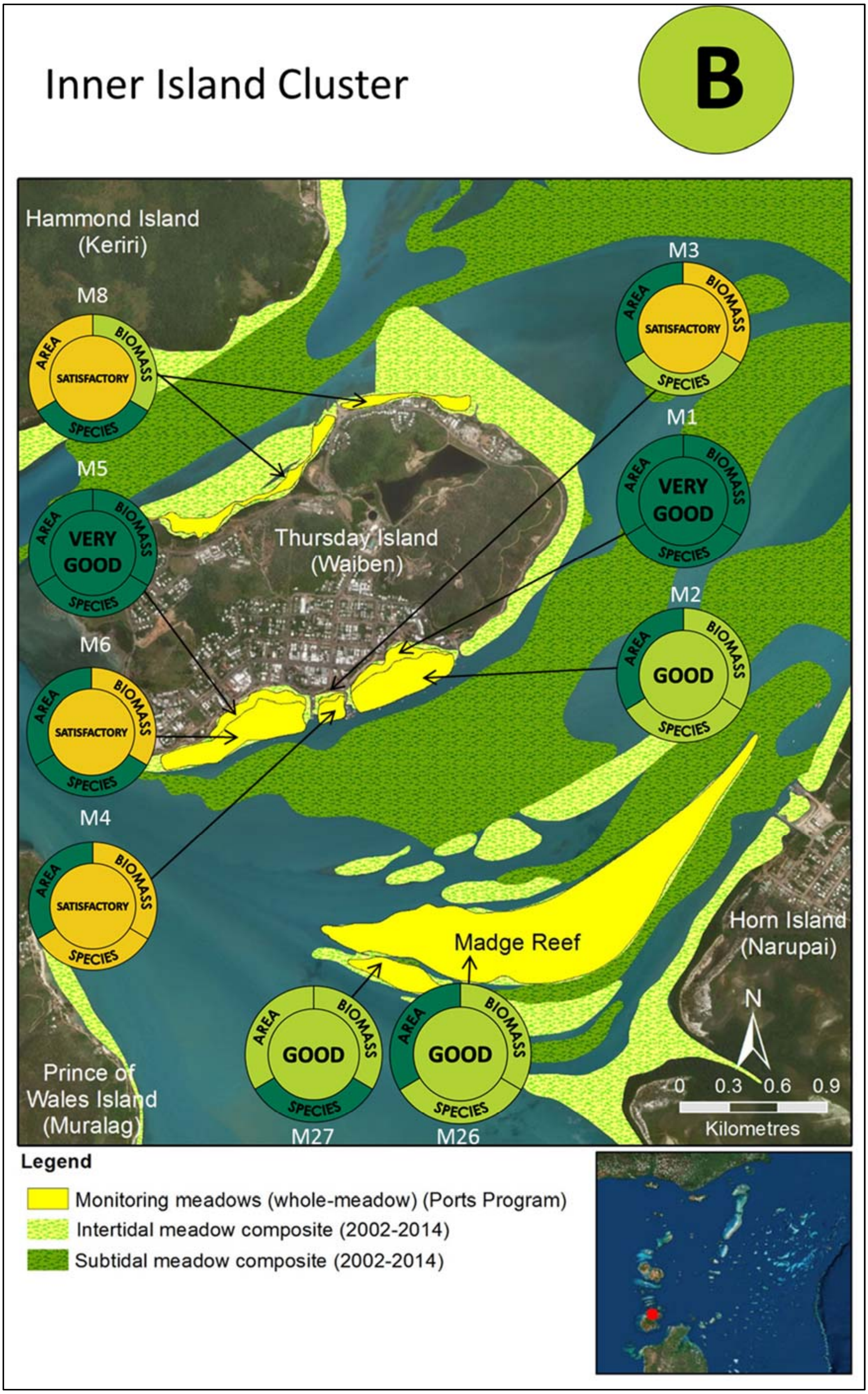
Map 1. Seagrass condition across the Western Island Cluster of Torres Strait



Map 2. Seagrass condition across the Central Island Cluster of Torres Strait



Map 3. Seagrass condition across the Eastern Island Cluster of Torres Strait



Map 4. Seagrass condition across the Inner Island Cluster of Torres Strait

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1 INTRODUCTION

1.1 Torres Strait seagrass

Torres Strait contains some of the most extensive seagrass meadows of northern Australia (Carter et al. 2014b; Coles et al. 2003; Poiner and Peterkin 1996; Figure 1), the largest dugong (*Dugong dugon*) population in the world (Marsh et al. 2011), and globally significant populations of green turtles (*Chelonia mydas*) (Miller and Limpus 1991). Seagrasses provide food for dugongs and green turtles and a valuable habitat that sustains populations of fish, prawns, beche de mer and tropical rock lobster (Marsh et al. 2015; Unsworth and Cullen 2010; Heck et al. 2008; Green 2006). Seagrasses also help maintain coastal water quality and clarity (Coles et al. 2015).

Torres Strait Island communities rely on coastal marine habitats for subsistence, and have strong cultural and spiritual links to these environments. The loss of seagrass habitat in Torres Strait would have detrimental effects on the species reliant on seagrass, and local island communities. For example, substantial seagrass diebacks (up to 60%) have been documented twice in central Torres Strait and linked to dramatic increases in local dugong mortality (Marsh et al. 2004; Long and Skewes 1996). Threats to seagrass in the region include shipping-related oil spills and structural habitat damage (Halpern et al. 2008), climate change (Carter et al. 2014a) and seagrass diebacks. Torres Strait seagrass distribution, density and species composition also varies significantly seasonally and annually, with change largely driven by environmental conditions (Carter et al. 2014a; Mellors et al. 2008).

Because seagrass meadows show measurable responses to changes in environmental condition, they are ideal sensitive receptors for monitoring marine environmental health (Orth et al. 2006; Abal and Dennison 1996; Dennison et al. 1993). A robust assessment of seagrass condition first requires baseline information on seagrass abundance (biomass or percent cover), species composition, and meadow area, plus ongoing monitoring to understand natural variation and detect seagrass change.

1.2 Torres Strait Seagrass Monitoring Program (TSSMP)

The Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) at James Cook University (JCU) have been collecting baseline Torres Strait seagrass data (Carter et al. 2014b) and monitoring seagrass condition in the Port of Thursday Island (Sozou et al. 2017) since 2002. Seagrass monitoring was prioritised by the Torres Strait Scientific Advisory Committee, and expanded by the Torres Strait Regional Authority (TSRA) Land and Sea Management Unit (LSMU) with the advent of the Torres Strait Ranger Program in 2009. Today, the Torres Strait Seagrass Monitoring Program (TSSMP) incorporates two major types of seagrass monitoring data: small-scale transect based approach, and larger-scale seagrass meadow assessments that incorporate spatial change in seagrass area. Within each monitoring category there are several long-term monitoring programs undertaken by TropWATER in conjunction with the TSRA LSMU or Ports North that assess seagrass condition and change in the region (Table 1). These programs are:

<u>Small-scale transect-based monitoring:</u>

(1) **Torres Strait Seagrass Observers Program** – The observers program evolved from the Torres Strait CRC *Project 4.1: Education Opportunities for Indigenous Involvement in Marine Ecosystem(Mellors et al. 2008)*. The program's focus is to provide Torres Strait rangers with the skills to monitor independently intertidal seagrass at permanently marked transect sites representative of their home patch intertidal meadows. Rangers select sites based on traditional use of the meadow or disturbance concerns (e.g. proximity to a storm water drain). Six islands (Mabuiag, Badu, Mua, Poruma, Iama, and Mer) are monitored as part of the program, with two sites on each island.

(2) **Ranger Subtidal Monitoring Program** – This program commenced in 2011 as a collaboration between TropWATER and TSRA LSMU Badu and Mabuiag Island Rangers to monitor seagrass in the Dugong

Sanctuary. Rangers are trained by TropWATER staff to independently collect data in subtidal monitoring blocks. The program was extended to subtidal blocks at Dungeness Reef in 2017 and Orman Reefs in 2018.

Large-scale meadow-based monitoring:

(1) **Reef-top Monitoring Program** – The reef-top program commenced in 2017 at Dungeness Reef and 2018 at Orman Reef. Aerial surveys are conducted by TropWATER staff annually and provide an assessment of intertidal reef-top seagrass condition at known turtle and dugong foraging areas.

(2) **Queensland Ports Seagrass Monitoring Program** – The ports program is a long-term seagrass monitoring and assessment program that occurs in the majority of Queensland's commercial ports. The program is delivered by TropWATER in partnership with various Queensland port authorities; the Thursday Island component is funded by Ports North. The program provides an ongoing assessment of many of the seagrass communities most at risk from cumulative threats in Queensland (Grech et al. 2011). A condition report card is produced annually for each port, and this information is also included in several regional reports cards including the Wet Tropics Healthy Waterways Partnership, Mackay-Whitsundays Healthy Rivers to Reef Partnership, and the Gladstone Healthy Harbour Partnership.

The individual programs that make up TSSMP differ in the spatial and temporal scale and coverage of monitoring and the seagrass condition indicators assessed. The program collectively monitors seagrass condition at 12 intertidal transect sites, 16 intertidal and subtidal whole-meadows, and three subtidal meadow blocks (Figure 1, Table 1). Monitoring incorporates eleven seagrass species from three families (Figure 2), and occurs within four of the five traditional island clusters (http://www.tsra.gov.au/the-torres-strait/community-profiles). These are:

- Western (Badu, Mabuiag, Mua (Kubin and St Pauls communities))
- Central (Iama, Masig, Poruma, Warraber)
- Eastern (Kemer Mer, Erub and Ugar)
- Inner (Kiriri, Muralug, Ngurupai and Waiben)

No monitoring currently occurs in the Top-Western Cluster (Boigu, Dauan, Saibai).

Table 1. The Torres Strait Seagrass Monitoring Program (TSSMP) incorporates several long-term monitoring programs

	Torres Strait Seagrass Monitoring Program			
	Torres Strait Seagrass Observers Program	**Reef-top Intertidal Program**	**Ranger Subtidal Monitoring Program**	**Thursday Island Ports Program**
Island cluster	Western, Central, Eastern	Western, Central	Western, Central	Inner
No. sites/meadows	12 sites	7 meadows	3 meadows	9 meadows
Condition indicators	Percent cover, species composition	Biomass, area, species composition	Biomass, species composition	Biomass, area, species composition
Habitat	Intertidal island	Intertidal reef-top	Subtidal	Intertidal island and reef-top, subtidal
Spatial scale	3 permanent transects per site	Whole-meadow	3 monitoring blocks per meadow	Whole-meadow
Temporal scale	Quarterly - biannual	Annual	Biannual	Annual
Funding provider	TSRA	TSRA	TSRA	Ports North

1.3 Report Card Objectives

The objectives of the 2018 Torres Strait report card were to provide:

1. An assessment of Torres Strait seagrass condition in 2018 including grades and scores.
2. A report describing data collection and methods used to determine grades and scores.

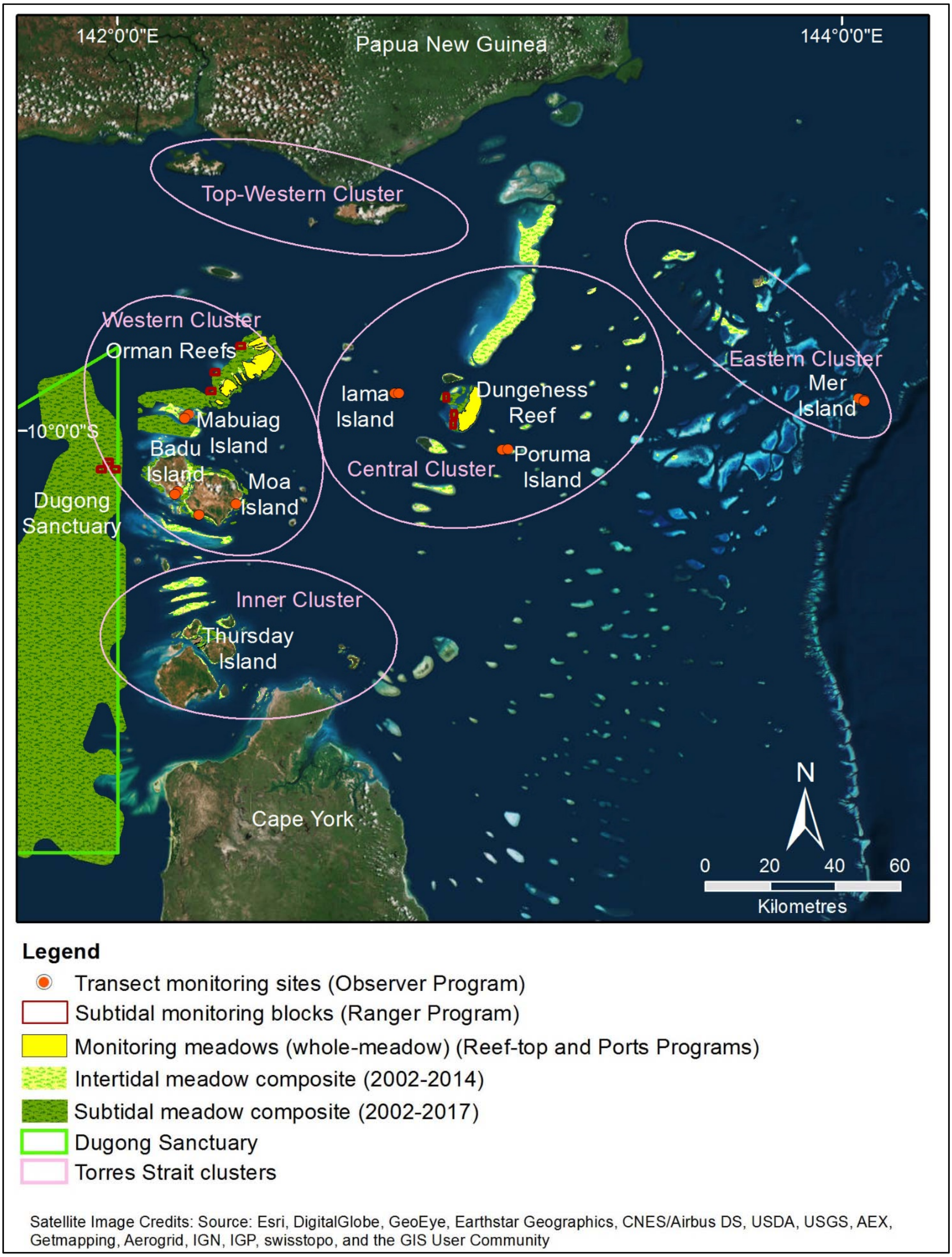


Figure 1. The Torres Strait Seagrass Monitoring Program incorporates four long-term monitoring programs spanning four island clusters

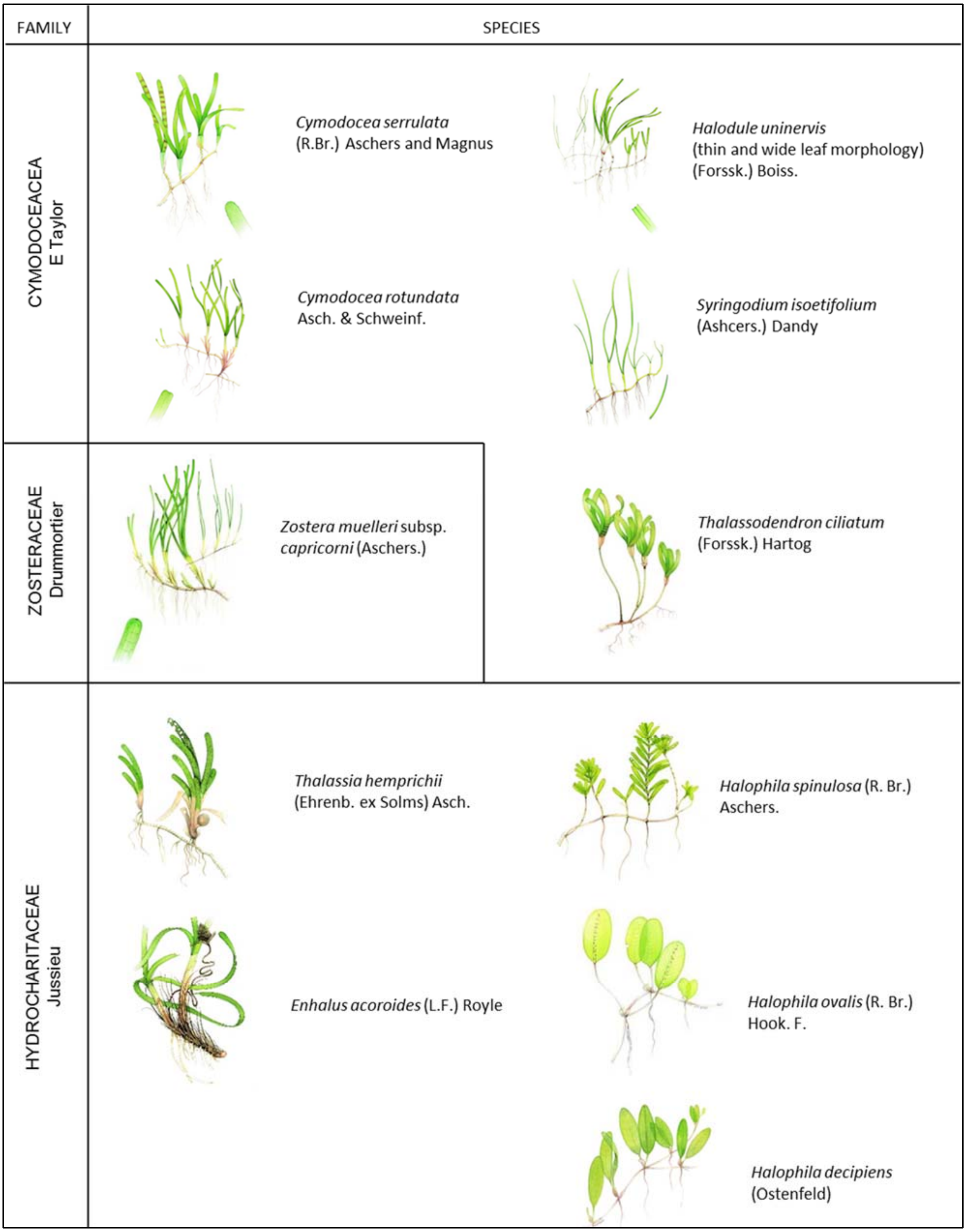


Figure 2. Seagrass species recorded across Torres Strait Seagrass Monitoring Program monitoring sites/ meadows

2 METHODS

2.1 Sampling Approach and Data Collection Methods for Seagrass Indicators

The TSSMP survey times and frequencies vary, ranging from quarterly (observer program) to annual (reef-top and ports programs). This report card only used data collected from September to April for intertidal surveys, and September – March for subtidal block surveys. The exclusion of data from late-autumn and winter was based on expert discussion and examination of historical monitoring data, where a season of low seagrass abundance occurred from May to August during Sager, the south-east wind period. High seagrass abundance occurs from September to April during Naiger (north-east wind period) and Kuki (north-west monsoon) (McNamara et al. 2010; also see https://www.qcaa.qld.edu.au/about/k-12-policies/aboriginal-torres-strait-islander-perspectives/resources/seasons-stars). Excluding data collected during May-August when seagrass senesces controlled for seasonal variation at each site, and meant results for programs that survey only during the peak seagrass growing season were comparable with programs that survey throughout the year. This is a common practice for other Queensland report cards (Carter et al. 2016).

Survey methods also vary among the TSSMP programs. These are:

<u>Small-scale transect-based monitoring:</u>

(1) **Torres Strait Seagrass Observers Program** – Each site is a 50m x 50m relatively homogeneous area (low variability, even topography) in each seagrass meadow. Within each site, three replicate 50m long transects are laid parallel to each other, 25m apart and perpendicular to the beach. Along each transect, the rangers record seagrass percent cover and species composition within a 0.25m^2 quadrat, with quadrats placed at 5 m intervals along a transect (Figure 3a). For each quadrat percent cover is estimated with the assistance of standardized percent cover photographs, and the percent contribution of individual species to total cover (species composition). 27% of quadrats are photographed for verification by TropWATER scientists during the QAQC process.

(2) **Ranger Subtidal Monitoring Program** – Survey methods follow the established techniques for the TropWATER subtidal block seagrass monitoring program, where 3 transects are surveyed in each of three blocks per meadow (Carter et al. 2017). Quadrats are assessed using underwater video. At each site, a GoPro is lowered from the ranger vessel to the sea floor (Figure 3b) and 10 replicate "camera drops" are conducted approximately 5m apart while the boat moves at drift speed. The camera frame serves as a 0.25 m^2 quadrat, and the footage is viewed on an iPad at the surface and recorded. A sample of seagrass is collected in the field using a van Veen grab (grab area 0.0625 m^2) to identify species present at each transect (Figure 3c). Video footage is sent back to TropWATER scientists where biomass and species composition estimates are made.

<u>Large-scale meadow-based monitoring:</u>

(3) **Queensland Ports Seagrass Monitoring Program** – Survey methods follow the established techniques for the TropWATER Queensland-wide ports seagrass monitoring program (see Unsworth et al. 2012; Rasheed and Unsworth 2011; Taylor and Rasheed 2011). Intertidal meadows are sampled at low tide using a helicopter (Figure 3d). GPS is used to record the position of meadow boundaries. Seagrass presence/absence, biomass, species composition is estimated from three replicate 0.25 m^2 quadrats placed randomly within a 10m^2 circular area while the helicopter maintains a low hover. Sites are randomly scattered within each meadow. Shallow subtidal meadows are sampled by boat using underwater video camera and van Veen grab. The camera frame serves as a 0.25 m^2 quadrat with 3 replicate quadrats per site, and the video footage is analysed in real time using CCTV on the boat. Sites are located along transects perpendicular to the shoreline at ~100 - 500 m intervals, or where major changes in bottom topography occur, and extend to the offshore edge of each seagrass meadow.

(4) **Reef-top Monitoring Program** – Survey methods are the same as for intertidal meadows in the ports program.

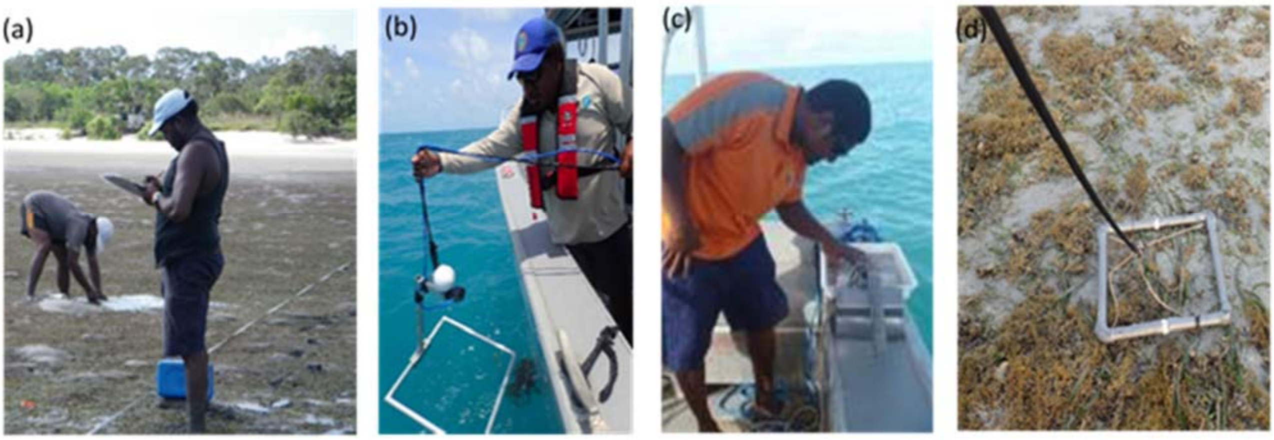


Figure 3. Seagrass surveys use (a) walking along permanent transects, (b) underwater video drops, (c) van Veen grab, and (d) quadrat lowered from a hovering helicopter.

2.1.1 Biomass and Species Composition

Seagrass above-ground biomass was determined for the ranger, ports, and reef-top programs using a "visual estimates of biomass" technique (Mellors 1991; Kirkman 1978). For each quadrat a TropWATER trained observer assigns a biomass rank made in reference to a series of 12 quadrat photographs of similar seagrass habitats for which the above-ground biomass was previously harvested and measured in the laboratory (calibration quadrats). The percent contribution of each seagrass species to above-ground biomass within each quadrat is also recorded. Three separate ranges are used - low biomass, high biomass, and *Enhalus* biomass. At the completion of ranking, the observer ranks a series of five calibration quadrat photographs of for each range. A separate regression equation of biomass ranks versus actual biomass is calculated for each observer and each range and applied to the biomass ranks given in the field. Field biomass ranks are converted into above-ground biomass estimates in grams dry weight per square metre (gdw m^{-2}).

Species composition is calculated as the percent contribution of individual species to either above-ground biomass (ranger, ports, and reef-top programs) or total percent cover (observer program).

2.1.2 Meadow Area

Meadow area is only assessed in the large-scale meadow-based monitoring programs (ports and reef-top programs). Seagrass presence/absence site data, mapping sites, field notes, and satellite imagery were used to construct meadow boundaries in ArcGIS®. Seagrass meadows were assigned a meadow identification number; this allows individual meadows to be compared among years. Monitoring meadows are referred to by identification numbers throughout this report. Meadow area was determined in hectares using the calculate geometry function in ArcGIS. Meadows were assigned a mapping precision estimate (in metres) based on mapping methods used for that meadow (Table 2). The mapping precision estimates were used to create a buffer representing the error around each meadow, the area of which is expressed as a meadow reliability estimate (R) in hectares.

Table 2. Mapping precision and methodology for seagrass meadows in Torres Strait.

Mapping precision	Mapping methodology
5 m	Meadow boundary mapped in detail by GPS from helicopter, Intertidal meadows completely exposed or visible at low tide.
10 m	Meadow boundary determined from helicopter and/or boat surveys, Inshore boundaries interpreted from helicopter sites, Offshore boundaries interpreted from survey sites and aerial photography, Moderately high density of mapping and survey sites.
20 m	Meadow boundaries determined from helicopter and/or boat surveys, Inshore boundaries interpreted from helicopter sites, Offshore boundaries interpreted from boat survey sites, Lower density of survey sites for some sections of boundary.
50 m	Meadow boundaries determined from helicopter and/or boat surveys, Meadow boundaries determined from seagrass presence/absence data, Low density of survey sites for some sections of boundary.

2.2 Seagrass Condition

Seagrass condition was determined using a condition index to assess changes in abundance (biomass/percent cover), species composition, and meadow area (reef-top and ports programs only) relative to each site/meadow's baseline. Seagrass condition for each indicator in each site/meadow was scored from 0 - 1 and assigned one of five grades: A (very good), B (good), C (satisfactory), D (poor) and E (very poor). The flow chart in Figure 4 summarises the methods used to calculate seagrass condition. Detailed description of how the report card method was developed, initially for the Gladstone Healthy Harbour Partnership, can be found in Bryant et al. (2014), Carter et al. (2015), and Carter et al. (2016).

2.2.1 Baseline Calculations

Baseline conditions for site/meadow biomass/percent cover, area and species composition were established from annual means calculated during the first 10 years of monitoring. This baseline was set based on results of the 2014 pilot report card (Bryant et al. 2014). Where <10 years of data were available the baseline was calculated over the longest available time period. Condition assessments with 5-10 years of data should be considered preliminary as the baseline will be updated annually. Sites/meadows with <5 years of data are included in this report but no overall grades/scores are presented due to the lack of data.

Baseline conditions for species composition were determined based on the annual percent contribution of each species to mean site/meadow biomass/percent cover of the baseline years. Meadows were classified as single species (one species comprising ≥80% of baseline species composition) or mixed species dominated (no species comprise ≥80% of baseline species composition). Where a meadow baseline contained an approximately equal split in two species (i.e. two species accounted for 40–60% of the baseline), the baseline was set according to the percent composition of the more persistent/stable species of the two (see Section 2.2.4 and Figure 5).

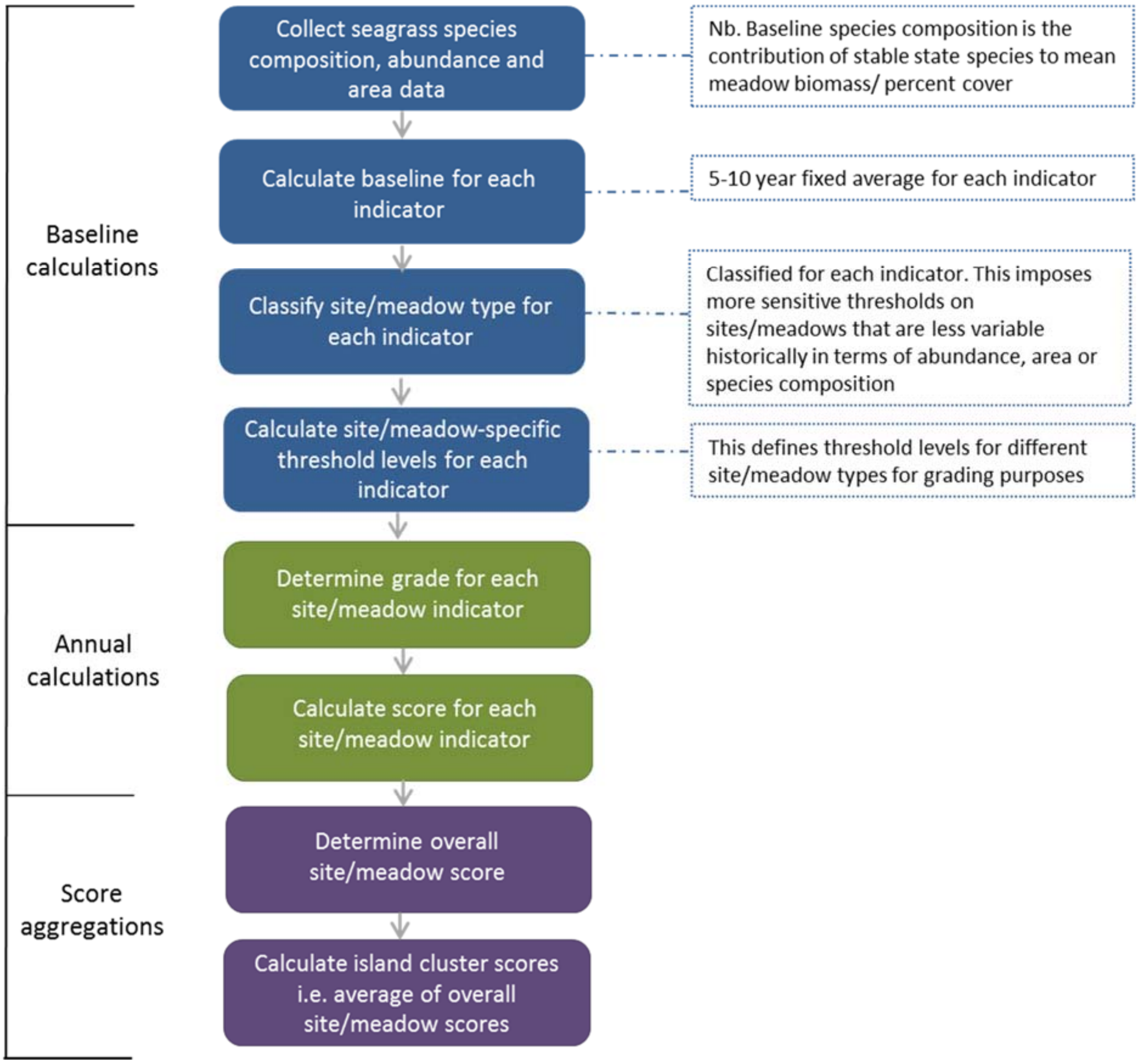


Figure 4. Flow chart of steps used to determine Torres Strait grades and scores.

2.2.2 Meadow Classification

A classification system was developed for the three condition indicators in recognition that for some seagrass sites/meadows these measures are historically stable, while in others they are relatively variable. The coefficient of variation (CV) for each baseline for each site/meadow was used to determine historical variability. Site/meadow biomass/percent cover and species composition were classified as stable or variable (Table 3). Meadow area also has additional highly stable and highly variable classes (Table 3). The CV was calculated by dividing the standard deviation of the baseline years by the baseline for each condition indicator.

Table 3. Coefficient of variation (CV; %) thresholds used to classify stability or variability of site/meadow abundance (biomass/percent cover), area and species composition baselines.

Indicator	Class			
	Highly stable	**Stable**	**Variable**	**Highly variable**
Abundance	-	< 40%	≥ 40%	-
Area	< 10%	≥ 10, < 40%	≥ 40, <80%	≥ 80%
Species composition	-	< 40%	≥ 40%	-

2.2.3 Threshold Definition

Each seagrass condition indicator was assigned one of five grades: very good (A), good (B), satisfactory (C), poor (D), very poor (E). Threshold levels for each grade were set relative to the baseline and based on site/meadow class. This approach accounted for historical variability within the monitoring sites/meadows and expert knowledge of the different site/meadow types and assemblages in the region (Table 4).

Table 4. Threshold levels for grading seagrass indicators for various site/meadow classes relative to the baseline. Upwards/downwards arrows are included in figures where a change in condition grade has occurred in any of the three indicators (biomass/percent cover, area, species composition) from the previous year.

Seagrass condition indicators/ Site/meadow class		Seagrass grade				
		A Very good	B Good	C Satisfactory	D Poor	E Very Poor
Biomass/ Percent cover	Stable	>20% above	20% above - 20% below	20-50% below	50-80% below	>80% below
	Variable	>40% above	40% above - 40% below	40-70% below	70-90% below	>90% below
Area	Highly stable	>5% above	5% above - 10% below	10-20% below	20-40% below	>40% below
	Stable	>10% above	10% above - 10% below	10-30% below	30-50% below	>50% below
	Variable	>20% above	20% above - 20% below	20-50% below	50-80% below	>80% below
	Highly variable	> 40% above	40% above - 40% below	40-70% below	70-90% below	>90% below
Species composition	Stable and variable; Single species dominated	>0% above	0-20% below	20-50% below	50-80% below	>80% below
	Stable; Mixed species	>20% above	20% above - 20% below	20-50% below	50-80% below	>80% below
	Variable; Mixed species	>20% above	20% above- 40% below	40-70% below	70-90% below	>90% below
	Increase above threshold from previous year		BIOMASS	Decrease below threshold from previous year		BIOMASS

2.2.4 Grade and Score Calculations

A score system (0 – 1) and score range was applied to each grade to allow numerical comparisons of seagrass condition among sites/meadows and Torres Strait Island Clusters (Table 5).

Score calculations for each site/meadow's condition required calculating the biomass/percent cover, area and species composition for that year (described in Section 2.1), allocating a grade for each indicator by comparing 2018 biomass/percent cover, area, and species values against site/meadow-specific thresholds for each grade, then scaling biomass/percent cover, area and species composition values against the prescribed score range for that grade.

Scaling was required because the score range in each grade was not equal (Table 5). Within each site/meadow, the upper limit for the very good grade (score = 1) for percent cover and species composition were set as 100%. For biomass and area, the upper limit was set as the maximum mean plus standard error (SE; i.e. the top of the error bar) value for a given year, compared among years during the baseline period. For sites/meadows with <10 years of baseline data this upper limit will be recalculated each year until the 10-year baseline period is complete.

An example of calculating a meadow score for area in satisfactory condition is provided in Appendix 1.

Table 5. Score range and grading colours used in the Torres Strait report card.

Grade	Description	Score Range	
		Lower bound	Upper bound
A	Very good	$\geq$0.85	1.00
B	Good	$\geq$0.65	<0.85
C	Satisfactory	$\geq$0.50	<0.65
D	Poor	$\geq$0.25	<0.50
E	Very poor	0.00	<0.25

Where species composition was determined to be anything less than in "perfect" condition (i.e. a score <1), a decision tree was used to determine whether equivalent and/or more persistent/stable species were driving this grade/score (Figure 5). If this was the case, the species composition score and grade for that year was recalculated including those species. Concern regarding any decline in the stable state species was reserved for those meadows where the directional change from the stable state species is of concern (Figure 5). This would occur when the stable state species is replaced by species considered earlier colonisers. Such a shift indicates a decline in meadow stability (e.g. a shift from *T. hemprichii* to *H. ovalis*). An alternate scenario can occur where the stable state species is replaced by what is considered an equivalent species (e.g. shifts between *C. rotundata* and *C. serrulata*), or replaced by a species indicative of an improvement in meadow stability (e.g. a shift from *H. decipiens* to *H. uninervis* or any other species). The directional change assessment was based largely on dominant traits of colonising, opportunistic and persistent seagrass genera described by Kilminster et al. (2015). Adjustments to the Kilminster model included: (1) positioning *S. isoetifolium* further towards the colonising species end of the list, as successional studies following disturbance demonstrate this is an early coloniser in Queensland seagrass meadows (Rasheed 2004); and (2) separating and ordering the *Halophila* genera by species. Shifts between *Halophila* species are ecologically relevant; for example, a shift from *H. ovalis* to *H. decipiens*, the most marginal species found in Torres Strait, may indicate declines in water quality and available light for seagrass growth as *H. decipiens* has a lower light requirement (Collier et al. 2016) (Figure 5).

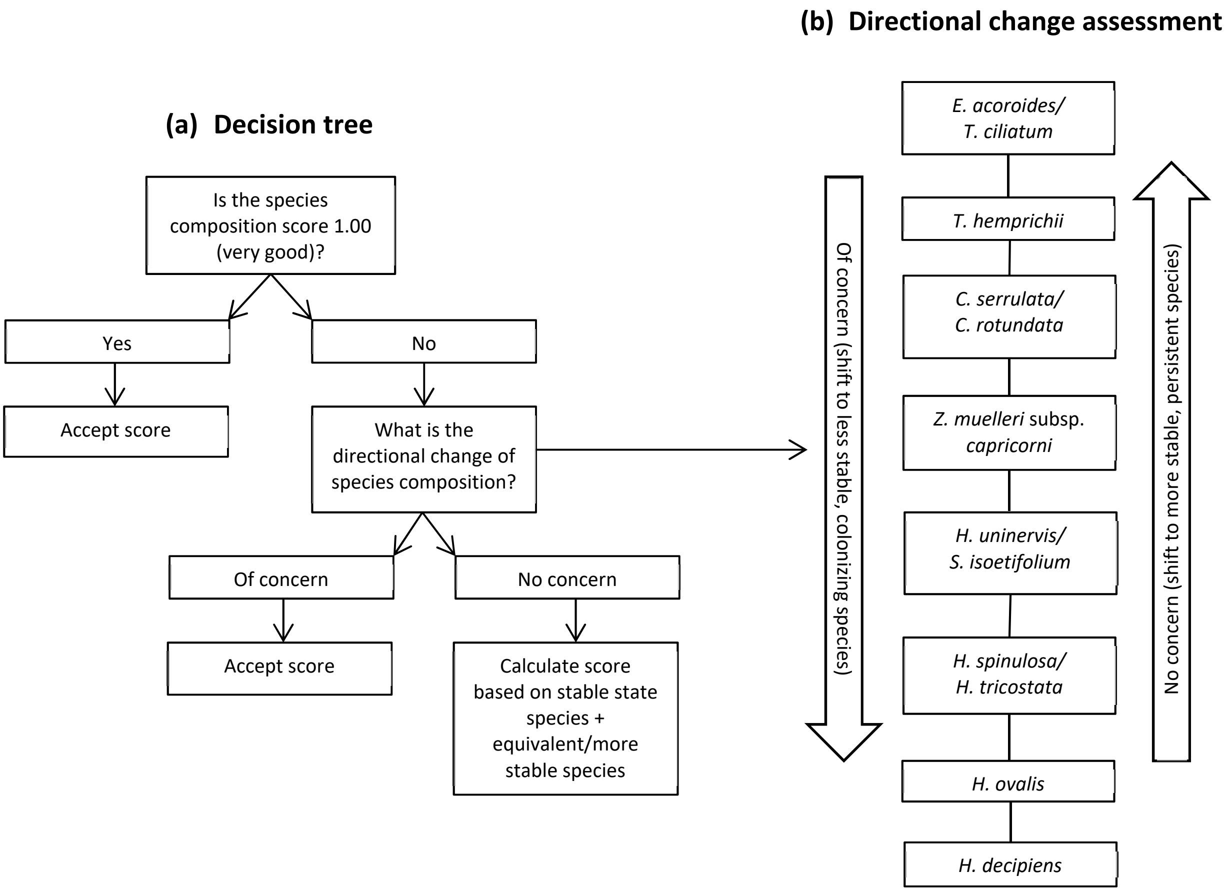


Figure 5. (a) Decision tree and (b) directional change assessment for grading and scoring species composition.

2.2.5 Score Aggregation

The overall site/meadow grade and score is defined as the lowest indicator score where this is driven by biomass/percent cover or area. Where species composition is the lowest score, it contributes 50% of the overall site/meadow score, and the next lowest indicator (area or biomass/percent cover) contributes the remaining 50%. The lowest of the biomass/percent cover or area scores, rather than the mean of the three indicator scores, was applied in recognition that a poor grade for either of these indicators described a seagrass meadow in poor condition. The 50% weighting of species composition acknowledges that this is an important characteristic of a seagrass meadow in terms of defining meadow stability, resilience, and ecosystem services, but is not as fundamental as having some seagrass present, regardless of species, when defining overall condition.

Torres Strait Island Cluster grades/scores were calculated by averaging the overall site/meadow scores for each monitoring site/meadow within a given cluster, and assigning the corresponding grade to that score. Where multiple sites/meadows were present within a cluster, no weighting system was applied at this stage of the analysis. The classification process (outlined in Section 2.2.2) applies smaller and more sensitive thresholds for stable sites/meadows, and less sensitive thresholds for variable sites/meadows. The classification process serves therefore as a proxy weighting system where any condition decline in the stable sites/meadows is more likely to trigger a grade reduction compared with more variable sites/meadows. Cluster grades therefore are more sensitive to changes in stable than variable sites/meadows.

3 RESULTS

3.1 Meadow Classifications

Thirty-one sites/meadows were classified for this report card. Of those, ~80% were characterised as stable with mixed species. Only three meadows were classed as having variable species composition, two of these were subtidal meadows (Table 6). Biomass/ percent cover was stable in 65% of sites/meadows; variable biomass was more often found at Thursday Island meadows and subtidal blocks. Area was classed as stable or highly stable for 15 of the 16 monitoring meadows (Table 6).

3.2 Overall Seagrass Condition for the 2018

3.2.1 Overall Site/Meadow Condition

Grades and scores were produced for 19 of the sites/meadows. Grades and scores were not calculated for 11 sites/meadows because they had <5 years of baseline data. Scores will be added to the report card for these sites/meadows as monitoring progresses. No score was given for the Dugong Sanctuary in 2018 as no monitoring occurred. Of the sites/meadows with scores, the majority (11) were in good condition, two meadows at Thursday Island were in very good condition, five were satisfactory, and one was in poor condition. No condition indicators or overall grades were very poor in 2018 (Table 7).

Percent cover determined the overall site scores for all of the transect sites in the Western Cluster, where species composition condition was generally very good. Species composition was more likely to influence site condition in the Central and Eastern Clusters. The only poor condition site (MR2 at Mer Island) was due to the loss of *T. hemprichii* relative to the less persistent species *C. rotundata* and *H. ovalis* (Table 7). Meadow area or biomass, but not species composition, dictated overall scores and grades for Thursday Island meadows (Table 7).

3.2.2 Overall Cluster Condition

All Torres Strait Island Clusters were in good condition (Table 7).

Table 6. Classifications representing the historical stability or variability of seagrass site/meadow for biomass/ percent cover, area and species composition within Torres Strait Island Clusters. Classifications were based on the coefficient of variation of the baseline for each indicator. int = intertidal; sub = subtidal.

ISLAND CLUSTER	LOCATION	SITE/ MEADOW ID	ABUNDANCE (BIOMASS or PERCENT COVER)	AREA	SPECIES COMPOSITION
Western	Mabuiag Island (int)	MG1#	Stable	^	Variable – mixed species
		MG2#	Stable	^	Stable – mixed species
	Badu Island (int)	BD1#	Stable	^	Stable – mixed species
		BD2#	Stable	^	Stable – mixed species
	Mua Island (int)	MU1#	Variable	^	Stable – mixed species
		MU3#	Stable	^	Stable – mixed species
	Orman Reef (int)	OR1#	Stable	Highly stable	Stable – mixed species
		OR 2#	Stable	Highly stable	Stable – mixed species
		OR 3#	Variable	Stable	Stable – mixed species
		OR 4#	Stable	Highly stable	Stable – mixed species
		OR 5#	Stable	Highly stable	Stable – mixed species
		OR 6#	Stable	Stable	Stable – mixed species
	Orman Reef (sub)	OR 7#	Stable	^	Variable – mixed species
	Dugong Sanctuary (sub)	DS1#	Variable	^	Stable – mixed species
Central	Iama Island (int)	IM1#	Stable	^	Stable – mixed species
		IM2#	Stable	^	Stable – mixed species
	Poruma Island (int)	PM1#	Stable	^	Stable – mixed species
		PM2#	Stable	^	Stable – mixed species
	Dungeness Reef (int)	DR6#	Stable	Stable	Stable – mixed species
	Dungeness Reef (sub)	DR1#	Variable	^	Variable – mixed species
Eastern	Mer Island (int)	MR1#	Stable	^	Stable – single species
		MR2#	Stable	^	Stable – mixed species
Inner	Thursday Island (int)	M1#	Variable	Stable	Stable – mixed species
		M3#	Variable	Variable	Stable – mixed species
		M5#	Variable	Stable	Stable – mixed species
		M8#	Variable	Stable	Stable – mixed species
	Thursday Island (int-sub)	M2#	Variable	Stable	Stable – single species
		M4#	Stable	Stable	Stable – single species
		M6#	Stable	Stable	Stable – mixed species
	Madge Reef (int)	M26#	Variable	Highly stable	Stable – mixed species
		M27#	Variable	Stable	Stable – mixed species

<10 years of data available to classify meadows. Classifications for these sites/meadows should be interpreted with caution until 10-year baselines are available. ^ No data from any monitoring program.

Table 7. Grades and scores for seagrass condition indicators (abundance (biomass or percent cover), area, species composition) for sites/meadows and Torres Strait Island Clusters in 2018. Scores are on 0 - 1 scale; cells are coloured according to grade, where dark green = very good, light green = good, yellow = satisfactory, orange = poor, red = very poor. See Table 5 for grading scale.

ISLAND CLUSTER	LOCATION	SITE/ MEADOW ID	ABUNDANCE (BIOMASS or PERCENT COVER)	AREA	SPECIES COMP.	OVERALL SITE/ MEADOW SCORE	OVERALL CLUSTER SCORE
Top-Western	^	^	^	^	^	^	^
Western	Mabuiag Island (int)	MG1#	0.84	^	0.96	0.84	0.71
		MG2#	0.74	^	0.98	0.74	
	Badu Island (int)	BD1#	0.75	^	0.81	0.75	
		BD2#	0.60	^	0.84	0.60	
	Mua Island (int)	MU1#	0.68	^	0.84	0.68	
		MU3#	0.66	^	0.92	0.66	
	Orman Reef (int)	OR1*	0.76	0.76	0.93	*	
		OR2*	0.71	0.81	0.95	*	
		OR3*	0.62	0.59	0.92	*	
		OR4*	0.82	0.83	0.97	*	
		OR5*	0.69	0.72	0.90	*	
		OR6*	0.65	0.79	0.82	*	
	Orman Reef (sub)	OR7*	0.68	^	0.92	*	
	Dugong Sanctuary (sub)	DS1#	NS	^	NS	NS	
Central	Iama Island (int)	IM1#	0.79	^	0.77	0.78	0.80
		IM2#	0.82	^	0.79	0.81	
	Poruma Island (int)	PM1#	0.73	^	1.00	*	
		PM2#	0.66	^	0.98	*	
	Dungeness Reef (int)	DR6*	0.79	0.93	0.98	*	
	Dungeness Reef (sub)	DR1*	0.93	^	0.90	*	
Eastern	Mer Island (int)	MR1#	0.83	^	0.92	0.83	0.66
		MR2#	0.60	^	0.37	0.49	
Inner	Thursday Island (int)	M1	1.00	0.92	0.97	0.92	0.70
		M3	0.55	0.85	0.78	0.55	
		M5	0.87	0.87	0.97	0.87	
		M8	0.71	0.62	0.94	0.62	
	Thursday Island (int-sub)	M2	0.70	0.90	0.83	0.70	
		M4	0.62	0.90	0.64	0.62	
		M6	0.64	0.86	0.91	0.64	
	Madge Reef (int)	M26	0.65	0.88	0.82	0.65	
		M27	0.73	0.69	0.88	0.69	

Baseline conditions based on 5-10 years of data. Grades/scores for these sites/meadows should be interpreted with caution until 10-year baseline has been established.

* Baseline conditions based on <5 years of data. No overall grades or scores provided until 5 years of monitoring data is available.

^ No data from any monitoring program.

NS, no survey in 2018

3.3 Seagrass Condition for each Monitoring Site/Meadow

3.3.1 Western Island Cluster

Seagrass condition in the Western Island Cluster was good (Figure 6). Seagrass monitoring in this cluster includes six intertidal transect sites at Mabuiag, Badu and Mua Islands, whole-meadow monitoring of six intertidal meadows at Orman Reefs, and block monitoring of the Dugong Sanctuary and Orman Reef subtidal meadows (Figure 6). Orman Reefs were surveyed for the first time in 13 years as part of the reef-top program. This reef system was selected for monitoring because of its known value as a foraging ground for mega herbivores including turtle and dugong.

Figure 6. Seagrass condition across the Western Island Cluster of Torres Strait

Mabuiag Island Site (MG1)

The transect monitoring site MG1 at Mabuiag Island was established in 2009 and is monitored by the Mabuygiw Rangers (Figure 7). The site is characterised by stable percent cover and variable species composition and is in good condition. In 2018, mean percent cover was in good condition and at 65% was the highest since monitoring commenced. This is a mixed species site, with seven species recorded. Species composition was in very good condition in 2018 because although the dominant species *Cymodocea serrulata* has declined, it has been replaced with equivalent or more stable species *Cymodocea rotundata, Thalassia hemprichii* and *Enhalus acoroides* (Figure 7).

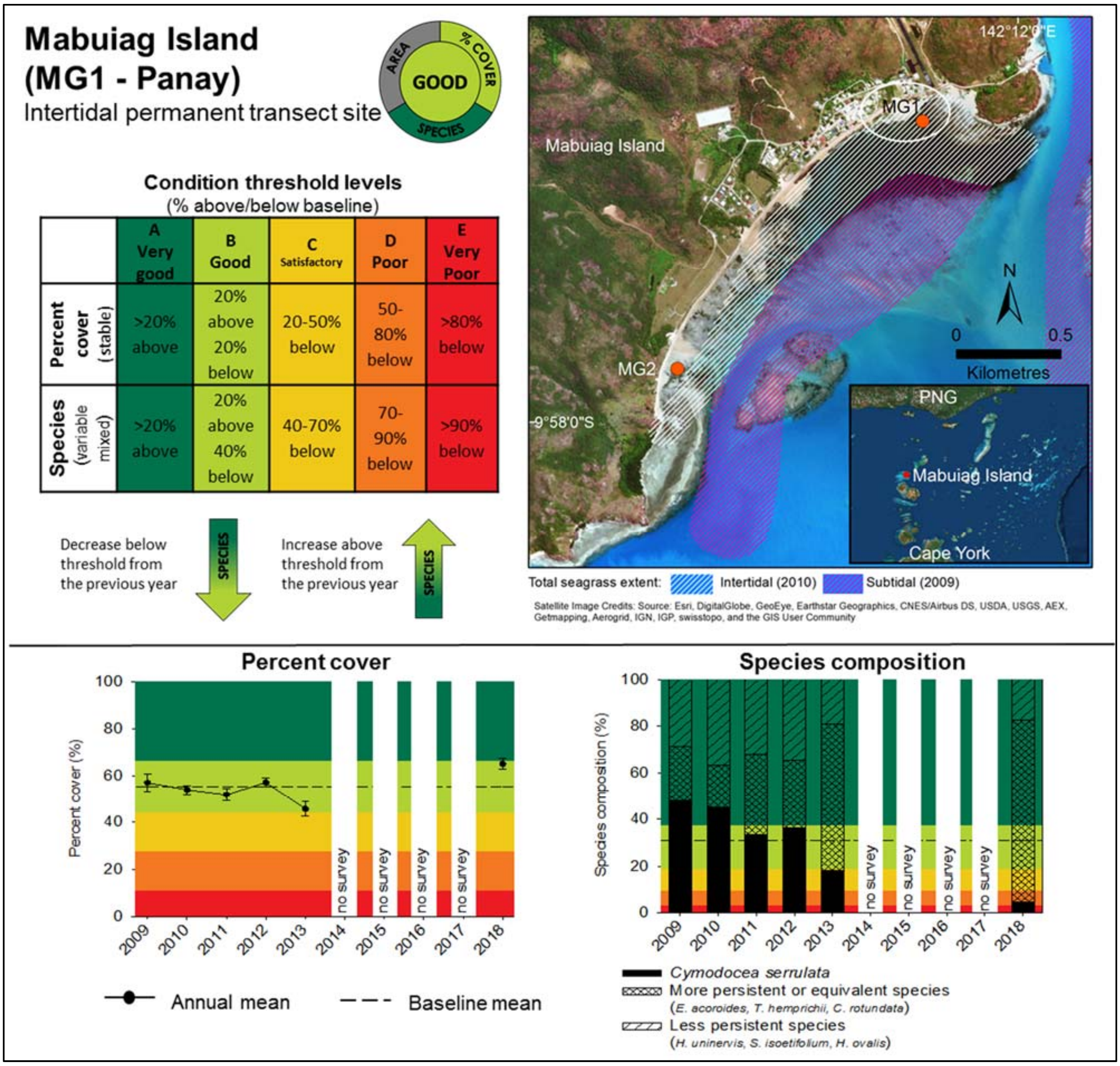
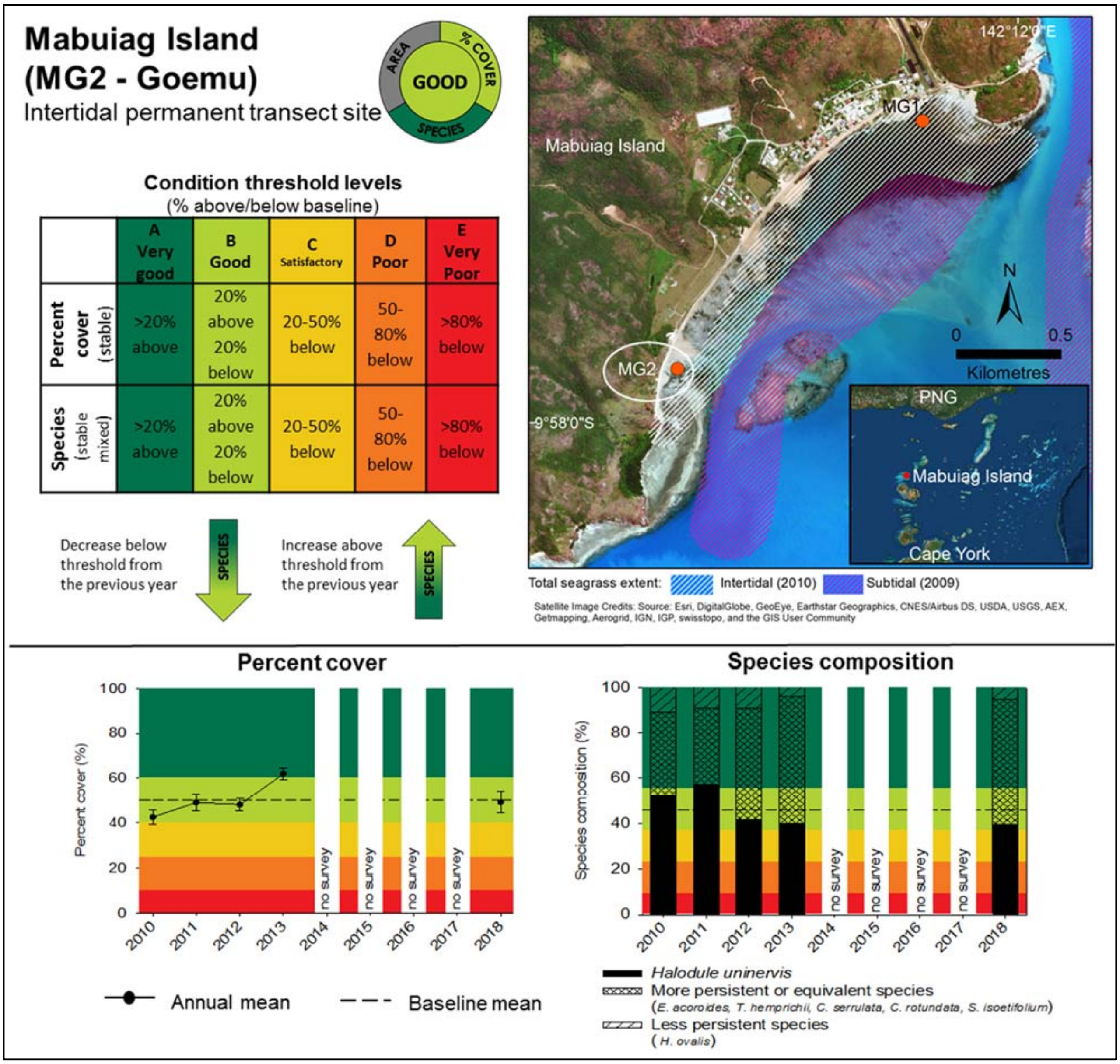


Figure 7. Seagrass mean percent cover and species composition at Mabuiag Island permanent transect site MG1, western Torres Strait, 2009 - 2018 (percent cover error bars = SE). Total seagrass extent from mapping surveys in 2009-2010. Note: Baseline conditions based on 6 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Mabuiag Island Site (MG2)

The transect monitoring site MG2 (Goemu) at Mabuiag Island was established in 2010 and is monitored by the Mabuygiw Rangers (Figure 8). The site is in good condition, and is characterised by stable percent cover and species composition. In 2018, mean percent cover was at baseline levels of ~50% and in good condition. Species composition was in very good condition in 2018 due to the stability of the dominant species *Halodule uninervis* plus an increase from 3% (2010) to 21% (2018) in the higher ranked persistent species *Thalassia hemprichii* (Figure 8).



	A Very good	B Good	C Satisfactory	D Poor	E Very Poor
Percent cover (stable)	>20% above	20% above 20% below	20-50% below	50-80% below	>80% below
Species (stable mixed)	>20% above	20% above 20% below	20-50% below	50-80% below	>80% below

Figure 8. Seagrass mean percent cover and species composition at Mabuiag Island permanent transect site MG2, western Torres Strait, 2010 - 2018 (percent cover error bars = SE). Total seagrass extent from mapping surveys in 2009-2010. Note: Baseline conditions based on 5 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Badu Island Site (BD1)

The transect monitoring site BD1 (Dogai Wok) at Badu Island was established in 2010 and is monitored by the Mura Badhulgau Rangers (Figure 9). The site is in good condition and characterised by stable percent cover and stable species composition. In 2018, mean percent cover was at baseline levels of ~35% and in good condition, marking a recovery from 2016 when percent cover was at its lowest recorded level of ~20%. Only two species are present at this site, reflecting the impact of a nearby stormwater drain. In 2018 species composition was considered good due to above-average presence of the dominant species *Halodule uninervis* relative to *Halophila ovalis* (Figure 9).

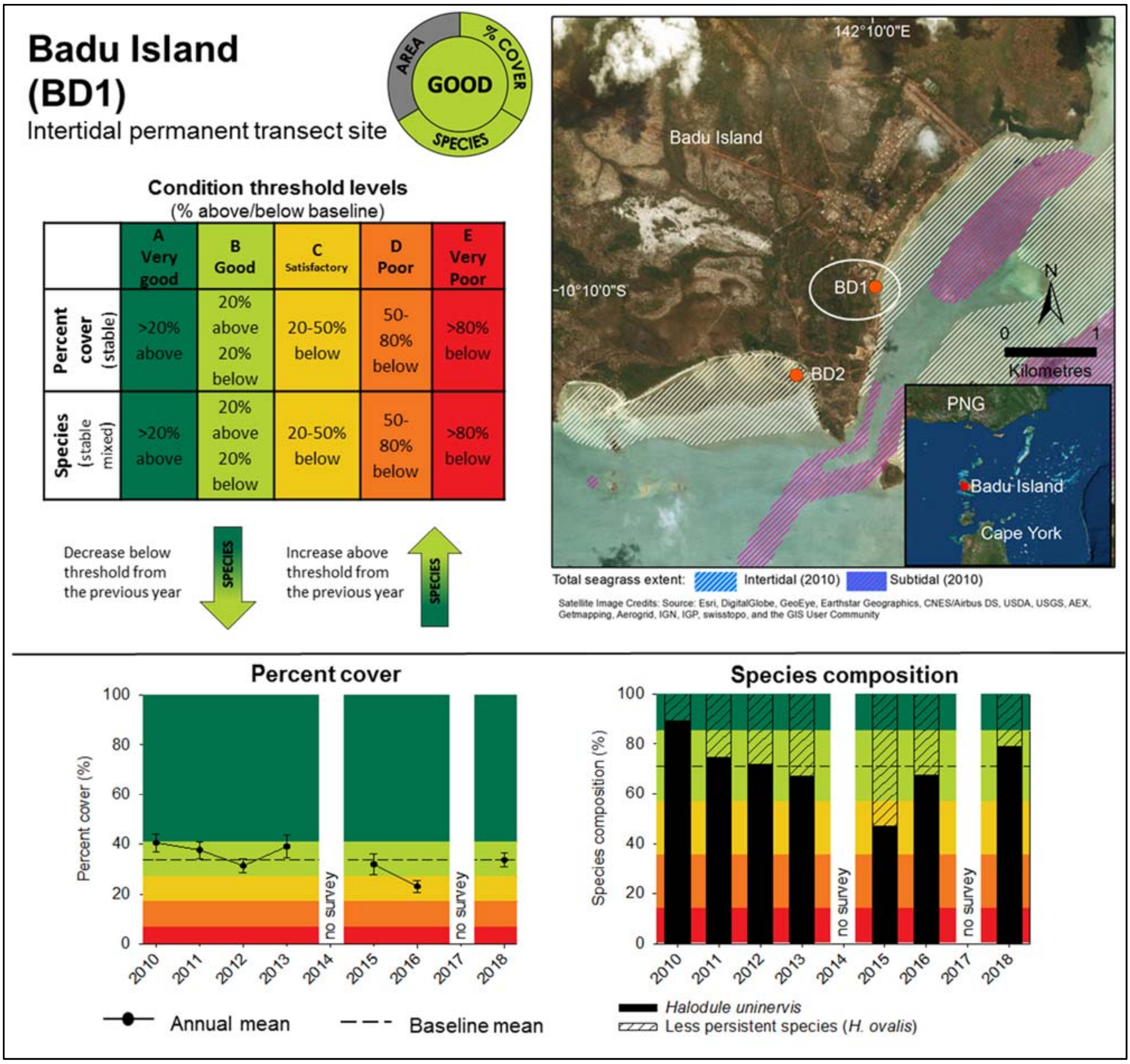


Figure 9. Seagrass mean percent cover and species composition at Badu Island permanent transect site BD1, western Torres Strait, 2010 - 2018 (percent cover error bars = SE). Total seagrass extent from mapping surveys in 2010. Note: Baseline conditions based on 7 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Badu Island Site (BD2)

The transect monitoring site BD2 (Araki) at Badu Island was established in 2011 and is monitored by the Mura Badhulgau Rangers (Figure 10). The site is characterised by stable percent cover and stable species composition. The site is in satisfactory condition in 2018 due to below-average percent cover, following a decline between 2015 and 2016. This site has greater species diversity than BD1, with seven species recorded here. In 2018 species composition was good due to above-average presence of the dominant species *Halodule uninervis* and several more persistent species (Figure 10).

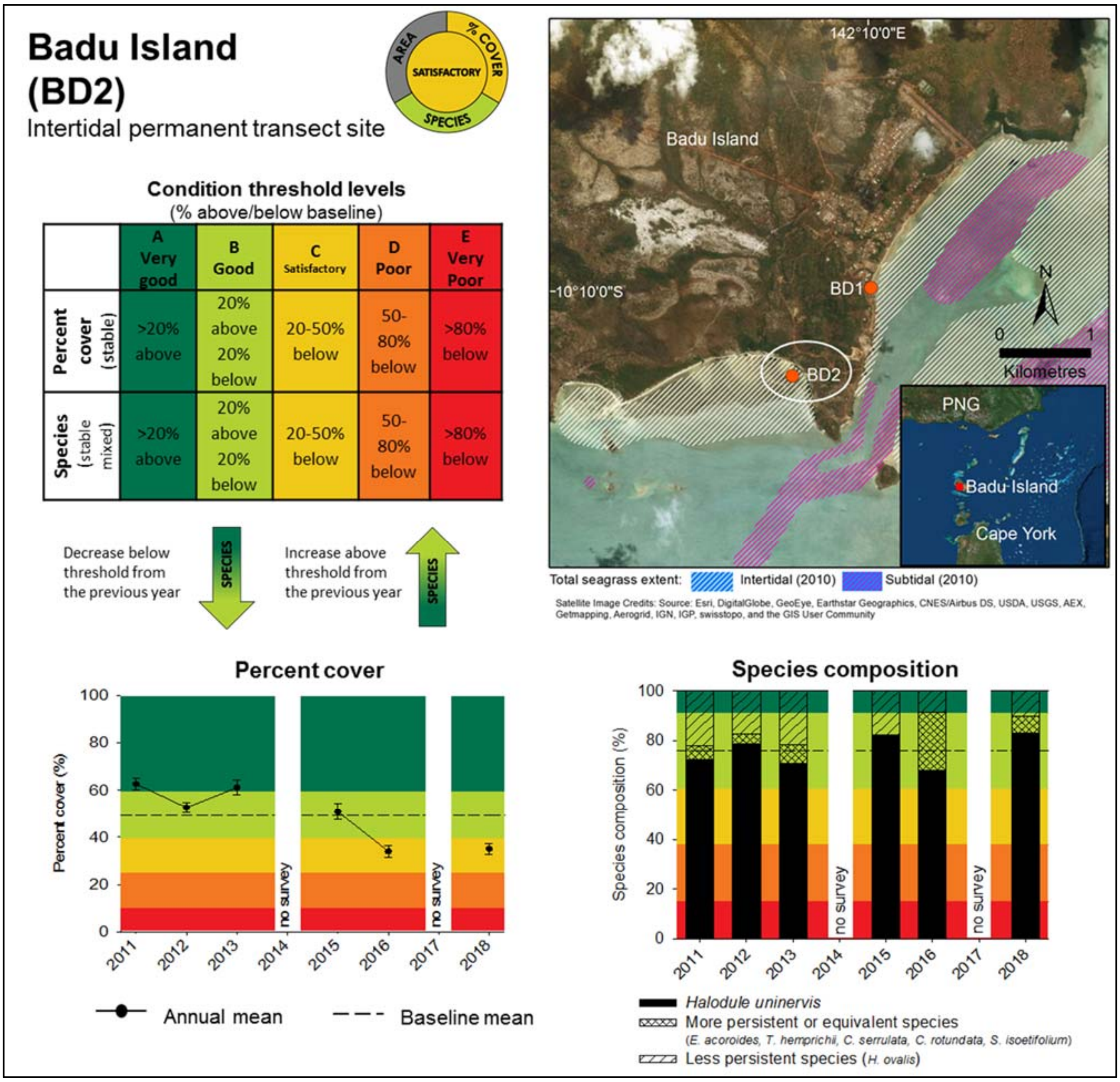


Figure 10. Seagrass mean percent cover and species composition at Badu Island permanent transect site BD2, western Torres Strait, 2011 - 2018 (percent cover error bars = SE). Total seagrass extent from mapping surveys in 2010. Note: Baseline conditions based on 6 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Mua Island Site (MU1)

The transect monitoring site MU1, Kubin Beach Hotel, at Mua Island was established in 2011 and is monitored by the Mua Lagalgau Rangers (Figure 11). The site is characterised by variable percent cover and stable species composition. The site is in good condition in 2018. Percent cover has remained at ~20% for the past two years and is in good condition. This site has high species diversity with seven species recorded here. Between 2017 and 2018 species composition improved from satisfactory to good due to an increase in the dominant species *Thalassia hemprichii* relative to less persistent, colonising species (Figure 11).

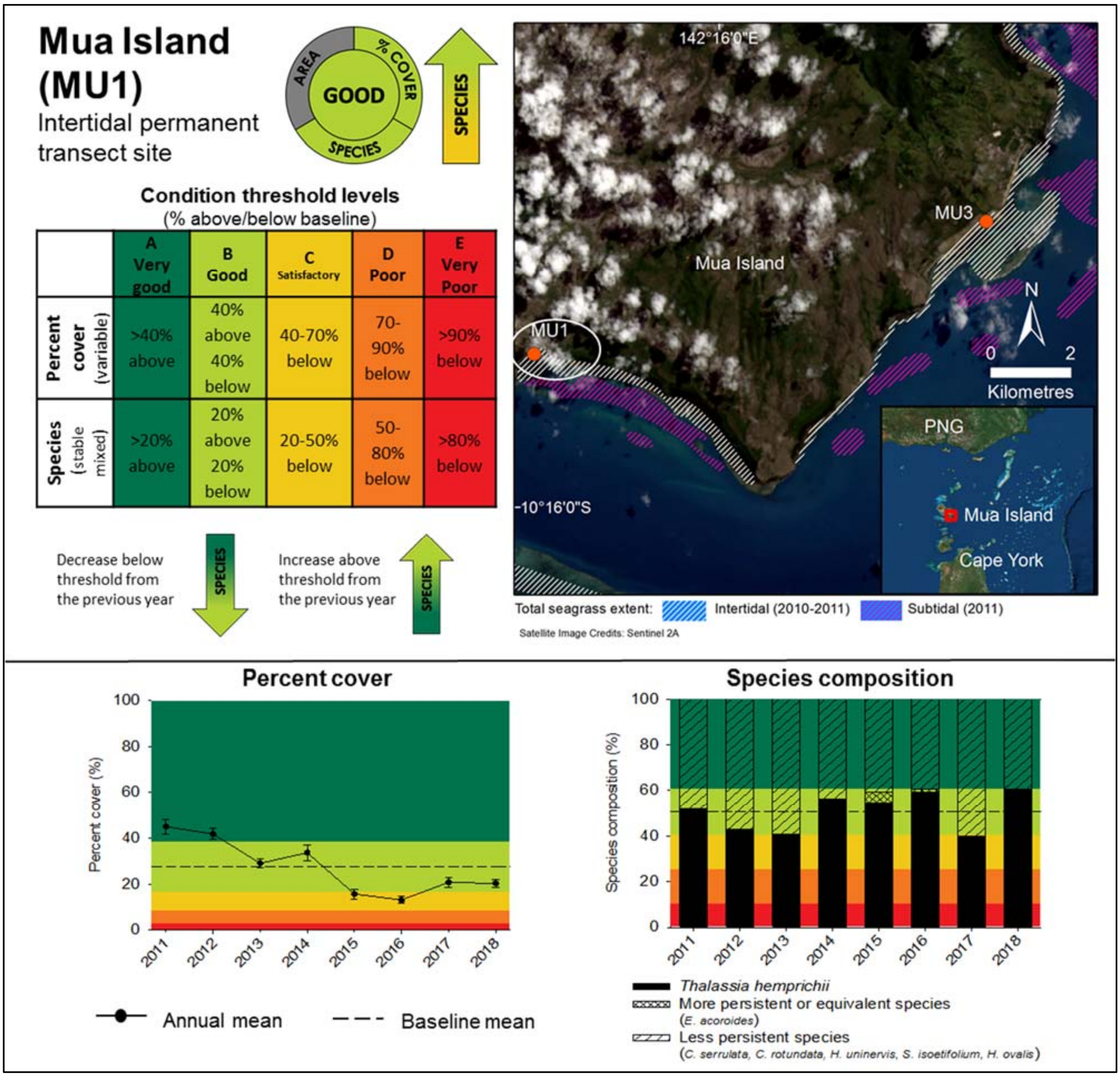


Figure 11. Seagrass mean percent cover and species composition at Mua Island permanent transect site MU1, western Torres Strait, 2011 - 2018 (percent cover error bars = SE). Total seagrass extent from mapping surveys in 2010-2011. Note: Baseline conditions based on 8 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Mua Island Site (MU3)

The transect monitoring site MU3, St Pauls Sigan Beach, at Mua Island was established in 2012 and is monitored by the Mua Lagalgau Rangers (Figure 12). The site is characterised by stable percent cover and species composition. The site is in good condition in 2018. Percent cover remained in good condition despite a small decline to 36% below the ~40% baseline level. This site has high species diversity with six species recorded here. Species composition was very good in 2018, reflecting the stability of the dominant species *Cymodocea rotundata* and above-average presence of the more persistent and stable species *Thalassia hemprichii* (Figure 12).

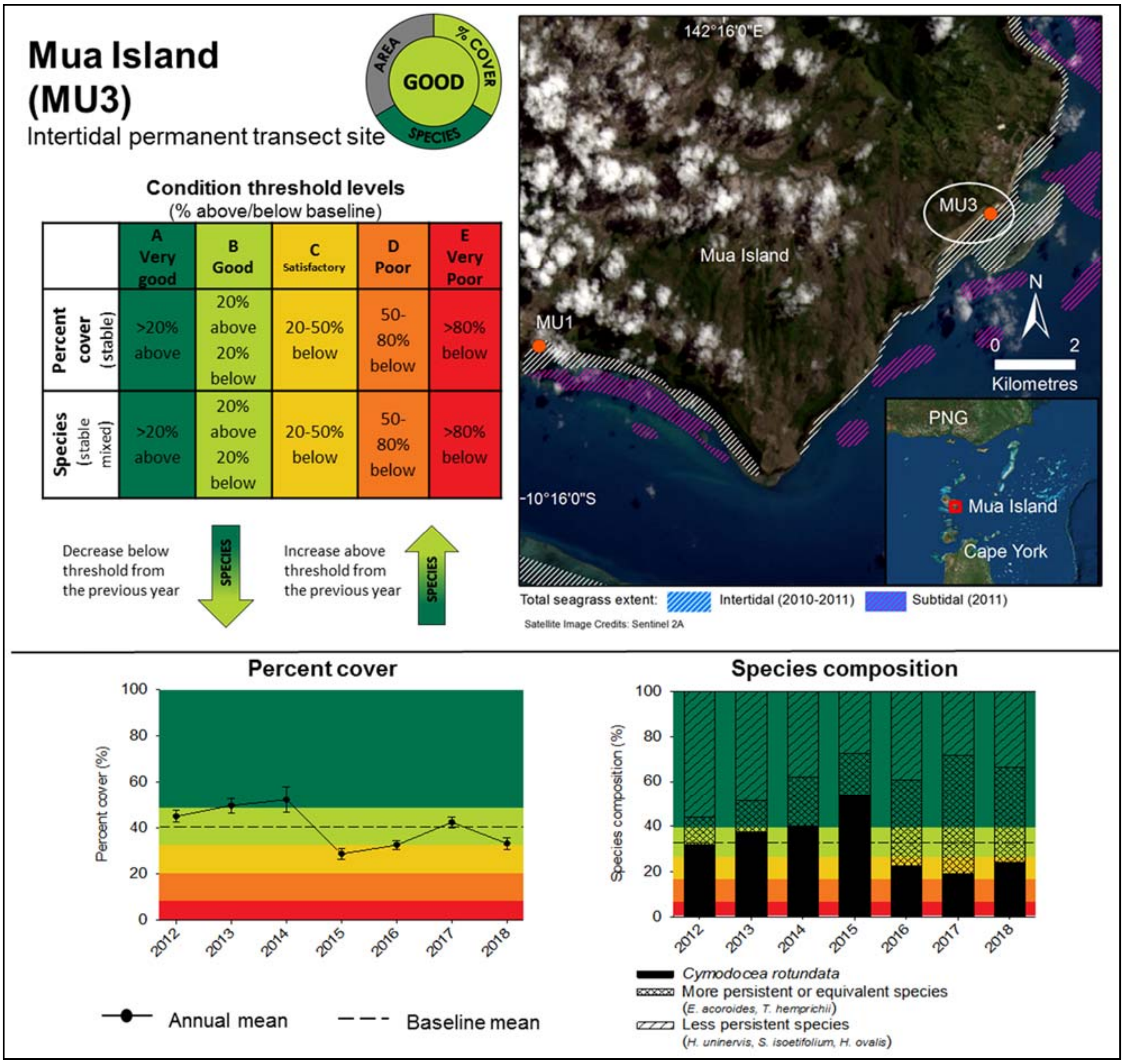


Figure 12. Seagrass mean percent cover and species composition at Mua Island permanent transect site MU3, western Torres Strait, 2012 - 2018 (percent cover error bars = SE). Total seagrass extent from mapping surveys in 2010-2011. Note: Baseline conditions based on 7 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Beka Reef - Orman Reefs Intertidal Meadow (OR1)

Beka Reef (OR1) is the northernmost reef in the Orman Reef system. No score is provided for this reef due to limited sampling events; however, preliminary assessments indicate remarkably stable biomass, area and species composition between 2004/05 surveys and those conducted for the 2018 report card (Figure 13). This meadow covers the majority of the intertidal reef-top and has high species diversity (7 species). Mean meadow biomass of ~7 gdw m^{-2} was typical of the *Thalassia hemprichii* dominated meadows at Orman Reefs (Figure 13).

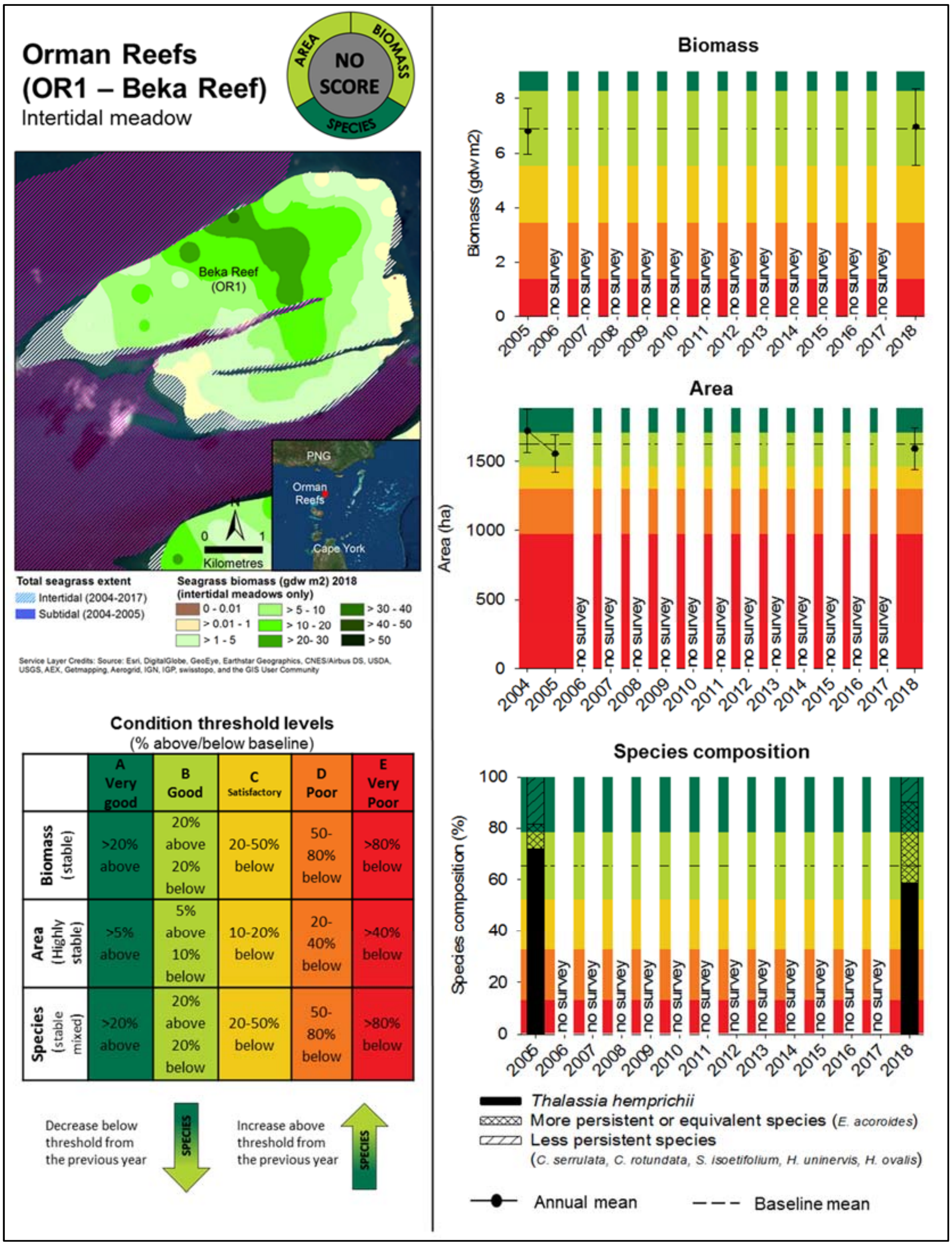


Figure 13. Seagrass mean biomass, area, and species composition at Orman Reef (Beka Reef) intertidal meadow OR1, western Torres Strait, 2004/05 - 2018 (biomass error bars = SE; area error bars = reliability estimate). Note: Baseline conditions based on 2-3 years of data; no preliminary grades or scores available until 5 years of data is available.

Kai Reef - Orman Reefs Intertidal Meadow (OR2)

Kai Reef (OR2) is the largest reef in the Orman Reef system. No score is provided for this reef due to limited sampling events; however, preliminary assessments indicate stable biomass, area and species composition between 2004/05 surveys and those conducted for the 2018 report card (Figure 14). This meadow covers the majority of the intertidal reef-top and has high species diversity (7 species). Mean meadow biomass of ~12.5 gdw m^{-2} was the greatest of the *Thalassia hemprichii* dominated meadows at Orman Reefs, driven by high biomass hotspots in the central-eastern side of the reef (Figure 14).

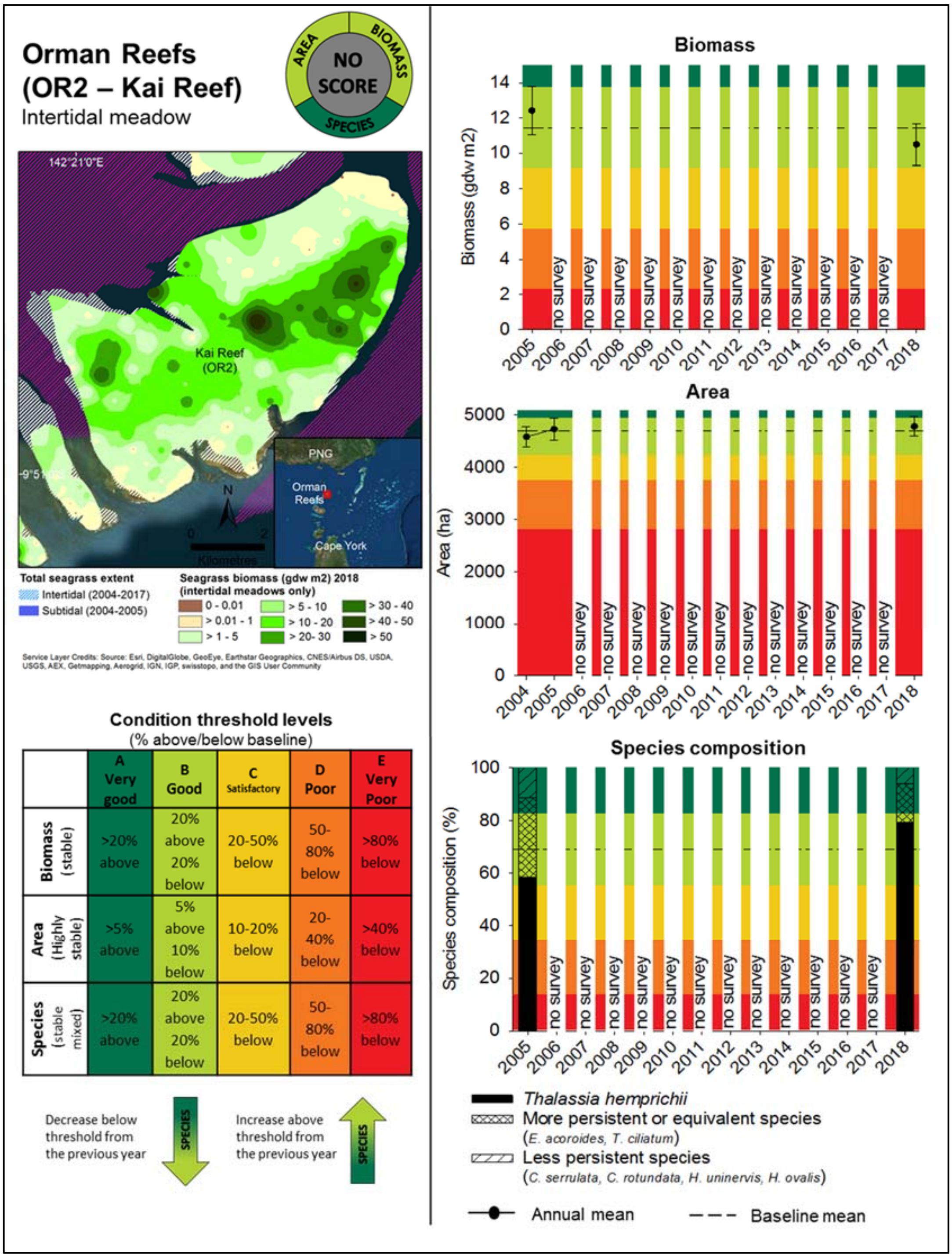


Figure 14. Seagrass mean biomass, area, and species composition at Orman Reef (Kai Reef) intertidal meadow OR2, western Torres Strait, 2004/05 - 2018 (biomass error bars = SE; area error bars = reliability estimate). Note: Baseline conditions based on 2-3 years of data; no preliminary grades or scores available until 5 years of data is available.

Orman Reefs Intertidal Meadow (OR3)

OR3 is one of the two smallest reefs in the Orman Reef system. No score is provided for this reef due to limited sampling events. Biomass and area were considerably lower in 2018 compared with 2004/05 surveys (Figure 15). The meadow has high species diversity and is dominated by *Thalassia hemprichii* and other climax species *Enhalus acoroides* and *Thalassodendron ciliatum* (Figure 15).

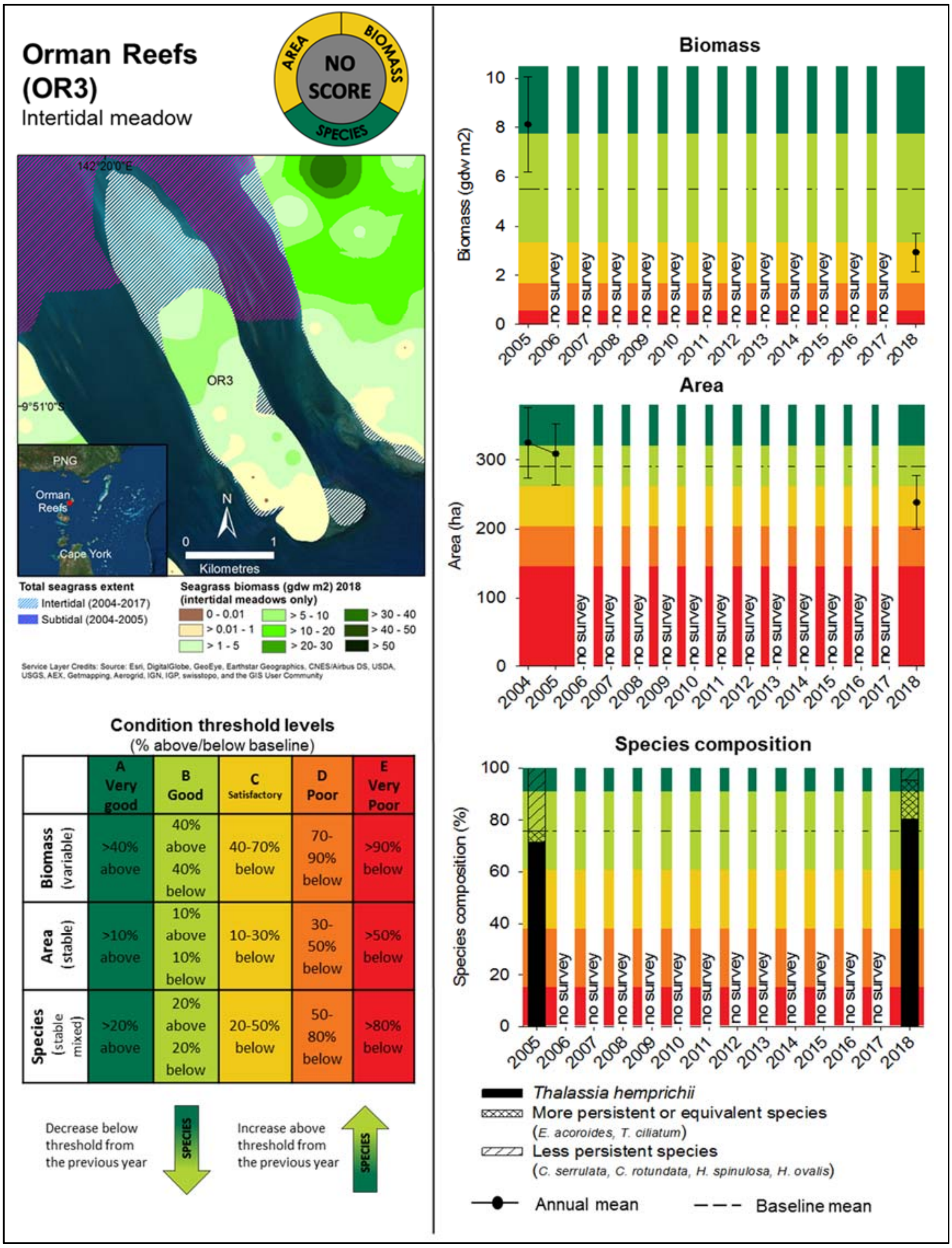


Figure 15. Seagrass mean biomass, area, and species composition at Orman Reef intertidal meadow OR3, western Torres Strait, 2004/05 - 2018 (biomass error bars = SE; area error bars = reliability estimate). Note: Baseline conditions based on 2-3 years of data; no preliminary grades or scores available until 5 years of data is available.

Orman Reefs Intertidal Meadow (OR4)

OR4 is one of the two smallest reefs in the Orman Reef system. No score is provided for this reef due to limited sampling events; however, preliminary assessments indicate stable biomass, area and species composition between 2004/05 surveys and those conducted for the 2018 report card (Figure 16). This meadow covers the majority of the intertidal reef-top and has high species diversity (6 species). In 2018 the meadow was dominated by *Thalassia hemprichii* and other climax species *Enhalus acoroides* and *Thalassodendron ciliatum*. Mean meadow biomass of ~6 gdw m^{-2} was typical of the *Thalassia hemprichii* dominated meadows at Orman Reefs (Figure 16).

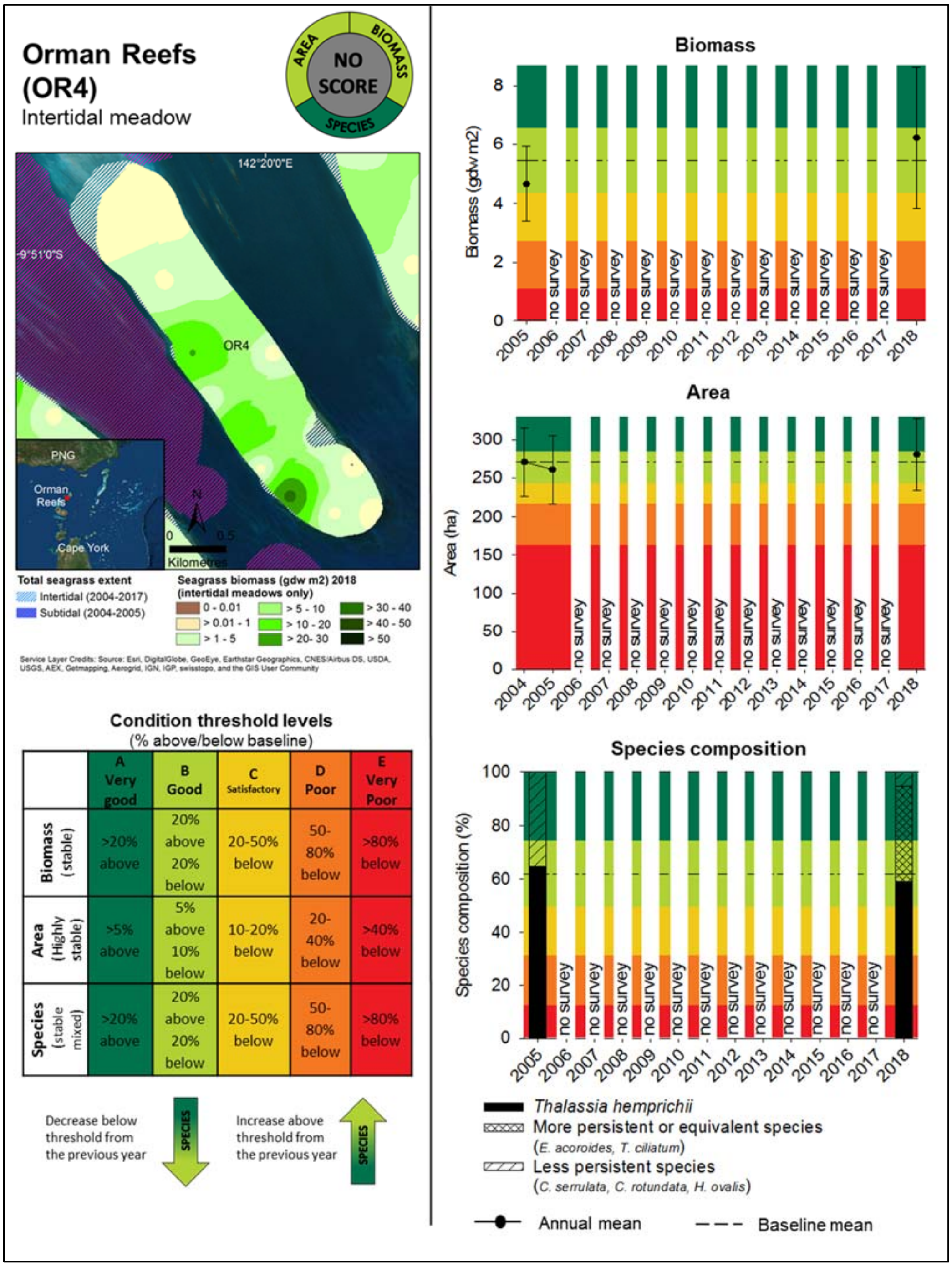
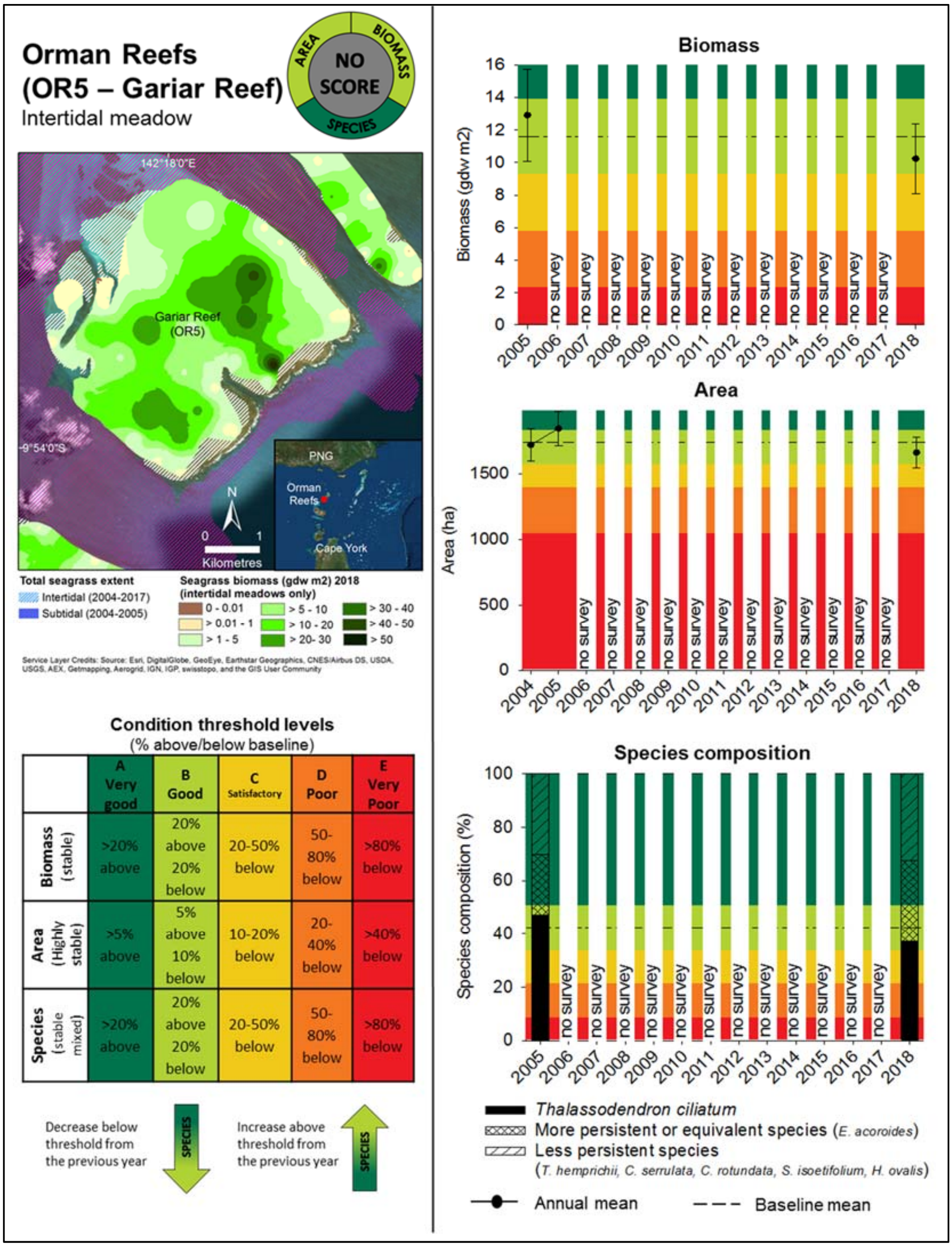


Figure 16. Seagrass mean biomass, area, and species composition at Orman Reef intertidal meadow OR4, western Torres Strait, 2004/05 - 2018 (biomass error bars = SE; area error bars = reliability estimate). Note: Baseline conditions based on 2-3 years of data; no preliminary grades or scores available until 5 years of data is available.

Gariar Reef - Orman Reefs Intertidal Meadow (OR5)

Gariar Reef (OR5) is a large meadow in the southern section of the Orman Reef system. No score is provided for this reef due to limited sampling events; however, preliminary assessments indicate stable biomass, area and species composition between 2004/05 surveys and those conducted for the 2018 report card (Figure 17). This meadow covers the majority of the intertidal reef-top. The two southernmost reefs in Orman Reefs (Gariar and Anui Reefs) are ~70% *Thalassodendron ciliatum* and *Enhalus acoroides*, the two most stable and persistent species found in Queensland. Mean meadow biomass of ~12 gdw m^{-2} was typical of the *Thalassodendron ciliatum* dominated meadows at Orman Reefs (Figure 17).



	A Very good	B Good	C Satisfactory	D Poor	E Very Poor
Biomass (stable)	>20% above	20% above 20% below	20-50% below	50-80% below	>80% below
Area (Highly stable)	>5% above	5% above 10% below	10-20% below	20-40% below	>40% below
Species (stable mixed)	>20% above	20% above 20% below	20-50% below	50-80% below	>80% below

Figure 17. Seagrass mean biomass, area, and species composition at Orman Reef (Gariar Reef) intertidal meadow OR5, western Torres Strait, 2004/05 - 2018 (biomass error bars = SE; area error bars = reliability estimate). Note: Baseline conditions based on 2-3 years of data; no preliminary grades or scores available until 5 years of data is available.

Anui Reef – Orman Reefs Intertidal Meadow (OR6)

Anui Reef (OR6) is the southernmost reef in the Orman Reef system. No score is provided for this reef due to limited sampling events; however, preliminary assessments indicate stable biomass, area and species composition between 2004/05 surveys and those conducted for the 2018 report card (Figure 18). This meadow covers the majority of the intertidal reef-top. The Anui Reef meadow is very similar to the neighbouring Gariar Reef (OR5) meadow, with mean meadow biomass ~10 gdw m^{-2} and the two most stable and persistent species *Thalassodendron ciliatum* and *Enhalus acoroides* contributing ~70% meadow biomass (Figure 18).

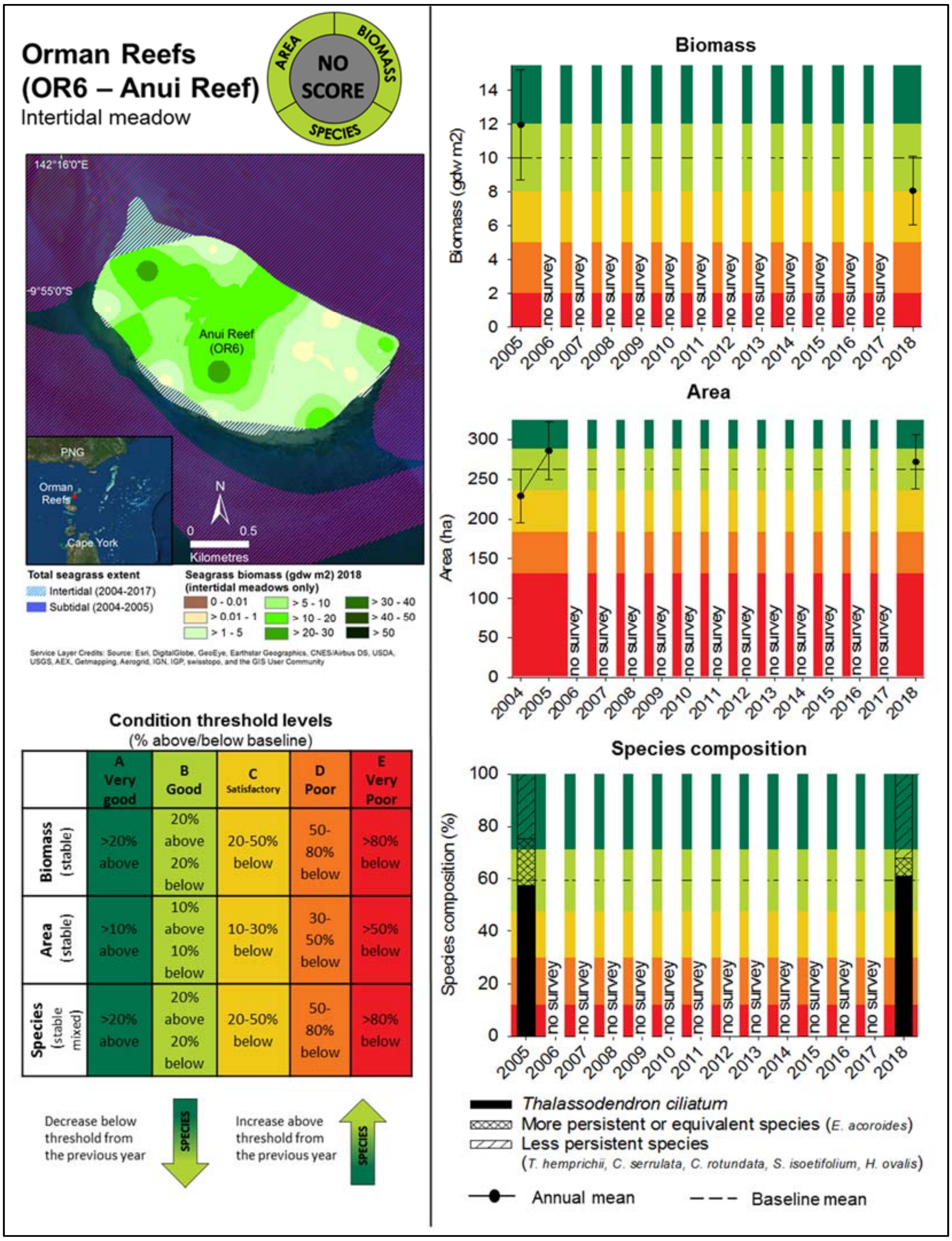


Figure 18. Seagrass mean biomass, area, and species composition at Orman Reef (Anui Reef) intertidal meadow OR6, western Torres Strait, 2004/05 - 2018 (biomass error bars = SE; area error bars = reliability estimate). Note: Baseline conditions based on 2-3 years of data; no preliminary grades or scores available until 5 years of data is available.

Orman Reefs Subtidal Blocks (OR7)

Subtidal seagrass meadows surround the intertidal reef-top meadows of Orman Reefs. Subtidal monitoring blocks are positioned along the western side of the reef system and are collectively referred to as OR7 (Figure 19). Subtidal blocks are monitored by Mabuiag and Badu Island LSMU Rangers. No score is provided for this subtidal meadow due to limited sampling events. Preliminary assessments indicate mean biomass is similar to adjacent *Thalassia hemprichii* dominated reef-top meadows ~6.5 gdw m^{-2}, although the dominant species is *Halophila spinulosa,* a common subtidal species. Species diversity is high (7 species) and composition is variable, with the more persistent species *Syringodium isoetifolium* and *Cymodocea serrulata* contributing ~50% of biomass (Figure 19).

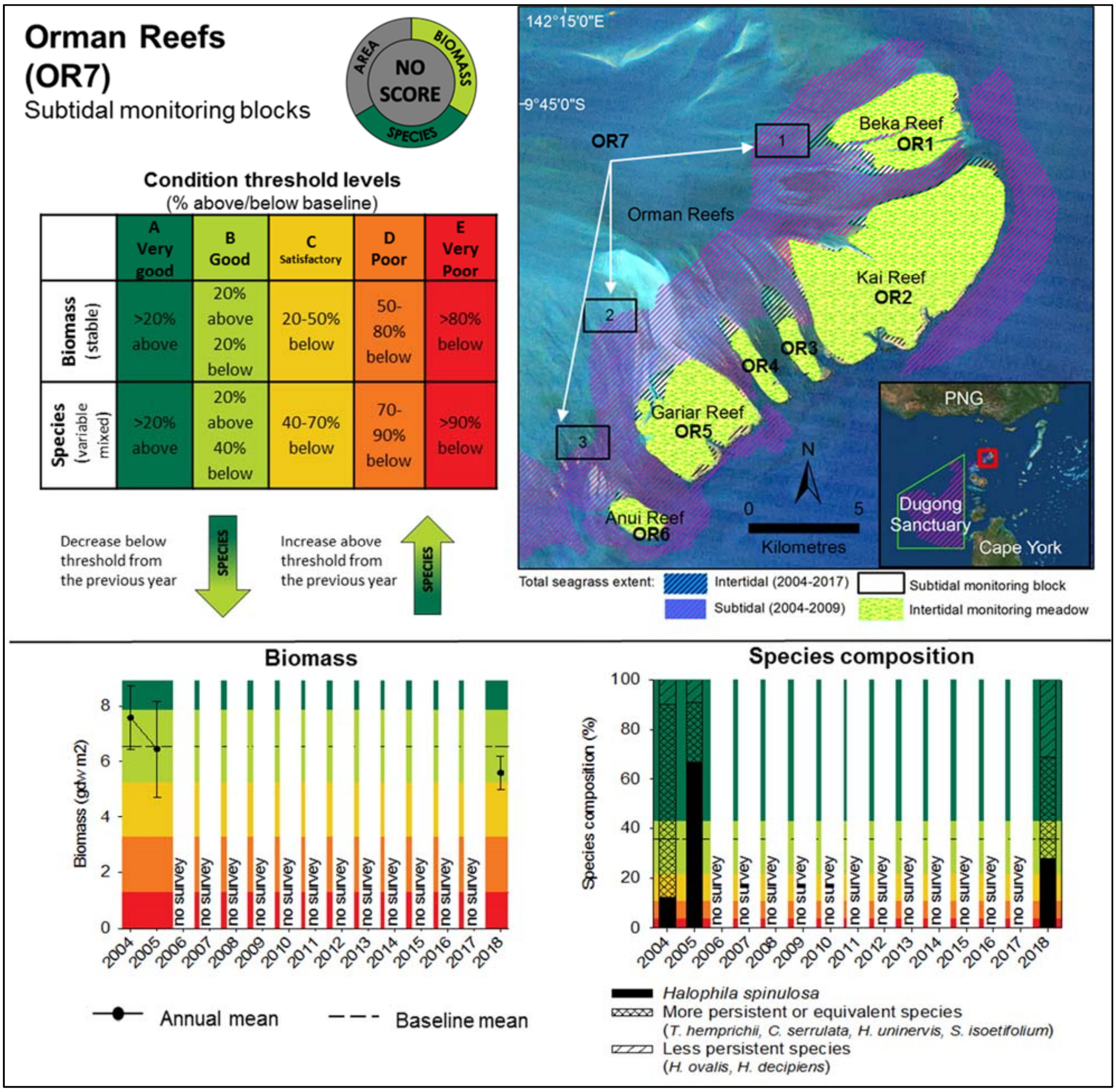


Figure 19. Seagrass mean biomass and species composition at Orman Reefs subtidal monitoring blocks, Western Cluster, 2004 - 2018 (biomass error bars = SE). Note: Baseline conditions based on 3 years of data; no preliminary grades or scores available until 5 years of data is available.

Dugong Sanctuary Subtidal Blocks (DS1)

The Dugong Sanctuary contains a large subtidal meadow that spans most of the sanctuary. Subtidal monitoring blocks are positioned in the north-eastern part of the meadow and are collectively referred to as DS1 (Figure 20). Subtidal blocks are monitored by Badu and Mabuiag Island LSMU Rangers. No score is provided for 2018 as no survey was conducted. The dominant species *Halophila spinulosa* is typical of subtidal meadows, although mean biomass of ~2 gdw m^{-2} is one third less than at Orman and Dungeness Reef subtidal blocks (OR7 and DR1). Biomass is variable and was poor in 2017; future monitoring will determine whether biomass condition is declining or if the 2017 value represented a natural fluctuation from which the meadow recovered (Figure 20).

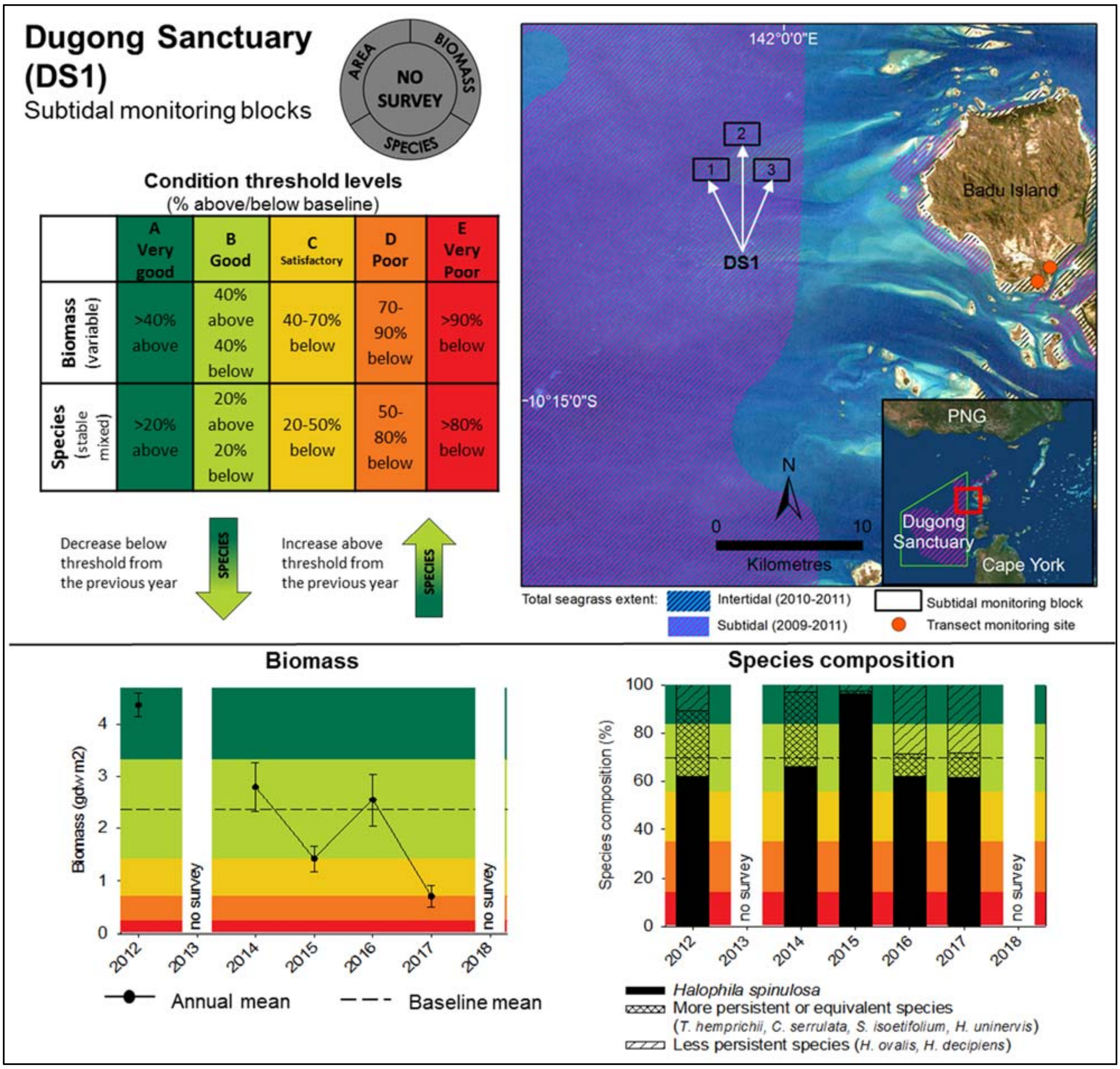


Figure 20. Seagrass mean biomass and species composition at Dugong Sanctuary subtidal monitoring blocks, western Torres Strait, 2012 - 2018 (biomass error bars = SE). Total seagrass extent from mapping surveys in 2010-2011. Note: Baseline conditions based on 5 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

3.3.2 Central Island Cluster

Seagrass condition in the Central Island Cluster was good (Figure 21). Seagrass monitoring in this cluster includes four intertidal transect sites at Iama and Poruma Islands, whole-meadow monitoring of Dungeness Reef intertidal reef-top, and block monitoring of the Dungeness Reef subtidal meadow (Figure 21).

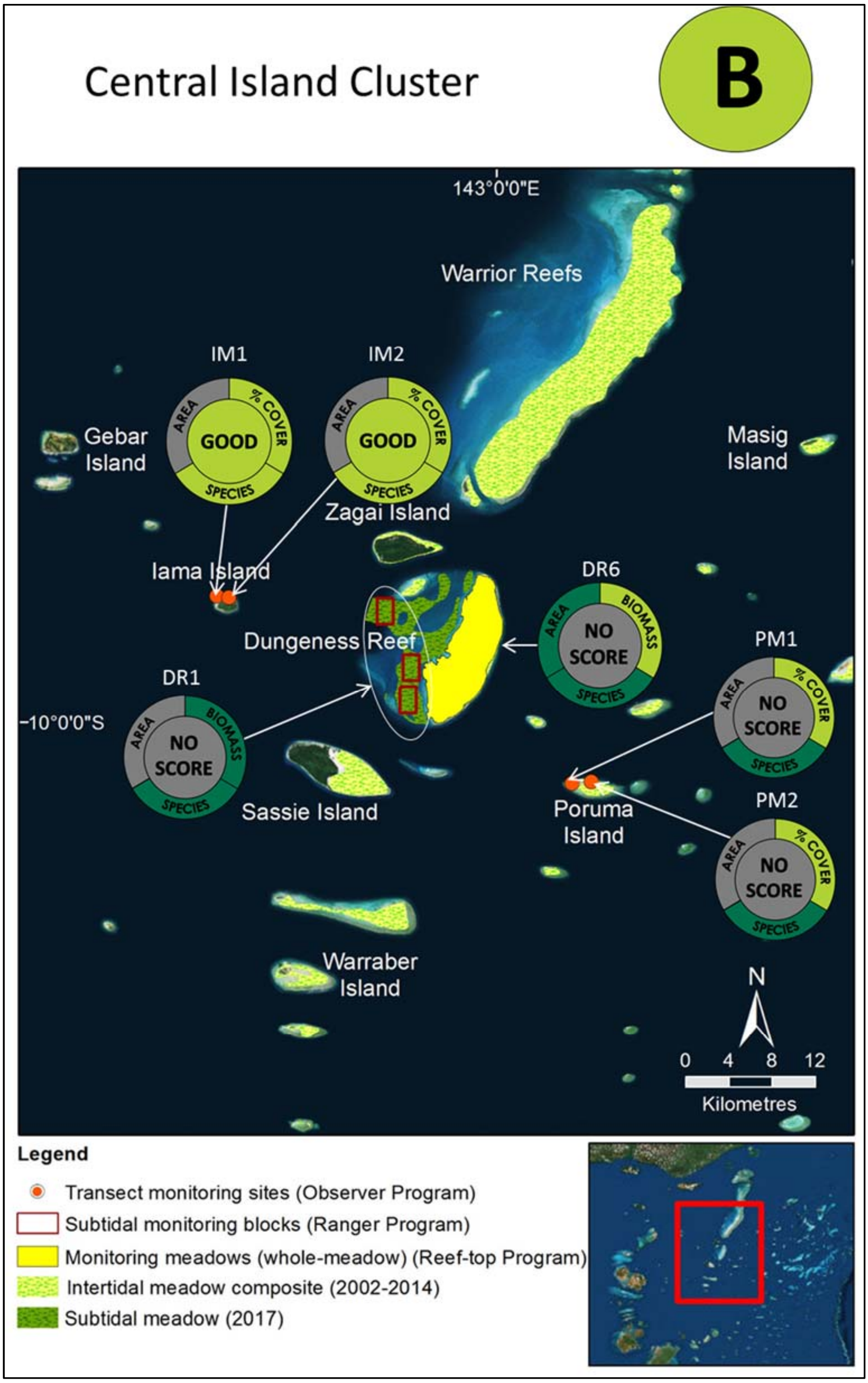


Figure 21. Seagrass condition across the Central Island Cluster of Torres Strait

Iama Island Site (IM1)

The transect monitoring site IM1 at Mabuiag Point, north-west Iama Island, was established in 2011 and is monitored by the Iamalgal Rangers (Figure 22). The site is characterised by stable percent cover and species composition. In 2018 mean percent cover was in good condition and slightly above the ~40% cover baseline following increases over two years. Five species have been recorded at this site. Species composition was in good condition in 2018 with the contribution of the dominant species *Thalassia hemprichii* to percent cover at approximately the baseline value of 77% (Figure 22).

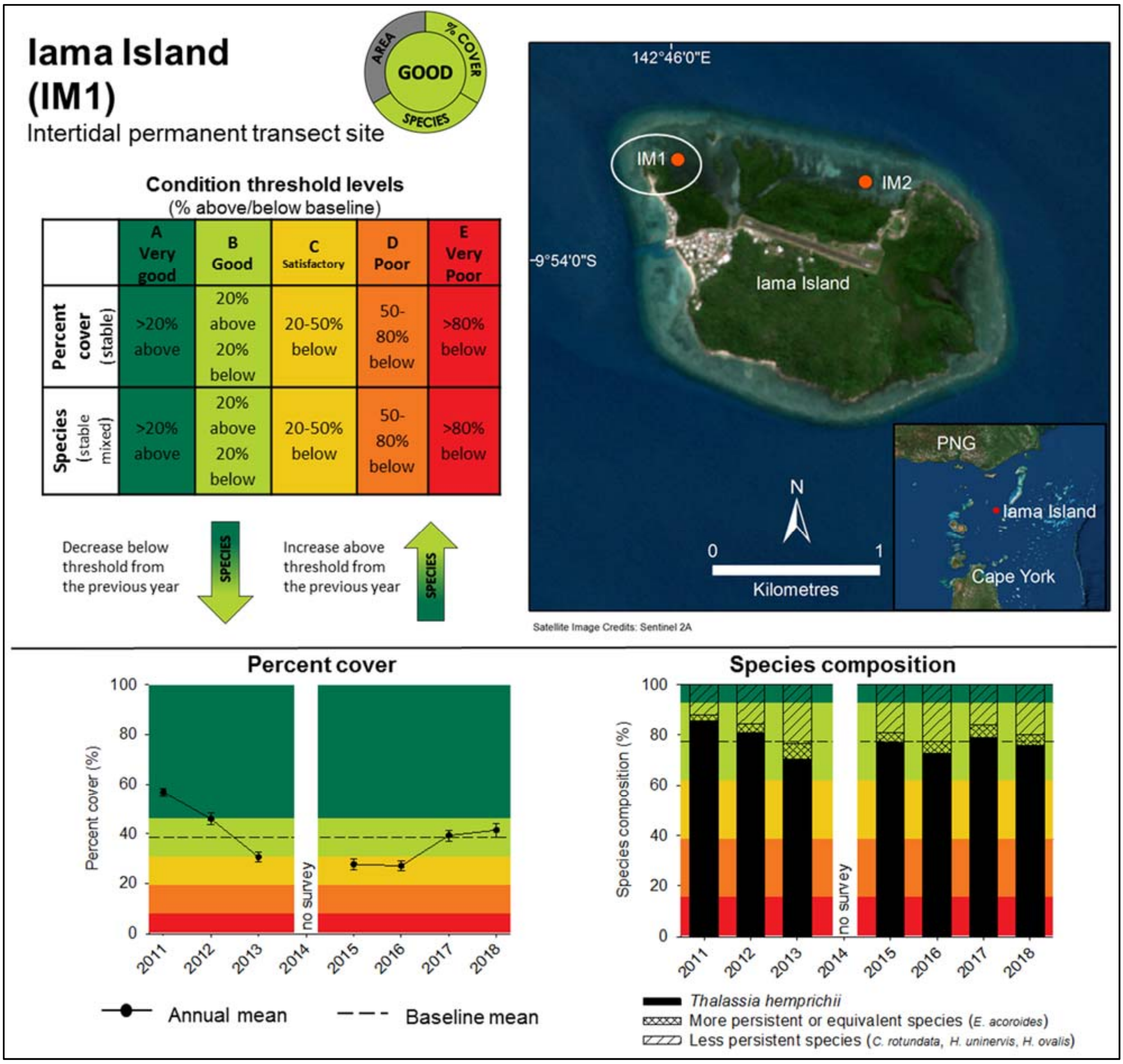


Figure 22. Seagrass mean percent cover and species composition at Iama Island permanent transect site IM1, central Torres Strait, 2011 - 2018 (percent cover error bars = SE). Note: Baseline conditions based on 7 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Iama Island Site (IM2)

The transect monitoring site IM2 at Tura, Iama Island, was established in 2011 and is monitored by the Iamalgal Rangers (Figure 23). The site is characterised by stable percent cover and species composition. As with site IM1, mean percent cover was in good condition and slightly above the ~40% cover baseline in 2018. Six species have been recorded at this site. Species composition was in good condition in 2018 due to above average (~80%) contribution of the dominant species *Thalassia hemprichii* to percent cover relative to less persistent species (Figure 23).

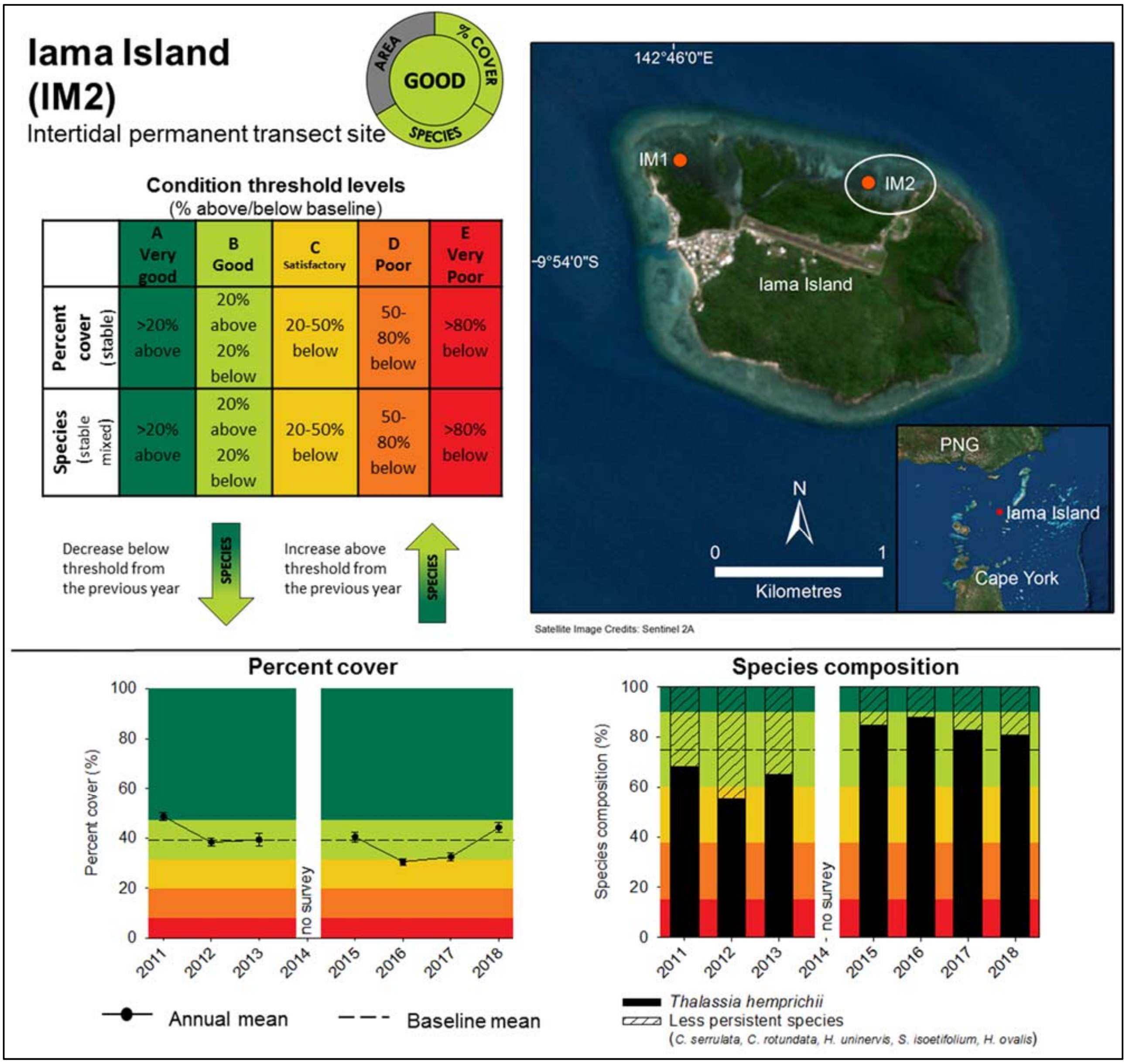


Figure 23. Seagrass mean percent cover and species composition at Iama Island permanent transect site IM2, central Torres Strait, 2011 - 2018 (percent cover error bars = SE). Note: Baseline conditions based on 7 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Poruma Island Site (PM1)

The Poruma Island transect monitoring site PM1 was established in 2017 at the request of the Poruma community. The site is monitored by the Porumalgal Rangers. No score is provided for this site due to limited sampling events; however, preliminary assessments indicate stable percent cover and species composition. Mean percent cover of ~35% was approximately double the cover of site PM2, likely because of the presence of the large-leaved *Enhalus acoroides* at this site. Six species are found at the site but the dominant species *Cymodocea rotundata* and the more stable and persistent species *Thalassia hemprichii* contribute ~99% of seagrass cover (Figure 24).

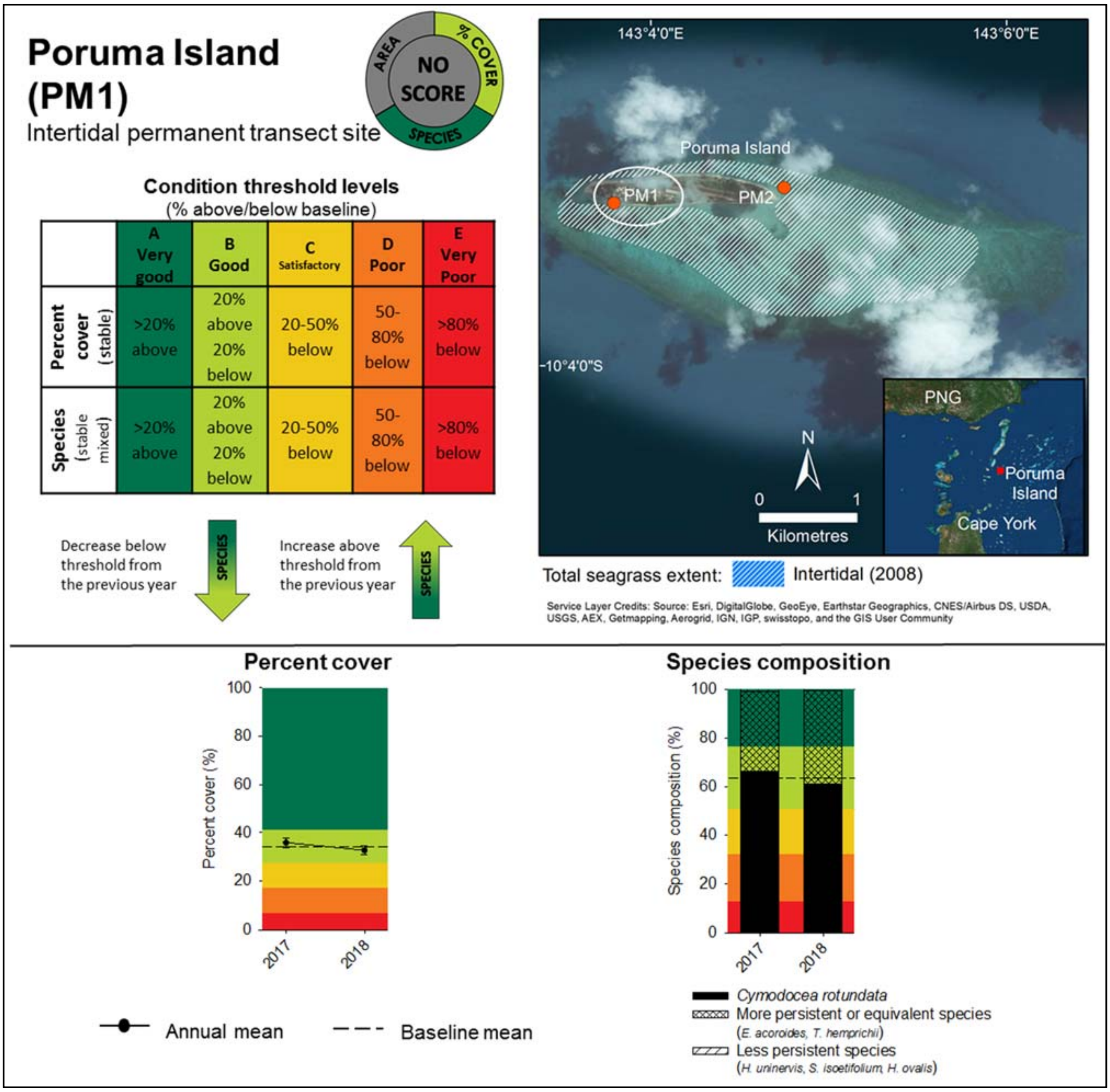


Figure 24. Seagrass mean percent cover and species composition at Poruma Island permanent transect site PM1, central Torres Strait, 2017 - 2018 (percent cover error bars = SE). Note: Baseline conditions based on 2 years of data; no preliminary grades or scores available until 5 years of data is available.

Poruma Island Site (PM2)

The Poruma Island transect monitoring site PM2 was established in 2017 at the request of the Poruma community. The site is monitored by the Porumalgal Rangers. No score is provided for this site due to limited sampling events; however, preliminary assessments indicate stable percent cover and species composition. Mean percent cover was approximately ~15%. Species diversity is lower at PM2 than PM1 with only three species recorded; however the dominant species are the same with *Cymodocea rotundata* and the more stable and persistent species *Thalassia hemprichii* accounting for ~95% of seagrass cover (Figure 25).

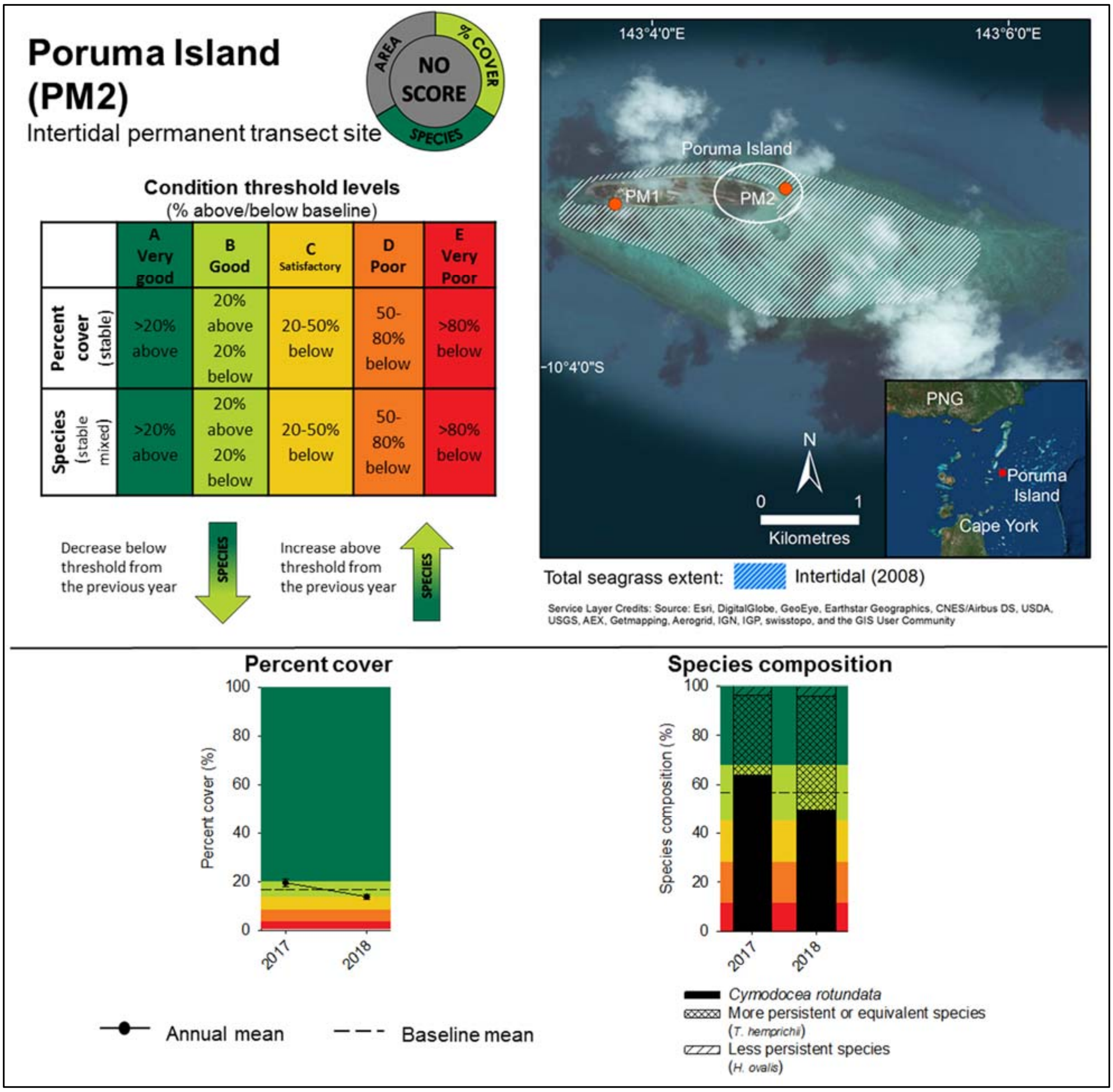


Figure 25. Seagrass mean percent cover and species composition at Poruma Island permanent transect site PM2, central Torres Strait, 2017 - 2018 (percent cover error bars = SE). Note: Baseline conditions based on 2 years of data; no preliminary grades or scores available until 5 years of data is available.

Dungeness Reef Intertidal Meadow (DR6)

The Dungeness Reef meadow DR6 covers the majority of the reef-top intertidal area (Figure 26). Dungeness Reef monitoring established in 2017 because of its known value as a foraging ground for turtle. No score is provided for this reef due to limited sampling events; however, preliminary assessments indicate stable biomass, area and species composition between 2009 surveys and those conducted in 2017 and 2018. Mean meadow biomass of ~5 gdw m^{-2} was typical of other *Thalassia hemprichii* dominated meadows at Orman Reefs. Five species are found in the meadow but the dominant species *Thalassia hemprichii* and the more stable and persistent species *Enhalus acoroides* contribute ~95% of meadow biomass (Figure 26).

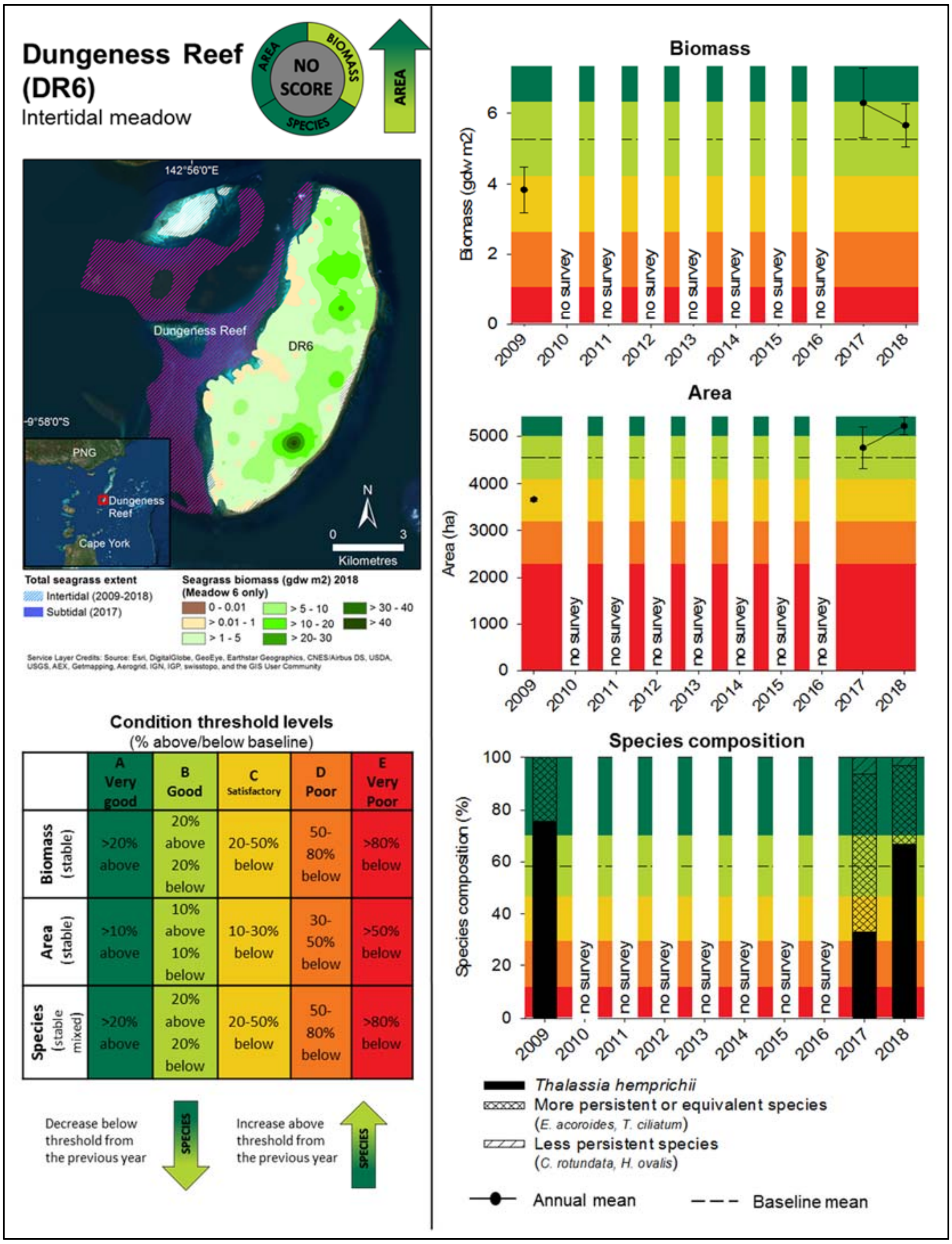


Figure 26. Seagrass mean biomass and species composition at Dungeness Reef intertidal meadow 6, central Torres Strait, 2009 - 2018 (biomass error bars = SE; area error bars = reliability estimate). Note: Baseline conditions based on 3 years of data; no preliminary grades or scores available until 5 years of data is available.

Dungeness Reef Subtidal Blocks (DR1)

An extensive subtidal seagrass meadow extends west of Dungeness Reef. Subtidal monitoring blocks positioned here are collectively referred to as DR1 (Figure 27) and are monitored by Poruma, Iama and Warraber Island LSMU Rangers. No score is provided for this subtidal meadow due to limited sampling events. Preliminary assessments indicate mean biomass of ~7.5 gdw m^{-2}, similar to the adjacent *Thalassia hemprichii* dominated reef-top meadow (DR6), reef-top *Thalassia hemprichii* dominated meadows at Orman Reefs, and the *Halophila spinulosa* dominated Orman Reef subtidal meadow. The dominant species *Halophila spinulosa* is typical of subtidal communities (Figure 27).

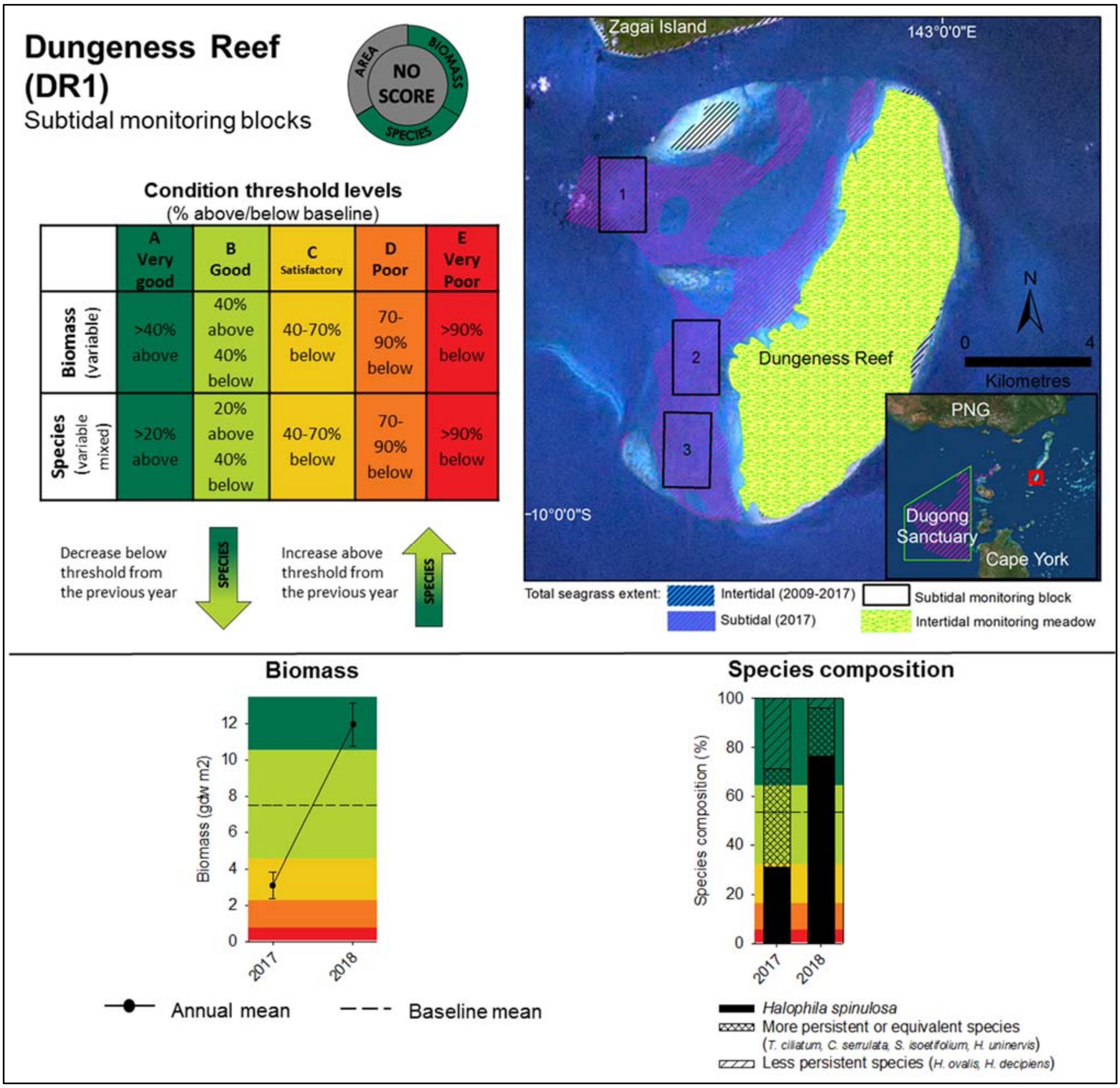


Figure 27. Seagrass mean biomass and species composition at Dungeness Reef subtidal monitoring blocks, central Torres Strait, 2017 - 2018 (biomass error bars = SE). Note: Baseline conditions based on 2 years of data; no preliminary grades or scores available until 5 years of data is available.

3.3.3 Eastern Island Cluster

Seagrass condition in the Eastern Island Cluster was good (Figure 28). Seagrass monitoring in this cluster is limited to two intertidal transect sites at Mer Island (Figure 28).

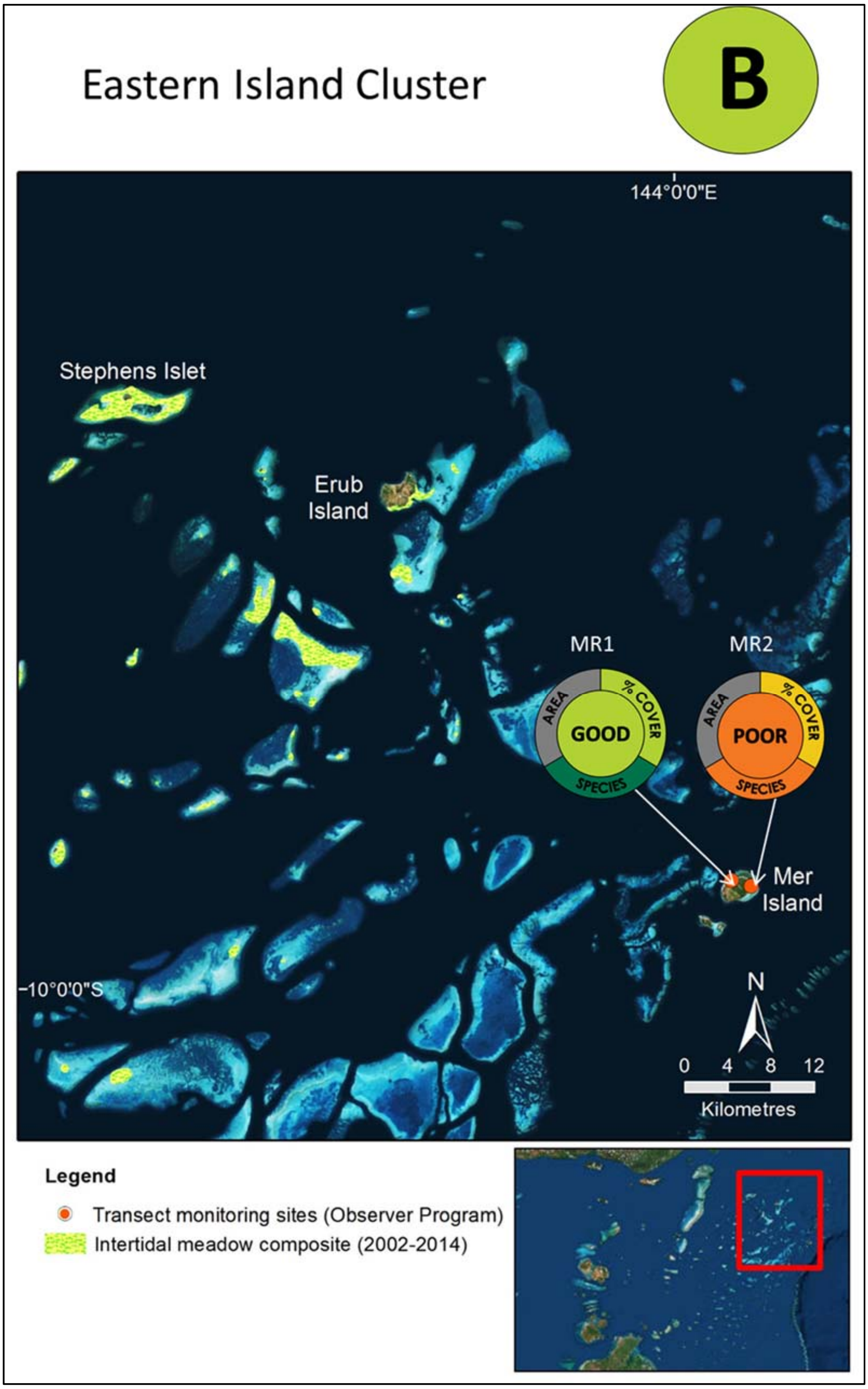


Figure 28. Seagrass condition across the Eastern Island Cluster of Torres Strait

Mer Island Site (MR1)

The transect monitoring site MR1 (Maad) was established in 2010 on the northern side of Mer Island, and is monitored by the Meriam Gesep A Gur Keparem Le Rangers (Figure 29). The site is characterised by stable percent cover and species composition. In 2018 mean percent cover was in good condition and slightly above the ~45% cover baseline. Only two species have been recorded at this site. Species composition was very good in 2018 due to above average contribution of the dominant species *Thalassia hemprichii* to percent cover relative to *Cymodocea rotundata* (Figure 29).

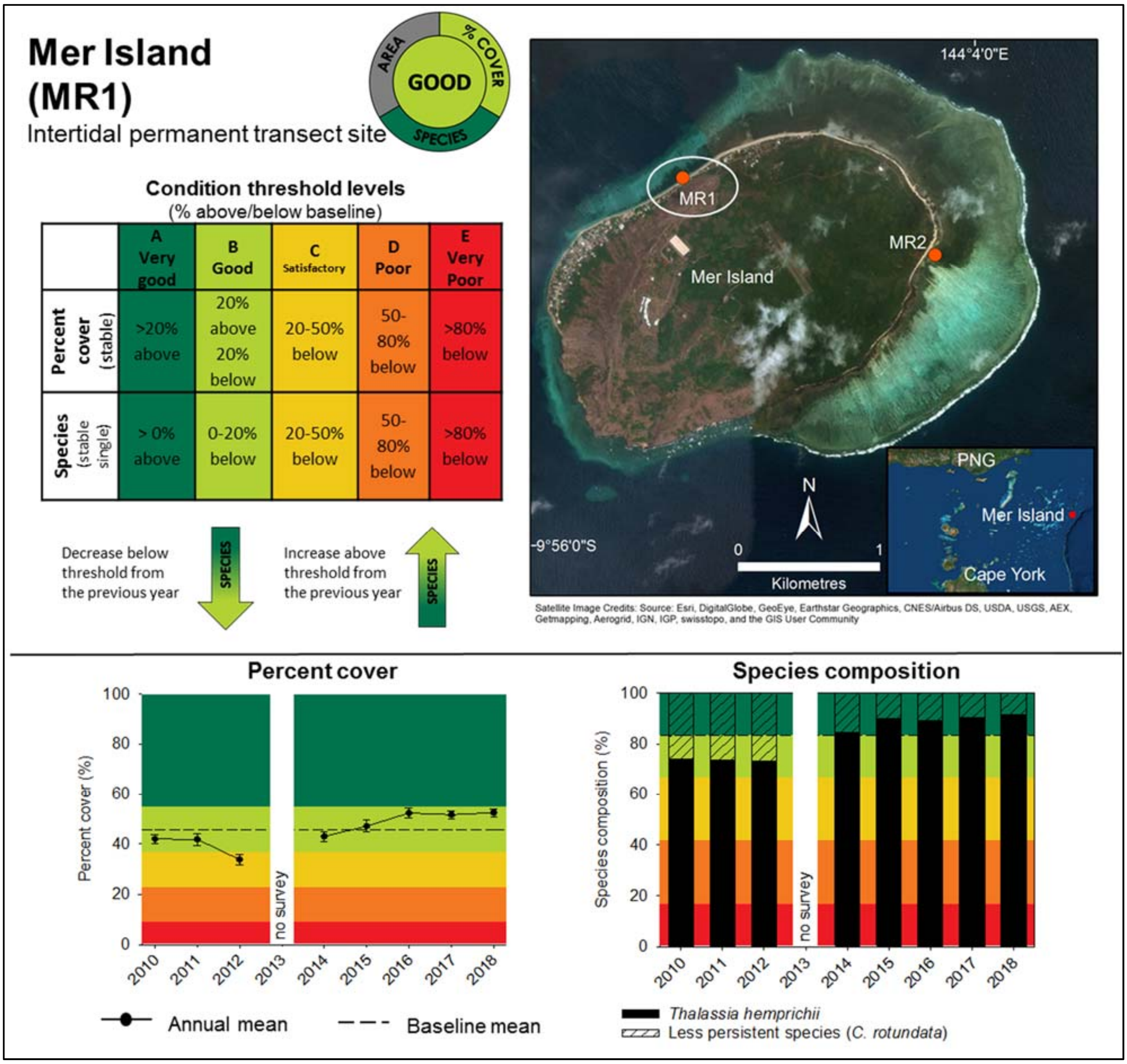


Figure 29. Seagrass mean percent cover and species composition at Mer Island permanent transect site MR1, eastern Torres Strait, 2010 - 2018 (percent cover error bars = SE). Note: Baseline conditions based on 8 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

Mer Island Site (MR2)

The transect monitoring site MR2 (Lei) was established in 2010 on the eastern side of Mer Island, and is monitored by the Meriam Gesep A Gur Keparem Le Rangers (Figure 30). The site is characterised by variable percent cover and stable species composition. Mean percent cover has declined from very good condition in 2012 to satisfactory condition in 2017 and 2018. This site is more diverse than MR1 with four species recorded. Species composition condition has also declined from very good to poor in recent years following a reduction in the dominant species *Thalassia hemprichii* relative to the less persistent species *Cymodocea rotundata* (Figure 30).

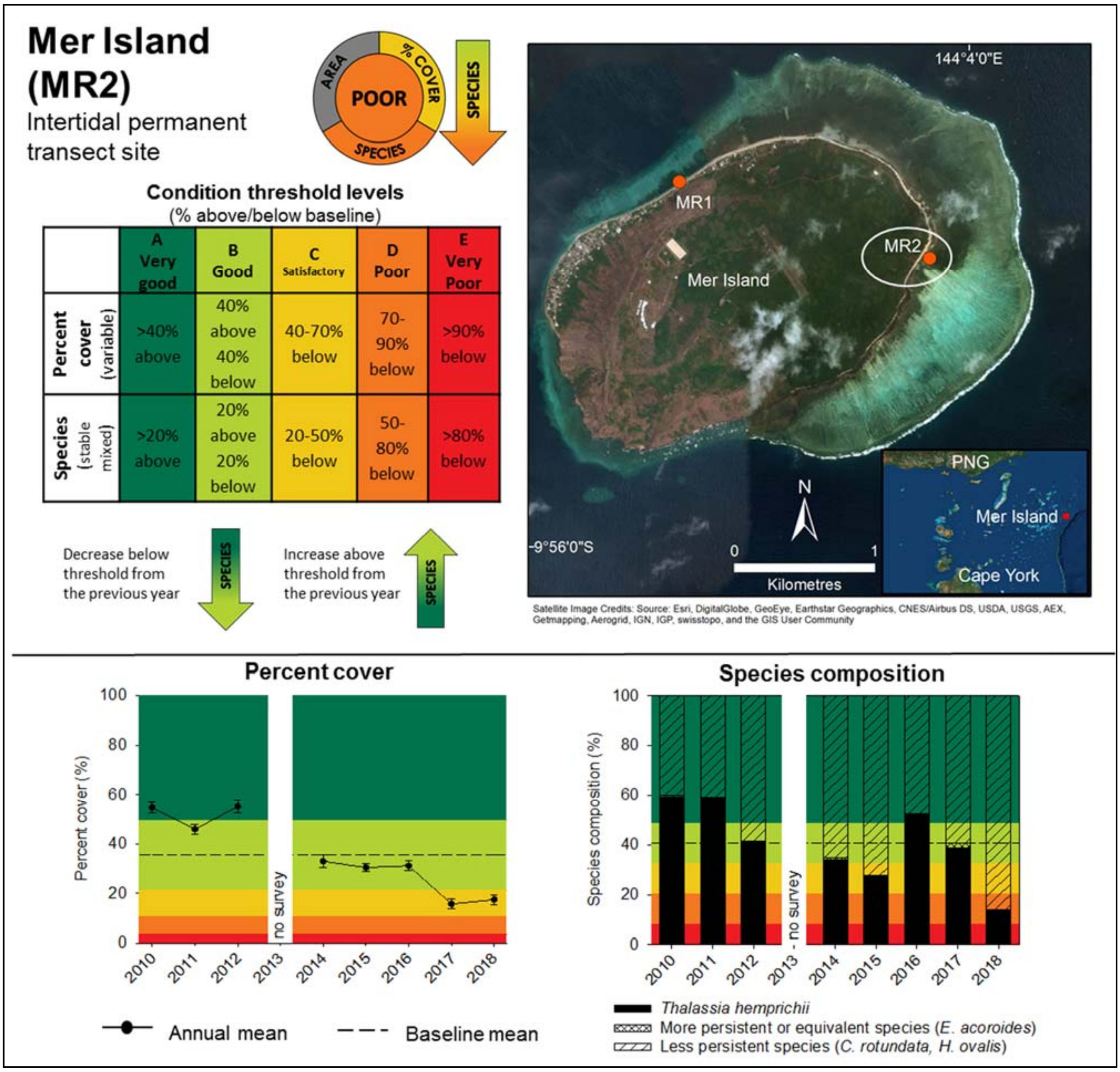


Figure 30. Seagrass mean percent cover and species composition at Mer Island permanent transect site IM2, eastern Torres Strait, 2010 - 2018 (percent cover error bars = SE). Note: Baseline conditions based on 8 years of data; resulting grades should be interpreted with caution until the full 10-year baseline is available.

3.3.4 Inner Island Cluster

Seagrass condition in the Inner Island Cluster was good (Figure 31). Seagrass in this cluster is monitored across six intertidal and three intertidal-subtidal meadows as part of the ports program (Figure 31).

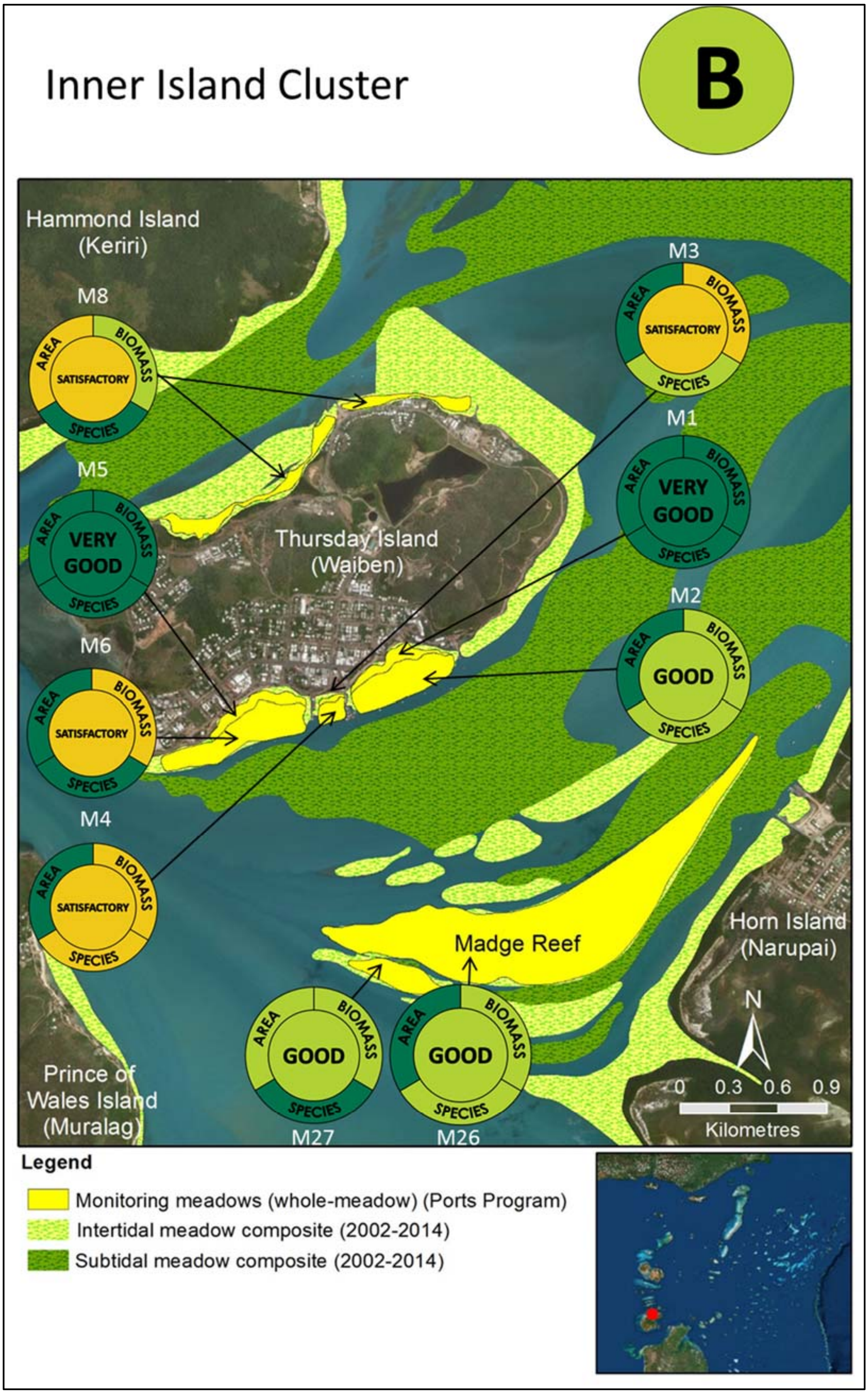


Figure 31. Seagrass condition across the Inner Island Cluster of Torres Strait

Thursday Island Intertidal Meadow (M1)

The Thursday Island meadow M1 is a small intertidal meadow characterised by stable area and species composition, but variable biomass (Figure 32). Baseline meadow biomass of ~5.5 gdw m^{-2} is typical of other *Halodule uninervis* dominated meadows at Thursday Island. In 2018 all indicators were in very good condition; biomass was the highest recorded since monitoring began, and ~80% of meadow biomass was contributed by the dominant species *Halodule uninervis* and the more stable and persistent species *Thalassia hemprichii* (Figure 32).

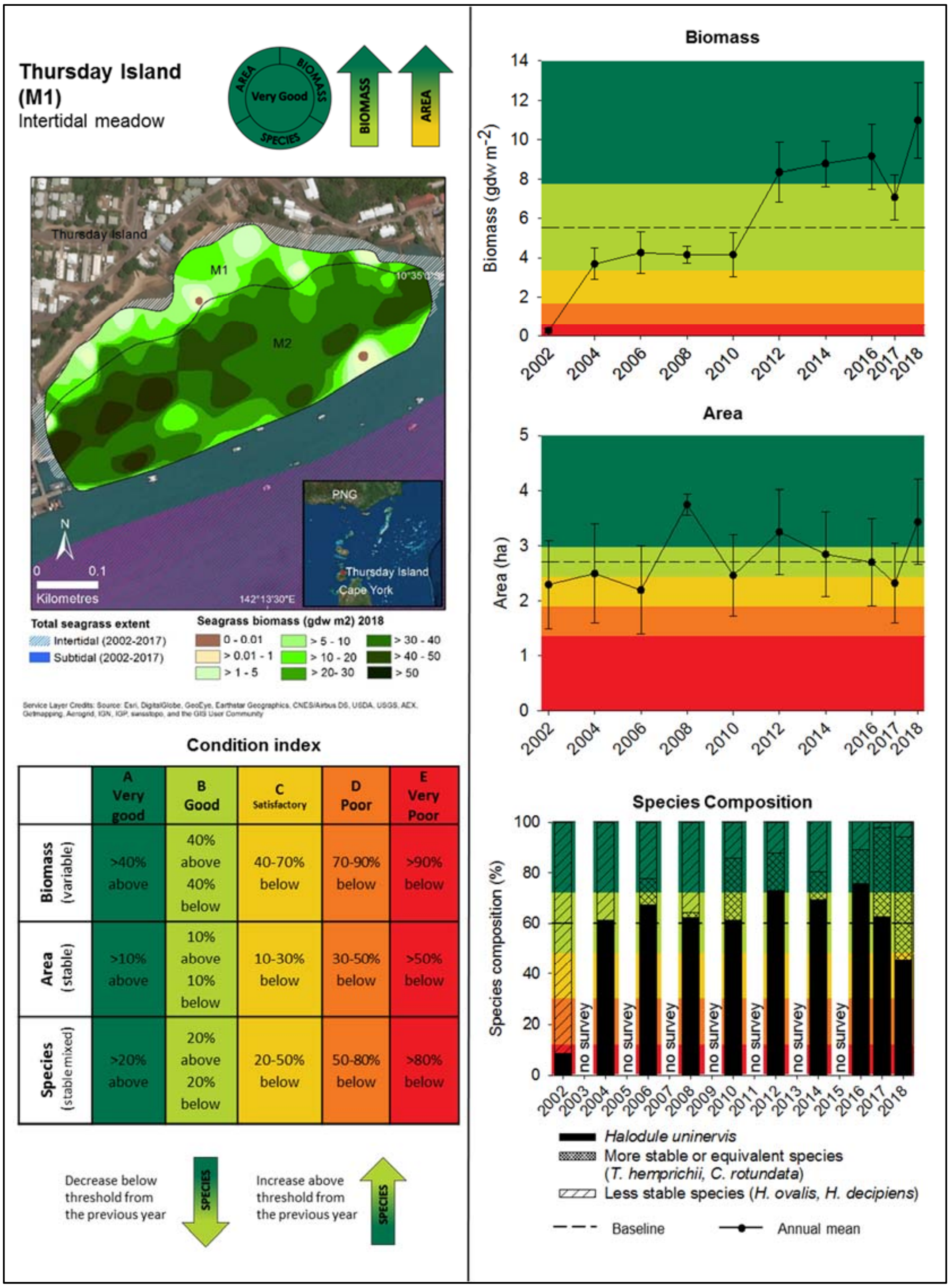


Figure 32. Seagrass mean biomass, area and species composition at Thursday Island intertidal meadow 1, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

Thursday Island Intertidal-Subtidal Meadow (M2)

The Thursday Island meadow M2 is adjacent to M1 and is characterised by stable area and species composition, but variable biomass (Figure 33). The M1-M2 boundary is defined by the transition from a *Halodule uninervis* dominated to *Enhalus acoroides* dominated meadow. Meadow 2 extends from the intertidal zone into shallow subtidal waters. Area was in very good condition with the largest area recorded since monitoring began in 2002, while biomass remained relatively unchanged since 2017. Species composition improved from satisfactory in 2017 to good in 2018 due to the increased contribution of the dominant species *Enhalus acoroides* relative to less persistent species, particularly *Thalassia hemprichii* and *Halodule uninervis* (Figure 33).

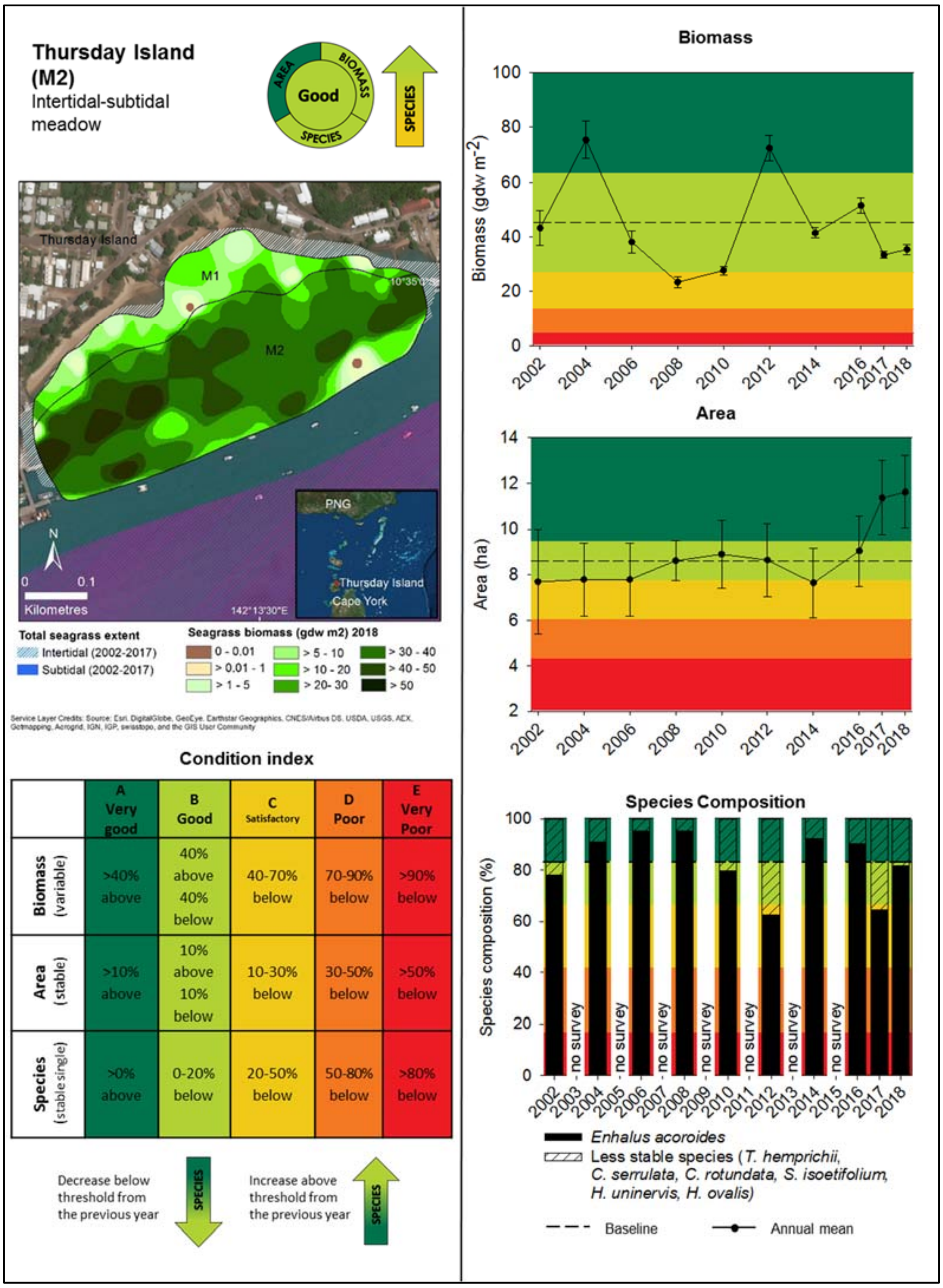


Figure 33. Seagrass mean biomass, area and species composition at Thursday Island intertidal-subtidal meadow 2, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

Thursday Island Intertidal Meadow (M3)

The Thursday Island meadow M3 is a small intertidal meadow characterised by stable species composition, but variable biomass and area (Figure 34). The meadow is in satisfactory condition, driven by the second consecutive year of decline in meadow biomass. A shift in the species composition of the meadow is likely to have contributed to this decline despite the relative stability of the dominant species *Halodule uninervis*, with the loss of the more stable species *Thalassia hemprichii* and increase in the colonising species *Halophila ovalis.* Meadow area improved from good to very good condition in 2018 with a modest area increase (Figure 34).

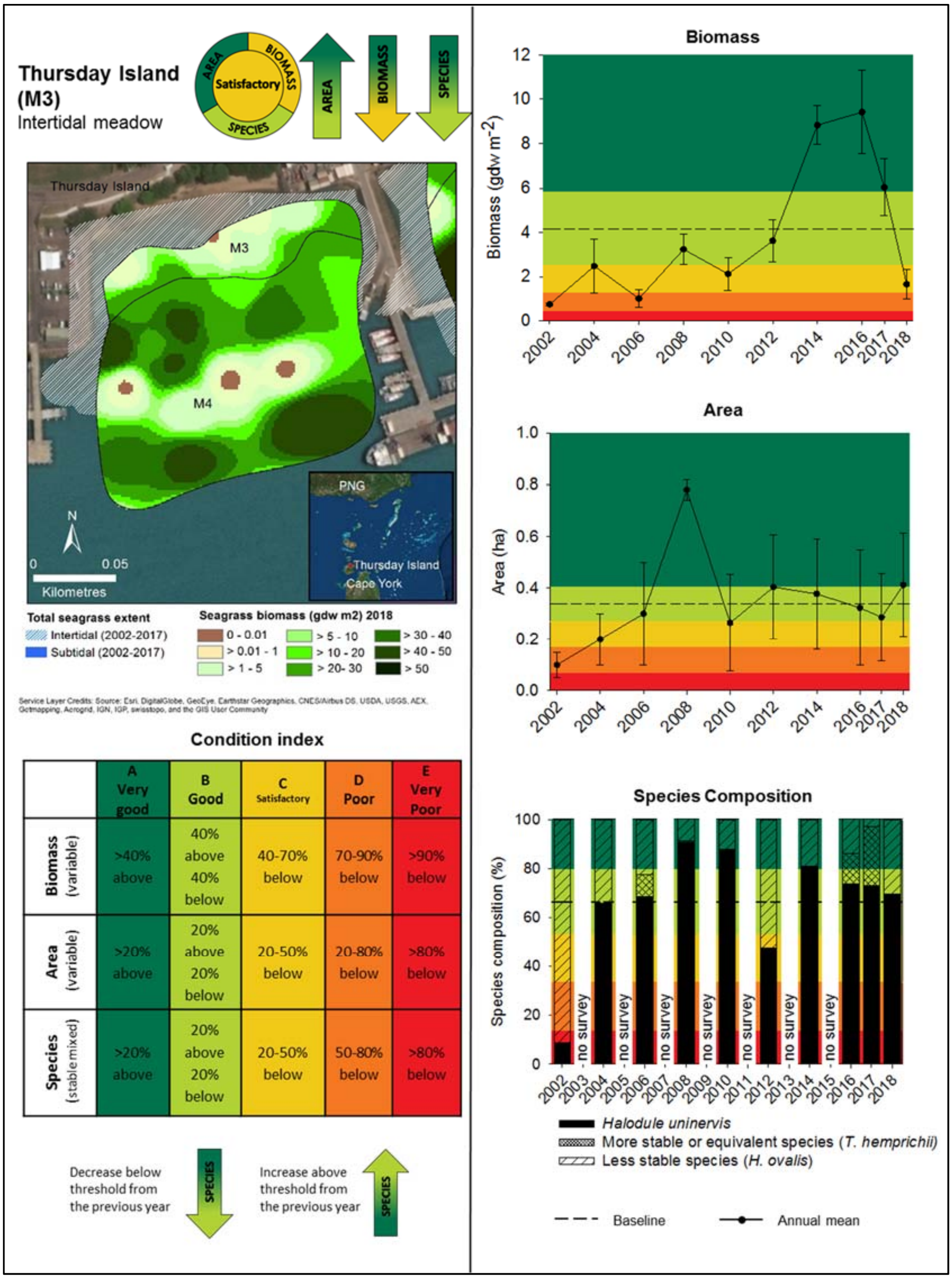


Figure 34. Seagrass mean biomass, area and species composition at Thursday Island intertidal meadow 3, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

Thursday Island Intertidal/Subtidal Meadow (M4)

The Thursday Island meadow M4 is adjacent to M3 and is characterised by stable area, biomass, and species composition (Figure 35). The M3-M4 boundary is defined by the transition from a *Halodule uninervis* dominated to *Enhalus acoroides* dominated meadow. Meadow 4 extends from the intertidal zone into shallow subtidal waters. The meadow was in satisfactory condition in 2018. Area was in very good condition and largely unchanged from 2017, with the largest area recorded since monitoring began. Biomass remained in satisfactory condition following a decline between 2016 and 2017. Species composition remained in satisfactory condition following a decline between 2016 and 2017 in the dominant species *Enhalus acoroides* relative to less persistent species, particularly *Thalassia hemprichii, Cymodocea serrulata* and *Halodule uninervis* (Figure 35).

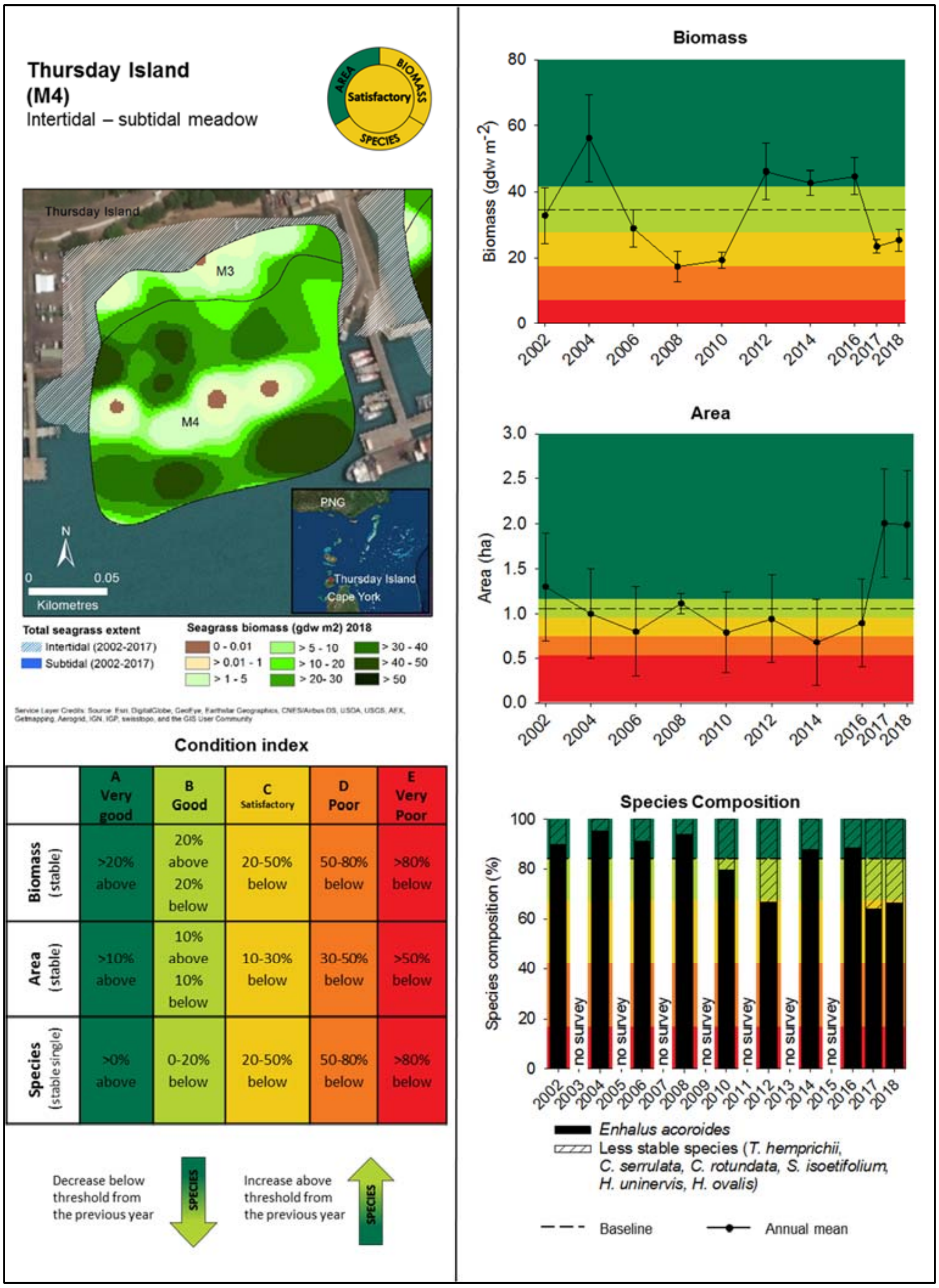


Figure 35. Seagrass mean biomass, area and species composition at Thursday Island intertidal-subtidal meadow 4, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

Thursday Island Intertidal Meadow (M5)

The Thursday Island meadow M5 is a small intertidal meadow characterised by stable area and species composition, but variable biomass (Figure 36). In 2018 all indicators and overall meadow condition were very good. Meadow area increased 50% between 2017 and 2018, biomass was at the second highest recorded level since 2002, and the meadow was comprised almost entirely of the dominant species *Halodule uninervis* and more stable and persistent species (Figure 36).

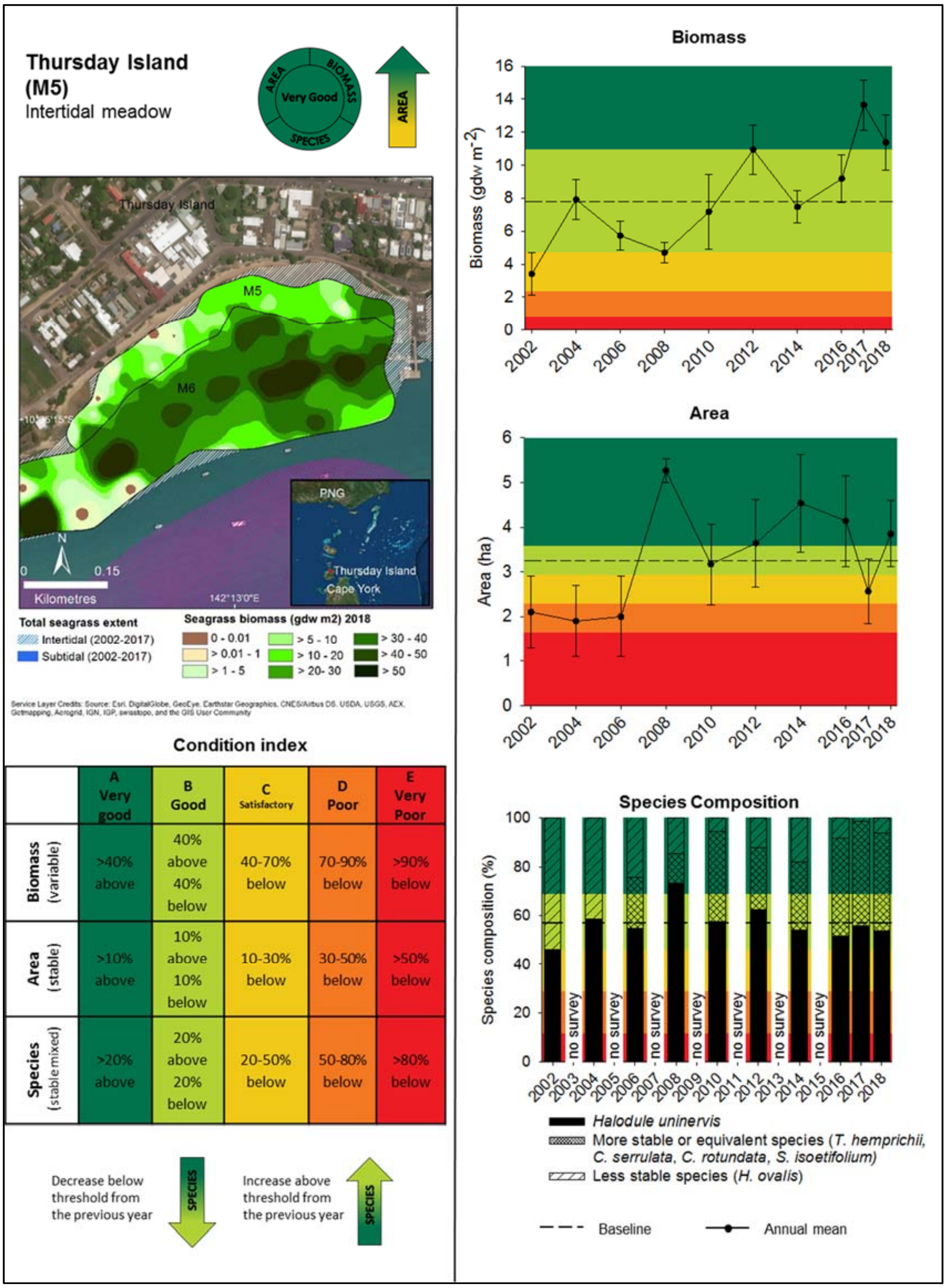


Figure 36. Seagrass mean biomass, area and species composition at Thursday Island intertidal meadow 5, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

Thursday Island Intertidal/Subtidal Meadow (M6)

The Thursday Island meadow M6 is adjacent to M5 and is characterised by stable area, biomass, and species composition (Figure 37). The M5-M6 boundary is defined by the transition from a *Halodule uninervis* dominated to *Enhalus acoroides* dominated meadow. Meadow 6 extends from the intertidal zone into shallow subtidal waters. The meadow was in satisfactory condition in 2018, driven by two consecutive years of biomass declines. Area was in very good condition in 2018 following a small increase from 2017. Species composition improved from good to very good condition due to an increase in the dominant species *Enhalus acoroides* relative to less persistent species (Figure 37).

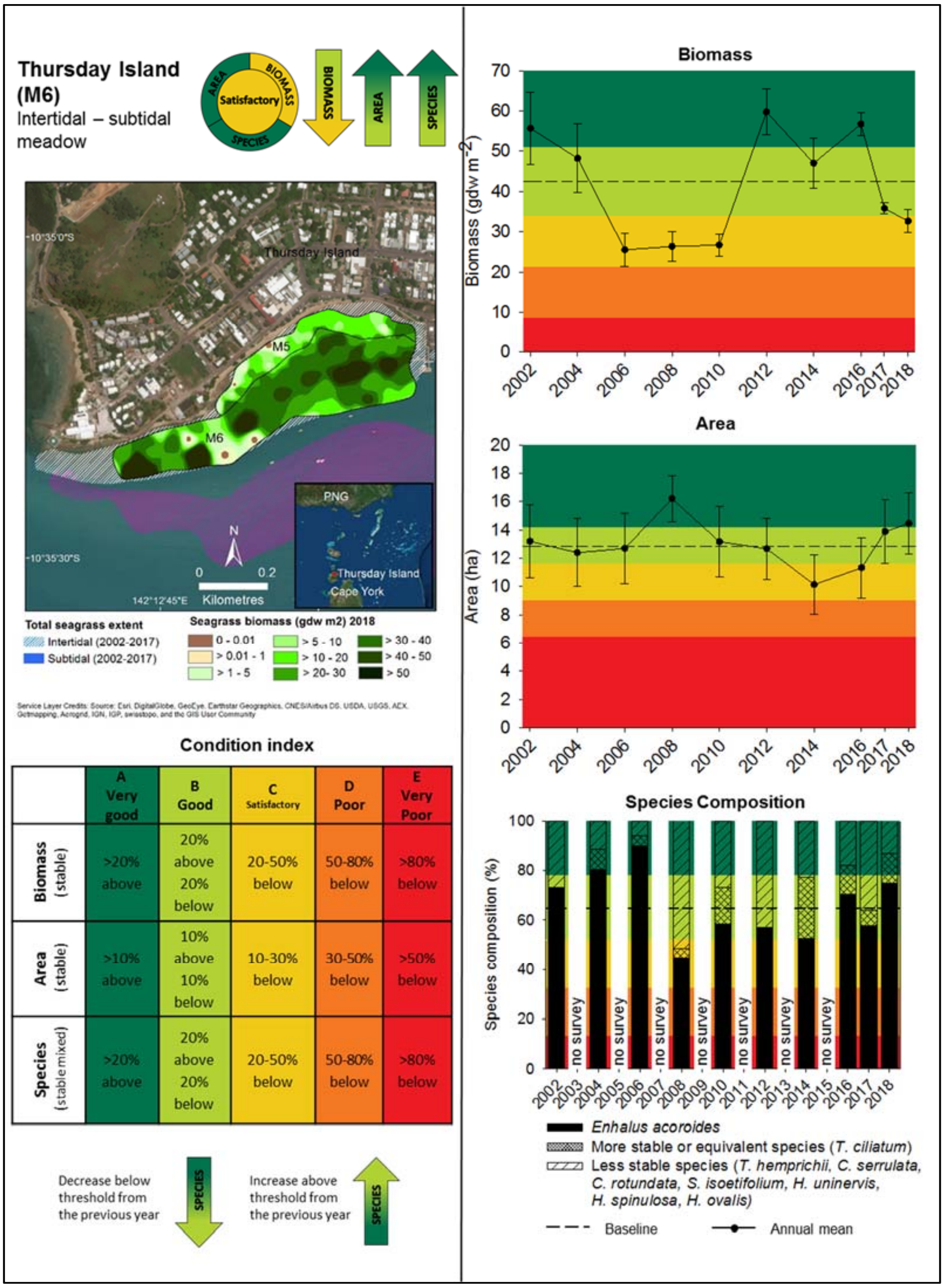


Figure 37. Seagrass mean biomass, area and species composition at Thursday Island intertidal-subtidal meadow 6, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

Thursday Island Intertidal Meadow (M8)

Meadow 8 is a long thin intertidal meadow that extends along the northern shore of Thursday Island. It is characterised by stable area and species composition, but variable biomass (Figure 38). The meadow is in satisfactory condition, driven by the second consecutive year of decline in meadow area. Biomass also declined from very good to good condition. Species composition remained in very good condition due to the stability of the dominant species *Halodule uninervis* and presence of more stable and persistent species *Thalassia hemprichii* and *Cymodocea rotundata* (Figure 38).

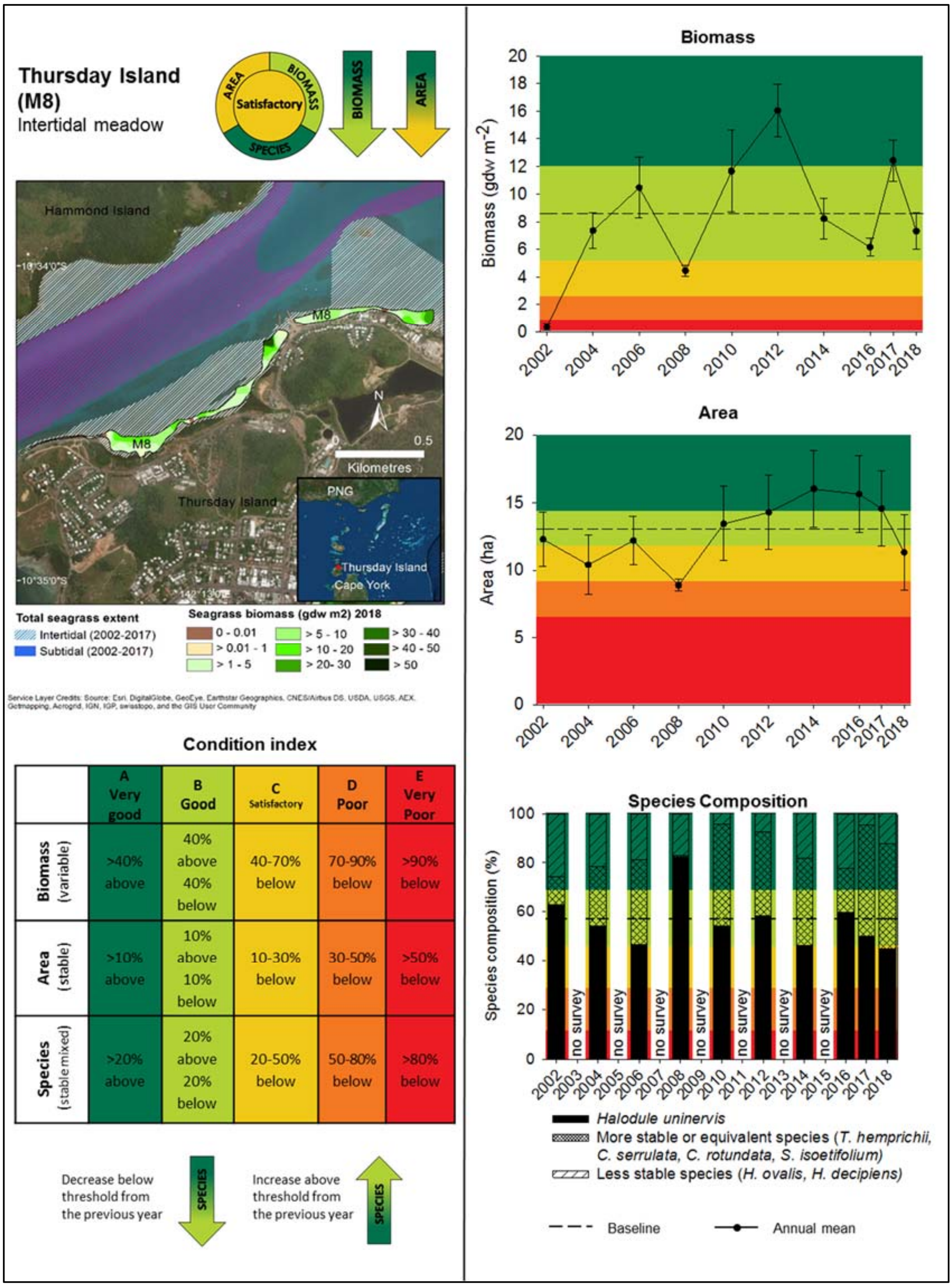
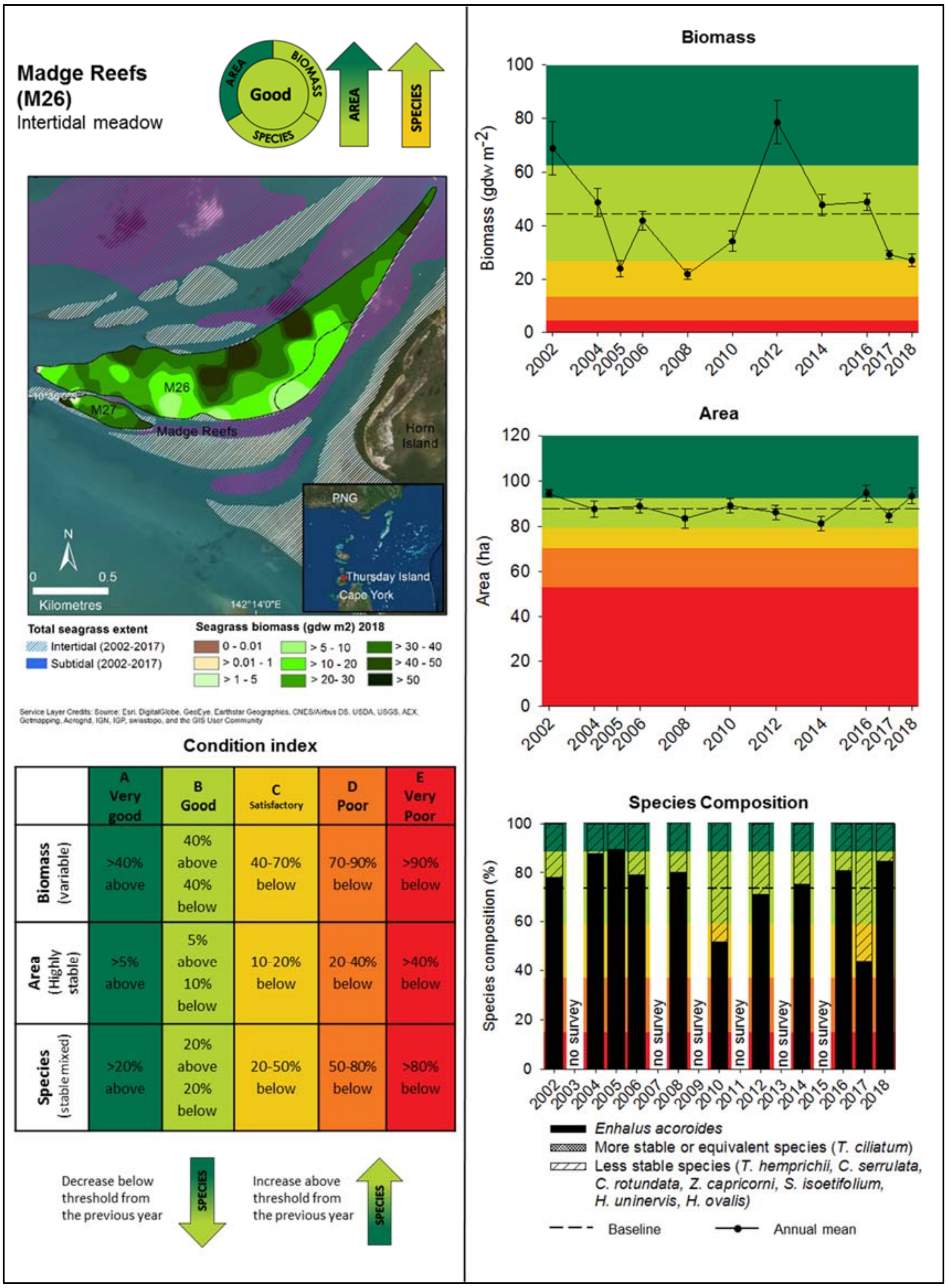


Figure 38. Seagrass mean biomass, area and species composition at Thursday Island intertidal meadow 8, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

Madge Reef Intertidal Meadow (M26)

The Madge Reefs meadow M26 covers the majority of the reef-top intertidal area (Figure 39). Meadow area is highly stable, species composition is stable, while biomass is variable. The meadow was in good condition in 2018. Biomass was relatively unchanged from 2017, but meadow area increased and species composition improved, with an increase in the dominant species *Enhalus acoroides* relative to less persistent species (Figure 39).



	A Very good	B Good	C Satisfactory	D Poor	E Very Poor
Biomass (variable)	>40% above	40% above 40% below	40-70% below	70-90% below	>90% below
Area (Highly stable)	>5% above	5% above 10% below	10-20% below	20-40% below	>40% below
Species (stable mixed)	>20% above	20% above 20% below	20-50% below	50-80% below	>80% below

Figure 39. Seagrass mean biomass, area and species composition at Madge Reefs intertidal meadow 26, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

Madge Reef Intertidal Meadow (M27)

The Madge Reefs meadow M27 covers the majority of the reef-top intertidal area (Figure 40). Meadow area and species composition are stable, while biomass is variable. The meadow was in good condition in 2018. Biomass and area were relatively unchanged from 2017, while species composition improved from good to very good condition following increases in the dominant species *Enhalus acoroides* and the equally stable species *Thalassodendron ciliatum* (Figure 40).

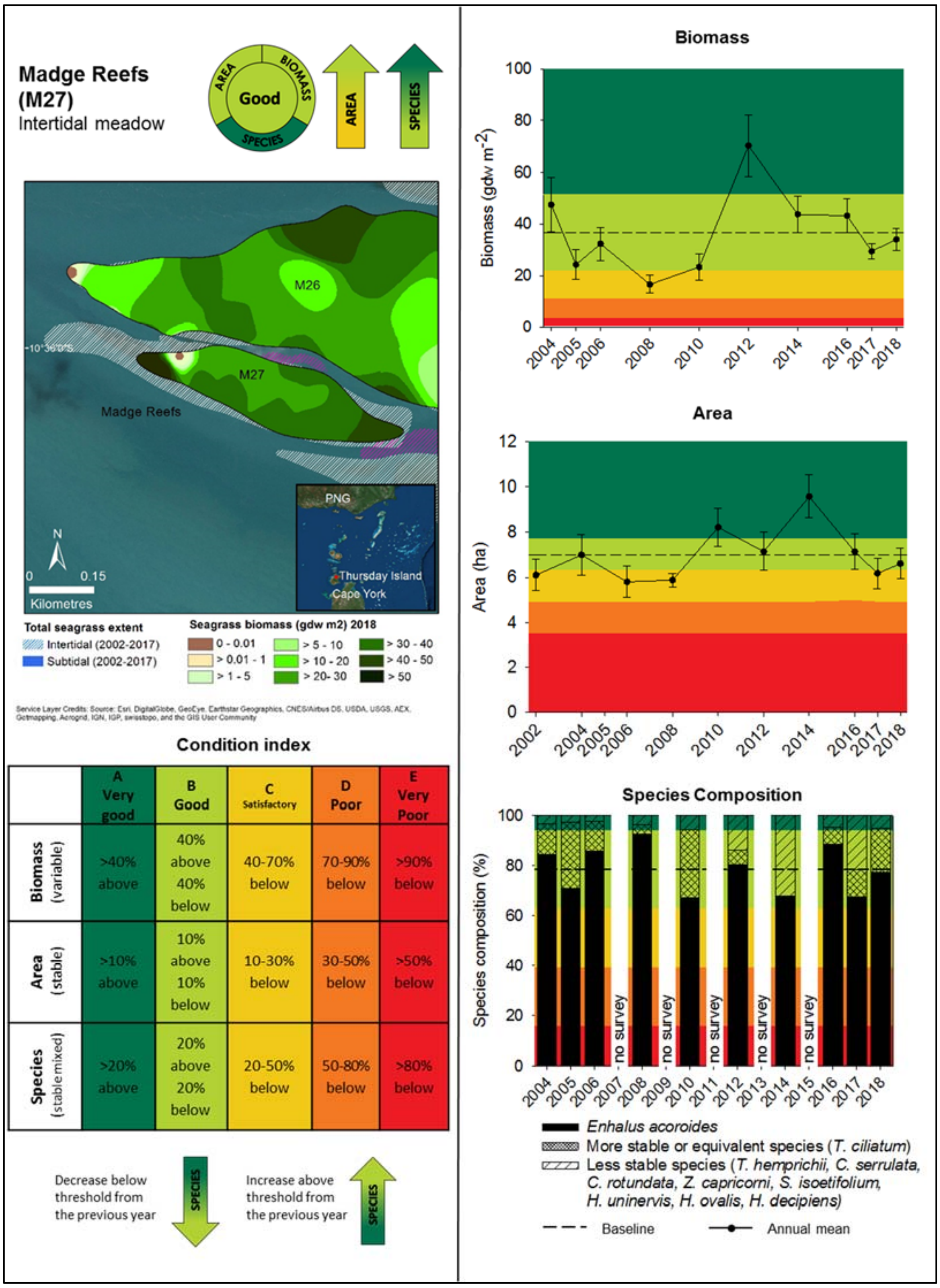


Figure 40. Seagrass mean biomass, area and species composition at Madge Reefs intertidal meadow 27, Torres Strait Inner Island Cluster, 2002 - 2018 (biomass error bars = SE; area error bars = reliability estimate).

4 DISCUSSION

4.1 Seagrass condition in Torres Strait, 2018

The Torres Strait seagrass report card incorporates the best available data on the fundamental characteristics of seagrass meadows - seagrass abundance (biomass/percent cover), area, and species composition - into a series of grades and scores that enable comparisons among sites, meadows, and Torres Strait Island Clusters. In 2018, Torres Strait seagrasses were in an overall good condition. For individual meadows and clusters within the region, the results were fairly consistent. However, for some clusters and areas this is based on relatively limited data, and for many areas the short time series of baseline data (< 10 years) means that scores cannot be produced yet. Despite these limitations, the relatively consistent result across sites indicates that in 2018 seagrasses in the Torres Strait were in good condition. This report highlights areas where information is lacking and suggests a pathway for improving representativeness and reliability of condition scores for seagrass in the Torres Strait and Island Clusters.

Only one monitoring site in the entire Torres Strait monitoring network received a poor score in 2018, site MR2 (Lei) at Mer Island. The condition decline at this site includes a decline in percent cover and a shift in species composition to less stable species since 2016 (Table 7, Figure 30). These changes are likely reflective of a localised change in conditions at that particular site rather than a large-scale decline of seagrasses around Mer Island. The changes at MR2 (2016-2017) coincided with increased beach erosion in this area. Beach sand was observed smothering the seagrass, corresponding with the burial of fish trap walls at this site (Doug Passi, *pers comm.*). This change is further supported by a change in the dominant grain size recorded by the Meriam Gesep A Gur Keparem Le Rangers. The second transect site at Mer Island, MR1 (Maad), remained in good condition, resulting in an overall grade of good for this island cluster when site scores were averaged (Table 7).

The good condition of Torres Strait seagrass reflects broader trends in other monitored locations in the Gulf of Carpentaria at Karumba (very good condition; Shepherd et al. 2018) and Weipa (good condition; Sozou and Rasheed 2018). These regions generally experienced a lower frequency or severity of extreme weather events, rainfall and flooding, than along Queensland's east coast south of Cooktown in recent years. By contrast, seagrasses along Queensland's east coast have been slowly recovering following large-scale losses from approximately 2009-2011 at Cairns (York et al. 2016), Mourilyan (Reason et al. 2016), Townsville (Davies and Rasheed 2016), Abbot Point (McKenna et al. 2016), and Gladstone (Rasheed et al. 2017). These declines coincided with above average rainfall and river flow (McKenna et al. 2015) often associated with tropical cyclones (TC) that have impacted the Cairns to Gladstone region. While many locations have experienced some recovery, the trajectory of that recovery has varied between meadows and at many locations in the southern two thirds of the Queensland east coast, seagrass remains in poor condition in 2017 (Chartrand et al. 2018; Davey and Rasheed 2018; Reason and Rasheed 2018a; Reason and Rasheed 2018b).

Threats to Torres Strait seagrass include shipping-related oil spills and structural habitat damage (Halpern et al. 2008), climate change (Carter et al. 2014a) and seagrass diebacks. Substantial seagrass diebacks (up to 60%) have been documented twice in central Torres Strait and linked to dramatic increases in local dugong mortality (Marsh et al. 2004; Long and Skewes 1996). Extremely low numbers of nesting turtles due to reduced reproductive capacity are linked to reductions in algae and seagrass following major La Nina events on the Great Barrier Reef (Limpus and Nicholls 2000). The current report card approach provides a tool to assess future trends in Torres Strait seagrass, and a mechanism to highlight potential issues with regional and local seagrass declines. The extensive seagrass monitoring and research efforts in the Western, Inner and Central Island Clusters are enhancing our understanding of these processes so that measures can be implemented to reduce the chances of exacerbating natural impacts by human activities.

It is important to note that tropical seagrass communities naturally vary in condition due to environmental factors; a meadow classified as being in poor condition can reflect the natural range of expected conditions and is not necessarily due to human impacts. The report card provides a means of evaluating current meadow condition against baseline conditions and provides some indication of the likely level of resilience to future impacts.

4.2 Report Card Limitations and Recommendations

4.2.1 Long-term baseline information

The time scale for effective long-term monitoring of ecosystems depends on the time scale of the ecological process being studied, which for many systems is measured in decades (Lindenmayer and Likens 2009). This period allows studies to separate subtle changes in population patterns from seasonal differences (within year variability) and the year-to-year variability or "noise," which is then compared to the trend of the data established by many years of data collection. The year-to-year variability is often large compared to the magnitude of the trend. Analysis of long-term datasets on seagrass change throughout Queensland, including sites where there are more than 24 years of data, has shown that a 10 year period of monitoring is required to set reliable baselines for seagrass change (Bryant et al. 2014). For many of the Torres Strait monitoring locations we have yet to reach 10 years of monitoring data. We have provided interim scores for meadows with at least 5 years of baseline data, but for those with less than 5 years no score has been produced. As the program matures, and more of these sites achieve 10 years of information, the representativeness of the program will be substantially improved.

4.2.2 Improve coverage of larger spatial "meadow scale" monitoring

Currently the seagrass scores for many of the Island Clusters are largely reliant on small-scale permanent transect monitoring. This scale of monitoring does not provide the essential information on change in seagrass meadow extent, which is both a key indicator of change for a range of pressures on seagrass meadows, and an essential component of seagrass condition required for management of associated assets such as dugong, turtle and fisheries.

The spatial scale at which monitoring occurs is an important consideration when extrapolating monitoring results to determine trends. Where small-scale variability occurs within a meadow, larger meadow-scale monitoring is likely to produce a more reliable measure of overall condition and change. The results from Mer Island, where two permanent transect sites are assessed, are a good example of this. Localised changes at one of these sites has a strong influence on the overall score, which in reality only reflects the small area of seagrass where the transects are located. We recommend that meadow scale monitoring be expanded to include examples in all island clusters. This will improve the mix of information and provide a more reliable assessment of seagrass changes at the scale in which regional management decisions are likely to operate.

4.2.3 Gaps in monitoring coverage

There are significant gaps in our knowledge of seagrass condition in some Torres Strait Island Clusters. No monitoring occurs in the Top-Western Cluster, in the Eastern Cluster monitoring is limited to just two transect sites at Mer Island, and across all clusters a limited number of subtidal seagrass meadows are currently assessed.

While the current monitoring effort in the Torres Strait is substantial, to improve the programs ability to meet management requirements we recommend the following, should resources and funding opportunities allow:

(1) Establish monitoring in the Top-Western Cluster. Seagrass data collected during a large-scale baseline survey in late 2015 provides a good basis for selecting intertidal and subtidal meadows suitable for monitoring. The Mura Buway and Simakal Rangers also have suggested areas that would be ideal for intertidal permanent transect monitoring.

(2) Expand monitoring in the Eastern Cluster so there is a better representation of the diversity of seagrass habitats.
(3) Establish additional whole-meadow scale seagrass monitoring in clusters where this currently does not occur (Eastern and Top-Western Clusters) or is limited (Central Cluster), so that change in meadow area, a fundamental indictor of seagrass meadow condition, can be included in future condition assessments.
(4) Establish intertidal transect monitoring sites at either Warraber or Masig Islands to improve the validity of the condition scores for home patch intertidal meadows.
(5) Establish additional subtidal block monitoring in clusters where this currently does not occur (Eastern and Top-Western Clusters) or is limited (Central Cluster), so that this important and extensive habitat is better represented in future condition assessments.
(6) Establish additional monitoring meadows within the Inner Cluster that can act as control sites away from Thursday Island, as current monitoring occurs only at meadows most likely to be affected by anthropogenic impacts.

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APPENDICES

Appendix 1. An example of calculating a meadow score for area in satisfactory condition in 2018.

1. Determine the grade for the 2018 (current) area value (i.e. satisfactory).

2. Calculate the difference in area (A_{diff}) between the 2018 area value (A_{2015}) and the area value of the lower threshold boundary for the satisfactory grade ($A_{satisfactory}$):

$$\mathrm{A_{diff}} = \mathrm{A_{2018}} - \mathrm{A_{satisfactory}}$$

Where $A_{satisfactory}$ or any other threshold boundary will differ for each condition indicator depending on the baseline value, meadow class (highly stable [area only], stable, variable, highly variable [area only]), and whether the meadow is dominated by a single species or mixed species.

3. Calculate the range for area values (A_{range}) in that grade:

$$\mathrm{A_{range}} = \mathrm{A_{good}} - \mathrm{A_{satisfactory}}$$

Where $A_{satisfactory}$ is the upper threshold boundary for the satisfactory grade.
Note: For species composition and percent cover, the upper limit for the very good grade is set as 100%. For area and biomass, the upper limit for the very good grade is set as the maximum value of the mean plus the standard error (i.e. the top of the error bar) for a given year during the baseline period for that indicator and meadow.

4. Calculate the proportion of the satisfactory grade (A_{prop}) that A_{2018} takes up:

$$\mathrm{A_{prop}} = \frac{\mathrm{A_{diff}}}{\mathrm{A_{range}}}$$

5. Determine the area score for 2018 ($Score_{2018}$) by scaling A_{prop} against the score range (SR) for the satisfactory grade ($SR_{satisfactory}$), i.e. 0.15 units:

$$\mathrm{Score_{2018}} = \mathrm{LB_{satisfactory}} + \left(\mathrm{A_{prop}} \times \mathrm{SR_{satisfactory}}\right)$$

Where $LB_{satisfactory}$ is the defined lower bound (LB) score threshold for the satisfactory grade, i.e. 0.50 units.