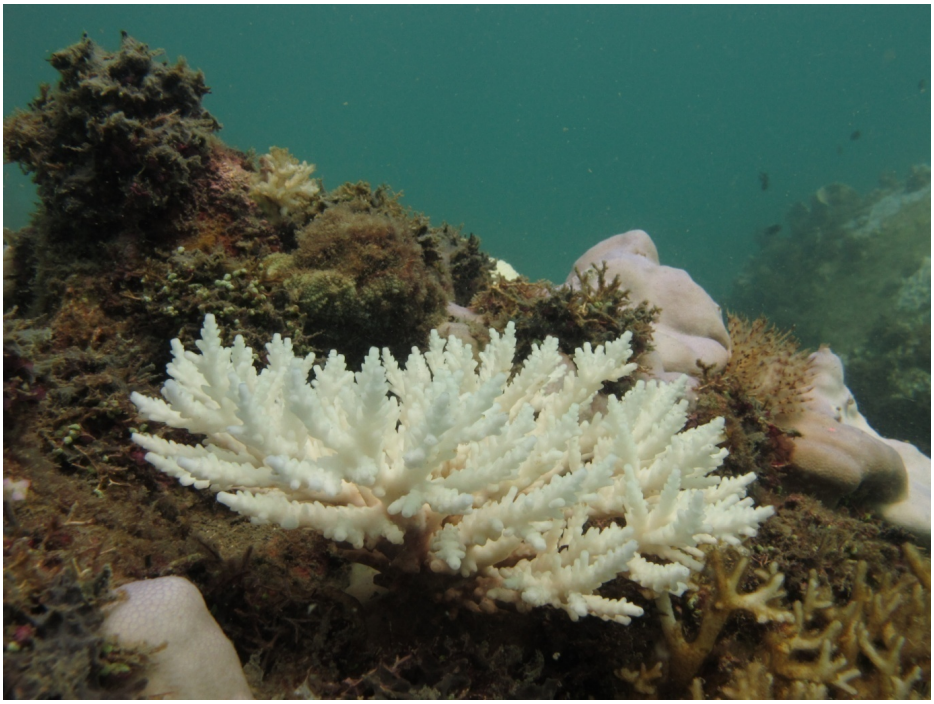
Marine Conservation Cambodia: Report on Coral Bleaching

30/08/2010



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marine conservation
CAMBODIA

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Acknowledgements

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Introduction

The coral reefs around Koh Rong Samloem, Koh Koun and Koh Rong are an essential part of the livelihood for the Community of Village 23 and integral in Cambodia's marine ecosystem. The reef is a habitat for numerous fish and invertebrate species and a healthy reef means more abundant fish life.

This report is the second in a series following a mass bleaching incident which occurred around the reefs of Koh Rong Samloem and Koh Koun in May 2010. The bleaching event affected corals and also certain invertebrates in the area.

Corals get a majority of their energy through the farming of unicellular algae (Zooxanthellae), which photosynthesize energy from the sunlight. It is these algae which give the corals their famous colours (Allen and Steene). Bleaching of the coral occurs when the algae leave the coral colony, showing nothing but the white skeleton through the coral's translucent skin. Invertebrates such as giant clams and anemones also use zooanthellae and are therefore vulnerable to bleaching. Bleaching tends to happen when the coral is put under stress. Stressors include long-term change in water temperature, change in water pH and increase in light intensity.

Luminescence of the coral is an indicator of stress before the final bleached stage. The process of luminescence is a reaction of the zooxanthellae to increased sun exposure and acts as a sunscreen. The algae pigment cells react to the additional sun energy by breaking up the sunlight into the colour spectrum and expelling the more damaging energies, giving the coral a new, flourescent colour. Near the end of this process, if the health of the coral is not improving, the algae leave the zooxanthellae and the coral is considered bleached.

The fate of the bleached coral is dependent on the ability of the coral to out-compete algae. Bleached coral may recover if zooxanthellae return to the coral. Recovery of corals may take place because there are different species of zooanthellae, corals may replace the expelled zooanthellae with a better adapted species. It has been documented that corals that recover zooxanthellae within four to six months after a bleaching event are more likely to return to a healthy state and not be colonised by algae (Diaz-Pulido and McCook 2002).

Locations Map

Below is a map which shows both the areas currently being studied for the effects of coral bleaching and general reef health within the community fishing area.

Figure 1 - Map of Main Survey Sites

Table 1 - The four survey sites

Site Designation	Local Name
1	Corner Bar
2	Back Door
3	Beach Bar
4	House Reef

All the sites were chosen for their abundance and diversity of coral and other benthic life likely to be affected by bleaching as well as their popularity with local dive centres and as fishing grounds.

Methodology

Reef survey equipment

- Tape measure, at least 30m long
- Slate with pencil for each survey person
- Reserve pencil
- Dive computer

The tape measure is placed at 5 m depth (3 m depth for House Reef) and unrolled to the 30 m marker. Along the 30 m tape measure, 10 areas of 2 m^2 (1 m x 2 m, 5 areas on each side of the tape) are observed by two surveyors (each surveyor does 5 areas along one side of the tape) for the percentage coverage of healthy, luminous, half bleached and completely bleached hard corals of the three life forms, including massive, submassive and encrusting. The percentage coverage of dead coral covered with algae is also noted.

Two other surveyors note the health status of mushroom, tabulate, branching and foliose hard corals over an area of 30 m x 3 m on both sides of the tape measure. The number of healthy, luminous, half bleached, completely bleached hard corals of these four life forms is counted to give an estimation of the health status of these corals. The number of dead corals of these life forms covered with algae is also noted. In addition, the number of healthy, luminous, half bleached and completely bleached giant clams and anemones is also determined.

The following types of coral life forms are noted, as are giant clams and anemones, which also suffer from bleaching:

Table 2- Types of hard coral surveyed and notation used in the graphs

Type of Coral	Notation Used
Hard Coral Massive	HCMA
Hard Coral Submassive	HCSM
Hard Coral Encrusting	HCEN
Hard Coral Mushroom	HCMU
Hard Coral Tabulate	HCTA
Hard Coral Branching	HCBR
Hard Coral Foliose	HCFO
Dead Coral with Algae Coverage	DWA

Carly 9/7/10 6:10 PM
Comment [1]: Actually table 2 will need to change the numbers of all tables

Standard statistical 2 tailed, paired t-tests were used to compare data from June 2010 and August 2010.

Results

The following results have been collected on a dive at each site as a way of presenting the current situation. Surveys were conducted on the same dive sites but not at the exact location as the previous report.

The following figures present the data collected during one dive at each dive site.

Bleaching by Dive Site

To assess the amount of bleached coral, transect surveys were done on each dive site and the type of damage to different corals, anemones and giant clams was noted and recorded before undergoing collation and analysis.

Health status of coral on Corner Bar

Corner Bar's coral life forms are relatively healthy, with encrusting coral being the healthiest. There was also a large proportion of encrusting coral that was half bleached and luminescent (Fig.2). The majority of massive corals were either dead or half bleached however a large percentage was considered healthy (Fig. 2). Submassive corals at Corner Bar were mainly half bleached but a great deal were also healthy. From transect data it was found that no submassive corals were actually suffering from bleaching (Fig.2).

Branching corals suffered the highest rates of bleaching, closely followed by tabulate corals. All the anemones on the transect were healthy also mushroom corals where relatively healthy. All giant clams were luminescent. 50% of foliose corals were half bleached and 20% healthy (Fig. 3).

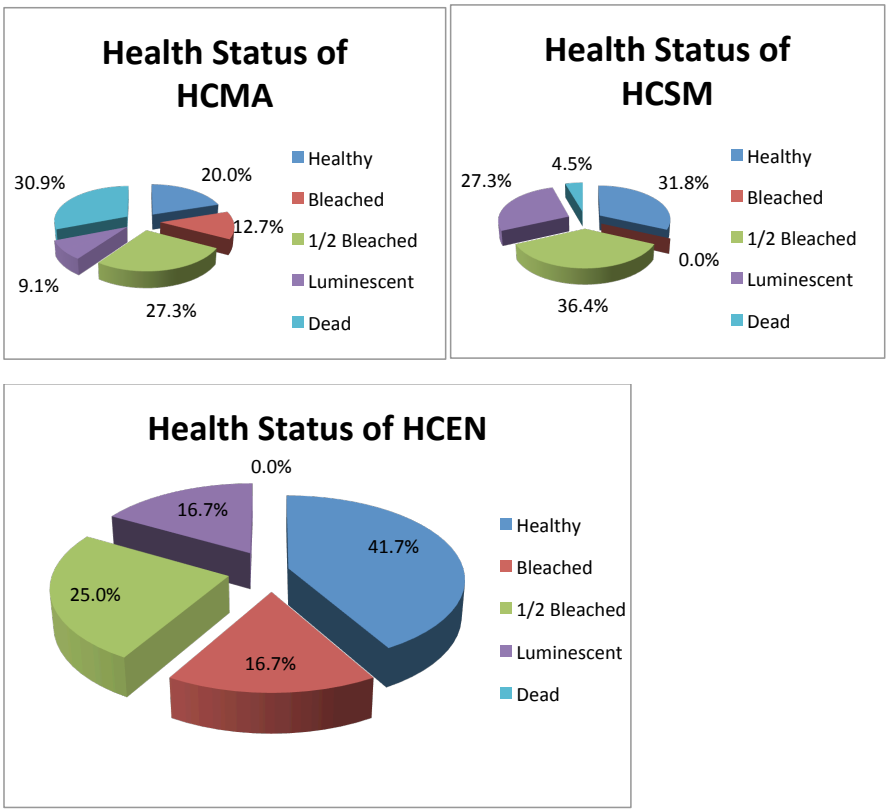

Figure 2 – Health status statistics of hard coral life forms at Corner Bar (Site 1)

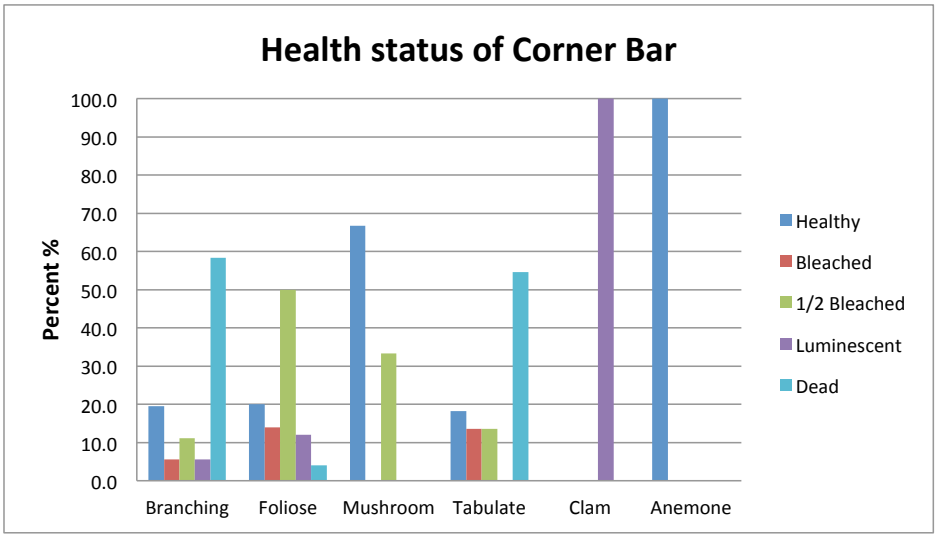

Figure 3- Bleaching statistics for coral types and select invertebrates at Corner Bar (Site 1)

Health status of coral on Beach Bar

On Beach Bar submassive corals were the healthiest of all the coral life forms. However, there was a large proportion recorded as dead. The majority of massive corals were showing signs of being half bleached. There were equal proportions of encrusting coral healthy and dead; there were no observed signs of bleaching (Fig. 4).

The majority of branching coral at Beach Bar were dead and covered in algae, no branching corals were suffering from bleaching. The health status of foliose corals was relatively acceptable with most half bleached or healthy. Mushroom corals were the healthiest with 58% classed as healthy. Tabulate corals on the whole were relatively healthy but 23% were either bleached or dead. 50% of giant clams were healthy while the other 50% were luminescent. There were no anemones present on the transect line (Fig. 5).

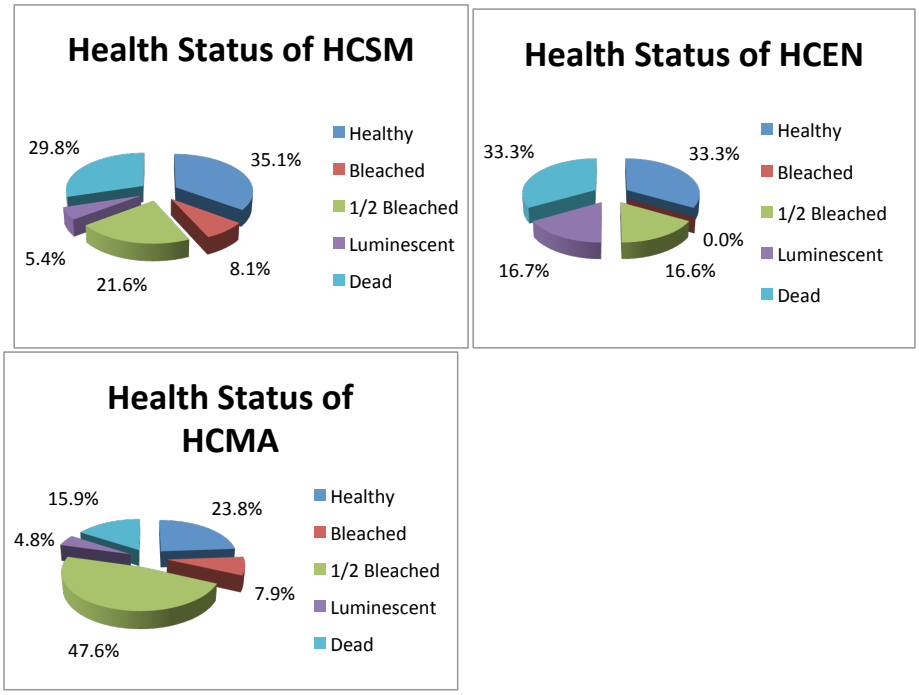

Figure 4- Health status statistics for coral life forms at Beach Bar (Site 2)

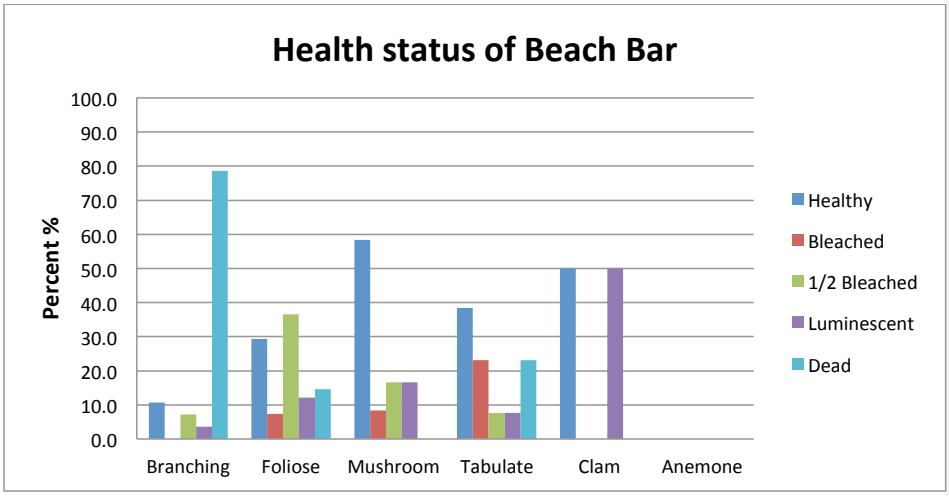

Figure 5- Bleaching statistics for coral types and select invertebrates for Beach Bar (Site 2)

Health status of coral on House Reef

There were equal proportions of bleached, half bleached, luminescent and dead encrusting coral present on house reef. There was no encrusting coral that was classed as healthy. A high portion of submassive corals were healthy. Most of the massive corals were half bleached, a considerable percentage however were healthy (Fig. 6).

Mushroom corals were mainly healthy as were the giant clams. All anemones on the transect were suffering from bleaching to some extent. There were high percentages of branching, foliose and tabulate corals that were healthy. However branching coral also had the same percentage that had died (Fig. 7)

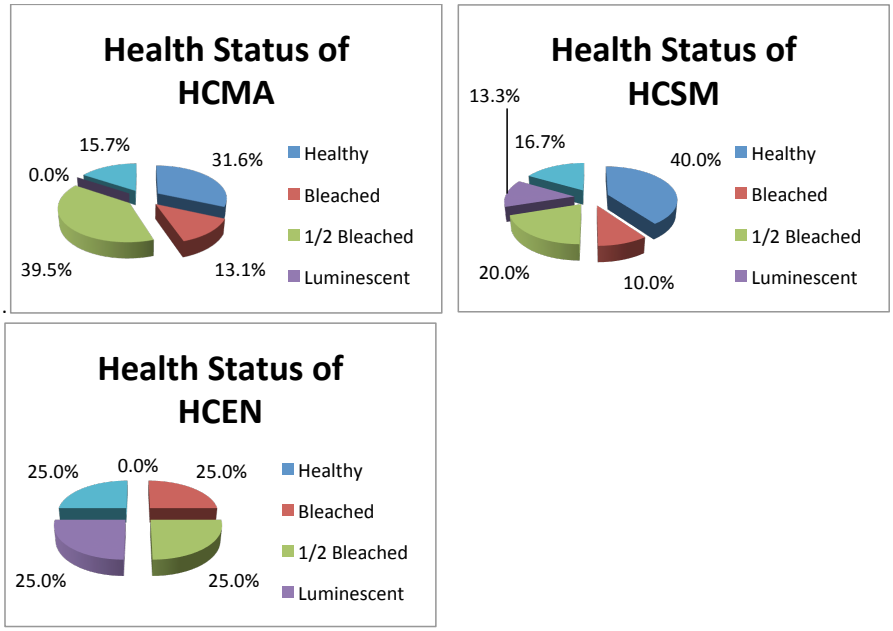

Figure 6- Health status of coral life forms on House Reef (Site 3)

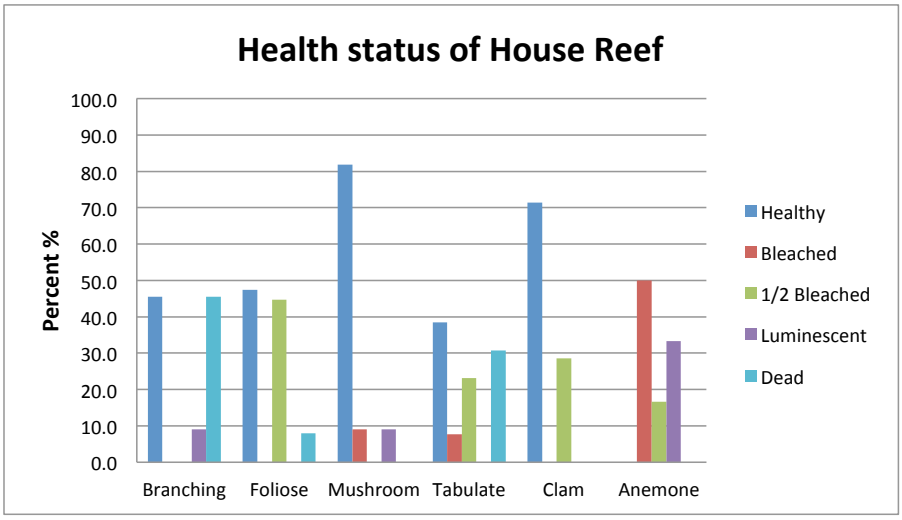

Figure 7- Bleaching statistics for coral types and select invertebrates for House Reef (Site 3)

Health status of Back Door

Figure 8 shows that most coral life forms are actually fairly healthy on Backdoor. Yet massive corals also had a high percentage that were dead. Submassive and encrusting corals were also showing high numbers that were luminescent or half bleached respectively.

On the transect 100% of the clams were healthy and 100% of anemones were luminescent. Foliose corals were mostly healthy. Mushroom and tabulate corals were suffering badly from bleaching. A high number of branching corals were dead; nonetheless 45% were still healthy (Fig. 9).

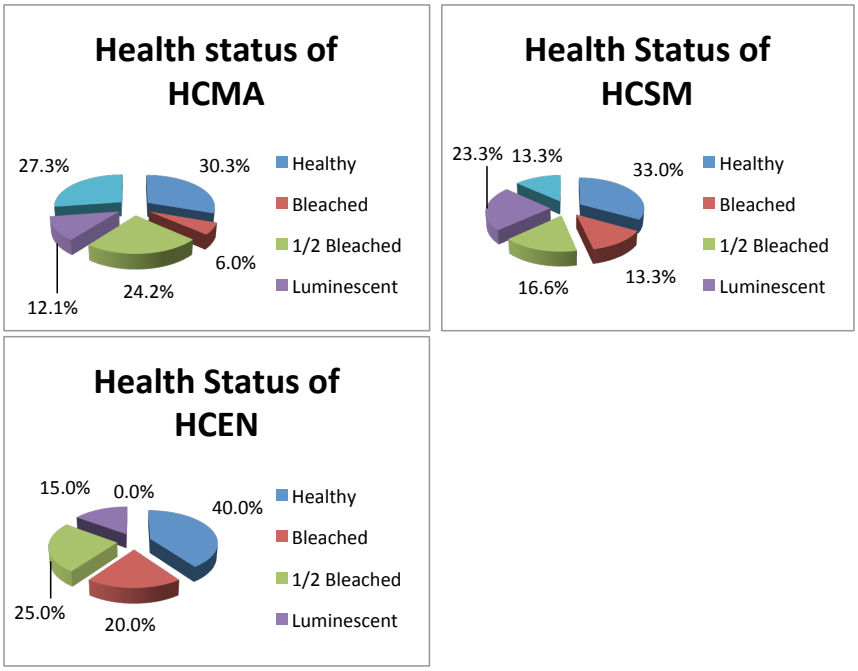

Figure 8- Health status statistics for coral life forms on Backdoor (Site 4)

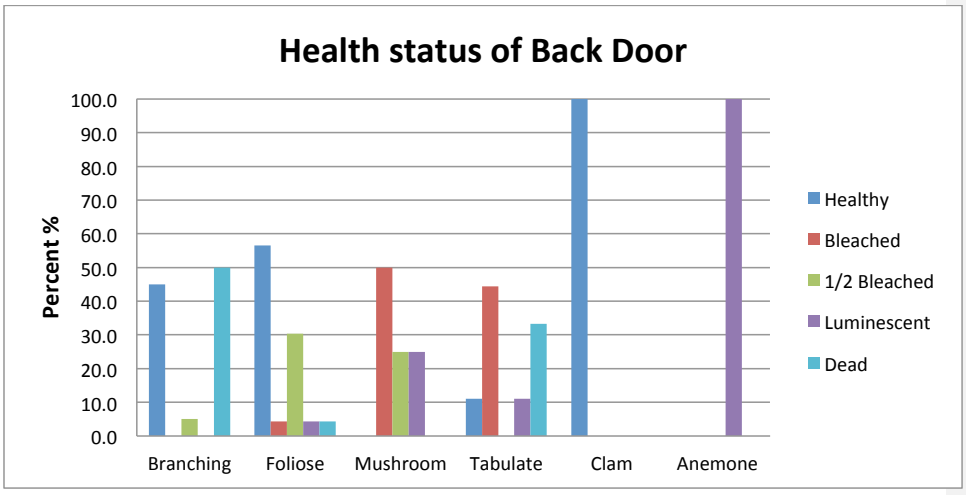

Figure 9- Bleaching statistics for coral types and select invertebrates at Backdoor (Site 4)

Month to Month Comparison of Results

To understand the changes and rates of recovery to the ecosystem around Koh Rong Samloem and Koh Koun it is necessary to keep a record of monthly results and compare on a month by month basis. Below are the results from June 2010 and August 2010 for each dive site.

Corner Bar

The overall percentage of healthy coral has significantly increased in August compared with June (P=0.013). There was also a significant decrease in bleached coral in August (P=0.039). In August there was a trend for the presence of half bleached corals and luminescent corals to decrease however results show that this trend was not significant (P=0.33, P=0.56 respectively). Standard t tests were not used for analysing dead coral trends as a portion of data was missing. Though the general trend does seem to indicate an increase in dead corals (Table 3).

Table 3-Health status comparison for June and August 2010 at Corner Bar (Site 1)

% Dist	Healthy		Bleached		1/2 Bleached		Luminescent		Dead	
Branching	2.0	19.4	30.0	5.6	8.0	11.1	30.0	5.6	30.0	58.3
Foliose	6.0	20.0	23.0	14.0	35.0	50.0	24.0	12.0	12.0	4.0
Mushroom	4.0	66.7	42.0	0.0	35.0	33.3	19.0	0.0	0.0	0.0
Tabulate	3.0	18.2	11.0	13.6	9.0	13.6	50.0	0.0	27.0	54.5
Clam	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0
Anemone	0.0	100.0	58.0	0.0	0.0	0.0	42.0	0.0	0.0	0.0
Massive	2.0	20.0	11.0	12.7	35.0	27.3	20.0	9.1		30.9
Submassive	5.0	31.8	24.0	0.0	49.0	36.4	20.0	27.3		4.5
Encrusting	0.0	41.7	21.0	16.7	30.0	25.0	46.0	16.7		0.0

June
August

Beach Bar

As can be seen from Table 4 there has been a significant increase (P=0.003) in healthy corals in August. There was also a significant decrease in bleached (P=0.005) and luminescent (0.018) corals present at Beach Bar. The presence of half bleached corals were similar in both June and August. Dead corals underwent no statistical analyses due to absent data however there seems to be a general increase in dead corals in August.

Table 4- Health status comparison for June and August 2010 at Beach Bar (Site 2)

% Dist	Healthy		Bleached		1/2 Bleached		Luminescent		Dead	
Branching	3.0	10.7	23.0	0.0	10.0	7.1	41.0	3.6	23.0	78.6
Foliose	6.0	29.3	21.0	7.3	25.0	36.6	27.0	12.2	21.0	14.6
Mushroom	9.0	58.3	68.0	8.3	9.0	16.7	9.0	16.7	5.0	0.0
Tabulate	4.0	38.5	34.0	23.1	27.0	7.7	29.0	7.7	15.0	23.1
Clam	30.0	50.0	10.0	0.0	30.0	0.0	30.0	50.0	0.0	0.0
Anemone	0.0	0.0	33.0	0.0	0.0	0.0	67.0	0.0	0.0	0.0
Massive	17.0	23.8	19.0	7.9	15.0	47.6	58.0	4.8		15.9
Submassive	5.0	35.1	21.0	8.1	21.0	21.6	50.0	5.4		29.7
Encrusting	17.0	33.3	11.0	0.0	22.0	16.7	57.0	16.7		33.3

June
August

House Reef

House Reef is significantly more healthy in August than in June (P= 0.002). The percentage of luminescent corals and invertebrates also significantly decreased (P= 0.0007) over the same period. There was no significant change in the numbers of bleached (P= 0.39) and half bleached corals (P=0.57). The percentage of dead corals tended to increase (Table 5) however a statistical analysis was not preformed on the data.

Table 5- Health status comparison on House Reef (Site 3) for June and August 2010

%Dist	Healthy		Bleached		1/2 Bleached		Luminescent		Dead	
Branching	3.0	45.5	21.0	0.0	10.0	0.0	48.0	9.1	18.0	45.5
Foliose	19.0	47.4	7.0	0.0	23.0	44.7	30.0	0.0	21.0	7.9
Mushroom	13.0	81.8	19.0	9.1	40.0	0.0	26.0	9.1	2.0	0.0
Tabulate	0.0	38.5	12.0	7.7	3.0	23.1	68.0	0.0	17.0	30.8
Clam	13.0	71.4	50.0	0.0	35.0	28.6	2.0	0.0	0.0	0.0
Anemone	0.0	0.0	33.0	50.0	0.0	16.7	67.0	33.3	0.0	0.0
Massive	3.0	31.6	30.0	13.2	15.0	39.5	51.0	0.0		15.8
Submassive	1.0	40.0	3.0	10.0	12.0	20.0	82.0	13.3		16.7
Encrusting	0.0	0.0	0.0	25.0	23.0	25.0	87.0	25.0		25.0

June
August

Back Door

Backdoor showed improvement this month with significant increase (P=0.011) in healthy corals present. There was also a significant decrease (P=0.011) in the percentage of luminescent corals. There was no significant decrease in bleached (P=0.74) and half bleached (P=0.31) corals however the figures in August show a slight tendency for numbers to decrease. Though no statistical analyses was performed the general trend was for an increase in the percentage of dead corals (Table 6).

Table 6- Health status comparison for June and August 2010 for Backdoor (Site 4)

% Dist	Healthy		Bleached		1/2 Bleached		Luminescent		Dead	
Branching	0.0	45.0	31.0	0.0	9.0	5.0	21.0	0.0	40.0	50.0
Foliose	5.0	56.5	21.0	4.3	29.0	30.4	35.0	4.3	10.0	4.3
Mushroom	16.0	0.0	46.0	50.0	11.0	25.0	25.0	25.0	2.0	0.0
Tabulate	0.5	11.1	8.0	44.4	7.0	0.0	60.0	11.1	24.5	33.3
Clam	44.0	100.0	0.0	0.0	22.0	0.0	34.0	0.0	0.0	0.0
Anemone	0.0	0.0	17.0	0.0	0.0	0.0	83.0	100.0	0.0	0.0
Massive	8.0	30.3	14.0	6.1	51.0	24.2	27.0	12.1		27.3
Submassive	3.0	33.3	15.0	13.3	11.0	16.7	58.0	23.3		13.3
Encrusting	1.0	40.0	6.0	20.0	28.0	25.0	65.0	15.0		0.0

June
August

Final Analysis

Table 7- Average percentage differences for all sites

House Reef	June	August	Difference
Avg % Healthy	5.8	39.6	+33.8
Avg % Bleached	19.4	12.8	-6.6
Avg % 1/2 bleached	17.8	21.9	+4.1
Avg % Luminescent	51.2	10	-41.2
Avg % Dead	9.7	15.7	+6

Corner Bar	June	August	Difference
Avg % Healthy	2.4	35.3	+32.9
Avg % Bleached	24.4	7	-17.4
Avg % 1/2 bleached	33.4	21.9	-11.5
Avg % Luminescent	27.9	19	-8.9
Avg % Dead	11.5	19.4	+7.9

Beach Bar	June	August	Difference
Avg % Healthy	10.1	31	+20.9
Avg % Bleached	26.7	6.1	-20.60
Avg % 1/2 bleached	17.7	17.1	-0.60
Avg % Luminescent	40.9	13	-27.90
Avg % Dead	10.7	21.7	+11.0

Back Door	June	August	Difference
Avg % Healthy	8.6	35.1	+26.5
Avg % Bleached	17.5	15.4	-2.1
Avg % 1/2 bleached	18.6	14	-4.6
Avg % Luminescent	45.3	21	-24.3
Avg % Dead	12.72	14	+1.3

As can be seen from table 7 all sites have a greater average of healthy coral in August compared to June 2010. However, there has been a minor increase of dead corals observed across all sites. The red numbers represent a negative impact on the environment. One anomalous result is that on House Reef where half bleached corals have slightly increased.

Dead corals were not counted in the June surveys for the Massive, Submassive and Encrusting coral life forms. This lack of data explains why in some graphs and tables the percentages may not add to 100. The results shown of dead corals in these tables from June are purely from the Branching, Foliose, Mushroom, Tabulate, Clam and Anemone data.

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Conclusions

At all sites similar results were obtained but to varying degrees (Table 6). Across all sites health improved especially at House Reef and Corner Bar. All sites also saw decreases in signs of bleaching and luminescent corals. One exception to this is house reef where half bleached coral increased slightly. This anomalous result could be due to the survey methodology. The same sites were surveyed in August as in June and methodology was replicated, transects laid at the same depths. However, the transects were not replicated at the exact locations as the previous month. Therefore the same corals were not surveyed, this is a limitation of the data and could therefore result in anomalies in the results. However results are still comparable and the data gives us an overall picture of each reef as a whole.

The trend in results can be explained through the biology of corals and how corals recover after a bleaching event. Perhaps the most surprising result is the speed of recovery. There is a cycle that corals follow after suffering stress. When the stressor is removed, in this case oceanic temperatures decreased with the coming of the rainy season, corals either are strong enough to recover in the following months or will be out competed by algae and die.

The increase in dead corals shows the severity of the original bleaching incident in May 2010. A large portion of the bleached corals in June were unable to recover zooanthelle and were eventually outcompeted by algae in the two months since the first survey. This also explains the decrease in completely bleached corals in August because the majority of previously bleached corals have either been too damaged to recover and died or have been able to regain some of the zooanthelle and now are most likely the half bleached corals that were observed in August.

The decrease in luminescent corals and invertebrates is also to be expected as luminescence is the initial survival mechanism when put under stress. Corals cannot stay luminescent for a lengthy period of time it is simply the first reaction to stress. If the coral was able to endure the stress the zoonathelle will have stayed in the coral and in August it would have appeared relatively healthy. If the stress was too much then perhaps some of the bleached corals witnessed in the August surveys were corals that were previously luminescent.

In the waters around Koh Rong Samloem and Koh Koun there is a high amount of sedimentation. This is an added stress which could be another factor in the high percentages of dead corals (Table 6). Sedimentation decreases the amount of light that the zooanthelle need to produce energy for the corals therefore hampering the rate of coral recovery. When the sediment settles on the corals it can suffocate the corals as well as providing nutrients for algae growth.

Some small limitations that may affect the data and produce anomalies is the fact that transects were not completed on exactly the same locations at each research site, however as previously mentioned this also allows us to get a picture of the entire reef system as a whole. Another is that different research volunteers were assisting on the transects and when measuring the extent of bleaching and damage in an area there is always a small amount of human error. The lack of certain coral and invertebrate types on a transect can also provide misleading results as several times only one or two giant clams and anemones were on a transect line.

Overall with the sudden decrease in oceanic temperatures bought on by the wet season it appears that the majority of corals have relatively high rates of recovery. It is a good sign that in two months there has been significant increases in health at all sites and continuing reaserch by MCC over the next four months will assess whether reefs will make a satisfactory recovery.

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