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Seagrass mapping synthesis: A resource for coastal management in the Great Barrier Reef World Heritage Area

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Project 3.1 – Seagrass mapping synthesis: A resource for coastal management in the Great Barrier Reef World Heritage Area

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Project 3.1: Seagrass mapping synthesis: A resource for coastal management in the Great Barrier Reef World Heritage Area

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ACRONYMS

CSIRO	Commonwealth Science and Industrial Research Organisation
DOE.....	Department of the Environment
GBR.....	Great Barrier Reef
GBRWHA	Great Barrier Reef World Heritage Area
GIS	Geographic Information System
NESP.....	National Environmental Science Programme
NRM	Natural Resource Management
RRRC	Reef and Rainforest Research Centre Limited
TropWATER ..	Centre for Tropical Water & Aquatic Ecosystem Research
TWQ	Tropical Water Quality

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EXECUTIVE SUMMARY

This project provides an up to date synthesis of the available information on seagrass in the Great Barrier Reef World Heritage Area (GBRWHA). It brings together more than 30 years of spatial information and data collection into easy to use spatial GIS layers that provide key information on species, meadow type and age and reliability of the data.

The project provides:

- Seagrass site and meadow-specific data in Geographic Information System (GIS) layers to provide seagrass data to inform research analysis and management advice.
- A site layer that includes >66,000 individual survey sites with information including latitude/longitude, Natural Resource Management region, site depth, seagrass presence/absence, dominant seagrass species, presence/absence of individual species, survey date, survey method, and data custodian.
- A meadow layer that includes 1169 individual and/or composite seagrass meadows with information including individual meadow persistence, meadow location (intertidal/subtidal), meadow density based on mean biomass and/or mean percent cover, meadow area, dominant seagrass species, seagrass species present, range of survey dates, survey method, and data custodian.
- Metadata to enable interpretation of the information and to identify the original data custodians for assistance with interpretation.

Outcomes:

- This study consolidates all available seagrass spatial data for the GBRWHA collected from 1984 to December 2014 by the TropWATER Seagrass Group and CSIRO in a GIS database.
- It assembles and documents the state of spatial knowledge of seagrass in the GBRWHA.
- The spatial data is based on methods developed by TropWATER and CSIRO for seagrass habitat surveys of subtidal meadows, and TropWATER methods for intertidal surveys. Methods include sampling by boat (free divers, underwater video camera, grabs, sled with net sampling), helicopter and walking.
- 447,530 hectares of seagrasses were mapped (modelled deep water seagrass areas are not included in area figures in this report) within the GBRWHA; much of which provides habitat for commercial and traditional fishery species, and an important food resource for dugong and green turtle populations.
- Data is included for twelve seagrass species from three families. Seagrass was present at 39% of all sites visited.
- The study identifies areas where much of the data available for management is more than 20 years old or where there are specific habitats unsurveyed. Large areas of central and northern Queensland require updating. Several key habitat types such as reef platform seagrass meadows are poorly represented in the data.

1.0 INTRODUCTION

Seagrass meadows are important globally for their role in substrate stabilisation, filtering the water of organic matter, recycling nitrogen, and baffling wave and tidal energy (Kenworthy et al. 2006). Seagrass meadows are one of the most efficient and powerful marine carbon sinks, storing nearly three times more organic carbon than the carbon stocks of the world's forests (Fourqurean et al. 2012; Pendleton et al. 2012; Lavery et al. 2013). The north-east Australian coastline includes extensive seagrass meadows that stretch along shallow coastal waters and intertidal banks, from the tropics (10°S) to the subtropical (~25°S) zone of the Great Barrier Reef World Heritage Area (GBRWHA). These meadows are particularly important as food and shelter for fish and prawns and food for some of the largest remaining populations of dugong (*Dugong dugon*) and green sea turtles (*Chelonia mydas*) (Coles et al. 1993; Watson et al. 1993; Marsh et al. 2011). Seagrasses are critical to the survival of these animals.

The GBRWHA includes coastal areas with diverse physical characteristics. The tropical north coast is influenced by monsoonal rains and associated pulses of turbid waters draining from adjacent catchments; the subtropical coast is more developed with downstream impacts from coastal development. The coasts are predominantly lined with muddy sediments, extensive intertidal flats and shallow inshore reefs, and sheltered by the Great Barrier Reef which effectively encloses a long lagoon. It is within this lagoon that seagrass meadows flourish. Inshore meadows are influenced by coastal topography and shelter, with most meadows occurring in north-facing bays and estuaries that are protected from the dominant south-easterly winds.

Managing seagrass resources in the GBRWHA requires adequate baseline information on where seagrass is (presence/absence), how much is there (biomass/percent cover/meadow area), and what is there (species composition). This baseline is particularly important as a reference point against which to compare seagrass loss or change through time. The scale of the GBRWHA (1000s of kilometres) and the remoteness of many seagrass meadows from human populations present a challenge for research and management agencies reporting on the state of seagrass ecological indicators. Broad-scale and repeated surveys/studies of areas this large are logistically and financially impracticable. However seagrass data is being collected through various projects which, although designed for specific reasons, are amenable to collating a picture of the extent and state of the seagrass resource.

Queensland seagrass meadow research extends back to the 1970s (Birch and Birch 1984), however major mapping projects did not commence until the mid-1980s. James Cook University's Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Seagrass Group (formerly part of Queensland Department of Agriculture and Fisheries) has been collecting spatial data on GBRWHA seagrass since the early 1980s. In the present project TropWATER has co-ordinated a process of collating seagrass mapping data from these early days until the present, and making this publically available for management purposes. The most recent version that has been available was published in 2014 (McKenzie et al. 2014b). A previous (and more regionally comprehensive) version is also available in report form (Coles et al. 2007). These collations are comprehensive but excluded some data sets that were previously confidential or part of collaborative projects, and did not include

meadow-specific information, site data or information on species. This is now included. Some regions have been monitored repetitively and these sites can now be sorted through time. The spatial data comes from a range of research and monitoring programs with different methods, purposes and scales and we have now reviewed this data and present it in a common format.

The project aim was to make publically available the enormous amount of seagrass data collected over 30 years. The site and meadow GIS available on e-Atlas and through TropWATER at James Cook University should be considered a “living” document that will be updated and modified as new data become available. In making this data publically available for management, the authors from the TropWATER Seagrass Group request being contacted and involved in decision making processes that incorporate this data, to ensure its limitations are fully understood. More detailed information exists for many of the individual locations and may be provided upon request. Details of the source data for each area are provided as part of the metadata associated with the GIS files.

2.0 METHODOLOGY

2.1 Sampling Methods

The sampling methods used to study, describe and monitor seagrass meadows were developed by the TropWATER Seagrass Group and tailored to the location and habitat surveyed; these are described in detail in the relevant publications (<https://research.jcu.edu.au/tropwater>). Methods for data sets collected by CSIRO are reported in Pitcher et al. (Pitcher et al. 2007).

2.1.1 Location

Latitudes and longitudes are from converted RADAR fix or GPS. Depth is depth below mean sea level (dbMSL) in metres.

2.1.2 Seagrass metrics

Visual estimation methods prior to 1990 were mostly percent cover estimates matched to standard photographs. Data limitations for these early surveys are specific to each survey and advice from the TropWATER data custodians should be sought for assistance with interpretation. For recent surveys (post-1990) above-ground biomass was determined using a “visual estimates of biomass” technique (Mellors 1991) using trained observers. A linear regression was calculated for the relationship between the observer ranks and the harvested values. This regression was used to calculate above-ground biomass for all estimated ranks made from the survey sites. Biomass ranks were converted into above-ground biomass estimates in grams dry weight per square metre (g DW m^{-2}) for each site. Observers estimated biomass data using video transect, grabs, free diving, helicopter and walking:

- **Video transect:** Commonly used for subtidal meadows at each transect site. A CCTV camera was lowered to the bottom and towed at drift speed (less than one knot). Footage was observed on a TV monitor and digitally recorded. The recording was paused at random times and frames selected. From this frame, an observer estimated a rank of seagrass biomass and a species composition. On completion of the video analysis, the video observer ranked five additional quadrats that had been previously videoed and then harvested for calibration. The camera sled included a small collecting net to obtain a specimen for identification.
- **van Veen grab:** Commonly used for subtidal meadows. A sample of seagrass was collected using a van Veen grab (grab area 0.0625 m^2) to identify species present at each site. Species identified from the grab sample were used to inform species composition assessments made from the recorded video transects (Kuo and McComb 1989), or to record presence/absence where visibility was too poor for video transects.
- **Free diving, helicopter and walking:** At each site seagrass above-ground biomass and species composition were estimated from 0.25 m^2 quadrats placed randomly. Seagrass percent cover was recorded at each site. The “visual estimates of biomass” technique when applied to free

diving/helicopter/walking surveys involves ranking while referring to a series of quadrat photographs of similar seagrass habitats for which the above-ground biomass has been previously measured. The relative proportion of the above-ground biomass (percentage) of each seagrass species within each survey quadrat was also recorded. Field biomass ranks were converted into above-ground biomass estimates in grams dry weight per square metre (g DW m⁻²) by reference to a series of ranked and then harvested quadrats.

2.2 Geographic Information System (GIS)

All survey data were entered into a Geographic Information System (GIS) using MapInfo (generally pre-2005) then ArcMap® software. MapInfo spatial data was converted to ArcMap shapefiles. Rectified colour satellite imagery of the region (Source: ESRI), field notes and aerial photographs taken from helicopter surveys were used to identify geographical features such as reef platforms, channels and deep-water drop-offs to assist in determining seagrass meadow boundaries. Two GIS layers - a site layer and a meadow layer - were created to describe seagrass. The projection used for these layers is GDA94.

2.2.1 Seagrass site layer

This layer contains information on data collected at assessment sites, and includes:

1. Temporal survey details - month, year, and whether the survey occurred in the growing (September to January) or senescent (February to August) season;
2. Spatial survey details - latitude/longitude, NRM region, site depth in metres below mean sea level (dbMSL);
3. Seagrass information including presence/absence of seagrass, and whether individual species were present at a site;
4. Sampling methods – helicopter, walking, boat with camera, diver, grab and/or sled;
5. Data custodians.

2.2.2 Seagrass meadow layer

This layer contains all the spatial data we could locate for meadows surveyed within the GBRWHA. Where multiple sampling events occurred for the same meadow, a meadow composite was created. Meadow data includes:

1. Temporal survey details – survey month and year, or a list of survey dates for meadows repeatedly sampled;
2. Names of original layers used and data custodians;
3. Sampling and mapping methods – GPS/aerial photography, helicopter, walking, boat with camera, diver, grab and/or sled;
4. Meadow persistence – meadows were classed according to four categories:
 - a. **Stable** - enduring meadow form; seagrass presence, biomass and area expected to be stable over time and seagrass meadow expected to be a permanent feature apart from extreme events or sustained long term impacts;

- b. **Variable** - meadow presence, biomass and area expected to fluctuate within and among years, but generally some seagrass expected to be present apart from extreme events or sustained long term impacts;
 - c. **Highly variable ephemeral** - meadow not persistent over time; at some time periods seagrass will be present and at other times absent. Ephemeral meadows that have a naturally extreme level of variation in area and biomass within and among years;
 - d. **Unknown** – undetermined persistence as meadow sampled only once.
5. Meadow location – meadows were classed according to three categories, although some meadows cover a range of these locations:
- a. **Intertidal** - all sites surveyed by helicopter or walking within a meadow and/or comments in field books identified an intertidal meadow,
 - b. **Shallow subtidal** - meadows where free divers SCUBA, sled collection, or cameras were used to sample and water depth was generally <10 m;
 - c. **Deep subtidal** - for this project meadows >10 m deep were included as deep subtidal.
6. Meadow density categories (light, dense, variable among years, unknown) were determined by the consistency of mean above-ground biomass of the dominant species among all years sampled (Table 1). For example, a *Halophila ovalis* dominated meadow would be classed as “light” if the mean meadow biomass was always <1 grams dry weight m⁻² (g DW m⁻²) among years, “variable” if mean meadow biomass ranged from <1 - >5 g DW m⁻², and “dense” if mean meadow biomass was always >5 g DW m⁻² among years. Meadows with only one year of data were classed as light or dense according to biomass for the survey year;

Table 1: Density categories and mean above-ground biomass (grams dry weight m⁻²) ranges for each species used in determining seagrass density.

Density category	<i>H. uninervis</i> (<i>wide</i>)					
	<i>H. uninervis</i> (narrow)*	<i>H. ovalis</i> <i>H. decipiens</i> <i>H. capricorni</i>	<i>C. serrulata</i> <i>C. rotundata</i> <i>S. isoetifolium</i> <i>T. hemprichii</i>	<i>H. spinulosa</i> <i>H. tricostata</i>	<i>Z. capricorni</i>	<i>E. acoroides</i>
Light	<1	<1	<5	<15	<20	<40
Dense	>4	>5	>25	>35	>60	>100
Variable	<1 - >4	<1 - >5	<5 - >25	<15 - >35	<20 - >60	<40 - >100

**Halodule uninervis* occurs as narrow and wide leaf morphologies. These are not differentiated in the site or meadow GIS layers, but are when calculating seagrass meadow density categories.

7. Dominant species and species present;
8. Mean meadow biomass in g DW m⁻² (\pm standard error if available), or the minimum and maximum biomass recorded for meadows sampled more than once.
9. Meadow percent cover - this value represents mean seagrass percent cover, or the range of percent cover (if >1 number in the data cell). Meadow percent

cover was most commonly calculated in pre-1990s surveys and recorded as “n/a” if not available.

10. Meadow area in hectares (\pm reliability estimate if available), or the minimum and maximum area recorded for meadows sampled more than once. In more recent surveys each seagrass meadow was assigned a mapping precision estimate (\pm m) based on the mapping method used for that meadow (Table 2). Mapping precision estimates ranged from <5 m for isolated intertidal seagrass meadows to 10–100 m for larger patchy intertidal/subtidal meadows. The mapping precision estimate was used to calculate a meadow reliability estimate (R) in hectares. The reliability estimate for subtidal habitat is based on the distance between sites with and without seagrass when determining the habitat boundary. Additional sources of mapping error associated with digitising aerial photographs into base maps and with GPS fixes for survey sites were embedded within the meadow reliability estimates.

Table 2: Mapping precision and methods for seagrass meadows

Mapping precision	Mapping method
1-10 m	Meadow boundaries mapped in detail by GPS from helicopter or walking; Intertidal meadows completely exposed or visible at low tide; Relatively high density of mapping and survey sites; Recent aerial photography aided in mapping.
10-50 m	Meadow boundaries determined from helicopter and camera/grab surveys; Inshore boundaries mapped from helicopter; Offshore boundaries interpreted from survey sites and aerial photography; Relatively high density of mapping and survey sites.
100 m	Sites generally surveyed by boat Seagrass meadow boundary determined from distance between sites No distinct topographic features from satellite imagery aided in mapping Relatively low density of survey sites

2.2.3 Spatial limits

Seagrass data north and south of the GBRWHA were excluded from the layers but are available on request. Data were included when sites and meadows extended west of the GBRWHA boundary into coastal and estuarine water immediately adjacent. In shallow coastal waters seagrass meadows have been mapped and estimates of meadow boundaries are provided in the meadow GIS layer. For deeper water seagrass information is provided as data points in the site layer. Modelled distributions are available (Pitcher et al. 2007; Coles et al. 2009) but not included here.

2.2.4 Data limitations

Data included extends back to the mid-1980s. Large parts of the coast have not been mapped for seagrass presence since that time. Technology and methods for mapping and position fixing have improved dramatically in 30 years. Early data included here has been re-checked and re-entered on several occasions and previously included in other spatial platforms (McKenzie et al. 2014b). We are confident the layers included in this report represent the most reliable interpretation of that early data. Where data was collected only in

winter an underestimate of the extent of ephemeral species such as *Halophila decipiens* and *Halophila tricostata* may occur. This is important if this composite is used to compare annual changes.

2.2.5 Taxonomy

Seagrass taxonomy has changed through time, with species such as *Halophila ovata* no longer recognised and some doubts expressed about other species whose morphology is relatively plastic. Field surveys have at times grouped species that are difficult to distinguish outside a laboratory. To address these issues we have amalgamated some species into complexes: *Halophila ovata*, *Halophila minor*, *Halophila colesi/australis* and *Halophila ovalis* are included as *Halophila ovalis*. *Halodule pinifolia* is grouped with *Halodule uninervis*. *Zostera muelleri* subsp. *capricorni* has been abbreviated to *Zostera capricorni* throughout.

2.2.6 Base map

The base map used is courtesy ESRI 2015. Since the original surveys in 1980 there have been numerous changes to the shoreline, the most obvious being seaward encroachment of mangrove forests and reclamations for marina and coastal development. We have not edited seagrass site or meadow layers to prevent older data from overlapping these features.

2.2.7 Data sets

Spatial data from 167 site layers (Table 3) and 136 meadow layers (Table 4) are included in these composite layers.

Table 3: Mapping precision and methods for seagrass meadows.

Survey name/ location	Survey date
Abbot Pt coastal	March 2005, March 2008, July 2008, August-September 2008, November 2008, April-May 2009, August 2009, December 2009, June 2010, November-December 2010, March 2011, May 2011, September 2011, February 2012, June 2012, September 2012, January 2013, April 2013, August 2013, September 2013, December 2013, March 2014, July 2014, September 2014
Abbot Pt deepwater	March 2005, February 2008, July 2008, August-September 2008, November 2008, April-May 2009, August 2009, February 2010, June 2010, November-December 2010, March 2011, May 2011, September 2011, February 2012, June 2012, September 2012, April 2013, August 2013, September 2013, March 2014, July 2014, September 2014, December 2014
Bowen to Water Park Point	March-April 1987
Bustard Bay	November 2009
Cairns	December 1993, December 1996, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014
Cairns to Bowen	October-November 1987
Cape Flattery	February 1996
Cape York to Cairns	November 1984-February 1985
Clump Point	December 1997
Dugong	May 1999, October 1999

Protection Area coastal	
Dugong Protection Area deepwater	May 1999, October 1999
Dunk Island to Cleveland Bay	October 1996
Edgecumbe Bay	August 2008
GBR deepwater	1994-1999
GBR seabed biodiversity	September - November 2005 (data custodians are CSIRO)
Gladstone coastal	2002, 2004, 2005, 2006, 2007, November 2008, 2009, June 2010, November 2010, June 2011, November 2011, June 2012, November 2012, June 2013, November 2013, June 2014, November 2014
Gladstone deepwater	2002, 2009, November 2013, November 2014
Green Island	1997, 2003
Hay Point coastal	October 2010, November 2011, 2014
Hay Point offshore	2004, July 2007, September 2007, November 2007, July 2009, October 2009, 2010, November 2011, 2014
Hydrographers Passage	September - October 2003
Lizard Island	1995, 2014
Low Isles	1997
Lucinda to Bowling Green Bay	March 2007
Mackay coastal	February 2001
Mackay deepwater	February 2001
Margaret Bay	August 2001
Mourilyan Harbour	1993, July 1994, January 1995, July 1995, December 1995, July 1996, December 1996, July 1997, July 2000, December 2000, 2001, 2002, 2003, December 2004, 2005, November 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014
Oil Spill Response Atlas – Princess Charlotte Bay to Cape Flattery	September 2011, September 2012, September 2013, September 2014
Oyster Pt	1995, 1996, 1997, 1998
Shoalwater Bay	September 1995, April 1996
Townsville coastal	2007, June 2008, October 2008, 2009, 2010, 2011, 2012, 2013, 2014
Townsville deepwater	2007, June 2008, October 2013
Water Park Point to Hervey Bay	1988
Whitsundays	1999-2000

Table 4: Spatial datasets used in seagrass meadow layer composite.

Survey name/ location	Survey date
Abbot Point coastal	March 2005, March 2008, July 2008, August-September 2008, November 2008, April-May 2009, August 2009, December 2009, June 2010, November-December 2010, March 2011, May 2011, September 2011, February 2012, June 2012, April 2013, August 2013, September 2013, December 2013, March 2014, July 2014, September 2014
Abbot Point deepwater	March 2005, February 2008, August-September 2008, April 2013, September 2013
Bowen to Water Park Point	March-April 1987
Bustard Bay	November 2009
Cairns	December 1993, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014
Cairns to Bowen	October-November 1987
Cape Flattery	February 1996
Cape York to Cairns	November 1984-February 1985
Clump Point	December 1997
Dugong Protection Area coastal	May 1999, October 1999
Dunk Island to Cleveland Bay	Dunk to Cleveland Bay October 1996 meadows
Gladstone coastal	2002, 2004, 2005, 2006, 2007, 2008, 2009, June 2010, November 2010, June 2011, November 2011, June 2012, November 2012, June 2013, November 2013, June 2014, November 2014
Gladstone deepwater	2002, 2009, November 2013, November 2014
Green Island	1997, 2003
Hay Point coastal	October 2010, November 2011, 2014
Hay Point offshore	2004, 2005, 2010, November 2011, 2014
Lizard Island	1995
Low Isles	1997
Lucinda to Bowling Green Bay	March 2007
Mackay	February 2001
Margaret Bay	August 2001
Mourilyan Harbour	1993, July 1994, January 1995, July 1995, December 1995, July 1996, December 1996, July 1997, July 2000, December 2000, 2001, 2002, 2003, December 2004, 2005, May 2006, November 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014
Oil Spill Response Atlas – Princess Charlotte Bay to Cape Flattery	September 2011, September 2012, September 2013, September 2014

Oyster Pt	1995, 1996, 1997, 1998
Shoalwater Bay	April 1996
Starcke River	1989
Townsville coastal	2007, June 2008, October 2008, 2009, 2010, 2011, 2012, 2013, 2014
Townsville deepwater	2007, June 2008, October 2013
Water Park Point to Hervey Bay	1988
Whitsundays	1999-2000

3.0 SUMMARY AND DATA USAGE

3.1 Seagrass of the GBRWHA

Twelve seagrass species from three families were included from 66 201 sites sampled in the GBRWHA between 1984 and 2014 (Figure 1). The majority of sites (74%) were sampled during the spring/early summer growing season. Seagrass was recorded at 39% of sites sampled however many surveys were targeted at known meadows and sites were not randomly assigned. Some seagrass was present in all NRM regions surveyed. Sites were surveyed to a depth of 117 m but seagrass included was recorded no deeper than 78 m (*Halophila spinulosa*). 447 530 hectares of seagrass are recorded in this analysis as a composite of all years.

3.2 Example products

The data loaded into e-Atlas and from TropWATER can be interpreted and used in many ways illustrated by the following general examples:

1. The data layers can be used to examine broad spatial questions on the distribution of seagrass in the GBRWHA. Figure 2 is an example representation of all data points where we have sampled for seagrass at the scale of the GBRWHA with green points representing locations where seagrass has been found.
2. The site layers can be separated through time to show the age of the data and changes in species when sampling has been repeated through time. Figure 3 shows the age of sampling in the Wet Tropics as an example. Recent sampling has occurred at Cairns and Mourilyan due to annual port monitoring, and at Hinchinbrook Island due to 2011 surveys following Tropical Cyclone Yasi; however outside these three locations the majority of data along this coastline was collected in the 1980s and 1990s.
3. Species distribution can be analysed by location. Figure 4 is an example of the dominance of *Zostera capricorni* in north facing muddy bays, making it a species that is common within port limits.
4. The meadow layer can be used to examine the historical extent of seagrass meadows in an area. Figure 5 is an example of the ability to obtain meadow-specific data for Townsville and Magnetic Island.
5. The layers can be used with other spatial layers to compare known seagrass data with current management boundaries. Figure 6 is an example of seagrass data within and surrounding a Dugong Protection Area at Edgecumbe Bay.












FAMILY	SPECIES		
CYMODOCACEAE E Taylor	 <p data-bbox="582 331 790 358"><i>Cymodocea serrulata</i></p>	 <p data-bbox="1109 340 1428 398"><i>Halodule uninervis</i> (thin and wide leaf morphology)</p>	
	 <p data-bbox="582 564 805 591"><i>Cymodocea rotundata</i></p>	 <p data-bbox="1109 575 1364 602"><i>Syringodium isoetifolium</i></p>	
	ZOSTERACEAE Drummondier	 <p data-bbox="566 907 805 965"><i>Zostera muelleri</i> subsp. <i>capricorni</i></p>	 <p data-bbox="1173 936 1364 963"><i>Halophila tricostata</i></p>
		HYDROCHARITACEAE Jussieu	 <p data-bbox="582 1205 774 1232"><i>Thalassia hemprichii</i></p>
 <p data-bbox="582 1500 758 1527"><i>Enhalus acoroides</i></p>	 <p data-bbox="1189 1496 1348 1523"><i>Halophila ovalis</i></p>		
 <p data-bbox="582 1720 774 1747"><i>Halophila spinulosa</i></p>	 <p data-bbox="1189 1720 1380 1747"><i>Halophila decipiens</i></p>		

Figure 1: Seagrass species recorded within the GBRWHA, 1984-2014

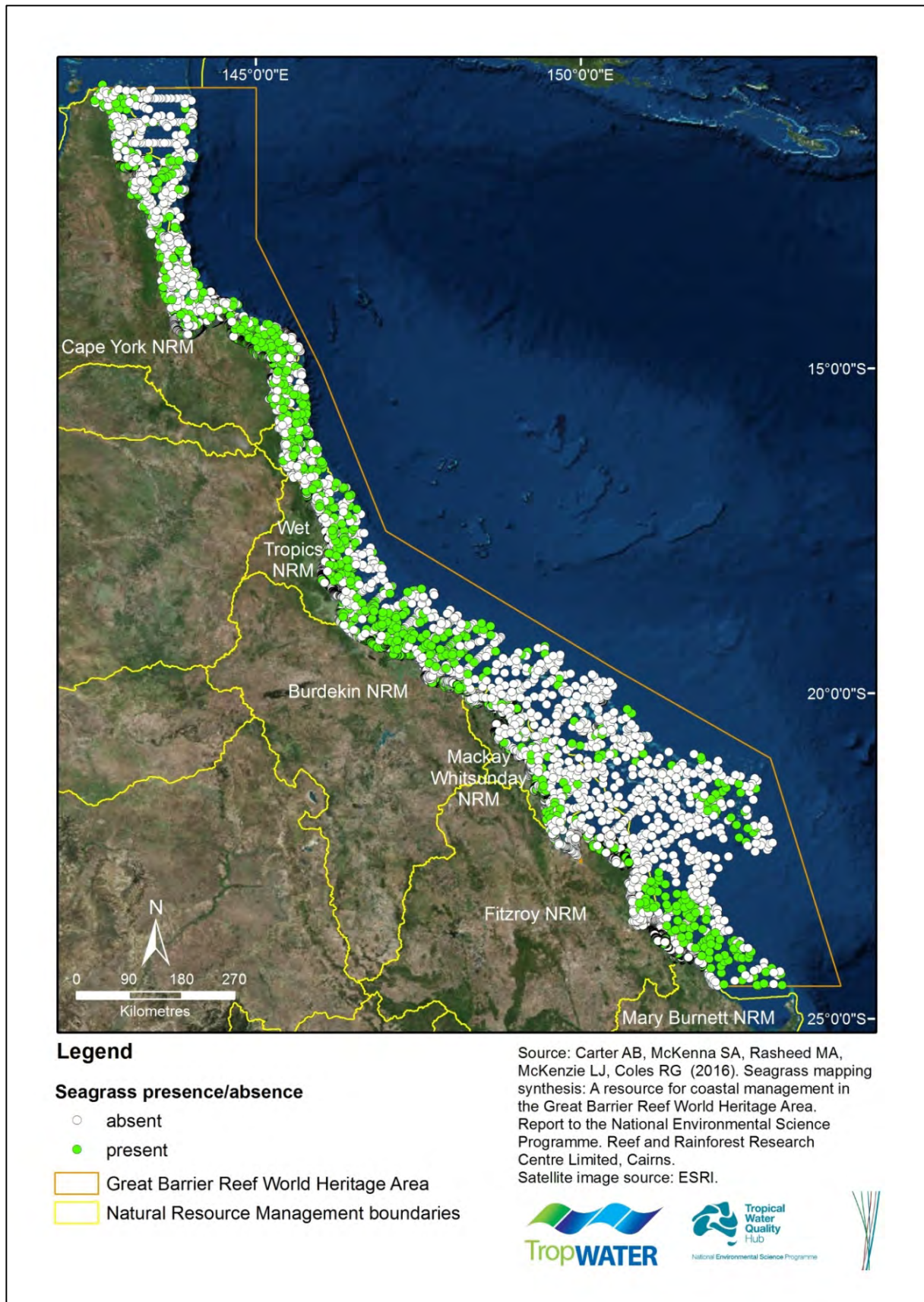


Figure 2: Seagrass presence/absence at survey sites within the GBRWHA, 1984-2014.

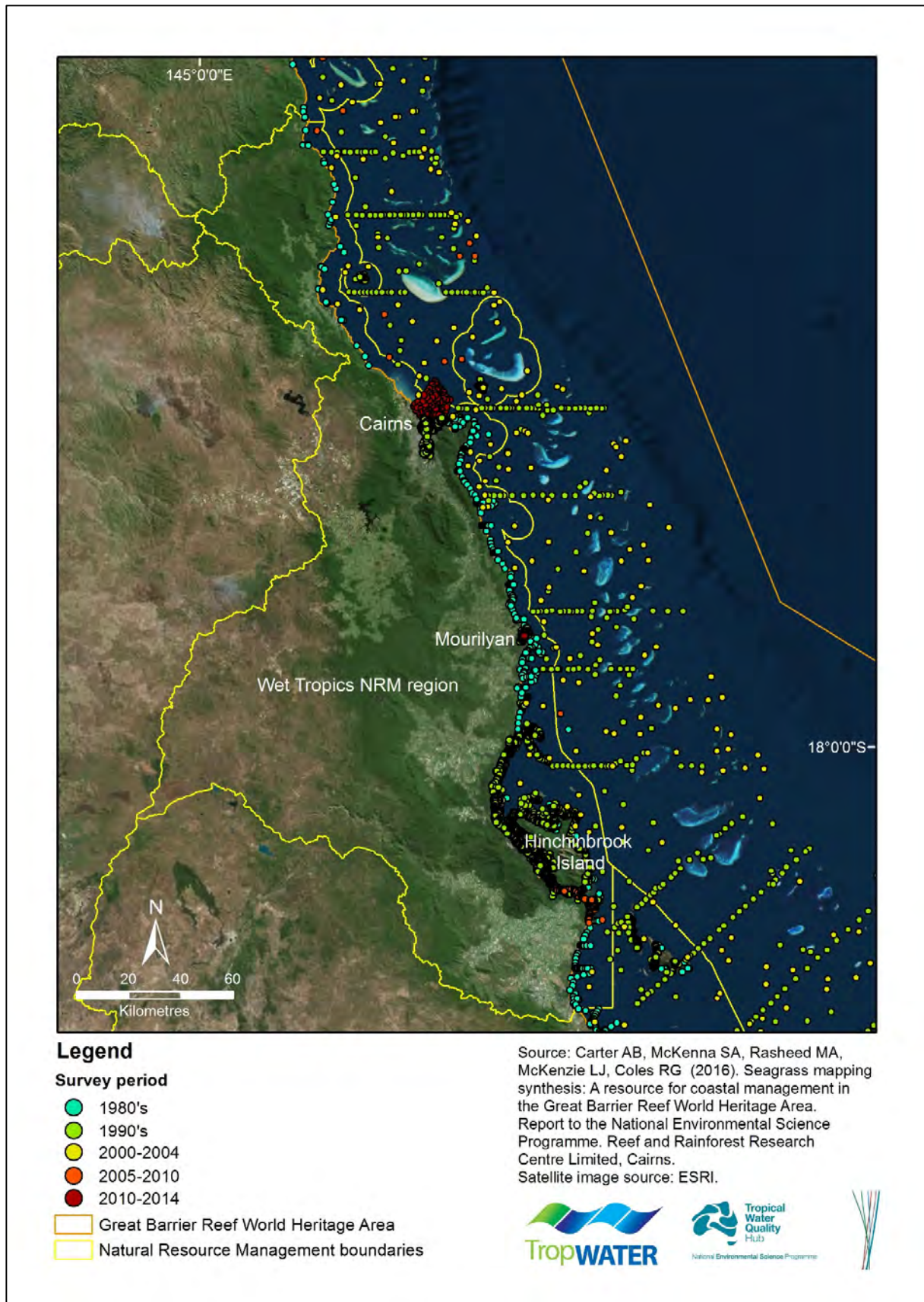


Figure 3: Age of seagrass data within the Wet Tropics NRM region, 1984-2014.

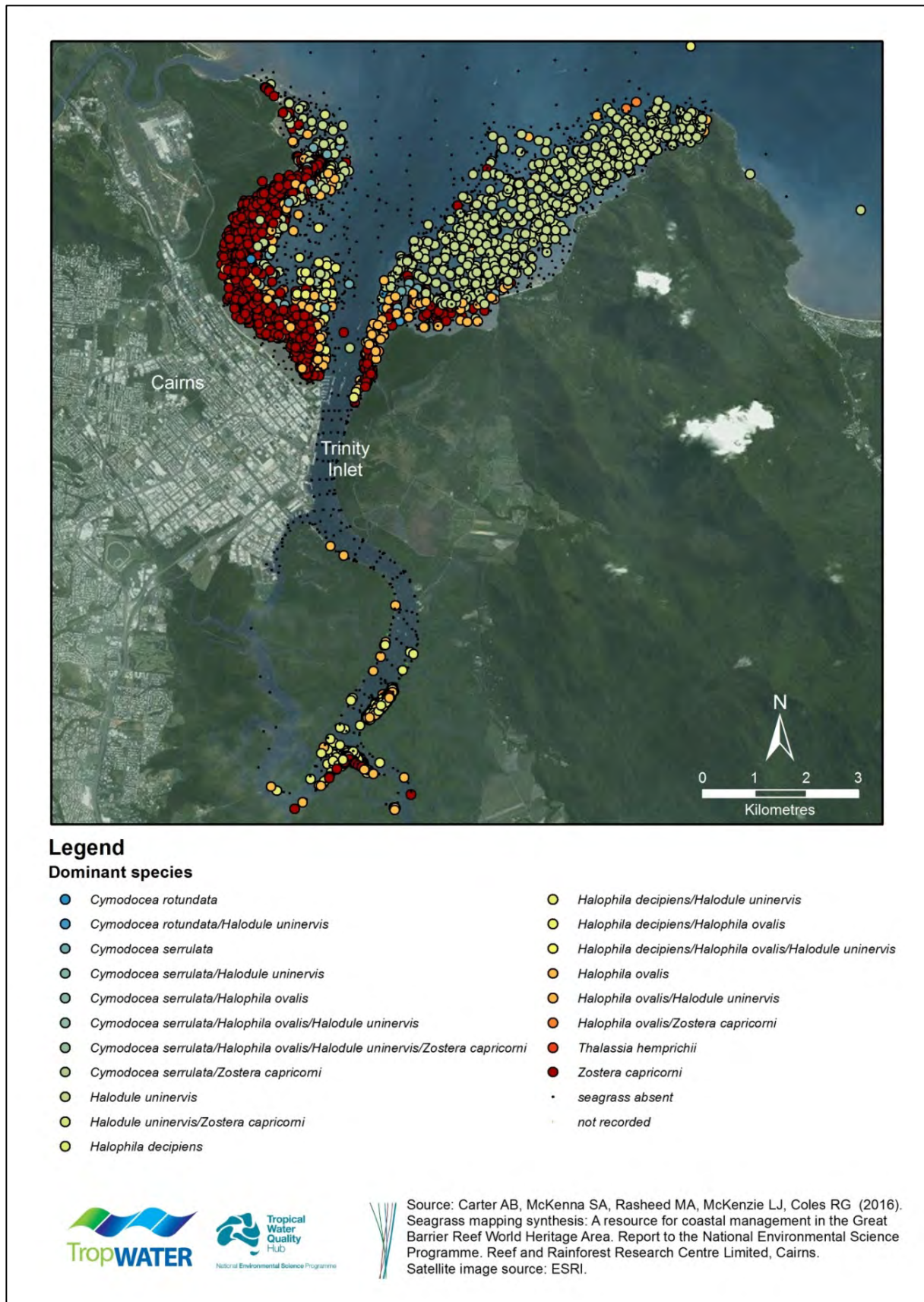


Figure 4: Dominant species recorded at survey sites in the Cairns area, 1993-2014.



Figure 5: Example of meadow composite for locations sampled over multiple years in the Townsville/Magnetic Island region, 2007-2014.

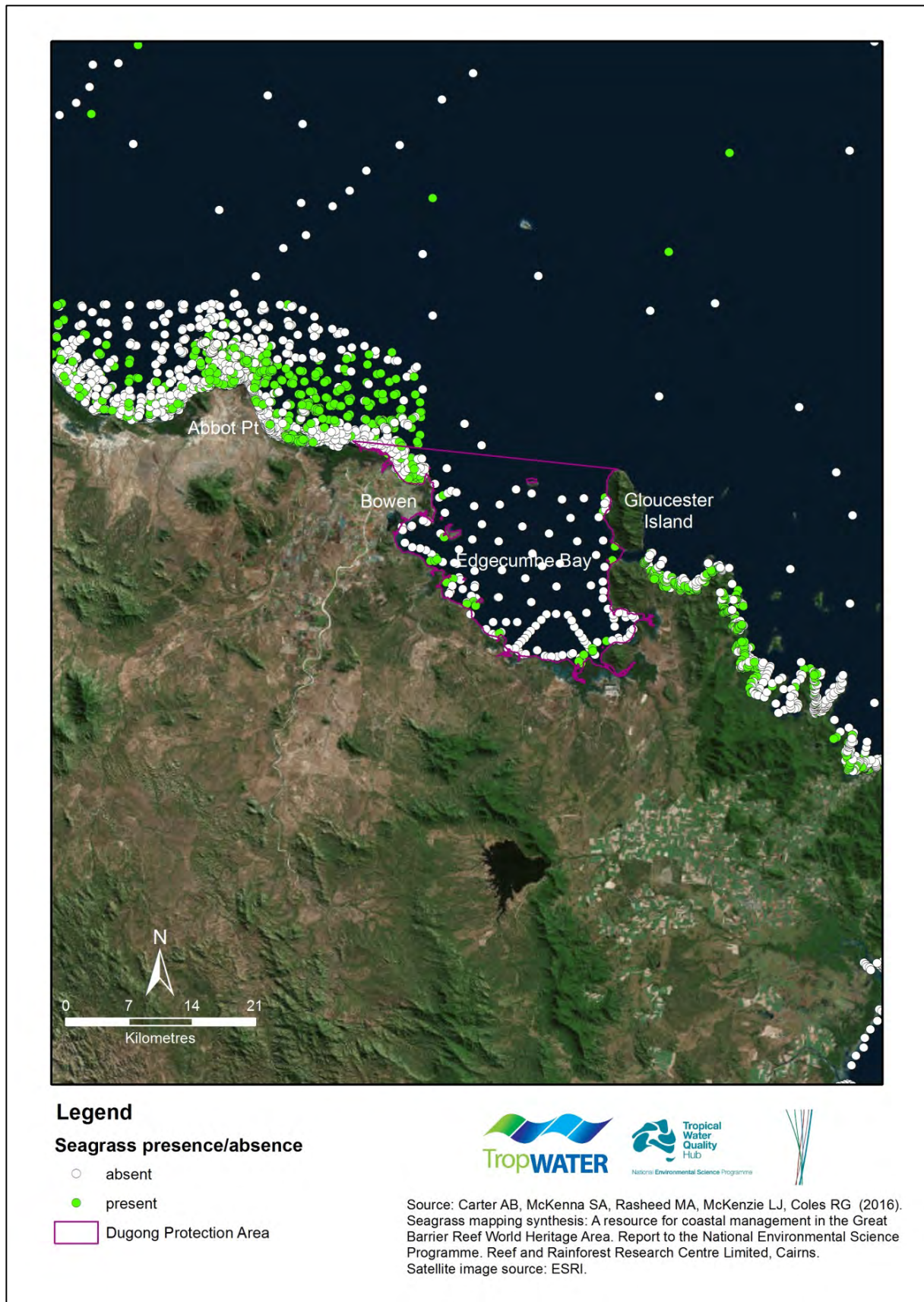


Figure 6: Seagrass presence/absence in the region within and surrounding the Edgumbe Bay Dugong Protection Area.

4.0 RECOMMENDATIONS AND CONCLUSION

This project has produced a unique spatial synthesis of more than 30 years of data on Great Barrier Reef seagrasses. It updates previous composite seagrass data sets and importantly, for the first time, includes site data and information on meadow and species characteristics that can be interrogated and analysed.

Almost a quarter of the world's seagrass species are found in the GBRWHA. Habitats range from dense coastal pastures to vast, sprawling and patchy meadows down to over 70 meters deep in clear offshore waters. All are important.

We have excellent seagrass mapping and monitoring programs in the GBRWHA. Seagrass is monitored by the Reef Rescue Marine Monitoring program twice yearly. Every major port in the GBRWHA has a seagrass monitoring program supported by research (<https://research.jcu.edu.au/tropwater/publications/technical-reports>). Seagrasses have high light requirements for survival making them particularly vulnerable to changes in water quality so they are ideal sentinel communities, valuable for measuring the impact of environmental change.

Queensland and Commonwealth legislation has been successful in avoiding the disasters such as the loss of mangroves and seagrass from poorly managed aquaculture and coastal development of our tropical neighbours. Our fisheries are controlled and laws enforced, avoiding the “clear felling” concerns from bottom trawling; the number of trawlers in the GBRWHA has greatly reduced as has the area in which they can operate ([Grech and Coles 2011](#)). Seagrass and mangroves as marine plants are protected by the Queensland Fisheries Act 1994 and by Fish Habitat Area declarations. State Marine Parks legislation zone activities to limit environmental damage as does the Great Barrier Reef Marine Park legislation.

Seagrass meadows have been under stress in recent years with well reported cases of meadows in poor condition ([McKenzie et al. 2014a](#)). Most of this has resulted from a series of floods and cyclones: Yasi, Larry, Ita, Hamish, Oswald and others. Recovery has been patchy and site dependent ([Rasheed et al. 2014](#)). With climate change this may be a crystal ball to the future.

Seagrass risk analysis emphasizes that risks to seagrass accumulate where people live and work (Grech et al. 2012). We build cities and ports in sheltered estuaries and farm the catchments adding herbicides and fertilizers to the mix of chemicals and sediment that washes out to sea. Farm management may be improving (<http://www.reefplan.qld.gov.au/>) and city environment management is better than most places in the world but each year there are more of us, and nearly all of us want to live on the coastal plain.

Vast areas of seagrass do remain in Queensland. Anywhere north of Cooktown and on outer reef platforms seagrasses are likely in good condition based on the visits we have made as are the meadows of Torres Strait and the Queensland Gulf of Carpentaria coast. Key locations under the spotlight such as Gladstone Harbour also have surprisingly extensive seagrass meadows.

The marine area is huge and remote and expensive to visit. Many of our seagrass maps are 1980's vintage and that needs addressing. We are seeing shifts in species which may be permanent. Increases in extreme weather events, warming water and shifts in ocean systems will all place meadows under increasing stress.

A key strategy to assist our understanding change in habitats and to develop the management approaches that will be necessary to adapt is to ensure we share the available data that has been collected over the years. The present project assembles all our seagrass data in a form that can be reliably used by other researchers and authorities with coastal management responsibilities to address that need.

4.1 Further Information and Feedback

The TropWATER Seagrass Group are committed to providing high quality data and advice. The group would appreciate any feedback on ways to improve the data, its usability, and content. The group can be contacted through:

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REFERENCES

- Birch, W. R. and Birch, M. 1984. Succession and pattern of tropical intertidal seagrasses in Cockle Bay, Queensland, Australia: a decade of observations. *Aquatic Botany*, **19**: 343-367
- Coles, R., McKenzie, L., De'ath, G., Roelofs, A. and Long, W. L. 2009. Spatial distribution of deepwater seagrass in the inter-reef lagoon of the Great Barrier Reef World Heritage Area. *Marine Ecology Progress Series*, **392**: 57-68
- Coles, R. G., Lee Long, W. J., Watson, R. A. and Derbyshire, K. J. 1993. Distribution of seagrasses, and their fish and penaeid prawn communities, in Cairns Harbour, a tropical estuary, Northern Queensland, Australia. *Marine and Freshwater Research*, **44**: 193-210
- Coles, R. G., McKenzie, L. J., Rasheed, M. A., Mellors, J. E., Taylor, H., Dew, K., McKenna, S., L., S. T., B., C. A. and A., G. 2007. Status and Trends of Seagrass Habitats in the Great Barrier Reef World Heritage Area. Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns, pp.
- Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., Apostolaki, E. T., Kendrick, G. A., Krause-Jensen, D. and McGlathery, K. J. 2012. Seagrass ecosystems as a globally significant carbon stock. *Nature Geoscience*, **5**: 505-509
- Grech, A., Chartrand-Miller, K., Erftemeijer, P., Fonseca, M., McKenzie, L., Rasheed, M., Taylor, H. and Coles, R. 2012. A comparison of threats, vulnerabilities and management approaches in global seagrass bioregions. *Environmental Research Letters*, **7**: 024006
- Grech, A. and Coles, R. G. 2011. Interactions between a Trawl Fishery and Spatial Closures for Biodiversity Conservation in the Great Barrier Reef World Heritage Area, Australia. *PLoS ONE*, **6.6**: e21094
- Kenworthy, W. J., Wyllie-Echeverria, S., Coles, R. G., Pergent, G. and Pergent-Martini, C. 2006. Seagrass conservation biology: an interdisciplinary science for protection of the seagrass biome. Page 595-623. In A. W. D. Larkum, R. J. Orth and C. M. Duarte (eds), *Seagrasses: Biology, Ecology and Conservation*. Springer, The Netherlands
- Kuo, J. and McComb, A. J. 1989. Seagrass taxonomy, structure and development. Page 6-73. In A. W. D. Larkum, A. J. McComb and S. A. Shepherd (eds), *Biology of seagrasses: a treatise on the biology of seagrasses with special reference to the Australian Region*. Elsevier, New York
- Lavery, P. S., Mateo, M. A., Serrano, O. and Rozaimi, M. 2013. Variability in the carbon storage of seagrass habitats and its implications for global estimates of blue carbon ecosystem service. *PLoS ONE*, **8**: e73748
- Marsh, H., O'Shea, T. J. and Reynolds III, J. E. 2011. Ecology and conservation of the sirenians: dugongs and manatees. Cambridge University Press,
- McKenzie, L., Collier, C. and Waycott, M. 2014a. Reef Rescue Marine Monitoring Program: Inshore seagrass, annual report for the sampling period 1st July 2011 – 31st May 2012. TropWATER, James Cook University, pp.
- McKenzie, L. J., Yoshida, R. L., Grech, A. and Coles, R. G. 2014b. Composite of coastal seagrass meadows in Queensland, Australia - November 1984 to June 2010. PANGAEA.

Mellors, J. E. 1991. An evaluation of a rapid visual technique for estimating seagrass biomass. *Aquatic Botany*, **42**: 67-73

Pendleton, L., Donato, D. C., Murray, B. C., Crooks, S., Jenkins, W. A., Sifleet, S., Craft, C., Fourqurean, J. W., Kauffman, J. B., Marba, N., Megonigal, P., Pidgeon, E., Herr, D., Gordon, D. and Baldera, A. 2012. Estimating Global "Blue Carbon" Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems. *PLoS ONE*, **7**: e43542

Pitcher, C. R., Doherty, P., Arnold, P., Hooper, J., Gribble, N., Bartlett, C., Browne, M., Campbell, N., Cannard, T., Cappel, M., Carini, G., Chalmers, S., Cheers, S., Chetwynd, D., Colefax, A., Coles, R., Cook, S., Davie, P., De'ath, G., Devereux, D., Done, B., Donovan, T., Ehrke, B., Ellis, N., Ericson, G., Fellegara, I., Forcey, K., Furey, M., Gledhill, D., Good, N., Gordon, S., Haywood, M., Hendriks, P., Jacobsen, I., Johnson, J., Jones, M., Kinninmoth, S., Kistle, S., Last, P., Leite, A., Marks, S., McLeod, I., Oczkowicz, S., Robinson, M., Rose, C., Seabright, D., Sheils, J., Sherlock, M., Skelton, P., Smith, D., Smith, G., Speare, P., Stowar, M., Strickland, C., Van der Geest, C., Venables, W., Walsh, C., Wassenberg, T., Welna, A. and Yearsley, G. 2007. Seabed Biodiversity on the Continental Shelf of the Great Barrier Reef World Heritage Area. AIMS/CSIRO/QM/QDPI CRC Reef Research Task Final Report. 320 pp.

Rasheed, M. A., McKenna, S. A., Carter, A. B. and Coles, R. G. 2014. Contrasting recovery of shallow and deep water seagrass communities following climate associated losses in tropical north Queensland, Australia. *Marine pollution bulletin*, **83**: 491-499

Watson, R. A., Coles, R. G. and Lee Long, W. J. 1993. Simulation estimates of annual yield and landed value for commercial penaeid prawns from a tropical seagrass habitat, northern Queensland, Australia. *Marine and Freshwater Research*, **44**: 211-220

