

Coral Bleaching Assessment on Key Tourism Sites in the Cairns and Port Douglas Region

Crown of Thorns Starfish Targeted Control Program

Compiled by RRRC and AMPTO



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Executive Summary

The corals of the northern section of the Great Barrier Reef (GBR) are experiencing significant stress as a result of higher than average water temperatures. This stress has resulted in coral bleaching, which has serious implications for the future of the northern section of GBR. Whilst bleached corals are certainly compromised, corals with less severe levels of bleaching remain alive and can recover if favourable conditions return.

The Great Barrier Reef tourism industry is worth \$5.4 billion per year with over 60,000 jobs depending upon the Reef's ongoing health. Around half of this total value is generated by tourism to visit reefs in the Cairns – Port Douglas – Ribbon Reefs region. This report presents detailed coral health monitoring data collected from 32 high-value tourism reefs between Cairns and the Ribbon Reefs, just south of Lizard Island. The information from this report will help the marine tourism industry plan their response, and will contribute to the work already being undertaken by the Great Barrier Reef Marine Park Authority and the Coral Bleaching Task Force, among others.

Importantly, this report contains preliminary monitoring assessment data of bleaching **severity levels**. Bleaching severity levels are key information for reef managers as each level has corresponding recovery chances should conditions improve.

The coral bleaching severity levels in this report have been recorded as a percentage of coral cover per site per reef with coral condition itself assessed as per the Reef Health Impact Surveys methodology developed by the Great Barrier Reef Marine Park Authority. The field work has been conducted by the Australian Government's Crown of Thorns Starfish (COTS) Targeted Control Program, implemented by the Association of Marine Park Tourism (AMPTO), with qualified and experienced divers who have been undertaking the Reef Health Impact Surveys since 2012.

The bleaching assessment data was collected from the COTS Targeted Control Program sites. The COTS Targeted Control Program has the primary objective of protecting high-value tourism sites from the impacts of COTS predation, and the success of the Program is quantified through coral cover and coral health measurements taken during each control event at each control site and collected using the Reef Health Impact Survey methodology. The advantage of using these sites as part of the bleaching assessment process is that each site has long-term coral health data sets.

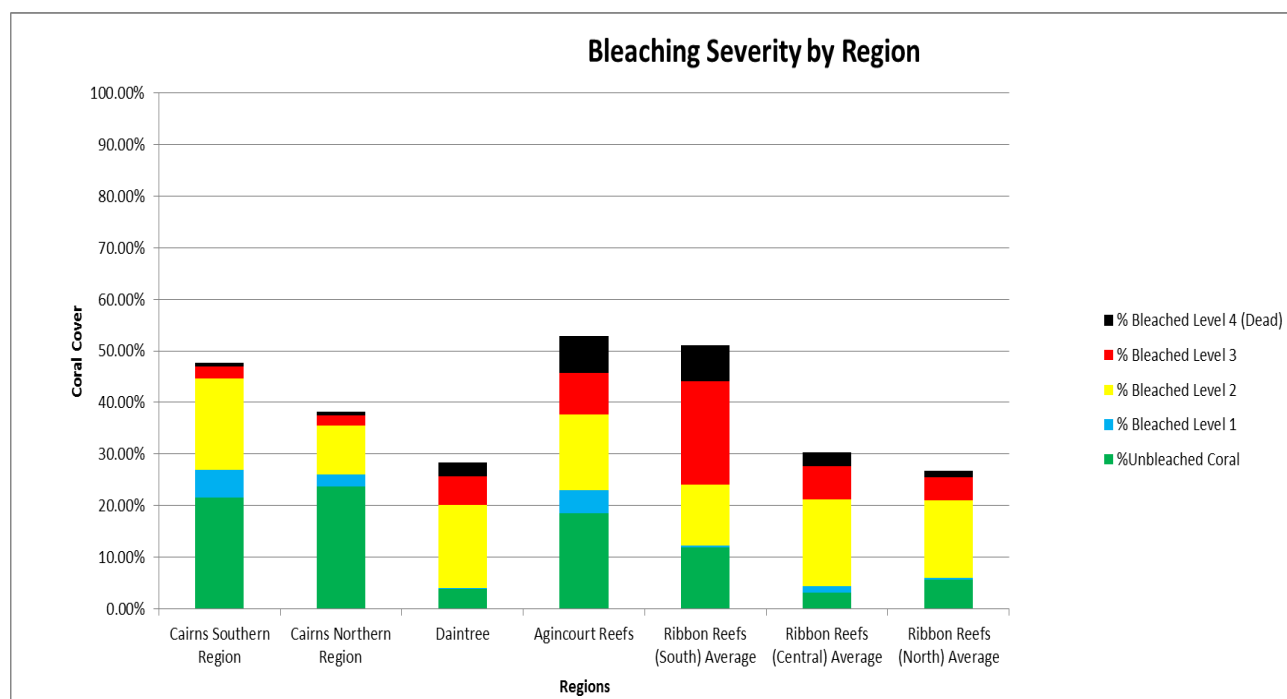
A total of 378 surveys were conducted at 126 sites on 32 reefs over 13 days (23 March to 7 April 2016) encompassing 252 km of the Reef between Cairns and the Ribbon Reefs, just south of Lizard Island. Coral bleaching severity was recorded from Levels 1-4; with Level 1 being the lowest level bleaching (only the upper surface of the coral) to level 4 where coral has died as a result of the bleaching.

The results have been clustered into six regions (with a seventh, Agincourt Reef, added as Appendix 1) showing the severity of coral bleaching as a percentage of coral cover. Table 1 describes bleaching severity by region. Figure 1 illustrates the proportion of various levels of bleaching per region.

Table 1: Northern GBR Bleaching Severity by Region

Region	Av. Depth (m)	% Live Coral	%Unbleached Coral	%Bleached Level 1	% Bleached Level 2	%Bleached Level 3	% Bleached Level 4 (Dead)	Number of surveys
Cairns Southern Region	3.1	47.33%	45.68%	11.15%	37.54%	4.93%	0.73%	129
Cairns Northern Region	3.9	37.76%	62.85%	5.95%	25.33%	5.09%	0.79%	144
Daintree	3.9	26.42%	14.34%	0.75%	61.10%	21.04%	2.72%	12
Agincourt Reefs	2.6	49.28%	37.53%	9.03%	29.72%	16.52%	7.20%	24
Ribbon Reefs (South) Average	3.2	47.59%	24.86%	0.75%	25.02%	42.04%	7.36%	36
Ribbon Reefs (Central) Average	3.2	28.35%	11.28%	3.90%	59.45%	22.66%	2.75%	27
Ribbon Reefs (North) Average	5.9	25.89%	21.48%	1.84%	57.89%	17.61%	1.19%	30
Overall Average	3.7	37.52%	31.14%	4.77%	42.29%	18.55%	3.25%	402

Figure 1: Northern GBR Bleaching Severity by Region

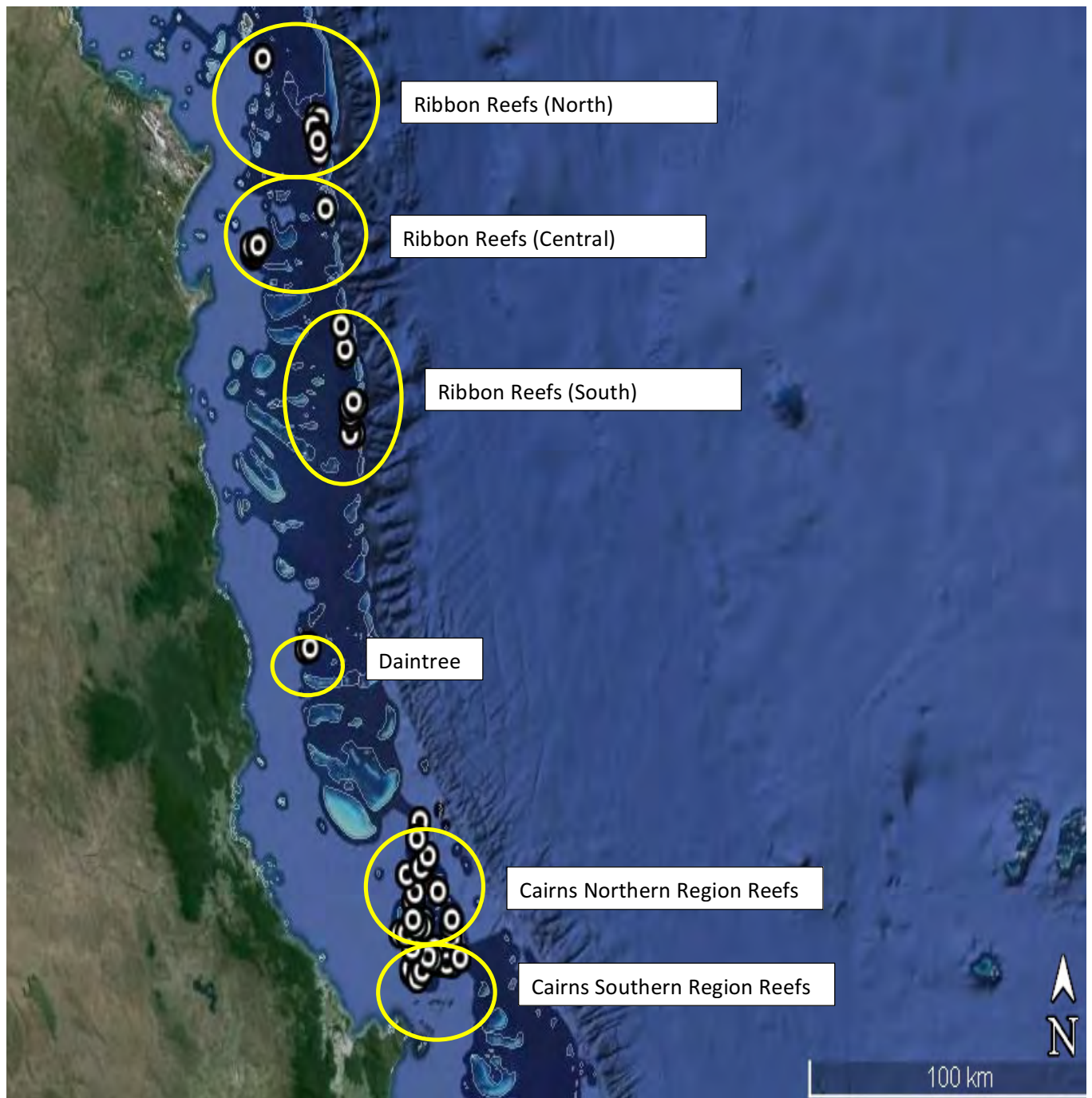


While the survey results are nuanced, a clear north-south trend in bleaching severity is evident: the northern-most reefs within the surveyed region (the Ribbon Reefs) were the worst affected, while the southern-most reefs off Cairns were less affected.

These results are important because they show that despite serious bleaching impacts, with the likelihood of significant subsequent mortality, many reefs in this region currently remain viable assets for the marine tourism industry. While the ultimate cause of coral bleaching events (increasing global temperatures due to climate change) is beyond the scope of regional leaders to manage, the knowledge that all is not lost is catalysing industry, managers, researchers and the community to work together to actively defend and sustain reef health in the region.

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Survey sites in the Cairns – Port Douglas – Ribbon Reefs region

Introduction

In response to an increased number of bleaching reports the Crown of Thorns Starfish Targeted Control Program was tasked by the Department to conduct underwater coral health surveys using the Reef Health Impact Surveys (RHIS) methodology on key tourism reefs between Cairns and the Ribbon Reefs, just south of Lizard Island. RHIS are an assessment tool designed by the Great Barrier Reef Marine Park Authority (GBRMPA) to assess coral reef health and impacts. Divers with marine science qualifications and extensive RHIS experience conducted the surveys. A total of 381 surveys at 127 sites on 32 reefs were undertaken to determine the severity and extent of the current coral bleaching event at tourism sites in the region.

Methodology

Reef Health Impact Surveys (RHIS)

Three RHIS were conducted at each site. RHIS point surveys covered approximately 80 m² of reef from a fixed central point. Each survey recorded coral cover, coral type (e.g. branching) and coral health (percentage and level of bleaching). The three RHIS at each site were on the same reef habitat type (i.e. reef flat and crest) to ensure average coral cover for each site was not skewed.

Site Selection





Each site visited is part of the COTS Targeted Control Program which is itself focused on high value tourism sites. These sites tend to be well-managed as they generally occur in a Marine National Park zone (green zone) and have a high level of COTS control and post-storm management by tourism operators. The COTS control sites were identified as good subjects for more detailed bleaching assessment as each site has associated long term coral health data sets collected using the standard RHIS assessment. This allows the impact of this current bleaching event to be quantified against the recorded longer term state at each site.

Bleaching Categories

The proportion of the coral cover that has been bleached and is still alive can fall into one of three categories with a fourth category being recently-dead coral.

1. Upper surface – The least severe bleaching effect where the tips or upper surface of the corals begin to whiten. Although the whole colony is recorded as bleached, the bleaching is only occurring on the upper surface.
2. Pale/Fluoro – The next most severe category is where the whole colony pales as it begins to lose its photosynthetic zooxanthellae. This will sometimes give the corals a fluorescent appearance. These corals are in a state of stress but still maintain some of their photosynthetic zooxanthellae.
3. Totally white – This is the most severe type of bleaching when the coral polyps will eject their photosynthetic zooxanthellae and the colony will appear totally white. Although the coral polyps are still alive they are in a highly compromised state, unable to produce sufficient energy to maintain normal functions.
4. Recently dead – The coral polyps have died and the remaining calcium carbonate skeleton will become covered with algae.

Table 2: Coral Bleaching Categories

Severity	Bleaching Description	
Level 1	Upper surface – The least severe bleaching effect where the tips or upper surface of the corals begin to whiten. Although the whole colony is recorded as bleached, the bleaching is only occurring on the upper surface.	
Level 2	Pale/Fluoro – The next most severe category is where the whole colony pales as it begins to lose its photosynthetic zooxanthellae. This will sometimes give the corals a fluorescent appearance. These corals are in a state of stress but still maintain some of their photosynthetic zooxanthellae.	
Level 3	Totally white – This is the most severe type of bleaching when the coral polyps will eject their photosynthetic zooxanthellae and the colony will appear totally white. Although the coral polyps are still alive they are in a highly compromised state, unable to produce sufficient energy to maintain normal functions.	
Level 4	Recently dead – The coral polyps have died and the remaining calcium carbonate skeleton will become covered with algae.	

Categories as described in GBRMPA's [Coral Bleaching Response Plan 2010-2011](#)

Results

Overview of Bleaching Severity by Region

The reefs between Cairns and the Ribbon Reefs have been clustered into six regions: Cairns South; Cairns North; Daintree; Ribbons South; Ribbons Central; and Ribbons North. The data from Agincourt Reef would normally be included in the Daintree Region, but the as the survey was delayed the data are included as Appendix 1.

Table 3: Coral bleaching severity by Region

Region	Av. Depth (m)	% Live Coral	%Unbleached Coral	%Bleached Level 1	% Bleached Level 2	%Bleached Level 3	% Bleached Level 4 (Dead)	Number of surveys
Cairns Southern Region	3.1	47.33%	45.68%	11.15%	37.54%	4.93%	0.73%	129
Cairns Northern Region	3.9	37.76%	62.85%	5.95%	25.33%	5.09%	0.79%	144
Daintree	3.9	26.42%	14.34%	0.75%	61.10%	21.04%	2.72%	12
Agincourt Reefs	2.6	49.28%	37.53%	9.03%	29.72%	16.52%	7.20%	24
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Ribbon Reefs (Central) Average	3.2	28.35%	11.28%	3.90%	59.45%	22.66%	2.75%	27
Ribbon Reefs (North) Average	5.9	25.89%	21.48%	1.84%	57.89%	17.61%	1.19%	30
Overall Average	3.7	37.52%	31.14%	4.77%	42.29%	18.55%	3.25%	402

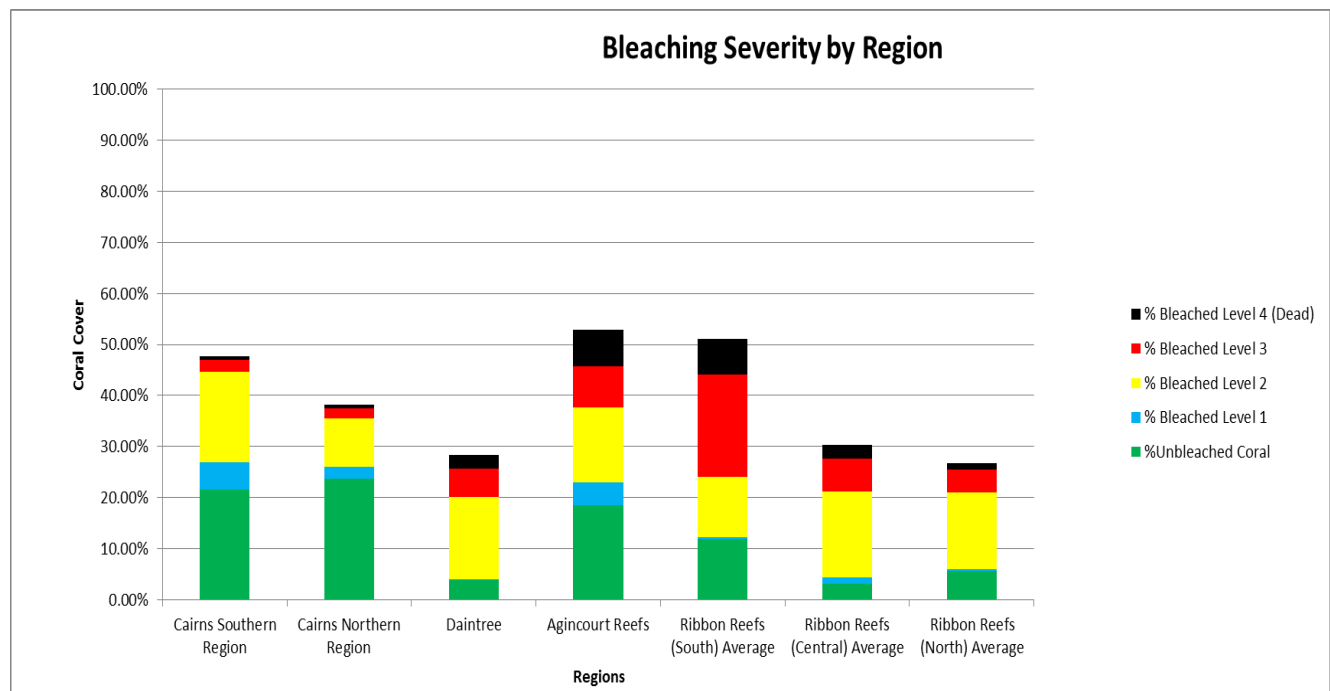


Figure 2: Bleaching Severity by Region

Cairns Southern Area Reefs

The reefs south of Cairns are of high value for tourism. There are three pontoons maintained in this area as well as Fitzroy Island Resort and numerous dive boat operations that utilise these reefs.

Figure 3: RHIS sites conducted in Cairns south

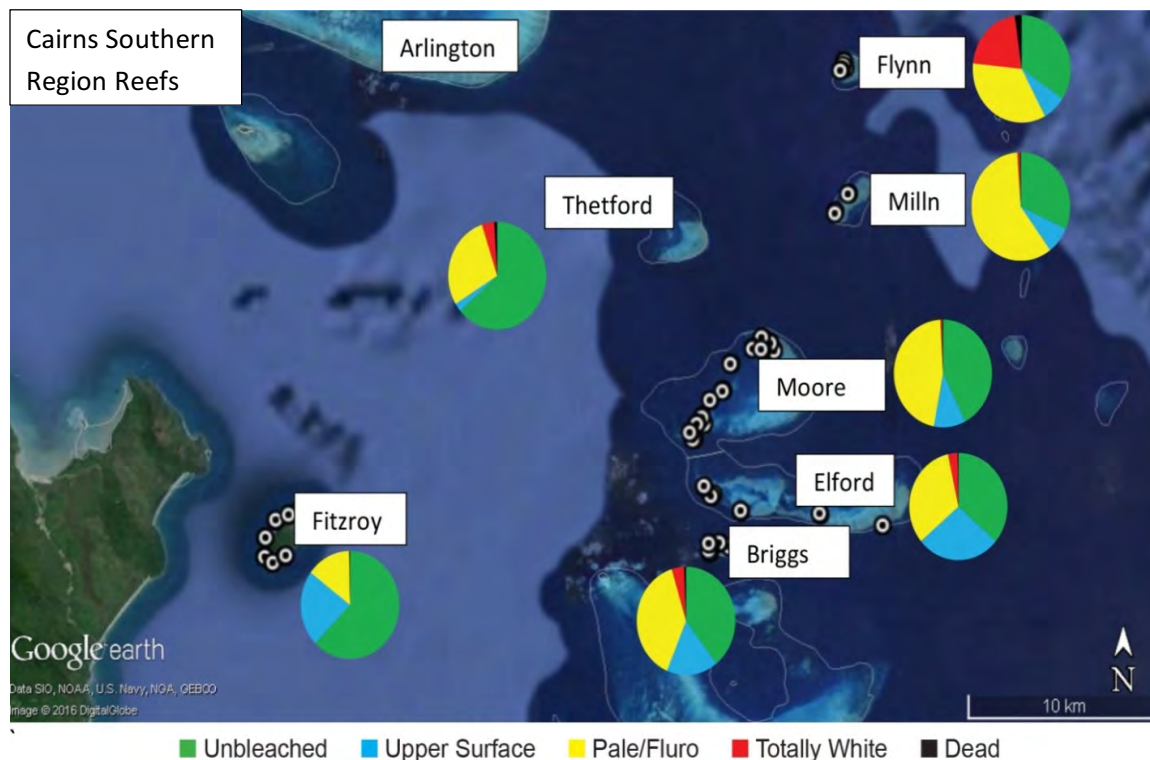


Table 4: Coral bleaching severity by Reef (Cairns Southern Area Reefs)

Reef	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)	Number of surveys
Briggs	3.6	45.60%	39.51%	16.86%	38.97%	4.04%	0.65%	15
Elford	1.9	46.33%	45.23%	9.71%	40.85%	3.86%	0.35%	15
Fitzroy Island	2.9	50.60%	62.67%	22.71%	14.52%	0.04%	0.23%	21
Flynn	3.8	40.48%	34.46%	7.66%	34.53%	21.06%	2.29%	9
Milln	4.3	43.45%	31.77%	8.08%	58.98%	0.86%	0.30%	6
Moore	2.1	62.53%	42.50%	10.49%	46.17%	0.55%	0.29%	39
Thetford	3.3	42.33%	63.63%	2.56%	28.75%	4.07%	0.98%	24
Cairns Southern Region	3.1	47.33%	45.68%	11.15%	37.54%	4.93%	0.73%	129

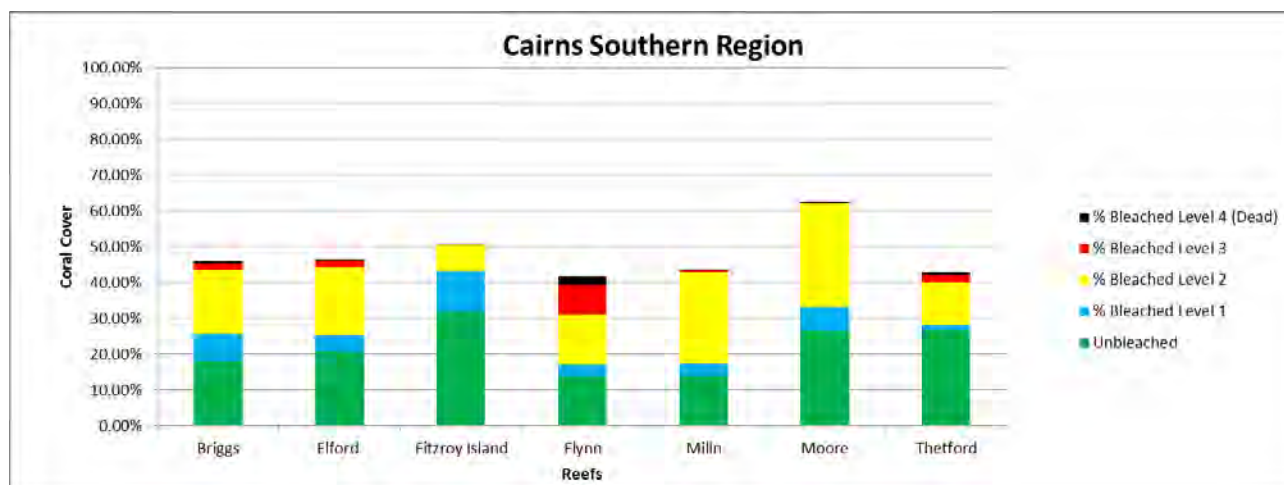


Figure 4: Coral bleaching severity (Cairns Southern Region).

Briggs Reef 15-074 – RHIS Results



Figure 5: Briggs Reef RHIS sites

Table 5: Coral bleaching severity by site*, Briggs Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Briggs	SW Wall	3.5	36.33%	43.40%	16.93%	19.26%	20.21%	0.36%
Briggs	Central Lagoon	2.0	37.00%	30.02%	26.20%	43.16%	0.00%	0.60%
Briggs	360	6.0	65.00%	31.96%	27.46%	38.40%	0.00%	2.10%
Briggs	Hand of God	4.5	40.33%	57.73%	10.68%	31.41%	0.00%	0.17%
Briggs	North Wall	2.0	49.33%	34.43%	3.02%	62.63%	0.00%	0.00%
Briggs	Average	3.6	45.60%	39.51%	16.86%	38.97%	4.04%	0.65%

*3 surveys undertaken per site

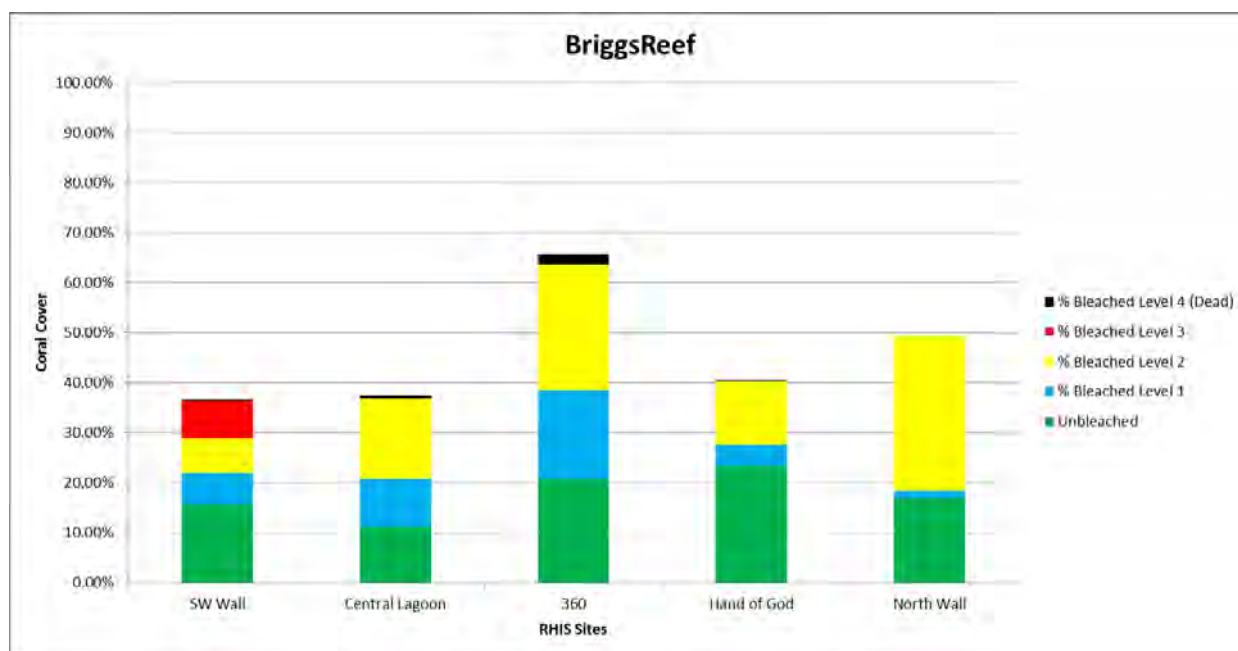


Figure 6: Coral bleaching severity by site, Briggs Reef

Elford Reef 15-073 – RHIS Results



Figure 7: Elford Reef RHIS sites.

Table 6: Coral bleaching severity by site*, Elford Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Elford	Site 1	2.0	54.67%	53.52%	22.66%	22.71%	0.00%	1.10%
Elford	Site 2	1.5	52.33%	49.66%	0.40%	49.94%	0.00%	0.00%
Elford	Site 3	2.0	46.67%	29.41%	13.80%	56.75%	0.00%	0.04%
Elford	Site 4	2.0	33.67%	51.04%	9.15%	38.47%	1.33%	0.00%
Elford	Site 5	2.0	44.33%	42.52%	2.52%	36.38%	17.97%	0.62%
Elford	Average	1.9	46.33%	45.23%	9.71%	40.85%	3.86%	0.35%

*3 surveys undertaken per site

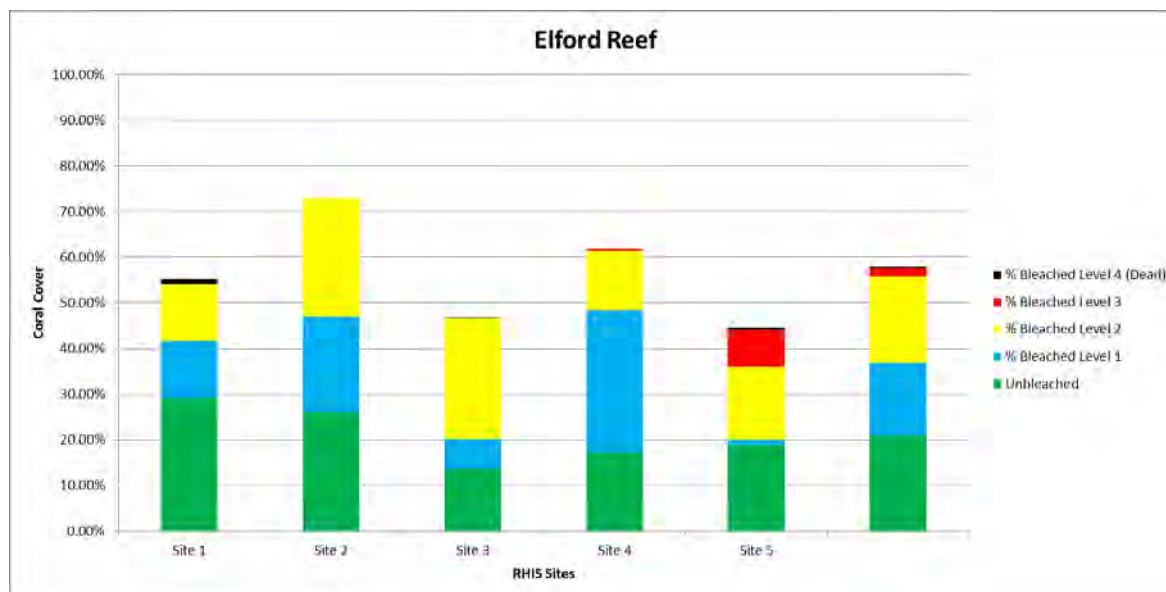


Figure 8: Coral bleaching severity by site, Elford Reef

Fitzroy Reef 15-075 – RHIS Results



Figure 9: Fitzroy Island Reef RHIS sites

Table 7: Coral bleaching severity by site*, Fitzroy Island Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Fitzroy Island	Hidden Beach	4.0	33.67%	63.28%	28.05%	8.63%	0.00%	1.33%
Fitzroy Island	Welcome Bay	3.0	66.67%	46.73%	27.20%	26.07%	0.00%	0.00%
Fitzroy Island	South Nudey Beach	2.5	43.33%	57.72%	35.98%	6.00%	0.30%	0.00%
Fitzroy Island	South Fitzroy	3.0	27.67%	68.40%	19.33%	12.27%	0.00%	0.00%
Fitzroy Island	Little Fitzroy	3.0	73.67%	68.28%	17.81%	13.65%	0.00%	0.27%
Fitzroy Island	Shark Fin Bay	3.0	56.33%	75.24%	18.48%	6.23%	0.00%	0.05%
Fitzroy Island	North Welcome Bay	2.0	52.00%	59.05%	12.13%	28.82%	0.00%	0.00%
Fitzroy Island	Average	2.9	50.60%	62.67%	22.71%	14.52%	0.04%	0.23%

*3 surveys undertaken per site

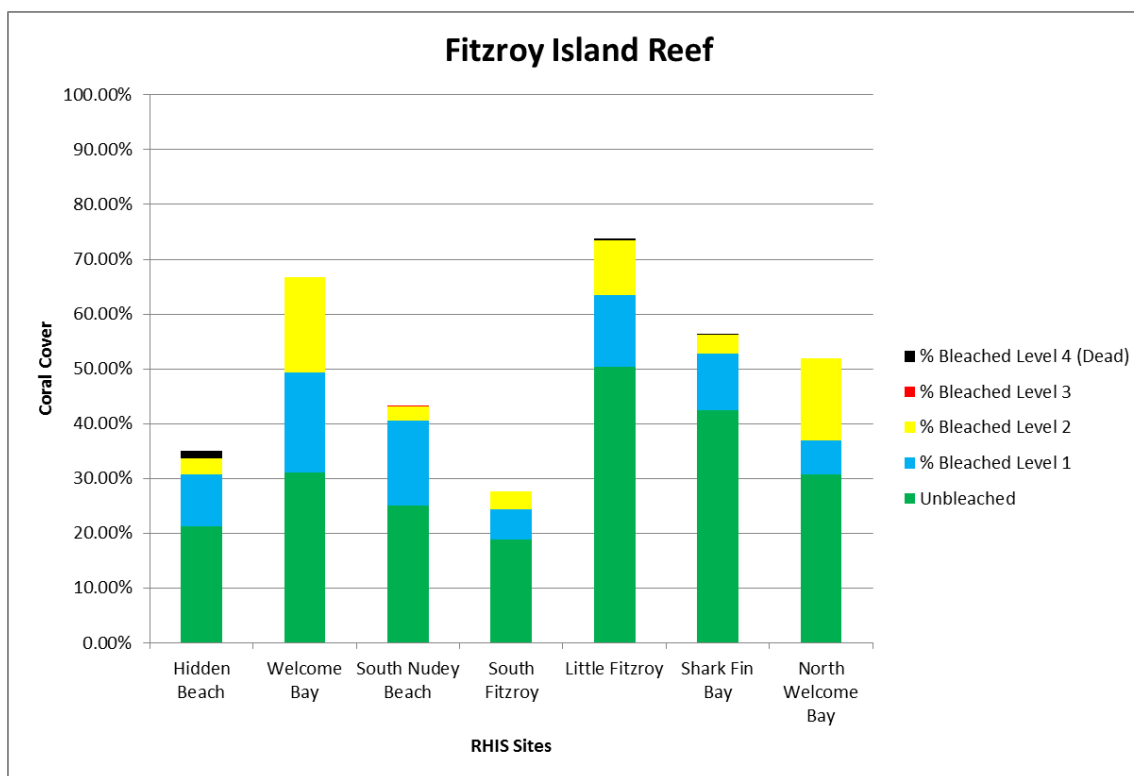


Figure 10: Coral bleaching severity by site, Fitzroy Island Reef site, Fitzroy Island Reef

Flynn Reef 15-065 – RHIS Results



Figure 11: Flynn Reef RHIS sites

Table 8: Coral bleaching severity by site, Flynn Reef

Reef	Site	Av. Depth (m)	% Live Coral	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Flynn	Tracys	3.5	50.33%	37.49%	4.92%	31.12%	22.92%	3.55%
Flynn	Gordons	4.0	30.67%	45.83%	15.94%	15.70%	20.42%	2.11%
Flynn	Tennis Courts	4.0	30.33%	20.06%	2.13%	56.76%	19.85%	1.20%
Flynn	Average	3.8	40.48%	34.46%	7.66%	34.53%	21.06%	2.29%

*3 surveys undertaken per site

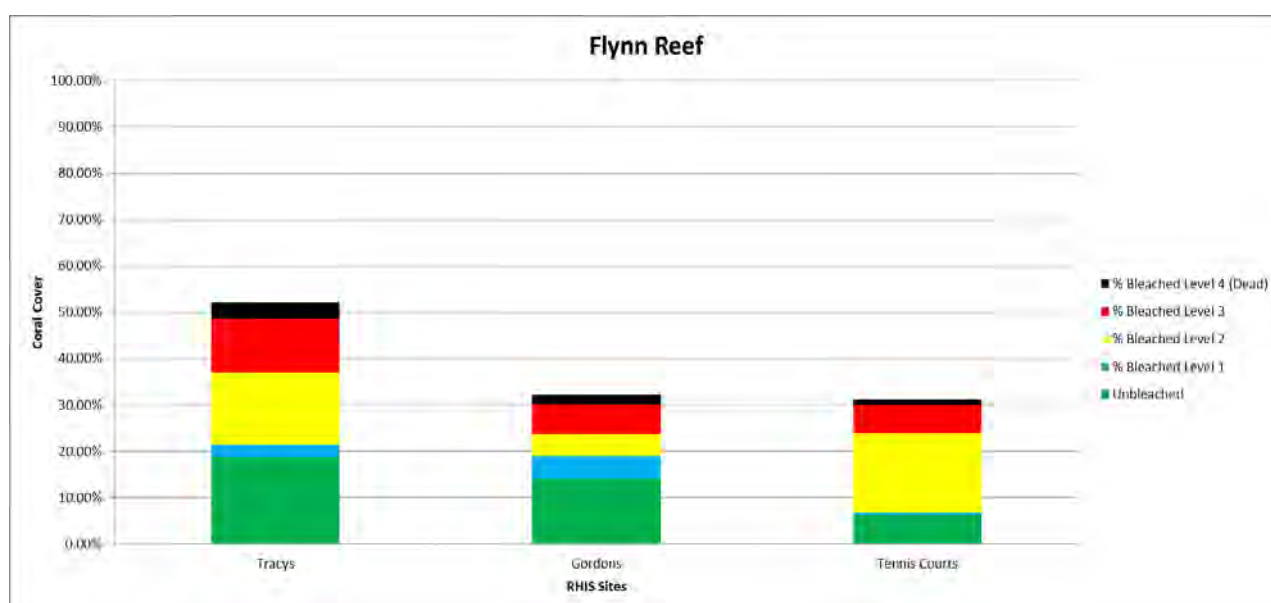


Figure 12: Coral bleaching severity by site, Flynn Reef

Milln Reef 15-067 – RHIS Results



Figure 13: Milln Reef RHIS sites

Table 9: Coral bleaching severity by site*, Milln Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Milln	Club 10	3.5	61.00%	17.42%	14.00%	68.33%	0.00%	0.25%
Milln	Fishtown	5.0	42.00%	46.13%	2.17%	49.62%	1.72%	0.36%
Milln	Average	4.3	43.45%	31.77%	8.08%	58.98%	0.86%	0.30%

*3 surveys undertaken per site

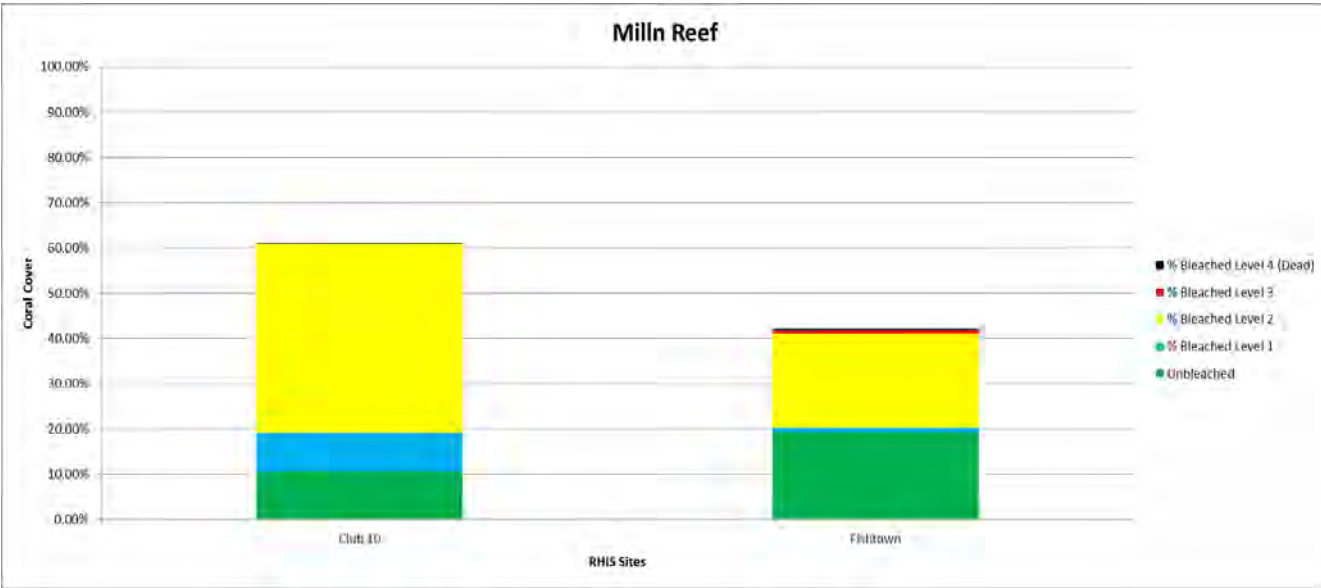


Figure 14: Milln Reef Bleaching Severity by Reef

Moore Reef 15-071 – RHIS Results

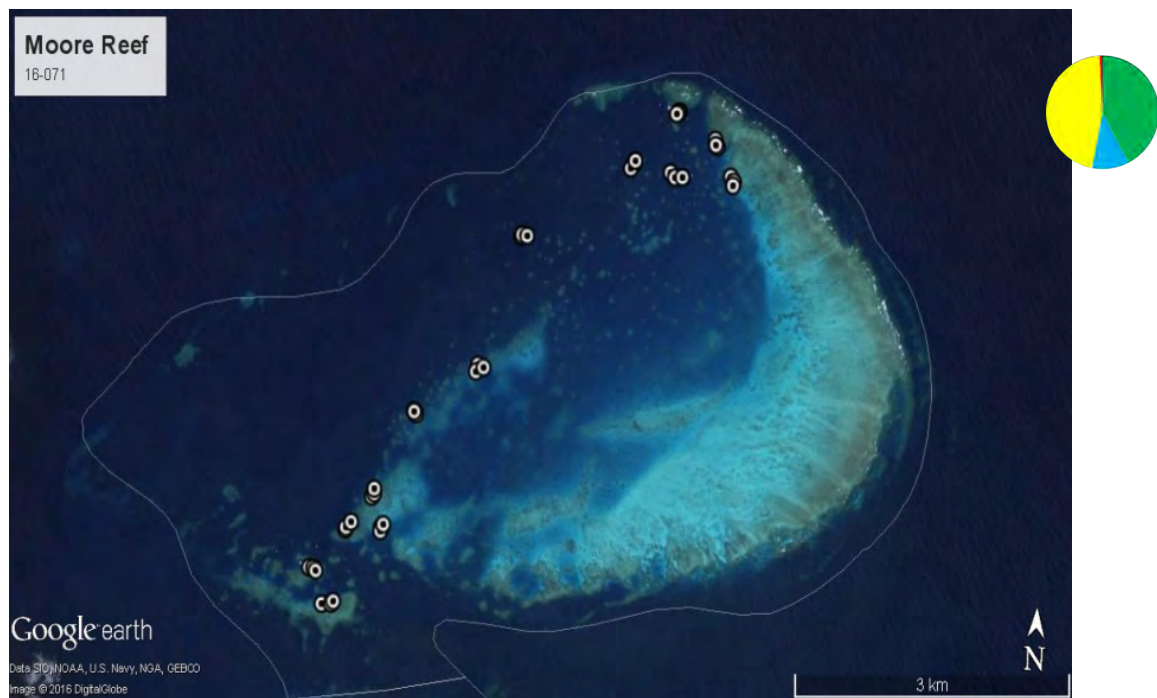


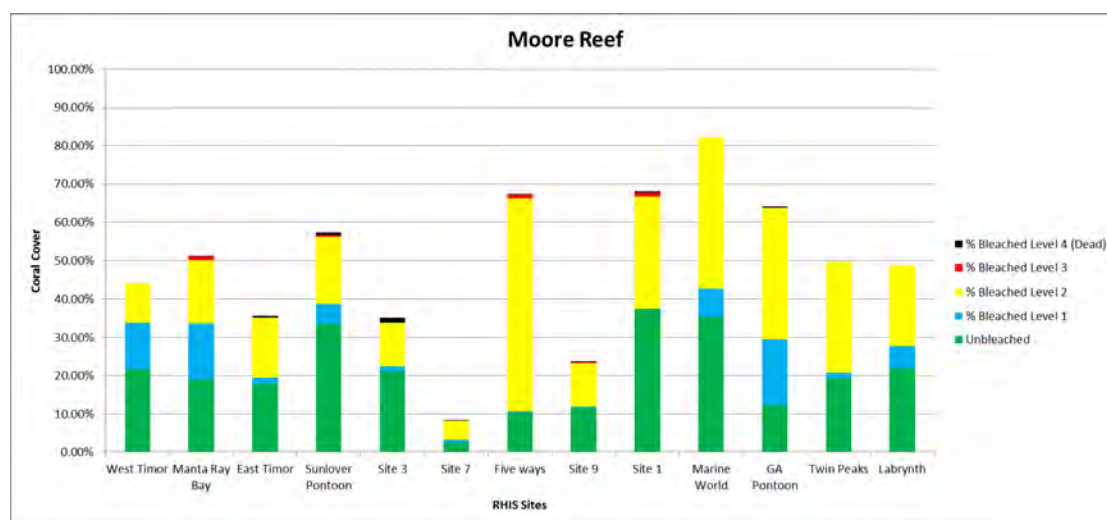
Figure 15: Moore Reef RHIS sites

Table 10: Coral bleaching severity by site, Moore Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Moore	West Timor	1.0	44.33%	49.24%	27.33%	23.43%	0.00%	0.00%
Moore	Manta Ray Bay	3.0	51.00%	37.39%	28.77%	32.03%	1.77%	0.05%
Moore	East Timor	1.5	35.33%	50.60%	4.58%	44.30%	0.00%	0.51%
Moore	Sunlover Pontoon	3.0	57.00%	58.91%	9.27%	30.31%	0.89%	0.63%
Moore	Site 3	1.0	34.33%	61.47%	4.00%	33.14%	0.00%	1.38%
Moore	Site 7	2.8	8.33%	28.91%	10.40%	60.58%	0.00%	0.12%
Moore	Five ways	1.8	67.33%	15.45%	0.43%	82.48%	1.43%	0.20%
Moore	Site 9	2.0	23.67%	48.94%	1.33%	48.04%	1.43%	0.26%
Moore	Site 1	2.0	68.00%	55.09%	0.00%	43.06%	1.58%	0.27%
Moore	Marine World	4.0	82.33%	42.97%	8.98%	48.05%	0.00%	0.00%
Moore	GA Pontoon	2.0	64.00%	19.47%	26.73%	53.48%	0.00%	0.31%
Moore	Twin Peaks	2.0	49.67%	38.87%	2.89%	58.24%	0.00%	0.00%
Moore	Labrynth	1.8	48.67%	45.20%	11.68%	43.12%	0.00%	0.00%
Moore	Average	2.1	62.53%	42.50%	10.49%	46.17%	0.55%	0.29%

*3 surveys undertaken per site

Figure 16: Coral bleaching severity by site, Moore Reef



Thetford Reef 15-068 – RHIS Results



Figure 17: Thetford Reef RHIS sites

Table 11: Coral bleaching severity by site, Thetford Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Thetford	Blue Lagoon	4.3	36.33%	91.05%	3.00%	5.33%	0.00%	0.62%
Thetford	Mystery	3.0	49.67%	55.28%	2.18%	35.68%	6.37%	0.49%
Thetford	Horseshoe bay	3.0	21.00%	74.02%	0.03%	22.78%	3.17%	0.00%
Thetford	Rosco's Wall	2.0	56.00%	42.26%	0.07%	39.74%	15.21%	2.73%
Thetford	Rosco's	2.8	67.00%	58.95%	6.60%	23.83%	7.45%	3.12%
Thetford	Cathedral	5.0	32.00%	71.64%	6.70%	20.95%	0.00%	0.72%
Thetford	Tusa Canyons	5.0	51.67%	81.69%	1.90%	16.01%	0.40%	0.00%
Thetford	Nolans	1.0	25.00%	34.16%	0.00%	65.68%	0.00%	0.17%
Thetford	Average	3.3	42.33%	63.63%	2.56%	28.75%	4.07%	0.98%

*3 surveys undertaken per site

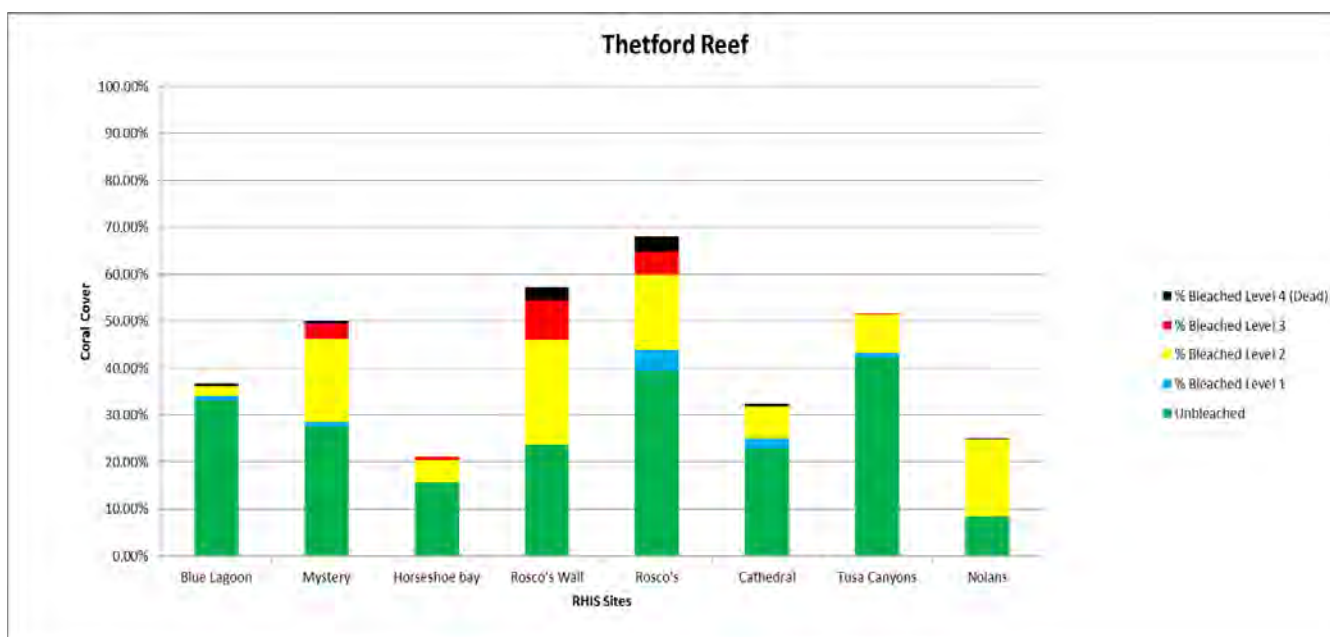


Figure 18: Coral bleaching severity by site, Thetford Reef

Northern Cairns Region Reefs

The Northern Cairns Region has eleven reefs of high value to the tourism industry. There is one pontoon maintained in this area at Norman Reef. Green Island Resort falls within this region and close to a dozen dive boat operations utilise these reefs.

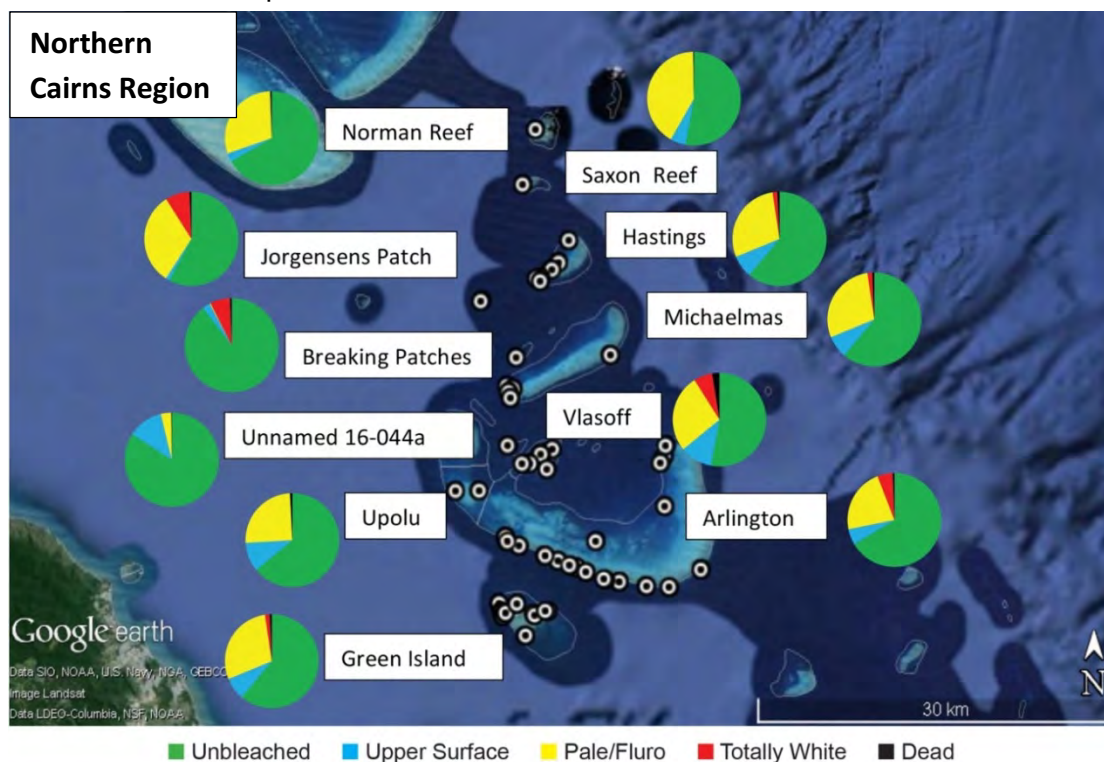


Figure 19: RHIS sites surveyed in Northern Cairns Region

Table 12: Coral bleaching severity by reef, Northern Cairns Region Reefs

Reef	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)	Number of surveys
Arlington	3.9	30.67%	66.38%	5.46%	22.31%	5.26%	0.59%	54
Breaking Patches	3.4	41.00%	89.55%	2.64%	0.31%	6.86%	0.63%	3
Green Island	3.5	43.14%	61.11%	7.69%	28.84%	1.62%	0.74%	21
Hastings	5.7	40.94%	54.89%	4.63%	27.74%	11.43%	1.31%	18
Jorgensens Patch	3.0	19.00%	57.81%	1.33%	31.83%	8.36%	0.66%	3
Michaelmas	2.8	48.47%	40.85%	2.03%	40.64%	16.04%	0.45%	15
Norman	5.3	37.33%	66.71%	2.96%	29.80%	0.00%	0.53%	3
Saxon	4.0	32.00%	52.90%	5.33%	41.52%	0.00%	0.24%	3
Unnamed 16-044a	6.0	52.00%	84.17%	12.10%	3.57%	0.00%	0.17%	3
Upolu	1.8	33.50%	64.00%	10.07%	25.13%	0.00%	0.81%	6
Vlasoff	3.4	37.27%	52.94%	11.18%	26.91%	6.45%	2.51%	15
Cairns Northern Region	3.9	37.76%	62.85%	5.95%	25.33%	5.09%	0.79%	144

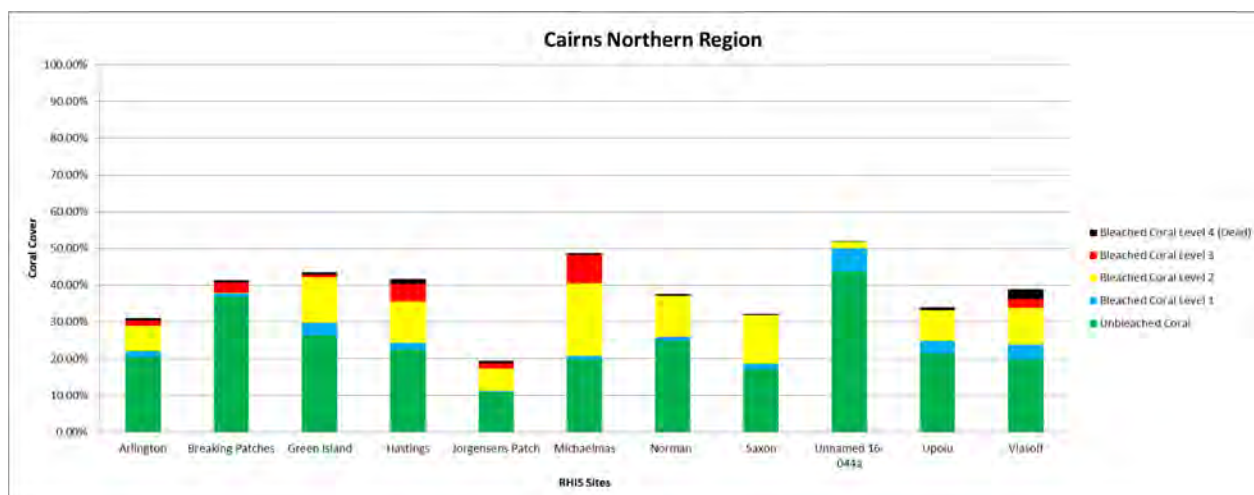


Figure 20: Coral bleaching severity by reef, Northern Cairns Region Reefs

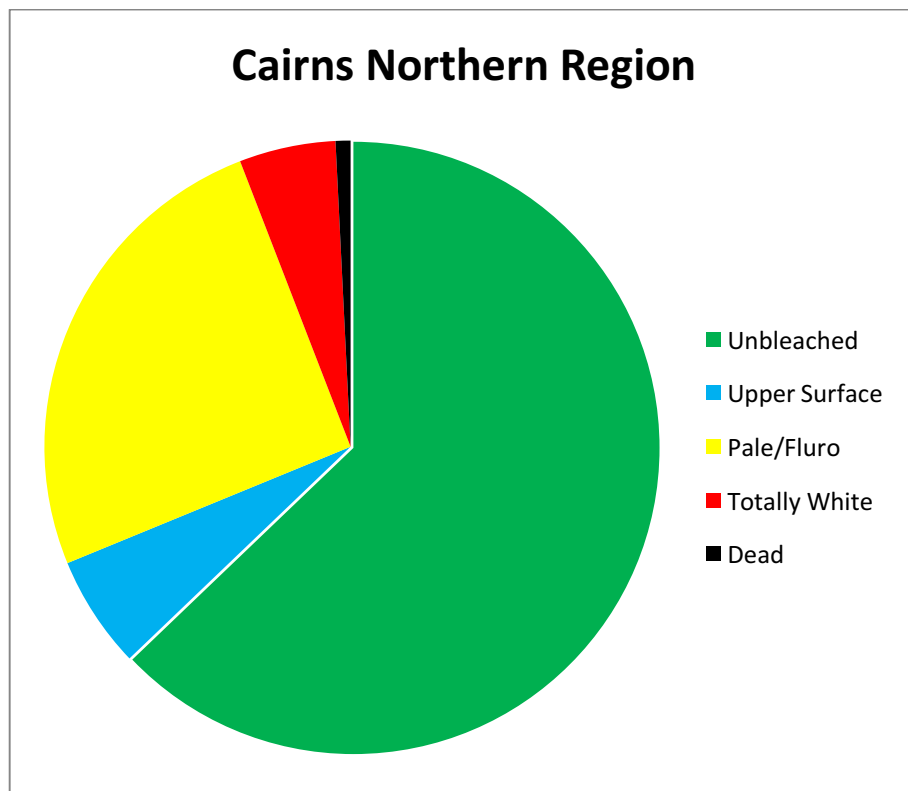


Figure 21: Bleaching Severity averaged over entire Northern Cairns Region

Arlington Reef 16-054 – RHIS Results

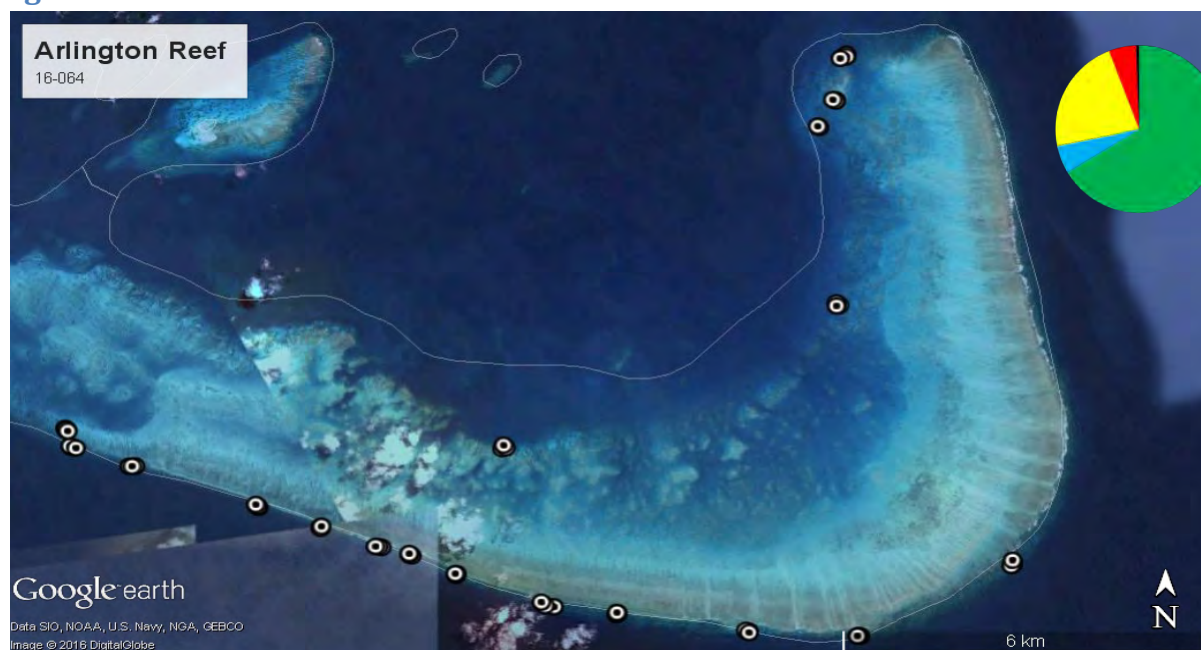


Figure 22: Arlington Reef 16-054

Table 13: Coral bleaching severity by site*, Arlington Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Arlington	Site 1	5.0	52.67%	66.70%	0.00%	33.3%	0.0%	0.00%
Arlington	Site 2	2.5	34.67%	65.21%	10.48%	22.5%	1.6%	0.21%
Arlington	Site 3	3.0	26.33%	44.72%	0.00%	25.9%	29.3%	0.10%
Arlington	Site 4	3.5	14.67%	70.53%	7.91%	21.5%	0.0%	0.10%
Arlington	Site 5	3.5	42.67%	37.70%	0.92%	61.0%	0.0%	0.37%
Arlington	Site 6	4.0	36.33%	63.39%	12.95%	22.8%	0.0%	0.87%
Arlington	Site 7	5.0	47.00%	87.54%	6.33%	0.0%	4.7%	1.46%
Arlington	Site 8	3.8	10.67%	90.64%	9.17%	0.0%	0.0%	0.20%
Arlington	Site 9	3.5	30.00%	16.62%	3.90%	30.5%	44.8%	4.23%
Arlington	Site 10	4.0	29.33%	72.40%	3.90%	23.7%	0.0%	0.00%
Arlington	Site 11	2.5	16.67%	76.57%	1.00%	20.6%	1.7%	0.17%
Arlington	Site 13	4.2	15.33%	87.55%	2.00%	8.8%	1.7%	0.03%
Arlington	Site 14	6.0	36.33%	78.95%	4.82%	16.2%	0.0%	0.03%
Arlington	Site 16	3.6	36.33%	79.35%	11.62%	8.9%	0.0%	0.11%
Arlington	Site 16	3.4	31.33%	70.04%	5.45%	23.2%	1.1%	0.22%
Arlington	Site 17	5.0	34.00%	81.68%	6.72%	8.7%	2.8%	0.07%
Arlington	Site 18	6.0	23.67%	88.44%	11.43%	0.0%	0.0%	0.13%
Arlington	Site 19	3.0	30.33%	57.81%	5.22%	23.8%	12.3%	0.85%
Arlington	Site 20	3.1	40.00%	25.35%	0.00%	72.6%	0.0%	2.05%
Arlington	Average	3.9	30.67%	66.38%	5.46%	22.3%	5.3%	0.59%

*3 surveys undertaken per site

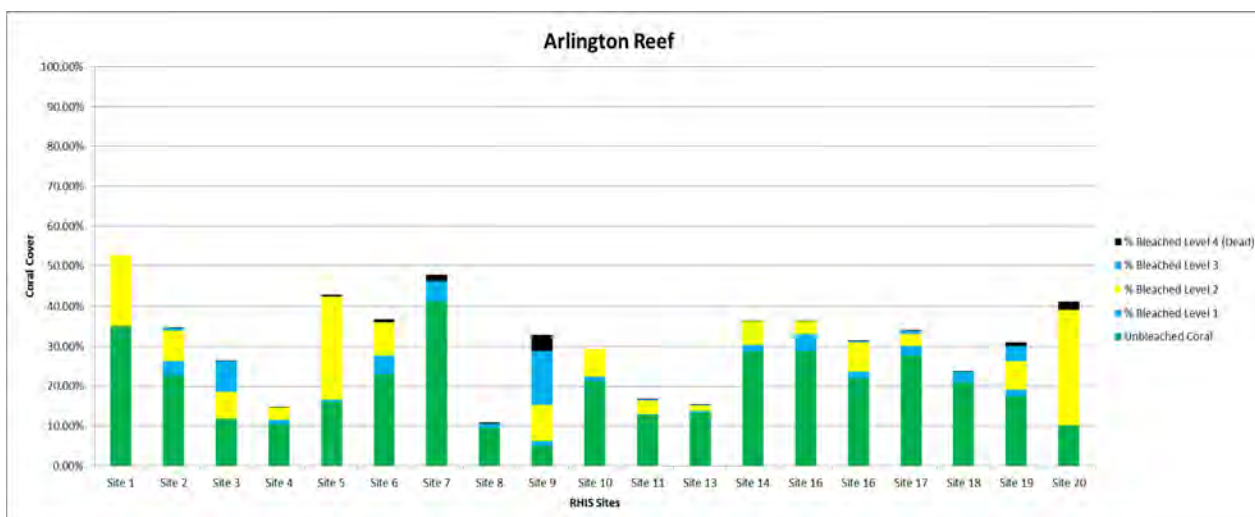


Figure 23: Coral bleaching severity by site, Arlington Reef

Small Reefs



Figure 24: Unnamed Reef RHIS sites



Figure 25: RHIS sites Jorgenson Patch



Figure 26: Breaking Patches 16-042



Figure 27: Norman Reef 16-030



Figure 28: Saxon Reef 16-032

Table 14: Coral bleaching severity at Northern Cairns Area Reefs - small reefs

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Breaking Patches	Breaking Patches	3.4	41.00%	89.55%	2.64%	0.31%	6.86%	0.63%
Jorgensens Patch	Jorgies	3.0	19.00%	57.81%	1.33%	31.83%	8.36%	0.66%
Norman	Norman Pontoon	5.3	37.33%	66.71%	2.96%	29.80%	0.00%	0.53%
Saxon	GM0191	4.0	32.00%	52.90%	5.33%	41.52%	0.00%	0.24%
Unnamed 16-044a	Site 1	6.0	52.00%	84.17%	12.10%	3.57%	0.00%	0.17%

*3 surveys undertaken per site

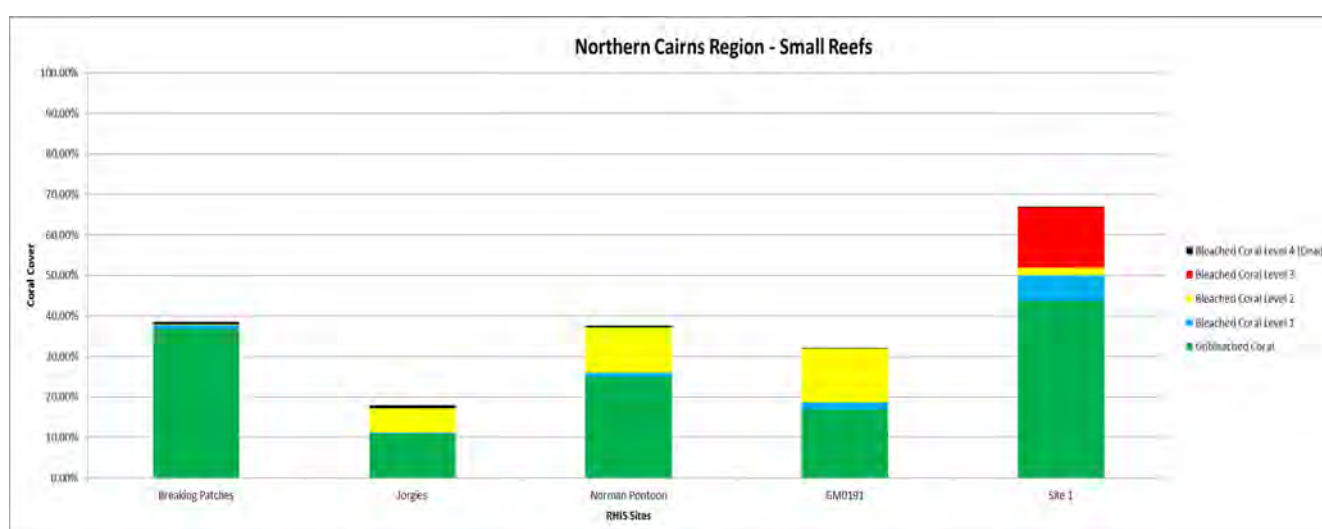


Figure 29: Coral bleaching severity at Northern Cairns Area Reefs - small reefs

Green Island Reef 16-049 – RHIS Results



Figure 30: Green Island Reef RHIS sites

Table 15: Coral bleaching severity by site, Green Island Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Green Island	Glassy patch	3.8	30.67%	45.30%	5.80%	45.38%	0.00%	3.52%
Green Island	NE Wall	2.5	35.33%	76.90%	10.80%	11.00%	0.18%	1.12%
Green Island	NE Wall Site 2	5.0	32.33%	71.99%	5.65%	21.73%	0.00%	0.63%
Green Island	New York	3.6	34.00%	62.26%	5.18%	19.72%	12.47%	0.37%
Green Island	Ocean free	3.2	53.67%	56.08%	1.17%	42.75%	0.00%	0.00%
Green Island	Site 1	3.5	69.33%	61.63%	18.27%	19.90%	0.00%	0.20%
Green Island	South Glassy Patch	3.0	46.67%	53.11%	10.75%	36.07%	0.00%	0.07%
Green Island	South Wall	4.0	21.33%	61.63%	3.92%	34.15%	0.30%	0.00%
Green Island	Average	3.5	43.14%	61.11%	7.69%	28.84%	1.62%	0.74%

*3 surveys undertaken per site

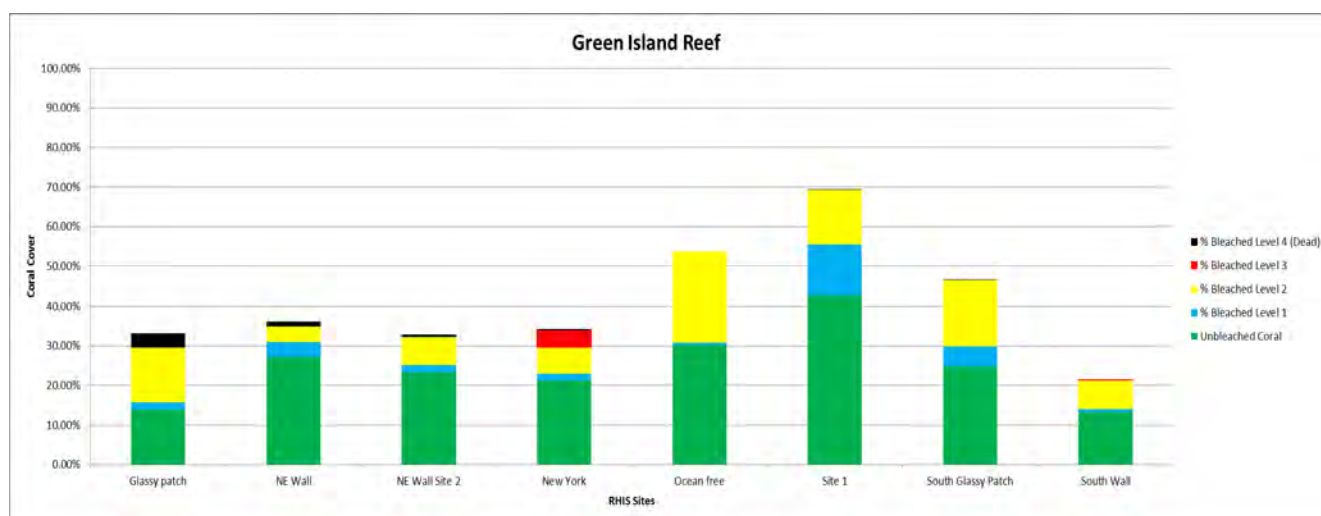


Figure 31: Coral cover by site, Green Island Reef

Hastings Reef 16-057 – RHIS Results



Figure 32: Hastings Reef RHIS sites

Table 16: Coral bleaching severity by site, Hastings Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Hastings	GM0419	4.9	44.00%	38.11%	1.27%	54.60%	2.40%	3.62%
Hastings	GM0087	3.8	48.67%	42.10%	8.07%	31.68%	18.01%	0.14%
Hastings	GM0418	5.0	47.33%	45.78%	4.42%	25.75%	23.19%	0.87%
Hastings	Site 1	5.5	31.67%	71.30%	3.28%	21.08%	3.93%	0.40%
Hastings	Site 2	11.0	20.33%	70.52%	1.90%	5.64%	21.04%	0.90%
Hastings	Site 3	4.0	53.67%	61.51%	8.83%	27.71%	0.00%	1.94%
Hastings	Average	5.7	40.94%	54.89%	4.63%	27.74%	11.43%	1.31%

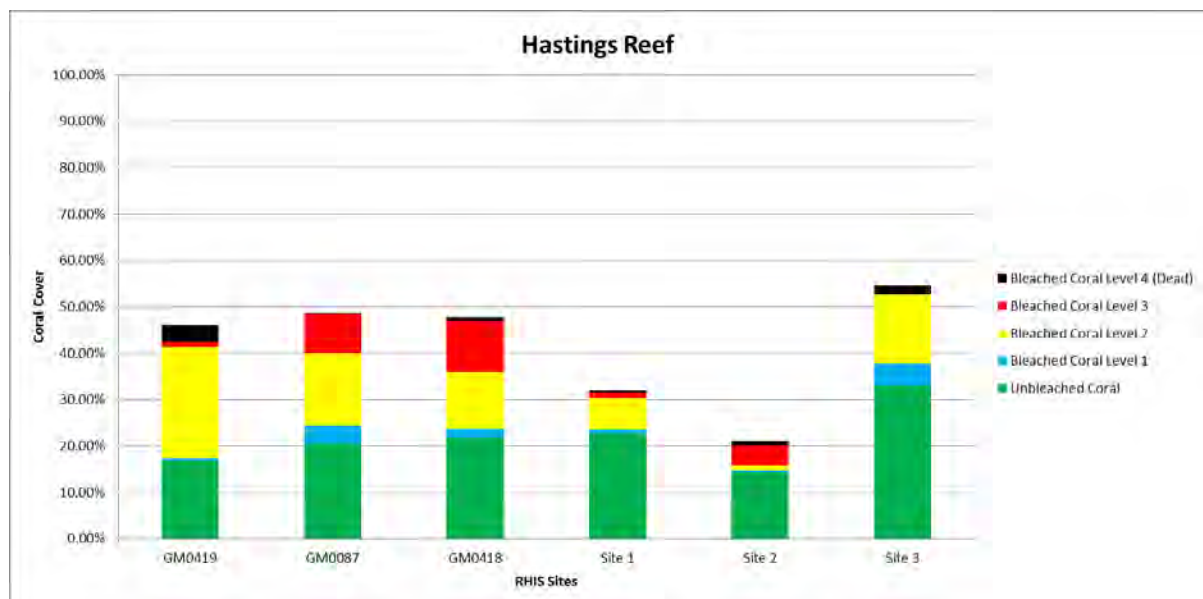


Figure 33: Coral bleaching severity by site, Hastings Reef

Michaelmas Reef – 16-060 RHIS Results

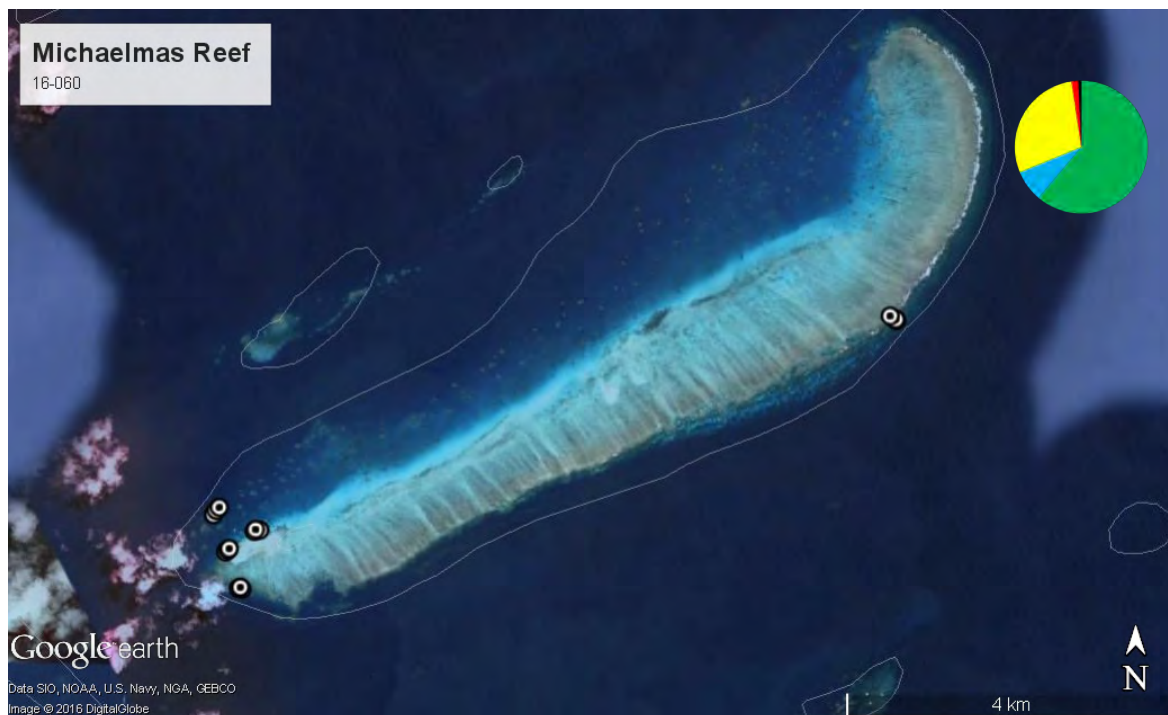


Figure 34: Michaelmas Reef

Table 17: Coral bleaching severity by site, Michaelmas Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Michaelmas	GM0453	4	50.00%	73.50%	7.47%	18.02%	0.00%	1.02%
Michaelmas	Ocean Spirit	3	57.00%	26.48%	0.00%	71.18%	2.33%	0.00%
Michaelmas	Ocean Spirit Deep	2	53.33%	11.87%	0.00%	30.46%	57.54%	0.13%
Michaelmas	Passions	3.5	67.00%	35.56%	0.00%	44.93%	19.25%	0.27%
Michaelmas	Site 3	1.3	15.00%	56.86%	2.66%	38.59%	1.07%	0.82%
Michaelmas	Average	2.8	48.47%	40.85%	2.03%	40.64%	16.04%	0.45%

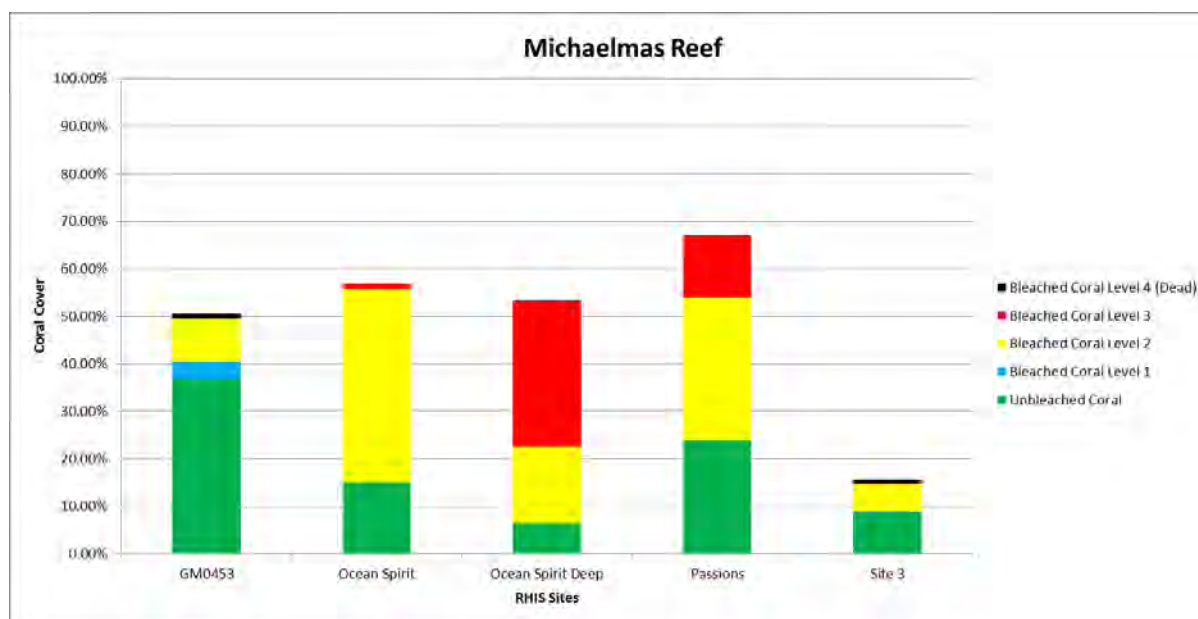


Figure 35: Coral bleaching severity by site, Michaelmas Reef

Upolu Reef- 16-046 – RHIS Results

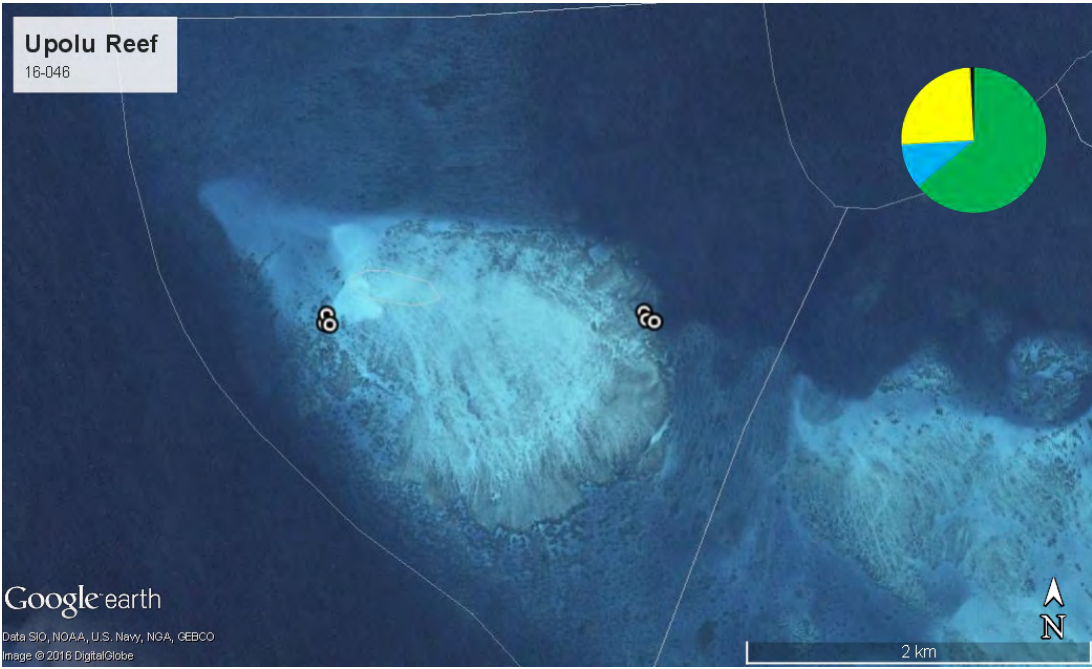


Figure 36: Upolu Reef RHIS sites

Table 18: Coral bleaching severity by site*, Upolu Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Upolu	Jaws	1.5	48.67%	70.91%	6.51%	22.43%	0.00%	0.15%
Upolu	Ocean Freedom	2	18.33%	57.08%	13.63%	27.82%	0.00%	1.47%
Upolu	Average	1.8	33.50%	64.00%	10.07%	25.13%	0.00%	0.81%

*3 surveys undertaken per site

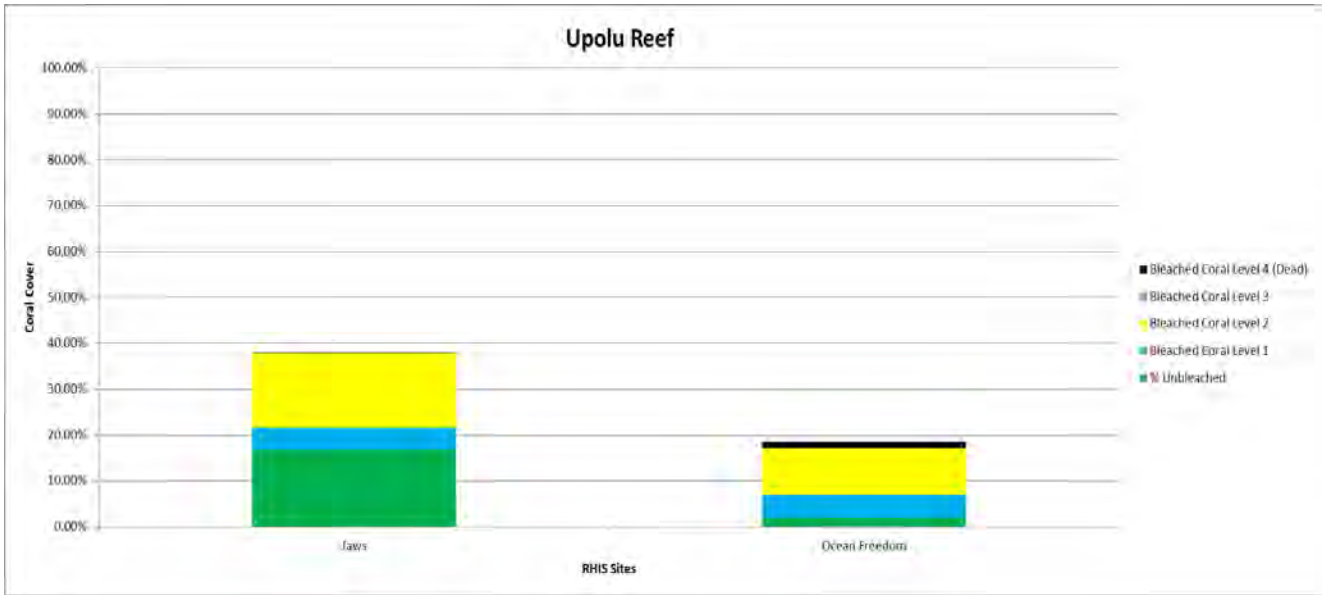


Figure 37: Coral bleaching severity by site, Upolu Reef

Vlasoff Reef 16-044 b – RHIS Results

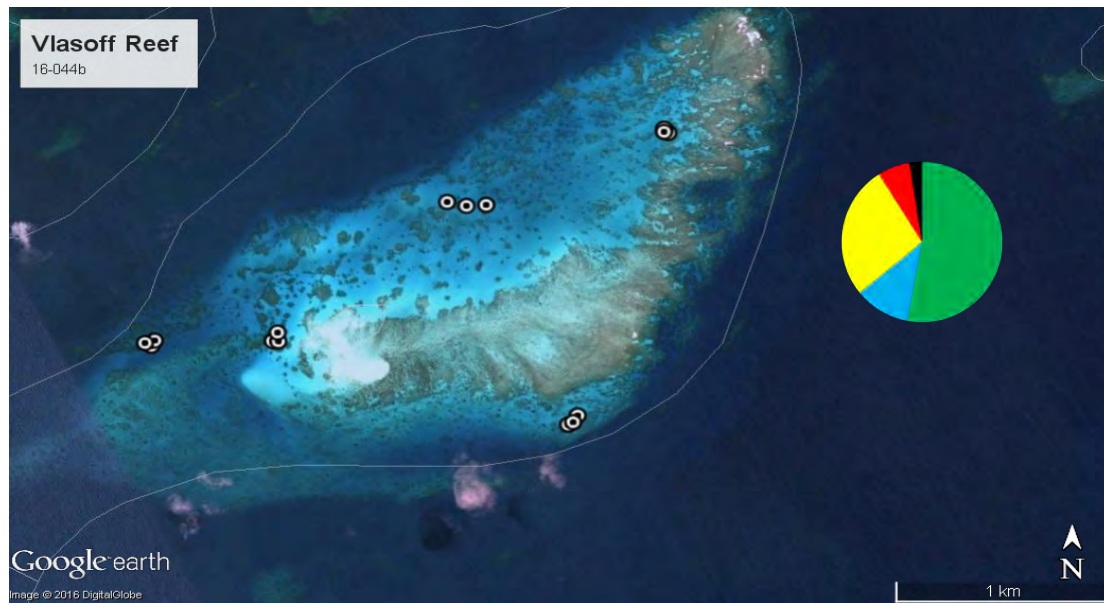


Figure 38: Vlasoff Reef 16-044a

Table 19: Coral bleaching severity by site*, Vlasoff Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Vlasoff	Site 1	3	50.00%	67.55%	25.39%	6.29%	0.00%	0.78%
Vlasoff	Site 2	2.5	30.00%	32.07%	0.50%	56.74%	0.00%	10.69%
Vlasoff	Site 3	4.5	24.00%	64.92%	16.86%	17.93%	0.00%	0.29%
Vlasoff	Site 4	4	36.00%	68.13%	13.17%	18.70%	0.00%	0.00%
Vlasoff	Site 5	3.2	46.33%	32.02%	0.00%	34.91%	32.27%	0.79%
Vlasoff	Average	3.44	37.27%	52.94%	11.18%	26.91%	6.45%	2.51%

*3 surveys undertaken per site

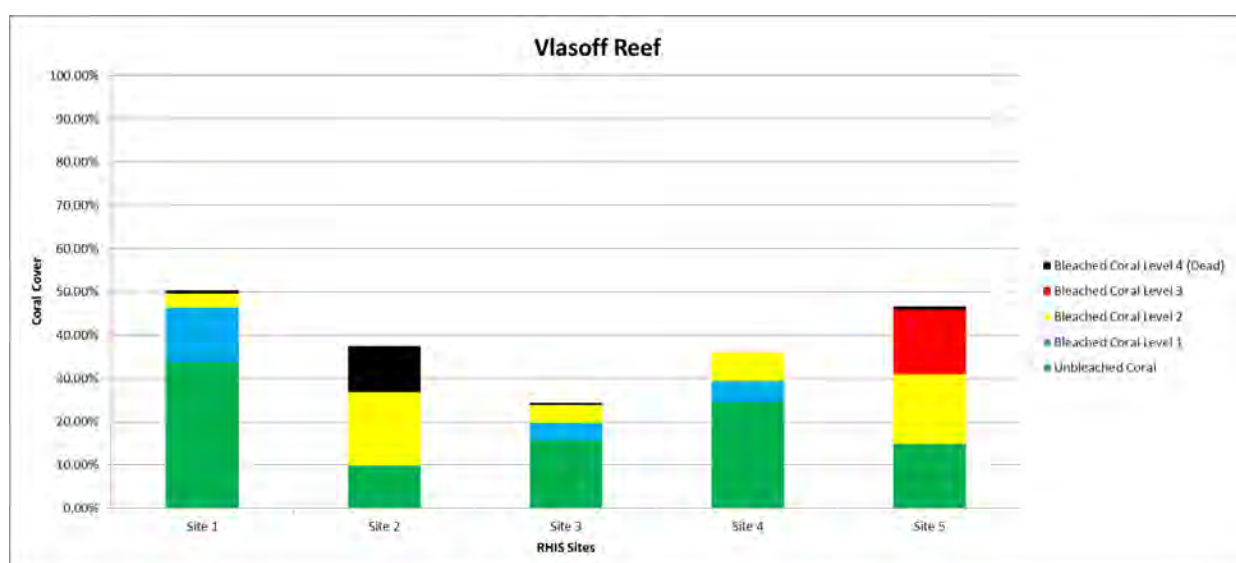


Figure 39: Coral bleaching severity by site, Vlasoff Reef

Daintree Area Reefs

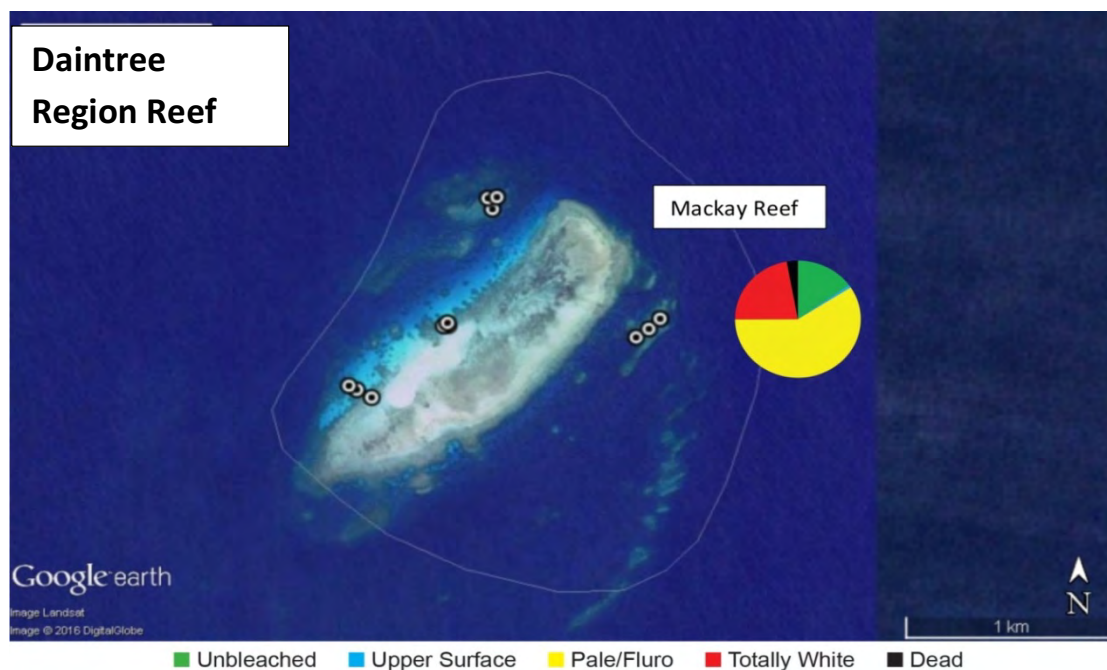


Figure 40: RHIS sites surveyed in Target Area 5, Mackay Reef 16-015

Table 20: Coral bleaching severity by site, Mackay Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Mackay	Angels	3.3	29.67%	9.08%	0.00%	85.91%	1.70%	3.30%
Mackay	Site 2	3.0	21.00%	15.79%	0.00%	64.48%	14.81%	4.91%
Mackay	Site 3	4.5	31.33%	21.26%	0.00%	44.48%	33.16%	1.10%
Mackay	Site 4	4.8	23.67%	11.24%	3.00%	49.54%	34.48%	1.55%
Mackay	Average	3.9	26.42%	14.34%	0.75%	61.10%	21.04%	2.72%

*3 surveys undertaken per site

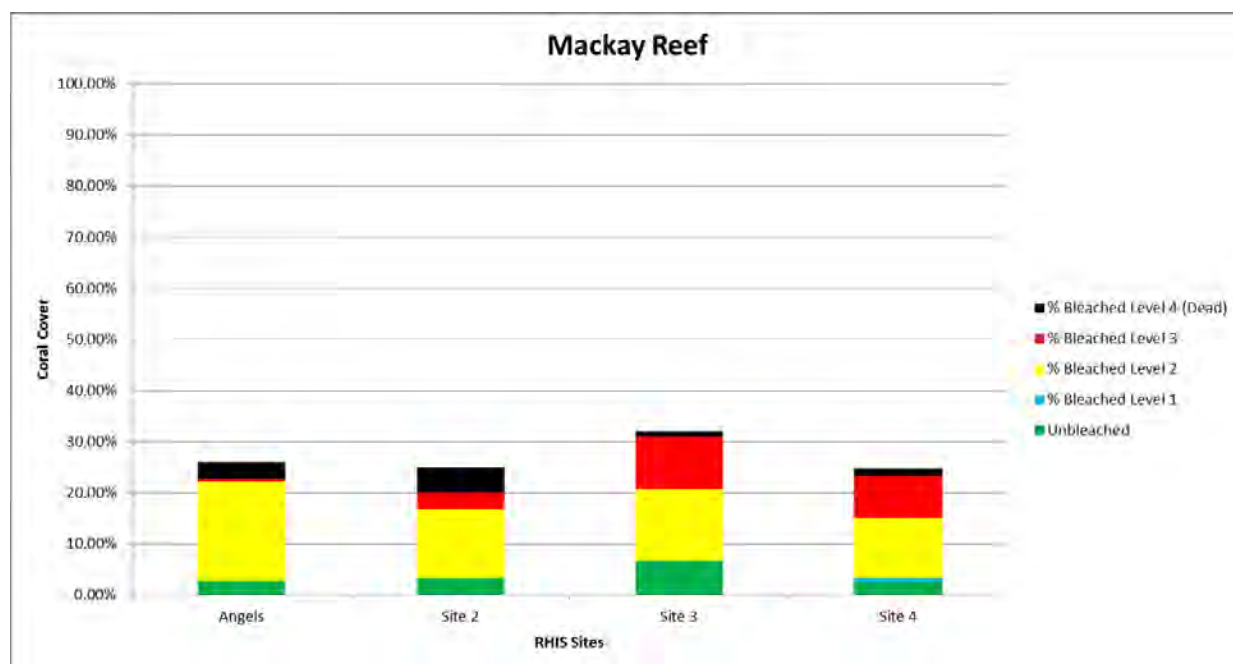


Figure 41: Coral bleaching severity by site, Mackay Reef

Overview Ribbon Reefs (South) Region Reefs

Figure 42: RHIS sites surveyed in Ribbon Reefs South

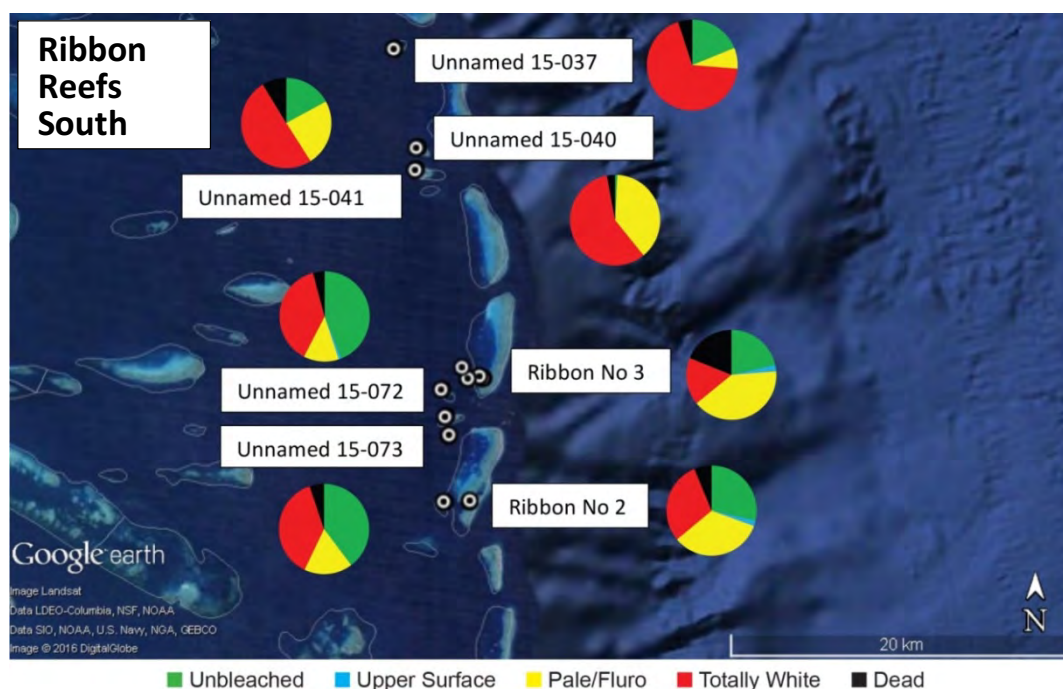


Table 21: Coral bleaching severity by reef, Ribbon Reefs (South)

Reef	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)	Number of surveys
Ribbon No. 2	3.8	53.78%	28.59%	2.00%	33.34%	29.83%	6.24%	9
Ribbon No. 3	3.6	41.00%	21.51%	2.25%	40.34%	17.03%	18.88%	12
Unnamed 15-072	2.5	41.00%	43.69%	1.00%	12.63%	38.12%	4.14%	3
Unnamed 15-073	3.5	49.67%	39.74%	0.00%	17.38%	37.70%	5.18%	3
Unnamed 15-041	2.8	50.33%	20.80%	0.00%	25.68%	44.93%	9.14%	3
Unnamed 15-040	2.0	44.00%	0.83%	0.00%	38.32%	57.93%	2.92%	3
Unnamed 15-037	4.2	53.33%	18.85%	0.00%	7.43%	68.71%	5.02%	3
Ribbon Reefs (South) Average	3.2	47.59%	24.86%	0.75%	25.02%	42.04%	7.36%	36

*3 surveys undertaken per site

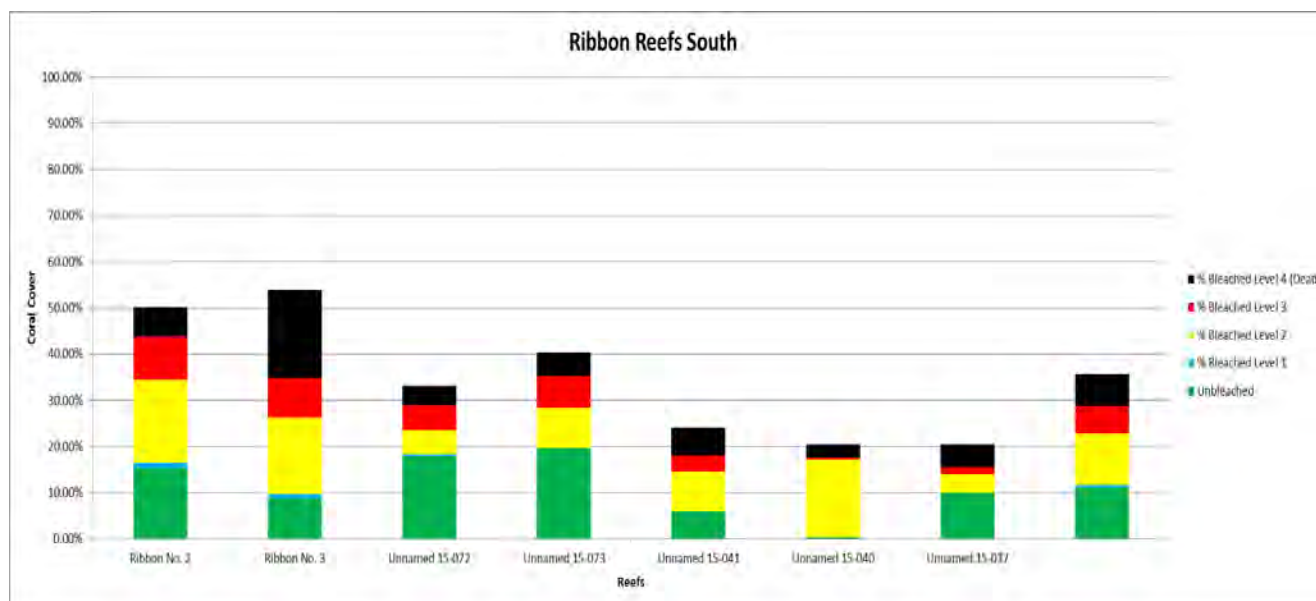


Figure 44: Ribbon No. 2 Reefs RHIS sites

Ribbon No. 2 15-075 – RHIS Results

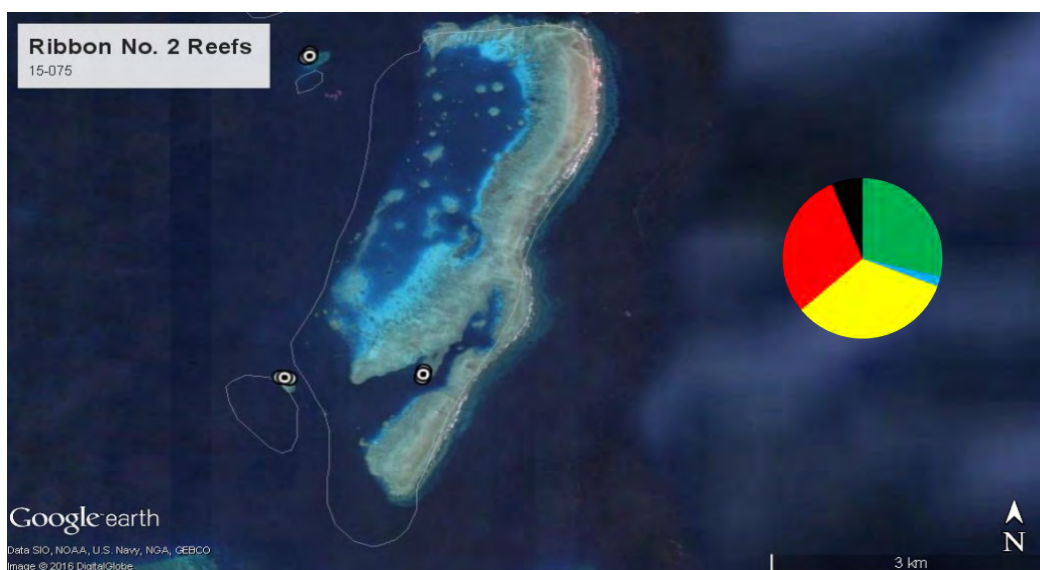


Table 22: Coral bleaching severity by site, Ribbon No. 2 Reefs

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Ribbon No. 2 (No. 1)	No Site #1	5.0	44.00%	25.68%	0.00%	18.92%	41.37%	14.03%
Ribbon No. 2 (No. 2)	No Site #2	3.8	55.67%	27.33%	0.00%	32.47%	36.38%	3.82%
Ribbon No. 2 (No. 3)	Grouper Garden	2.6	61.67%	32.76%	6.00%	48.63%	11.74%	0.87%
Ribbon No. 2	Average	3.8	53.78%	28.59%	2.00%	33.34%	29.83%	6.24%

*3 surveys undertaken per site

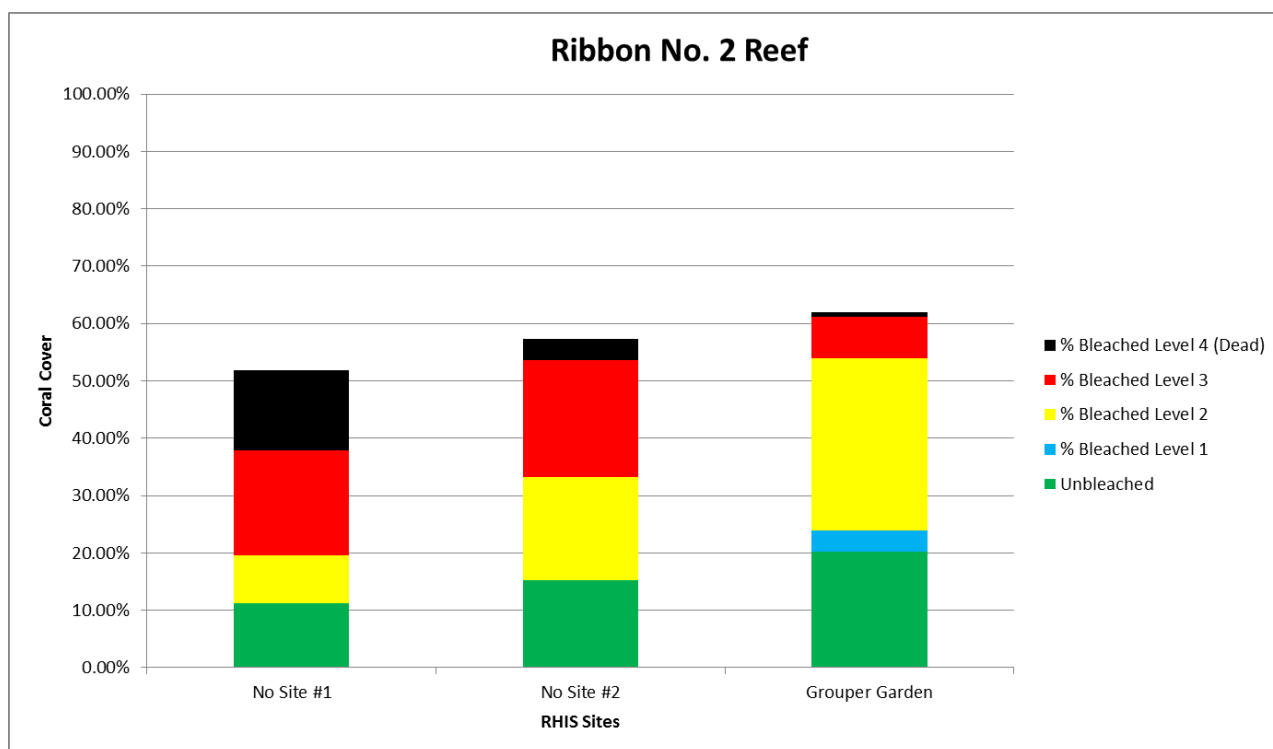


Figure 45: Coral bleaching severity by site, Ribbon No. 2 Reefs

Ribbon No. 3 15-050 – RHIS Results

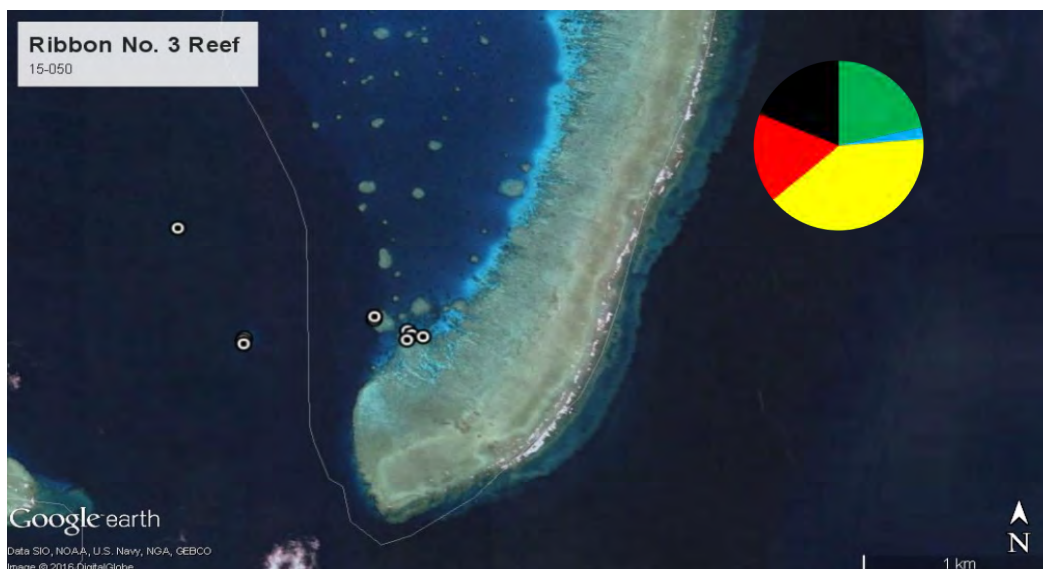


Figure 46: Ribbon No 3 Reef 15-050

Table 23: Table Coral bleaching severity by site, Ribbon Reef No. 3

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Ribbon No. 3	Steves Bommie	8.0	69.33%	19.57%	9.00%	47.07%	22.78%	1.60%
Ribbon No. 3	Temple of Doom	3.5	42.33%	46.15%	0.00%	52.35%	0.67%	0.83%
Ribbon No. 3	No Site #1	1.0	25.00%	4.79%	0.00%	21.67%	41.96%	31.58%
Ribbon No. 3	No Site #2	2.0	27.33%	15.52%	0.00%	40.27%	2.70%	41.51%
Ribbon No. 3	Average	3.6	41.00%	21.51%	2.25%	40.34%	17.03%	18.88%

*3 surveys undertaken per site

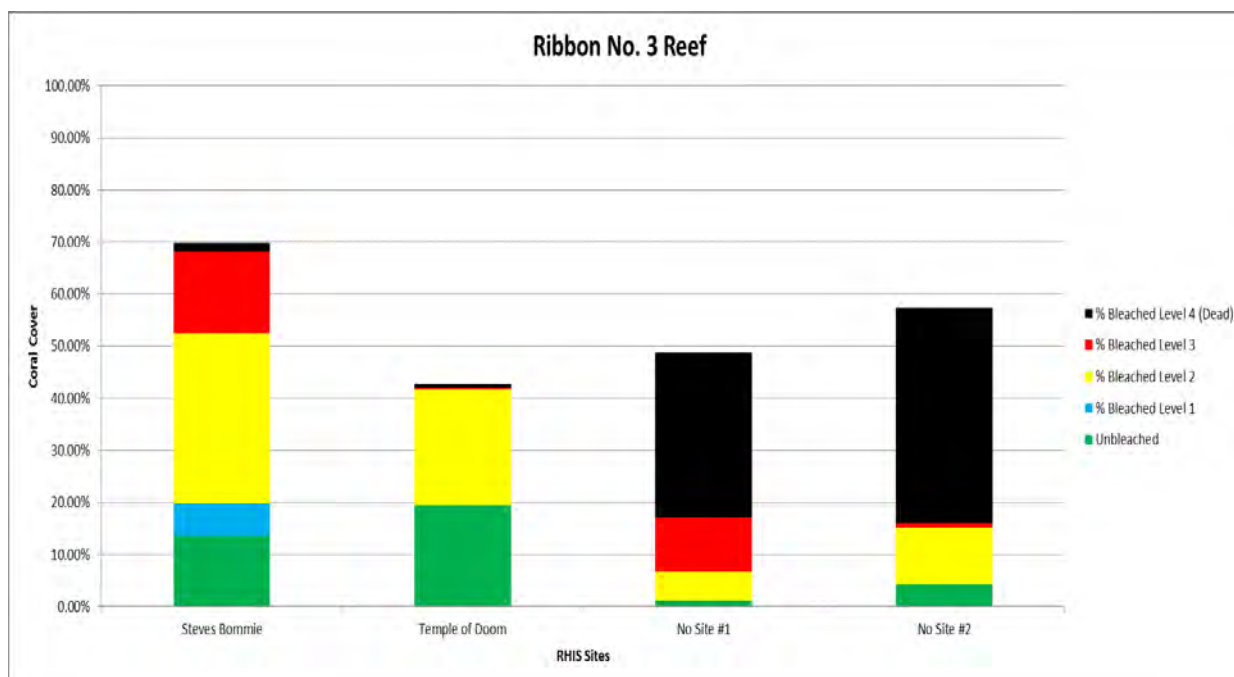


Figure 47: Coral bleaching severity by site, Ribbon No. 3 Reef

Small Reefs: Ribbon Reefs (South) – RHIS Results

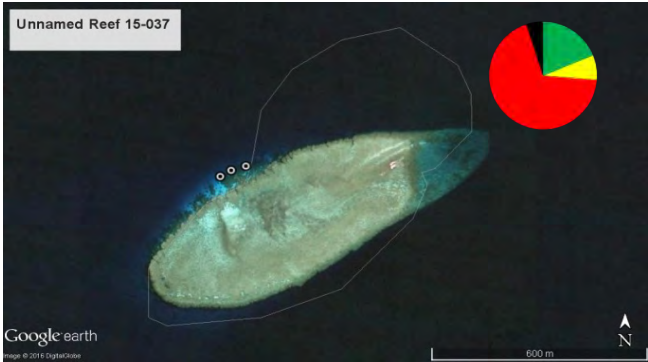


Figure 48: Unnamed Reef 15-037



Figure 49: Unnamed Reef 15-040



Figure 50: Unnamed Reef 15-041



Figure 51: Unnamed Reef 15-072



Figure 52: Unnamed Reef 15-073

Table 24: Coral bleaching severity Ribbon Reefs (South) Small Reefs

Reef	Site	v. Depth (m)	% Coral Cover	% Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Unnamed 15-072	Flare point	2.5	41.00%	43.69%	1.00%	12.63%	38.12%	4.14%
Unnamed 15-073	Joanis Joy	3.5	49.67%	39.74%	0.00%	17.38%	37.70%	5.18%
Unnamed 15-041	Clam Beds	2.8	50.33%	20.80%	0.00%	25.68%	44.93%	9.14%
Unnamed 15-040	Gorgonian	2.0	44.00%	0.83%	0.00%	38.32%	57.93%	2.92%
Unnamed 15-037	Rogues	4.2	53.33%	18.85%	0.00%	7.43%	68.71%	5.02%

*3 surveys undertaken per site

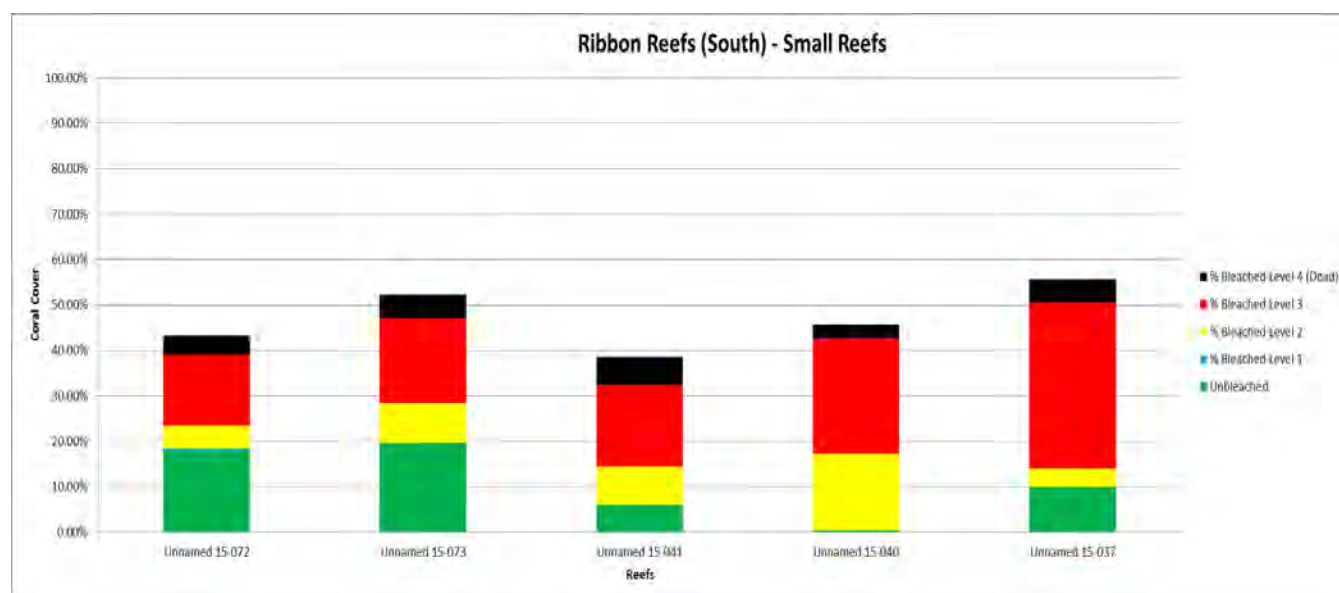


Figure 53: Coral bleaching severity by reef, Ribbon Reefs (South), small reefs

Overview Ribbon Reefs (Central) Region Reefs

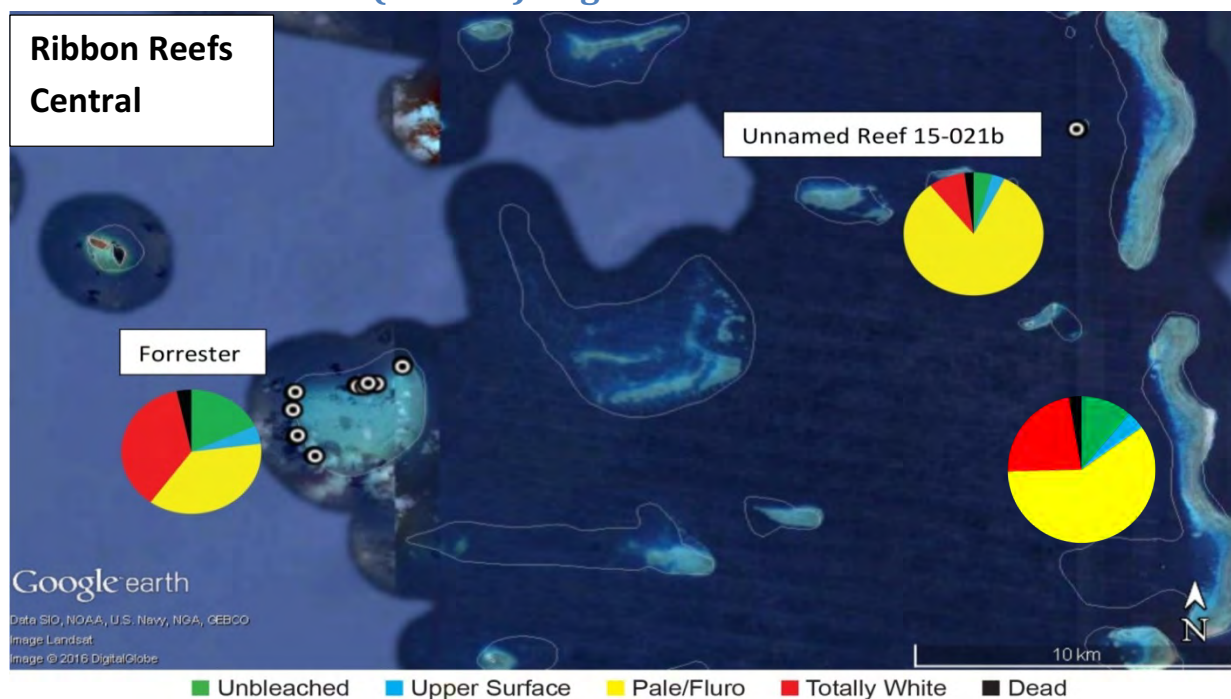


Figure 54: RHIS sites surveyed, Ribbon Reefs (Central)

Table 25: Coral bleaching severity by Reef, Ribbon Reefs (Central)

Reef	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)	umber of survey
Unnamed 15-021b	3.7	25.67%	4.31%	3.00%	81.80%	8.46%	2.10%	3
Forrester	2.6	31.04%	18.25%	4.79%	37.09%	36.85%	3.40%	24
Ribbon Reefs (Central) Average	3.2	28.35%	11.28%	3.90%	59.45%	22.66%	2.75%	27

*3 surveys undertaken per site

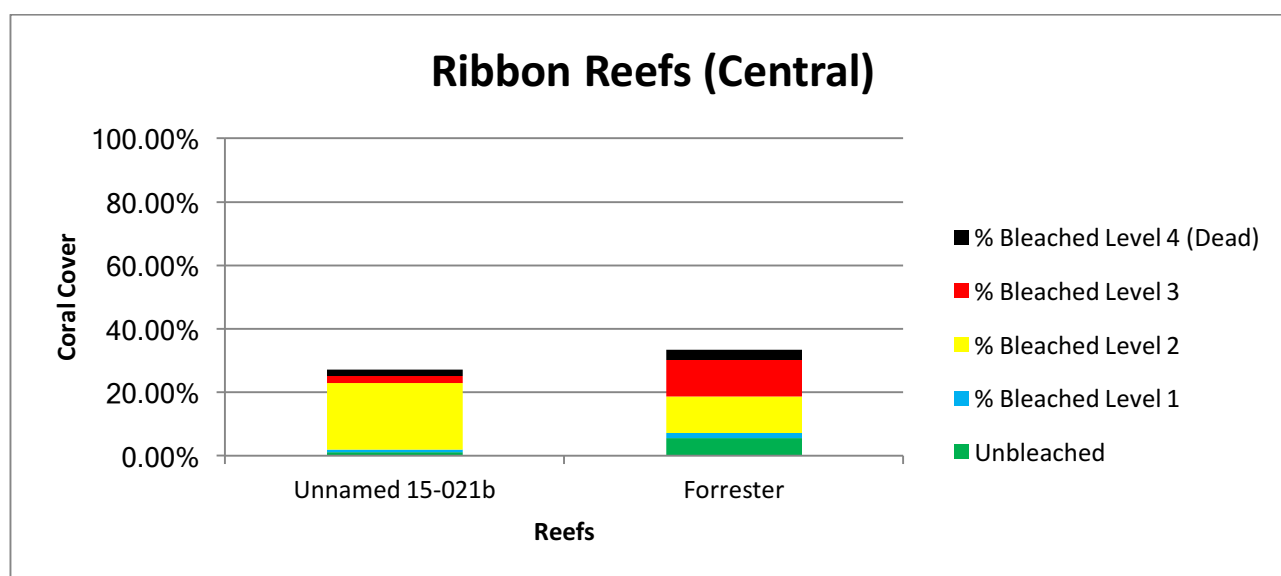


Figure 55: Coral bleaching severity by Reef, Ribbon Reefs (Central)

Unnamed Reef 15-021b – RHIS Results

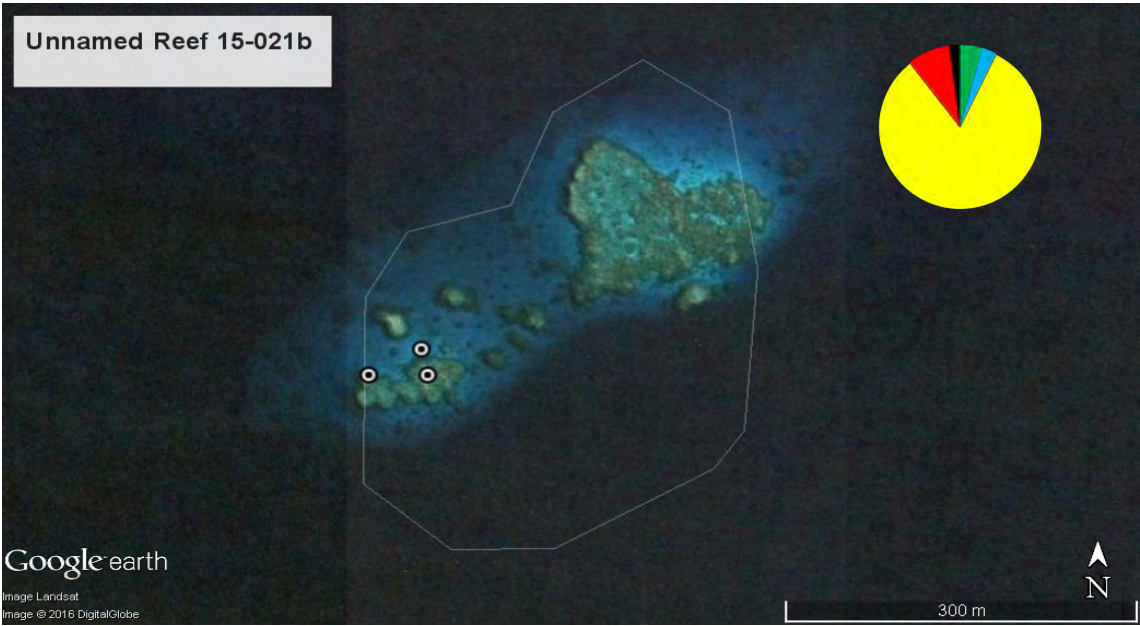


Figure 56: Unnamed Reef RHIS Sites

Table 26: Coral bleaching severity at Unnamed Reef 15-021b

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Unnamed 15-021b	Site 1	3.7	25.67%	4.31%	3.00%	81.80%	8.46%	2.10%

*3 surveys undertaken per site

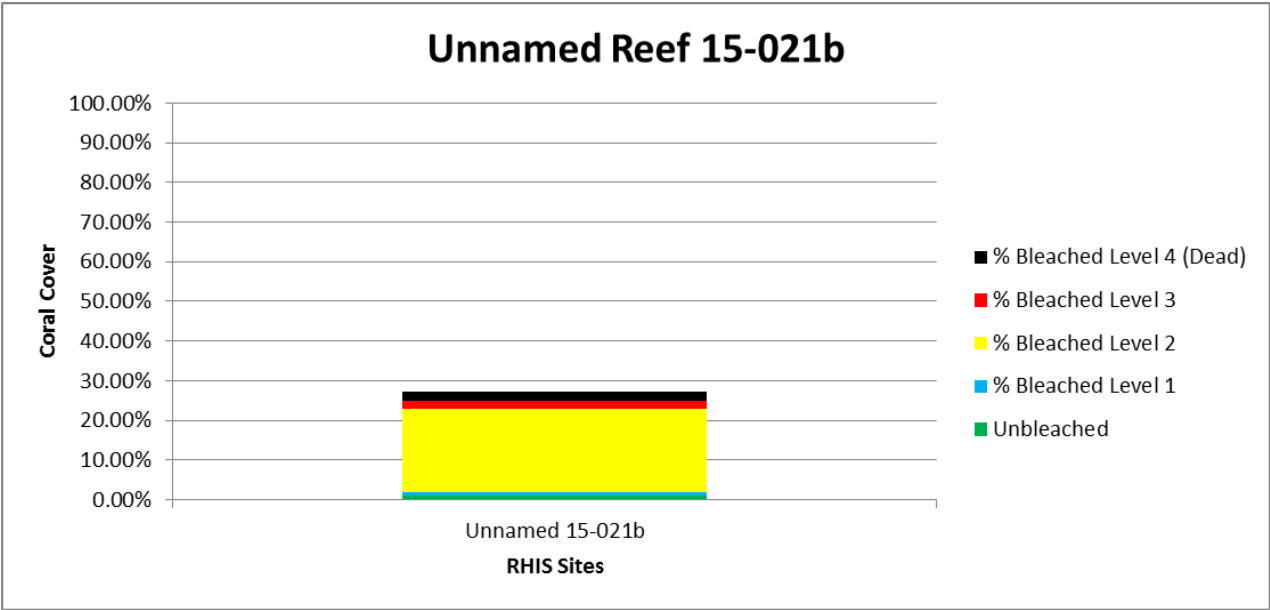


Figure 57: Coral cover at Unnamed Reef 15-021b

Forrester Reef 15-009 – RHIS Results



Figure 58: Forrester Reef RHIS Sites

Table 27: Coral bleaching severity by site, Forrester Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Forrester	Site 1	2.0	35.00%	9.88%	0.00%	21.67%	66.93%	1.52%
Forrester	Site 2	2.2	15.33%	18.44%	0.00%	46.25%	26.37%	8.94%
Forrester	Site 3	2.3	22.67%	0.00%	0.00%	39.50%	56.40%	4.10%
Forrester	Site 4	3.0	16.67%	0.00%	26.67%	12.33%	55.58%	5.42%
Forrester	Site 5	2.8	21.33%	19.81%	6.01%	9.00%	63.05%	2.13%
Forrester	Site 7	3.8	24.33%	9.59%	1.67%	61.73%	26.16%	0.86%
Forrester	Site 6	3.2	12.00%	38.76%	0.00%	57.97%	0.00%	3.27%
Forrester	Site 8	3.0	12.00%	46.48%	4.00%	48.28%	0.33%	0.92%
Forrester	Average	2.8	19.92%	18.25%	4.79%	37.09%	36.85%	3.40%

*3 surveys undertaken per site

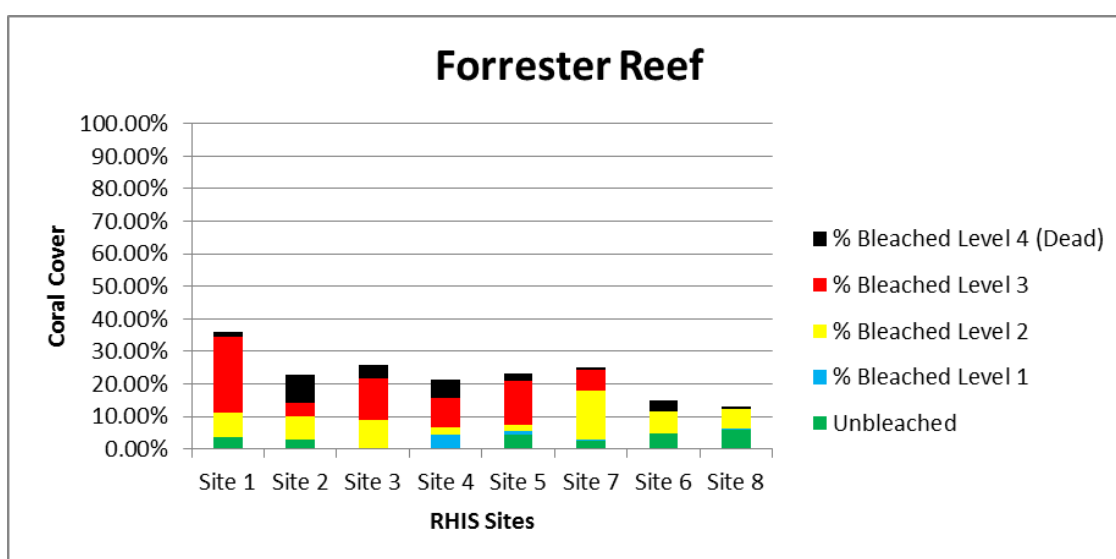


Figure 59: Coral bleaching severity by site, Forrester Reef

Overview Ribbon Reef (North) Region Reefs

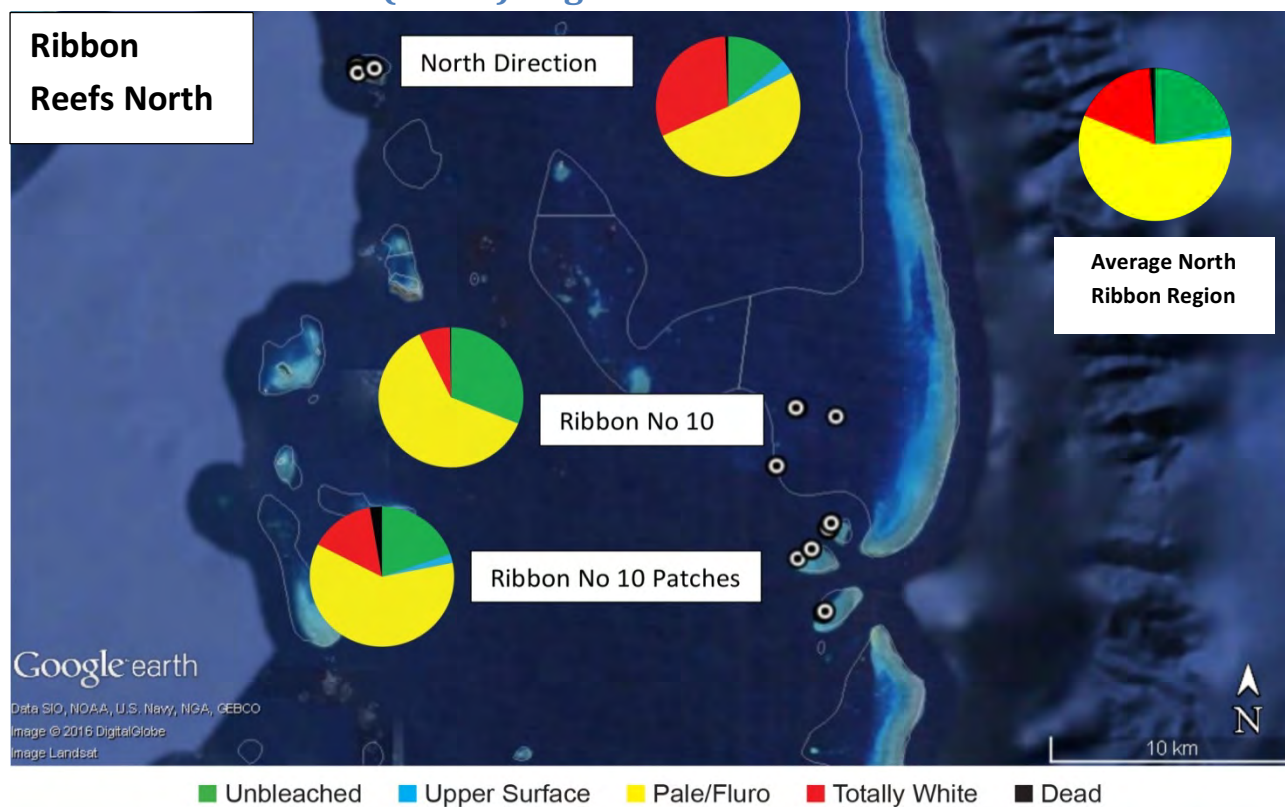


Figure 60: RHIS sites surveyed, Ribbon Reefs (North)

Table 28: Coral bleaching severity by reef, Ribbon Reefs (North)

Reef	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
No. 10 Patches	3.4	32.50%	19.76%	2.08%	60.77%	14.69%	2.70%
Ribbon No. 10	7.7	27.38%	30.99%	0.11%	61.76%	6.93%	0.22%
North Direction	4.1	17.78%	13.68%	3.33%	51.14%	31.20%	0.64%
Ribbon Reefs (North) Average	5.9	25.89%	21.48%	1.84%	57.89%	17.61%	1.19%

*3 surveys undertaken per site

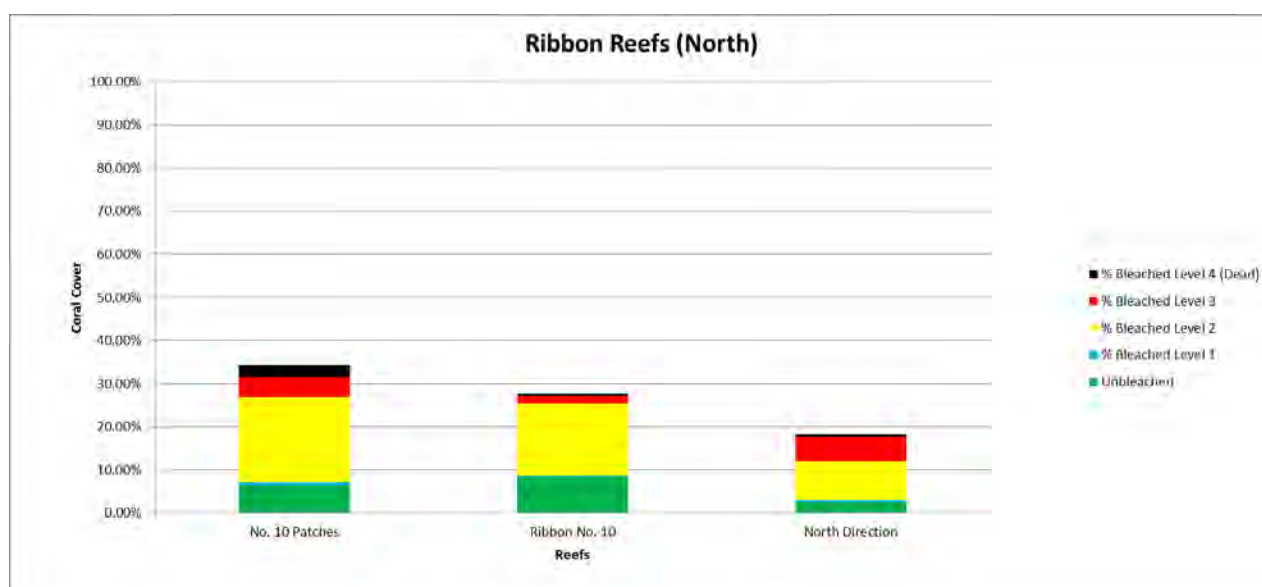


Figure 61: Coral cover by Reef, Ribbon Reefs (North)

No. 10 Patches 14-151, 14-152, 14-153 – RHIS Results



Figure 62: No. RHIS sites, No. 10 Patches

Table 29: Coral bleaching severity by site, No. 10 Patches

Reef	Site	Av. Depth (m)	%Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
No. 10 Patches (No. 2)	Pixie pinnacles	8.0	41.33%	47.51%	5.00%	44.89%	0.00%	2.60%
No. 10 Patches (No. 2)	Pixie gardens	3.0	24.67%	19.20%	3.33%	42.02%	32.37%	3.07%
No. 10 Patches (No. 1)	Challenger Bay	1.4	29.00%	5.50%	0.00%	70.63%	19.75%	4.13%
No. 10 Patches (No. 1)	No Site #1	1.0	35.00%	6.83%	0.00%	85.52%	6.64%	1.02%
No. 10 Patches	Average	3.6	37.53%	19.76%	2.08%	60.77%	14.69%	2.70%

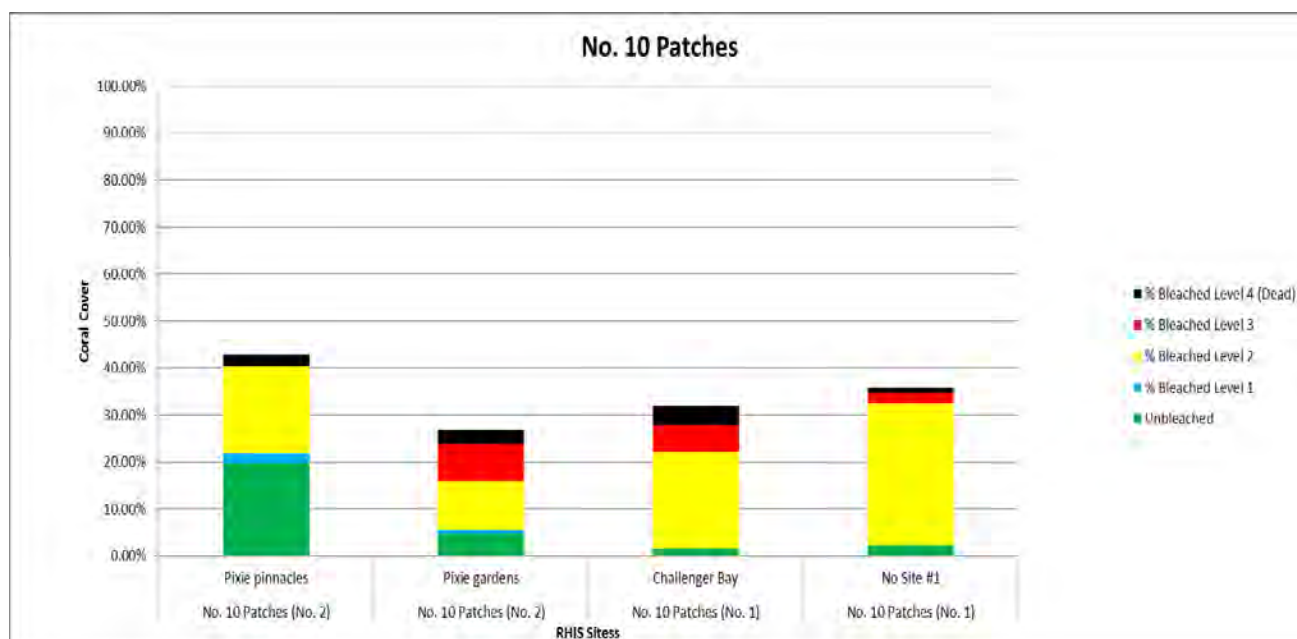


Figure 63: Coral bleaching severity by site, No. 10 Patches

Ribbon No. 10 14-146 – RHIS Results

Figure 64: Ribbon No. 10 Reef RHIS sites

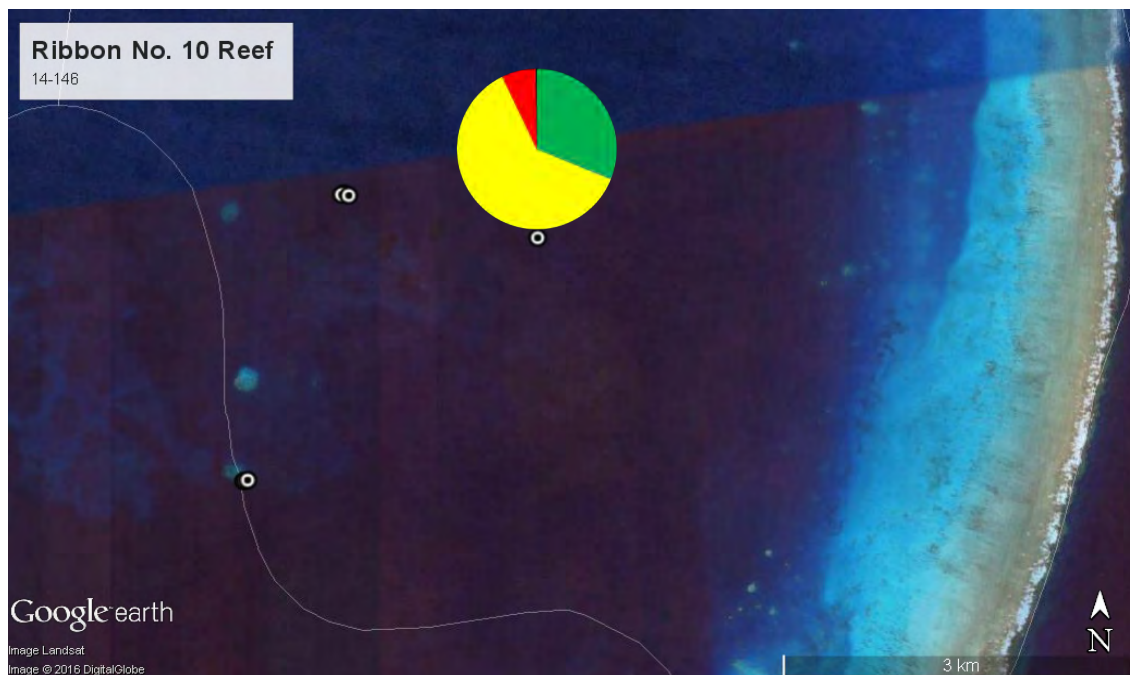


Table 30: Coral bleaching severity by site, Ribbon No. 10 Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Ribbon No. 10	Lighthouse bommie	12.0	23.33%	33.10%	0.00%	66.90%	0.00%	0.00%
Ribbon No. 10	Acropolis	8.0	23.33%	34.89%	0.00%	65.11%	0.00%	0.00%
Ribbon No. 10	Two Towers	3.0	35.47%	24.97%	0.33%	53.27%	20.79%	0.65%
Ribbon No. 10	Average	7.7	27.38%	30.99%	0.11%	61.76%	6.93%	0.22%

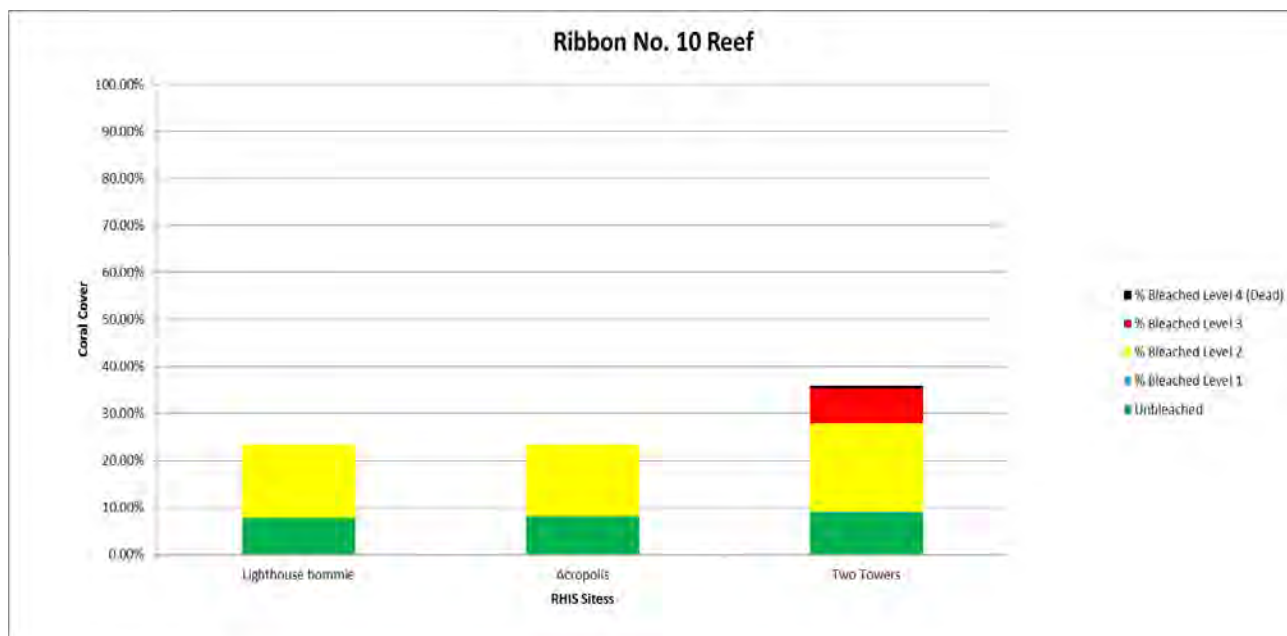


Figure 65: Coral bleaching severity by site, Ribbon No. 10 Reef

North Direction Reef 14-143 – RHIS Results

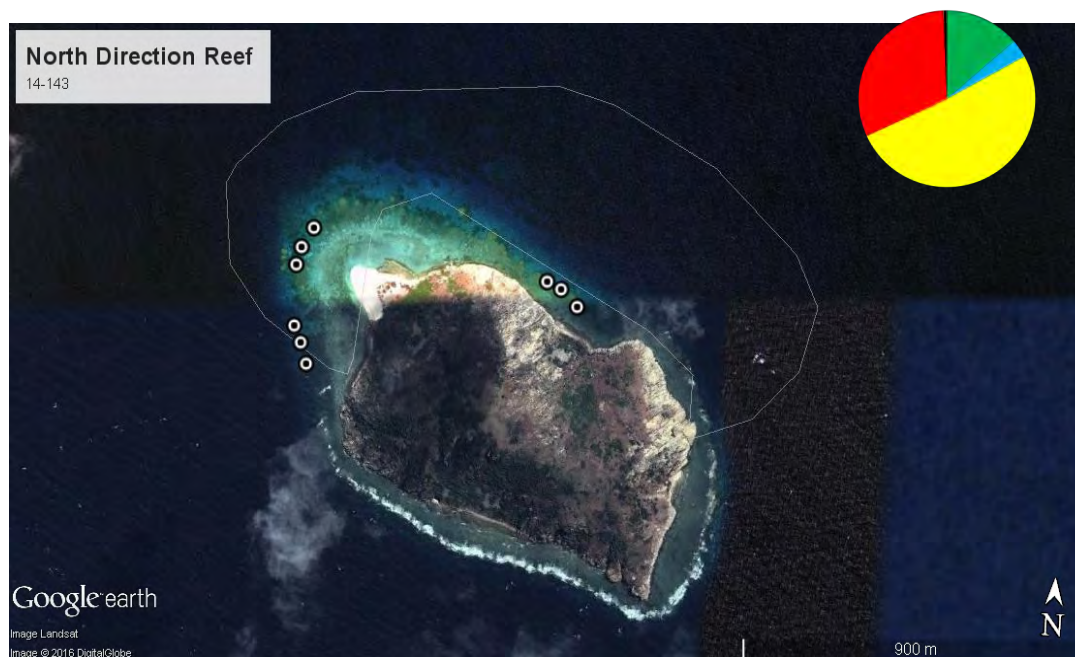


Figure 66: North Direction Reef 14-143

Table 31: Coral bleaching severity by site, North Direction Reef

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
North Direction	Site 1	2.3	14.33%	9.40%	0.00%	18.00%	71.14%	1.46%
North Direction	Site 2	4.0	8.67%	21.74%	5.00%	66.36%	6.67%	0.23%
North Direction	Site 3	6.0	30.33%	9.91%	5.00%	69.06%	15.80%	0.23%
North Direction	Average	4.1	17.78%	13.68%	3.33%	51.14%	31.20%	0.64%

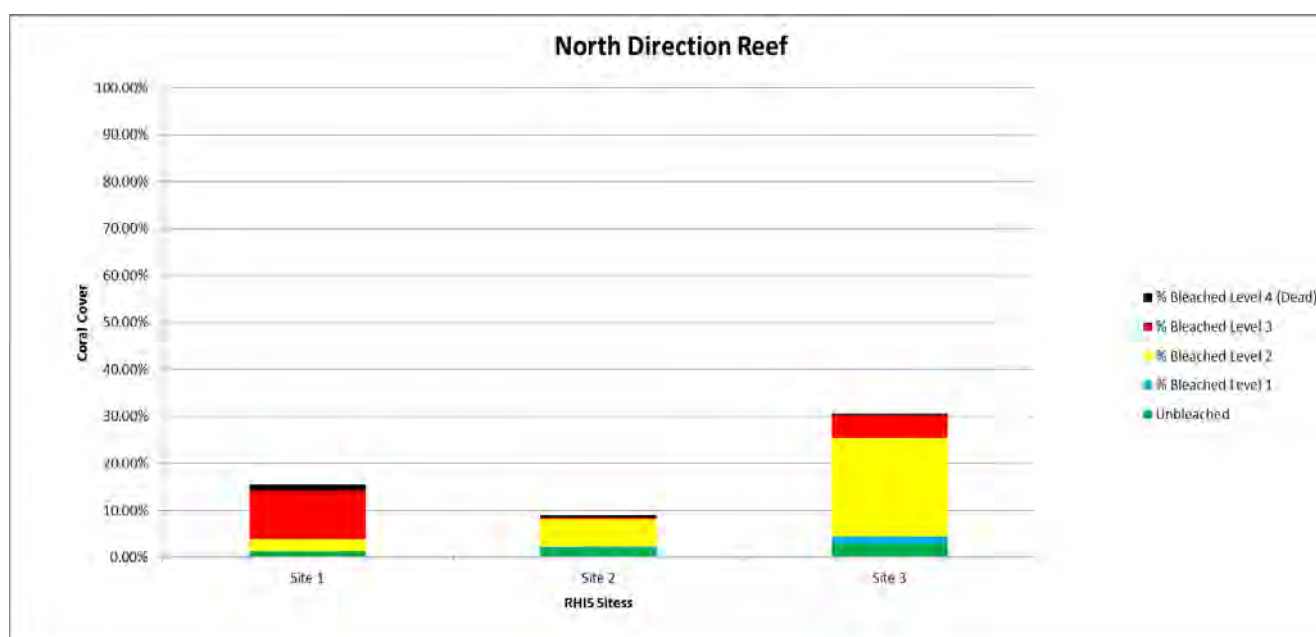


Figure 67: Coral bleaching severity by site, North Direction Reef

Appendix A

Overview Agincourt Reefs (Daintree region)

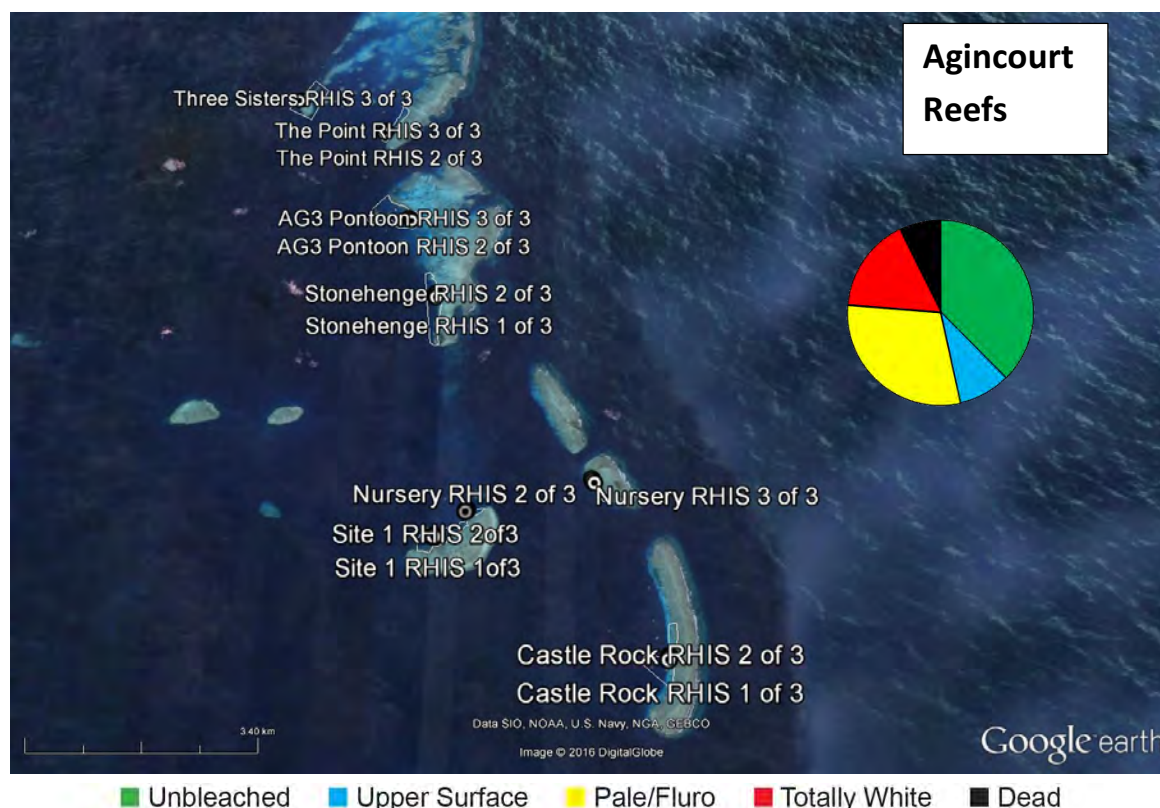


Figure 69: RHIS sites surveyed, Agincourt Reefs

Table 32: Coral bleaching severity by site, Agincourt Reefs (Bloomfield Region)

Reef	Site	Av. Depth (m)	% Coral Cover	Unbleached Coral	% Bleached Level 1	% Bleached Level 2	% Bleached Level 3	% Bleached Level 4 (Dead)
Agincourt No. 1	Castle Rock	2.3	37.66%	13.01%	2.17%	29.30%	36.79%	18.73%
Agincourt No. 2	Nursery Bommie	3.3	45.66%	35.79%	37.98%	8.15%	12.82%	5.25%
Agincourt No. 3	Stonehenge	3.7	46.67%	50.15%	0.00%	33.82%	13.27%	2.75%
Agincourt No. 3	AG3 Pontoon	2.7	44.33%	28.28%	14.73%	49.93%	2.27%	4.79%
Agincourt No. 4	Three Sisters	1.2	49.00%	32.50%	4.77%	31.28%	23.25%	8.20%
Agincourt No. 4	The Point	2.3	72.33%	41.82%	6.10%	22.17%	22.87%	7.05%
Agincourt No. 5	2D Pontoon	4.7	56.00%	42.33%	1.94%	38.47%	9.72%	7.53%
Agincourt No. 5	Turtle Bay	4.7	43.00%	56.34%	4.55%	24.62%	11.15%	3.33%
Agincourt Reefs	Average	2.6	49.28%	37.53%	9.03%	29.72%	16.52%	7.20%

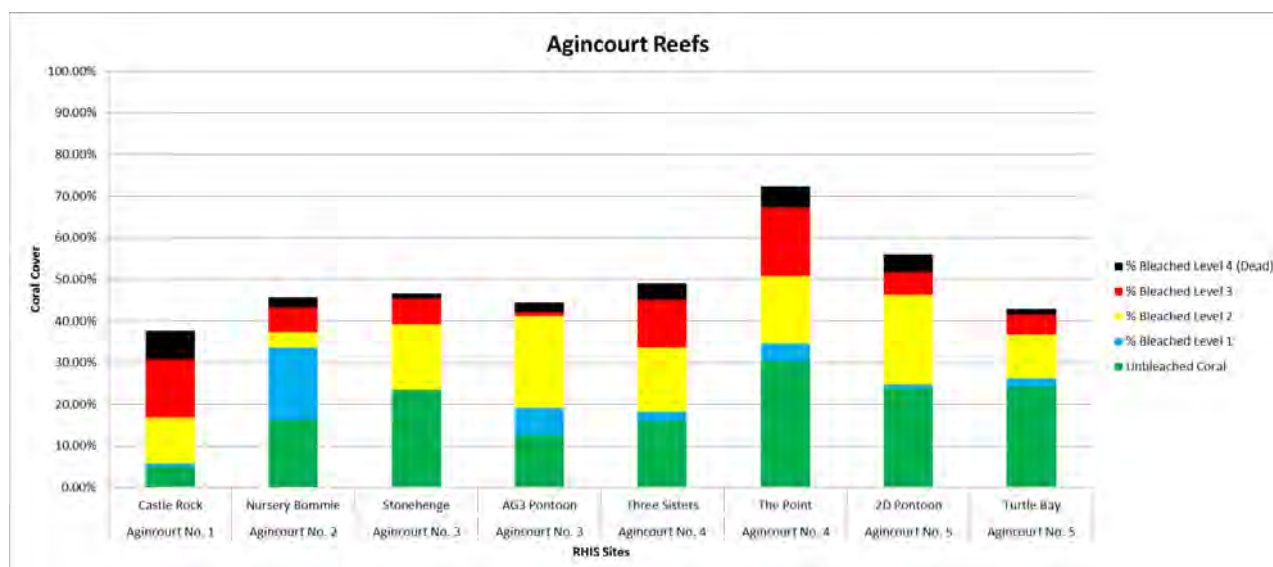


Figure 70: Bleaching severity as a proportion of the RHIS sites surveyed, Agincourt Reefs