Coral Monitoring Post-dredging Report

Ichthys Nearshore Environmental Monitoring Program

L384-AW-REP-10103

Prepared for
INPEX

August 2015

Document Information

Prepared for	INPEX
Project Name	Ichthys Nearshore Environmental Monitoring Program
File Reference	L384-AW-REP-10103_Rev0_Coral Monitoring Post-dredging Report.docm
Job Reference	L384-AW-REP-10103
Date	August 2015

Contact Information

Cardno (NSW/ACT) Pty Ltd
Level 9, The Forum
203 Pacific Highway
St Leonards NSW 2065

Telephone: 02 9496 7700
Facsimile: 02 9499 3902
International: +61 2 9496 7700
www.cardno.com.au

Cardno (WA) Pty Ltd
11 Harvest Terrace
West Perth WA 6005

Telephone: 08 9273 3888
Facsimile: 08 9486 8664
International: +61 8 9273 3888
www.cardno.com.au

Cardno (NT) Pty Ltd
Level 6, 93 Mitchell Street
Darwin NT 0800

Telephone: 08 8942 8200
Facsimile: 08 8942 8211
International: +61 8 8942 8211
www.cardno.com.au

Document Control

Version	Date	Author	Author Initials	Reviewer	Reviewer Initials
A	28/04/2015	Chris Roberts Dr Andrea Nicastro Dr Mathieu Pernice Dr Craig Blount	CR AN MP CB	Dr Isabel Jimenez	IJ
B	25/06/2015	Dr Andrea Nicastro	AN	Dr Craig Blount	CB
C	30/07/2015	Dr Andrea Nicastro	AN	Dr Craig Blount	CB
0	25/08/2015	Dr Andrea Nicastro Dr Craig Blount	AN CB	Dr Lachlan Barnes	LB

Executive Summary

The Coral Monitoring Program was developed to monitor potential changes in coral health indicators in Darwin Harbour as a result of dredging and/or spoil disposal activities associated with the Ichthys LNG Project (the Project). The Baseline Phase of three coral surveys was undertaken from June 2012 to August 2012 prior to the commencement of dredging. During the Dredging Phase, the monitoring program involved regular sampling of individually tagged coral colonies and repeat surveys of permanent transects to determine trends in the condition of corals at the reactive sites throughout Darwin Harbour. To assist with interpretation of the mechanisms and drivers of patterns and processes observed in the coral communities and to determine if dredging was having an influence, indicators of coral health were collected in parallel with data for the Water Quality and Subtidal Sedimentation Monitoring Program.

Season One dredging commenced on 27 August 2012 and ceased on 30 April 2013. Season Two dredging commenced on 23 October 2013 along the gas export pipeline (GEP) route, then in East Arm (EA) on 1 November 2013 and ceased on 12 July 2014 and 11 June 2014 respectively. This report outlines the findings of the Post-dredging Phase of coral monitoring surveys (P_{RS}: 5 July 2014 to 9 July 2014, P1: 18 August 2014 to 22 August 2014; P2: 16 October 2014 to 20 October 2014; P3: 14 December 2014 to 18 December 2014) and covers the intervening period since the end of survey D13 (11 June 2014). Results are presented for reactive coral sites Channel Island, Weed Reef 1 and Weed Reef 2 and informative Impact sites South Shell Island and Northeast Wickham Point in EA and contingency site Mandorah. The four Post-dredging Phase surveys following the cessation of dredging provide a means to investigate potential short-, medium-, or longer-term changes to coral health indicators at the monitoring sites since the completion of Project dredging activities.

During the monitoring program all sites (informative and reactive) have shown a consistent increasing trend in partial mortality of tagged corals, which is entirely expected for living corals that eventually die from natural causes. However, the extent of mortality differed among the sites. Natural differences in the rate of coral mortality between sites are likely due to inherent spatial variability in terms of the physical environment of sites as well as their biological characteristics. All of which make it challenging to discriminate this variability from potential effects of dredging.

During the Post-dredging Phase, the measured coral mortality of tagged corals at reactive sites Channel Island, Weed Reef 1 and Weed Reef 2 remained below the Generalised Linear Mixed Model (GLMM; the model) mean partial mortality prediction for each site (e.g. predicted level of natural mortality). Mortality at informative Impact sites Northeast Wickham Point and South Shell Island was primarily above the predicted mean mortality of the model in Post-dredging Phase surveys but lower than the 95% upper confidence limit (UCL), which was the trigger value used in the Dredging Phase at reactive sites.

Rates of mortality at sites during the Dredging Phase were considered to be natural with the exception of South Shell Island between April 2014 (Dredging survey 11) and June 2014 (Dredging survey 13), which had a potential dredge influence and temporary increase in perceived mortality (sediment cover). As partial mortality decreased or remained unchanged in the subsequent surveys, this indicates the sediment cover was temporary and overlaying live coral tissue that was exposed in subsequent surveys.

Species composition contributed greatly to the mortality at South Shell Island, which was the highest for all sites between the Baseline and Post-dredging Phases. This was partly due to the low number of tagged Faviidae and Dendrophyllidae colonies which have generally shown less partial mortality at all sites, and the large number of tagged Pectiniidae and Poritidae which have shown substantially greater partial mortality at many sites. Although Pectiniidae and Poritidae corals (i.e. the most prevalent species at South Shell Island) had shown high levels of mortality at many sites in Darwin Harbour, the level of mortality for these families, particularly Pectiniidae, were among the highest at South Shell Island. Although the composition of taxa played a large role in the high mortality at South Shell Island, it may have not been the sole driver. Low profile growth forms of Pectiniidae are known to be highly susceptible to increases in sedimentation and turbidity, among other factors, and the elevated levels of turbidity and reduced light that occurred in EA at times during Season Two dredging potentially had an influence.

At Channel Island, Weed Reef 1 and Northeast Wickham Point there were no differences indicative of a decline in coral cover from the Baseline Phase to the Post-dredging Phase. A decline in coral cover at Weed Reef 2 was recorded during the Dredging Phase following a thermal bleaching event, where water temperatures exceeded 32°C. The patterns in coral bleaching observed in the Coral Monitoring Program indicate bleaching is likely to be an annual phenomenon in Darwin Harbour that can occur when water temperatures rise above 30°C. It is likely that the rate at which temperatures rise above 30°C, the duration of this warm water and the timing, frequency, intensity and duration of wet season tropical storms all have an influence on the timing and intensity of bleaching..

In the Post-dredging Phase, coral cover at South Shell Island was less than the Baseline Phase, with a decline in coral cover primarily occurring between D7 (October 2013) and the Post-dredging Phase. This likely reflects a site-wide trend in the loss of corals at South Shell Island, with 51% of tagged corals missing by the end of the Post-dredging Phase at South Shell Island, more than double any other site. Coral loss is defined in this instance as missing corals that could not be located and therefore were not available for analysis. For South Shell Island it is likely that the missing corals have ‘rolled-away’ down the unconsolidated slope. The loss of these corals is not directly related to dredging and it is possible that other activities in Darwin Harbour are negatively influencing corals at this location. Coral cover also appeared to decline by 3.4% in the Post-dredging Phase at South Shell Island, which was in part attributable to tentacle retraction of *Goniopora* sp., likely as a consequence of increasing water temperatures between P1 and P2.

Generally, during the monitoring program there were no patterns that were indicative of long-term shifts in coral family composition. At South Shell Island, reductions in the cover of Pectiniidae and Poritidae since the Baseline Phase in some transects have potentially made this site become more similar to Northeast Wickham Point over time. This is likely to be a result of loss of coral colonies and subsequent reduced coral cover with 46% and 50% of tagged Pectiniidae and Poritidae colonies missing in the Post-dredging Phase.

With the exception of Weed Reef 2, peaks in the number of coral recruits (i.e. small corals of a size visible in the photos) were recorded for all sites in either June or July in 2012, 2013 and 2014. Considering the slow growth rate of coral recruits (Babcock et al. 2002), these were potentially indicative of a seasonal recruitment pulse at least one year prior. The subsequent decline following each peak may have been due to the naturally high mortality rates experienced by coral recruits, but may also have been a result of some recruits growing larger than the 20 mm size class where corals are no longer being recorded as recruits. Coral gravity assessment supported an autumn spawning hypothesis, where Faviidae colonies at least, had numerous mature oocytes on 8 April 2014 (one week prior to the April 2014 full moon), which were subsequently released prior to 10 May 2014.

A potential suppression of recruitment at South Shell Island as a consequence of dredging influences (increased turbidity) was recorded, with reduced recruits relative to Baseline and other monitoring sites. Given high natural rates of mortality of corals at South Shell Island and instability of the substratum, recruitment is likely to be an important process in maintaining coral cover.

Overall, the influence of dredging on coral communities in Darwin Harbour was confined to some sites in EA, in particular South Shell Island, with dredging having much less of an effect than what had been predicted in the Draft EIS (INPEX 2011). In summary, the measured potential impacts of dredging can be summarised as:

- Temporary increase of sediment on corals at the end of the Dredging Phase at South Shell Island. Partial mortality decreased or remained unchanged in the subsequent surveys indicating the sediment cover was temporarily overlaying live coral tissue that was exposed in subsequent surveys; and
- Potential suppression of recruitment at South Shell Island due to indirect effect of increased turbidity (from dredging) at the site, and the susceptibility of coral recruits to sedimentation.

No impacts to coral health were recorded at reactive monitoring sites Channel Island Weed Reef 1 and Weed Reef 2 or at informative site Northeast Wickham Point in EA, which interestingly is also located in proximity to dredging and recorded a similar magnitude of dredging influence (increased turbidity) as South Shell Island..

Glossary

Term or Acronym	Definition
Actual mortality	Partial mortality in a coral colony where the tissue is dead
ADAS	Australian Diver Accreditation Scheme
AIMS	Australian Institute of Marine Science
BACI	Before After Control Impact
Benthic assemblages	Biota (living) and abiota (non-living) components of the sea bed
Bleached	Corals that have lost their symbiotic algae due to stress and the live tissue of which appears pale or white
Bray-Curtis dissimilarity matrix	An index of dissimilarity between samples in the types and relative abundance of species
BHD	Backhoe dredger
B1	First Baseline Phase survey prior to commencement of dredging activities (16 June 2012 to 18 July 2012)
B2	Second Baseline Phase survey prior to commencement of dredging activities (27 July 2012 to 30 July 2012)
B3	Third Baseline Phase survey prior to commencement of dredging activities (11 August 2012 to 14 August 2012)
CHI	Channel Island
CHP	Charles Point
Contingency management	Management based on defaulting to more ‘environmentally secure operations’ when required
CPCe	Coral Point Count with Excel extensions
CSD	Cutter suction dredger
D1	First Dredging Phase survey after commencement of dredging activities (22 October 2012 to 26 October 2012)
D2	Second Dredging Phase survey after commencement of dredging activities (5 December 2012 to 9 December 2012)
D3	Third Dredging Phase survey after commencement of dredging activities (17 February 2013 to 22 February 2013)
D4	Fourth Dredging Phase survey after commencement of dredging activities (17 April 2013 to 21 April 2013)

Term or Acronym	Definition
D5	Fifth Dredging Phase survey after commencement of dredging activities (16 June 2013 to 20 June 2013)
D6	Sixth Dredging Phase survey after commencement of dredging activities (14 August 2013 to 19 August 2013)
D7	Seventh Dredging Phase survey after commencement of dredging activities (26 October 2013 to 30 October 2013)
D8	Eighth Dredging Phase survey after commencement of dredging activities (9 December 2013 to 14 December 2013)
D9	Ninth Dredging Phase survey after commencement of dredging activities (23 February 2014 to 28 February 2014)
D10	Tenth Dredging Phase survey after commencement of dredging activities (8 March 2014 to 14 March 2014)
D11	Eleventh Dredging Phase survey after commencement of dredging activities (7 April 2014 to 10 April 2014)
D12	Twelfth Dredging Phase survey after commencement of dredging activities (8 May 2014 to 10 May 2014)
D13	End of dredging survey. Thirteenth Dredging Phase survey after commencement of dredging activities (5 June 2014 to 11 June 2014)
DSDMP	Dredging and Spoil Disposal Management Plan
EA	East Arm
GEP	Gas Export Pipeline
GLMM	Generalized Linear Mixed Model
Informative monitoring	Monitoring programs designed to measure environmental responses to dredging and spoil disposal activities and to provide textual information on effects of sedimentation and turbidity on sensitive receptors
LCL	Lower confidence limit
MAN	Mandorah
NEW	Northeast Wickham Point
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric Turbidity Units
Oocytes	Unfertilised female gametes (eggs) in the gonads of corals
P_{RS}	An additional Post-dredging reactive survey conducted after the cessation of dredging activities (5 July 2014 to 9 July 2014)

Term or Acronym	Definition
P1	First Post-dredging Phase survey after cessation of dredging activities (18 August 2014 to 22 August 2014)
P2	Second Post-dredging Phase survey after cessation of dredging activities (16 October 2014 to 20 October 2014)
P3	Third Post-dredging Phase survey after cessation of dredging activities (14 December 2014 to 18 December 2014)
Pale bleached	Bleached tissue that appears to be a lighter hue than healthy tissue
Partial mortality	A portion of a coral colony that is dead
PAR	Photosynthetically active radiation
Peak flux	In relation to PAR measurements
Perceived mortality	Mortality is assumed as part of a coral is obscured by sediment, mobile fauna or algal fronds.
PERMANOVA	Permutational analysis of variance
Planulae	Free-swimming larval stage of corals
Reactive monitoring	Monitoring programs that include triggers that initiate targeted monitoring and adaptive and contingency management responses to manage impacts within the limits of acceptable loss
SCUBA	Self-contained underwater breathing apparatus
SSBA	Surface supply breathing apparatus
SSI	South Shell Island
TARP	Trigger Action Response Plan
TSHD	Trailer suction hopper dredger
UCL	Upper confidence limit
White bleached	Bleached tissue that appears white or near-white
WR1	Weed Reef 1
WR2	Weed Reef 2
Zooxanthellae	Symbiotic algae that live in coral tissue and provide nutrition to coral hosts

Table of Contents

Tables

Figures

Appendices

1 Introduction

1.1 Background

INPEX is the operator of the Ichthys LNG Project (the Project). The Project comprises the development of offshore production facilities at the Ichthys Field in the Browse Basin, some 820 km west-south-west of Darwin, an 889 km long subsea gas export pipeline (GEP) and an onshore processing facility and product loading jetty at Bladin Point on Middle Arm Peninsula in Darwin Harbour. To support the nearshore infrastructure at Bladin Point, dredging works were carried out to extend safe shipping access from near East Arm Wharf to the new product loading facilities at Bladin Point, which is supported by piles driven into the sediment. A trench was also dredged to seat and protect the GEP for the Darwin Harbour portion of its total length. Dredged material was disposed at the spoil ground located approximately 12 km north-west of Lee Point. A detailed description of the dredging and spoil disposal methodology is provided in Section 2 of the East Arm (EA) Dredging and Spoil Disposal Management Plan (DSDMP) (INPEX 2013) and GEP DSDMP (INPEX 2014a).

1.2 Requirement to Monitor Corals

Following an Environmental Impact Assessment (INPEX 2011) which predicted potential reduction in growth and mortality of corals at South Shell Island and Northeast Wickham Point, the Project was approved subject to conditions that included monitoring for potential effects of dredging or spoil disposal on local ecosystems, including corals. Sedimentation can cause stress in corals, as they may need to invest energy into the removal of sediment from their surface to prevent partial mortality and colony death (Cortes and Risk 1985). Turbidity and light attenuation stress corals by reducing the photosynthetic output of their zooxanthellae, thereby reducing the amount of autotrophic nutrition obtained by them (Phillipp and Fabricius 2003). Most corals obtain the majority of their nutrition autotrophically; hence, prolonged and elevated levels of turbidity and light attenuation may lead to mortality.

Following cessation of dredging at the end of Season One, a review of the Nearshore Environmental Management Plan (NEMP), including the Coral Monitoring Program, was undertaken. The review resulted in a number of changes being incorporated into the Coral Monitoring Program.

The Coral Monitoring Program was originally designed to specifically detect changes at Channel Island as the coral community at this site is listed on the Commonwealth Register of the National Estate and Northern Territory Heritage Register (AHPI 2012). Although sediment plume and sedimentation modelling did not indicate any potential for ecologically significant impacts at the Channel Island coral community (INPEX 2011), given the listed status of the area, it was determined appropriate by the Department of Natural Resources, Environment, the Arts and Sport (NRETAS, now NT EPA) to apply the precautionary principle and to treat Channel Island as a potential Impact site. For this reason, reactive triggers were developed to provide an early warning indicator of potential changes in coral health that would allow for early management actions for protecting the Channel Island coral community. Two other sites in Darwin Harbour with a similar assemblage of corals to Channel Island that were also not predicted to be affected by dredging (Weed Reef 1 and Weed Reef 2) were considered to be appropriate Control sites for monitoring in comparison with Channel Island in a Before After Control Impact (BACI) framework (Underwood 1992). South Shell Island and Northeast Wickham Point were included in this design as informative Impact sites as potential mortality or reduced growth was predicted at these sites in the Draft EIS (INPEX 2011). Monitoring at South Shell Island and Northeast Wickham Point was intended to help determine potential upper tolerance thresholds for Darwin Harbour coral communities to elevated turbidity as a consequence of dredging.

During the review process, the appropriateness of the BACI design was reassessed. As a result, the classification of Channel Island as an Impact site based on its listed status was identified as unsuitable given that no impact on coral health was predicted and similar turbidity influences were also predicted for Control sites at Weed Reef. To address this concern, the coral mortality reactive trigger was redesigned to include Weed Reef 1 and Weed Reef 2, as well as Channel Island, and to detect potential changes to the rate of site-wide coral mortality above long-term trends for each site (i.e. above what would be expected). The revised NEMP outlines the updated methodology and parameters used for Season Two dredging trigger assessments for the Coral Monitoring Program (Cardno 2013a).

In addition to the changes to the design of the Coral Monitoring Program in terms of the reactive triggers, the EA DSDMP was revised to allow adaptive dredge management. To ensure that no increase in coral mortality occurs as a result of adaptive dredge management, the coral monitoring frequency during implementation of adaptive dredge management (i.e. between February 2014 and June 2014 in Season Two dredging) was increased from bimonthly to monthly.

1.3 Results of the Baseline Phase Surveys

Baseline Phase sampling for the Coral Monitoring Program was undertaken between June 2012 and August 2012 at Channel Island, two sites in EA (Northeast Wickham Point and South Shell Island), two sites in Middle Harbour (Weed Reef 1 and 2) and two sites in Darwin Outer (Mandorah and Charles Point). At each of the monitoring sites, photos were obtained of 75 tagged coral colonies and at 1 m intervals along four fixed 50 m long transects.

The objectives of the Baseline Phase were to:

> Describe natural temporal and spatial changes in coral health indicators; and

> Determine the statistical power of the original (BACI) monitoring design to detect specified levels of change to indicators of coral health, were they to occur as a consequence of dredging.

Thirteen families of hard coral were identified, no more than ten of which occurred at any one site. Hard coral percentage cover ranged from 13% to 23% at most sites, apart from Northeast Wickham Point, which had approximately 2% cover in the three surveys (Cardno 2013b). Hard coral cover was generally constant throughout the Baseline Phase, whereas overall benthic assemblages differed among Baseline Phase surveys due to varying proportions of silt, sand and turf algae. Temporal differences were similar between Impact and Control sites. The most common families of hard corals were Dendrophylliidae, Faviidae, Pectiniidae and Poritidae. The most common morphology was encrusting and foliose, although massive and submassive forms were also present. At all sites, the majority of the substratum recorded was bare (between 25% and 60%, depending on the site and the survey) and was comprised of a sand or silt veneer covering or infilling consolidated material.

1.4 Results of the Dredging Phase Surveys

During the Dredging Phase, the monitoring program involved regular sampling of individually tagged coral colonies and repeat surveys of permanent transects to determine trends in the condition of corals at sites throughout Darwin Harbour. Coral monitoring during Season One dredging (27 August 2012 to 30 April 2013) occurred every two months, while during Season Two dredging (23 October 2013 to 11 June 2014) coral surveys were initially every two months and increased to monthly from February 2014 onwards.

An increase in mean partial mortality of tagged colonies between the Baseline Phase and the end of dredging was recorded for all monitoring sites (informative and reactive sites); although the extent of mortality differed among the sites. Increasing partial mortality is an expected result of the tagged coral methodology, as total or partial mortality of a finite number of individual corals is inevitable over time. With the exception of South Shell Island, which was predicted to be potentially impacted, the increases during the Dredging Phase were considered to be natural at all sites, with a potential dredge influence at South Shell Island recorded in the final Dredging survey D13 (June 2014). At the time it was noted that the increase at South Shell Island was, in part, caused by an increase in sediment on corals, and should, to some extent, be interpreted as perceived mortality as sediment can be removed by corals in subsequent surveys.

Measured mean partial mortality (i.e. the average of the dead portions of tagged colonies) between the Baseline Phase and the end of dredging at South Shell Island was greater than for all other monitoring sites. For all of Season Two dredging, the mean partial mortality in tagged corals at South Shell Island was below the predicted mean partial mortality apart from the final Dredging survey (end of dredging) when it increased to close to the 95% upper confidence limit (UCL) suggesting a potential impact. South Shell Island is located in proximity to dredging operations, and frequently recorded elevated turbidity and subsequent reductions to light available for photosynthesis and a potential increase in sedimentation. Although turbidity increased, and consequently light availability decreased at South Shell Island throughout Season One and Season Two dredging, changes to coral health of a similar magnitude were not recorded at Northeast Wickham Point. As such, water quality alone is not considered to be the cause of the changes to corals observed. Additionally, turbidity at South Shell Island between D11 and D13 was not abnormally elevated compared to Northeast Wickham Point or to that recorded throughout monitoring. At the conclusion of the Dredging Phase, the observed changes at South Shell Island were consistent with potential dredge impacts predicted by the Draft EIS; that is, small patches of coral at this site could exhibit reduced growth or mortality due to dredging (INPEX 2011). However, the draft EIS predicted similar impacts to occur at Northeast Wickham Point, which had not eventuated as at the conclusion of dredging activities.

In terms of the average coral cover along transects, there was no statistically significant change at any site as of the end of dredging; however, there was a significant reduction for all sites combined. The overall reduction in combined coral cover was driven by declines at Weed Reef 2 and South Shell Island, while Channel Island, Weed Reef 1 and Northeast Wickham Point showed minimal change in coral cover. The decline at Weed Reef 2 followed an isolated thermal bleaching event at this site in February 2013, which led to the mortality of some colonies (namely *Goniopora sp*.). The decline in coral cover at South Shell Island may be in part a consequence of the proximity of this site to dredging and measured influences on water quality, although Northeast Wickham Point is approximately the same distance from dredging and showed minimal change with similar magnitudes of influence. The unstable substratum at the site is likely to have been a factor in the decrease in coral cover. The site at South Shell Island is situated on an unconsolidated slope and corals at this site can become dislodged and move down the slope or overturn. This was observed for the tagged colonies, where, by the end of dredging over 40% of tagged colonies were missing, more than double for any other site. South Shell Island also showed a potential reduction in the number of coral recruits during the Dredging Phase. The reduction in coral cover at South Shell Island was proportionally greater for Pectiniidae than for the other coral families. Interestingly, at Northeast Wickham Point there was also a reduction in Pectiniidae cover, although there was no reduction in coral cover as there was an increase in Faviidae cover.

At the end of dredging, observed potential impacts to coral as a possible consequence of dredging were isolated to South Shell Island in EA, which was predicted to be potentially impacted in the Draft EIS (INPEX 2011), with no detected effects to coral at any other monitoring site throughout Darwin Harbour.

1.5 Objectives

There are two components to the Coral Monitoring Program: ‘reactive’ and ‘informative’ monitoring. Reactive monitoring is carried out at Channel Island, Weed Reef 1 and Weed Reef 2.

The objective of the reactive component of the Coral Monitoring Program was to:

> Protect Channel Island and Weed Reef coral communities by monitoring and implementing appropriate adaptive and/or contingency management measures for limiting potential impacts on corals as a result of dredging (where required).

To allow for rapid assessment of potential impacts on the Channel Island and Weed Reef reactive monitoring sites, a series of water quality and coral health triggers were assessed throughout dredging (**Table 1-1**). Although, these triggers were no longer applicable in the Post-dredging Phase, similar analyses to the trigger assessments were included in this report for comparative purposes. The complete process from monitoring corals and assessing data for trigger exceedances to implementing management responses is described in the coral monitoring Trigger Action Response Plan (TARP). The TARP defines the water quality (turbidity) and coral health (net mortality and bleaching) triggers and describes the management response(s) required in the event of an exceedance in accordance with escalating risk to coral communities at Channel Island and Weed Reef.

To improve understanding of the potential impacts of dredging on corals, informative monitoring is carried out on a routine basis at Northeast Wickham Point and South Shell Island, which are located within the EA of Darwin Harbour (**Figure 2-1**). Data collected at these informative monitoring sites were used for interpretative purposes and to support management decisions using a ‘multiple lines of evidence’ approach, particularly if reactive triggers were exceeded and required a management response.

The objectives of the informative component of the Coral Monitoring Program are to:

> Detect potential changes in coral health; and

> Infer whether any potential changes are a result of dredging and spoil disposal activities.

The reactive and informative programs both involved regular sampling of individually tagged coral colonies and repeat surveys of permanent transects to determine trends in the condition of the coral communities. These data were collected in parallel with informative water quality parameters. The suite of coral health and supporting water quality data were monitored to help determine whether or not dredging was influencing coral communities. Tagged coral colonies were used as a measure of potential changes to coral health at a site and were useful to obtain very detailed information about changes in coral health and changes in mortality at the colony level. Although tagged coral colonies are representative of the local coral community, they cannot provide suitable information about site-wide effects on coral health, as they only represent a small proportion of the total coral cover and the methodology does not take into account growth or recruitment. In addition, mortality generally only ever 'increases' for a constrained selection of individual corals, as partial or total mortality of corals is inevitable given a long enough monitoring period. Given that tagged colonies provide an estimate of mortality for the individual corals selected only, and not for the entire coral community or reef (i.e. the change in the total number/cover of corals), coral health needed to be assessed also on a site-wide level. This was carried out using permanent transects. If the rate of mortality recorded for the tagged coral colonies was unnaturally high (i.e. in excess of the replacement rate through recruitment and growth), coral mortality would likely be recorded in the fixed transects as a reduction in coral cover.

This report outlines the findings of the Post-dredging Phase coral monitoring surveys (P1: 18 August 2014 to 22 August 2014; P2: 16 October 2014 to 20 October 2014; and P3: 14 December 2014 to 18 December 2014). An additional Post-dredging reactive survey was conducted approximately one month after the end of EA dredging (P_{RS}: 5 July 2014 to 9 July 2014) due to a dry season water quality trigger exceedance. The report also provides a summary of all Dredging Phase results collected as part of the Coral Monitoring Program, with data compared with that collected prior to the commencement of dredging (Baseline Phase). Results are presented for reactive coral sites Channel Island, Weed Reef 1 and Weed Reef 2 and informative Impact sites in EA South Shell Island and Northeast Wickham Point. Results are also presented for the Darwin Outer site Mandorah which was sampled in all three Post dredging Phase surveys, but only surveyed every six months throughout the Dredging Phase in accordance with the requirements of the NEMP (Cardno 2013a). Charles Point has been excluded from this report and all analyses as the site could not be safely accessed during the Post-dredging Phase due to increased crocodile activity in the area.

Table 1-1 Channel Island, Weed Reef 1 and Weed Reef 2 coral trigger values (INPEX 2013, 2014a)

Components	Normal Situation	Level 1 Trigger			Level 2 Trigger		Level 3 Trigger
		Daily Average Turbidity			Coral Bleaching	Coral Mortality	Coral Mortality
		Intensity (95%ile)	Duration (90%ile)	Frequency (90%ile)			
Channel Island							
Trigger value (Wet Season) (1 November to 31 April)	Not triggered	>44 NTU	>26 NTU over 7 consecutive days	>26 NTU > 3 days per 7-day rolling period	>20% gross coral bleaching	Recorded mean partial mortality greater than upper 95% confidence limit of the predicted mortality	For two consecutive surveys recorded mean partial mortality greater than upper 95% confidence limit of the predicted mortality
Trigger value (Dry Season) (1 May to 31 October)	Not triggered	>21 NTU	>15 NTU over 5 consecutive days	>15 NTU > 3 days per 7-day rolling period			
Weed Reef 1 and Weed Reef 2							
Trigger value (Wet Season) (1 November to 31 April)	Not triggered	>65 NTU	>46 NTU over 6 consecutive days	>46 NTU > 3 days per 7-day rolling period	>20% gross coral bleaching	Recorded mean partial mortality greater than upper 95% confidence limit of the predicted mortality	For two consecutive surveys recorded mean partial mortality greater than upper 95% confidence limit of the predicted mortality
Trigger value (Dry Season) (1 May to 31 October)	Not triggered	>14 NTU	>11 NTU over 4 consecutive days	>11 NTU > 3 days per 7-day rolling period			

N.B. Trigger levels 1 to 3 are associated with different management responses and the extent of intervention increases with the trigger level.

2 Methodology

2.1 Overview

To meet the objectives of the Coral Monitoring Program, the condition of corals was monitored using:

> Tagged coral colonies; and

> Fixed (permanent) transects.

In each survey, divers took photographs of the tagged coral colonies and of the seabed along transects at the monitoring sites to assess and categorise the health (mortality, bleaching and sediment accumulation) of tagged corals and to describe the benthic composition along the transects (including family and growth form of corals and the number of coral recruits). A full description of the methodology is given in the Coral Monitoring Program Baseline Report (Cardno 2013b) and the Coral Monitoring Program Method Statement (Cardno 2012).

2.2 Vessels, Diving, Safety and Environmental Management

Field work was carried out from the diving vessel DSV Joshsarelle. Work was completed in accordance with the Project Health, Safety and Environment Plan. Diving was conducted using a combination of Self Contained Underwater Breathing Apparatus (SCUBA) (Australian Diver Accreditation Scheme (ADAS) Level AS 2815.1) and Surface Supply Breathing Apparatus (SSBA) (ADAS Level AS 2815.2) in accordance with Australia/New Zealand Standard Occupational Diving Operations Part 1: Standard Operational Practice (ASNZS 2299.1:2007). Data were collected by scientific divers and site maintenance was completed by commercial divers from Neptune Diving Services.

2.3 Sites, Timing and Frequency of Surveys

The locations of coral monitoring sites are given in **Figure 2-1**. A reef flat and reef slope occurs at all of the coral monitoring sites, with patchy, hard coral growth extending down the slope from the edge of the flat to a deeper flat area at approximately -3 m LAT at most sites and at approximately -2 m LAT at Charles Point. To facilitate meaningful comparisons between sites, coral monitoring was undertaken on the reef slope of sites in a depth range of approximately -1 m LAT to –3 m LAT (approximately 0 m LAT to -2 m LAT at Charles Point). A full description of the physical characteristics and coral cover at each site is provided in the Coral Monitoring Program Baseline Report (Cardno 2013b).

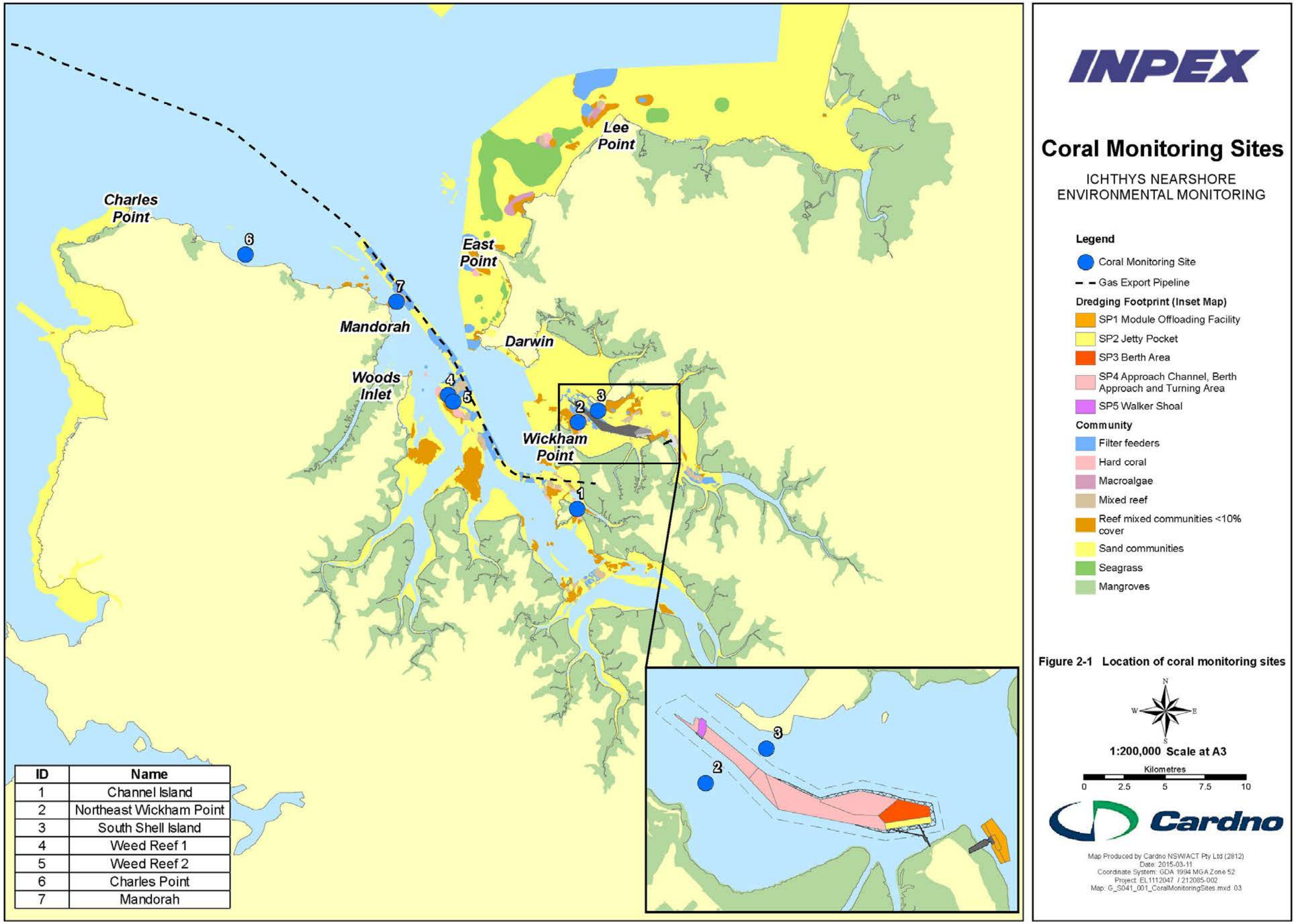
The temporal sampling design was structured around three ‘Phases’:

> ‘Baseline’, a period of sampling between 16 June 2012 and 14 August 2012 prior to dredging; and

> ‘Dredging’, a period of sampling between 27 August 2012 and 11 June 2014 which included initial backhoe dredging, Season One EA dredging, the 2013 dry season dredging hiatus period and Season Two EA dredging and GEP dredging.

> ‘Post-dredging’, a period of sampling between 5 July 2014 and 18 December 2014 after the cessation of EA and GEP dredging activities on 11 June 2014 and 12 July 2014 respectively.

The timing of coral surveys is presented in **Table 2-1**. A summary of data collected in the Post-dredging Phase is given in **Table 2-2**.



ID	Name
1	Channel Island
2	Northeast Wickham Point
3	South Shell Island
4	Weed Reef 1
5	Weed Reef 2
6	Charles Point
7	Mandorah

Figure 2-1 Locations of coral monitoring sites

N.B. Habitats given are based on mapping of parts of Darwin Harbour by GeoOceans (2011)

Table 2-1 Field sampling dates for coral monitoring in the Baseline, Dredging and Post-dredging Phases

Period	Survey	Sampling Dates	Sites Surveyed	Relevant Report
Before Dredging	B1	16 June 2012 to 18 July 2012	CHI, NEW, SSI, WR1, WR2, CHP, MAN	Cardno 2013b
	B2	27 July 2012 to 30 July 2012	CHI, NEW, SSI, WR1, WR2, CHP, MAN	Cardno 2013b
	B3	11 August 2012 to 14 August 2012	CHI, NEW, SSI, WR1, WR2, CHP, MAN	Cardno 2013b
During Season One Dredging	D1	22 October 2012 to 26 October 2012	CHI, WR1, WR2	Cardno 2013c
	D2	5 December 2012 to 9 December 2012	CHI, WR1, WR2, CHP, MAN	Cardno 2013d
	D3	17 February 2013 to 22 February 2013	CHI, NEW, SSI, WR1, WR2	Cardno 2013e
	D4	17 April 2013 to 21 April 2013	CHI, NEW, SSI, WR1, WR2	Cardno 2013f
Dry Season Dredging Hiatus	D5	16 June 2013 to 20 June 2013	CHI, NEW, SSI, WR1, WR2	Cardno 2013g
	D6	14 August 2013 to 19 August 2013	CHI, NEW, SSI, WR1, WR2, CHP, MAN	Cardno 2014a
During Season Two Dredging	D7	26 October 2013 to 30 October 2013	CHI, NEW, SSI, WR1, WR2	Cardno 2014b
	D8	9 December 2013 to 14 December 2013	CHI, NEW, SSI, WR1, WR2	Cardno 2014c
	D9	23 February 2014 to 28 February 2014	CHI, NEW, SSI, WR1, WR2	Cardno 2014d
	D10	8 March 2014 to 14 March 2014	CHI, NEW, SSI, WR1, WR2, CHP, MAN	Cardno 2014e
	D11	7 April 2014 to 10 April 2014	CHI, NEW, SSI, WR1, WR2	Cardno 2014f
	D12	8 May 2014 to 10 May 2014	CHI, WR1, WR2	Cardno 2014g
	D13	5 June 2014 to 11 June 2014	CHI, NEW, SSI, WR1, WR2	Cardno 2014h
Post-dredging	P_{RS}*	5 July 2014 to 9 July 2014	CHI, NEW, SSI, WR1, WR2	This Report
	P1	18 August 2014 to 22 August 2014	CHI, NEW, SSI, WR1, WR2, MAN	
	P2	16 October 2014 to 20 October 2014	CHI, NEW, SSI, WR1, WR2, MAN	
	P3	14 December 2014 to 18 December	CHI, NEW, SSI, WR1, WR2, MAN	

* Reactive survey conducted after EA dredging operations had ceased and reported in a trigger report only (Cardno 2014i).

Table 2-2 Summary of the number of tagged colonies (75 tagged originally) included in the mortality estimate and fixed transects sampled (max = 4) during P1 to P3. NS = Not Surveyed

Site Name	Tagged corals				Transects			
	P_{RS}	P1	P2	P3	P_{RS}	P1	P2	P3
Channel Island	61	60	59	59	4	4	4	4
Weed Reef 1	69	70	69	69	4	4	4	4
Weed Reef 2	58	58	57	58	4	4	4	4
South Shell Island	40	38	38	37	4	4	4	4
Northeast Wickham Point	63	63	64	62	4	4	4	4
Mandorah	NS	63	65	66	NS	4	4	4

2.4 Tagged Colonies

2.4.1 Mortality and Bleaching

Seventy-five coral colonies were tagged at each site in the Baseline Phase (**Appendix A-1**). The number and type of tagged colonies are summarised in the Coral Monitoring Program Baseline Report, along with details of the equipment and methods used by divers to photograph each tagged coral (Cardno 2013b).

The health of tagged corals was assessed visually by assigning several health categories to the photographs, including healthy coral, dead coral, turf algae and sediment (**Table 2-3**). The images were assessed using 'Coral Point Count with Excel extensions' (CPCe) (Kohler and Gill 2006), which involved visually assigning the appropriate category to 100 points (crosshairs), distributed on a 10 x 10 stratified random grid on the photos. It is noteworthy that turf algae cover on corals is considered to be actual mortality, as coral tissue beneath turf algae will rarely, if ever, recover, whereas sediment on corals is considered to be only potential or perceived mortality as the underlying tissue may be either alive or dead. When sediment is covering living coral tissue, the corals can actively clear the sediment away, revealing living tissue in subsequent surveys. However, sediment also covers non-living coral tissue, including when the sediment remains unmoved for prolonged periods, resulting in death of the underlying tissue and also where sediment covers coral tissue that has died of other causes (e.g. turf algae). In this case, the coral's active sediment clearance will not be occurring. Given the uncertainty of the health of coral covered by sediment, in this program, mortality is assumed as a precautionary measure (i.e. worst-case mortality scenario).

Categories assigned to each grid point were used to determine the partial mortality of each tagged coral, measured as the number of points falling on dead coral (perceived and actual) over the total number of points falling on each colony. Global coral mortality for each site was calculated as the sum of dead coral points (perceived and actual) over the total number of coral counts in each site.

Table 2-3 Coral health categories for tagged coral CPCe analysis

Main Category	Sub-category
Actual mortality	Encrusting algae Turf algae Immobile fauna Dead coral (e.g. exposed coral skeleton with no live tissue) Missing section (e.g. broken segments)
Potential or perceived mortality	Macroalgae Mobile fauna Sediment
Live coral	Healthy coral Pale bleached White bleached

2.4.1.1 Coral Mortality Modelling

Using the observed rate of coral mortality (i.e. the site-wide trend) in tagged corals at the reactive sites (Channel Island, Weed Reef 1 and Weed Reef 2) during the ten surveys preceding commencement of Season Two dredging in EA (i.e. Baseline Phase surveys B1 to B3, and Dredging Phase surveys D1 to D7, undertaken from June 2012 to October 2013), it was possible to forecast levels of mortality in subsequent surveys. A generalized linear mixed model (GLMM) was used to predict the expected site-wide partial mortality of tagged colonies (measured as the number of points falling on dead coral (perceived and actual) over the total number of points falling on colonies).

The GLMM was fitted to the partial mortality data (total dead/total coral count) collected over the first ten surveys, and used for interpolating and forecasting global coral mortality for each site. The GLMM is an enhanced logistic regression model that predicts coral mortality as a function of time (see **Section 2.6.1** for details). The GLMM predictions of mortality are assumed to represent a natural level of expected mortality (not influenced by dredging activities) that can be compared to the measured coral mortality to assess potential impacts on coral health from dredging activities. Throughout the Dredging Phase, coral mortality triggers were used based on the tagged coral data to provide a rapid assessment of coral condition at monitoring sites. A Level 2 coral mortality trigger exceedance would occur if the mean partial mortality measured at Channel Island, Weed Reef 1 or Weed Reef 2 during any survey in Season Two dredging was above the upper 95% UCL of the predicted mortality for each site. Although the triggers were no longer applied in the Post-dredging Phase, the same technique has been included in this report as a useful assessment of potential ongoing effects following dredging activities.

2.4.1.2 Coral Gross Bleaching Assessment

Throughout Season Two dredging, a coral bleaching trigger assessment was calculated based on the gross coral bleaching (bleaching above the Baseline Phase amount) at Channel Island, Weed Reef 1 and Weed Reef 2. In a given survey, a Level 2 trigger exceedance would occur if gross bleaching for any reactive site was greater than 20%. Although coral bleaching triggers were not applicable in the Post-dredging Phase, they have been included here for comparative purposes. Gross coral bleaching was estimated by summing the percentage (partial) bleaching of each colony and dividing by the number of colonies that were successfully analysed. For simplicity all Post-dredging Phase surveys have been combined for the gross bleaching assessment in this report as follows.

> B_{Gross} (gross bleaching per colony) = ($B_{\text{Post-dredging}} – B_{\text{Baseline}}$); and

> B_{Av} (mean gross bleaching) = $\sum B_{\text{Gross}} / N$, with ‘N’ being the number of corals measured at the site.

2.4.2 Sediment Accumulation

At each site, divers measured the depth of sediment using a ruler on two 20 cm x 20 cm pavers previously placed next to two colonies from each of the families Faviidae, Dendrophylliidae, Pectiniidae and Poritidae, where colonies from these families had been tagged. Pavers were cleaned of sediment after each measurement.

2.4.3 Coral Colour and Area

Colour and surface area analyses undertaken from the photographed colonies, with the exception of *Goniopora* spp. and *Alveopora* spp. colonies, are described fully in the Coral Monitoring Program Baseline Report (Cardno 2013b). In summary, for coral colour, the mean greyscale brightness (on the scale 0 = black, 255 = white) of about 1 cm^2 (4,675 pixels) of two of the darkest areas and two of the lightest areas of each colony was measured using the lasso tool in Adobe Photoshop CS3. The greyscale brightness was assigned to one of six colour brightness classes, as follows, in order from darkest to brightest: 6 = 0 to 77.5; 5 = 77.5 to 122.5; 4 = 122.5 to 170; 3 = 170 to 205; 2 = 205 to 228; and 1 = 228 to 255. Mean light and dark brightness class values at each site were assessed graphically to evaluate whether colour brightness had changed among surveys given corals may darken in response to low to moderate levels of turbidity and stressed corals will bleach in response to increases in sedimentation, water temperatures and extreme reductions in salinity or light at the benthos.

Coral surface area analysis was carried out to interpret potential changes to colony growth that could have occurred due to increased turbidity (and changes in the availability of light) at some sites or from sedimentation. The surface area of each coral was measured by using the lasso tool in Adobe Photoshop to count the number of pixels within the perimeter of the coral, translated into area. Surface area analysis for this Post-dredging Report was carried out between images from B1 and P3 due to unsuitability of photographs from P1 and P2 for measurements. The images were unsuitable as a wide-angle conversion lens was used to obtain images in low-visibility conditions. The wide-angle lens alters the image dimensions and does not allow for direct comparison of coral area with previous surveys. The area analysis in this report included all corals of the families Faviidae, Dendrophylliidae and Pectiniidae from Channel Island, Weed Reef 1 and Weed Reef 2, Northeast Wickham Point and Mandorah which had not shown visibly apparent mortality or substantial physical disturbance. South Shell Island was excluded from this analysis due to the absence of corals which had shown no visibly apparent mortality.

2.5 Fixed Transects

2.5.1 Percentage Composition

At each site, benthic cover was estimated from sets of 50 photoquadrats of the seabed collected by divers at approximately 1 m intervals along four 50 m permanent, lead-line transects. The photographs were taken of the same side of each transect and in the same direction as was carried out for the Baseline Phase surveys. A camera was attached to a small steel frame to collect photoquadrats with dimensions of 43 cm x 35 cm. Further information about the equipment used and the methodology are described in the Coral Monitoring Program Baseline Report (Cardno 2013b).

For analysis of benthic cover, 40 photoquadrats were chosen randomly from the total of 50 for each transect. The percentage cover of organisms and substratum were quantified based on 64 points (5 mm circles) overlaid in an 8 x 8 stratified random grid on the photoquadrats using CPCe.

Corals were identified to family level and their growth form assigned based on Veron (1986, 2000) and the Coral Finder (Kelley 2009). The coral form categories used were in accordance with the Australian Institute of Marine Science (AIMS 2008), as described in the Coral Monitoring Program Baseline Report (Cardno 2013b).

2.5.2 Recruitment (Juvenile Corals)

Juvenile corals (<20 mm in diameter) were counted within the entire image for the 40 random photoquadrats (used for CPCe) to determine the total number of juveniles present in each transect.

2.5.3 Reproduction

To assess coral gravidity and timing of gamete maturity in Darwin Harbour, tissue samples were collected from massive and submassive colonies from the families Faviidae, Merulinidae, Siderasteidae and Poritidae. Samples were collected from either Weed Reef 1 or Weed Reef 2 during most of the routine surveys carried out between April 2013 and December 2014. The coral gravidity assessment was undertaken in accordance with Baird et al (2010). A total of 9 to 10 coral colonies measuring at least 30 cm in diameter located near but outside the monitoring sites were tagged and photographed by divers. Two coral cores (approximately 2 cm diameter) were collected on each coral colony using a pneumatic drill, and transferred to a sample jar. Samples were initially fixed in 10% formalin for at least 24 hours then transferred to 70% ethanol. Samples were decalcified in the laboratory using 20% Ethylenediaminetetraacetic acid (EDTA) solution, which was refreshed every 2 to 3 days until only soft tissue was remaining.

Samples from April 2013, October 2013, April 2014, May 2014 and June 2014 were selected for further processing based on the expected timing of reproduction according to the known spawning period in north-eastern and north-western Australia. Samples were examined and the tissue of interest (i.e. part of the tissue corresponding to individual polyp, from mid-polyp to mesenteries) was subsequently dissected under a microscope. Coral tissue was then embedded in wax, transversally sectioned at 7 microns thickness using a microtome, and a total of 100 to 200 sections were mounted on microscope slides for each sample (10 to 15 slides with 10 to 15 sections per slide). Slides were then stained using Mayer's haematoxylin for 8 minutes to stain nuclei in blue, and using Young's eosin-erythrosine for 3 minutes to stain cytoplasmic elements in various shades of red. Slides were then dehydrated, mounted and observed under a microscope. A minimum of 100 histological sections were observed under a microscope for each sample.

2.6 Data Analysis

2.6.1 Coral Mortality Modelling

Using observed proportions of coral mortality (total dead/total coral count), a GLMM was fitted for interpolating and forecasting global coral mortality for each site. The GLMM is an enhanced logistic regression model that estimates coral mortality as a function of time, using a set of parameters specific to each site as well as individual colonies.

Mathematically, the model is:

$$\log\left(\frac{p_{ijt}}{1-p_{ijt}}\right) = \mu_i + \beta_i t + \gamma_j + \tau_j t + \epsilon_{ijt}$$

where,

p_{ijt} is the modelled proportion of coral mortality at location i, on colony j, at time t (measured in days);

μ_i is the global intercept parameter for location i;

β_i is the global temporal slope parameter for location i;

$\gamma_j \sim Normal(0, \sigma_C^2)$ is the random effect for individual colony j, allowing that colony's predicted intercept to deviate from the global intercept for the site (μ_i);

$\tau_i \sim Normal(0, \sigma_T^2)$ is the random temporal slope effect for colony j, allowing that colony's predicted temporal slope to deviate from the global site temporal slope (β_i). and

ϵ_{ijt} is a normally distributed, mean 0 error term behaving according to a CAR(1) time series structure, as described above. That is, the correlation of two observations on the same colony depends on the time between them (say t_1 and t_2), i.e., $\mathrm{cor}(\epsilon_{ijt_1}, \epsilon_{ijt_2}) = \rho^{|t_1-t_2|}$.

The above parameters were derived for each site/colony by fitting the model equation to the coral mortality data collected during the ten surveys preceding the commencement of Season Two dredging in EA (i.e. Baseline Phase surveys B1 to B3, and Dredging Phase surveys D1 to D7, undertaken from June 2012 to October 2013).

The output from the model includes, for each site, a fit of the temporal trend in average partial mortality of tagged corals (expressed as percentage) measured up to D7 and extrapolation of this trend (i.e. a prediction) to the next coral surveys.

Below are several notable features of the model:

1. Each colony has its own intercept parameter as accomplished by a random effect on the intercept for each colony. By including a colony random effect, each colony is allowed to have its own mean mortality value (its own model intercept), while still informing overall site-level trends;
2. The temporal trend component is calculated using the dates of the observations (as opposed to survey number). The result is that the model accounts for irregularly timed samples (i.e. the model handles surveys separated by 70 days differently than surveys separated by 30 days);
3. Similar to the temporal trend component, the model accounts for temporal autocorrelation (the time series component) within each colony. It is assumed that observations across colonies are independent, while observations within a colony are correlated according to a continuous first order autoregressive (CAR(1)) process. This type of correlation structure is a generalisation of an AR(1) structure, but properly accounts for irregularly timed samples. That is, the correlation between adjacent observations within a colony depends on the timing between the observations;
4. Missing observations that disrupt the time series component of other models are handled effectively in this framework. Missing values for each colony can be predicted effectively using this model and standard errors are adjusted accordingly when observations are indeed missing; and
5. The model results in predictions at the individual colony and at the entire site level. Along with these predictions, confidence intervals are calculated and available and can be used to specify trigger values for future observations, given the information content in the data along with the model itself. Notably, the confidence intervals become less certain (broader) the further into the future that predictions are made.

2.6.2 Multivariate and Univariate Analyses of Variance

Benthic assemblages, sediment (sand/silt) cover, hard coral cover and recruitment variables derived from fixed transect monitoring were all analysed using Repeated Measures Analyses of Variance with PERMANOVA+ software in PRIMER v6. The analyses tested the null hypothesis that there were no significant differences in these variables among Sites and Surveys (**Table 2-4** and **Table 2-5**). Multivariate analyses undertaken for percentage cover of all biota and abiota categories, coral families and coral growth forms were based on a Bray-Curtis dissimilarity matrix. Vectors were superimposed on the non-metric multidimensional scaling ordination (nMDS) plots, where significant interactions were found in order to graphically represent the variables that were most correlated with patterns in the multivariate dataset. The length and orientation of a vector shows the strength of the correlation between a variable and the two axes of the nMDS plot. Thus, a vector indicates a gradient in the abundance of the variable that it represents. Multiple correlation was used to calculate the vectors. This takes all of the other variables into consideration when calculating the correlation coefficient for each variable. Only variables with a multiple correlation coefficient greater than 0.1 were plotted.

Univariate analyses of variance of percentage transect hard coral cover, total sediment (sand/silt) cover, and recruitment were undertaken based on Euclidean dissimilarity matrices (Anderson et al. 2008) using the same factors described above. The repeated measure term for these analyses was ‘Transect within Sites’.

Where significant interactions or main factors’ effects were detected, post-hoc permutational t-tests using PERMANOVA+ were undertaken to identify the levels of factors in which differences occurred. No multiple test corrections were applied to t-test results, consistent with a conservative statistical approach and consistent with the Precautionary Principle.

Table 2-4 Explanation of factors used in statistical analyses

Component of Variation	Interpretation
Survey	Indicates a difference among surveys
Site	Indicates a difference among sites
Site x Survey	Indicates that variability at the scale of surveys differs among sites and vice versa
Residual	A measure of the variation in the data not explained by the variation attributed to the main factors in the experimental model (i.e. surveys and sites and their associated interactions)

Table 2-5 Terms used in describing the outcomes of statistical analyses

Outcome	Interpretation
Redundant term, RED	A term becomes redundant if a lower order interaction including that term is significant
Non-significant, ns	Describes the convention by which a statistical comparison is deemed not to be an actual effect (i.e. accept the null hypothesis that there is no effect). Here, the cut-off point was set at $p > 0.05$. This differs from the criterion used to decide whether to pool a factor, which is much more conservative
Asterisks	These signify the probability (p) of an effect being considered to actually occur. Where: * indicates $p \leq 0.05$; ** indicates $p \leq 0.01$; and *** indicates $p \leq 0.001$. These specify that the likelihood of an effect occurring by chance alone (and therefore not explained by the factor being considered) would be 5 in 100, 1 in 100, or 1 in 1000 respectively

2.6.3 Regression Analysis

Regression analysis was used to test if there was a significant relationship between the sediment depth on pavers and sediment cover of colonies. If corals are not able to cope with potential increases in sedimentation rates, they would likely accumulate sediment cover at a rate proportional to increasing sediment depth on the tiles (i.e. a linear relationship, hence no transformation was applied). Regression analysis was undertaken using the Analysis ToolPack add-in for Microsoft Excel.

2.7 Physical Environment

Temperature, sedimentation and light are major environmental drivers of coral health. Time series measurements of temperature, water turbidity and underwater light were therefore used to assist the interpretation of changes in monitored coral biological parameters. The monitoring stations, established as part of the Water Quality and Subtidal Sedimentation Monitoring Program, were installed at approximately -4 m to -6 m LAT at a height of approximately 1.5 m above the seabed.

2.8 Quality Control

The Quality Control processes followed in the field and in the office by all Project personnel (i.e. divers, field staff and office staff) in order to complete the scope of work to a consistent and high quality are described in detail in the Coral Monitoring Method Statement (Cardno 2012). Results of the checks of consistency and accuracy of the CPCe Analysts are provided in **Appendix F**.

3 Dredging Operations

The dredging program involved a number of dredge vessels including backhoe dredgers (BHDs), cutter suction dredger (CSD) and trailing suction hopper dredgers (TSHDs) operating in different areas depending on water depths, bed material characteristics and the volume of material to be removed.

The EA dredging footprint was divided into five separable portions (SP1 to SP5), which refer to the location and duration of specific dredging activities. The SPs are summarised in **Table 3-1** and presented in **Figure 2-1**.

Season One of the EA dredging campaign commenced on 27 August 2012 with BHDs, and the CSD commencing on 4 November 2012, with all Season One dredging operations ceasing on 30 April 2013. The 'dry season' dredging hiatus extended from 1 May 2013 to 31 October 2013. Season Two of the EA dredging campaign commenced on 1 November 2013 and finished on 11 June 2014, while the GEP dredging program commenced 23 October 2013 and concluded on 12 July 2014.

Table 3-1 East Arm dredge footprint summary

ID	Separable Portion
SP1	Separable Portion 1 − Module Offloading Facility (MOF)
SP2	Separable Portion 2 − Jetty Pocket
SP3	Separable Portion 3 − Berth Area
SP4	Separable Portion 4 − Approach Channel, Berth Approach and Turning Area
SP5	Separable Portion 5 − Walker Shoal

4 Results

This report presents the results of the Post-dredging coral monitoring reactive survey (P_{RS} (July 2014)) and the routine Post-dredging Phase surveys (P1 (August 2014), P2 (October 2014) and P3 (December 2014)). Comparisons are made to the Baseline Phase and the Dredging Phase, details of which are presented in previous reports (Cardno 2013b-g, 2014a-h).

4.1 Tagged Colonies

4.1.1 Mortality

4.1.1.1 Coral Mortality Modelling

Throughout the Post-dredging Phase, the measured mean partial mortality at Channel Island, Weed Reef 1 and Weed Reef 2 was below the GLMM predicted mean partial mortality, and substantially below the 95% UCL of predicted mortality (**Table 4-1**, **Figure 4-1**).

South Shell Island and Northeast Wickham Point are informative sites and the predicted trend at these sites was used to assist interpretation of the trends at reactive monitoring sites. Throughout the Post-dredging Phase, the measured mean partial mortality at South Shell Island varied greatly and was above the predicted mean partial mortality in P1 and P3 but below the predicted mean in P2; however, all surveys were well below the 95% UCL (**Table 4-1**, **Figure 4-1**). The measured mean partial mortality at Northeast Wickham Point was slightly above the predicted mean partial mortality, but it was well below the 95% UCL (**Table 4-1**, **Figure 4-1**).

It is also worth noting that throughout the surveys not included in the GLMM trend analysis (i.e. D8 to P3), the measured mean partial mortality at all sites was within the 95% UCL and lower confidence limit (LCL) of the GLMM predicted mortality with only three exceptions at Weed Reef 2 in D12, P_{RS} and P2 when mortality was below the 95% LCL (**Figure 4-1**).

Table 4-1 Measured mortality, predicted mortality and 95% UCL for Post-dredging surveys P1, P2 and P3 from GLMM trend analysis using data from B1 to D7

	Channel Island	Weed Reef 1	Weed Reef 2	South Shell Island	Northeast Wickham Point
P1					
Measured mean partial mortality	30.9%	16.7%	34.6%	48.3%	28.0%
Predicted mean partial mortality	32.8%	19.3%	42.3%	45.7%	25.7%
95% UCL*	44.8%	27.7%	53.9%	55.6%	33.9%
P2					
Measured mean partial mortality	32.1%	16.0%	30.2%	43.2%	28.6%
Predicted mean partial mortality	35.1%	20.5%	45.1%	49.2%	27.2%
95% UCL*	48.5%	30.2%	57.9%	60.0%	36.5%
P3					
Measured mean partial mortality	32.1%	18.2%	34.7%	53.7%	30.2%
Predicted mean partial mortality	37.4%	21.8%	48.0%	52.6%	28.8%
95% UCL*	52.3%	32.8%	61.9%	64.2%	39.3%

* The 95% UCL was used as a trigger value for reactive management during the Dredging Phase. It is provided here for consistency with previous reporting.

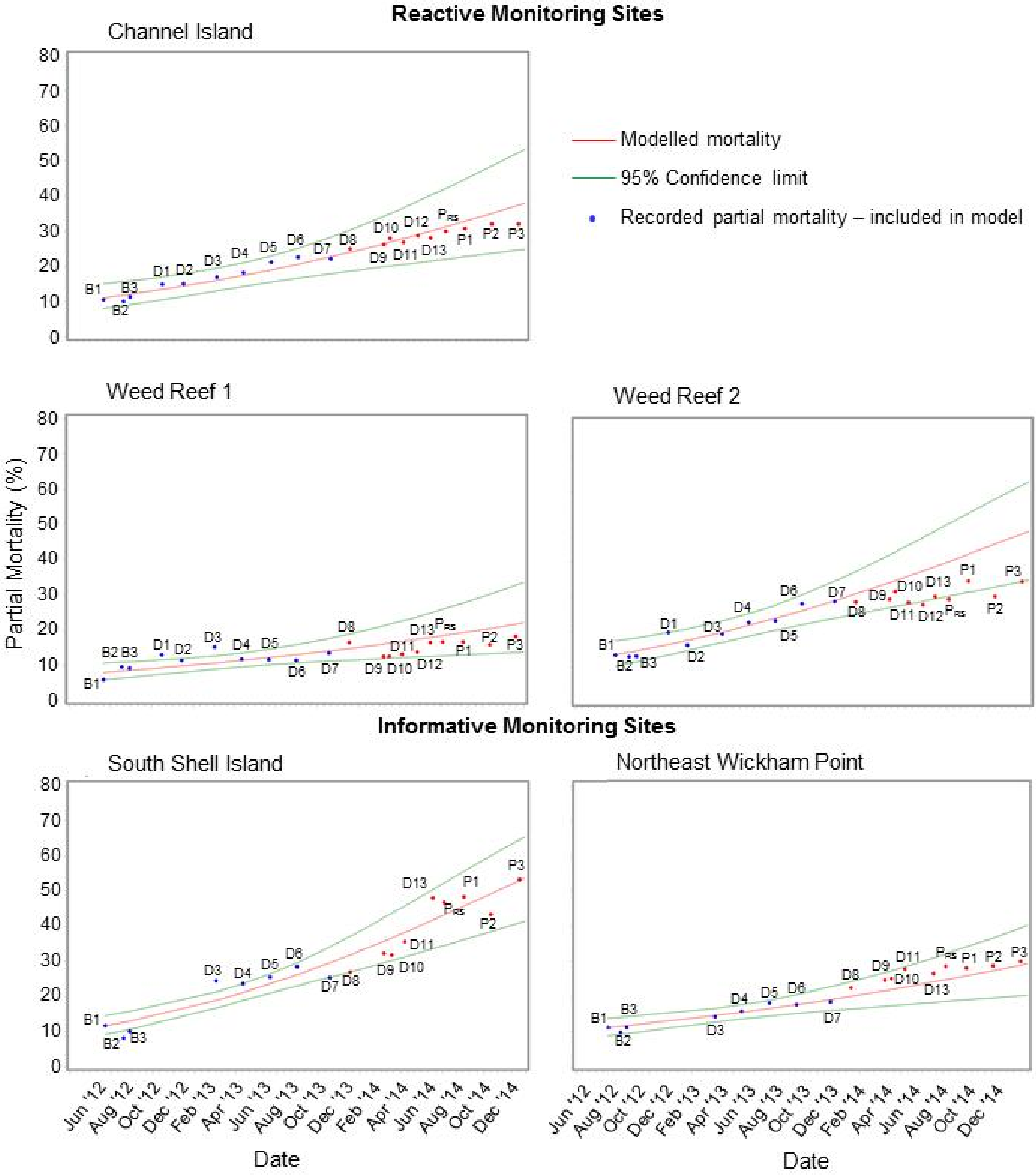


Figure 4-1 GLMM trend analysis of mean coral mortality (red line) and 95% LCL and UCL (green lines) for surveys B1 to D7 (blue dots). Observed mean partial mortality (red dots) for D8 to P3 was not included in GLMM trend analysis

4.1.1.2 Description of Partial Mortality

Throughout the monitoring program there has been a general increasing trend in partial mortality of the tagged coral colonies at all sites. The main contributors of partial mortality at all sites have been turf algae and sediment.

The increase in mean partial mortality of tagged corals at Channel Island from 28.2% at the end of dredging (D13) to 32.1% in P3, was due primarily to an increase in sediment on coral of 2.1% as well as an increase in turf algae of 1.1% (**Figure 4-2**, **Appendix B-1**). Mean partial mortality increased slightly at Weed Reef 1 from 16.6% at the end of dredging (D13) to 18.2% by P3 due primarily to an increase in sediment on coral (**Figure 4-2**, **Appendix B-1**). At Weed Reef 2, mean partial mortality increased from 30.3% at the end of dredging (D13) to 34.4% in P3 due to an increase in sediment on coral of 6.4%, noting a slight decline in turf algae of 2.3% was also recorded (**Figure 4-2**, **Appendix B-1**).

The informative monitoring sites South Shell Island and Northeast Wickham Point showed similar increases in mortality to the reactive sites. South Shell Island increased from 48.0% at the end of dredging (D13) to 53.2% by P3 due largely to an increase in sediment on coral of 4.2% (**Figure 4-2**, **Appendix B-1**). Northeast Wickham Point showed a lesser increase in mean partial mortality from 26.5% at the end of dredging (D13) to 29.9% in P3, due to an increase in sediment on coral of 2.6% (**Figure 4-2**, **Appendix B-1**). Although no end of dredging survey was carried out at Mandorah, this site has also shown an increase from 18.6% in D10 to 20.6% in P1 followed by a further increase to 22.5% by P3 (**Figure 4-2**, **Appendix B-1**). There was minimal increase in sediment on coral or turf algae at Mandorah with the increase instead being due to a combination of macro algae, immobile fauna (e.g. sponges) and the complete mortality of one coral.

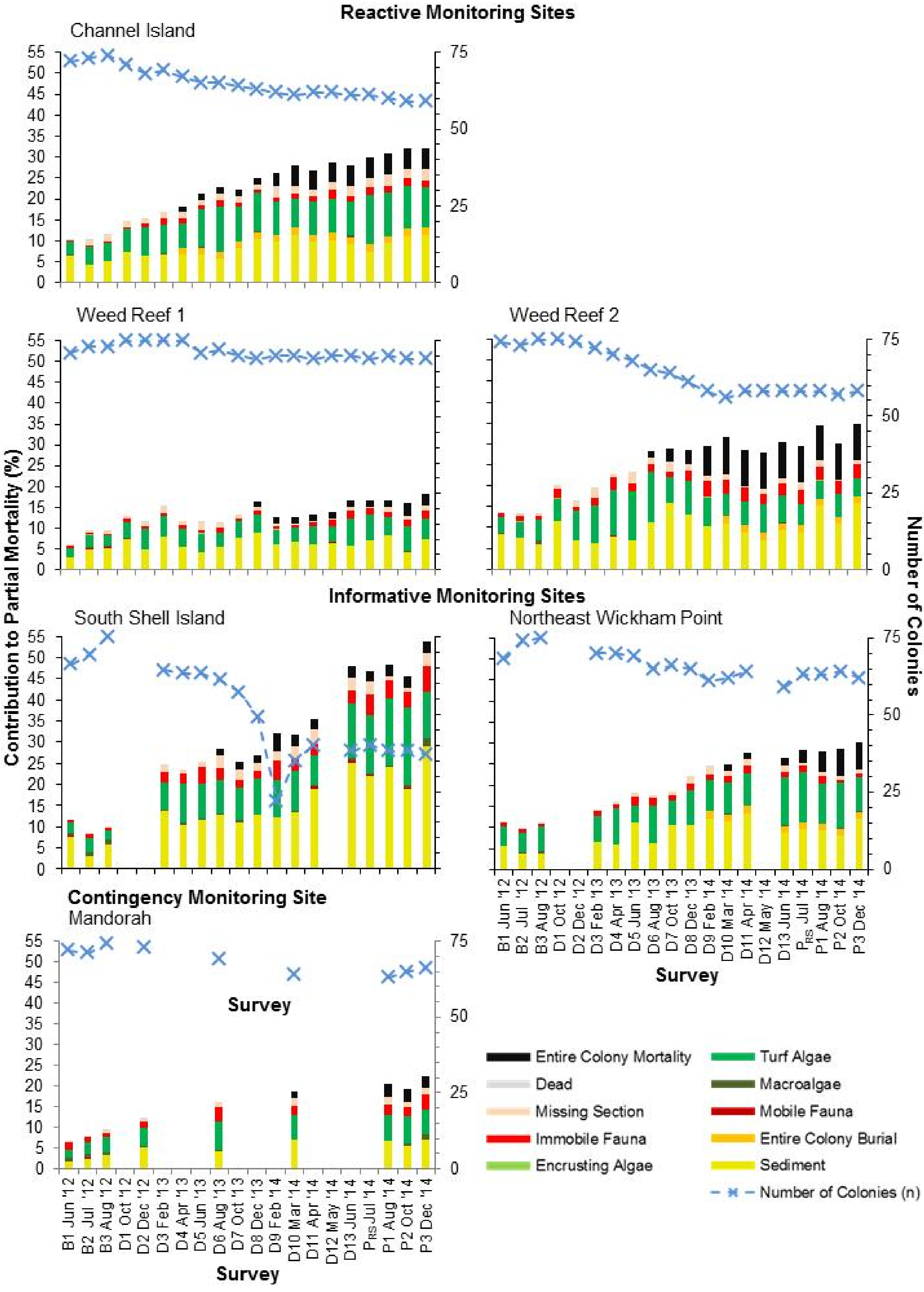


Figure 4-2 Mean contribution (%) of each of the tagged coral mortality categories and the number of tagged corals included in the mortality estimate (i.e. coral present and of suitable quality photograph obtained)

4.1.1.3 Gross Mortality between Baseline and Post-dredging Phases

Over the duration of the monitoring program, the mean of partial mortality in coral colonies has generally increased as expected, although the rate of increase through time and between sites has varied. Mean partial mortality (± SE) at South Shell Island by the Post-dredging Phase had shown a greater increase (38 ± 4%) than the other sites, and Weed Reef 1 showed less increase in mortality (9 ± 2%) than Weed Reef 2, Channel Island, Northeast Wickham Point and Mandorah (**Figure 4-3**, **Appendix B-2**). Weed Reef 2, Channel Island and Northeast Wickham Point had similar increases in partial mortality by the end of dredging of 18 ± 4%, 20 ± 4% and 19 ± 3% respectively, while Mandorah had a lesser increase of 12 ± 3% (**Figure 4-3**).

The increase in mean partial mortality varied between the different coral families (**Figure 4-4**) and may, in part, explain the variability in coral partial mortality between sites. Overall, Pectiniidae showed a consistently large increase in mortality between Baseline and Post-dredging Phases at all sites, while Faviidae showed a consistently small increase in mortality (**Figure 4-4**). Poritidae showed substantial variability in mortality between sites showing greater mortality than the other families at Channel Island, Weed Reef 2 and Mandorah, but among the least mortality at Weed Reef 1 and Northeast Wickham Point. Dendrophyllidae also showed substantial variability between sites with moderate levels of mortality recorded at Channel Island, Weed Reef 2 and Northeast Wickham Point, while low levels or mortality were recorded at Weed Reef 1, South Shell Island and Mandorah. There was also substantial variability in mortality recorded for Dendrophyllidae within sites, as indicated by the large error associated with the mortality estimates (**Figure 4-4**).

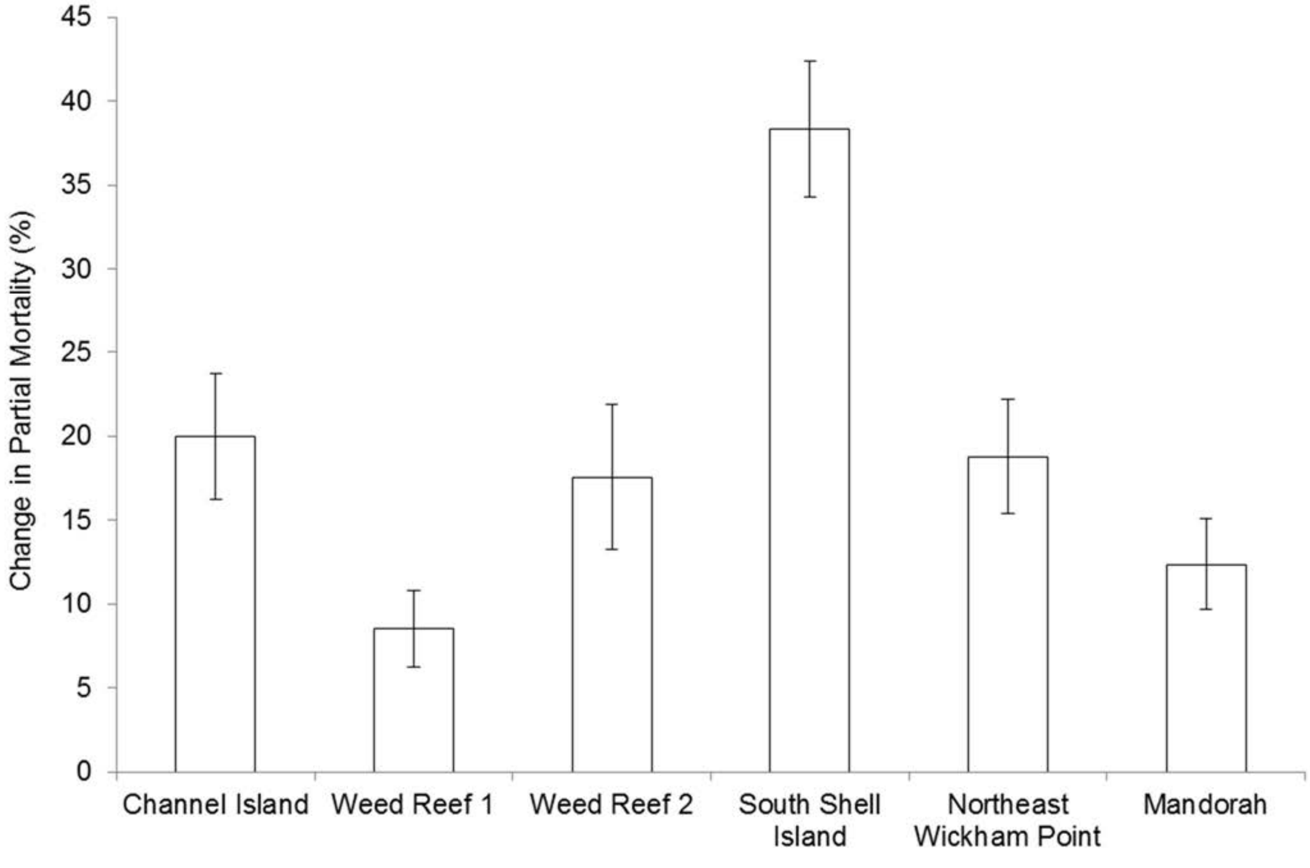


Figure 4-3 Change in mean partial mortality (±SE) between Baseline (B1, B2 and B3 combined) and Post-dredging Phases (P_{RS}, P1, P2 and P3 combined)

N.B. calculation of gross mortality excludes colonies not present throughout the Post-dredging Phase

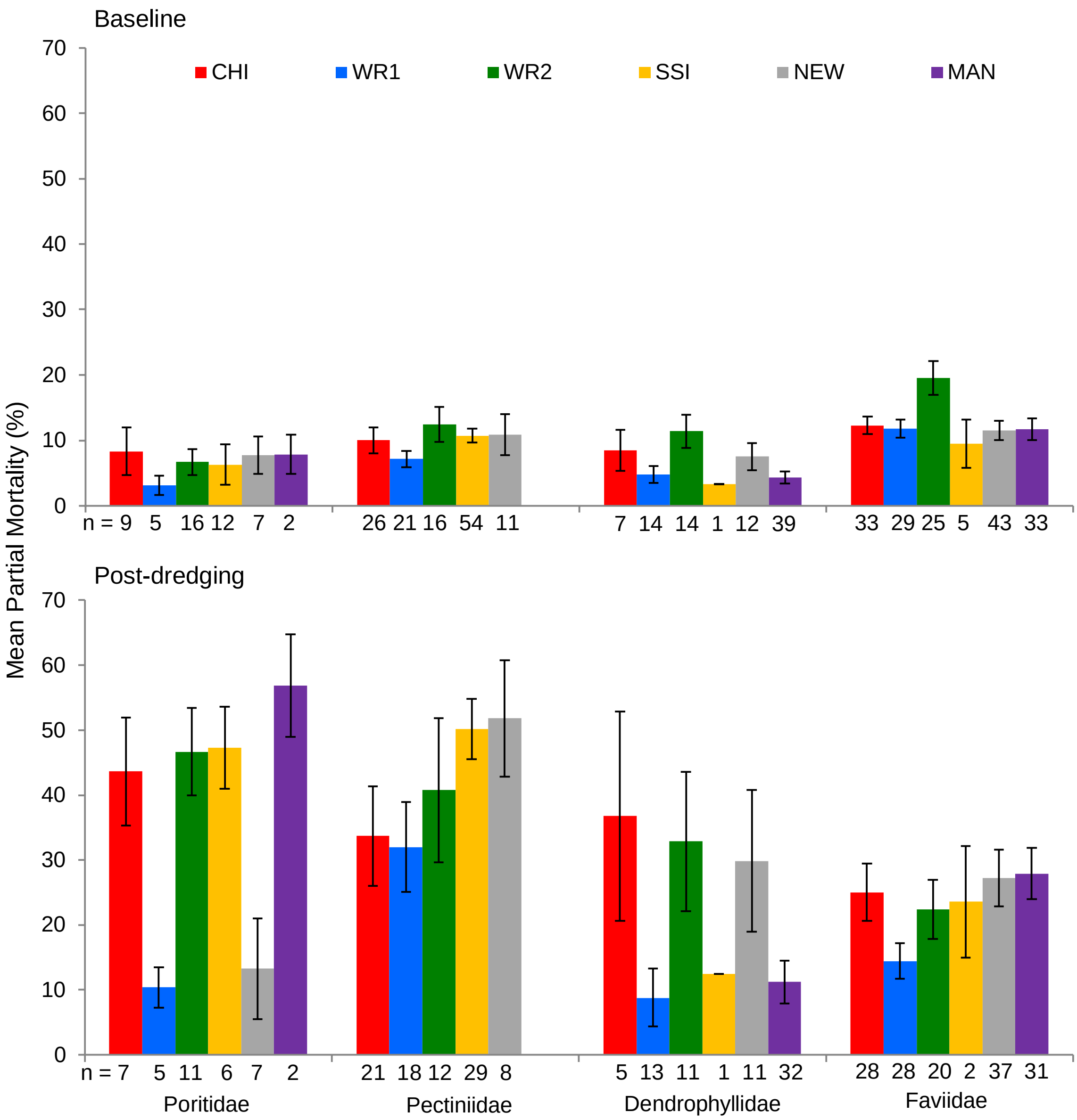


Figure 4-4 **Comparison of mean (±SE) partial colony mortality (%) between Baseline (B1, B2 and B3 combined) and Post-dredging Phases (P_{RS}, P1, P2 and P3 combined) at each of the monitoring sites for the four main coral families**

n = the number of replicate coral colonies

4.1.1.4 Signs and Symptoms of Compromised Health

Coral diseases and other causes of compromised health occur naturally in coral ecosystems; however, the incidence of disease and ill health can increase as a consequence of disturbances such as dredging. In the Dredging Phase surveys, almost complete colony mortality (i.e. >95% mortality) occurred in 24 (6%) of the baseline tagged corals. Seven of these were at Weed Reef 2, six at both Channel Island and Northeast Wickham Point, three at South Shell Island and two at Weed Reef 1 (**Table 4-2**). These coral colonies showed various signs and symptoms of ill health prior to mortality increasing and in some cases, their prior condition may have potentially contributed to their mortality (**Table 4-2**, **Appendix C**). The types of conditions associated with whole colony mortality were:

- Sediment burial (seven colonies);
- Covered by coral (one colony);
- Bleaching (three colonies);
- Tumours (two colonies);
- White syndrome-like diseases followed by increasing cover of turf algae and/or sediment (four colonies);
- Sponge overgrowth (two colonies); and
- Increasing cover of turf algae (five colonies).

Table 4-2 Putative causes of mortality for tags that experienced greater than 95% mortality

Site	Tag	Family	Genus	Putative cause
CHI	3	Poritidae	Goniopora	Bleaching, borers
CHI	8	Dendrophylliidae	*Turbinaria*	Tumours
CHI	10	Faviidae	*Favia*	White syndrome and turf algae
CHI	31	Pectiniidae	*Mycedium*	Sediment
CHI	61	Faviidae	*Favia*	Turf algae
CHI	64	Pectiniidae	*Mycedium*	White syndrome and turf algae
NEW	2	Dendrophylliidae	*Turbinaria*	Sediment, Turf algae
NEW	3	Faviidae	*Moseleya*	Turf algae
NEW	13	Faviidae	*Favites*	Sediment
NEW	20	Pectiniidae	*Mycedium*	Turf algae
NEW	69	Dendrophylliidae	*Turbinaria*	Tumours
NEW	72	Faviidae	*Favia*	Sponge
SSI	3	Pectiniidae	*Mycedium*	Sediment
SSI	15	Pectiniidae	*Mycedium*	Sediment, Turf algae
SSI	56	Poritidae	*Goniopora*	Sponge overgrowth
WR1	62	Pectiniidae	*Mycedium*	White syndrome and turf algae
WR1	74	Pectiniidae	*Mycedium*	White syndrome, sediment and turf algae
WR2	10	Pectiniidae	*Mycedium*	Sediment
WR2	20	Pectiniidae	*Mycedium*	Turf algae
WR2	26	Dendrophylliidae	*Turbinaria*	Turf algae, bleaching
WR2	45	Poritidae	*Alveopora*	Bleaching, turf algae
WR2	46	Poritidae	*Alveopora*	Bleaching, turf algae
WR2	47	Pectiniidae	*Mycedium*	Sediment, turf algae
WR2	60	Dendrophylliidae	*Turbinaria*	Covered by coral

4.1.2 Sediment Deposition and Clearance

Substantial deposition and erosion of sediments from the surface of some tagged corals has been observed at times during the monitoring program (**Figure 4-5**). Sediment depth (mean ± SE) on pavers, a measure of net sediment accretion, has shown substantial variability throughout the Dredging and Post-dredging Phases. No clear trend in sediment accretion was apparent since the end of dredging survey, with some sites showing a general increase (Weed Reef 1, Weed Reef 2 and Northeast Wickham Point), while others showed decreases (Channel Island and South Shell Island) (**Figure 4-6**, **Appendix B-2**).

The trends in accumulation of sediment on pavers and changes in cover of sediment on corals during Post-dredging Phase surveys showed no clear relationship; that is, there appears to be no clear link between increases in paver sediment depth and increased sediment on tagged corals (**Figure 4-6**). The amount of sediment cover (mean ± SE) on tagged corals during Post-dredging Phase surveys for all sites combined varied between different coral growth forms (**Figure 4-7**). The sediment cover on encrusting corals underwent the greatest increase from Baseline to the Post-dredging Phase at 9.8%, followed by foliose corals which increased by 6.7 %. Submassive and massive corals experienced a lesser increase of 4.0% and 3.5% respectively.

D3 February 2013 D4 April 2013 D5 June 2013

D9 February 2014 D10 March 2014 D13 June 2014

P1 August 2014 P2 October 2014 P3 December 2014

Figure 4-5 Photographic time-series demonstrating an example (i.e. for tagged colony number 2 at WR2) of the large natural changes in sediment on coral

N.B. Part of the colony has been covered by a piece of rock in P3 as well as sediment

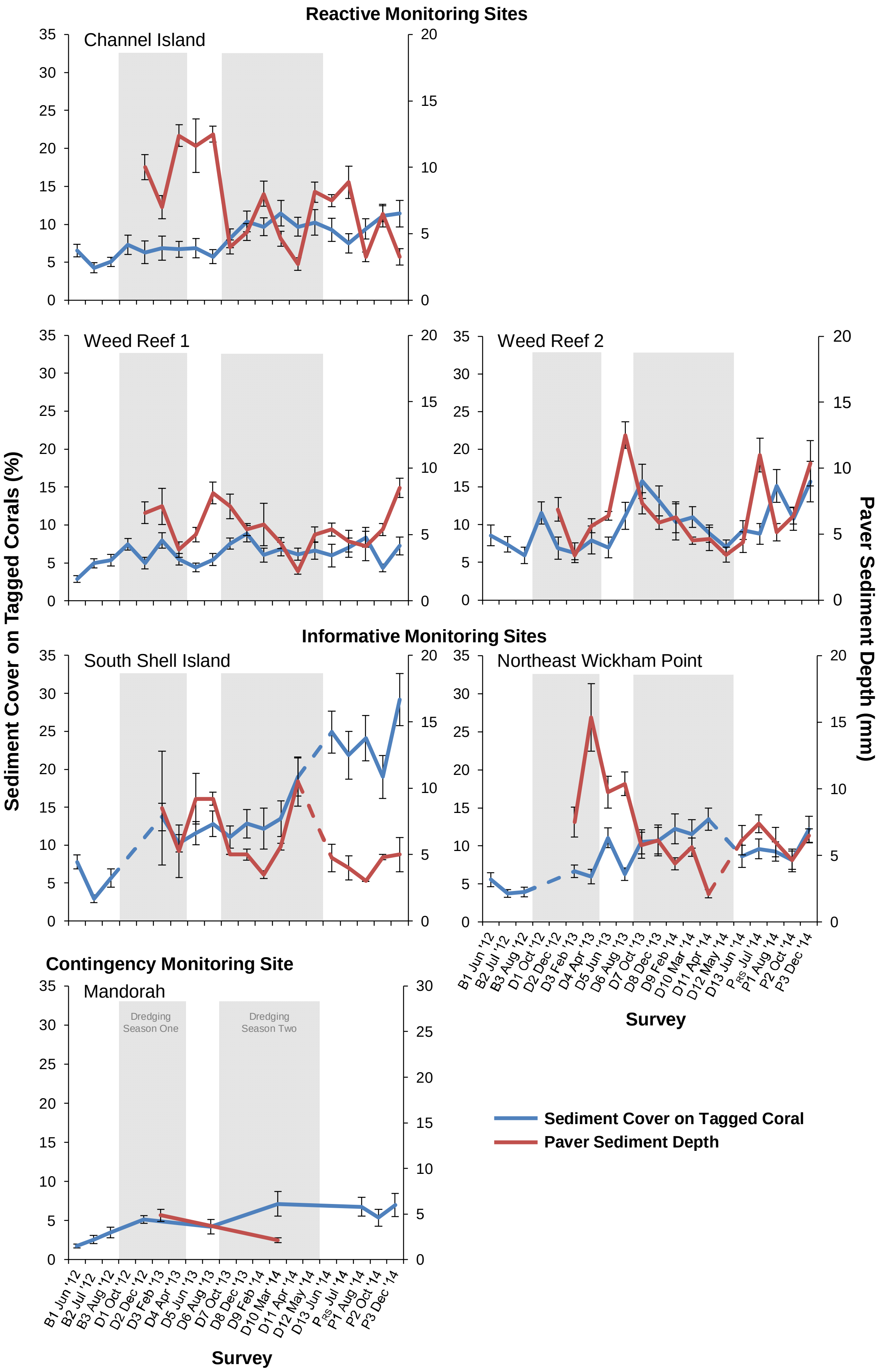


Figure 4-6 Mean (±SE) sediment cover (%) on tagged corals from B1 to P3 and mean sediment depth on pavers (mm) from D2 to P3

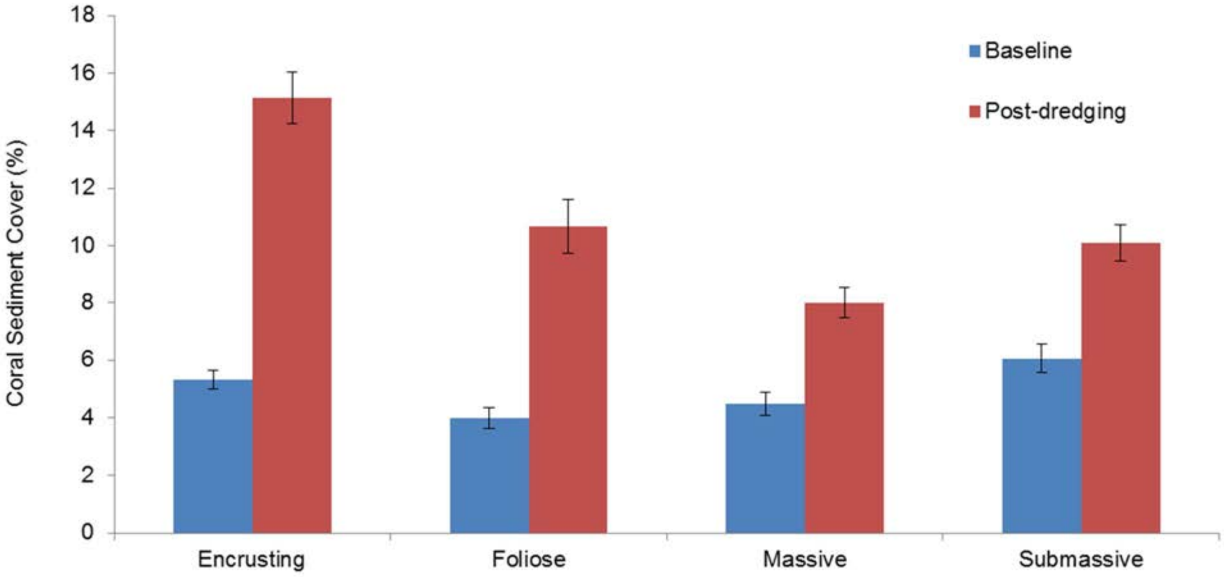


Figure 4-7 Mean (±SE) cover (%) of sediment on different growth forms during the Baseline (B1, B2 and B3) and Post-dredging surveys (P_{RS}, P1, P2 and P3) for all sites combined

4.1.3 Bleaching

During the Baseline and Dredging Phases, there were apparent peaks in bleaching, during June 2012 to August 2012 (B1 to B3), February 2013 to April 2013 (D3 to D4) and March 2014 to June 2014 (D10 to D13) (**Figure 4-8**). During the Post-dredging Phase, Channel Island and Weed Reef 2 showed an increase from 1.5 ± 0.9% and 1.3 ± 0.6% in P1 respectively to 4.0 ± 1.7% and 3.8 ± 1.9% in P2, which is similar to levels recorded in previous bleaching periods. Similarly, Northeast Wickham Point increased from 1.4 ± 0.8% in P2 to 4.3 ± 1.5% in P3. The bleaching in P2 at Channel Island and Weed Reef 2 was due primarily to several colonies of *Goniopora* sp. (four and three colonies respectively) showing an increase in partial bleaching. The increase in bleaching in P3 at Northeast Wickham Point was due primarily to an increase in bleaching of six tagged colonies (three *Turbinaria* sp., two *Alveopora* sp. and one *Goniopora* sp.).

Throughout the Post-dredging Phase, the mean partial bleaching was below levels recorded during the Baseline Phase at all sites, resulting in negative gross bleaching (i.e. a reduction in bleaching) (**Figure 4-9**). The greatest reduction in bleaching was recorded at Channel Island (-5.6%) followed by Weed Reef 1, Mandorah, Northeast Wickham Point, South Shell Island and Weed Reef 2 (-3.9%, -3.7%, -2.9%, -2.1% and -1.5% respectively).

The average coral tissue brightness (grouped into colour class) for each location showed minimal change in terms of either the lightest or darkest coral tissue (**Figure 4-10**). The dark coral tissue remained consistently close to coral brightness class 5; however, there was a slight overall darkening from D9 onwards. The light coral tissue remained consistently close to class 4, with no overall shifts apparent; however, there was a substantial lightening of tissue evident at Weed Reef 2 in P2 (decrease in brightness class; **Figure 4-10**) which corresponds to the observed increase in bleaching recorded at this site in P2. The increase in brightness was due to a substantial number of colonies showing a slight (one colour class) lightening of tissue (**Appendix B-3**).

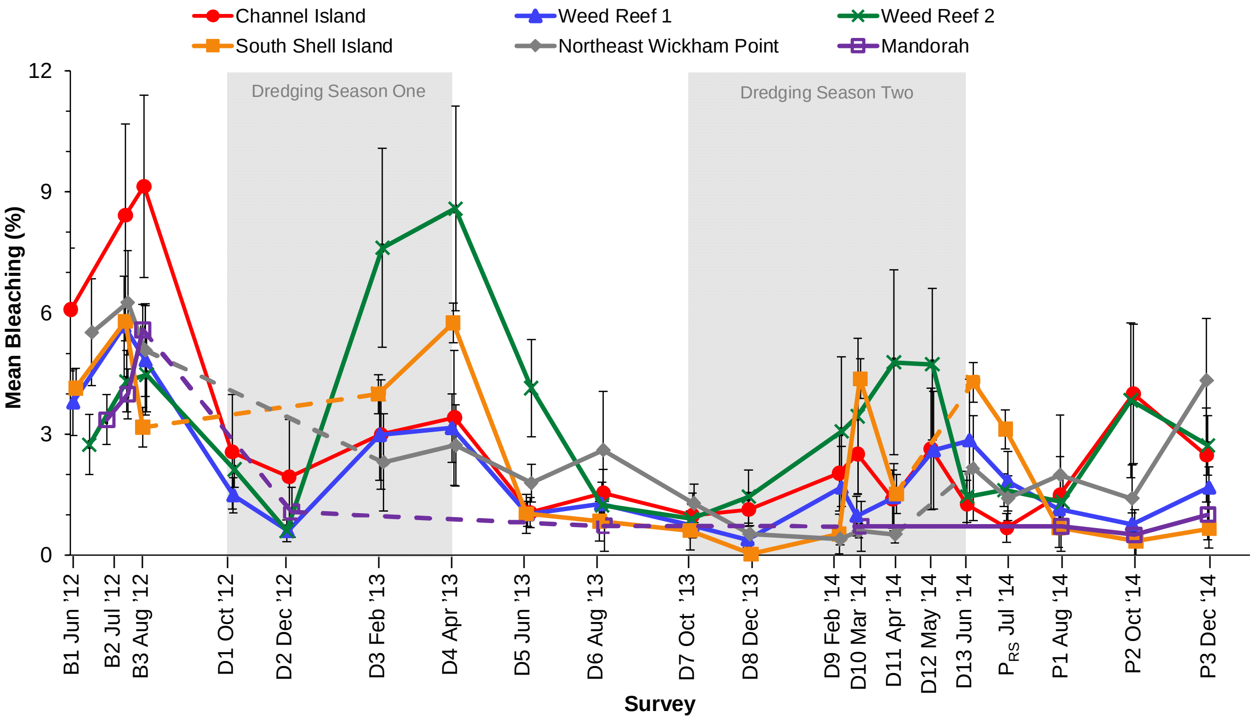


Figure 4-8 Mean (±SE) partial bleaching (%) of tagged corals at each monitoring site for surveys B1 to P3

N.B. surveys plotted on a continuous timeline based on number of days since the commencement of monitoring

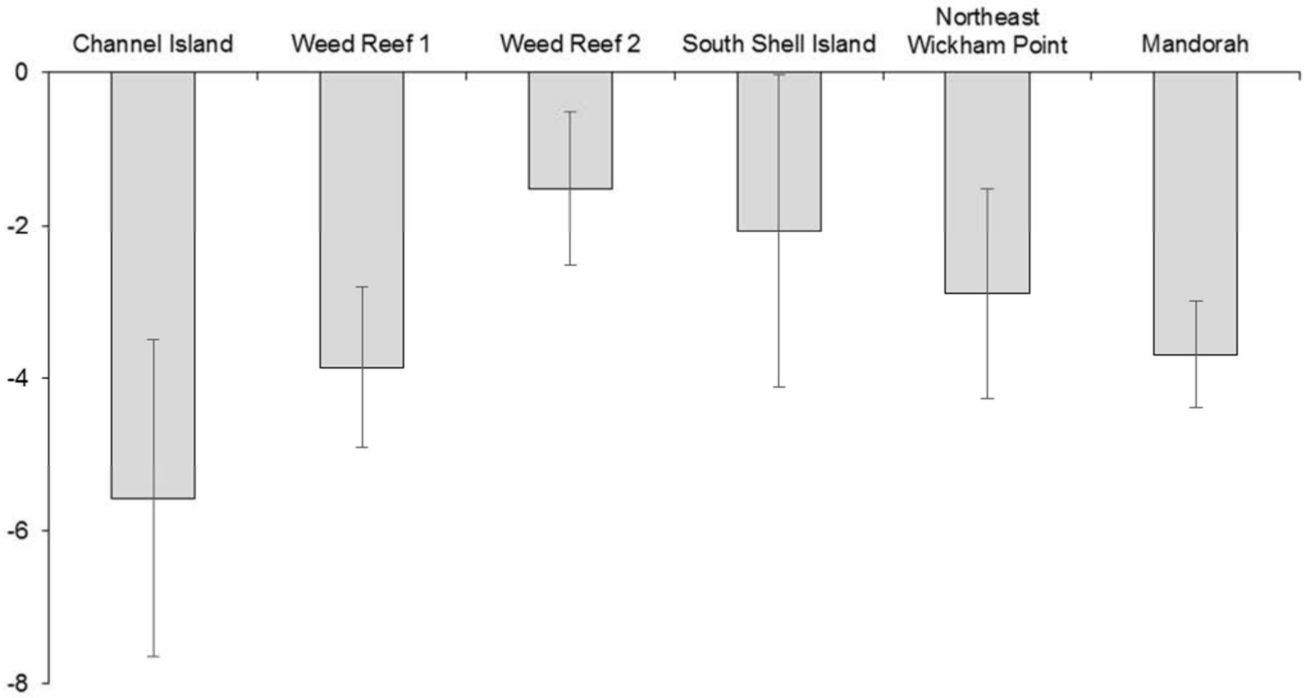


Figure 4-9 Gross bleaching (mean ± SE) for the Post-dredging Phase (P_{RS}, P1, P2 and P3 combined) relative to the Baseline Phase (B1, B2 and B3 combined)

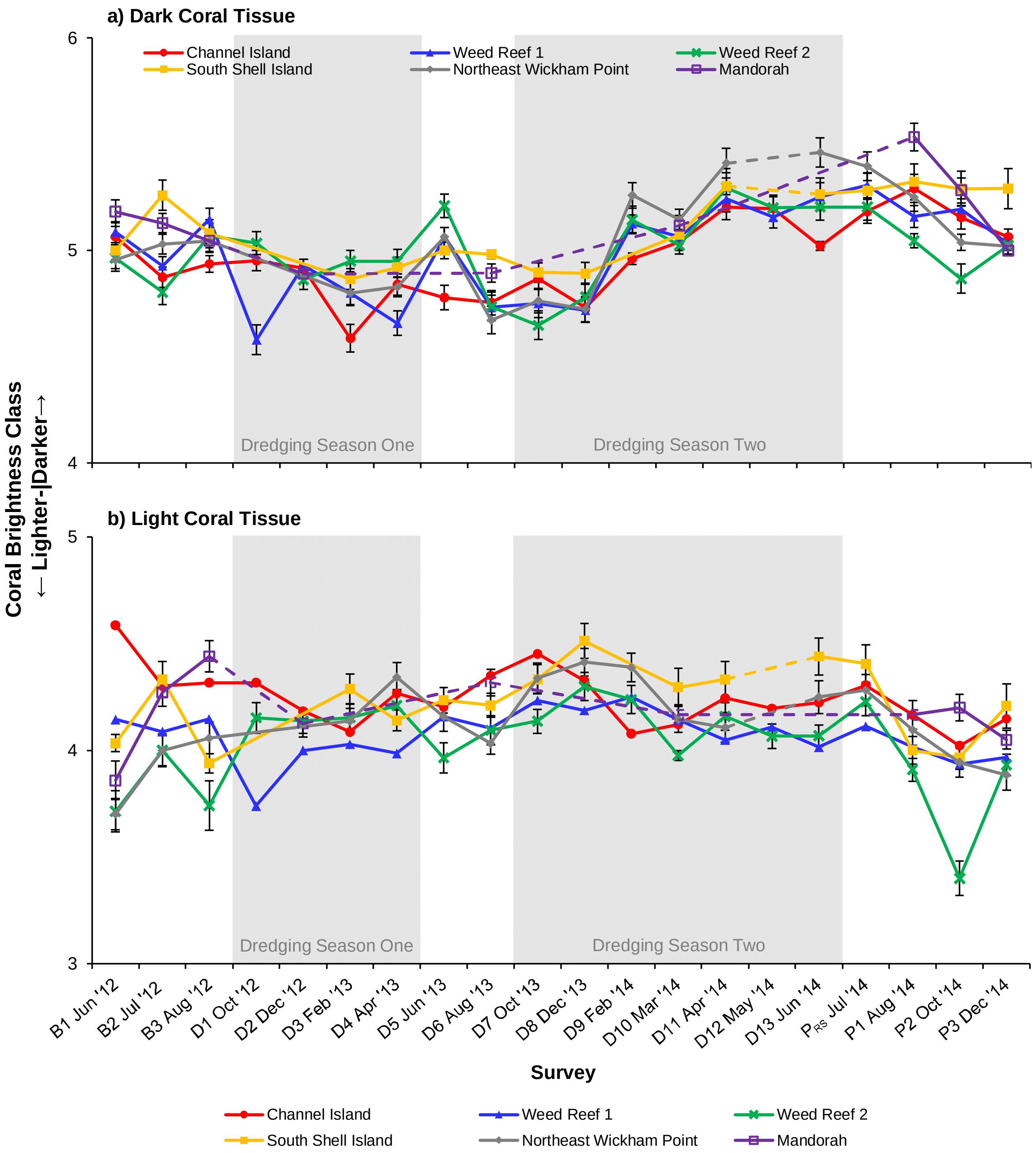
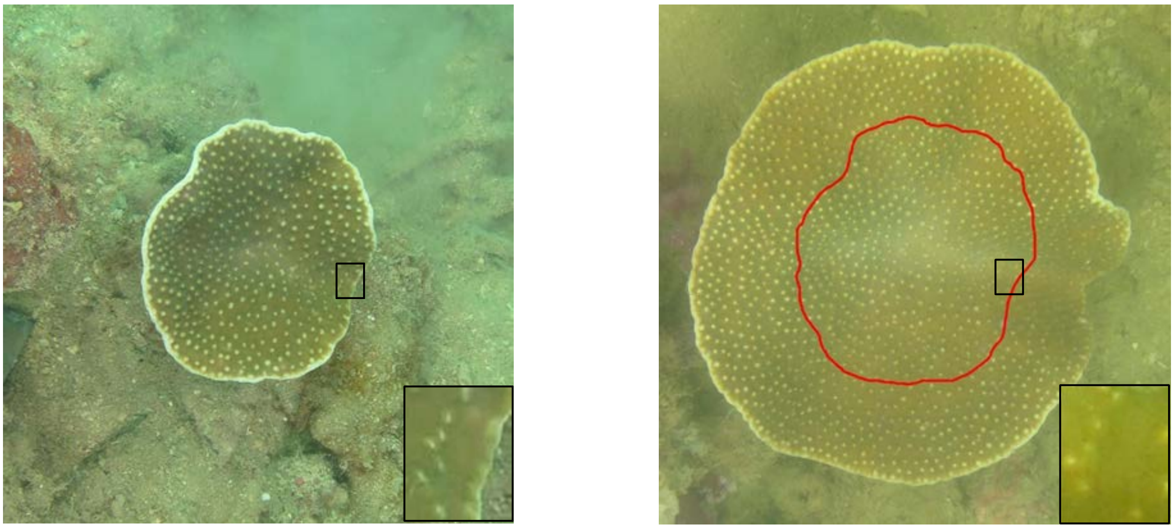


Figure 4-10 Mean (±SE) coral brightness class for surveys B1 to P3 for: a) darkest coral tissue; and b) lightest coral tissue

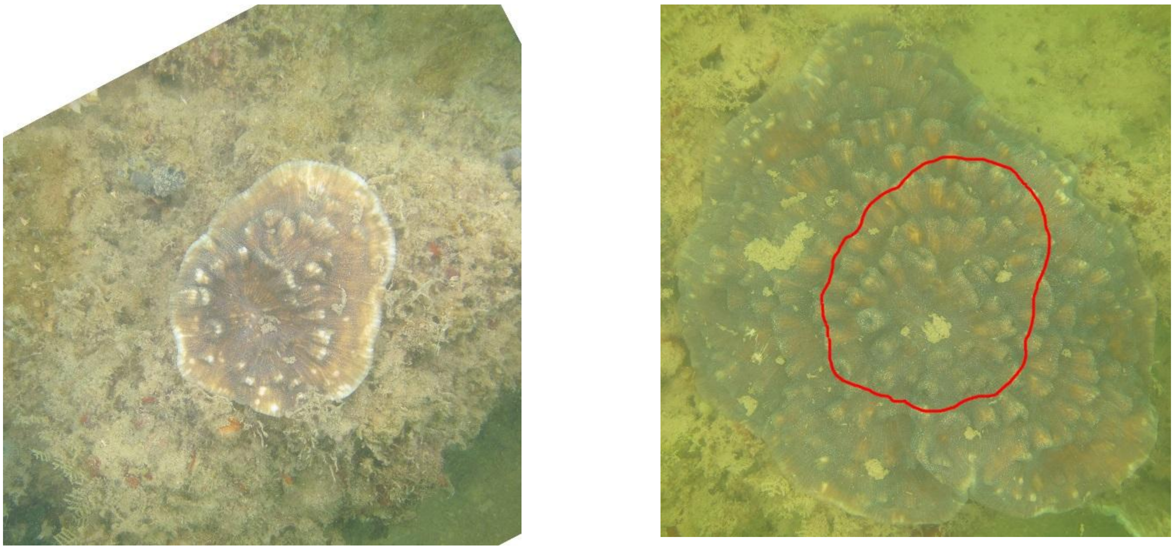
4.1.4 Colony Surface Area

Substantial increases in size have occurred for a number of the tagged coral colonies, with growth visibly apparent in many cases (**Figure 4-11**). Analysis of the change in surface area from B1 to P3 of 160 suitable and healthy tagged corals (i.e. colonies which had not moved or shown visibly apparent mortality) from three of the most prevalent families (Pectiniidae, Dendrophyllidae and Faviidae) indicated mean (±SE) increase of 70 ± 6%. The increase in size of corals differed between families and between sites. The greatest overall increase in size was recorded for Pectiniidae (n = 26) which on average more than doubled in size with a mean increase of 123 ± 16% across all sites. The mean increase of Dendrophyllidae (n = 41) was slightly less at 84 ± 14%, while Faviidae (n = 68) showed substantially less increase in size at 42 ± 5% (**Figure 4-12**). The substantially greater increase in size for Pectiniidae compared to Faviidae was consistent across sites. Dendrophyllidae, however, showed substantial variability in growth between sites (**Figure 4-12**). Growth of Dendrophyllidae was similar to Pectiniidae at Weed Reef 1, and to Faviidae at Weed Reef 2 and Mandorah. Northeast Wickham Point had a consistently greater increase in size compared to the other sites across families (**Figure 4-12**), although only one Pectinidae colony was suitable for analysis. Mandorah generally showed the least increase in size, due to limited growth of Dendrophillidae colonies and no Pectinidae being measured at this site.



a) B1 June 2012

P3 December 2014



b) B1 June 2012

P3 December 2014

Figure 4-11 Photographs of two colonies that have grown since June 2012 (B1) to four times their original size by December 2014 (P3). The original extent of colony is shown in red. a) *Turbinaria* sp. at Weed Reef 1 including inset showing polyps on edge in June 2012 and the same polyps in December 2014; and b) *Mycedium* sp. at Northeast Wickham Point

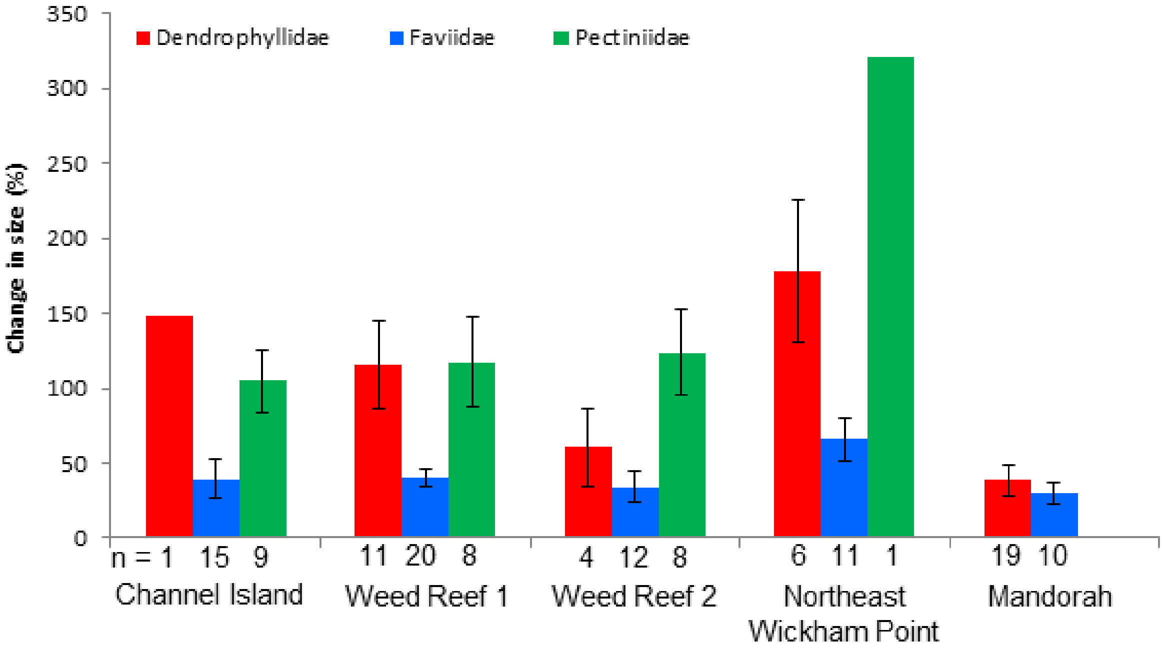


Figure 4-12 Mean (±SE) proportional change in coral size (%) in P3 relative to size recorded in B1

n = the number of replicate coral colonies. N.B. corals which have shown visibly apparent mortality were excluded

N.B. In P3 there were no corals suitable for analysis of growth at South Shell Island

4.2 Fixed Transects

4.2.1 Composition of Sites (Multivariate Analyses)

The main benthic categories at most sites during the Post-dredging Phase (and throughout monitoring) were sand and silt (ranging from 19.2% to 73.6%), turf algae (ranging from 9.3% to 46.6%) and hard coral (ranging from 1.5% to 17.9%) (**Figure 4-13**, **Appendix B-4** to **B-7**), with the exception of Northeast Wickham Point which had a greater cover of sponges (ranging from 4.0% to 7.2%) than coral cover (ranging from 1.5% to 3.2%). There were significant differences in the structure of the benthic assemblages between Surveys throughout monitoring, but the differences varied between Sites (p < 0.01) (**Table 4-3**, **Figure 4-14a**, **Appendix D-1a**). Pairwise analyses comparing Surveys for each Site independently indicated a general increase in sand and silt and a decrease in turf algae at most sites throughout monitoring (**Appendix D-1b**, **c**). Despite this overall shift being apparent, there was not a consistent significant difference between Baseline Surveys and Post-dredging Surveys.

The informative Impact sites and contingency site Mandorah also showed minimal differences between Baseline and Post-dredging Phase surveys.

Pairwise comparison between sites for each survey indicated a consistent difference between Mandorah and all other sites during all surveys, except compared with South Shell Island in D6 (**Appendix D-1d**). These differences were mainly due to a greater cover of other fauna and algae categories and lesser cover of sand and silt (**Figure 4-13**). Weed Reef 2 showed significant differences from Channel Island, Weed Reef 1, South Shell Island and Northeast Wickham Point during a small number of surveys. As these significant surveys were spread throughout monitoring, there was no apparent pattern to indicate a shift in assemblage at Weed Reef 2. In contrast, there were no significant differences among Channel Island, Weed Reef 1, South Shell Island and Northeast Wickham Point, with the exception of B3, in which South Shell Island differed from Northeast Wickham Point and Weed Reef 1.

Table 4-3 Summary of multivariate PERMANOVA analyses of entire benthic composition and coral assemblages at the monitoring sites

Significant factors indicated by *** p ≤ 0.001, ** p ≤ 0.01, NS = non-significant result, RED = Redundant term

Source	Survey	Site	Survey x Site
Entire benthic composition	RED	RED	**
Coral assemblage (family)	RED	RED	**
Coral assemblage (growth form)	RED	RED	***

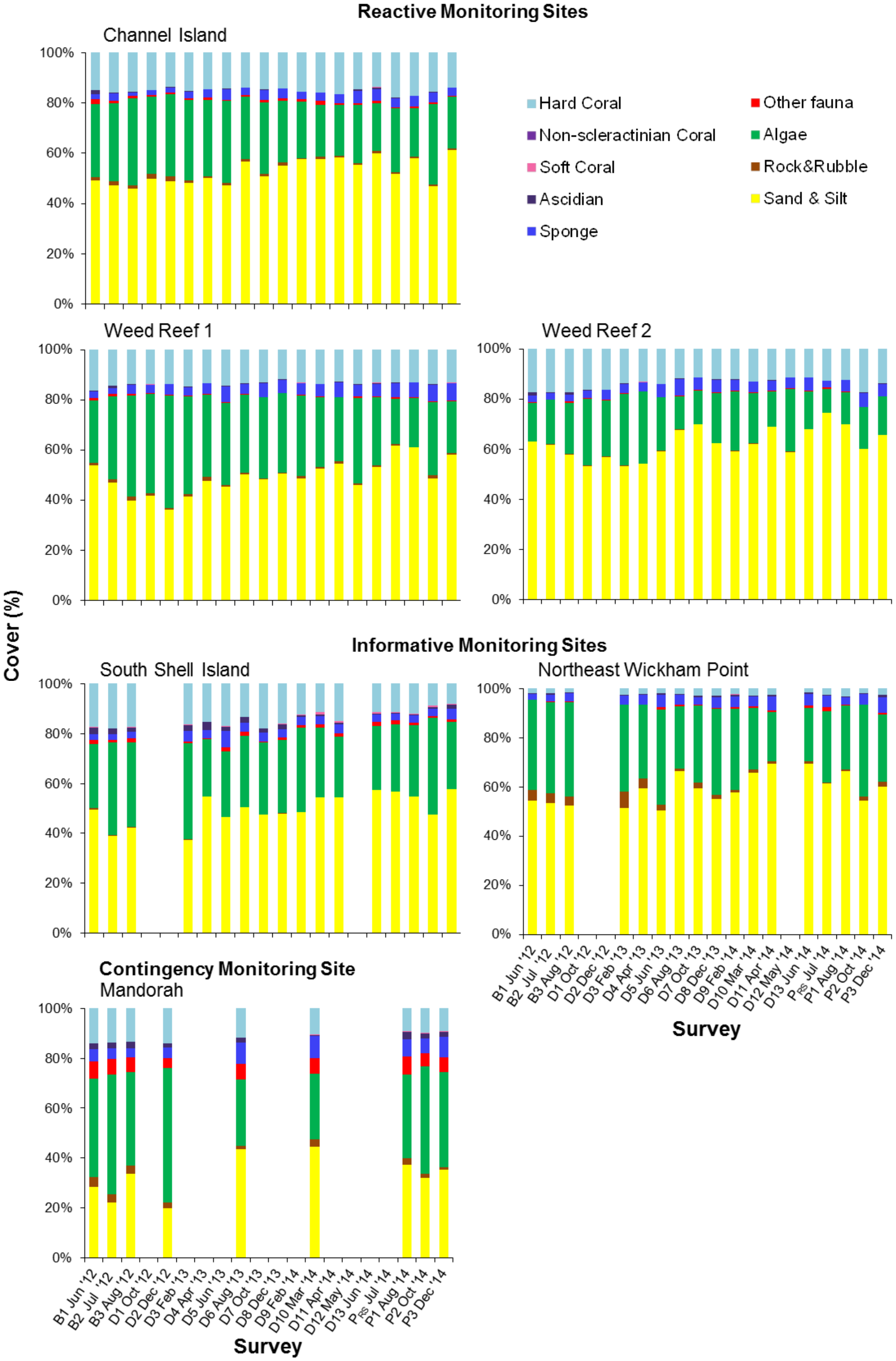
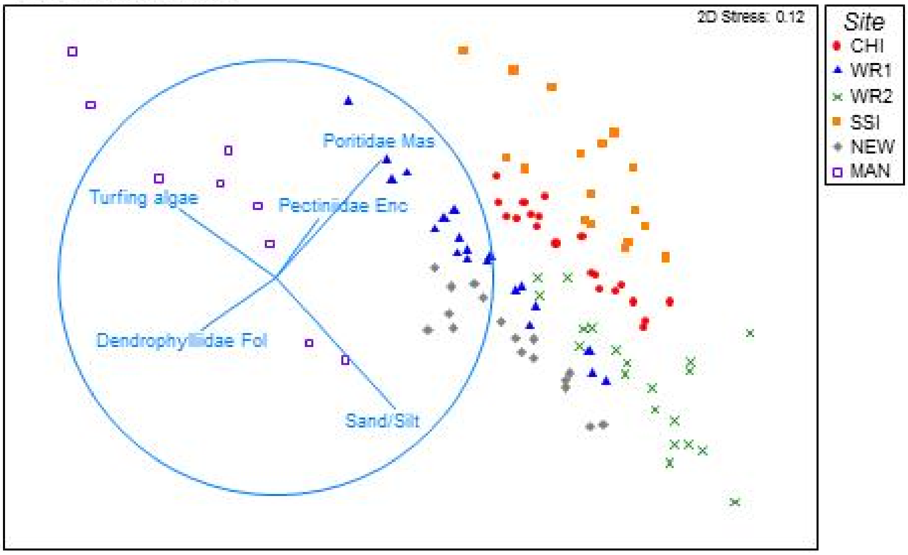
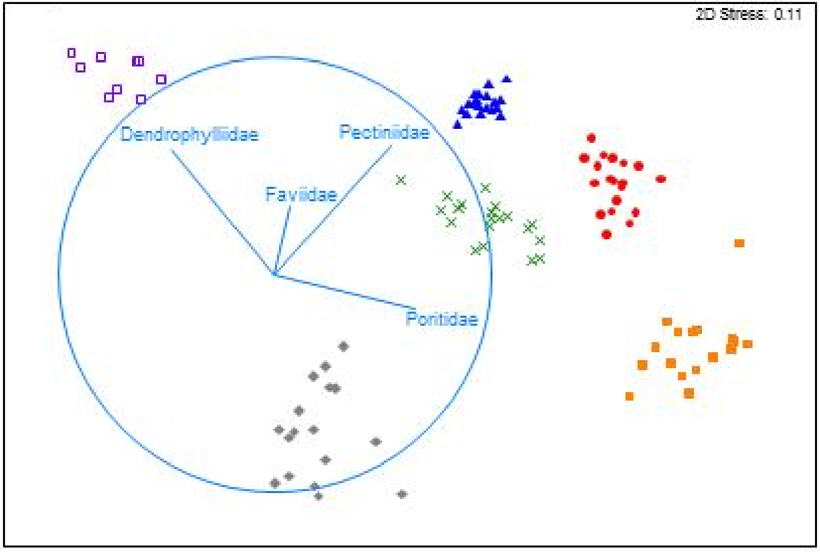


Figure 4-13 Contribution (%) of main categories to the composition of benthic assemblage along transects at the monitoring sites throughout the monitoring program

a) All categories



b) Coral families



c) Coral growth forms

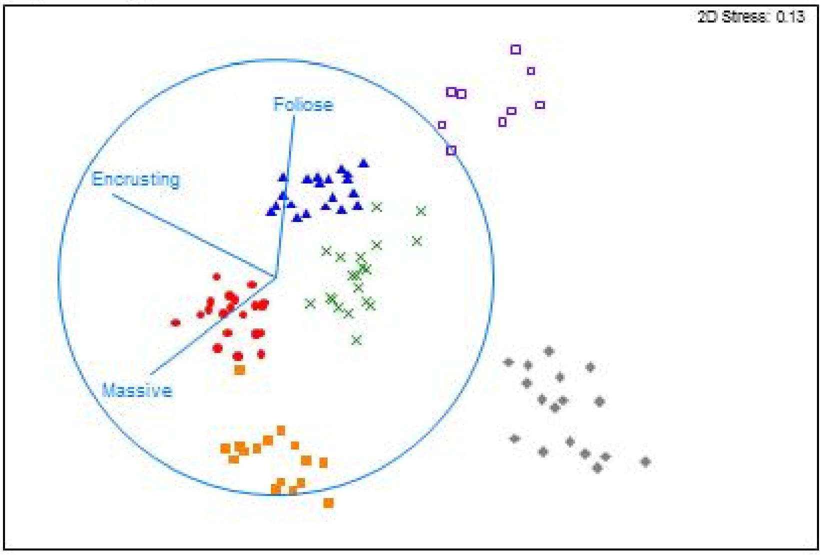


Figure 4-14 nMDS ordinations showing the centroids of the four transects at a site for each survey since the start of monitoring based on: a) the entire benthic composition; b) coral families; and c) coral growth forms at the monitoring sites

The composition of coral families showed minimal change from the Baseline to Post-dredging Phase at most monitoring sites (**Figure 4-15**). The greatest proportional change was a reduction in Poritidae at Weed Reef 2 which was driven by the mortality of *Alveopora* sp. following a thermal bleaching event. There was also a reduction in coral cover at South Shell Island; however, the reduction was consistent across families with minimal change in the proportion of the different families present. Although the temporal variability in coral cover was small at Northeast Wickham Point due to the minimal coral cover, there was a relative reduction in cover of Faviidae that was compensated for by an increase in cover of Poritidae and Pectiniidae. Mandorah only showed a decrease in coral for the dominant family, Dendrophylliidae, while the other families showed no change or slight increases (**Figure 4-15**).

There were statistical differences in the composition of coral families, irrespective of their growth form, between Sites but these differences varied among Surveys ($p < 0.01$) (**Table 4-3**, **Appendix D-2a**). Graphical interpretation of the spatial and temporal variability among coral families (**Figure 4-14b**) suggests there was a large degree of difference between sites but minimal changes for most sites through time. This is supported by pairwise analyses which detected very few significant differences among surveys for most sites (**Appendix D-2b**) and or consistent similarity or differences between most sites for most surveys (**Appendix D-2c**). Mandorah was significantly different to all other sites throughout monitoring mainly due to a greater cover of Dendrophylliidae and lesser cover of Poritidae. Northeast Wickham Point was also substantially different to the other monitoring sites in terms of coral family composition, mainly due to less cover of Dendrophylliidae, Pectiniidae and Faviidae (**Figure 4-14b**). Channel Island, Weed Reef 1 and Weed Reef 2 did not have a significantly different composition of coral families for any survey, apart from in D2 and D12 where Channel Island and Weed Reef 2 differed. South Shell Island was significantly different from Weed Reef 1 in B1, B3, D5, D7 and D11 to P3, mainly due to more cover of Poritidae and less Dendrophyllidae (**Figure 4-14b**). Moreover, South Shell Island composition of coral families was similar to Channel Island, with the exception of B1 and B2, and to Weed Reef 2 with the exception of D11 and P2.

The informative Impact sites showed less consistent relationships to the other monitoring sites among surveys (**Appendix D-2c**). Northeast Wickham Point only showed a consistent difference (in terms of the coral families) with Channel Island (**Appendix D-2c**). The comparison of Northeast Wickham Point to Weed Reef 1 and Weed Reef 2 showed significant differences for only some surveys during the Dredging and Post-dredging Phases, with no clear pattern of difference indicating a shifting composition (**Figure 4-14b**, **Appendix D-2c**). In both cases, the low cover of coral at Northeast Wickham Point (**Figure 4-13**) means that small changes in coral cover have a large influence on the overall composition. Since the Baseline Phase, there was an increase in similarity between Northeast Wickham Point and Weed Reef 1 due to a slight increase in Pectiniidae and Poritidae through time at Northeast Wickham Point. Whereas, variable similarity between Northeast Wickham Point and Weed Reef 2 was influenced by two large Dendrophylliidae colonies along transect 1 which were sampled in only some surveys due to the random selection of quadrats.

In contrast, the pattern of difference between South Shell Island and Northeast Wickham Point appeared to show a possible trend with the sites being different in all surveys up to D7 and then showing no significant difference in six of the nine surveys from D8 to P3 (**Appendix D-2c**). This appears to be due to a decrease in both Pectiniidae in transect 2 and Poritidae in transect 3 at South Shell Island to cover more similar to those at Northeast Wickham Point. Comparison of South Shell Island to Weed Reef 1 showed significant differences between the sites for some surveys prior to D10 and all subsequent surveys differing in part also due to the reduction in Pectiniidae in transect 2. However, these changes at South Shell Island did not influence the relationship with all sites as there was no significant difference to Channel Island or Weed Reef 2 for most surveys throughout monitoring.

Analysis of coral growth form, irrespective of family, indicated there were significant differences between Sites but these differences varied among Surveys ($p < 0.01$) (**Table 4-3**, **Appendix D-3a**). Graphical interpretation of spatial and temporal variability of coral growth forms (**Figure 4-14c**) suggests a large degree of difference between sites and minimal changes within sites through time. This is supported by pairwise analyses comparing Surveys for each Site which detected very few significant differences (**Appendix D-3a**). Whereas, pairwise analyses comparing sites for each survey indicated substantial differences between the sites, but not consistently throughout all surveys (**Appendix D-3c**). Mandorah was significantly different to all other sites for the majority of surveys throughout monitoring, mainly due to a greater cover of foliose and lesser cover of massive growth forms (**Figure 4-14c**). Northeast Wickham Point also showed a consistent difference from Channel Island due to a generally greater cover of most growth forms at Channel Island, particularly encrusting corals. The remaining sites either showed minimal differences through time, or differences for only some surveys, but with no clear patterns apparent at any site which would indicate a shift in the composition of growth forms through time.

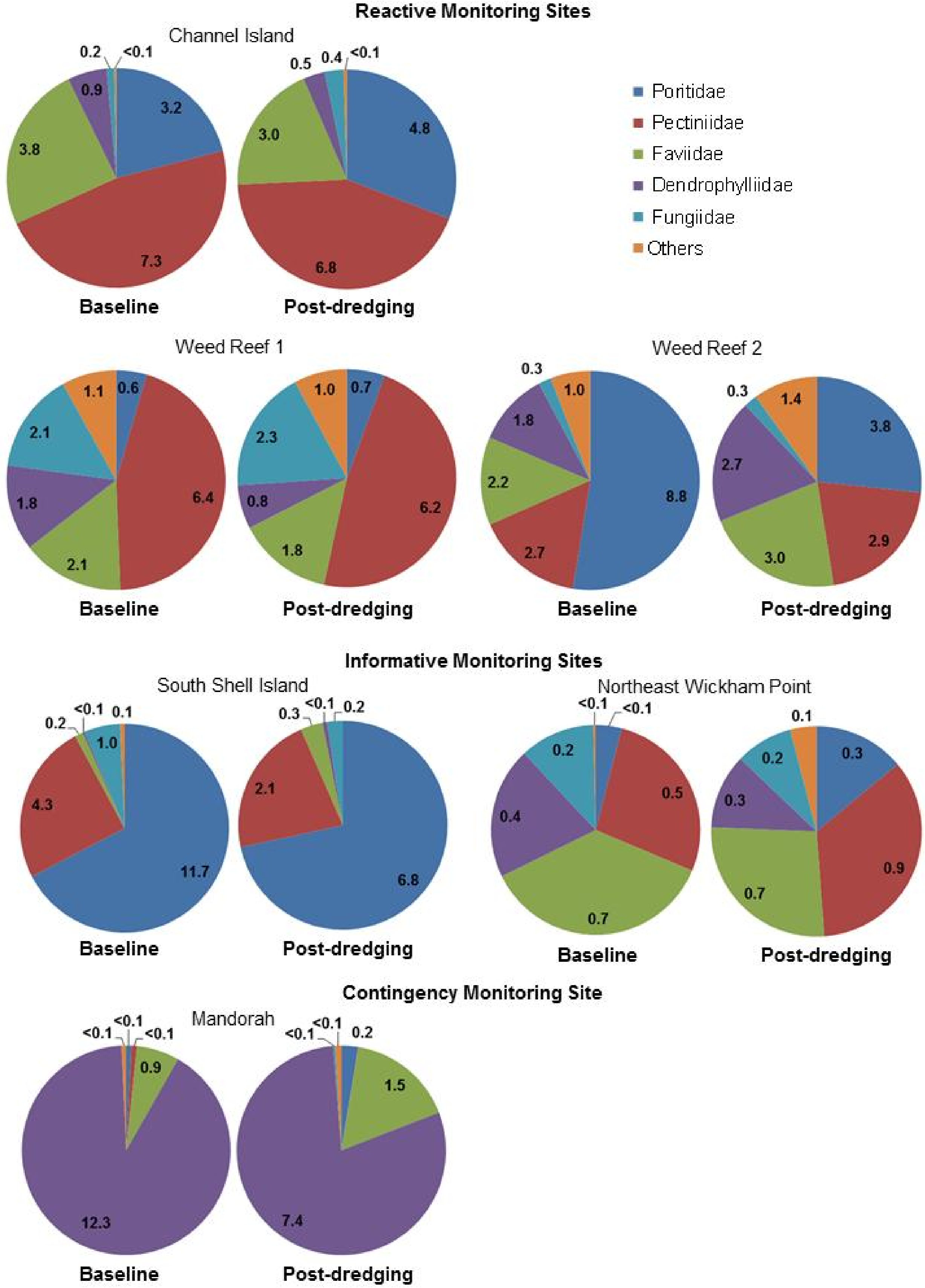


Figure 4-15 Proportional contribution of coral families (actual percentage cover shown on charts) to the composition of benthic assemblage along transects at the monitoring sites in Baseline (B1 to B3 average) and Post-dredging (P1 to P3 average) Phases

4.2.2 Percentage Cover Analyses (Univariate Analyses)

There were significant differences in hard coral cover between Surveys but these differences varied among Sites ($p < 0.01$) (**Table 4-4**, **Figure 4-16a**, **Appendix D-4a**). At Channel Island, Weed Reef 1 and Weed Reef 2 pairwise analyses indicated that although coral cover differed between Baseline and Dredging Phase surveys, among Dredging Phase surveys, and between Dredging and Post-dredging Phase surveys there were effectively no significant differences between Baseline and Post-dredging Phase surveys (**Appendix D-4b**). The only exception was a significant decrease in coral cover at Weed Reef 1 between B1 and P1 due to an anomalously high cover of coral in B1. Northeast Wickham Point also showed no changes in coral cover between Baseline and Post-dredging Phase surveys as well as minimal change throughout the Baseline and Dredging Phase surveys (**Figure 4-16a**, **Appendix D-4b**). In contrast, South Shell Island showed a significant decrease in coral cover from Baseline to Post-dredging Phase surveys primarily due to decreasing cover from approximately October 2013 (D7) in the Dredging Phase through to the Post-dredging Phase (**Figure 4-16a**, **Appendix D-4b**). A slight decline in coral cover was also recorded at Mandorah between Baseline and Post-dredging Phases; however, the decrease was only statistically significant between B2 and surveys P1 and P3 (**Figure 4-16a**, **Appendix D-4b**).

Comparison of coral cover between sites indicated that Northeast Wickham Point had significantly lower coral cover than all other sites except South Shell Island throughout monitoring (**Appendix D-4c**). The coral cover at South Shell Island was initially significantly greater than at Northeast Wickham Point but by D9 coral cover had reduced to a point where there was no longer a statistically significant difference between the sites (**Figure 4-16a**, **Appendix D-4b**). At South Shell Island, visual inspection of transect photographs indicates that the reduction in coral cover between P1 and P2 was at least partially due to the retraction of tentacles in *Goniopora* sp. (**Figure 4-17**) likely as a consequence of increasing water temperatures (see **Section 4.4**).

Statistical analysis of sand and silt cover showed significant differences among Surveys independent of Site ($p < 0.01$), and between Sites independent of Survey ($p < 0.01$) (**Table 4-4**, **Appendix D-5a**). Pairwise analysis comparing Surveys irrespective of Sites suggested that sand and silt cover was generally greater during the Post-dredging Phase (range: 47% to 61%) than Baseline Phase surveys (range: 44% to 51%) (**Appendix D-5b**, **c**). However, the cover of sand and silt did not increase since the end of dredging (D13). Instead there was a significant decrease in survey P2 to 47% which was not significantly different from Baseline Phase surveys, before increasing slightly to 55% in P3 (**Appendix D-5c**). The increase in sand and silt occurred incrementally throughout the Dredging Phase and there was an overall decrease from the amount of sand and silt at the end of dredging (D13) to the Post-dredging Phase surveys (P1 to P3). The significant difference in sand and silt between sites for all surveys combined was due to Mandorah having consistently less sand and silt than all other monitoring sites and Weed Reef 2 having greater cover than Weed Reef 1 and South Shell Island (**Appendix D-5d**, **e**).

There were significant differences in the cover of turf algae between Surveys ($p < 0.01$) and among Sites ($p < 0.01$) (**Table 4-4**, **Figure 4-16c**, **Appendix D-6a**). Pairwise analysis indicated no consistent difference between the Baseline and Post-dredging Phase surveys (**Appendix D-6b**, **c**). That is, survey B1 had significantly less turf algae than P2, while B2 had significantly greater turf algae than P_{RS}, P1 and P3, and B3 showed no difference from any Post-dredging Phase survey. Similar variability in cover of turf algae was recorded within and between Baseline and Post-dredging Phase surveys. The significant difference in turf algae between sites for all surveys combined was due to Weed Reef 2 having consistently less turf algae than all other monitoring sites and Mandorah having greater cover than Channel Island (**Appendix D-6d**, **e**). Overall, the increase in sand and silt at Channel Island, Weed Reef 1 and Northeast Wickham Point (**Figure 4-16b**, **Figure 4-18**) between the Baseline and Post-dredging Phase surveys have coincided with a reduction in turf algae (**Figure 4-16c**, **Figure 4-18**). Whereas, at Weed Reef 2, South Shell Island and Mandorah, the increases in sand and silt appear to have coincided with a reduction in coral cover (**Figure 4-16a**, **Figure 4-18**).

Table 4-4 Summary of univariate PERMANOVA analyses of hard coral, sand and silt, and turf algae at the monitoring sites (excluding Charles Point)

Significant factors indicated by *** p ≤ 0.001, ** p ≤ 0.01, NS = non-significant result

Source	Survey	Site	Survey x Site
Hard coral cover	RED	RED	***
Sand and silt	***	**	NS
Turf algae	***	***	NS

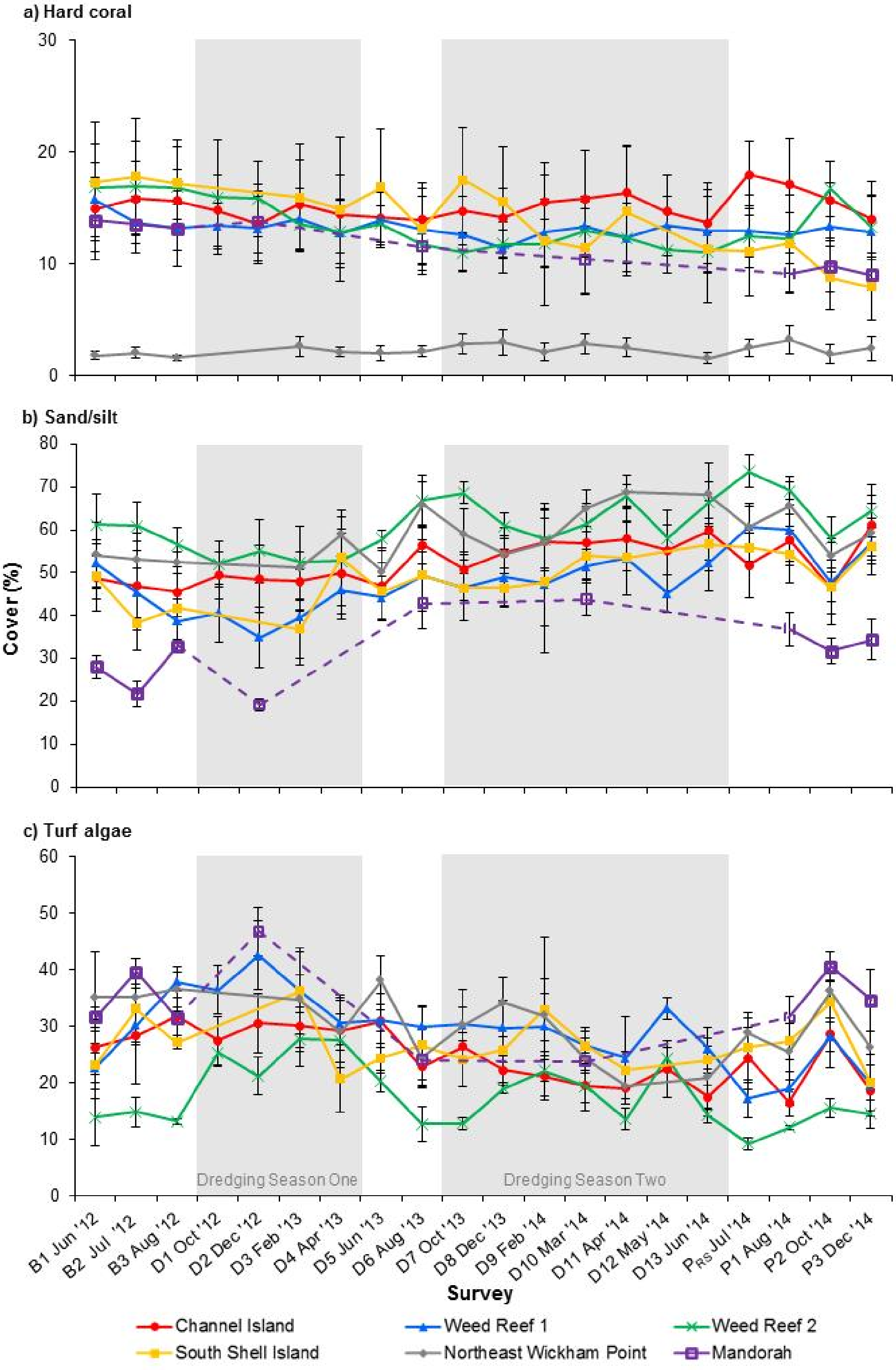


Figure 4-16 Mean (±SE) hard coral, sand/silt and turf algae cover for all sites throughout the monitoring program

P1 August 2014 – Transect 1

P2 October 2014 – Transect 1

P1 August 2014 – Transect 4

P2 October 2014 – Transect 4

Figure 4-17 Photoquadrats from transects 1 and 4 during P1 (August 2014) and P2 (October 2014) showing examples of the substantial retraction of *Goniopora* sp. observed

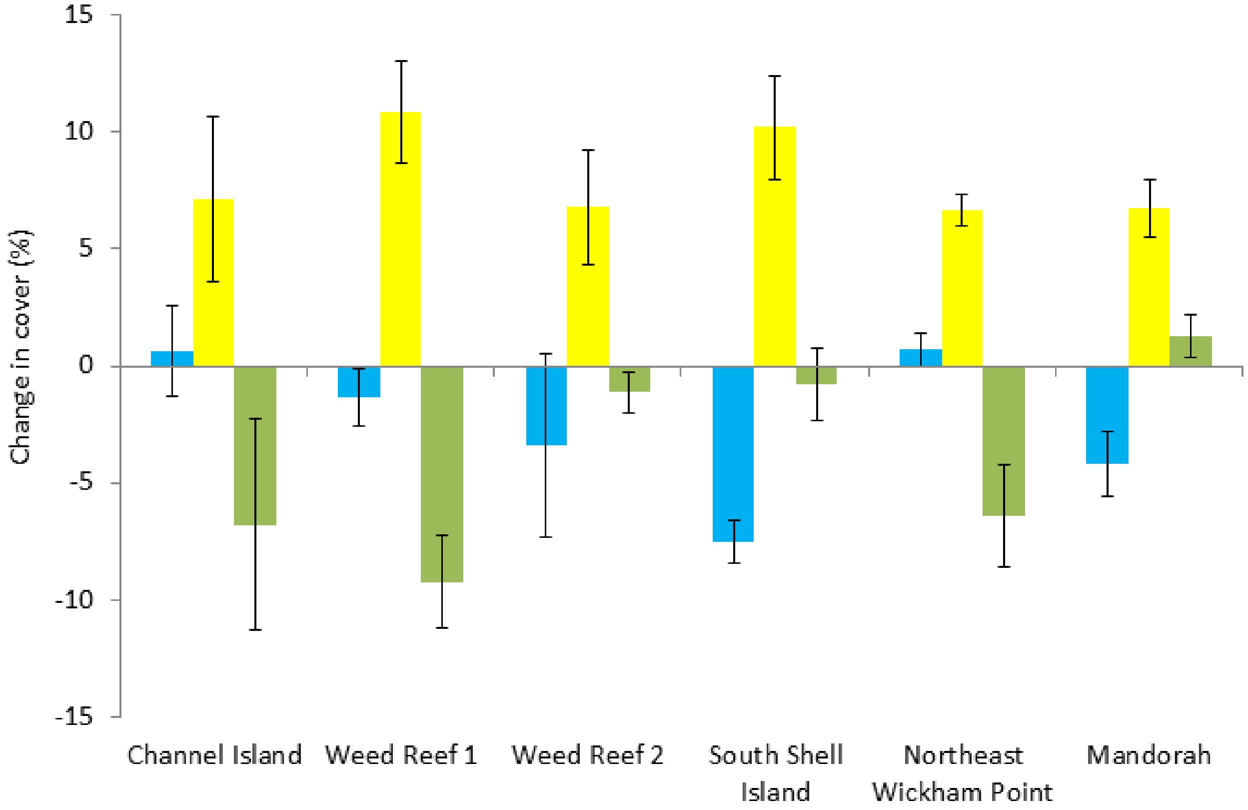


Figure 4-18 Change in mean percentage cover (±SE) of coral (blue), sand/silt (yellow) and turf algae (green) between the Baseline (B1, B2 and B3 combined) and Post-dredging Phases (P_{RS}, P1, P2 and P3 combined)

4.2.3 Reproduction and Recruitment (Juvenile Corals)

In April 2013 and April 2014, mature oocytes were present in four colonies representing 44% and 66% of samples respectively (**Figure 4-19**, **Appendix C-2**). In contrast, only one colony in October 2013 showed the presence of mature oocytes, representing 17% of samples. At the coral family level, the presence of mature oocytes was detected only in Faviidae. In Faviidae, oocytes were numerous and matured synchronously within colonies and the proportion of colonies with mature oocytes was high in both April 2013 (67%) and April 2014 (100%) (**Figure 4-20**). Importantly, mature oocytes were absent in the May 2014 and June 2014 surveys (**Figure 4-19**, **Figure 4-20**, **Appendix C-2**) indicating spawning had occurred between 8 April 2014 and 10 May 2014.

No planulae were observed in histological sections of any of the four coral families collected suggesting potential dominance of broadcaster reproductive mode (i.e. release of eggs instead of larvae).

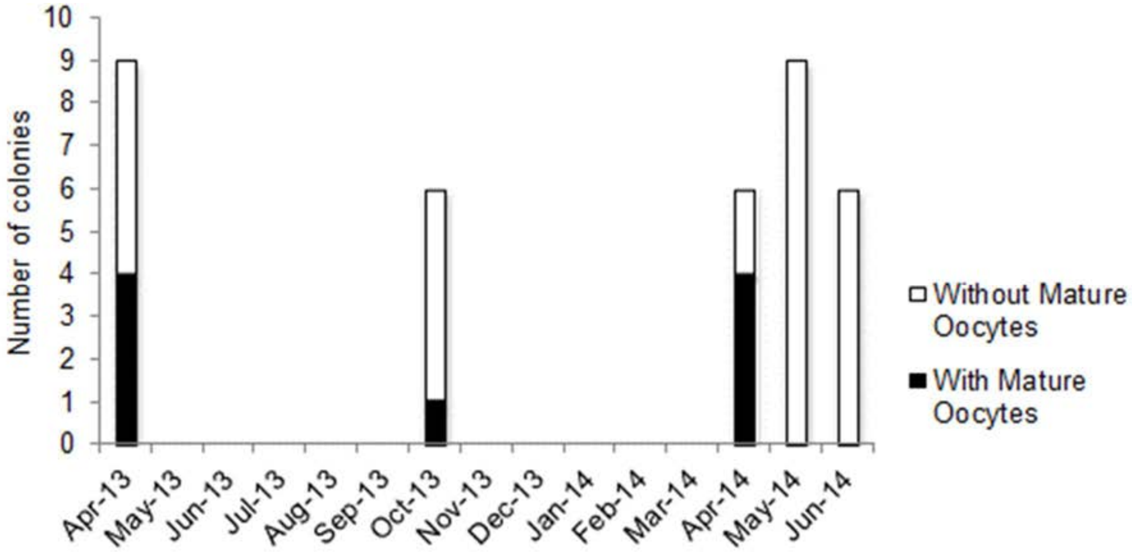


Figure 4-19 Number of coral colonies with mature oocytes present

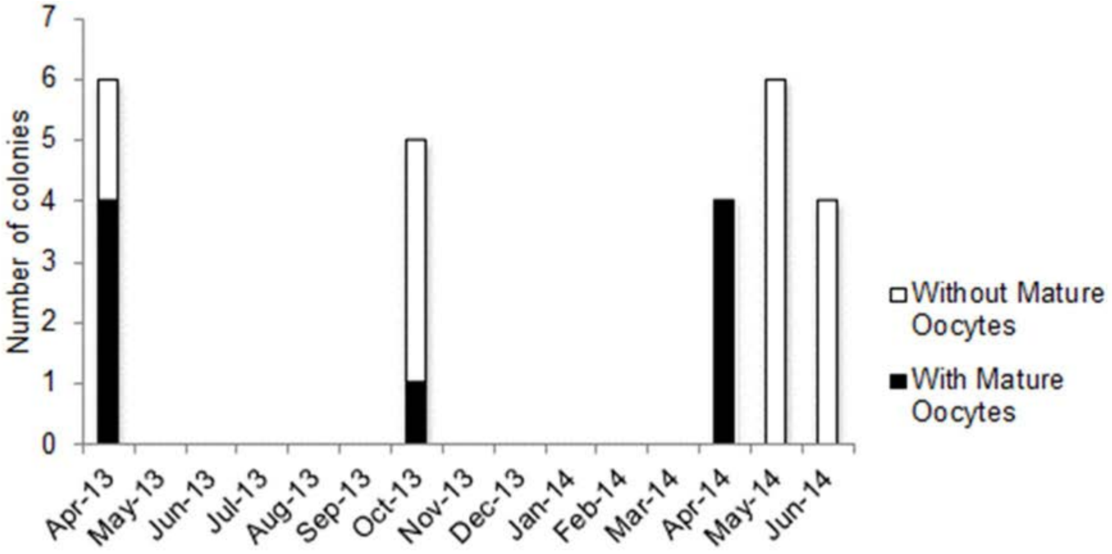


Figure 4-20 Number of Faviidae with mature oocytes present

A significant interaction between Survey and Site was detected in the analysis of number of coral recruits (p < 0.01) (**Table 4-5**, **Appendix D-7a**); that is, differences between Surveys were dependent on the Site considered and vice versa. Pairwise analyses between Surveys at each Site showed no clear patterns (**Appendix D-7b**). Inspection of the patterns indicates peaks in the number of recruits in approximately June 2012, June 2013 and June 2014, although the presence and timing of peaks in recruits varied considerably between locations (**Figure 4-21**). This was partially supported by pairwise analyses which showed that there were significantly greater recruits at Channel Island in June 2012 and July 2014 compared to several other surveys (**Appendix D-7b**). South Shell Island also had significantly greater recruits in June 2012 while Northeast Wickham Point also had a greater number of recruits in June 2013 and July 2014. Mandorah had a greater number of recruits in D6 and D10 compared with B3 and D2; however, no inter-annual pattern was evident. Comparison of the number of recruits between sites showed no consistent differences, although Northeast Wickham Point had significantly less recruits in at least some surveys compared to all other sites apart from South Shell Island (**Appendix D-7c**). Similarly, South Shell Island had significantly fewer recruits than all other sites except Northeast Wickham Point in some of the Dredging and Post-dredging surveys, especially for times of year when peaks in recruitment were recorded, indicating a potential decrease in recruits at South Shell Island. In addition, there were no differences among Channel Island, Weed Reef 1 and 2 in any of the surveys.

Table 4-5 Summary of univariate PERMANOVA analyses of the number of coral recruits for all sites Significant factors indicated by *** p ≤ 0.001, NS = non-significant result

Source	Survey	Site	Survey x Site
Number of coral recruits	RED	RED	***

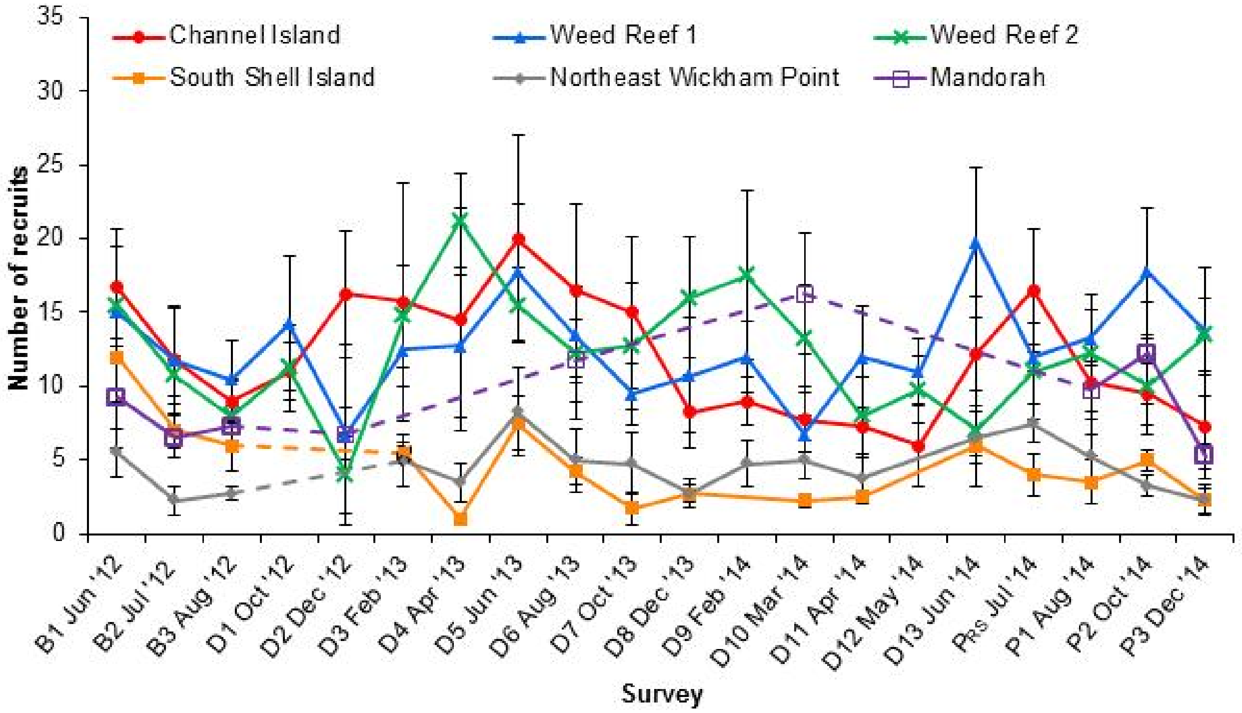


Figure 4-21 Mean (±SE) number of coral recruits (< 20 mm diameter) at all sites throughout the monitoring program

4.3 Comparative Analysis of Tagged Corals and Fixed Transects

4.3.1 Sediment on Tagged Corals and Transects[1]

Changes in sediment cover on tagged corals were compared with changes in sediment at a site-wide level to determine whether sediment on tagged corals was representative of a site-wide trend or natural variability (**Figure 4-22**). Although there was variability among the Surveys in sediment on tagged corals at all Sites, overall there was an increase in sediment on tagged corals from the Baseline Phase (range from 1.8% to 8.6%, mean = 4.9%) to the Post-dredging Phase (range from 4.4% to 29.2%, mean = 11.9%) at all monitoring sites (**Figure 4-22**, see **Section 4.1.1**).

Similarly, there was an overall increase in sediment cover in transects through time at all sites from the Baseline Phase (range from 21.8% to 32.3%, mean = 46.8%) to the Post-dredging Phase (31.7% to 69.1%, mean = 53.3%) (**Figure 4-22**). However, there was substantial variability in sediment cover along transects throughout monitoring, including within the Baseline and Post-dredging Phases. Importantly, in Post-dredging survey P2, the sediment cover decreased to 47.5% at all sites to levels similar to the Baseline Phase (46.8%), but then subsequently increased in survey P3 to 55.3%.

4.3.2 Mortality of Tagged Corals and Coral Cover in Transects

As a consequence of mortality being measured using a permanently tagged subset of corals, partial mortality of tagged corals increased during the monitoring period at all sites as expected, but at differing rates (**Figure 4-23**, see **Section 4.1.1**). If the mortality of individual corals was occurring at a rate that was greater than replacement by growth and recruitment, it would be expected that site-wide coral cover would also be declining. It is therefore necessary to interpret coral mortality on a site-wide level in addition to that observed for individual tagged coral colonies.

Although variability in coral cover was recorded throughout monitoring, overall there was minimal change to coral cover at Channel Island, Weed Reef 1 or Northeast Wickham Point from the Baseline to Post-dredging Phase (**Figure 4-23**). Whereas at Weed Reef 2, South Shell Island and Mandorah there was an overall decrease in coral cover from the Baseline to Post-dredging Phase. Weed Reef 2 showed a decrease from B1 (16.8%) to D7 (11%) which was considered to be primarily due to coral mortality following the thermal bleaching event recorded in D3 (February 2013) (**Figure 4-23**, see **Section 4.2.2**). Between D7 and P1 coral cover at Weed Reef 2 ranged between 11.0% and 12.9% with minimal change, before increasing temporarily to 16.7% in P2, and decreasing slightly to 13.3% in P3. At South Shell Island, coral cover showed a high degree of spatial (between transects) and temporal (between surveys) variability, although there was an overall decline apparent from 17.4% in D7 to 11.3% in the end of dredging survey (D13), and a further decline to 7.9% by P3, although, this latter decline was in part, due to tentacle retraction of *Goniopora* sp., (see **Section 4.2.2**). At Mandorah there was a general decline in coral cover throughout dredging from 13.8% in B1 to 9.0% in P3.

---

[1] 'Sediment on transects' is the percentage cover of sediment along the transect strip (i.e. the cover of sediment on the substratum and overlaying biota). For transect photos, each point analysed is assigned as 'sediment' if sand or silt occupies more than 50% of the 5 mm circle that constitutes the point.

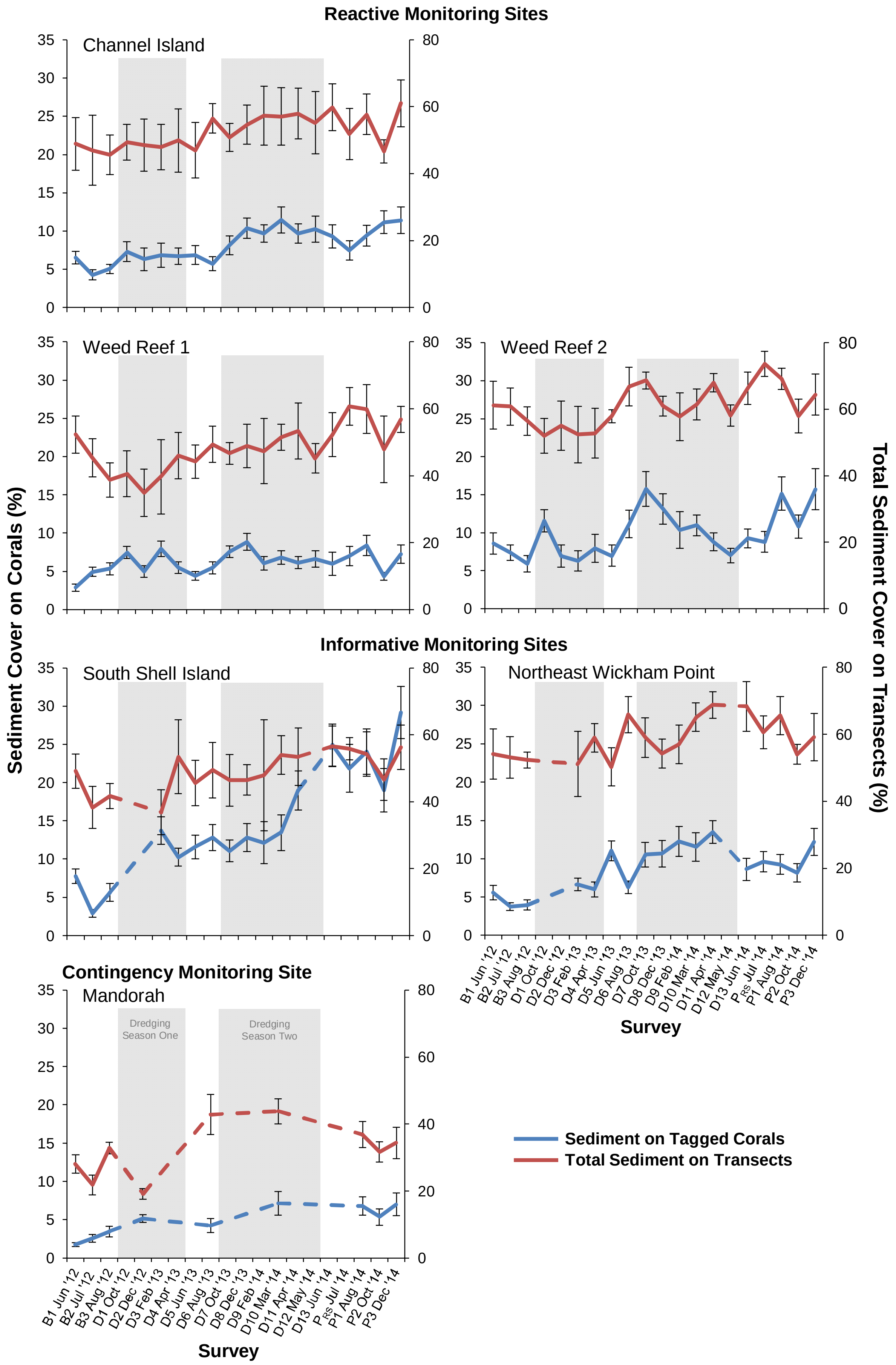


Figure 4-22 Mean (±SE) sediment cover on tagged corals (n ranging from 37 to 70) and mean (±SE) total sediment cover along transects (n = 4) throughout the monitoring program

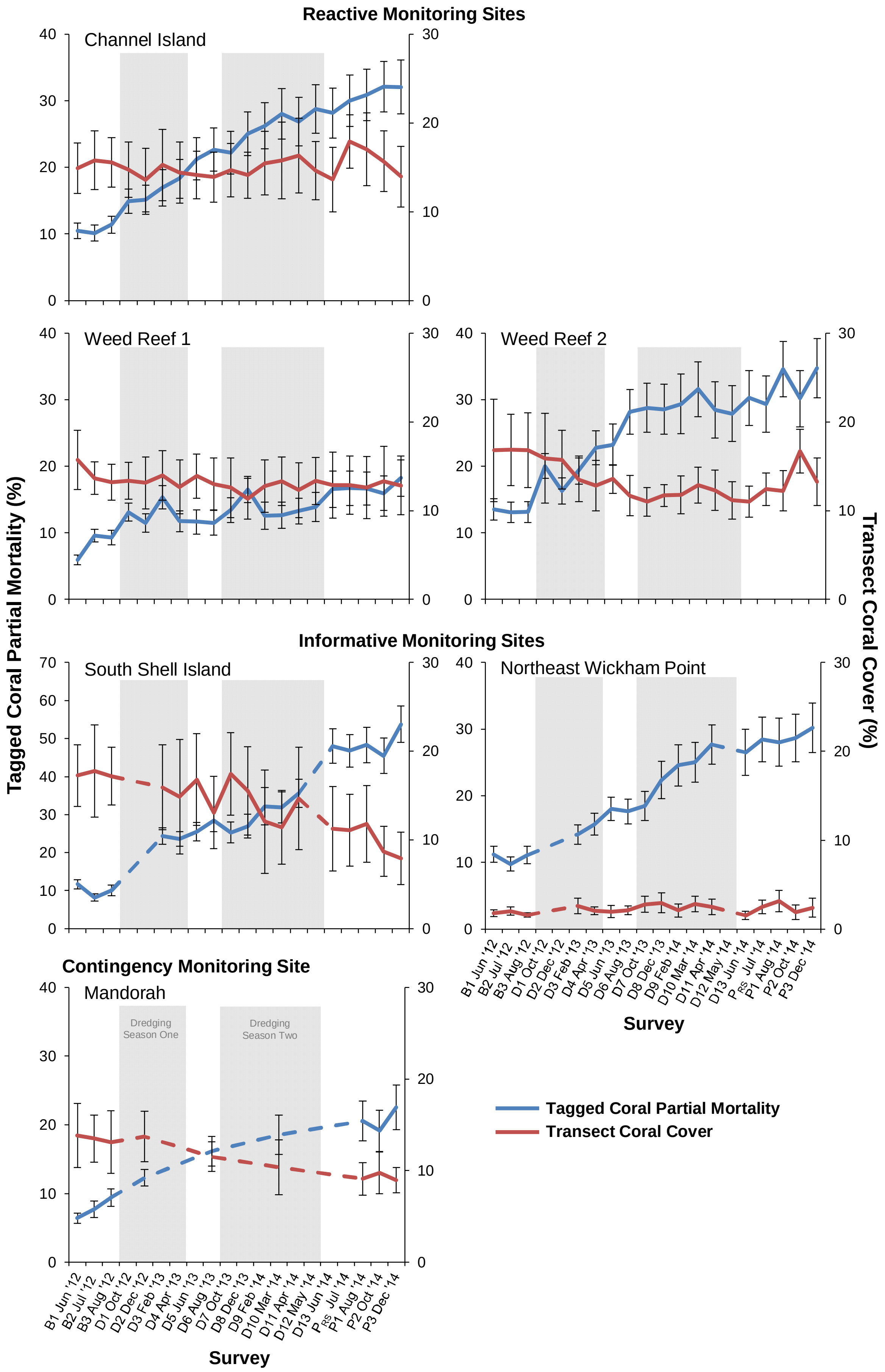


Figure 4-23 Mean (±SE) partial mortality of tagged corals (n ranging from 37 to 70) and mean (±SE) coral cover along transects (n = 4) throughout the monitoring program

4.4 Physical Environment

No rainfall was recorded in the first half of the Post-dredging Phase between June 2014 and September 2014. The total rainfall for October 2014 was 14.8 mm (BOM 2015a) which is less than the monthly average of 69.9 mm (BOM 2015b). November 2014 recorded 165.8 mm of rainfall (BOM 2015a) which is greater than the monthly average of 142.1 mm (BOM 2015b), while cumulative rainfall up to 18 December 2014 was 48.8 mm (BOM 2015a).

The daily average water temperature during the Post-dredging Phase initially fluctuated between 26°C and 24°C from 12 June 2014 to 18 August 2014 before increasing to approximately 32°C by 18 December 2014 (**Table 4-6** to **Table 4-8**, **Figure 4-24**, **Appendix E-1** to **E-3**).

The mean daily-averaged turbidity was similar throughout the Post-dredging Phase at Channel Island, Weed Reef 1 and Weed Reef 2, whereas at South Shell Island, Northeast Wickham Point and Mandorah, there was an increase in turbidity from the D13 to P1 period, to the P1 to P2 period (**Table 4-6** to **Table 4-8**). The mean daily-averaged turbidity for the period 12 June 2014 to 22 August 2014 (D13 to P1) was greater at Channel Island (6.6 NTU) and lesser at Mandorah (3.3 NTU) compared to the other monitoring sites (range of 4.5 NTU to 4.9 NTU) (**Table 4-6**, **Appendix E-4**). Comparison to the corresponding periods from 2013 (during the hiatus between Season One and Season Two dredging) and 2012 (effectively prior to commencement of dredging) shows a slight increase across all sites of between 1.6 NTU and 2.4 NTU in the mean from 2012 to 2014.

For the period 23 August 2014 to 20 October 2014 (P1 to P2), the mean daily-averaged turbidity was slightly greater at South Shell Island (6.7 NTU), Channel Island (6.6 NTU) and Mandorah (6.4 NTU) than at Weed Reef 1 (4.7 NTU), Weed Reef 2 (5.2 NTU) and Northeast Wickham Point (5.8 NTU) (**Table 4-7 Appendix E-5**). Comparison to the corresponding periods from 2013 (effectively prior to commencement of Season Two dredging) and 2012 (at the commencement of Season One dredging) shows minimal difference at Channel Island, Weed Reef 1 and Weed Reef 2; whereas South Shell Island showed a general increase in turbidity from 2012 to 2014 and Northeast Wickham Point showed a peak in turbidity in 2013.

Finally, for the period 21 October 2014 to 18 December 2014 (P2 to P3), the mean daily-averaged turbidity was greater at South Shell Island (7.0 NTU) than Channel Island (6.2 NTU), Mandorah (5.8 NTU) and Northeast Wickham Point (5.6 NTU) which were greater still than Weed Reef 1 (4.2 NTU) and Weed Reef 2 (4.6 NTU) (**Table 4-8**, **Appendix E-6**). Comparison to the corresponding periods from 2013 (during Season Two dredging) and 2012 (during Season One dredging) showed minimal difference at Channel Island, Weed Reef 1, Weed Reef 2 and Mandorah; whereas turbidity at South Shell Island and Northeast Wickham Point peaked in 2013 at 9.8 NTU and 11.8 NTU respectively.

Photosynthetically active radiation (PAR) differed among the monitoring sites during the Post-dredging Phase (D13 to P3). The greatest mean PAR peak flux (323.6 µmol/m^2/s in P3) and daily dose (3.5 mol/m^2/d in P2) were recorded at Weed Reef 1 (**Table 4-6** to **Table 4-8**, **Figure 4-24**, **Appendices E-7** to **E11**). Comparison to the corresponding periods from 2013 and 2012 indicated that for the P1 to P2 (**Table 4-7**) and P2 to P3 (**Table 4-8**) periods there was a general reduction of PAR in 2013 at most sites compared to 2012 and 2014.

Table 4-6 Summary of daily-averaged turbidity, daily-averaged water temperature, PAR peak flux and PAR daily dose (mean, minimum and maximum) at monitoring stations during the P1 reporting period (D13 to P1) and the corresponding periods in 2013 and 2012

Site	Post-dredging Survey P1	Mean	Min	Max	Corresponding Period 2013	Mean	Min	Max	Corresponding Period 2012	Mean	Min	Max
Water Temperature (^{0}C)												
CHI	12/06/14 – 22/08/14	25.2	24.0	26.6	12/06/13 – 22/08/13	25.7	24.5	27.6	12/06/12 – 22/08/12	23.9	22.0	25.0
WR1	12/06/14 – 22/08/14	25.4	24.3	26.6	12/06/13 – 22/08/13	25.7	24.8	27.1	12/06/12 – 20/08/12	23.9	22.4	24.7
WR2	12/06/14 – 22/08/14	25.4	24.3	26.6	12/06/13 – 22/08/13	25.7	24.7	27.4	12/06/12 – 19/08/12	23.9	22.4	24.7
SSI	12/06/14 – 22/08/14	25.3	24.2	26.6	12/06/13 – 22/08/13	26.0	24.6	27.5	12/06/12 – 22/08/12	23.9	22.2	24.9
NEW	12/06/14 – 22/08/14	25.3	24.2	26.6	12/06/13 – 22/08/13	25.9	24.4	27.5	12/06/12 – 22/08/12	24.0	22.2	25.1
MAN	12/06/14 – 22/08/14	25.4	24.3	26.5	12/06/13 – 22/08/13	26.0	24.9	27.5	17/08/12 – 22/08/12	24.7	24.5	25.0
Turbidity (NTU)												
CHI	12/06/14 – 22/08/14	6.6	1.9	19.2	12/06/13 – 22/08/13	4.7	2.1	11.0	12/06/12 – 19/08/12	4.6	1.0	10.3
WR1	12/06/14 – 22/08/14	4.5	0.8	15.6	12/06/13 – 22/08/13	3.6	1.3	10.5	12/06/12 – 22/08/12	2.8	0.5	8.0
WR2	12/06/14 – 22/08/14	4.6	0.8	16.5	12/06/13 – 22/08/13	4.1	1.1	12.8	12/06/12 – 22/08/12	3.0	0.5	8.0
SSI	12/06/14 – 22/08/14	4.9	0.9	16.5	12/06/13 – 22/08/13	4.2	1.5	10.9	12/06/12 – 22/08/12	3.5	0.6	9.3
NEW	12/06/14 – 22/08/14	4.6	1.0	15.8	12/06/13 – 22/08/13	5.1	1.2	11.8	12/06/12 – 22/08/12	2.2	0.6	6.0
MAN	12/06/14 – 11/08/14	3.3	0.9	6.2	12/06/13 – 22/08/13	5.5	1.5	16.6				
PAR Peak Flux (µmol/ m^2/s, adjusted to -3m LAT)												
CHI	12/06/14 – 22/08/14	64.1	17.3	137.4	12/06/13 – 22/08/13	67.3	24.2	127.7	09/08/12 – 18/08/12	144.5	99.0	214.0
WR1	12/06/14 – 22/08/14	188.6	31.6	489.1	12/06/13 – 22/08/13	202.7	64.2	400.0	09/08/12 – 22/08/12	324.4	165.6	510.1
WR2	12/06/14 – 22/08/14	195.0	29.4	487.0	12/06/13 – 22/08/13	180.7	18.2	432.1	09/08/12 – 22/08/12	301.3	194.1	548.4
SSI	12/06/14 – 22/08/14	116.6	33.2	352.2	12/06/13 – 22/08/13	112.1	45.6	248.5	16/08/12 – 22/08/12	240.7	188.9	277.4
NEW	12/06/14 – 22/08/14	137.7	39.3	367.5	12/06/13 – 22/08/13	122.1	25.9	293.4				
MAN	12/06/14 – 22/08/14	169.5	85.4	318.9	12/06/13 – 22/08/13	130.5	19.5	342.4				
PAR Daily Dose (mol/m^2/d, adjusted to -3m LAT)												
CHI	12/06/14 – 22/08/14	0.7	0.1	1.8	12/06/13 – 22/08/13	0.7	0.2	1.4	09/08/12 – 18/0813	1.8	1.2	2.5
WR1	12/06/14 – 22/08/14	2.4	0	8.0	12/06/13 – 22/08/13	2.5	0.3	6.1	09/08/12 – 22/0813	4.2	2.1	9.0
WR2	12/06/14 – 22/08/14	2.5	0.1	7.8	12/06/13 – 22/08/13	2.2	0.1	6.4	09/08/12 – 22/0813	3.8	1.8	9.8
SSI	12/06/14 – 22/08/14	1.5	0.2	5.2	12/06/13 – 22/08/13	1.3	0.3	3.7	16/08/12 – 22/0813	2.6	1.5	4.5
NEW	12/06/14 – 22/08/14	1.7	0.2	5.5	12/06/13 – 22/08/13	1.3	0.1	4.1				
MAN	12/06/14 – 22/08/14	2.1	0.8	4.3	12/06/13 – 22/08/13	1.5	0.1	4.1				

Table 4-7 Summary of daily-averaged turbidity, daily-averaged water temperature, PAR peak flux and PAR daily dose (mean, minimum and maximum) at monitoring stations during the P2 reporting period (P1 to P2) and the corresponding periods in 2013 and 2012

Site	Post-dredging Survey P2	Mean	Min	Max	Corresponding Period 2013	Mean	Min	Max	Corresponding Period 2012	Mean	Min	Max
Water Temperature (^{0}C)												
CHI	23/08/14 – 20/10/14	28.0	24.3	30.5	23/08/13 – 20/10/13	29.0	27.1	30.7	23/08/12 – 20/10/12	28.5	25.3	30.3
WR1	23/08/14 – 20/10/14	27.8	24.4	30.2	23/08/13 – 13/10/13	28.6	27.1	30.4	26/08/12 – 20/10/12	28.5	26.2	30.1
WR2	23/08/14 – 20/10/14	27.8	24.4	30.2	23/08/13 – 20/10/13	28.8	27.1	30.6	27/08/12 – 20/10/12	28.6	26.3	30.2
SSI	23/08/14 – 20/10/14	28.0	24.5	30.4	23/08/13 – 20/10/13	29.0	27.1	30.7	23/08/12 – 20/10/12	29.0	24.7	30.3
NEW	23/08/14 – 20/10/14	27.9	24.4	30.3	23/08/13 – 20/10/13	28.9	27.1	30.7	23/08/12 – 20/10/12	28.6	25.3	30.3
MAN	23/08/14 – 20/10/14	27.9	24.4	30.3	23/08/13 – 20/10/13	28.8	27.1	30.8	23/08/12 – 20/10/12	28.4	25.2	30.3
Turbidity (NTU)												
CHI	23/08/14 – 20/10/14	6.5	1.7	19.3	23/08/13 – 20/10/13	6.4	1.5	16.9	23/08/12 – 20/10/12	6.0	1.5	17.2
WR1	23/08/14 – 20/10/14	4.7	0.8	14.3	23/08/13 – 20/10/13	5.1	1.2	11.0	26/08/12 – 17/10/12	4.2	1.2	10.8
WR2	23/08/14 – 20/10/14	5.2	1.1	15.6	23/08/13 – 20/10/13	5.6	1.1	12.8	23/08/12 – 20/10/12	5.3	0.9	15.3
SSI	23/08/14 – 14/10/14	6.7	1.4	19.5	23/08/13 – 20/10/13	5.6	1.4	13.2	23/08/12 – 20/10/12	4.5	0.8	14.8
NEW	23/08/14 – 20/10/14	5.8	1.4	18.6	23/08/13 – 20/10/13	7.1	1.3	18.6	23/08/12 – 20/10/12	4.5	1.0	15.3
MAN	01/09/14 – 17/09/14	6.4	1.0	16.3	23/08/13 – 20/10/13	7.2	1.6	16.5	03/09/12 – 20/10/12	8.8	0.9	22.3
PAR Peak Flux (µmol/ m^2/s, adjusted to -3m LAT)												
CHI	23/08/14 – 20/10/14	131.0	48.8	252.4	23/08/13 – 20/10/13	122.0	47.9	240.0	23/08/12 – 20/10/12	166.9	56.1	298.1
WR1	25/08/14 – 20/10/14	285.5	118.5	598.3	23/08/13 – 20/10/13	254.7	112.9	486.7	23/08/12 – 20/10/12	279.0	135.0	508.0
WR2	23/08/14 – 20/10/14	260.4	76.7	518.9	23/08/13 – 20/10/13	230.0	79.3	467.6	23/08/12 – 20/10/12	292.4	103.6	685.5
SSI	23/08/14 – 14/10/14	159.5	76.8	288.5	23/08/13 – 20/10/13	160.9	87.5	287.1	23/08/12 – 20/10/12	228.4	80.3	553.9
NEW	23/08/14 – 20/10/14	170.9	58.4	280.7	23/08/13 – 20/10/13	157.6	47.8	364.3	23/08/12 – 20/10/12	192.8	65.7	379.4
MAN	01/09/14 – 16/09/14	199.1	77.5	395.0	23/08/13 – 20/10/13	166.9	55.7	383.6	23/08/12 – 20/10/12	224.6	76.1	517.0
PAR Daily Dose (mol/m^2/d, adjusted to -3m LAT)												
CHI	23/08/14 – 20/10/14	1.3	0.6	2.1	23/08/13 – 20/10/13	1.2	0.5	2.5	05/09/12 – 20/10/12	1.63	0.80	2.84
WR1	25/08/14 – 20/10/14	3.5	0.7	9.7	23/08/13 – 20/10/13	2.9	0.9	8.8	04/09/12 – 17/10/12	3.33	0.97	6.87
WR2	23/08/14 – 20/10/14	3.2	0.5	8.5	23/08/13 – 20/10/13	2.5	0.5	8.5	06/09/12 – 20/10/12	3.45	0.66	11.55
SSI	23/08/14 – 14/10/14	1.7	0.5	4.3	23/08/13 – 20/10/13	1.7	0.6	4.9	23/08/12 – 20/10/12	2.59	0.65	7.00
NEW	23/08/14 – 20/10/14	1.8	0.6	4.0	23/08/13 – 20/10/13	1.6	0.4	5.0	04/09/12 – 20/10/12	2.21	0.53	5.07
MAN	01/09/14 – 16/09/14	2.5	0.6	4.94	23/08/13 – 20/10/13	1.7	0.5	3.8	03/09/12 – 20/10/12	2.41	0.48	6.79

Table 4-8 Summary of daily-averaged turbidity, daily-averaged water temperature, PAR peak flux and PAR daily dose (mean, minimum and maximum) at monitoring stations during the P3 reporting period (P2 to P3) and the corresponding periods in 2013 and 2012

Site	Post-dredging Survey P3	Mean	Min	Max	Corresponding Period 2013	Mean	Min	Max	Corresponding Period 2012	Mean	Min	Max
Water Temperature (^{0}C)												
CHI	21/10/14 – 18/12/14	31.2	30.3	32.0	21/10/13 – 18/12/13	31.2	30.2	31.8	21/10/12 – 18/12/12	31.3	30.3	32.3
WR1	21/10/14 – 18/12/14	31.1	30.2	31.8	11/11/13 – 18/12/13	31.1	30.3	31.7	21/10/12 – 14/11/12	30.8	30.2	31.2
WR2	21/10/14 – 18/12/14	31.1	30.2	31.8	21/10/13 – 18/12/13	31.3	30.7	31.7	21/10/12 – 18/12/12	31.3	30.2	32.1
SSI	21/10/14 – 18/12/14	31.1	30.3	31.9	21/10/13 – 18/12/13	31.1	30.2	31.7	21/10/12 – 18/12/12	31.3	30.3	32.1
NEW	21/10/14 – 18/12/14	31.1	30.3	31.9	21/10/13 – 18/12/13	31.1	30.1	31.7	21/10/12 – 18/12/12	31.3	30.2	32.2
MAN	21/11/14 – 18/12/14	31.2	30.2	31.9	21/10/13 – 18/12/13	31.1	30.3	31.7	21/10/12 – 10/12/12	31.2	30.2	32.1
Turbidity (NTU)												
CHI	21/10/14 – 18/12/14	6.2	2.0	13.4	21/10/13 – 18/12/13	7.3	1.5	25.3	21/10/12 – 18/12/12	6.4	1.8	19.2
WR1	21/10/14 – 18/12/14	4.2	1.1	11.5	21/10/13 – 18/12/13	5.7	1.1	16.8	14/11/12 – 18/12/12	5.0	1.8	11.9
WR2	21/10/14 – 18/12/14	4.6	1.1	11.5	21/10/13 – 18/12/13	5.7	1.0	17.4	21/10/12 – 18/12/12	6.0	1.5	19.2
SSI	21/10/14 – 18/12/14	7.0	2.1	15.5	21/10/13 – 18/12/13	9.8	1.5	25.9	21/10/12 – 18/12/12	7.5	1.8	20.0
NEW	21/10/14 – 18/12/14	5.6	1.7	12.5	21/10/13 – 18/12/13	11.8	1.7	40.9	21/10/12 – 18/12/12	6.9	0.4	19.5
MAN	14/11/14 – 18/12/14	5.8	1.2	14.8	21/10/13 – 18/12/13	7.2	0.9	18.5	21/10/12 – 14/12/12	7.3	1.5	25.0
PAR Peak Flux (µmol/ m^2/s, adjusted to -3m LAT)												
CHI	21/10/14 – 18/12/14	148.6	18.4	330.5	21/10/13 – 18/12/13	139.5	5.0	402.7	21/10/12 – 18/12/12	129.0	14.8	379.5
WR1	21/10/14 – 18/12/14	323.6	28.6	724.7	21/10/13 – 18/12/13	247.5	9.6	516.4	15/11/12 – 18/12/12	292.3	38.7	548.7
WR2	21/10/14 – 18/12/14	313.3	36.8	621.1	21/10/13 – 18/12/13	253.4	9.2	609.0	21/10/12 – 18/12/12	226.4	15.5	516.1
SSI	22/10/14 – 18/12/14	110.8	13.9	233.4	21/10/13 – 18/12/13	80.8	2.4	301.2	21/10/12 – 18/12/12	107.8	15.1	278.6
NEW	21/10/14 – 18/12/14	161.5	21.1	290.0	21/10/13 – 18/12/13	108.0	3.9	311.5	21/10/12 – 18/12/12	174.2	12.2	785.9
MAN	15/11/14 – 18/12/14	217.2	17.4	528.6	21/10/13 – 18/12/13	209.0	5.3	482.1	21/10/12 – 13/12/12	188.8	43.8	494.1
PAR Daily Dose (mol/m^2/d, adjusted to -3m LAT)												
CHI	21/10/14 – 18/12/14	1.3	0.2	3.2	21/10/13 – 18/12/13	1.2	0.03	3.6	21/10/12 – 18/12/12	1.1	0.1	2.6
WR1	21/10/14 – 18/12/14	3.5	0.3	9.3	21/10/13 – 18/12/13	2.4	0.07	7.8	15/11/12 – 18/12/12	2.8	0.3	5.2
WR2	21/10/14 – 18/12/14	3.3	0.4	10.2	21/10/13 – 18/12/13	2.5	0.07	8.8	21/10/12 – 18/12/12	2.2	0.1	6.0
SSI	22/10/14 – 18/12/14	1.0	0.2	2.5	21/10/13 – 18/12/13	0.7	0.02	3.6	21/10/12 – 18/12/12	0.9	0.1	2.3
NEW	21/10/14 – 18/12/14	1.6	0.3	3.6	21/10/13 – 18/12/13	0.9	0.02	3.6	21/10/12 – 18/12/12	1.7	0.1	10.2
MAN	15/11/14 – 18/12/14	2.1	0.2	4.7	21/10/13 – 18/12/13	2.1	0.05	6.8	21/10/12 – 13/12/12	1.8	0.4	5.1

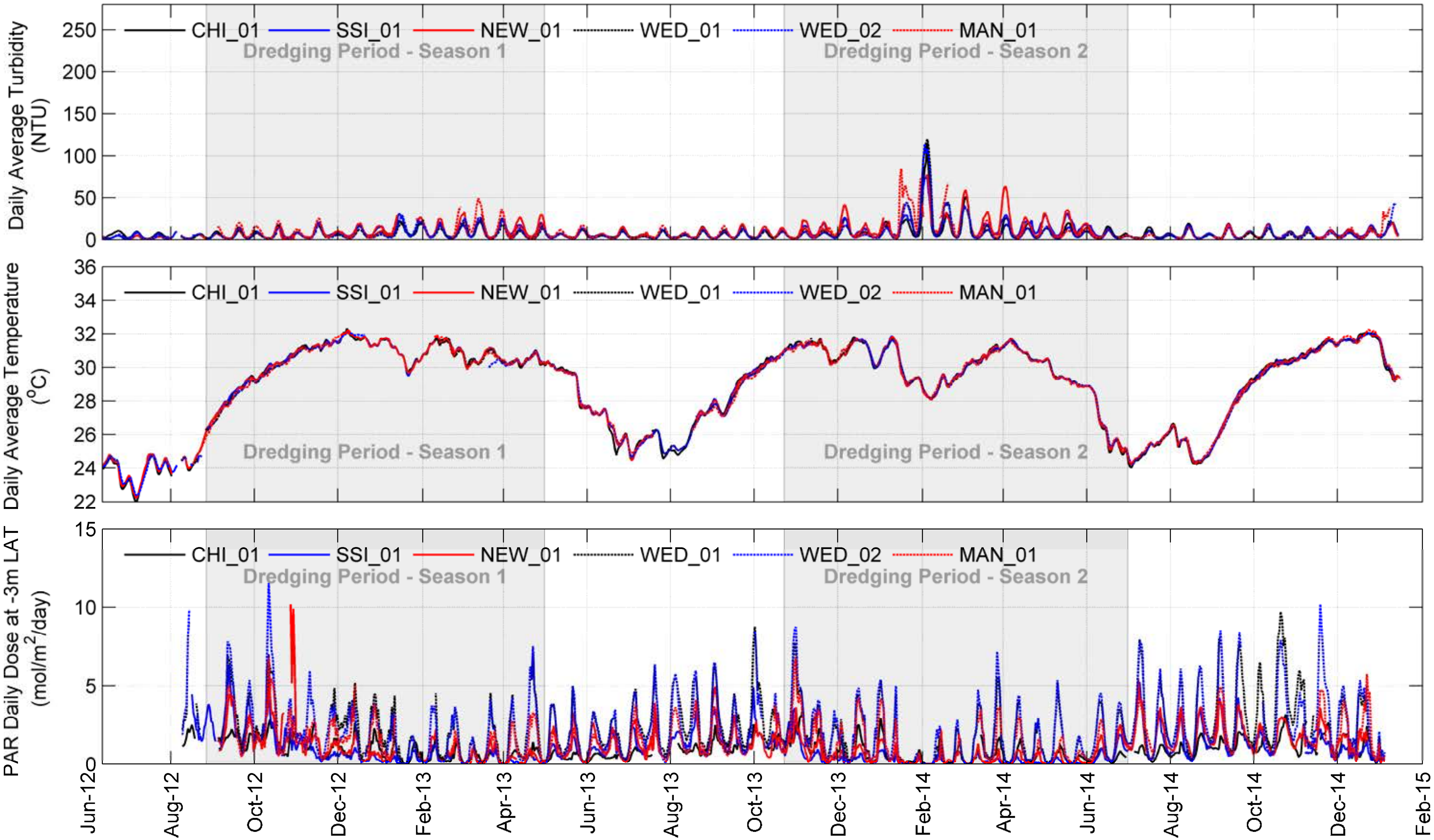


Figure 4-24 Temperature, turbidity and PAR daily dose data (adjusted to -3 m LAT) from all coral monitoring sites between June 2012 and January 2015

5 Discussion

The Coral Monitoring Program was originally designed to specifically detect changes at Channel Island potentially resulting from the Project given the coral community at this site is listed on the Commonwealth Register of the National Estate and Northern Territory Heritage Register (AHPI 2012). Reactive triggers developed for Channel Island, and later expanded to include Weed Reef 1 and Weed Reef 2, were designed to provide early warning indicators of potential changes in coral communities that would allow for early protective management actions if required. The EA sites of South Shell Island and Northeast Wickham Point were included in the Coral Monitoring Program as informative Impact sites, as potential mortality or reduced growth were predicted at these sites in the Draft EIS (INPEX 2011). These sites were to be used for interpretative purposes and to support management decisions using a ‘multiple lines of evidence’ approach, particularly if reactive triggers were exceeded. Other sites, Mandorah and Charles Point, were also monitored at times to get a perspective of harbour-wide natural changes to coral communities.

Data collected during the Post-dredging Phase provided a means to investigate potential short-, medium- and longer-term changes to coral health indicators at the monitoring sites since the completion of Project dredging activities, as well as a direct comparison to the Baseline and Dredging Phase data. The comprehensive suite of coral health indicators along with the scale of temporal and spatial sampling provided useful information about natural patterns and processes occurring in coral communities in Darwin Harbour. As the data were collected in parallel with the Water Quality and Subtidal Sedimentation Monitoring Program it was possible to interpret some of the mechanisms and drivers of natural patterns and processes observed in the coral communities and to determine if dredging was having an influence.

5.1 Coral Mortality

Increasing partial mortality is an expected result of the tagged coral methodology as total or partial mortality of a finite number of individual corals is inevitable, although the amount of mortality recorded is dependent on the length of the monitoring program and the natural rate of mortality. The tagged coral monitoring component was designed to detect increased rates of mortality above those expected to be naturally occurring. During Season One dredging, coral mortality triggers were applied to Channel Island only, and were based on the gross change in coral mortality since the Baseline Phase relative to the change occurring at Weed Reef 1 and Weed Reef 2. During Season One dredging, there were no coral mortality trigger exceedances.

Prior to the commencement of Season Two dredging, the Level 2 and 3 coral mortality trigger test was redesigned to include Weed Reef 1 and Weed Reef 2 as reactive sites in addition to Channel Island. The redesigned methodology focused on detecting potential increases to the rates of coral mortality at the reactive sites that were above long-term trends. A trigger would occur if the measured mortality was above the 95% UCL of predicted mortality based on the long-term rate recorded during the Baseline Phase and Season One dredging, as the increase in mortality in that period was unrelated to dredging (Cardno 2014b).

During Season Two dredging, there were no coral mortality triggers at Channel Island, Weed Reef 1 or Weed Reef 2. Although the reactive triggers were no longer applicable during the Post-dredging Phase, the assessment technique was continued as a useful indicator of potential ongoing effects after dredging. At Channel Island, Weed Reef 1 and Weed Reef 2, mortality only increased slightly as per natural predictions during the Post-dredging Phase resulting in the measured partial mortality remaining below the modelled mortality and, as such, the 95% UCL.

Coral mortality triggers were not applicable at the informative monitoring sites South Shell Island and Northeast Wickham Point, however the same mortality modelling technique was applied for comparative purposes. Despite the proximity to dredging operations, neither of these sites exceeded the 95% UCL of modelled mortality throughout Season Two dredging, or in the Post-dredging Phase.

A general increase in mean mortality of tagged colonies since the first Baseline Phase survey (B1) has been recorded for all monitoring sites; however, the extent of mortality has differed among the sites. There are many potential causes for the variability in mortality among the sites and the challenge for the monitoring program has been to discriminate these from potential effects of dredging. Natural differences in the rate of coral mortality between sites are expected due to inherent spatial variability in terms of the differing physical features of sites as well as the types of corals (species or growth forms) tagged at each site.

Species composition, for example, contributed greatly to the mortality of tagged corals at South Shell Island being highest for all sites between the Baseline and Post-dredging Phases. This is due to the low number of tagged Faviidae and Dendrophyllidae colonies which have generally shown less partial mortality at all sites, and the large number of tagged Pectiniidae and Poritidae which have shown substantially greater partial mortality at many sites. On the other hand, the mean mortality of tagged colonies between the Baseline and Post-dredging Phases at Weed Reef 1 was the least for all sites. In this instance, species composition does not appear to have contributed as greatly to the site-wide mortality, given Poritidae showed substantially less mortality at this site than it had shown for other sites.

Although the composition of taxa played a large role in the high mortality at South Shell Island since the Baseline Phase, it may not have been the sole driver. Although Pectiniidae and Poritidae corals (i.e. the most prevalent species at South Shell Island) had shown high levels of mortality at many sites in Darwin Harbour, the level of mortality for Pectiniidae was among the highest at South Shell Island, with the highest level recorded at Northeast Wickham Point. The low profile growth forms of Pectiniidae are known to be highly susceptible to increases in sedimentation, turbidity, temperature and salinity (Gilmour et al. 2006) and given the elevated levels of turbidity and reduced light that occurred at South Shell Island at times during Season Two dredging (Cardno 2014h), dredging potentially had an influence. The mortality of Poritidae was also high at South Shell Island relative to other families but was similar to other monitoring sites (e.g. Channel Island, Weed Reef 2). Mortality of Poritidae was spatially variable, as levels at Northeast Wickham Point, which experienced similar environmental conditions to South Shell Island during the Dredging Phase, were among the lowest for all sites and for all families.

It is important to note that tagged corals are useful as an indicator of mortality, but are not suitable for measuring the overall condition of a coral community. This is because an individual tagged coral colony will inevitably show partial or complete mortality, given a long enough monitoring program. If the mortality of tagged corals was occurring at an unnaturally high rate, it would be expected that the amount of coral present in the whole reef/site would also be declining.

At the majority of monitoring sites, there were no differences indicative of a decline in coral cover from the Baseline to the Post-dredging Phase, with the exception of South Shell Island and Weed Reef 2, as a result of a natural thermal bleaching event for the latter. Coral cover at South Shell Island had declined during monitoring but unlike tagged colony mortality, which is expected to increase through time, site-wide coral cover would be expected to show long-term stability as any natural losses should be compensated by recruitment and growth. Coral cover declined by approximately 6% during the Dredging Phase, from 17.2% in B3 to 11.3% in D13, which was considered likely to be due to loss of corals through roll-aways. A further decline in coral cover of 3.4% was recorded in the Post-dredging Phase. At the end of the Post-dredging Phase, mean coral cover and presence of tagged corals at South Shell Island was at the lowest recorded for the entire monitoring program at 7.9% (54% reduction since B1) and n = 37 (51% reduction since B1, more than double the amount than for any other monitoring site) respectively. Most of the decline in the Post-dredging Phase occurred between P1 (August 2014) and P2 (October 2014), which was in part attributable to tentacle retraction of *Goniopora* sp. likely as a consequence of increasing water temperatures.

Analysis of entire community composition (transects) from B1 (June 2012) to P3, including both biota (hard coral families and their growth forms, soft corals, algae and sessile invertebrates) and abiota (sand, silt and rock), indicated that there was a general shift in composition through time (surveys) at most sites. This was due primarily to increasing sand and silt and decreasing turf algae rather than changes in hard corals. However, at Weed Reef 2, there was also a reduction in massive Poritidae through time, which was driven by losses that occurred following a natural thermal bleaching event. At South Shell Island, there were increases in both turf algae and sand and silt and a reduction in the number of massive Poritidae.

The community analysis was also undertaken when only hard coral families (irrespective of growth form) were included, and again when only growth forms (irrespective of family) were included, which allows a more targeted analysis for potential changes in coral family composition or growth forms. This is important as the varying sensitivity of corals to the potential effects of dredging (i.e. turbidity and sedimentation) may not reduce the density of coral as a whole, but may cause changes in the dominance of certain coral families or growth forms. Although there was minimal change in coral family composition through time (i.e. between surveys), there were differences in the composition of coral families between sites, but the degree of difference varied between surveys.

Generally, there were no patterns that were indicative of long-term shifts in composition, apart from South Shell Island, where a reduction in the cover of Pectiniidae and Poritidae since the Baseline Phase in some transects have potentially made this site become more similar to Northeast Wickham Point over time. This is not surprising as 46% and 50% of tagged Pectiniidae and Poritidae corals went missing during the monitoring program, with these two taxa comprising 88% of the tagged colonies at South Shell Island. These two coral taxa also comprised approximately 93% of the coral cover in the Baseline Phase. Inspection of photoquadrats indicated that physical movement of corals had contributed to the reduced coral cover along transects at South Shell Island. The unconsolidated sandy slope at South Shell Island appears to have been a factor in the higher loss of corals at that site. This physical disturbance of corals has no causative link to dredging-induced turbidity but may be a consequence of other unknown influences.

The composition of coral growth forms showed a similar relationship with minimal change through time, but some differences in the composition of coral families between sites. Generally, there were no patterns in the relationships between sites through time indicative of long-term shifts in growth form composition.

5.2 Changes in Sand and Silt

Sediment on tagged coral, which is conservatively included in the estimate of partial mortality, has generally increased through time at most sites, although there has been substantial short-term variability at times. As sediment has constituted up to half of the partial mortality of tagged corals recorded, this variability in sediment often translated to variability in the overall mortality trend, indicating that sediment is settling on living coral; which is then both actively and passively cleared by the coral before subsequent surveys. For example, one coral at Weed Reef 2 (Tag Number 2) underwent complete or almost complete burial on two occasions before being unburied in subsequent surveys, with no apparent changes to nearby tagged corals. This example demonstrates the large degree of localised natural variability in the movement of sediment. However, in some instances, an increase in sediment did not translate to an increase in coral mortality indicating other components of mortality, in particular turf algae, had potentially become covered in sediment.

Increasing sediment on tagged corals through time is expected, similar to the expected increase in mortality, as areas of dead coral can no longer actively remove sediment. In addition, as many of the corals in Darwin Harbour, including the tagged corals, are growing directly on the unconsolidated seabed and are not elevated above the seabed, localised movement of sediment due to currents will inevitably cause some corals to become buried, particularly low-growing encrusting and submassive corals. Although sediment accumulation is often temporary and is subsequently removed by active and passive processes, some corals may become permanently buried and may suffer mortality as a consequence.

The use of pavers to measure the accretion of sediment at each site between surveys has shown substantial variability both spatially (between pavers) and temporally (between surveys). This likely reflects the highly variable nature of sedimentation at small spatial scales; that is, the position of individual pavers has a considerable influence on sediment accumulation. In addition, it is not known to what extent and how often, if at all, the pavers are naturally cleared by tidal currents. Therefore it is unclear what period of sediment accumulation the pavers represent (i.e. whether they accumulate sediment slowly through the whole inter-survey period or whether the sediment accumulates largely during the neap tide cycle when the pavers are measured). Despite this uncertainty, the deposition of sediment on the settlement pavers throughout the monitoring program did not correlate with sediment cover on the corals. This gives an indication that the amount of sediment on the corals is not generally a direct result of sediment deposition processes and that the corals can actively remove sediment.

Corals have the ability to remove sediment through the excretion of mucus from individual polyps (Erftemeijer et al. 2012). The rate that corals can clear the sediment is highly variable between species and can be influenced by factors such as sediment load, growth form, stress and the general health of the coral colony (Lirman and Manzello 2009; Erftemeijer et al. 2012). In this monitoring program, the low profile encrusting corals showed the greatest increase in cover of sediment. It is likely that the amount of sediment cover on the tagged corals was the result of a combination of both physical and biological processes. However, all corals have a limit in terms of the amount of sediment they can successfully remove and, where sedimentation is above this rate, coral burial is likely to occur. This limit appears to have been exceeded at

South Shell Island on two occasions during monitoring when a greater change in mortality compared to the other monitoring sites appeared to be largely driven by increased sediment cover on coral.

South Shell Island showed two distinct periods of increased sediment accumulation and mortality, one near the beginning of the Dredging Phase (B3 (August 2012) to D3 (February 2013)) and again at the end of the Dredging Phase (D11 (April 2014) to D13 (June 2014)). It should also be noted that in both instances sediment cover declined in the subsequent surveys. Partial mortality also decreased or remained unchanged in the subsequent surveys indicating the sediment cover was temporary with underlying live coral tissue that was exposed in subsequent surveys. This sediment accumulation could have been a consequence of the proximity of this site to dredging or a consequence of local hydrodynamics, with the site located in the lee of the island during an ebbing tide. Currents are generally minimal at the site during an ebb tide when monitoring is conducted, which may increase the level of sediment deposition in comparison to other sites. It should be noted that South Shell Island also has a naturally greater population turnover rate (i.e. high rates of loss through mortality and dislodgement and high rates replacement through growth).

For all sites combined (at a site-wide level), the analysis of the cover of sand and silt indicated an increase between Baseline and Dredging Phases. Importantly the cover of sand and silt did not increase since the end of dredging, instead there was a decrease in P2 (October 2014) compared to Baseline Phase levels. Although the statistical analysis found a significant difference for all sites combined, inspection of the trends at individual sites suggests that the trends varied among the sites, with no significant change at a site level. It is important to note that the significant difference between surveys when all sites are combined could be a result of the increased power at this level (i.e. less variability relative to the number of replicates), rather than an indicator that the trends are consistent between the sites. It is also important to note that increases in sand and silt appear to be strongly correlated with decreases in turf algae, suggesting that increases in sand and silt primarily occurred on turf algae rather than on live coral.

5.3 Bleaching

Throughout Season One dredging, the Level 2 coral bleaching trigger was only assessed at Channel Island and was set at a 20% net change in coral bleaching (i.e. increase relative to both Baseline Phase conditions and Weed Reef 1 and Weed Reef 2). During this period (D1 (October 2012) to D7 (October 2013)), net bleaching at Channel Island was negative, as greater bleaching was recorded both in the Baseline Phase surveys and at Weed Reef 2.

Prior to the commencement of Season Two dredging, the Level 2 coral bleaching trigger was redesigned to include Weed Reef 1 and Weed Reef 2 as reactive sites, in addition to Channel Island. The Level 2 coral bleaching trigger assessment was changed to gross coral bleaching (bleaching above the Baseline Phase amount) and in a given survey, the Level 2 trigger would be exceeded if gross bleaching for any reactive site was greater than 20%. During Season Two dredging, no coral bleaching triggers occurred at Channel Island, Weed Reef 1 or Weed Reef 2. During this period (D8 (December 2013) to D13 (June 2014), gross bleaching at all sites was generally negative, as greater bleaching had been recorded during the Baseline Phase.

Throughout the monitoring program, there were four apparent peaks in bleaching: June 2012 to August 2012 (B1 to B3), February 2013 to April 2013 (D3 to D4) and March 2014 to June 2014 (D10 to D13) and during October 2014 to December 2014 (P2 and P3). Peaks in bleaching recorded from February 2013 to April 2013 and March 2014 to May 2014 coincided generally with increases in water temperatures above 30°C. The most severe bleaching event occurred at Weed Reef 2 during the period from February 2013 to April 2013, where a substantial number of *Alveopora* sp. bleached. In this bleaching event water temperatures exceeded 32°C. Elevated water temperature was considered to be the cause of the bleaching event (Cardno 2013e) but tropical storms may have also had a positive influence. The first main tropical storm in the 2012/2013 wet season occurred in mid-January 2013 resulting in temperatures declining below 30°C for a short period of time before increasing to approximately 32°C.

Bleaching is known to occur where there have been acute rises in temperature over a short period of time (Goreau and Hayes 1994). *Alveopora* sp. are substantially more common at Weed Reef 2 than at other locations within Darwin Harbour, which was considered to be the reason for the isolated nature of the bleaching event. Interestingly, *Goniopora* sp. and *Alveopora* sp. have elsewhere been observed to be more resilient to temperature bleaching than many other coral types (Ammar et al. 2011; Marshall and Baird 2000;

Wilson et al. 2012; Yeemin et al. 2001). The amount of bleaching subsequently reduced from D5 (June 2013) onwards, partly as a result of recovery of some colonies; however, total mortality of some bleached colonies also occurred.

Given the length of time that corals have remained bleached following the thermal bleaching event between December 2012 and February 2013 (D2 and D3), it is possible that the high levels of bleaching reported between June 2012 and August 2012 during the Baseline Phase were the result of an earlier warm water bleaching event in the 2011/2012 wet season. Sea surface temperature archives (NOAA 2013a) confirm that waters within Darwin Harbour exceeded 31°C in January 2012 resulting in bleaching Alert levels 1 and 2 being reached (NOAA 2013b).

The March 2014 to June 2014 (D10 to D13) bleaching event started later than for bleaching in the previous wet season, potentially due to the effect tropical storms had on water temperature. There was an early start to the 2013/2014 wet season and record rainfall was measured in November 2013, which included the passing of Tropical Cyclone Alessia. During this period there was a decline in water temperature. Another tropical low (Tropical System 05U) then passed over the region in January 2014 resulting in another decline in water temperature. A large monsoonal trough then established in the region, causing heavy rainfall and an increase in waves for an extended period. As a result, temperatures decreased nearly 4°C to 28°C, and remained below 30°C for approximately six weeks until March 2014, where temperature again increased above 30°C until the end of April 2014.

Unlike the 2012/2013 and 2013/2014 wet season bleaching events, the bleaching observed in the Post-dredging Phase (i.e. P2 and P3) was observed to have started at the end of the dry season in October 2014. A rise in water temperature early in October 2014 to above 30°C may have been the driver.

The patterns in coral bleaching observed in the Coral Monitoring Program indicate bleaching is likely to be an annual phenomenon in Darwin Harbour that can occur when water temperatures rise above 30°C. It is likely that the rate to which temperatures rise to above 30°C, the duration of this warm water and the timing, frequency, intensity and duration of wet season tropical storms all have an influence on the timing and intensity of bleaching.

5.4 Reproduction, Recruitment and Growth

As discussed in **Section 5.1**, tagged coral mortality increased at all sites; however, at a site-wide level the mortality and physical loss of colonies would be expected to naturally be compensated for by growth in the short term, and by recruitment in the long term.

Coral gravidity assessments for a selection of massive and submassive colonies from Weed Reef 1 and Weed Reef 2 in Darwin Harbour showed that Faviidae colonies had numerous mature oocytes on 8 April 2014 (one week prior to the April 2014 full moon) which were subsequently released prior to 10 May 2014, indicating that Faviidae in Darwin Harbour had (broadcast) spawned between April and May. The timing of this coral spawning event in Darwin Harbour is consistent with results from previous studies (Stoddart and Gilmour 2005; Baird et al. 2010) that have indicated autumn (March to May) to be the major spawning season for many coral taxa in north-western Australia, but it in contrast to anecdotal information from the local Territory Wildlife Park where corals in aquaria have been recorded spawning in spring. Mature oocytes were also noted in one faviid colony in October 2013 but there was insufficient temporal sampling to determine whether this indicated another (spring) spawning season for this taxa. No oocytes were observed in the histological sections of any of Merulinidae, Poritidae and Siderastreidae families potentially indicating for these taxa that there are either: different reproductive schedules; or different reproductive mode for these three coral families. However, given there were very small sample sizes for these taxa, interpretation requires caution. It should be noted that the four coral families sampled for gravidity in Darwin Harbour are likely to have different dominant reproductive modes, the Faviidae and Merulinidae being generally hermaphroditic broadcast spawners (i.e. release eggs and sperm bundled together into the water column), the Poritidae gonochoric broadcasters (i.e. release eggs and sperm separately into the water column) and the Siderastreidae brooders (internal fertilisation following uptake of sperm released from nearby colonies).

With the exception of Weed Reef 2, peaks in the number of coral recruits (i.e. small corals of a size visible in the photos) were recorded for all sites in either June or July in 2012, 2013 and 2014, indicative of a seasonal recruitment. Given the slow and variable growth rate of coral recruits (Babcock et al. 2002), and that the coral recruits observed in this monitoring program were likely to have been at least one year old, it is difficult to back calculate the precise spawning period from the peaks in recruitment. The subsequent decline following each recruitment peak may have been due to the naturally high mortality rates experienced by coral recruits (Rogers 1990; Erftemeijer et al. 2012), but may also have been a result of some recruits growing larger than the 20 mm size class and hence no longer being recorded. It is important to note, however, that there is also the potential for the counts of recruits recorded to be influenced by changes in photograph quality; that is, during times of high turbidity, photograph quality is reduced and, due to the small and sometimes cryptic nature of coral recruits, the ability to identify and hence count recruits is likely to be reduced in poor conditions.

Coral recruits have previously been found to be more susceptible to sedimentation than established corals (Rogers 1990; Fabricius 2005; Erftemeijer et al. 2012). As such, the number of coral recruits could be influenced by dredging at sites with elevated turbidity. At Northeast Wickham Point, there were significantly fewer recruits present during the Baseline Phase, suggesting that coral recruitment at this site is naturally lower than for other sites. This is further supported by Northeast Wickham Point having naturally less coral which is likely related to the limited amount of suitable hard substrata available for coral recruit settlement at this site. At South Shell Island, there were only slightly fewer coral recruits than the other monitoring sites during the Baseline Phase, but significantly fewer recruits than some of the other monitoring sites in most surveys during the Dredging and Post-dredging Phases. This suggests a potential suppression of recruitment at South Shell Island as a consequence of dredging influences (increased turbidity) at the site, and the aforementioned susceptibility of coral recruits to sedimentation. Given high natural rates of coral loss at South Shell Island due to the instability of the substratum, recruitment is likely to be an important process in maintaining coral cover.

Although many tagged corals exhibited partial mortality, considerable coral growth was also recorded for many tagged coral colonies. In individual tagged coral colonies from the families Pectiniidae, Dendrophyllidae and Faviidae that showed no visibly apparent mortality since the Baseline Phase (135 individuals from three families and five sites) there was a mean increase in size of 70% with some individual colonies increasing by over 300% to four times their original size. The type of family had an important influence on the average change in size, with Pectiniidae showing the greatest increase in size, followed by a slightly slower rate for Dendrophyllidae, while Faviidae showed a substantially slower rate of increase. This is likely to be at least partly related to the differences in growth forms between families, with Pectiniidae being predominantly encrusting, while Dendrophyllidae were foliose or vase-shaped and Faviidae were generally massive or submassive. The amount of growth recorded in some tagged corals over the monitoring program suggests that growth of some individual colonies may assist in maintaining the stability of the overall coral cover by replacing colonies lost through mortality or physical removal. The prevalence of fast growing dendrophyllid corals at South Shell Island is important as it possibly offsets the higher rate of mortality and loss of corals from natural disturbance.

6 Conclusions

> Throughout the monitoring program there were four water quality Level 1 turbidity exceedance periods. Two occurred during wet season dredging with the first exceedance period attributed to monsoonal conditions (INPEX 2014b), while the second exceedance period was primarily attributable to natural causes (INPEX 2014c). Two water quality exceedance periods also occurred at the onset of the 2014 dry season with the first exceedance period considered to be primarily attributable to natural causes (INPEX 2014d). The INPEX Exceedance Attributability and Implementation Report for the second dry season trigger exceedance period concluded that dredging activities may have had a very minor influence (relative to natural drivers; spring tide) at Channel Island, Weed Reef 1 and Weed Reef 2 (INPEX 2014e).

> Throughout monitoring no Level 2 or Level 3 coral bleaching or mortality trigger exceedances were recorded at reactive monitoring sites Channel Island, Weed Reef 1 and Weed Reef 2.

> The measured mortality at Channel Island, Weed Reef 1 and Weed Reef 2 throughout Season Two dredging was primarily below the GLMM modelled mean mortality and, as such, well below the 95% UCL. This indicates that the rate of coral mortality in Season Two dredging and the Post-dredging Phase was similar to, or less than, the mortality in Baseline Phase and Season One dredging, where turbidity remained within the envelope of natural variability.

> Mortality at informative Impact site Northeast Wickham Point increased above the predicted mean mortality in D8 (December 2013) and remained slightly above predicted mortality for the remainder of the program, but was below the 95% UCL trigger value. Measured mortality at informative Impact site, South Shell Island was below the predicted mortality from D8 to D11 (April 2014), before a substantial increase above that predicted in D13 (June 2014), but below the 95% UCL. Mortality returned to be slightly above the mean prediction and well within the 95% UCL during most of the Post-dredging Phase surveys, with the exception of P2 (October 2014) were mortality decreased well below the mean prediction.

> The greater mortality at South Shell Island compared to Northeast Wickham Point, which was also close to dredging operations and showed similar water quality regimes, was likely to have been as a consequence of differences in the types of corals (species or growth forms) tagged at each site and natural differences in the rate of mortality for the different types of corals (i.e. South Shell Island had more Pectinidae corals which had the highest mortality rate of all families). However, given that Pectiniidae corals also had a higher (although not significant) mortality at South Shell Island and Northeast Wickham Point compared to the other sites, turbidity from Season Two, a potential dredging influence cannot be excluded as a factor that may have had an influence on mortality.

> No impacts to coral health were recorded at reactive monitoring sites Channel Island Weed Reef 1 and Weed Reef 2 or at informative site Northeast Wickham Point in EA, which interestingly is also located in proximity to dredging and recorded a similar magnitude of dredging influence (increased turbidity) as South Shell Island.

> Communities at Channel Island, Weed Reef 1 and Northeast Wickham Point were remarkably stable throughout the two and a half years of the Coral Monitoring Program. At Weed Reef 2 a thermal bleaching event had a notable effect, while at South Shell Island coral cover declined by approximately 6% during the Dredging Phase, from 17.2% in B3 to 11.3% in D13. This was considered primarily to be a result of the loss of entire colonies due to the unconsolidated nature of the reef slope at this site but also potentially as a consequence of suppressed recruitment (see below). Most of the decline in the Post-dredging Phase occurred between P1 (August 2014) and P2 (October 2014), which was in part due to tentacle retraction of *Goniopora* sp. likely to be associated with increase in water temperature and thermal stress indicated by increase in bleaching.

> South Shell Island showed a potential reduction in the number of coral recruits observed during the Dredging and Post-dredging Phases. Coral recruits have previously been found to be more susceptible to sedimentation than established corals (Rogers 1990; Fabricius 2005; Erftemeijer et al. 2012). Given the increased turbidity measured at South Shell Island, a suppression of recruitment (i.e. preventing recruit settlement), or a reduction in recruits (i.e. burial of new recruits) is plausible. To a lesser extent, reduced recruitment may have contributed to the decline in coral cover at this site during the Dredging

and Post-dredging Phases along with the high number of dislodged and/or overturned coral colonies observed at South Shell Island in comparison to all other monitoring sites.

> With the exception of Weed Reef 2, peaks in the number of coral recruits (i.e. small corals of a size visible in the photos) were recorded for all sites in either June or July in 2012, 2013 and 2014, indicative of a seasonal recruitment pulse. The subsequent decline following recruitment peaks may have been due to the naturally high mortality rates experienced by coral recruits (Rogers 1990; Erftemeijer et al. 2012), but may also have been a result of some recruits growing larger than 20 mm where corals are no longer being recorded as recruits. Coral gravity assessment supports an autumn spawning hypothesis where Faviidae colonies, at least, had numerous mature oocytes on 8 April 2014 (one week prior to full moon) which were subsequently released prior to sampling on 10 May 2014. Mature oocytes were also noted in one faviid colony in October 2013 but there was insufficient temporal sampling to determine whether this indicated another (spring) spawning season for these taxa.

> Although many tagged corals exhibited partial mortality, considerable coral growth was also recorded for many tagged coral colonies. In individual tagged coral colonies from the families Pectiniidae, Dendrophyllidae and Faviidae that showed no visibly apparent mortality since the Baseline Phase, there was a mean increase in size of over 50%, with some individual colonies increasing to four times their original size. Corals of the family Pectiniidae have shown the greatest increase in size, followed by a slightly slower rate for Dendrophyllidae, while Faviidae showed noticeably less growth. The amount of growth recorded in tagged corals over the monitoring program demonstrates the substantial contribution that coral growth would have in maintaining overall coral cover at monitoring sites. Given the predominance of Pectiniidae at South Shell Island, a rapid recovery through growth is expected to occur at this site once the loss of coral has abated.

> Throughout the monitoring program, there were four apparent peaks in bleaching: June 2012 to August 2012 (B1 to B3), February 2013 to April 2013 (D3 to D4), March 2014 to June 2014 (D10 to D13) and during October 2014 to December 2014 (P2 and P3). The most severe bleaching event occurred at Weed Reef 2 during the period from February 2013 to April 2013, where a substantial number of *Alveopora* sp. bleached. The amount of bleaching subsequently reduced from D5 (June 2013) onwards, partly as a result of recovery of some colonies; however, total mortality of some bleached colonies also occurred. The patterns in coral bleaching observed in the Coral Monitoring Program indicate bleaching is likely to be an annual phenomenon in Darwin Harbour that can occur when water temperatures rise above 30°C. It is likely that the rate at which temperatures rise above 30°C, the duration of this warm water and the timing, frequency, intensity and duration of wet season tropical storms all have an influence on the timing and intensity of bleaching.

> Overall, the influence of dredging on coral communities in Darwin Harbour was confined to some sites in EA, in particular South Shell Island, with dredging having much less of an effect than what had been predicted in the Draft EIS (INPEX 2011). In summary, the measured potential impacts of dredging can be summarised as:

  - Temporary increase of sediment on corals at the end of the Dredging Phase at South Shell Island. Partial mortality decreased or remained unchanged in the subsequent surveys indicating the sediment cover was temporarily overlaying live coral tissue that was exposed in subsequent surveys; and
  - Potential suppression of recruitment at South Shell Island due to indirect effect of increased turbidity (from dredging) at the site, and the susceptibility of coral recruits to sedimentation.

7 Acknowledgements

This report was prepared by Chris Roberts, Dr Andrea Nicastro and Dr Craig Blount and reviewed by Dr Isabel Jimenez, Dr Craig Blount and Dr Lachlan Barnes. Field work during the Coral Monitoring Program was undertaken by Chris Roberts, Dr Craig Blount, Hamish Maitland, Dr Brendan Alderson, Barry Kruger, Kade Mills, Mathieu Pernice, Dr David Cummings, Dan Pygas, Dr Lachlan Barnes, Tim Harriden, Kane Organ and Joe Neilson with diving and vessel support provided by Neptune Marine Services.

Data management has been undertaken by Greig Campbell who oversaw the receipt, organisation, preparation and lifecycle control of over 67,000 original images. A combined total of over 7,900 coral health assessments and 16,400 community composition photoquadrats have been analysed using CPCe during the Coral Monitoring Program by Yesmin Chikhani, Dan Aveling, Dr Rad Nair, Guy Graham, Belinda Parkes, Belinda McCarthy, Andrea Nicastro, Nicola Pradella, Joanna Browne, Valeriya Komyakova, Monique Ladds, Gemma Carroll, Sean Smith, Ben Muscat and Dustin O’Hara

Dr Kelley Whitaker has overseen QA/QC of CPCe analyses throughout the monitoring program, including checking coral identifications, health assessments and the classification of other biota and abiota.

8 References

Ammar, M.S.A., Obuid-Allah, A.H., and Al-Hammady, M.A.M. (2011). Corals differential susceptibilities to bleaching along the Red Sea Coast, Egypt. *Nusantara Bioscience*, 3, pp. 73–81.

Anderson, M.J., Gorley, R. N. and Clarke, K.R. (2008). *PERMANOVA+ for PRIMER: Guide to Software and Statistical Methods.* PRIMER-E: Plymouth, UK.

AHPI (2012). *Australian Heritage Places Inventory.* Web publication http://www.heritage.gov.au/cgi-bin/ahpi/record.pl?RNE16462. Date of access 22 October 2012.

Australian Institute of Marine Science (2008). *Surveys of benthic reef communities using underwater digital photography and counts of juvenile corals.* Long-term Monitoring of the Great Barrier Reef Standard Operation Procedure Number 10.

Baird, A.H., Guest J.R., Willis B.L. (2009) Systematic and biogeographical patterns in the reproductive biology of Scleractinian corals. *Annual Review of Ecology, Evolution and Systematics* 40: 551 – 571.

Babcock, R.C., Baird, A.H., Piromvaragorn, S., Thomson, D.P., Willis, B.L. (2003). Identification of scleractinian coral recruits from Indo-Pacific Reefs. Zoological Studies, 42, pp. 211-226.

BOM (2015a). *Daily rainfall: Darwin Airport.* Web publication *http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=2014&p_c=-39285777&p_stn_num=014015*. Date of access 24 February 2015.

BOM (2015b). *Climate statistics for Australian locations: Summary statistics Darwin Airport.* Web publication *http://www.bom.gov.au/climate/averages/tables/cw_014015.shtml*. Date of access 24 February 2015.

Cardno (2012). *Coral Monitoring Method Statement − Ichthys Nearshore Environmental Monitoring Program*. Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2013a). *Nearshore Environmental Monitoring Plan (Rev 2)*. Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2013b). *Coral Monitoring Program Baseline Report − Ichthys Nearshore Environmental Monitoring Program*. Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2012c). *Bimonthly Coral Monitoring Report: Dredging Report 1 − Ichthys Nearshore Environmental Monitoring Program*. Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2013d). *Bimonthly Coral Monitoring Report: Dredging Report 2 − Ichthys Nearshore Environmental Monitoring Program*. Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2013e). *Bimonthly Coral Monitoring Report: Dredging Report 3 − Ichthys Nearshore Environmental Monitoring Program*. Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2013f). *Bimonthly Coral Monitoring Report: Dredging Report 4 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2013g). *Bimonthly Coral Monitoring Report: Dredging Report 5 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014a). *Bimonthly Coral Monitoring Report: Dredging Report 6 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014b). *Bimonthly Coral Monitoring Report: Dredging Report 7 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014c). *Bimonthly Coral Monitoring Report: Dredging Report 8 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014d). *Coral Monitoring Report: Dredging Report 9 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014e). *Coral Monitoring Report: Dredging Report 10 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014f). *Coral Monitoring Report: Dredging Report 11 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014g). *Coral Monitoring Report: Dredging Report 12 − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014h). *Coral Monitoring End of Dredging Report − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cardno (2014i). *Trigger Compliance Report 14: Routine Coral Monitoring − Ichthys Nearshore Environmental Monitoring Program.* Report for INPEX. Cardno (NSW/ACT) Pty Ltd, Sydney.

Cortes, J. and Risk, M. J. (1985). A reef under siltation stress: Cahuita, Costa Rica. *Bulletin of Marine Science,* 36(2), pp. 339−356.

Erftemeijer, P. L. A., Riegl, B., Hoeksema, B. W. and Todd, P. A. (2012). Environmental impacts of dredging and other sediment disturbances on corals: a review. *Marine Pollution Bulletin,* 64, pp. 1737–1765.

Fabricius, K. E. (2005). Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. *Marine Pollution Bulletin,* 50, pp. 125−146.

Geo Oceans (2011). Ichthys Gas Field Development Project: Benthic Habitat Mapping of the Darwin region – Methods of Data Collection, Collation, and Map Production, Ichthys Technical Appendix S6.

Goreau, T.J. and Hayes, R.L. (1994). Coral bleaching and ocean "hot spots". *Ambio* **23**: 176-180.

INPEX (2011). *Ichthys Gas Field Development Project – Draft Environmental Impact Statement*. INPEX Operations Australia Pty Ltd.

INPEX (2013). *Dredging and Spoil Disposal Management Plan – East Arm (Rev 4).* INPEX Operations Australia Pty Ltd.

INPEX (2014a). *Dredging and Spoil Disposal Management Plan – Gas Export Pipeline (Rev 6)*. INPEX Operations Australia Pty Ltd.

INPEX (2014b). Exceedance Attributability and Implementation Report: 30 January 2014 to 5 February 2014. INPEX Operations Australia Pty Ltd.

INPEX (2014c). Exceedance Attributability and Implementation Report: Channel Island 5 and 6 March 2014. INPEX Operations Australia Pty Ltd.

INPEX (2014d). Exceedance Attributability and Implementation Report: Weed Reef 1, 4 May 2014. INPEX Operations Australia Pty Ltd

INPEX (2014e). Exceedance Attributability and Implementation Report – 16 to 20 May 2014. INPEX Operations Australia Pty Ltd.

Kelley, R. (2009). *Indo Pacific Coral Finder,* BYO Guides. The Australian Coral Reef Society, Townsville.

Kohler, K.E. and Gill, S.M. (2006). Coral Point Count with Excel Extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. *Computers and Geosciences,* 32, pp. 1258−1269.

Lirman, D. and Manzello, D. (2009). Patterns of resistance and resilience of the stress-tolerant coral Siderastrea radians (Pallas) to sub-optimal salinity and sediment burial. *Journal of Experimental Marine Biology and Ecology,* 369, pp. 72−77.

Marshall, P.A. and Baird, A.H. (2000). Bleaching of corals on the Great Barrier Reef: differential susceptibilities among taxa. *Coral Reefs*, 19(2), pp. 155-163.

NOAA Coral Reef Watch. (2013a). *Operational 50 km Nighttime SST Charts for the Year 2012*. Web publication *http://www.ospo.noaa.gov/Products/ocean/sst/50km_night/2012.html*. Date of access 26 Sept 2013.

NOAA Coral Reef Watch. (2013b). *Satellite 50 km Coral Bleaching Alert Area.* Web publication http://coralreefwatch.noaa.gov/satellite/baa/bleachingalertarea.php. Date of access 26 Sept 2013

Phillipp, E. and Fabricius, K.E. (2003). Photophysiological stress in scleractinian corals in response to short-term sedimentation. *Journal of Experimental Marine Biology and Ecology* 287**,** 57-58.

Rogers, C.S. (1990). Responses of Coral Reefs and Reef Organisms to Sedimentation. *Marine Ecology Progress Series,* 62, pp. 185-202.

Stoddart, J.A. and Gilmour, J. (2004) Patterns of reproduction of in-shore corals of the Dampier Harbour, Western Australia, and comparisons with other reefs. In Stoddart, J.A. and Stoddard, S.E. (Eds) Corals of the Dampier Harbour: their survival and reproduction during the Dredging programs of 2004. Mscience Pty. Ltd., Perth Western Australia, 53-64.

Underwood, A. J. (1992). Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. *Journal of Experimental Marine Biology and Ecology,* 161, pp. 145−178.

Veron, J. E. N. (1986). *Corals of Australia and the Indo Pacific*. Angus and Robertson Ltd, Hong Kong, 644 pp.

Veron, J. E. N. (2000). *Corals of the World.* Australian Institute of Marine Science, Townsville, 489 pp.

Wilson, J.R., Ardiwijaya, R.L. and Prasetia, R. (2012). A Study of the Impact of the 2010 Coral Bleaching Event on Coral Communities in Wakatobi national park. *The Nature Conservancy*, Indonesia.

Yeemin, T., Sudara, S., Krairapanond, N., Silpsoonthorn, C., Ruengsawang, N. and Asa, S. (2001). Web publication *http://www.reefbase.org/resource_center/publication/main.aspx?refid=12388*. Date of access 09 May 2014.

APPENDIX A

TYPE AND FORM OF CORAL COLONIES

Appendix A-1 Type and form of all tagged coral colonies

Site	Tag	Family	*Genus*	Form
Channel Island	CHI_01	Faviidae	*Favia*	Massive
	CHI_02	Faviidae	*Favites*	Submassive
	CHI_03	Poritidae	*Goniopora*	Massive
	CHI_04	Faviidae	*Cyphastrea*	Submassive
	CHI_05	Pectiniidae	*Echinophyllia*	Foliose
	CHI_06	Pectiniidae	*Mycedium*	Encrusting
	CHI_07	Pectiniidae	*Mycedium*	Encrusting
	CHI_08	Dendrophylliidae	*Turbinaria*	Foliose
	CHI_09	Poritidae	*Goniopora*	Massive
	CHI_10	Pectiniidae	*Mycedium*	Encrusting
	CHI_11	Faviidae	*Favites*	Encrusting
	CHI_12	Pectiniidae	*Echinophyllia*	Submassive
	CHI_13	Faviidae	*Favites*	Submassive
	CHI_14	Faviidae	*Favia*	Massive
	CHI_15	Pectiniidae	*Mycedium*	Foliose
	CHI_16	Poritidae	*Goniopora*	Massive
	CHI_17	Pectiniidae	*Mycedium*	Encrusting
	CHI_18	Faviidae	*Favia*	Massive
	CHI_19	Poritidae	*Goniopora*	Massive
	CHI_20	Pectiniidae	*Mycedium*	Encrusting
	CHI_21	Faviidae	*Favites*	Submassive
	CHI_22	Faviidae	*Favites*	Submassive
	CHI_23	Faviidae	*Favia*	Massive
	CHI_24	Pectiniidae	*Echinophyllia*	Encrusting
	CHI_25	Faviidae	*Favia*	Massive
	CHI_26	Dendrophylliidae	*Turbinaria*	Foliose
	CHI_27	Poritidae	*Goniopora*	Massive
	CHI_28	Pectiniidae	*Echinophyllia*	Submassive
	CHI_29	Faviidae	*Cyphastrea*	Encrusting
	CHI_30	Dendrophyllidae	*Turbinaria*	Foliose
	CHI_31	Pectiniidae	*Mycedium*	Encrusting
	CHI_32	Faviidae	*Favia*	Massive
	CHI_33	Faviidae	*Favites*	Submassive
	CHI_34	Faviidae	*Cyphastrea*	Submassive
	CHI_35	Dendrophylliidae	*Turbinaria*	Foliose
	CHI_36	Faviidae	*Cyphastrea*	Submassive
	CHI_37	Poritidae	*Goniopora*	Massive
	CHI_38	Poritidae	*Goniopora*	Massive
	CHI_39	Faviidae	*Platygyra*	Encrusting
	CHI_40	Dendrophylliidae	*Turbinaria*	Foliose
	CHI_41	Faviidae	*Montastrea*	Encrusting
	CHI_42	Pectiniidae	*Mycedium*	Encrusting
	CHI_43	Pectiniidae	*Echinophyllia*	Submassive

Site	Tag	Family	*Genus*	Form
	CHI_44	Faviidae	*Moseleya*	Submassive
	CHI_45	Pectiniidae	*Mycedium*	Encrusting
	CHI_46	Faviidae	*Favia*	Massive
	CHI_47	Faviidae	*Favia*	Massive
	CHI_48	Faviidae	*Favites*	Submassive
	CHI_49	Dendrophylliidae	*Turbinaria*	Encrusting
	CHI_50	Faviidae	*Favia*	Massive
	CHI_51	Faviidae	*Cyphastrea*	Submassive
	CHI_52	Pectiniidae	*Mycedium*	Foliose
	CHI_53	Faviidae	*Favia/Montastrea*	Encrusting
	CHI_54	Pectiniidae	*Mycedium*	Encrusting
	CHI_55	Pectiniidae	*Mycedium*	Encrusting
	CHI_56	Pectiniidae	*Echinophyllia*	Encrusting
	CHI_57	Dendrophylliidae	*Turbinaria*	Foliose
	CHI_58	Pectiniidae	*Echinophyllia*	Submassive
	CHI_59	Faviidae	*Favia*	Encrusting
	CHI_60	Faviidae	*Favia*	Massive
	CHI_61	Faviidae	*Favia*	Massive
	CHI_62	Faviidae	*Favia*	Encrusting
	CHI_63	Poritidae	*Goniopora*	Massive
	CHI_64	Pectiniidae	*Mycedium*	Encrusting
	CHI_65	Faviidae	*Moseleya*	Submassive
	CHI_66	Poritidae	*Goniopora*	Massive
	CHI_67	Pectiniidae	*Mycedium*	Encrusting
	CHI_68	Pectiniidae	*Mycedium*	Encrusting
	CHI_69	Pectiniidae	*Mycedium*	Encrusting
	CHI_70	Faviidae	*Favia*	Massive
	CHI_71	Faviidae	*Cyphastrea*	Encrusting
	CHI_72	Pectiniidae	*Echinophyllia*	Submassive
	CHI_73	Pectiniidae	*Mycedium*	Encrusting
	CHI_74	Faviidae	*Favia*	Massive
	CHI_75	Pectiniidae	*Echinophyllia*	Encrusting
Charles Point	CHP_01	Poritidae	*Goniopora*	Massive
	CHP_02	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_03	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_04	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_05	Faviidae	*Favia/Montastrea*	Massive
	CHP_06	Poritidae	*Goniopora*	Massive
	CHP_07	Faviidae	*Favia/Montastrea*	Massive
	CHP_08	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_09	Faviidae	*Favia/Montastrea*	Encrusting
	CHP_10	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_11	Poritidae	*Porites*	Encrusting
	CHP_12	Dendrophylliidae	*Turbinaria*	Encrusting

Site	Tag	Family	*Genus*	Form
	CHP_13	Dendrophylliidae	*Turbinaria*	Encrusting
	CHP_14	Poritidae	*Goniopora*	Massive
	CHP_15	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_16	Faviidae	*Favites*	Submassive
	CHP_17	Faviidae	*Goniastrea*	Massive
	CHP_18	Faviidae	*Platygyra*	Submassive
	CHP_19	Poritidae	*Goniopora*	Massive
	CHP_20	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_21	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_22	Faviidae	*Favia/Montastrea*	Massive
	CHP_23	Poritidae	*Goniopora*	Massive
	CHP_24	Faviidae	*Favites*	Submassive
	CHP_25	Faviidae	*Favia/Montastrea*	Massive
	CHP_26	Faviidae	*Moseleya*	Submassive
	CHP_27	Faviidae	*Favia*	Massive
	CHP_28	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_29	Poritidae	*Goniopora*	Massive
	CHP_30	Faviidae	*Favites*	Massive
	CHP_31	Faviidae	*Favia/Montastrea*	Massive
	CHP_32	Faviidae	*Favia*	Encrusting
	CHP_33	Poritidae	*Goniopora*	Massive
	CHP_34	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_35	Faviidae	*Favites*	Submassive
	CHP_36	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_37	Poritidae	*Goniopora*	Massive
	CHP_38	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_39	Faviidae	*Favia*	Massive
	CHP_40	Faviidae	*Favia/Montastrea*	Massive
	CHP_41	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_42	Faviidae	*Favites*	Submassive
	CHP_43	Faviidae	*Favia*	Massive
	CHP_44	Poritidae	*Porites*	Submassive
	CHP_45	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_46	Faviidae	*Montastrea*	Submassive
	CHP_47	Oculinidae	*Galaxea*	Submassive
	CHP_48	Faviidae	*Favia*	Massive
	CHP_49	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_50	Poritidae	*Goniopora*	Massive
	CHP_51	Faviidae	*Goniastrea*	Submassive
	CHP_52	Faviidae	*Favia*	Massive
	CHP_53	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_54	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_55	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_56	Faviidae	*Platygyra*	Submassive

Site	Tag	Family	*Genus*	Form
	CHP_57	Faviidae	*Favia/Montastrea*	Encrusting
	CHP_58	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_59	Faviidae	*Barabattoia*	Massive
	CHP_60	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_61	Faviidae	*Favia/Montastrea*	Massive
	CHP_62	Faviidae	*Favites*	Encrusting
	CHP_63	Faviidae	*Favia/Montastrea*	Massive
	CHP_64	Faviidae	*Favia*	Massive
	CHP_65	Dendrophylliidae	*Turbinaria*	Foliose
	CHP_66	Faviidae	*Favia/Montastrea*	Massive
	CHP_67	Faviidae	*Favia/Montastrea*	Massive
	CHP_68	Faviidae	*Platygyra*	Submassive
	CHP_69	Poritidae	*Goniopora*	Massive
	CHP_70	Faviidae	*Montastrea*	Massive
	CHP_71	Faviidae	*Favia/Montastrea*	Massive
	CHP_72	Faviidae	*Montastrea*	Massive
	CHP_73	Faviidae	*Favia/Montastrea*	Massive
	CHP_74	Faviidae	*Favia/Montastrea*	Massive
	CHP_75	Faviidae	*Favia/Montastrea*	Submassive
Mandorah	MAN_01	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_02	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_03	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_04	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_05	Faviidae	*Favia*	Encrusting
	MAN_06	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_07	Faviidae	*Goniastrea*	Submassive
	MAN_08	Faviidae	*Favia*	Encrusting
	MAN_09	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_10	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_11	Faviidae	*Favites*	Encrusting
	MAN_12	Faviidae	*Favia*	Encrusting
	MAN_13	Faviidae	*Favites*	Submassive
	MAN_14	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_15	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_16	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_17	Faviidae	*Favia/Montastrea*	Encrusting
	MAN_18	Faviidae	*Cyphastrea*	Encrusting
	MAN_19	Faviidae	*Montastrea*	Encrusting
	MAN_20	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_21	Faviidae	*Cyphastrea*	Submassive
	MAN_22	Faviidae	*Favia/Montastrea*	Encrusting
	MAN_23	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_24	Poritidae	*Goniopora*	Massive
	MAN_25	Faviidae	*Favia*	Encrusting

Site	Tag	Family	*Genus*	Form
	MAN_26	Faviidae	*Favites*	Submassive
	MAN_27	Faviidae	*Favia*	Encrusting
	MAN_28	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_29	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_30	Faviidae	*Favia*	Encrusting
	MAN_31	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_32	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_33	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_34	Faviidae	*Favia/Montastrea*	Encrusting
	MAN_35	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_36	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_37	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_38	Faviidae	*Cyphastrea*	Massive
	MAN_39	Faviidae	*Goniastrea*	Submassive
	MAN_40	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_41	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_42	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_43	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_44	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_45	Faviidae	*Favites*	Submassive
	MAN_46	Faviidae	*Favia*	Submassive
	MAN_47	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_48	Faviidae	*Favia*	Encrusting
	MAN_49	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_50	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_51	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_52	Faviidae	*Favia*	Massive
	MAN_53	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_54	Faviidae	*Favia*	Encrusting
	MAN_55	Faviidae	*Favia/Montastrea*	Encrusting
	MAN_56	Faviidae	*Leptastrea*	Submassive
	MAN_57	Faviidae	*Moseleya*	Submassive
	MAN_58	Faviidae	*Favia*	Massive
	MAN_59	Faviidae	*Favia*	Encrusting
	MAN_60	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_61	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_62	Faviidae	*Favia*	Massive
	MAN_63	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_64	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_65	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_66	Faviidae	*Favia/Montastrea*	Submassive
	MAN_67	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_68	Faviidae	*Moseleya*	Submassive
	MAN_69	Faviidae	*Favia*	Submassive

Site	**Tag**	**Family**	***Genus***	**Form**
	MAN_70	Faviidae	*Favia*	Encrusting
	MAN_71	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_72	Poritidae	*Goniopora*	Massive
	MAN_73	Faviidae	*Favites*	Submassive
	MAN_74	Dendrophylliidae	*Turbinaria*	Foliose
	MAN_75	Dendrophylliidae	*Turbinaria*	Foliose
South Shell Island	SSI_01	Pectiniidae	*Mycedium*	Encrusting
	SSI_02	Pectiniidae	*Mycedium*	Encrusting
	SSI_03	Pectiniidae	*Mycedium*	Encrusting
	SSI_04	Pectiniidae	*Mycedium*	Encrusting
	SSI_05	Pectiniidae	*Mycedium*	Encrusting
	SSI_06	Pectiniidae	*Mycedium*	Foliose
	SSI_07	Pectiniidae	*Mycedium*	Encrusting
	SSI_08	Pectiniidae	*Mycedium*	Foliose
	SSI_09	Poritidae	*Goniopora*	Massive
	SSI_10	Pectiniidae	*Mycedium*	Foliose
	SSI_11	Poritidae	*Goniopora*	Massive
	SSI_12	Pectiniidae	*Mycedium*	Encrusting
	SSI_13	Poritidae	*Goniopora*	Massive
	SSI_14	Pectiniidae	*Mycedium*	Encrusting
	SSI_15	Pectiniidae	*Mycedium*	Encrusting
	SSI_16	Pectiniidae	*Mycedium*	Foliose
	SSI_17	Pectiniidae	*Mycedium*	Encrusting
	SSI_18	Pectiniidae	*Mycedium*	Encrusting
	SSI_19	Pectiniidae	*Mycedium*	Encrusting
	SSI_20	Pectiniidae	*Mycedium*	Foliose
	SSI_21	Pectiniidae	*Mycedium*	Foliose
	SSI_22	Pectiniidae	*Mycedium*	Encrusting
	SSI_23	Merulinidae	*Hydnophora*	Encrusting
	SSI_24	Pectiniidae	*Mycedium*	Foliose
	SSI_25	Pectiniidae	*Mycedium*	Foliose
	SSI_26	Pectiniidae	*Mycedium*	Foliose
	SSI_27	Pectiniidae	*Mycedium*	Foliose
	SSI_28	Pectiniidae	*Mycedium*	Encrusting
	SSI_29	Pectiniidae	*Mycedium*	Encrusting
	SSI_30	Pectiniidae	*Mycedium*	Encrusting
	SSI_31	Faviidae	*Favia/Montastrea*	Massive
	SSI_32	Pectiniidae	*Mycedium*	Encrusting
	SSI_33	Faviidae	*Favia/Montastrea*	Massive
	SSI_34	Faviidae	*Favia/Montastrea*	Massive
	SSI_35	Pectiniidae	*Mycedium*	Foliose
	SSI_36	Pectiniidae	*Mycedium*	Encrusting
	SSI_37	Pectiniidae	*Mycedium*	Encrusting
	SSI_38	Pectiniidae	*Mycedium*	Encrusting

Site	Tag	Family	*Genus*	Form
	SSI_39	Pectiniidae	*Mycedium*	Encrusting
	SSI_40	Faviidae	*Moseleya*	Submassive
	SSI_41	Pectiniidae	*Mycedium*	Encrusting
	SSI_42	Pectiniidae	*Mycedium*	Foliose
	SSI_43	Fungiidae	*Lithophyllon*	Foliose
	SSI_44	Pectiniidae	*Mycedium*	Encrusting
	SSI_45	Pectiniidae	*Mycedium*	Encrusting
	SSI_46	Dendrophylliidae	*Duncanopsammia*	Branching
	SSI_47	Pectiniidae	*Mycedium*	Foliose
	SSI_48	Pectiniidae	*Mycedium*	Encrusting
	SSI_49	Pectiniidae	*Mycedium*	Foliose
	SSI_50	Pectiniidae	*Mycedium*	Foliose
	SSI_51	Pectiniidae	*Mycedium*	Foliose
	SSI_52	Pectiniidae	*Mycedium*	Encrusting
	SSI_53	Pectiniidae	*Mycedium*	Encrusting
	SSI_54	Oculinidae	*Galaxea*	Submassive
	SSI_55	Pectiniidae	*Mycedium*	Encrusting
	SSI_56	Poritidae	*Goniopora*	Massive
	SSI_57	Poritidae	*Goniopora*	Massive
	SSI_58	Poritidae	*Goniopora*	Massive
	SSI_59	Pectiniidae	*Mycedium*	Encrusting
	SSI_60	Pectiniidae	*Mycedium*	Encrusting
	SSI_61	Pectiniidae	*Mycedium*	Encrusting
	SSI_62	Pectiniidae	*Mycedium*	Foliose
	SSI_63	Poritidae	*Goniopora*	Massive
	SSI_64	Poritidae	*Goniopora*	Massive
	SSI_65	Poritidae	*Goniopora*	Massive
	SSI_66	Pectiniidae	*Mycedium*	Foliose
	SSI_67	Poritidae	*Goniopora*	Massive
	SSI_68	Pectiniidae	*Mycedium*	Encrusting
	SSI_69	Pectiniidae	*Mycedium*	Encrusting
	SSI_70	Pectiniidae	*Mycedium*	Encrusting
	SSI_71	Pectiniidae	*Mycedium*	Encrusting
	SSI_72	Pectiniidae	*Mycedium*	Encrusting
	SSI_73	Poritidae	*Goniopora*	Massive
	SSI_74	Faviidae	*Moseleya*	Submassive
	SSI_75	Poritidae	*Goniopora*	Massive
Weed Reef 1	WR1_01	Faviidae	*Goniastrea*	Massive
	WR1_02	Faviidae	*Montastrea*	Massive
	WR1_03	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_04	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_05	Faviidae	*Goniastrea*	Massive
	WR1_06	Poritidae	*Goniopora*	Massive
	WR1_07	Faviidae	*Montastrea*	Massive

Site	Tag	Family	*Genus*	Form
	WR1_08	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_09	Faviidae	*Favia*	Massive
	WR1_10	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_11	Dendrophylliidae	*Turbinaria*	Encrusting
	WR1_12	Faviidae	*Favites*	Submassive
	WR1_13	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_14	Faviidae	*Favia*	Massive
	WR1_15	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_16	Faviidae	*Favites*	Encrusting
	WR1_17	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_18	Faviidae	*Goniastrea*	Encrusting
	WR1_19	Faviidae	*Goniastrea*	Massive
	WR1_20	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_21	Faviidae	*Favia*	Encrusting
	WR1_22	Agariciidae	*Pachyseris*	Foliose
	WR1_23	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_24	Merulinidae	*Hydnophora*	Submassive
	WR1_25	Faviidae	*Moseleya*	Submassive
	WR1_26	Siderastreidae	*Coscinaraea*	Encrusting
	WR1_27	Faviidae	*Goniastrea*	Submassive
	WR1_28	Faviidae	*Platygyra*	Encrusting
	WR1_29	Faviidae	*Favia*	Massive
	WR1_30	Poritidae	*Goniopora*	Massive
	WR1_31	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_32	Poritidae	*Goniopora*	Massive
	WR1_33	Fungiidae	*Lithophyllon*	Encrusting
	WR1_34	Faviidae	*Leptastrea*	Submassive
	WR1_35	Faviidae	*Favites*	Massive
	WR1_36	Faviidae	*Favia*	Massive
	WR1_37	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_38	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_39	Faviidae	*Goniastrea*	Massive
	WR1_40	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_41	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_42	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_43	Pectiniidae	*Mycedium*	Encrusting
	WR1_44	Faviidae	*Favites*	Submassive
	WR1_45	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_46	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_47	Faviidae	*Favites*	Submassive
	WR1_48	Pectiniidae	*Mycedium*	Encrusting
	WR1_49	Poritidae	*Goniopora*	Massive
	WR1_50	Faviidae	*Favia*	Encrusting
	WR1_51	Dendrophylliidae	*Turbinaria*	Foliose

Site	Tag	Family	*Genus*	Form
	WR1_52	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_53	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_54	Poritidae	*Goniopora*	Massive
	WR1_55	Faviidae	*Favites*	Submassive
	WR1_56	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_57	Faviidae	*Goniastrea*	Massive
	WR1_58	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_59	Mussidae	*Lobophyllia*	Massive
	WR1_60	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_61	Fungiidae	*Lithophyllon*	Encrusting
	WR1_62	Pectiniidae	*Mycedium*	Encrusting
	WR1_63	Pectiniidae	*Mycedium*	Encrusting
	WR1_64	Faviidae	*Favia*	Submassive
	WR1_65	Pectiniidae	*Mycedium*	Encrusting
	WR1_66	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_67	Pectiniidae	*Echinophyllia*	Encrusting
	WR1_68	Faviidae	*Montastrea*	Massive
	WR1_69	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_70	Faviidae	*Favia*	Massive
	WR1_71	Dendrophylliidae	*Turbinaria*	Foliose
	WR1_72	Pectiniidae	*Mycedium*	Encrusting
	WR1_73	Faviidae	*Goniastrea*	Encrusting
	WR1_74	Pectiniidae	*Mycedium*	Encrusting
	WR1_75	Faviidae	*Favites*	Submassive
Weed Reef 2	WR2_01	Faviidae	*Montastrea*	Massive
	WR2_02	Poritidae	*Porites*	Massive
	WR2_03	Faviidae	*Favites*	Encrusting
	WR2_04	Faviidae	*Favia*	Encrusting
	WR2_05	Faviidae	*Favia*	Encrusting
	WR2_06	Poritidae	*Goniopora*	Massive
	WR2_07	Faviidae	*Moseleya*	Submassive
	WR2_08	Pectiniidae	*Mycedium*	Foliose
	WR2_09	Faviidae	*Montastrea*	Submassive
	WR2_10	Pectiniidae	*Mycedium*	Encrusting
	WR2_11	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_12	Faviidae	*Favia*	Massive
	WR2_13	Poritidae	*Goniopora*	Massive
	WR2_14	Faviidae	*Favia/Montastrea*	Encrusting
	WR2_15	Pectiniidae	*Mycedium*	Encrusting
	WR2_16	Pectiniidae	*Echinophyllia*	Encrusting
	WR2_17	Faviidae	*Favia/Montastrea*	Encrusting
	WR2_18	Faviidae	*Montastrea*	Encrusting
	WR2_19	Pectiniidae	*Echinophyllia*	Encrusting
	WR2_20	Pectiniidae	*Mycedium*	Encrusting

Site	Tag	Family	*Genus*	Form
	WR2_21	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_22	Pectiniidae	*Mycedium*	Encrusting
	WR2_23	Pectiniidae	*Mycedium*	Encrusting
	WR2_24	Poritidae	*Goniopora*	Massive
	WR2_25	Faviidae	*Favia*	Encrusting
	WR2_26	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_27	Fungiidae	*Lithophyllon*	Encrusting
	WR2_28	Poritidae	*Goniopora*	Massive
	WR2_29	Pectiniidae	*Mycedium*	Encrusting
	WR2_30	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_31	Poritidae	*Alveopora*	Massive
	WR2_32	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_33	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_34	Faviidae	*Cyphastrea*	Massive
	WR2_35	Poritidae	*Alveopora*	Massive
	WR2_36	Poritidae	*Alveopora*	Massive
	WR2_37	Poritidae	*Alveopora*	Massive
	WR2_38	Faviidae	*Favites*	Encrusting
	WR2_39	Poritidae	*Goniopora*	Massive
	WR2_40	Pectiniidae	*Mycedium*	Encrusting
	WR2_41	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_42	Poritidae	*Alveopora*	Massive
	WR2_43	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_44	Faviidae	*Favites*	Submassive
	WR2_45	Poritidae	*Alveopora*	Massive
	WR2_46	Poritidae	*Alveopora*	Massive
	WR2_47	Pectiniidae	*Mycedium*	Encrusting
	WR2_48	Faviidae	*Montastrea*	Massive
	WR2_49	Faviidae	*Montastrea*	Massive
	WR2_50	Faviidae	*Favia*	Massive
	WR2_51	Poritidae	*Alveopora*	Massive
	WR2_52	Faviidae	*Favia/Montastrea*	Massive
	WR2_53	Poritidae	*Goniopora*	Massive
	WR2_54	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_55	Fungiidae	*Lithophyllon*	Encrusting
	WR2_56	Pectiniidae	*Echinophyllia*	Submassive
	WR2_57	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_58	Faviidae	*Favites*	Encrusting
	WR2_59	Siderastreidae	*Psammocora*	Submassive
	WR2_60	Dendrophylliidae	*Turbinaria*	Encrusting
	WR2_61	Pectiniidae	*Mycedium*	Encrusting
	WR2_62	Faviidae	*Favia*	Submassive
	WR2_63	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_64	Pectiniidae	*Mycedium*	Encrusting

Site	Tag	Family	*Genus*	Form
	WR2_65	Poritidae	*Goniopora*	Massive
	WR2_66	Pectiniidae	*Mycedium*	Encrusting
	WR2_67	Dendrophylliidae	*Turbinaria*	Encrusting
	WR2_68	Faviidae	*Favia*	Submassive
	WR2_69	Faviidae	*Favia/Montastrea*	Massive
	WR2_70	Faviidae	*Favites*	Submassive
	WR2_71	Pectiniidae	*Mycedium*	Encrusting
	WR2_72	Fungiidae	*Lithophyllon*	Encrusting
	WR2_73	Dendrophylliidae	*Turbinaria*	Foliose
	WR2_74	Faviidae	*Montastrea*	Massive
	WR2_75	Faviidae	*Favites*	Submassive
Northeast Wickham Point	NEW_01	Faviidae	*Cyphastrea*	Massive
	NEW_02	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_03	Faviidae	*Moseleya*	Submassive
	NEW_04	Faviidae	*Favites*	Submassive
	NEW_05	Faviidae	*Favia*	Massive
	NEW_06	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_07	Faviidae	*Favia*	Massive
	NEW_08	Faviidae	*Cyphastrea*	Submassive
	NEW_09	Faviidae	*Favia/Montastrea*	Massive
	NEW_10	Faviidae	*Cyphastrea*	Submassive
	NEW_11	Poritidae	*Goniopora*	Massive
	NEW_12	Faviidae	*Favia/Montastrea*	Massive
	NEW_13	Faviidae	*Favites*	Encrusting
	NEW_14	Faviidae	*Cyphastrea*	Submassive
	NEW_15	Faviidae	*Montastrea*	Massive
	NEW_16	Faviidae	*Moseleya*	Submassive
	NEW_17	Faviidae	*Favia/Montastrea*	Submassive
	NEW_18	Faviidae	*Favites*	Submassive
	NEW_19	Faviidae	*Favia*	Massive
	NEW_20	Pectiniidae	*Mycedium*	Encrusting
	NEW_21	Faviidae	*Montastrea*	Massive
	NEW_22	Faviidae	*Moseleya*	Submassive
	NEW_23	Faviidae	*Favia/Montastrea*	Massive
	NEW_24	Faviidae	*Favia/Montastrea*	Massive
	NEW_25	Pectiniidae	*Mycedium*	Encrusting
	NEW_26	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_27	Faviidae	*Moseleya*	Submassive
	NEW_28	Faviidae	*Favia*	Encrusting
	NEW_29	Faviidae	*Favia/Montastrea*	Massive
	NEW_30	Faviidae	*Favites*	Encrusting
	NEW_31	Pectiniidae	*Mycedium*	Foliose
	NEW_32	Faviidae	*Favia*	Massive
	NEW_33	Faviidae	*Favia*	Encrusting

Site	Tag	Family	*Genus*	Form
	NEW_34	Faviidae	*Favia*	Massive
	NEW_35	Pectiniidae	*Mycedium*	Encrusting
	NEW_36	Pectiniidae	*Mycedium*	Encrusting
	NEW_37	Pectiniidae	*Mycedium*	Encrusting
	NEW_38	Pectiniidae	*Mycedium*	Encrusting
	NEW_39	Faviidae	*Favia*	Encrusting
	NEW_40	Faviidae	*Favia/Montastrea*	Massive
	NEW_41	Faviidae	*Moseleya*	Submassive
	NEW_42	Poritidae	*Porites*	Encrusting
	NEW_43	Fungiidae	*Lithophyllon*	Encrusting
	NEW_44	Faviidae	*Favia*	Massive
	NEW_45	Siderastreidae	*Coscinaraea*	Submassive
	NEW_46	Faviidae	*Favites*	Encrusting
	NEW_47	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_48	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_49	Faviidae	*Moseleya*	Submassive
	NEW_50	Faviidae	*Favia/Montastrea*	Massive
	NEW_51	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_52	Faviidae	*Favia/Montastrea*	Encrusting
	NEW_53	Faviidae	*Favia/Montastrea*	Massive
	NEW_54	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_55	Pectiniidae	*Mycedium*	Encrusting
	NEW_56	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_57	Pectiniidae	*Mycedium*	Encrusting
	NEW_58	Poritidae	*Goniopora*	Massive
	NEW_59	Poritidae	*Goniopora*	Massive
	NEW_60	Poritidae	*Goniopora*	Massive
	NEW_61	Dendrophylliidae	*Turbinaria*	Encrusting
	NEW_62	Poritidae	*Goniopora*	Massive
	NEW_63	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_64	Faviidae	*Favia*	Massive
	NEW_65	Pectiniidae	*Mycedium*	Encrusting
	NEW_66	Faviidae	*Favia/Montastrea*	Massive
	NEW_67	Poritidae	*Goniopora*	Massive
	NEW_68	Faviidae	*Montastrea*	Massive
	NEW_69	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_70	Faviidae	*Favia*	Massive
	NEW_71	Faviidae	*Cyphastrea*	Submassive
	NEW_72	Faviidae	*Favia*	Massive
	NEW_73	Dendrophylliidae	*Turbinaria*	Foliose
	NEW_74	Faviidae	*Cyphastrea*	Submassive
	NEW_75	Pectiniidae	*Mycedium*	Encrusting

APPENDIX B

RAW DATA

Appendix B-1 Mean (±SE) percentage cover of sub-categories contributing to total mortality for D13 to P3

A. Likely perceived mortality

	D13		P_{RS}		P1		P2		P3	
Sediment	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Channel Island	9.26	1.52	7.47	1.27	9.39	1.34	11.13	1.49	11.40	1.76
Weed Reef 1	5.97	1.50	7.02	1.26	8.37	1.32	4.35	0.51	7.25	1.18
Weed Reef 2	9.26	1.25	8.78	1.37	15.13	2.20	10.79	1.53	15.73	2.69
South Shell Island	24.91	2.78	21.85	3.13	24.08	2.98	19.00	2.83	29.16	3.42
Northeast Wickham Point	8.63	1.45	9.60	1.30	9.25	1.28	8.14	1.20	12.17	1.77
Mandorah					6.77	1.19	5.38	1.07	7.01	1.48
Entire Colony Sediment Burial										
Channel Island	1.64	1.64	1.64	1.64	1.67	1.67	1.69	1.69	1.69	1.69
Weed Reef 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weed Reef 2	1.72	1.72	1.72	1.72	1.72	1.72	1.75	1.75	1.72	1.72
South Shell Island	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northeast Wickham Point	1.69	1.69	1.59	1.59	1.59	1.59	1.56	1.56	1.61	1.61
Mandorah					0.00	0.00	0.00	0.00	0.00	0.00
Macroalgae										
Channel Island	0.34	0.17	0.10	0.08	0.14	0.07	0.15	0.07	0.16	0.08
Weed Reef 1	0.00	0.00	0.04	0.03	0.06	0.04	0.17	0.11	0.15	0.06
Weed Reef 2	0.11	0.09	0.03	0.03	0.03	0.03	0.00	0.00	0.03	0.03
South Shell Island	0.77	0.26	0.16	0.13	0.26	0.22	0.65	0.36	1.80	0.73
Northeast Wickham Point	0.12	0.06	0.03	0.03	0.05	0.03	0.31	0.19	0.19	0.10
Mandorah					0.17	0.09	0.67	0.23	1.29	0.48
Mobile Fauna										
Channel Island	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weed Reef 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Weed Reef 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Shell Island	0.62	0.62	0.54	0.54	0.08	0.08	0.16	0.12	0.00	0.00
Northeast Wickham Point	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00
Mandorah					0.00	0.00	0.00	0.00	0.00	0.00
Total Perceived Dead Coral										
Channel Island	11.24	2.12	9.20	1.97	11.20	2.02	12.97	2.12	13.25	2.33
Weed Reef 1	5.97	1.50	7.06	1.26	8.43	1.32	4.52	0.53	7.41	1.18
Weed Reef 2	11.10	1.99	10.53	2.08	16.88	2.62	12.54	2.18	17.48	3.05
South Shell Island	26.30	2.97	22.55	3.30	24.42	2.96	19.80	2.89	30.97	3.53
Northeast Wickham Point	10.44	2.12	11.22	1.93	10.91	1.91	10.01	1.87	13.97	2.25
Mandorah					6.94	1.19	6.05	1.10	8.30	1.54

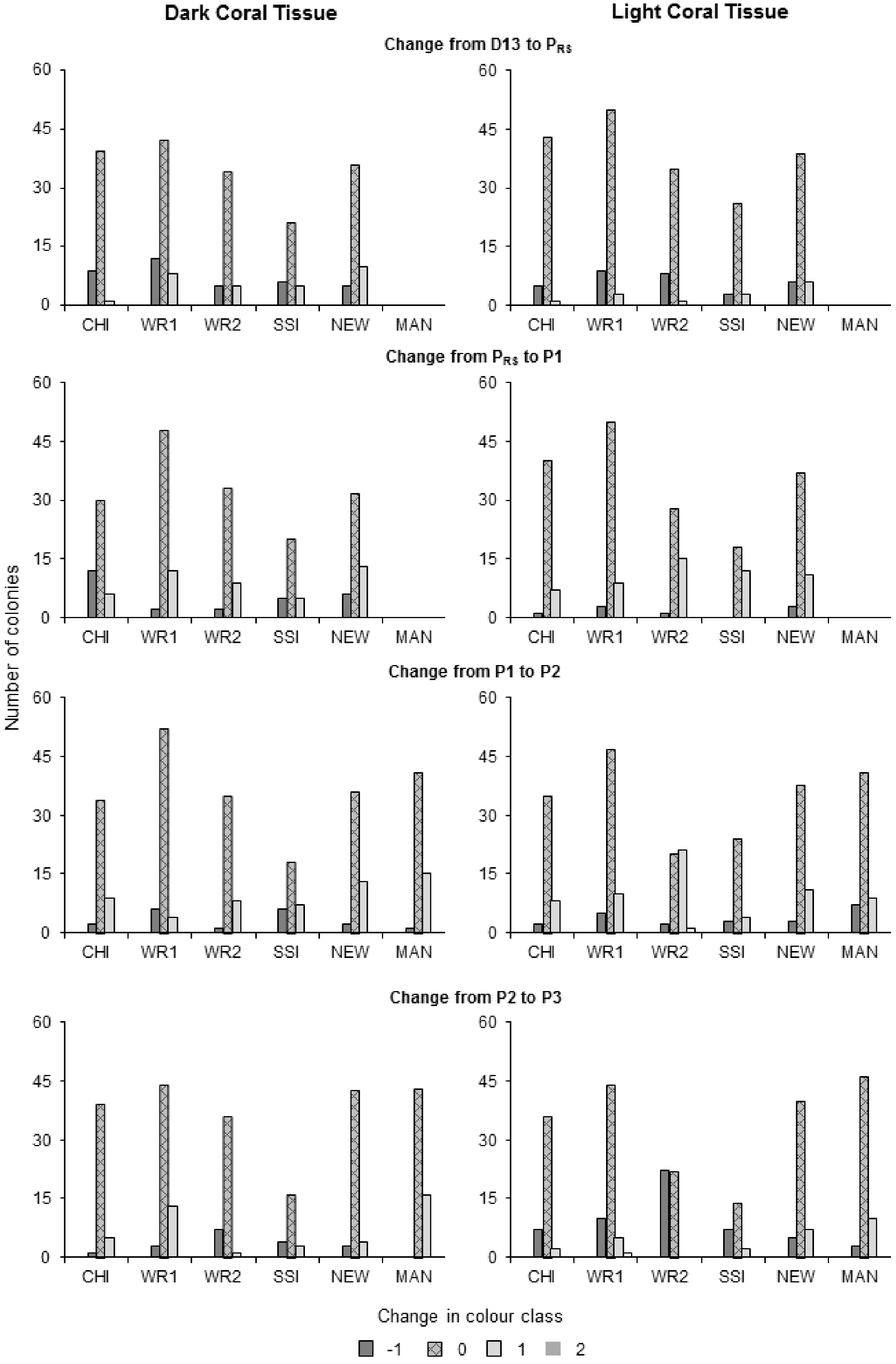
B. Actual mortality

	D13		P_{RS}		P1		P2		P3	
Total Dead Coral	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Channel Island	28.15	3.77	29.98	3.86	30.89	3.85	32.09	3.80	32.07	4.05
Weed Reef 1	16.56	2.71	16.72	2.57	16.66	2.47	15.96	2.58	18.23	2.76
Weed Reef 2	30.27	4.15	29.37	4.23	34.59	4.16	30.19	4.23	34.72	4.46
South Shell Island	48.01	4.54	46.76	4.25	48.32	4.67	45.48	4.62	53.72	4.78
Northeast Wickham Point	26.50	3.48	28.44	3.35	28.04	3.59	28.63	3.58	30.19	3.70
Mandorah			20.56	2.89	19.15	2.99	22.54	3.28	20.56	2.89
Entire Colony Mortality										
Channel Island	4.92	2.79	4.92	2.79	5.00	2.84	5.08	2.88	5.08	2.88
Weed Reef 1	1.43	1.43	1.45	1.45	1.43	1.43	2.90	2.03	2.90	2.03
Weed Reef 2	8.62	3.72	8.62	3.72	8.62	3.72	8.77	3.78	8.62	3.72
South Shell Island	2.63	2.63	2.50	2.50	2.63	2.63	2.63	2.63	2.70	2.70
Northeast Wickham Point	1.69	1.69	3.17	2.23	4.76	2.70	6.25	3.05	6.45	3.15
Mandorah					3.17	2.23	3.08	2.16	3.03	2.13
Missing section										
Channel Island	2.65	1.17	2.33	1.28	2.78	1.21	2.04	1.13	2.53	1.09
Weed Reef 1	0.62	0.18	0.56	0.16	1.30	0.73	1.12	0.74	1.25	0.75
Weed Reef 2	1.02	0.71	1.70	0.91	1.31	0.92	0.34	0.12	0.89	0.74
South Shell Island	2.94	1.29	3.10	1.34	1.12	0.36	1.03	0.29	2.90	1.50
Northeast Wickham Point	1.57	1.18	0.46	0.18	1.02	0.53	0.97	0.53	0.92	0.57
Mandorah					1.97	0.92	1.05	0.45	1.57	0.56
Turf algae										
Channel Island	8.31	2.10	11.67	2.60	10.36	2.43	10.21	2.34	9.39	2.46
Weed Reef 1	6.48	1.54	6.23	1.42	4.20	0.71	6.10	1.26	4.86	0.85
Weed Reef 2	6.54	1.88	5.10	1.44	4.29	1.06	5.52	1.37	4.24	1.01
South Shell Island	12.94	1.91	13.97	1.71	15.83	2.06	18.31	2.19	10.99	1.76
Northeast Wickham Point	11.59	2.36	12.07	1.96	9.39	1.71	10.62	1.98	7.82	1.63
Mandorah					6.24	1.21	6.78	1.26	5.90	1.23
Encrusting algae										
Channel Island	0.00	0.00	0.00	0.00	0.05	0.05	0.03	0.03	0.00	0.00
Weed Reef 1	0.02	0.02	0.02	0.02	0.10	0.04	0.00	0.00	0.00	0.00
Weed Reef 2	0.03	0.03	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00
South Shell Island	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northeast Wickham Point	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandorah					0.00	0.00	0.02	0.02	0.00	0.00
Immobile Fauna										
Channel Island	1.04	0.35	1.87	0.52	1.49	0.45	1.76	0.48	1.81	0.51
Weed Reef 1	1.88	0.54	1.40	0.39	1.18	0.30	1.32	0.36	1.81	0.41
Weed Reef 2	2.97	1.55	3.42	1.61	3.33	1.61	3.01	1.53	3.35	1.65
South Shell Island	3.01	0.82	4.61	1.25	4.32	0.89	3.71	0.82	6.17	1.50
Northeast Wickham Point	1.17	0.28	1.50	0.30	1.96	1.06	0.78	0.28	1.03	0.27
Mandorah					2.23	0.55	2.18	0.47	3.74	0.83
Total Actual Dead Coral										
Channel Island	5.28	0.61	20.78	3.67	19.69	3.65	19.12	3.58	18.82	3.70
Weed Reef 1	3.49	0.36	9.66	2.10	8.23	1.80	11.44	2.52	10.81	2.42
Weed Reef 2	5.44	0.63	18.84	4.03	17.70	3.96	17.65	3.99	17.24	4.01
South Shell Island	3.38	0.33	24.21	2.99	23.90	2.96	25.68	3.25	22.75	3.36
Northeast Wickham Point	5.90	0.54	17.23	2.86	17.13	3.28	18.62	3.38	16.22	3.34
Mandorah					13.62	2.53	13.10	2.51	14.24	2.63

Appendix B-2 Paver sediment depth and coral sediment cover on adjacent pavers and corresponding tagged colony in Post-dredging surveys P1, P2 and P3

Site	ID No.	Family	P1		P2		P3	
			Paver Sediment Depth (mm)	Coral Sediment Cover (%)	Paver Sediment Depth (mm)	Coral Sediment Cover (%)	Paver Sediment Depth (mm)	Coral Sediment Cover (%)
CHI	1	Faviidae	4	5.6	6	3.0	2	2.9
	2	Faviidae	3	10.3	8	16.4	4	10.6
	3	Poritidae	3	2.9	6	0.0	3	0.0
	5	Pectiniidae	3	2.8	5	20.3	1	12.7
	6	Pectiniidae	5	5.7	5	1.4	3	12.0
	8	Dendrophylliidae	2	0.0	6	11.4	3	16.0
	16	Poritidae	4	0.0	10	4.0	7	3.6
	26	Poritidae	2	6.4	6	7.0	3	7.0
WR1	3	Dendrophylliidae	10	6.3	4	2.6	10	1.4
	4	Pectiniidae	7	37.8	5	13.4	10	56.9
	6	Poritidae	5	0.0	6	2.0	8	2.2
	8	Dendrophylliidae	3	2.5	6	0.0	6	2.5
	14	Faviidae	3	5.8	5	0.0	12	0.0
	15	Pectiniidae	3	14.1	8	No CPCe	8	16.1
	29	Faviidae	2	1.5	5	1.5	8	1.5
	30	Poritidae	0	4.4	4	4.8	6	No CPCe
WR2	1	Faviidae	2	34.3	5	6.8	10	13.8
	4	Faviidae	6	8.6	6	6.9	20	4.2
	6	Poritidae	8	8.6	5	6.7	15	12.2
	8	Pectiniidae	5	12.5	6	4.4	6	12.3
	10	Pectiniidae	3	100.0	8	100.0	8	100.0
	13	Poritidae	6	No CPCe	5	No CPCe	10	7.3
	21	Dendrophylliidae	6	28.6	10	11.3	10	13.8
	26	Dendrophylliidae	5	0.0	6	0.0	8	No CPCe
SSI	31	Faviidae	3	11.3	5	9.5	6	4.2
NEW	1	Faviidae	7	2.5	4	4.1	8	4.0
	2	Dendrophyllidae	8	0.0	2	0.0	5	No CPCe
	5	Faviidae	4	2.9	3	1.4	6	1.3
	6	Dendrophyllidae	10	5.1	10	2.7	5	6.9
	11	Poritidae	3	12.1	4	10.3	8	19.5
	14	Faviidae	10	5.0	5	3.1	7	5.3
	20	Pectiniidae	3	20.0	5	3.0	8	15.7
	25	Pectiniidae	3	14.9	4	9.1	5	26.0
MAN	1	Dendrophyllidae	3	8.0	6	2.9	6	1.5
	4	Dendrophyllidae	3	0.0	6	4.1	10	2.7
	5	Faviidae	5	28.8	8	11.9	12	11.4
	7	Faviidae	3	10.0		9.9	10	13.2
	8	Faviidae	12	56.9	10	19.4	10	17.7
	17	Faviidae	8	5.7	15	4.0	20	2.9
	24	Poritidae	10	No CPCe	10	23.9	8	21.8

Appendix B-3 Number of coral colonies between the Post-dredging surveys showing a decrease in coral brightness (negative coral class change), an increase in coral brightness (positive coral class change), and no change in coral brightness



Appendix B-4 Benthic composition (%) of the different sites in field survey P_{RS}, including coral families and growth form, algae, seagrass and other invertebrates

	CHI		WR1		WR2		SSI		NEW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
HARD CORALS										
Acroporidae	**0.00**		**0.26**		**0.06**		**0.00**		**0.00**	
Encrusting	0.00	0.00	0.26	0.26	0.06	0.06	0.00	0.00	0.00	0.00
Agariciidae	**0.00**		**0.02**		**0.00**		**0.00**		**0.00**	
Other	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Submassive	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Dendrophylliidae	**0.63**		**0.82**		**3.08**		**0.00**		**0.68**	
Encrusting	0.44	0.32	0.24	0.13	0.36	0.26	0.00	0.00	0.04	0.04
Foliose	0.20	0.12	0.58	0.32	2.72	0.85	0.00	0.00	0.64	0.62
Euphyllidae	**0.00**		**0.00**		**0.30**		**0.00**		**0.00**	
Other	0.00	0.00	0.00	0.00	0.30	0.30	0.00	0.00	0.00	0.00
Faviidae	**3.91**		**2.16**		**2.43**		**0.16**		**0.78**	
Encrusting	2.85	0.56	0.83	0.32	0.67	0.30	0.06	0.03	0.27	0.12
Massive	0.65	0.46	0.49	0.37	0.41	0.22	0.00	0.00	0.19	0.15
Submassive	0.40	0.20	0.83	0.26	1.35	0.76	0.10	0.07	0.33	0.14
Fungiidae	**0.27**		**2.07**		**0.39**		**0.29**		**0.20**	
Encrusting	0.19	0.19	0.21	0.21	0.33	0.28	0.00	0.00	0.00	0.00
Foliose	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Massive	0.01	0.01	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Solitary	0.07	0.07	1.77	1.02	0.06	0.04	0.29	0.18	0.20	0.18
Merulinidae	**0.04**		**0.93**		**0.00**		**0.00**		0.01	
Encrusting	0.04	0.04	0.93	0.65	0.00	0.00	0.00	0.00	0.00	0.00
Submassive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Mussidae	**0.00**		**0.01**		**0.03**		**0.00**		**0.00**	
Other	0.00	0.00	0.01	0.01	0.03	0.03	0.00	0.00	0.00	0.00
Oculinidae	**0.00**		**0.00**		**0.11**		**0.00**		**0.00**	
Encrusting	0.00	0.00	0.00	0.00	0.11	0.11	0.00	0.00	0.00	0.00
Pectiniidae	**7.97**		**5.53**		**1.90**		**1.81**		**0.55**	
Encrusting	7.90	2.40	4.95	2.30	1.52	0.39	1.76	1.07	0.55	0.27
Foliose	0.07	0.02	0.58	0.26	0.32	0.23	0.05	0.04	0.00	0.00
Submassive	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00
Poritidae	**5.11**		**0.87**		**3.60**		**8.82**		**0.27**	
Encrusting	0.08	0.06	0.57	0.57	0.45	0.21	0.00	0.00	0.01	0.01
Massive	4.91	0.94	0.31	0.19	3.11	1.98	8.79	3.44	0.01	0.01
Submassive	0.13	0.13	0.00	0.00	0.04	0.04	0.03	0.03	0.25	0.25
Siderastreidae	**0.00**		**0.02**		**0.38**		**0.00**		**0.00**	
Submassive	0.00	0.00	0.02	0.02	0.38	0.23	0.00	0.00	0.00	0.00
Growth Forms										
Encrusting	11.49	2.38	8.00	3.10	3.50	0.37	1.82	1.08	0.87	0.37
Foliose	0.26	0.14	1.40	0.28	3.18	0.77	0.05	0.04	0.64	0.62

	CHI		WR1		WR2		SSI		NEW	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Massive	5.57	1.29	0.84	0.42	3.52	1.91	8.79	3.44	0.20	0.15
Solitary	0.07	0.07	1.77	1.02	0.06	0.04	0.29	0.18	0.20	0.18
Submassive	0.53	0.31	0.86	0.25	1.83	0.97	0.13	0.07	0.59	0.37
SOFT CORALS										
Leather	0.03	0.02	0.56	0.36	0.74	0.40	0.07	0.06	0.00	0.00
Tree Coral	0.00	0.00	0.26	0.07	0.41	0.31	1.33	0.40	1.04	0.42
Sea Whip	0.06	0.05	0.83	0.77	0.22	0.20	0.06	0.03	0.05	0.05
Other	0.01	0.01	0.03	0.03	0.01	0.01	0.52	0.32	0.15	0.07
ALGAE										
Encrusting	0.09	0.04	0.07	0.04	0.03	0.01	0.03	0.02	0.02	0.01
Macroalgae	1.05	0.45	0.30	0.18	0.11	0.05	0.31	0.08	0.14	0.09
Turf Algae	24.34	5.50	17.19	3.34	9.25	1.01	26.22	6.21	28.72	2.71
OTHER BIOTA										
Anemones	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Ascidian	0.09	0.04	0.23	0.10	0.11	0.06	0.25	0.12	0.32	0.06
Bryozoa	0.01	0.01	0.08	0.06	0.00	0.00	0.03	0.03	0.17	0.09
Hydroids	0.36	0.08	0.66	0.18	0.29	0.22	1.64	0.47	0.94	0.50
Sponge	3.68	0.56	5.31	0.42	2.68	0.63	2.53	0.21	4.62	1.36
Tube Worm	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Molluscs Immobile	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00
Mucus Tubes	0.11	0.05	0.00	0.00	0.05	0.02	0.00	0.00	0.30	0.09
SUBSTRATA										
Rock	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rubble	0.39	0.14	0.75	0.27	0.05	0.02	0.06	0.05	0.36	0.13
Sand/Silt	51.80	7.60	60.70	5.60	73.60	3.78	55.82	3.28	60.58	4.84

Appendix B-5 Benthic composition (%) of the different sites in field survey P1, including coral families and growth form, algae, seagrass and other invertebrates

	CHI		WR1		WR2		SSI		NEW		MAN	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
HARD CORALS												
Acroporidae	**0.00**		**0.16**		**0.00**		**0.00**		**0.00**		**0.00**	
Encrusting	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Foliose	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agariciidae	**0.00**		**0.11**		**0.00**		**0.00**		**0.00**		**0.00**	
Foliose	0.00	0.00	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dendrophylliidae	**0.19**		**0.97**		**1.67**		**0.00**		**0.50**		**7.07**	
Encrusting	0.02	0.02	0.19	0.08	0.44	0.43	0.00	0.00	0.24	0.24	0.34	0.27
Foliose	0.17	0.05	0.76	0.33	1.23	0.43	0.00	0.00	0.26	0.16	6.73	1.39
Other	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euphyllidae	**0.00**		**0.01**		**0.38**		**0.00**		**0.00**		**0.00**	
Other	0.00	0.00	0.01	0.01	0.38	0.38	0.00	0.00	0.00	0.00	0.00	0.00
Faviidae	**3.13**		**2.19**		**2.83**		**0.40**		**0.72**		**1.59**	
Encrusting	2.07	0.36	1.08	0.39	0.74	0.40	0.19	0.12	0.21	0.07	0.51	0.32
Foliose	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Massive	0.70	0.43	0.30	0.13	0.43	0.26	0.03	0.02	0.25	0.15	0.32	0.23
Submassive	0.32	0.17	0.80	0.61	1.65	0.73	0.19	0.08	0.26	0.06	0.75	0.60
Fungiidae	**0.44**		**2.18**		**0.26**		**0.28**		**0.26**		**0.00**	
Encrusting	0.40	0.24	0.40	0.24	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Foliose	0.00	0.00	0.06	0.06	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solitary	0.04	0.03	1.69	1.21	0.00	0.00	0.28	0.14	0.26	0.26	0.00	0.00
Merulinidae	**0.06**		0.72		**0.09**		**0.00**		**0.03**		**0.00**	
Encrusting	0.06	0.06	0.72	0.60	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00
Submassive	0.00	0.00	0.00	0.00	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Mussidae	**0.00**		**0.01**		**0.05**		**0.00**		**0.00**		**0.00**	
Encrusting	0.00	0.00	0.01	0.01	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Oculinidae	**0.00**		**0.00**		**0.15**		**0.00**		**0.00**		**0.00**	
Encrusting	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Pectiniidae	**7.82**		**5.90**		**2.87**		**1.76**		**1.24**		**0.00**	
Encrusting	7.47	3.13	3.46	1.24	1.68	0.22	1.76	0.95	1.18	0.80	0.00	0.00
Foliose	0.35	0.15	2.44	1.19	1.19	0.60	0.00	0.00	0.06	0.06	0.00	0.00
Poritidae	**5.39**		**0.35**		**3.42**		**9.35**		**0.19**		**0.30**	
Encrusting	0.02	0.01	0.03	0.03	0.21	0.10	0.00	0.00	0.09	0.08	0.03	0.02
Massive	5.33	0.87	0.23	0.15	3.17	2.06	9.35	3.76	0.08	0.08	0.27	0.10
Submassive	0.04	0.04	0.09	0.09	0.04	0.03	0.00	0.00	0.02	0.02	0.00	0.00
Siderastreidae	**0.00**		**0.01**		**0.53**		**0.00**		**0.25**		**0.16**	
Encrusting	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Submassive	0.00	0.00	0.00	0.00	0.53	0.32	0.00	0.00	0.25	0.25	0.14	0.14
Growth Forms												
Encrusting	10.05	3.43	5.98	1.40	3.31	0.45	1.95	0.92	1.74	0.80	0.90	0.28
Foliose	0.55	0.16	3.43	0.92	2.59	0.92	0.00	0.00	0.32	0.19	6.74	1.39
Massive	6.03	1.27	0.54	0.21	3.61	2.05	9.38	3.78	0.33	0.22	0.60	0.31
Solitary	0.04	0.03	1.69	1.21	0.00	0.00	0.28	0.14	0.26	0.26	0.00	0.00

	CHI		WR1		WR2		SSI		NEW		MAN	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Submassive	0.36	0.20	0.89	0.70	2.30	1.12	0.19	0.08	0.54	0.28	0.88	0.73
SOFT CORALS												
Leather	0.00	0.00	0.50	0.22	0.36	0.36	0.06	0.04	0.20	0.20	0.02	0.02
Tree Coral	0.01	0.01	0.28	0.08	0.42	0.29	0.81	0.04	0.77	0.43	0.59	0.07
Sea Whip	0.08	0.08	1.06	1.01	0.37	0.36	0.03	0.02	0.06	0.04	0.15	0.06
Other	0.02	0.01	0.04	0.00	0.02	0.02	0.44	0.22	0.02	0.02	0.16	0.08
ALGAE												
Encrusting	0.05	0.05	0.01	0.01	0.04	0.02	0.02	0.02	0.07	0.01	0.08	0.05
Macroalgae	2.64	1.54	0.26	0.01	0.31	0.04	0.93	0.34	0.41	0.26	1.76	0.28
Turf Algae	16.47	2.43	18.95	2.89	12.12	0.35	27.28	3.18	25.35	4.98	31.52	3.79
OTHER BIOTA												
Anemones	0.00	0.00	0.00	0.00	0.01	0.01	0.06	0.06	0.01	0.01	0.20	0.17
Ascidian	0.15	0.07	0.13	0.04	0.02	0.02	0.47	0.09	0.24	0.14	3.14	0.30
Bryozoa	0.09	0.03	0.07	0.02	0.05	0.02	0.16	0.06	0.18	0.03	0.78	0.11
Hydroids	0.54	0.12	0.29	0.13	0.10	0.04	1.00	0.25	0.14	0.09	6.14	1.56
Sponge	4.27	0.42	5.68	0.55	4.53	0.92	2.65	0.49	2.91	0.51	6.77	0.58
Tube Worm	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.01	0.00	0.00	0.03	0.01
Molluscs Immobile	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00
Mucus Tubes	0.05	0.03	0.03	0.01	0.05	0.02	0.00	0.00	0.10	0.05	0.01	0.01
SUBSTRATA												
Rock	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.06	0.05
Rubble	0.75	0.31	0.15	0.05	0.16	0.10	0.01	0.01	0.75	0.23	2.50	1.18
Sand/Silt	57.67	6.05	59.92	7.28	69.13	3.16	54.26	6.59	65.62	5.69	36.86	3.98

Appendix B-6 Benthic composition (%) of the different sites in field survey P2, including coral families and growth form, algae, seagrass and other invertebrates

	CHI		WR1		WR2		SSI		NEW		MAN	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
HARD CORALS												
Acroporidae	**0.00**		**0.38**		**0.20**		**0.00**		**0.00**		**0.02**	
Branching	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Encrusting	0.00	0.00	0.35	0.35	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Agariciidae	**0.00**		**0.22**		**0.11**		**0.00**		**0.00**		**0.00**	
Foliose	0.00	0.00	0.22	0.19	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Caryophylliidae	**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.01**	
Caryophylliidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Dendrophylliidae	**0.78**		**0.58**		**3.70**		**0.02**		**0.10**		**7.93**	
Encrusting	0.27	0.26	0.06	0.03	0.31	0.30	0.01	0.01	0.02	0.01	0.64	0.25
Foliose	0.51	0.39	0.52	0.49	3.39	0.78	0.01	0.01	0.08	0.07	7.28	1.62
Euphyllidae	**0.00**		**0.02**		**0.00**		**0.00**		**0.00**		**0.00**	
Other	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faviidae	**2.70**		**1.58**		**3.42**		**0.38**		**0.52**		**1.59**	
Encrusting	1.25	0.38	0.75	0.18	1.20	0.16	0.19	0.16	0.37	0.15	0.95	0.49
Massive	0.82	0.69	0.36	0.30	1.54	1.29	0.01	0.01	0.10	0.10	0.37	0.32
Submassive	0.63	0.29	0.47	0.20	0.68	0.09	0.19	0.10	0.05	0.04	0.27	0.16
Fungiidae	**0.36**		**2.30**		**0.29**		**0.26**		**0.21**		**0.01**	
Encrusting	0.32	0.13	0.02	0.02	0.20	0.20	0.00	0.00	0.00	0.00	0.01	0.01
Foliose	0.02	0.02	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Solitary	0.03	0.02	2.28	1.39	0.07	0.03	0.26	0.10	0.21	0.16	0.00	0.00
Merulinidae	**0.03**		**0.91**		**0.11**		**0.00**		**0.01**		0.00	
Encrusting	0.03	0.03	0.91	0.60	0.11	0.11	0.00	0.00	0.01	0.01	0.00	0.00
Oculinidae	**0.00**		**0.02**		**0.78**		**0.00**		**0.00**		**0.01**	
Encrusting	0.00	0.00	0.02	0.02	0.31	0.31	0.00	0.00	0.00	0.00	0.01	0.01
Submassive	0.00	0.00	0.00	0.00	0.47	0.47	0.00	0.00	0.00	0.00	0.00	0.00
Pectiniidae	**5.84**		**6.37**		**3.47**		**2.08**		**0.73**		**0.00**	
Encrusting	5.16	2.72	5.73	2.30	2.19	1.17	1.77	0.96	0.72	0.42	0.00	0.00
Foliose	0.68	0.49	0.64	0.31	1.29	0.82	0.31	0.16	0.01	0.01	0.00	0.00
Poritidae	**5.95**		**0.93**		**4.06**		**5.98**		**0.32**		**0.20**	
Encrusting	0.06	0.05	0.73	0.71	0.76	0.41	0.00	0.00	0.28	0.28	0.08	0.04
Massive	5.89	1.43	0.20	0.18	3.27	1.92	5.95	2.16	0.04	0.04	0.12	0.09
Submassive	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.03	0.00	0.00	0.00	0.00
Siderastreidae	**0.01**		**0.01**		**0.57**		**0.00**		**0.01**		**0.01**	
Encrusting	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Submassive	0.00	0.00	0.01	0.01	0.57	0.37	0.00	0.00	0.01	0.01	0.00	0.00
Growth Forms												
Branching	0.00	0.00	0.00	0.00	0.02	0.02	0.03	0.03	0.00	0.00	0.00	0.00
Encrusting	7.10	2.69	5.27	1.45	1.70	0.36	8.57	2.86	1.97	0.93	1.41	0.68
Foliose	1.21	0.52	4.81	0.62	7.28	1.62	1.38	0.24	0.32	0.16	0.09	0.06
Massive	6.71	1.86	4.80	1.69	0.50	0.41	0.56	0.28	5.96	2.17	0.14	0.14
Solitary	0.03	0.02	0.07	0.03	0.00	0.00	2.28	1.39	0.26	0.10	0.21	0.16
Submassive	0.63	0.29	1.75	0.32	0.27	0.16	0.48	0.20	0.22	0.09	0.06	0.03

	CHI		WR1		WR2		SSI		NEW		MAN	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
SOFT CORALS												
Leather	0.00	0.00	0.58	0.30	1.09	0.54	0.12	0.09	0.00	0.00	0.00	0.00
Tree Coral	0.07	0.02	0.39	0.15	1.39	0.68	1.36	0.37	0.59	0.22	1.07	0.14
Sea Whip	0.08	0.06	1.02	0.81	0.98	0.83	0.06	0.03	0.08	0.07	0.10	0.06
Other	0.02	0.02	0.01	0.01	0.03	0.03	0.37	0.21	0.04	0.03	0.10	0.05
ALGAE												
Encrusting	0.07	0.04	0.30	0.16	0.02	0.01	0.00	0.00	0.02	0.01	0.32	0.17
Macroalgae	3.41	1.80	0.32	0.08	0.26	0.08	3.97	2.04	1.04	0.55	1.78	0.38
Turf Algae	28.50	2.98	28.13	5.41	15.58	1.67	34.20	3.56	36.08	2.03	40.44	2.63
OTHER BIOTA												
Anemones	0.00	0.00	0.00	0.00	0.02	0.02	0.04	0.03	0.00	0.00	0.01	0.01
Ascidian	0.04	0.03	0.32	0.07	0.05	0.01	0.82	0.10	0.41	0.14	1.94	0.40
Bryozoa	0.04	0.02	0.04	0.02	0.03	0.02	0.15	0.05	0.10	0.04	0.61	0.13
Hydroids	0.37	0.11	0.13	0.06	0.10	0.03	0.44	0.14	0.06	0.03	4.47	1.66
Sponge	4.18	1.63	6.46	0.67	5.45	1.23	2.91	0.53	4.04	0.43	5.99	0.78
Tube Worm	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Molluscs Immobile	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01
Mucus Tubes	0.03	0.03	0.00	0.00	0.02	0.02	0.00	0.00	0.04	0.02	0.02	0.01
SUBSTRATA												
Rubble	0.84	0.56	1.04	0.31	0.11	0.05	0.11	0.06	1.54	0.45	1.63	0.59
Sand/Silt	46.63	3.48	47.86	10.01	58.00	5.06	46.62	6.28	53.98	2.96	31.70	3.05

Appendix B-7 **Benthic composition (%) of the different sites in field survey P3, including coral families and growth form, algae, seagrass and other invertebrates**

	CHI		WR1		WR2		SSI		NEW		MAN	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
HARD CORALS												
Acroporidae	**0.01**		**0.14**		**0.12**		**0.00**		**0.00**		**0.00**	
Branching	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Encrusting	0.00	0.00	0.13	0.13	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Agariciidae	**0.00**		**0.19**		**0.26**		**0.00**		**0.00**		**0.00**	
Foliose	0.00	0.00	0.19	0.19	0.26	0.26	0.00	0.00	0.00	0.00	0.00	0.00
Dendrophylliidae	**0.54**		**0.97**		**2.68**		**0.17**		**0.27**		**7.19**	
Encrusting	0.07	0.06	0.10	0.09	0.26	0.19	0.00	0.00	0.01	0.01	1.01	0.48
Foliose	0.47	0.28	0.87	0.46	2.41	1.08	0.00	0.00	0.26	0.15	6.18	1.13
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.00	0.00	0.00	0.00
Euphyllidae	**0.00**		**0.00**		**0.43**		**0.00**		**0.00**		**0.00**	
Other	0.00	0.00	0.00	0.00	0.43	0.41	0.00	0.00	0.00	0.00	0.00	0.00
Faviidae	**3.14**		**1.69**		**2.80**		**0.19**		**0.77**		**1.41**	
Encrusting	1.65	0.76	0.88	0.16	1.14	0.42	0.14	0.10	0.39	0.18	0.83	0.38
Massive	0.84	0.51	0.19	0.12	0.45	0.20	0.00	0.00	0.19	0.12	0.02	0.02
Submassive	0.65	0.13	0.63	0.18	1.21	0.77	0.05	0.04	0.19	0.13	0.57	0.33
Fungiidae	**0.49**		**2.55**		**0.30**		**0.16**		**0.20**		**0.07**	
Encrusting	0.26	0.21	0.28	0.28	0.13	0.13	0.00	0.00	0.01	0.01	0.02	0.02
Foliose	0.03	0.03	0.00	0.00	0.16	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Massive	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02
Solitary	0.15	0.11	2.27	1.66	0.02	0.01	0.16	0.04	0.19	0.19	0.02	0.02
Merulinidae	**0.13**		**0.09**		**0.11**		**0.00**		**0.00**		0.00	
Encrusting	0.12	0.12	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Foliose	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Submassive	0.00	0.00	0.00	0.00	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Mussidae	**0.00**		**0.05**		**0.04**		**0.00**		**0.00**		**0.00**	
Other	0.00	0.00	0.05	0.04	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Oculinidae	**0.00**		**0.00**		**0.06**		**0.00**		**0.00**		**0.05**	
Encrusting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04
Submassive	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Pectiniidae	**6.60**		**6.25**		**2.43**		**2.36**		**0.64**		**0.02**	
Encrusting	5.73	1.77	5.73	2.22	1.49	0.48	1.92	1.10	0.58	0.34	0.00	0.00
Foliose	0.40	0.32	0.52	0.23	0.95	0.29	0.10	0.05	0.06	0.06	0.02	0.02
Massive	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Submassive	0.45	0.45	0.00	0.00	0.00	0.00	0.34	0.34	0.00	0.00	0.00	0.00
Pocilloporidae	**0.00**		**0.00**		**0.00**		**0.01**		**0.00**		**0.00**	
Submassive	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Poritidae	**3.05**		**0.88**		**3.78**		**5.03**		**0.54**		**0.22**	
Branching	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Encrusting	0.03	0.02	0.00	0.00	0.58	0.28	0.00	0.00	0.28	0.28	0.00	0.00
Massive	3.02	0.98	0.77	0.56	3.11	2.04	5.03	1.95	0.26	0.09	0.21	0.10
Submassive	0.00	0.00	0.11	0.11	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Siderastreidae	**0.00**		**0.02**		**0.25**		**0.00**		**0.00**		**0.02**	
Encrusting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02

	CHI		WR1		WR2		SSI		NEW		MAN	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Submassive	0.00	0.00	0.02	0.02	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Growth Forms												
Branching	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Encrusting	7.88	2.23	3.72	0.48	1.93	0.28	7.20	2.24	2.06	1.05	1.29	0.73
Foliose	0.91	0.56	3.78	1.36	6.20	1.13	1.58	0.51	0.10	0.05	0.31	0.12
Massive	3.91	1.40	3.56	1.86	0.26	0.10	0.96	0.68	5.03	1.95	0.44	0.05
Solitary	0.15	0.11	0.02	0.01	0.02	0.02	2.27	1.66	0.16	0.04	0.19	0.19
Submassive	1.10	0.58	1.72	1.12	0.57	0.33	0.76	0.23	0.40	0.39	0.19	0.13
SOFT CORALS												
Leather	0.00	0.00	0.50	0.31	0.56	0.54	0.00	0.00	0.00	0.00	0.01	0.01
Tree Coral	0.05	0.04	0.51	0.14	0.64	0.28	2.25	0.59	1.11	0.52	1.98	0.33
Sea Whip	0.05	0.03	1.18	1.16	0.60	0.53	0.11	0.03	0.21	0.11	0.15	0.08
Other	0.03	0.02	0.05	0.02	0.03	0.03	0.20	0.13	0.11	0.11	0.15	0.07
ALGAE												
Encrusting	0.06	0.05	0.12	0.02	0.08	0.04	0.00	0.00	0.10	0.03	0.08	0.06
Macroalgae	2.07	0.88	0.24	0.10	0.29	0.14	6.46	2.91	0.86	0.33	2.71	0.43
Turf Algae	18.50	4.52	19.64	0.75	14.45	2.46	19.97	5.00	26.16	7.31	34.51	5.46
OTHER BIOTA												
Anemones	0.03	0.02	0.01	0.01	0.00	0.00	0.08	0.06	0.07	0.06	0.22	0.22
Ascidian	0.05	0.03	0.15	0.04	0.36	0.28	1.63	0.49	0.93	0.22	1.91	0.38
Bryozoa	0.04	0.02	0.09	0.02	0.03	0.02	0.09	0.02	0.11	0.03	0.48	0.12
Hydroids	0.15	0.08	0.26	0.14	0.15	0.10	0.85	0.25	0.32	0.25	4.96	1.97
Sponge	3.25	0.93	6.69	0.81	4.87	1.32	4.11	0.52	6.32	0.63	8.27	1.65
Tube Worm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.03
Molluscs Immobile	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Mucus Tubes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
SUBSTRATA												
Rock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Rubble	0.71	0.30	0.85	0.36	0.26	0.10	0.04	0.03	2.06	0.78	1.11	0.33
Sand/Silt	60.99	6.98	56.82	3.84	64.40	6.15	56.22	6.58	59.10	7.05	34.38	4.70

Appendix B-8 **Number of coral recruits (<20 mm) at different sites during Baseline, Dredging and Post-dredging Phase surveys. Blanks indicate sites not sampled**

Survey	CHI		WR1		WR2		SSI		NEW		CHP		MAN	
	Mean	SE	Mean	Mean	SE	Mean	Mean	SE	Mean	SE	Mean	SE	Mean	SE
B1	16.8	4.0	15.0	1.8	15.5	3.9	12.0	3.1	5.5	1.7	6.3	4.0	9.3	3.4
B2	11.8	3.8	11.8	3.6	10.8	1.4	7.0	1.8	2.3	0.9	0.8	0.3	6.5	0.6
B3	9.0	1.5	10.5	2.6	8.0	2.4	6.0	1.7	2.8	0.5	3.5	2.8	7.3	1.4
D1	11.0	2.0	14.3	4.6	11.3	3.0								
D2	16.3	4.3	6.8	6.1	4.0	2.6					1.5	0.9	6.8	1.8
D3	15.8	8.1	12.5	2.5	14.8	3.5	5.5	0.6	5.0	1.8				
D4	14.5	7.5	12.8	4.8	21.3	3.3	1.0	0.4	3.5	1.3				
D5	20.0	7.1	17.8	4.6	15.5	2.5	7.5	1.8	8.3	3.0				
D6	16.5	5.9	13.5	3.3	12.3	4.5	4.3	0.9	5.0	2.1	4.8	1.3	11.8	2.8
D7	15.0	5.1	9.5	2.1	12.8	4.3	1.8	1.1	4.8	2.1				
D8	8.3	2.5	10.8	3.9	16.0	4.1	2.8	0.9	2.8	0.6				
D9	9.0	1.7	12.0	2.4	17.5	5.7			4.8	1.5				
D10	7.8	2.2	6.8	1.3	13.3	3.7	2.3	0.5	5.0	1.3	1.8	1.0	16.3	4.1
D11	7.3	3.4	12.0	3.5	8.0	2.6	2.5	0.5	3.8	1.4				
D12	6.0	2.8	11.0	2.3	9.8	2.3								
D13	12.3	3.9	19.8	5.0	7.0	1.7	6.0	1.2	6.5	3.3				
P_{RS}	16.5	4.1	12.0	0.9	11.0	3.3	4.0	1.4	7.5	1.3				
P1	10.3	4.9	13.3	1.9	12.3	3.9	3.5	1.5	5.3	1.5			9.8	2.0
P2	9.5	2.1	17.8	4.3	10.0	3.3	5.0	0.7	3.3	0.8			12.3	3.4
P3	7.3	3.5	13.8	4.4	13.5	2.5	2.3	0.9	2.3	1.0			5.3	0.9

APPENDIX C

TAGGED CORALS CONDITION: SUPPLEMENTARY MATERIAL

Appendix C-1 Time series from survey B1 to P3 of tagged corals that have recorded between 95% and 100% mortality

a) CHI TAG 03

B1 Jun ’12

B2 Jul ’12

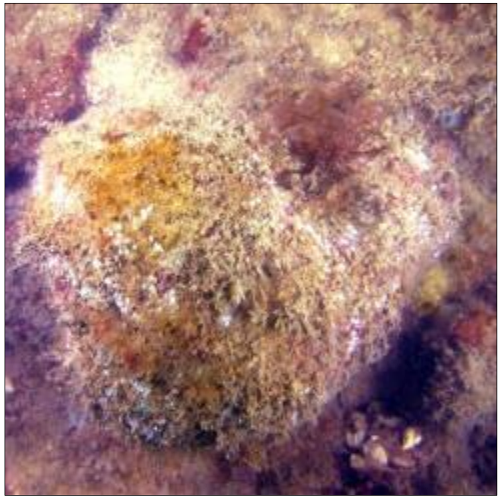
B3 Aug ’12

D1 Oct ’12

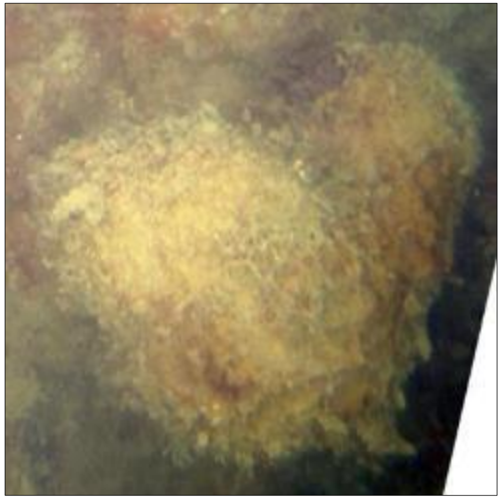
D2 Dec ’12

D3 Feb ’13

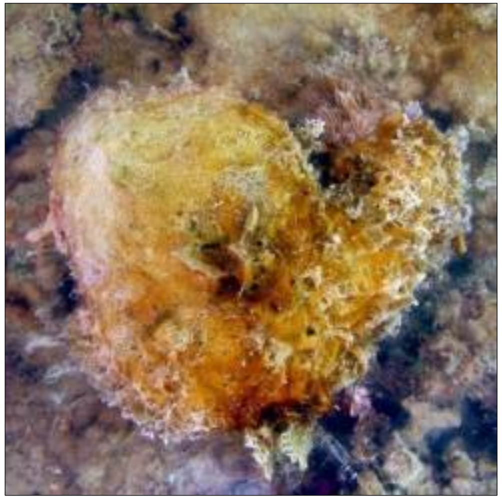
D4 Apr ’13



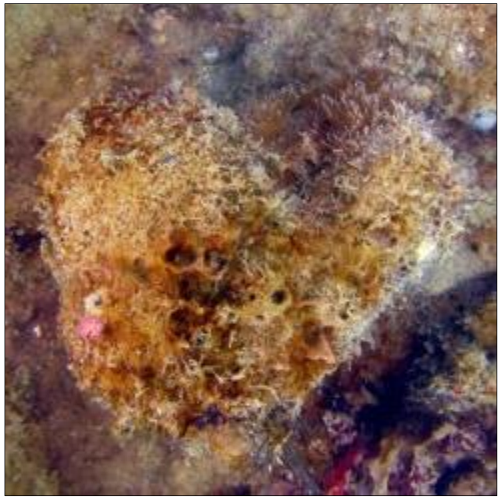
D5 Jun ’13



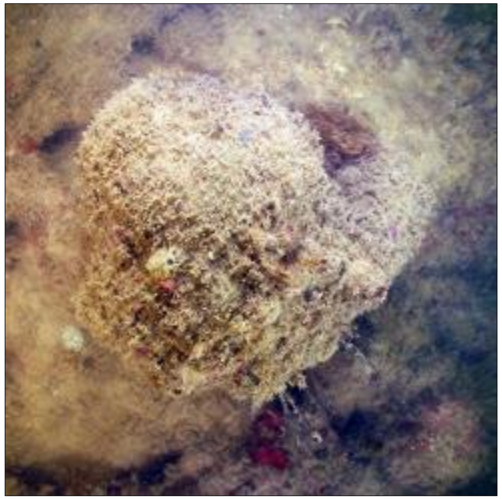
D6 Aug ’13



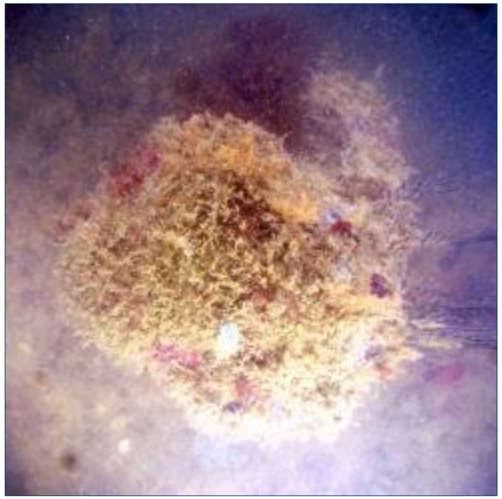
D7 Oct ’13



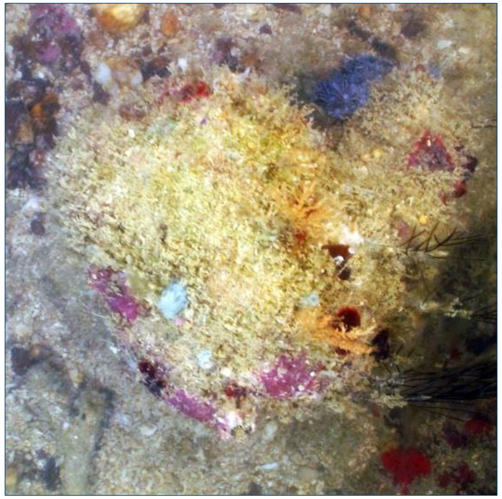
D8 Dec ’13



D9 Feb ’14

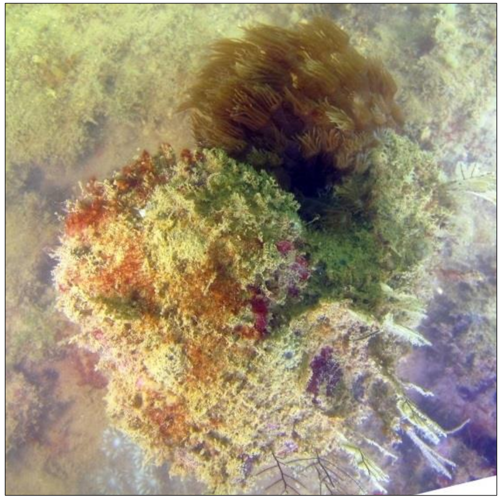


D10 Mar ’14

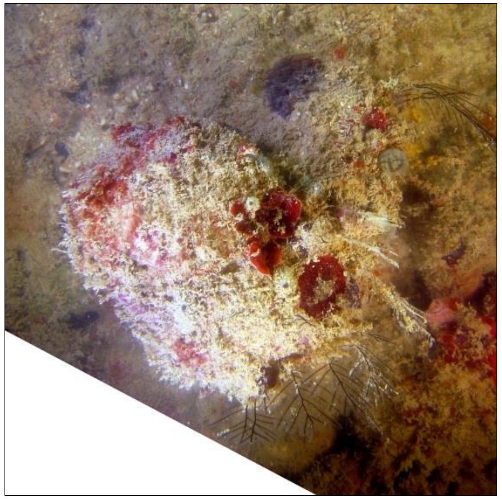


D11 Apr ’14

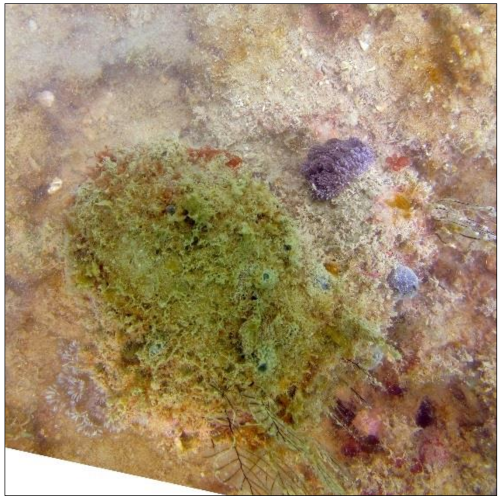
D12 May ’14



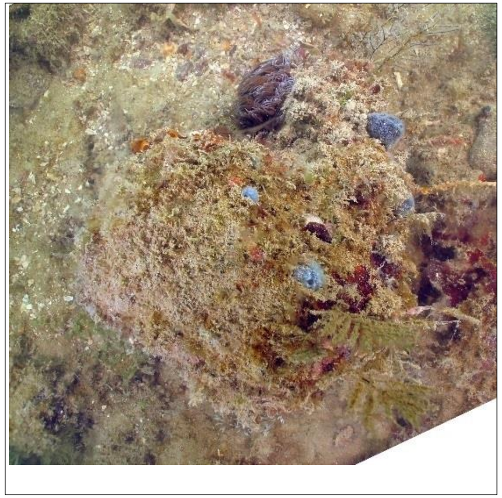
D13 Jun ’14



D14 Jul ’14

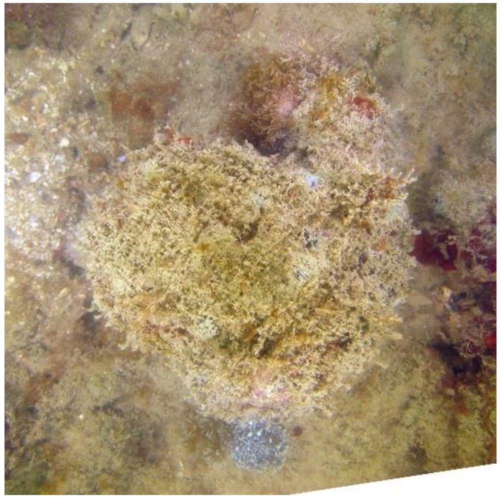


P1 Aug ’14



P2 Oct ’14

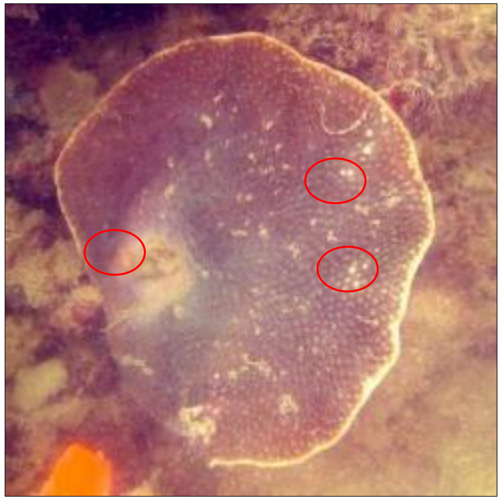
P3 Dec ’14



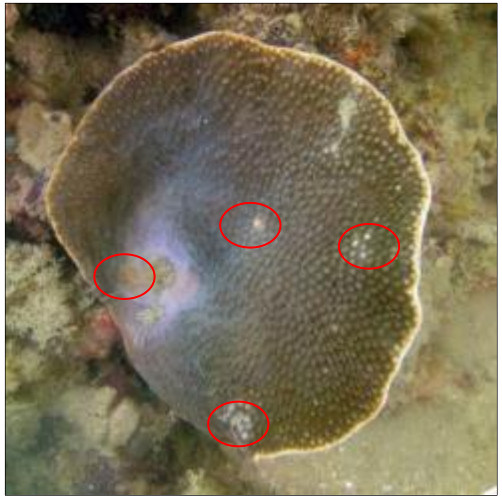
b) CHI TAG 08

B1 Jun ’12

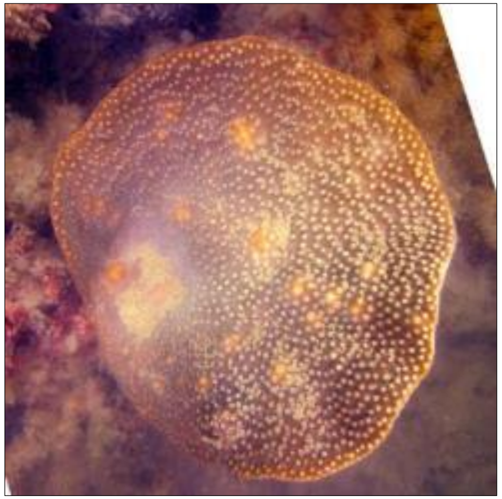
B2 Jul ’12



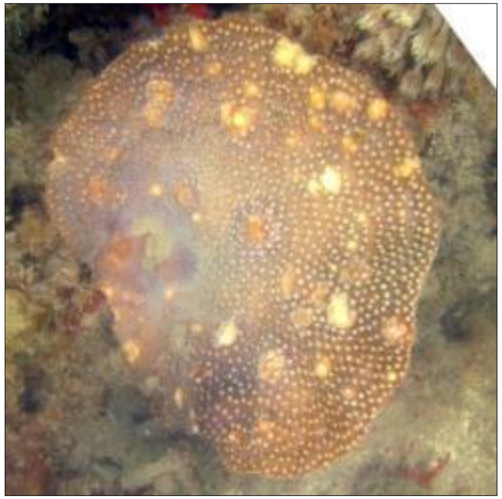
B3 Aug ’12



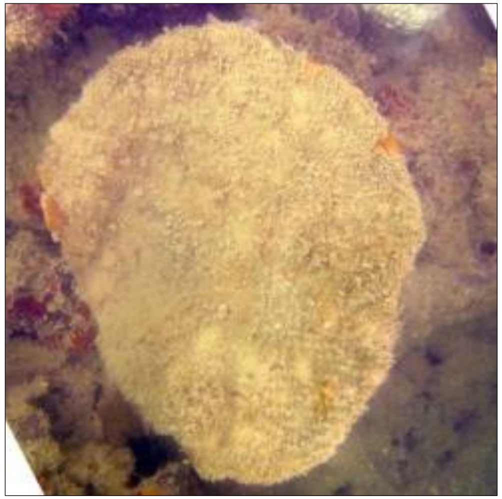
D1 Oct ’12



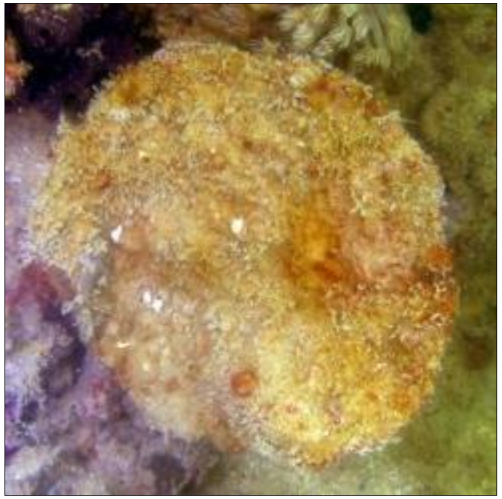
D2 Dec ’12



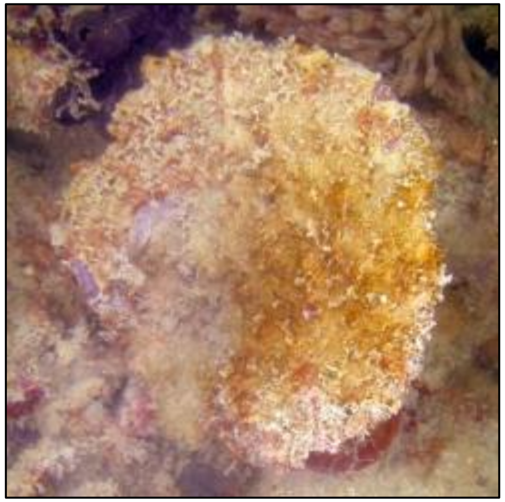
D3 Feb ’13



D4 Apr ’13

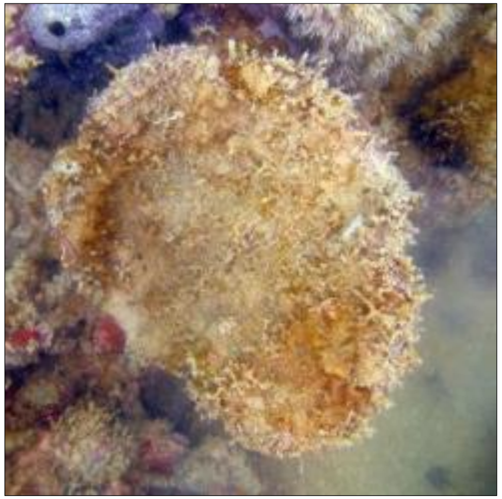


D5 Jun ’13

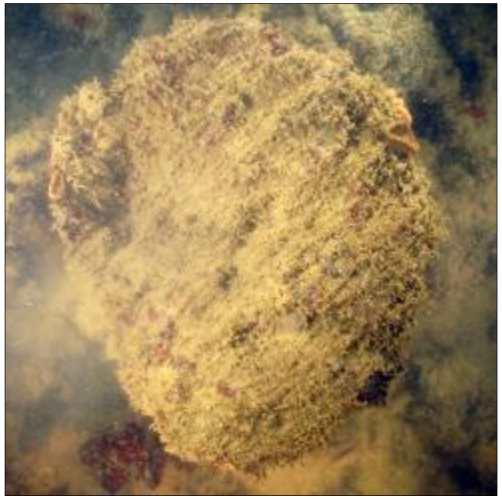


D6 Aug ’13

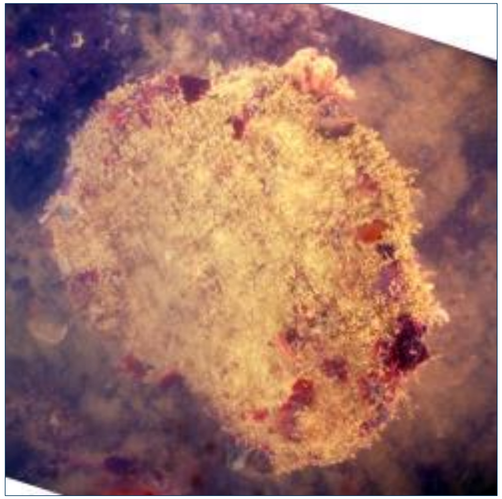
D7 Oct ’13



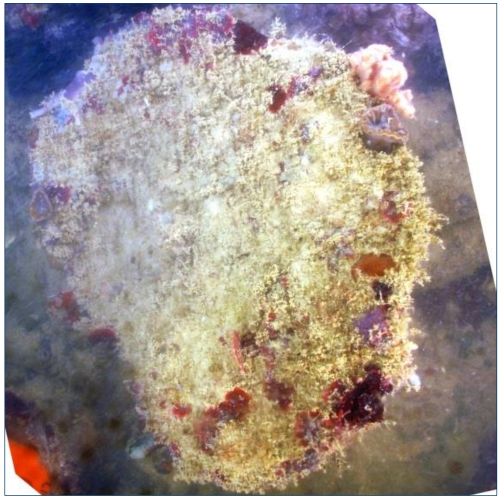
D8 Dec ’13



D9 Feb ’14

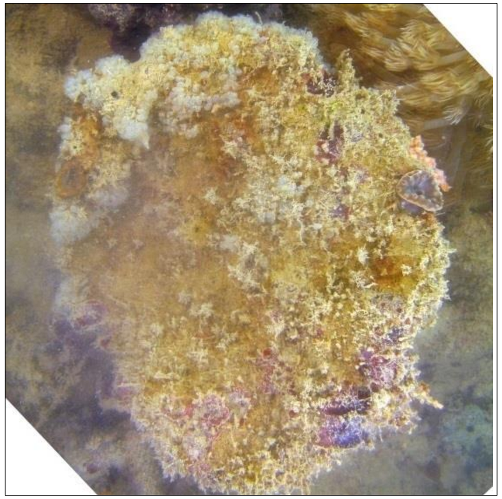


D10 Mar ’14

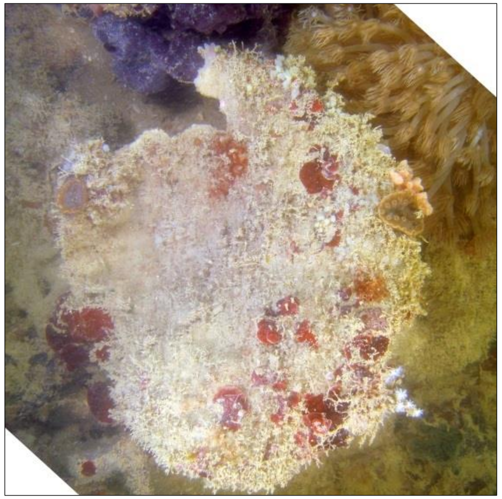


D11 Apr ’14

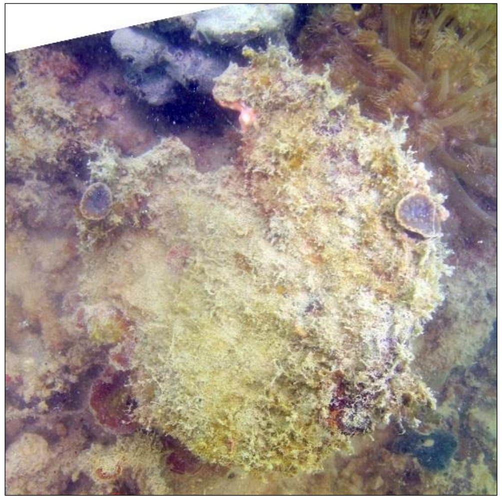
D12 May ’14



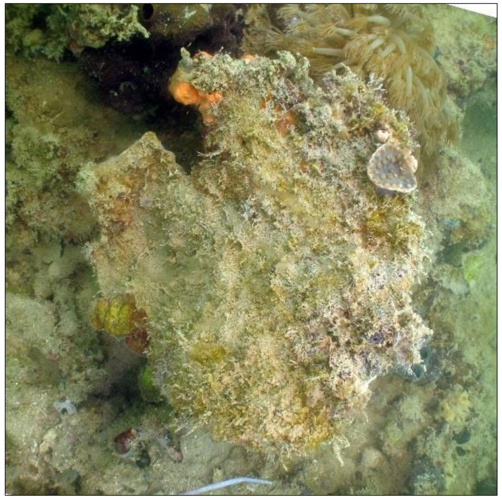
D13 Jun’ 14



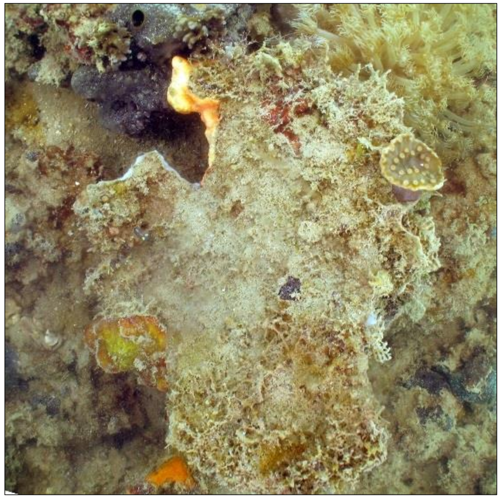
D14 Jul ’14



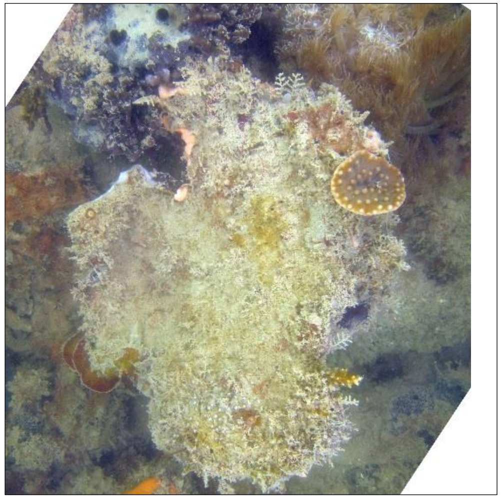
P1 Aug ’14



P2 Oct ’14



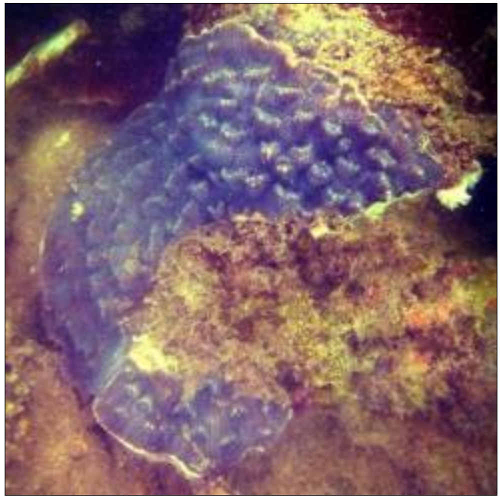
P3 Dec ’14



c) CHI TAG 10

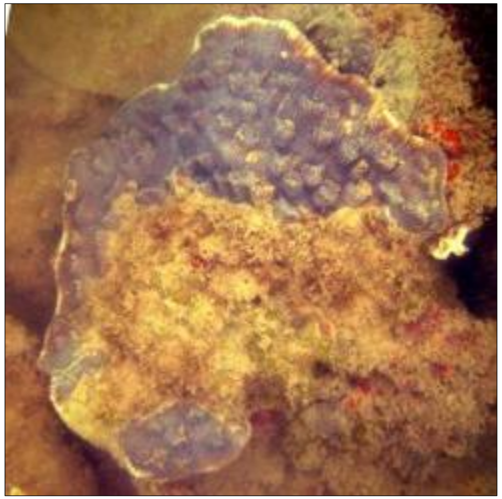
B1 Jun '12

B2 Jul '12



B3 Aug '12

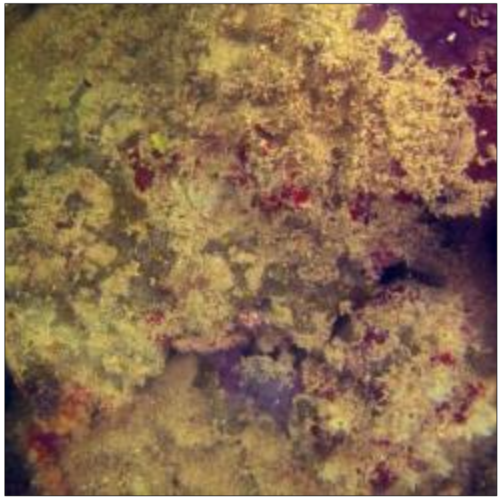
D1 Oct '12



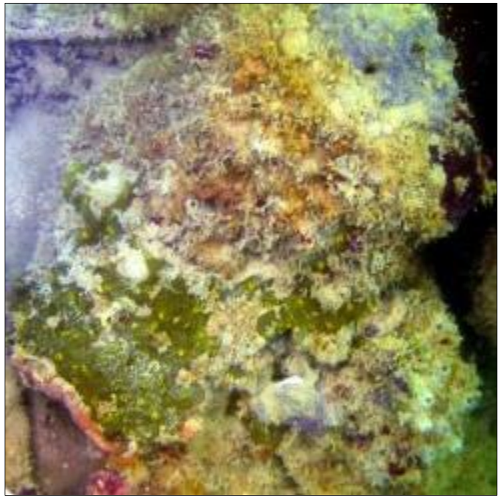
D2 Dec '12

NO PHOTO

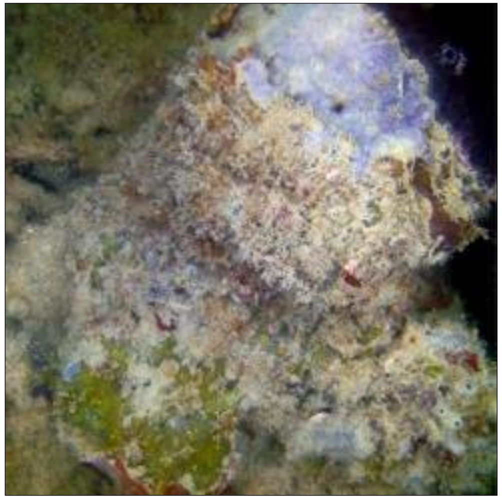
D3 Feb '13



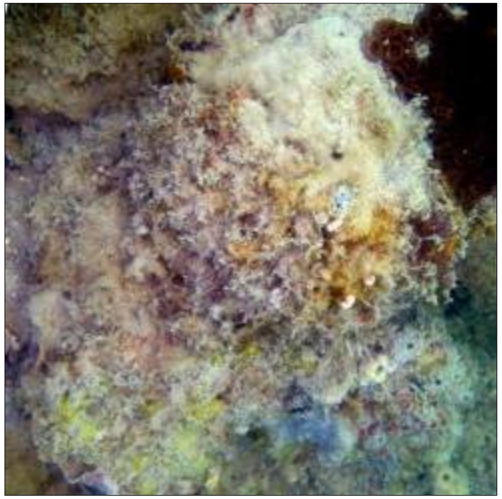
D4 Apr ’13



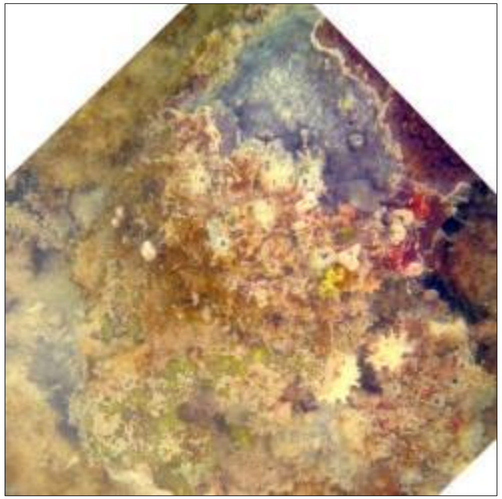
D5 Jun ’13



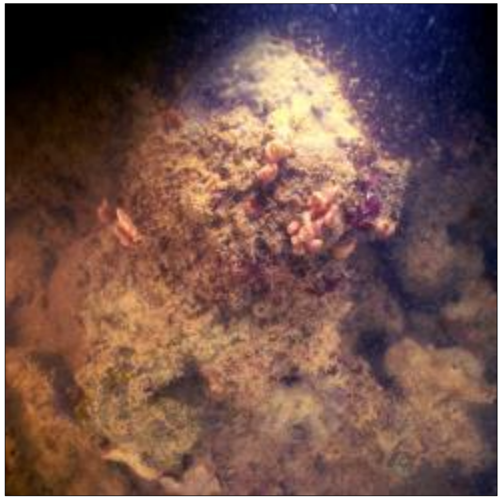
D6 Aug ’13



D7 Oct ’13



D8 Dec ’13

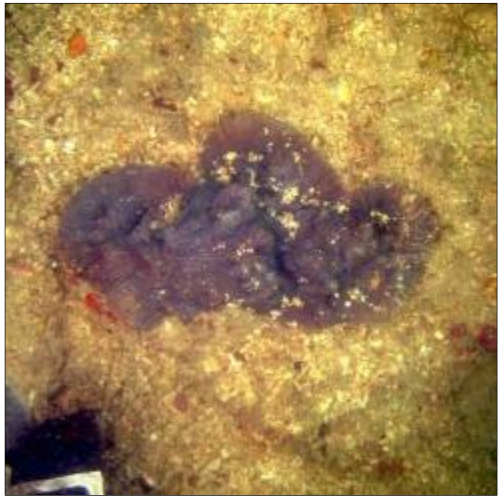


D9 Feb ’14

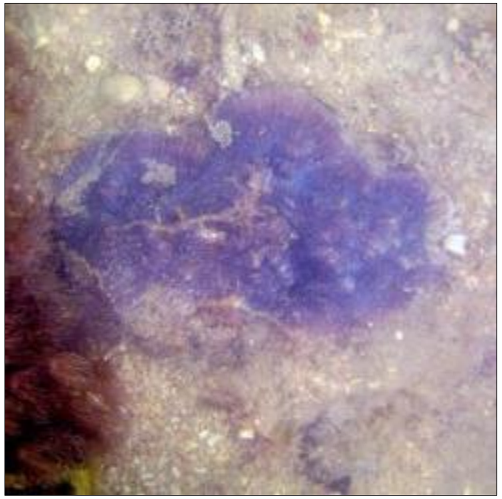
Entire Colony Mortality
(No photograph taken)

d) CHI TAG 31

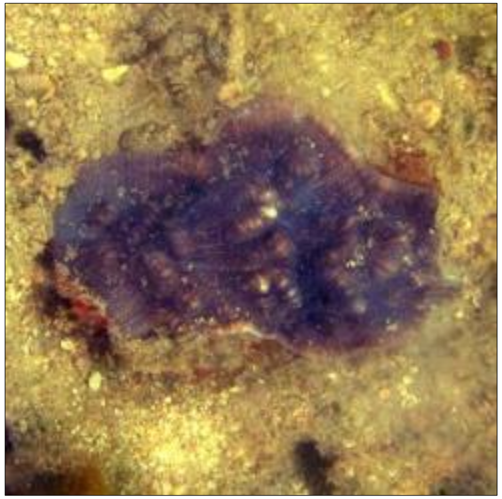
B1 Jun ’12



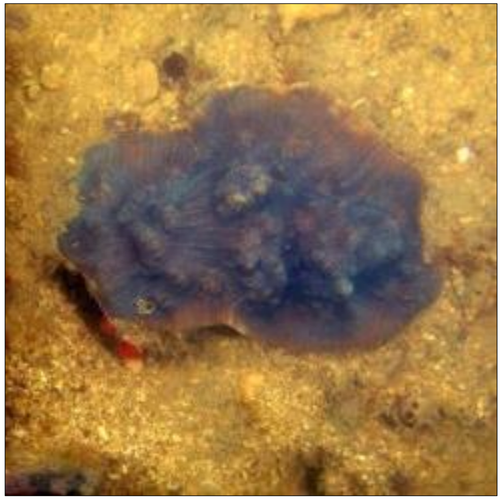
B2 Jul ’12



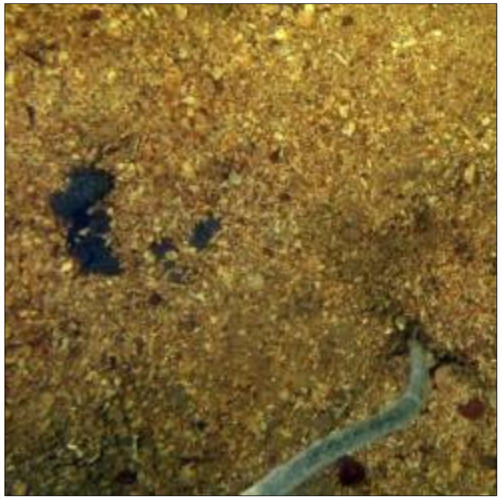
B3 Aug ’12



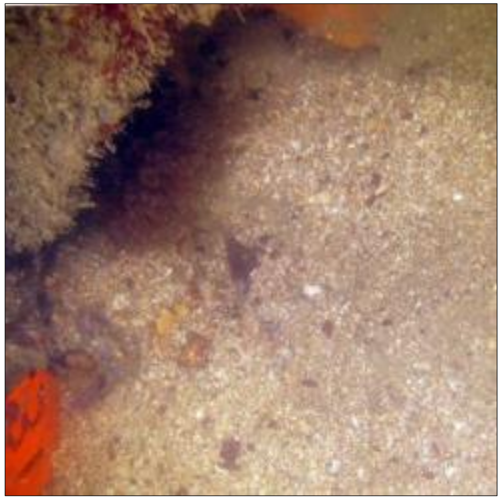
D1 Oct ’12



D2 Dec ’12



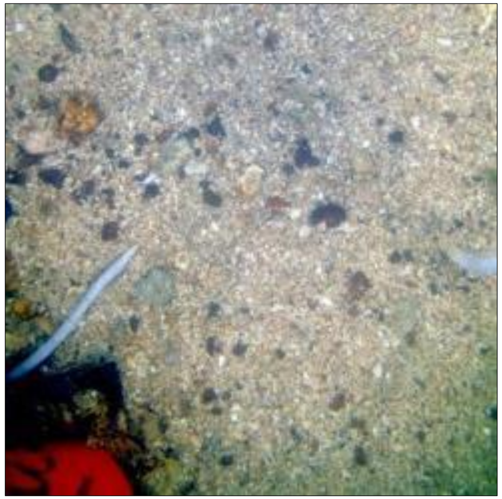
D3 Feb ’13



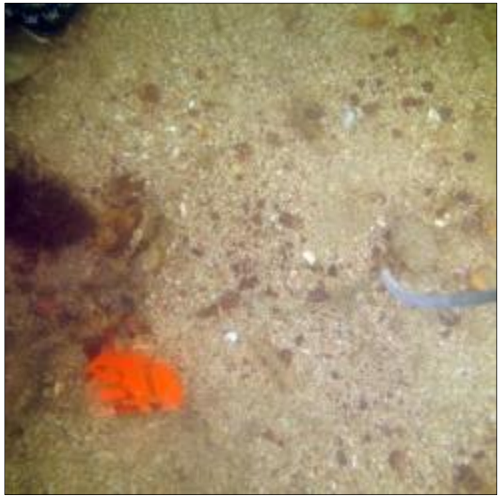
D4 Apr ’13

NO PHOTO

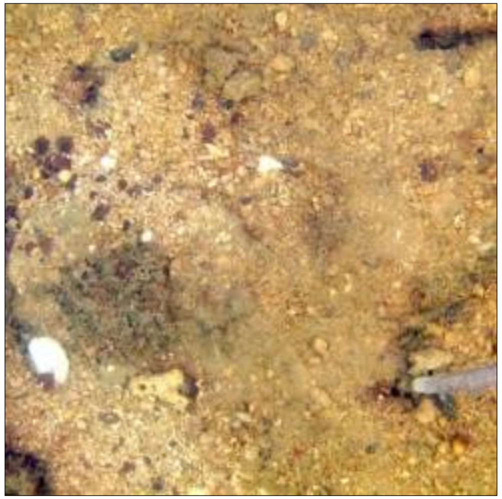
D5 Jun ’13



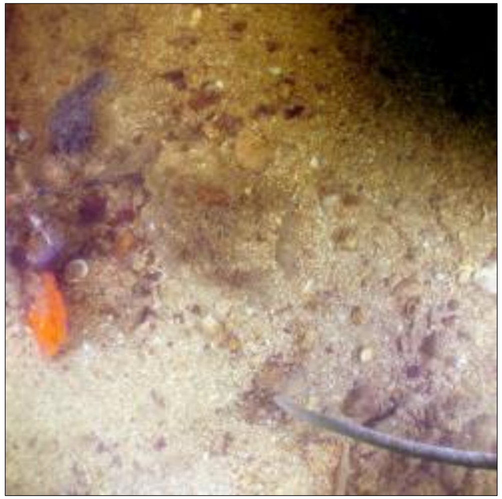
D6 Aug ’13



D7 Oct ’13



D8 Dec ’13



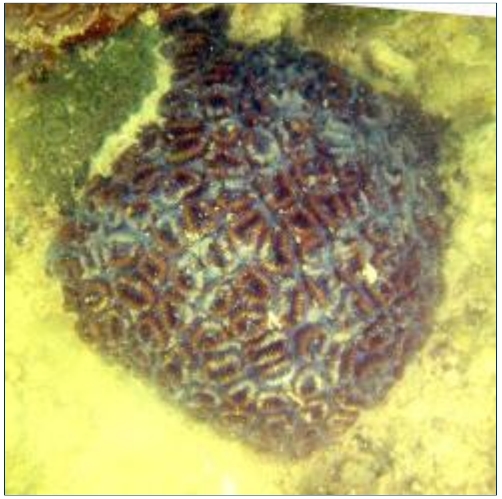
D9 Feb ’14

Entire Colony Mortality
(No photograph taken)

e) CHI TAG 61

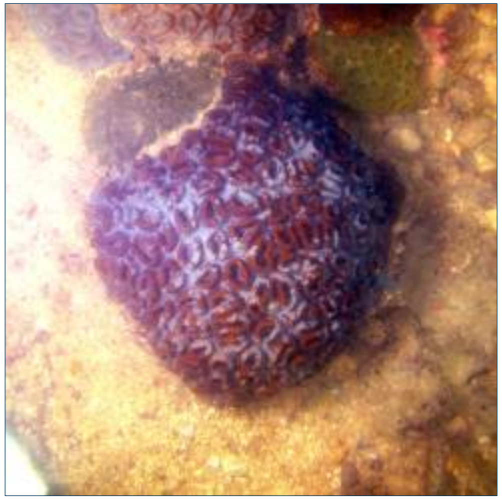
B1 Jun ’12

B2 Jul ’12

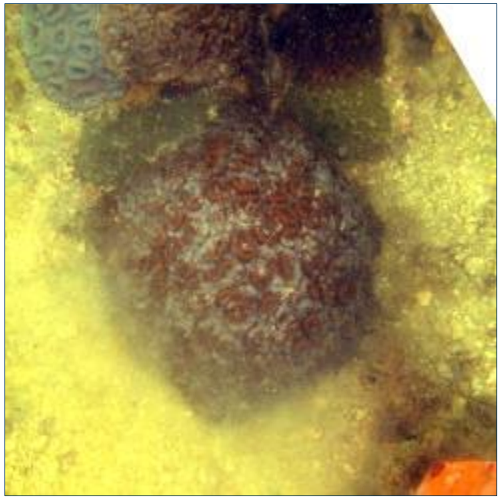


B3 Aug ’12

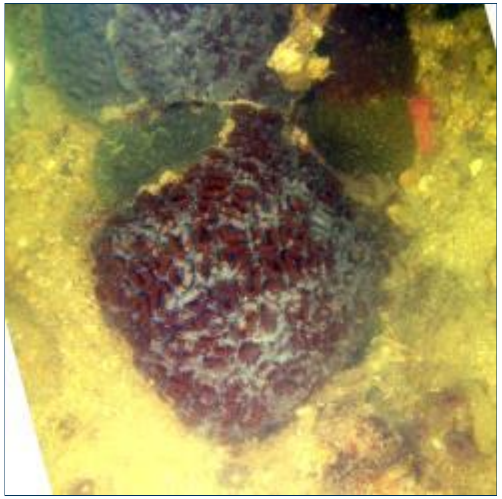
D1 Oct ’12



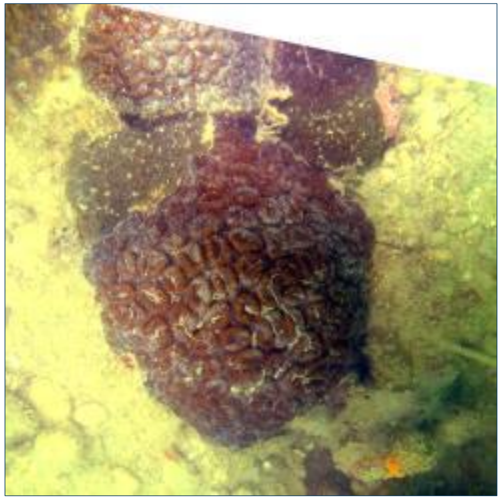
D2 Dec ’12



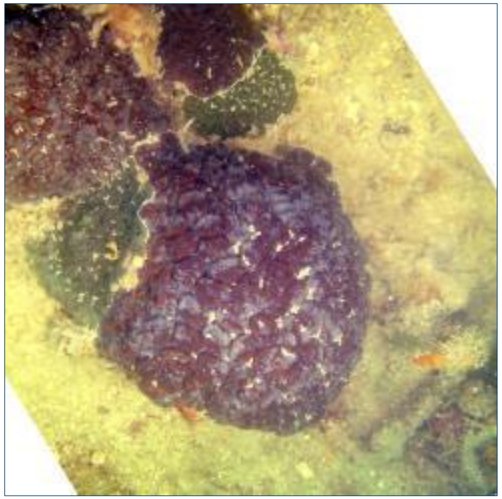
D3 Feb ’13



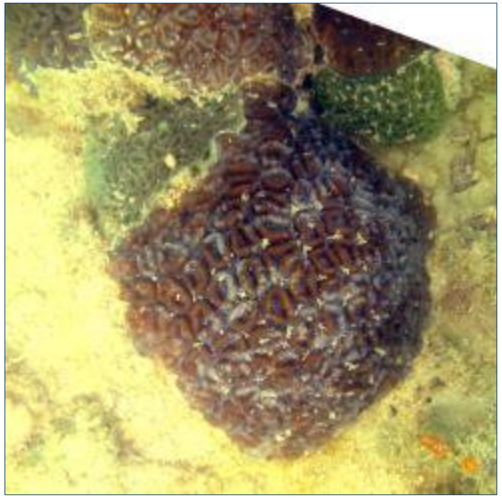
D4 Apr ’13



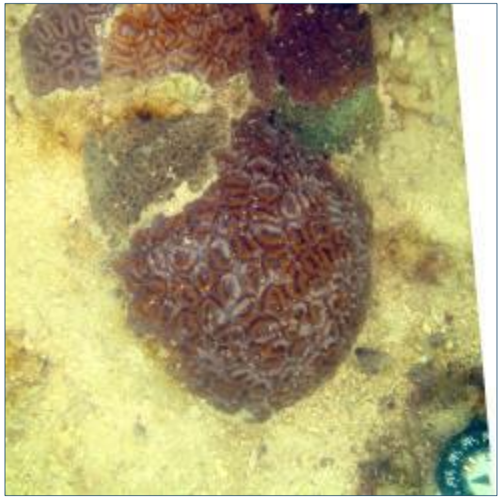
D5 Jun ’13



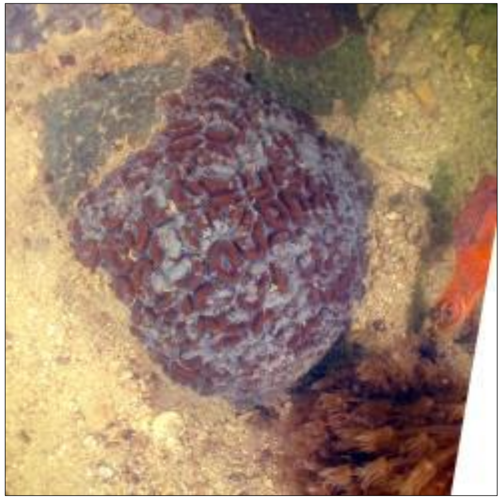
D6 Aug ’13



D7 Oct ’13



D8 Dec ’13



D9 Feb ’14

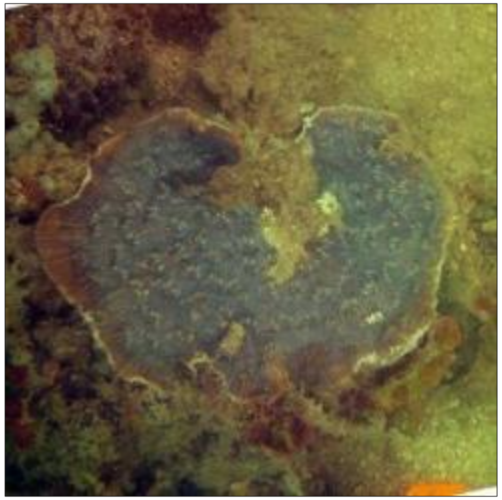
D10 Mar’14

D11 Apr ’14

Entire Colony Mortality
(No photograph taken)

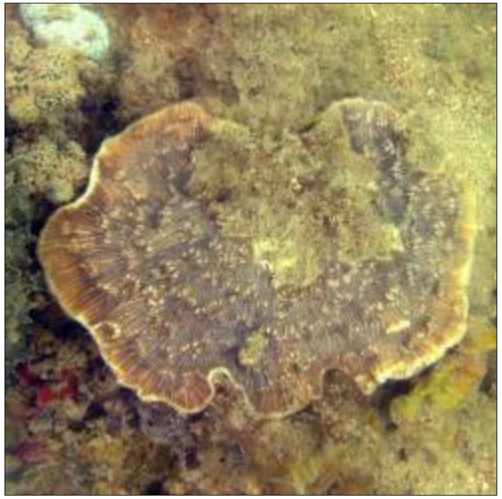
f) CHI TAG 64

B1 Jun ’12



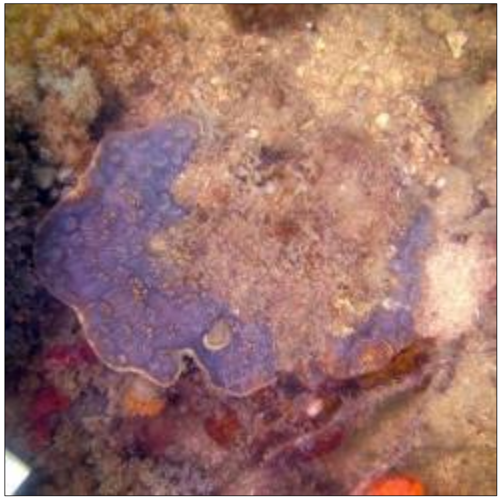
B2 Jul ’12

B3 Aug ’12

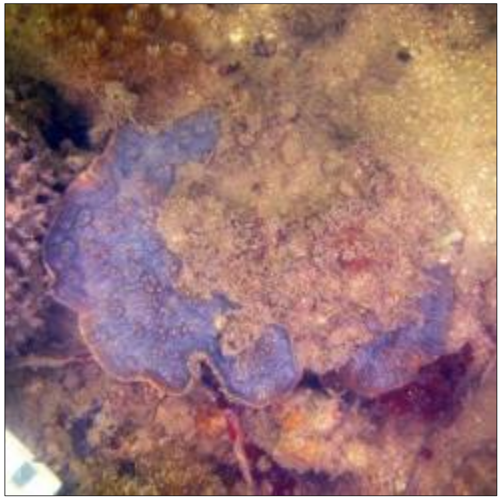


D1 Oct ’12

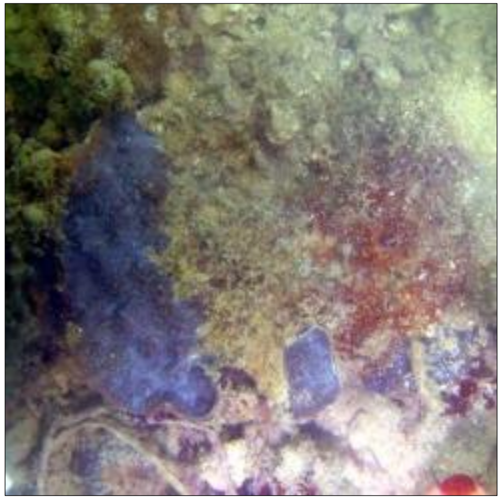
D2 Dec ’12



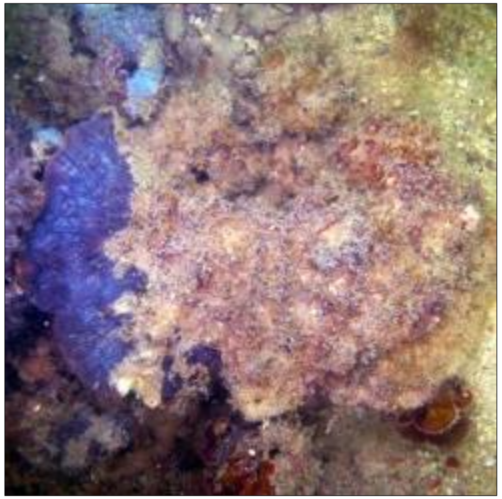
D3 Feb ’13



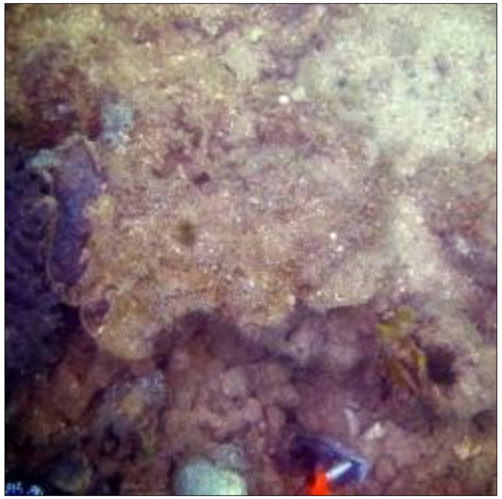
D4 Apr ’13



D5 Jun ’13



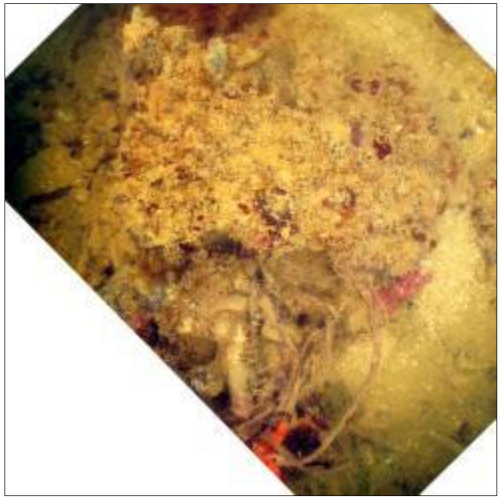
D6 Aug ’13



D7 Oct ’13

D8 Dec ’13

D9 Feb ’14



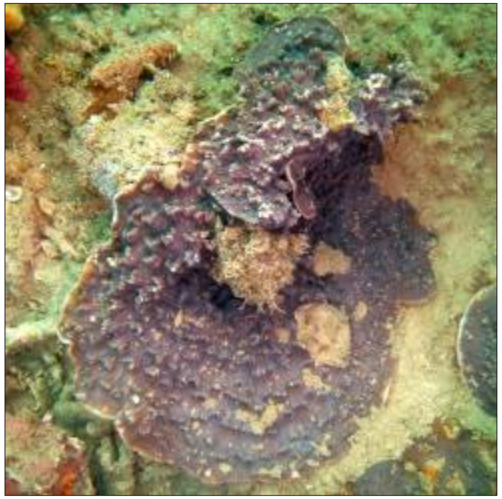
D10 Mar ’14

D11 Apr ’14

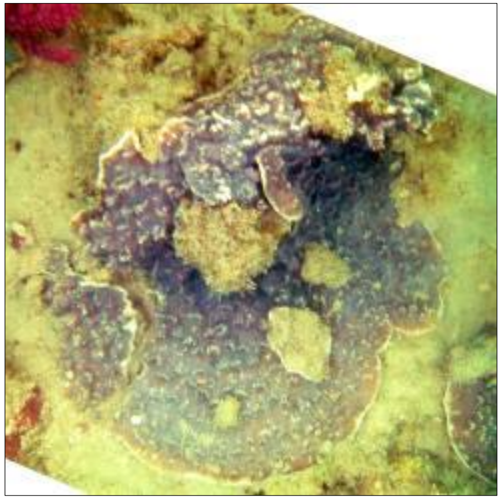
Entire Colony Mortality
(No photograph taken)

g) WR1 TAG 62

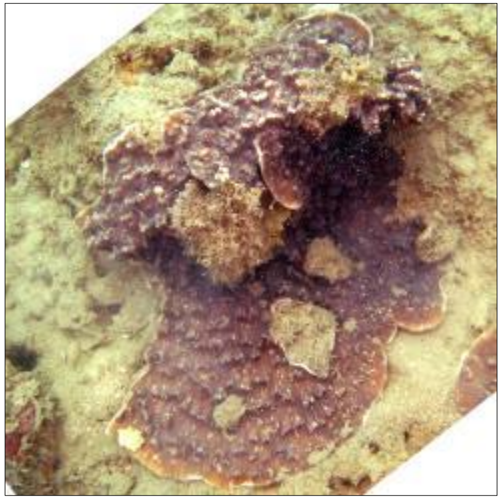
B1 Jun ’12



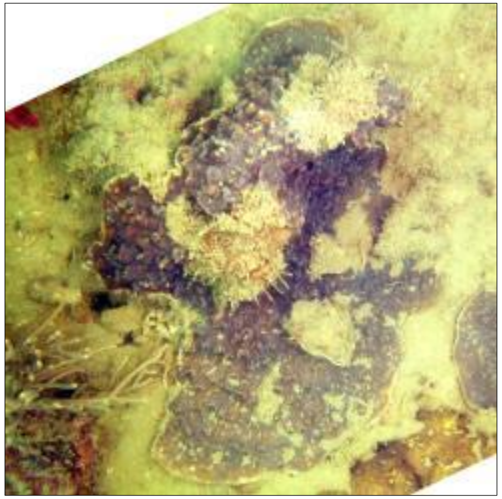
B2 Jul ’12



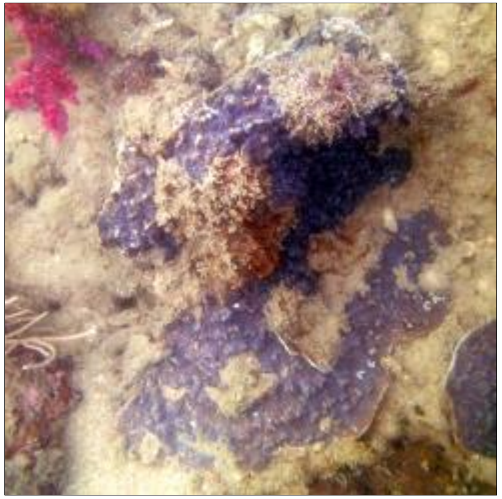
B3 Aug ’12



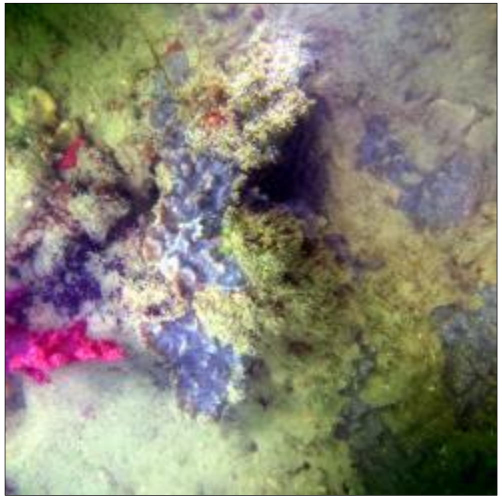
D1 Oct ’12



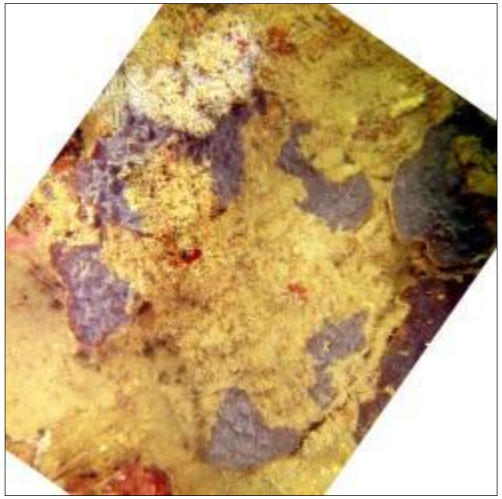
D2 Dec ’12



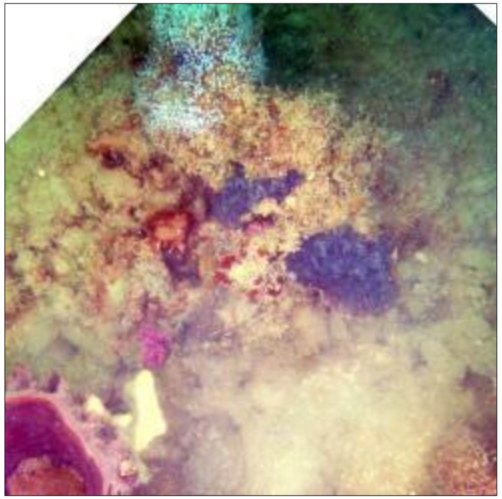
D3 Feb ’13



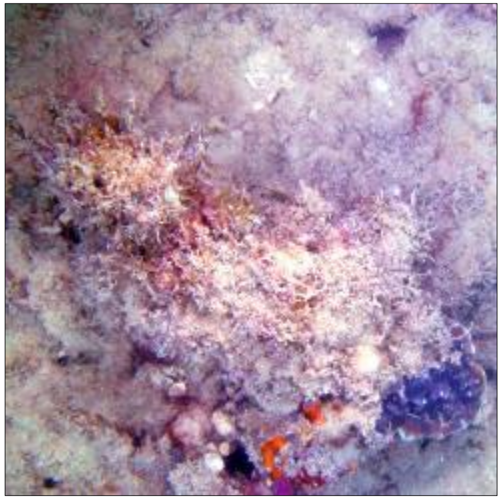
D4 Apr '13



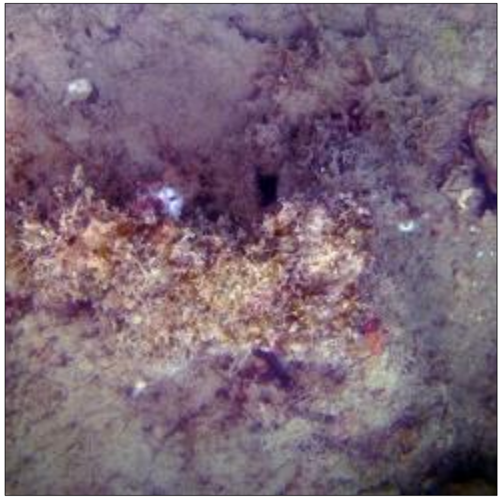
D5 Jun '13



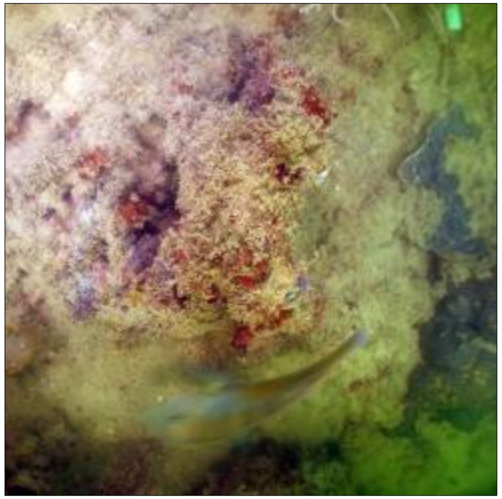
D6 Aug '13



D7 Oct '13



D8 Dec '13



D9 Feb '14

Entire Colony Mortality
(No photograph taken)

h) WR1 TAG 74

B1 Jun ’12

B2 Jul ’12

B3 Aug ’12

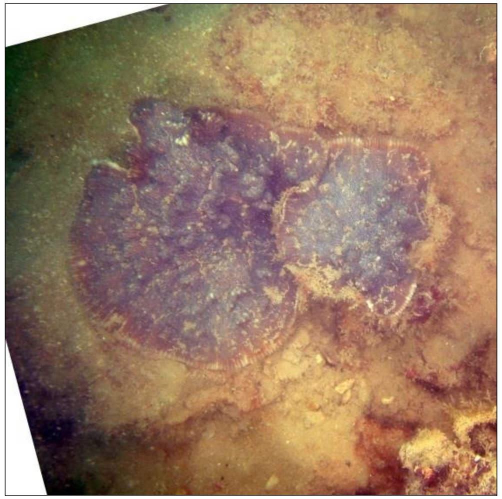
D1 Oct ’12

D2 Dec ’12

D3 Feb ’13

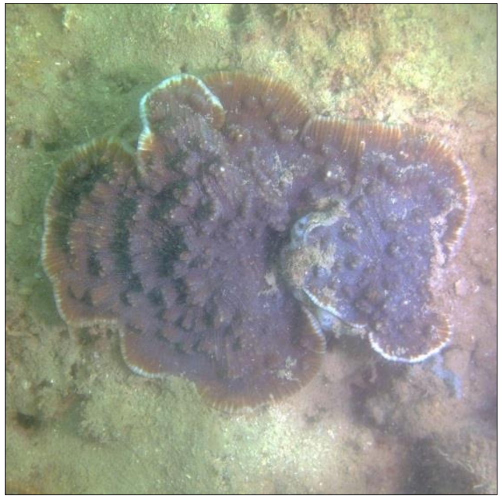
D4 Apr ’13

D5 Jun ’13



D6 Aug ’13

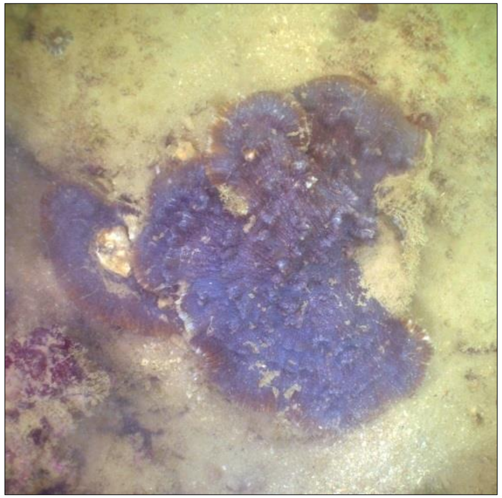
D7 Oct ’13



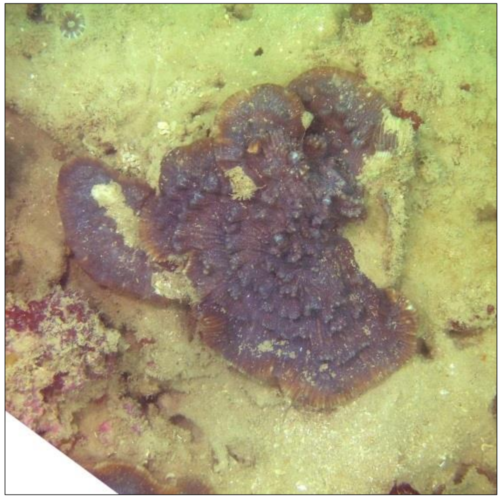
D8 Dec ’13

D9 Feb ’14

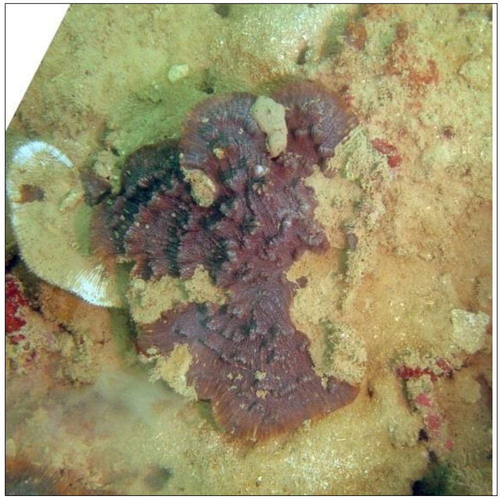
D10 Mar ’14



D11 Apr ’14



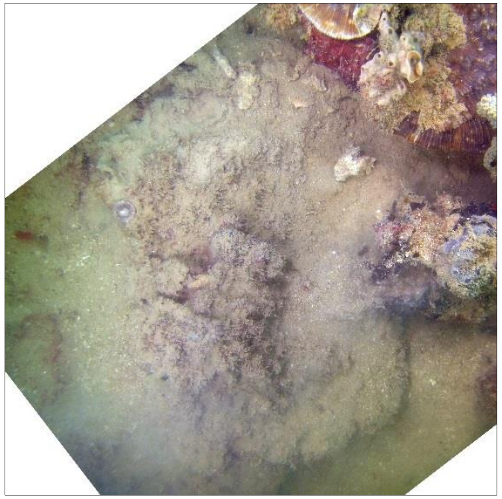
D12 May ’14



D13 Jun ’14

D14 Jul ’14

P1 Aug ‘14



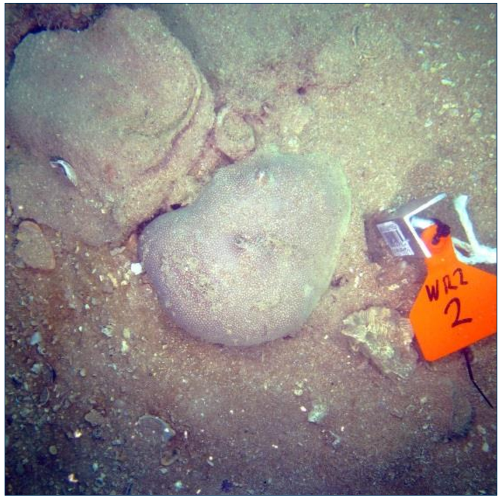
P2 Oct ’14

P3 Dec ‘14

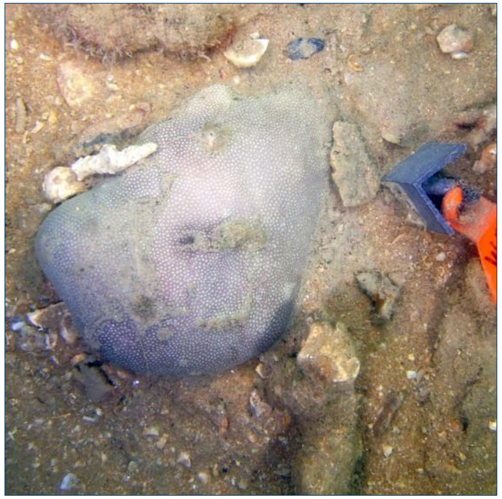
Entire Colony Mortality
(No photograph taken)

i) WR2 TAG 02

B1 Jun ’12



B2 Jul ’12



B3 Aug ’12


D1 Oct ’12


D2 Dec ’12


D3 Feb ’13


D4 Apr ’13


D5 Jun ’13


D6 Aug ’13

D7 Oct ’13

D8 Dec ’13

D9 Feb ’14

D10 Mar ’14

D11 Apr ’14

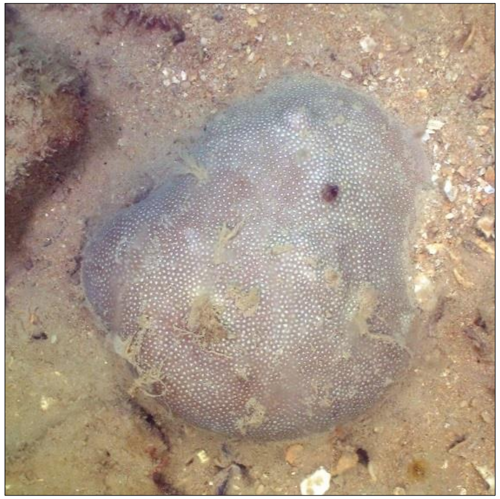
D12 May ’14

D13 Jun '14

D14 Jul '14

P1 Aug '14

P2 Oct '14

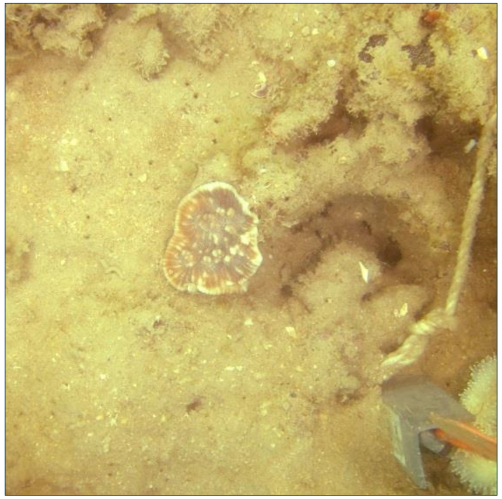


P3 Dec '14

j) WR2 TAG 10

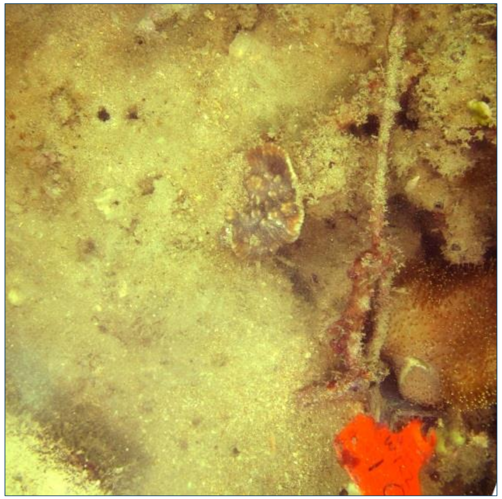
B1 Jun ’12

B2 Jul ’12

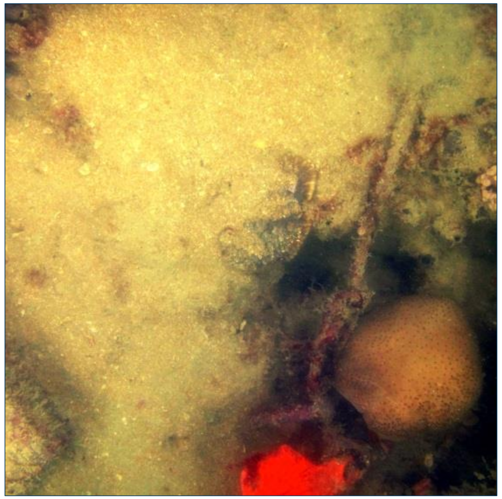


B3 Aug ’12

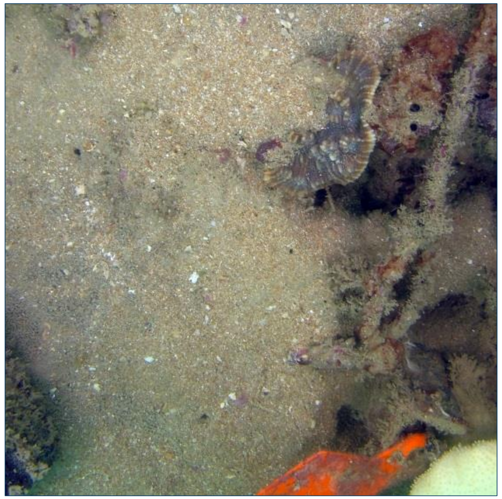
D1 Oct ’12



D2 Dec ’12

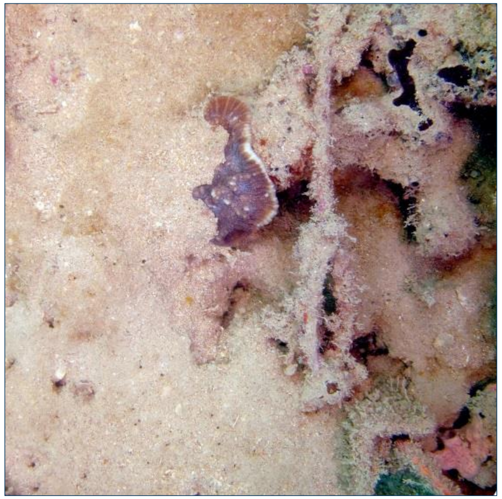


D3 Feb ’13



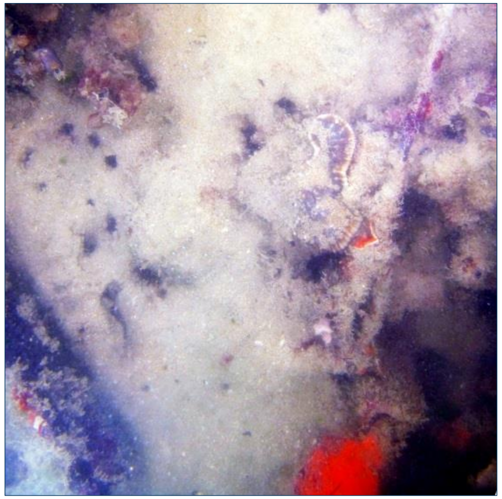
D4 Apr ’13

D5 Jun ’13



D6 Aug ’13

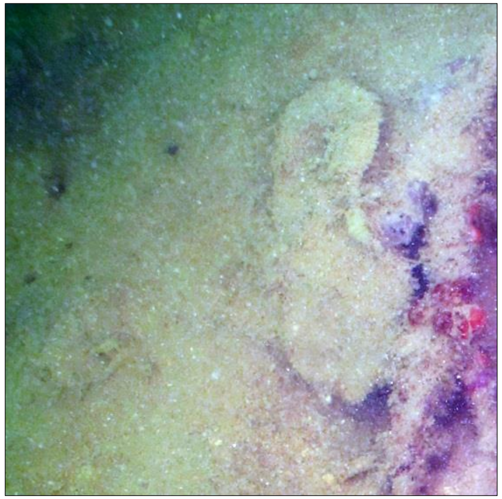
D7 Oc t’13



D8 Dec ’13

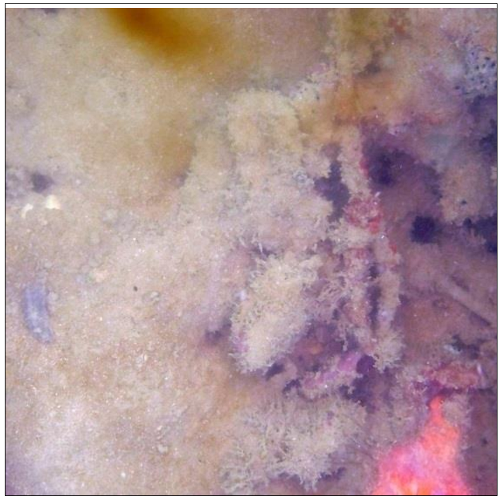
D9 Feb ’14

D10 Mar ’14

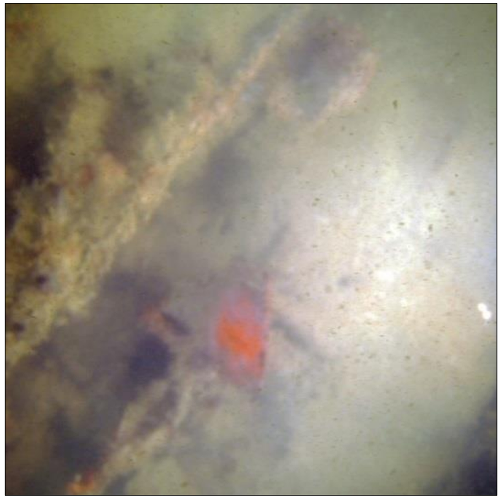


D11 Apr ’14

D12 May ’14

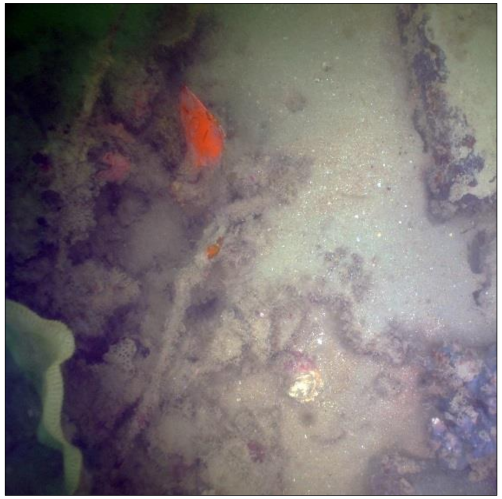


D13 Jun’14



D14 Jul ‘14

P1 Aug ‘14



P2 Oct ‘14

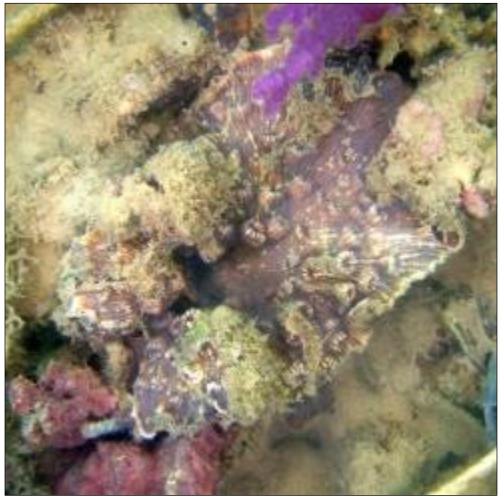
P3 Dec ‘14

Entire Colony Sediment Burial
(No photograph taken)

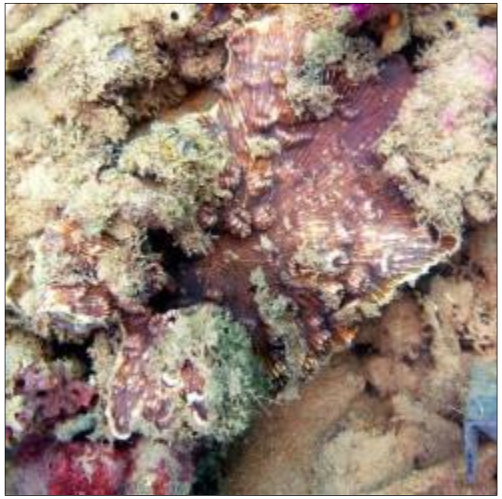
k) WR2 TAG 20

B1 Jun ’12

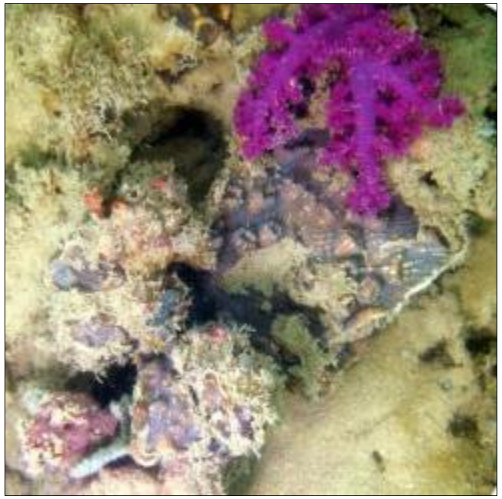
B2 Jul ’12



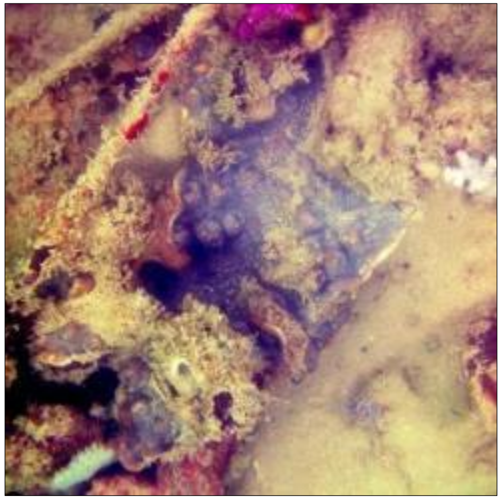
B3 Aug ’12



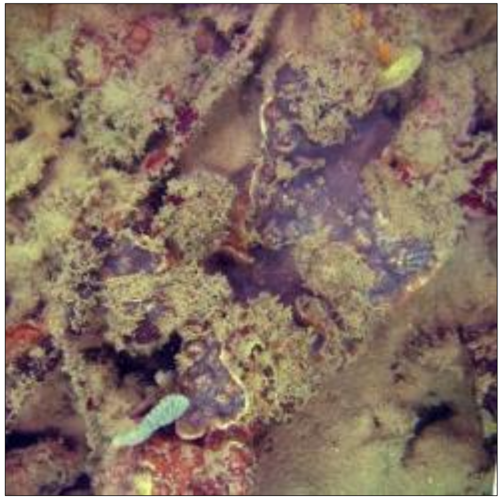
D1 Oct ’12



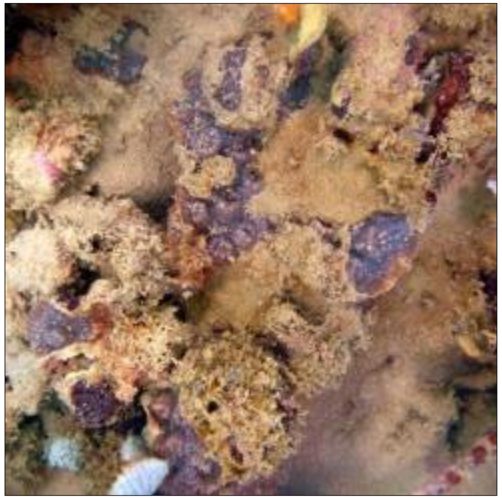
D2 Dec ’12



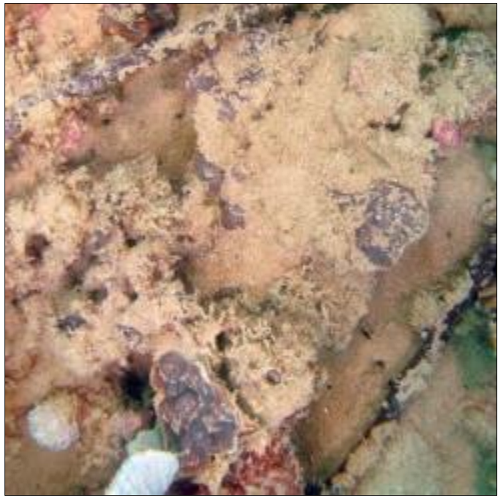
D3 Feb ’13



D4 Apr ’13

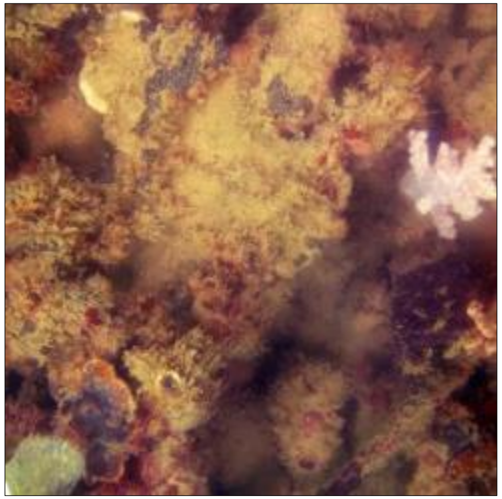


D5 Jun ’13

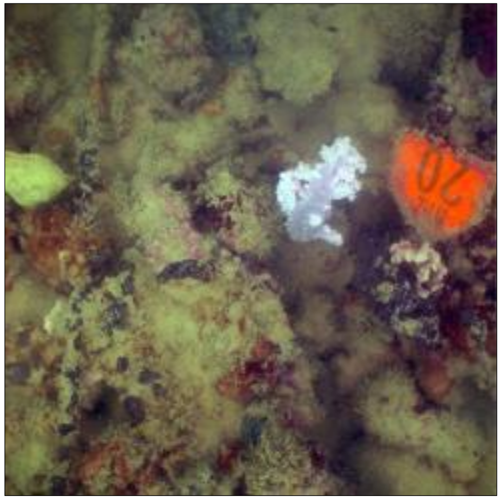


D6 Aug ’13

D7 Oct ’13



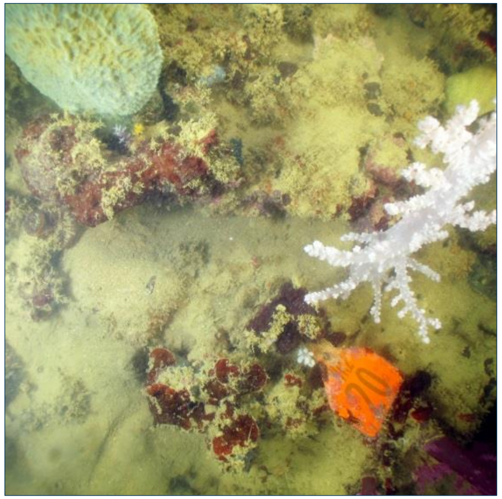
D8 Dec ’13



D9 Feb ’14

D10 Mar ’14

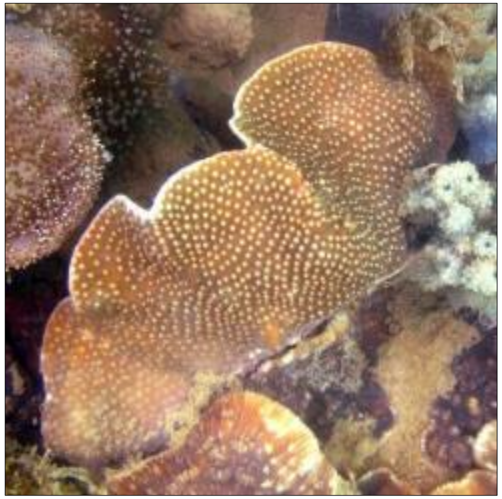
D11 Apr ’14

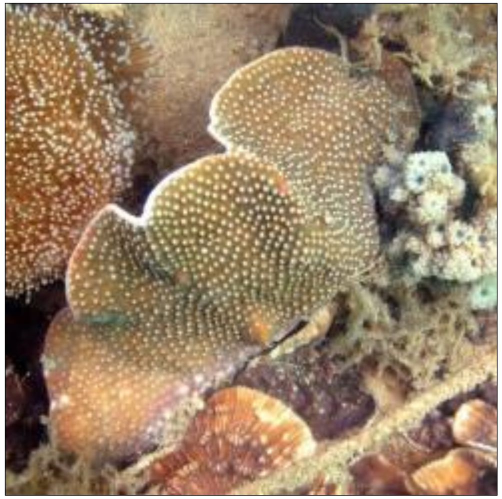


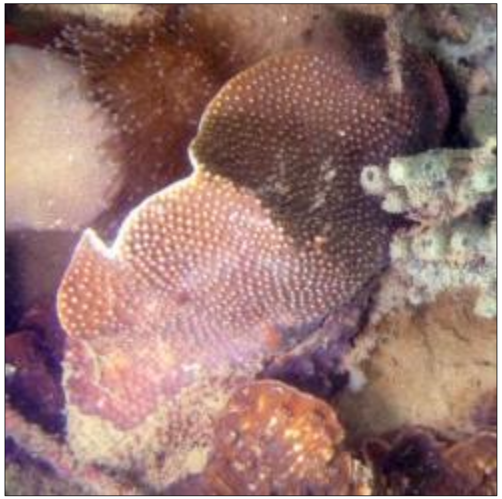
Entire Colony Mortality
(No photograph taken)

I) WR2 TAG 26


B1 Jun ’12


B2 Jul ’12


B3 Aug ’12


D1 Oct ’12

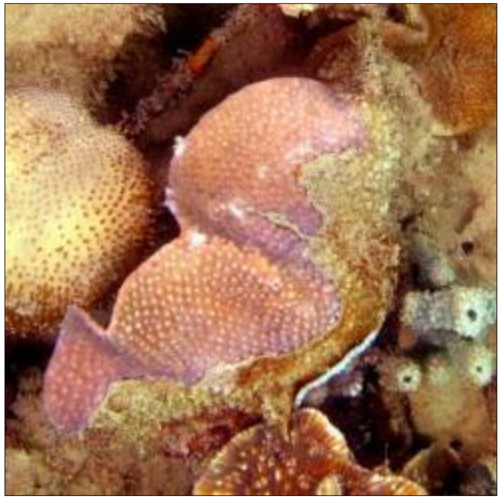

D2 Dec ’12


D3 Feb ’13

D4 Apr ’13

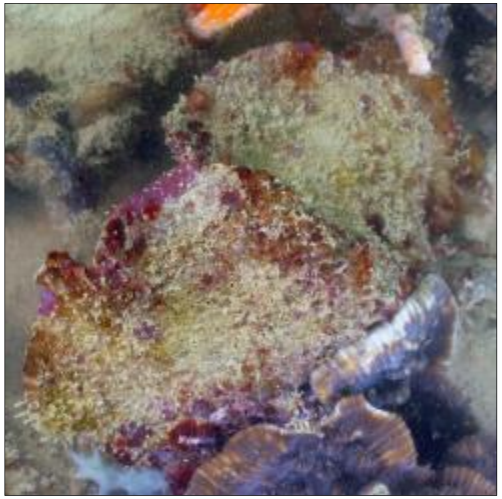
D5 Jun ’13

D6 Aug ’13

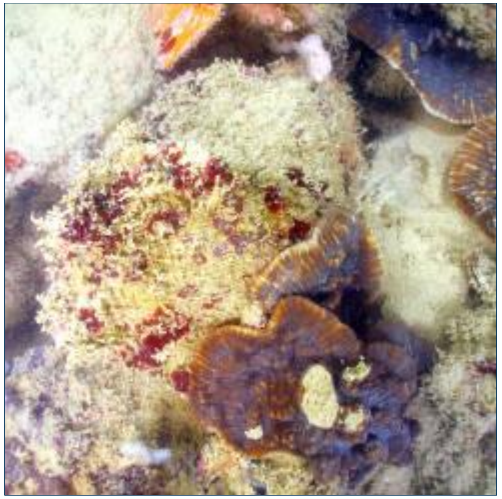


D7 Oct ’13

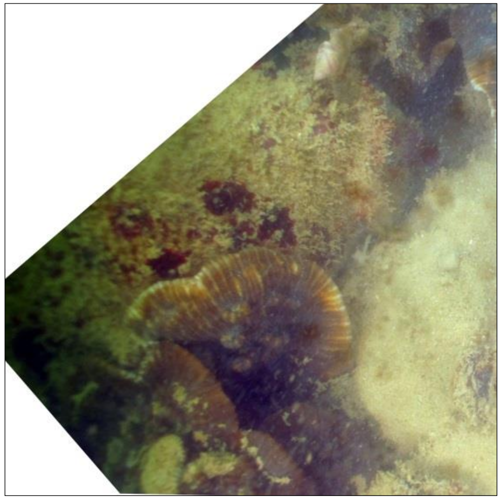
D8 Dec ’13



D9 Feb ’14



D10 Mar ’14

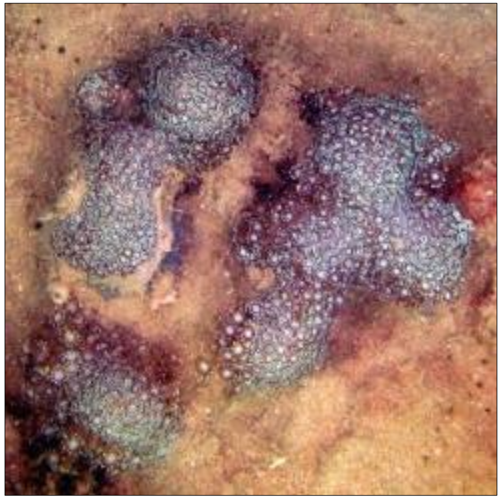


D11 Apr ’14

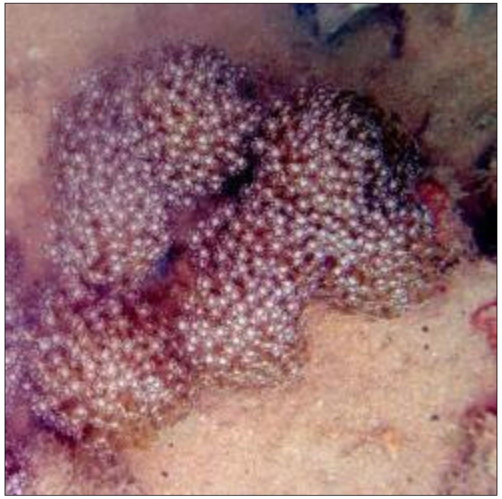
Entire Colony Mortality
(No photograph taken)

m) WR2 TAG 45

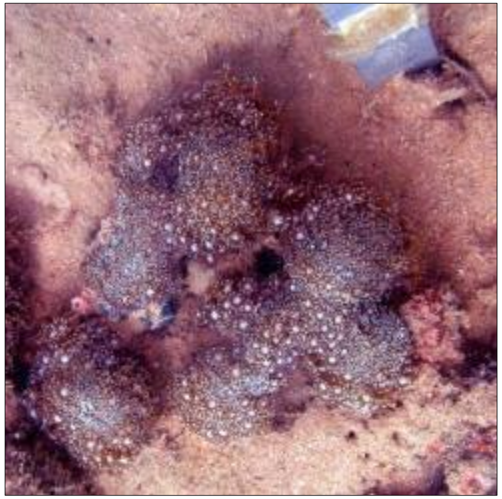
B1 Jun ’12



B2 Jul ’12

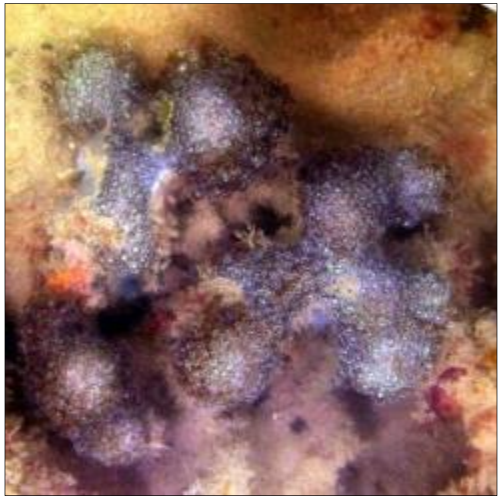


B3 Aug ’12



D1 Oct ’12

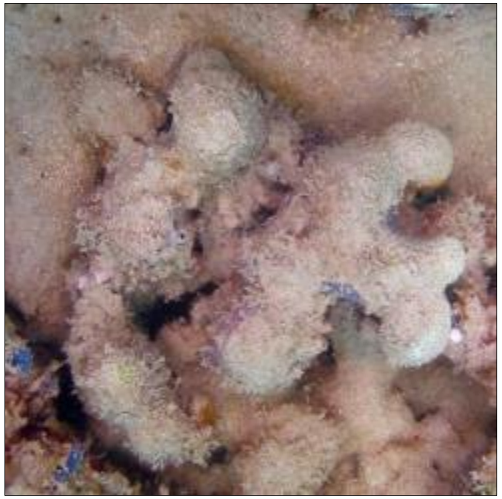
D2 Dec ’12



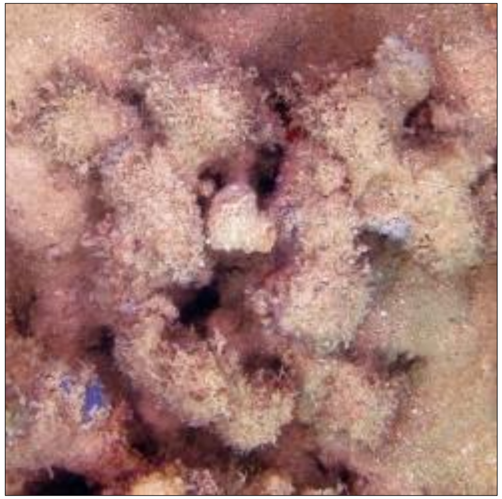
D3 Feb ’13

D4 Apr ’13

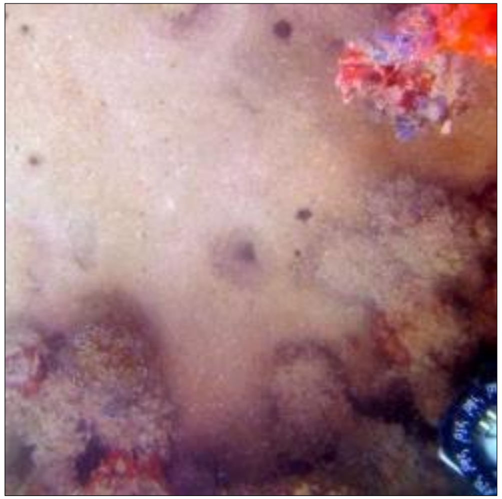
D5 Jun ’13



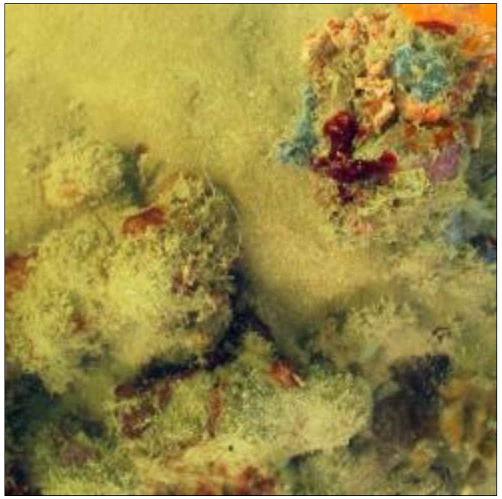
D6 Aug ’13



D7 Oct ’13



D8 Dec ’13

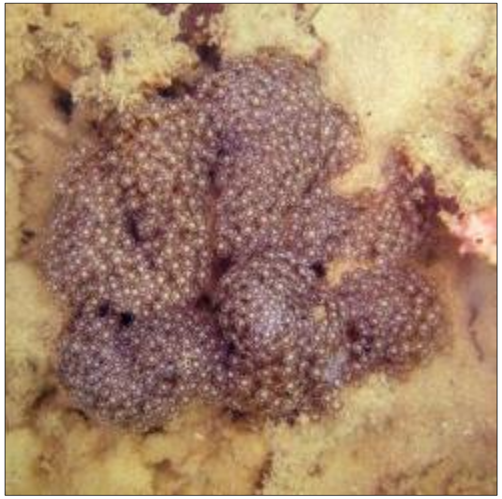


D9 Feb ’14

Entire Colony Mortality
(No photograph taken)

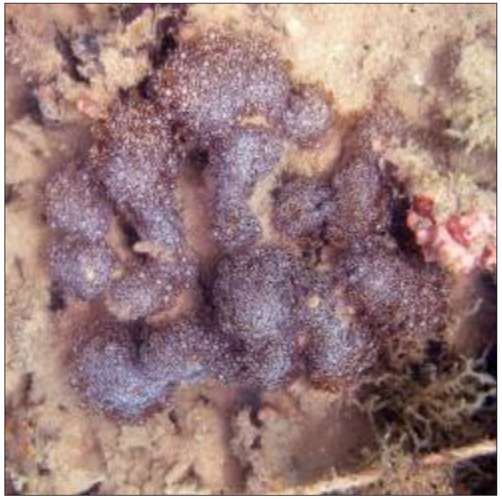
n) WR2 TAG 46

B1 Jun ’12

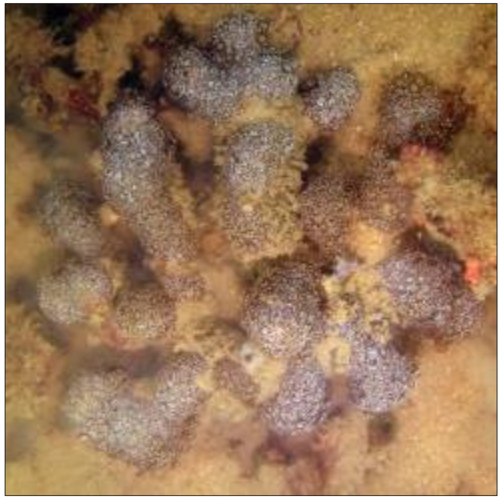


B2 Jul ’12

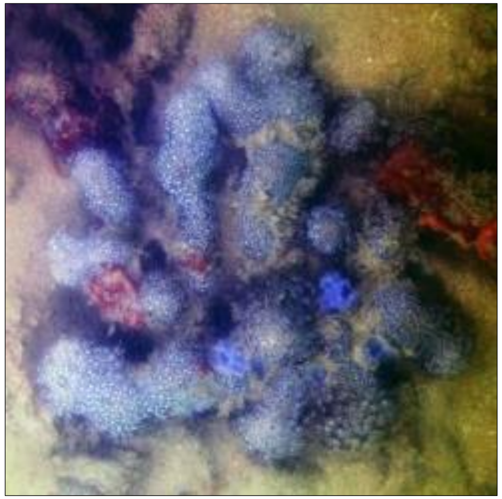
B3 Aug ’12



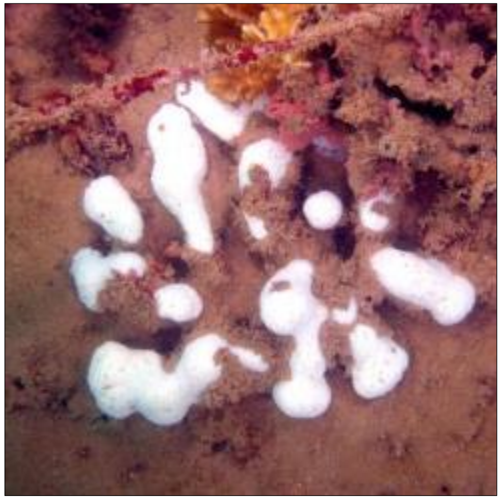
D1 Oct ’12



D2 Dec ’12

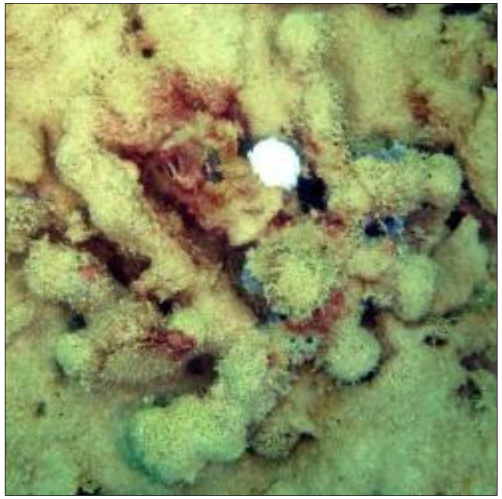


D3 Feb ’13

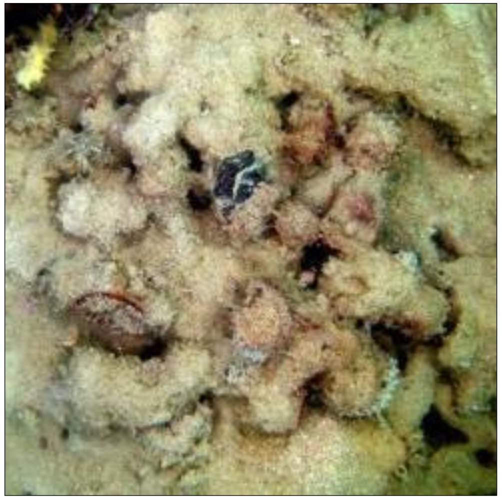


D4 Apr ’13

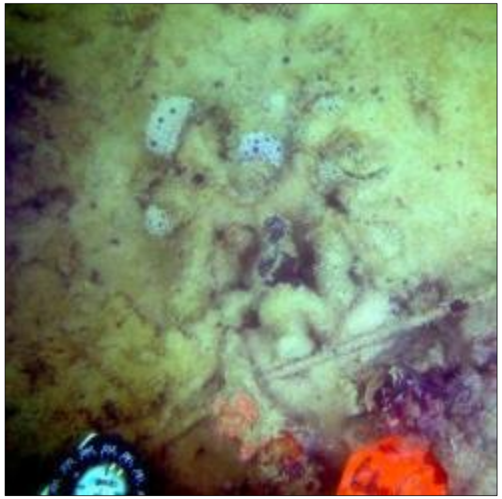
D5 Jun ’13



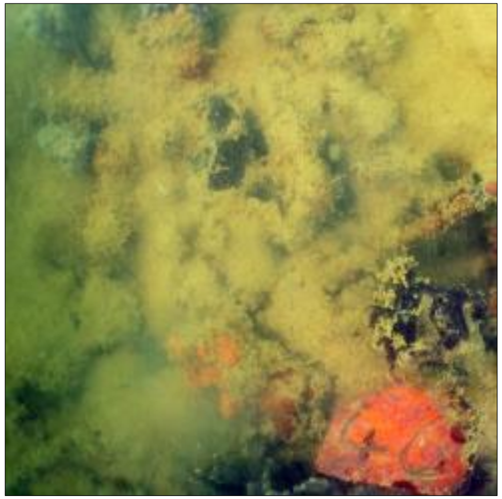
D6 Aug ’13



D7 Oct ’13



D8 Dec ’13

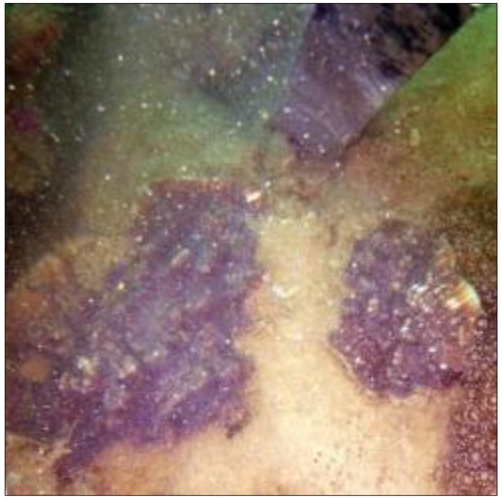


D9 Feb ’14

Entire Colony Mortality
(No photograph taken)

o) WR2 TAG 47

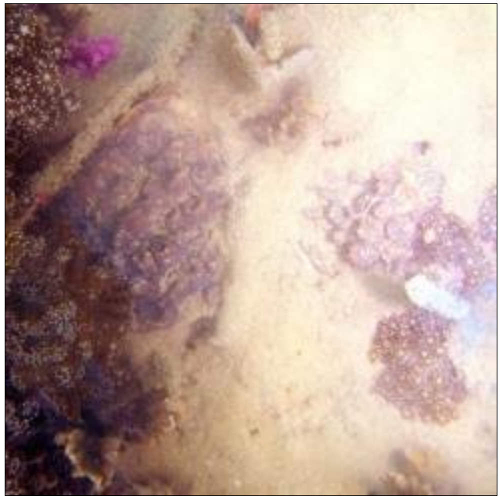
B1 Jun ’12



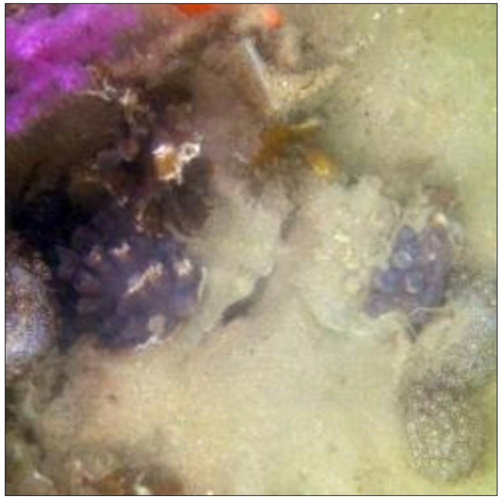
B2 Jul ’12

B3 Aug ’12

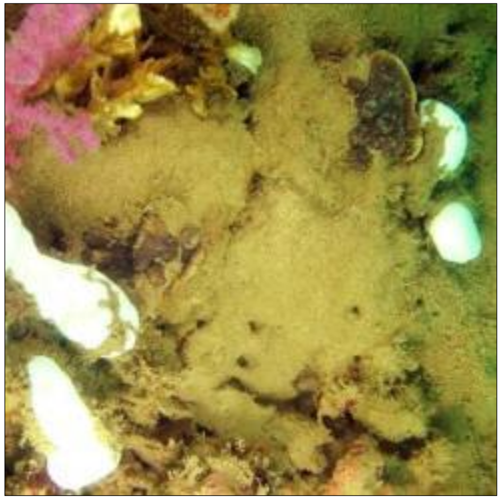
D1 Oct ’12



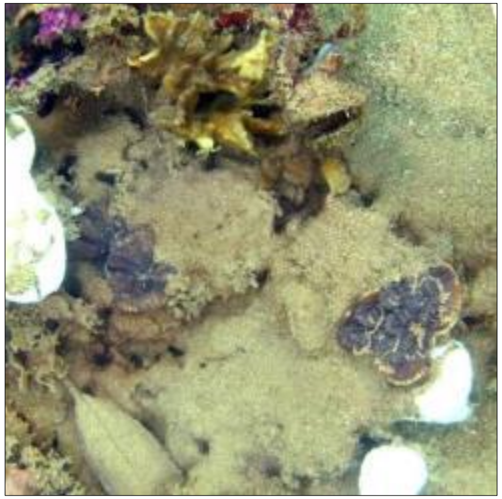
D2 Dec ’12



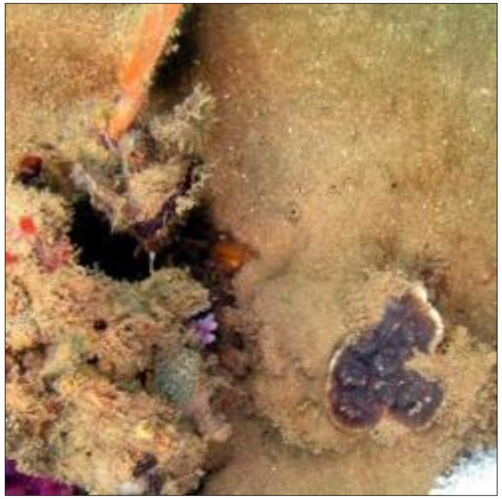
D3 Feb ’13



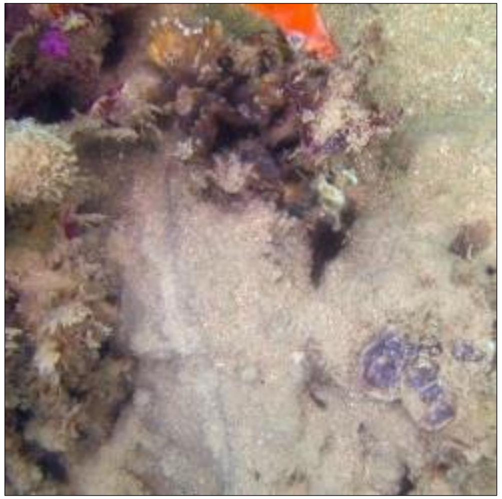
D4 Apr ’13



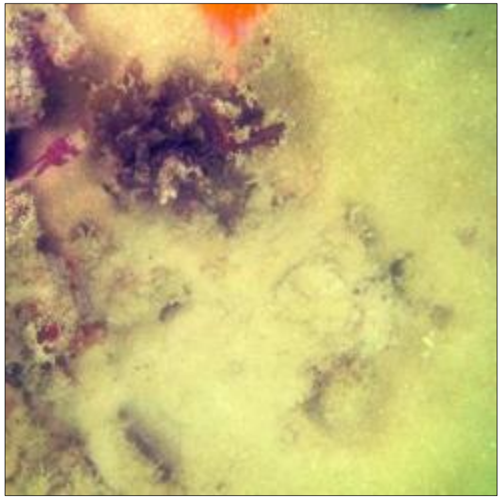
D5 Jun ’13



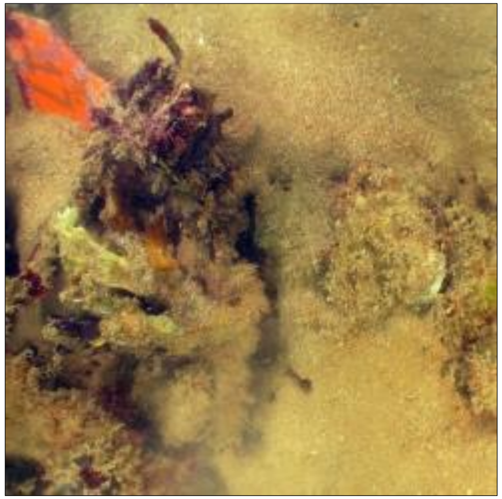
D6 Aug ’13



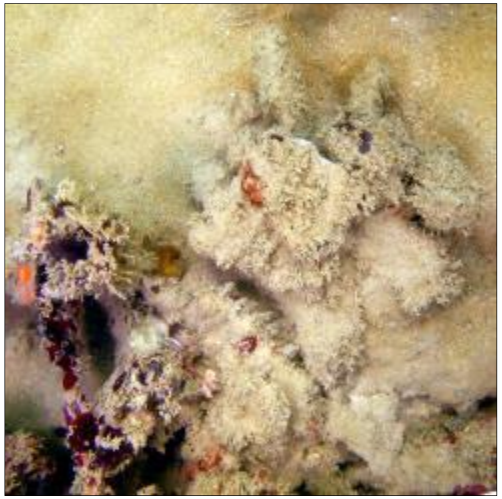
D7 Oct'13



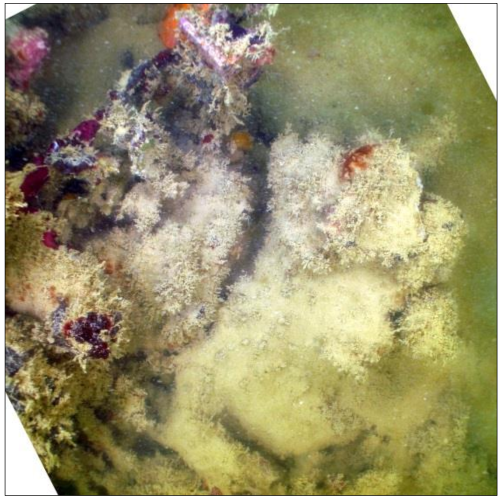
D8 Dec'13



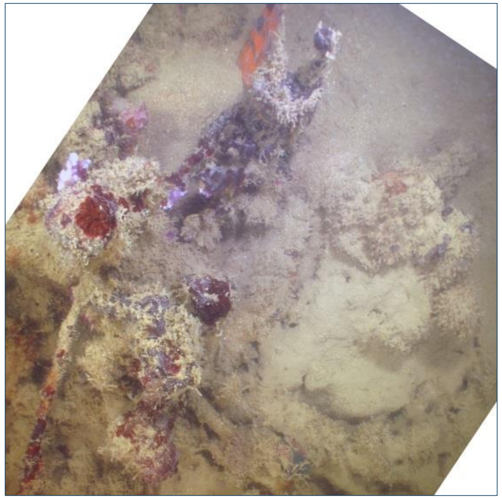
D9 Feb'14



D10 Mar '14



D11 Apr '14



Entire Colony Mortality
(No photograph taken)

p) WR2 TAG 60

B1 Jun ‘12

B2 Jul ’12

B3 Aug ‘12

D1 Oct ‘12

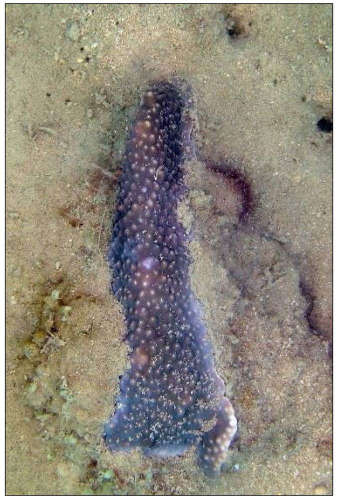
D2 Dec ’12

D3 Feb ’13

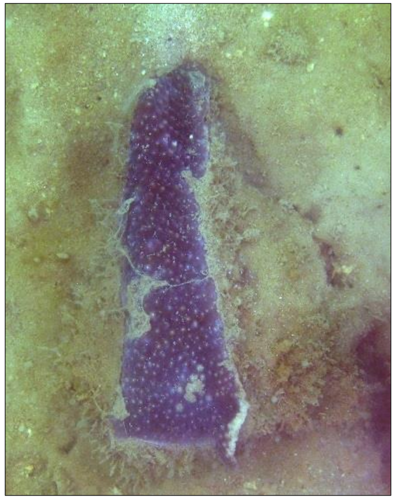
D4 Apr ’13

D5 Jun ’13

D6 Aug ’13

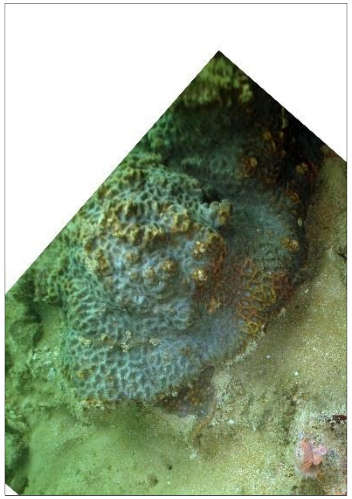


D7 Oct ‘13



D8 Dec ’13

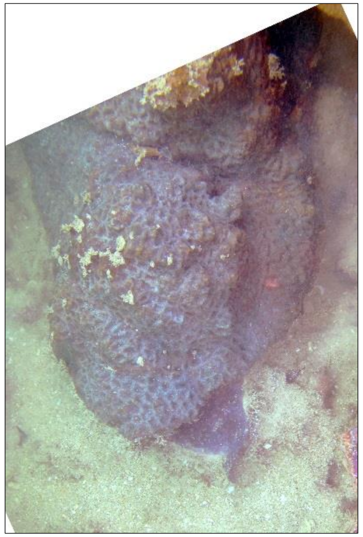
D9 Feb ’14



D10 Mar ’14

D11 Apr ’14

D12 May ’14



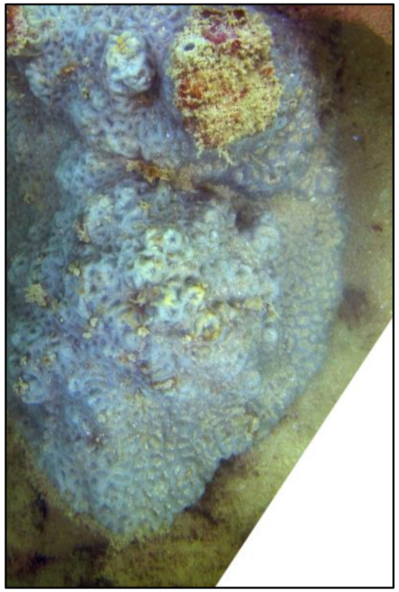
D13 Jun ‘14

D14 Jul ’14

P1 Aug ‘14

P2 Oct ‘14

P3 Dec ‘14



q) SSI TAG 03

B1 Jun ’12

B2 Jul ’12

B3 Aug ’12

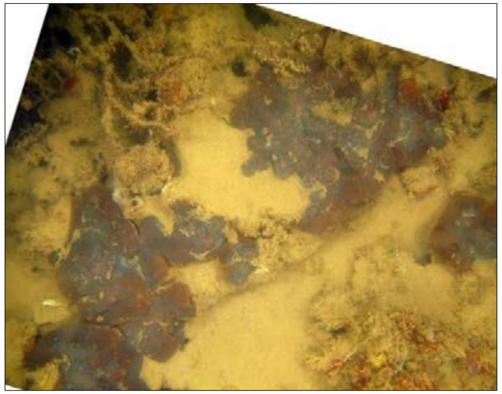
D1 Oct ’12

NO PHOTO

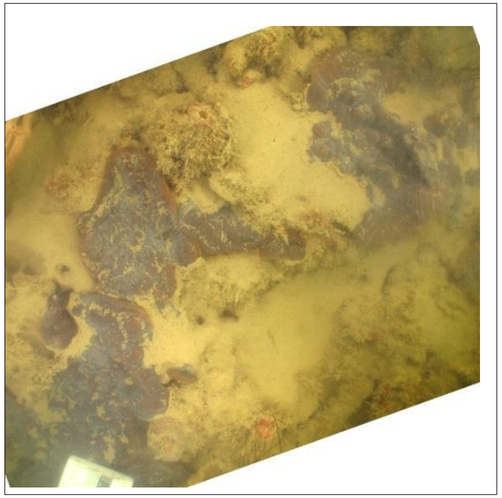
D2 Dec ’12

NO PHOTO

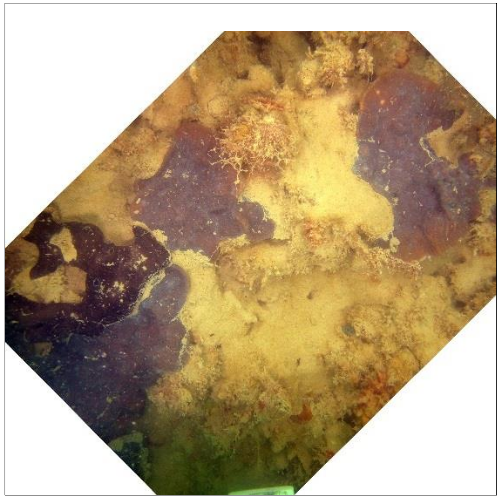
D3 Feb ’13



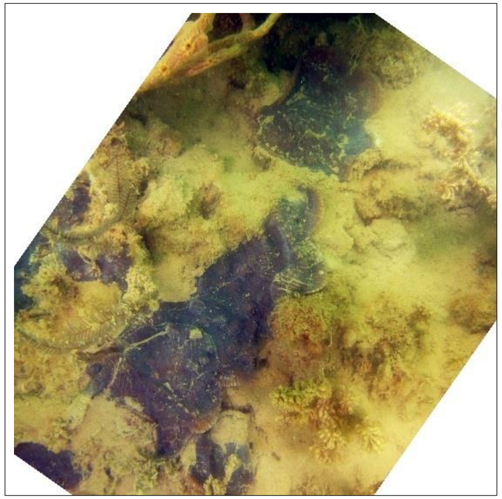
D4 Apr ’13



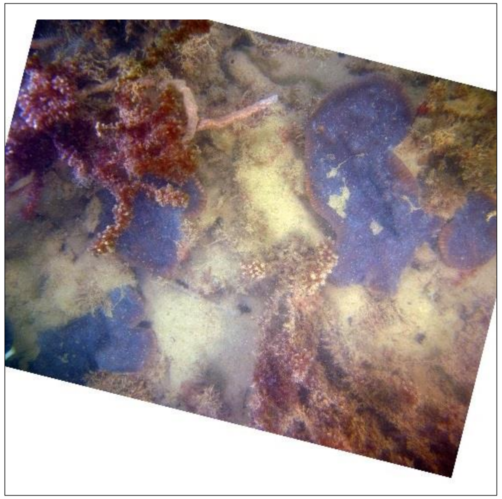
D5 Jun ’13



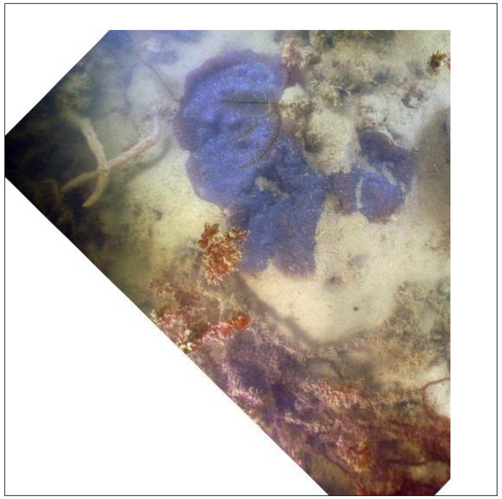
D6 Aug ’13



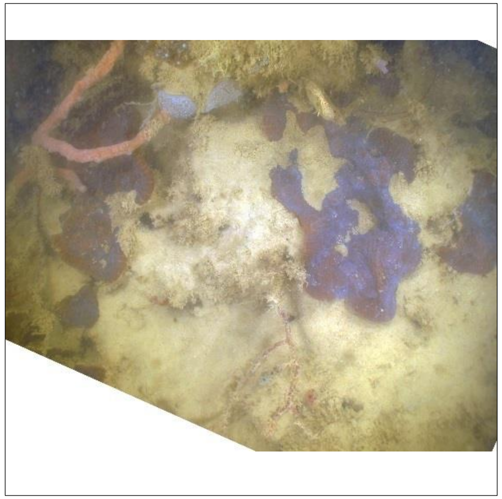
D7 Oct ‘13



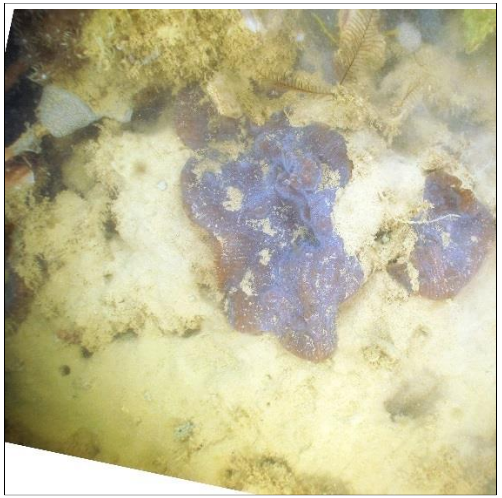
D8 Dec ’13



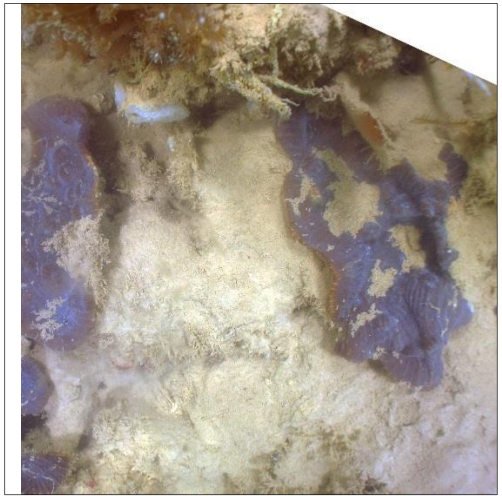
D9 Feb ’14



D10 Mar ’14



D11 Apr ’14

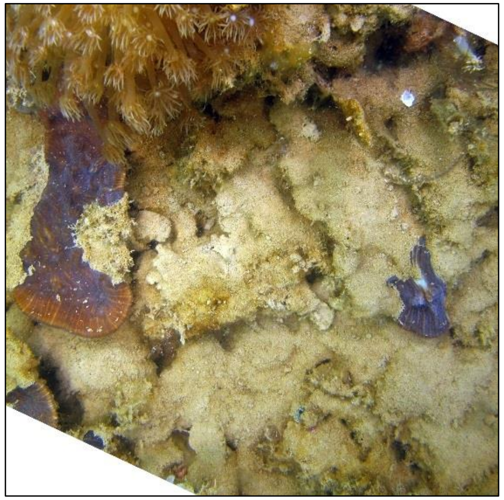


D12 May ’14

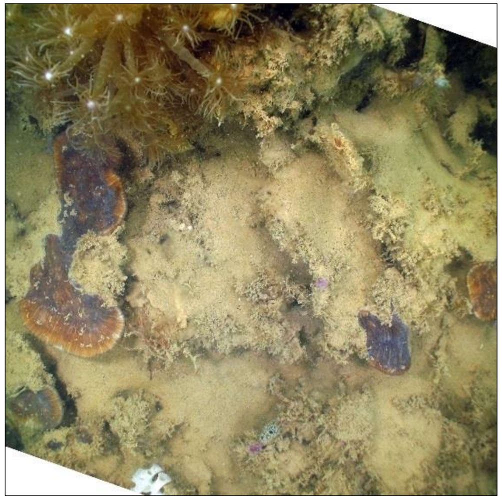
NO PHOTO

D13 Jun ‘14

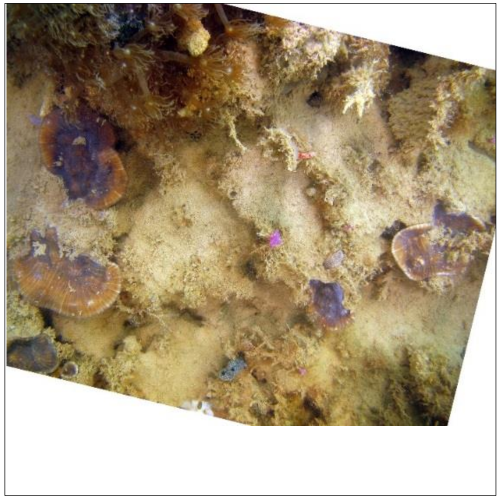
D14 Jul ’14



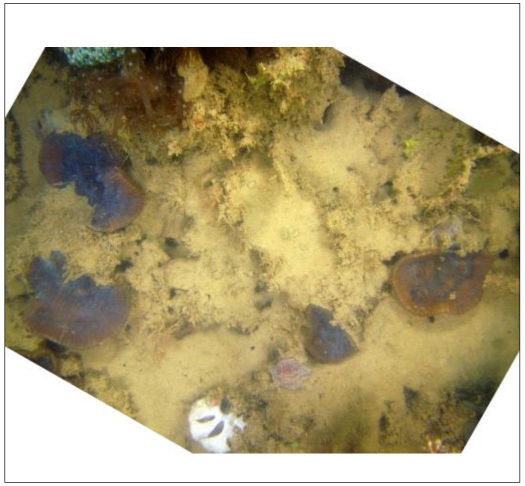
P1 Aug ‘14



P2 Oct ‘14

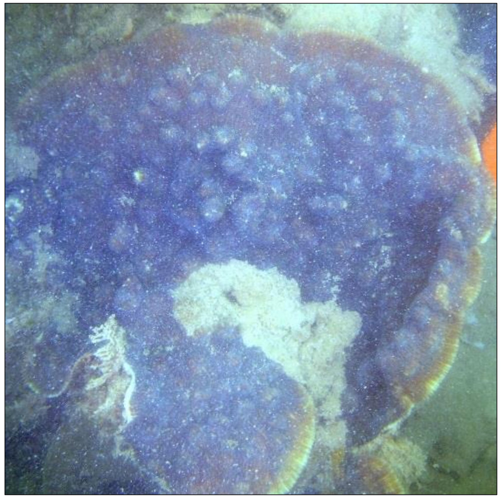


P3 Dec ‘14

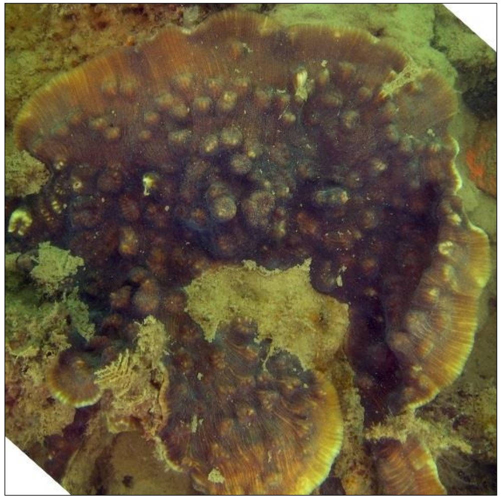


r) SSI TAG 15

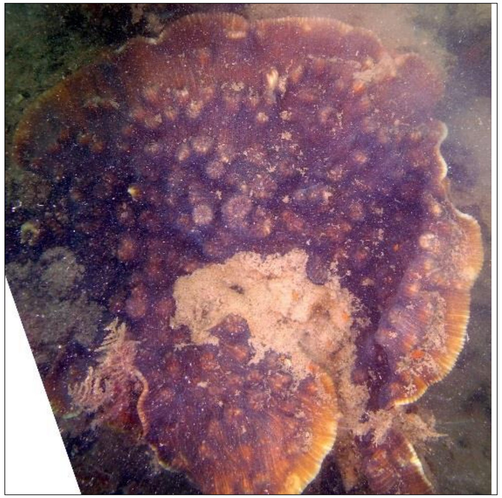
B1 Jun ’12



B2 Jul ’12



B3 Aug ’12



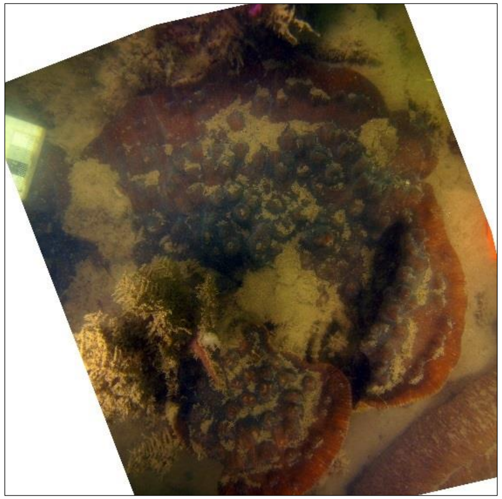
D1 Oct ’12

NO PHOTO

D2 Dec ’12

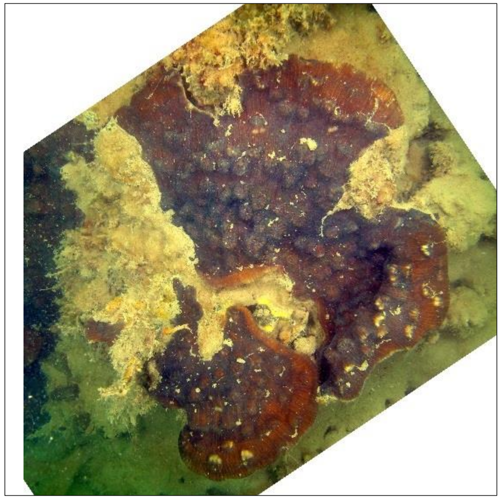
NO PHOTO

D3 Feb ’13

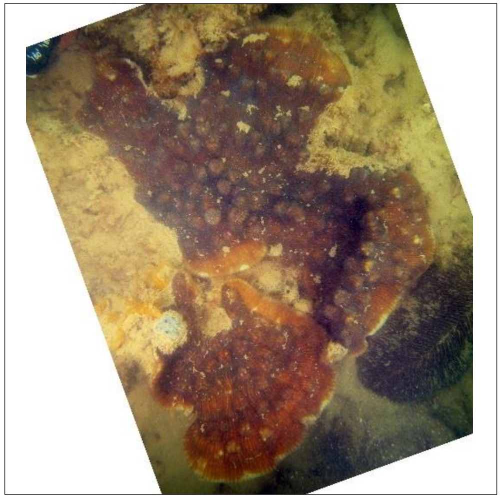


D4 Apr ’13

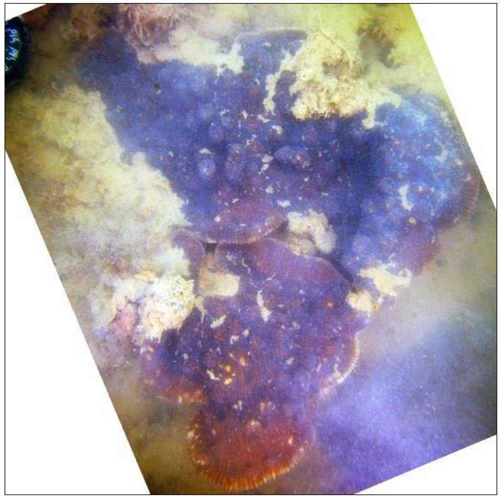
D5 Jun ’13



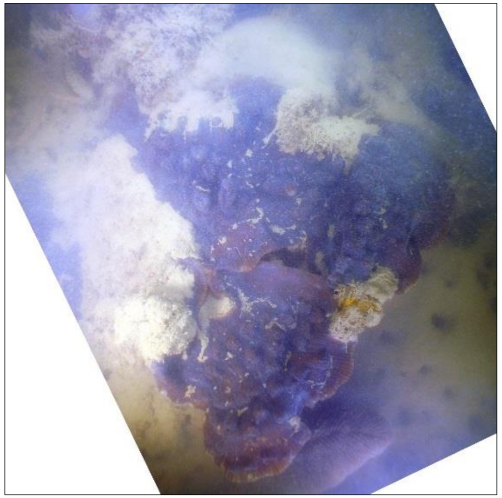
D6 Aug ’13



D7 Oct ‘13

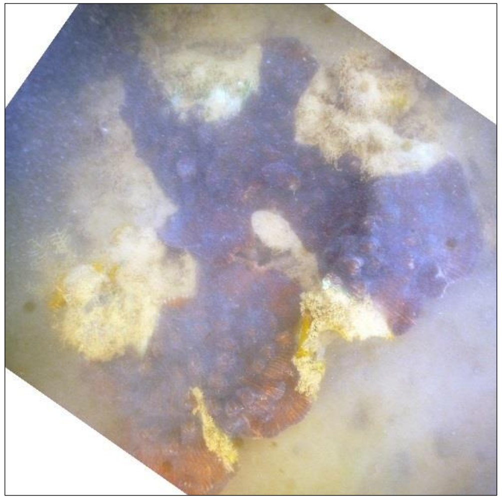


D8 Dec ’13

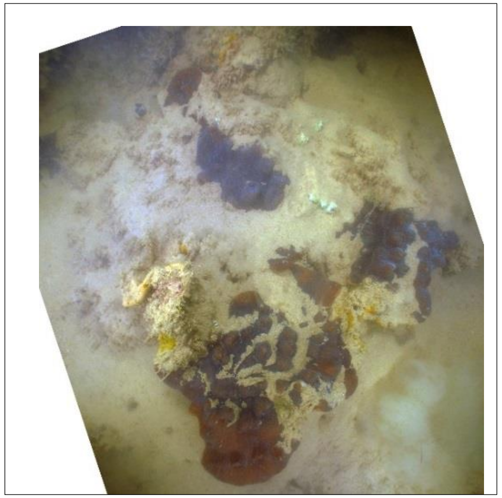


D9 Feb ’14

D10 Mar ’14



D11 Apr ’14

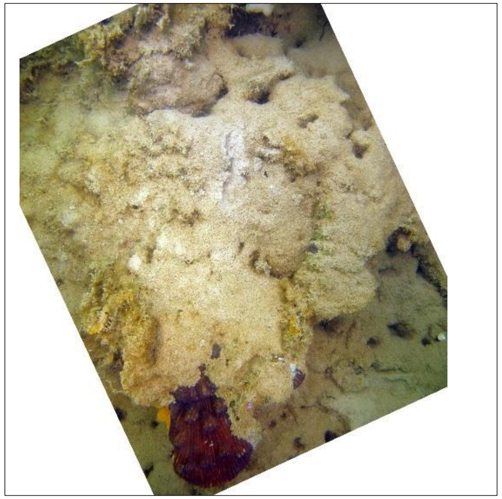


D12 May ’14

NO PHOTO

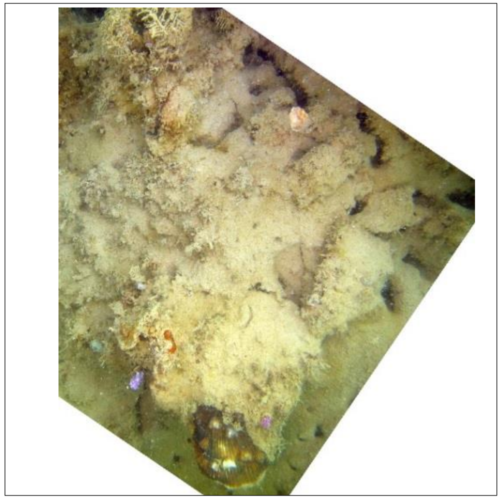
D13 Jun ‘14

D14 Jul ’14

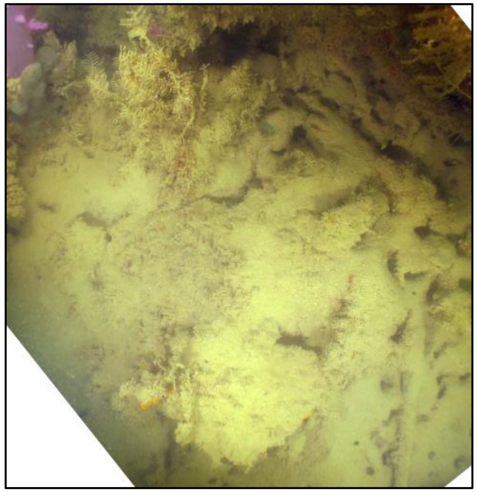


P1 Aug ‘14

P2 Oct ‘14



P3 Dec ‘14

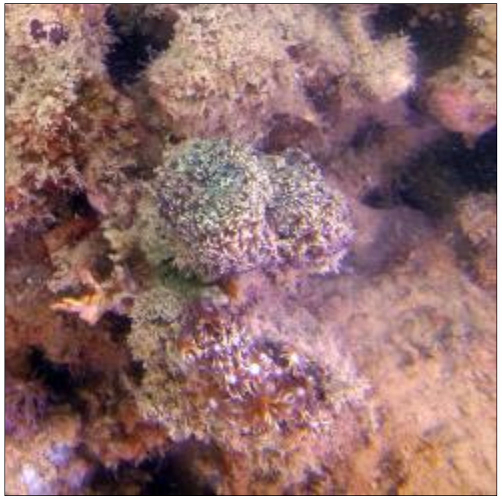


s) SSI TAG 56

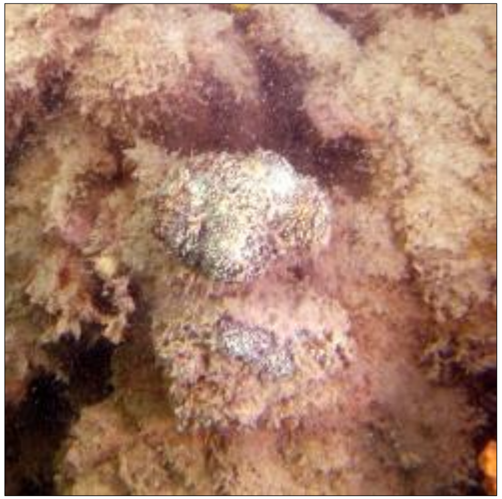
B1 Jun ’12

NO PHOTO

B2 Jul ’12



B3 Aug ’12



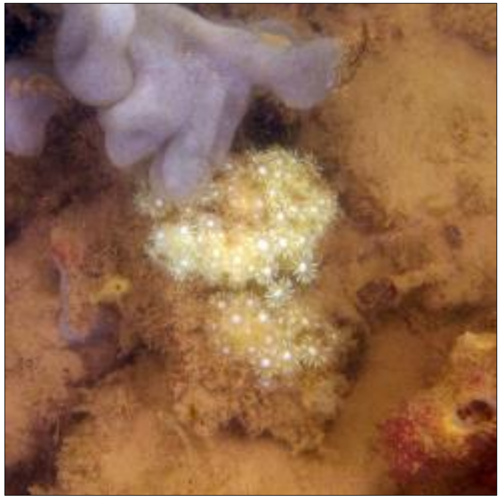
D1 Oct’12

NO PHOTO

D2 Dec’12

NO PHOTO

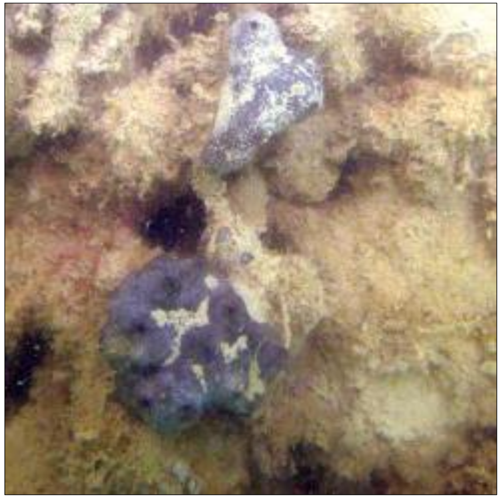
D3 Feb’13



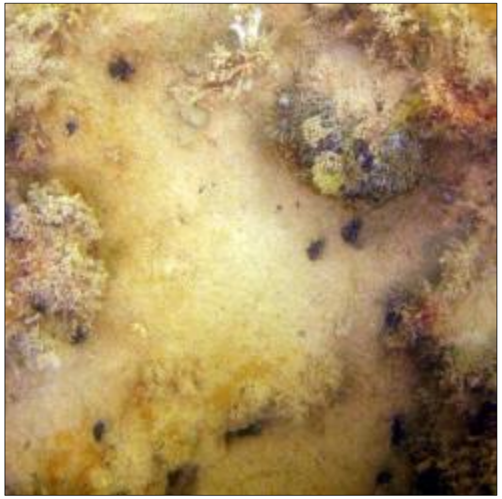
D4 Apr’13

D5 Jun’13

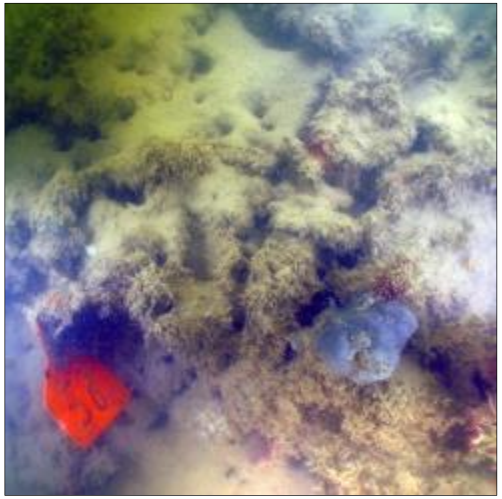
D6 Aug’13



D7 Oct'13



D8 Dec'13



D9 Feb'14

Entire Colony Mortality
(No photograph taken)

t) NEW TAG 02

B1 Jun '12

B2 Jul '12

B3 Aug '12

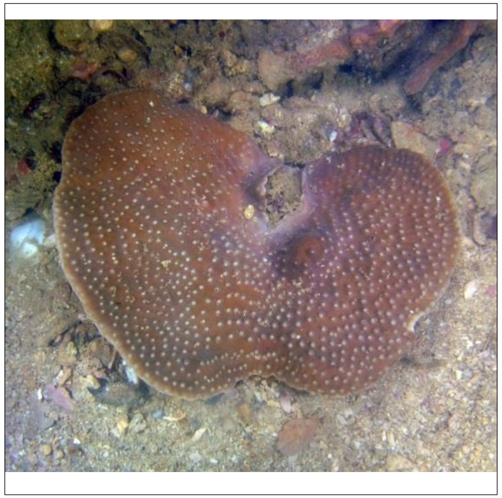
D1 Oct '12

NO PHOTO

D2 Dec '12

NO PHOTO

D3 Feb '13

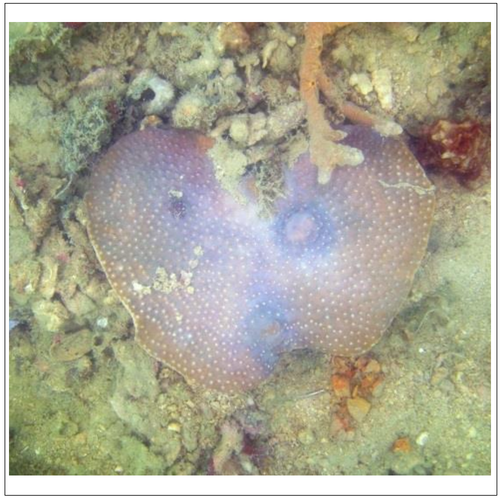


D4 Apr '13

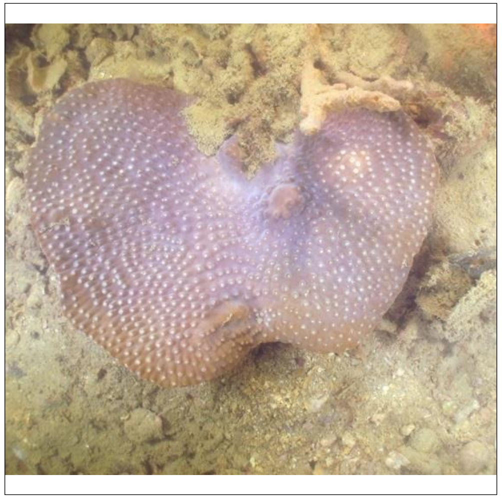
D5 Jun '13

D6 Aug '13

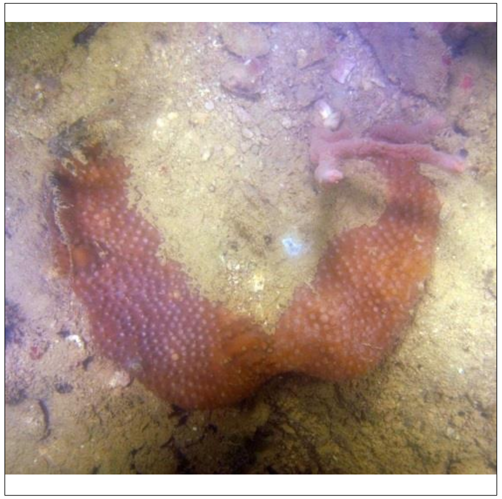
D7 Oct ’13



D8 Dec ’13



D9 Feb ’14



D10 Mar ’14

D11 Apr ’14

D12 May ‘14

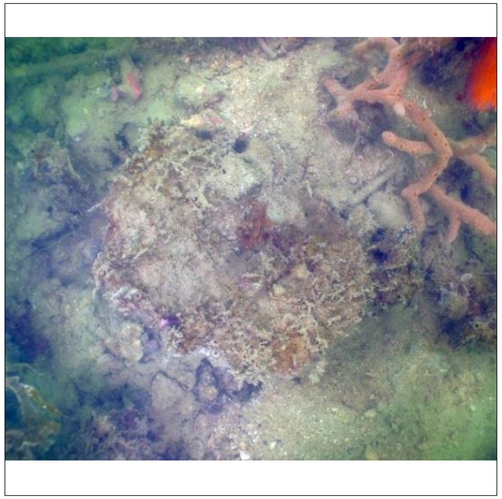
NO PHOTO

D13 Jun '14

D14 Jul '14

P1 Aug '14

P2 Oct '14



P3 Dec '14

Entire Colony Mortality
(No photograph taken)

u) NEW TAG 03

B1 Jun ’12

B2 Jul ’12

B3 Aug ’12

D1 Oct ’12

NO PHOTO

D2 Dec ’12

NO PHOTO

D3 Feb ’13

D4 Apr '13

D5 Jun '13

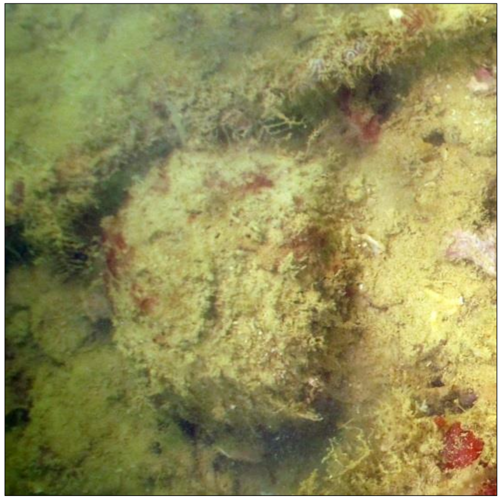
D6 Aug '13

D7 Oct '13

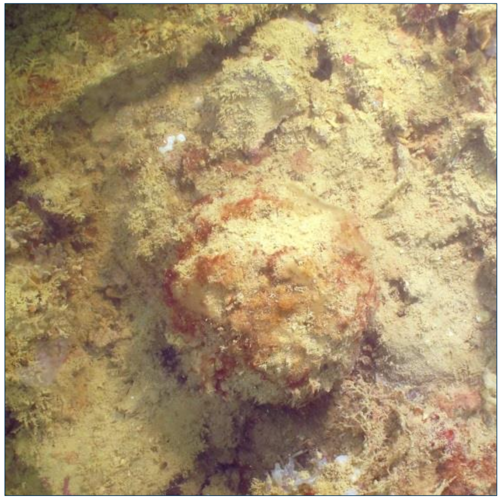
D8 Dec '13

D9 Feb '14

D10 Mar ’14



D11 Apr ’14



D12 May ’14

Entire Colony Mortality
(No photograph taken)

v) NEW TAG 13

B1 Jun ’12

NO PHOTO

B2 Jul ’12

B3 Aug ’12

D1 Oct ’12

NO PHOTO

D2 Dec ’12

NO PHOTO

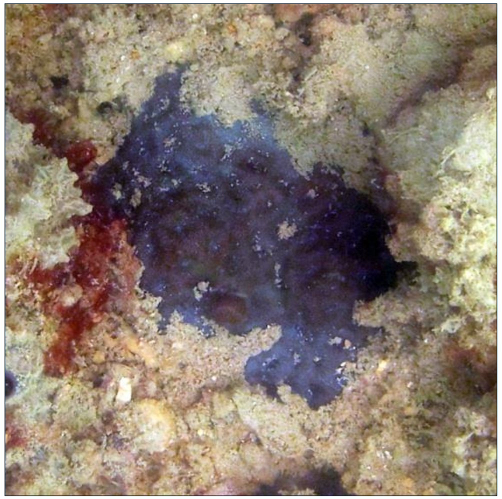
D3 Feb ’13

D4 Apr ’13

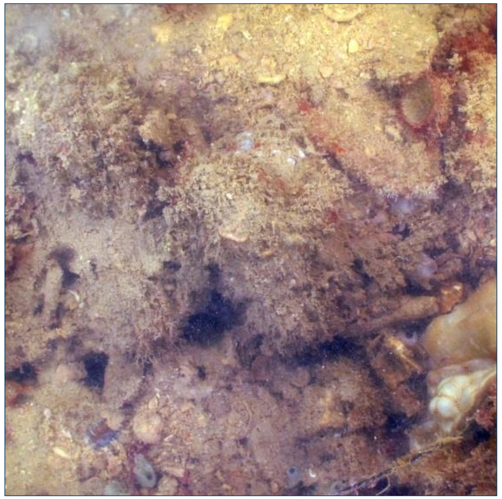
D5 Jun ’13

D6 Aug ’13

D7 Oct '13



D8 Dec '13



D9 Feb '14

NO PHOTO

D10 Mar '14

NO PHOTO

D11 Apr '14

D12 May '14

NO PHOTO

D13 Jun ’ 14

D14 Jul ‘14

P1 Aug ‘14

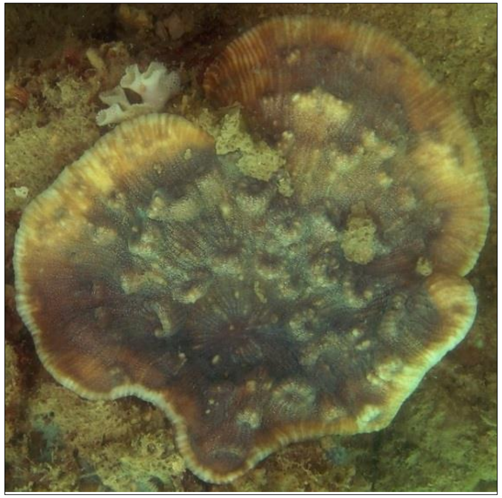
Entire Colony Mortality
(No photograph taken)

w) NEW TAG 20

B1 Jun ’12

B2 Jul ’12

B3 Aug ’12



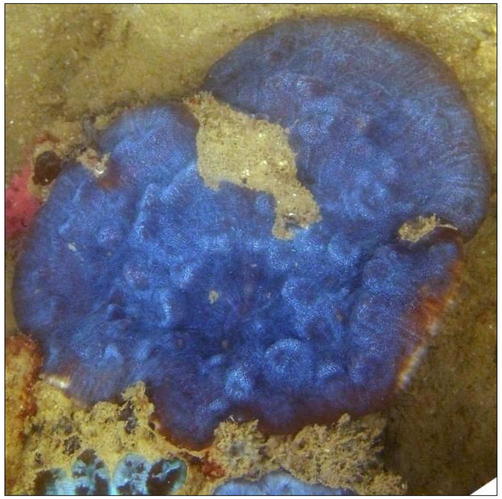
D1 Oct ’12

NO PHOTO

D2 Dec ’12

NO PHOTO

D3 Feb ’13



D4 Apr ‘13

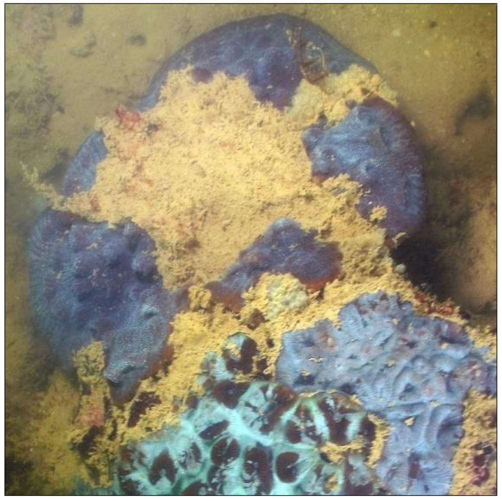
D5 Jun ’13

D6 Aug ’13

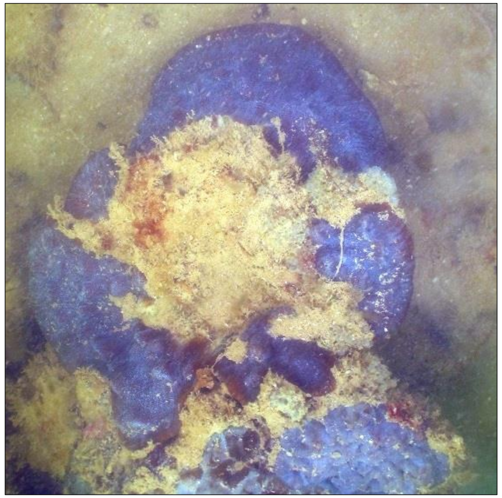
D7 Oct ’13

D8 Dec ’13

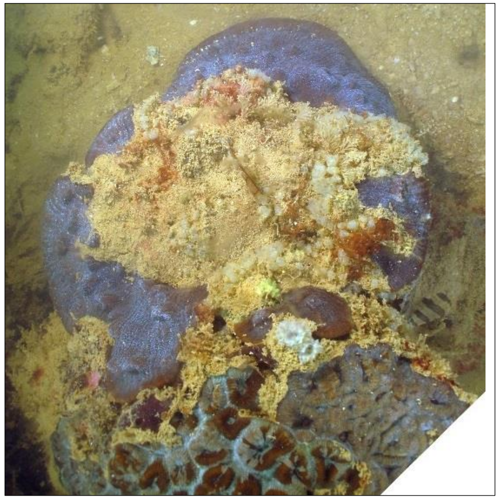
D9 Feb ’14



D10 Mar’14



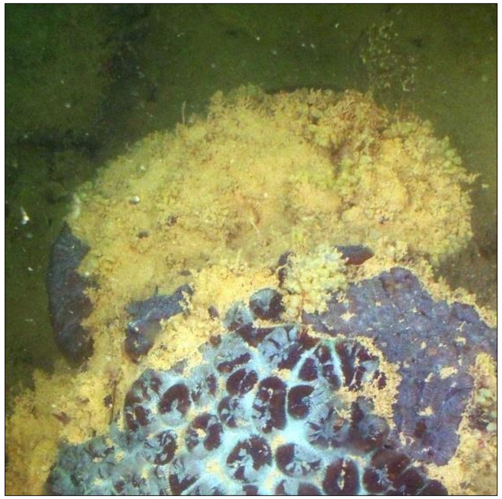
D11 Apr ’14



D12 May

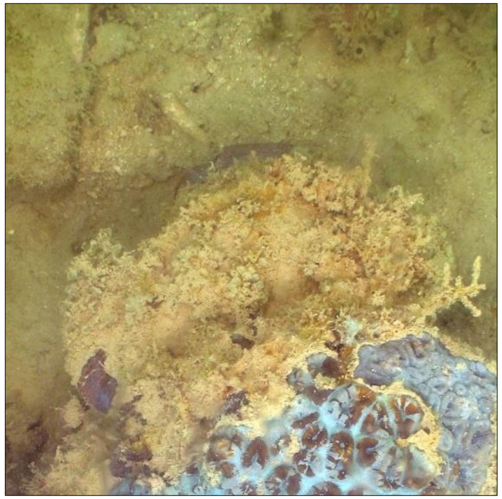
NO PHOTO

D13 Jun ’14



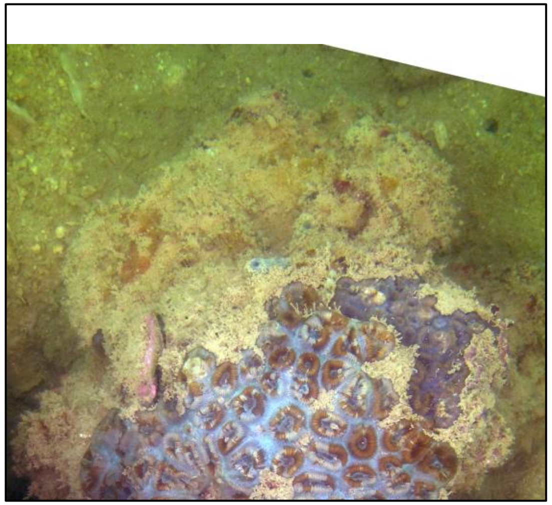
D14 Jul ‘14

P1 Aug ‘14



P2 Oct ‘14

P3 Dec ‘14

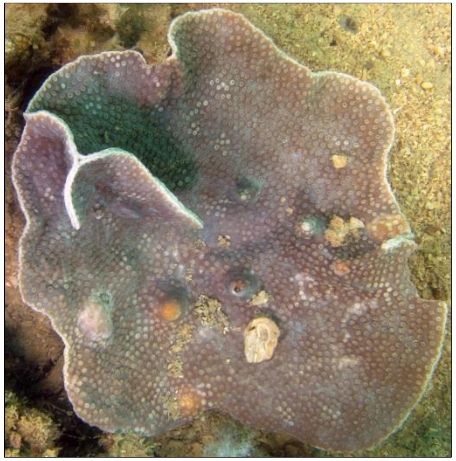


x) NEW TAG 69

B1 Jun ’12

B2 Jul ’12

B3 Aug ’12



D1 Oct ’12

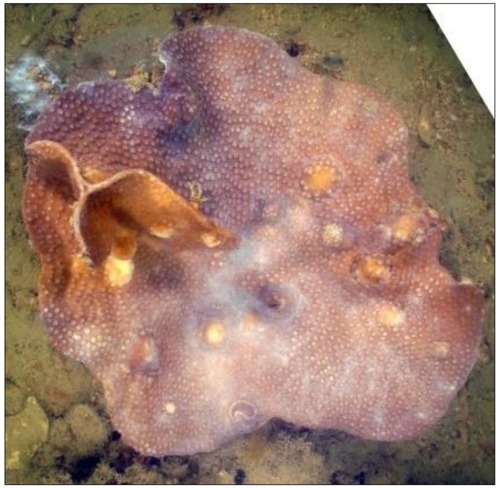
NO PHOTO

D2 Dec ’12

NO PHOTO

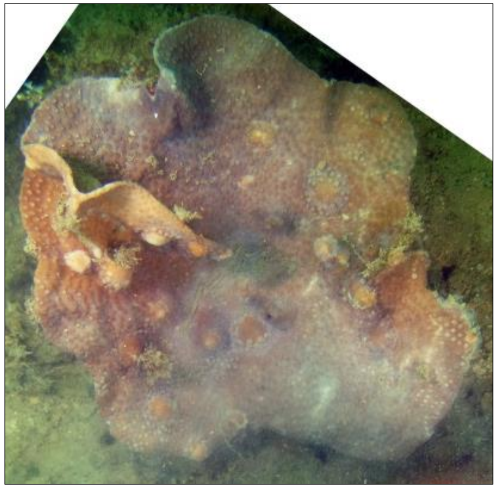
D3 Feb ’13

D4 Apr ’13



D5 Jun ’13

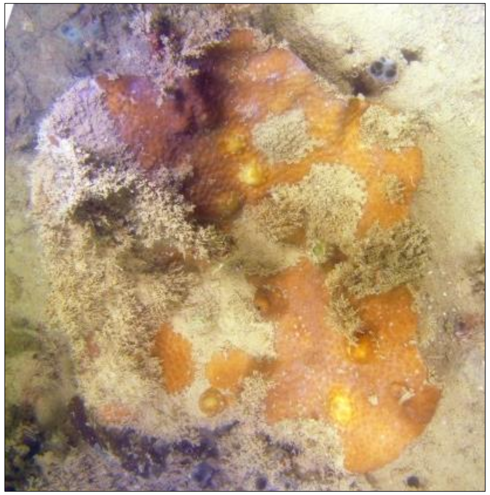
D6 Aug ’13



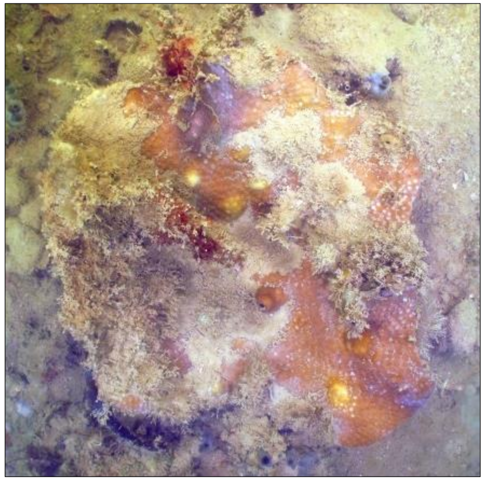
D7 Oct ’13

D8 Dec ’13

D9 Feb ’14



D10 Mar ’14



D11 Apr ’14

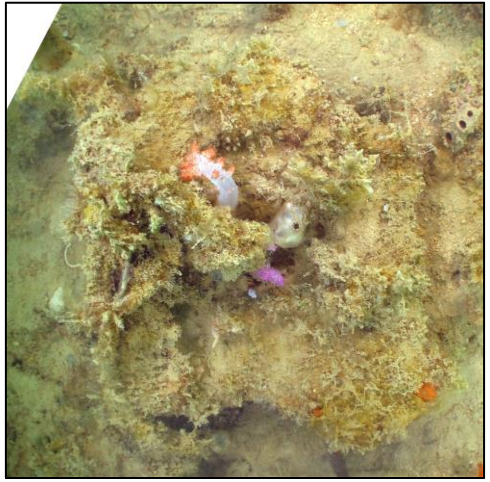
D12 May ‘14

NO PHOTO

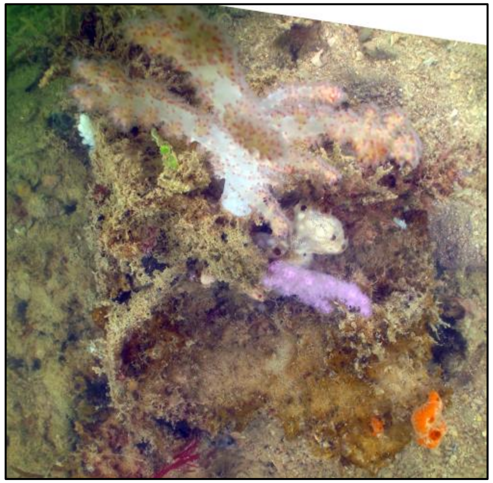
D13 Jun ’14

NO PHOTO

P1 Aug ‘14



P2 Oct ‘14



y) NEW TAG 72

B1 Jun ’12

B2 Jul ’12

B3 Aug ’12

D1 Oct ’12

NO PHOTO

D2 Dec ’12

NO PHOTO

D3 Feb ’13

D4 Apr ’13

D5 Jun ’13

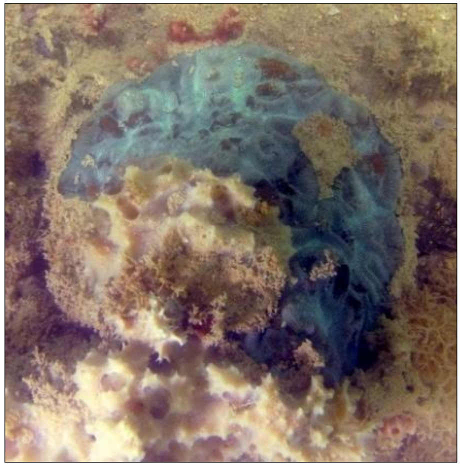
D6 Aug ’13

NO PHOTO

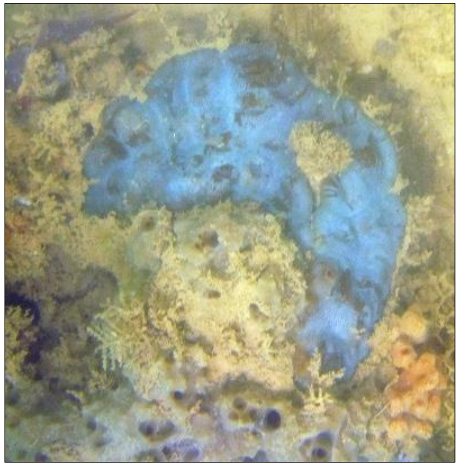
D7 Oct ’13

NO PHOTO

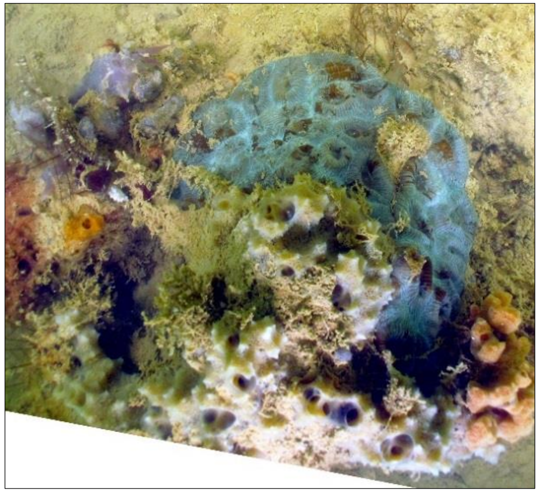
D8 Dec ’13



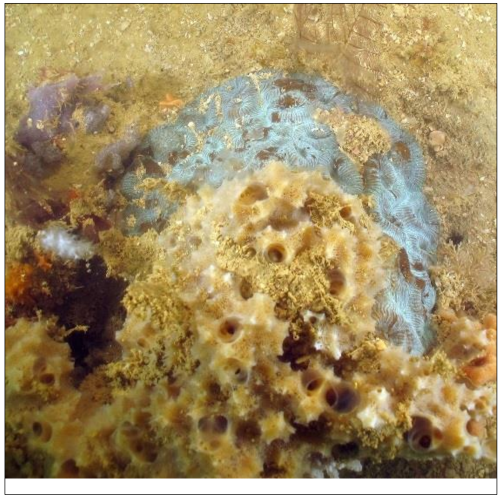
D9 Feb ’14



D10 Mar’14



D11 Apr ’14



D12 May

NO PHOTO

D13 Jun’ 14

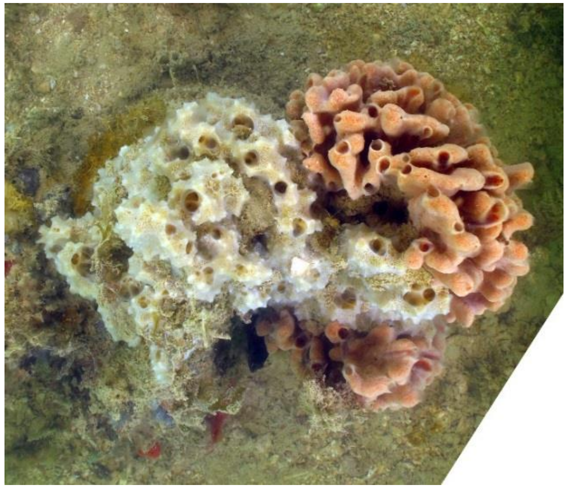
NO PHOTO

D14 Jul ‘14

NO PHOTO

P1 Aug ‘14

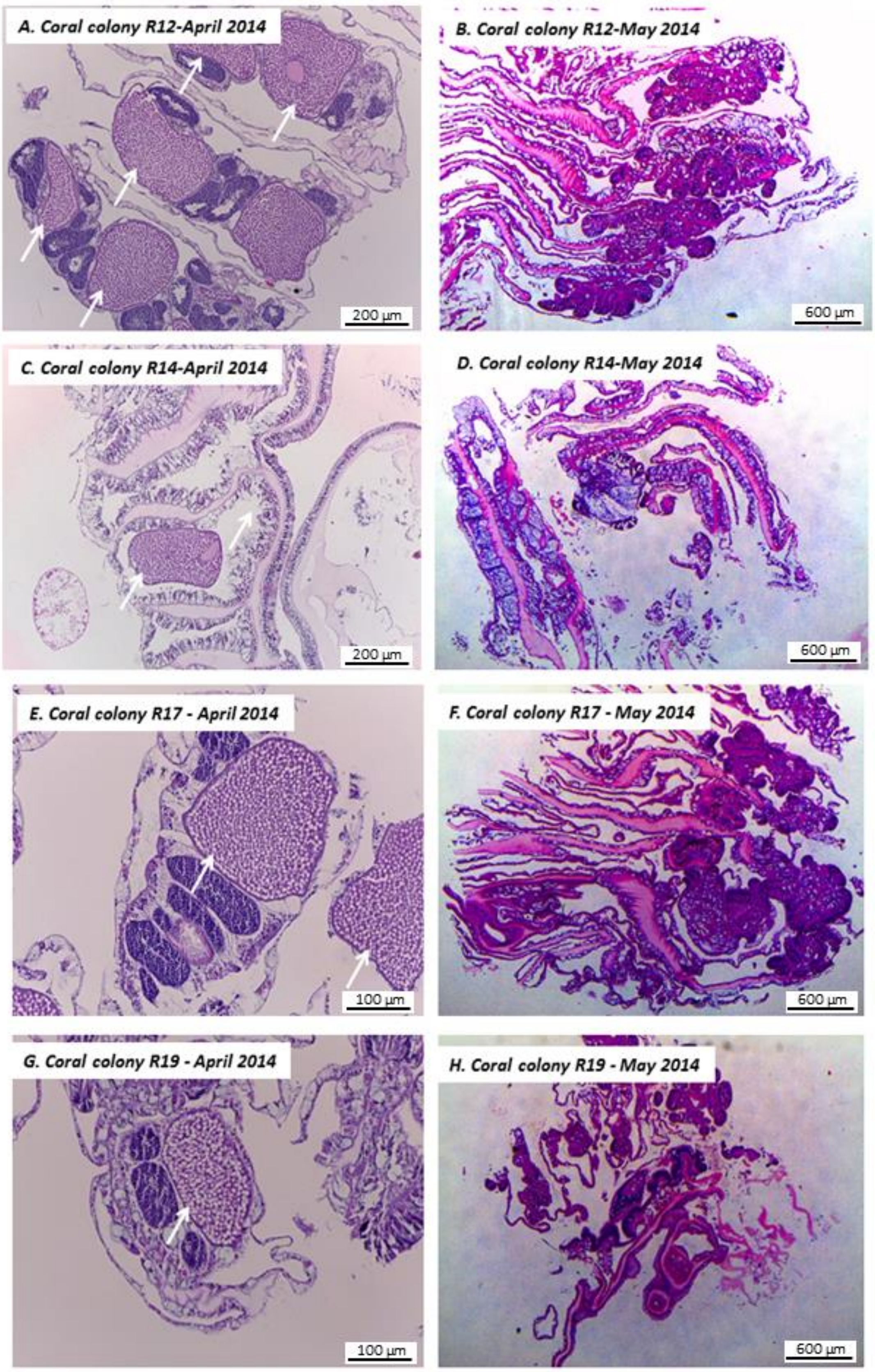
P2 Oct ‘14



P3 Dec ‘14

Entire Colony Mortality
(No photograph taken)

Appendix C-2 Microscope images indicating presence of mature oocytes in histological section from coral samples collected in Darwin Harbor in April 2014 (A, C, E and G) and absence of mature oocytes in coral samples collected in May 2014 (B, D, F, H). Arrows indicate mature oocytes



APPENDIX D

STATISTICAL ANALYSES

Appendix D-1 Multivariate analysis using PERMANOVA testing for differences in the benthic composition among Sites (CHI, WR1, WR2, SSI, NEW and MAN) and across surveys (B1 to P3). Significant (p ≤ 0.05) p-values in bold. RED = redundant terms due to significant interaction. MC = Monte Carlo simulation was used to calculate p-values where unique permutations < 100. Baseline versus Post-dredging pair-wise comparisons highlighted in teal

a. PERMANOVA analysis

Source of Variation	df	SS	MS	Pseudo-F	p(perm)
Survey	19	19048	1002.5	6.42	RED
Site	5	61724	12345.0	3.98	RED
Transect (Site)	18	55527	3084.8		
Survey x Site	**78**	**12195**	**156.3**	**1.36**	**0.0094**
Residual	289	33109	114.6		
Total	409	184300			

b. Pair-wise tests between surveys for each site for the significant Survey x Site term

Comparisons between Surveys	t	p-value
Within level 'CHI' of factor 'Site'		
B1, B2	1.11	0.4493
B1, B3	1.85	0.0645
B1, D1	1.42	0.1701
B1, D2	0.67	0.7808
B1, D3	1.15	0.2884
B1, D4	0.96	0.5115
B1, D5	1.58	0.1426
B1, D6	1.48	0.1908
B1, D7	0.98	0.4602
B1, D8	1.32	0.2104
B1, D9	1.70	0.1266
B1, D10	1.48	0.1901
B1, D11	1.56	0.1651
B1, D12	1.65	0.1410
B1, D13	1.85	0.1380
B1, PRS	1.06	0.3579
B1, P1	2.30	0.0620
B1, P2	0.83	0.5659
B1, P3	1.65	0.1581
B2, B3	1.08	0.3967
B2, D1	1.09	0.4468
B2, D2	0.91	0.4716
B2, D3	0.80	0.6916
B2, D4	0.65	0.7861
B2, D5	0.86	0.5564
B2, D6	1.00	0.4937
B2, D7	0.76	0.6712
B2, D8	1.03	0.4664
B2, D9	1.59	0.1114
B2, D10	1.16	0.3525
B2, D11	1.41	0.2076
B2, D12	1.34	0.2083
B2, D13	1.59	0.1289
B2, PRS	0.68	0.6215
B2, P1	1.84	0.1279
B2, P2	0.82	0.5925
B2, P3	1.59	0.1404
B3, D1	2.01	0.0668
B3, D2	1.20	0.3368
B3, D3	1.41	0.1646
B3, D4	1.02	0.4502
B3, D5	1.38	0.1386
B3, D6	2.32	0.0598
B3, D7	1.62	0.1116
B3, D8	**2.37**	**0.0409**
B3, D9	**2.38**	**0.0445**
B3, D10	2.10	0.0741
B3, D11	**2.25**	**0.0424**
B3, D12	2.16	0.0629
B3, D13	**2.80**	**0.0399**
B3, PRS	1.41	0.2054
B3, P1	**4.30**	**0.0276**
B3, P2	0.93	0.4773
B3, P3	**2.82**	**0.0498**
D1, D2	0.81	0.6442
D1, D3	2.06	0.0708
D1, D4	1.23	0.2571
D1, D5	1.54	0.1099
D1, D6	1.41	0.1750
D1, D7	1.40	0.1475
D1, D8	1.61	0.1233
D1, D9	1.83	0.0856
D1, D10	1.46	0.1503
D1, D11	1.89	0.0811
D1, D12	1.86	0.0792
D1, D13	2.24	0.0580
D1, PRS	1.06	0.3901
D1, P1	**2.70**	**0.0435**
D1, P2	0.95	0.4834
D1, P3	2.12	0.1117
D2, D3	0.81	0.6949
D2, D4	1.46	0.1445
D2, D5	1.25	0.2783
D2, D6	1.06	0.3460
D2, D7	1.13	0.3629
D2, D8	1.83	0.0976
D2, D9	2.04	0.0548

Comparisons between Surveys	t	p-value
D2, D10	1.45	0.2103
D2, D11	**2.43**	**0.0277**
D2, D12	1.88	0.0514
D2, D13	**2.53**	**0.0376**
D2, PRS	0.95	0.4997
D2, P1	**3.04**	**0.0275**
D2, P2	1.11	0.3293
D2, P3	2.59	0.0571
D3, D4	0.84	0.6467
D3, D5	1.10	0.3707
D3, D6	1.41	0.1927
D3, D7	1.11	0.3215
D3, D8	1.80	0.0876
D3, D9	**2.37**	**0.0489**
D3, D10	1.53	0.1929
D3, D11	2.20	0.0547
D3, D12	1.75	0.0870
D3, D13	**3.01**	**0.0391**
D3, PRS	0.75	0.6089
D3, P1	**2.84**	**0.0356**
D3, P2	0.85	0.5449
D3, P3	2.16	0.0860
D4, D5	1.08	0.3964
D4, D6	1.16	0.3110
D4, D7	0.90	0.5168
D4, D8	1.56	0.1666
D4, D9	2.17	0.1017
D4, D10	2.36	0.0761
D4, D11	2.18	0.1044
D4, D12	1.92	0.1425
D4, D13	3.13	0.0673
D4, PRS	0.81	0.5553
D4, P1	2.53	0.0659
D4, P2	0.77	0.6302
D4, P3	2.01	0.1595
D5, D6	1.62	0.1411
D5, D7	1.09	0.3795
D5, D8	2.08	0.1048
D5, D9	2.82	0.0720
D5, D10	2.64	0.0578
D5, D11	2.88	0.0676
D5, D12	2.76	0.0692
D5, D13	**4.36**	**0.0311**
D5, PRS	1.51	0.2266
D5, P1	2.99	0.0518
D5, P2	0.82	0.5583
D5, P3	2.26	0.1069
D6, D7	0.98	0.4656
D6, D8	0.67	0.7189
D6, D9	0.62	0.7790
D6, D10	0.69	0.7050
D6, D11	0.62	0.7025
D6, D12	0.62	0.8095
D6, D13	1.04	0.3973
D6, PRS	1.08	0.3504
D6, P1	1.17	0.2444
D6, P2	1.25	0.3797
D6, P3	0.67	0.6032
D7, D8	1.40	0.1551
D7, D9	1.38	0.2224
D7, D10	1.10	0.3145
D7, D11	1.92	0.0732
D7, D12	1.01	0.4598
D7, D13	**2.42**	**0.0356**
D7, PRS	0.59	0.6812
D7, P1	**2.61**	**0.0351**
D7, P2	0.97	0.4971
D7, P3	2.34	0.0846
D8, D9	1.58	0.1266
D8, D10	0.87	0.5903
D8, D11	1.74	0.1731
D8, D12	1.29	0.2249
D8, D13	**1.97**	**0.0418**
D8, PRS	0.95	0.4647
D8, P1	1.66	0.0876
D8, P2	1.60	0.1756
D8, P3	1.46	0.2141
D9, D10	0.96	0.4335
D9, D11	0.90	0.5215
D9, D12	1.48	0.1609
D9, D13	2.12	0.0670
D9, PRS	0.86	0.4808
D9, P1	1.38	0.1839
D9, P2	1.71	0.1680
D9, P3	0.79	0.6103
D10, D11	0.92	0.4581
D10, D12	1.11	0.3469
D10, D13	1.23	0.2864
D10, PRS	1.95	0.0800
D10, P1	1.27	0.2453
D10, P2	1.19	0.3081
D10, P3	0.90	0.4999
D11, D12	1.01	0.4212
D11, D13	1.08	0.3724
D11, PRS	1.04	0.3594
D11, P1	1.11	0.3536
D11, P2	2.00	0.0740
D11, P3	1.23	0.2467
D12, D13	1.94	0.0722
D12, PRS	0.81	0.4985
D12, P1	1.63	0.1504
D12, P2	1.21	0.3287
D12, P3	1.51	0.1588
D13, PRS	1.80	0.1917
D13, P1	1.76	0.0995
D13, P2	2.70	0.0674
D13, P3	1.00	0.4714
PRS, P1	1.62	0.2118
PRS, P2	0.71	0.6491
PRS, P3	1.12	0.3213
P1, P2	2.29	0.0899
P1, P3	1.12	0.3356
P2, P3	2.23	0.0970
Within level 'MAN' of factor 'Site'		
B1, B2	**4.19**	**0.0341**
B1, B3	0.85	0.5993

Comparisons between Surveys	t	p-value
B1, D2	**2.94**	**0.0371**
B1, D6	1.87	0.1225
B1, D10	**4.01**	**0.0314**
B1, P1	**1.95**	**0.0322**
B1, P2	1.66	0.0768
B1, P3	1.56	0.1322
B2, B3	2.42	0.0649
B2, D2	1.97	0.1027
B2, D6	2.79	0.0502
B2, D10	**9.33**	**0.0109**
B2, P1	**3.16**	**0.0315**
B2, P2	2.01	0.0813
B2, P3	2.13	0.1000
B3, D2	**5.51**	**0.0280**
B3, D6	1.77	0.0925
B3, D10	**3.54**	**0.0285**
B3, P1	1.32	0.1889
B3, P2	**2.49**	**0.0323**
B3, P3	1.25	0.2528
D2, D6	**3.23**	**0.0361**
D2, D10	**5.53**	**0.0177**
D2, P1	**4.13**	**0.0333**
D2, P2	2.38	0.0673
D2, P3	2.28	0.0755
D6, D10	0.77	0.6145
D6, P1	0.90	0.5062
D6, P2	2.01	0.0681
D6, P3	1.27	0.2985
D10, P1	1.59	0.1234
D10, P2	**2.62**	**0.0317**
D10, P3	1.54	0.1879
P1, P2	1.39	0.2196
P1, P3	0.84	0.5305
P2, P3	0.66	0.5520
Within level 'NEW' of factor 'Site'		
B1, B2	0.26	0.8380
B1, B3	0.71	0.6207
B1, D3	0.72	0.6333
B1, D4	1.41	0.2273
B1, D5	1.96	0.1052
B1, D6	1.19	0.2981
B1, D7	1.41	0.1864
B1, D8	1.10	0.3780
B1, D9	0.91	0.5055
B1, D10	1.58	0.1646
B1, D11	2.31	0.1003
B1, D13	2.22	0.0910
B1, PRS	1.96	0.0851
B1, P1	1.90	0.1289
B1, P2	0.79	0.5452
B1, P3	**5.46**	**0.0216**
B2, B3	0.60	0.7424
B2, D3	1.25	0.3016
B2, D4	0.90	0.5160
B2, D5	1.88	0.1111
B2, D6	1.81	0.1242
B2, D7	1.23	0.2879
B2, D8	0.81	0.5689

Comparisons between Surveys	t	p-value
B2, D9	0.94	0.4859
B2, D10	2.10	0.0872
B2, D11	2.16	0.1115
B2, D13	1.68	0.1569
B2, PRS	1.90	0.1080
B2, P1	**3.09**	**0.0303**
B2, P2	1.15	0.3378
B2, P3	1.80	0.1328
B3, D3	0.51	0.8509
B3, D4	2.20	0.0993
B3, D5	1.81	0.0869
B3, D6	1.93	0.1511
B3, D7	1.55	0.2081
B3, D8	1.25	0.2808
B3, D9	1.16	0.3443
B3, D10	2.53	0.0611
B3, D11	**4.23**	**0.0272**
B3, D13	2.60	0.0729
B3, PRS	**2.41**	**0.0384**
B3, P1	2.47	0.0809
B3, P2	0.92	0.5294
B3, P3	1.93	0.1382
D3, D4	0.68	0.5567
D3, D5	1.20	0.2935
D3, D6	1.38	0.2556
D3, D7	1.13	0.3018
D3, D8	0.74	0.5765
D3, D9	0.84	0.5075
D3, D10	1.61	0.1495
D3, D11	1.87	0.1418
D3, D13	1.58	0.2095
D3, PRS	1.62	0.1765
D3, P1	2.26	0.0707
D3, P2	0.86	0.5699
D3, P3	1.65	0.1714
D4, D5	2.36	0.1110
D4, D6	0.75	0.5373
D4, D7	0.89	0.4940
D4, D8	2.12	0.0812
D4, D9	1.03	0.4119
D4, D10	0.88	0.4770
D4, D11	**2.65**	**0.0351**
D4, D13	2.30	0.0580
D4, PRS	1.11	0.3527
D4, P1	0.84	0.5382
D4, P2	1.16	0.3886
D4, P3	1.18	0.2992
D5, D6	1.90	0.1559
D5, D7	2.06	0.1031
D5, D8	1.04	0.4180
D5, D9	0.92	0.4385
D5, D10	2.79	0.0899
D5, D11	**3.91**	**0.0408**
D5, D13	2.47	0.0956
D5, PRS	**3.19**	**0.0471**
D5, P1	**3.20**	**0.0478**
D5, P2	1.02	0.3894
D5, P3	1.94	0.1185

Comparisons between Surveys	t	p-value	
D6, D7	0.87	0.4687	
D6, D8	1.22	0.2790	
D6, D9	1.25	0.3159	
D6, D10	0.23	0.8583	
D6, D11	0.59	0.5917	
D6, D13	0.33	0.7320	
D6, PRS	0.83	0.4638	
D6, P1	0.50	0.7401	
D6, P2	2.05	0.1228	
D6, P3	0.54	0.8027	
D7, D8	0.96	0.4074	
D7, D9	1.03	0.4396	
D7, D10	1.58	0.1682	
D7, D11	2.03	0.1242	
D7, D13	1.67	0.1779	
D7, PRS	1.93	0.0743	
D7, P1	1.40	0.2615	
D7, P2	0.88	0.4832	
D7, P3	2.52	0.0901	
D8, D9	0.48	0.8101	
D8, D10	1.46	0.2270	
D8, D11	**3.84**	**0.0311**	
D8, D13	2.52	0.0540	
D8, PRS	1.25	0.2756	
D8, P1	1.39	0.2774	
D8, P2	0.31	0.8370	
D8, P3	1.02	0.3881	
D9, D10	1.73	0.1507	
D9, D11	2.50	0.0868	
D9, D13	1.68	0.1912	
D9, PRS	0.81	0.5658	
D9, P1	1.21	0.2936	
D9, P2	0.61	0.6658	
D9, P3	0.72	0.5828	
D10, D11	0.98	0.4235	
D10, D13	0.53	0.6309	
D10, PRS	1.15	0.2998	
D10, P1	0.94	0.4564	
D10, P2	2.14	0.1089	
D10, P3	0.96	0.4528	
D11, D13	0.72	0.6601	
D11, PRS	2.39	0.0669	
D11, P1	1.02	0.5055	
D11, P2	2.95	0.0790	
D11, P3	1.18	0.2981	
D13, PRS	1.45	0.2207	
D13, P1	0.61	0.6371	
D13, P2	1.62	0.1953	
D13, P3	1.20	0.3943	
PRS, P1	1.23	0.2704	
PRS, P2	1.44	0.2300	
PRS, P3	1.08	0.3563	
P1, P2	2.39	0.0949	
P1, P3	1.32	0.2506	
P2, P3	1.04	0.3899	
Within level 'SSI' of factor 'Site'			
B1, B2	0.98	0.3673	
B1, B3	2.27	0.1018	
B1, D3	1.66	0.1790	
B1, D4	0.36	0.7616	
B1, D5	1.15	0.3331	
B1, D6	0.51	0.7982	
B1, D7	0.69	0.5860	
B1, D8	0.79	0.5578	
B1, D9	1.25	0.4242	MC
B1, D10	1.24	0.2595	
B1, D11	0.76	0.5837	
B1, D13	1.21	0.3113	
B1, PRS	1.57	0.1309	
B1, P1	1.35	0.1893	
B1, P2	1.70	0.1631	
B1, P3	1.05	0.3685	
B2, B3	0.67	0.5705	
B2, D3	Negative		
B2, D4	1.96	0.1194	
B2, D5	2.90	0.0829	
B2, D6	0.77	0.5284	
B2, D7	1.06	0.3570	
B2, D8	1.18	0.3973	
B2, D9	1.27	0.3886	MC
B2, D10	2.11	0.0696	
B2, D11	1.95	0.1273	
B2, D13	**2.82**	**0.0358**	
B2, PRS	1.83	0.1314	
B2, P1	1.33	0.2385	
B2, P2	1.16	0.3234	
B2, P3	**3.43**	**0.0328**	
B3, D3	1.87	0.0875	
B3, D4	1.40	0.2993	
B3, D5	1.46	0.2116	
B3, D6	1.19	0.3242	
B3, D7	1.29	0.2688	
B3, D8	0.94	0.4832	
B3, D9	0.91	0.5521	MC
B3, D10	1.70	0.1589	
B3, D11	1.53	0.1952	
B3, D13	1.96	0.1108	
B3, PRS	2.13	0.0846	
B3, P1	2.22	0.0516	
B3, P2	1.60	0.0825	
B3, P3	1.91	0.1490	
D3, D4	2.23	0.1116	
D3, D5	2.02	0.0892	
D3, D6	2.33	0.0754	
D3, D7	2.16	0.0833	
D3, D8	**2.59**	**0.0442**	
D3, D9	1.66	0.2692	MC
D3, D10	**2.86**	**0.0376**	
D3, D11	**3.41**	**0.0336**	
D3, D13	**3.33**	**0.0414**	
D3, PRS	1.91	0.1614	
D3, P1	**2.79**	**0.0494**	
D3, P2	1.42	0.1698	
D3, P3	2.60	0.0624	
D4, D5	2.04	0.0811	
D4, D6	0.29	0.8124	

Comparisons between Surveys	t	p-value	
D4, D7	1.24	0.3323	
D4, D8	1.05	0.3885	
D4, D9	0.40	0.8220	MC
D4, D10	1.14	0.3611	
D4, D11	0.96	0.4454	
D4, D13	1.14	0.3522	
D4, PRS	0.32	0.8189	
D4, P1	0.84	0.5015	
D4, P2	1.77	0.1146	
D4, P3	1.04	0.3978	
D5, D6	0.77	0.6025	
D5, D7	1.85	0.1312	
D5, D8	1.30	0.2299	
D5, D9	1.60	0.3165	MC
D5, D10	**2.20**	**0.0442**	
D5, D11	2.12	0.1179	
D5, D13	**2.33**	**0.0290**	
D5, PRS	1.32	0.2464	
D5, P1	1.36	0.2353	
D5, P2	2.01	0.0635	
D5, P3	2.40	0.0688	
D6, D7	0.72	0.6660	
D6, D8	0.83	0.6176	
D6, D9	0.86	0.5601	MC
D6, D10	0.64	0.6804	
D6, D11	0.69	0.6522	
D6, D13	0.54	0.7410	
D6, PRS	0.32	0.8510	
D6, P1	0.79	0.5836	
D6, P2	0.90	0.4716	
D6, P3	0.93	0.4982	
D7, D8	0.79	0.5248	
D7, D9	1.33	0.3680	MC
D7, D10	1.60	0.1133	
D7, D11	**2.40**	**0.0434**	
D7, D13	1.41	0.1650	
D7, PRS	0.84	0.5333	
D7, P1	1.70	0.1221	
D7, P2	1.64	0.1477	
D7, P3	1.30	0.2421	
D8, D9	0.52	0.7593	MC
D8, D10	1.11	0.3370	
D8, D11	1.58	0.1912	
D8, D13	1.58	0.1653	
D8, PRS	1.31	0.2440	
D8, P1	1.24	0.2769	
D8, P2	1.47	0.1905	
D8, P3	1.75	0.1214	
D9, D10	0.91	0.5388	MC
D9, D11	1.13	0.4493	MC
D9, D13	1.04	0.4835	MC
D9, PRS	0.40	0.7681	MC
D9, P1	1.27	0.3894	MC
D9, P2	0.88	0.5589	MC
D9, P3	1.00	0.5010	MC
D10, D11	1.28	0.2824	
D10, D13	0.73	0.6748	
D10, PRS	0.60	0.6475	
D10, P1	0.67	0.7343	
D10, P2	1.96	0.0526	
D10, P3	1.87	0.1228	
D11, D13	0.53	0.8015	
D11, PRS	0.56	0.6276	
D11, P1	0.88	0.4648	
D11, P2	**2.14**	**0.0453**	
D11, P3	1.53	0.1795	
D13, PRS	0.64	0.7203	
D13, P1	0.78	0.5257	
D13, P2	**2.27**	**0.0400**	
D13, P3	1.82	0.1127	
PRS, P1	Negative		
PRS, P2	1.31	0.2588	
PRS, P3	0.99	0.4490	
P1, P2	1.66	0.1084	
P1, P3	1.24	0.2721	
P2, P3	2.27	0.0959	
Within level 'WR1' of factor 'Site'			
B1, B2	2.02	0.0812	
B1, B3	**3.63**	**0.0297**	
B1, D1	**2.66**	**0.0441**	
B1, D2	**3.62**	**0.0335**	
B1, D3	1.84	0.1784	
B1, D4	1.44	0.1906	
B1, D5	**2.68**	**0.0291**	
B1, D6	1.54	0.1669	
B1, D7	1.83	0.0937	
B1, D8	1.77	0.0926	
B1, D9	1.37	0.3258	
B1, D10	1.07	0.3669	
B1, D11	1.23	0.2771	
B1, D12	**3.29**	**0.0302**	
B1, D13	1.31	0.1985	
B1, PRS	2.09	0.0655	
B1, P1	**3.26**	**0.0291**	
B1, P2	2.04	0.0737	
B1, P3	2.20	0.0703	
B2, B3	1.38	0.1990	
B2, D1	1.71	0.0891	
B2, D2	2.32	0.0839	
B2, D3	1.30	0.2530	
B2, D4	1.39	0.1680	
B2, D5	**3.32**	**0.0304**	
B2, D6	1.40	0.1614	
B2, D7	0.93	0.4783	
B2, D8	1.47	0.1380	
B2, D9	**1.86**	**0.0388**	
B2, D10	1.25	0.2372	
B2, D11	1.48	0.1600	
B2, D12	1.58	0.0965	
B2, D13	1.32	0.2742	
B2, PRS	**2.50**	**0.0323**	
B2, P1	**2.79**	**0.0305**	
B2, P2	1.59	0.0872	
B2, P3	**2.89**	**0.0400**	
B3, D1	0.64	0.6523	
B3, D2	0.93	0.4198	

Comparisons between Surveys	t	p-value
B3, D3	0.46	0.7861
B3, D4	1.38	0.2234
B3, D5	2.14	0.0616
B3, D6	1.66	0.1638
B3, D7	1.65	0.1595
B3, D8	1.71	0.1281
B3, D9	1.17	0.3974
B3, D10	2.31	0.0950
B3, D11	2.05	0.1112
B3, D12	1.93	0.0829
B3, D13	**2.51**	**0.0324**
B3, PRS	**3.66**	**0.0292**
B3, P1	**4.16**	**0.0263**
B3, P2	1.60	0.1426
B3, P3	**5.65**	**0.0327**
D1, D2	1.21	0.3771
D1, D3	0.72	0.6621
D1, D4	1.32	0.1896
D1, D5	**2.52**	**0.0280**
D1, D6	1.72	0.0875
D1, D7	1.18	0.3269
D1, D8	1.27	0.2552
D1, D9	1.90	0.0631
D1, D10	1.65	0.1610
D1, D11	1.59	0.1600
D1, D12	1.49	0.1556
D1, D13	1.93	0.1069
D1, PRS	**3.21**	**0.0320**
D1, P1	**3.65**	**0.0285**
D1, P2	1.63	0.0964
D1, P3	**3.75**	**0.0342**
D2, D3	1.41	0.1698
D2, D4	1.40	0.2145
D2, D5	2.12	0.1119
D2, D6	**2.88**	**0.0452**
D2, D7	2.10	0.1289
D2, D8	**2.68**	**0.0436**
D2, D9	2.07	0.1029
D2, D10	**3.37**	**0.0470**
D2, D11	**3.35**	**0.0311**
D2, D12	1.97	0.1279
D2, D13	2.34	0.1010
D2, PRS	**4.94**	**0.0269**
D2, P1	**4.51**	**0.0279**
D2, P2	2.42	0.0526
D2, P3	**4.02**	**0.0414**
D3, D4	0.74	0.5533
D3, D5	1.29	0.2685
D3, D6	1.32	0.2553
D3, D7	1.07	0.3284
D3, D8	1.45	0.2273
D3, D9	1.17	0.3850
D3, D10	1.60	0.1801
D3, D11	2.23	0.0902
D3, D12	1.07	0.3806
D3, D13	1.58	0.2307
D3, PRS	2.86	0.0616
D3, P1	2.85	0.0656
D3, P2	2.03	0.0882
D3, P3	2.10	0.1334
D4, D5	1.20	0.3304
D4, D6	0.54	0.7919
D4, D7	0.43	0.7492
D4, D8	0.35	0.8643
D4, D9	0.42	0.9077
D4, D10	0.72	0.5279
D4, D11	0.79	0.5193
D4, D12	1.00	0.4095
D4, D13	1.18	0.3181
D4, PRS	2.09	0.1214
D4, P1	2.14	0.0832
D4, P2	0.78	0.6951
D4, P3	2.22	0.0924
D5, D6	1.33	0.2734
D5, D7	0.27	0.8878
D5, D8	0.77	0.6129
D5, D9	0.92	0.5368
D5, D10	1.35	0.2398
D5, D11	1.26	0.3420
D5, D12	1.65	0.0835
D5, D13	2.09	0.0765
D5, PRS	**3.29**	**0.0289**
D5, P1	**3.30**	**0.0279**
D5, P2	0.75	0.6630
D5, P3	**3.52**	**0.0337**
D6, D7	0.53	0.7243
D6, D8	0.83	0.5946
D6, D9	0.68	0.6806
D6, D10	0.95	0.4735
D6, D11	1.21	0.3017
D6, D12	1.40	0.2175
D6, D13	0.88	0.4391
D6, PRS	**3.60**	**0.0312**
D6, P1	**2.96**	**0.0314**
D6, P2	1.20	0.2866
D6, P3	2.56	0.0643
D7, D8	0.53	0.8213
D7, D9	0.37	0.7704
D7, D10	1.31	0.2981
D7, D11	1.29	0.2160
D7, D12	1.07	0.3887
D7, D13	1.27	0.2517
D7, PRS	2.46	0.0624
D7, P1	2.17	0.0912
D7, P2	0.33	0.8477
D7, P3	**2.53**	**0.0451**
D8, D9	Negative	
D8, D10	1.18	0.3612
D8, D11	1.61	0.1359
D8, D12	1.25	0.2467
D8, D13	1.02	0.3941
D8, PRS	**2.88**	**0.0303**
D8, P1	**2.33**	**0.0499**
D8, P2	0.91	0.6025
D8, P3	2.05	0.1320
D9, D10	0.10	0.9125

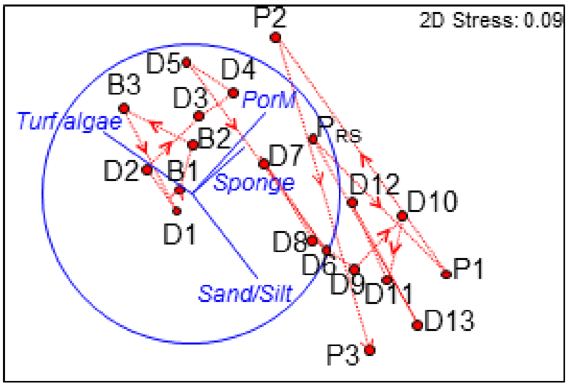
Comparisons between Surveys	t	p-value
D9, D11	0.52	0.6676
D9, D12	0.79	0.5152
D9, D13	0.61	0.6291
D9, PRS	1.77	0.1261
D9, P1	1.90	0.1157
D9, P2	0.74	0.6844
D9, P3	1.50	0.2466
D10, D11	1.11	0.3371
D10, D12	2.44	0.0907
D10, D13	0.63	0.6542
D10, PRS	**2.39**	**0.0336**
D10, P1	1.71	0.1320
D10, P2	0.87	0.4742
D10, P3	1.80	0.1306
D11, D12	1.93	0.1345
D11, D13	0.81	0.5529
D11, PRS	1.62	0.1444
D11, P1	1.21	0.4247
D11, P2	1.16	0.3103
D11, P3	0.74	0.5707
D12, D13	3.13	0.0655
D12, PRS	**6.65**	**0.0271**
D12, P1	**3.79**	**0.0302**
D12, P2	0.89	0.4982
D12, P3	**9.77**	**0.0131**
D13, PRS	2.36	0.0817
D13, P1	1.75	0.1211
D13, P2	0.97	0.4045
D13, P3	1.74	0.1661
PRS, P1	1.18	0.2998
PRS, P2	3.08	0.0612
PRS, P3	0.99	0.4226
P1, P2	3.36	0.0506
P1, P3	1.18	0.3170
P2, P3	1.73	0.1756
Within level 'WR2' of factor 'Site'		
B1, B2	0.42	0.7182
B1, B3	**2.08**	**0.0449**
B1, D1	2.31	0.0672
B1, D2	1.34	0.2563
B1, D3	1.89	0.1268
B1, D4	1.48	0.1867
B1, D5	0.98	0.4894
B1, D6	1.47	0.1573
B1, D7	1.37	0.2221
B1, D8	1.24	0.2587
B1, D9	1.60	0.1192
B1, D10	0.75	0.6957
B1, D11	1.15	0.3092
B1, D12	1.42	0.2040
B1, D13	1.07	0.4555
B1, PRS	1.51	0.1461
B1, P1	1.26	0.2689
B1, P2	1.26	0.2241
B1, P3	0.94	0.5495
B2, B3	1.84	0.1260
B2, D1	2.08	0.1139
B2, D2	1.60	0.1517
B2, D3	1.60	0.1785
B2, D4	1.46	0.2008
B2, D5	1.39	0.1653
B2, D6	1.20	0.3004
B2, D7	1.30	0.3119
B2, D8	1.20	0.2905
B2, D9	1.01	0.4155
B2, D10	0.71	0.6478
B2, D11	1.44	0.2062
B2, D12	1.47	0.1564
B2, D13	0.96	0.4276
B2, PRS	1.99	0.0927
B2, P1	1.49	0.1944
B2, P2	1.06	0.4055
B2, P3	0.86	0.5556
B3, D1	Negative	
B3, D2	**4.03**	**0.0344**
B3, D3	**3.33**	**0.0330**
B3, D4	**2.84**	**0.0303**
B3, D5	**4.03**	**0.0295**
B3, D6	**2.63**	**0.0294**
B3, D7	**2.87**	**0.0470**
B3, D8	**3.78**	**0.0299**
B3, D9	2.14	0.0700
B3, D10	1.99	0.0669
B3, D11	2.68	0.0556
B3, D12	**4.14**	**0.0241**
B3, D13	**2.34**	**0.0382**
B3, PRS	**4.75**	**0.0304**
B3, P1	**3.00**	**0.0346**
B3, P2	2.14	0.0576
B3, P3	1.96	0.0523
D1, D2	0.92	0.4640
D1, D3	0.65	0.7143
D1, D4	0.56	0.7945
D1, D5	1.38	0.2205
D1, D6	**2.85**	**0.0264**
D1, D7	**3.13**	**0.0342**
D1, D8	1.93	0.1049
D1, D9	1.32	0.1846
D1, D10	1.15	0.3083
D1, D11	2.68	0.0550
D1, D12	1.05	0.3812
D1, D13	**2.45**	**0.0359**
D1, PRS	**4.88**	**0.0281**
D1, P1	**3.28**	**0.0293**
D1, P2	1.89	0.0717
D1, P3	**2.31**	**0.0309**
D2, D3	1.65	0.1681
D2, D4	0.89	0.4689
D2, D5	0.86	0.5337
D2, D6	2.02	0.1060
D2, D7	2.65	0.1033
D2, D8	1.39	0.2119
D2, D9	1.00	0.4378
D2, D10	0.89	0.4599
D2, D11	2.35	0.0960
D2, D12	0.85	0.5613

Comparisons between Surveys	t	p-value
D2, D13	1.81	0.1677
D2, PRS	**4.44**	**0.0324**
D2, P1	3.27	0.0694
D2, P2	1.14	0.4050
D2, P3	1.62	0.1896
D3, D4	1.13	0.3510
D3, D5	1.49	0.2180
D3, D6	2.49	0.0892
D3, D7	3.08	0.0700
D3, D8	2.44	0.0924
D3, D9	1.08	0.3430
D3, D10	1.59	0.1660
D3, D11	2.82	0.0683
D3, D12	0.84	0.4998
D3, D13	2.26	0.1104
D3, PRS	**4.96**	**0.0395**
D3, P1	3.73	0.0664
D3, P2	2.37	0.0833
D3, P3	2.23	0.1150
D4, D5	1.36	0.2700
D4, D6	2.08	0.1242
D4, D7	3.01	0.0695
D4, D8	1.78	0.1592
D4, D9	0.64	0.5658
D4, D10	1.44	0.1985
D4, D11	**2.69**	**0.0483**
D4, D12	0.62	0.6045
D4, D13	2.05	0.1336
D4, PRS	3.50	0.0532
D4, P1	**3.78**	**0.0386**
D4, P2	1.73	0.1410
D4, P3	1.61	0.2004
D5, D6	1.66	0.1563
D5, D7	**3.12**	**0.0296**
D5, D8	1.09	0.3612
D5, D9	0.59	0.7923
D5, D10	0.72	0.7184
D5, D11	**2.75**	**0.0402**
D5, D12	1.11	0.3595
D5, D13	1.87	0.1389
D5, PRS	**7.97**	**0.0125**
D5, P1	**6.35**	**0.0141**
D5, P2	1.15	0.3160
D5, P3	1.13	0.3518
D6, D7	1.56	0.1489
D6, D8	1.73	0.1259
D6, D9	**2.54**	**0.0296**
D6, D10	1.24	0.2723
D6, D11	1.03	0.4244
D6, D12	**2.71**	**0.0413**
D6, D13	1.28	0.2184
D6, PRS	2.14	0.0815
D6, P1	1.30	0.2152
D6, P2	1.76	0.0930
D6, P3	1.26	0.2615
D7, D8	**3.06**	**0.0272**
D7, D9	1.94	0.1217
D7, D10	1.88	0.1217
D7, D11	1.14	0.3042
D7, D12	**3.99**	**0.0302**
D7, D13	0.82	0.6319
D7, PRS	1.89	0.0677
D7, P1	0.90	0.5382
D7, P2	2.02	0.0928
D7, P3	0.87	0.4952
D8, D9	0.83	0.5239
D8, D10	0.68	0.7413
D8, D11	**2.59**	**0.0462**
D8, D12	1.59	0.1621
D8, D13	1.76	0.1354
D8, PRS	**4.74**	**0.0236**
D8, P1	**4.70**	**0.0244**
D8, P2	1.21	0.2796
D8, P3	0.77	0.5910
D9, D10	0.56	0.6727
D9, D11	1.80	0.1519
D9, D12	0.72	0.7572
D9, D13	1.84	0.0920
D9, PRS	3.47	0.0640
D9, P1	2.31	0.0959
D9, P2	1.23	0.2885
D9, P3	1.39	0.2160
D10, D11	1.56	0.1549
D10, D12	0.57	0.5742
D10, D13	1.05	0.3891
D10, PRS	3.01	0.0564
D10, P1	2.46	0.0551
D10, P2	1.14	0.2977
D10, P3	0.30	0.8280
D11, D12	2.82	0.0532
D11, D13	1.08	0.4531
D11, PRS	1.91	0.0972
D11, P1	1.72	0.0746
D11, P2	1.82	0.0978
D11, P3	0.61	0.6826
D12, D13	**2.89**	**0.0432**
D12, PRS	Negative	
D12, P1	**4.23**	**0.0251**
D12, P2	1.98	0.0952
D12, P3	2.16	0.0600
D13, PRS	1.88	0.1047
D13, P1	1.05	0.4542
D13, P2	1.66	0.1291
D13, P3	0.85	0.5610
PRS, P1	2.52	0.0769
PRS, P2	**4.61**	**0.0336**
PRS, P3	2.75	0.0919
P1, P2	**2.89**	**0.0382**
P1, P3	1.04	0.3646
P2, P3	1.08	0.4388

c. nMDS ordinations for the entire benthic composition showing the differences between Surveys at each site.

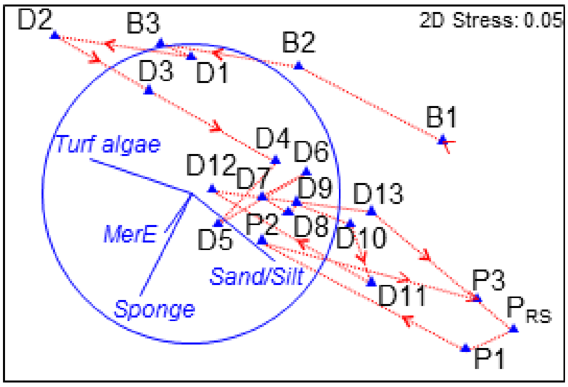
Reactive Monitoring Sites

Channel Island

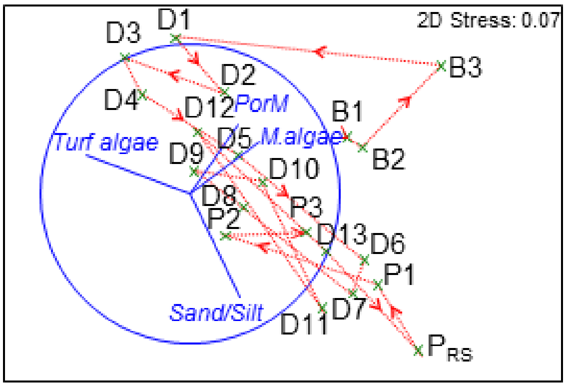


⇢	Trajectory
—	Vectors
DendE	Dendrophylliidae Encrusting
M.algae	Macroalgae
MerE	Merulinidae Encrusting
MerM	Merulinidae Massive
PorM	Poritidae Massive

Weed Reef 1

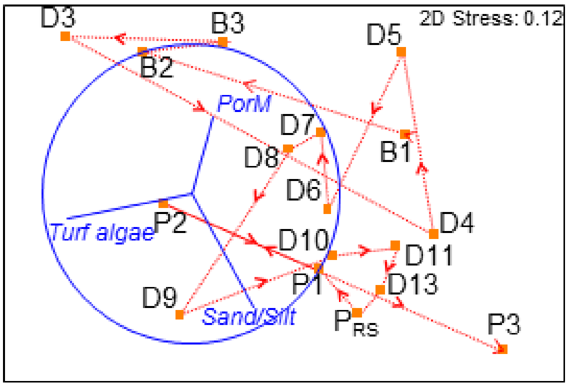


Weed Reef 2

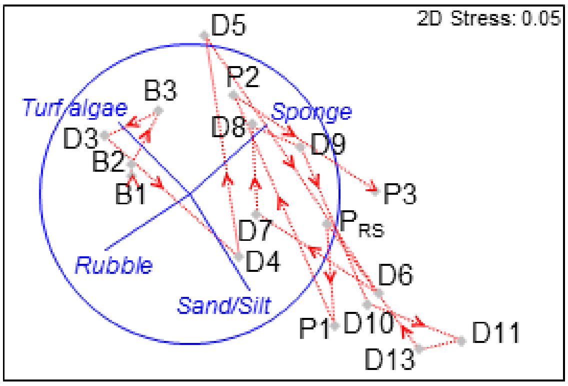


Informative Monitoring Sites

South Shell Island

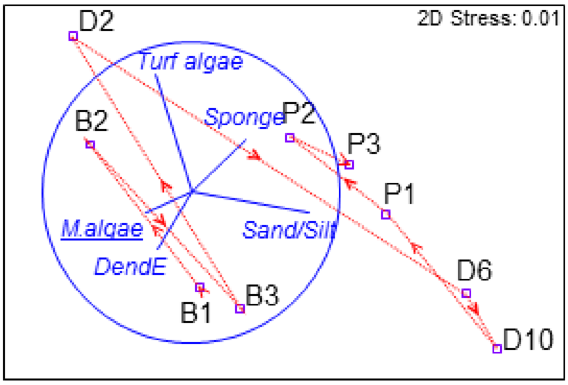


Northeast Wickham Point



Contingency Monitoring Site

Mandorah



d. Matrix of pair-wise comparisons between sites for each survey for the significant Survey x Site term. Surveys in which the site comparisons are significantly different are highlighted in bold.

	CHI	WR1	WR2	SSI	NEW
WR1	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3				
WR2	B1, B2, **B3**, D1, D2, D3, D4, D5, D6, **D7**, D8, D9, D10, D11, D12, D13, **P_{RS}**, **P1**, **P2**, P3	B1, **B2**, **B3**, D1, **D2**, D3, D4, **D5**, **D6**, **D7**, D8, D9, D10, **D11**, D12, D13, **P_{RS}**, P1, P2, P3			
SSI	B1, B2, B3, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	B1, B2, **B3**, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	B1, **B2**, **B3**, D3, D4, D5, D6, **D7**, **D8**, D9, D10, **D11**, D13, **P_{RS}**, **P1**, **P2**, P3		
NEW	B1, B2, B3, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	B1, B2, B3, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	B1, B2, **B3**, D3, D4, **D5**, D6, **D7**, **D8**, D9, D10, D11, D13, **P_{RS}**, P1, **P2**, P3	B1, B2, **B3**, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	
MAN	**B1**, **B2**, **B3**, **D2**, **D6**, **D10**, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, **D2**, **D6**, **D10**, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, **D2**, **D6**, **D10**, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, D6, **D10**, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, **D6**, **D10**, **P1**, **P2**, **P3**

Appendix D-2 Multivariate analysis using PERMANOVA testing for differences in the percent cover of corals grouped by family among Sites (CHI, WR1, WR2, SSI, NEW and MAN) and across surveys (B1 to P3). Significant (p(perm) ≤ 0.05) terms in bold. RED = redundant terms due to significant interaction. Baseline versus Post-dredging pair-wise comparisons highlighted in teal

a. PERMANOVA analysis

Source of Variation	df	SS	MS	Pseudo-F	p(perm)
Survey	19	10225	538	1.05	RED
Site	5	432920	86584	4.14	RED
Transect (Site)	18	383040	21280	52.29	
Survey x Site	**78**	**40101**	**514**	**1.26**	**0.0010**
Residual	289	117610	407		
Total	409	1005100			

b. Pair-wise tests between surveys for each site for the significant Survey x Site term

Comparisons between Surveys	t	p-value
Within level 'CHI' of factor 'Site'		
B1, B2	1.43	0.2012
B1, B3	1.43	0.2266
B1, D1	1.27	0.2791
B1, D2	1.18	0.3391
B1, D3	Negative	
B1, D4	0.95	0.4991
B1, D5	1.11	0.3724
B1, D6	0.77	0.5787
B1, D7	1.08	0.3936
B1, D8	0.81	0.5256
B1, D9	0.92	0.5405
B1, D10	0.87	0.5105
B1, D11	0.54	0.6767
B1, D12	1.87	0.1413
B1, D13	1.04	0.4500
B1, PRS	1.36	0.2336
B1, P1	2.02	0.0750
B1, P2	1.46	0.2134
B1, P3	0.89	0.5276
B2, B3	0.79	0.6496
B2, D1	0.90	0.5784
B2, D2	1.64	0.1382
B2, D3	0.62	0.6960
B2, D4	0.94	0.5296
B2, D5	0.49	0.8168
B2, D6	0.83	0.5471
B2, D7	1.11	0.3644
B2, D8	0.88	0.5955
B2, D9	0.46	0.7027
B2, D10	1.09	0.4094
B2, D11	1.04	0.4677
B2, D12	1.25	0.2988
B2, D13	1.38	0.2664
B2, PRS	1.33	0.2671
B2, P1	1.81	0.1246
B2, P2	1.45	0.2308
B2, P3	0.83	0.7417
B3, D1	1.91	0.1678
B3, D2	2.22	0.0769
B3, D3	0.83	0.5934
B3, D4	0.99	0.4773
B3, D5	0.92	0.5206
B3, D6	1.10	0.3783
B3, D7	1.57	0.1453
B3, D8	1.25	0.2520
B3, D9	1.03	0.3808
B3, D10	1.16	0.3466
B3, D11	1.37	0.2009
B3, D12	2.48	0.0602
B3, D13	1.82	0.1424
B3, PRS	2.25	0.1488
B3, P1	2.04	0.0686
B3, P2	1.74	0.1360
B3, P3	1.74	0.1720
D1, D2	0.97	0.4892
D1, D3	0.79	0.5585
D1, D4	0.89	0.5181
D1, D5	0.34	0.8473
D1, D6	0.95	0.5214
D1, D7	1.61	0.1351
D1, D8	1.23	0.4020
D1, D9	0.62	0.5475
D1, D10	0.90	0.5320
D1, D11	1.43	0.2273
D1, D12	1.17	0.2965
D1, D13	1.75	0.1277
D1, PRS	1.77	0.1023
D1, P1	**2.38**	**0.0404**
D1, P2	1.89	0.0949
D1, P3	0.46	0.8628
D2, D3	1.13	0.3760
D2, D4	1.68	0.1195
D2, D5	0.87	0.5722
D2, D6	1.92	0.1088
D2, D7	1.70	0.1273
D2, D8	1.91	0.0853
D2, D9	1.89	0.1427
D2, D10	1.91	0.1837
D2, D11	2.65	0.0810

Comparisons between Surveys	t	p-value
D2, D12	1.37	0.2350
D2, D13	2.23	0.1014
D2, PRS	2.17	0.0801
D2, P1	**4.70**	**0.0296**
D2, P2	2.68	0.0637
D2, P3	0.99	0.4770
D3, D4	0.98	0.4225
D3, D5	0.64	0.6546
D3, D6	0.60	0.7280
D3, D7	Negative	
D3, D8	0.90	0.5421
D3, D9	1.48	0.2025
D3, D10	0.70	0.6824
D3, D11	0.45	0.8592
D3, D12	1.00	0.5183
D3, D13	1.45	0.1429
D3, PRS	0.72	0.6751
D3, P1	1.03	0.3834
D3, P2	2.28	0.0961
D3, P3	0.61	0.7936
D4, D5	0.66	0.5367
D4, D6	0.58	0.7677
D4, D7	0.92	0.5003
D4, D8	0.68	0.5970
D4, D9	1.74	0.1977
D4, D10	0.93	0.5337
D4, D11	1.24	0.2940
D4, D12	0.73	0.5070
D4, D13	1.38	0.2695
D4, PRS	0.78	0.5153
D4, P1	1.03	0.4074
D4, P2	1.55	0.1686
D4, P3	0.95	0.5042
D5, D6	0.63	0.6546
D5, D7	1.07	0.4182
D5, D8	0.57	0.6458
D5, D9	0.34	0.7873
D5, D10	0.51	0.6945
D5, D11	0.67	0.5792
D5, D12	0.92	0.5849
D5, D13	1.12	0.4466
D5, PRS	1.33	0.2227
D5, P1	1.09	0.4620
D5, P2	1.58	0.1886
D5, P3	0.66	0.7525
D6, D7	Negative	
D6, D8	1.00	0.4655
D6, D9	1.70	0.1233
D6, D10	0.66	0.6333
D6, D11	0.98	0.4516
D6, D12	1.38	0.2484
D6, D13	1.54	0.1916
D6, PRS	1.43	0.2213
D6, P1	1.06	0.4210
D6, P2	1.96	0.1199
D6, P3	0.86	0.5593
D7, D8	0.90	0.5006
D7, D9	1.79	0.1018

Comparisons between Surveys	t	p-value
D7, D10	0.84	0.6312
D7, D11	Negative	
D7, D12	1.48	0.1782
D7, D13	1.13	0.3730
D7, PRS	1.20	0.2993
D7, P1	0.95	0.4991
D7, P2	1.40	0.2190
D7, P3	1.06	0.3966
D8, D9	0.81	0.5574
D8, D10	0.99	0.4925
D8, D11	1.49	0.2037
D8, D12	1.06	0.4150
D8, D13	1.35	0.2795
D8, PRS	1.41	0.2238
D8, P1	1.34	0.2658
D8, P2	1.58	0.1644
D8, P3	0.84	0.5672
D9, D10	1.73	0.1185
D9, D11	1.66	0.1645
D9, D12	0.97	0.4158
D9, D13	2.70	0.0873
D9, PRS	1.56	0.1534
D9, P1	2.56	0.0823
D9, P2	2.47	0.0837
D9, P3	0.29	0.8350
D10, D11	1.72	0.1062
D10, D12	0.76	0.5310
D10, D13	0.94	0.4191
D10, PRS	0.73	0.6447
D10, P1	0.79	0.6751
D10, P2	1.41	0.2573
D10, P3	0.79	0.5635
D11, D12	1.22	0.3370
D11, D13	1.85	0.1574
D11, PRS	0.79	0.6175
D11, P1	1.56	0.2199
D11, P2	1.96	0.1133
D11, P3	1.04	0.4186
D12, D13	1.71	0.1871
D12, PRS	2.32	0.0856
D12, P1	1.47	0.2042
D12, P2	1.98	0.1072
D12, P3	1.04	0.4402
D13, PRS	1.29	0.3090
D13, P1	1.71	0.1884
D13, P2	2.12	0.0908
D13, P3	1.17	0.3182
PRS, P1	0.96	0.4699
PRS, P2	1.39	0.2164
PRS, P3	1.91	0.1249
P1, P2	1.10	0.4046
P1, P3	1.64	0.1390
P2, P3	1.65	0.1737
Within level 'MAN' of factor 'Site'		
B1, B2	1.31	0.3330
B1, B3	0.87	0.5846
B1, D2	0.90	0.5806
B1, D6	1.09	0.4013

Comparisons between Surveys	t	p-value
B1, D10	1.63	0.1383
B1, P1	1.84	0.1209
B1, P2	2.06	0.0803
B1, P3	2.29	0.0762
B2, B3	0.88	0.5527
B2, D2	2.73	0.0661
B2, D6	1.93	0.1041
B2, D10	1.52	0.1947
B2, P1	2.00	0.0912
B2, P2	2.06	0.0601
B2, P3	3.14	0.0591
B3, D2	0.79	0.6107
B3, D6	1.01	0.4729
B3, D10	1.37	0.2365
B3, P1	2.27	0.0977
B3, P2	1.88	0.1003
B3, P3	1.84	0.1057
D2, D6	1.38	0.3031
D2, D10	1.64	0.1669
D2, P1	1.75	0.1452
D2, P2	1.84	0.0963
D2, P3	3.40	0.0560
D6, D10	1.12	0.3990
D6, P1	1.78	0.1168
D6, P2	1.54	0.1789
D6, P3	**3.07**	**0.0492**
D10, P1	0.82	0.4999
D10, P2	0.86	0.6272
D10, P3	0.93	0.5486
P1, P2	0.68	0.6111
P1, P3	0.56	0.7513
P2, P3	0.93	0.5037
Within level 'NEW' of factor 'Site'		
B1, B2	0.50	0.7311
B1, B3	0.57	0.7703
B1, D3	0.71	0.6934
B1, D4	0.57	0.8359
B1, D5	1.65	0.1681
B1, D6	0.50	0.9037
B1, D7	1.00	0.4525
B1, D8	0.95	0.5104
B1, D9	0.16	0.8813
B1, D10	0.94	0.4945
B1, D11	0.45	0.7659
B1, D13	0.71	0.6871
B1, PRS	0.91	0.5841
B1, P1	0.54	0.8382
B1, P2	0.88	0.5600
B1, P3	1.84	0.0934
B2, B3	1.09	0.4348
B2, D3	0.72	0.7060
B2, D4	Negative	
B2, D5	1.17	0.3638
B2, D6	0.20	0.8819
B2, D7	1.18	0.3409
B2, D8	0.94	0.5292
B2, D9	0.58	0.8341
B2, D10	0.72	0.6195
B2, D11	0.53	0.7806
B2, D13	0.83	0.6390
B2, PRS	0.89	0.5130
B2, P1	0.49	0.8352
B2, P2	0.86	0.5374
B2, P3	1.34	0.2059
B3, D3	0.80	0.6482
B3, D4	0.49	0.7608
B3, D5	1.12	0.3756
B3, D6	0.63	0.8554
B3, D7	1.27	0.2641
B3, D8	1.30	0.2170
B3, D9	0.75	0.5820
B3, D10	0.98	0.4233
B3, D11	0.61	0.7946
B3, D13	0.76	0.7852
B3, PRS	1.16	0.2927
B3, P1	0.89	0.5816
B3, P2	1.12	0.4104
B3, P3	1.87	0.1225
D3, D4	0.88	0.6625
D3, D5	0.94	0.5069
D3, D6	1.05	0.4182
D3, D7	0.97	0.4782
D3, D8	1.13	0.3552
D3, D9	0.84	0.5961
D3, D10	1.08	0.3888
D3, D11	0.79	0.6863
D3, D13	0.74	0.7468
D3, PRS	1.49	0.2135
D3, P1	0.83	0.6913
D3, P2	0.87	0.5343
D3, P3	1.46	0.1774
D4, D5	0.97	0.5010
D4, D6	0.72	0.6963
D4, D7	0.64	0.8536
D4, D8	1.06	0.4528
D4, D9	0.80	0.7195
D4, D10	1.02	0.4693
D4, D11	0.27	0.9167
D4, D13	0.59	0.7923
D4, PRS	1.45	0.2255
D4, P1	0.61	0.8129
D4, P2	0.87	0.5292
D4, P3	1.50	0.1716
D5, D6	1.00	0.4893
D5, D7	1.01	0.4963
D5, D8	1.08	0.3317
D5, D9	1.07	0.3809
D5, D10	0.89	0.5209
D5, D11	0.79	0.5898
D5, D13	0.09	0.9145
D5, PRS	1.04	0.4793
D5, P1	1.03	0.3970
D5, P2	1.08	0.4481
D5, P3	2.14	0.0747
D6, D7	0.89	0.5946
D6, D8	1.29	0.2729

Comparisons between Surveys	t	p-value	
D6, D9	0.91	0.6034	
D6, D10	1.03	0.4386	
D6, D11	0.74	0.7238	
D6, D13	0.75	0.6945	
D6, PRS	1.99	0.1350	
D6, P1	1.03	0.4817	
D6, P2	0.96	0.4965	
D6, P3	1.47	0.2000	
D7, D8	0.76	0.5766	
D7, D9	1.03	0.4296	
D7, D10	0.50	0.7754	
D7, D11	0.65	0.8343	
D7, D13	0.70	0.7705	
D7, PRS	0.90	0.5431	
D7, P1	0.72	0.7387	
D7, P2	0.76	0.6784	
D7, P3	1.17	0.2993	
D8, D9	1.40	0.1749	
D8, D10	0.87	0.5516	
D8, D11	1.40	0.1769	
D8, D13	0.96	0.5049	
D8, PRS	1.13	0.3452	
D8, P1	1.04	0.4205	
D8, P2	0.83	0.5709	
D8, P3	1.16	0.3050	
D9, D10	1.21	0.3561	
D9, D11	1.44	0.2159	
D9, D13	0.75	0.6858	
D9, PRS	1.19	0.2871	
D9, P1	1.02	0.4465	
D9, P2	0.94	0.5563	
D9, P3	1.69	0.1645	
D10, D11	0.80	0.6838	
D10, D13	0.66	0.7164	
D10, PRS	0.99	0.4913	
D10, P1	1.04	0.4787	
D10, P2	0.78	0.6172	
D10, P3	1.57	0.1195	
D11, D13	0.67	0.7370	
D11, PRS	1.08	0.3556	
D11, P1	1.29	0.2573	
D11, P2	0.95	0.5248	
D11, P3	1.64	0.1964	
D13, PRS	0.96	0.5030	
D13, P1	1.03	0.4367	
D13, P2	0.88	0.6323	
D13, P3	1.70	0.1135	
PRS, P1	1.10	0.4071	
PRS, P2	0.85	0.6015	
PRS, P3	1.49	0.1631	
P1, P2	0.79	0.5704	
P1, P3	1.31	0.2257	
P2, P3	1.27	0.3016	
Within level 'SSI' of factor 'Site'			
B1, B2	Negative		
B1, B3	0.44	0.8107	
B1, D3	0.75	0.7022	
B1, D4	0.73	0.7316	
B1, D5	1.31	0.2329	
B1, D6	1.42	0.1702	
B1, D7	1.29	0.3009	
B1, D8	1.08	0.4343	
B1, D9	4.29	0.0857	MC
B1, D10	1.19	0.3015	
B1, D11	1.25	0.2548	
B1, D13	1.26	0.2777	
B1, PRS	1.35	0.2962	
B1, P1	1.47	0.2147	
B1, P2	**2.03**	**0.0430**	
B1, P3	1.66	0.0841	
B2, B3	Negative		
B2, D3	0.91	0.4917	
B2, D4	0.82	0.5784	
B2, D5	1.97	0.1325	
B2, D6	2.24	0.0562	
B2, D7	**3.91**	**0.0343**	
B2, D8	1.51	0.1960	
B2, D9	2.23	0.1971	MC
B2, D10	1.17	0.3586	
B2, D11	1.48	0.2326	
B2, D13	1.38	0.2430	
B2, PRS	1.34	0.3194	
B2, P1	1.46	0.2089	
B2, P2	1.98	0.0614	
B2, P3	1.69	0.0944	
B3, D3	0.61	0.8288	
B3, D4	0.69	0.7124	
B3, D5	1.25	0.2593	
B3, D6	1.36	0.1898	
B3, D7	1.08	0.3856	
B3, D8	0.96	0.5156	
B3, D9	1.62	0.3022	MC
B3, D10	1.11	0.4207	
B3, D11	1.23	0.2766	
B3, D13	1.29	0.2575	
B3, PRS	1.29	0.3311	
B3, P1	1.43	0.2161	
B3, P2	**2.03**	**0.0348**	
B3, P3	1.80	0.0792	
D3, D4	0.93	0.5210	
D3, D5	1.29	0.2319	
D3, D6	1.79	0.0967	
D3, D7	1.23	0.3255	
D3, D8	1.83	0.1905	
D3, D9	1.51	0.3148	MC
D3, D10	1.45	0.1763	
D3, D11	1.62	0.1842	
D3, D13	1.62	0.1423	
D3, PRS	1.51	0.2796	
D3, P1	1.36	0.2974	
D3, P2	1.95	0.0535	
D3, P3	1.95	0.0671	
D4, D5	0.17	0.9146	
D4, D6	0.91	0.4568	
D4, D7	0.70	0.6077	
D4, D8	0.71	0.5710	

Comparisons between Surveys	t	p-value	
D4, D9	1.01	0.5033	MC
D4, D10	1.16	0.3398	
D4, D11	0.92	0.5450	
D4, D13	1.23	0.4103	
D4, PRS	0.94	0.5128	
D4, P1	0.62	0.5620	
D4, P2	1.53	0.1675	
D4, P3	1.49	0.1743	
D5, D6	1.32	0.2567	
D5, D7	0.80	0.5991	
D5, D8	0.93	0.4538	
D5, D9	0.77	0.6247	MC
D5, D10	0.81	0.6027	
D5, D11	Negative		
D5, D13	1.13	0.4454	
D5, PRS	0.67	0.6069	
D5, P1	0.77	0.6469	
D5, P2	1.41	0.2002	
D5, P3	1.20	0.2759	
D6, D7	1.40	0.1913	
D6, D8	1.11	0.3420	
D6, D9	0.75	0.6163	MC
D6, D10	0.73	0.5534	
D6, D11	1.39	0.2052	
D6, D13	1.30	0.3409	
D6, PRS	0.87	0.5652	
D6, P1	1.09	0.3788	
D6, P2	2.00	0.0736	
D6, P3	1.45	0.1286	
D7, D8	1.02	0.4538	
D7, D9	0.71	0.6539	MC
D7, D10	1.09	0.4460	
D7, D11	1.11	0.4096	
D7, D13	1.31	0.2726	
D7, PRS	1.10	0.4246	
D7, P1	1.27	0.2464	
D7, P2	1.82	0.0821	
D7, P3	1.55	0.1085	
D8, D9	0.56	0.7473	MC
D8, D10	1.31	0.2020	
D8, D11	1.19	0.4189	
D8, D13	1.35	0.3118	
D8, PRS	1.07	0.4743	
D8, P1	1.08	0.4208	
D8, P2	1.74	0.0775	
D8, P3	1.45	0.1894	
D9, D10	0.94	0.5317	MC
D9, D11	0.96	0.5209	MC
D9, D13	1.46	0.3415	MC
D9, PRS	1.18	0.4382	MC
D9, P1	1.43	0.3458	MC
D9, P2	1.31	0.4062	MC
D9, P3	1.17	0.4497	MC
D10, D11	0.69	0.7304	
D10, D13	1.03	0.4770	
D10, PRS	0.69	0.7167	
D10, P1	Negative		
D10, P2	0.92	0.5241	
D10, P3	1.03	0.4681	
D11, D13	0.95	0.4986	
D11, PRS	0.87	0.5036	
D11, P1	0.23	0.6464	
D11, P2	1.80	0.2045	
D11, P3	1.49	0.1995	
D13, PRS	0.92	0.5341	
D13, P1	0.81	0.6238	
D13, P2	1.11	0.4204	
D13, P3	1.27	0.2290	
PRS, P1	0.89	0.5136	
PRS, P2	1.52	0.1267	
PRS, P3	1.68	0.1329	
P1, P2	1.56	0.2271	
P1, P3	1.30	0.2317	
P2, P3	0.74	0.6532	
Within level 'WR1' of factor 'Site'			
B1, B2	2.24	0.1119	
B1, B3	0.86	0.6213	
B1, D1	1.35	0.2194	
B1, D2	2.17	0.0755	
B1, D3	1.47	0.2162	
B1, D4	0.94	0.4863	
B1, D5	1.04	0.4328	
B1, D6	1.40	0.2791	
B1, D7	1.68	0.1749	
B1, D8	1.43	0.1904	
B1, D9	**3.68**	**0.0289**	
B1, D10	0.85	0.5617	
B1, D11	1.44	0.1678	
B1, D12	2.27	0.0842	
B1, D13	1.24	0.3003	
B1, PRS	1.49	0.1679	
B1, P1	0.94	0.5689	
B1, P2	1.56	0.1792	
B1, P3	1.79	0.1245	
B2, B3	0.88	0.6422	
B2, D1	1.35	0.1910	
B2, D2	0.61	0.8118	
B2, D3	1.67	0.0856	
B2, D4	0.57	0.8281	
B2, D5	1.33	0.2326	
B2, D6	0.63	0.8065	
B2, D7	1.07	0.4362	
B2, D8	1.58	0.1619	
B2, D9	0.99	0.4847	
B2, D10	1.18	0.3220	
B2, D11	1.22	0.2894	
B2, D12	1.65	0.0976	
B2, D13	0.89	0.5441	
B2, PRS	1.10	0.3933	
B2, P1	1.18	0.3449	
B2, P2	0.84	0.6117	
B2, P3	0.82	0.6555	
B3, D1	Negative		
B3, D2	Negative		
B3, D3	0.15	0.8191	
B3, D4	0.41	0.7518	

Comparisons between Surveys	t	p-value
B3, D5	0.80	0.6525
B3, D6	1.09	0.3743
B3, D7	0.67	0.7240
B3, D8	1.07	0.3738
B3, D9	0.98	0.4244
B3, D10	0.52	0.7780
B3, D11	0.35	0.8504
B3, D12	1.21	0.2516
B3, D13	0.81	0.5877
B3, PRS	0.90	0.5790
B3, P1	0.29	0.7853
B3, P2	0.88	0.5446
B3, P3	0.97	0.5147
D1, D2	1.32	0.2170
D1, D3	0.92	0.5854
D1, D4	0.27	0.8441
D1, D5	0.72	0.5832
D1, D6	1.13	0.3728
D1, D7	0.97	0.4605
D1, D8	1.03	0.4133
D1, D9	1.23	0.3043
D1, D10	0.94	0.5196
D1, D11	1.13	0.3355
D1, D12	0.91	0.5057
D1, D13	0.92	0.5237
D1, PRS	1.02	0.4642
D1, P1	0.89	0.5749
D1, P2	1.12	0.4446
D1, P3	1.07	0.4489
D2, D3	1.84	0.1181
D2, D4	0.38	0.8581
D2, D5	0.42	0.7982
D2, D6	0.87	0.4467
D2, D7	0.52	0.8107
D2, D8	1.43	0.1764
D2, D9	0.93	0.4624
D2, D10	1.61	0.2046
D2, D11	1.32	0.2021
D2, D12	1.37	0.2119
D2, D13	1.22	0.3146
D2, PRS	1.23	0.2795
D2, P1	0.78	0.7826
D2, P2	0.95	0.5442
D2, P3	1.20	0.3109
D3, D4	0.57	0.6657
D3, D5	Negative	
D3, D6	2.26	0.0857
D3, D7	1.41	0.2670
D3, D8	1.23	0.2949
D3, D9	Negative	
D3, D10	0.75	0.7169
D3, D11	1.12	0.3668
D3, D12	0.34	0.5722
D3, D13	1.22	0.3850
D3, PRS	0.83	0.5788
D3, P1	0.74	0.7364
D3, P2	1.66	0.1078
D3, P3	1.19	0.3000

Comparisons between Surveys	t	p-value
D4, D5	0.17	0.8098
D4, D6	0.48	0.7130
D4, D7	0.68	0.7415
D4, D8	Negative	
D4, D9	Negative	
D4, D10	0.47	0.8520
D4, D11	Negative	
D4, D12	Negative	
D4, D13	0.98	0.4359
D4, PRS	Negative	
D4, P1	Negative	
D4, P2	0.99	0.4822
D4, P3	Negative	
D5, D6	1.27	0.3050
D5, D7	0.96	0.4787
D5, D8	1.16	0.3334
D5, D9	1.39	0.2514
D5, D10	0.51	0.7507
D5, D11	0.81	0.5898
D5, D12	1.32	0.2445
D5, D13	0.80	0.5917
D5, PRS	0.46	0.7512
D5, P1	0.82	0.6171
D5, P2	0.86	0.5412
D5, P3	0.90	0.5766
D6, D7	1.23	0.3042
D6, D8	1.53	0.2032
D6, D9	0.80	0.5550
D6, D10	2.22	0.0937
D6, D11	1.41	0.2021
D6, D12	1.84	0.1491
D6, D13	0.78	0.5283
D6, PRS	1.24	0.2797
D6, P1	0.84	0.5708
D6, P2	0.41	0.8298
D6, P3	0.57	0.7917
D7, D8	1.27	0.2390
D7, D9	0.97	0.4937
D7, D10	0.80	0.5759
D7, D11	0.64	0.7515
D7, D12	0.68	0.5031
D7, D13	1.39	0.2282
D7, PRS	0.44	0.6210
D7, P1	0.65	0.6071
D7, P2	1.34	0.2868
D7, P3	0.45	0.7448
D8, D9	1.61	0.2065
D8, D10	0.64	0.7380
D8, D11	0.60	0.8101
D8, D12	0.80	0.5453
D8, D13	0.91	0.5311
D8, PRS	0.52	0.7779
D8, P1	0.36	0.8677
D8, P2	1.55	0.1391
D8, P3	1.09	0.3425
D9, D10	3.01	0.0763
D9, D11	1.58	0.2185
D9, D12	1.85	0.1559

Comparisons between Surveys	t	p-value
D9, D13	1.23	0.3168
D9, PRS	1.59	0.1916
D9, P1	0.94	0.4327
D9, P2	1.08	0.4380
D9, P3	0.92	0.5404
D10, D11	1.30	0.2094
D10, D12	Negative	
D10, D13	1.63	0.2127
D10, PRS	0.85	0.5266
D10, P1	0.32	0.8198
D10, P2	1.31	0.2349
D10, P3	1.31	0.2308
D11, D12	Negative	
D11, D13	1.46	0.1815
D11, PRS	1.00	0.4355
D11, P1	Negative	
D11, P2	1.67	0.1508
D11, P3	1.27	0.2603
D12, D13	1.21	0.3608
D12, PRS	1.08	0.3579
D12, P1	0.71	0.7439
D12, P2	1.74	0.1792
D12, P3	1.35	0.2065
D13, PRS	0.99	0.3768
D13, P1	Negative	
D13, P2	1.18	0.3429
D13, P3	0.72	0.6856
PRS, P1	Negative	
PRS, P2	1.89	0.1690
PRS, P3	1.57	0.1815
P1, P2	1.22	0.2722
P1, P3	0.34	0.8641
P2, P3	1.34	0.2392
Within level 'WR2' of factor 'Site'		
B1, B2	1.02	0.3900
B1, B3	1.61	0.1268
B1, D1	0.51	0.7529
B1, D2	1.81	0.0721
B1, D3	0.93	0.5845
B1, D4	0.97	0.5367
B1, D5	0.99	0.4853
B1, D6	1.28	0.2238
B1, D7	1.15	0.3293
B1, D8	1.24	0.2940
B1, D9	1.12	0.3498
B1, D10	1.11	0.3869
B1, D11	1.31	0.2495
B1, D12	1.28	0.2331
B1, D13	0.97	0.5069
B1, PRS	1.32	0.2106
B1, P1	1.10	0.3533
B1, P2	1.42	0.1381
B1, P3	0.82	0.6918
B2, B3	0.19	0.8752
B2, D1	0.42	0.8145
B2, D2	1.54	0.1166
B2, D3	0.32	0.8581
B2, D4	0.95	0.5658

Comparisons between Surveys	t	p-value
B2, D5	0.86	0.5530
B2, D6	0.95	0.5197
B2, D7	0.82	0.6493
B2, D8	1.32	0.2184
B2, D9	0.79	0.6838
B2, D10	0.70	0.7330
B2, D11	1.03	0.4469
B2, D12	1.18	0.2636
B2, D13	0.98	0.5607
B2, PRS	1.16	0.3198
B2, P1	0.70	0.7903
B2, P2	1.10	0.3999
B2, P3	0.75	0.7108
B3, D1	Negative	
B3, D2	2.46	0.0566
B3, D3	0.43	0.8310
B3, D4	1.18	0.2791
B3, D5	0.92	0.5712
B3, D6	1.43	0.1663
B3, D7	1.02	0.4068
B3, D8	1.47	0.1771
B3, D9	1.38	0.1842
B3, D10	1.05	0.4142
B3, D11	1.45	0.2330
B3, D12	1.66	0.1475
B3, D13	1.54	0.1457
B3, PRS	1.73	0.0843
B3, P1	0.91	0.5645
B3, P2	1.48	0.1839
B3, P3	0.85	0.6283
D1, D2	1.40	0.2581
D1, D3	0.85	0.6475
D1, D4	1.00	0.4601
D1, D5	0.61	0.7720
D1, D6	1.08	0.3680
D1, D7	1.00	0.4233
D1, D8	1.32	0.2523
D1, D9	0.90	0.5159
D1, D10	1.12	0.3556
D1, D11	1.35	0.2507
D1, D12	0.83	0.6295
D1, D13	0.93	0.5418
D1, PRS	1.17	0.2928
D1, P1	0.84	0.6731
D1, P2	1.29	0.2418
D1, P3	1.02	0.3776
D2, D3	1.53	0.2391
D2, D4	0.94	0.4649
D2, D5	1.46	0.1888
D2, D6	1.82	0.0862
D2, D7	2.33	0.0614
D2, D8	1.41	0.1721
D2, D9	2.29	0.0620
D2, D10	1.84	0.1095
D2, D11	1.91	0.1075
D2, D12	**3.14**	**0.0332**
D2, D13	**2.53**	**0.0393**
D2, PRS	1.37	0.2167

Comparisons between Surveys	t	p-value
D2, P1	2.41	0.0583
D2, P2	1.23	0.2442
D2, P3	1.17	0.3255
D3, D4	1.13	0.4526
D3, D5	0.57	0.7397
D3, D6	1.04	0.4735
D3, D7	0.62	0.8496
D3, D8	1.31	0.2586
D3, D9	0.76	0.7335
D3, D10	0.81	0.7456
D3, D11	1.33	0.2085
D3, D12	1.01	0.4506
D3, D13	0.97	0.5016
D3, PRS	1.61	0.1443
D3, P1	0.70	0.7677
D3, P2	1.79	0.1201
D3, P3	1.09	0.3416
D4, D5	0.68	0.6308
D4, D6	1.17	0.3930
D4, D7	1.34	0.2401
D4, D8	0.51	0.8784
D4, D9	0.96	0.5322
D4, D10	1.00	0.4914
D4, D11	0.67	0.7579
D4, D12	1.66	0.1628
D4, D13	0.50	0.8498
D4, PRS	0.56	0.7314
D4, P1	1.46	0.2356
D4, P2	1.15	0.3752
D4, P3	0.49	0.7642
D5, D6	1.07	0.3882
D5, D7	1.12	0.3285
D5, D8	0.68	0.6893
D5, D9	0.39	0.9163
D5, D10	Negative	
D5, D11	0.98	0.4550
D5, D12	1.36	0.2158
D5, D13	0.71	0.7386
D5, PRS	1.17	0.3203
D5, P1	0.91	0.5600
D5, P2	1.24	0.2798
D5, P3	Negative	
D6, D7	1.36	0.2773
D6, D8	1.50	0.1957
D6, D9	1.90	0.1015
D6, D10	1.43	0.1945
D6, D11	1.36	0.1985
D6, D12	2.54	0.0746
D6, D13	1.26	0.2356
D6, PRS	2.97	0.0605
D6, P1	1.71	0.1378
D6, P2	2.05	0.0872
D6, P3	1.26	0.2558
D7, D8	1.49	0.2358
D7, D9	1.11	0.3246
D7, D10	0.87	0.5281
D7, D11	1.60	0.1733
D7, D12	1.02	0.4100
D7, D13	1.03	0.4521
D7, PRS	**5.27**	**0.0173**
D7, P1	0.78	0.6726
D7, P2	2.17	0.0862
D7, P3	1.36	0.2117
D8, D9	0.98	0.4272
D8, D10	1.46	0.1458
D8, D11	2.07	0.1257
D8, D12	1.43	0.2167
D8, D13	1.57	0.1641
D8, PRS	0.93	0.5247
D8, P1	1.65	0.1433
D8, P2	1.01	0.4133
D8, P3	0.80	0.5905
D9, D10	0.58	0.8539
D9, D11	0.99	0.4397
D9, D12	1.10	0.3499
D9, D13	0.91	0.5355
D9, PRS	1.40	0.1723
D9, P1	1.50	0.2146
D9, P2	1.62	0.1300
D9, P3	0.51	0.8011
D10, D11	2.16	0.1080
D10, D12	0.99	0.4082
D10, D13	1.09	0.4040
D10, PRS	1.81	0.1898
D10, P1	0.78	0.8216
D10, P2	1.94	0.0982
D10, P3	0.30	0.8570
D11, D12	1.32	0.1720
D11, D13	1.69	0.1405
D11, PRS	1.22	0.3019
D11, P1	1.28	0.2326
D11, P2	1.23	0.3463
D11, P3	0.67	0.6922
D12, D13	1.31	0.2171
D12, PRS	3.02	0.0595
D12, P1	1.51	0.1952
D12, P2	2.44	0.0672
D12, P3	1.23	0.2993
D13, PRS	0.53	0.8152
D13, P1	1.34	0.2374
D13, P2	1.14	0.3426
D13, P3	0.55	0.7497
PRS, P1	2.93	0.0532
PRS, P2	1.85	0.1140
PRS, P3	1.27	0.3373
P1, P2	2.90	0.0778
P1, P3	1.23	0.3286
P2, P3	1.25	0.2661

c. Matrix of pair-wise comparisons between sites for each survey for the significant Survey x Site term. Surveys in which the site comparisons are significantly different are highlighted in bold.

	CHI	WR1	WR2	SSI	NEW
WR1	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3				
WR2	B1, B2, B3, D1, **D2**, D3, D4, D5, D6, D7, D8, D9, D10, D11, **D12**, D13, P_{RS}, P1, P2, P3	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3			
SSI	**B1, B2,** B3, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	**B1,** B2, **B3**, D3, D4, **D5**, D6, **D7**, D8, D9, D10, **D11**, **D13**, **P_{RS}**, **P1, P2, P3**	B1, B2, B3, D3, D4, D5, D6, D7, D8, D9, D10, **D11**, D13, P_{RS}, P1, **P2**, P3		
NEW	**B1, B2, B3, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1,** P2, **P3**	**B1**, **B2**, **B3**, D3, D4, **D5**, D6, D7, D8, D9, D10, D11, D13, P_{RS}, **P1**, P2, P3	**B1**, **B2**, **B3**, D3, D4, **D5**, **D6**, D7, D8, **D9**, D10, **D11**, **D13**, P_{RS}, P1, **P2**, P3	**B1**, **B2**, **B3**, **D3**, **D4**, **D5**, **D6**, **D7**, D8, D9, D10, **D11**, **D13**, P_{RS}, **P1**, P2, P3	
MAN	**B1, B2, B3, D2, D6, D10, P1, P2, P3**	**B1, B2, B3, D2, D6, D10, P1, P2, P3**	**B1, B2, B3, D2, D6, D10, P1, P2, P3**	**B1, B2, B3, D6, D10, P1, P2, P3**	**B1, B2, B3, D6, D10, P1, P2, P3**

Appendix D-3 Multivariate analysis using PERMANOVA testing for differences in the percent cover of corals grouped by growth form among Sites (CHI, WR1, WR2, SSI, NEW and MAN) and across surveys (B1 to P3). Significant (p(perm) ≤ 0.05) terms in bold. RED = redundant term due to significant interaction. MC = Monte Carlo simulation was used to calculate P values where unique permutations < 100. Baseline versus Post-dredging pair-wise comparisons highlighted in teal

a. PERMANOVA analysis

Source of Variation	df	SS	MS	Pseudo-F	p(perm)
Survey	19	13509	711	1.22	RED
Site	5	367390	73479	4.48	RED
Transect (Site)	18	297480	16527	36.83	
Survey x Site	**78**	**45462**	**583**	**1.30**	**0.0004**
Residual	289	129680	449		
Total	409	871050			

b. Pair-wise tests between surveys for each site for the significant Survey x Site term

Comparisons between Surveys	t	p-value
Within level 'CHI' of factor 'Site'		
B1, B2	1.84	0.1510
B1, B3	1.03	0.4580
B1, D1	0.72	0.6526
B1, D2	1.16	0.3550
B1, D3	0.53	0.8422
B1, D4	0.76	0.6058
B1, D5	0.87	0.5108
B1, D6	1.05	0.3531
B1, D7	0.97	0.4501
B1, D8	Negative	
B1, D9	1.07	0.3921
B1, D10	0.88	0.5939
B1, D11	1.02	0.4542
B1, D12	1.28	0.2610
B1, D13	0.84	0.5302
B1, PRS	2.04	0.1003
B1, P1	1.16	0.3039
B1, P2	1.04	0.4673
B1, P3	0.48	0.8612
B2, B3	1.13	0.3723
B2, D1	0.96	0.4452
B2, D2	1.51	0.2145
B2, D3	0.78	0.6164
B2, D4	0.95	0.5324
B2, D5	0.58	0.6894
B2, D6	1.41	0.2374
B2, D7	1.25	0.2867
B2, D8	1.05	0.3520
B2, D9	0.76	0.6407
B2, D10	1.06	0.4693
B2, D11	1.09	0.3768
B2, D12	0.88	0.5503
B2, D13	1.13	0.3335
B2, PRS	1.84	0.1295
B2, P1	1.39	0.2177
B2, P2	1.20	0.3139
B2, P3	0.96	0.4050
B3, D1	1.31	0.2306
B3, D2	1.50	0.1557
B3, D3	1.07	0.3795
B3, D4	1.07	0.4690
B3, D5	0.97	0.4736
B3, D6	1.24	0.2837
B3, D7	1.40	0.2318
B3, D8	0.84	0.5612
B3, D9	1.69	0.1452
B3, D10	1.00	0.5047
B3, D11	1.35	0.2575
B3, D12	1.83	0.1152
B3, D13	1.53	0.2162
B3, PRS	2.69	0.0572
B3, P1	1.50	0.1319
B3, P2	1.23	0.2909
B3, P3	1.29	0.2520
D1, D2	0.81	0.6170
D1, D3	0.65	0.6519
D1, D4	0.88	0.5450
D1, D5	0.75	0.7312
D1, D6	1.19	0.3544
D1, D7	0.46	0.7714
D1, D8	0.52	0.8427
D1, D9	1.05	0.3905
D1, D10	0.73	0.7167
D1, D11	0.84	0.5619
D1, D12	1.09	0.3842
D1, D13	1.36	0.2648
D1, PRS	1.77	0.0961
D1, P1	1.26	0.2568
D1, P2	1.37	0.2342
D1, P3	0.77	0.5855
D2, D3	0.49	0.8478
D2, D4	1.25	0.3552
D2, D5	0.67	0.7168
D2, D6	1.11	0.3533
D2, D7	1.04	0.3925

Comparisons between Surveys	t	p-value
D2, D8	1.13	0.3576
D2, D9	1.43	0.1978
D2, D10	1.05	0.3522
D2, D11	1.44	0.2075
D2, D12	1.24	0.2810
D2, D13	1.23	0.2700
D2, PRS	2.18	0.0663
D2, P1	2.13	0.0575
D2, P2	1.71	0.1319
D2, P3	0.59	0.7846
D3, D4	1.22	0.2891
D3, D5	0.58	0.7661
D3, D6	0.57	0.7158
D3, D7	0.71	0.5656
D3, D8	0.41	0.7880
D3, D9	1.37	0.2427
D3, D10	0.68	0.6562
D3, D11	0.28	0.6434
D3, D12	0.93	0.5164
D3, D13	0.99	0.4778
D3, PRS	1.38	0.2375
D3, P1	1.32	0.2671
D3, P2	1.63	0.1524
D3, P3	0.37	0.8890
D4, D5	0.71	0.5499
D4, D6	1.28	0.3110
D4, D7	0.74	0.6163
D4, D8	0.80	0.5381
D4, D9	1.90	0.1794
D4, D10	0.80	0.6184
D4, D11	1.56	0.1546
D4, D12	0.90	0.5110
D4, D13	1.09	0.3875
D4, PRS	1.36	0.2986
D4, P1	1.00	0.4512
D4, P2	0.48	0.7113
D4, P3	0.68	0.6226
D5, D6	1.20	0.3378
D5, D7	0.90	0.5678
D5, D8	0.39	0.7321
D5, D9	Negative	
D5, D10	0.48	0.6351
D5, D11	0.89	0.5897
D5, D12	Negative	
D5, D13	0.88	0.4896
D5, PRS	0.92	0.4417
D5, P1	0.75	0.5680
D5, P2	1.52	0.2396
D5, P3	1.09	0.3621
D6, D7	1.59	0.1688
D6, D8	1.09	0.3698
D6, D9	2.09	0.1337
D6, D10	1.08	0.4432
D6, D11	1.59	0.2074
D6, D12	2.08	0.1195
D6, D13	1.14	0.2956
D6, PRS	2.56	0.0866
D6, P1	2.17	0.1158

Comparisons between Surveys	t	p-value
D6, P2	1.52	0.2357
D6, P3	0.72	0.5277
D7, D8	0.75	0.5506
D7, D9	2.22	0.1031
D7, D10	1.05	0.4242
D7, D11	1.20	0.3558
D7, D12	1.04	0.4161
D7, D13	0.93	0.3912
D7, PRS	1.73	0.1897
D7, P1	0.67	0.6634
D7, P2	1.48	0.2413
D7, P3	0.73	0.5766
D8, D9	1.88	0.1086
D8, D10	0.77	0.6668
D8, D11	1.17	0.3071
D8, D12	1.35	0.2481
D8, D13	0.99	0.4145
D8, PRS	**3.06**	**0.0368**
D8, P1	1.24	0.2523
D8, P2	0.96	0.4907
D8, P3	0.48	0.7448
D9, D10	1.22	0.2512
D9, D11	1.99	0.1044
D9, D12	0.39	0.6824
D9, D13	2.39	0.1076
D9, PRS	1.26	0.3399
D9, P1	2.77	0.0699
D9, P2	1.84	0.1229
D9, P3	1.33	0.2723
D10, D11	1.50	0.1978
D10, D12	0.74	0.6100
D10, D13	0.29	0.8589
D10, PRS	1.27	0.3587
D10, P1	0.85	0.5853
D10, P2	0.42	0.7116
D10, P3	0.31	0.8611
D11, D12	1.51	0.1949
D11, D13	1.53	0.1966
D11, PRS	1.76	0.1662
D11, P1	2.02	0.1174
D11, P2	1.98	0.0960
D11, P3	1.14	0.3499
D12, D13	1.95	0.1644
D12, PRS	1.87	0.1048
D12, P1	1.51	0.1648
D12, P2	1.71	0.1336
D12, P3	1.31	0.3099
D13, PRS	2.04	0.1507
D13, P1	1.57	0.2154
D13, P2	1.70	0.1859
D13, P3	0.86	0.5744
PRS, P1	2.19	0.1193
PRS, P2	1.83	0.1335
PRS, P3	1.59	0.1205
P1, P2	1.04	0.4571
P1, P3	1.01	0.3925
P2, P3	1.07	0.4371

Comparisons between Surveys	t	p-value
Within level 'MAN' of factor 'Site'		
B1, B2	Negative	
B1, B3	0.90	0.5734
B1, D2	2.83	0.0684
B1, D6	1.12	0.3158
B1, D10	1.58	0.2333
B1, P1	1.56	0.1171
B1, P2	1.85	0.0936
B1, P3	2.09	0.0749
B2, B3	0.56	0.7379
B2, D2	2.81	0.0693
B2, D6	0.92	0.5705
B2, D10	1.76	0.1477
B2, P1	1.63	0.1319
B2, P2	1.26	0.2594
B2, P3	2.28	0.0559
B3, D2	1.50	0.1581
B3, D6	0.92	0.5859
B3, D10	1.32	0.2774
B3, P1	1.58	0.0821
B3, P2	1.41	0.1879
B3, P3	1.55	0.1226
D2, D6	1.21	0.2713
D2, D10	2.31	0.0590
D2, P1	1.53	0.1892
D2, P2	1.41	0.1944
D2, P3	2.54	0.0578
D6, D10	1.45	0.2103
D6, P1	1.56	0.1438
D6, P2	1.32	0.2156
D6, P3	2.01	0.0918
D10, P1	1.41	0.1254
D10, P2	1.20	0.3099
D10, P3	1.46	0.1587
P1, P2	1.48	0.2004
P1, P3	1.19	0.2804
P2, P3	1.01	0.4409
Within level 'NEW' of factor 'Site'		
B1, B2	1.13	0.4209
B1, B3	1.42	0.1901
B1, D3	1.24	0.2932
B1, D4	1.04	0.3791
B1, D5	1.19	0.3167
B1, D6	1.53	0.1465
B1, D7	1.60	0.1747
B1, D8	1.05	0.4155
B1, D9	1.43	0.1985
B1, D10	1.74	0.1248
B1, D11	1.00	0.4370
B1, D13	0.35	0.8576
B1, PRS	0.79	0.7359
B1, P1	1.11	0.3429
B1, P2	1.60	0.1582
B1, P3	1.78	0.1331
B2, B3	0.97	0.5088
B2, D3	1.05	0.4134
B2, D4	1.00	0.4376
B2, D5	0.58	0.6879
B2, D6	1.49	0.2175
B2, D7	1.91	0.0796
B2, D8	1.11	0.4166
B2, D9	0.84	0.5746
B2, D10	1.27	0.2509
B2, D11	Negative	
B2, D13	0.47	0.8237
B2, PRS	0.24	0.8564
B2, P1	0.89	0.5342
B2, P2	1.19	0.3513
B2, P3	1.45	0.1835
B3, D3	1.44	0.1304
B3, D4	1.22	0.2769
B3, D5	0.94	0.4945
B3, D6	2.00	0.0823
B3, D7	1.88	0.0682
B3, D8	1.66	0.0760
B3, D9	1.23	0.2756
B3, D10	1.79	0.0522
B3, D11	0.94	0.5101
B3, D13	0.49	0.8125
B3, PRS	0.89	0.5485
B3, P1	1.23	0.2875
B3, P2	1.52	0.1351
B3, P3	2.21	0.0569
D3, D4	0.63	0.8306
D3, D5	0.57	0.7143
D3, D6	1.27	0.2541
D3, D7	1.58	0.1275
D3, D8	1.15	0.4502
D3, D9	0.64	0.7974
D3, D10	1.15	0.3148
D3, D11	0.46	0.8814
D3, D13	0.76	0.7363
D3, PRS	0.62	0.7046
D3, P1	1.27	0.2397
D3, P2	0.97	0.5184
D3, P3	1.14	0.3558
D4, D5	0.76	0.6011
D4, D6	1.08	0.3902
D4, D7	0.98	0.4741
D4, D8	0.88	0.5260
D4, D9	0.78	0.7598
D4, D10	1.21	0.2979
D4, D11	0.04	0.8542
D4, D13	0.71	0.7348
D4, PRS	0.68	0.6922
D4, P1	1.12	0.3809
D4, P2	1.22	0.3450
D4, P3	1.13	0.3038
D5, D6	1.23	0.3530
D5, D7	1.18	0.4370
D5, D8	1.02	0.4546
D5, D9	0.83	0.6224
D5, D10	1.12	0.4159
D5, D11	0.89	0.5650
D5, D13	0.63	0.7697
D5, PRS	0.81	0.5869

Comparisons between Surveys	t	p-value
D5, P1	1.01	0.4764
D5, P2	1.08	0.4483
D5, P3	1.81	0.1605
D6, D7	0.93	0.5164
D6, D8	1.06	0.4188
D6, D9	1.26	0.2465
D6, D10	0.94	0.5225
D6, D11	0.96	0.4186
D6, D13	1.19	0.3040
D6, PRS	1.32	0.2811
D6, P1	1.33	0.2188
D6, P2	1.12	0.3791
D6, P3	1.01	0.4609
D7, D8	0.95	0.5145
D7, D9	1.04	0.4246
D7, D10	1.40	0.2567
D7, D11	0.81	0.5958
D7, D13	0.99	0.5183
D7, PRS	1.65	0.1241
D7, P1	1.57	0.1397
D7, P2	1.14	0.3585
D7, P3	1.08	0.3529
D8, D9	1.14	0.3154
D8, D10	0.92	0.4709
D8, D11	0.71	0.6905
D8, D13	0.86	0.5954
D8, PRS	0.72	0.6608
D8, P1	1.15	0.4449
D8, P2	0.92	0.5057
D8, P3	1.01	0.4330
D9, D10	0.93	0.5361
D9, D11	1.29	0.2464
D9, D13	0.99	0.4700
D9, PRS	0.89	0.5673
D9, P1	1.38	0.1745
D9, P2	1.37	0.2767
D9, P3	1.59	0.1649
D10, D11	0.71	0.6838
D10, D13	1.09	0.3897
D10, PRS	0.78	0.5615
D10, P1	1.11	0.4519
D10, P2	0.84	0.5739
D10, P3	1.17	0.4484
D11, D13	0.88	0.6236
D11, PRS	0.45	0.9087
D11, P1	0.88	0.6089
D11, P2	1.34	0.2836
D11, P3	1.48	0.2341
D13, PRS	0.64	0.7899
D13, P1	0.89	0.5105
D13, P2	1.24	0.2308
D13, P3	1.58	0.1393
PRS, P1	0.55	0.8428
PRS, P2	0.86	0.5924
PRS, P3	1.40	0.1649
P1, P2	1.12	0.4529
P1, P3	1.52	0.2232
P2, P3	1.66	0.1692

Comparisons between Surveys	t	p-value	
Within level 'SSI' of factor 'Site'			
B1, B2	0.76	0.8029	
B1, B3	Negative		
B1, D3	0.71	0.7871	
B1, D4	0.76	0.7144	
B1, D5	1.63	0.2007	
B1, D6	0.95	0.5306	
B1, D7	1.33	0.2476	
B1, D8	1.10	0.4242	
B1, D9	1.36	0.3760	MC
B1, D10	0.96	0.4933	
B1, D11	1.45	0.1972	
B1, D13	1.30	0.2411	
B1, PRS	1.29	0.3154	
B1, P1	1.46	0.2084	
B1, P2	**1.96**	**0.0420**	
B1, P3	1.74	0.0745	
B2, B3	Negative		
B2, D3	0.30	0.8432	
B2, D4	0.84	0.5931	
B2, D5	1.99	0.1808	
B2, D6	1.67	0.0989	
B2, D7	2.70	0.0529	
B2, D8	1.51	0.1788	
B2, D9	1.43	0.3350	MC
B2, D10	0.87	0.5779	
B2, D11	1.68	0.1710	
B2, D13	1.43	0.2076	
B2, PRS	1.22	0.4234	
B2, P1	1.31	0.2406	
B2, P2	1.73	0.0633	
B2, P3	1.73	0.0985	
B3, D3	Negative		
B3, D4	0.67	0.7064	
B3, D5	1.52	0.1957	
B3, D6	0.93	0.5286	
B3, D7	1.55	0.1730	
B3, D8	1.15	0.4068	
B3, D9	1.12	0.4492	MC
B3, D10	0.98	0.4887	
B3, D11	1.49	0.1903	
B3, D13	1.32	0.2359	
B3, PRS	1.23	0.3569	
B3, P1	1.43	0.2278	
B3, P2	**2.00**	**0.0343**	
B3, P3	1.81	0.0648	
D3, D4	1.15	0.4532	
D3, D5	1.48	0.2430	
D3, D6	1.27	0.2405	
D3, D7	1.60	0.2007	
D3, D8	2.75	0.0676	
D3, D9	1.23	0.3959	MC
D3, D10	0.96	0.5095	
D3, D11	1.81	0.1597	
D3, D13	1.57	0.1777	
D3, PRS	1.36	0.3202	
D3, P1	1.22	0.3239	
D3, P2	1.69	0.0771	

Comparisons between Surveys	t	p-value	
D3, P3	1.95	0.0594	
D4, D5	1.24	0.3176	
D4, D6	0.88	0.5259	
D4, D7	0.89	0.5214	
D4, D8	2.11	0.1116	
D4, D9	0.71	0.6178	MC
D4, D10	1.06	0.3854	
D4, D11	1.84	0.1794	
D4, D13	1.33	0.3126	
D4, PRS	0.84	0.5439	
D4, P1	0.56	0.5766	
D4, P2	1.43	0.1548	
D4, P3	1.52	0.1803	
D5, D6	1.62	0.1890	
D5, D7	1.69	0.1996	
D5, D8	1.41	0.2724	
D5, D9	1.87	0.2449	MC
D5, D10	0.82	0.6556	
D5, D11	1.51	0.2521	
D5, D13	1.12	0.4376	
D5, PRS	1.09	0.4109	
D5, P1	1.23	0.2788	
D5, P2	1.40	0.1695	
D5, P3	1.47	0.1457	
D6, D7	1.23	0.2796	
D6, D8	0.75	0.7659	
D6, D9	0.79	0.6032	MC
D6, D10	Negative		
D6, D11	1.96	0.1143	
D6, D13	1.41	0.2812	
D6, PRS	0.90	0.5343	
D6, P1	0.93	0.4747	
D6, P2	1.34	0.1492	
D6, P3	1.42	0.1587	
D7, D8	1.14	0.4217	
D7, D9	1.04	0.4774	MC
D7, D10	1.04	0.4367	
D7, D11	1.60	0.1866	
D7, D13	1.47	0.1900	
D7, PRS	1.07	0.4231	
D7, P1	1.28	0.2414	
D7, P2	1.77	0.0758	
D7, P3	1.63	0.0983	
D8, D9	0.87	0.5701	MC
D8, D10	1.12	0.3622	
D8, D11	**3.74**	**0.0231**	
D8, D13	1.37	0.3124	
D8, PRS	1.21	0.4212	
D8, P1	1.20	0.3624	
D8, P2	1.68	0.1113	
D8, P3	1.67	0.1272	
D9, D10	1.08	0.4636	MC
D9, D11	1.65	0.2955	MC
D9, D13	1.37	0.3566	MC
D9, PRS	1.13	0.4497	MC
D9, P1	1.24	0.4113	MC
D9, P2	1.22	0.4308	MC
D9, P3	1.27	0.4124	MC

Comparisons between Surveys	t	p-value	
D10, D11	0.79	0.7463	
D10, D13	0.64	0.5702	
D10, PRS	Negative		
D10, P1	Negative		
D10, P2	0.65	0.6903	
D10, P3	0.80	0.5614	
D11, D13	1.04	0.4437	
D11, PRS	0.83	0.5357	
D11, P1	Negative		
D11, P2	1.54	0.1581	
D11, P3	1.55	0.1845	
D13, PRS	0.98	0.4813	
D13, P1	0.75	0.6875	
D13, P2	1.11	0.3940	
D13, P3	1.19	0.2804	
PRS, P1	0.64	0.6855	
PRS, P2	1.58	0.1557	
PRS, P3	1.75	0.1403	
P1, P2	2.02	0.1153	
P1, P3	1.44	0.1978	
P2, P3	0.95	0.4437	
Within level 'WR1' of factor 'Site'			
B1, B2	1.51	0.2253	
B1, B3	Negative		
B1, D1	Negative		
B1, D2	0.83	0.5695	
B1, D3	0.30	0.8121	
B1, D4	**2.13**	**0.0408**	
B1, D5	0.73	0.6098	
B1, D6	1.30	0.2439	
B1, D7	0.86	0.5161	
B1, D8	0.67	0.6230	
B1, D9	1.14	0.3241	
B1, D10	1.12	0.3396	
B1, D11	2.32	0.0690	
B1, D12	1.89	0.1864	
B1, D13	1.81	0.1152	
B1, PRS	1.66	0.1065	
B1, P1	1.45	0.1403	
B1, P2	2.41	0.0512	
B1, P3	1.64	0.1039	
B2, B3	1.79	0.1792	
B2, D1	Negative		
B2, D2	1.02	0.4288	
B2, D3	1.89	0.1704	
B2, D4	1.07	0.4425	
B2, D5	2.50	0.0960	
B2, D6	1.95	0.0741	
B2, D7	0.46	0.8237	
B2, D8	1.36	0.2026	
B2, D9	2.12	0.0870	
B2, D10	1.16	0.3421	
B2, D11	1.84	0.0903	
B2, D12	1.87	0.1247	
B2, D13	1.07	0.4493	
B2, PRS	0.68	0.7445	
B2, P1	0.87	0.5187	
B2, P2	1.45	0.1665	

Comparisons between Surveys	t	p-value
B2, P3	0.99	0.4694
B3, D1	Negative	
B3, D2	1.29	0.2645
B3, D3	0.66	0.6222
B3, D4	1.68	0.1197
B3, D5	1.21	0.3165
B3, D6	1.32	0.2198
B3, D7	0.31	0.8603
B3, D8	0.79	0.6393
B3, D9	1.57	0.1778
B3, D10	1.21	0.2908
B3, D11	2.50	0.0699
B3, D12	2.14	0.0861
B3, D13	1.45	0.2208
B3, PRS	0.92	0.4372
B3, P1	0.48	0.7447
B3, P2	1.65	0.0886
B3, P3	1.08	0.3825
D1, D2	0.86	0.5785
D1, D3	0.85	0.4978
D1, D4	1.34	0.2712
D1, D5	1.29	0.2527
D1, D6	1.46	0.1831
D1, D7	0.43	0.8528
D1, D8	1.07	0.3905
D1, D9	1.49	0.1900
D1, D10	0.89	0.5690
D1, D11	1.36	0.2189
D1, D12	1.37	0.2482
D1, D13	1.31	0.2775
D1, PRS	1.16	0.3030
D1, P1	0.65	0.6034
D1, P2	2.00	0.0767
D1, P3	1.16	0.3022
D2, D3	2.34	0.0865
D2, D4	1.36	0.2772
D2, D5	2.72	0.0536
D2, D6	**3.05**	**0.0322**
D2, D7	0.71	0.6268
D2, D8	**2.52**	**0.0485**
D2, D9	**5.45**	**0.0128**
D2, D10	1.62	0.1234
D2, D11	**2.37**	**0.0284**
D2, D12	2.18	0.0619
D2, D13	1.48	0.1756
D2, PRS	1.57	0.1132
D2, P1	0.96	0.4920
D2, P2	**2.15**	**0.0357**
D2, P3	1.62	0.0943
D3, D4	1.34	0.2819
D3, D5	0.49	0.7112
D3, D6	0.27	0.7697
D3, D7	0.74	0.5576
D3, D8	0.87	0.4711
D3, D9	1.53	0.2106
D3, D10	0.58	0.5713
D3, D11	1.62	0.2006
D3, D12	1.26	0.2567

Comparisons between Surveys	t	p-value
D3, D13	1.26	0.2909
D3, PRS	0.88	0.5327
D3, P1	0.62	0.6009
D3, P2	1.52	0.1654
D3, P3	1.02	0.4370
D4, D5	2.42	0.0663
D4, D6	1.38	0.2390
D4, D7	1.00	0.4415
D4, D8	0.86	0.5223
D4, D9	1.07	0.4203
D4, D10	1.07	0.3530
D4, D11	0.90	0.5202
D4, D12	0.88	0.5042
D4, D13	0.29	0.8751
D4, PRS	Negative	
D4, P1	1.74	0.0988
D4, P2	0.60	0.6807
D4, P3	0.03	0.8254
D5, D6	1.01	0.4073
D5, D7	0.87	0.5847
D5, D8	1.07	0.3909
D5, D9	1.52	0.1676
D5, D10	1.07	0.3818
D5, D11	2.45	0.0678
D5, D12	**3.03**	**0.0482**
D5, D13	2.81	0.0848
D5, PRS	3.07	0.0538
D5, P1	0.86	0.5552
D5, P2	2.07	0.0559
D5, P3	1.47	0.1476
D6, D7	Negative	
D6, D8	Negative	
D6, D9	Negative	
D6, D10	Negative	
D6, D11	0.90	0.3558
D6, D12	1.34	0.2746
D6, D13	2.03	0.1250
D6, PRS	2.26	0.0931
D6, P1	0.47	0.7551
D6, P2	1.86	0.1569
D6, P3	1.34	0.2578
D7, D8	0.31	0.7925
D7, D9	0.52	0.7861
D7, D10	0.61	0.7697
D7, D11	1.06	0.3658
D7, D12	0.81	0.4919
D7, D13	1.19	0.3224
D7, PRS	0.58	0.7482
D7, P1	Negative	
D7, P2	0.93	0.4815
D7, P3	0.79	0.6422
D8, D9	1.00	0.4338
D8, D10	0.86	0.5473
D8, D11	0.74	0.6630
D8, D12	1.15	0.3282
D8, D13	1.45	0.1695
D8, PRS	1.01	0.4233
D8, P1	Negative	

Comparisons between Surveys	t	p-value
D8, P2	1.06	0.4047
D8, P3	0.52	0.8210
D9, D10	Negative	
D9, D11	0.95	0.5161
D9, D12	1.04	0.3940
D9, D13	1.69	0.1719
D9, PRS	1.24	0.2940
D9, P1	0.63	0.6480
D9, P2	1.22	0.2749
D9, P3	1.06	0.3981
D10, D11	1.61	0.2117
D10, D12	1.21	0.3124
D10, D13	1.85	0.1662
D10, PRS	1.43	0.2439
D10, P1	0.64	0.6706
D10, P2	1.69	0.1695
D10, P3	0.93	0.4946
D11, D12	1.46	0.2414
D11, D13	1.64	0.2159
D11, PRS	0.50	0.7752
D11, P1	1.11	0.3604
D11, P2	Negative	
D11, P3	0.43	0.7771
D12, D13	1.33	0.3321
D12, PRS	1.29	0.2750
D12, P1	1.01	0.4207
D12, P2	1.56	0.1725
D12, P3	1.43	0.1726
D13, PRS	1.32	0.2970
D13, P1	2.31	0.0541
D13, P2	1.62	0.1837
D13, P3	1.34	0.2745
PRS, P1	1.25	0.2947
PRS, P2	0.42	0.7617
PRS, P3	Negative	
P1, P2	1.48	0.1984
P1, P3	1.09	0.3539
P2, P3	1.71	0.1403
Within level 'WR2' of factor 'Site'		
B1, B2	0.89	0.5813
B1, B3	1.10	0.4064
B1, D1	0.07	0.5874
B1, D2	1.59	0.1200
B1, D3	0.47	0.8220
B1, D4	0.99	0.4582
B1, D5	0.88	0.6091
B1, D6	1.15	0.3233
B1, D7	0.67	0.6661
B1, D8	1.36	0.2249
B1, D9	0.98	0.3944
B1, D10	0.68	0.6845
B1, D11	1.35	0.2474
B1, D12	0.86	0.5949
B1, D13	1.17	0.3424
B1, PRS	1.09	0.3906
B1, P1	0.57	0.8739
B1, P2	1.14	0.3282
B1, P3	0.94	0.4733

Comparisons between Surveys	t	p-value
B2, B3	0.98	0.4056
B2, D1	0.40	0.5466
B2, D2	1.41	0.2423
B2, D3	0.66	0.7519
B2, D4	1.21	0.2465
B2, D5	0.83	0.6127
B2, D6	1.14	0.3359
B2, D7	1.02	0.3890
B2, D8	1.20	0.2897
B2, D9	1.25	0.2866
B2, D10	0.58	0.7223
B2, D11	1.35	0.2570
B2, D12	0.76	0.5952
B2, D13	1.27	0.2570
B2, PRS	1.11	0.3762
B2, P1	0.30	0.9176
B2, P2	1.24	0.2763
B2, P3	1.09	0.3373
B3, D1	1.18	0.2546
B3, D2	0.92	0.4315
B3, D3	1.10	0.3605
B3, D4	0.82	0.6538
B3, D5	0.30	0.8594
B3, D6	1.11	0.3493
B3, D7	1.02	0.4373
B3, D8	1.10	0.3934
B3, D9	1.15	0.3234
B3, D10	0.60	0.6670
B3, D11	1.34	0.2459
B3, D12	0.76	0.6543
B3, D13	0.99	0.4619
B3, PRS	0.82	0.5904
B3, P1	0.47	0.8578
B3, P2	1.17	0.3016
B3, P3	0.98	0.4611
D1, D2	1.15	0.4075
D1, D3	1.00	0.4319
D1, D4	1.05	0.3772
D1, D5	0.94	0.4488
D1, D6	1.00	0.4719
D1, D7	1.10	0.3538
D1, D8	1.42	0.1757
D1, D9	0.99	0.4367
D1, D10	0.72	0.6382
D1, D11	1.47	0.1971
D1, D12	0.75	0.7293
D1, D13	0.89	0.5917
D1, PRS	1.09	0.3880
D1, P1	0.55	0.8028
D1, P2	1.32	0.2308
D1, P3	1.12	0.3471
D2, D3	1.82	0.1408
D2, D4	1.34	0.2241
D2, D5	1.79	0.1027
D2, D6	1.36	0.2677
D2, D7	2.34	0.0812
D2, D8	0.98	0.4932
D2, D9	2.24	0.0686

Comparisons between Surveys	t	p-value
D2, D10	1.38	0.2519
D2, D11	1.04	0.4262
D2, D12	1.91	0.0719
D2, D13	1.92	0.1208
D2, PRS	1.26	0.2900
D2, P1	1.21	0.4143
D2, P2	0.59	0.8253
D2, P3	1.13	0.3529
D3, D4	1.39	0.2500
D3, D5	2.22	0.1173
D3, D6	1.38	0.2030
D3, D7	0.72	0.7321
D3, D8	2.62	0.0865
D3, D9	0.56	0.6385
D3, D10	0.39	0.7744
D3, D11	1.55	0.1495
D3, D12	1.11	0.3807
D3, D13	0.59	0.7658
D3, PRS	1.12	0.3756
D3, P1	1.03	0.4454
D3, P2	1.55	0.1204
D3, P3	0.98	0.5096
D4, D5	0.94	0.4936
D4, D6	1.18	0.3506
D4, D7	1.03	0.3780
D4, D8	Negative	
D4, D9	0.64	0.8181
D4, D10	0.90	0.5315
D4, D11	0.74	0.7271
D4, D12	1.57	0.2033
D4, D13	0.76	0.5854
D4, PRS	0.93	0.5911
D4, P1	0.93	0.5642
D4, P2	1.46	0.2140
D4, P3	1.19	0.3355
D5, D6	0.78	0.6983
D5, D7	1.11	0.3308
D5, D8	0.85	0.6683
D5, D9	1.06	0.3824
D5, D10	0.59	0.7570
D5, D11	1.25	0.3002
D5, D12	1.25	0.3195
D5, D13	1.22	0.2975
D5, PRS	0.58	0.7283
D5, P1	0.63	0.6340
D5, P2	0.75	0.6691
D5, P3	1.05	0.3806
D6, D7	1.91	0.0986
D6, D8	0.61	0.7625
D6, D9	1.95	0.0930
D6, D10	1.05	0.4501
D6, D11	1.05	0.4322
D6, D12	1.12	0.3470
D6, D13	1.40	0.2504
D6, PRS	1.33	0.2726
D6, P1	0.78	0.4848
D6, P2	1.14	0.3848
D6, P3	1.19	0.3571
D7, D8	1.39	0.1927
D7, D9	0.58	0.7616
D7, D10	0.86	0.5024
D7, D11	1.09	0.3989
D7, D12	Negative	
D7, D13	Negative	
D7, PRS	1.23	0.3165
D7, P1	0.87	0.4535
D7, P2	0.98	0.4722
D7, P3	0.85	0.5975
D8, D9	0.77	0.5931
D8, D10	0.92	0.5578
D8, D11	1.16	0.2891
D8, D12	1.81	0.1415
D8, D13	1.87	0.1151
D8, PRS	0.89	0.5917
D8, P1	1.38	0.2338
D8, P2	0.72	0.7152
D8, P3	1.06	0.3932
D9, D10	Negative	
D9, D11	0.75	0.5780
D9, D12	0.85	0.5210
D9, D13	0.97	0.3949
D9, PRS	0.15	0.8207
D9, P1	0.57	0.7698
D9, P2	1.11	0.3332
D9, P3	0.39	0.7856
D10, D11	1.32	0.2102
D10, D12	0.39	0.8066
D10, D13	0.13	0.9124
D10, PRS	Negative	
D10, P1	0.09	0.8539
D10, P2	0.94	0.5008
D10, P3	0.31	0.9063
D11, D12	1.57	0.1472
D11, D13	1.95	0.1364
D11, PRS	1.53	0.1822
D11, P1	1.71	0.0759
D11, P2	1.48	0.1977
D11, P3	1.25	0.2521
D12, D13	0.77	0.3776
D12, PRS	1.36	0.2941
D12, P1	0.75	0.4959
D12, P2	1.79	0.1358
D12, P3	1.33	0.2557
D13, PRS	1.09	0.3633
D13, P1	0.61	0.8274
D13, P2	1.85	0.1144
D13, P3	0.91	0.4685
PRS, P1	0.13	0.7960
PRS, P2	1.64	0.1740
PRS, P3	0.66	0.6141
P1, P2	1.20	0.3304
P1, P3	0.72	0.6321
P2, P3	1.28	0.3006

c. Matrix of pair-wise comparisons between sites for each survey for the significant Survey x Site term. Surveys in which the site comparisons are significantly different are highlighted in bold.

	CHI	WR1	WR2	SSI	NEW
WR1	**B1**, B2, B3, D1, D2, D3, D4, **D5**, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, **P1**, P2, P3				
WR2	B1, **B2**, **B3**, D1, **D2**, D3, D4, **D5**, D6, D7, D8, D9, D10, **D11**, D12, D13, **P_{RS}**, P1, P2, P3	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3			
SSI	B1, B2, B3, D3, D4, **D5**, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	**B1**, **B2**, **B3**, D3, D4, **D5**, **D6**, **D7**, D8, D9, D10, **D11**, **D13**, **P_{RS}**, P1, **P2**, **P3**	B1, B2, B3, D3, D4, D5, **D6**, D7, D8, D9, D10, **D11**, D13, P_{RS}, P1, **P2**, P3		
NEW	**B1**, **B2**, **B3**, **D3**, **D4**, **D5**, **D6**, **D7**, **D8**, **D9**, D10, **D11**, **D13**, **P_{RS}**, **P1**, **P2**, **P3**	B1, **B2**, **B3**, D3, D4, **D5**, **D6**, D7, D8, **D9**, D10, D11, **D13**, P_{RS}, **P1**, P2, **P3**	B1, **B2**, **B3**, D3, **D4**, **D5**, **D6**, D7, D8, **D9**, D10, **D11**, **D13**, P_{RS}, P1, **P2**, **P3**	B1, **B2**, **B3**, **D3**, D4, **D5**, **D6**, **D7**, D8, D9, D10, **D11**, D13, P_{RS}, **P1**, P2, P3	
MAN	**B1**, **B2**, **B3**, **D2**, **D6**, **D10**, **P1**, **P2**, **P3**	**B1**, **B2**, B3, **D2**, **D6**, D10, **P1**, **P2**, **P3**	**B1**, **B2**, B3, D2, **D6**, D10, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, **D6**, **D10**, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, **D6**, D10, **P1**, **P2**, **P3**

Appendix D-4 Univariate analysis using PERMANOVA testing for differences in hard coral cover among Sites (CHI, WR1, WR2, SSI, NEW and MAN) and across surveys (B1 to P3). Significant (p(perm) ≤ 0.05) terms in bold. RED = redundant terms due to significant interaction. Baseline versus Post-dredging pair-wise comparisons highlighted in teal

a. PERMANOVA analysis

Source of Variation	df	SS	MS	Pseudo-F	p(perm)
Survey	19	402.7	21.2	1.84	RED
Site	5	7418.7	1483.7	2.74	RED
Transect (Site)	18	9923.8	551.3		
Survey x Site	**78**	**901.6**	**11.6**	**1.77**	**0.0004**
Residual	289	1882.9	6.5		
Total	409	20759.0			

b. Pair-wise for the Survey x Site term

Comparisons between Surveys	t	p-value
Within level 'CHI' of factor 'Site'		
B1, B2	1.48	0.2545
B1, B3	1.05	0.4025
B1, D1	0.14	0.8065
B1, D2	0.80	0.4795
B1, D3	0.27	0.7930
B1, D4	0.16	0.7986
B1, D5	0.46	0.5933
B1, D6	1.07	0.4279
B1, D7	0.18	0.8383
B1, D8	0.48	0.6103
B1, D9	0.22	0.8215
B1, D10	0.24	0.8246
B1, D11	0.58	0.5973
B1, D12	0.10	0.9112
B1, D13	0.55	0.5949
B1, PRS	1.38	0.2483
B1, P1	1.08	0.3690
B1, P2	0.30	0.7752
B1, P3	0.44	0.6103
B2, B3	0.32	0.7089
B2, D1	1.16	0.3828
B2, D2	1.56	0.2118
B2, D3	0.62	0.5608
B2, D4	0.50	0.6506
B2, D5	0.90	0.4364
B2, D6	2.00	0.1403
B2, D7	1.27	0.3069
B2, D8	0.97	0.4113
B2, D9	0.14	0.8573
B2, D10	0.01	0.9533
B2, D11	0.24	0.7888
B2, D12	0.39	0.7428
B2, D13	0.99	0.4074
B2, PRS	0.95	0.4017
B2, P1	0.74	0.5016
B2, P2	0.05	0.9535
B2, P3	0.87	0.4413
B3, D1	1.53	0.2458
B3, D2	1.77	0.1881
B3, D3	0.23	0.7969
B3, D4	0.52	0.6280
B3, D5	1.14	0.3687
B3, D6	**4.60**	**0.0321**
B3, D7	1.73	0.1828
B3, D8	1.35	0.2835
B3, D9	0.06	0.9226
B3, D10	0.06	0.9738
B3, D11	0.38	0.6894
B3, D12	0.40	0.7404
B3, D13	1.11	0.3562
B3, PRS	1.42	0.2487
B3, P1	0.92	0.4319
B3, P2	0.05	0.9551
B3, P3	0.98	0.4197
D1, D2	1.87	0.1709
D1, D3	0.40	0.6539
D1, D4	0.16	0.9247
D1, D5	0.58	0.5417
D1, D6	**2.77**	**0.0401**
D1, D7	0.07	0.8797
D1, D8	0.66	0.5469
D1, D9	0.43	0.7187
D1, D10	0.39	0.7418
D1, D11	1.10	0.3752
D1, D12	0.06	0.9593
D1, D13	0.86	0.4649
D1, PRS	2.33	0.1022
D1, P1	2.16	0.1243
D1, P2	0.55	0.5930
D1, P3	0.65	0.5374
D2, D3	1.11	0.3743
D2, D4	0.48	0.6697
D2, D5	0.46	0.5957
D2, D6	0.39	0.6087
D2, D7	1.09	0.3667
D2, D8	0.50	0.6060
D2, D9	1.46	0.2283
D2, D10	1.02	0.3528
D2, D11	3.36	0.0559

Comparisons between Surveys	t	p-value
D2, D12	0.54	0.6113
D2, D13	0.07	0.8924
D2, PRS	3.77	0.0613
D2, P1	**6.09**	**0.0189**
D2, P2	1.59	0.2104
D2, P3	0.41	0.6124
D3, D4	0.30	0.7699
D3, D5	0.48	0.6302
D3, D6	0.93	0.4257
D3, D7	0.50	0.6141
D3, D8	0.54	0.5943
D3, D9	0.08	0.9510
D3, D10	0.14	0.9079
D3, D11	0.51	0.6137
D3, D12	0.19	0.8492
D3, D13	0.69	0.5082
D3, PRS	1.03	0.3849
D3, P1	1.13	0.3343
D3, P2	0.15	0.8601
D3, P3	0.55	0.5873
D4, D5	0.16	0.8355
D4, D6	0.26	0.8367
D4, D7	0.14	0.8872
D4, D8	0.22	0.8230
D4, D9	2.08	0.1284
D4, D10	1.42	0.2757
D4, D11	1.15	0.3125
D4, D12	0.10	0.9262
D4, D13	0.52	0.6440
D4, PRS	2.87	0.0715
D4, P1	1.25	0.2815
D4, P2	1.69	0.2191
D4, P3	0.27	0.8322
D5, D6	0.23	0.7257
D5, D7	0.38	0.6635
D5, D8	0.03	0.9665
D5, D9	0.78	0.4783
D5, D10	0.67	0.5411
D5, D11	1.28	0.2898
D5, D12	0.42	0.6938
D5, D13	0.46	0.6129
D5, PRS	**4.97**	**0.0281**
D5, P1	1.75	0.1832
D5, P2	1.14	0.3243
D5, P3	0.21	0.7803
D6, D7	1.30	0.3091
D6, D8	0.25	0.7303
D6, D9	0.91	0.4085
D6, D10	0.69	0.5350
D6, D11	1.47	0.2408
D6, D12	0.34	0.7751
D6, D13	0.19	0.7964
D6, PRS	3.06	0.0752
D6, P1	2.34	0.1119
D6, P2	1.05	0.3602
D6, P3	0.04	0.9470
D7, D8	0.53	0.6097
D7, D9	0.47	0.6472

Comparisons between Surveys	t	p-value
D7, D10	0.40	0.7076
D7, D11	0.93	0.4213
D7, D12	0.03	0.9487
D7, D13	0.62	0.5538
D7, PRS	1.99	0.1321
D7, P1	1.60	0.2028
D7, P2	0.54	0.6036
D7, P3	0.43	0.6590
D8, D9	1.08	0.3459
D8, D10	0.78	0.4740
D8, D11	1.40	0.2391
D8, D12	0.35	0.7508
D8, D13	0.44	0.6597
D8, PRS	**6.06**	**0.0250**
D8, P1	1.82	0.1655
D8, P2	1.48	0.2268
D8, P3	0.15	0.8645
D9, D10	0.28	0.7303
D9, D11	0.73	0.5095
D9, D12	0.45	0.6716
D9, D13	1.57	0.1981
D9, PRS	2.28	0.1188
D9, P1	0.98	0.3982
D9, P2	0.34	0.7116
D9, P3	1.05	0.3460
D10, D11	0.34	0.7505
D10, D12	0.54	0.6188
D10, D13	1.25	0.2964
D10, PRS	1.27	0.3009
D10, P1	0.56	0.5805
D10, P2	0.08	0.9210
D10, P3	0.90	0.4191
D11, D12	0.88	0.4326
D11, D13	3.39	0.0603
D11, PRS	1.17	0.3335
D11, P1	1.07	0.3867
D11, P2	0.53	0.5976
D11, P3	2.18	0.1194
D12, D13	0.83	0.4441
D12, PRS	3.40	0.0546
D12, P1	1.09	0.3073
D12, P2	0.82	0.4613
D12, P3	0.64	0.5633
D13, PRS	**6.24**	**0.0165**
D13, P1	3.16	0.0645
D13, P2	2.49	0.0957
D13, P3	0.90	0.4464
PRS, P1	0.56	0.5988
PRS, P2	**3.71**	**0.0496**
PRS, P3	**5.86**	**0.0175**
P1, P2	0.82	0.4562
P1, P3	2.57	0.0922
P2, P3	1.65	0.1866
Within level 'MAN' of factor 'Site'		
B1, B2	0.30	0.7282
B1, B3	0.65	0.5444
B1, D2	0.09	0.8743
B1, D6	0.90	0.4104

Comparisons between Surveys	t	p-value
B1, D10	**4.79**	**0.0267**
B1, P1	2.00	0.1322
B1, P2	3.09	0.0586
B1, P3	2.29	0.0965
B2, B3	0.28	0.7576
B2, D2	0.49	0.6351
B2, D6	1.32	0.2827
B2, D10	**5.81**	**0.0208**
B2, P1	2.87	0.0728
B2, P2	**4.31**	**0.0417**
B2, P3	**3.66**	**0.0451**
B3, D2	0.36	0.7085
B3, D6	0.67	0.5321
B3, D10	1.91	0.1653
B3, P1	2.16	0.1316
B3, P2	2.53	0.1076
B3, P3	1.94	0.1445
D2, D6	1.37	0.2300
D2, D10	**5.84**	**0.0190**
D2, P1	2.51	0.0983
D2, P2	3.03	0.0833
D2, P3	3.10	0.0612
D6, D10	0.58	0.5854
D6, P1	2.59	0.0775
D6, P2	1.03	0.3636
D6, P3	2.25	0.1173
D10, P1	0.61	0.5465
D10, P2	0.52	0.6388
D10, P3	0.83	0.4447
P1, P2	0.50	0.6508
P1, P3	0.13	0.8533
P2, P3	0.84	0.4280
Within level 'NEW' of factor 'Site'		
B1, B2	0.36	0.7345
B1, B3	0.76	0.4821
B1, D3	0.91	0.4094
B1, D4	0.63	0.5749
B1, D5	0.61	0.5771
B1, D6	0.61	0.5535
B1, D7	1.57	0.1742
B1, D8	1.27	0.2907
B1, D9	0.63	0.5490
B1, D10	1.46	0.2339
B1, D11	1.26	0.2994
B1, D13	0.51	0.6260
B1, PRS	1.08	0.3352
B1, P1	1.51	0.2061
B1, P2	0.22	0.8270
B1, P3	0.89	0.4326
B2, B3	0.92	0.4413
B2, D3	0.88	0.4161
B2, D4	0.08	0.9170
B2, D5	0.05	0.9917
B2, D6	0.27	0.8309
B2, D7	0.81	0.5389
B2, D8	0.92	0.4353
B2, D9	0.07	0.8737
B2, D10	0.97	0.3989

Comparisons between Surveys	t	p-value
B2, D11	0.49	0.6728
B2, D13	1.09	0.3262
B2, PRS	0.74	0.5058
B2, P1	0.95	0.4374
B2, P2	0.13	0.9263
B2, P3	0.33	0.7617
B3, D3	1.47	0.2645
B3, D4	1.51	0.2431
B3, D5	0.73	0.5074
B3, D6	1.50	0.2308
B3, D7	1.86	0.1014
B3, D8	1.55	0.1825
B3, D9	0.79	0.4552
B3, D10	1.82	0.1388
B3, D11	1.30	0.3134
B3, D13	0.08	0.9831
B3, PRS	1.57	0.2086
B3, P1	1.63	0.1698
B3, P2	0.46	0.7018
B3, P3	0.96	0.4370
D3, D4	0.94	0.4187
D3, D5	0.61	0.5518
D3, D6	1.05	0.3681
D3, D7	0.31	0.7989
D3, D8	0.64	0.5699
D3, D9	0.51	0.5634
D3, D10	0.43	0.7047
D3, D11	0.10	0.7998
D3, D13	1.26	0.3151
D3, PRS	0.19	0.8479
D3, P1	0.67	0.5288
D3, P2	0.70	0.5160
D3, P3	0.17	0.7814
D4, D5	0.13	0.8866
D4, D6	0.41	0.5747
D4, D7	1.17	0.2997
D4, D8	1.22	0.3004
D4, D9	0.07	0.9773
D4, D10	1.48	0.2399
D4, D11	0.73	0.5093
D4, D13	1.82	0.1825
D4, PRS	1.21	0.3166
D4, P1	1.27	0.2737
D4, P2	0.26	0.8504
D4, P3	0.44	0.6712
D5, D6	0.18	0.8732
D5, D7	1.50	0.2223
D5, D8	1.15	0.3219
D5, D9	0.30	0.6604
D5, D10	1.26	0.2888
D5, D11	1.30	0.2890
D5, D13	0.66	0.5455
D5, PRS	0.74	0.4947
D5, P1	1.63	0.1956
D5, P2	0.16	0.8591
D5, P3	0.96	0.3994
D6, D7	1.05	0.3702
D6, D8	1.16	0.3166

Comparisons between Surveys	t	p-value	
D6, D9	0.02	0.9792	
D6, D10	1.34	0.2505	
D6, D11	0.55	0.6012	
D6, D13	1.46	0.2354	
D6, PRS	1.08	0.3584	
D6, P1	1.17	0.3265	
D6, P2	0.29	0.8189	
D6, P3	0.34	0.7447	
D7, D8	0.47	0.6420	
D7, D9	1.18	0.3063	
D7, D10	0.12	0.8540	
D7, D11	0.64	0.5609	
D7, D13	1.54	0.1966	
D7, PRS	0.68	0.5495	
D7, P1	1.09	0.3604	
D7, P2	1.51	0.2234	
D7, P3	0.80	0.4698	
D8, D9	1.15	0.3119	
D8, D10	0.59	0.6516	
D8, D11	0.77	0.5003	
D8, D13	1.53	0.2080	
D8, PRS	1.18	0.3101	
D8, P1	0.65	0.5707	
D8, P2	1.48	0.2222	
D8, P3	0.86	0.4555	
D9, D10	1.33	0.2628	
D9, D11	2.17	0.1106	
D9, D13	1.15	0.3290	
D9, PRS	0.73	0.5092	
D9, P1	1.61	0.1970	
D9, P2	2.18	0.0889	
D9, P3	0.81	0.4946	
D10, D11	0.75	0.4902	
D10, D13	1.85	0.1373	
D10, PRS	1.69	0.2193	
D10, P1	0.89	0.4362	
D10, P2	1.75	0.1755	
D10, P3	0.76	0.4862	
D11, D13	1.55	0.2227	
D11, PRS	0.02	0.9749	
D11, P1	1.39	0.2555	
D11, P2	**3.94**	**0.0429**	
D11, P3	0.35	0.6326	
D13, PRS	1.71	0.1735	
D13, P1	1.62	0.1861	
D13, P2	0.69	0.5199	
D13, P3	1.03	0.3889	
PRS, P1	1.14	0.3142	
PRS, P2	1.09	0.3232	
PRS, P3	0.14	0.9115	
P1, P2	2.03	0.1091	
P1, P3	1.94	0.1626	
P2, P3	1.41	0.2689	
Within level 'SSI' of factor 'Site'			
B1, B2	0.21	0.9194	
B1, B3	0.13	0.7049	
B1, D3	0.56	0.5917	
B1, D4	0.62	0.5711	
B1, D5	0.23	0.7576	
B1, D6	2.25	0.1399	
B1, D7	0.08	0.9366	
B1, D8	0.83	0.4572	
B1, D9	**35.71**	**0.0171**	**MC**
B1, D10	2.94	0.0722	
B1, D11	0.94	0.4271	
B1, D13	2.58	0.1179	
B1, PRS	**4.27**	**0.0419**	
B1, P1	3.47	0.0594	
B1, P2	**6.08**	**0.0274**	
B1, P3	**4.08**	**0.0376**	
B2, B3	0.27	0.8537	
B2, D3	**3.31**	**0.0344**	
B2, D4	2.09	0.1470	
B2, D5	1.16	0.3480	
B2, D6	**3.99**	**0.0235**	
B2, D7	0.29	0.6994	
B2, D8	**4.15**	**0.0302**	
B2, D9	1.85	0.3111	MC
B2, D10	**5.15**	**0.0124**	
B2, D11	**3.67**	**0.0433**	
B2, D13	**9.03**	**0.0027**	
B2, PRS	3.52	0.0555	
B2, P1	**4.87**	**0.0269**	
B2, P2	**3.77**	**0.0174**	
B2, P3	**3.88**	**0.0119**	
B3, D3	0.62	0.5572	
B3, D4	0.64	0.5681	
B3, D5	0.20	0.7994	
B3, D6	2.93	0.0733	
B3, D7	0.14	0.8697	
B3, D8	0.87	0.4402	
B3, D9	**21.68**	**0.0272**	**MC**
B3, D10	**3.59**	**0.0491**	
B3, D11	0.96	0.4122	
B3, D13	3.02	0.0765	
B3, PRS	**5.20**	**0.0247**	
B3, P1	**4.22**	**0.0322**	
B3, P2	**9.81**	**0.0068**	
B3, P3	**5.38**	**0.0181**	
D3, D4	0.64	0.5496	
D3, D5	0.70	0.5187	
D3, D6	**3.45**	**0.0392**	
D3, D7	1.26	0.3147	
D3, D8	0.59	0.6156	
D3, D9	1.88	0.3179	MC
D3, D10	**5.97**	**0.0070**	
D3, D11	0.91	0.4198	
D3, D13	**7.17**	**0.0034**	
D3, PRS	2.58	0.0823	
D3, P1	3.38	0.0662	
D3, P2	**3.58**	**0.0283**	
D3, P3	**3.88**	**0.0078**	
D4, D5	0.95	0.3805	
D4, D6	0.72	0.5206	
D4, D7	1.12	0.3307	
D4, D8	0.37	0.7068	

Comparisons between Surveys	t	p-value	
D4, D9	1.01	0.4890	MC
D4, D10	1.45	0.2553	
D4, D11	0.12	0.8367	
D4, D13	1.93	0.1714	
D4, PRS	1.17	0.3364	
D4, P1	1.18	0.3295	
D4, P2	1.66	0.1906	
D4, P3	1.91	0.1673	
D5, D6	2.56	0.0893	
D5, D7	0.49	0.6115	
D5, D8	1.83	0.1907	
D5, D9	1.56	0.3699	MC
D5, D10	3.33	0.0567	
D5, D11	2.66	0.0701	
D5, D13	**4.68**	**0.0197**	
D5, PRS	3.57	0.0533	
D5, P1	**4.80**	**0.0284**	
D5, P2	**3.33**	**0.0398**	
D5, P3	**3.14**	**0.0370**	
D6, D7	**5.05**	**0.0152**	
D6, D8	2.03	0.1705	
D6, D9	1.10	0.4677	MC
D6, D10	2.15	0.1378	
D6, D11	0.88	0.4144	
D6, D13	2.60	0.0802	
D6, PRS	1.61	0.2121	
D6, P1	1.68	0.2213	
D6, P2	**3.34**	**0.0455**	
D6, P3	**3.65**	**0.0106**	
D7, D8	1.34	0.2923	
D7, D9	1.45	0.3878	MC
D7, D10	3.84	0.0535	
D7, D11	2.01	0.1447	
D7, D13	**10.66**	**0.0012**	
D7, PRS	**6.24**	**0.0193**	
D7, P1	**8.65**	**0.0051**	
D7, P2	**4.48**	**0.0169**	
D7, P3	**4.71**	**0.0069**	
D8, D9	1.79	0.3303	MC
D8, D10	**3.88**	**0.0338**	
D8, D11	0.74	0.5058	
D8, D13	**4.07**	**0.0244**	
D8, PRS	2.38	0.1000	
D8, P1	3.09	0.0620	
D8, P2	3.08	0.0531	
D8, P3	**3.02**	**0.0475**	
D9, D10	1.32	0.4121	MC
D9, D11	0.77	0.5858	MC
D9, D13	0.32	0.7988	MC
D9, PRS	0.33	0.7637	
D9, P1	0.25	0.8505	MC
D9, P2	**25.91**	**0.0250**	**MC**
D9, P3	3.03	0.2014	MC
D10, D11	1.60	0.2261	
D10, D13	0.12	0.8361	
D10, PRS	0.17	0.8486	
D10, P1	0.29	0.7347	
D10, P2	1.84	0.1720	
D10, P3	2.17	0.1358	
D11, D13	**2.81**	**0.0461**	
D11, PRS	1.78	0.1744	
D11, P1	1.94	0.1731	
D11, P2	2.00	0.1658	
D11, P3	2.11	0.1577	
D13, PRS	0.12	0.8805	
D13, P1	0.63	0.5747	
D13, P2	1.27	0.2880	
D13, P3	1.65	0.2231	
PRS, P1	1.05	0.4002	
PRS, P2	1.50	0.2366	
PRS, P3	1.57	0.2066	
P1, P2	1.92	0.1832	
P1, P3	1.97	0.1788	
P2, P3	0.87	0.4501	
Within level 'WR1' of factor 'Site'			
B1, B2	1.31	0.2591	
B1, B3	1.32	0.2552	
B1, D1	1.05	0.3506	
B1, D2	1.54	0.2094	
B1, D3	2.20	0.1264	
B1, D4	1.67	0.2250	
B1, D5	1.23	0.2991	
B1, D6	1.89	0.1696	
B1, D7	**5.18**	**0.0205**	
B1, D8	3.49	0.0533	
B1, D9	3.54	0.0568	
B1, D10	1.88	0.1804	
B1, D11	**3.87**	**0.0454**	
B1, D12	2.55	0.0910	
B1, D13	2.80	0.0846	
B1, PRS	1.93	0.1697	
B1, P1	**6.88**	**0.0182**	
B1, P2	2.03	0.1401	
B1, P3	2.68	0.0942	
B2, B3	0.34	0.7379	
B2, D1	0.16	0.8287	
B2, D2	0.28	0.7689	
B2, D3	0.26	0.7979	
B2, D4	0.48	0.6977	
B2, D5	0.19	0.8707	
B2, D6	0.38	0.6919	
B2, D7	0.60	0.6182	
B2, D8	**4.00**	**0.0355**	
B2, D9	0.64	0.5646	
B2, D10	0.21	0.8373	
B2, D11	0.85	0.4480	
B2, D12	0.25	0.7946	
B2, D13	0.34	0.7458	
B2, PRS	0.37	0.6969	
B2, P1	0.62	0.5909	
B2, P2	0.14	0.8561	
B2, P3	0.43	0.6676	
B3, D1	0.51	0.6125	
B3, D2	0.05	0.9227	
B3, D3	0.68	0.5309	
B3, D4	0.24	0.8096	

Comparisons between Surveys	t	p-value
B3, D5	0.94	0.3993
B3, D6	0.17	0.8421
B3, D7	0.36	0.7576
B3, D8	1.12	0.3410
B3, D9	0.35	0.7276
B3, D10	0.18	0.8217
B3, D11	0.66	0.5204
B3, D12	0.17	0.8517
B3, D13	0.16	0.8639
B3, PRS	0.24	0.8329
B3, P1	0.27	0.7913
B3, P2	0.06	0.9594
B3, P3	0.25	0.8263
D1, D2	0.18	0.8325
D1, D3	0.40	0.6871
D1, D4	0.32	0.7549
D1, D5	0.49	0.6226
D1, D6	0.28	0.7778
D1, D7	0.41	0.6945
D1, D8	1.03	0.3673
D1, D9	0.40	0.6874
D1, D10	0.04	0.9420
D1, D11	0.66	0.5455
D1, D12	0.02	0.9754
D1, D13	0.24	0.8303
D1, PRS	0.35	0.7489
D1, P1	0.31	0.7645
D1, P2	0.03	0.9747
D1, P3	0.34	0.7551
D2, D3	0.84	0.4563
D2, D4	0.17	0.8709
D2, D5	1.44	0.2644
D2, D6	0.57	0.5381
D2, D7	0.43	0.6655
D2, D8	0.88	0.4133
D2, D9	0.47	0.6013
D2, D10	0.26	0.7287
D2, D11	1.02	0.4092
D2, D12	0.21	0.8280
D2, D13	0.17	0.8840
D2, PRS	0.32	0.6914
D2, P1	0.31	0.7669
D2, P2	0.13	0.8430
D2, P3	0.30	0.7437
D3, D4	0.70	0.5451
D3, D5	0.11	0.8893
D3, D6	1.25	0.3149
D3, D7	2.19	0.1278
D3, D8	2.24	0.1320
D3, D9	**4.67**	**0.0265**
D3, D10	1.17	0.3174
D3, D11	**4.29**	**0.0346**
D3, D12	2.66	0.0832
D3, D13	1.02	0.3718
D3, PRS	1.14	0.3343
D3, P1	1.34	0.2547
D3, P2	0.54	0.6095
D3, P3	1.56	0.2313
D4, D5	0.53	0.6151
D4, D6	0.13	0.8908
D4, D7	0.05	0.9109
D4, D8	0.81	0.4531
D4, D9	0.03	0.9745
D4, D10	0.34	0.6716
D4, D11	0.18	0.8600
D4, D12	0.40	0.6370
D4, D13	0.10	0.8776
D4, PRS	0.09	0.9130
D4, P1	0.04	0.9669
D4, P2	0.25	0.8111
D4, P3	0.07	0.8865
D5, D6	1.79	0.1951
D5, D7	1.07	0.3561
D5, D8	1.65	0.2001
D5, D9	1.66	0.2053
D5, D10	0.99	0.4175
D5, D11	2.09	0.1367
D5, D12	0.75	0.4781
D5, D13	0.65	0.5278
D5, PRS	1.02	0.3950
D5, P1	0.81	0.4737
D5, P2	0.38	0.6970
D5, P3	0.99	0.3923
D6, D7	0.39	0.6994
D6, D8	0.88	0.4350
D6, D9	0.41	0.6293
D6, D10	0.57	0.6039
D6, D11	1.21	0.3267
D6, D12	0.42	0.6744
D6, D13	0.09	0.9250
D6, PRS	0.18	0.7446
D6, P1	0.26	0.8059
D6, P2	0.28	0.7290
D6, P3	0.21	0.7610
D7, D8	0.78	0.4878
D7, D9	0.28	0.7534
D7, D10	0.85	0.4327
D7, D11	0.54	0.6188
D7, D12	1.05	0.3619
D7, D13	0.59	0.5646
D7, PRS	0.32	0.7020
D7, P1	0.01	0.9457
D7, P2	0.97	0.4050
D7, P3	0.50	0.6371
D8, D9	0.99	0.3904
D8, D10	1.28	0.2785
D8, D11	0.62	0.5335
D8, D12	1.76	0.1747
D8, D13	0.76	0.5020
D8, PRS	0.73	0.4863
D8, P1	0.86	0.4477
D8, P2	0.86	0.4351
D8, P3	0.81	0.4641
D9, D10	1.02	0.3718
D9, D11	2.82	0.0595
D9, D12	1.35	0.2854

Comparisons between Surveys	t	p-value
D9, D13	0.14	0.8756
D9, PRS	0.16	0.8049
D9, P1	0.15	0.8653
D9, P2	0.58	0.5659
D9, P3	0.13	0.8414
D10, D11	1.76	0.2109
D10, D12	0.06	0.9168
D10, D13	0.40	0.6833
D10, PRS	0.75	0.4757
D10, P1	0.48	0.6493
D10, P2	0.01	0.9754
D10, P3	0.82	0.4467
D11, D12	1.91	0.1629
D11, D13	0.64	0.5653
D11, PRS	0.78	0.4891
D11, P1	0.28	0.7728
D11, P2	1.17	0.3361
D11, P3	0.98	0.3670
D12, D13	0.43	0.6708
D12, PRS	0.51	0.6526
D12, P1	0.62	0.5632
D12, P2	0.03	0.9287
D12, P3	0.71	0.5121
D13, PRS	0.01	0.9757
D13, P1	0.22	0.8428
D13, P2	0.61	0.5718
D13, P3	0.10	0.8376
PRS, P1	0.16	0.8833
PRS, P2	0.45	0.6672
PRS, P3	0.11	0.7262
P1, P2	0.59	0.5828
P1, P3	0.17	0.8949
P2, P3	0.60	0.5809
Within level 'WR2' of factor 'Site'		
B1, B2	0.03	0.9734
B1, B3	0.02	0.9460
B1, D1	0.64	0.5241
B1, D2	0.31	0.7873
B1, D3	0.71	0.6436
B1, D4	0.77	0.5943
B1, D5	0.70	0.6988
B1, D6	1.04	0.4119
B1, D7	1.18	0.3116
B1, D8	0.87	0.6023
B1, D9	0.84	0.5724
B1, D10	0.68	0.6962
B1, D11	0.63	0.7341
B1, D12	1.02	0.4357
B1, D13	1.04	0.4230
B1, PRS	0.84	0.5623
B1, P1	0.95	0.4718
B1, P2	0.02	0.9831
B1, P3	0.67	0.6522
B2, B3	0.02	0.9522
B2, D1	0.85	0.4211
B2, D2	0.69	0.5347
B2, D3	1.11	0.3606
B2, D4	1.20	0.3379

Comparisons between Surveys	t	p-value
B2, D5	1.20	0.3153
B2, D6	1.61	0.1870
B2, D7	1.84	0.1334
B2, D8	1.26	0.2982
B2, D9	1.17	0.3217
B2, D10	1.01	0.4066
B2, D11	0.86	0.4836
B2, D12	1.53	0.2321
B2, D13	1.54	0.2124
B2, PRS	1.33	0.2655
B2, P1	1.47	0.2323
B2, P2	0.04	0.9549
B2, P3	1.05	0.3696
B3, D1	0.84	0.4520
B3, D2	0.81	0.4662
B3, D3	1.23	0.2980
B3, D4	1.30	0.3072
B3, D5	1.15	0.3201
B3, D6	1.76	0.1858
B3, D7	1.91	0.1178
B3, D8	1.27	0.2834
B3, D9	1.24	0.3009
B3, D10	1.04	0.3614
B3, D11	0.87	0.5098
B3, D12	1.62	0.1906
B3, D13	1.61	0.1768
B3, PRS	1.37	0.2389
B3, P1	1.61	0.2036
B3, P2	0.03	0.9797
B3, P3	1.10	0.3397
D1, D2	0.07	0.9425
D1, D3	0.64	0.5878
D1, D4	0.77	0.4836
D1, D5	0.63	0.6322
D1, D6	1.06	0.3623
D1, D7	1.20	0.3198
D1, D8	0.83	0.5465
D1, D9	0.80	0.5336
D1, D10	0.64	0.6381
D1, D11	0.58	0.6480
D1, D12	1.05	0.3795
D1, D13	1.05	0.4104
D1, PRS	0.83	0.5073
D1, P1	0.94	0.4361
D1, P2	0.16	0.8986
D1, P3	0.64	0.5924
D2, D3	1.28	0.2944
D2, D4	1.62	0.2534
D2, D5	1.23	0.2956
D2, D6	2.16	0.1359
D2, D7	2.24	0.1183
D2, D8	1.36	0.2679
D2, D9	1.28	0.2915
D2, D10	1.12	0.3034
D2, D11	0.86	0.4567
D2, D12	1.97	0.1357
D2, D13	1.87	0.1442
D2, PRS	1.66	0.2151

Comparisons between Surveys	t	p-value
D2, P1	1.90	0.1715
D2, P2	0.36	0.6736
D2, P3	1.30	0.3093
D3, D4	0.56	0.5248
D3, D5	0.05	0.9256
D3, D6	**5.77**	**0.0041**
D3, D7	3.05	0.0683
D3, D8	1.09	0.3399
D3, D9	1.22	0.2995
D3, D10	0.43	0.6342
D3, D11	0.44	0.7186
D3, D12	2.24	0.1143
D3, D13	2.31	0.1161
D3, PRS	0.92	0.4694
D3, P1	**5.70**	**0.0012**
D3, P2	2.90	0.0700
D3, P3	0.14	0.8551
D4, D5	0.45	0.6980
D4, D6	1.10	0.4464
D4, D7	1.15	0.3361
D4, D8	0.57	0.6024
D4, D9	0.54	0.6189
D4, D10	0.05	0.8894
D4, D11	0.21	0.8692
D4, D12	1.79	0.2004
D4, D13	1.30	0.3147
D4, PRS	0.40	0.5532
D4, P1	0.50	0.5313
D4, P2	**3.43**	**0.0078**
D4, P3	0.94	0.4868
D5, D6	1.34	0.2868
D5, D7	2.35	0.1183
D5, D8	1.22	0.2976
D5, D9	0.82	0.4637
D5, D10	0.46	0.6321
D5, D11	0.48	0.6797
D5, D12	1.67	0.1974
D5, D13	1.79	0.1608
D5, PRS	1.29	0.3426
D5, P1	0.95	0.4037
D5, P2	1.60	0.2173
D5, P3	0.20	0.7988
D6, D7	0.99	0.3923
D6, D8	0.02	0.9170
D6, D9	0.06	0.9519
D6, D10	1.06	0.3835
D6, D11	0.24	0.8328
D6, D12	0.71	0.5134
D6, D13	0.85	0.4681
D6, PRS	0.83	0.4896
D6, P1	**3.89**	**0.0082**
D6, P2	**5.66**	**0.0136**
D6, P3	1.21	0.3938
D7, D8	0.73	0.5038
D7, D9	0.62	0.5768
D7, D10	1.52	0.2349
D7, D11	0.55	0.5886
D7, D12	0.19	0.8319
D7, D13	0.02	0.9732
D7, PRS	1.57	0.2235
D7, P1	1.93	0.1674
D7, P2	**4.45**	**0.0459**
D7, P3	1.34	0.2890
D8, D9	0.04	0.9590
D8, D10	1.19	0.3264
D8, D11	0.39	0.6816
D8, D12	0.52	0.5971
D8, D13	1.14	0.3324
D8, PRS	0.63	0.5887
D8, P1	0.37	0.7481
D8, P2	**3.86**	**0.0467**
D8, P3	0.82	0.4741
D9, D10	0.87	0.4335
D9, D11	0.30	0.7873
D9, D12	0.52	0.6434
D9, D13	0.95	0.3805
D9, PRS	0.42	0.6902
D9, P1	0.37	0.7376
D9, P2	**5.71**	**0.0245**
D9, P3	0.71	0.5317
D10, D11	0.40	0.7469
D10, D12	**4.20**	**0.0095**
D10, D13	2.80	0.0905
D10, PRS	0.69	0.5095
D10, P1	0.51	0.5837
D10, P2	**4.72**	**0.0276**
D10, P3	0.38	0.5981
D11, D12	0.62	0.5653
D11, D13	0.75	0.5104
D11, PRS	0.07	0.9823
D11, P1	0.02	0.9825
D11, P2	2.45	0.1001
D11, P3	0.42	0.7892
D12, D13	0.33	0.6835
D12, PRS	2.13	0.1137
D12, P1	1.26	0.3534
D12, P2	**9.58**	**0.0084**
D12, P3	2.07	0.1386
D13, PRS	1.80	0.2094
D13, P1	1.43	0.2507
D13, P2	**7.59**	**0.0156**
D13, P3	1.53	0.2584
PRS, P1	0.18	0.8369
PRS, P2	**3.71**	**0.0384**
PRS, P3	0.95	0.4766
P1, P2	**4.47**	**0.0334**
P1, P3	0.72	0.5152
P2, P3	2.49	0.0872

c. Matrix of pair-wise comparisons between sites for each survey for the significant Survey x Site term. Surveys in which the site comparisons are significantly different are highlighted in bold.

	CHI	WR1	WR2	SSI	NEW
WR1	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3				
WR2	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3			
SSI	B1, B2, B3, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	B1, B2, B3, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3	B1, B2, B3, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, P2, P3		
NEW	**B1**, **B2**, **B3**, **D3**, **D4**, **D5**, **D6**, **D7**, **D8**, **D9**, **D10**, **D11**, **D13**, **P_{RS}**, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, **D3**, **D4**, **D5**, **D6**, **D7**, **D8**, **D9**, **D10**, **D11**, **D13**, **P_{RS}**, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, **D3**, **D4**, **D5**, **D6**, **D7**, **D8**, **D9**, **D10**, **D11**, **D13**, **P_{RS}**, **P1**, **P2**, **P3**	**B1**, **B2**, **B3**, **D3**, D4, **D5**, **D6**, **D7**, **D8**, D9, D10, D11, D13, P_{RS}, P1, P2, P3	
MAN	B1, B2, B3, D2, D6, D10, P1, P2, P3	B1, B2, B3, D2, D6, D10, P1, P2, P3	B1, B2, B3, D2, D6, D10, P1, P2, P3	B1, B2, B3, D6, D10, P1, P2, P3	**B1**, **B2**, **B3**, **D6**, **D10**, **P1**, **P2**, **P3**

Appendix D-5 Univariate analysis using PERMANOVA testing for differences in silt and sand cover among Sites (CHI, WR1, WR2, SSI, NEW and MAN) and across surveys (B1 to P3). Significant (p ≤ 0.05) terms in bold. RED = Redundant term due to significant interaction. MC = Monte Carlo simulation was used to calculate P values where unique permutations < 100. Baseline versus Post-dredging pair-wise comparisons highlighted in teal

a. PERMANOVA analysis

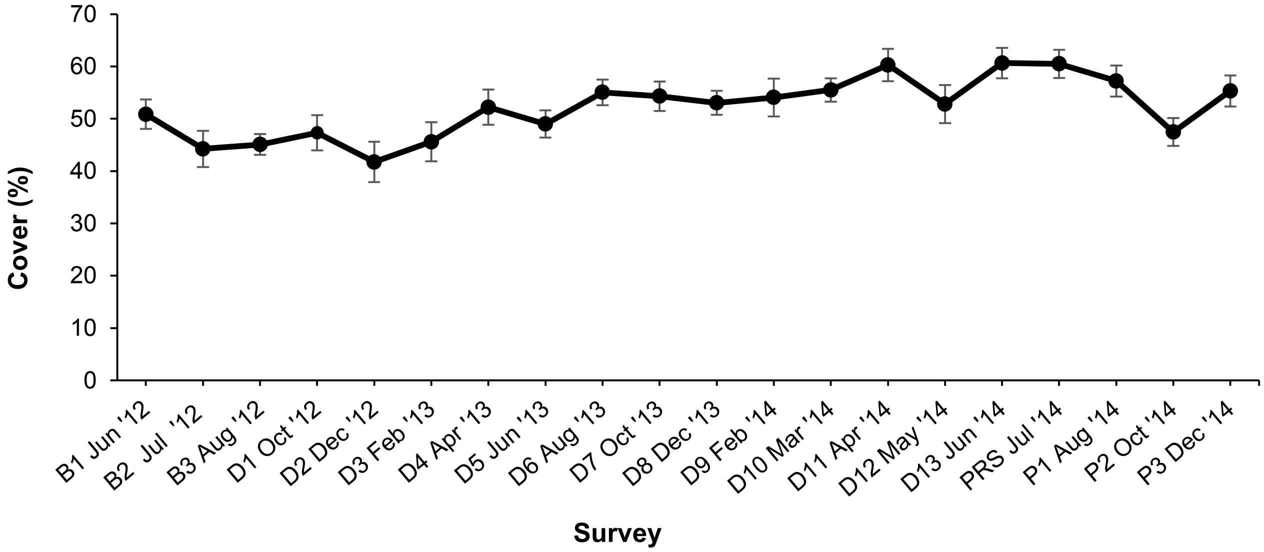
Source of Variation	df	SS	MS	Pseudo-F	p(perm)
Survey	**19**	**11294**	**594.44**	**11.499**	**0.0001**
Site	**5**	**23338**	**4667.5**	**2.6256**	**0.0042**
Transect (Site)	18	32600	1811.1	34.193	
Survey x Site	78	4032	51.692	0.9759	0.5385
Residual	289	15308	52.968		
Total	409	88568			

b. Pair-wise for the term Survey

Comparisons between Survey	t	p-value	
B1, B2	**2.70**	**0.0371**	
B1, B3	1.73	0.1395	
B1, D1	1.82	0.1739	
B1, D2	2.31	0.0921	
B1, D3	**3.14**	**0.0269**	
B1, D4	0.33	0.8412	
B1, D5	**3.98**	**0.0052**	
B1, D6	2.27	0.0651	
B1, D7	0.50	0.6672	
B1, D8	0.05	0.9821	
B1, D9	0.35	0.8238	
B1, D10	**2.50**	**0.0352**	
B1, D11	**3.12**	**0.0214**	
B1, D12	0.32	0.8501	
B1, D13	**3.09**	**0.0199**	
B1, PRS	**4.79**	**0.0005**	
B1, P1	**9.80**	**0.0002**	
B1, P2	1.25	0.2910	
B1, P3	**5.01**	**0.0011**	
B2, B3	0.09	0.9420	
B2, D1	1.14	0.3583	
B2, D2	1.72	0.1877	
B2, D3	1.98	0.1083	
B2, D4	0.88	0.4624	
B2, D5	0.05	0.9684	
B2, D6	**4.39**	**0.0065**	
B2, D7	**4.23**	**0.0093**	
B2, D8	**2.52**	**0.0487**	
B2, D9	1.86	0.1258	
B2, D10	**3.65**	**0.0095**	
B2, D11	**6.41**	**0.0017**	
B2, D12	0.53	0.6831	
B2, D13	**4.82**	**0.0068**	
B2, PRS	**4.87**	**0.0046**	
B2, P1	**10.73**	**0.0001**	
B2, P2	1.50	0.1916	
B2, P3	**5.07**	**0.0012**	
B3, D1	0.16	0.8822	
B3, D2	1.14	0.3372	
B3, D3	0.98	0.3824	
B3, D4	2.07	0.1037	
B3, D5	1.57	0.1907	
B3, D6	**13.98**	**0.0002**	
B3, D7	**5.48**	**0.0076**	
B3, D8	**3.97**	**0.0268**	
B3, D9	2.61	0.0647	
B3, D10	**9.01**	**0.0003**	
B3, D11	**14.11**	**0.0008**	
B3, D12	2.53	0.1550	
B3, D13	**13.30**	**0.0002**	
B3, PRS	**4.70**	**0.0115**	
B3, P1	**5.68**	**0.0038**	
B3, P2	1.92	0.1131	
B3, P3	**4.16**	**0.0088**	
D1, D2	0.47	0.7100	
D1, D3	1.26	0.3603	
D1, D4	1.40	0.3062	
D1, D5	0.96	0.4190	
D1, D6	**4.38**	**0.0441**	
D1, D7	1.79	0.2150	
D1, D8	**6.55**	**0.0282**	
D1, D9	**10.52**	**0.0178**	
D1, D10	**9.94**	**0.0163**	
D1, D11	**5.76**	**0.0364**	
D1, D12	**12.66**	**0.0068**	**MC**
D1, D13	**10.50**	**0.0162**	
D1, PRS	2.39	0.1417	
D1, P1	4.42	0.0641	
D1, P2	1.11	0.3904	
D1, P3	**9.36**	**0.0072**	
D2, D3	0.23	0.8465	
D2, D4	0.86	0.5314	
D2, D5	1.13	0.3885	
D2, D6	**4.33**	**0.0199**	
D2, D7	2.63	0.0991	
D2, D8	**3.26**	**0.0443**	
D2, D9	2.79	0.0542	
D2, D10	**3.37**	**0.0283**	

Comparisons between Survey	t	p-value
D2, D11	**5.19**	**0.0233**
D2, D12	3.15	0.0517
D2, D13	**6.62**	**0.0091**
D2, PRS	2.40	0.1201
D2, P1	**4.95**	**0.0114**
D2, P2	1.81	0.1665
D2, P3	**5.51**	**0.0003**
D3, D4	2.33	0.0838
D3, D5	1.78	0.1566
D3, D6	**9.56**	**0.0005**
D3, D7	**3.96**	**0.0139**
D3, D8	**6.20**	**0.0023**
D3, D9	**6.19**	**0.0069**
D3, D10	**7.96**	**0.0025**
D3, D11	**10.79**	**0.0012**
D3, D12	**11.11**	**0.0151**
D3, D13	**10.08**	**0.0011**
D3, PRS	**4.25**	**0.0131**
D3, P1	**8.95**	**0.0023**
D3, P2	2.54	0.0665
D3, P3	**6.95**	**0.0012**
D4, D5	1.31	0.2642
D4, D6	1.84	0.1433
D4, D7	0.56	0.6299
D4, D8	0.29	0.7595
D4, D9	1.24	0.2852
D4, D10	**4.03**	**0.0210**
D4, D11	**3.29**	**0.0293**
D4, D12	1.59	0.2553
D4, D13	**4.77**	**0.0110**
D4, PRS	2.08	0.0861
D4, P1	**3.31**	**0.0295**
D4, P2	0.72	0.5512
D4, P3	**3.03**	**0.0275**
D5, D6	**4.19**	**0.0067**
D5, D7	**2.80**	**0.0323**
D5, D8	**3.69**	**0.0261**
D5, D9	**2.69**	**0.0441**
D5, D10	**4.77**	**0.0119**
D5, D11	**6.00**	**0.0052**
D5, D12	1.22	0.3676
D5, D13	**6.40**	**0.0035**
D5, PRS	**5.43**	**0.0063**
D5, P1	**8.94**	**0.0026**
D5, P2	1.87	0.1261
D5, P3	**7.89**	**0.0015**
D6, D7	2.18	0.1029
D6, D8	2.31	0.0869
D6, D9	2.24	0.0948
D6, D10	0.24	0.8090
D6, D11	**4.48**	**0.0158**
D6, D12	2.17	0.1808
D6, D13	2.53	0.0735
D6, PRS	0.87	0.4330
D6, P1	0.94	0.3872
D6, P2	**4.27**	**0.0078**
D6, P3	0.07	0.9405
D7, D8	0.59	0.6019
D7, D9	0.27	0.7335
D7, D10	1.28	0.2671
D7, D11	**3.40**	**0.0327**
D7, D12	0.58	0.6123
D7, D13	2.76	0.0624
D7, PRS	2.51	0.0677
D7, P1	**3.45**	**0.0306**
D7, P2	1.75	0.1584
D7, P3	1.70	0.1581
D8, D9	0.42	0.6639
D8, D10	2.50	0.0734
D8, D11	**3.69**	**0.0233**
D8, D12	1.52	0.2683
D8, D13	**3.89**	**0.0262**
D8, PRS	**2.67**	**0.0485**
D8, P1	**5.54**	**0.0058**
D8, P2	1.63	0.1679
D8, P3	**5.85**	**0.0010**
D9, D10	2.29	0.0966
D9, D11	2.77	0.0544
D9, D12	1.61	0.2546
D9, D13	**3.57**	**0.0243**
D9, PRS	1.76	0.1380
D9, P1	**3.64**	**0.0197**
D9, P2	1.29	0.2726
D9, P3	**2.77**	**0.0232**
D10, D11	2.04	0.1220
D10, D12	2.95	0.1147
D10, D13	**4.33**	**0.0192**
D10, PRS	0.77	0.4889
D10, P1	0.77	0.4718
D10, P2	**5.14**	**0.0030**
D10, P3	0.06	0.9537
D11, D12	3.18	0.0896
D11, D13	0.42	0.6532
D11, PRS	0.07	0.9462
D11, P1	0.66	0.5698
D11, P2	**5.84**	**0.0032**
D11, P3	0.30	0.8385
D12, D13	**6.10**	**0.0369**
D12, PRS	1.46	0.2585
D12, P1	2.60	0.1139
D12, P2	0.59	0.6452
D12, P3	**4.27**	**0.0080**
D13, PRS	0.05	0.9463
D13, P1	0.33	0.7898
D13, P2	**5.66**	**0.0042**
D13, P3	0.50	0.7281
PRS, P1	0.41	0.7250
PRS, P2	**5.11**	**0.0055**
PRS, P3	0.33	0.7724
P1, P2	**8.69**	**0.0006**
P1, P3	1.23	0.3102
P2, P3	**4.72**	**0.0021**

c. Plot showing mean (±SE) sand and silt cover at all sites combined during surveys
N.B. no data for SSI and NEW in surveys D1, D2 and D12, and for MAN in surveys D1, D3 to D5, D7 to D9 and D11 to P_{RS}

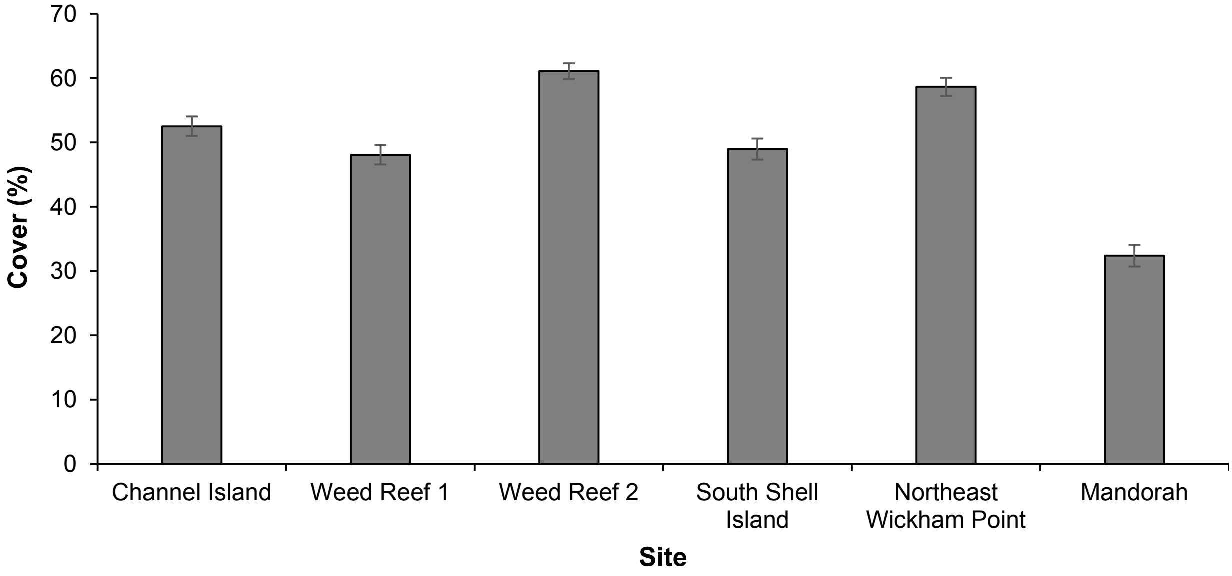


d. Pair-wise for the term Site

Comparisons between Sites	t	p-value
CHI, MAN	**2.43**	**0.0136**
CHI, NEW	0.74	0.7497
CHI, SSI	0.45	0.9989
CHI, WR1	0.51	0.9956
CHI, WR2	1.08	0.3020
MAN, NEW	**4.87**	**0.0001**
MAN, SSI	**2.28**	**0.0172**
MAN, WR1	**2.20**	**0.0189**

Comparisons between Sites	t	p-value
MAN, WR2	**5.30**	**0.0001**
NEW, SSI	1.41	0.1232
NEW, WR1	1.25	0.1906
NEW, WR2	0.60	0.9424
SSI, WR1	0.17	1.0000
SSI, WR2	**1.91**	**0.0271**
WR1, WR2	**1.79**	**0.0370**

e. Plot showing mean (±SE) sand and silt cover at each site across all surveys combined
N.B. no data for SSI and NEW in surveys D1, D2 and D12, and for MAN in surveys D1, D3 to D5, D7 to D9 and D11 to P_{RS}



Appendix D-6 Univariate analysis using PERMANOVA testing for differences in turf algae cover among Sites (CHI, WR1, WR2, SSI and NEW) and across surveys (B1 to D13). Significant ($p \leq 0.05$) terms in bold. RED = Redundant term due to significant interaction. MC = Monte Carlo simulation was used to calculate P values where unique permutations < 100. Baseline versus Post-dredging pair-wise comparisons highlighted in teal

a. PERMANOVA analysis

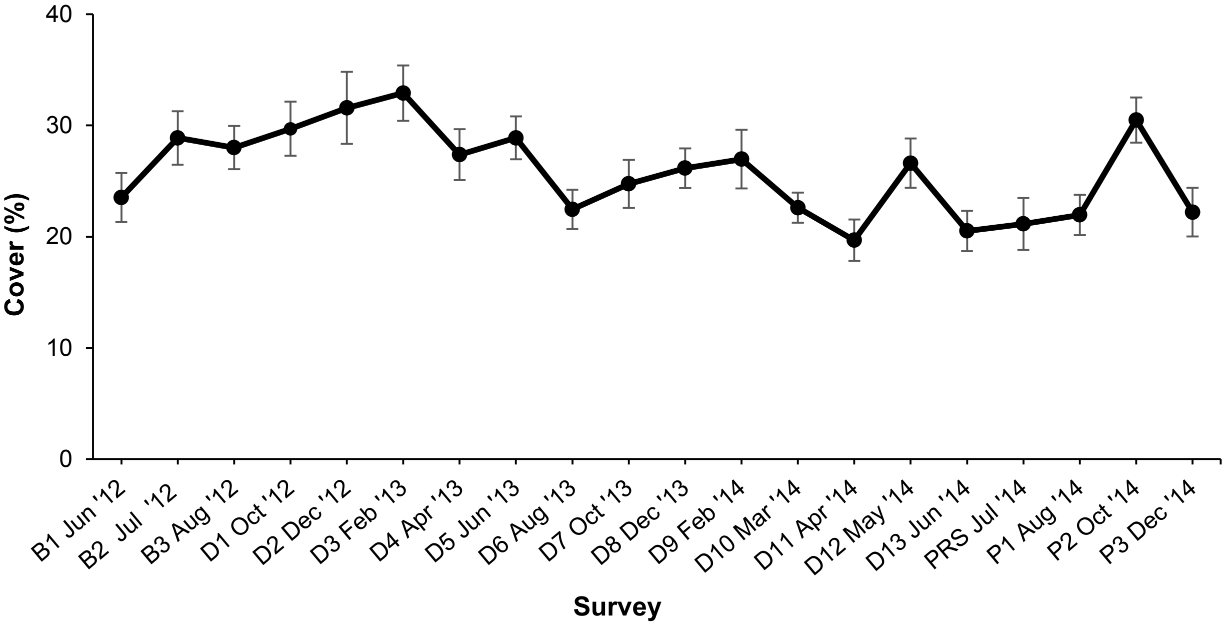
Source of Variation	df	SS	MS	Pseudo-F	p(perm)
Survey	**19**	**7424**	**390.74**	**5.8749**	**0.0001**
Site	**5**	**10235**	**2047**	**4.2426**	**0.0002**
Transect (Site)	18	7988.1	443.79	8.7064	
Survey x Site	78	5191.5	66.558	1.3058	0.0610
Residual	289	14731	50.972		
Total	409	45029			

b. Pair-wise for the term Survey

Comparisons between Surveys	t	p-value	
B1, B2	**2.73**	**0.0429**	
B1, B3	1.75	0.1452	
B1, D1	2.26	0.1541	
B1, D2	3.26	0.0579	
B1, D3	**2.96**	**0.0393**	
B1, D4	0.91	0.4148	
B1, D5	**3.79**	**0.0245**	
B1, D6	0.75	0.4737	
B1, D7	0.27	0.7882	
B1, D8	0.97	0.3851	
B1, D9	1.25	0.2762	
B1, D10	0.73	0.4957	
B1, D11	1.43	0.2249	
B1, D12	1.18	0.3683	
B1, D13	1.11	0.3163	
B1, PRS	1.80	0.1468	
B1, P1	1.55	0.1794	
B1, P2	**3.00**	**0.0369**	
B1, P3	1.73	0.1424	
B2, B3	0.22	0.8051	
B2, D1	1.61	0.2388	
B2, D2	3.43	0.0535	
B2, D3	2.04	0.0827	
B2, D4	0.21	0.8481	
B2, D5	0.26	0.8072	
B2, D6	**2.93**	**0.0359**	
B2, D7	2.24	0.0872	
B2, D8	1.01	0.3655	
B2, D9	0.88	0.4280	
B2, D10	2.41	0.0605	
B2, D11	**3.53**	**0.0306**	
B2, D12	0.50	0.6672	
B2, D13	**3.22**	**0.0441**	
B2, PRS	**4.57**	**0.0116**	
B2, P1	**5.77**	**0.0028**	
B2, P2	0.73	0.4860	
B2, P3	**4.30**	**0.0105**	
B3, D1	0.43	0.7525	
B3, D2	1.96	0.1432	
B3, D3	1.08	0.3687	
B3, D4	0.45	0.6843	
B3, D5	0.15	0.9037	
B3, D6	**3.22**	**0.0231**	
B3, D7	**3.56**	**0.0153**	
B3, D8	1.13	0.3201	
B3, D9	0.32	0.7731	
B3, D10	2.04	0.0969	
B3, D11	3.00	0.0518	
B3, D12	0.15	0.8983	
B3, D13	2.67	0.0648	
B3, PRS	2.40	0.0785	
B3, P1	2.22	0.0778	
B3, P2	0.32	0.7432	
B3, P3	2.20	0.0828	
D1, D2	0.56	0.6029	
D1, D3	1.75	0.2263	
D1, D4	0.25	0.8194	
D1, D5	0.80	0.4863	
D1, D6	**3.28**	**0.0355**	
D1, D7	1.97	0.1625	
D1, D8	**13.79**	**0.0078**	
D1, D9	5.01	0.0591	
D1, D10	**6.91**	**0.0040**	
D1, D11	**9.33**	**0.0087**	
D1, D12	2.67	0.1193	MC
D1, D13	**32.08**	**0.0009**	
D1, PRS	2.59	0.0853	
D1, P1	**7.28**	**0.0228**	
D1, P2	1.66	0.2290	
D1, P3	**5.17**	**0.0464**	
D2, D3	0.03	0.9762	
D2, D4	0.44	0.7034	
D2, D5	1.07	0.3754	
D2, D6	**3.76**	**0.0195**	
D2, D7	3.58	0.0712	
D2, D8	2.54	0.1450	
D2, D9	1.73	0.2357	
D2, D10	**2.92**	**0.0328**	
D2, D11	**4.09**	**0.0283**	
D2, D12	1.21	0.3438	

Comparisons between Surveys	t	p-value
D2, D13	**4.43**	**0.0328**
D2, PRS	2.56	0.1386
D2, P1	**5.17**	**0.0181**
D2, P2	2.71	0.0860
D2, P3	**3.99**	**0.0213**
D3, D4	2.04	0.1042
D3, D5	1.46	0.2182
D3, D6	**6.32**	**0.0023**
D3, D7	**3.66**	**0.0089**
D3, D8	**4.06**	**0.0201**
D3, D9	**3.25**	**0.0296**
D3, D10	**24.56**	**0.0001**
D3, D11	**16.80**	**0.0001**
D3, D12	3.16	0.0905
D3, D13	**19.21**	**0.0001**
D3, PRS	**4.02**	**0.0125**
D3, P1	**7.69**	**0.0010**
D3, P2	1.79	0.1314
D3, P3	**8.81**	**0.0011**
D4, D5	0.58	0.6045
D4, D6	1.20	0.3107
D4, D7	0.83	0.5005
D4, D8	0.42	0.6930
D4, D9	0.15	0.9209
D4, D10	1.53	0.1961
D4, D11	**2.95**	**0.0467**
D4, D12	0.89	0.4499
D4, D13	2.30	0.0870
D4, PRS	1.45	0.2345
D4, P1	1.84	0.1445
D4, P2	0.26	0.8019
D4, P3	**3.12**	**0.0404**
D5, D6	1.99	0.1178
D5, D7	2.56	0.0652
D5, D8	1.58	0.1867
D5, D9	0.81	0.4445
D5, D10	1.85	0.1287
D5, D11	**3.23**	**0.0382**
D5, D12	0.19	0.8696
D5, D13	2.74	0.0546
D5, PRS	**2.88**	**0.0456**
D5, P1	2.82	0.0575
D5, P2	0.15	0.8875
D5, P3	**5.39**	**0.0078**
D6, D7	1.01	0.3939
D6, D8	1.34	0.2548
D6, D9	2.02	0.1135
D6, D10	0.04	0.9665
D6, D11	**3.09**	**0.0382**
D6, D12	1.36	0.3230
D6, D13	2.37	0.0836
D6, PRS	0.72	0.5083
D6, P1	0.55	0.5960
D6, P2	**2.70**	**0.0456**
D6, P3	0.39	0.7206
D7, D8	0.79	0.4761
D7, D9	0.94	0.4242
D7, D10	0.58	0.6117
D7, D11	2.47	0.0794
D7, D12	0.77	0.5366
D7, D13	1.92	0.1284
D7, PRS	1.41	0.2308
D7, P1	1.72	0.1607
D7, P2	1.84	0.1417
D7, P3	2.40	0.0781
D8, D9	0.74	0.4816
D8, D10	1.55	0.1922
D8, D11	**3.06**	**0.0407**
D8, D12	1.99	0.2130
D8, D13	**2.88**	**0.0482**
D8, PRS	1.77	0.1477
D8, P1	**2.94**	**0.0490**
D8, P2	1.04	0.3488
D8, P3	**5.55**	**0.0062**
D9, D10	**3.16**	**0.0393**
D9, D11	**3.61**	**0.0282**
D9, D12	3.91	0.0630
D9, D13	**4.25**	**0.0222**
D9, PRS	1.96	0.1160
D9, P1	**5.98**	**0.0059**
D9, P2	0.50	0.6398
D9, P3	**4.04**	**0.0181**
D10, D11	**3.62**	**0.0220**
D10, D12	**4.46**	**0.0359**
D10, D13	**3.47**	**0.0275**
D10, PRS	0.64	0.5789
D10, P1	0.57	0.5762
D10, P2	2.41	0.0660
D10, P3	0.40	0.7092
D11, D12	3.50	0.0531
D11, D13	1.31	0.2583
D11, PRS	0.47	0.6648
D11, P1	0.16	0.8831
D11, P2	**3.27**	**0.0403**
D11, P3	0.03	0.9770
D12, D13	**5.00**	**0.0362**
D12, PRS	1.66	0.2440
D12, P1	4.32	0.0704
D12, P2	0.57	0.6161
D12, P3	3.24	0.0812
D13, PRS	0.19	0.8372
D13, P1	0.24	0.8210
D13, P2	2.97	0.0507
D13, P3	0.38	0.7333
PRS, P1	0.56	0.6028
PRS, P2	**6.65**	**0.0059**
PRS, P3	0.62	0.5606
P1, P2	**6.90**	**0.0019**
P1, P3	0.17	0.8855
P2, P3	**4.59**	**0.0091**

c. Plot showing mean (±SE) turf algae cover at all sites combined during surveys.
N.B. no data for SSI and NEW in surveys D1, D2 and D12, and for MAN in surveys D1, D3 to D5, D7 to D9 and D11 to P_{RS}

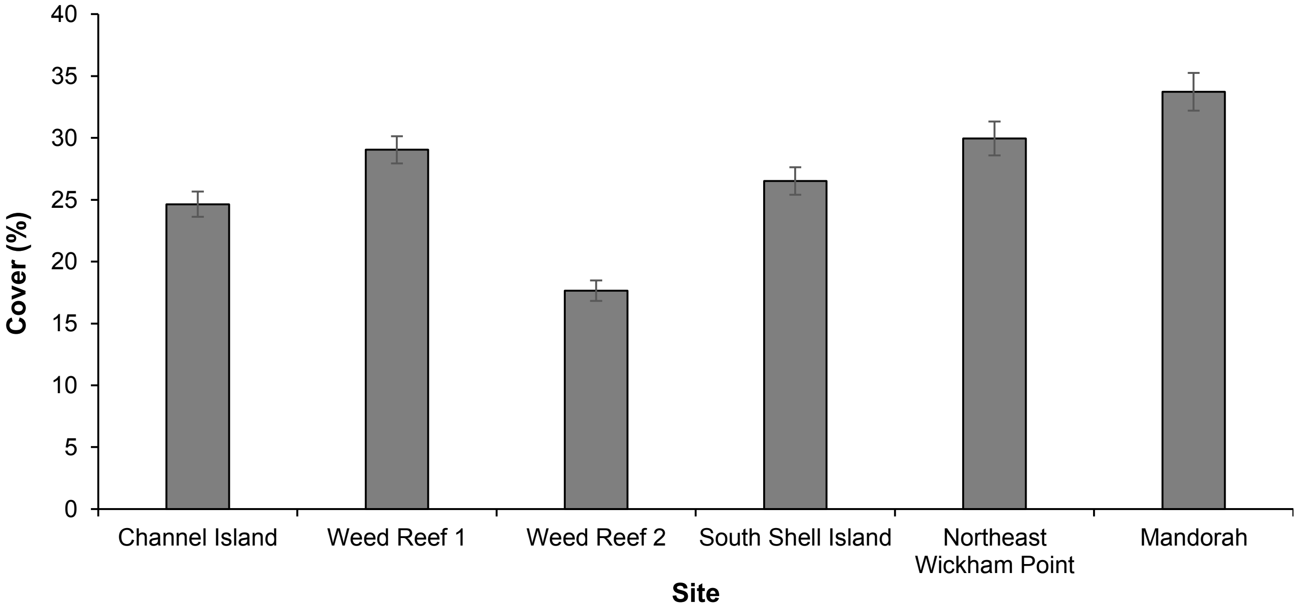


d. Pair-wise for the term Site

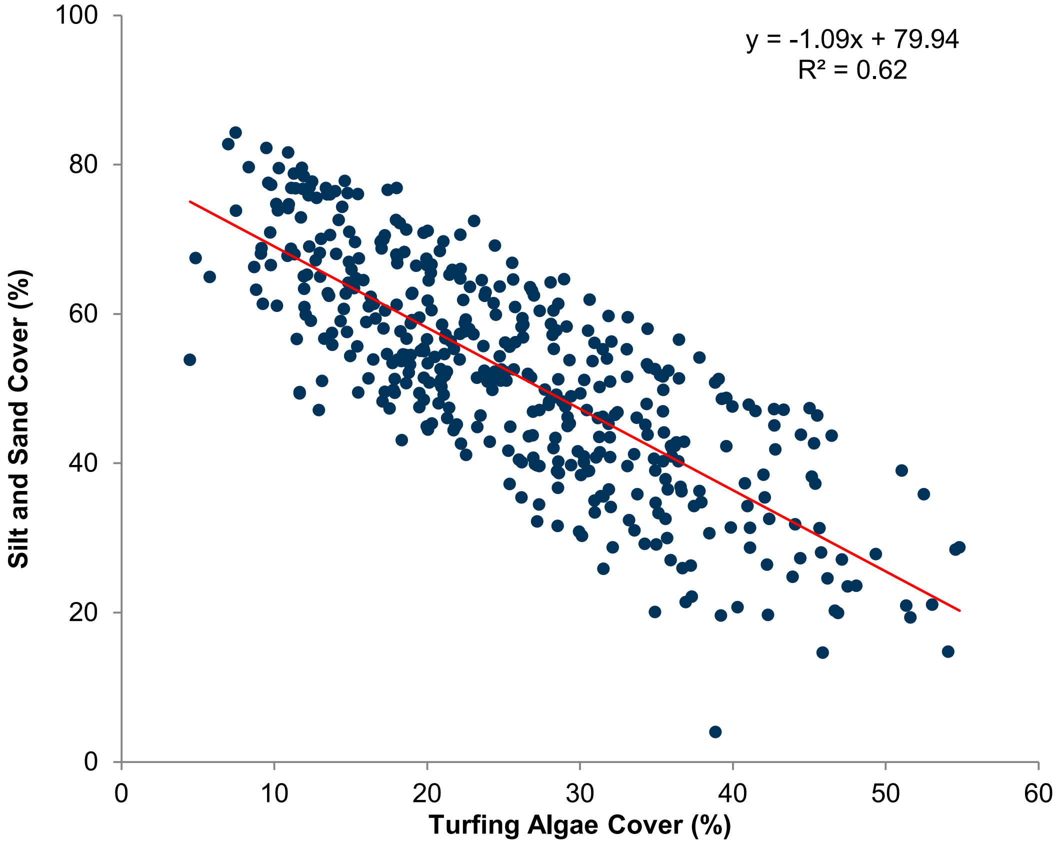
Comparison between Sites	t	p-value
CHI, MAN	**2.03**	**0.0336**
CHI, NEW	1.14	0.2535
CHI, SSI	0.68	0.8488
CHI, WR1	1.06	0.3229
CHI, WR2	**1.94**	**0.0224**
MAN, NEW	0.48	0.9780
MAN, SSI	1.84	0.0522
MAN, WR1	1.31	0.1880

Comparison between Sites	t	p-value
MAN, WR2	**7.02**	**0.0001**
NEW, SSI	0.82	0.6304
NEW, WR1	0.56	0.9756
NEW, WR2	**3.22**	**0.0008**
SSI, WR1	0.48	0.9964
SSI, WR2	**4.43**	**0.0001**
WR1, WR2	**3.89**	**0.0001**

e. Plot showing mean (±SE) turf algae cover at each site across all surveys combined.
N.B. no data for SSI and NEW in surveys D1, D2 and D12, and for MAN in surveys D1, D3 to D5, D7 to D9 and D11 to P_{RS}



f. Scatter plot of turf algae and silt and sand cover at all sites across all surveys combined



Appendix D-7 Univariate analysis using PERMANOVA testing for differences in the number of coral recruits (≤ 2 cm) among Sites (CHI, WR1, WR2, SSI and NEW) and across surveys (B1 to D13). n = 4. Significant (p(perm) ≤ 0.05) terms in bold. RED = redundant terms due to significant interaction. MC = Monte Carlo simulation was used to calculate P values where unique permutations < 100

a. PERMANOVA analysis for number of coral recruits

Source of Variation	df	SS	MS	Pseudo-F	p(perm)
Survey	19	1270.1	66.847	1.93	RED
Site	5	5417.7	1083.5	2.7944	RED
Transect (Site)	18	6711.4	372.86	19.941	
Survey x Site	**77**	**2666.9**	**34.635**	**1.8524**	**0.0002**
Residual	287	5366.2	18.698		
Total	406	21486			

b. Pair-wise for the term Survey x Site

Comparisons between Surveys	t	p-value
Within level 'CHI' of factor 'Site'		
B1, B2	0.71	0.5302
B1, B3	2.55	0.0788
B1, D1	2.16	0.1196
B1, D2	0.26	0.8038
B1, D3	0.18	0.9050
B1, D4	0.47	0.6542
B1, D5	0.70	0.5326
B1, D6	0.10	0.8850
B1, D7	1.02	0.3918
B1, D8	2.99	0.0698
B1, D9	3.06	0.0638
B1, D10	**4.32**	**0.0324**
B1, D11	**5.73**	**0.0222**
B1, D12	**5.57**	**0.0128**
B1, D13	2.89	0.0904
B1, PRS	0.40	0.6620
B1, P1	**3.92**	**0.0476**
B1, P2	**3.75**	**0.0466**
B1, P3	**7.55**	**0.0138**
B2, B3	0.60	0.6096
B2, D1	0.15	0.8318
B2, D2	0.67	0.5362
B2, D3	0.35	0.8292
B2, D4	0.26	0.8166
B2, D5	0.93	0.4114
B2, D6	0.55	0.6252
B2, D7	0.39	0.7368
B2, D8	0.56	0.6350
B2, D9	0.56	0.6652
B2, D10	0.80	0.4736
B2, D11	0.65	0.5906
B2, D12	0.97	0.3668
B2, D13	0.07	0.9904
B2, PRS	0.64	0.5822
B2, P1	0.18	0.8748
B2, P2	0.41	0.7192
B2, P3	0.64	0.5754
B3, D1	**3.46**	**0.0470**
B3, D2	2.37	0.0736
B3, D3	0.99	0.5008
B3, D4	0.88	0.6102
B3, D5	1.90	0.1640
B3, D6	1.65	0.1878
B3, D7	1.64	0.1766
B3, D8	0.39	0.7060
B3, D9	0.24	0.7894
B3, D10	0.87	0.4334
B3, D11	0.73	0.5006
B3, D12	2.04	0.1524
B3, D13	1.27	0.2654
B3, PRS	2.40	0.0762
B3, P1	0.34	0.7830
B3, P2	0.42	0.6744
B3, P3	0.69	0.5246
D1, D2	2.10	0.1500
D1, D3	0.72	0.5208
D1, D4	0.59	0.8244
D1, D5	1.73	0.2094
D1, D6	1.36	0.2652
D1, D7	1.25	0.2898
D1, D8	1.29	0.2764
D1, D9	1.80	0.1992
D1, D10	2.93	0.0808
D1, D11	1.69	0.1852
D1, D12	**4.63**	**0.0316**
D1, D13	0.60	0.6088
D1, PRS	1.98	0.1304
D1, P1	0.23	0.8344
D1, P2	1.44	0.2514
D1, P3	1.64	0.2056
D2, D3	0.09	0.9354
D2, D4	0.35	0.7170
D2, D5	1.29	0.3038
D2, D6	0.12	0.9158
D2, D7	1.04	0.3536
D2, D8	2.13	0.1546
D2, D9	2.32	0.1012
D2, D10	**3.83**	**0.0302**
D2, D11	3.36	0.0534

Comparisons between Surveys	t	p-value
D2, D12	**5.19**	**0.0120**
D2, D13	2.95	0.0652
D2, PRS	0.11	0.9278
D2, P1	2.83	0.0798
D2, P2	2.67	0.0734
D2, P3	3.67	0.0598
D3, D4	1.46	0.4708
D3, D5	0.64	0.6122
D3, D6	0.18	0.7820
D3, D7	0.23	0.7498
D3, D8	1.28	0.2518
D3, D9	1.10	0.4222
D3, D10	1.15	0.3186
D3, D11	1.73	0.0708
D3, D12	1.75	0.0578
D3, D13	0.72	0.5220
D3, PRS	0.15	0.9278
D3, P1	1.39	0.3056
D3, P2	0.99	0.4830
D3, P3	1.70	0.1022
D4, D5	0.95	0.3804
D4, D6	0.60	0.5370
D4, D7	0.07	0.8598
D4, D8	1.17	0.4012
D4, D9	1.00	0.4862
D4, D10	1.08	0.3672
D4, D11	1.70	0.1178
D4, D12	1.73	0.0726
D4, D13	0.55	0.6296
D4, PRS	0.47	0.6366
D4, P1	1.34	0.3458
D4, P2	0.88	0.4452
D4, P3	1.68	0.1544
D5, D6	1.21	0.3230
D5, D7	1.59	0.2222
D5, D8	1.80	0.1948
D5, D9	1.86	0.2002
D5, D10	2.48	0.0746
D5, D11	2.42	0.1024
D5, D12	**3.00**	**0.0434**
D5, D13	2.00	0.1644
D5, PRS	0.73	0.5054
D5, P1	2.45	0.1110
D5, P2	1.95	0.1516
D5, P3	2.53	0.1058
D6, D7	1.58	0.2418
D6, D8	1.83	0.1426
D6, D9	1.78	0.1770
D6, D10	2.24	0.0616
D6, D11	**3.02**	**0.0400**
D6, D12	**3.36**	**0.0166**
D6, D13	2.11	0.1322
D6, PRS	Negative	
D6, P1	**4.54**	**0.0098**
D6, P2	1.83	0.1484
D6, P3	**3.26**	**0.0248**
D7, D8	1.84	0.1752
D7, D9	1.80	0.1728

Comparisons between Surveys	t	p-value
D7, D10	2.31	0.0780
D7, D11	**3.44**	**0.0180**
D7, D12	**4.25**	**0.0076**
D7, D13	2.61	0.0722
D7, PRS	0.97	0.4134
D7, P1	**4.70**	**0.0068**
D7, P2	1.83	0.1574
D7, P3	**3.71**	**0.0174**
D8, D9	0.52	0.5983
D8, D10	0.20	0.8516
D8, D11	0.68	0.5084
D8, D12	1.19	0.3394
D8, D13	1.49	0.2376
D8, PRS	3.18	0.0656
D8, P1	0.62	0.5842
D8, P2	0.78	0.4906
D8, P3	0.56	0.5736
D9, D10	0.59	0.5746
D9, D11	0.90	0.3956
D9, D12	2.00	0.1570
D9, D13	1.46	0.2420
D9, PRS	3.03	0.0566
D9, P1	0.46	0.7314
D9, P2	0.88	0.4474
D9, P3	0.81	0.4236
D10, D11	0.21	0.8396
D10, D12	1.17	0.2922
D10, D13	2.06	0.0944
D10, PRS	**3.60**	**0.0368**
D10, P1	0.77	0.5424
D10, P2	1.85	0.1662
D10, P3	0.23	0.8348
D11, D12	0.95	0.4400
D11, D13	**3.40**	**0.0352**
D11, PRS	**7.40**	**0.0046**
D11, P1	1.69	0.1910
D11, P2	1.45	0.2550
D11, P3	Negative	
D12, D13	**5.64**	**0.0036**
D12, PRS	**5.55**	**0.0162**
D12, P1	1.89	0.1378
D12, P2	3.36	0.0632
D12, P3	0.91	0.4298
D13, PRS	2.96	0.0796
D13, P1	1.55	0.2430
D13, P2	1.42	0.2590
D13, P3	**3.69**	**0.0338**
PRS, P1	**5.00**	**0.0250**
PRS, P2	3.43	0.0586
PRS, P3	**10.83**	**0.0050**
P1, P2	0.26	0.8154
P1, P3	1.90	0.1572
P2, P3	1.45	0.2508
Within level 'MAN' of factor 'Site'		
B1, B2	0.81	0.6282
B1, B3	0.83	0.5226
B1, D2	0.91	0.4814
B1, D6	1.15	0.3520

Comparisons between Surveys	t	p-value
B1, D10	1.50	0.2364
B1, P1	0.14	0.8616
B1, P2	0.91	0.4318
B1, P3	1.43	0.1982
B2, B3	0.57	0.5974
B2, D2	0.17	0.8238
B2, D6	2.19	0.0724
B2, D10	2.42	0.0632
B2, P1	2.26	0.1200
B2, P2	1.51	0.2254
B2, P3	1.67	0.2040
B3, D2	0.27	0.7668
B3, D6	2.14	0.1118
B3, D10	**2.78**	**0.0464**
B3, P1	1.61	0.2130
B3, P2	1.75	0.1810
B3, P3	3.46	0.0540
D2, D6	**3.40**	**0.0452**
D2, D10	1.92	0.1308
D2, P1	1.41	0.2400
D2, P2	1.27	0.2894
D2, P3	0.96	0.4198
D6, D10	0.97	0.3932
D6, P1	0.93	0.3978
D6, P2	0.11	0.9392
D6, P3	**2.98**	**0.0184**
D10, P1	2.01	0.1150
D10, P2	1.06	0.3464
D10, P3	**3.07**	**0.0088**
P1, P2	0.59	0.5810
P1, P3	3.12	0.0742
P2, P3	2.20	0.1302
Within level 'NEW' of factor 'Site'		
B1, B2	1.19	0.3508
B1, B3	1.22	0.3462
B1, D3	Negative	
B1, D4	0.65	0.5754
B1, D5	2.20	0.1114
B1, D6	1.51	0.2736
B1, D7	0.00	1.0000
B1, D8	1.96	0.1422
B1, D9	0.19	0.8632
B1, D10	0.16	0.8854
B1, D11	1.51	0.2732
B1, D13	0.57	0.6678
B1, PRS	3.46	0.0732
B1, P1	0.92	0.4320
B1, P2	1.73	0.2198
B1, P3	1.60	0.2204
B2, B3	1.00	0.3926
B2, D3	**3.22**	**0.0184**
B2, D4	1.13	0.3540
B2, D5	1.98	0.0534
B2, D6	1.07	0.3638
B2, D7	1.35	0.2706
B2, D8	0.52	0.6308
B2, D9	1.19	0.3138
B2, D10	**4.37**	**0.0292**
B2, D11	1.26	0.3006
B2, D13	1.24	0.3058
B2, PRS	**3.52**	**0.0362**
B2, P1	1.90	0.1492
B2, P2	0.68	0.5500
B2, P3	Negative	
B3, D3	1.71	0.1902
B3, D4	0.73	0.5234
B3, D5	**1.93**	**0.0328**
B3, D6	1.02	0.4400
B3, D7	1.12	0.3452
B3, D8	Negative	
B3, D9	1.19	0.3344
B3, D10	2.63	0.0810
B3, D11	0.93	0.4330
B3, D13	1.17	0.3150
B3, PRS	**4.02**	**0.0276**
B3, P1	1.73	0.1928
B3, P2	0.48	0.6638
B3, P3	0.77	0.4880
D3, D4	1.00	0.4020
D3, D5	1.03	0.4236
D3, D6	0.00	1.0000
D3, D7	0.13	0.8374
D3, D8	1.41	0.2642
D3, D9	0.09	0.9316
D3, D10	Negative	
D3, D11	0.87	0.4536
D3, D13	0.42	0.7096
D3, PRS	1.29	0.2782
D3, P1	0.13	0.8778
D3, P2	0.80	0.4816
D3, P3	2.33	0.0790
D4, D5	**2.11**	**0.0490**
D4, D6	0.63	0.5810
D4, D7	1.00	0.3904
D4, D8	0.60	0.5742
D4, D9	0.87	0.4492
D4, D10	1.26	0.2960
D4, D11	0.29	0.7778
D4, D13	1.07	0.3834
D4, PRS	**3.27**	**0.0492**
D4, P1	0.80	0.4664
D4, P2	0.14	0.9368
D4, P3	2.61	0.0996
D5, D6	1.68	0.1770
D5, D7	2.78	0.0562
D5, D8	**2.17**	**0.0042**
D5, D9	1.81	0.1284
D5, D10	1.22	0.3056
D5, D11	**2.43**	**0.0396**
D5, D13	2.33	0.0930
D5, PRS	0.42	0.7154
D5, P1	1.02	0.4236
D5, P2	1.75	0.1778
D5, P3	**2.52**	**0.0204**
D6, D7	0.14	0.9064
D6, D8	1.36	0.3056

Comparisons between Surveys	t	p-value
D6, D9	0.15	0.8688
D6, D10	Negative	
D6, D11	0.71	0.5252
D6, D13	0.88	0.4716
D6, PRS	2.10	0.1316
D6, P1	0.15	0.8854
D6, P2	1.13	0.3408
D6, P3	1.24	0.3100
D7, D8	1.26	0.3060
D7, D9	0.00	1.0000
D7, D10	0.17	0.8690
D7, D11	1.41	0.2636
D7, D13	1.00	0.4416
D7, PRS	2.67	0.0890
D7, P1	0.24	0.8264
D7, P2	0.71	0.5506
D7, P3	1.99	0.1292
D8, D9	1.36	0.2636
D8, D10	2.38	0.1090
D8, D11	1.10	0.3436
D8, D13	1.35	0.1852
D8, PRS	**6.33**	**0.0102**
D8, P1	2.40	0.0898
D8, P2	0.77	0.4922
D8, P3	0.58	0.5970
D9, D10	0.12	0.9148
D9, D11	0.68	0.5474
D9, D13	0.78	0.5468
D9, PRS	2.48	0.1214
D9, P1	0.21	0.8428
D9, P2	0.96	0.3998
D9, P3	1.61	0.1934
D10, D11	1.46	0.2306
D10, D13	0.50	0.7648
D10, PRS	1.99	0.1484
D10, P1	0.19	0.8682
D10, P2	1.13	0.3532
D10, P3	**3.67**	**0.0370**
D11, D13	1.22	0.3368
D11, PRS	**5.96**	**0.0104**
D11, P1	0.96	0.3564
D11, P2	0.33	0.7608
D11, P3	2.32	0.1112
D13, PRS	0.49	0.6920
D13, P1	0.42	0.7894
D13, P2	1.09	0.3532
D13, P3	1.50	0.2294
PRS, P1	1.63	0.2268
PRS, P2	**3.83**	**0.0282**
PRS, P3	**5.09**	**0.0256**
P1, P2	1.85	0.1586
P1, P3	1.73	0.1666
P2, P3	0.68	0.5528
Within level 'SSI' of factor 'Site'		
B1, B2	1.50	0.2412
B1, B3	**3.37**	**0.0068**
B1, D3	1.90	0.0622
B1, D4	**4.02**	**0.0038**
B1, D5	**2.98**	**0.0352**
B1, D6	**3.63**	**0.0100**
B1, D7	**5.09**	**0.0140**
B1, D8	**3.36**	**0.0246**
B1, D10	**3.10**	**0.0294**
B1, D11	2.85	0.0698
B1, D13	1.72	0.1778
B1, PRS	**4.75**	**0.0170**
B1, P1	**5.13**	**0.0152**
B1, P2	**2.58**	**0.0060**
B1, P3	**3.81**	**0.0124**
B2, B3	0.63	0.5758
B2, D3	0.73	0.5079
B2, D4	3.13	0.0542
B2, D5	0.45	0.6836
B2, D6	1.46	0.2656
B2, D7	2.41	0.1046
B2, D8	**3.83**	**0.0436**
B2, D10	**3.61**	**0.0242**
B2, D11	2.71	0.0706
B2, D13	1.41	0.2542
B2, PRS	1.47	0.2554
B2, P1	1.50	0.2348
B2, P2	1.02	0.3428
B2, P3	3.45	0.0502
B3, D3	0.24	0.8470
B3, D4	**3.40**	**0.0230**
B3, D5	0.40	0.6694
B3, D6	1.85	0.1504
B3, D7	**3.83**	**0.0424**
B3, D8	2.93	0.0670
B3, D10	2.42	0.0922
B3, D11	1.89	0.1576
B3, D13	0.00	1.0000
B3, PRS	2.83	0.0728
B3, P1	2.40	0.0978
B3, P2	0.68	0.5450
B3, P3	**3.64**	**0.0426**
D3, D4	**4.70**	**0.0315**
D3, D5	0.30	0.7926
D3, D6	0.91	0.4344
D3, D7	2.51	0.0976
D3, D8	2.33	0.1084
D3, D10	**3.81**	**0.0448**
D3, D11	**7.35**	**0.0046**
D3, D13	0.35	0.7416
D3, PRS	0.81	0.4750
D3, P1	1.12	0.3396
D3, P2	0.38	0.7290
D3, P3	2.93	0.0808
D4, D5	**3.09**	**0.0250**
D4, D6	**5.17**	**0.0124**
D4, D7	1.00	0.3862
D4, D8	1.70	0.1880
D4, D10	1.67	0.1968
D4, D11	1.73	0.1784
D4, D13	**3.40**	**0.0384**
D4, PRS	2.78	0.0690

Comparisons between Surveys	t	p-value
D4, P1	2.10	0.1232
D4, P2	**9.80**	**0.0062**
D4, P3	1.46	0.2450
D5, D6	1.55	0.2278
D5, D7	**3.12**	**0.0443**
D5, D8	2.33	0.1078
D5, D10	2.25	0.1136
D5, D11	1.72	0.1848
D5, D13	0.13	0.8314
D5, PRS	2.18	0.1152
D5, P1	1.84	0.1624
D5, P2	0.81	0.4634
D5, P3	2.72	0.0792
D6, D7	**8.66**	**0.0094**
D6, D8	1.57	0.2052
D6, D10	1.85	0.1614
D6, D11	1.40	0.2616
D6, D13	1.06	0.3704
D6, PRS	0.52	0.6468
D6, P1	1.19	0.3062
D6, P2	1.00	0.3890
D6, P3	2.83	0.0682
D7, D8	0.82	0.4688
D7, D10	0.38	0.7294
D7, D11	0.52	0.6248
D7, D13	2.20	0.1124
D7, PRS	**4.70**	**0.0052**
D7, P1	**3.66**	**0.0402**
D7, P2	**3.81**	**0.0300**
D7, P3	0.52	0.6182
D8, D10	0.77	0.5010
D8, D11	0.29	0.7888
D8, D13	**3.81**	**0.0296**
D8, PRS	1.00	0.3986
D8, P1	0.54	0.6332
D8, P2	1.80	0.1608
D8, P3	1.73	0.1906
D10, D11	0.52	0.6248
D10, D13	**5.00**	**0.0188**
D10, PRS	1.17	0.3216
D10, P1	0.76	0.4972
D10, P2	2.91	0.0610
D10, P3	0.00	1.0000
D11, D13	**3.36**	**0.0428**
D11, PRS	0.88	0.4560
D11, P1	0.58	0.6046
D11, P2	2.10	0.1316
D11, P3	0.29	0.8058
D13, PRS	1.02	0.3848
D13, P1	1.15	0.3284
D13, P2	0.63	0.5822
D13, P3	3.38	0.0560
PRS, P1	1.00	0.3886
PRS, P2	0.93	0.4242
PRS, P3	1.70	0.1866
P1, P2	1.13	0.3378
P1, P3	1.13	0.3378
P2, P3	2.48	0.1070

Comparisons between Surveys	t	p-value
Within level 'WR1' of factor 'Site'		
B1, B2	1.58	0.2316
B1, B3	1.42	0.2724
B1, D1	0.26	0.8088
B1, D2	0.25	0.8526
B1, D3	1.89	0.1428
B1, D4	0.55	0.6252
B1, D5	0.86	0.4548
B1, D6	0.81	0.4816
B1, D7	2.44	0.0950
B1, D8	1.37	0.2604
B1, D9	1.47	0.2314
B1, D10	**3.73**	**0.0476**
B1, D11	0.70	0.6148
B1, D12	1.96	0.1606
B1, D13	1.10	0.3782
B1, PRS	1.78	0.1844
B1, P1	0.91	0.4344
B1, P2	0.55	0.7014
B1, P3	0.31	0.7454
B2, B3	0.27	0.8066
B2, D1	0.95	0.4132
B2, D2	1.06	0.3518
B2, D3	0.31	0.8132
B2, D4	0.19	0.8426
B2, D5	1.64	0.1896
B2, D6	0.74	0.5016
B2, D7	0.55	0.6294
B2, D8	0.24	0.8590
B2, D9	0.06	0.9272
B2, D10	1.18	0.3500
B2, D11	0.04	0.9866
B2, D12	0.20	0.8318
B2, D13	1.44	0.2418
B2, PRS	0.07	0.9554
B2, P1	0.38	0.7418
B2, P2	0.87	0.4530
B2, P3	0.36	0.6978
B3, D1	0.74	0.5054
B3, D2	1.42	0.2390
B3, D3	0.76	0.5044
B3, D4	0.37	0.7892
B3, D5	1.45	0.2390
B3, D6	0.61	0.5758
B3, D7	0.25	0.8150
B3, D8	0.04	0.9774
B3, D9	0.52	0.6320
B3, D10	1.61	0.2106
B3, D11	0.29	0.7882
B3, D12	0.12	0.9406
B3, D13	1.99	0.1382
B3, PRS	0.52	0.6200
B3, P1	0.96	0.4244
B3, P2	1.90	0.1572
B3, P3	0.79	0.4652
D1, D2	0.54	0.5726
D1, D3	0.71	0.5100
D1, D4	0.41	0.7344

Comparisons between Surveys	t	p-value
D1, D5	2.78	0.0634
D1, D6	0.34	0.7184
D1, D7	1.16	0.3294
D1, D8	1.04	0.3909
D1, D9	0.69	0.5204
D1, D10	1.67	0.1916
D1, D11	0.37	0.6442
D1, D12	0.90	0.4200
D1, D13	1.52	0.2228
D1, PRS	0.54	0.6316
D1, P1	0.27	0.8086
D1, P2	0.57	0.5984
D1, P3	0.13	0.9676
D2, D3	1.27	0.2860
D2, D4	0.54	0.6704
D2, D5	0.50	0.6086
D2, D6	0.52	0.6034
D2, D7	1.15	0.3128
D2, D8	0.88	0.4426
D2, D9	0.99	0.3820
D2, D10	1.89	0.1666
D2, D11	0.54	0.5824
D2, D12	0.95	0.3962
D2, D13	0.94	0.4070
D2, PRS	0.79	0.4322
D2, P1	0.61	0.5926
D2, P2	0.29	0.7784
D2, P3	0.51	0.6652
D3, D4	0.06	0.9576
D3, D5	1.95	0.1752
D3, D6	0.39	0.7834
D3, D7	0.99	0.3924
D3, D8	0.47	0.6664
D3, D9	0.27	0.8808
D3, D10	2.30	0.1026
D3, D11	0.10	0.8694
D3, D12	0.55	0.6340
D3, D13	2.03	0.1610
D3, PRS	0.21	0.8612
D3, P1	0.36	0.7476
D3, P2	1.13	0.3312
D3, P3	0.37	0.6712
D4, D5	1.79	0.1958
D4, D6	0.25	0.8600
D4, D7	1.11	0.3502
D4, D8	1.26	0.2672
D4, D9	0.24	0.9048
D4, D10	1.41	0.2900
D4, D11	0.20	0.7924
D4, D12	0.67	0.5320
D4, D13	2.16	0.1270
D4, PRS	0.19	0.8864
D4, P1	0.15	0.9128
D4, P2	1.02	0.3904
D4, P3	0.32	0.6972
D5, D6	1.70	0.1824
D5, D7	2.19	0.1344
D5, D8	2.31	0.1076
D5, D9	2.07	0.1464
D5, D10	2.59	0.0784
D5, D11	1.05	0.3432
D5, D12	2.06	0.1428
D5, D13	0.81	0.4692
D5, PRS	1.42	0.2504
D5, P1	1.37	0.2448
D5, P2	0.00	1.0000
D5, P3	1.37	0.2456
D6, D7	1.61	0.1930
D6, D8	1.53	0.2448
D6, D9	0.54	0.6302
D6, D10	1.93	0.1316
D6, D11	0.34	0.7366
D6, D12	1.19	0.3302
D6, D13	1.45	0.2384
D6, PRS	0.53	0.6472
D6, P1	0.09	0.9182
D6, P2	0.74	0.4988
D6, P3	0.06	0.9384
D7, D8	0.60	0.6078
D7, D9	1.35	0.2566
D7, D10	1.53	0.2054
D7, D11	1.21	0.3066
D7, D12	3.00	0.0824
D7, D13	2.49	0.0896
D7, PRS	1.99	0.1404
D7, P1	2.72	0.0864
D7, P2	2.11	0.1130
D7, P3	1.24	0.2836
D8, D9	0.42	0.7110
D8, D10	1.08	0.3822
D8, D11	0.37	0.7240
D8, D12	0.14	0.8862
D8, D13	2.17	0.1328
D8, PRS	0.40	0.7482
D8, P1	0.86	0.4274
D8, P2	1.32	0.2992
D8, P3	0.78	0.4740
D9, D10	**3.39**	**0.0334**
D9, D11	0.00	1.0000
D9, D12	0.63	0.5554
D9, D13	2.92	0.0508
D9, PRS	Negative	
D9, P1	1.99	0.1412
D9, P2	1.84	0.1598
D9, P3	0.85	0.4274
D10, D11	1.78	0.1720
D10, D12	2.20	0.1150
D10, D13	**3.20**	**0.0238**
D10, PRS	**6.15**	**0.0242**
D10, P1	**6.25**	**0.0060**
D10, P2	**3.57**	**0.0076**
D10, P3	2.13	0.1008
D11, D12	0.41	0.7238
D11, D13	1.52	0.2370
D11, PRS	0.00	1.0000
D11, P1	0.43	0.7486

Comparisons between Surveys	t	p-value
D11, P2	1.55	0.2362
D11, P3	0.41	0.7058
D12, D13	2.33	0.0966
D12, PRS	0.71	0.5327
D12, P1	1.80	0.1722
D12, P2	1.70	0.2022
D12, P3	0.87	0.4328
D13, PRS	1.79	0.1866
D13, P1	2.01	0.1374
D13, P2	0.56	0.6176
D13, P3	**6.00**	**0.0150**
PRS, P1	1.13	0.3362
PRS, P2	1.52	0.1998
PRS, P3	0.48	0.6554
P1, P2	1.44	0.2428
P1, P3	0.20	0.9000
P2, P3	1.51	0.2258
Within level 'WR2' of factor 'Site'		
B1, B2	1.34	0.2562
B1, B3	1.66	0.1960
B1, D1	2.15	0.1374
B1, D2	1.66	0.2018
B1, D3	0.57	0.5428
B1, D4	2.40	0.0978
B1, D5	Negative	
B1, D6	1.07	0.3112
B1, D7	0.66	0.5302
B1, D8	0.16	0.8544
B1, D9	0.62	0.5616
B1, D10	0.98	0.4482
B1, D11	2.04	0.1322
B1, D12	2.24	0.1258
B1, D13	2.93	0.0790
B1, PRS	1.93	0.1482
B1, P1	1.09	0.3128
B1, P2	3.54	0.0500
B1, P3	0.75	0.4980
B2, B3	1.84	0.1626
B2, D1	0.22	0.8996
B2, D2	0.52	0.6418
B2, D3	1.29	0.2798
B2, D4	**3.99**	**0.0252**
B2, D5	**2.88**	**0.0330**
B2, D6	0.45	0.6714
B2, D7	0.54	0.7294
B2, D8	1.58	0.1892
B2, D9	1.47	0.2992
B2, D10	0.74	0.4826
B2, D11	1.62	0.1942
B2, D12	0.71	0.5338
B2, D13	**4.39**	**0.0348**
B2, PRS	0.11	0.9026
B2, P1	0.54	0.6436
B2, P2	0.24	0.7960
B2, P3	1.53	0.2188
B3, D1	1.18	0.3550
B3, D2	0.22	0.7914
B3, D3	1.55	0.2214
B3, D4	**3.40**	**0.0494**
B3, D5	**25.98**	**0.0012**
B3, D6	1.13	0.2886
B3, D7	0.98	0.4256
B3, D8	2.57	0.0924
B3, D9	1.91	0.1810
B3, D10	1.41	0.2608
B3, D11	Negative	
B3, D12	0.89	0.4198
B3, D13	0.58	0.5880
B3, PRS	0.93	0.4246
B3, P1	1.24	0.2724
B3, P2	0.45	0.6664
B3, P3	1.78	0.1820
D1, D2	0.53	0.6140
D1, D3	1.42	0.2558
D1, D4	**3.57**	**0.0378**
D1, D5	1.60	0.2320
D1, D6	0.37	0.7488
D1, D7	0.33	0.7654
D1, D8	3.07	0.0640
D1, D9	1.82	0.1734
D1, D10	1.41	0.2778
D1, D11	1.04	0.3506
D1, D12	1.73	0.1882
D1, D13	2.96	0.0776
D1, PRS	0.12	0.9484
D1, P1	0.37	0.7356
D1, P2	0.47	0.6260
D1, P3	0.91	0.4250
D2, D3	2.16	0.1296
D2, D4	**7.65**	**0.0132**
D2, D5	1.34	0.2752
D2, D6	0.94	0.4234
D2, D7	**5.00**	**0.0064**
D2, D8	1.23	0.3154
D2, D9	1.88	0.1698
D2, D10	0.78	0.4806
D2, D11	0.53	0.6182
D2, D12	0.19	0.8286
D2, D13	0.54	0.7220
D2, PRS	0.82	0.4360
D2, P1	1.20	0.2666
D2, P2	0.38	0.6800
D2, P3	2.43	0.1212
D3, D4	**5.17**	**0.0270**
D3, D5	0.17	0.9792
D3, D6	0.87	0.4376
D3, D7	0.67	0.5398
D3, D8	0.32	0.7770
D3, D9	0.80	0.4528
D3, D10	0.46	0.6612
D3, D11	2.43	0.0880
D3, D12	1.89	0.1518
D3, D13	2.82	0.0916
D3, PRS	2.14	0.1340
D3, P1	1.00	0.3660
D3, P2	**9.92**	**0.0100**

Comparisons between Surveys	t	p-value
D3, P3	0.71	0.5310
D4, D5	1.43	0.2464
D4, D6	**3.78**	**0.0270**
D4, D7	**4.60**	**0.0388**
D4, D8	1.25	0.2790
D4, D9	1.12	0.3496
D4, D10	2.03	0.1314
D4, D11	**7.79**	**0.0106**
D4, D12	**4.37**	**0.0326**
D4, D13	**5.49**	**0.0164**
D4, PRS	**9.25**	**0.0044**
D4, P1	**5.20**	**0.0106**
D4, P2	**7.83**	**0.0082**
D4, P3	**9.08**	**0.0034**
D5, D6	0.86	0.4444
D5, D7	0.54	0.5868
D5, D8	0.17	0.9010
D5, D9	0.40	0.7120
D5, D10	0.63	0.5932
D5, D11	2.49	0.0948
D5, D12	**2.98**	**0.0446**
D5, D13	**4.84**	**0.0162**
D5, PRS	1.35	0.2632
D5, P1	0.92	0.4322
D5, P2	1.22	0.3180
D5, P3	0.62	0.5390
D6, D7	0.15	0.9160
D6, D8	1.12	0.3316
D6, D9	3.66	0.0506
D6, D10	0.25	0.8996
D6, D11	1.56	0.2222
D6, D12	0.91	0.4302
D6, D13	1.70	0.2058
D6, PRS	0.87	0.4938
D6, P1	Negative	
D6, P2	0.68	0.5312
D6, P3	0.51	0.5858
D7, D8	0.56	0.5694
D7, D9	1.13	0.2958
D7, D10	0.09	0.9016
D7, D11	2.27	0.0782
D7, D12	0.72	0.5636
D7, D13	1.43	0.2040
D7, PRS	0.70	0.5064
D7, P1	0.20	0.8958
D7, P2	0.90	0.4608
D7, P3	0.34	0.7366
D8, D9	0.40	0.7198
D8, D10	1.66	0.2156
D8, D11	1.84	0.1588
D8, D12	3.10	0.0596
D8, D13	**3.49**	**0.0368**
D8, PRS	1.50	0.2196
D8, P1	1.04	0.3470
D8, P2	1.45	0.2449
D8, P3	0.65	0.5724
D9, D10	0.98	0.3812
D9, D11	2.32	0.1134
D9, D12	2.07	0.1402
D9, D13	2.49	0.0820
D9, PRS	2.50	0.1016
D9, P1	2.41	0.1120
D9, P2	1.91	0.1672
D9, P3	1.10	0.3408
D10, D11	1.18	0.3192
D10, D12	1.67	0.2002
D10, D13	2.47	0.1006
D10, PRS	0.65	0.5470
D10, P1	0.25	0.8836
D10, P2	0.98	0.4028
D10, P3	0.07	0.9580
D11, D12	0.70	0.5258
D11, D13	0.45	0.6770
D11, PRS	1.78	0.1788
D11, P1	2.20	0.1332
D11, P2	0.70	0.5408
D11, P3	**5.28**	**0.0282**
D12, D13	**4.37**	**0.0430**
D12, PRS	0.63	0.5586
D12, P1	1.00	0.3604
D12, P2	0.09	0.8542
D12, P3	1.82	0.1988
D13, PRS	1.89	0.1664
D13, P1	1.95	0.1768
D13, P2	1.07	0.3574
D13, P3	**3.43**	**0.0438**
PRS, P1	1.46	0.2784
PRS, P2	0.48	0.6546
PRS, P3	2.40	0.1018
P1, P2	0.78	0.4868
P1, P3	0.73	0.4960
P2, P3	1.89	0.1854

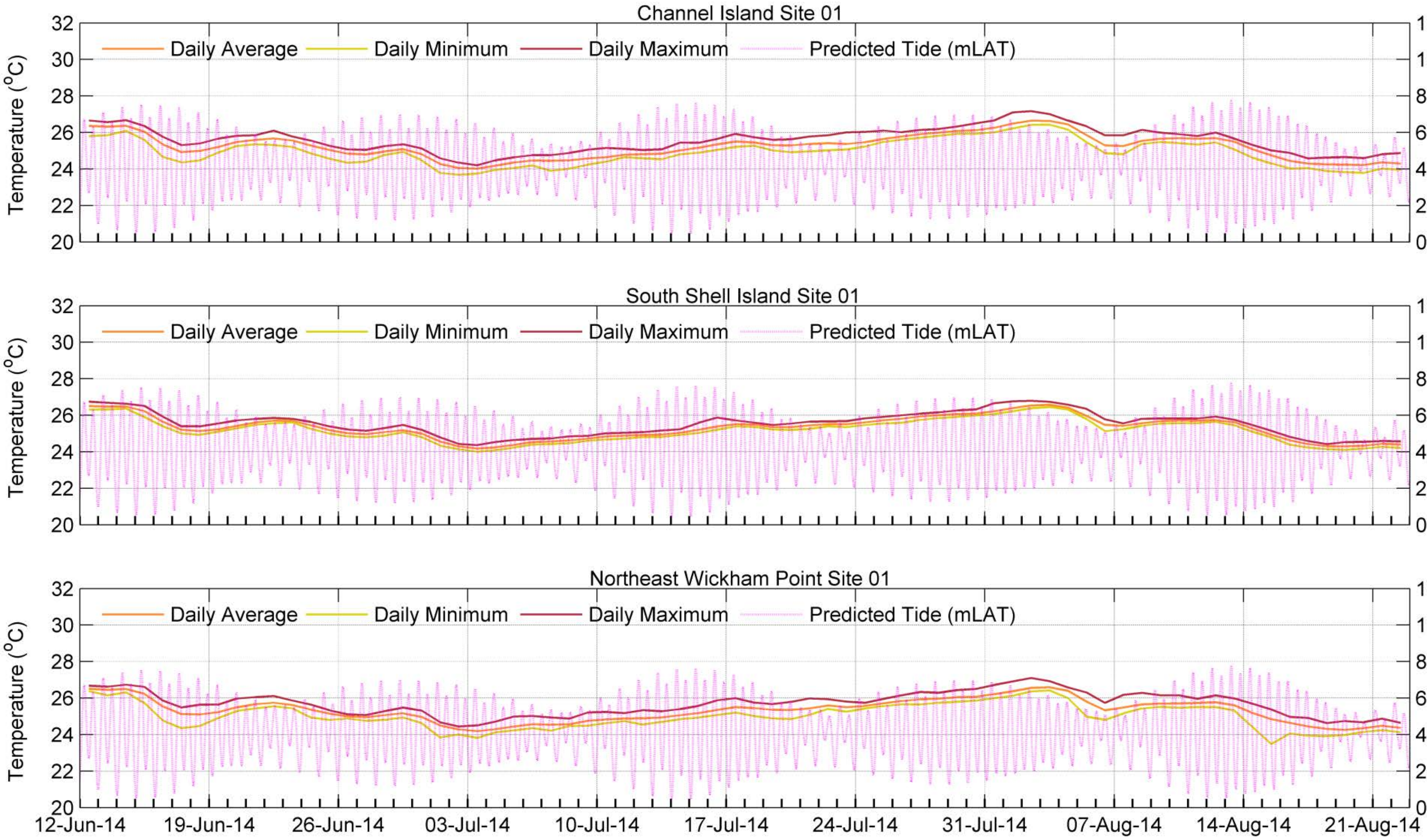
c. Matrix of pair-wise comparisons between sites for each survey for the significant Survey x Site term. Surveys in which the site comparisons are significantly different are highlighted in bold.

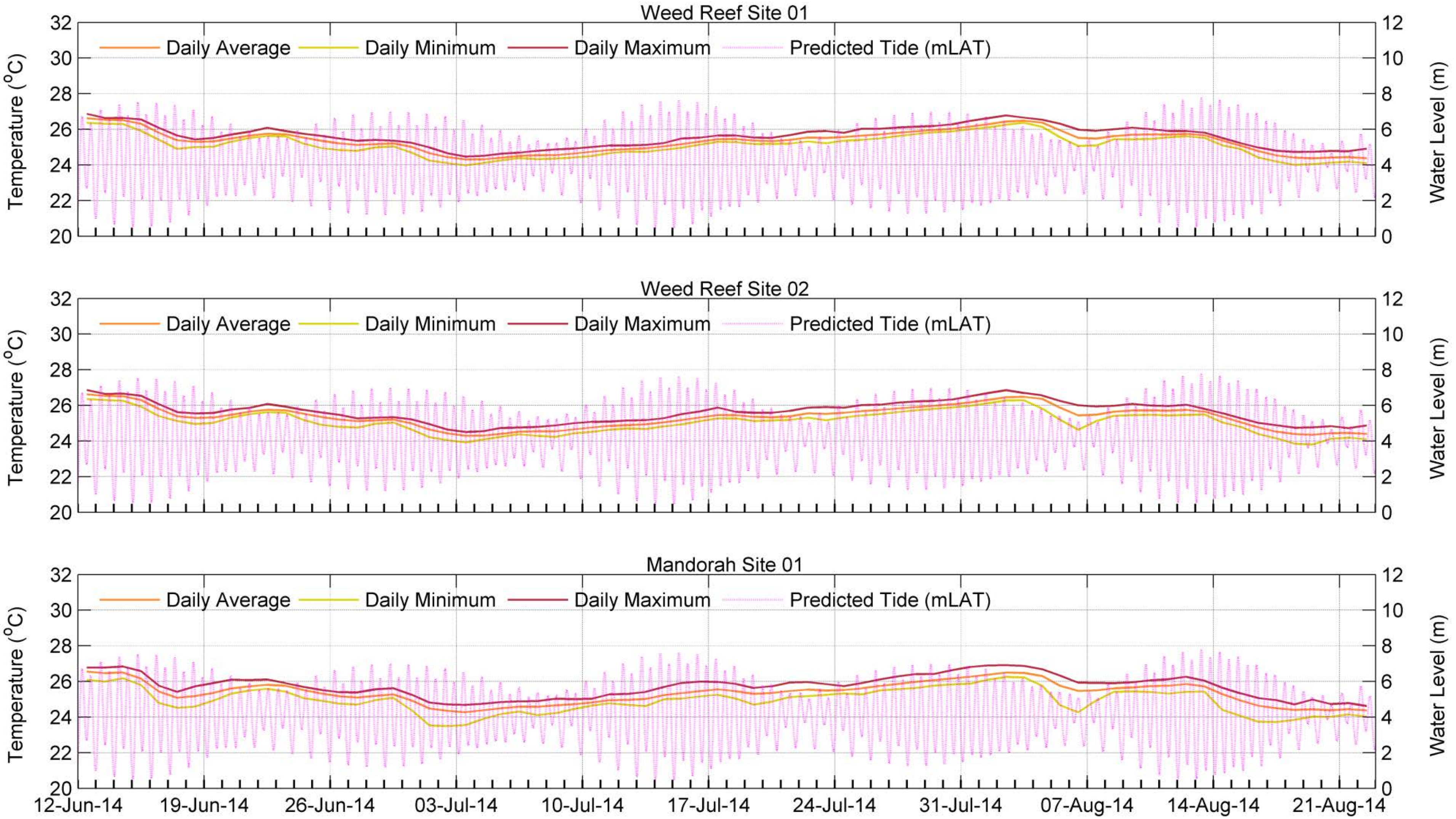
	CHI	WR1	WR2	SSI	NEW
WR1	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3				
WR2	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3	B1, B2, B3, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, P_{RS}, P1, P2, P3			
SSI	B1, B2, B3, D3, D4, D5, D6, **D7**, D8, **D10**, D11, D13, **P_{RS}**, P1, P2, P3	B1, B2, B3, D3, D4, D5, **D6**, **D7**, D8, **D10**, **D11**, **D13**, **P_{RS}**, **P1**, **P2**, **P3**	B1, B2, B3, **D3**, **D4**, **D5**, D6, D7, **D8**, **D10**, D11, D13, P_{RS}, P1, P2, **P3**		
NEW	B1, B2, **B3**, D3, D4, D5, D6, D7, D8, D9, D10, D11, D13, P_{RS}, P1, **P2**, P3	**B1**, **B2**, **B3**, D3, D4, D5, D6, D7, D8, **D9**, D10, D11, D13, **P_{RS}**, **P1**, **P2**, **P3**	B1, **B2**, B3, **D3**, **D4**, D5, D6, D7, **D8**, D9, D10, D11, D13, P_{RS}, P1, P2, **P3**	B1, B2, B3, D3, D4, D5, D6, D7, D8, D10, D11, D13, P_{RS}, P1, P2, P3	
MAN	B1, B2, B3, D2, D6, D10, P1, P2, P3	B1, B2, B3, D2, **D6**, D10, P1, P2, P3	B1, **B2**, B3, D2, D6, D10, P1, P2, **P3**	B1, B2, B3, D6, **D10**, **P1**, P2, **P3**	B1, **B2**, B3, D6, **D10**, P1, **P2**, P3

APPENDIX E

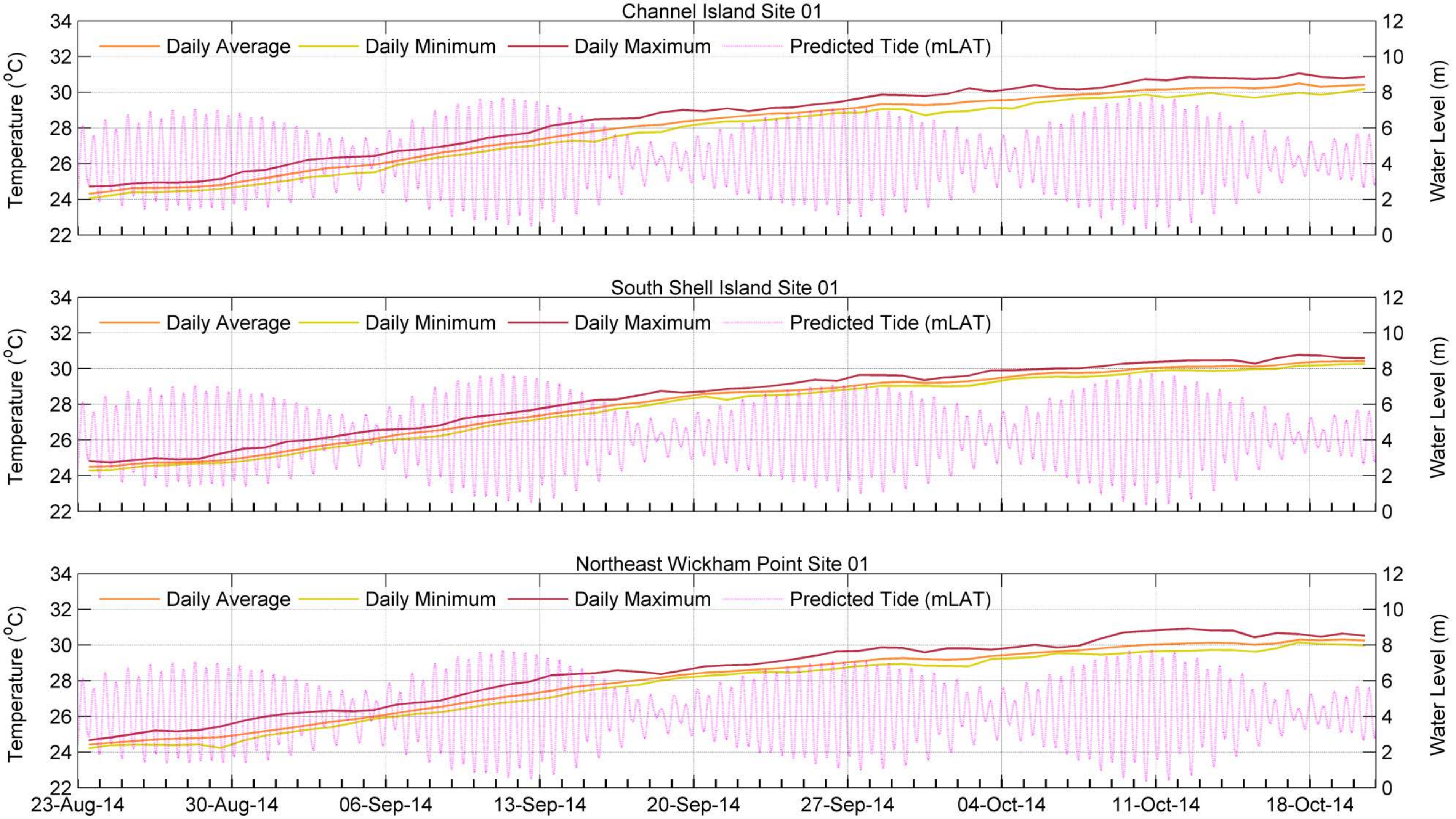
WATER QUALITY DATA

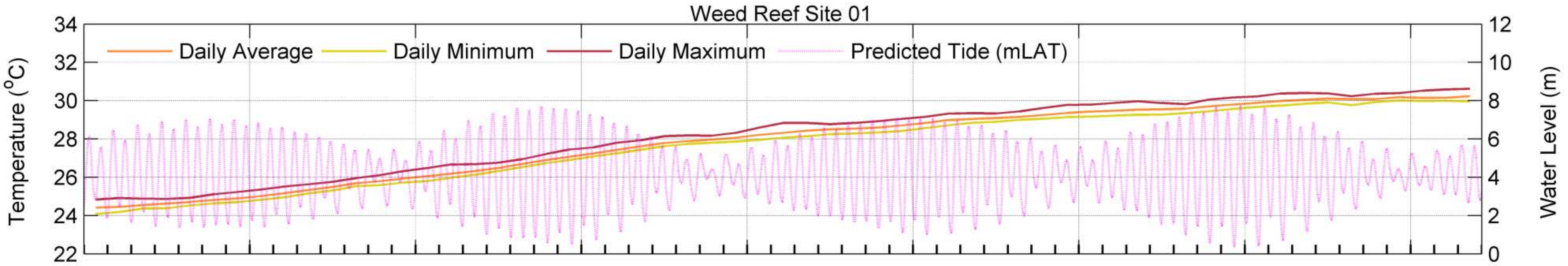
Appendix E-1 **Daily mean, maximum and minimum water temperature data from Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 12/06/2014 and 22/08/2014. Extract from Cardno Water Quality database on 12/03/2015**

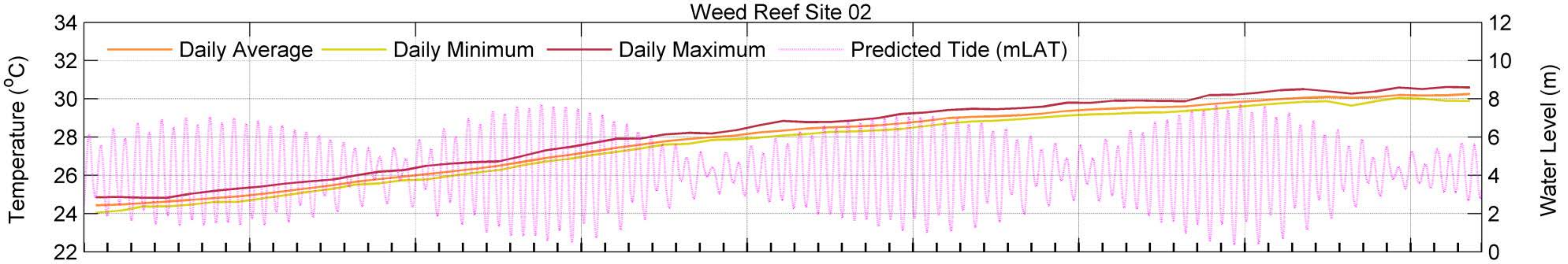


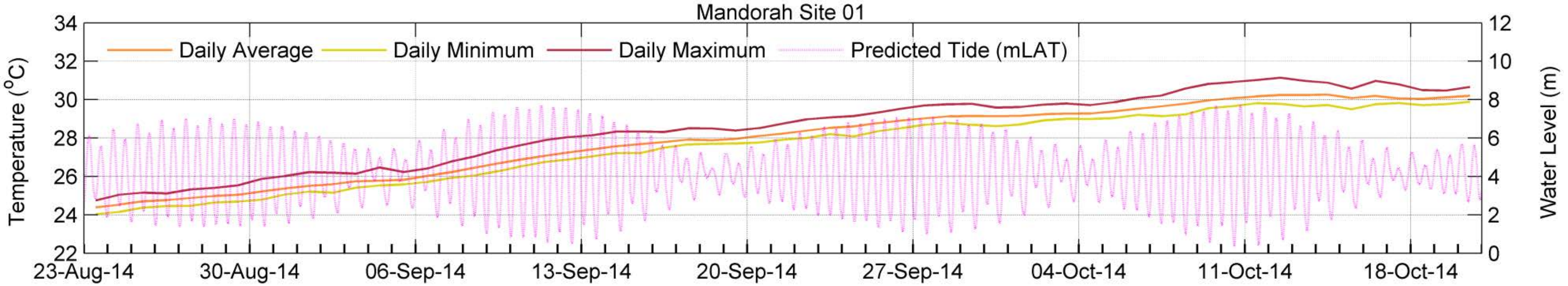

Weed Reef Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Temperature (^oC)
Water Level (m)
32
30
28
26
24
22
20
12
10
8
6
4
2
0
Weed Reef Site 02
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Temperature (^oC)
Water Level (m)
Mandorah Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Temperature (^oC)
Water Level (m)
12-Jun-14
19-Jun-14
26-Jun-14
03-Jul-14
10-Jul-14
17-Jul-14
24-Jul-14
31-Jul-14
07-Aug-14
14-Aug-14
21-Aug-14

Appendix E-2 **Daily mean, maximum and minimum water temperature data from Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 23/08/2014 and 20/10/2014. Extract from Cardno Water Quality database on 23/02/2015**

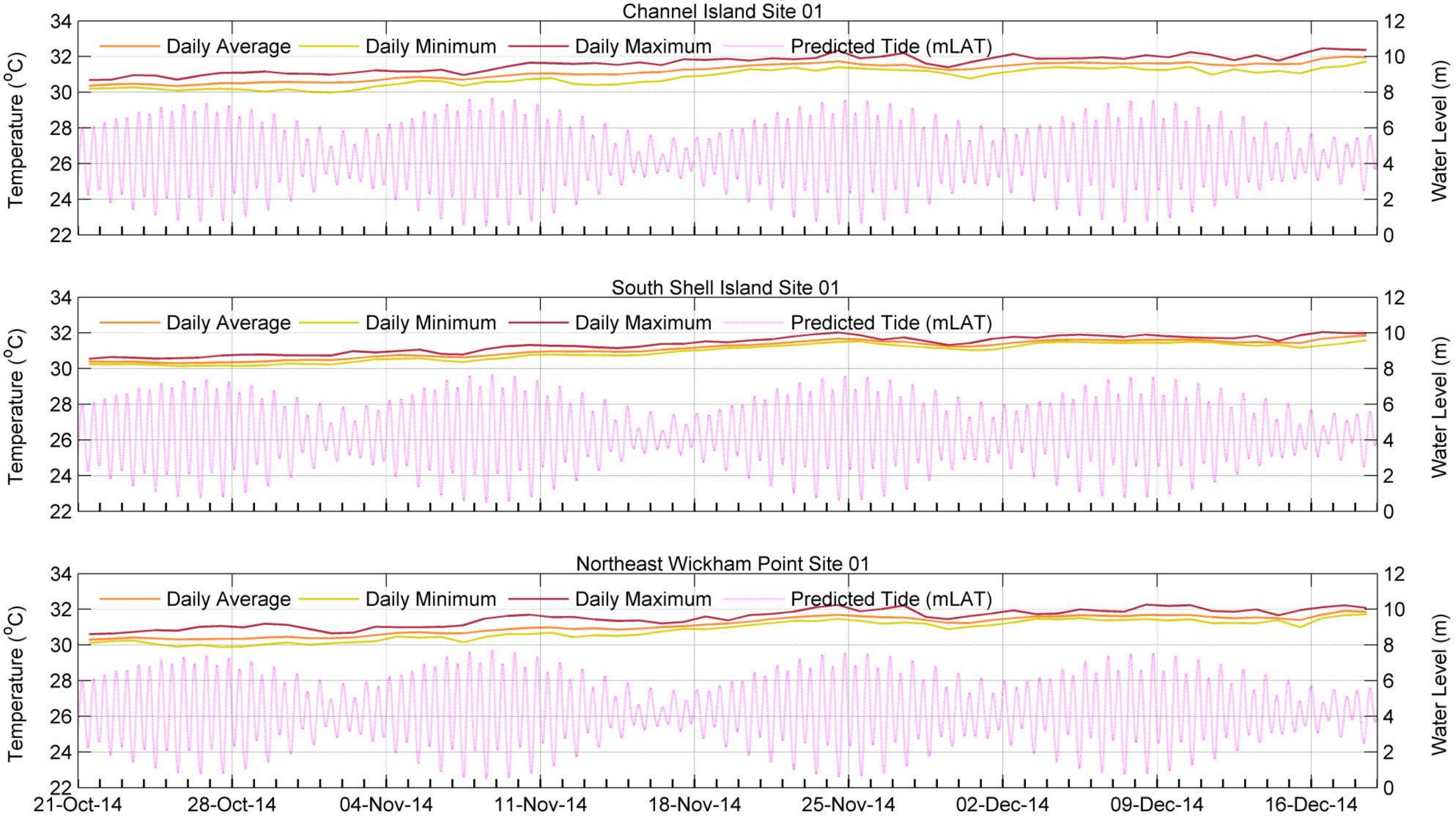


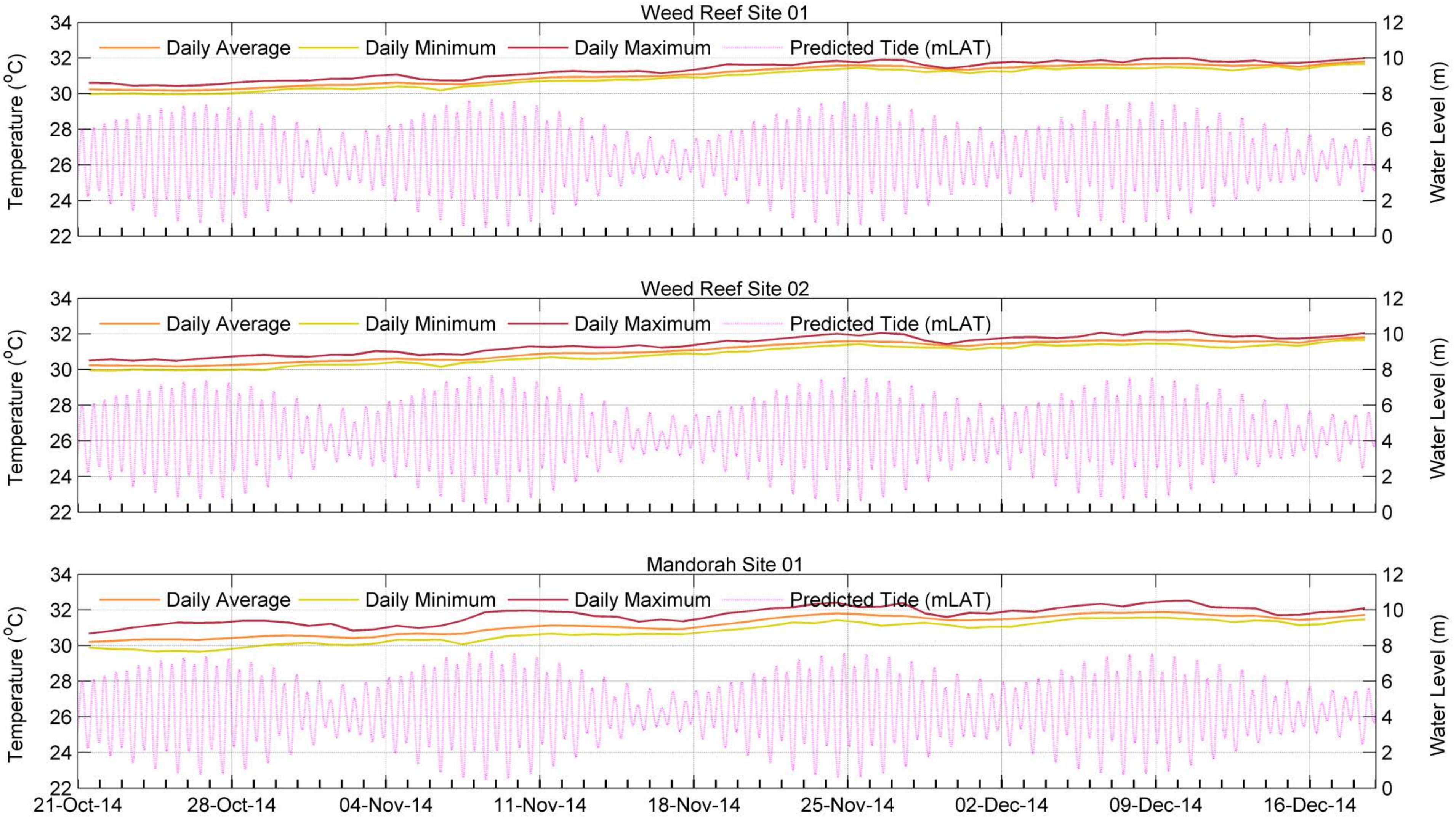

Weed Reef Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Temperature (°C)
Water Level (m)
34
32
30
28
26
24
22
12
10
8
6
4
2
0


Weed Reef Site 02
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Temperature (°C)
Water Level (m)
34
32
30
28
26
24
22
12
10
8
6
4
2
0

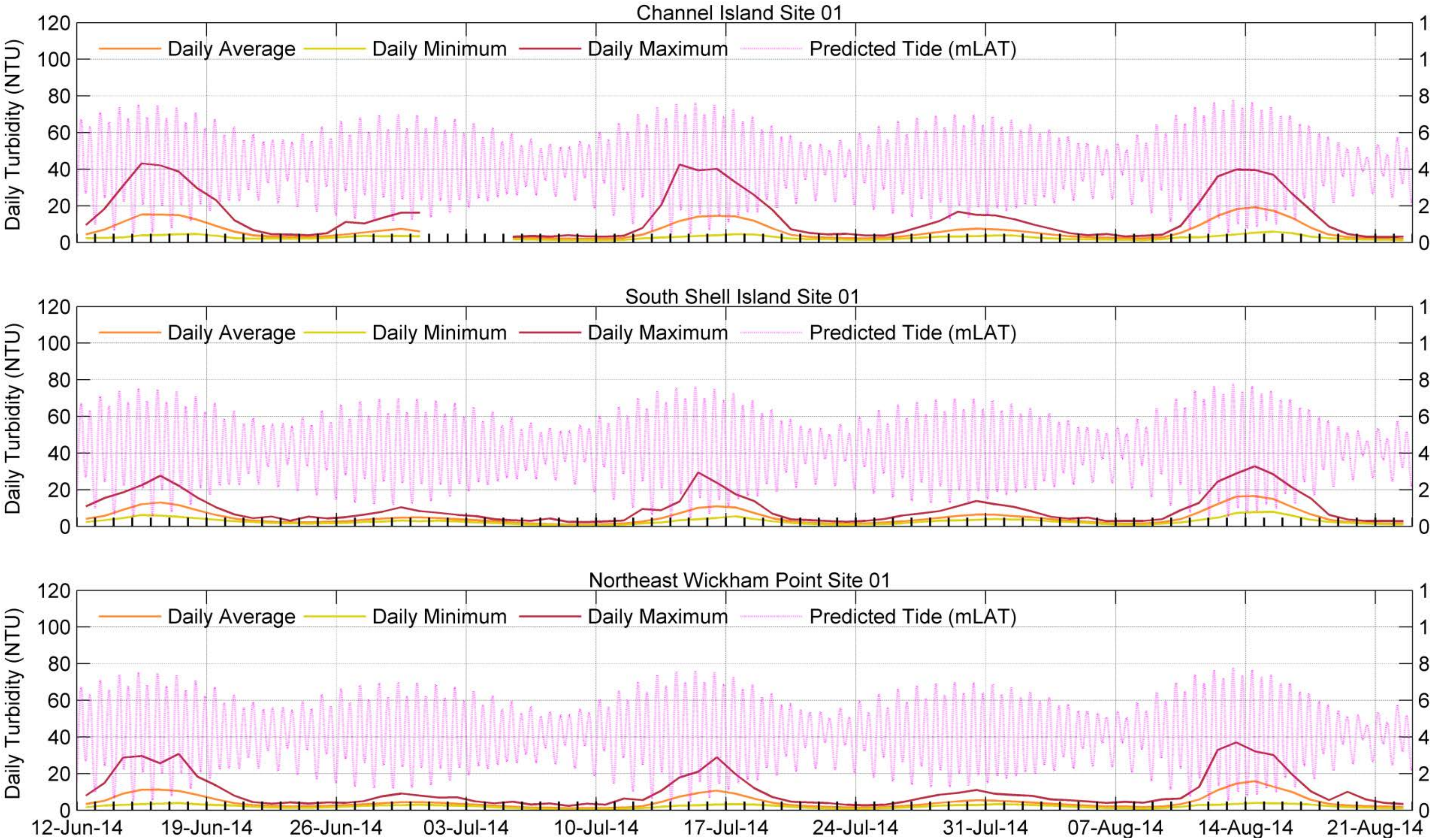

Mandorah Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Temperature (°C)
Water Level (m)
34
32
30
28
26
24
22
12
10
8
6
4
2
0
23-Aug-14
30-Aug-14
06-Sep-14
13-Sep-14
20-Sep-14
27-Sep-14
04-Oct-14
11-Oct-14
18-Oct-14

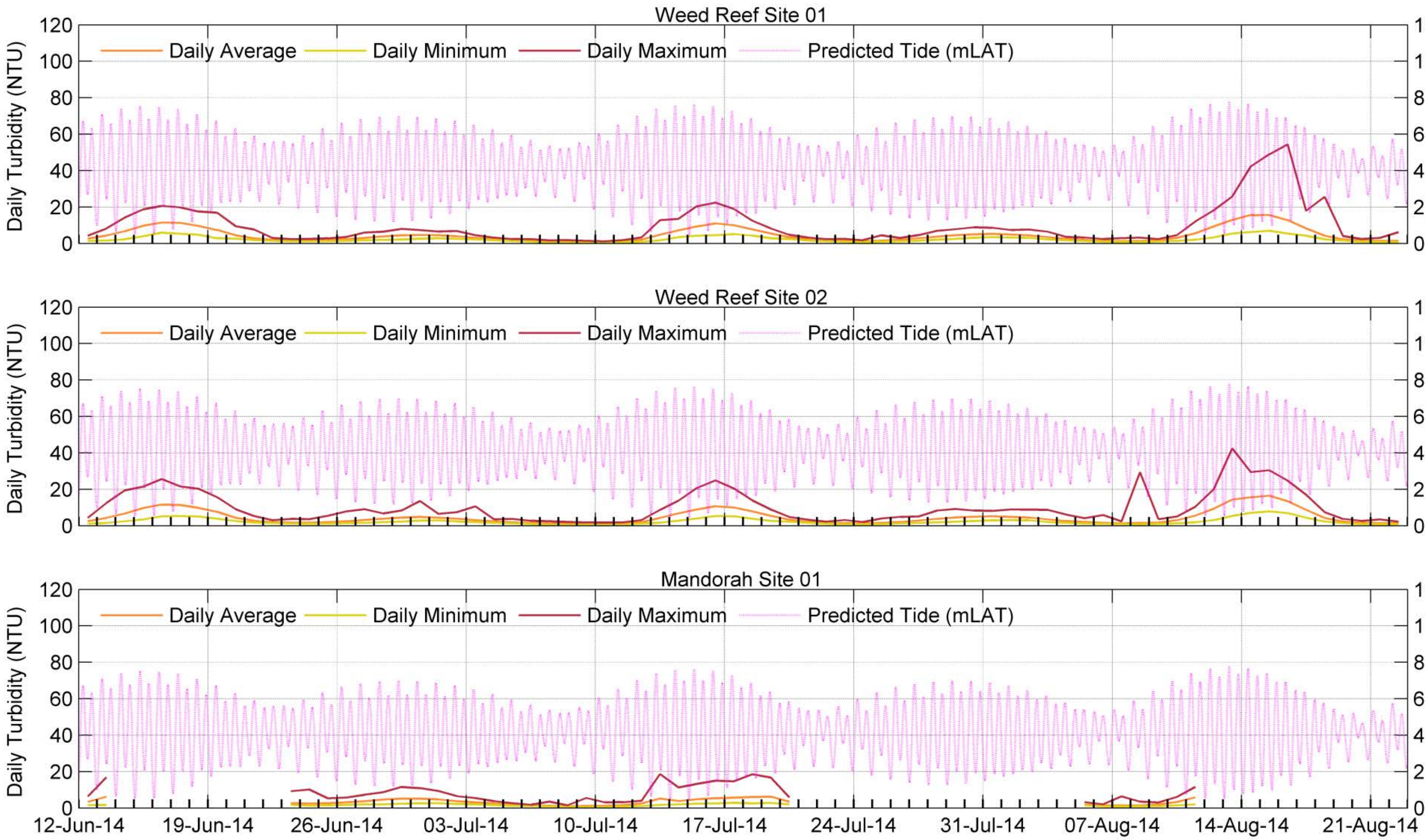
Appendix E-3 **Daily mean, maximum and minimum water temperature data from Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 21/10/2014 and 18/12/2014. Extract from Cardno Water Quality database on 23/02/2015**



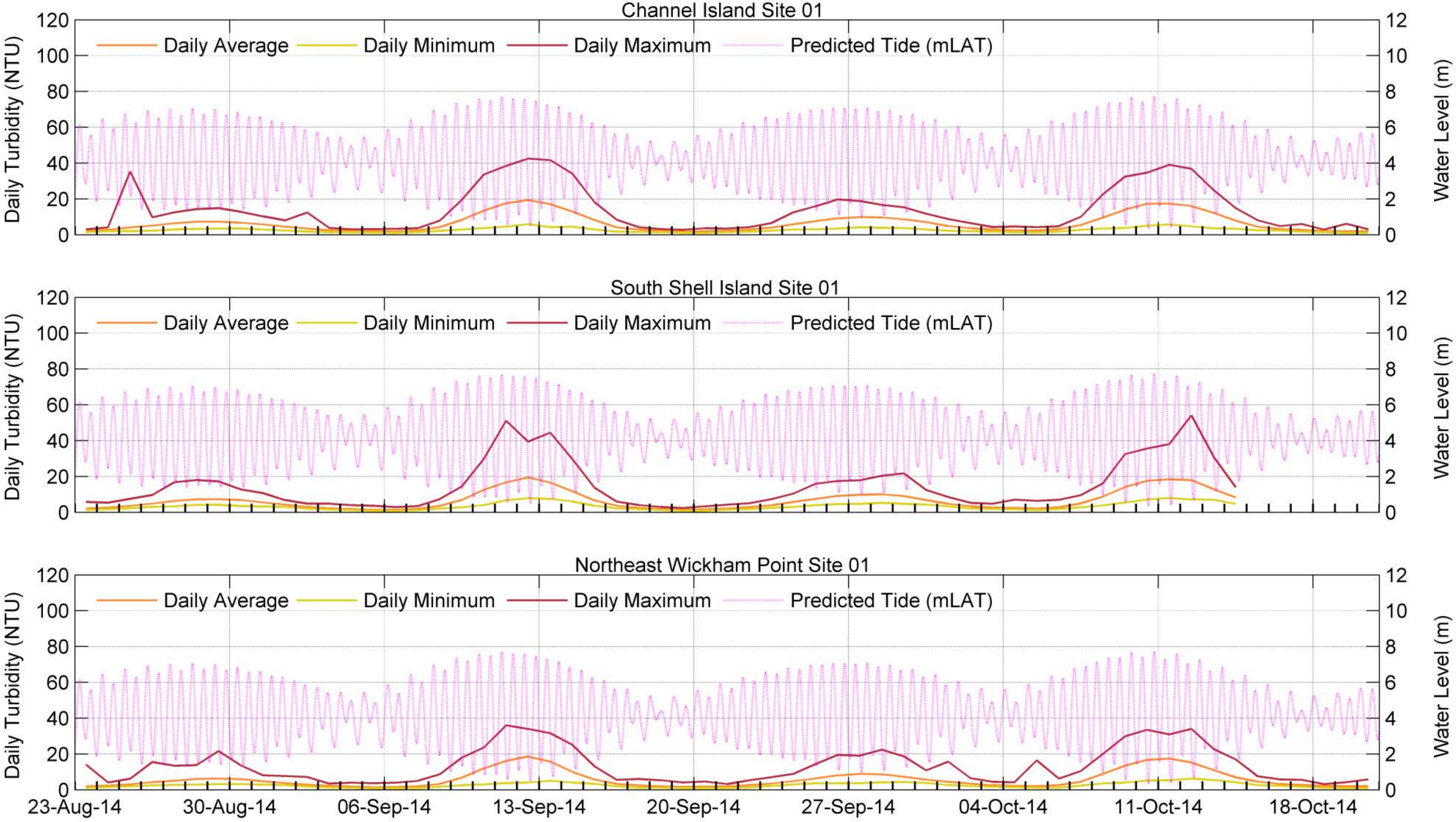

Weed Reef Site 01
Weed Reef Site 02
Mandorah Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Temperature (°C)
Water Level (m)
34
32
30
28
26
24
22
12
10
8
6
4
2
0
21-Oct-14
28-Oct-14
04-Nov-14
11-Nov-14
18-Nov-14
25-Nov-14
02-Dec-14
09-Dec-14
16-Dec-14

Appendix E-4 **Daily mean, maximum and minimum water turbidity at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 12/06/2014 and 22/08/2014. Extract from Cardno Water Quality database 12/03/2015**




Weed Reef Site 01
Weed Reef Site 02
Mandorah Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Daily Turbidity (NTU)
Water Level (m)
0
20
40
60
80
100
120
0
2
4
6
8
10
12
12-Jun-14
19-Jun-14
26-Jun-14
03-Jul-14
10-Jul-14
17-Jul-14
24-Jul-14
31-Jul-14
07-Aug-14
14-Aug-14
21-Aug-14

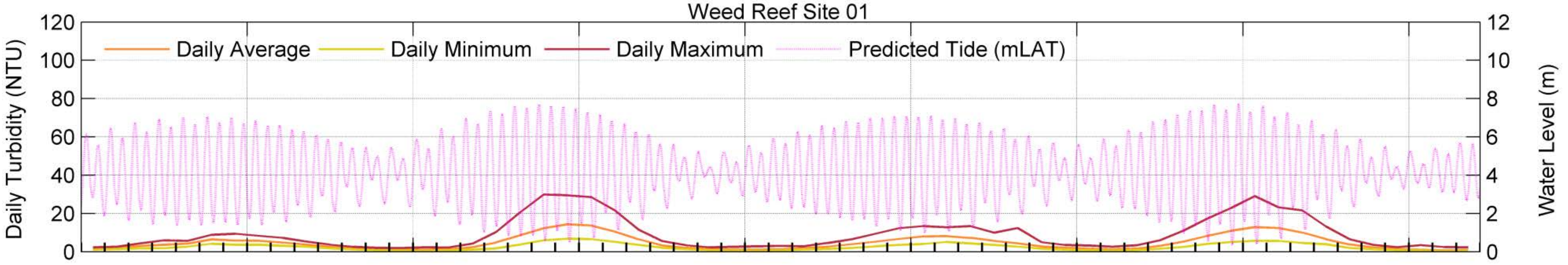
Appendix E-5 **Daily mean, maximum and minimum water turbidity at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 23/08/2014 and 20/10/2014. Extract from Cardno Water Quality database 23/02/2015**

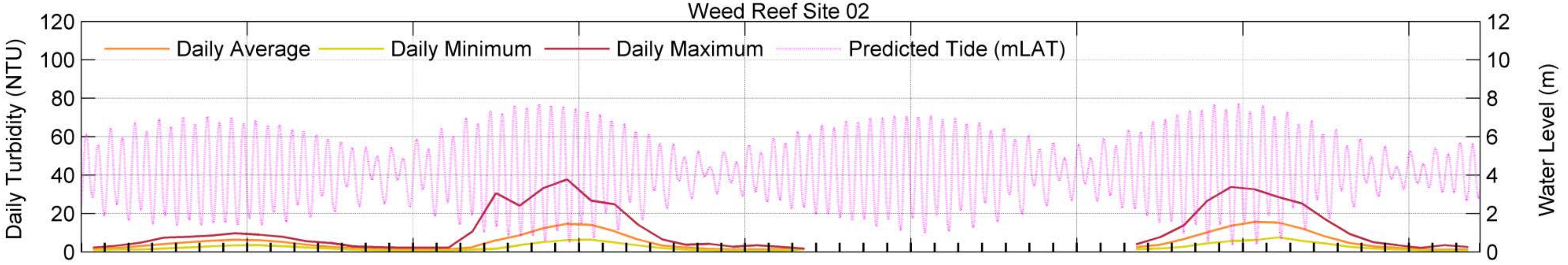


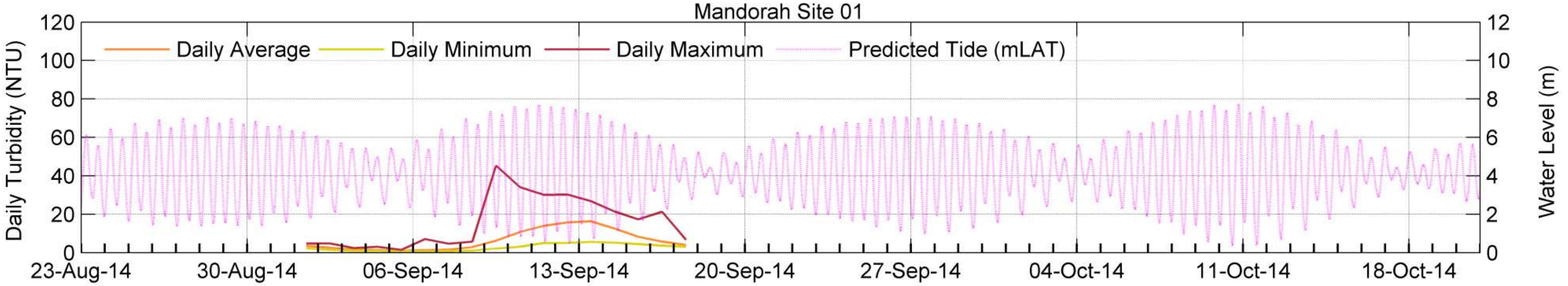
Channel Island Site 01

South Shell Island Site 01

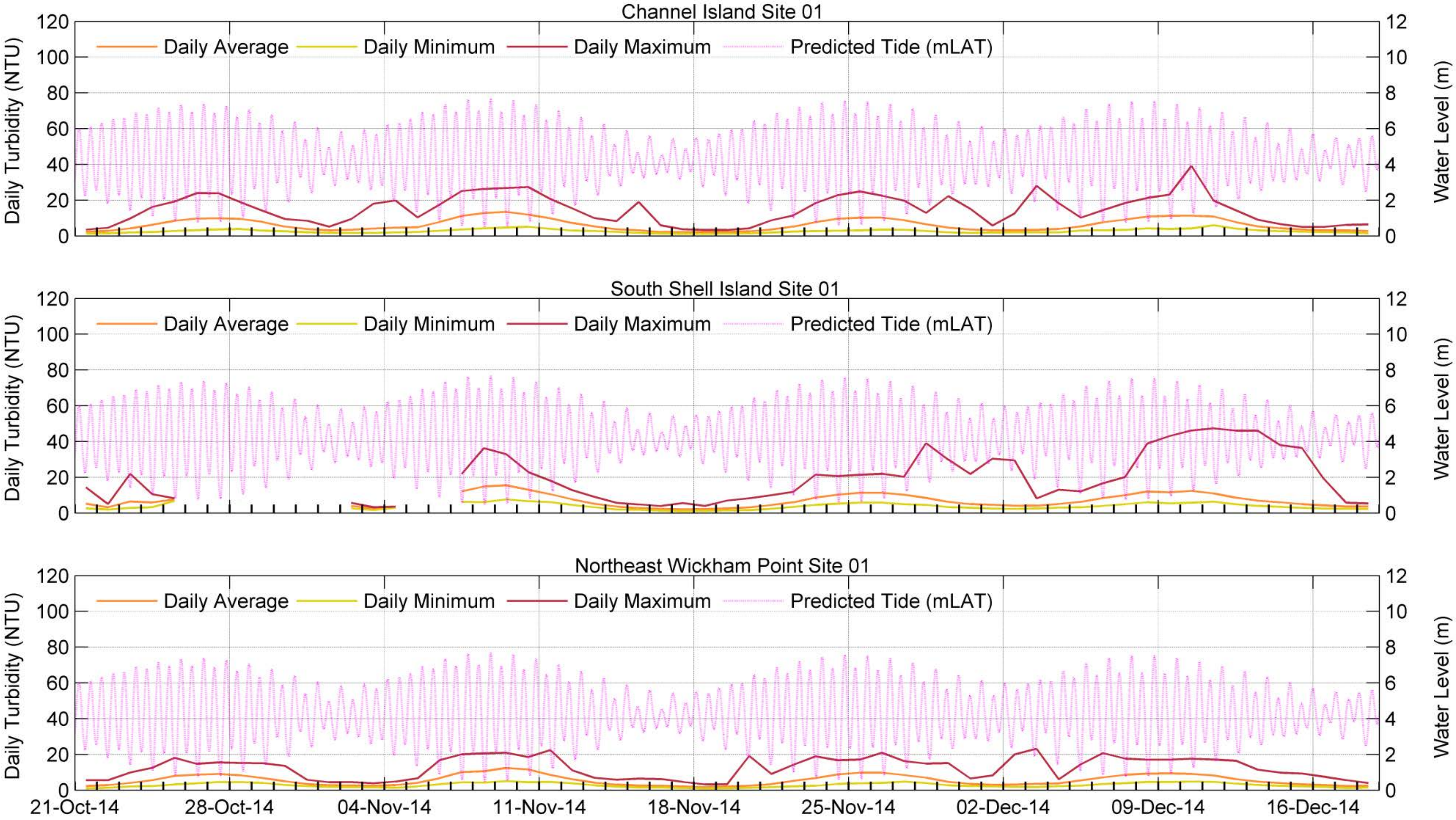
Northeast Wickham Point Site 01

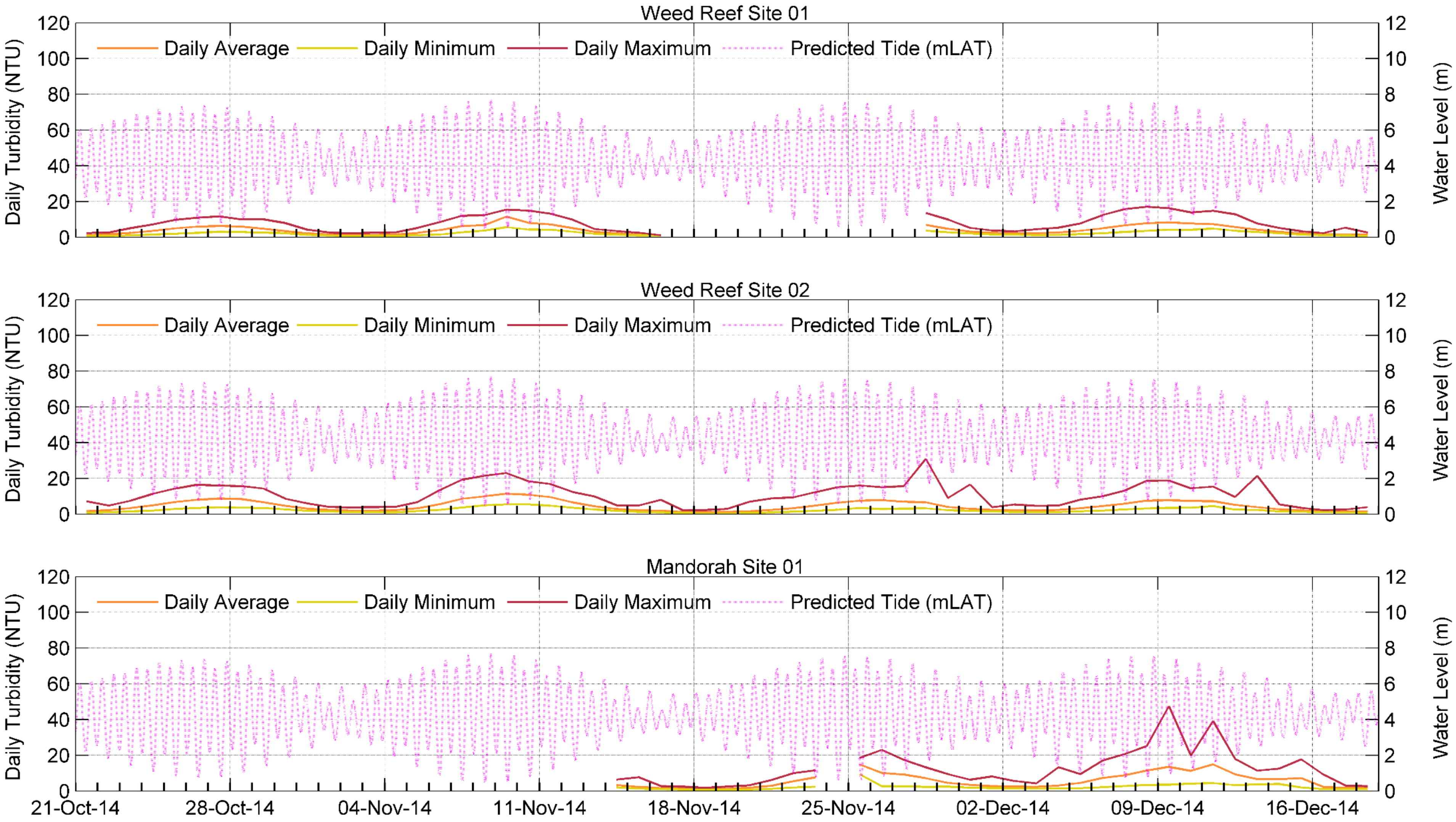

Weed Reef Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Daily Turbidity (NTU)
Water Level (m)
0
20
40
60
80
100
120
0
2
4
6
8
10
12


Weed Reef Site 02
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Daily Turbidity (NTU)
Water Level (m)
0
20
40
60
80
100
120
0
2
4
6
8
10
12

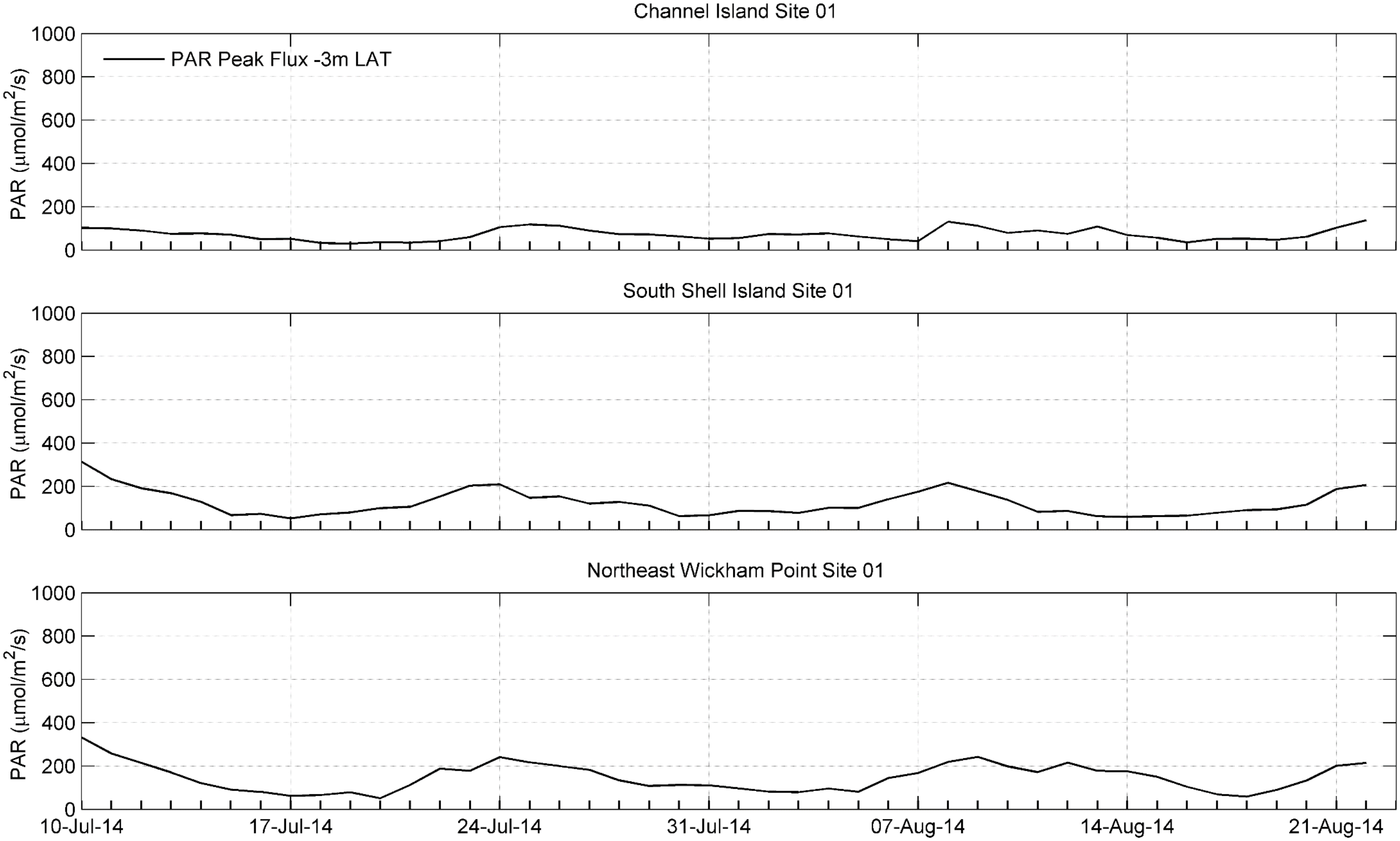

Mandorah Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Daily Turbidity (NTU)
Water Level (m)
0
20
40
60
80
100
120
0
2
4
6
8
10
12
23-Aug-14
30-Aug-14
06-Sep-14
13-Sep-14
20-Sep-14
27-Sep-14
04-Oct-14
11-Oct-14
18-Oct-14

Appendix E-6 **Daily mean, maximum and minimum water turbidity at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 21/10/2014 and 18/12/2014. Extract from Cardno Water Quality database 23/02/2015**



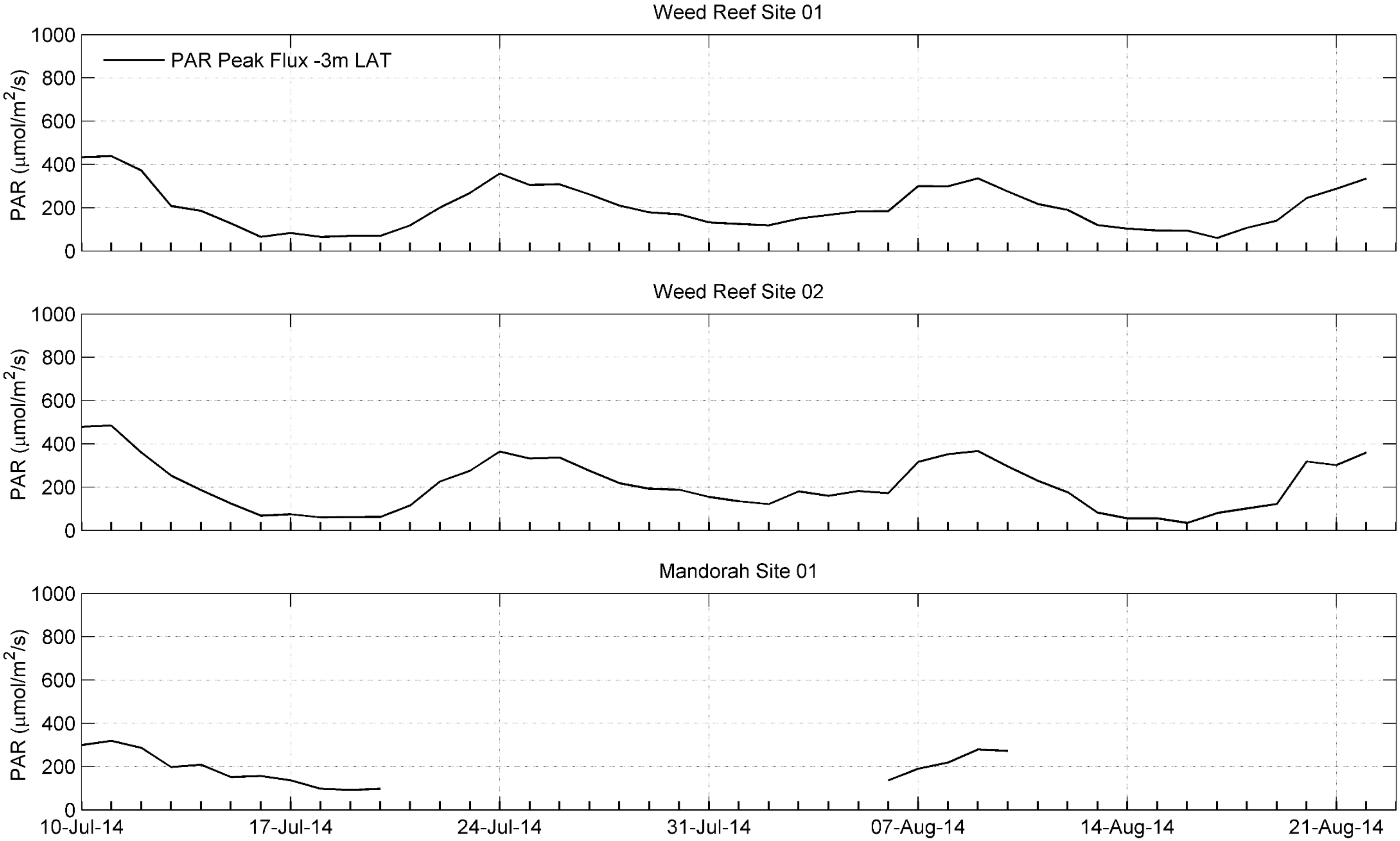

Weed Reef Site 01
Daily Average
Daily Minimum
Daily Maximum
Predicted Tide (mLAT)
Daily Turbidity (NTU)
Water Level (m)
120
100
80
60
40
20
0
12
10
8
6
4
2
0
Weed Reef Site 02
Mandorah Site 01
21-Oct-14
28-Oct-14
04-Nov-14
11-Nov-14
18-Nov-14
25-Nov-14
02-Dec-14
09-Dec-14
16-Dec-14

Appendix E-7 Peak flux PAR (adjusted to -3 m LAT) at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 10/07/2014 and 22/08/2014. Extract from Cardno Water Quality database 23/02/2015


Channel Island Site 01

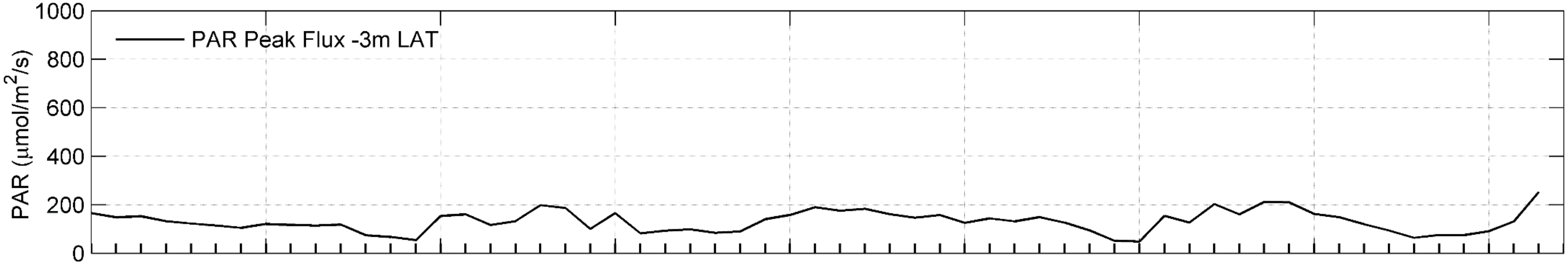
South Shell Island Site 01

Northeast Wickham Point Site 01

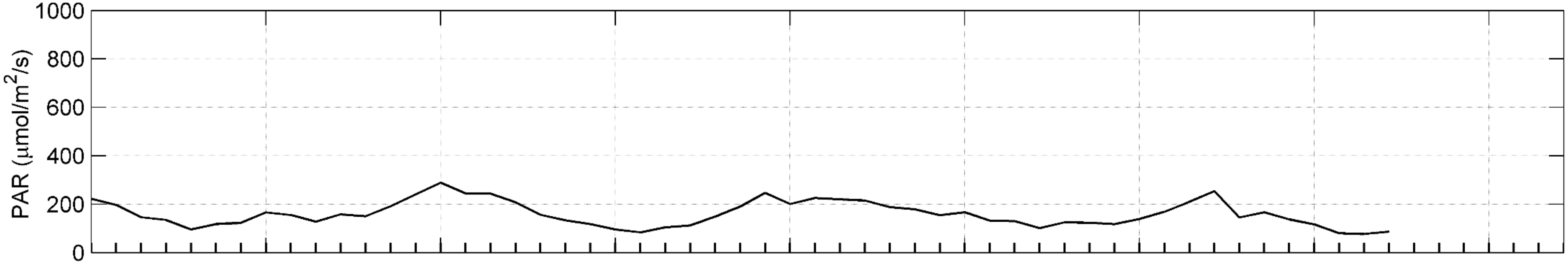

Weed Reef Site 01
PAR Peak Flux -3m LAT
PAR (μmol/m²/s)
1000
800
600
400
200
0
Weed Reef Site 02
PAR (μmol/m²/s)
1000
800
600
400
200
0
Mandorah Site 01
PAR (μmol/m²/s)
1000
800
600
400
200
0
10-Jul-14
17-Jul-14
24-Jul-14
31-Jul-14
07-Aug-14
14-Aug-14
21-Aug-14

Appendix E-8 **Peak flux PAR (adjusted to -3 m LAT) at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 23/08/2014 and 20/10/2014. Extract from Cardno Water Quality database 23/02/2015**

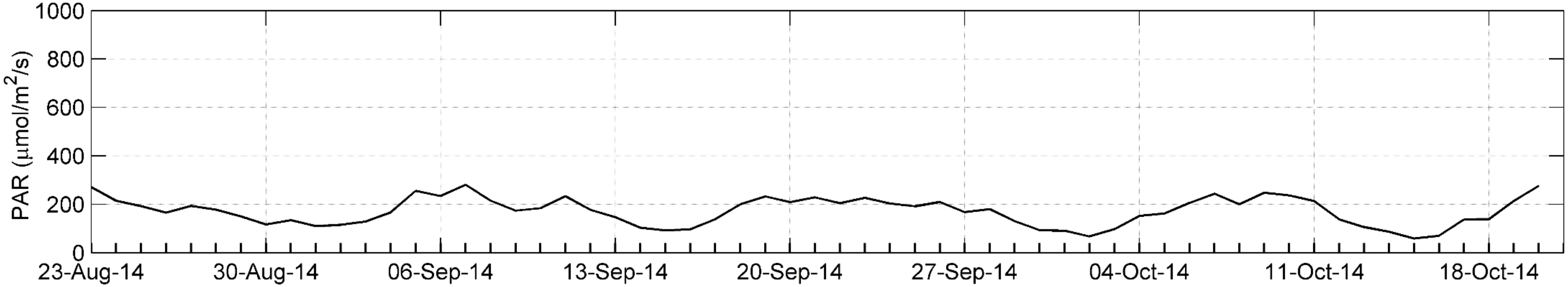
Channel Island Site 01

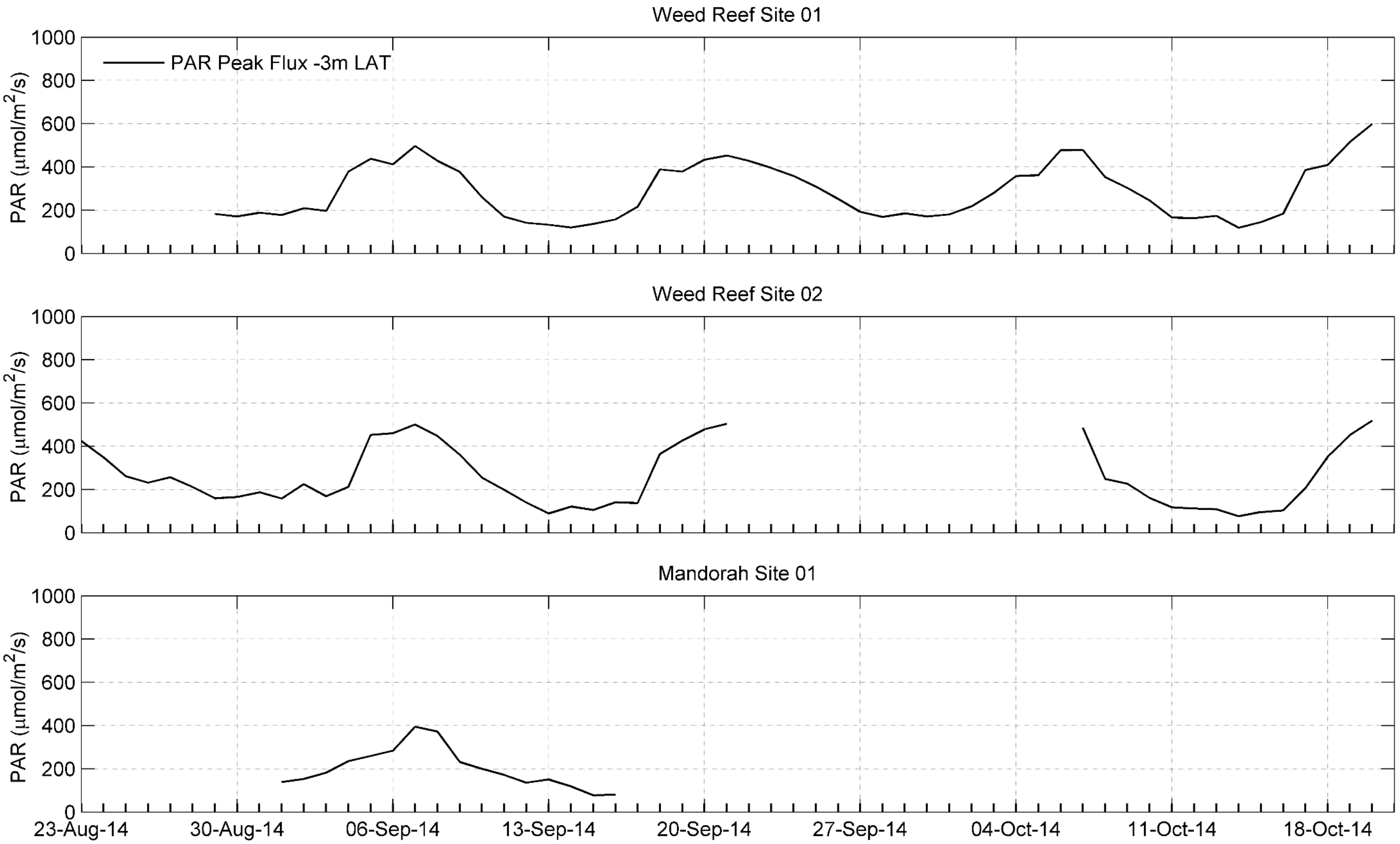


South Shell Island Site 01

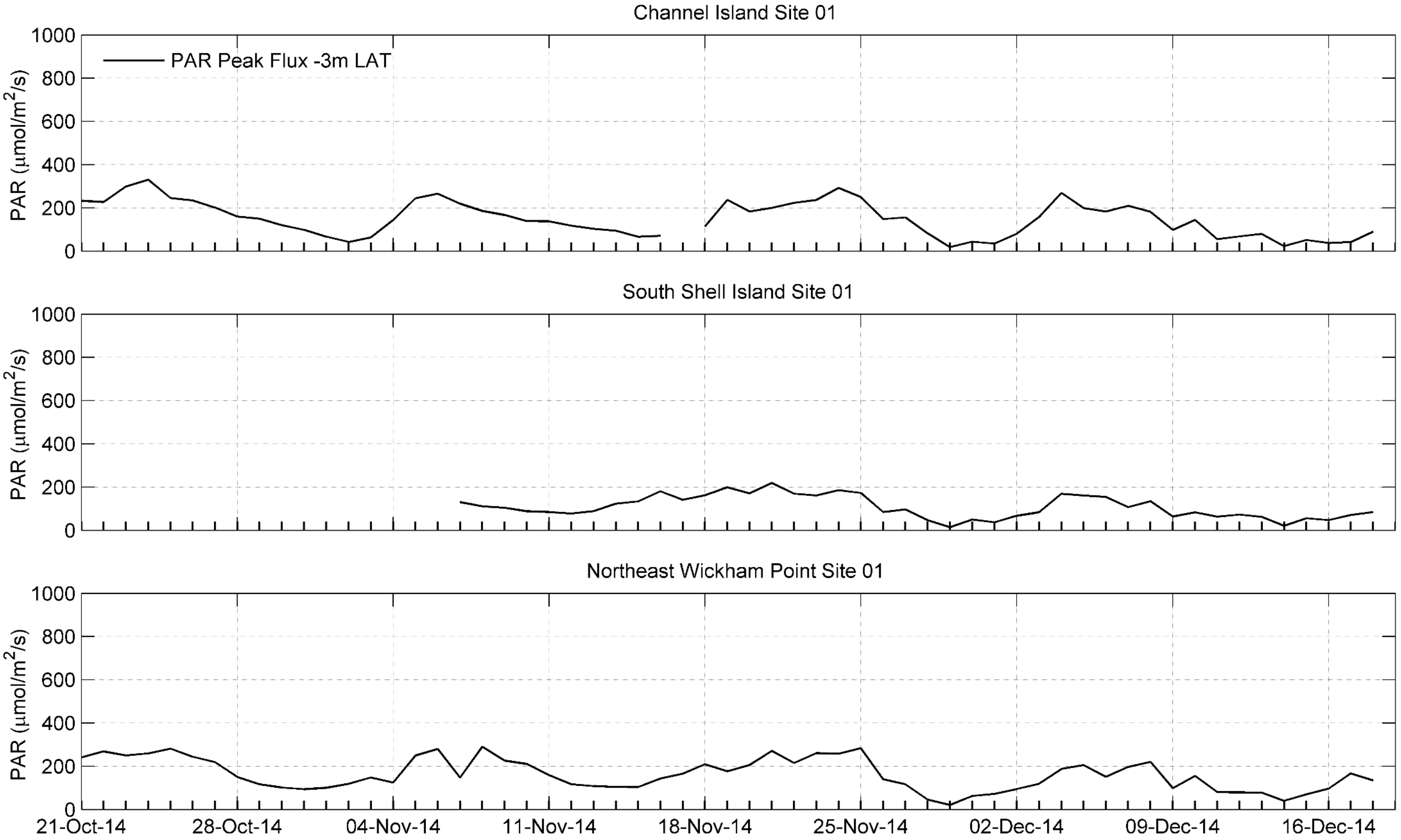


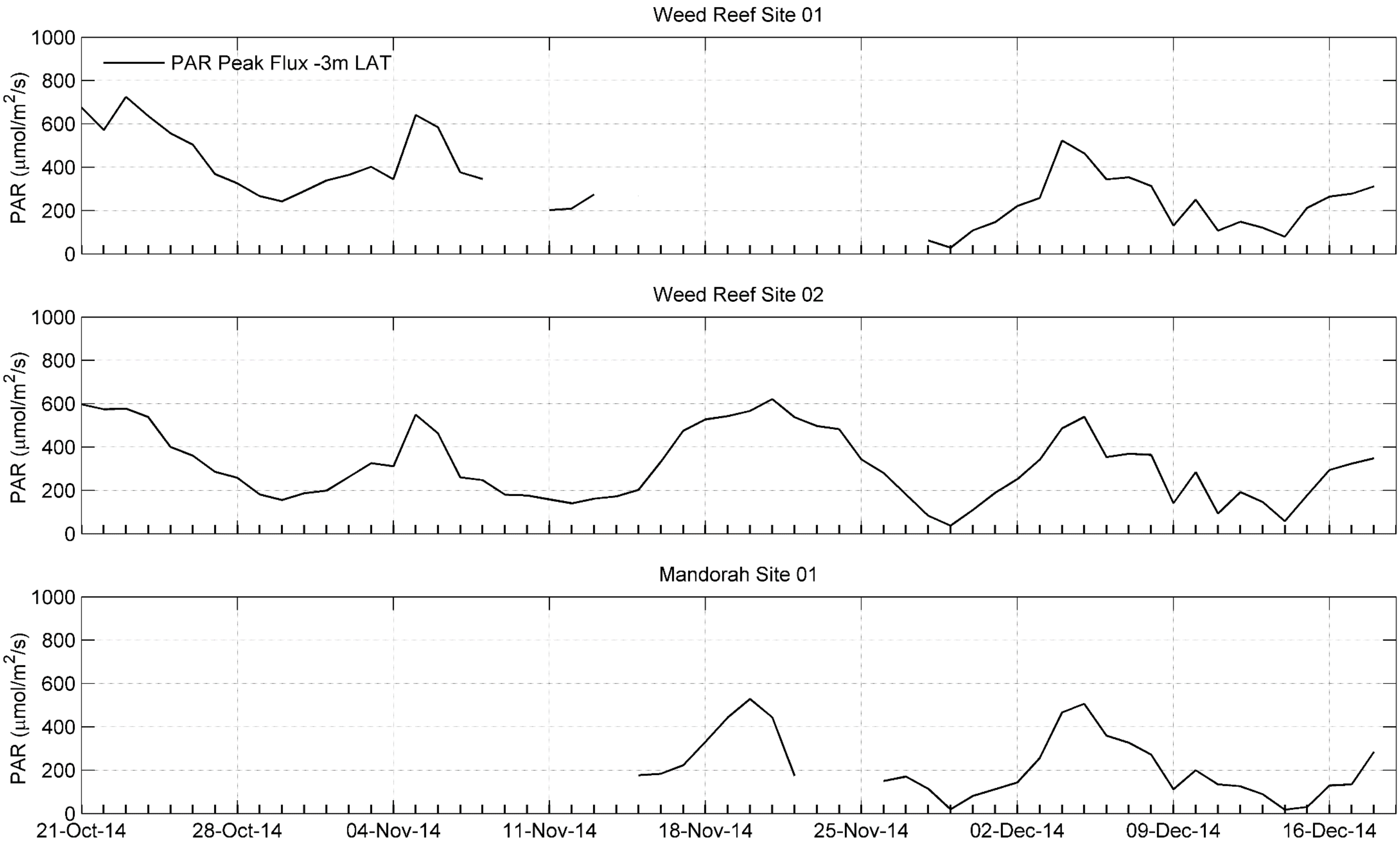
Northeast Wickham Point Site 01



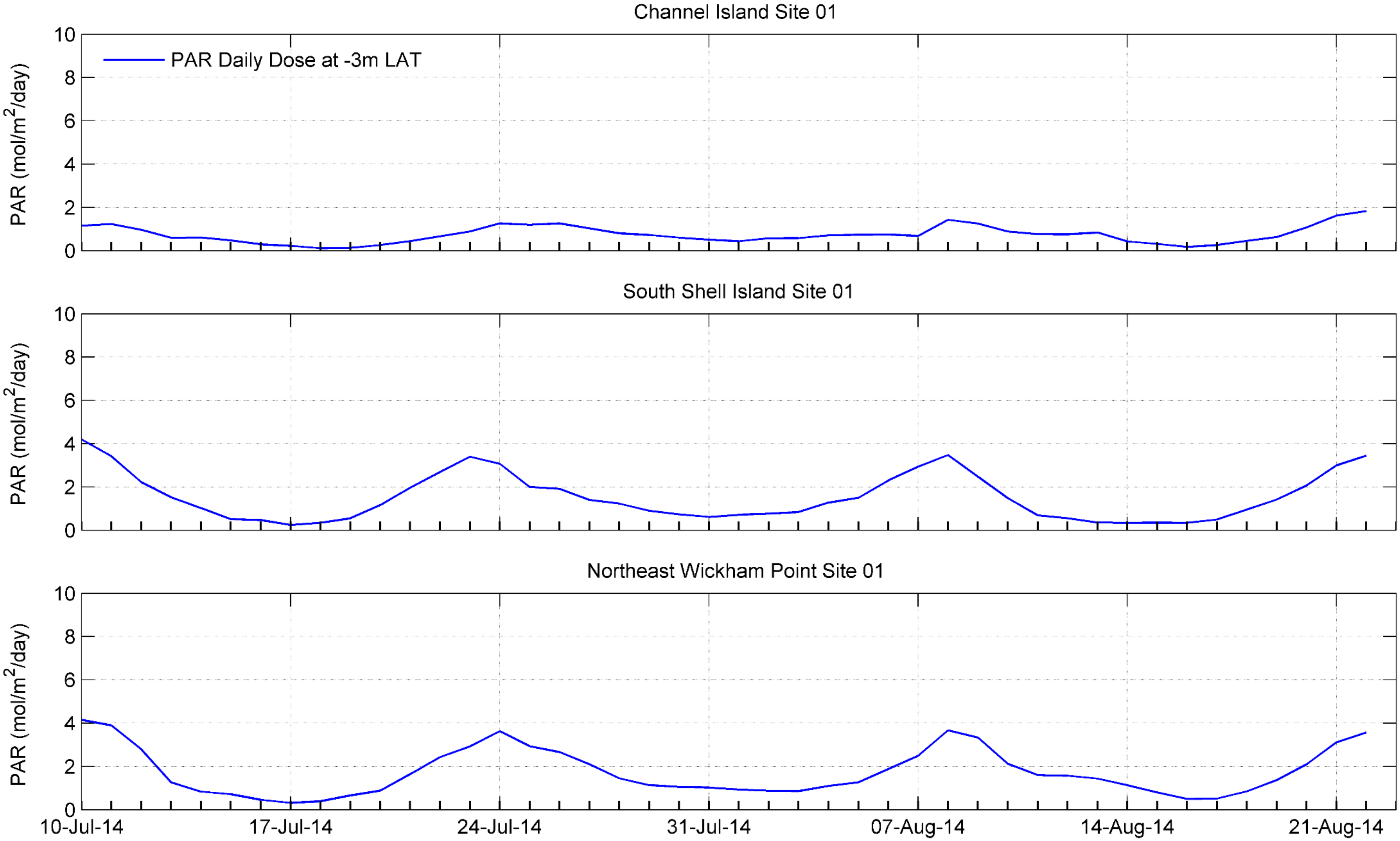

Weed Reef Site 01
PAR Peak Flux -3m LAT
PAR (µmol/m²/s)
1000
800
600
400
200
0
Weed Reef Site 02
PAR (µmol/m²/s)
1000
800
600
400
200
0
Mandorah Site 01
PAR (µmol/m²/s)
1000
800
600
400
200
0
23-Aug-14
30-Aug-14
06-Sep-14
13-Sep-14
20-Sep-14
27-Sep-14
04-Oct-14
11-Oct-14
18-Oct-14

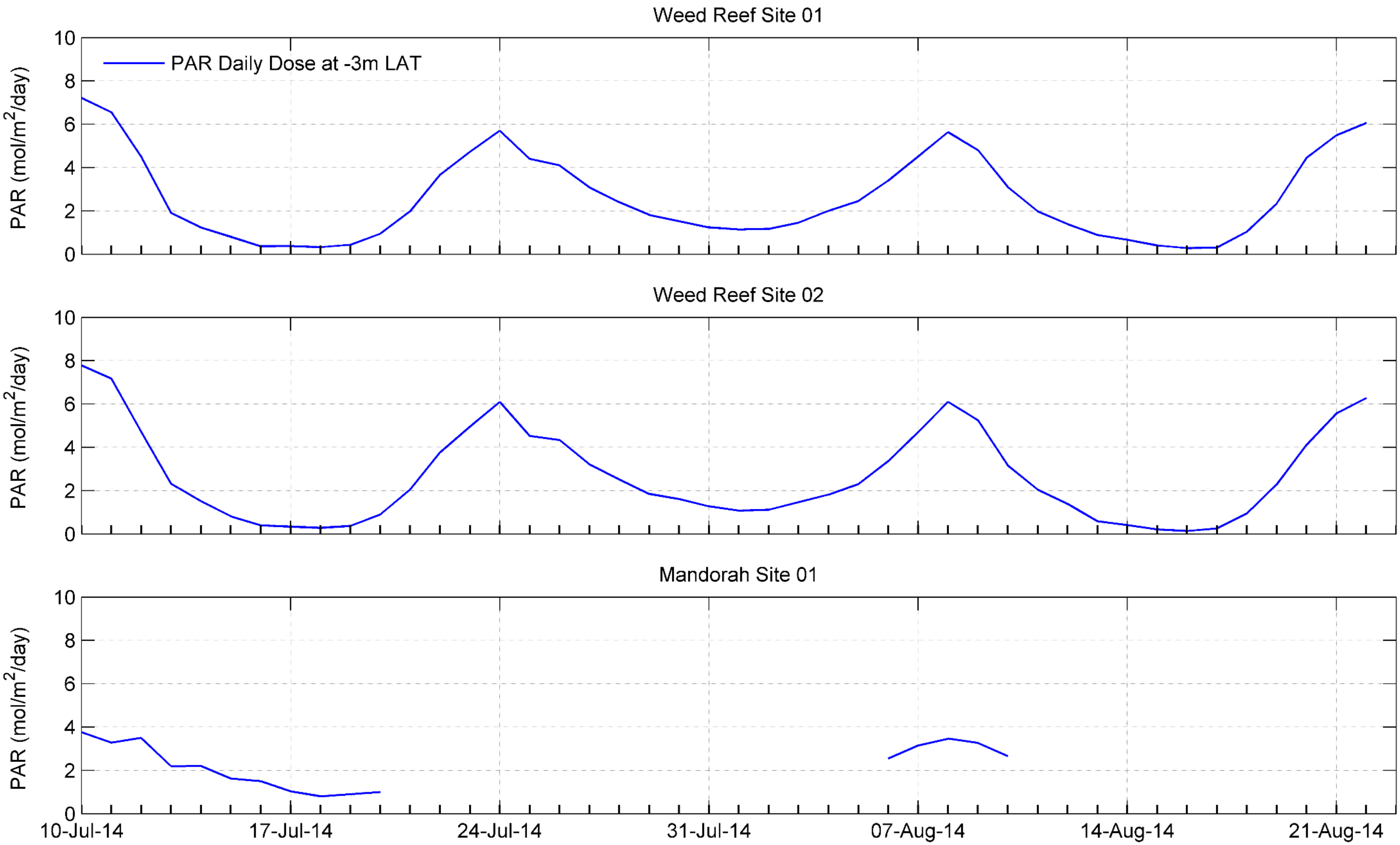
Appendix E-9 **Peak flux PAR (adjusted to -3 m LAT) at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 21/10/2014 and 18/12/2014. Extract from Cardno Water Quality database 23/02/2015**



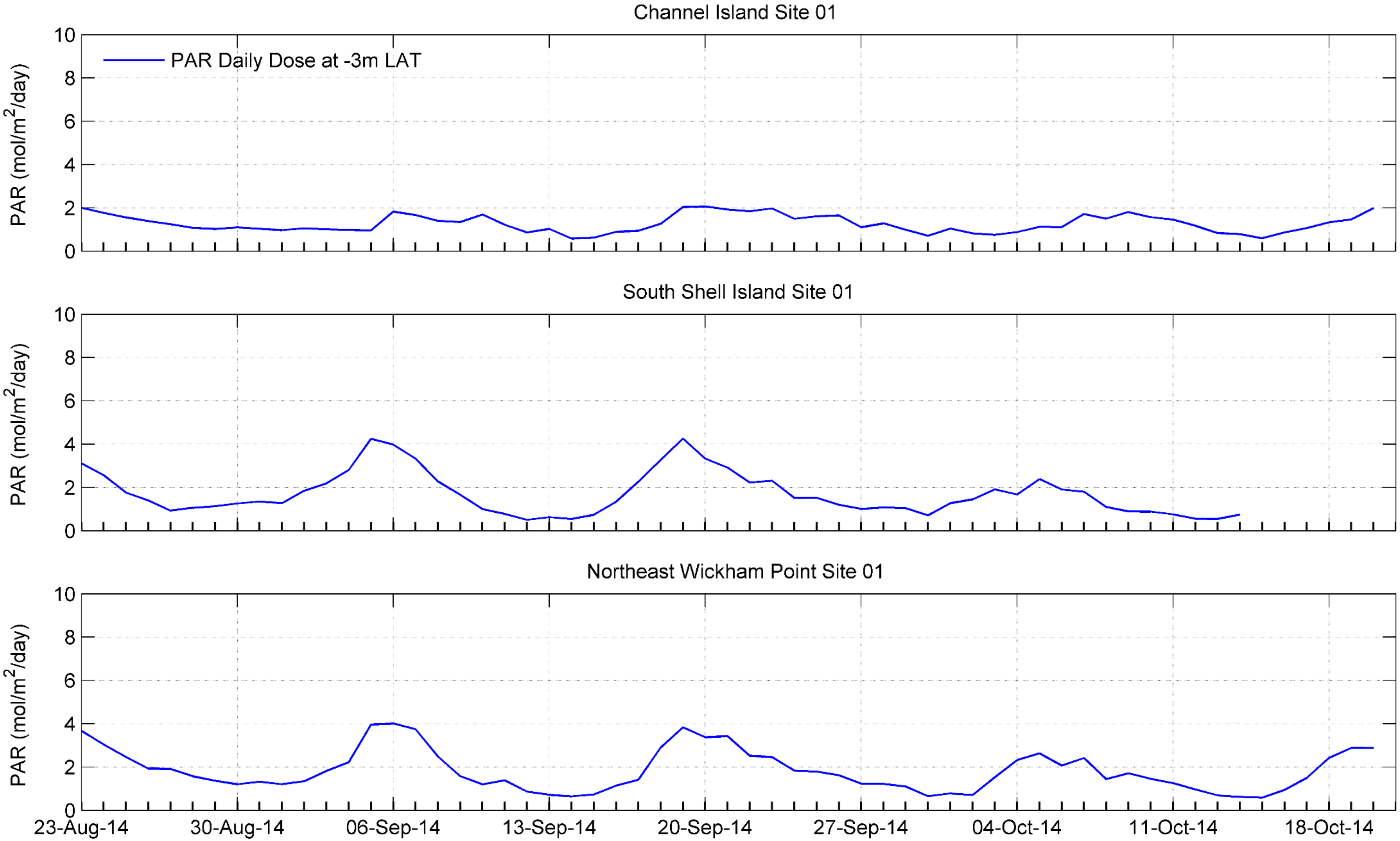

Weed Reef Site 01
PAR Peak Flux -3m LAT
PAR (µmol/m²/s)
1000
800
600
400
200
0
Weed Reef Site 02
PAR (µmol/m²/s)
1000
800
600
400
200
0
Mandorah Site 01
PAR (µmol/m²/s)
1000
800
600
400
200
0
21-Oct-14
28-Oct-14
04-Nov-14
11-Nov-14
18-Nov-14
25-Nov-14
02-Dec-14
09-Dec-14
16-Dec-14

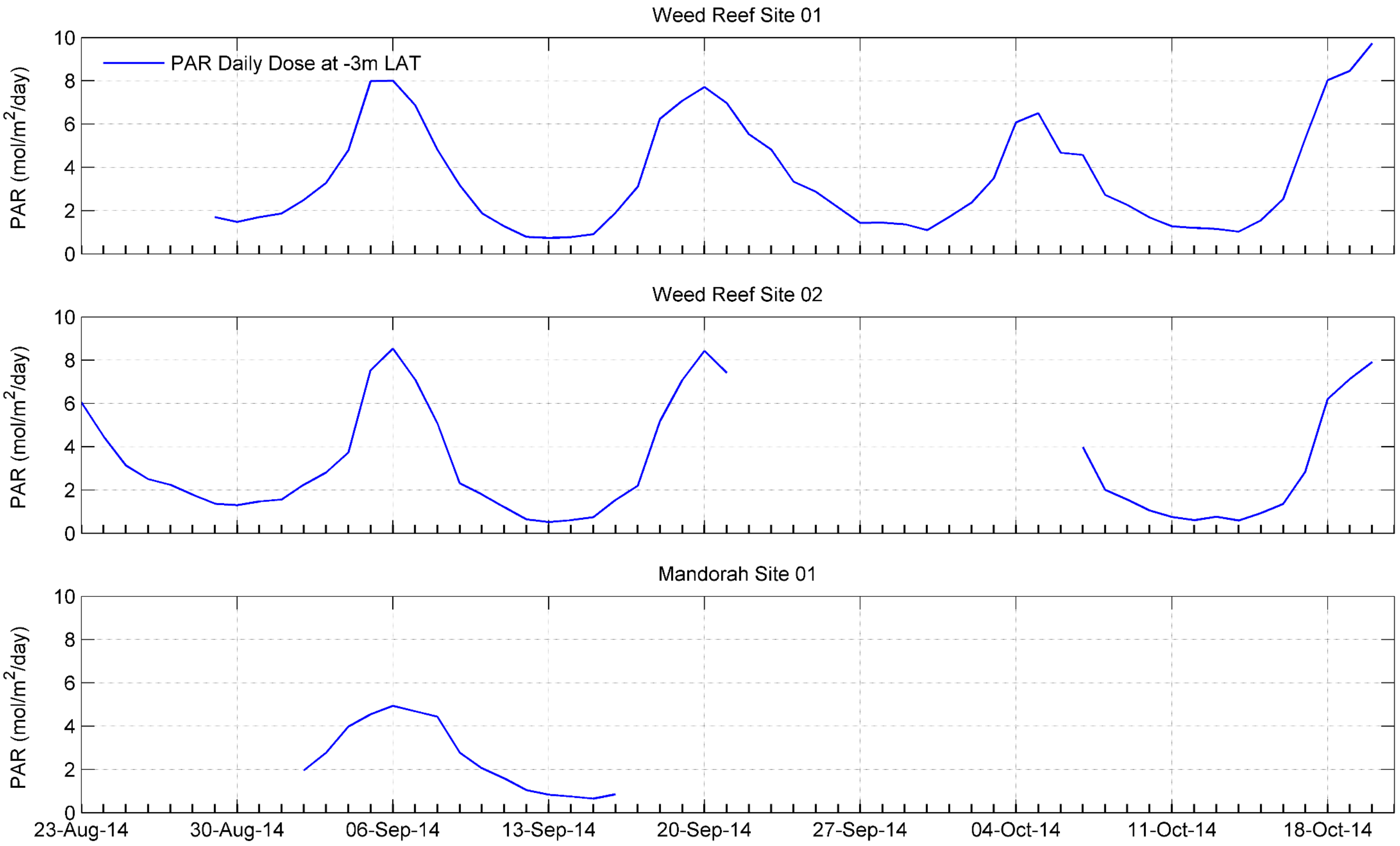
Appendix E-10 **Daily Dose PAR (adjusted to -3 m LAT) at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 10/07/2014 and 22/08/2014. Extract from Cardno Water Quality database 23/02/2015**



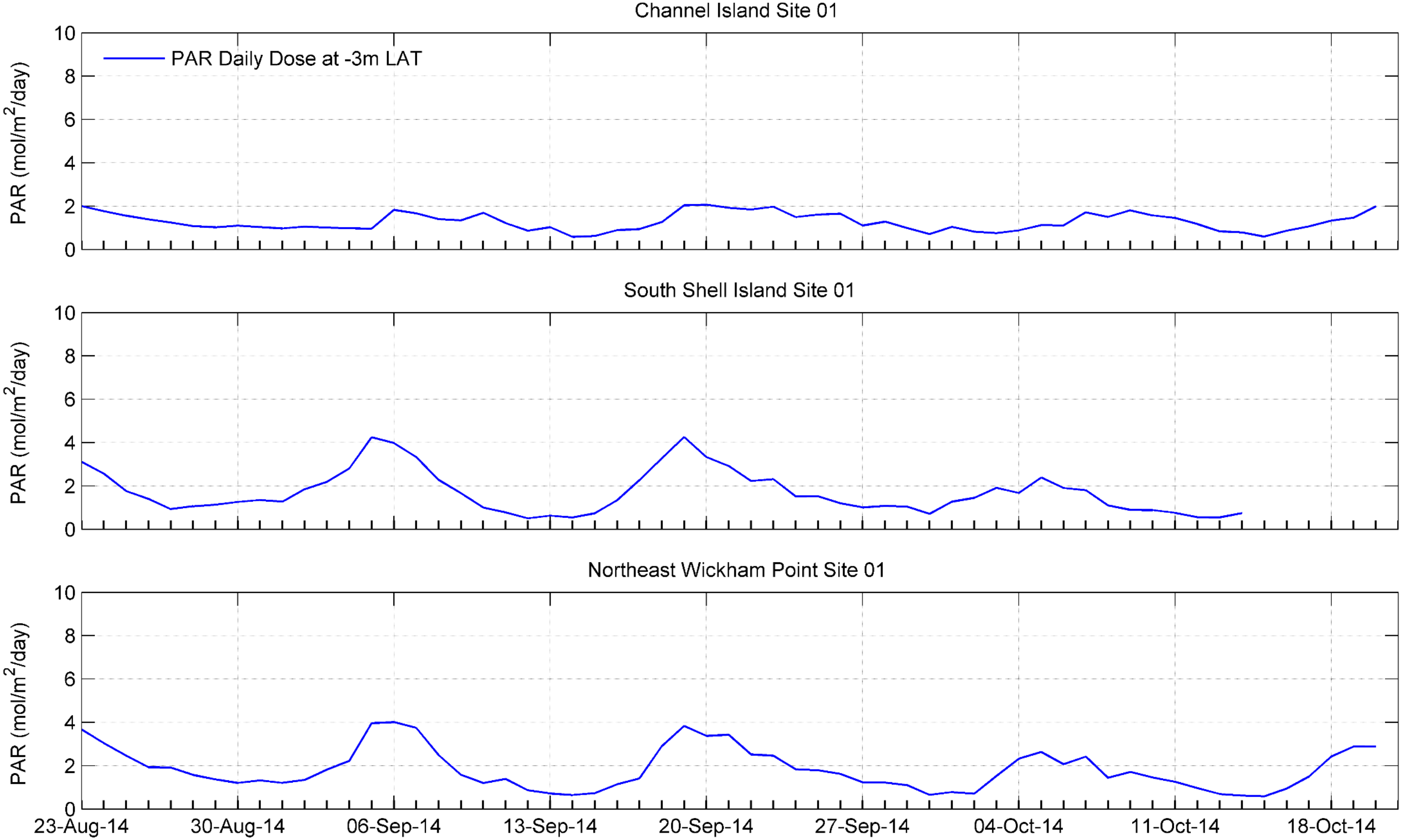

Weed Reef Site 01
PAR Daily Dose at -3m LAT
PAR (mol/m^2/day)
0
2
4
6
8
10
Weed Reef Site 02
PAR (mol/m^2/day)
Mandorah Site 01
PAR (mol/m^2/day)
10-Jul-14
17-Jul-14
24-Jul-14
31-Jul-14
07-Aug-14
14-Aug-14
21-Aug-14

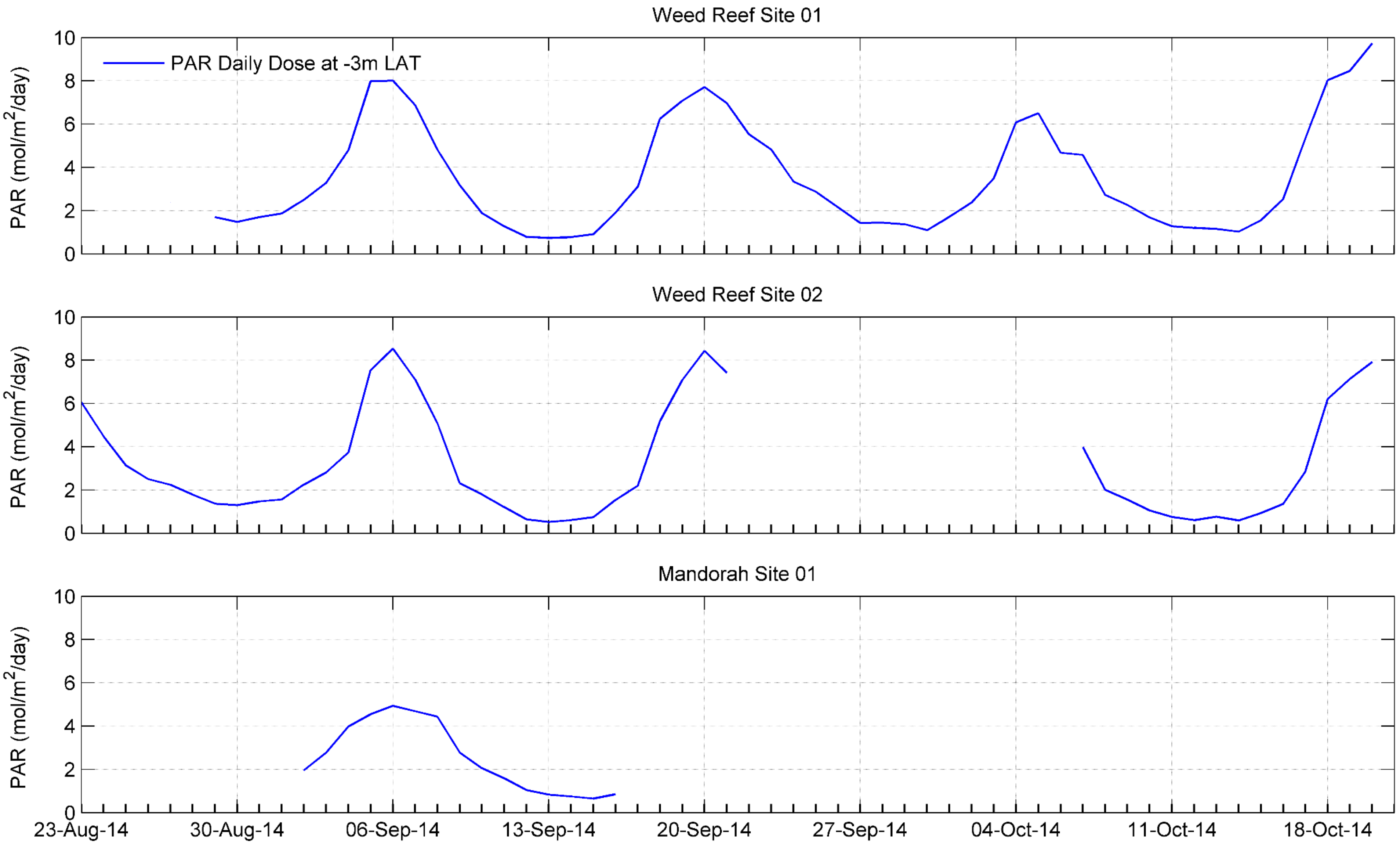
Appendix E-11 **Daily Dose PAR (adjusted to -3 m LAT) at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 23/08/2014 and 20/10/2014. Extract from Cardno Water Quality database 23/02/2015**




Weed Reef Site 01
PAR Daily Dose at -3m LAT
PAR (mol/m^2/day)
0
2
4
6
8
10
Weed Reef Site 02
Mandorah Site 01
23-Aug-14
30-Aug-14
06-Sep-14
13-Sep-14
20-Sep-14
27-Sep-14
04-Oct-14
11-Oct-14
18-Oct-14

Appendix E-12 Daily Dose PAR (adjusted to -3 m LAT) at Channel Island, South Shell Island, Northeast Wickham Point, Weed Reef 1 and Weed Reef 2 and Mandorah between 21/10/2014 and 18/12/2014. Extract from Cardno Water Quality database 23/02/2015




Weed Reef Site 01
PAR Daily Dose at -3m LAT
PAR (mol/m²/day)
0
2
4
6
8
10
Weed Reef Site 02
Mandorah Site 01
23-Aug-14
30-Aug-14
06-Sep-14
13-Sep-14
20-Sep-14
27-Sep-14
04-Oct-14
11-Oct-14
18-Oct-14

APPENDIX F

QUALITY CONTROL RESULTS

Cardno®
Shaping the Future

Appendix F-1 **Summary of scoring error rates for tagged coral CPCe during P1. At each site, CPCe is performed on 75 corals divided into three batches of 25. Each batch is scored by one CPCe analyst. The QA is carried out on three randomly selected tagged corals within each of the three batches. The error rates presented in the table below show the percentage differences between the CPCe analyst and QA/QC supervisor. The average error is of the three from each batch**

Site	Tag	Error	Average Error
Channel Island	3	7%	4%[1]
	11	2%	
	21	3%	
	29	0%	3%[2]
	38	9%	
	47	1%	
	55	1%	2%
	69	4%	
	70	1%	
Weed Reef 1	1	1%	1%
	6	0%	
	21	2%	
	39	1%	3%
	44	1%	
	49	7%	
	53	2%	4%[3]
	54	9%	
	65	1%	
Weed Reef 2	6	1%	1%
	21	2%	
	25	0%	
	39	1%	0%
	44	0%	
	49	0%	
	56	2%	1%
	67	0%	
	75	0%	
South Shell Island	2	2%	2%
	13	2%	
	17	2%	
	28	2%	2%
	31	3%	
	49	0%	
	58	9%	7%[3]
	67	13%	
	75	0%	

Site	Tag	Error	Average Error
Northeast Wickham Point	5	2%	1%
	16	0%	
	20	1%	
	29	0%	0%
	34	0%	
	44	1%	
	53	2%	1%
	60	0%	
	72	2%	
Mandorah	3	0%	2%
	5	4%	
	24	1%	
	33	3%	2%
	38	3%	
	45	0%	
	51	0%	2%
	54	2%	
	64	3%	

[1] A few points were scored as IF instead of HC. No need to redo batch.

[2] Border was tricky to determine so a couple of points were scored as HC instead of NOTC and vice versa. No need to redo batch.

[3] Too many points were scored as BP instead of HC. Entire batch was checked for this type of error.

Appendix F-2 Summary of scoring error rates for tagged coral CPCe during P2. At each site, CPCe is performed on 75 corals divided into three batches of 25. Each batch is scored by one CPCe analyst. The QA is carried out on three randomly selected tagged corals within each of the three batches. The error rates presented in the table below show the percentage differences between the CPCe analyst and QA/QC supervisor. The average error is of the three from each batch

Site	Tag	Error	Average Error
Channel Island	8	0%	1%
	16	1%	
	25	2%	
	26	0%	2%
	46	3%[1]	
	48	3%[2]	
	51	1%	2%
	53	4%	
	54	2%	
Weed Reef 1	1	0%	0%
	5	0%	
	12	0%	
	27	4%[4]	3%
	37	2%	
	47	3%	
	54	5%[5]	2%
	58	1%	
	72	0%	
Weed Reef 2	4	4%[6]	3%
	7	4%[6]	
	24	0%	
	29	2%	2%
	37	1%	
	38	4%[7]	
	63	0%	1%
	70	1%	
	73	1%	
South Shell Island	8	3%	2%
	15	3%	
	18	1%	
	32	2%	1%
	41	0%	
	42	1%	
	57	1%	0%
	70	0%	
	74	0%	

Site	Tag	Error	Average Error
Northeast Wickham Point	4	3%	1%
	12	1%	
	20	0%	
	26	0%	2%
	27	0%	
	41	5%[3]	
	62	0%	2%
	65	5%	
	73	0%	
Mandorah	5	6%[8]	5%
	8	8%[8]	
	22	2%	
	28	3%	2%
	38	2%	
	43	0%	
	53	0%	0%
	65	0%	
	70	0%	

[1] A couple of points were scored as HC instead of S. No need to redo batch.

[2] A couple of points were scored as MA instead of S. These were mis-clicks. No need to redo batch.

[3] A few points were mis-scored as HC instead of TA and vice versa. Photo a little blurry so no need to redo batch.

[4] A few points were scored as HC instead of BP and a few points were scored as TA instead of IF. Entire batch was checked for these types of errors.

[5] A few points were scored as BP instead of HC. Entire batch was redone.

[6] A few points were scored as HC instead of BP and S and vice versa. Entire batch was redone.

[7] A couple of points were scored as HC instead of S. No need to redo batch.

[8] A few images had tricky borders as well as mis-scoring of TA, S and BP. Entire batch was redone.

Appendix F-3 Summary of scoring error rates for tagged coral CPCe during P3. At each site, CPCe is performed on 75 corals divided into three batches of 25. Each batch is scored by one CPCe analyst. The QA is carried out on three randomly selected tagged corals within each of the three batches. The error rates presented in the table below show the percentage differences between the CPCe analyst and QA/QC supervisor. The average error is of the three from each batch

Site	Tag	Error	Average Error
Channel Island	3	1%	1%
	20	2%	
	21	0%	
	43	0%	1%
	47	1%	
	50	1%	
	51	1%	5%
	60	1%	
	63	13%[1]	1%
Weed Reef 1	1	0%	1%
	5	1%	
	13	3%[6]	
	33	2%	5%
	35	0%	
	46	12%[7]	
	51	2%	1%
	56	0%	
	66	0%	
Weed Reef 2	6	1%	3%
	16	4%[6]	
	19	5%[6]	
	35	3%	4%
	41	10%[8]	
	50	0%	
	54	0%	1%
	56	3%	
	60	0%	
South Shell Island	2	2%	2%
	8	2%	
	17	1%	
	31	0%	4%
	32	4%[2]	
	46	7%[3]	
	53	0%	1%
	70	2%	

Site	Tag	Error	Average Error
	72	2%	
Northeast Wickham Point	6	2%	2%
	12	3%[4]	
	21	1%	
	34	2%	30%
	38	60%[5]	
	42	29%[5]	
	66	1%	1%
	68	2%	
	75	0%	
Mandorah	3	0%	0%
	5	1%	
	24	0%	
	33	0%	1%
	38	0%	
	45	3%	
	51	0%	3%
	54	2%	
	64	6%[2]	

[1] Too many points scored as BP instead of HC and vice versa. Entire batch was checked for this type of error.

[2] Border was very tricky so a couple points were scored as NOTC instead of S or vice versa.

[3] A few points were scored as BP instead of HC. Although they were mis-clicks the entire batch was checked for bleaching scoring errors

[4] A couple of points were labelled as BP instead of HC. Entire batch was checked for this type of error.

[5] Border was incorrect so was redone and coral rescored.

[6] A couple of points were scored as S instead of HC and vice versa because the photo was a little blurry. No need to redo batch.

[7] Too many points were scored as HC instead of BP/BW. Entire batch was checked for this type of error.

[8] The dead parts of this coral were incorrectly scored. Entire batch was checked for this type of error.

Appendix F-4 Percentage difference between CPCe operators and QA/QC supervisor across categories for transect data during P1. Quality checks on CPCe scorers were performed on 10% of randomly sampled quadrats, i.e. four quadrats from each of four transects within the five sites. The table below is a summary of the percentage difference between CPCe analyst and the QA/QC supervisor across categories, averaged across the four quadrats

Site	Transect	Coral Family	Coral Morphology	Coral Health	Octocorals	Other Biota	Sediment on Other Biota	Algae	Substrate	Equipment
Channel Island	1	0%	0%	2%	0%	0%	0%	2%	3%	0%
	2	0%	13%	1%	0%	0%	0%	1%	7%	0%
	3	0%	1%[1]	0%	0%	2%	0%	4%	13%	0%
	4	0%	0%	0%	0%	1%	0%	6%	13%	0%
Weed Reef 1	1	0%	0%	0%	0%	3%	0%	5%	9%	0%
	2	1%[3]	0%	0%	0%	1%	0%	7%	10%	0%
	3	0%	1%	3%	0%	0%	0%	2%	2%	0%
	4	0%	4%[4]	1%	0%	1%	0%	4%	6%	0%
Weed Reef 2	1	1%	0%	0%	0%	1%	0%	2%	3%	0%
	2	0%	1%	0%	0%	1%	0%	2%	2%	0%
	3	0%	0%	1%	0%	0%	0%	0%	0%	0%
	4	0%	0%	0%	0%	0%	0%	5%	4%	0%
South Shell Island	1	1%[2]	1%	3%	0%	1%	0%	5%	4%	0%
	2	0%	0%	0%	0%	0%	0%	3%	3%	0%
	3	0%	0%	0%	0%	3%	0%	13%	8%	0%
	4	0%	0%	2%	0%	2%	0%	18%	9%	1%
Northeast Wickham Point	1	0%	0%	0%	0%	1%	0%	1%	11%	0%
	2	0%	0%	1%	0%	1%	0%	5%	9%	0%
	3	0%	0%	0%	0%	4%	0%	7%	6%	1%
	4	0%	0%	0%	0%	2%	0%	9%	11%	0%
Mandorah	1	0%	0%	0%	0%	1%	0%	1%	11%	0%
	1	2%[3]	0%	0%	0%	4%	0%	4%	7%	0%
	2	0%	0%	0%	0%	2%	0%	7%	17%	0%
	3	0%	0%	2%	0%	2%	0%	2%	5%	0%
	4	0%	0%	0%	0%	4%	0%	13%	15%	1%

[1] One coral, a FuE was mis-scored as PeE. Transect was checked for coral IDs and morphologies.

[2] One point was labelled as CIJ instead of FaE. No need to redo transect.

[3] A few Faviids were mis-identified. Entire transect checked for coral ID and morphology mis-scoring.

[4] A few points had incorrect coral morphologies and one ID error that was a mis-click error. Entire transect was checked for ID/mis-click and morphology errors.

[5] A few corals were mis-identified. Entire transect checked for ID errors.

[6] Too much silt scored and not enough TA and sand. Entire transect was rescored.

[7] A couple of points had incorrect morphologies, entire transect was checked for this type of error.

[8] A couple of points had incorrect morphologies assigned and one point was scored as coral instead of sponge but that was a mis-click. Transect checked for coral and morphology scoring errors.

[9] A few corals and their morphologies were mis-identified. Entire transect was redone.

[10] One coral was mis-identified. Entire transect was checked for coral ID errors.

Appendix F-5 Percentage difference between CPCe operators and QA/QC supervisor across categories for transect data during P2. Quality checks on CPCe scorers were performed on 10% of randomly sampled quadrats, i.e. four quadrats from each of four transects within the five sites. The table below is a summary of the percentage difference between CPCe analyst and the QA/QC supervisor across categories, averaged across the four quadrats

Site	Transect	Coral Family	Coral Morphology	Coral Health	Octocorals	Other Biota	Sediment on Other Biota	Algae	Substrate	Equipment
Channel Island	1	0%	10%[1]	2%	0%	2%	0%	8%	9%	0%
	2	0%	0%	2%	0%	2%	0%	7%	11%	1%
	3	4%[2]	12%[2]	4%	0%	0%	0%	15%	17%	1%
	4	2%[3]	1%	0%	0%	1%	0%	7%	11%	0%
Weed Reef 1	1	0%	0%	1%	0%	0%	0%	4%	9%	0%
	2	1%[3]	1%[3]	2%	0%	4%	0%	9%	9%	0%
	3	0%	0%	2%	0%	0%	0%	7%	8%	0%
	4	0%	0%	0%	0%	2%	0%	7%	9%	0%
Weed Reef 2	1	0%	0%	1%	0%	1%	0%	2%	2%	0%
	2	0%	0%	0%	0%	1%	0%	2%	2%	0%
	3	0%	1%	1%	0%	0%	0%	7%	6%	0%
	4	0%	0%	0%	0%	0%	0%	4%	7%	0%
South Shell Island	1	2%[3]	4%[3]	4%	0%	3%	0%	15%	12%	0%
	2	0%	0%	3%	0%	3%	0%	5%	5%	0%
	3	1%[3]	2%[3]	0%	0%	5%	0%	19%	15%	1%
	4	0%	0%	1%	1%	1%	0%	4%	3%	0%
Northeast Wickham Point	1	0%	0%	0%	0%	2%	0%	20%[4]	21%[4]	0%
	2	0%	0%	0%	0%	7%	0%	18%[4]	14%	2%
	3	0%	0%	0%	0%	2%	0%	9%	20%	1%
	4	0%	0%	0%	0%	1%	0%	7%	11%	0%
Mandorah	1	0%	0%	0%	0%	4%	0%	7%	7%	0%
	2	0%	0%	0%	0%	7%	0%	18%	14%	2%
	3	0%	0%	2%	0%	3%	0%	9%	16%	0%
	4	0%	9%[3]	0%	0%	4%	0%	13%	21%	0%

[1] Too many PeE scored as PeF. Entire transect was checked for morphology errors.

[2] One coral was mis-identified as PeE instead of FuE and a few points contained morphology errors. Entire transect was checked for these errors.

[3] A few corals were mis-identified as were their morphologies. Entire transect was checked for these errors.

[4] Too many substrate and other biota errors. Entire transect was checked for these errors.

Appendix F-6 Percentage difference between CPCe operators and QA/QC supervisor across categories for transect data during P3. Quality checks on CPCe scorers were performed on 10% of randomly sampled quadrats, i.e. four quadrats from each of four transects within the five sites. The table below is a summary of the percentage difference between CPCe analyst and the QA/QC supervisor across categories, averaged across the four quadrats

Site	Transect	Coral Family	Coral Morphology	Coral Health	Octocorals	Other Biota	Sediment on Other Biota	Algae	Substrate	Equipment
Channel Island	1	1%	1%	1%	0%	1%	0%	5%	11%	3%
	2	0%	0%	0%	0%	2%	0%	6%	8%	2%
	3	0%	0%	0%	0%	0%	0%	3%	7%	0%
	4	0%	0%	0%	0%	1%	0%	3%	13%	0%
Weed Reef 1	1	0%	0%	2%	0%	2%	0%	7%	26%[1]	0%
	2	0%	0%	0%	0%	4%	0%	9%	11%	0%
	3	0%	4%[2]	1%	0%	2%	0%	13%	11%	1%
	4	0%	0%	0%	0%	0%	0%	6%	10%	0%
Weed Reef 2	1	0%	0%	1%	0%	2%	0%	2%	1%	0%
	2	1%	1%	2%	0%	1%	0%	3%	3%	1%
	3	2%[3]	3%[3]	2%	0%	4%	0%	11%	10%	0%
	4	0%	0%	2%	0%	1%	0%	4%	14%	0%
South Shell Island	1	2%	2%	3%	0%	2%	0%	4%	4%	0%
	2	0%	0%	0%	0%	4%	0%	5%	5%	0%
	3	0%	0%	0%	0%	1%	0%	10%	6%	0%
	4	1%	1%	0%	0%	4%	0%	9%	10%	2%
Northeast Wickham Point	1	0%	1%	1%	0%	2%	0%	2%	9%	0%
	2	0%	0%	0%	0%	1%	0%	4%	5%	0%
	3	0%	0%	0%	0%	3%	0%	10%	11%	2%
	4	0%	0%	0%	0%	4%	0%	5%	7%	0%
Mandorah	1	0%	0%	0%	0%	5%	0%	9%	7%	1%
	2	0%	0%	2%	1%	9%	0%	9%	14%	0%
	3	0%	0%	1%	0%	2%	0%	3%	5%	0%
	4	1%[4]	2%[4]	2%	0%	3%	0%	9%	14%	1%

[1] Too many points scored as sand instead of silt – entire transect checked for this type of error.

[2] The morphology of one coral was mis-identified – entire transect was checked for coral morphology errors.

[3] A couple of points on a DeF coral were scored as DeE – mis-click error – no need to redo transect.

[4] Two points on a DeF coral were scored incorrectly because of a growth anomaly. No need to redo transect.