# Norfolk Island Lagoonal Reef

# Ecosystem Health Assessment

# 2020-2021

**CONTENTS**

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## Executive Synopsis

The Temperate East Marine Park Network, managed by Parks Australia, incorporates the coral reefs and coral reef lagoons of Norfolk Island. The most accessible reef within the Norfolk Island coral reef ecosystem includes the Emily Bay and Slaughter Bay lagoonal reef, and neighbouring Cemetery Bay lagoonal reef, both of which adjoin the Kingston lowland catchment and world heritage listed Kingston and Arthur's Vale historic sites.

During 2020 unusually high sea surface temperatures extended across the Southern Hemisphere, including the Great Barrier Reef, the Coral Sea and the reef habitats of Norfolk Island. This event resulted in extensive coral bleaching within the lagoonal reefs of Norfolk Island including Emily Bay and Slaughter Bay. The 2020 bleaching event is the first record within the Norfolk Island coral reef ecosystem, however bleaching events have also likely occurred within the bay during previous anomalously high temperature conditions, including 2005, 2011 and 2017, based on satellite derived past sea-surface conditions. Additional impacts to the reef ecosystem in 2020 following the bleaching event included disturbance caused by Cyclone Gretel in March and significant rain events through winter and autumn resulting in flooding, sedimentation and nutrient input into the inshore lagoon. Coral bleaching within the lagoonal reef was extensive and corals remained bleached through the subsequent winter, which was followed by inshore pollution events and declining water quality. Nutrient concentrations within both Emily and Slaughter Bay, associated with periods of high rainfall and land-based runoff, exceeded the Australian and New Zealand Environment and Conservation Council recommendations. Coincident with this event was an increase in fleshy algal cover within Emily and Slaughter Bay. In April 2021 algal populations, specifically fleshy macroalgae, dominate the benthic cover in Emily and Slaughter Bay, whereas neighbouring Cemetery Bay, which is a coral dominated benthic system, maintained nutrient concentrations similar to those of the northern open ocean beaches of Norfolk Island and low macroalgal cover. From December 2021 a coral disease outbreak also occurred in Emily and Slaughter Bay, providing further evidence for declines in reef health within the inshore bays during 2020-21 period. Coral diseases were not observed on the inshore reef of neighbouring Cemetery Bay in April 2021. Disturbance events and associated reef responses reported here, namely high sea surface temperatures, coral bleaching, land-based pollution, increased coral mortality and coral disease outbreaks, are known to be associated with declining coral reef health and phase-shifts from coral to algal dominated coral reef systems. Taken together these provide evidence of declines in coral health within the lagoonal inshore coral reef ecosystem of Emily and Slaughter Bay.

Ongoing investigation and monitoring of the inshore coral reef lagoon of Emily and Slaughter Bay is recommended to support management decision making and determine if management interventions are improving the resilience of the Norfolk Island coral reef ecosystem. Given the increased abundance of large fleshy algae seen over the study period, and as these are generally more unpalatable to herbivores, it is recommended that on-going monitoring continues to examine the benthic community structure to ensure that the changes in algal abundance do not indicate the continuation of a phase shift away from a coral dominated reef. It is also suggested that active coral restoration efforts are examined to improve the resilience of the Emily and Slaughter Bay inshore lagoonal coral reef ecosystem given they are of substantial socio-economic value to the local communities and stakeholders. It is recommended that further study of coral recruitment is undertaken to determine recruitment rates and possible larval sources of supply for corals, and fish communities on Norfolk. Other management considerations for the Emily, Slaughter and Cemetery Bay coral reef ecosystem include highlighting reef areas of potential high conservation value, cultural value, areas for targeted rehabilitation and visitor educational opportunities for the reef ecosystem.

## *Executive Summary*


**Background.** The coral reefs and coral reef lagoons of Norfolk Island are within the Temperate East Marine Park Network managed by Parks Australia. The island has a 200-year history of settlement within the Kingston Lowlands wetland adjacent to the coral reef lagoon of Emily Bay, Slaughter Bay and Cemetery Bay of Norfolk Island. The catchment has been modified over time diverting the water course and altering the wetland structure. Reports of declining coral reef health are evident from 1998 with land-based sources linked to potential declines in reef health and diversity. Declines in coral reef health, coral cover and coral diversity in other coral reefs link management considerations for the inshore coral reef lagoons to divers of decline that include sedimentation, poor water quality, pollution from land-based sources, fresh-water influx, and increased sea surface temperatures.

- Norfolk Island is a sub-tropical system with coral reefs and coral reef lagoons that host a diverse range of tropical hard corals and other reef species. The most easily accessible coral reefs are located at Emily and Slaughter Bay lagoon on the southern side of the island. These coral reefs are impacted by a variety of anthropogenic influences, including global scale issues, such as climate change leading to coral bleaching, and local scale issues such as freshwater runoff and nutrient inputs.

- Following predictions of coral bleaching across the Great Barrier Reef, Coral Sea and temperate east marine networks, for February 2020, caused by elevated water temperatures, Parks Australia commissioned a survey of coral health of Emily and Slaughter Bay in Late February/early March with subsequent surveys conducted in June, September, December 2020 and April 2021. These surveys covered a period when the reef was also impacted by a tropical cyclone and high rainfall events leading to increases in bacteria and nutrients entering the bays.

***Section 1. Drivers of reef health including lagoonal water quality and ocean temperature 2020-2021.***

Emily and Slaughter Bay were impacted by a number of environmental impacts that resulted in declining coral health. In summer 2020 seawater temperatures exceeded the local coral bleaching threshold in February and March, resulting in significant coral bleaching. Coral mortality was not evident associated with the bleaching event at the time of survey in March, however bleaching remained evident from the video survey taken in June 2020, while there was no evidence for recent coral bleaching associated mortality found during June, August and November surveys. The bleaching event was followed in winter 2020 with high rainfall events (>30 mm in

one day) recorded in May, July, August, September and November, leading to increases in inorganic nitrogen (ammonium and nitrate/nitrite) while *Enterococcus* counts and thermotolerant bacterial counts were also recorded in the bays during this time. Ammonium concentrations in September, November and December samples were between 5 and 14 times above the Australian and New Zealand Environment and Conservation Council water quality guidelines, while nitrate/nitrite levels were up to 2 times higher. Due to travel restrictions associated with Covid-19 video transects of the bays were performed from a boat (GP Services) in June and September with a subsequent in water benthic survey and water quality assessment conducted in November/December 2020.

***Section 2. Lagoonal coral reef condition Emily Bay, Slaughter Bay and Cemetery Bay 2020-2021***

Monitoring of benthic community structure in Slaughter and Emily Bay was conducted from March 2020 until April 2021. In both bays coral cover was approximately 30% over the survey periods and did not significantly alter. The dominate coral growth forms were branching coral and encrusting corals. Algal cover during the survey period was approximately 60%, which indicated that this reef would be categorised as algal dominated. In comparison, the nearby Cemetery Bay, has coral cover of 50.8% and algal cover of only 36.5%. During the survey period the dominant type of algae changed, from green turfing alga in March 2020, to fleshy algal dominated by April 2021, these changes are consistent with a reef subjected to increased nutrient input into the system. Generally, fleshy algae are less susceptible to herbivory and can compete more effectively with corals, as such increases in their abundance can lead to further decreased coral health.

***Section 3a. Coral bleaching event March 2020 Emily Bay and Slaughter Bay Norfolk Island.***

The majority of coral species, representing multiple coral growth forms, within Emily and Slaughter Bays were impacted by bleaching in 2020. The lowest bleaching prevalence was recorded in branching corals (16% of individuals bleached); in contrast, 56% of mounding coral colonies experienced bleaching. As such, bleaching susceptibility was found to be highest in mounding and encrusting species. Indicators such as coral cover and algal cover suggest reef condition is in a degrading state. In March 2020 live hard-coral cover was approximately 30%, and there was evidence of coral skeletons, recently dead coral, and coral overgrown with algae across the reef. In 1988 coral cover ranged between 14% on the intertidal platform to 64% at mid-lagoonal Bommies (Veron 1997), at that time there was no evidence of dead or algal overgrown corals in the bays, but Veron noted declining coral health and species loses, attributed to poor water quality and land-based pollution. During the March survey period there was no evidence of significant freshwater inflow into the lagoonal waters at the time of survey as the island.

***Section 3c. Lagoon-wide coral disease outbreak.*** We report evidence for increased signs of poor coral health and report on the first recording, although probably not the first instance, of a coral disease outbreak at Norfolk Island, putatively identified as Atrementous Necrosis. The disease impacted over 50% of plating and encrusting *Montipora* colonies in the lagoon. Atrementous Necrosis has previously been identified on the central GBR and is corelated to run-off events and resultant low salinity, high nutrients and sedimentation, where it caused high mortality in *Montipora spp.* during the summer with a maximum recorded prevalence of 75%. Further monitoring of coral health and disease are critical to understand the impacts of this disease outbreak on the reefs of Norfolk Island. As such we recommend ongoing monitoring of prevalence, tissue loss and colony fate of disease on the reefs of Norfolk Island.

***Section 4. Recommendation summary.***

***Reducing pressure on the reef*:** It is recommended that Marine Park Managers continue to engage with local Norfolk Island community and relevant land managers to examine ways in which nutrient/pollution inputs into the bays can be reduced or eliminated to improve water quality and subsequently coral health. Further study of groundwater inputs into the bay are also necessary to clarify sources and routes of inputs. In addition, given that negative impacts often have synergistic effects, reef mangers should consider the extent of already existing pressures on the Emily and Slaughter Bay reefs when assessing the impact of future activities/undertakings (e.g., dredging, capital works) that would negatively impact the local marine environment.

***Further research and monitoring:*** Monitoring of water quality, nutrient enrichment, coral bleaching, coral disease, and algal cover are needed to determine long-term patterns of reef ecosystem state. We recommend initiating an annual reef health report card system to communicate with stakeholders the on-going health of the reef and environs. Ongoing assessment and monitoring of drivers of coral reef decline are needed within the Kingston lowland inshore lagoonal reef ecosystem including Slaughter Bay, Emily Bay and neighbouring Cemetery Bay to determine the effectiveness of management interventions. We also recommend extending the reef health assessment to other reefs of Norfolk Island including the islets and other bays to determine if changing reef structure, algal growth, poor water quality and indicators of poor coral health are evident in neighbouring reefs. We also propose assessing the efficacy of active management intervention such as targeted algae removal and coral re-introduction for rehabilitation of algae colonised regions of the lagoonal reef.

***Tourism opportunities:*** There are several tourism related initiatives that could be undertaken to increase the eco-tourism potential of the bays. Included below is a detailed benthic structure assessment for use with possible education snorkel trails, proposed coral health educational card and establishment of citizen science records.

- Areas with noteworthy coral diversity or unknown taxonomy are also highlighted for future investigation.
- Proposed snorkel trails (dotted lines) provide potential paths for both advanced and beginner swimmers and seek to take advantage of existing healthy areas of the reef
- Proposed Coral Preservation Areas, that are highlighted to members of the public and could be rezoned differently for areas of Emily Bay and Slaughter Bay (yellow, green)
- Cemetery Bay (pink and red) have extensive coral cover and may require specific site management.

- Map of suggested areas for scientific investigation of site rehabilitation in Slaughter and Emily Bay. Areas outlined for algae removal (green) and coral re-introduction following algal removal efforts. Illustrative snorkel trail locations based on assessment on reef structure and management goals
- Icons display noteworthy coral to be viewed along the trail and corals of cultural and/or ecological significance
- The possibility of tourism opportunities around coral spawning should also be examined
- Possible citizen science project based around active management intervention such as targeted algae removal and coral re-introduction for rehabilitation of algae colonised regions of the lagoonal reef.




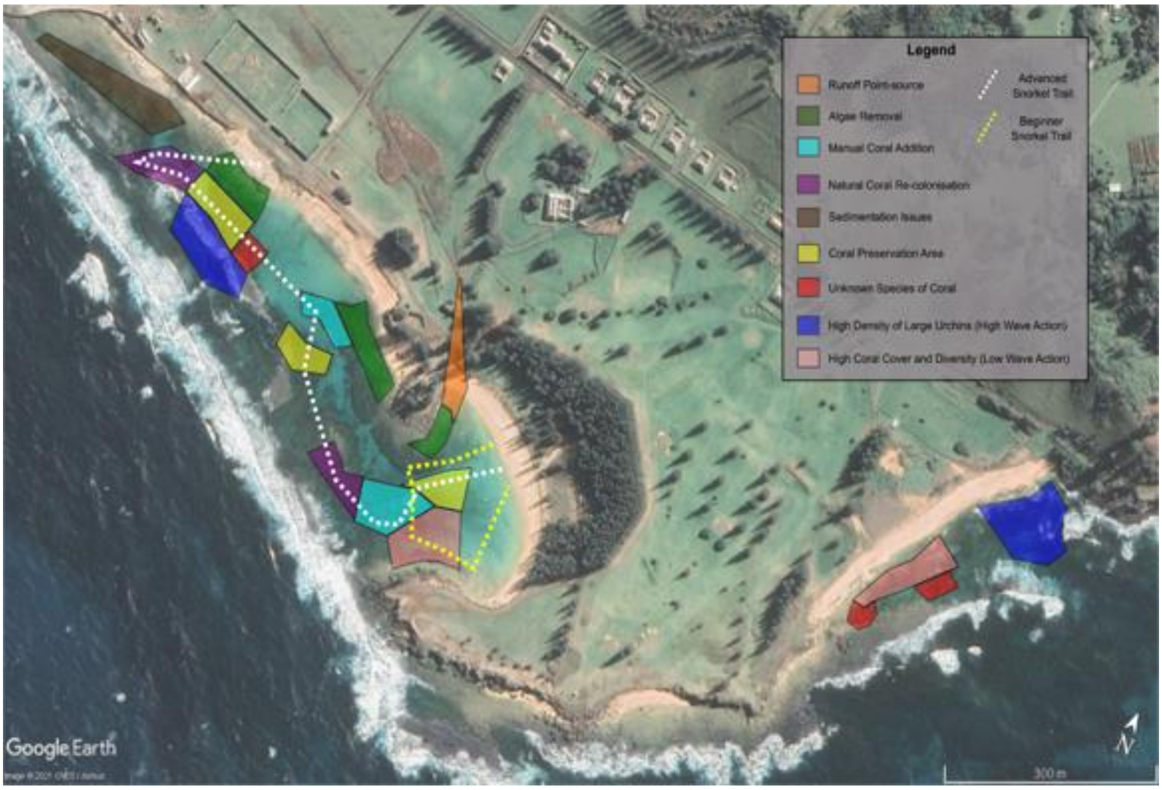

*Figure 1. Proposed Emily Bay, Slaughter Bay and Cemetery Bay Site Orientation Summary*

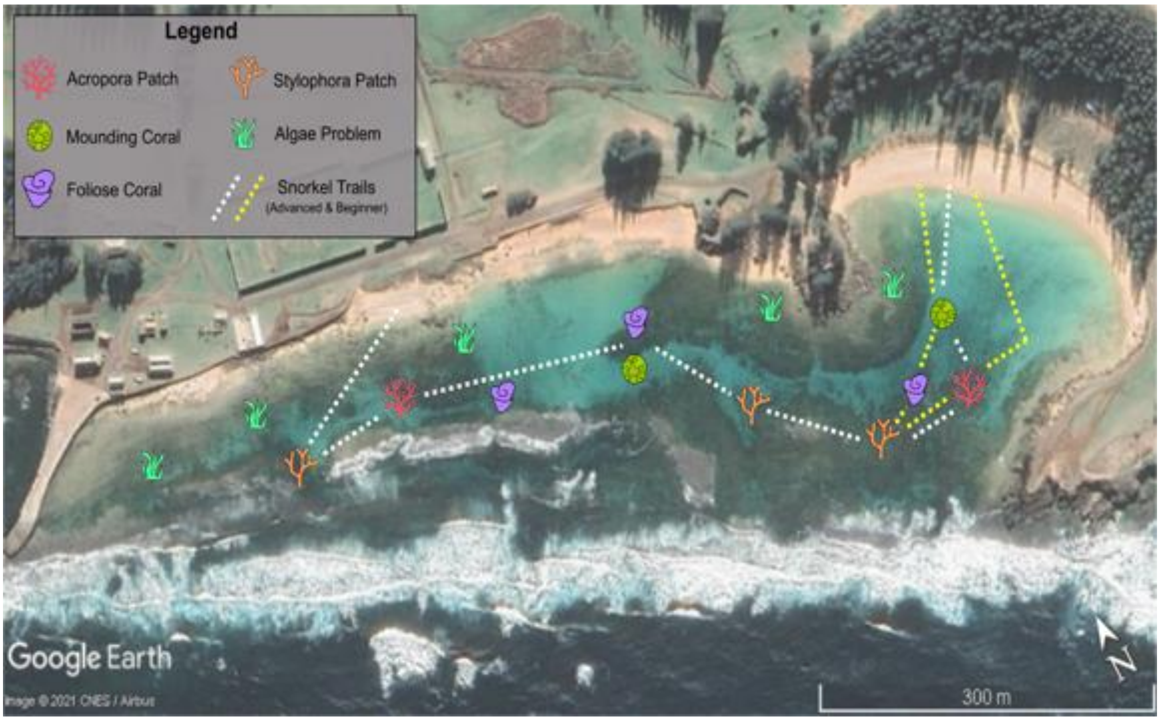

*Figure 2. Proposed educational coral reef snorkel trail locations*

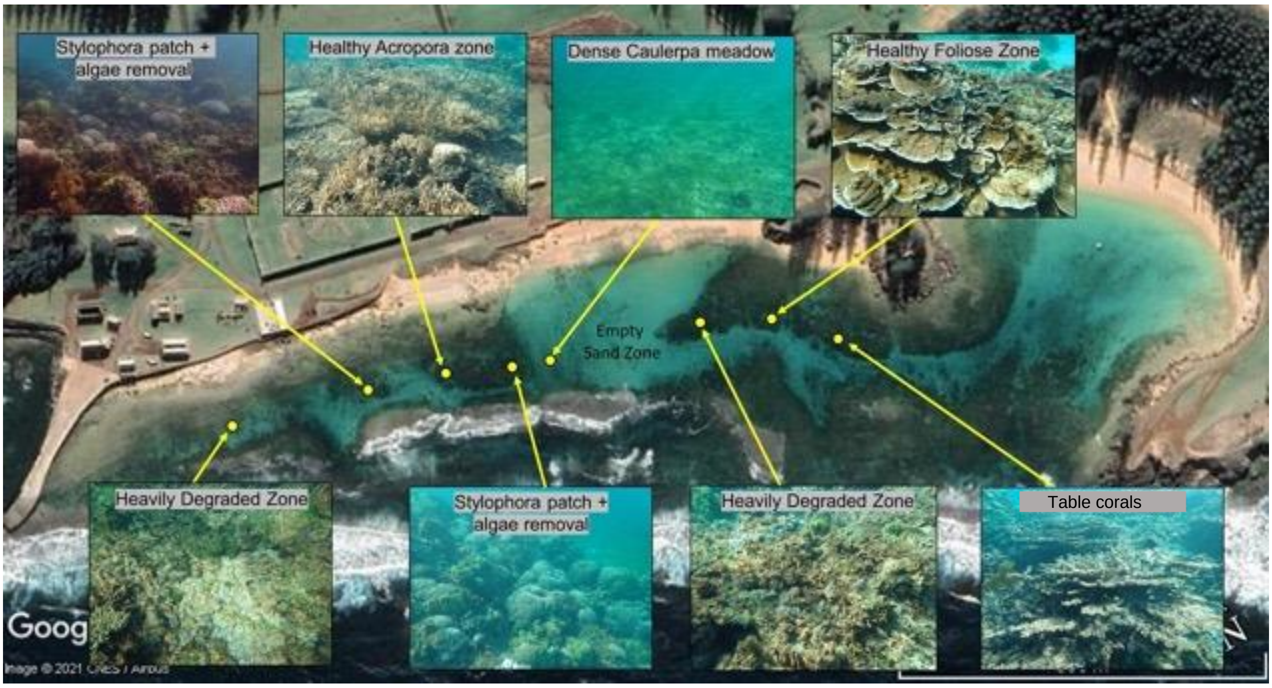


**Figure 3. Slaughter Bay points of interest.**

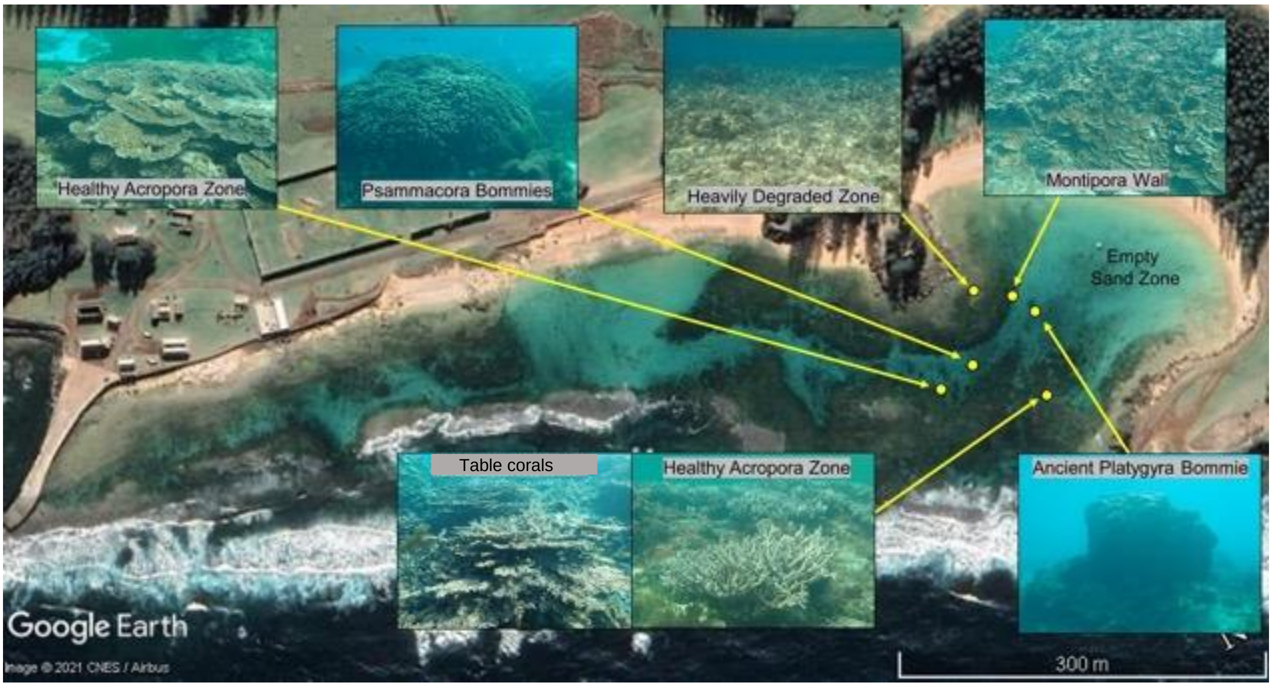


**Figure 4. Emily Bay points of interest.**

## *Section 1. Norfolk Island lagoonal nutrient concentrations, temperatures and site conditions 2020-2021.*

Site conditions within Emily Bay and Slaughter Bay were assessed with a variety of biophysical measurements. Water quality was assessed by measuring seawater nutrient concentrations and overall organic matter loads within reef sediments, ocean temperatures were assessed with satellite sea surface monitoring (National Oceanographic and Atmospheric Administration (NOAA) and in situ logger deployment, additionally salinity, tidal range, water flow speed and direction, were assessed. *Methodology is provided in section 6*.

### Emily Bay and Slaughter Bay inshore water quality 2020-2021.

***Summary findings.*** Concentrations of dissolved inorganic nitrogen (DIN) in the Norfolk lagoon are above ANZECC trigger values for coastal and marine waters from June 2020 to April 2021. The ANZECC guidelines trigger values are designed to assist management agencies to determine if coastal and marine waters are "fit" to support environmental values. ANZECC recommend that when these values are exceeded specific investigations are performed to determine the cause of elevated values and then further develop, and possible adapt, the guidelines to suit the local area. In comparison seawater outside of the lagoonal catchment from the north side of the island was found to be below guidelines in April 2021 (the sole period they were examined). As such inshore lagoonal waters are consistent with other near shore reef areas impacted by land-based runoff. Nutrient concentrations were highest following rain events but were also elevated in Slaughter Bay during dry periods (this suggests that contaminated ground water infiltrates into the lagoon outside of rain events).

According to ANZECC guidelines the Norfolk lagoonal reefs of Emily and Slaughter Bay would be classified as disturbed during April 2021 (Figure 1-1) and during the period of September 2020 to December 2021 (Figure 1-2).

- In comparison, in seawater samples from open water areas of north Norfolk Island $NO_x$ and $NH_4^+$ were undetectable (< 0 µg $L^{-1}$ ) (Figure 1-1).

- Nutrient concentrations for the inshore lagoonal water of Cemetery Bay were also found to be below guidelines in April 2021 (Figure 1-1).

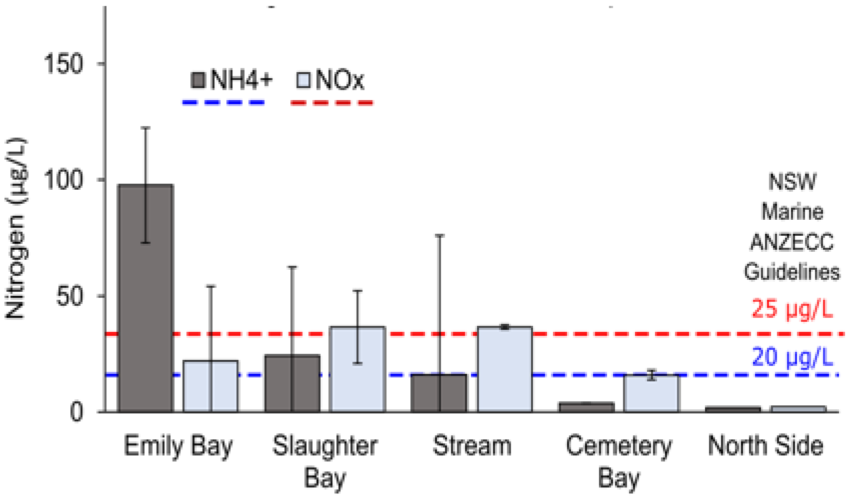


**Figure 1-1. Concentrations of dissolved inorganic nitrogen (nitrate + nitrite [$NO_x$] and ammonium [$NH_4^+$]) In April 2021. Dashed red line indicates ANZECC trigger values.**

The highest concentrations of dissolved inorganic nitrogen are evident in the lagoonal waters of Emily and Slaughter Bay following higher than average rainfall in autumn 2020. Specifically, we find September, November and December 2020 concentrations were consistently higher than that of March 2020 and March 2021 (Figure 1-2).

Conditions in March of 2020 can be classified as oligotrophic, exhibiting relatively low concentrations of DIN in line with other coral reef ecosystems (Table 1-1) and following rainfall events the system is consistent with transitioning to a eutrophic state (Table 1-1). Between the periods of December 2020 to March of 2021, rainfall was relatively low and nutrient sampling in late March and early April along Emily and Slaughter Bay indicated a general decrease in levels of both $NO_x$ and $NH_4^+$ relative peak values in September of 2020, however, were still higher than those initially measured a year prior in March 2020, especially for $NH_4^+$. Average $NO_x$ and $NH_4^+$ concentrations were higher than trigger values set by the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC; Table 1-1).

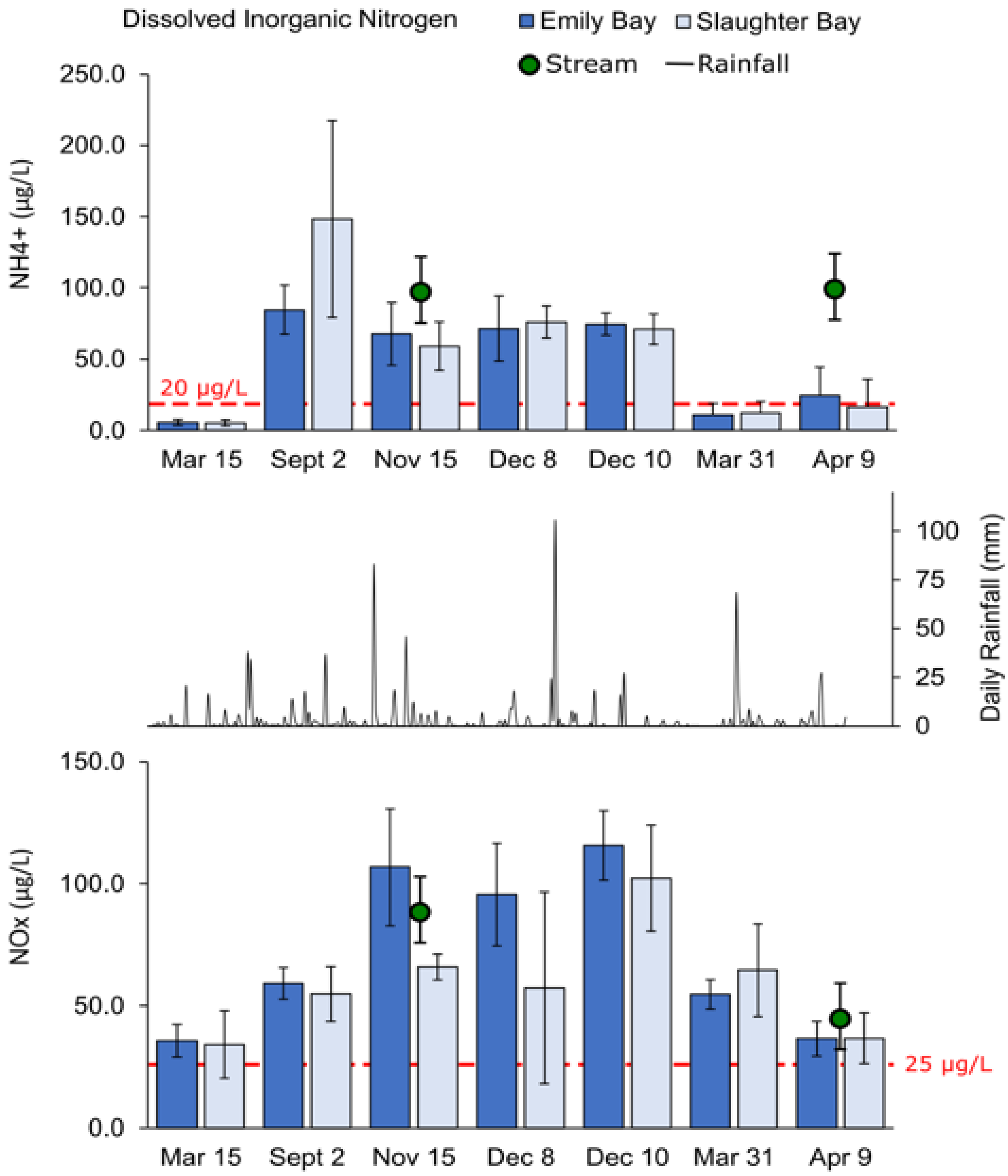


**Figure 1-2. Concentrations of dissolved inorganic nitrogen (nitrate + nitrite [$NO_x$] and ammonium [$NH_4^+$]) at Emily Bay, Slaughter Bay, Cemetery Bay, the stream behind Kingston. Dashed red line indicates ANZECC trigger values.**

**Table 1-1: ANZECC Guidelines Table indicating trigger values for Ammonium ($NH_4^+$) and Nitrate + Nitrite ($NO_x$) based on ecosystem type and state.**

| **Nitrogen** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Ecosystem type** | NZ | VIC | NSW | ACT | TAS | QLD south east | QLD tropical |
| **Estuaries and lakes** | | 13 | 10 | | 10 | | 395 |
| **Marine** | | 3 | 25 | | 3 | | 4 |
| **Rivers** | 167-444 | | | | 190 | 20 | 30 |
| **Ammonium** | | | | | | | |
| **Ecosystem type** | NZ | VIC | NSW | ACT | TAS | QLD south east | QLD tropical |
| **Estuaries and lakes** | | 8 | 20 | | | 19 | 17 |
| **Marine** | | 11 | 20 | | | 4 | 15 |
| **Rivers** | 10-21 | | 40 | | 13 | 6 | 6 |

**Table 1-2: Mean coliform (cfu/100 ml) (data: Norfolk Island Regional council) and nutrient (µg L$^{-1}$) data averaged across all sites within Emily Bay (EB), Slaughter Bay (SB), and Cemetery Bay (CB) for each time point (date) and location (lagoon or shoreline). Rainfall data represents the 7-day and 30-day accumulation of rainfall (mm) prior to the sampling time point.**

| Date | Site | Coliform (cfu/100ml) | 7-day Rainfall mm | 30-day Rainfall mm | Nutrients NH4 ug/L | NOx ug/L | Above Limits ANZECC Guidelines |
|---|---|---|---|---|---|---|---|
| March 15, 2020 | SB Shore | NA | 74 | 114 | 5.4 | 34.1 | No |
| | EB Shore | | | | 5.7 | 35.8 | No |
| September 2 | SB Lagoon | <1 | 16 | 118 | 148.2 | 54.9 | Yes |
| | EB Lagoon | 400 | | | 84.6 | 59.1 | Yes |
| November 15 | SB Shore | 150 | 12 | 161 | 59.1 | 65.9 | Yes |
| | EB Shore | 475 | | | 67.7 | 106.9 | Yes |
| December 8 | SB Shore | NA | 0 | 40 | 76.2 | 57.3 | Yes |
| | EB Shore | | | | 68.4 | 90.8 | Yes |
| | EB Lagoon | | | | 74.6 | 100.4 | Yes |
| | CB Shore | | | | 66.5 | 32.9 | Yes |
| December 10 | SB Shore | NA | 22 | 62 | 73.4 | 105.6 | Yes |
| | SB Lagoon | | | | 68.9 | 99.1 | Yes |
| | EB Shore | | | | 74.4 | 115.2 | Yes |
| | EB Lagoon | | | | 74.8 | 116.3 | Yes |
| April 1 2021 | SB Shore | NA | 37 | 54 | 16.9 | 36.6 | No |
| | EB Shore | | | | 24.4 | 36.7 | Yes |
| | CB Shore | | | | 3.7 | 16.0 | No |
| | Stream | | | | 97.7 | 22.1 | No |
| | North Side | | | | 1.8 | <0.01 | No |

In comparison, in coastal lagoons on the Great Barrier Reef $NO_x$ and $NH_4^+$ concentrations of < 5-10 µg L$^{-1}$ are generally reported. These levels for an oligotrophic coral reef lagoonal ecosystem are almost order of magnitude lower than the values measured from September to December in the Emily Bay coral reef lagoonal waters (~ 75 µg L$^{-1}$). Other reef ecosystems associated with GBR Islands outer lagoonal reefs, and reef associated waterways nutrient concentrations are lower than that recorded from 2020-2021 in Norfolk Island lagoonal waters (Table 1-3). Above average accumulation of rainfall for 2020 on Norfolk Island is likely contributing to eutrophication in Emily and Slaughter Bay as evident from Autumn 2020. Multiple sources of nutrient delivery into the lagoon seawater, including both ground water or point source locations, are the likely drivers of the comparatively high concentrations evident in both Emily and Slaughter Bay within the current study in both periods of high and low rainfall. For example, relatively high concentrations of dissolved inorganic nitrogen were observed on Dec 8$^{th}$ in Cemetery Bay (above ANZECC trigger values) despite no apparent point-source runoff location. Similarly, nutrients have been highest at some time points in the middle of Slaughter Bay, farther from the point source runoff location at Emily Bay. Together, these observations suggest that there may be multiple sources of dissolved inorganic nitrogen to the reef. Low concentrations in April 2021 of the north side of the island shows surrounding ocean waters are extremely nutrient poor (undetectable), further supporting the conclusion that nutrient source to the lagoonal waters as terrestrial.

**Table 1-3: Dissolved inorganic nitrogen concentrations measured within oligotrophic and eutrophic coral reef lagoons worldwide. Oligotrophic conditions are in white and eutrophic conditions are highlighted in green. Values noted are the concentration of nitrate + nitrite ($NO_x$; µM) and ammonium ($NH_4^+$; µM).**

| Location | Study | $NO_x$ (µM) | $NH_4^+$ (µM) |
|---|---|---|---|
| **Norfolk Island (March 2020)** | **Current study** | **0.30** | **0.41** |
| **Norfolk Island (December 2020)** | **Current Study** | **4.02** | **4.70** |
| One-Tree Island, GBR | Koop et al., 2001 | 2.94 | 0.65 |
| Waimanalo, Hawaii | Atkinson, 2011 | 1.12 | 0.56 |
| Outer Lagoon, GBR | Bell, 1992 | 0.05 | 0.10 |
| Lizard Island, GBR | Bell, 1992 | 0.22 | 0.99 |
| Coastal Lagoon, GBR | Bell, 1992 | 25.00 | 30.00 |
| Kaneohe Bay, Hawaii | Atkinson, 2011 | 20.00 | 12.00 |
| Rio Bueno, Jamaica | Mallela & Perry, 2007 | 36.61 | 61.11 |

## Coral Lagoon and Ocean Temperature (SST) Conditions.

***Summary of findings.*** Conditions likely to cause bleaching were evident in the Norfolk Island reef region from late January 2020, when heat stress (measured by Degree Heating Week, DHW) began to accumulate. Heat stress accumulation in the Norfolk region was consistent with severe coral bleaching and extensive coral mortality. The accumulation of heat stress was mitigated by TC Gretel in April 2020. This is the first formal record of coral bleaching for Norfolk Island coral reefs. Both this analysis and historic satellite derived sea surface data suggest bleaching has also occurred in 2016 and 2011 on the Norfolk Island coral reef.

In the period of January–May 2020 the region accumulated DHW of 9.36°C-weeks (Figure 1-3). DHWs accumulated until a tropical cyclone impacted the region on March 16th, rapidly cooling surface waters. Significant coral bleaching is typically associated with DHW of 4°C-weeks, which the region reached on February 17th, whilst DHW of 8°C-weeks (reached on March 9th) is associated with severe bleaching and significant mortality. Tropical Cyclone Gretel affected the region on March 16th, rapidly reducing SST and therefore heat stress. For comparison, SST in 2019 had a summer average around 2°C lower than in 2020. As a result, the heat stress accumulation was 1.1°C-weeks in 2019, beginning February 12th, 2019 and with only a brief additional accumulation in late-April (Figure 1-3).

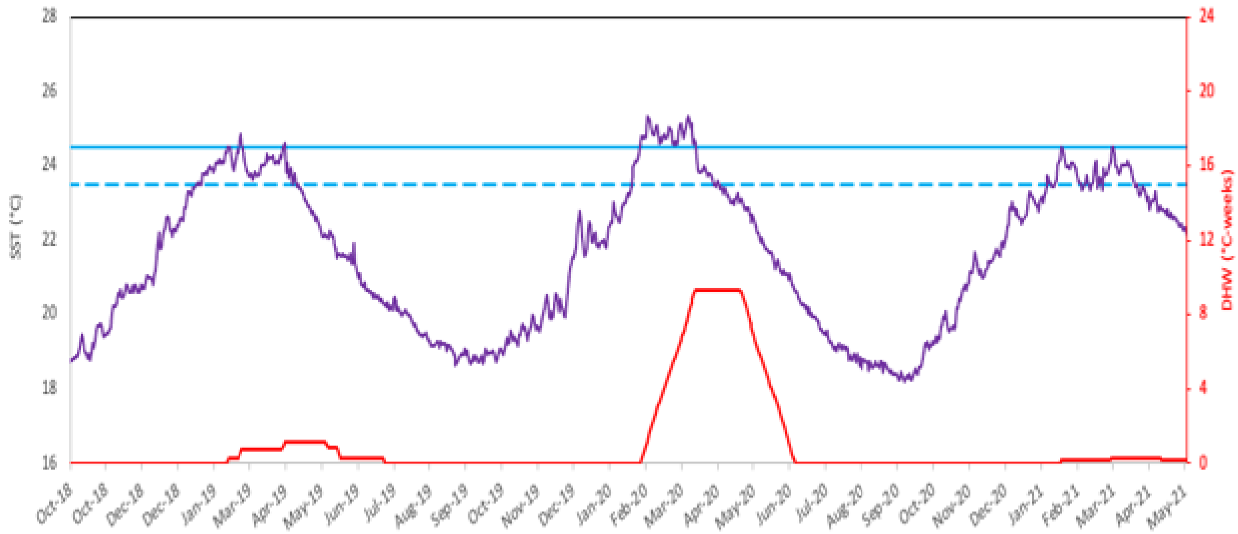


**Figure 1-3. Sea surface temperature (purple line) and Degree Heating Week accumulation (red line, DHW) for Emily Bay Norfolk Island from October 2018 to April 2021. The bleaching threshold (blue line) is 1°C above the summertime climatology (blue dashed; maximum of the monthly mean climatologies, MMM).**

At the time of this report there are no other known scientific studies documenting bleaching occurrence within the Emily and Slaughter Bay lagoonal reef systems, or Norfolk Island's other reefs systems. However, coral bleaching has been recorded on reefs of neighbouring islands including Lord Howe Island, 885 km south-west of Norfolk Island, (bleaching recorded in 1998, 2009, 2010, 2019) and the Barrier reef of New Caledonia, located 724 km north of Norfolk Island. Millar (2000) and Rotschi and Lemasson (1967) refer to oceanographic connectivity between the Coral Sea and Norfolk Island ocean waters, with Norfolk Island influenced by the East Australia Current/Tasman Front from the Coral Sea. The co-occurrence of bleaching on the Great Barrier Reef and Norfolk Island in 2020 suggests bleaching events may have occurred in previous years. Analysis of historic satellite derived sea surface temperature, in the context of the 2020 thermal anomaly that resulted in bleaching on Southern Norfolk Island's lagoonal reefs, indicates that bleaching conditions were likely to have occurred on the reef in 2004 where the reef experienced heat stress of 12°C-weeks. SST that exceeded the local bleaching threshold (Figure 1-4 solid blue line) also occurred in 2011 and 2016. We also note that the mass bleaching events of 2016 and 2017 on the northern and central Great Barrier Reef did not appear to coincide with a similar accumulation of heat stress on Norfolk Island. In 2016 the accumulation of 7°C-weeks was abruptly halted on February 25th when SST cooled to more than 1°C below the summertime peak as Tropical Cyclone (TC) Winston passed 200 km north of Norfolk Island, which experienced Category 1 winds. In 2016, TC Winston travelled westward from Fiji to the Southern Great Barrier Reef where wind and cloud conditions also mitigated bleaching conditions on the southern reef from late February 2016.

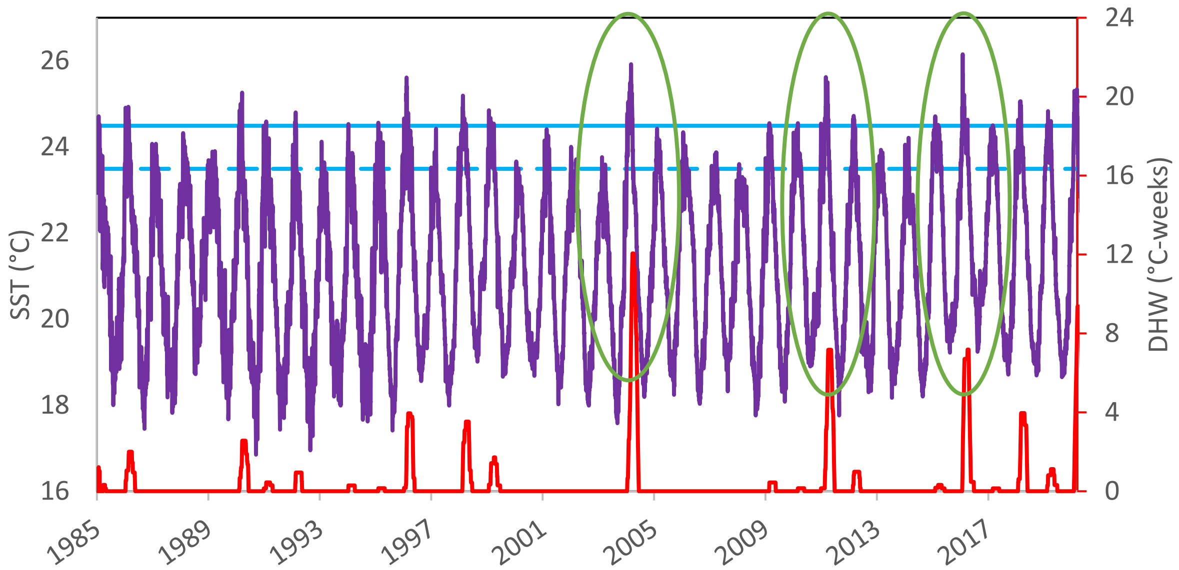


**Figure 1-4. Satellite derived sea surface temperature records for Emily Bay Norfolk Island from 1985 to 2020.** ****Satellite data prior to December 2002 have a greater degree of uncertainty than recent years.***

**Norfolk Island as a Regional Virtual Station (RVS)**

An important management output provided within this project was the addition of Norfolk Island as a Regional Virtual Station (RVS) in the suite of monitoring products supplied by the Coral Reef Watch (CRW) program of the U.S. National Oceanic and Atmospheric Administration (NOAA). The RVS system was first described in Heron et al. (2016). The Norfolk Island station is now available via: https://coralreefwatch.noaa.gov/product/vs/gauges/norfolk_island.php

The virtual stations provide managers and other stakeholders with regional assessments of current and potential heat stress levels based on satellite data and climate model output (at 5 km and 50 km resolution, respectively). This information is delivered as spatial maps and quick-reference gauges; historical information is also available for these products and also as a time-series of the satellite-derived data. Maps of the metrics that underpin and complement the heat stress levels are also available (e.g., Sea Surface Temperature, SST; HotSpot; Degree Heating Week, DHW).

For example, conditions at Norfolk Island on 21st February 2020 indicated that heat stress was present at Alert Level 1 (red, top left map and top gauge, see Figure 1-5), typically associated with significant coral bleaching. Future predictions at that time suggested that heat stress would continue to accumulate to Alert Level 2 (severe bleaching likely) around Norfolk Island during the subsequent 1-4 weeks (and potentially also the four-week period following that) but were predicted to subside by a lead-time of 9-12 weeks. The time series (Figure 1-5, 1-6) of regionally summarised, satellite-based metrics confirms that the predicted heat stress level (Alert 2; dark red shading) was realised, with peak heat stress occurring in mid-March. The time series graph displays several regionally-summarised elements including the SST (purple solid), expected temperatures through the year (monthly mean climatologies, blue +), the SST threshold for heat stress (horizontal blue solid), accumulated heat stress (DHW, red solid) and the associated heat stress level (yellow to dark red shading). Following the heat stress of early 2020, the graph shows that SST had dropped to historically expected (i.e., climatological) values from mid-May. Time series graphs span two years allowing comparisons between years, beginning in 1985.

The details of how the regional summaries are derived are available via the website.
https://coralreefwatch.noaa.gov/product/vs/gauges/norfolk_island.php

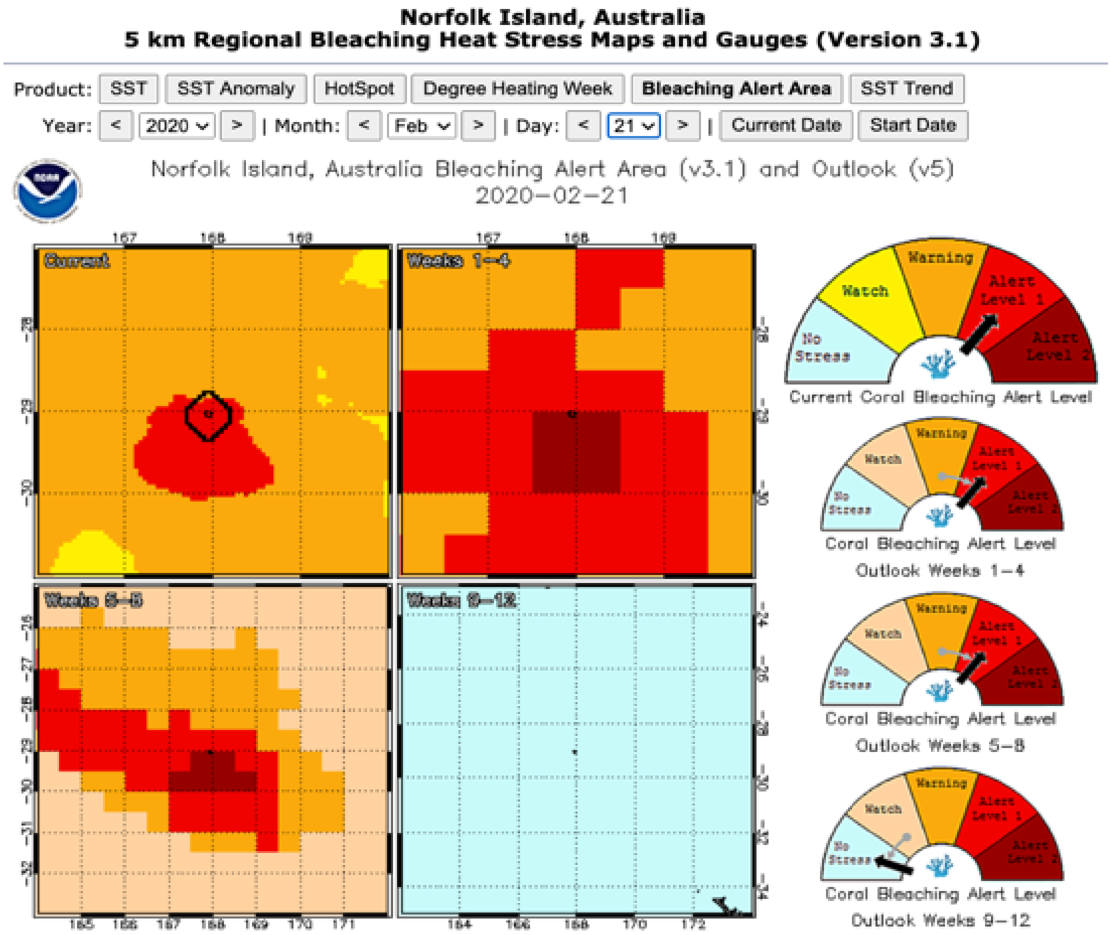


**Figure 1-5. Norfolk Island heat stress monitoring by the NOAA Coral Reef Watch 'Regional Virtual Station'. Maps of satellite-based current heat stress level and model-based predictions (left) are complemented by regional-summary gauges (right), with colours representing the different levels. Satellite-based metrics are available from January 1985, with model-based predictions from November 2017.**

A key aspect of the RVS system for use in management is that the information is also disseminated via an automated email alert system, for which subscription is free. Emails are sent to subscribers whenever a *change* in the satellite-based alert level occurs (e.g., from Watch to Warning) at the specific global reef locations for which they are registered (now over 200 locations worldwide). Subscription to the automated email alerts is via the CRW website, https://coralreefwatch.noaa.gov/subscriptions/vs.php. The addition of the Norfolk Island RVS was made possible through collaboration with NOAA Coral Reef Watch.

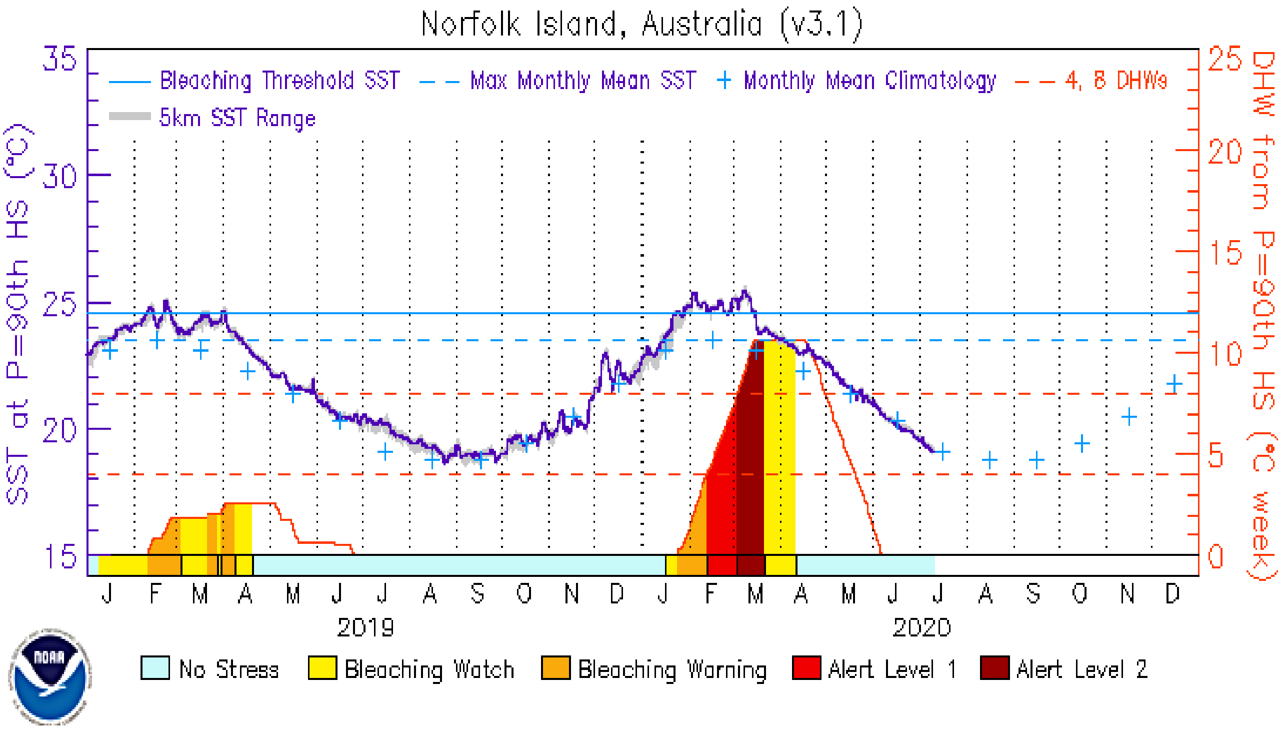


**Figure 1-6. Time series of regionally-summarised, satellite-based metrics for Norfolk Island for 2019-2020. Elements including the SST (purple solid), expected temperatures through the year (monthly mean climatologies, blue +), the SST threshold for heat stress (horizontal blue solid), accumulated heat stress (DHW, red solid) and the associated heat stress level (yellow to dark red shading). Graphs spanning two years are available from 1985.**

Bluetooth Temperature loggers (Hobo, Massachusetts) were also deployed at 6 sites across the Emily and Slaughter Bay lagoonal reef between March 6th 2020 and April 23rd 2020 to determine *in situ* thermal variability during the survey period (see Figure 1-7). In situ temperatures allow for determination of the maximum temperature exposure during bleaching conditions and the spatio-temporal variability within the study site. Thermal variance is an important driver of bleaching severity and the capacity of corals to withstand bleaching conditions and recover from bleaching events[3,4]. One degree above the maximum monthly mean (MMM) indicates the temperature at which degree heating weeks accumulate for bleaching alerts on coral reef systems. Temperatures remained at approximately the Emily Bay MMM+1 of 25.5 °C at all sites throughout March and April 2020, with temperatures remaining slightly higher at inshore sites (6, 7 and 10), reflecting less water mixing, when compared to that of sites 1, 3 and 4, closer to offshore wave action. We find that mean water temperature in Emily Bay varied from 23.8 °C to 25.7 °C, and in Slaughter Bay from 23.9 °C to 25.7 °C (see Table 1-4 for min/max recorded temperatures) within a daily cycle. Given bleaching had begun prior to the survey period the influence of daily and tidally driven thermal variance in bleaching responses requires further investigation.

**Table 1-4. Minimum, maximum, and mean temperatures (°C) recorded during the period of March 7th – Apr 23rd at six of the recovered logger sites.**

| Location | Site | mean (°C) | min (°C) | max (°C) |
|---|---|---|---|---|
| Slaughter Bay | 01 | 23.9 | 22.5 | 25.7 |
| Slaughter Bay | 03 | 23.8 | 22.3 | 25.5 |
| Slaughter Bay | 04 | 23.9 | 22.5 | 25.5 |
| Emily Bay | 06 | 23.7 | 21.6 | 25.7 |
| Emily Bay | 07 | 23.8 | 22.0 | 25.4 |
| Emily Bay | 10 | 23.8 | 22.4 | 25.6 |


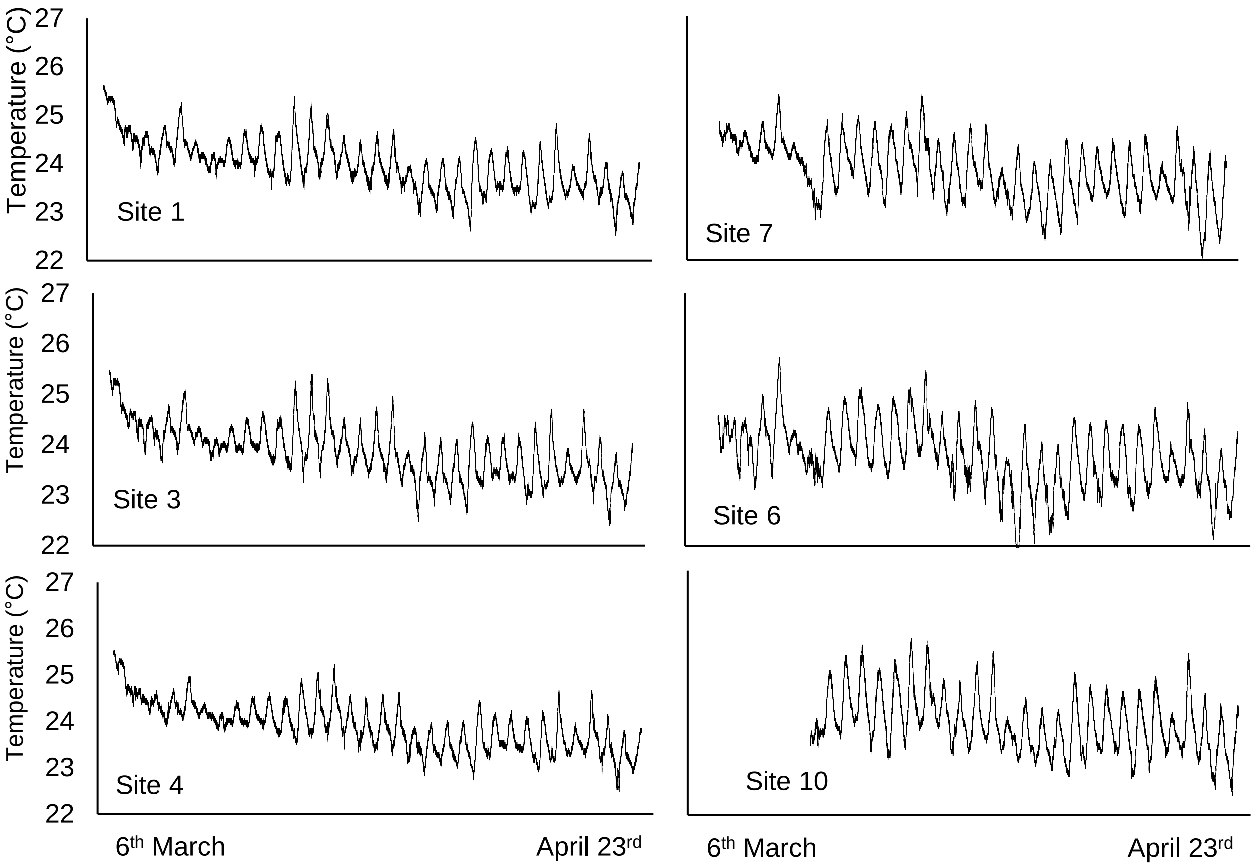


**Figure 1-7. In situ water temperature at 6 inshore lagoonal sites of Emily and Slaughter Bay in March 2020. Squares represent temperature loggers, circles represent temperature loggers and flow meters, triangles represent temperature loggers, current meters and tide gauges.**

However, the thermal peaks in SST evident in January, February and March, suggest that protective and repetitive pre-bleaching temperature stressors (as described of the Great Barrier Reef) may have an influence in alleviating and accelerating the severity of bleaching response on some reefs of Norfolk Island. The potential for increased sea surface temperatures to alter the thermal variance and corals bleaching responses on Norfolk Island reefs therefore also requires further investigation.

## Water Flow and Tidal Currents

A tide meter was deployed on March 7th 2020 and recorded data until April 23rd 2020. Mean depth at the location of deployment was ~3.1 m and tidal variations ranged between 1.75 m, at peak low tide, and 3.9 m at peak high tide, equating to a 1.75 m tidal range, within the lagoon at time of survey (spring tide was 25th Feb).

Flow meters were deployed at 5 to 7 sites across the lagoon from March to June of 2020 and December 2020 to April 2021. Mean flow speeds in the lagoon for non-storm times were recorded as 0.12 m $s^{-1}$ and varied from 0.001 to 1.19 m $s^{-1}$ (Table 1-6). Water flow was strongest at the western side of the lagoon in Slaughter Bay (SB5), especially at the lagoon exit channel, and weakest at the east end of Emily Bay (Figure 1-8, EB1 and EB3). Mean flow speeds (0.12 m $s^{-1}$) were predominately driven by tidal/wave action and E-SE trade winds, with flow speeds in the lagoon fastest at high- and mid-tide and lowest at low tide (Figure 1-9). Deployments in March of 2020 provided the opportunity to measure lagoon flow during two extreme weather events. On March 13th Cyclone Gretel passed Norfolk Island (winds of 40+ km $h^{-1}$) and on April 4th a storm event with high winds from the north (30+ km $h^{-1}$) (see windrose figures for comparison of normal and storm event wind characteristics, Figure 1-10). Analysis of salinity during March, dry period, found no significant differences between sites (Figure 1-11).

**Table 1-5. Minimum, maximum, and mean flow speeds recorded during the period of March 7th – Apr 23rd at the five flow logger sites.**

| Location | Site # | Mean (m $s^{-1}$) | Minimum (m $s^{-1}$) | Maximum (m $s^{-1}$) |
|---|---|---|---|---|
| Slaughter Bay | 01 | 0.11 | 0.01 | 0.42 |
| Slaughter Bay | 03 | 0.10 | 0.009 | 0.41 |
| Slaughter Bay | 04 | 0.16 | 0.01 | 0.78 |
| Slaughter Bay | 05 | 0.22 | 0.01 | 1.19 |
| Emily Bay | 01 | 0.06 | 0.002 | 0.39 |
| Emily Bay | 03 | 0.05 | 0.001 | 0.26 |
| Lagoon Average | | 0.12 | 0.007 | 0.57 |

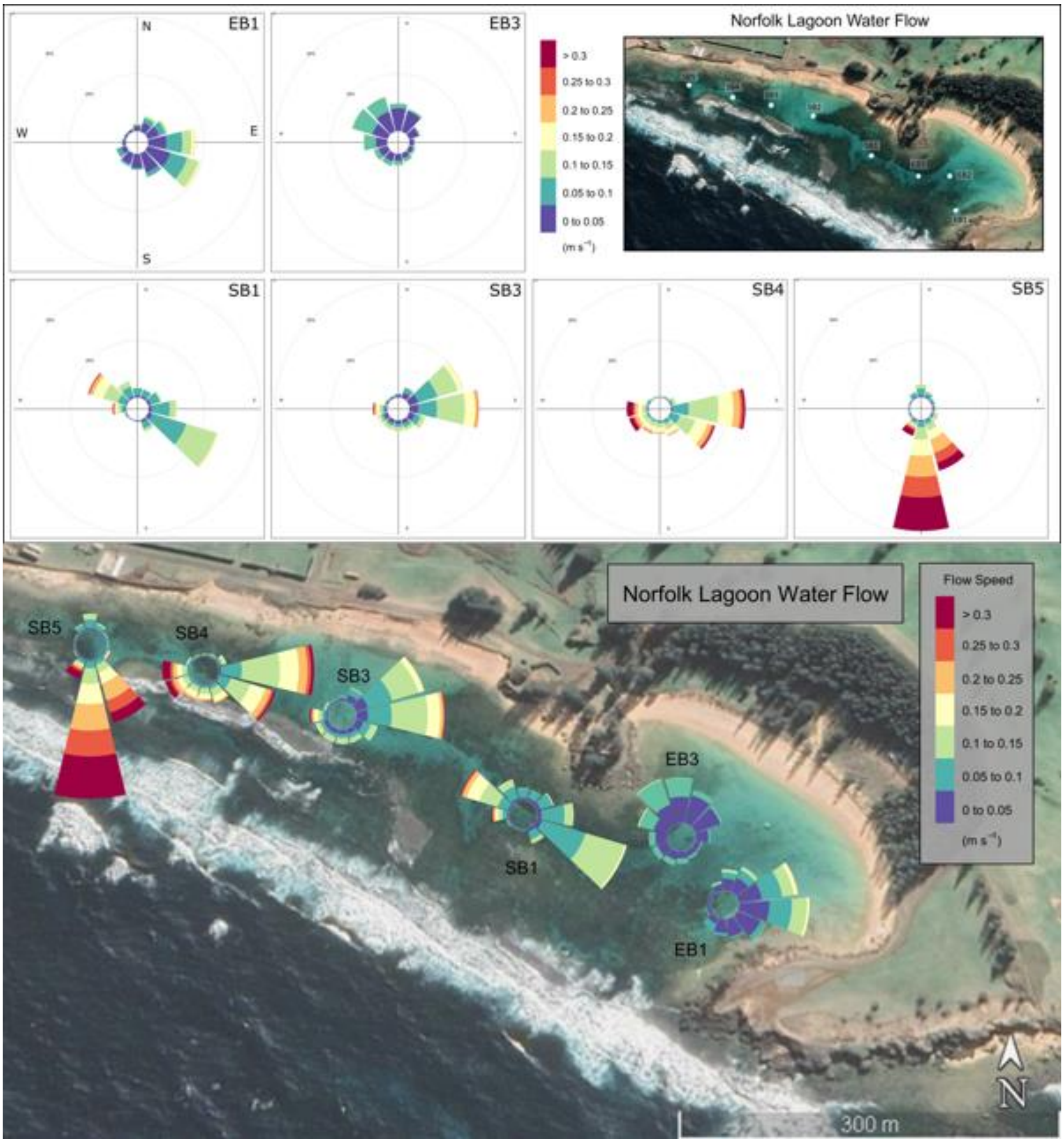


**Figure 1-8. Windrose flow diagrams displaying the mean flow speed (m s$^{-1}$) and cardinal direction of flow at the five locations where flow meters were deployed. Bars represent magnitude and direction of flow March-April 2020**.

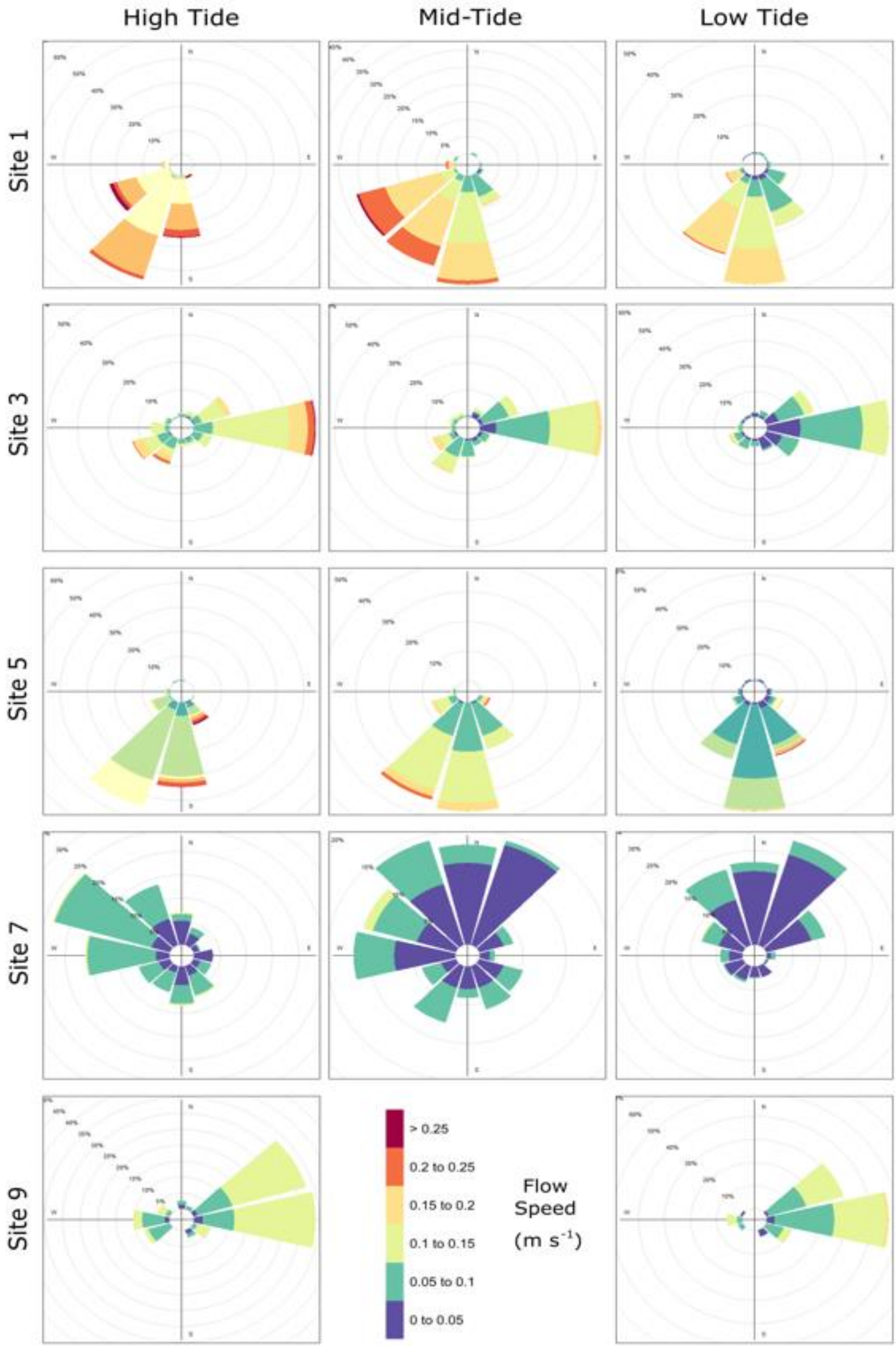


**Figure 1-9. Windrose flow diagrams displaying the mean flow speed ($m\ s^{-1}$) and cardinal direction during low (< 2.7 m depth), mid (~ 3.1 m depth), and high (> 3.5 m depth) tide at each site.**

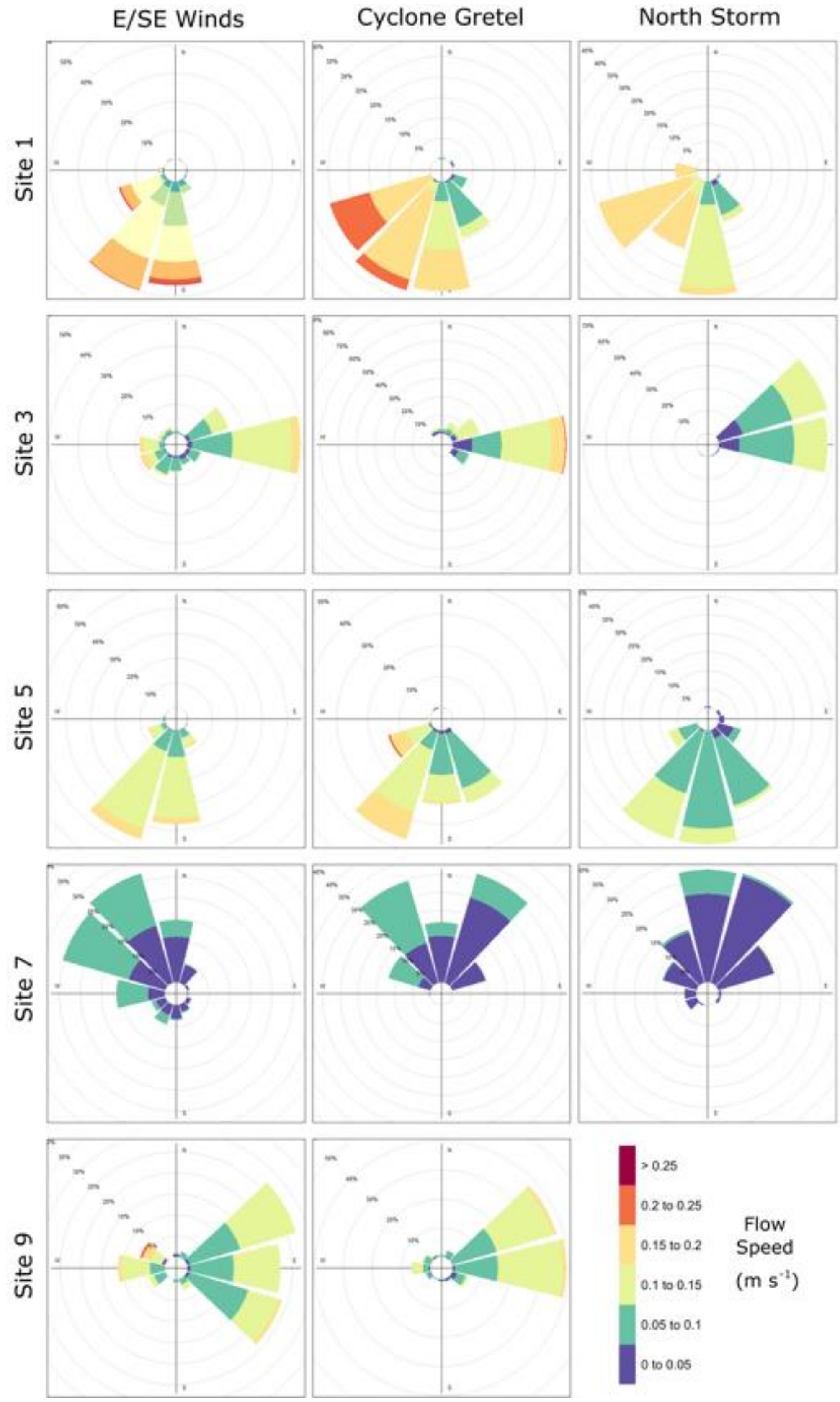


**Figure 1-10. Windrose flow diagrams displaying the mean flow speed (m s$^{-1}$) and cardinal direction during three distinct weather events; common E-SE winds, Cyclone Gretel, and a northerly storm.**

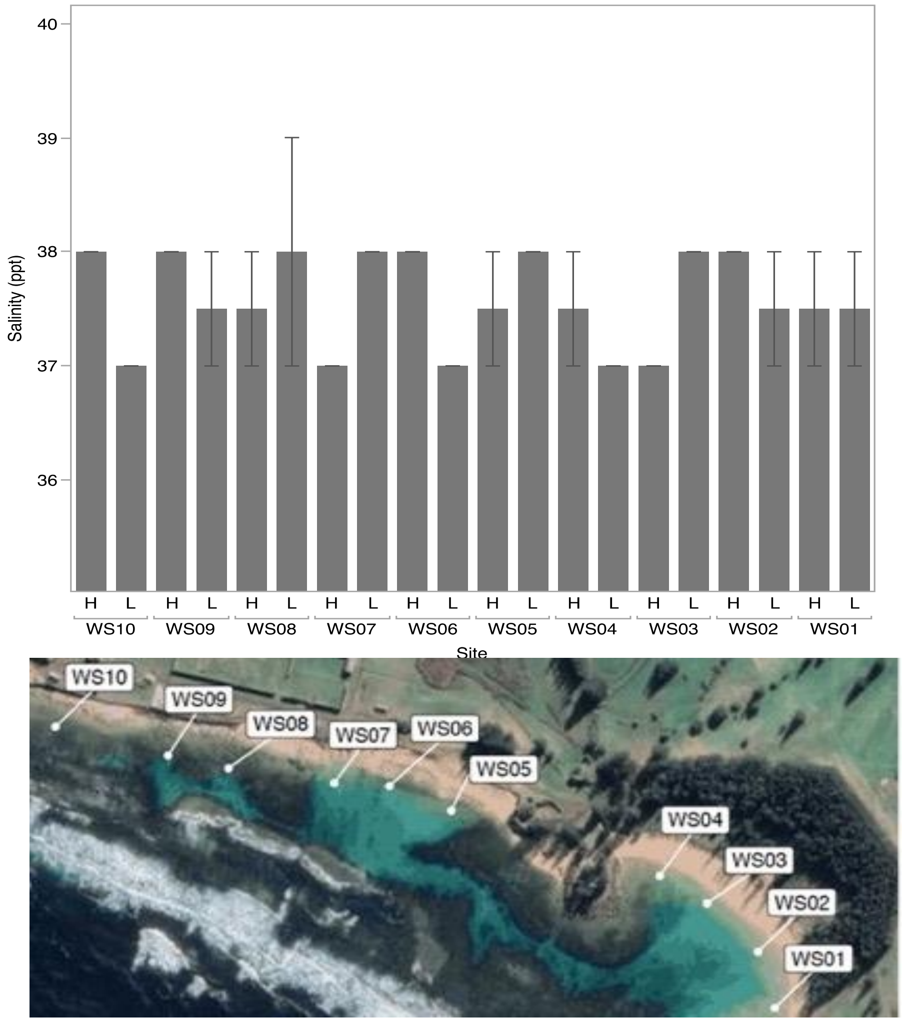


**Figure 1-11. Salinity records for Emily and Slaughter Bay inshore reef during March 2020.**

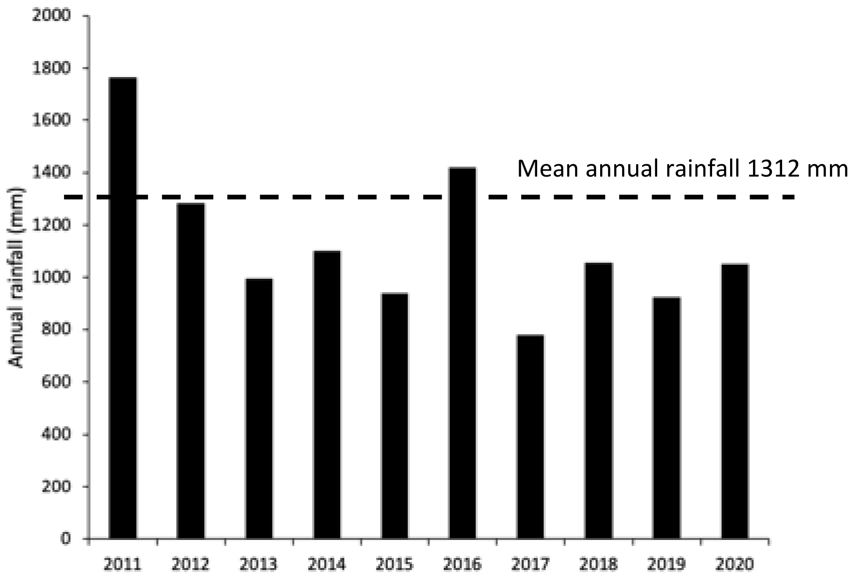


**Figure 1-12. Annual total rainfall at Norfolk airport. Data obtained from the Australian Bureau of Meteorology**.

The historic mean annual rainfall for Norfolk Island is 1312mm, in 2011 rainfall exceeded the decadal average with over 1700 mm of rainfall while only one other year in the decade experienced above average rainfall (2016). An extended period of below average rainfall was experienced between 2017-2020 and throughout 2019 (Figures 1-12, 1-13, 1-14)**.**

In 2020 Norfolk Island experienced significant rainfall events were associated with T.C. Gretel (March 16$^{th}$) with subsequent high rainfall events occurring in May (38 mm on 25/5/2020 and 34.2 mm on 26/5/2020), July (37.2 mm on 5/7/2020 and 83 mm on 31/7/2020), August (45.6 mm on 17/8/2020) and November (105.6 mm on 5/11/2020) (Figure 1-14). Freshwater incursion, sedimentation and flooding of Emily Bay was observed by residents on Island following the high rainfall event during winter 2020.

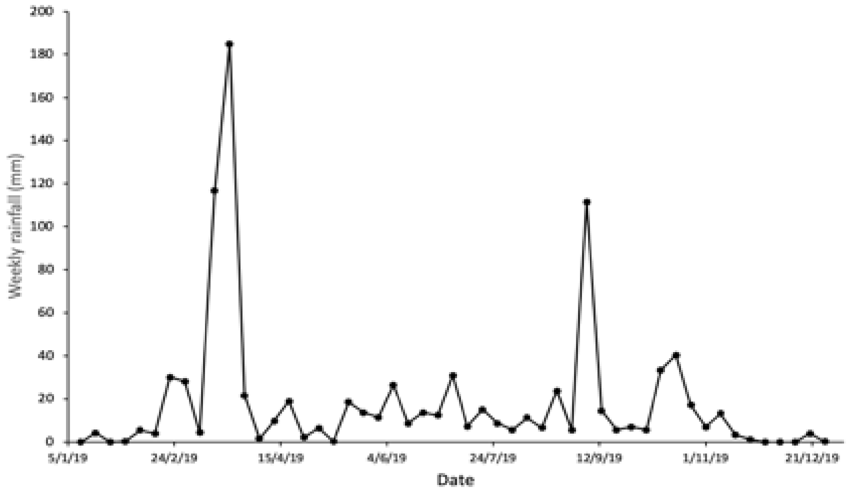


**Figure 1-13. Seven-day rainfall totals for Norfolk Island airport during 2019. Data obtained from the Australian Bureau of Meteorology.**

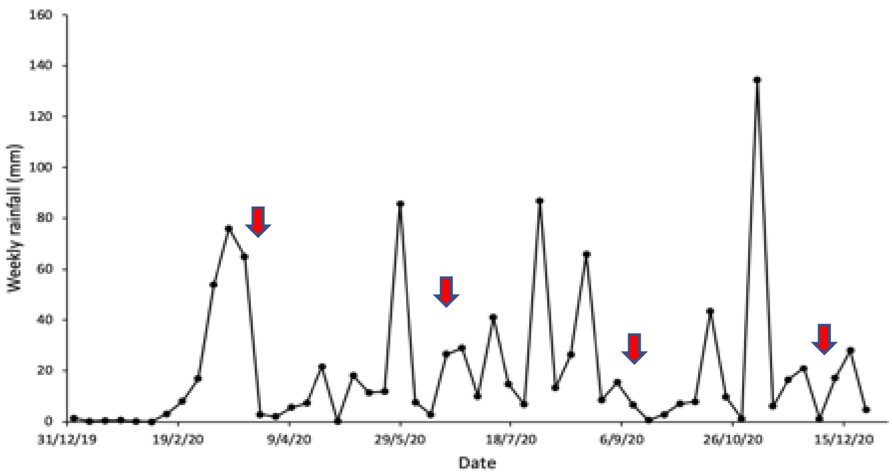


**Figure 1-14. Seven-day rainfall totals for Norfolk Island airport during 2020 (red arrows represent benthic survey periods). Data obtained from the Australian Bureau of Meteorology.**

Sediment samples were collected along the shoreline at approximately 20 cm depth (same location as nutrient samples, *see above*) in Emily and Slaughter Bay (March 2020) and the concentration of organic carbon, nitrogen, hydrogen, and sulphur present was determined. Samples were collected at each shoreline location on two separate days, resulting in a total of 20 sediment samples taken across the survey region. Samples were collected in 60 ml sterilised jars, frozen, and transported to the UNSW Analytical Centre for Micro-combustion environmental analysis. Sediments were predominately composed of organic carbons (mean: 11.3%) and, to a small extent, hydrogen (0.10 %) and sulphur (0.07%; Table 1-6). Nitrogen was, relatively, the least concentrated of the analysed organics, suggesting a relatively low input of terrestrially derived organic matter. Data exhibited an even distribution of these elements across the shoreline sampling transect. Relative % concentration of CHNS did not significantly differ between location ($p = 0.694$) or tide ($p = 0.751$) in a one-way analysis of variance (ANOVA).

**Table 1-6: Relative concentration of organic Carbon, Nitrogen, Hydrogen, and Sulphur in the sediment collected at high and low tide along the shoreline at 10 sampling locations (noted in Figure 1-11). Values noted are the relative % concentration.**

| Location | Site # | Tide | N (%) | C (%) | H (%) | S (%) |
|---|---|---|---|---|---|---|
| Emily Bay | WS01 | High | 0.05 | 11.36 | 0.13 | 0.05 |
| Emily Bay | WS01 | Low | 0.03 | 11.46 | 0.09 | 0.09 |
| Emily Bay | WS02 | High | 0.04 | 11.46 | 0.10 | 0.08 |
| Emily Bay | WS02 | Low | 0.02 | 11.41 | 0.17 | 0.11 |
| Emily Bay | WS03 | High | 0.04 | 11.51 | 0.09 | 0.10 |
| Emily Bay | WS03 | Low | 0.05 | 11.61 | 0.08 | 0.10 |
| Emily Bay | WS04 | High | 0.05 | 11.20 | 0.11 | 0.08 |
| Emily Bay | WS04 | Low | 0.04 | 10.51 | 0.13 | 0.04 |
| Emily Bay | WS05 | High | 0.03 | 11.65 | 0.03 | 0.03 |
| Emily Bay | WS05 | Low | 0.01 | 11.72 | 0.04 | 0.05 |
| Slaughter Bay | WS06 | High | 0.02 | 11.57 | 0.04 | 0.05 |
| Slaughter Bay | WS06 | Low | 0.03 | 11.64 | 0.07 | 0.05 |
| Slaughter Bay | WS07 | High | 0.03 | 11.51 | 0.17 | 0.11 |
| Slaughter Bay | WS07 | Low | 0.04 | 11.33 | 0.06 | 0.06 |
| Slaughter Bay | WS08 | High | 0.04 | 11.49 | 0.06 | 0.02 |
| Slaughter Bay | WS08 | Low | 0.03 | 11.51 | 0.07 | 0.04 |
| Slaughter Bay | WS09 | High | 0.02 | 11.13 | 0.14 | 0.07 |
| Slaughter Bay | WS09 | Low | 0.04 | 11.39 | 0.10 | 0.06 |
| Slaughter Bay | WS10 | High | 0.04 | 11.55 | 0.17 | 0.09 |
| Slaughter Bay | WS10 | Low | 0.03 | 10.95 | 0.30 | 0.16 |
| **Mean** | | | **0.03 ± 0.01** | **11.39 ± 0.27** | **0.10 ± 0.06** | **0.07 ± 0.03** |

*Section 2. Benthic Cover Assessment for Norfolk Island Inshore Lagoon*

***Benthic Health Assessment Summary of findings*.** The Norfolk lagoonal reef encompassing both Emily and Slaughter Bay sites show high benthic variability within the reef. Substantial cover of macro and turf algae was observed throughout the 2020-2021 study period. The average benthic cover in Emily Bay and Slaughter Bay is composed of approximately 30% coral cover and 60% algae cover, this algal cover would be categorised as high for a coral reef ecosystem. Coral cover consists primarily of branching corals (9.9% Emily Bay and 15% Slaughter Bay) encrusting (7.2% Emily Bay and 4.1% Slaughter Bay), foliose (5% Emily Bay and 3.2% Slaughter Bay), and mounding (6.4% Emily Bay and 3.8% Slaughter Bay) morphologies. Encrusting and branching coral growth forms dominate the reef while foliose and mounding species are more rarely observed. In comparison, in neighbouring Cemetery Bay, which also hosts a diverse inshore reef ecosystem, there is substantially higher coral cover (50.8%) and lower algal cover (36.5%), suggesting ongoing declines in coral cover within the neighbouring Emily and Slaughter Bay. As such Cemetery Bay would be considered a coral dominated system, whilst Emily and Slaughter are algal dominated systems.

Overall coral cover was not found to differ significantly across the year-long study period. Coral cover in both Emily and Slaughter Bay ranged from 24.6% to 35% of the benthic cover. Coral cover of 20-30% would be categorised as low coral cover for a coral reef ecosystem (Figure 2-1).

Algal cover on the reef is extensive, ranging from 48% to 54% of the benthic cover. Algal cover was consistent across the study period for both Emily and Slaughter Bay (Figure 2-1).

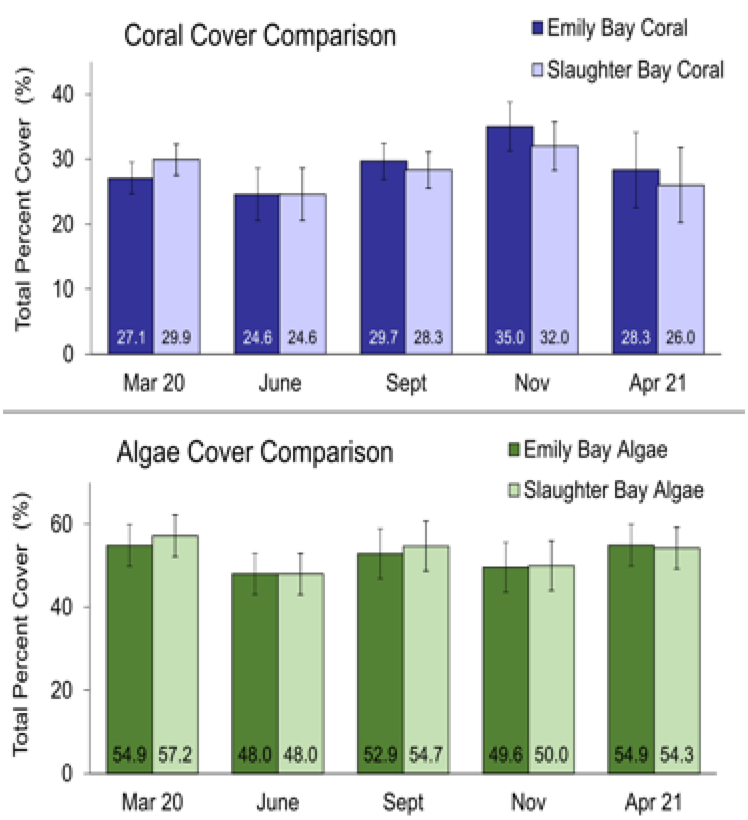


**Figure 2-1: The relative percent cover (% cover ± SD) of benthic cover at both Emily Bay and Slaughter Bay combined.** ***Coral categories are highlighted in blue*, *algae in green*.**

Cemetery Bay is an inshore lagoonal reef dominated by coral cover, with 50.8% of the benthic cover comprising coral and 36.5% comprising algae. Similarly, Cemetery Bay has substantially higher coral cover for all dominate coral growth forms, most notably 10-15% higher cover of the benthic habitat forming branching coral species (Figure 2-2). Branching coral species are critical habitat forming organisms for fish species and as such functionally important on healthy coral reef ecosystems. Branching coral cover in Cemetery Bay in April 2021 was found to be 25% of the benthic cover, whilst in Emily Bay 9.8% of the benthic cover and 15% of the benthic cover in Slaughter Bay. Given the close proximity of these sites the figures suggest a long-term decline in these habitat formers and increase in algal cover is occurring within the Emily and Slaughter Bay inshore reef ecosystem compared to the neighbouring Cemetery Bay (Figure 2-2).

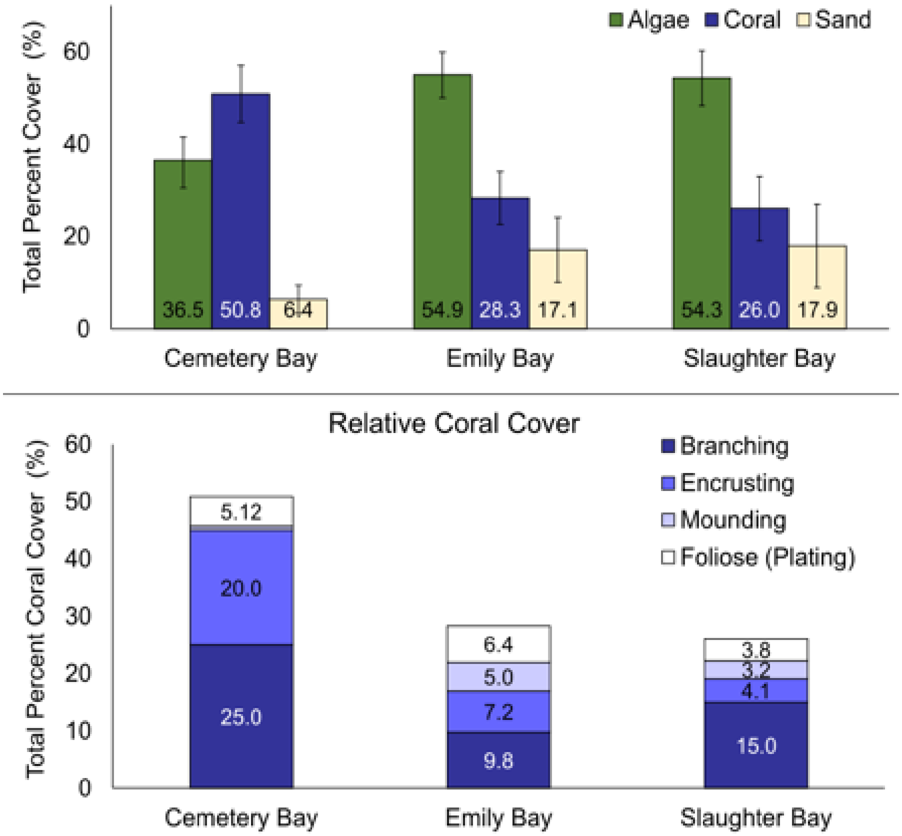


**Figure 2-2: The relative percent cover (% cover ± SD) of benthic cover at Cemetery Bay, Emily Bay, Slaughter Bay.** ***Coral categories are highlighted in blue*****,** ***algae in green*****.**

Emily and Slaughter bays are highly variable inshore coral reef ecosystems with substantial within-reef variability in coral cover, algal cover and coral growth form (Figure 2-3). Within site variability is also evident for coral condition with substantially higher diseased, dead and algal colonised corals evident with some reef areas such as those sites closer to point source runoff locations (Emily Bay outlet adjacent 37.6% dead/diseased/colonise coral) and other regions potentially impacted by ground-water based runoff (beach adjacent reef 18-22% dead/diseased/colonise coral) (ground water incursion was not investigated within the current study) (Figure 2-3). Those reef sites with high water flow and connectivity to open ocean waters have lower proportions of dead diseased and algal overgrown coral and higher proportions of live coral (Figure 2-3).

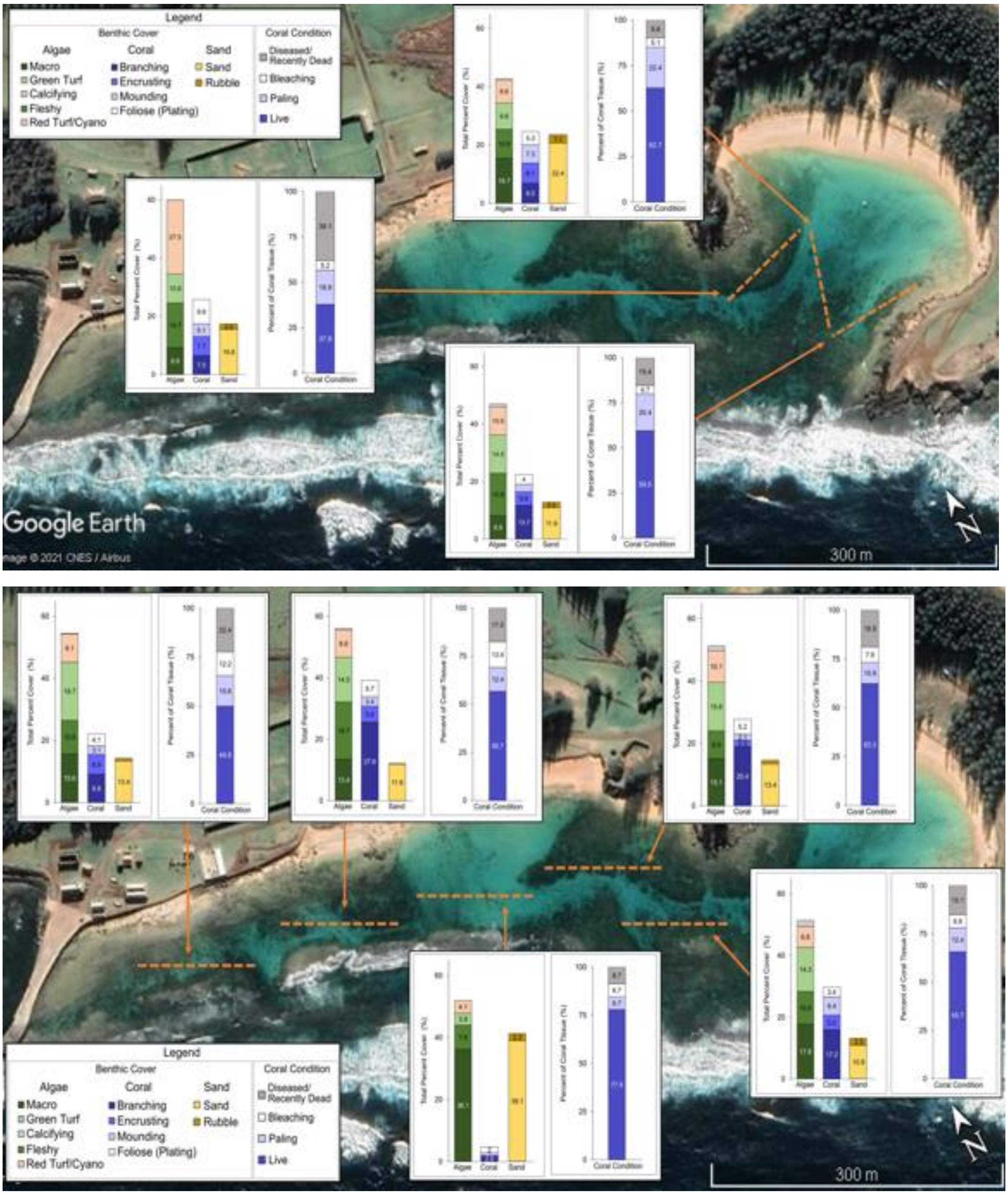


**Figure 2-3. Emily Bay (top) and Slaughter Bay (Bottom) within reef site variability in coral cover and coral condition.**

Within both Emily and Slaughter bays we find evidence for changes in algal composition over throughout the study period. Algal cover in Emily Bay in March 2020 was dominated by green turfing algae (25% of the algal community) reducing to 11% of the algal community 12 months later. In comparison fleshy algal increased from 3% of the algal community to 32% in November 2020 and reducing to 14% in April 2021 (Figure 2-4). Algal community changes such as reported here are consistent with those occurring on coral reef ecosystems impacted by increasing nutrient influx (Atkinson, 2011). The Slaughter Bay coral reef ecosystem also experienced similar changes in algal community composition shifting from a turf dominated system to a fleshy-algae dominated system within the year-long study period (Figure 2-4).

The algal groups present on the reef were classified by their functional group, which is based upon external morphology, size, productivity/growth, toughness and resistance to herbivory (Table 2-1) (Littler et al. 1983; Littler & Littler, 1984; Steneck & Dethier, 1994; Diaz-Pulido & McCook, 2008). A functional approach is a useful alternative to species-level identification, which is often very difficult, and in this instance aims to determine the capacity for herbivory to reduce algal abundance and pressure upon co-habiting corals. Categories of functionally benthic algae include;

- ***Algal turfs*** composed of microscopic algae (e.g. Cyanobacteria) or filamentous algae (e.g. Chlorodesmis) that have high colonization rates, fast growth and, in the case of cyanobacteria, can be rich in nitrogen relative to biomass due to their capacity to fix nitrogen from the surrounding water.

*Although some species such as Chlorodesmis produce chemical compounds designed to deter herbivory, in general algal turfs are grazed by a wide variety of herbivores.*

- ***Macroalgae*** are larger, anatomically more complex and usually more tough. The degree of complexity and 'toughness' (i.e. how corticated they are) is an indication of growth rates/productivity. The term 'fleshy' is commonly used to distinguish those non-calcified from calcified algae. Foliose fleshy algae have a high surface area to volume ratio and so often exhibit high productivity/growth (Littler et al. 1983), which means they are often highly responsive to nutrient enrichment (e.g. Ulva).

*Macroalga susceptibility to herbivory depends upon how corticated (i.e. tough) the alga is: Ulva is easily grazed while leathery Padina alga are less susceptible to herbivory. Additionally, some genera produce compounds that make them unpalatable (e.g. Dictyota, Laurencia).*

- ***Crustose algae*** are often the slowest growing and appear as a painted layer on the substrate. Crustose coralline algae *are applanate* (i.e., grow horizontally) and important in promoting the settlement of new corals on a reef. Rhodoliths (e.g., Lithophyllum) themselves produce protruding calcareous nodules and can be an important source of reef growth on temperate reefs.

As such benthic coral reef ecosystems with algal communities dominated by crustose coraline (encrusting algae's) and low in macroalga are generally considered indicators of healthy, coral dominated, ecosystems in which herbivory controls the benthic algal assemblage and reduces coral-algal competition. The increase in fleshy algae across the Emily and Slaughter Bay inshore coral reef ecosystem during the study period corresponds to a significant number of rainfall events that occurred on the Island in 2020 following an extended period of below average annual rainfall in comparison with previous years. Significant rainfall events were associated with T.C. Gretel (March 16$^{th}$) with subsequent high rainfall events occurring in May (38 mm on 25/5/2020 and 34.2 mm on 26/5/2020), in July (37.2 mm on 5/7/2020 and 83 mm on 31/7/2020), August (45.6 mm on 17/8/2020) and November (105.6 mm on 5/11/2020) (see report section 1). Water quality measures taken in September, November and December (see section 1) indicate significant terrestrial inputs into the marine system of the bays, with nutrient values exceeding the ANZECC guidelines. A significant increase in fleshy macroalgae over the study period is of particular concern for the health of the Emily and Slaughter Bay corals.

Algae are the major competitors with corals for space and are a natural part of any coral reef system, however algal cover is normally dominated by turfing algae in a healthy system. Large fleshy algae are generally more unpalatable to herbivores and as such generally have lower herbivory rates leading them to outcompete resident corals. As such it is recommended that on-going monitoring continues to examine the benthic community structure to ensure that the changes in algal abundance do not indicate the continuation of a phase shift away from a coral dominated reef. Furthermore, given the substantial differences in coral cover, algae cover, coral composition and algal composition between Emily and Slaughter Bay and neighbouring Cemetery Bay, site remediation with the goal of improving water quality across Emily and Slaughter Bay and reducing terrestrial inputs should be prioritised. A reduction in algal cover or removal of algae has the potential to increase cover of species that facilitate coral settlement, such as crustose coraline algae and benthic habitat conducive to coral settlement, growth and survival.

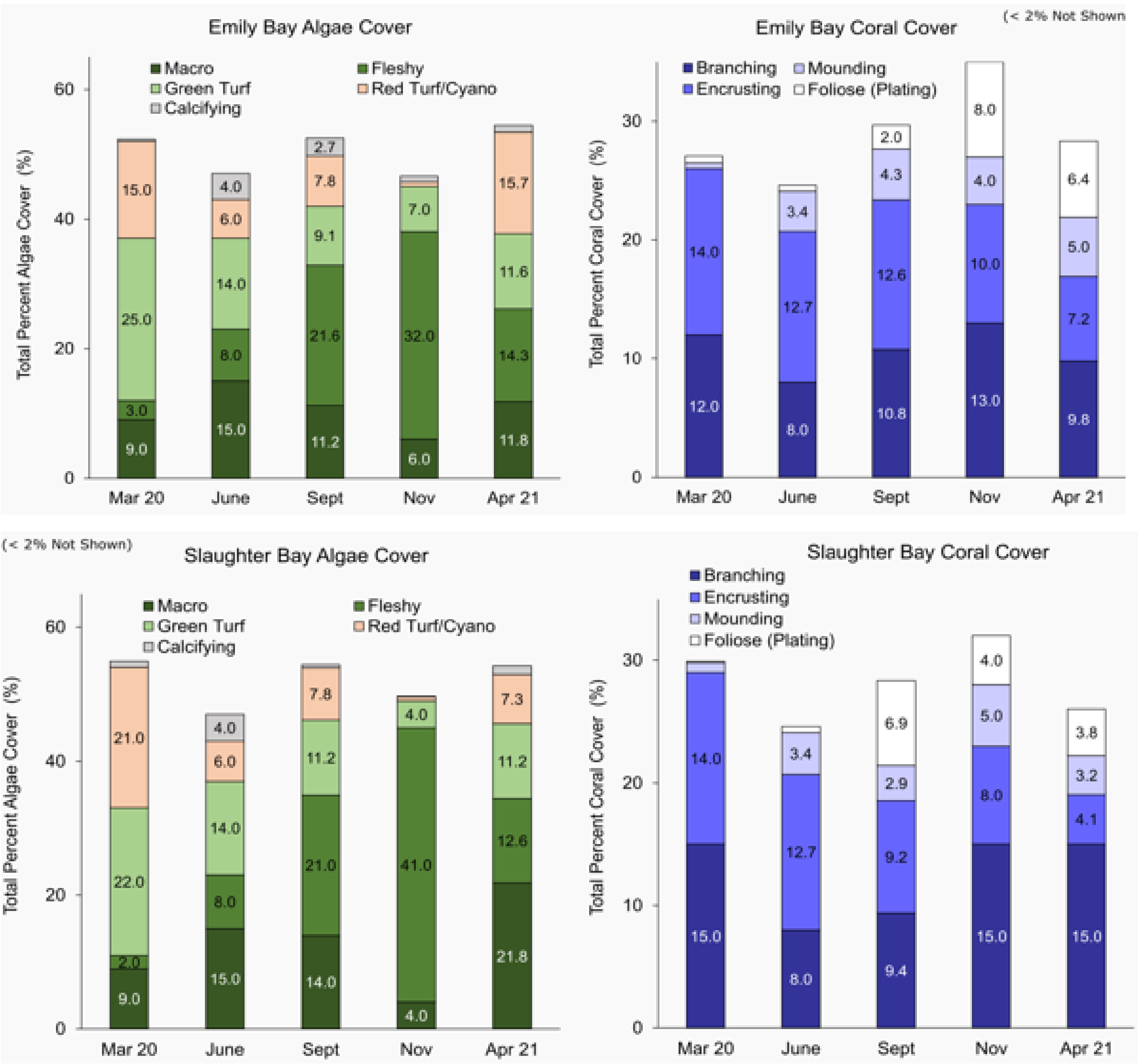


**Figure 2-4. Benthic composition of Emily and Slaughter Bay during the year-long study period March 2020-April 2021.**

**Table 2-1. Algae are classed by their expected response to high nutrient pulse events; their resistance to herbivory; and their direct competitive effect upon adjacent corals. Predictions are based on peer-reviewed comparative biology studies that examined both genera and functional groups (Littler et al., 1983; Brown et al. 2020).**

| Genera | Fun. Group (s) | Expected Response Rate of High Nutrients | Expected Resistance to Herbivory | Potential Effect on Adjacent Corals |
|---|---|---|---|---|
| Ulva, Chaetomorpha, Cladophora, Bryopsis, Cyanobactera | MAT FAT FolioseM | Fast-growing algae that respond quickly to nutrient pulses | Soft, generally non-toxic algae so not very resistant | Algal turfs in general are highly competitive with corals. |
| Dictyota, Dictyopteris, Chlorodesmis | FAT FolioseC | Filamentous and foliose species are fast-growing. | Produce chemical deterrents so resistant to herbivory | Toxin-producing alga such as Chlorodesmis have been previously identified as detrimental to adjacent corals. |
| Halimeda, Lithophyllum, Tricleocarpa | ACA CCA | Calcification is a high-energy process so ACAs and CCAs are slow-growing | Stony texture makes them unpalatable to all but specialist herbivores (e.g. parrotfish) | Calcifying algae, in part due to their slow growth rates, are not strong coral competitors. Usually more abundant in the summer. |
| Hormosira, Padina | Leathery | Slower growing than foliose but faster than calcifying | These are heavily corticated algae and so are resistant to herbivory. | These tough, persistent and large seaweeds can smother and overshadow corals. They are also likely to cause heavy abrasive damage. |
| Caulerpa | Fleshy | As Caulerpa species gather nutrients via subsurface rhizomes, they might be expected to respond groundwater discharge. Medium growth rates relative turfs and foliose algae. | Usually only lightly corticated so not very resistant to herbivory. | C. cf. cuppressoides (Cactus tree algae) forms meadows on sand patches in EB and SB. C. racemose (sea grapes) is commonly adjacent to corals and so may cause abrasive damage and smother corals. |

| | | | | |
|---|---|---|---|---|
| Laurencia, Plocamium, Amansia, Codium cf. fragile | Fleshy | Medium growth rates relative to turfs and foliose algae. | These fleshy red algae are, in general, not very resistant but some taxa (e.g. Laurencia) produce compounds that make them unpalatable. Codium cf. fragile is a tough, resistant green fleshy algae. | C. fragile is not often seen adjacent to corals but has the potential to cause abrasive damage. Red algae are usually more abundant in the winter and may cause light abrasive damage and smother corals. |
| Codium cf. lucasii, Colpomenia cf. sinuosa | Fleshy | Slow to medium growth rates | Tough algae that are resistant to generalist herbivores. | Low-lying, small algae are unlikely to have a significant impact on corals unless growing as epiphytes (e.g. Colpomenia) |

Historical estimates of benthic cover were conducted within the Southern Norfolk Island lagoon in June of 1988 by the Australian National Parks and Wildlife Service. The historical survey data was collected in both Emily and Slaughter Bay and are categorized by cardinal direction (E, SE, S) and depth (0-2 m lagoon, 2-5 m channel, 5 m slope) (Table 2-2). To provide comparison to lagoon survey sites in 2020 (n = 14), we specifically compared the 1988 survey data from sites at all cardinal directions within the 0-2 m lagoon area (n = 4). It is important to note that surveys in 1988 do not provide a breakdown of morphological distribution within the hard-coral category and have used individual categories for algae as follows: coralline, thallous and turf. The ‘hard coral’ category of 1988 corresponds to the encrusting, branching, foliose, and mounding categories used here. The historical study also categorises the reef into distinct zones, the subtidal reef platform, slope to the channel and mid lagoonal bommie.

**Table 2-2. Historical study locations 1988 and percentage benthic cover (Ivanovichi, 1988)**

| Location | Location | Depth | Hard Coral | Soft Coral | Anemone |
|---|---|---|---|---|---|
| Subtidal platform | E | 0.5-1 m | 14% | 0 | 1.7% |
| | S/E | | 19% | 2% | 0 |
| | S | | 0 | 0 | 0 |
| Slope | E | 1-4 m | 29% | 0 | 1 |
| | S/E | | 19% | 0 | 0 |
| | S | | 23% | 0 | 1.5% |
| Bommie | E | 1-2 m | 64% | 0 | 0 |

The algae categories, including encrusting, macro + fleshy, and turf, are here referred to as encrusting, macro-algae and turf for the surveys conducted in 2020. In comparison to the recorded coral cover in 1988, we find the analysed corresponding 2020 transects record significantly higher coral cover (18% in 1998 and to 29% 2020) ($p = 0.02$) while recorded algal cover is significantly lower ($p = 0.398$) (Table 2-2, Figure 2-5).

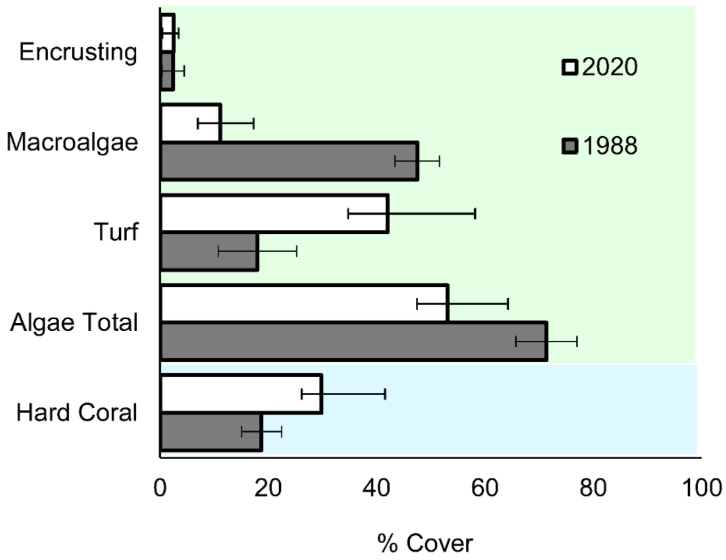


**Figure 2-5 Comparison of benthic survey data collected in Emily and Slaughter Bay in 1988 and March 2020. Algae total includes the sum of the three algal categories (encrusting, macroalgae, and turf). Hard coral includes the sum of coverage among all four coral morphologies (branching, encrusting, foliose, and mounding).**

**Table 2-3: Comparison of Southern Norfolk Island benthic survey data collected at lagoon survey sites in 2020 (n = 14) to those collected in 1988 within the 0-2 m lagoon area (n = 4). 1988 surveys did not differentiate between coral morphology, so % cover estimates here are compared as overall hard coral cover. Total algae accounts for the sum of the three individual algal categories used both in 2020 and 1988: encrusting, macroalgae, and turf.**

| Benthic category | 1988 % Cover | March 2020 % Cover | November 2020 % Cover |
|---|---|---|---|
| Hard Coral | 19 ± 4 | 27 ± 10 | 34 ± 15 |
| Total Algae | 71 ± 7 | 57 ± 5 | 50 ± 16 |
| Encrusting | 2.3 ± 1.9 | 2.5 ± 0.9 | 1 ± 1 |
| Macroalgae | 47 ± 4 | 11 ± 6 | 42 ± 10 |
| Turf | 18 ± 7 | 42 ± 16 | 6 ± 5 |

The 1988 reported benthic compositions suggests macroalgae as the dominant algae group at the time of survey, whilst in March 2020 we find the algae dominated by turf species, which shifts to macro-and fleshy algae dominance throughout the remaining survey period. However, it is important to note some of these trends may be due to categorical interpretations and also transect placement within the highly variable intertidal lagoonal reef system. It should also be noted that the 1988 values were diver estimates from long swim transects, in comparison to the current study utilising quadrats to quantify abundance, as such direct comparison should be made with caution. Finally, the 1988 surveys also did not discuss the relative proportion of bare space (sand, rubble, other).

Total fish abundance was not found to vary between the December and April sampling periods (Figure 2-6). Highest fish abundances were detected at SB2, SB1 and EB3 (39.3 fish/120 $m^2$, 41.5 fish/120 $m^2$, 37 fish/120 $m^2$) which have the highest structural complexity and are coral dominated regions within the Emily and Slaughter Bay reefs while lowest abundance was at site SB3, a sand/*Caulerpa* dominated site (5 fish/120 $m^2$). Average abundance across the entire reef was 11.8 fish/120 $m^2$, which is significantly lower than that found at Elizabeth and Middleton Reef, where herbivorous fish were found at mean densities of 26.3 fish/120 $m^2$ and 28.6 fish/120 $m^2$. Of the 28 species of fish observed in the bays (see supplemental table of fish species observed) the most abundant was the territorial herbivore *Parma polylepis*, the Banded Scalyfin (Figure 2-7), a herbivorous Pomacentridae, which was found in all survey sites. Densities of *P. polylepsis* varied from 1.8 ± 0.6 to 13.0 ± 0.8 individuals per transect. The next most abundant group were the remainder of the Pomacentridae (Damsel Fish) and then the Labridae (Wrasses), which include planktivorous and herbivorous species. The endemic temperate butterflyfish *Chaetodon tricinctus*, the three stripe butterfly fish was also observed the inshore reefs. While providing an estimate of fish abundance the current study only assessed fish greater than approximately 5 cm in length and did not assess cryptic or juvenile fish species generally found within the reef structure.

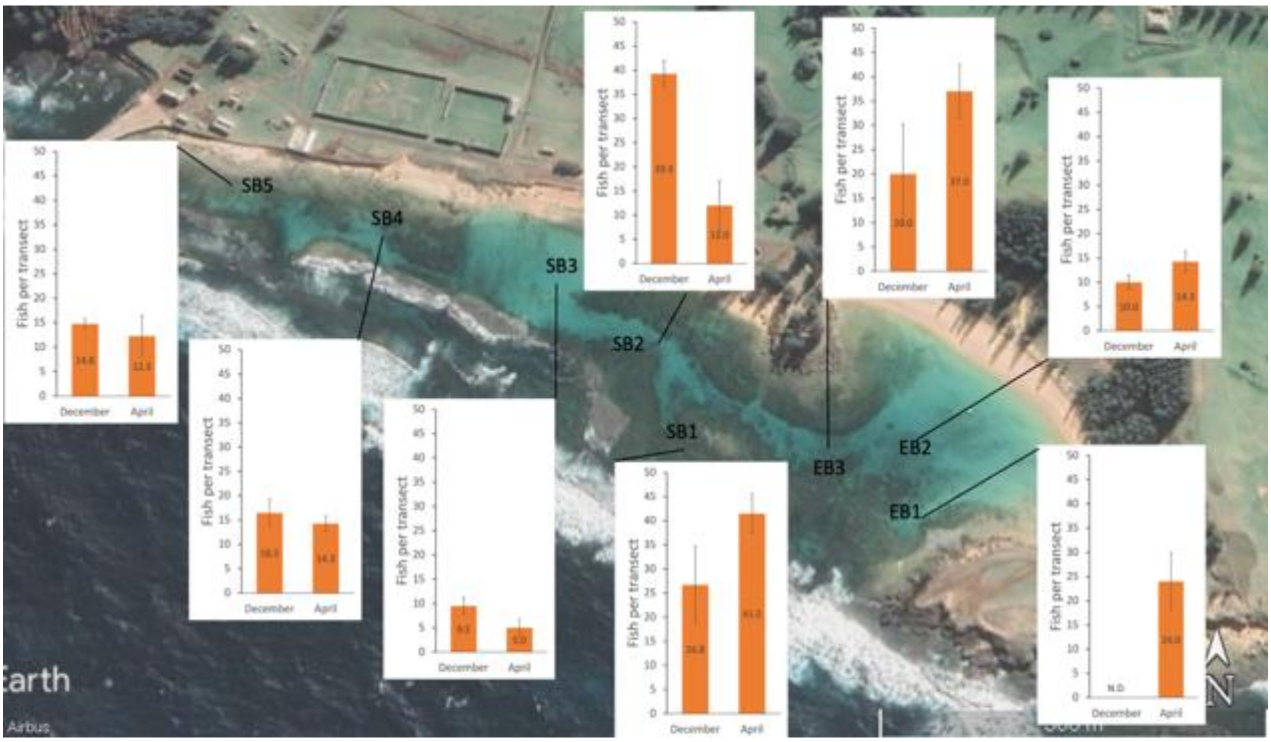


**Figure 2-6. Total fish abundance during December and April survey periods. Error bars represent standard errors, n=4 for all site expect for EB3 and EB2 in December. Area of transects is 120 $m^2$.**

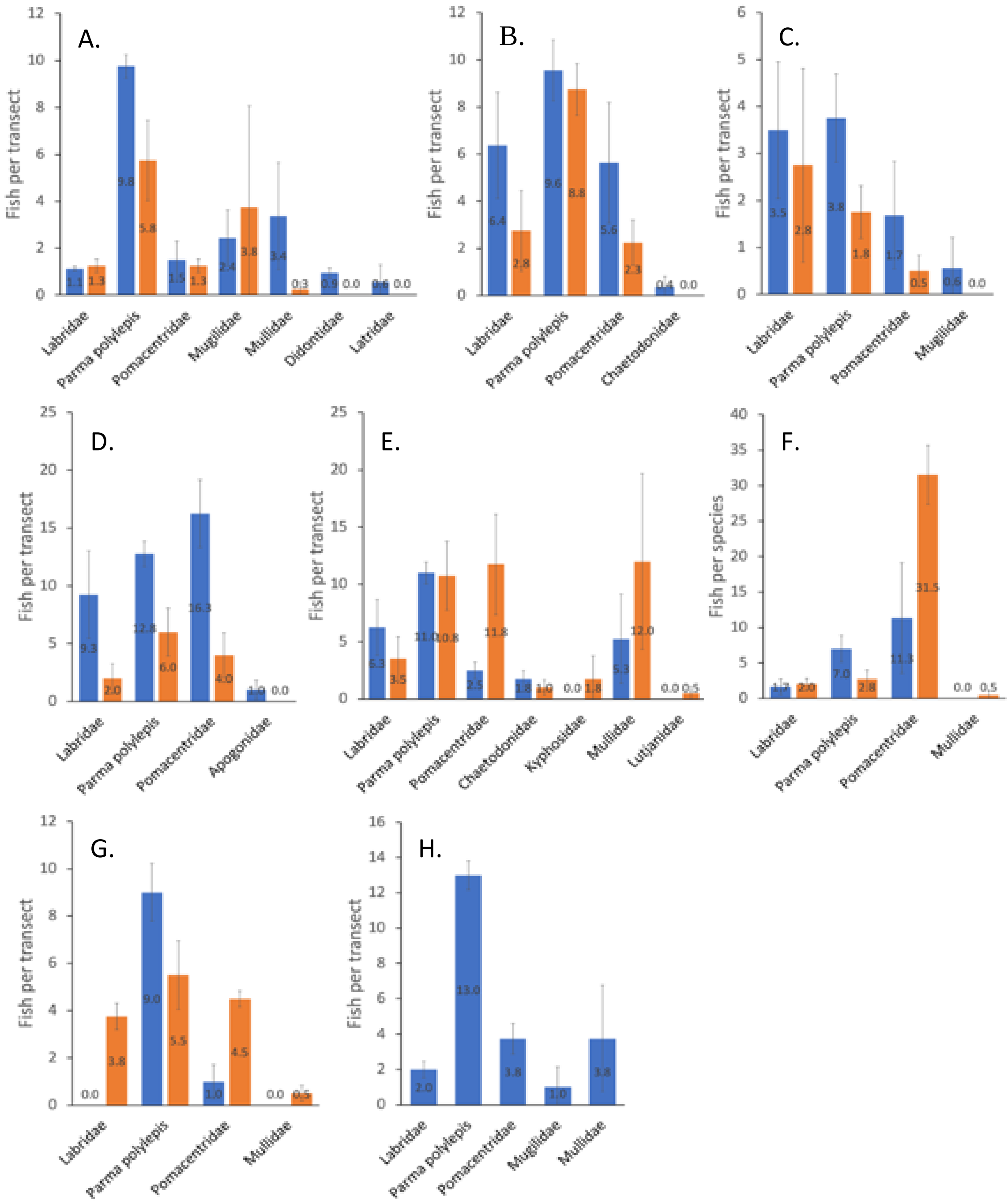


**Figure 2-7. Fish abundance during December 2020 (Blue) and April 2021 (Orange) (A) SB5, (B) SB4, (C) SB3, (D) SB2, (E) SB1, (F) EB3, (G) EB2, (H) EB1. Error bars represent standard errors, n=4 for all site expect for EB3 and EB2 in December (n=3). Area of transects is 120 m$^2$.**

***Norfolk Island coral bleaching event March 2020 and bleaching recovery June 2020***

***Summary of findings.*** All coral growth forms, representing the majority of coral species, were impacted by bleaching in 2020 within both Emily and Slaughter Bays in March 2020. Across the inshore lagoon of Emily and Slaughter Bay severe coral bleaching, evident as white colonies, were recorded in each of the coral growth forms. Mounding corals, while low in density on the reef were severely impacted by bleaching. Branching corals, which are the primary habitat forming corals on coral reef ecosystems where also found to be severely impacted by the bleaching event. Bleaching rates of over 20%, as found in the current study, are consistent with a severe bleaching event on a coral reef ecosystem. Through March 2020, there was also evidence of coral skeletons, recently dead coral, and coral overgrown with algae across the reef, in each of the coral types. Coral bleaching/paling remained evident across the reef in the months after bleaching, suggesting coral recovery from bleaching is slow within the ecosystem.

Coral bleaching occurrence was determined for all coral morphologies at each of Emily and Slaughter Bay during March 2020 as follows (Figure 3-1):

- ***Healthy coral*** defined as coral showing no signs on coral bleaching. *On the inshore reef ecosystem of Emily and Slaughter Bays healthy coral accounted for approximately 34% of the coral cover.*

- ***Paling coral*** defined as coral showing evidence of a reduction in algae density and mild coral bleaching response compared to healthy coral. *On the inshore reef ecosystem of Emily and Slaughter Bays pale coral accounted for approximately 30% of the coral cover.*

- ***Bleaching coral***, defined by white appearance of the colony and severe loss of algal symbionts from the coral tissues. *On the inshore reef ecosystem of Emily and Slaughter Bays bleached coral accounted for approximately 29% of the coral cover.*

- ***Recently dead*** coral, defined by bare coral skeleton with early algal colonisation. *On the inshore reef ecosystem of Emily and Slaughter Bays dead coral accounted for approximately 8% of the coral cover*.

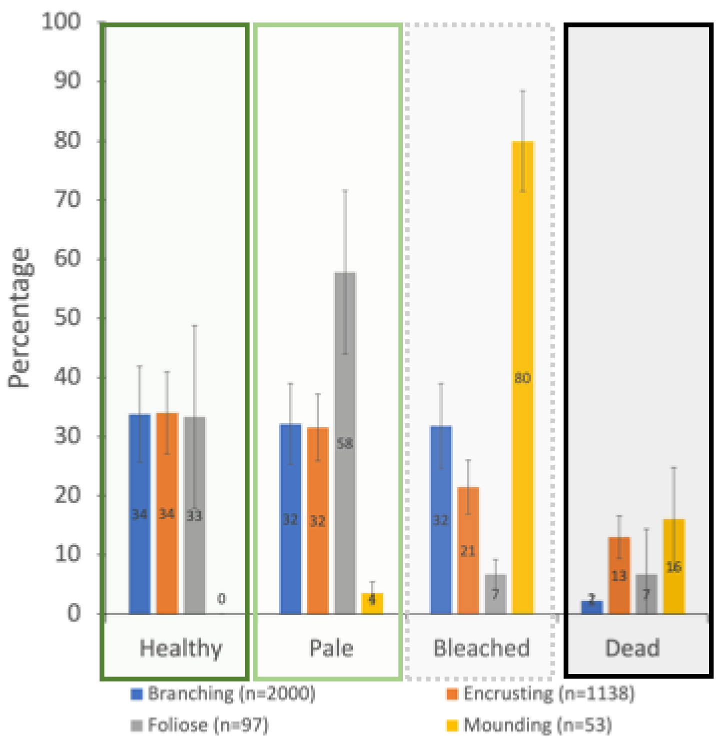


**Figure 3-1. Bleaching frequency in the inshore Norfolk Island lagoonal reef in March 2020**

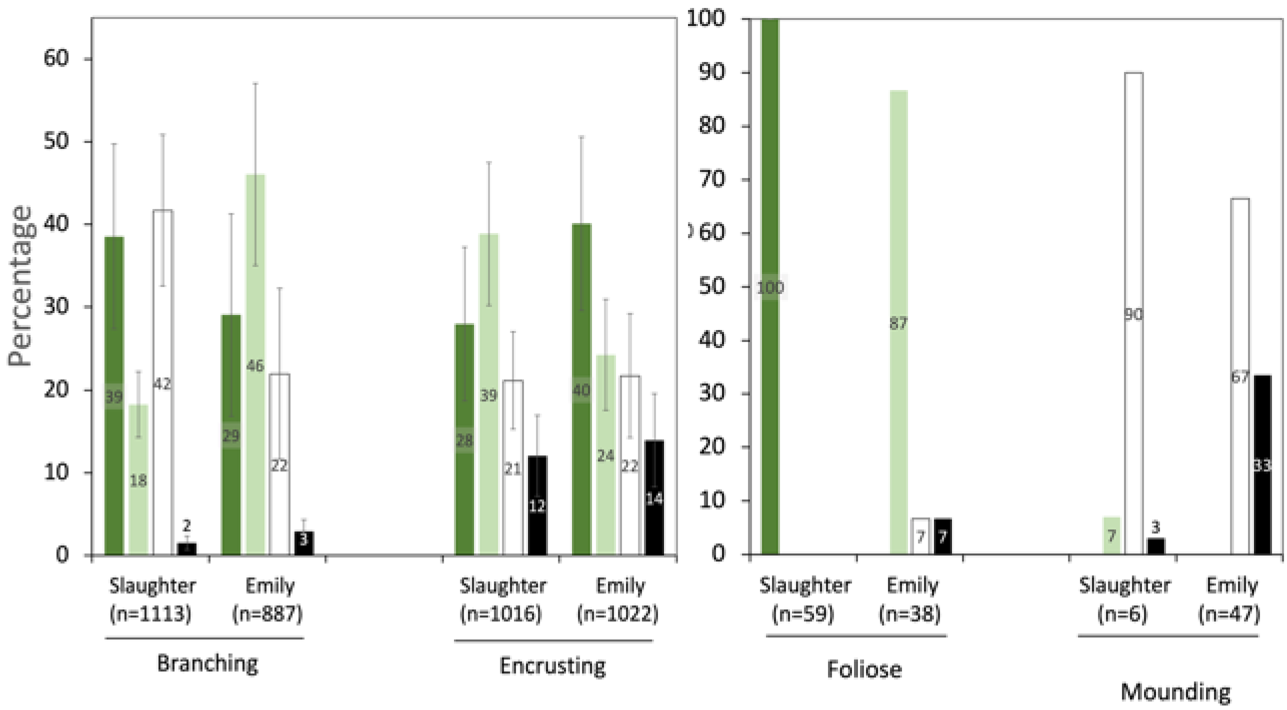


**Figure 3-2. Coral cover healthy (dark green), pale (light green), bleached (white), and dead (black), for each of branching, encrusting, foliose and mounding corals, during the March 2020 bleaching event on Norfolk Island** (*n, data points within benthic cover photoqudrats generated in CoralNet, see section 6 methods*).

Branching corals are important habitat forming species on coral reef ecosystems and are severely impacted by coral bleaching events on most reef ecosystems. In the current study branching corals in both Slaughter Bay and Emily Bay were found to have bleaching, with only approximately 34% of the branching corals remaining healthy (unbleached) through the event. Within Norfolk's Emily and Slaughter Bay bleaching rates of 22% and 42% were evident, while 46% and 18% of colonies were found to have paled for branching corals. Branching corals here include branching *Acropora* species, plating *Acropora* species, and branching *Pocillopora* and *Stylophora* coral species. Bleaching susceptibility research has previously shown that branching and plating growth forms of Acroporid species are the most susceptible to bleaching, bleaching first during anomalously high sea surface conditions and undergoing extensive mortality within weeks of bleaching. In contrast Pratchett *et al*,[10]report that the normally bleaching susceptible Pocilloporid corals are more thermally tolerant on reefs in Moorea. On Norfolk Island inshore reefs, *Pocilliopora* corals underwent extensive bleaching across the reef in March, whereas branching and plating *Acropora* were more thermally tolerant. Across the Norfolk Island inshore reef, the Foliose corals were the least impacted by the bleaching event, recording the lowest bleaching occurrence, but also found to be in low abundance on the reef ecosystem. The highest incidence of mortality (dead, diseased, and algal colonised) was evident in encrusting and mounding corals in both reef habitats during March 2020 (Figure 3-2).

A 1988 report into coral health within Emily and Slaughter Bay Norfolk Island also reported observations of potential past coral bleaching occurrence by residents (Ivanovichi, 1988); *"residents suggesting that some of the coral species develop an icy blue colour during the summer months, which changes to brown as the cooler weather sets in. Dr Veron (Australian Institute for Marine Science) has suggested this may be due to seasonal loss of endosymbionts, possibly associated with a temperature change, or some other environmental stress factor."*

Despite exceeding the accepted thermal limit for widespread bleaching related coral mortality (DHW 8) extensive mortality was not observed within the lagoonal reefs of Emily and Slaughter Bay Norfolk Island during March 2020. A lack of evidence for widespread bleaching associated coral mortality may be due to thermal susceptibility of the species in the lagoon and DHWs not exceeding the corals upper thermal limits during the 2020 event or the reduction in heat stress accumulation due to cyclonic conditions reducing immediate mortality occurring of the reef. Cyclonic conditions rapidly reducing heat stress, DHW accumulation and alleviating bleaching has been reported in other systems. While the reduction in heat stress as a result of cyclonic conditions coincident with the peak of summer temperatures potentially ameliorated the severity of coral bleaching within the Norfolk Island lagoon, corals in both Emily and Slaughter Bay were found to still exhibit bleached and pale tissue in June 2020 (see Figure 2-3). Approximately 57% of branching corals were still pale in the June survey period no signs of bleaching or paling was evident in the encrusting coral species. Mounding corals, while a low proportion of total coral cover on the reef, were also found to still be bleached/paled in June 2020 (no foliose corals were observed in this survey.

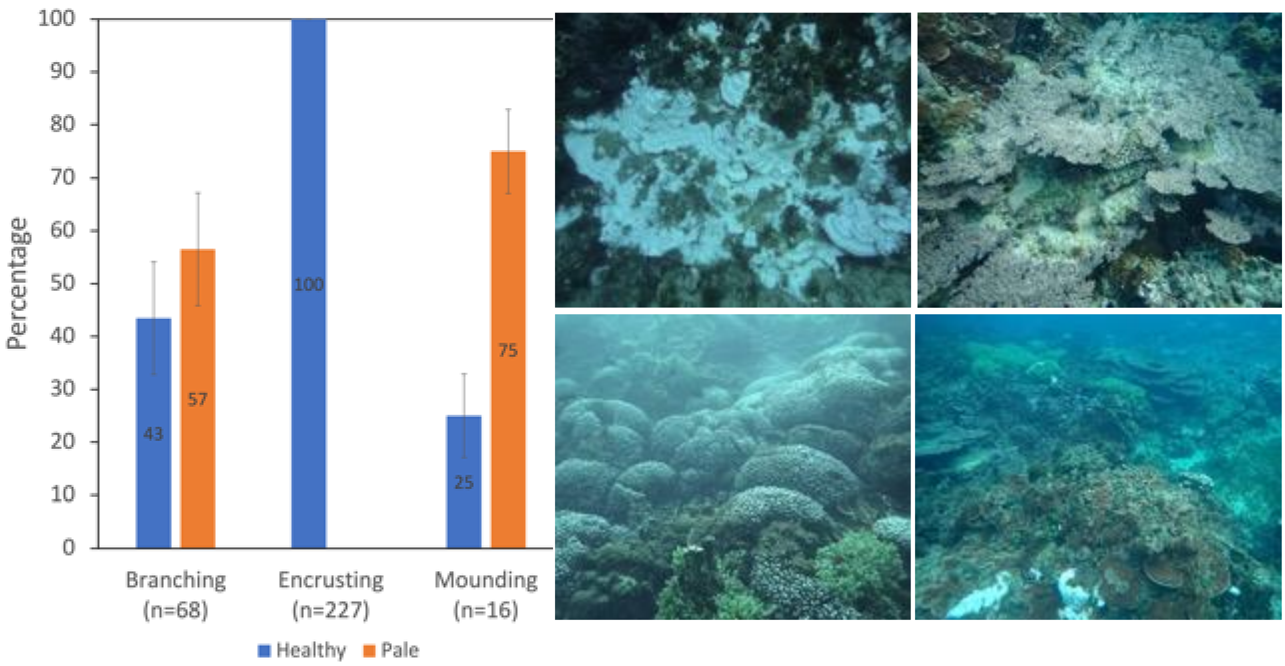


**Figure 3-3. Bleaching prevalence on Emily and Slaughter Bay in June 2020. Surveys conducted by GP services using timed in water video transects.**

**Coral microbiome associated with bleaching in March 2020**

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***Summary of findings***: Corals comprise some of the most diverse and abundant microbial communities. Various components of the coral holobiont, that is, the cnidarian host and its microbial community (the "microbiome"), play key roles in regulating corals' resistance to heat stress, and studies indicate that an intact and diverse coral microbiome may be essential to coral immunity and health[11-15]. Responses of coral-associated bacterial communities to environmental stressors have been reported with recent evidence suggesting flexibility of these communities may influence corals resilience to environmental stress and markers of pollution have been detected in the coral microbiome. In this study six bacterial taxa of the order Campylobacterales and the families Leigioinellaceae, Enterobacteriaceae, Peptostreptococcaceae, Staphylococcaceae and Vibrionaceae where found, which have been associated with faecal pollution[16,17]. However, the overall contribution of these taxa was low, the largest contribution was found to be from Vibrionaceae and *Escherichia coli* (also known as *E. coli*) was detected. Further time series investigation specifically targeting these bacterial types could be used to determine the extent and source of these phylotypes and to what extend they contribute to coral decline.

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Microbiome composition is important in determining coral health over space and time, yet is undescribed for the coral communities at Norfolk Island. Therefore, we evaluated bacterial diversity and community composition among key reef-building coral species (*Acropora sp*., plating *Acropora sp.*, *Montipora sp*., *Pocillopora sp*., and *Porites sp*.) collected from Emily Bay during bleaching conditions in March 2020. Importantly, this combination of species included those previously described as either heat-stress sensitive (*Acropora* spp.) or tolerant (*Porites* sp.), and we assessed the microbiome of both healthy and bleaching individuals of each genera. The generated microbiome data set comprised 41 16S rRNA gene libraries from 5 coral species. After quality filtering sequences were annotated to bacteria by clustering at the 97% similarity level, resulting in the identification of 948 operational taxonomic units (OTU), presented as a taxonomy stacked column plot to the phylogenetic level of family (Figures 3-4). The coral microbiome was dominated by taxa from the Oceanospirillales (blue), consistent with that described in other studies of the coral microbiome, and the *Acropora*, plating *Acropora* and *Pocillopora* species were found to have higher contributions from the Oceanospirillales compared with *Montipora* and *Porites* sp (Figure 3-4). The taxa contributing the most to the overall relative abundance included Oceanospirillales, Pseudomonadales, Burkholderiales and Propionibacteriales (Figure 3-4). A principal coordinates analysis (PCoA) of coral OTU composition shows the coral microbiome is distinct between species, as previously described (Figure 3-5). Significant differences in bacterial diversity were found between species (ADONIS: $F_{4,40} = 14.96$, $R^2 = 0.62$, $p < 0.001$), with similar dispersions (variance) around the group centroids (BETADISPER: $F = 1.51$, $p = 0.22$). Total species richness was highest for *Porites* sp. (87.69 ± 33.85, mean ± SE) indicating a more diverse and heterogeneous bacterial community and lowest for *Acropora* sp. (1.92 ± 0.86). Species diversity was highest for *Acropora* sp. (1.89 ± 0.19) and lowest for *Montipora* sp. (1.52 ± 1.04) (Figure 3-5). There was a significant difference between coral species in species richness (ANOVA; $F_{4,31}$ = 6.968, p = 0.0004; Figure 3-5), but no difference detected between coral species for diversity (p>0.05; Figure 3-5).

We also found six bacterial taxa of the order Campylobacterales and the families Leigioinellaceae, Enterobacteriaceae, Peptostreptococcaceae, Staphylococcaceae and Vibrionaceae, which have been associated with faecal pollution in other studies[16,17], however these can also occur naturally. The overall contribution of these taxa was found to be low within the coral microbiome representing less than 0.02% of the total microbial community. The largest contribution was found to be from Vibrionaceae (0.018 ± 0.01% relative abundance), we also detected *Escherichia coli* (also known as *E. coli*) contributing 0.002 ± 0.0009% to overall abundance. The family Peptostreptococcaceae from Clostridia class were also present in the coral samples from Emily Bay, Norfolk Island, but again found in low relative abundance. Further analysis using targeted quantitative analysis is required to determine the source of potential pathogens and their abundance within the marine environment.

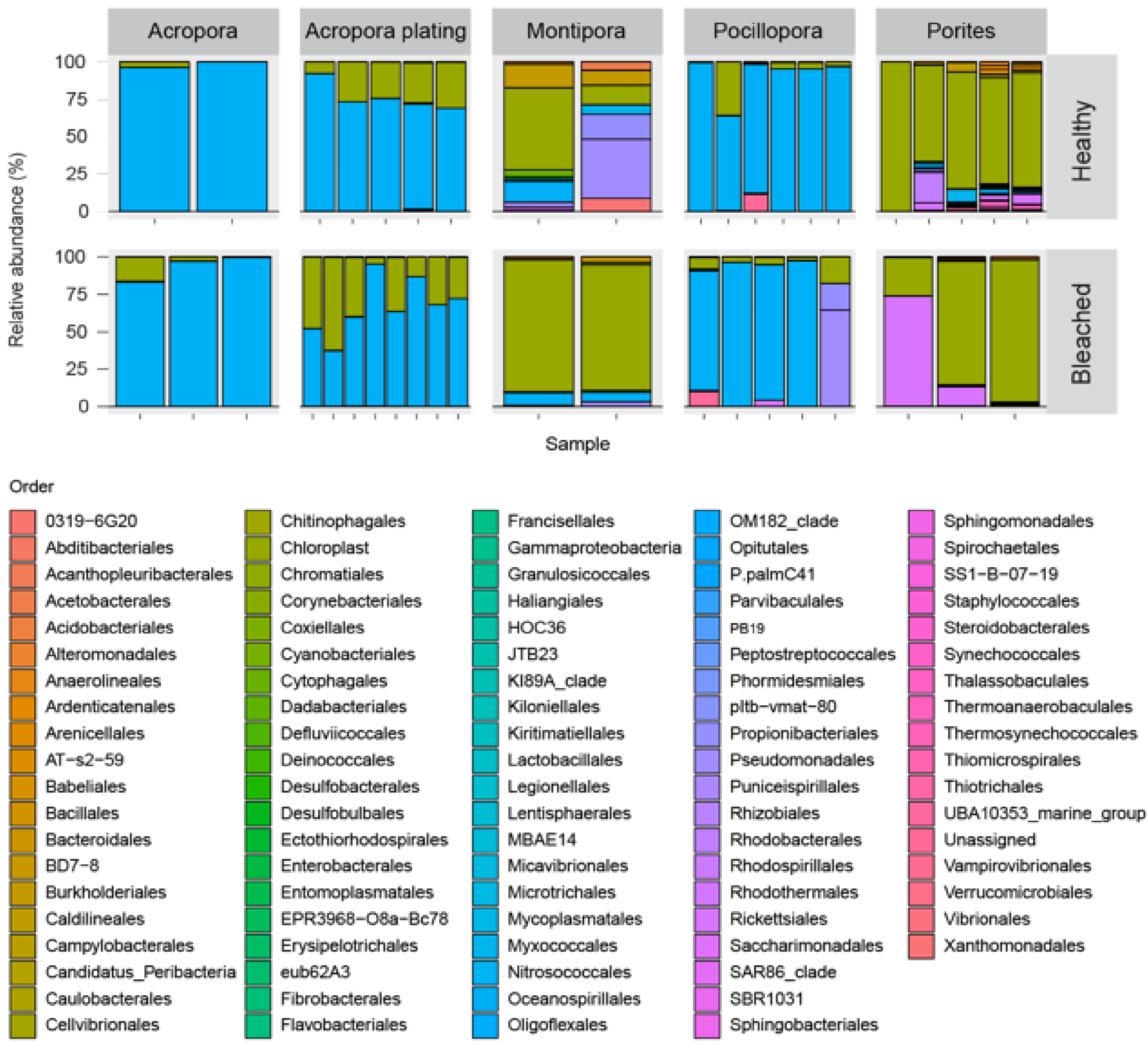


**Figure 3-4. Microbiome of dominant coral genera in Slaughter Bay in March 2020.**

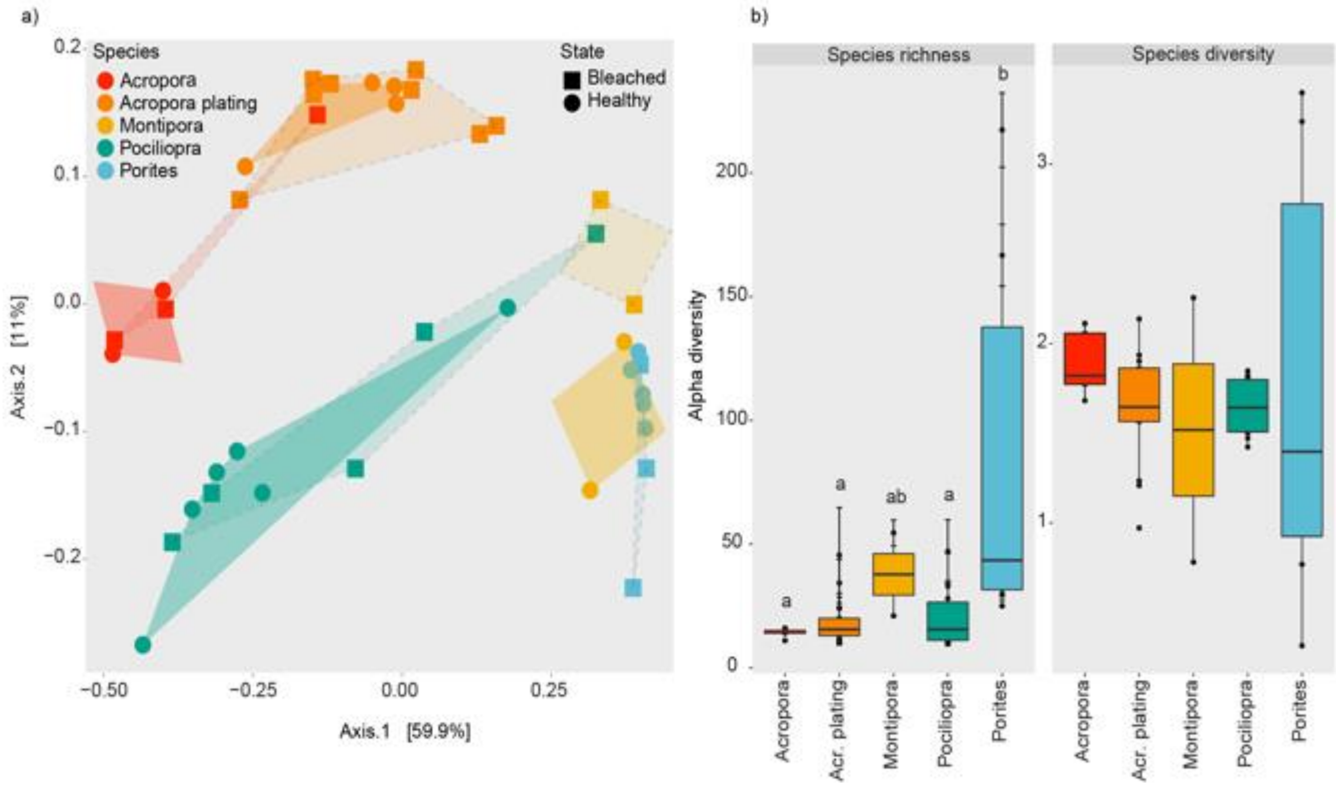


**Figure 3-5. (a) PCoA and (b) species richness and diversity for bleached and symbiotic (healthy) corals collected from Emily Bay during March 2020. Each point on (a) represents a different individual, patterns demonstrate that there are distinct microbial communities associated with each coral species but not discernible change due to bleaching. Similarly species richness and diversity differs between species but not between healthy and bleached corals.**

## *Coral Disease Outbreak 2020- 2021*

***Summary of findings***. Coral disease outbreaks are evident in reef ecosystems impacted by coral bleaching events and periods of poor water quality. During December 2020 and April 2021 disease signs were evident across the reef including growth anomalies, Atramentous necrosis, white syndromes, overgrowth by sponges and boring organisms. Most notably, a severe coral disease was evident within individuals of the genus *Montipora spp*., consistent with previously described Atramentous necrosis disease, with disease prevalence rates of over 50% recorded. This disease has previously been linked to poor water quality. Concerningly, a rapid tissue loss white syndrome was also evident in *Montipora* coral colonies during April 2021, up to 30 cm of live coral tissue was lost within a month from coral colonies estimated to be over 20 years of age. Causes of rapid tissue loss white syndrome diseases have also been linked to heat stress and poor water quality at other sites.

Across both Emily and Slaughter Bays 54% of surveyed *Montipora spp.* colonies were recorded with disease lesions including the white lesions, white spots, dead tissue, exposed coral skeleton, consistent in shape and size, and with previous descriptions of the disease Atrementous necrosis.

On average, 46% of corals of the Montipora genera were recorded as healthy with no disease lesions present. In Emily Bay disease prevalence of 74±7% in December 2020 and 60±7% in April 2021 were recorded. In Slaughter Bay disease prevalence of 56±8% in December and 58±8% in April 2021 (Figure 3-6) were recorded.


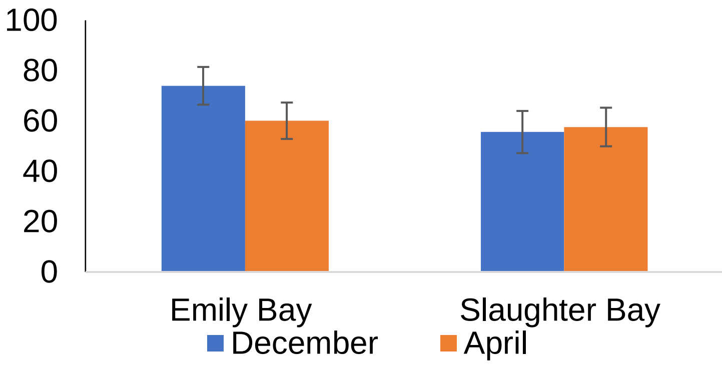


**Figure 3-6. Survey locations (top) and prevalence of Atramentous necrosis disease in *Montipora* colonies (bottom)**

*Atramentous necrosis* was recorded in *Montipora* coral colonies across both Slaughter and Emily Bay survey sites in both December 2020 and April 2021, prevalence was high in both growth of this genera (plating and encrusting-type growth) (Figure 3-7, 3-8).

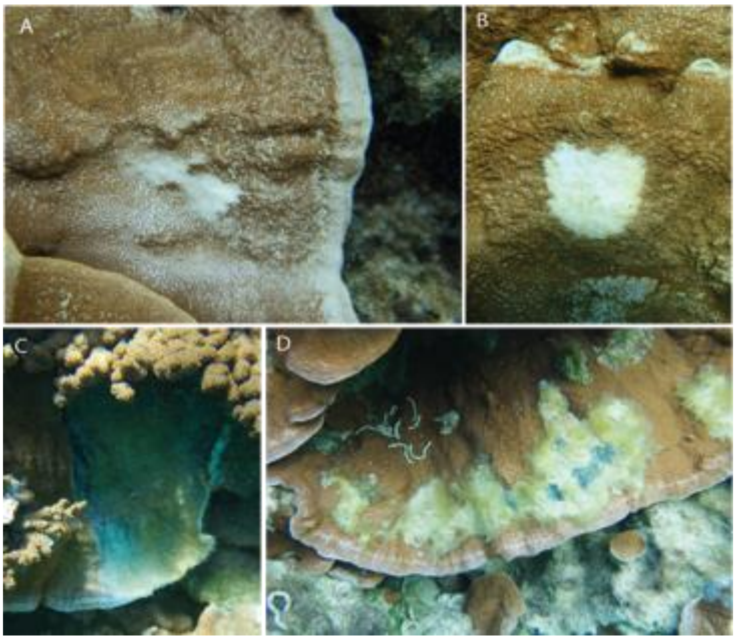


**Figure 3-7. Phases of disease outbreak recorded in *Montipora sp.* in Emily and Slaughter Bays. Initial stage is characterised by patchy bleaching of tissue (A), followed by death of tissue and the formation of a white lesion (B). Lesion can then become overgrown by turf algae, and/or suffer a secondary infection of sulphurous black bacteria (C, D).**

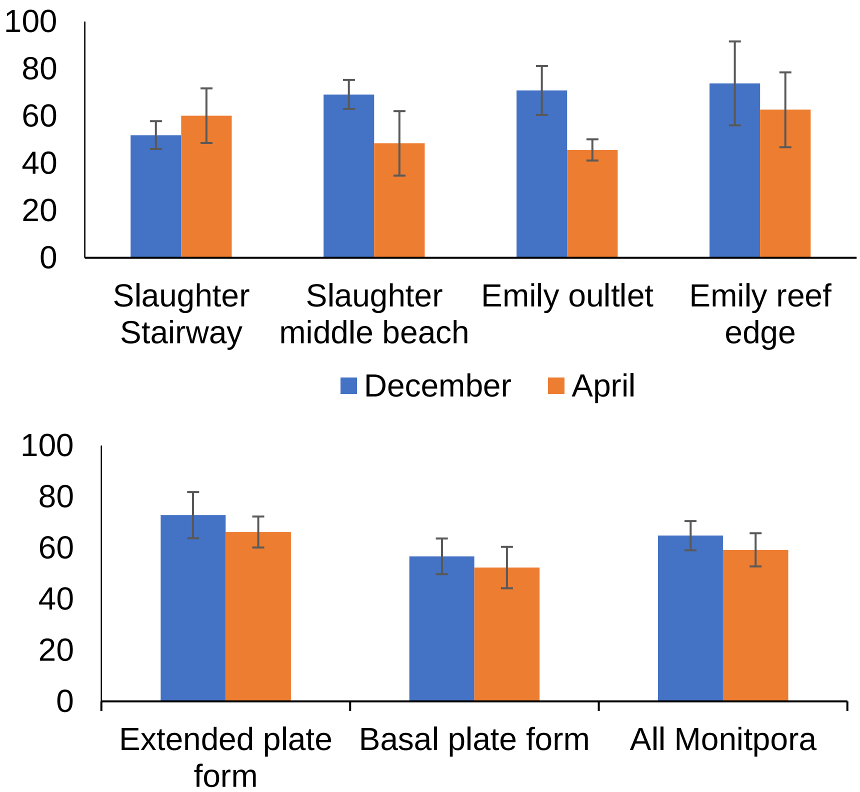


**Figure 3-8. Disease prevalence in corals across the 2 bays and coral growth forms affected.**

Presence and occurrence of Atrementous necrosis coral disease in Emily and Slaughter Bay is similar to a disease outbreak first identified on the Great Barrier Reef known as Atrementous necrosis (AN) in *Montipora spp*. and is one the of the few coral diseases with high prevalence values on GBR (see Table 3-2). Prevalence of the disease outbreak recorded in Emily and Slaughter bay is comparable to other recorded outbreaks of the disease on the central Great Barrier Reef (see Table 3-2). The overall prevalence of disease in other Indo-Pacific reefs, (i.e. Indonesia, <1% in Sulawesi:[18]; Philippines, 8.3%[19]) and the central pacific (<1%:[20]) are generally low. In the Caribbean, disease prevalence values as high as 70% have been recorded during recent outbreaks of stony coral tissue loss (SCTL), although studies have also shown that other disease prevalence on Caribbean reefs is much lower, around 4.2%[21]. Atramentous necrosis was first recorded on reefs around Magnetic Island, an inshore reef of the Central GBR in late December 2001 (Jones et al., 2004). In March 2002, a peak in AN caused significant mortality of the Magnetic Island populations of *Montipora aequituberculata* (species also identified at Norfolk Island) during a thermal mass-bleaching event. Disease prevalence generally increases during summer on reefs in both the Caribbean (Kuta and Richardson 2002) and on the GBR (Willis et al. 2004). Correlations have also been found between disease prevalence and coral bleaching (Page et al. 2009). Notably, on Magnetic Island the maximum prevalence recorded of this disease within the population was 75% during the summer (Jones et al 2004). Notably, prevalence of Atramentous necrosis on the central Great Barrier Reef has been linked to flood events during the wet season, and analysis has shown that spatial patterns in disease prevalence have been correlated to environmental drivers of low salinity and high particulate organic carbon, typical in terrestrial run-off (both sewage and agricultural) (Haapkylä et al. 2011).

In addition to the outbreak of Atramentous necrosis on Emily and Slaughter Bay in late 2020, we also found an increase in other coral disease signs between March 2020 and April 2021**.** White Syndrome disease lesions and coral growth anomalies, both previously linked to poor water quality and heat stress were evident on the reef in April 2021 (Table 3-1). White syndrome disease lesions were also observed to result in rapid tissue loss in affected coral in April 2021 with tissue loss of approximately 400 $cm^2$ observed between March 28$^{th}$ and April 25$^{th}$ within a colony of plating *Montipora* accounting for approximately 90% of the coral colony lost (Figure 3-9).

Coral disease occurrence on the inshore reefs of Norfolk Island from December 2020 to April 2021 is comparable to the highest recorded coral disease outbreaks (Table 3-2). Coral disease outbreaks exceeding 50% of the affected coral species have only been recorded on inshore reefs of the Great Barrier Reef (atramentous necrosis) and Florida Keys (stony coral tissue loss disease). As such we recommend ongoing monitoring of prevalence, tissue loss and colony fate of disease on the reefs of Norfolk Island in 2021.

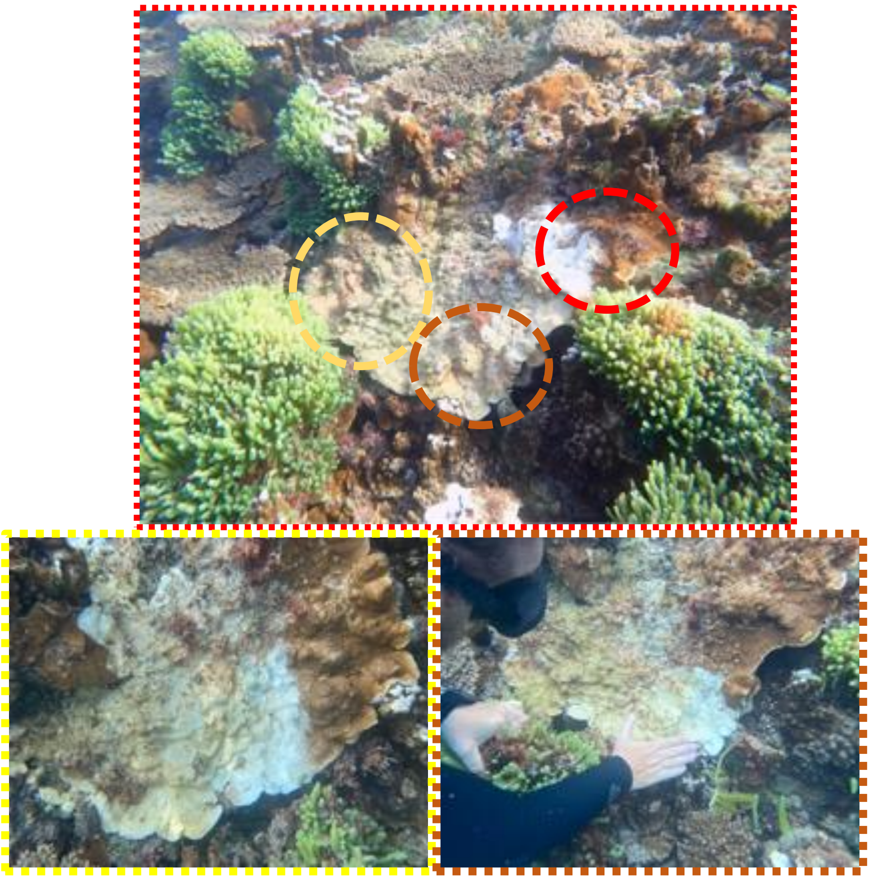

**Figure 3-9. White syndrome affected *Montipora* coral colony April 25th 2021 (top red-bordered image), location of live tissue bordered disease lesion on March 28th 20201 indicated in yellow, and on April 9th indicated in orange.**

**Table 3-1: Common coral health signs recorded on Norfolk Island lagoonal reef.**

| Coral Health category | Present March 2020 | Present April 2021 |
|---|---|---|
| Disease lesions * | No | Yes |
| White syndrome | No | Yes |
| Atrementous necrosis | No | Yes |
| Growth anomalies | No | Yes |
| Predation scaring * | Some | Yes |
| Bleaching | Yes | No |
| Paling | Yes | Yes |
| Coralivorous crabs | No | No |
| Coralivorous snails* | No | Yes |
| Coral ciliate bands * | No | Yes |
| Trauma/Breakage | Some | Yes |
| Sedimentation | Some | Yes |
| Competition with algae | Yes | Yes |

**Table 3-2. Coral disease outbreak occurrence globally.**

| Disease | Species | Location | Survey time | Prevalence | Reference |
|---|---|---|---|---|---|
| Atrementous Necrosis | *Montipora spp.* | Norfolk Island | Nov/Dec 2020 | 54% | |
| Atrementous Necrosis | *Montipora spp.* | Central GBR, Magnetic Island | 1st October 2003 (spring)<br>27th October 2003 (spring) | 12%<br>52% | 27 |
| Atrementous Necrosis | *Montipora aequituberculata* | Central GBR, Magnetic Island | 23rd January 2002 | 75% | 25 |
| Stony Coral Tissue Loss | *Montastrea cavernosa*<br>*Orbicella faveolata*<br>*Dichocoenia stokesii* | Florida Reef Tract | Average prevalence from May 2014 to December 2017 | 70%<br>52%<br>58% | 28 |
| Stony Coral Tissue Loss | *Pseudodiploria strigosa*<br>*Meandrina meandrites*<br>*Siderastrea siderea* | Mexican Caribbean | Average prevalence from 2018 - 2019 | 42%<br>40%<br>28% | 29 |
| Skeletal Eroding Band | *Pocillopora eydouxi*<br>*Seriatopora spp.*<br>*Stylophora pistillata* | GBR (18 reefs, spanning 500 km) | Average prevalence across the summers from 2004 - 2006 | 8.5%<br>5.8%<br>4% | 30 |
| Ulcerative White Spot | Staghorn *Acropora*<br>Massive *Porites* | Heron Island, Southern GBR | Average prevalence across November 2007 - August 2009 | 5.5%<br>1% | 31 |
| Black Band | *Dipastraea*<br>*Montipora*<br>*Pavona* | Red Sea | November and December 2015 | 6.1%<br>3.7%<br>8.2% | 32 |

***Section 4. Summary of findings and associated management considerations***

**1.** Repeated significant rainfall events (>30 mm in a single day) following an extended period of low rainfall (below average annual rainfall has been recorded in 8 of the previous 9 years) occurred in May, July, August and November. Rainfall periods corelated to elevated seawater nutrient levels above the above Australian and New Zealand Environment and Conservation Council trigger values within Emily Bay and Slaughter Bay, and increases in thermotolerant and enterococcus bacterial counts recorded by Norfolk Island Regional Council.

**2.** Elevated seawater temperatures recorded in February and March 2020 resulted in an accumulated thermal stress (coral bleaching) of 9.36 DHW's (degree heating weeks) exceeding the 8 DHW (degree heating weeks) associated with severe bleaching and significant coral mortality

**3.** Passage of Tropical cyclone Gretel (March 16$^{th}$) near Norfolk Island was corelated with high currents and significant rainfall, and alleviation of heat stress accumulation.

**4.** Extensive coral bleaching was recorded in March 2020, with over 30% of each of the 3 dominant growth forms of corals found to be bleached or paled during the bleaching event. Taken together the bleaching event would be categorised as a severe bleaching event for a coral reef ecosystem.

**5.** In June 2020 both branching and mounding corals were still found to be displaying signs of bleaching or paling, however by November 2020 no paling or bleaching was found, suggesting coral recovery. Coral mortality across the 2020 period was evident on the reef and was likely the result of the cumulative impacts of bleaching and land-based runoff.

**6.** Over the survey period we record a 19-fold increase in fleshy algal cover (from $2 \pm 1\%$ to $37 \pm 7\%$) with a concomitant decrease in green and red algae. A significant increase in fleshy macroalgae, as recorded within the study period, is consistent with declining reef health, however during the survey period there was no significant change in coral cover.

**7.** Algae are the major competitors with corals for space and are a natural part of any coral reef system, however on coral reefs in a healthy coral dominated state algal cover is dominated by turfing algae. Large fleshy algae are reported as unpalatable to herbivores and associated with lower herbivory rates leading them to outcompete resident corals, they also significantly benefit from increased nutrients.

**8.** A coral disease outbreak, putatively identified as Atrementous necrosis, was observed on *Montipora* spp. colonies during the December 2020 and April 2021 scientific survey period (54% of colonies affected). This disease was not evident in March 2020 in the Emily and Slaughter Bay targeted bleaching and disease surveys period or observed in the video transects collected by residents in June and September 2020. Causes for Atrementous necrosis outbreaks in other regions have been linked to inshore reefs, poor water quality and sedimentation.

**9.** Rapid tissue loss white syndrome disease outbreak was also evident within plating *Montipora* coral colonies during March and April 2021, tissue losses of 30 cm of live coral tissue within a month were observed in coral colonies estimate to be over 20 years of age (This potentially equates to a loss of 10-15 years of average growth). Large areas of growth anomalies were also observed on plating Acroporid corals.

**10.** On-going survey of disease in coral colonies is needed to determine the long-term impacts of this disease along with surveys of other sites around the island for disease occurrence.

**11.** It is recommended that an annual report card of coral cover and health is undertaken to inform stakeholders of the condition of the reef environment and changes relative to previous years.

**12.** Given the isolated nature of Norfolk Island, it is currently unknown the source of juvenile corals and fish recruiting onto the reef. In a disturbed environment, sufficient recruitment is required to maintain healthy population stocks and aid in recovery. Coral spawning was reported by the local residents of Norfolk Island in January 2021 occurring several days following the full moon. No juvenile corals were observed on the reef structure during surveys using GFP switch torch in March and April 2021, as such no evidence for recruitment could be obtained at the time of survey. It is recommended further study of coral recruitment is undertaken to determine recruitment rates and possible larval sources. Also given the remoteness of the island a comprehensive study for endemic species may be warranted.

**13.** Given the strong hydrodynamics around the Island, future survey efforts combining remote operated vehicle (ROV) would aid in surveying offshore lagoonal reef locations. This will also provide the potential for survey data in less accessible locations including Norther Islets, Bombora's, Anson Bay and Ball Bay.

**14.** It is recommended that a variety of public education resources, including coral identification card, coral health identification card, fish ID cards, are produced to increase community and tourist engagement with the reefs of Norfolk Island.

**Management resources provided**

1. 360 video of Cemetery Bay Norfolk Island (YouTube https://youtu.be/jGRnc3IA5bo) (high resolution video provided by file transfer)
2. 360 video of Slaughter Bay Norfolk Island (YouTube https://youtu.be/nXEZXZGXsSU) (high resolution video provided by file transer)
3. Video of proposed snorkel trail location and benthic survey sites used throughout the survey period (SB1-SB5, EB1-EB3) (high resolution video provided by file transfer)
4. Booklet Coral Species Identification
5. Booklet Algal species identification
6. Coral Health Card


**Figure 4-1. Path of continuous Gopro video footage of the benthic community for preliminary identification of specific reef zones ideal for snorkel trail activities**

## *Section 5. Review of Scientific literature and government reports*

**Introduction**. Southern Norfolk Island includes the regions of Emily and Slaughter Bay and the lagoonal reef incorporates an intertidal barrier platform with coral growth and the bays host the highest recorded coral cover adjacent to the Island. Emily Bay and Slaughter Bay together form a ~0.18 km$^2$ intertidal lagoon. The Emily and Slaughter Bay reefs support local tourism initiatives and have high societal value. One of the earliest reports on Norfolk Island coral reef ecosystem (1988), undertaken by the Australian National Parks and Wildlife Service, refers to the high value of the Southern reef to the local community and reports concerns within the local community regarding the health of the system (Ivanocivic 1988, NPWS report see attached). The 1988 report into benthic population structure and coral cover notes that at that time the local communities reported concerns for a reduction in corals, loss of fish species, decline in ecosystem health, and attributes long running land-based nutrient influx into the bay as a possible driver of declining ecosystem health. The report however also notes high coral cover in some study sites (ranging from 14% - 64%; *see section Historical Data*) with corals appearing healthy with little to no observations of dead or algal covered corals. Subsequent reports over the intervening 30 years also characterise coral species assemblages (Veron 1997 see attached), benthic algal species (Miller 2000), fish species (Francis and Randall 1998; Francis 1993, Van Der Mer 2015), and the general species occurrence (Edgar et al. 2017; Reef Life Survey conducted in 2009). Norfolk Island's catchment usage and water movement has also been investigated with early descriptions of the islands' hydrology in 1976 (Abel 1976, see Figure 3 from Abell). The work by Abell illustrates the position at the southern end of the island adjacent to the Kingston lowland (Figure 5-1) and the connectivity between ground water and the adjacent seawater in this location.

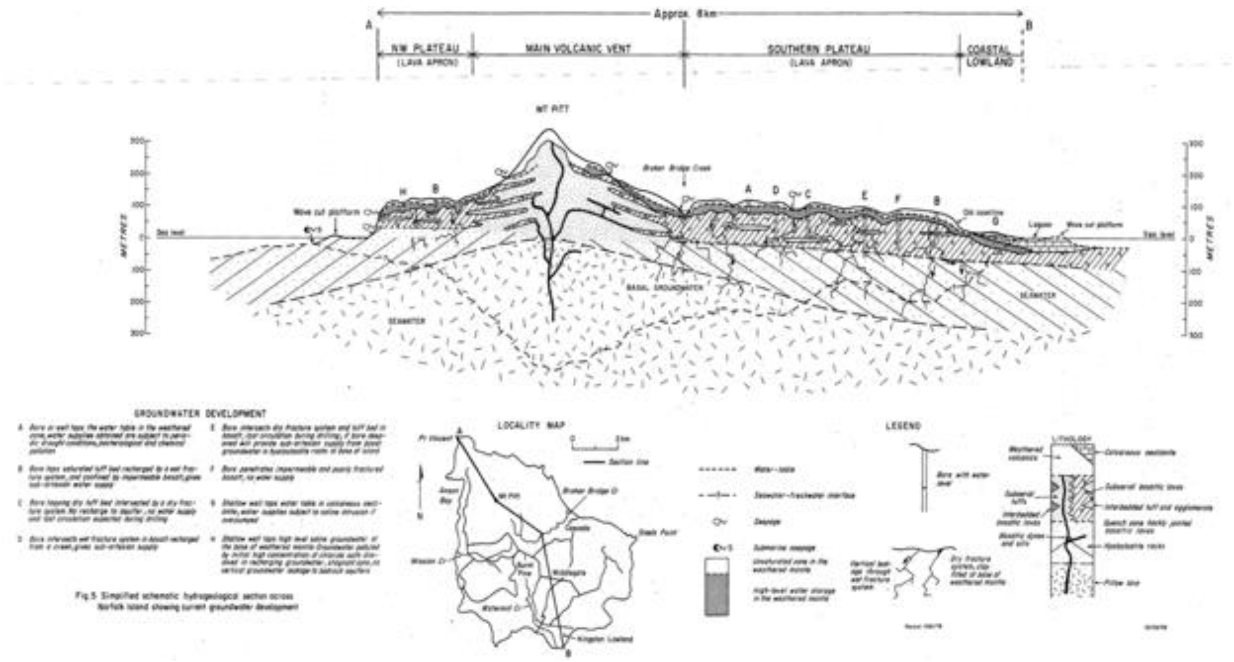


**Figure 5-1. Hydrogeological section of Norfolk Island prepared by Abell (1976).**

Coral reef lagoon ecosystems are generally classified as oligotrophic (nutrient poor) due to the relatively low concentrations of dissolved inorganic nutrients in the water column (< 1 µM $NH_4^+$ and $NO_x$) or organic matter deposited within the sediment (< 2% nitrogen; Koop et al., 2001). The surrounding surface oceans of tropical and sub-tropical latitudes are some of the most nutrient-depleted areas on the planet (referred to as ocean deserts; Atkinson, 2011) and any nutrients produced within the reef itself are quickly recycled by the nutrient-starved benthic community. Eutrophic conditions on coral reefs (5 – 20 µM $NH_4^+$ and $NO_x$; Fabricius, 2005) are generally caused by land-based nutrient introduction (e.g., runoff of organic matter or nutrients). Analysis of dissolved inorganic nutrients in coral reef seawater can therefore indicate if runoff is elevating the nutrient concentrations within a reef lagoon on relatively short time scales (hours to days) as pollution occurs, while the analysis of sediment organic matter composition helps determine the relatively longer, accumulated effect of nutrient runoff (months to years) (Yamamoto et al., 2001). Taken together these analyses can provide information for management agencies for alleviating the impacts of pollution prior to the emergence of impacts at biological and ecological scales. The impact of water quality and runoff on the health of corals and coral reefs has been widely documented within the scientific literature. Studies have shown high coral disease prevalence, increased sensitivity to coral bleaching, lower coral cover and higher competition with algae occurring on reefs that are impacted by pollution, runoff, land-based pollution, sedimentation and nutrient influxes. For example, on Australia's Great Barrier Reef the GBRMPA (Great Barrier Reef Marine Park Authority) Sewerage Discharge Policy provides regulations governing maximum nitrogen and total phosphorus loads discharged in the park. Monitoring guidelines within the GBR marine park include regulations on daily and monthly water quality monitoring, visual inspections for evidence of water contamination, including turbidity and slick formation adjacent to outfall and discharge sites. Coral disease, bleaching and poor health outcomes associated with pollution have been correlated to freshwater runoff, increased nutrients, pathogenic and opportunistic microbes and toxins, as well as the additive and synergistic impacts of these factors on impacted reef systems (Figure 5-2; Table 5-1).

**Table 5-1. Summary of published literature providing evidence linking incidence of coral disease and pollution (See Moriarty et al. 2020).**

| Location | Disease | Species | Main findings |
|---|---|---|---|
| Guam | White syndrome disease | *Porites* spp. | Increases in sewage derived N correlated significantly with increases in the severity of disease among Porites spp. $\delta^{15}N$ values account for more than 48% of variation in disease severity. |
| St Croix, US Virgin Islands | Black band disease<br>White plaque<br>Dark spot syndrome. | Various Scleractinia | Results of the study suggest a relationship between high prevalence of BBD and WP type II and exposure to sewage. |
| Florida Keys | White Pox disease | *Acropora palmata* (Elkhorn) | Identification of a strain of faecal enterobacterium (*Serratia marcescens*, PDR60) in sewage, diseased *Acropora palmata* and other reef invertebrates. |
| Puako, Hawaii | Porites growth anomalies | *Porites lobata* | Results implicate sewage pollution as a contributor to diminished reef health and a relationship between Porites growth anomalies and sewage pollution. |

In 2015 Wear and Thurber[38] reported that, compared to other threats to coral reef ecosystems, the potential impacts of sewerage have been understudied and highlight that for 112 distinct coral reef geographic regions listed in the World Atlas of Coral Reefs the majority utilise ocean outfalls as sewerage treatment, and only 3 regions are free of human sewerage impacts, due to a lack of significant human populations. Importantly the authors note that sewerage impacts are likely strongest in areas with little water flushing of the reef and in close proximity to human populations centres. Land-based runoff directly into reef lagoons can occur as a result of residential, commercial and industrial scale use of lagoon adjacent land, with the impact determined by the quantity of discharge into the marine environment including the rate of exposure, level of prior treatment, and the distance of the discharge from the adjacent reefs. Impacts to corals and coral reef ecosystems that have been associated with run-off and poor water quality from increased nutrients within the water column are evident across the levels of biological organisation include;

*Microbiome*

- Increase in disease associated microbes
- Decrease in symbiotic/mutualistic microbes (shifting from healthy microbiome)
- Increase in microalgal overgrowth

*Organism function*

- Reduction in coral growth
- Reduction in coral reproduction

*Organism health*

- Increase in coral diseases and disease occurrence within a species and reef location
- Increase occurrence specifically, but not exclusively, of black band disease, growth anomalies and white syndromes
- Increase in algal overgrowth
- Increase susceptibility to bleaching
- Decrease in immune function

*Ecosystem state*

- Invasive species and/or community shifts
- Increase in abundance of coral predators, urchins and starfish associated with poor water quality
- Blooms of phytoplankton and microbes within the water column
- Fish kills

- Disruption of normal ecological function

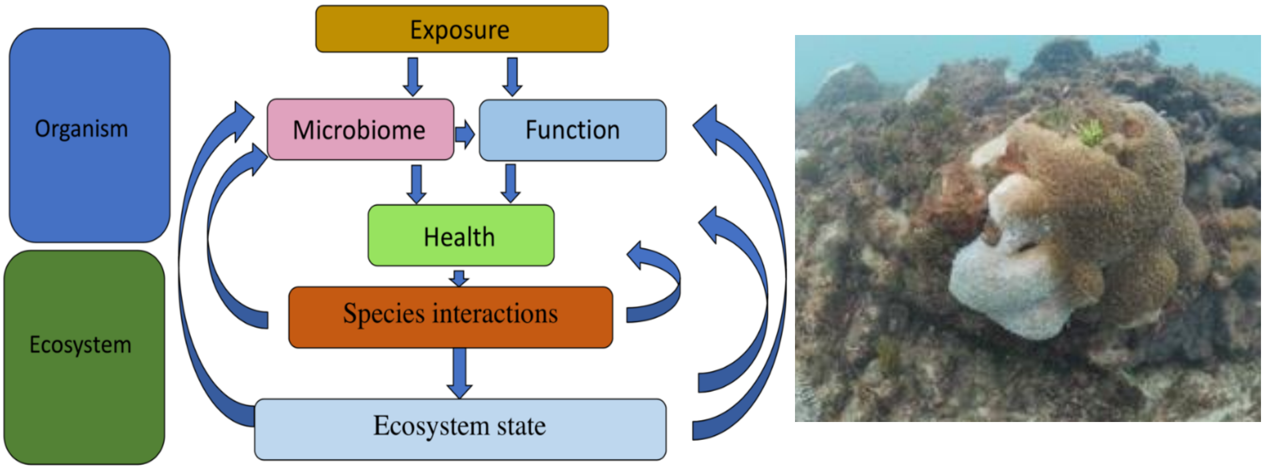


**Figure 5-2. Conceptual diagram of biological and ecological impacts from land-based pollution to coral reefs, photo illustrates a diseased coral (affected at organism level) with negative interaction with other species (ecosystem level).**

Worldwide water pollution regulations on coral reefs typically require that land-sourced outfalls do not directly flow into reef areas and receiving areas are designated for removal of potential pollutants associated with waste away from the reef system. Waste receiving areas are typically at water-depths exceeding reef lagoons and in areas of high-water flow. However, there are several local-scale and site-specific factors that influence the impact of land-based pollution to reef lagoons, and the subsequent impacts to the health of corals and the ecological variability on coral reefs, that are in proximity to human populations. Local-scale and site-specific variables that can influence the health of corals within a lagoonal reef include water residence time, water mixing via flow, current and wave action and tidal variation. Ground water incursion into lagoonal reefs can also impact water salinity, induce freshwater lensing as well as being a source of land-based pollution. These variables are also likely to impact the health of corals within the Emily and Slaughter Bay lagoonal reef system, however the health of the reef system has to date not been widely investigated, nor has the influence of variables such as water flow, tides, currents, and groundwater incursion on coral health and resilience. Therefore, effective reef management of the system requires a greater understanding of the ecological, environmental and anthropogenic influence over the future sustainability of the Norfolk Island lagoonal reefs system.

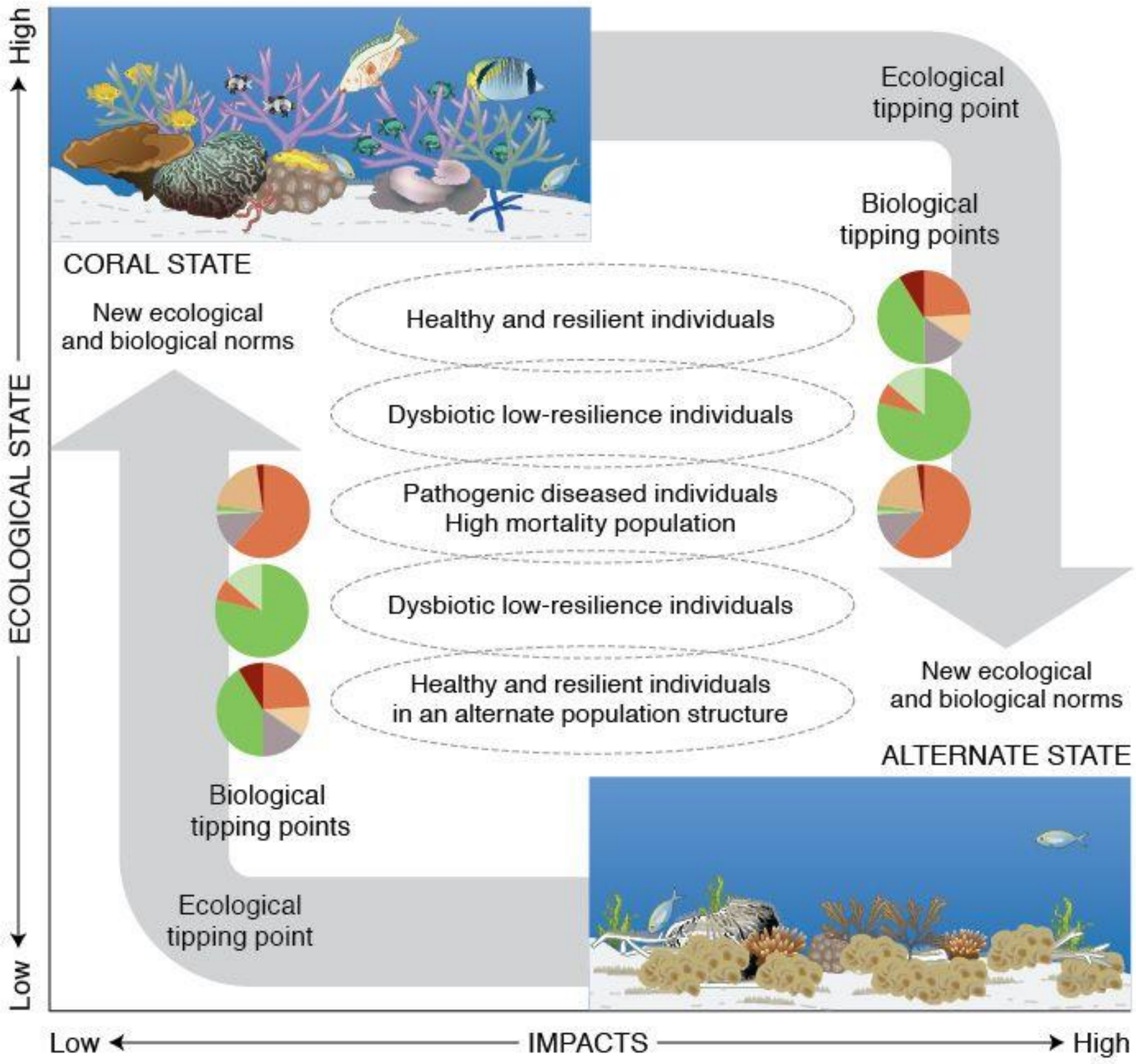


**Figure 5-3. Conceptual diagram of biological and ecological tipping points under increasing anthropogenic impacts.**

| TERM | DEFINITION |
| --- | --- |
| **Sea Surface Temperature (SST)** | Ocean 'skin' (top 10 micrometres) temperature remotely measured by satellites. Used to make predictions of coral bleaching events. |
| **MMM** | The area-specific, maximum temperature historically experienced by corals. Historical baseline is the average of the means of the hottest months, for each year between 1985-1993. |
| **HotSpot** | An anomalously high SST, where anomaly is relative to the MMM baseline. |
| **Degree Heating Weeks (DHW)** | A measure of heat stress representing the cumulative duration of Hotspots > MMM + 1°C within a three-month period. |
| **Marine heatwave (MHW)** | A discrete period of anomalously warm seawater temperatures. Formally defined as the temperature being above the 90$^{th}$ percentile of all temperatures at that location within its 30 year (1982-2012) climatological history, for at least five days consecutively. |
| **Biophysical drivers** | The suite of physical environmental conditions that directly interact with organism physiology to produces broader ecological patterns in response to environmental change. |
| **Ecological phase shift** | A shift between two alternative stable states in an ecosystem. On coral reefs, this most commonly refers to a transition from coral-dominated to algae dominated. |
| **Dissolved inorganic nutrients** | The major nutrient groups (phosphates, silicates, nitrates, nitrites, and ammonium) dissolved in seawater. |
| **Organic matter** | Organic sources of nutrients on coral reefs; subsequently consumed and broken down by reef organisms. |
| **Oligotrophic** | Lacking in, or very low, in nutrient concentrations. Characteristic of waters of a healthy coral reef. |
| **Eutrophic** | Describes a water body that is very high in nutrients, often causing rapid growth in algal populations. |
| **Benthic** | Related to the seafloor; as opposed to 'pelagic' |
| **Healthy coral** | Any coral that shows no visible signs of poor health (disease, paling, overgrowth) |
| **Coral paling** | The earliest visual signs of coral bleaching, due to a partial loss of symbionts and/or degradation of their pigments *in situ* |
| **Coral bleaching** | The breakdown of symbiosis between corals and algae living within their tissue. Leaves the coral looking white and at increased risk of mortality. A generalised stress response. |

| | |
|---|---|
| **Recently dead coral** | Dead within ca. the previous week, where the substrate is still identifiable by coral genus and significant overgrowth of the dead skeleton has not occurred |
| **Turf algae** | Though there is no commonly held definition of turf algae, they tend to be short (< 10mm) and do not contribute to reef structural complexity. |
| **Red turf algae** | As above, but red in colour suggesting the algal population is primarily red algae or cyanobacteria |
| **Fleshy algae** | Akin to 'ungrazed turf', these are overgrown patches of algae (including long, black cyanobacterial tufts) that smother corals and other algae (especially when growing as epiphytes). No structural complexity added by these algae, though they are larger than turfs. |
| **Macroalgae** | Tough, leathery algal species with distinguishable fronds, which often contribute structure to the reef (e.g. *Caulerpa* meadows on sand patches) but might also be harmful and not easily grazed (e.g. *Dictyota*). |
| **Calcifying algae** | Algae that produces hard skeletons of calcium carbonate, and so contribute to reef growth and sediment turnover. Includes rhodoliths, articulated coralline algae and crustose coralline algae. |
| **Coral disease** | Any impairment to coral health resulting in physiological dysfunction. |
| **Tissue loss** | The loss of coral tissue (i.e. detachment from skeleton) as a result of environmental and physiological stress. |
| **Lesion** | Coral paling, bleaching or tissue loss in a localised area of the colony. |
| **White syndrome** | A general term given to diseases that cause tissue loss (exposing the white skeleton underneath) without an identified causative agent. |
| **Atramentous necrosis** | A coral disease characterised by distinct lesions caused by an initial bleaching phase, follow by tissue loss and overgrowth by a number of secondary infections, including a sulphurous black bacterial community. |

## *Section 6. Methodology*

**Methodology. Water quality analysis**. Since March of 2020, seawater has been regularly collected at Emily and Slaughter Bay to assess seawater salinity and concentrations of dissolved inorganic nitrogen (nitrate + nitrite [$NO_x$] and ammonium [$NH_4^+$]). Salinity samples were collected in a 20 ml falcon tube, refrigerated, and measured with a refractometer. Nutrient samples were collected in a 15 ml falcon tube, frozen, and transported to the UNSW Analytical Centre for Flow Injection Analysis.

Collections have been undertaken at six timepoints: March 2020 (Results initially presented in July 2020 Report), September 2020, November 2020, December 2nd 2020, December 8$^{th}$ 2020, and December 10$^{th}$ 2020. During March 2020 sampling efforts, seawater samples were collected at 10 locations along the shoreline (Figure 5) in Emily and Slaughter Bay to assess seawater salinity and concentrations of dissolved inorganic nitrogen (nitrate + nitrite [$NO_x$] and ammonium [$NH_4^+$]). Samples were collected at each shoreline location at peak high and low tide on two separate days, resulting in a total of 40 seawater samples. Salinity samples were collected in a 20 ml falcon tube, refrigerated, and measured with a refractometer. Salinity was found to vary between 37 – 38 ppt, consistent with normal seawater salinity (Figure 16). Nutrient samples were collected in a 20 ml falcon tube, frozen, and transported to the UNSW.

Collection of seawater samples during the September and November timepoints was done by local Norfolk council members under the direction of Dr Lantz and Dr Ainsworth (who were off island). Collections in September were done by a boat at each survey starting GPS point (n = 7 per bay) and collections in November were done directly inshore of these points (coliform levels unsafe to access lagoon; n = 7 per bay). Collections by council in November also included two samples from the bore water well upstream of the Emily Bay outlet. All samples collected in September and November were frozen by council, packaged together, and shipped to UNSW for analysis in November of 2020. December seawater collections were performed by the team on-island and reflected a more comprehensive survey approach. Seawater samples were collected at locations both along the shoreline and at depth in the lagoon at each logger station to provide comparability to both September (lagoon) and November (shoreline) data. This effort was repeated on 3 separate days, once at the beginning while dry (December 2$^{nd}$ 2020 and December 8$^{th}$ 2020) and a third time following a rain event (Dec 10$^{th}$ 2020). Additionally, samples were also collected along the shoreline at Cemetery Bay on December 8$^{th}$ for comparability.

**Methodology : Benthic Survey** The work with this report was conducted under contract with Parks Australia. Initial benthic surveys were conducted on snorkel over a period of 14 days from February 28th to March 12th 2020, within the Norfolk Island lagoon encompassing Emily Bay and Slaughter Bay (Figure 5).

Due to Covid-19 travel restrictions, which meant researchers were unable to return to Norfolk between March and October, and high bacterial counts in Emily and Slaughter Bay following rain events, boat-based videos surveys were conducted by GP Services in June and September, followed by in-water surveys between the 28th November and the 11th of December by researchers.

Feb/March underwater surveys were conducted at 7 transects at both Emily and Slaughter Bay. For each 10 m transect 10 photos were taken at 1 m increments within the Emily Bay zone (EB) and Slaughter Bay zone (SB; n = 10 photos transect$^{-1}$; Figure 5; Supplementary Table 1). Photographs were taken underwater with a TG-6 Olympus underwater camera and photo area was standardised with the use of a 1 m$^2$ quadrat. Coral cover, species identification, disease and health signs, bleaching severity were all recorded. The resulting 140 photos (70 site$^{-1}$) were analysed using the online platform CoralNet (Figures 6, 7) with a grid of 100 points per photo. Data were recorded as the cover underneath each point according to a set of pre-defined labels which describe benthic cover and, should that cover be coral, its morphology and health. Data generated was also compared to previous reports from 1998. Comparisons of benthic data through space (Emily Bay vs. Slaughter bay) and time (1988 vs. 2020) were performed statistically with a t-test to test for significant differences in cover by category. However exact GPS

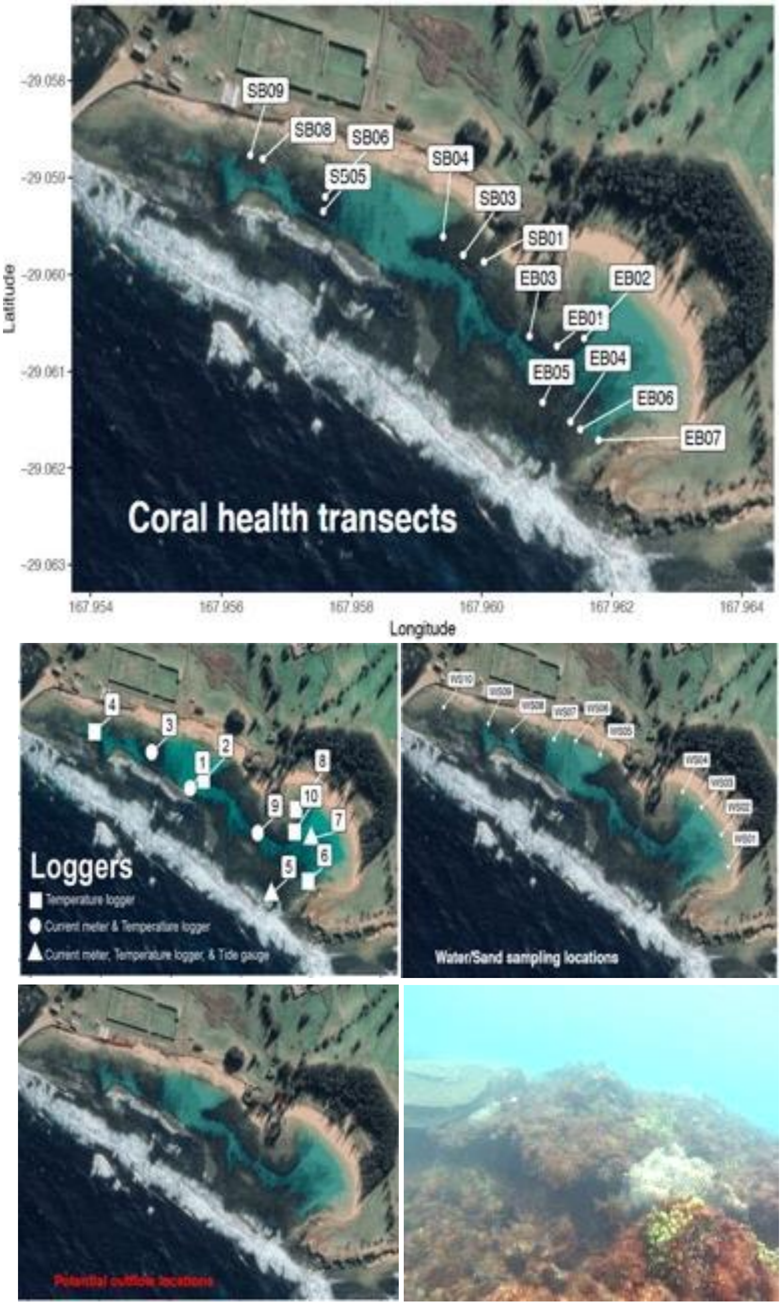


**Figure 6-1: Location of initial benthic surveys conducted in Emily Bay (EB; n = 7) and Slaughter Bay (SB; n = 7) within the southern facing lagoon on Norfolk Island.**

coordinates for historical surveys (1998) are not available and due to the highly heterogenous nature of the lagoonal reef habitats within Emily and Slaughter Bay survey location can influence the assessment of coral and algal cover, as such direct comparison between 2020 and 1998 should be viewed with this consideration.

In addition, loggers were deployed at a further 10 sites (Figure 5) and water and sediment samples were collected at an additional 10 inshore sites distributed across the length of the Emily Bay (sites annotated EB) and Slaughter Bay (sites annotated SB) region. In June (3rd June) boat-based surveys and individual photographs were taken at the GPS coordinates of the Feb/March in water surveys which were analysed as for the initial surveys (10 photos in total), as such this represents the survey with the least benthic coverage. A subsequent survey in September (1st September) include boat-based video transects overlaying the GPS coordinates of the initial surveys. For each assessment, the video survey footage was used to generate 10 non-overlapping stills per transect were and analysed as or the initial surveys (total of 70 photos), to provide benthic cover data.

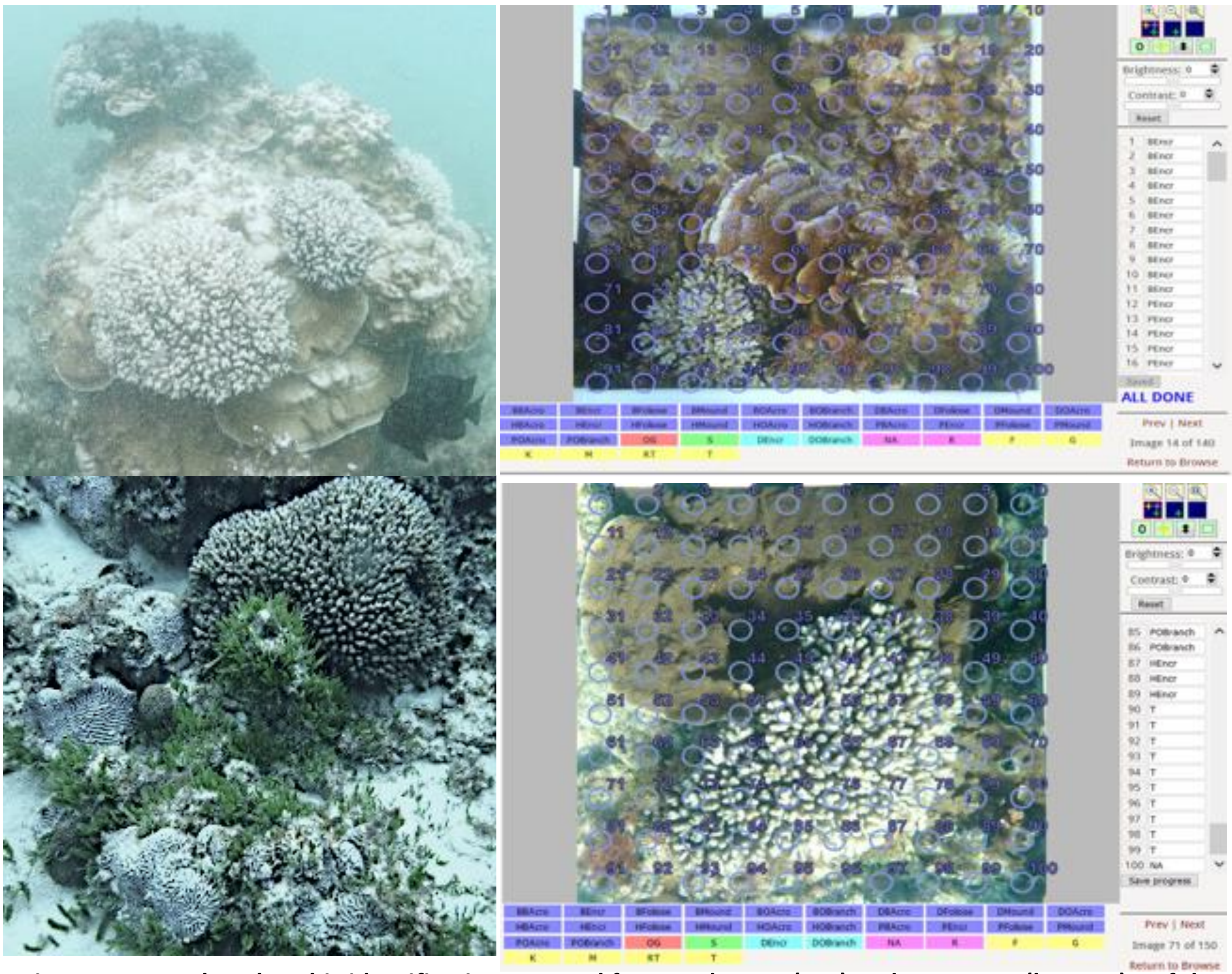

**Figure 6-2. CoralNet benthic identification protocol for March 2020 (top) and June 2020 (bottom). Left hand images provide representative coral images, right hand side images illustrated CoralNet analysis.**

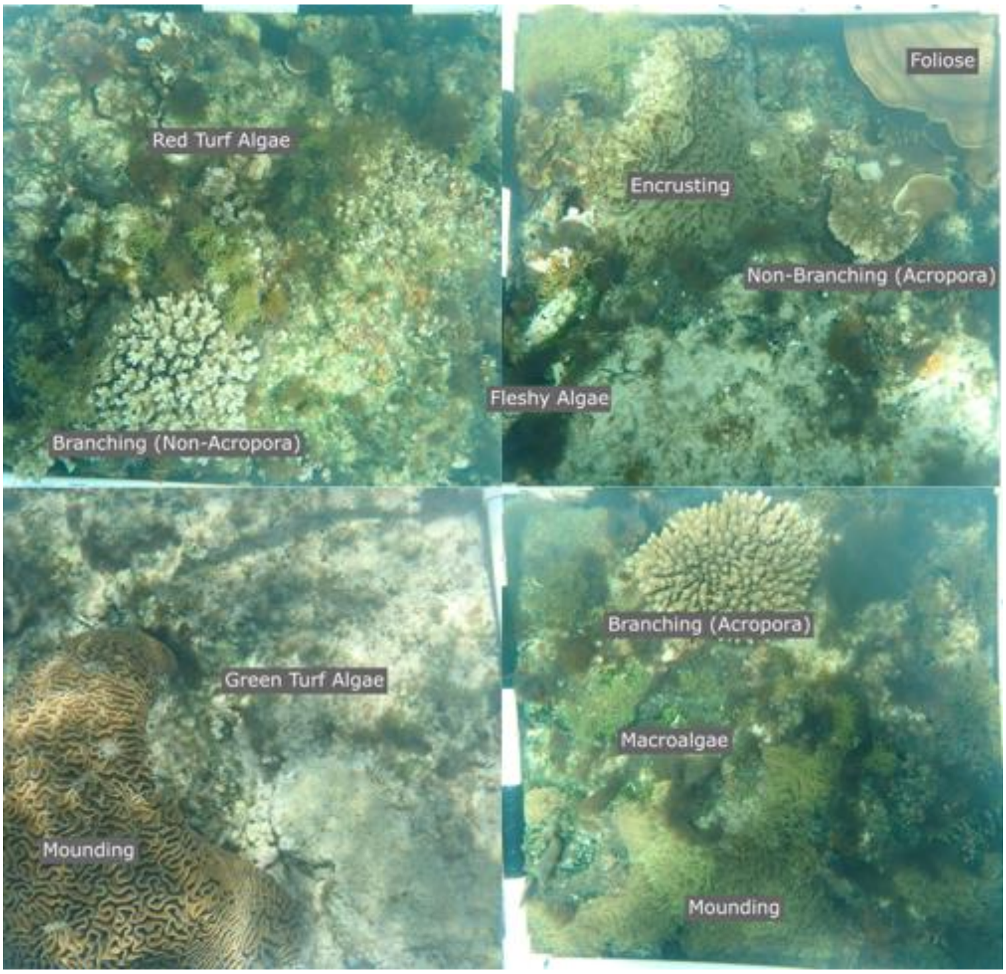


**Figure 6-3: Example benthic survey photos highlighting the commonly observed coral and algae categories**.

November and December 2020 in water surveys were conducted as per the initial surveys and for the 7 transects in each bay plus an additional 8 transects at Emily Bay (total of 15 transects) and 13 at Slaughter Bay (total of 20 transects), from each transect 10 photos were analyses (representing a total of 350 photos across both bays). These approaches are similar to other coral health monitoring approaches (Table 2) and algal cover. Coral samples for microbial analysis were collected within the Norfolk Marine Park under approval of Parks Science and Strategy Section, permit number AU-COM-2020-478.

**Table 6-1: Examples of sites and monitoring practices used to investigate water quality reef ecosystems**

| Location | Sites | Ecological | |
|---|---|---|---|
| Surin Marine Park, Thailand | 2 sites impacted by secondary treated discharges directly into the sea, 2 sites not impacted by sewage. | Corals – benthic assemblages surveyed using 50 m replicate line intercept transects at 3 depths (5, 10, 15 m) at each site. Categories used in the classification of the seabed were a) coral growth form and susceptibility to human impacts, b) algae taxa, c) type of bare substrate.<br><br>Fish – Fish abundance and diversity were quantified using 5 m wide belt transects that were 50 m long, also with at 3 depths per site. Identified to lowest possible taxon. | |
| Nanwan bay, Taiwan | 23 collection sites were chosen around Nanwan Bay. | Coral and macroalgae cover was estimated using the line intercept transect method (50 m in length) where every 5 m, the shape and length of transect tape covering the coral or algae were measured. | The following water quality parameters were measured: pH, five days of biochemical oxygen demand, nutrients, chlorophyll a, suspended solids and turbidity. |
| Puako, Hawaii | 10 study sites were selected to capture variation in coral health and sewage pollution. | Three replicate 15 m transects at each of the 10 sites, with 10 0.5 x 0.5 m quadrats placed along each side of the transect (20 quadrats per transect). | |
| Phuket, Thailand | Three sampling sites were chosen that were expected to have differing levels of pollution. | Coral conditions (percentage cover), fish species richness (number of species), fish abundance, macroalgae percentage cover and richness.<br><br>Corals – benthic assemblages surveyed using 50 m replicate line intercept transects at 3 depths (5,10,15 m) at each site. Categories used in the classification of the seabed were a) coral growth form and susceptibility to human impacts, b) algae taxa, c) type of bare substrate.<br><br>Fish – Fish abundance and diversity were quantified using 5 m wide belt transects that were 50 m long, also with at 3 depths per site. Identified to lowest possible taxon. | Water quality measured at five sites within each bay at three depths (5, 10 and 15 m). Parameters measured included: pH, DO, suspended solids, nutrients, salinity and turbidity. |

Water, sediment and coral samples were imported to New South Wales from Norfolk Island following collection under permit 0004258491 issued by Australian Government Department of Agriculture Water and the Environment (valid June 2020-June 2022). Coral type skeletons were provided to the Queensland Museum of Tropical Queensland Coral collection for taxonomic purposes, and all remaining coral samples collected on the Emily Bay reef in 2020 are held by The University of New South Wales. Water and sediment samples were destructively analysed.

Preliminary coral health assessment investigating the presence and occurrence of coral disease symptoms was conducted using standard coral survey photo quadrats from Emily and Slaughter Bay lagoonal reef for the February and November surveys. For the November survey, at each site, six randomly placed 10 x 2 m health transects were laid parallel to the reef crest. Within each 1 m belt on each side of the central transect tape, all hard coral colonies (> 10 cm in diameter) were assessed for signs of poor health and disease. Prevalence of disease was calculated as a proportion of the total number of surveyed colonies. Several colonies of *Montipora sp.* were tagged using flagging tape to follow the progression of the disease over a ~10 day period. The presence of general signs of coral disease and health (Table 3) were evaluated as per standard methodology for coral health assessment.

**Methodology: Algal Cover and Diversity Assessment in Emily and Slaughter Bay**

Surveying common algal genera in Emily Bay and Slaughter Bay aims to improve understanding of ecological changes associated with shifts in benthic community structure, as algae are corals' primary competitor for space on the reef floor and different algae perform different roles within an ecosystem. Some algae produce calcium carbonate like corals and contribute to reef growth, while others directly impair coral health and the recruitment of coral spat. Algae collected by hand from Emily Bay and Slaughter Bay were stored in seawater and identified the same day using a USB microscope at 10x and 40x resolution. Algae were identified using marine seaweed identification guides (Fuhrer, 1981; Huisman, 2000) and an online global database of algal taxonomy (AlgaeBase URL: https://www.algaebase.org/). Positive identification was then confirmed against the most recent complete taxonomic assessment of marine algae on Norfolk Island (Chapman, 1977; Miller, 1999) which identified 236 species (see Supp. Figure 1 for examples of algal types).

**Methodology. Fish diversity and abundance in Emily and Slaughter Bay.** Surveys for fish abundance were conducted in December 2020 and April 2021 at 8 sites in Emily and Slaughter Bay (SB1-5, EB2-3, EB1 was only surveyed in April). Video transects of abundance were conducted by laying a 30 m transect parallel to the beach, GoPro Hero 7 or 9 camera were used to recorded fish abundance by swimming above the transect at approximately 0.3 $ms^{-1}$ with the camera pointed forward capturing both the benthos and the water column. Using this method approximately 4 m each sided of the transect was recorded. The transect swims were repeated 4 times (except the recording in December at EB3 and EB2 where they were repeated 3 times) with at least 3 minutes between replicates to minimise observer effects. Videos were later analysed to identify fish to species where possible (see list of observed species).

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**Citations**


1 guidelines., A. A. (2020).

2 Heron, S. F. *et al.* Validation of Reef-Scale Thermal Stress Satellite Products for Coral Bleaching Monitoring. **8**, 59 (2016).

3 Ainsworth, T. D. *et al.* Climate change disables coral bleaching protection on the Great Barrier Reef. **352**, 338-342, doi:10.1126/science.aac7125 %J Science (2016).

4 Sully, S., Burkepile, D. E., Donovan, M. K., Hodgson, G. & van Woesik, R. A global analysis of coral bleaching over the past two decades. *Nature Communications* **10**, 1264, doi:10.1038/s41467-019-09238-2 (2019).

5 Littler, M. M. & Littler, D. S. Relationships between macroalgal functional form groups and substrata stability in a subtropical rocky-intertidal system. *JEMBE* **74**, 13-34, doi:https://doi.org/10.1016/0022-0981(84)90035-2 (1984).

6 Steneck, R. S. & Dethier, M. N. A functional group approach to the structure of algal-dominated communities. *Oikos* **69**, 476-498, doi:10.2307/3545860 (1994).

7 Diaz-Pulido, G. & McCook, L. in *The State of the Great Barrier Reef* (ed A. Chin) (Great Barrier Reef Marine Park Authority, 2008).

8 Littler, M. M., Littler, D. S. & Taylor, P. R. Evolutionary strategies in a tropical barrier reef system: Functional-form groups of marine macroalgae. *Journal of Phycology* **19**, 229-237, doi:https://doi.org/10.1111/j.0022-3646.1983.00229.x (1983).

9 Brown, K. T., Bender-Champ, D., Hoegh-Guldberg, O. & Dove, S. Seasonal shifts in the competitive ability of macroalgae influence the outcomes of coral-algal competition. *Royal Society Open Science* **7**, 201797, doi:doi:10.1098/rsos.201797 (2020).

10 Pratchett, M. S., McCowan, D., Maynard, J. A. & Heron, S. F. Changes in bleaching susceptibility among corals subject to ocean warming and recurrent bleaching in Moorea, French Polynesia. *PLOS ONE* **8**, e70443, doi:10.1371/journal.pone.0070443 (2013).

11 Hernandez-Agreda, A., Leggat, W. & Ainsworth, T. D. A place for taxonomic profiling in the study of the coral prokaryotic microbiome. *FEMS Microbiology Letters* **366**, doi:10.1093/femsle/fnz063 (2019).

12 Trevathan-Tackett, S. M. *et al.* A horizon scan of priorities for coastal marine microbiome research. *Nature Ecology & Evolution* **3**, 1509-1520, doi:10.1038/s41559-019-0999-7 (2019).

13 Roitman, S., Pollock, F. J. & Medina, M. Coral microbiomes as bioindicators of reef health. *Population Genomics: Marine Organisms* (2018).

14 Hernandez-Agreda, A., Leggat, W., Bongaerts, P., Herrera, C. & Ainsworth, T. D. Rethinking the Coral Microbiome: Simplicity Exists within a Diverse Microbial Biosphere. **9**, e00812-00818, doi:10.1128/mBio.00812-18 %J mBio (2018).

15 Roitman, S., Pollock, F. J. & Medina, M. in *Population Genomics* Vol. Series Print ISSN 2364-6764 (ed Om P. Rajora) (Springer, Cham, 2018).

16 Leite, D. C. A. *et al.* Coral Bacterial-Core Abundance and Network Complexity as Proxies for Anthropogenic Pollution. *Frontiers in Microbiology* **9**, doi:10.3389/fmicb.2018.00833 (2018).

17 Leight, A. K., Crump, B. C. & Hood, R. R. Assessment of Fecal Indicator Bacteria and Potential Pathogen Co-Occurrence at a Shellfish Growing Area. *Frontiers in Microbiology* **9**, doi:10.3389/fmicb.2018.00384 (2018).

18 Haapkylä, J., Seymour, A., Trebilco, J. & Smith, D. Coral disease prevalence and coral health in the Wakatobi Marine Park, south-east Sulawesi, Indonesia. *Journal of the Marine Biological Association of the united Kingdom* **87**, 403-414 (2007).

19 Raymundo, L. J., Rosell, K. B., Reboton, C. T. & Kaczmarsky, L. Coral diseases on Philippine reefs: genus Porites is a dominant host. *Diseases of aquatic organisms* **64**, 181-191 (2005).

20 Williams, G., Aeby, G. & Davy, S. Coral disease at Palmyra Atoll, a remote reef system in the Central Pacific. *Coral Reefs* **27**, 207 (2008).

21 Cróquer, A. & Weil, E. Spatial variability in distribution and prevalence of Caribbean scleractinian coral and octocoral diseases. II. Genera-level analysis. *Diseases of aquatic organisms* **83**, 209-222 (2009).

22 Kuta, K. & Richardson, L. Ecological aspects of black band disease of corals: relationships between disease incidence and environmental factors. *Coral Reefs* **21**, 393-398 (2002).

23 Willis, B. L., Page, C. A. & Dinsdale, E. A. in *Coral health and disease* 69-104 (Springer, 2004).
24 Page, C. A. *et al.* Influence of marine reserves on coral disease prevalence. *Diseases of Aquatic Organisms* **87**, 135-150 (2009).
25 Jones, R. J., Bowyer, J., Hoegh-Guldberg, O. & Blackall, L. L. Dynamics of a temperature-related coral disease outbreak. *Marine Ecology Progress Series* **281**, 63-77 (2004).
26 Haapkylä, J. *et al.* Seasonal rainfall and runoff promote coral disease on an inshore reef. *PloS one* **6**, e16893 (2011).
27 Anthony, S., Page, C., Bourne, D. & Willis, B. Newly characterized distinct phases of the coral disease 'atramentous necrosis' on the Great Barrier Reef. *Diseases of aquatic organisms* **81**, 255-259 (2008).
28 Muller, E. M., Sartor, C., Alcaraz, N. I. & van Woesik, R. Spatial epidemiology of the stony-coral-tissue-loss disease in Florida. *Frontiers in Marine Science* **7**, 163 (2020).
29 Alvarez-Filip, L., Estrada-Saldívar, N., Pérez-Cervantes, E., Molina-Hernández, A. & González-Barrios, F. J. A rapid spread of the stony coral tissue loss disease outbreak in the Mexican Caribbean. *PeerJ* **7**, e8069 (2019).
30 Page, C. & Willis, B. Epidemiology of skeletal eroding band on the Great Barrier Reef and the role of injury in the initiation of this widespread coral disease. *Coral Reefs* **27**, 257-272 (2008).
31 Haapkylä, J., Melbourne-Thomas, J., Flavell, M. & Willis, B. Spatiotemporal patterns of coral disease prevalence on Heron Island, Great Barrier Reef, Australia. *Coral Reefs* **29**, 1035-1045 (2010).
32 Hadaidi, G. *et al.* Ecological and molecular characterization of a coral black band disease outbreak in the Red Sea during a bleaching event. *PeerJ* **6**, e5169 (2018).
33 Stuart-Smith, R. D., Ceccarelli, D., Edgar, G. J. & Cooper, A. T. (ed Department of the Environment Report to Parks Australia) (2017).
34 Koop, K. *et al.* ENCORE: The Effect of Nutrient Enrichment on Coral Reefs. Synthesis of Results and Conclusions. *Marine Pollution Bulletin* **42**, 91-120, doi:https://doi.org/10.1016/S0025-326X(00)00181-8 (2001).
35 Atkinson, M. J. in *Coral Reefs: An Ecosystem in Transition* (eds Zvy Dubinsky & Noga Stambler) 199-206 (Springer Netherlands, 2011).
36 Fabricius, K. Effects of terrestrial runoff on the ecology of corals and coral reefs: Review and synthesis. *Marine pollution bulletin* **50**, 125-146, doi:10.1016/j.marpolbul.2004.11.028 (2005).
37 Yamamoto, M., Kayanne, H. & Yamamuro, M. Characteristic of organic matter in lagoonal sediments from the Great Barrier Reef. *GEOCHEMICAL JOURNAL* **35**, doi:10.2343/geochemj.35.385 (2001).
38 Wear, S. L. & Thurber, R. V. Sewage pollution: mitigation is key for coral reef stewardship. *Annals of the New York Academy of Sciences* **1355** (2015).
39 Fuhrer, B. *Seaweeds of Australia*. (Reed Pty Ltd, 1981).
40 Huisman, J. M. *Marine plants of Australia*. (University of Western Australia Press, 2000).
41 Chapman, V. J. Marine algae of Norfolk Island and the Cook Islands. *Botanica Marina* **20**, 161-165 (1977).
42 Millar, A. J. K. Marine benthic algae of Norfolk Island, South Pacific. *Australian Systematic Botany* **12**, 479-547, doi:https://doi.org/10.1071/SB98004 (1999).

## GPS coordinates indicating the starting point of transects conducted within both Emily Bay (n = 7) and Slaughter Bay (n = 7).

| Location | Site # | Label | Latitude | Longitude |
|---|---|---|---|---|
| Slaughter Bay | 01 | SB01 | 167.9600 | -29.0599 |
| Slaughter Bay | 03 | SB03 | 167.9597 | -29.0598 |
| Slaughter Bay | 04 | SB04 | 167.9594 | -29.0596 |
| Slaughter Bay | 05 | SB05 | 167.9576 | -29.0594 |
| Slaughter Bay | 06 | SB06 | 167.9576 | -29.0592 |
| Slaughter Bay | 08 | SB08 | 167.9566 | -29.0588 |
| Slaughter Bay | 09 | SB09 | 167.9565 | -29.0588 |
| Emily Bay | 01 | EB01 | 167.9612 | -29.0607 |
| Emily Bay | 02 | EB02 | 167.9616 | -29.0607 |
| Emily Bay | 03 | EB03 | 167.9607 | -29.0606 |
| Emily Bay | 04 | EB04 | 167.9614 | -29.0615 |
| Emily Bay | 05 | EB05 | 167.9609 | -29.0613 |
| Emily Bay | 06 | EB06 | 167.9615 | -29.0616 |
| Emily Bay | 07 | EB07 | 167.9618 | -29.0617 |

## Coral Survey location GPS coordinates

| GPS_Name | Longitude | Latitude | Bearing |
|---|---|---|---|
| EB01 | 167.96116 | -29.06074 | 175 |
| EB02 | 167.96158 | -29.06066 | 180 |
| EB03 | 167.96074 | -29.06064 | 207 |
| EB04 | 167.96137 | -29.06152 | 240 |
| EB05 | 167.96094 | -29.06132 | 30 |
| EB06 | 167.96152 | -29.0616 | 110 |
| EB07 | 167.9618 | -29.06171 | 200 |
| SB01 | 167.96004 | -29.05987 | 250 |
| SB02 | 167.96012 | -29.05982 | |
| SB03 | 167.95972 | -29.0598 | 150 |
| SB04 | 167.95941 | -29.05961 | 240 |
| SB05 | 167.95757 | -29.05935 | 230 |
| SB06 | 167.9576 | -29.0592 | 200 |
| SB07 | 167.95666 | -29.05899 | |
| SB08 | 167.95664 | -29.05881 | 180 |
| SB09 | 167.95645 | -29.05877 | 220 |
| SB10 | 167.9548 | -29.05868 | |

### Instrument deployment records

| Instrument | Serial number | Instrument number | Site | Longitude | Latitude | Entry date | Entrytime | Bottom depth |
|---|---|---|---|---|---|---|---|---|
| Current meter | B1651 | | 1 | 167.95856 | -29.05986 | 3/7/20 | 13:47 | 2.8 |
| Current meter | B1658 | | 3 | 167.95746 | -29.0592 | 3/10/20 | 16:55 | 2.3 |
| Current meter | B1593 | | 5 | 167.96088 | -29.0618 | 3/10/20 | 15:27 | 2.9 |
| Current meter | B1660 | | 9 | 167.96049 | -29.06068 | 3/8/20 | 16:14 | 3.2 |
| Current meter | B1659 | | 7 | 167.96202 | -29.06078 | 3/11/20 | 15:43 | 2.6 |
| Temperature logger | 20792120 | 1 | 1 | 167.95856 | -29.05986 | 3/7/20 | 13:47 | 2.8 |
| Temperature logger | 20791685 | 2 | 9 | 167.96049 | -29.06068 | 3/10/20 | 16:37 | 3.2 |
| Temperature logger | 20792113 | 3 | 8 | 167.96159 | -29.06025 | 3/8/20 | 14:45 | 2.7 |
| Temperature logger | 20792115 | 4 | 10 | 167.96155 | -29.06066 | 3/14/20 | 7:47 | 2.5 |
| Temperature logger | 2079114 | 5 | 7 | 167.96202 | -29.06078 | 3/8/20 | 15:15 | 2.6 |
| Temperature logger | 2079116 | 6 | 2 | 167.95895 | -29.05971 | 3/7/20 | 13:57 | 1.5 |
| Temperature logger | 20792121 | 7 | 6 | 167.96193 | -29.06156 | 3/8/20 | 15:02 | 1.1 |
| Temperature logger | 20791684 | 8 | 3 | 167.95746 | -29.0592 | 3/7/20 | 14:27 | 2.3 |
| Temperature logger | 20770567 | 9 | 4 | 167.95583 | -29.05883 | 3/7/20 | 14:57 | 0.8 |
| Temperature logger | 20770566 | 10 | 5 | 167.96088 | -29.0618 | 3/8/20 | 15:48 | 2.9 |
| Tide gauge | 39-7605 | | 7 | 167.96202 | -29.06078 | 3/8/20 | 15:15 | 2.6 |
| Tide gauge | 16563 | | 5 | 167.96088 | -29.0618 | 3/8/20 | 15:48 | 2.9 |

### Potential outflow site locations

| GPS_Name | Longitude | Latitude | Notes |
|---|---|---|---|
| OUTFLOW1 | 167.95624 | -29.0583 | |
| OUTFLOW2 | 167.9566 | -29.05838 | |
| OUTFLOW3 | 167.9568 | -29.05834 | |
| | 167.96111 | -29.05945 | Main outflow site in Emily Bay of concern |

### Water quality measurement over the study period.

| Date | Site | # | Coliform (cfu/100 ml) | Nutrients (UNSW) NH4 ug/L | NOx ug/L | Above Limits ANZECC Guidelines |
|---|---|---|---|---|---|---|
| March 15, 2020 | SB | 1 | No Coliform | 5.33 | 39.75 | **No** |
| March 15, 2020 | SB | 3 | | 5.77 | 25.00 | **No** |
| March 15, 2020 | SB | 4 | | 8.58 | 12.75 | **No** |
| March 15, 2020 | SB | 5 | | 4.71 | 6.75 | **No** |
| March 15, 2020 | SB | 6 | | 7.92 | 48.50 | **No** |
| March 15, 2020 | SB | 8 | | 1.43 | 82.75 | **No** |
| March 15, 2020 | SB | 9 | | 4.64 | 25.25 | **No** |
| March 15, 2020 | EB | 1 | | 5.58 | 73.75 | **No** |
| March 15, 2020 | EB | 2 | | 6.99 | 50.75 | **No** |
| March 15, 2020 | EB | 3 | | 2.39 | 76.50 | **No** |
| March 15, 2020 | EB | 4 | | 4.89 | 66.50 | **No** |
| March 15, 2020 | EB | 5 | | 8.31 | 0.00 | **No** |
| March 15, 2020 | EB | 6 | | 6.32 | 25.50 | **No** |
| March 15, 2020 | EB | 7 | | 5.57 | 27.89 | **No** |
| September 2, 2020 | SB | 1 | 2 | 125.00 | 64.70 | **Yes** |
| September 2, 2020 | SB | 3 | 2 | 37.20 | 69.62 | **Yes** |
| September 2, 2020 | SB | 4 | 2 | 116.35 | 54.75 | **Yes** |
| September 2, 2020 | SB | 5 | 2 | 41.85 | 77.88 | **Yes** |
| September 2, 2020 | SB | 6 | <1 | 132.00 | 8.60 | **Yes** |
| September 2, 2020 | SB | 8 | <1 | 34.60 | 67.55 | **Yes** |
| September 2, 2020 | SB | 9 | <1 | 550.50 | 41.80 | **Yes** |
| September 2, 2020 | EB | 1 | 600 | 37.90 | 65.10 | **Yes** |
| September 2, 2020 | EB | 2 | 600 | 38.60 | 44.33 | **Yes** |
| September 2, 2020 | EB | 3 | 200 | 39.15 | 64.00 | **Yes** |
| September 2, 2020 | EB | 4 | 100 | 202.50 | 59.05 | **Yes** |
| September 2, 2020 | EB | 5 | 100 | 51.15 | 58.00 | **Yes** |
| September 2, 2020 | EB | 6 | 100 | 191.00 | 61.15 | **Yes** |
| September 2, 2020 | EB | 7 | 100 | 31.65 | 61.90 | **Yes** |
| November 15, 2020 | SB | 1 | 200 | 68.20 | 76.88 | **Yes** |
| November 15, 2020 | SB | 3 | 100 | 85.35 | 62.50 | **Yes** |
| November 15, 2020 | SB | 4 | 100 | 35.15 | 64.79 | **Yes** |
| November 15, 2020 | SB | 5 | | 78.70 | 66.80 | **Yes** |
| November 15, 2020 | SB | 6 | | 43.25 | 67.40 | **Yes** |
| November 15, 2020 | SB | 8 | | 49.90 | 63.65 | **Yes** |
| November 15, 2020 | SB | 9 | | 53.40 | 59.35 | **Yes** |
| November 15, 2020 | EB | 1 | 1100 | 47.40 | 57.65 | **Yes** |
| November 15, 2020 | EB | 2 | 400 | 48.35 | 60.30 | **Yes** |
| November 15, 2020 | EB | 3 | 200 | 40.45 | 65.00 | **Yes** |
| November 15, 2020 | EB | 4 | 200 | 44.35 | 37.80 | **Yes** |
| November 15, 2020 | EB | 5 | | 50.10 | 61.75 | **Yes** |
| November 15, 2020 | EB | 6 | | 47.20 | 434.50 | **Yes** |
| November 15, 2020 | EB | 7 | | 196.00 | 31.55 | **Yes** |
| November 15, 2020 | Bore | | | 77.25 | 66.95 | **Yes** |
| November 15, 2020 | Bore | | | 81.60 | 76.50 | **Yes** |

| | | | | | |
|---|---|---|---|---|---|
| December 8, 2020 | SB | 1 | No Coliform | 106.35 | 25.15 |
| December 8, 2020 | SB | 3 | | 80.00 | 41.00 |
| December 8, 2020 | SB | 4 | | 79.17 | 39.65 |
| December 8, 2020 | SB | 5 | | 63.01 | 144.80 |
| December 8, 2020 | SB | 6 | | 67.09 | 39.85 |
| December 8, 2020 | SB | 8 | | 68.03 | 115.20 |
| December 8, 2020 | SB | 9 | | 80.00 | 120.95 |
| December 8, 2020 | EB | 1 | | 48.87 | 24.35 |
| December 8, 2020 | EB | 2 | | 74.07 | 88.75 |
| December 8, 2020 | EB | 3 | | 60.08 | 37.20 |
| December 8, 2020 | EB | 4 | | 80.00 | 38.25 |
| December 8, 2020 | EB | 5 | | 80.00 | 89.45 |
| December 8, 2020 | EB | 6 | | 59.86 | 42.60 |
| December 8, 2020 | EB | 7 | | 80.00 | 37.55 |
| December 8, 2020 | CB | 1 | | 47.28 | 21.25 |
| December 8, 2020 | CB | 2 | | 59.29 | 23.00 |
| December 8, 2020 | CB | 3 | | 73.75 | 36.10 |
| December 10, 2020 | SB | 1 | No Coliform | 74.29 | 96.20 |
| December 10, 2020 | SB | 3 | | 80.00 | 129.45 |
| December 10, 2020 | SB | 4 | | 72.16 | 89.60 |
| December 10, 2020 | SB | 5 | | 88.57 | 107.90 |
| December 10, 2020 | SB | 6 | | 68.54 | 123.95 |
| December 10, 2020 | SB | 8 | | 65.61 | 121.20 |
| December 10, 2020 | SB | 9 | | 66.23 | 106.90 |
| December 10, 2020 | EB | 1 | | 85.06 | 109.10 |
| December 10, 2020 | EB | 2 | | 80.00 | 89.23 |
| December 10, 2020 | EB | 3 | | 80.00 | 91.85 |
| December 10, 2020 | EB | 4 | | 70.17 | 121.65 |
| December 10, 2020 | EB | 5 | | 80.00 | 108.50 |
| December 10, 2020 | EB | 6 | | 56.50 | 153.05 |
| December 10, 2020 | EB | 7 | | 80.00 | 116.45 |

**Table. Observed Fish species**

| Species | Family | Common name/s |
|---|---|---|
| *Parma polylepis* | Pomacentridae | Banded Scalyfin, Banded Parma |
| *Abudefduf sordidus* | Pomacentridae | Black-spot Sergeant, Blackspot Sergeant Major, Black-spot Sergeant-major, Spot Damsel, Yellow-banded Sergeant-major |
| *Chromis fumea* | Pomacentridae | Fawn Chromis, Smokey Chromis, Smokey Puller, Yellow Demoiselle |
| *Pseudolabrus luculentus* | Labridae | Luculentus Wrasse, Orange Wrase |
| *Notolabrus inscriptus* | Labridae | Inscribed Wrasse, Green Wrasse |
| *Thalassoma hardwicke* | Labridae | Six-banded Wrasse, Six-bar Wrasse, Sixbarred Wrasse, Six-barred Wrasse |
| *Cymolutes praetextatus* | Labridae | Knife Wrasse, Knife Razorfish, Knife Razorwrasse, Knifefish, Razon Wrasse |
| *Thalassoma lunare* | Labridae | Moon Wrasse, Sunset Wrasse |
| *Gomphosus varius* | Labridae | Birdnose Wrasse, Bird Wrasse, Bird-nose Wrasse, Clubnosed Wrasse |
| *Cheilio inermis* | Labridae | Sharpnose Wrasse, Cigar Wrasse, Quaker, Sharp-nosed Rainbow-fish, Sharp-nosed Wrasse |
| *Anampses elegans* | Labridae | Elegant Wrasse, Elegans Wrasse |
| *Thalassoma purpureum* | Labridae | Surge Wrasse, Green-blocked Wrasse, Purple Wrasse, Red And Green Wrasse |
| *Myxus elongatus* | Muglidae | Sand Mullet, Black Spot Mullet, Bully Mullet, Lano, Poddy, Tallegalene, Wide Bay Mullet |
| *Parupeneus ciliatus* | Mullidae | Diamondscale Goatfish, Blackspot Goatfish, Cardinal Goatfish, Diamond-scale Goatfish, Diamondscaled Goatfish, Diamond-scaled Goatfish, Whitesaddle Goatfish |
| *Mulloidichthys vanicolensis* | Mullidae | Goldstripe Goatfish, Banded Goatfish, Golden Banded Goatfish, Goldenstripe goatfish, Gold-striped Goat-fish, Yellowfin Goatfish, Yellowstripe Goatfish, Yellow-stripe Goatfish |
| *Mulloidichthys flavolineatus* | Mullidae | Yellowstripe Goatfish, Gold-lined Goatfish, Pallid Goatfish, Samoan Goatfish, Slender Goldband Goatfish, Square-spot Goatfish, Yellow-lined Goatfish, Yellow-striped Goatfish |
| *Parupeneus spilurus* | Mullidae | Blacksaddle Goatfish, Black-saddled Goatfish, Blackspot Goatfish, Black-spot Goatfish, Black-spot Goat-fish, Black-spotted Goatfish, Goat Fish, Red Goatfish |
| *Chaetodon plebeius* | Chaetodontidae | Bluespot Butterflyfish, Blueblotch Butterflyfish, Blue-blotched Butterfly-fish, Blue-dash Butterflyfish, Blue-spot Butterflyfish, Coral Butterflyfish, Grey Blotched Butterflyfish, Two-spot Coralfish |
| *Chaetodon citrinellus* | Chaetodontidae | Citron Butterflyfish, Citron Coralfish, Speckled Butterflyfish, Speckled Butterfly-fish |
| *Chaetodon tricinctus* | Chaetodontidae | Threeband Butterflyfish, Three-band Coralfish, Three-stripe Butterflyfish |

| | | |
|---|---|---|
| *Chaetodon melannotus* | Chaetodontidae | Blackback Butterflyfish, Black-back Butterflyfish, Black-back Butterfly-fish, Blackbacked Butterflyfish, Black-backed Butterflyfish, Black-backed Butterfly-fish, Black-backed Coralfish |
| *Chaetodon lineolatus* | Chaetodontidae | Lined Butterflyfish, Line Butterflyfish, Lined Butterfly-fish, New-moon Coralfish, New-moon Coral-fish |
| *Kyphosus vaigiensis* | Kyphosidae | Brassy Drummer,  Brassy Chub, Long-finned Drummer, Low-finned Drummer, Northern Silver Drummer, Queensland Drummer, Southern Drummer |
| *Ostorhinchus norfolcensis* | Apogonidae | Norfolk Cardinalfish, |
| *Morwong ephippium* | Latridae | Painted Morwong |
| *Diodon hystrix* | Didontidae | Spotted Porcupinefish, Black-spotted Porcupine-fish, Porcupinefish, Spotfin Porcupinefish |

**Table. Observations of bleaching occurrence, colony size, and within severity type.**

| ID | Date | Site ID | Transect | Start depth | Genus observed | Size | % Colony bleaching | Location on colony | % Colony Pale |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 5 | top, side | |
| 2 | 3/4/20 | SB01 | 1 | 1.6 | *Platygyra* | M | | | |
| 3 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 5 | top, side | |
| 4 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 5 | side | 50 |
| 5 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | 5 | edge | |
| 6 | 3/4/20 | SB01 | 1 | 1.6 | *Stylophora* | S | 2 | top | |
| 7 | 3/4/20 | SB01 | 1 | 1.6 | *Pectinia* | S | | | |
| 8 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 5 | top | |
| 9 | 3/4/20 | SB01 | 1 | 1.6 | Anemone | S | | | |
| 10 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | 1 | top | 10 |
| 11 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | S | | | |
| 12 | 3/4/20 | SB01 | 1 | 1.6 | *Alveopora* | S | | | |
| 13 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | S | | | |
| 14 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | | | 20 |
| 15 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | | | |
| 16 | 3/4/20 | SB01 | 1 | 1.6 | Anemone | S | | | 100 |
| 17 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 1 | Whole colony | |
| 18 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | M | | | |
| 19 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 3 | top | |
| 20 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | 5 | edge | 10 |
| 21 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 5 | top | 90 |
| 22 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | | | 80 |
| 23 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 3 | top | 60 |
| 24 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 5 | top, side | |
| 25 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | M | 3 | patchy | |
| 26 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | L | 2 | patchy | |
| 27 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | | | |
| 28 | 3/4/20 | SB01 | 1 | 1.6 | *Paragoniastrea* | L | | | |
| 29 | 3/4/20 | SB01 | 1 | 1.6 | *Cythastrea* | L | | | |
| 30 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | M | 79 | top | 20 |
| 31 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | | | 10 |
| 32 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | | | |
| 33 | 3/4/20 | SB01 | 1 | 1.6 | *Homophyllia* | S | | | |
| 34 | 3/4/20 | SB01 | 1 | 1.6 | *Homophyllia* | L | | | |
| 35 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | | | |
| 36 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | | | |
| 37 | 3/4/20 | SB01 | 1 | 1.6 | *Paragoniastrea* | L | | | |
| 38 | 3/4/20 | SB01 | 1 | 1.6 | *Homophyllia* | L | | | |
| 39 | 3/4/20 | SB01 | 1 | 1.6 | *Homophyllia* | L | | | |
| 40 | 3/4/20 | SB01 | 1 | 1.6 | *Montipora* | L | | | 30 |
| 41 | 3/4/20 | SB01 | 1 | 1.6 | *Porites* | S | 1 | top | 90 |
| 42 | 3/4/20 | SB03 | 3 | 1.5 | *Paragoniastrea* | M | | | |
| 43 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | M | 8 | top, edge | |
| 44 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | S | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 45 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 46 | 3/4/20 | SB03 | 3 | 1.5 | *Goniopora* | S | | | |
| 47 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 48 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | S | | | |
| 49 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | M | 1 | top | 60 |
| 50 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 51 | 3/4/20 | SB03 | 3 | 1.5 | *Platygyra* | S | | | |
| 52 | 3/4/20 | SB03 | 3 | 1.5 | *Goniopora* | S | | | |
| 53 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 54 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 55 | 3/4/20 | SB03 | 3 | 1.5 | *Pectinia* | M | | | |
| 56 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 57 | 3/4/20 | SB03 | 3 | 1.5 | *Homophyllia* | S | | | |
| 58 | 3/4/20 | SB03 | 3 | 1.5 | *Goniopora* | S | | | |
| 59 | 3/4/20 | SB03 | 3 | 1.5 | *Goniopora* | S | | | |
| 60 | 3/4/20 | SB03 | 3 | 1.5 | *Goniopora* | S | | | |
| 61 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | | | |
| 62 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | L | | | 80 |
| 63 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | | | 50 |
| 64 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | M | 1 | top | |
| 65 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | S | | | |
| 66 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 5 | top | 40 |
| 67 | 3/4/20 | SB03 | 3 | 1.5 | *Platygyra* | M | | | |
| 68 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | L | | | |
| 69 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | 90 |
| 70 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 71 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 72 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 73 | 3/4/20 | SB03 | 3 | 1.5 | *Pocillopora* | M | 1 | top | |
| 74 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | 100 |
| 75 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | L | | | |
| 76 | 3/4/20 | SB03 | 3 | 1.5 | *Merulina* | S | 1 | whole_colony | |
| 77 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 1 | top | |
| 78 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 79 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 80 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | M | | | 30 |
| 81 | 3/4/20 | SB03 | 3 | 1.5 | *Platygyra* | M | | | |
| 82 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | M | 3 | top | |
| 83 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | S | | | |
| 84 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | M | | | 10 |
| 85 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 86 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 87 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 88 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | M | 4 | top, side | |
| 89 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 90 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | 50 |

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|---|---|---|---|---|---|---|---|---|---|
| 91 | 3/4/20 | SB03 | 3 | 1.5 | *Stylophora* | S | 1 | whole_colony | |
| 92 | 3/4/20 | SB03 | 3 | 1.5 | *Pocillopora* | M | 1 | whole_colony | |
| 93 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 94 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 95 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 96 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | 60 |
| 97 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 98 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | L | 5 | top | |
| 99 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | | | 30 |
| 100 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | M | 5 | top | |
| 101 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 6 | top, side | |
| 102 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | M | 5 | top | 80 |
| 103 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 104 | 3/4/20 | SB03 | 3 | 1.5 | *Homophyllia* | L | | | 100 |
| 105 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | 100 |
| 106 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 107 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 108 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 109 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | M | 5 | top | 50 |
| 110 | 3/4/20 | SB03 | 3 | 1.5 | *Stylophora* | S | 5 | exposed | 20 |
| 111 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | S | | | |
| 112 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | 100 |
| 113 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 114 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 115 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | 100 |
| 116 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 117 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | S | | | |
| 118 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 2 | top | |
| 119 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | M | | | |
| 120 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | 5 |
| 121 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 3 | top | |
| 122 | 3/4/20 | SB03 | 3 | 1.5 | *Pocillopora* | S | 3 | tips | 10 |
| 123 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 124 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 125 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | M | 1 | tips | |
| 126 | 3/4/20 | SB03 | 3 | 1.5 | *Pocillopora* | M | 9 | whole_colony | |
| 127 | 3/4/20 | SB03 | 3 | 1.5 | *Astrea* | L | | | 80 |
| 128 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | M | 2 | top | |
| 129 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 130 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 131 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 132 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 133 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 134 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 135 | 3/4/20 | SB03 | 3 | 1.5 | *Stylophora* | S | 8 | patchy | 20 |
| 136 | 3/4/20 | SB03 | 3 | 1.5 | *Stylophora* | S | 8 | patchy | 20 |

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|---|---|---|---|---|---|---|---|---|---|
| 137 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 138 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | L | | | |
| 139 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 140 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 141 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 142 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 143 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 144 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 145 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 146 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 147 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 148 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 149 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 150 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 151 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 152 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 2 | top | |
| 153 | 3/4/20 | SB03 | 3 | 1.5 | *Paragoniastrea* | M | | | |
| 154 | 3/4/20 | SB03 | 3 | 1.5 | *Paragoniastrea* | S | | | |
| 155 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 5 | top | 50 |
| 156 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 1 | top | |
| 157 | 3/4/20 | SB03 | 3 | 1.5 | | S | | | |
| 158 | 3/4/20 | SB03 | 3 | 1.5 | *Alveopora* | S | | | |
| 159 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | L | | | |
| 160 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 2 | tips | 80 |
| 161 | 3/4/20 | SB03 | 3 | 1.5 | *Porites* | S | 2 | top | 70 |
| 162 | 3/4/20 | SB03 | 3 | 1.5 | *Alveopora* | S | | | |
| 163 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | L | 2 | patchy | |
| 164 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | M | | | 50 |
| 165 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | M | 2 | patchy | |
| 166 | 3/4/20 | SB03 | 3 | 1.5 | *Acropora* | S | | | |
| 167 | 3/4/20 | SB03 | 3 | 1.5 | *Montipora* | L | 4 | patchy | 30 |
| 168 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | 1 | | |
| 169 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | 1 | | |
| 170 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | 1 | | |
| 171 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 172 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 173 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 174 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 175 | 3/4/20 | SB03 | 3 | 1.5 | Anemone | S | | | |
| 176 | 3/4/20 | SB04 | 4 | 2.5 | *Goniopora* | S | | | |
| 177 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | M | 15 | side | |
| 178 | 3/4/20 | SB04 | 4 | 2.5 | *Goniopora* | S | | | |
| 179 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | M | | | |
| 180 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | | | 15 |
| 181 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | | | |
| 182 | 3/4/20 | SB04 | 4 | 2.5 | *Goniopora* | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 183 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | M | | | 100 |
| 184 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | M | | | 10 |
| 185 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | 100 |
| 186 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | | | 50 |
| 187 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | | | 50 |
| 188 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | M | | | 50 |
| 189 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | | | 50 |
| 190 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | | | 50 |
| 191 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | M | 3 | top | |
| 192 | 3/4/20 | SB04 | 4 | 2.5 | *Pectinia* | S | | | 10 |
| 193 | 3/4/20 | SB04 | 4 | 2.5 | *Anemone* | S | | | |
| 194 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | 30 |
| 195 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | S | 5 | top | |
| 196 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | 8 | top | |
| 197 | 3/4/20 | SB04 | 4 | 2.5 | *Goniopora* | S | | | |
| 198 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | 100 |
| 199 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | 100 |
| 200 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | 100 |
| 201 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | 100 |
| 202 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | S | | | |
| 203 | 3/4/20 | SB04 | 4 | 2.5 | *Paragoniastrea* | S | | | |
| 204 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | 5 | top | |
| 205 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | M | 4 | top | |
| 206 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 207 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 208 | 3/4/20 | SB04 | 4 | 2.5 | *Stylophora* | M | | | 5 |
| 209 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | 1 | top | |
| 210 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | | | |
| 211 | 3/4/20 | SB04 | 4 | 2.5 | *Goniopora* | S | | | |
| 212 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 213 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 214 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 215 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | L | 25 | top | |
| 216 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 217 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 218 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | M | 7 | top | 15 |
| 219 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | 2 | top | 100 |
| 220 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | 2 | top | 100 |
| 221 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | 1 | exposed | 100 |
| 222 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | S | | | |
| 223 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | S | | | |
| 224 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | 100 |
| 225 | 3/4/20 | SB04 | 4 | 2.5 | Anemone | S | | | |
| 226 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | 1 | whole_colony | |
| 227 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | 1 | whole_colony | |
| 228 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 229 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 230 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | M | | | |
| 231 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | XL | | | |
| 232 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | M | | | 100 |
| 233 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | | | |
| 234 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | L | | | |
| 235 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | L | | | 90 |
| 236 | 3/4/20 | SB04 | 4 | 2.5 | *Stylophora* | S | 1 | patchy | 70 |
| 237 | 3/4/20 | SB04 | 4 | 2.5 | *Stylophora* | M | | | 70 |
| 238 | 3/4/20 | SB04 | 4 | 2.5 | *Stylophora* | M | | | 20 |
| 239 | 3/4/20 | SB04 | 4 | 2.5 | *Stylophora* | S | 1 | patchy | |
| 240 | 3/4/20 | SB04 | 4 | 2.5 | *Stylophora* | M | 2 | patchy | |
| 241 | 3/4/20 | SB04 | 4 | 2.5 | *Paragoniastrea* | M | 1 | patchy | 30 |
| 242 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | S | | | |
| 243 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | 5 | exposed | 50 |
| 244 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | M | 15 | exposed | 60 |
| 245 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | | | |
| 246 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | 2 | patchy | 40 |
| 247 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | | | |
| 248 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | S | 8 | exposed | 20 |
| 249 | 3/4/20 | SB04 | 4 | 2.5 | *Acropora* | S | | | |
| 250 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | M | | | |
| 251 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | 8 | patchy | 20 |
| 252 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | L | 15 | patchy | 15 |
| 253 | 3/4/20 | SB04 | 4 | 2.5 | *Homophyllia* | S | 3 | patchy | 70 |
| 254 | 3/4/20 | SB04 | 4 | 2.5 | *Pocillopora* | S | | | |
| 255 | 3/4/20 | SB04 | 4 | 2.5 | *Alveopora* | M | 1 | patchy | |
| 256 | 3/4/20 | SB04 | 4 | 2.5 | *Alveopora* | S | | | |
| 257 | 3/4/20 | SB04 | 4 | 2.5 | *Alveopora* | S | | | |
| 258 | 3/4/20 | SB04 | 4 | 2.5 | *Alveopora* | S | | | |
| 259 | 3/4/20 | SB04 | 4 | 2.5 | *Goniopora* | S | | | |
| 260 | 3/4/20 | SB04 | 4 | 2.5 | *Montipora* | M | 1 | patchy | |
| 261 | 3/4/20 | SB04 | 4 | 2.5 | *Porites* | S | 9 | exposed | |
| 262 | 3/4/20 | SB04 | 4 | 2.5 | Anemone | S | 1 | whole_colony | |
| 263 | 3/4/20 | SB04 | 4 | 2.5 | Anemone | S | | | |
| 264 | 3/5/20 | SB09 | 9 | 2.1 | *Porites* | M | 1 | top | |
| 265 | 3/5/20 | SB09 | 9 | 2.1 | *Porites* | M | 25 | side | 15 |
| 266 | 3/5/20 | SB09 | 9 | 2.1 | *Montipora* | M | | | |
| 267 | 3/5/20 | SB09 | 9 | 2.1 | *Montipora* | S | 1 | top | |
| 268 | 3/5/20 | SB09 | 9 | 2.1 | *Pectinia* | M | | | |
| 269 | 3/5/20 | SB09 | 9 | 2.1 | *Homophyllia* | S | | | 100 |
| 270 | 3/5/20 | SB09 | 9 | 2.1 | *Paragoniastrea* | M | | | |
| 271 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | S | 5 | top | 85 |
| 272 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | S | | | |
| 273 | 3/5/20 | SB09 | 9 | 2.1 | *Porites* | S | 1 | top | |
| 274 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 275 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | S | 5 | side | |
| 276 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | S | 4 | side | 20 |
| 277 | 3/5/20 | SB09 | 9 | 2.1 | *Anemone* | S | | | |
| 278 | 3/5/20 | SB09 | 9 | 2.1 | *Anemone* | S | | | |
| 279 | 3/5/20 | SB09 | 9 | 2.1 | *Anemone* | S | | | |
| 280 | 3/5/20 | SB09 | 9 | 2.1 | *Anemone* | S | | | |
| 281 | 3/5/20 | SB09 | 9 | 2.1 | *Anemone* | S | | | |
| 282 | 3/5/20 | SB09 | 9 | 2.1 | *Montipora* | S | | | |
| 283 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | S | 3 | top | |
| 284 | 3/5/20 | SB09 | 9 | 2.1 | *Porites* | S | 9 | whole_colony | 10 |
| 285 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | S | 1 | top | 90 |
| 286 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | S | 9 | whole_colony | 10 |
| 287 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | 100 |
| 288 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | |
| 289 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | |
| 290 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | |
| 291 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | |
| 292 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | |
| 293 | 3/5/20 | SB09 | 9 | 2.1 | *Astrea* | M | 5 | side | 40 |
| 294 | 3/5/20 | SB09 | 9 | 2.1 | *Porites* | S | 1 | top | 80 |
| 295 | 3/5/20 | SB09 | 9 | 2.1 | *Astrea* | L | 5 | top | 80 |
| 296 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | 5 |
| 297 | 3/5/20 | SB09 | 9 | 2.1 | *Porites* | L | 1 | side | 65 |
| 298 | 3/5/20 | SB09 | 9 | 2.1 | Anemone | S | | | |
| 299 | 3/5/20 | SB09 | 9 | 2.1 | *Pectinia* | L | | | |
| 300 | 3/5/20 | SB09 | 9 | 2.1 | *Pectinia* | L | | | |
| 301 | 3/5/20 | SB09 | 9 | 2.1 | *Stylophora* | S | 4 | top | |
| 302 | 3/5/20 | SB09 | 9 | 2.1 | *Acropora* | XL | | | |
| 303 | 3/5/20 | SB09 | 9 | 2.1 | *Stylophora* | M | 1 | exposed | |
| 304 | 3/5/20 | SB09 | 9 | 2.1 | *Porites* | M | 5 | top | |
| 305 | 3/5/20 | SB09 | 9 | 2.1 | *Porites* | M | 5 | top | |
| 306 | 3/5/20 | SB09 | 9 | 2.1 | *Acropora* | XL | | | |
| 307 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | M | 5 | patchy | |
| 308 | 3/5/20 | SB09 | 9 | 2.1 | *Alveopora* | S | | | |
| 309 | 3/5/20 | SB09 | 9 | 2.1 | *Pocillopora* | M | 5 | patchy | |
| 310 | 3/5/20 | SB09 | 9 | 2.1 | *Anemone* | S | | | |
| 311 | 3/5/20 | SB09 | 9 | 2.1 | *Anemone* | S | | | |
| 312 | 3/5/20 | SB09 | 9 | 2.1 | *Anemone* | S | | | |
| 313 | 3/5/20 | SB09 | 9 | 2.1 | *S* | | | | |
| 314 | 3/5/20 | SB09 | 9 | 2.1 | *S* | | | | |
| 315 | 3/5/20 | SB09 | 9 | 2.1 | *S* | | | | |
| 316 | 3/5/20 | SB09 | 9 | 2.1 | *S* | | | | |
| 317 | 3/5/20 | SB09 | 9 | 2.1 | *S* | | | | |
| 318 | 3/5/20 | SB09 | 9 | 2.1 | *S* | | | | |
| 319 | 3/5/20 | SB09 | 9 | 2.1 | *S* | | | | |
| 320 | 3/5/20 | SB08 | 8 | 1.2 | *Porites* | S | 9 | whole_colony | |

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|---|---|---|---|---|---|---|---|---|---|
| 321 | 3/5/20 | SB08 | 8 | 1.2 | *Porites* | S | 3 | top | 65 |
| 322 | 3/5/20 | SB08 | 8 | 1.2 | *Pocillopora* | S | 2 | top | |
| 323 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | 100 |
| 324 | 3/5/20 | SB08 | 8 | 1.2 | *Porites* | M | 4 | top | |
| 325 | 3/5/20 | SB08 | 8 | 1.2 | *Stylophora* | S | | | 100 |
| 326 | 3/5/20 | SB08 | 8 | 1.2 | *Stylophora* | S | | | 100 |
| 327 | 3/5/20 | SB08 | 8 | 1.2 | *Montipora* | L | 8 | top | |
| 328 | 3/5/20 | SB08 | 8 | 1.2 | *Zooanthid* | S | | | |
| 329 | 3/5/20 | SB08 | 8 | 1.2 | *Porites* | S | | | |
| 330 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | 100 |
| 331 | 3/5/20 | SB08 | 8 | 1.2 | *Montipora* | M | | | 100 |
| 332 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | 30 |
| 333 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | M | | | |
| 334 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | M | | | |
| 335 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | M | | | |
| 336 | 3/5/20 | SB08 | 8 | 1.2 | *Stylophora* | M | | | 100 |
| 337 | 3/5/20 | SB08 | 8 | 1.2 | *Stylophora* | S | | | 100 |
| 338 | 3/5/20 | SB08 | 8 | 1.2 | *Pocillopora* | S | | | 100 |
| 339 | 3/5/20 | SB08 | 8 | 1.2 | *Pocillopora* | M | | | 100 |
| 340 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | M | | | |
| 341 | 3/5/20 | SB08 | 8 | 1.2 | *Porites* | S | 2 | top | |
| 342 | 3/5/20 | SB08 | 8 | 1.2 | *Pocillopora* | S | 2 | exposed | 70 |
| 343 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | |
| 344 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | |
| 345 | 3/5/20 | SB08 | 8 | 1.2 | *Porites* | S | 5 | side | |
| 346 | 3/5/20 | SB08 | 8 | 1.2 | *Lobophyta* | M | | | |
| 347 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | |
| 348 | 3/5/20 | SB08 | 8 | 1.2 | *Acanthastrea* | M | | | |
| 349 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | |
| 350 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | 100 |
| 351 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | 100 |
| 352 | 3/5/20 | SB08 | 8 | 1.2 | *Paragoniastrea* | L | | | |
| 353 | 3/5/20 | SB08 | 8 | 1.2 | *Homophyllia* | S | | | |
| 354 | 3/5/20 | SB08 | 8 | 1.2 | *Paragoniastrea* | M | | | |
| 355 | 3/5/20 | SB08 | 8 | 1.2 | *Homophyllia* | XL | | | |
| 356 | 3/5/20 | SB08 | 8 | 1.2 | *Pocillopora* | S | 8 | exposed | 10 |
| 357 | 3/5/20 | SB08 | 8 | 1.2 | *Porites* | S | 5 | top | 50 |
| 358 | 3/5/20 | SB08 | 8 | 1.2 | *Alveopora* | S | | | |
| 359 | 3/5/20 | SB08 | 8 | 1.2 | *Porites* | S | 6 | top | 40 |
| 360 | 3/5/20 | SB08 | 8 | 1.2 | *Pocillopora* | M | 4 | exposed | 40 |
| 361 | 3/5/20 | SB08 | 8 | 1.2 | *Homophyllia* | S | | | |
| 362 | 3/5/20 | SB08 | 8 | 1.2 | *Stylophora* | S | 9 | whole_colony | 10 |
| 363 | 3/5/20 | SB08 | 8 | 1.2 | *Acropora* | S | | | 100 |
| 364 | 3/5/20 | SB08 | 8 | 1.2 | *Lobophyta* | M | | | |
| 365 | 3/5/20 | SB06 | 6 | 1.6 | *Platygyra* | L | | | |
| 366 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 367 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 368 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 369 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 370 | 3/5/20 | SB06 | 6 | 1.6 | *Porites* | L | | | 15 |
| 371 | 3/5/20 | SB06 | 6 | 1.6 | *Porites* | M | 1 | top | |
| 372 | 3/5/20 | SB06 | 6 | 1.6 | *Porites* | L | 5 | top | |
| 373 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 374 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 375 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 376 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 377 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 378 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 379 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 380 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 381 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 382 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 383 | 3/5/20 | SB06 | 6 | 1.6 | *Acanthastrea* | L | | | 20 |
| 384 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | S | | | 100 |
| 385 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | M | 1 | top | 80 |
| 386 | 3/5/20 | SB06 | 6 | 1.6 | *Montipora* | L | 15 | top | 5 |
| 387 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | M | 15 | top | 80 |
| 388 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 389 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 390 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 391 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 392 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | S | 2 | top | |
| 393 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | M | | | 60 |
| 394 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | M | | | 100 |
| 395 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 396 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 397 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 398 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 399 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 400 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 401 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 402 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 403 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | S | | | |
| 404 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 405 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 406 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 407 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 408 | 3/5/20 | SB06 | 6 | 1.6 | *Acropora* | L | | | 60 |
| 409 | 3/5/20 | SB06 | 6 | 1.6 | *Acropora* | L | | | |
| 410 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | S | 5 | top | 80 |
| 411 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 412 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 413 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 414 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 415 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 416 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 417 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 50 |
| 418 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 50 |
| 419 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 50 |
| 420 | 3/5/20 | SB06 | 6 | 1.6 | *Acropora* | L | | | |
| 421 | 3/5/20 | SB06 | 6 | 1.6 | *Stylophora* | L | 1 | top | |
| 422 | 3/5/20 | SB06 | 6 | 1.6 | *Stylophora* | S | 15 | top | |
| 423 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | L | 5 | top | |
| 424 | 3/5/20 | SB06 | 6 | 1.6 | *Acropora* | L | | | 5 |
| 425 | 3/5/20 | SB06 | 6 | 1.6 | *Montipora* | M | 5 | top, edge | |
| 426 | 3/5/20 | SB06 | 6 | 1.6 | *Acropora* | XL | | | 100 |
| 427 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 428 | 3/5/20 | SB06 | 6 | 1.6 | *Goniopora* | S | | | |
| 429 | 3/5/20 | SB06 | 6 | 1.6 | *Acropora* | M | | | |
| 430 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | L | 5 | top | |
| 431 | 3/5/20 | SB06 | 6 | 1.6 | *Platygyra* | L | | | |
| 432 | 3/5/20 | SB06 | 6 | 1.6 | *Montipora* | L | | | |
| 433 | 3/5/20 | SB06 | 6 | 1.6 | *Paragoniastrea* | L | | | |
| 434 | 3/5/20 | SB06 | 6 | 1.6 | *Stylophora* | M | 15 | patchy | |
| 435 | 3/5/20 | SB06 | 6 | 1.6 | *Stylophora* | L | 15 | patchy | 25 |
| 436 | 3/5/20 | SB06 | 6 | 1.6 | *Stylophora* | M | 25 | exposed | 25 |
| 437 | 3/5/20 | SB06 | 6 | 1.6 | *Alveopora* | S | | | |
| 438 | 3/5/20 | SB06 | 6 | 1.6 | *Porites* | L | 25 | top | 25 |
| 439 | 3/5/20 | SB06 | 6 | 1.6 | *Stylophora* | S | 2 | exposed | |
| 440 | 3/5/20 | SB06 | 6 | 1.6 | *Montipora* | M | 8 | exposed | 20 |
| 441 | 3/5/20 | SB06 | 6 | 1.6 | *Porites* | S | 6 | exposed | 40 |
| 442 | 3/5/20 | SB06 | 6 | 1.6 | *Montipora* | XL | 6 | exposed | 40 |
| 443 | 3/5/20 | SB06 | 6 | 1.6 | *Acropora* | S | | | |
| 444 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | L | 15 | tips | 10 |
| 445 | 3/5/20 | SB06 | 6 | 1.6 | *Montipora* | S | | | |
| 446 | 3/5/20 | SB06 | 6 | 1.6 | *Montipora* | S | | | |
| 447 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | M | 15 | tips | 15 |
| 448 | 3/5/20 | SB06 | 6 | 1.6 | *Alveopora* | S | | | |
| 449 | 3/5/20 | SB06 | 6 | 1.6 | *Montipora* | XL | 7 | exposed | |
| 450 | 3/5/20 | SB06 | 6 | 1.6 | *Porites* | S | 3 | top | |
| 451 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | M | 2 | tips | |
| 452 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | L | 2 | tips | |
| 453 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | M | 2 | tips | |
| 454 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | L | 1 | tips | |
| 455 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | M | 5 | tips | |
| 456 | 3/5/20 | SB06 | 6 | 1.6 | *Homophyllia* | XL | | | |
| 457 | 3/5/20 | SB06 | 6 | 1.6 | *Alveopora* | S | | | |
| 458 | 3/5/20 | SB06 | 6 | 1.6 | *Pocillopora* | L | 1 | tips | |

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|---|---|---|---|---|---|---|---|---|---|
| 459 | 3/5/20 | SB06 | 6 | 1.6 | *Stylophora* | M | 15 | patchy | 10 |
| 460 | 3/5/20 | SB06 | 6 | 1.6 | *Paragoniastrea* | L | | | |
| 461 | 3/5/20 | SB06 | 6 | 1.6 | *Alveopora* | S | | | |
| 462 | 3/5/20 | SB06 | 6 | 1.6 | *Porites* | S | | | |
| 463 | 3/5/20 | SB06 | 6 | 1.6 | *Paragoniastrea* | XL | | | |
| 464 | 3/5/20 | SB06 | 6 | 1.6 | *Porites* | L | 6 | patchy | 40 |
| 465 | 3/5/20 | SB06 | 6 | 1.6 | *Favia* | S | | | |
| 466 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 467 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 468 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 469 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 470 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 471 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 472 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 473 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 474 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 475 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 476 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 477 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 478 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 479 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 480 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 481 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 482 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | |
| 483 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 484 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 485 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 486 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 487 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 488 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 489 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 490 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 491 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 492 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 493 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 494 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 495 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 496 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 497 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 498 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 499 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 500 | 3/5/20 | SB06 | 6 | 1.6 | Anemone | S | | | 100 |
| 501 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 1 | top | |
| 502 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | M | 15 | exposed | 40 |
| 503 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 6 | exposed | |
| 504 | 3/5/20 | SB05 | 5 | 2.2 | *Acropora* | L | | | 100 |

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|---|---|---|---|---|---|---|---|---|---|
| 505 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 506 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 507 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 508 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 509 | 3/5/20 | SB05 | 5 | 2.2 | *Pectinia* | M | | | |
| 510 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | XL | 7 | top | |
| 511 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | L | 2 | top | |
| 512 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 513 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 514 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 515 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 516 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 517 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 518 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 519 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 520 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 521 | 3/5/20 | SB05 | 5 | 2.2 | *Acropora* | S | | | 100 |
| 522 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | M | 2 | top | 30 |
| 523 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | L | 15 | exposed | 20 |
| 524 | 3/5/20 | SB05 | 5 | 2.2 | *Stylophora* | M | | | 100 |
| 525 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | M | | | |
| 526 | 3/5/20 | SB05 | 5 | 2.2 | *Acropora* | S | | | 20 |
| 527 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 15 | exposed | |
| 528 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | | | 100 |
| 529 | 3/5/20 | SB05 | 5 | 2.2 | *Porites* | S | 2 | top | |
| 530 | 3/5/20 | SB05 | 5 | 2.2 | *Acropora* | L | | | |
| 531 | 3/5/20 | SB05 | 5 | 2.2 | *Acropora* | S | | | |
| 532 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 3 | exposed | |
| 533 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | M | | | 100 |
| 534 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | L | | | 40 |
| 535 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 5 | top | 10 |
| 536 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 45 | exposed | 55 |
| 537 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | | | 100 |
| 538 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | M | 5 | top | |
| 539 | 3/5/20 | SB05 | 5 | 2.2 | *Porites* | S | 3 | top | |
| 540 | 3/5/20 | SB05 | 5 | 2.2 | *Goniopora* | S | | | |
| 541 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 542 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 543 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 544 | 3/5/20 | SB05 | 5 | 2.2 | *Platygyra* | S | | | |
| 545 | 3/5/20 | SB05 | 5 | 2.2 | *Goniopora* | S | | | |
| 546 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | S | | | |
| 547 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | L | | | |
| 548 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 1 | top | 80 |
| 549 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 1 | top | 50 |
| 550 | 3/5/20 | SB05 | 5 | 2.2 | *Pectinia* | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 551 | 3/5/20 | SB05 | 5 | 2.2 | *Symphyllia* | M | 1 | top | |
| 552 | 3/5/20 | SB05 | 5 | 2.2 | *Lobophyllia* | S | | | |
| 553 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | XL | | | 10 |
| 554 | 3/5/20 | SB05 | 5 | 2.2 | *Acropora* | XL | | | |
| 555 | 3/5/20 | SB05 | 5 | 2.2 | *Stylophora* | S | 3 | tips | |
| 556 | 3/5/20 | SB05 | 5 | 2.2 | *Paragoniastrea* | M | | | |
| 557 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | L | | | 5 |
| 558 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | M | 2 | patchy | |
| 559 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | L | | | 10 |
| 560 | 3/5/20 | SB05 | 5 | 2.2 | *Acropora* | XL | | | |
| 561 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | M | 5 | tips | |
| 562 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | M | 1 | tips | |
| 563 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | M | 1 | tips | |
| 564 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | XL | 1 | edges | |
| 565 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | XL | 5 | edges | |
| 566 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | XL | 1 | exposed | |
| 567 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | S | 5 | edges | |
| 568 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | S | 3 | exposed | |
| 569 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | S | 5 | patchy | |
| 570 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | S | 5 | patchy | |
| 571 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | S | 7 | patchy | |
| 572 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | S | 7 | patchy | |
| 573 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | S | 1 | edges | |
| 574 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | XL | | | |
| 575 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | L | 6 | edges | |
| 576 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | L | 1 | tips | |
| 577 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | XL | 1 | exposed | |
| 578 | 3/5/20 | SB05 | 5 | 2.2 | *Porites* | M | 1 | top | |
| 579 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 1 | tips | |
| 580 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | M | 5 | exposed | |
| 581 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | S | 15 | tips | |
| 582 | 3/5/20 | SB05 | 5 | 2.2 | *Pocillopora* | M | 1 | tips | |
| 583 | 3/5/20 | SB05 | 5 | 2.2 | *Montipora* | L | | | |
| 584 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 585 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 586 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 587 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 588 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 589 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 590 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 591 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 592 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 593 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 594 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 595 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 596 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 597 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 598 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 599 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 600 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 601 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 602 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | |
| 603 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | 100 |
| 604 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | 100 |
| 605 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | 100 |
| 606 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | 100 |
| 607 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | 100 |
| 608 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | 100 |
| 609 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | 100 |
| 610 | 3/5/20 | SB05 | 5 | 2.2 | Anemone | S | | | 100 |
| 611 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | | | 60 |
| 612 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | 3 | top | |
| 613 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | 5 | edge | |
| 614 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | 3 | edge | |
| 615 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | | | |
| 616 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | L | 12 | top | 10 |
| 617 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | |
| 618 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | |
| 619 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | |
| 620 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | |
| 621 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | M | 1 | top | 10 |
| 622 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | S | | | 30 |
| 623 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | M | | | |
| 624 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | S | | | |
| 625 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | | | |
| 626 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | 2 | edge | |
| 627 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | | | |
| 628 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | S | 1 | top | |
| 629 | 3/6/20 | EB03 | 3 | 2.1 | *Pocillopora* | S | 5 | exposed | |
| 630 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | 5 | edge | |
| 631 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | | | |
| 632 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | S | | | |
| 633 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | S | | | |
| 634 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | L | 1 | edge | 70 |
| 635 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | S | | | |
| 636 | 3/6/20 | EB03 | 3 | 2.1 | *Paragoniastrea* | M | | | |
| 637 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | XL | | | 25 |
| 638 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | 1 | edge | |
| 639 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | M | | | |
| 640 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | | | |
| 641 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | | | |
| 642 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | 2 | top, edge | |

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|---|---|---|---|---|---|---|---|---|---|
| 643 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | | | |
| 644 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | | | 100 |
| 645 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | S | 1 | top | 90 |
| 646 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | S | | | |
| 647 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | L | 6 | exposed | 40 |
| 648 | 3/6/20 | EB03 | 3 | 2.1 | *Platygyra* | L | | | |
| 649 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | S | 5 | top | |
| 650 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | S | 5 | top | |
| 651 | 3/6/20 | EB03 | 3 | 2.1 | *Paragoniastrea* | L | | | |
| 652 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | XL | | | 10 |
| 653 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | | | 5 |
| 654 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | | | 40 |
| 655 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | | | 100 |
| 656 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | 1 | edges | |
| 657 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | | | |
| 658 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | M | 1 | top | |
| 659 | 3/6/20 | EB03 | 3 | 2.1 | *Paragoniastrea* | M | | | |
| 660 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | | | |
| 661 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | | | 20 |
| 662 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | | | |
| 663 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | S | 1 | whole_colony | |
| 664 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | | | 50 |
| 665 | 3/6/20 | EB03 | 3 | 2.1 | *Paragoniastrea* | S | | | |
| 666 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | 1 | side | |
| 667 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | L | 1 | tips | |
| 668 | 3/6/20 | EB03 | 3 | 2.1 | *Acropora* | S | | | 100 |
| 669 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | S | 1 | whole_colony | |
| 670 | 3/6/20 | EB03 | 3 | 2.1 | *Porites* | S | 1 | whole_colony | |
| 671 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | S | | | |
| 672 | 3/6/20 | EB03 | 3 | 2.1 | *Montipora* | M | 1 | edges | |
| 673 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | 100 |
| 674 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | 100 |
| 675 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | 100 |
| 676 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | 100 |
| 677 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | 100 |
| 678 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | 100 |
| 679 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | |
| 680 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | |
| 681 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | |
| 682 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | S | | | |
| 683 | 3/6/20 | EB03 | 3 | 2.1 | Anemone | M | | | |
| 684 | 3/6/20 | EB01 | 1 | 2.4 | *Plesiastrea* | S | | | |
| 685 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | 5 | side | |
| 686 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |
| 687 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |
| 688 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 689 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |
| 690 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | 100 |
| 691 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | 25 | top | |
| 692 | 3/6/20 | EB01 | 1 | 2.4 | *Porites* | M | 3 | top | 20 |
| 693 | 3/6/20 | EB01 | 1 | 2.4 | *Plesiastrea* | M | | | 10 |
| 694 | 3/6/20 | EB01 | 1 | 2.4 | *Plesiastrea* | S | | | |
| 695 | 3/6/20 | EB01 | 1 | 2.4 | *Plesiastrea* | S | | | |
| 696 | 3/6/20 | EB01 | 1 | 2.4 | *Paragoniastrea* | M | | | |
| 697 | 3/6/20 | EB01 | 1 | 2.4 | *Paragoniastrea* | S | | | |
| 698 | 3/6/20 | EB01 | 1 | 2.4 | *Paragoniastrea* | S | | | |
| 699 | 3/6/20 | EB01 | 1 | 2.4 | *Paragoniastrea* | S | | | |
| 700 | 3/6/20 | EB01 | 1 | 2.4 | *Zooanthid* | S | | | |
| 701 | 3/6/20 | EB01 | 1 | 2.4 | *Acropora* | XL | | | 5 |
| 702 | 3/6/20 | EB01 | 1 | 2.4 | *Plesiastrea* | M | | | |
| 703 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | | | |
| 704 | 3/6/20 | EB01 | 1 | 2.4 | *Paragoniastrea* | L | | | |
| 705 | 3/6/20 | EB01 | 1 | 2.4 | *Porites* | S | 1 | whole_colony | |
| 706 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | 5 | top | |
| 707 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |
| 708 | 3/6/20 | EB01 | 1 | 2.4 | *Acropora* | XL | | | 50 |
| 709 | 3/6/20 | EB01 | 1 | 2.4 | *Acropora* | XL | | | |
| 710 | 3/6/20 | EB01 | 1 | 2.4 | *Homophyllia* | L | 3 | patchy | |
| 711 | 3/6/20 | EB01 | 1 | 2.4 | *Porites* | S | 3 | exposed | |
| 712 | 3/6/20 | EB01 | 1 | 2.4 | *Porites* | S | | | 100 |
| 713 | 3/6/20 | EB01 | 1 | 2.4 | *Platygyra* | L | | | |
| 714 | 3/6/20 | EB01 | 1 | 2.4 | *Astrea* | XL | | | 100 |
| 715 | 3/6/20 | EB01 | 1 | 2.4 | *Stylophora* | S | 1 | whole_colony | |
| 716 | 3/6/20 | EB01 | 1 | 2.4 | *Porites* | S | 2 | top | |
| 717 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |
| 718 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | 1 | edges | |
| 719 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |
| 720 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | 4 | patchy | |
| 721 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | | | |
| 722 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | 2 | patchy | |
| 723 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | | | |
| 724 | 3/6/20 | EB01 | 1 | 2.4 | *Platygyra* | S | | | |
| 725 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | L | 8 | exposed | |
| 726 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | | | |
| 727 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |
| 728 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | 1 | edges | |
| 729 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | S | | | |
| 730 | 3/6/20 | EB01 | 1 | 2.4 | *Platygyra* | M | | | |
| 731 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | 1 | edges | |
| 732 | 3/6/20 | EB01 | 1 | 2.4 | *Montipora* | M | 1 | edges | |
| 733 | 3/6/20 | EB01 | 1 | 2.4 | *Zooanthid* | M | 1 | whole_colony | |
| 734 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | L | 8 | patchy | |

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|---|---|---|---|---|---|---|---|---|---|
| 735 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 5 | top | |
| 736 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | |
| 737 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | S | 15 | patchy | |
| 738 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | L | 2 | patchy | 60 |
| 739 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | |
| 740 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | |
| 741 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 3 | top, side | |
| 742 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | M | 15 | top, side | 10 |
| 743 | 3/6/20 | EB02 | 2 | 1.5 | *Pocillopora* | S | 45 | exposed | |
| 744 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 745 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 746 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 747 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 748 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 749 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 750 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 751 | 3/6/20 | EB02 | 2 | 1.5 | *Paragoniastrea* | M | | | |
| 752 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | M | | | |
| 753 | 3/6/20 | EB02 | 2 | 1.5 | *Pocillopora* | L | 8 | exposed | |
| 754 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | L | 1 | edge | |
| 755 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | M | 8 | top | |
| 756 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | XL | 3 | patchy | |
| 757 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | |
| 758 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | 50 |
| 759 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | 50 |
| 760 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 95 | whole_colony | 5 |
| 761 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | 25 |
| 762 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | 100 |
| 763 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | 25 |
| 764 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | 25 |
| 765 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 1 | side | |
| 766 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | M | 1 | top | 25 |
| 767 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 3 | top, side | 10 |
| 768 | 3/6/20 | EB02 | 2 | 1.5 | *Pocillopora* | L | 3 | exposed | 30 |
| 769 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | |
| 770 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | | | 80 |
| 771 | 3/6/20 | EB02 | 2 | 1.5 | *Plesiastrea* | S | | | 100 |
| 772 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | S | | | |
| 773 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | | | 70 |
| 774 | 3/6/20 | EB02 | 2 | 1.5 | *Homophyllia* | S | | | |
| 775 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | M | 5 | top | |
| 776 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | M | 85 | top, side | |
| 777 | 3/6/20 | EB02 | 2 | 1.5 | *Homophyllia* | L | | | |
| 778 | 3/6/20 | EB02 | 2 | 1.5 | *Homophyllia* | S | | | |
| 779 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | L | 25 | patchy | |
| 780 | 3/6/20 | EB02 | 2 | 1.5 | *Paragoniastrea* | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 781 | 3/6/20 | EB02 | 2 | 1.5 | *Paragoniastrea* | S | | | 100 |
| 782 | 3/6/20 | EB02 | 2 | 1.5 | *Homophyllia* | S | | | 100 |
| 783 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 3 | top | 30 |
| 784 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | M | 9 | whole_colony | 10 |
| 785 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | S | | | 80 |
| 786 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | S | 5 | top | |
| 787 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | M | 1 | side | |
| 788 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | L | 15 | top, side | |
| 789 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 9 | exposed | |
| 790 | 3/6/20 | EB02 | 2 | 1.5 | *Alveopora* | S | | | |
| 791 | 3/6/20 | EB02 | 2 | 1.5 | *Homophyllia* | XL | | mottled | |
| 792 | 3/6/20 | EB02 | 2 | 1.5 | *Pectinia* | XL | | | |
| 793 | 3/6/20 | EB02 | 2 | 1.5 | *Pectinia* | S | | | |
| 794 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 1 | top | |
| 795 | 3/6/20 | EB02 | 2 | 1.5 | *Alveopora* | S | | | |
| 796 | 3/6/20 | EB02 | 2 | 1.5 | *Paragoniastrea* | S | | | |
| 797 | 3/6/20 | EB02 | 2 | 1.5 | *Goniopora* | S | | | |
| 798 | 3/6/20 | EB02 | 2 | 1.5 | *Stylophora* | M | 1 | whole_colony | |
| 799 | 3/6/20 | EB02 | 2 | 1.5 | *Stylophora* | L | 4 | exposed | |
| 800 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | M | 5 | edges | |
| 801 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | XL | 5 | patchy | |
| 802 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | S | | | |
| 803 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | S | 6 | exposed | |
| 804 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | S | 8 | exposed | |
| 805 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | S | 5 | patchy | |
| 806 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | L | 3 | edges | |
| 807 | 3/6/20 | EB02 | 2 | 1.5 | *Platygyra* | S | | | |
| 808 | 3/6/20 | EB02 | 2 | 1.5 | *Porites* | S | 9 | exposed | |
| 809 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | M | 1 | edges | 30 |
| 810 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | M | 1 | edges | 20 |
| 811 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | L | 1 | edges | 30 |
| 812 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | M | 1 | edges | 40 |
| 813 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | L | 1 | edges | 20 |
| 814 | 3/6/20 | EB02 | 2 | 1.5 | *Montipora* | M | 1 | edges | 20 |
| 815 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | 100 |
| 816 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | 100 |
| 817 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | 100 |
| 818 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | 100 |
| 819 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 820 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 821 | 3/6/20 | EB02 | 2 | 1.5 | Anemone | S | | | |
| 822 | 3/9/20 | EB04 | 4 | 2.2 | *Porites* | S | 5 | side | 10 |
| 823 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | XL | 1 | patchy | 5 |
| 824 | 3/9/20 | EB04 | 4 | 2.2 | *Platygyra* | M | | | |
| 825 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | S | | | 20 |
| 826 | 3/9/20 | EB04 | 4 | 2.2 | *Cyphastrea* | L | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 827 | 3/9/20 | EB04 | 4 | 2.2 | *Homophyllia* | S | | | |
| 828 | 3/9/20 | EB04 | 4 | 2.2 | *Porites* | M | 5 | top | 95 |
| 829 | 3/9/20 | EB04 | 4 | 2.2 | *Porites* | S | | | 5 |
| 830 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | XL | | | 60 |
| 831 | 3/9/20 | EB04 | 4 | 2.2 | *Montipora* | XL | 5 | patchy | |
| 832 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | S | | | |
| 833 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | | | |
| 834 | 3/9/20 | EB04 | 4 | 2.2 | *Pectinia* | M | | | |
| 835 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | M | | | |
| 836 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | L | | | |
| 837 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | M | | | |
| 838 | 3/9/20 | EB04 | 4 | 2.2 | *Pocillopora* | S | 8 | exposed | |
| 839 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | XL | | | 15 |
| 840 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | XL | 1 | edges | |
| 841 | 3/9/20 | EB04 | 4 | 2.2 | *Montipora* | XL | 5 | middle | |
| 842 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | M | | | |
| 843 | 3/9/20 | EB04 | 4 | 2.2 | *Montipora* | L | | | |
| 844 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | XL | 5 | top | 80 |
| 845 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | M | | | |
| 846 | 3/9/20 | EB04 | 4 | 2.2 | *Anemone* | S | | | |
| 847 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | 100 |
| 848 | 3/9/20 | EB05 | 5 | 0.7 | *Homophyllia* | L | | | 80 |
| 849 | 3/9/20 | EB05 | 5 | 0.7 | *Homophyllia* | S | | | |
| 850 | 3/9/20 | EB05 | 5 | 0.7 | *Homophyllia* | S | | | |
| 851 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | 100 |
| 852 | 3/9/20 | EB05 | 5 | 0.7 | *Astrea* | S | 2 | edges | |
| 853 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | |
| 854 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | | | 12 |
| 855 | 3/9/20 | EB05 | 5 | 0.7 | *Pocillopora* | M | 10 | exposed | 30 |
| 856 | 3/9/20 | EB05 | 5 | 0.7 | *Astrea* | XL | 1 | patchy | 5 |
| 857 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | 4 | middle | 5 |
| 858 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | | | |
| 859 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | 10 |
| 860 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 5 | tips | 95 |
| 861 | 3/9/20 | EB05 | 5 | 0.7 | *Stylophora* | S | 5 | top | 80 |
| 862 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | L | 6 | patchy | 10 |
| 863 | 3/9/20 | EB05 | 5 | 0.7 | *Porites* | M | 4 | edges | |
| 864 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | |
| 865 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | | | 10 |
| 866 | 3/9/20 | EB05 | 5 | 0.7 | *Homophyllia* | M | | | |
| 867 | 3/9/20 | EB05 | 5 | 0.7 | *Astrea* | XL | | | |
| 868 | 3/9/20 | EB05 | 5 | 0.7 | *Montipora* | M | 4 | top | |
| 869 | 3/9/20 | EB05 | 5 | 0.7 | *Montipora* | S | | | 100 |
| 870 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | | | 50 |
| 871 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | | | |
| 872 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | | | |

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|---|---|---|---|---|---|---|---|---|---|
| 873 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | | | |
| 874 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | | | |
| 875 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | | | |
| 876 | 3/9/20 | EB05 | 5 | 0.7 | *Montipora* | S | | | |
| 877 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | 5 | edges | |
| 878 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | | | |
| 879 | 3/9/20 | EB05 | 5 | 0.7 | *Acanthastrea* | XL | | | |
| 880 | 3/9/20 | EB05 | 5 | 0.7 | *Montipora* | L | 30 | top | |
| 881 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | | | |
| 882 | 3/9/20 | EB05 | 5 | 0.7 | *Porites* | S | 40 | top | 70 |
| 883 | 3/9/20 | EB05 | 5 | 0.7 | *Montipora* | L | 1 | top | |
| 884 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | |
| 885 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | 6 | edges | 90 |
| 886 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | 100 |
| 887 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | 100 |
| 888 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | 100 |
| 889 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | | | 100 |
| 890 | 3/9/20 | EB05 | 5 | 0.7 | *Montipora* | L | 2 | top | |
| 891 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | XL | | | 5 |
| 892 | 3/9/20 | EB05 | 5 | 0.7 | *Acanthastrea* | M | | | |
| 893 | 3/9/20 | EB05 | 5 | 0.7 | *Acanthastrea* | M | | | |
| 894 | 3/9/20 | EB05 | 5 | 0.7 | *Pocillopora* | M | 10 | top | 80 |
| 895 | 3/9/20 | EB06 | 6 | 1.8 | *Platygyra* | M | | | |
| 896 | 3/9/20 | EB06 | 6 | 1.8 | *Platygyra* | S | | | 100 |
| 897 | 3/9/20 | EB06 | 6 | 1.8 | *Porites* | S | | | 100 |
| 898 | 3/9/20 | EB06 | 6 | 1.8 | *Porites* | M | 5 | top | |
| 899 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | M | | | 10 |
| 900 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | S | | | 30 |
| 901 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | M | | | |
| 902 | 3/9/20 | EB06 | 6 | 1.8 | *Goniopora* | S | | | |
| 903 | 3/9/20 | EB06 | 6 | 1.8 | *Porites* | S | 5 | top | |
| 904 | 3/9/20 | EB06 | 6 | 1.8 | *Cyphastrea* | M | | | |
| 905 | 3/9/20 | EB06 | 6 | 1.8 | *Zooanthid* | S | 2 | side | |
| 906 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | M | | | |
| 907 | 3/9/20 | EB06 | 6 | 1.8 | *Porites* | S | 5 | top | |
| 908 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | S | | | |
| 909 | 3/9/20 | EB06 | 6 | 1.8 | *Cyphastrea* | M | | | |
| 910 | 3/9/20 | EB06 | 6 | 1.8 | *Cyphastrea* | L | | | |
| 911 | 3/9/20 | EB06 | 6 | 1.8 | *Montipora* | M | 40 | top | |
| 912 | 3/9/20 | EB06 | 6 | 1.8 | *Platygyra* | S | | | |
| 913 | 3/9/20 | EB06 | 6 | 1.8 | *Cyphastrea* | S | | | |
| 914 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | S | | | |
| 915 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | S | | | |
| 916 | 3/9/20 | EB06 | 6 | 1.8 | *Cyphastrea* | L | | | |
| 917 | 3/9/20 | EB06 | 6 | 1.8 | *Montipora* | M | 30 | top | |
| 918 | 3/9/20 | EB06 | 6 | 1.8 | *Lobophyta* | S | 2 | top | 25 |

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|---|---|---|---|---|---|---|---|---|---|
| 919 | 3/9/20 | EB06 | 6 | 1.8 | *Lobophyta* | S | 2 | top | 25 |
| 920 | 3/9/20 | EB07 | 7 | 1.5 | *Paragoniastrea* | S | | | |
| 921 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | S | | | 50 |
| 922 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | S | | | |
| 923 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | S | | | |
| 924 | 3/9/20 | EB07 | 7 | 1.5 | *Montipora* | S | 5 | top | |
| 925 | 3/9/20 | EB07 | 7 | 1.5 | *Montipora* | M | 5 | top | 25 |
| 926 | 3/9/20 | EB07 | 7 | 1.5 | *Platygyra* | M | | | |
| 927 | 3/9/20 | EB07 | 7 | 1.5 | *Pocillopora* | M | 15 | exposed | 60 |
| 928 | 3/9/20 | EB07 | 7 | 1.5 | *Acanthastrea* | S | | | |
| 929 | 3/9/20 | EB07 | 7 | 1.5 | *Acanthastrea* | M | | | |
| 930 | 3/9/20 | EB07 | 7 | 1.5 | *Pocillopora* | S | 10 | exposed | 75 |
| 931 | 3/9/20 | EB07 | 7 | 1.5 | *Zooanthid* | S | | | |
| 932 | 3/9/20 | EB07 | 7 | 1.5 | *Pocillopora* | S | 10 | top | 80 |
| 933 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | S | | | |
| 934 | 3/9/20 | EB07 | 7 | 1.5 | *Paragoniastrea* | M | | | |
| 935 | 3/9/20 | EB07 | 7 | 1.5 | *Acanthastrea* | M | | | |
| 936 | 3/9/20 | EB07 | 7 | 1.5 | *Porites* | S | 60 | whole_colony | 30 |
| 937 | 3/9/20 | EB07 | 7 | 1.5 | *Porites* | M | 10 | top | 20 |
| 938 | 3/9/20 | EB07 | 7 | 1.5 | *Porites* | S | 10 | side | 80 |
| 939 | 3/9/20 | EB07 | 7 | 1.5 | *Pectinia* | S | | | |
| 940 | 3/9/20 | EB07 | 7 | 1.5 | *Platygyra* | S | | | |
| 941 | 3/9/20 | EB07 | 7 | 1.5 | *Pectinia* | M | | | |
| 942 | 3/9/20 | EB07 | 7 | 1.5 | *Pocillopora* | S | 15 | exposed | 50 |
| 943 | 3/9/20 | EB07 | 7 | 1.5 | *Acropora* | M | | | 100 |
| 944 | 3/9/20 | EB07 | 7 | 1.5 | *Platygyra* | L | | | |
| 945 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | M | 0 | | |
| 946 | 3/9/20 | EB04 | 4 | 2.2 | *Homophyllia* | S | 0 | | |
| 947 | 3/9/20 | EB04 | 4 | 2.2 | *Platygyra* | L | 0 | | |
| 948 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | M | 0 | | |
| 949 | 3/9/20 | EB04 | 4 | 2.2 | *Turbinaria* | M | 0 | | |
| 950 | 3/9/20 | EB04 | 4 | 2.2 | *Montipora* | L | 60 | exposed | 10 |
| 951 | 3/9/20 | EB04 | 4 | 2.2 | *Montipora* | M | 0 | | |
| 952 | 3/9/20 | EB04 | 4 | 2.2 | *Montipora* | S | 0 | | 10 |
| 953 | 3/9/20 | EB04 | 4 | 2.2 | *Alveopora* | S | 0 | | |
| 954 | 3/9/20 | EB04 | 4 | 2.2 | *Alveopora* | S | 0 | | |
| 955 | 3/9/20 | EB04 | 4 | 2.2 | *Montipora* | XL | 50 | exposed | 10 |
| 956 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | L | 0 | | |
| 957 | 3/9/20 | EB04 | 4 | 2.2 | *Stylophora* | S | 90 | interior | |
| 958 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | S | 0 | | |
| 959 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | S | 0 | | |
| 960 | 3/9/20 | EB04 | 4 | 2.2 | *Goniastrea* | M | 0 | | |
| 961 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | S | 0 | | |
| 962 | 3/9/20 | EB04 | 4 | 2.2 | *Alveopora* | S | 0 | | |
| 963 | 3/9/20 | EB04 | 4 | 2.2 | *Goniopora* | M | 0 | | |
| 964 | 3/9/20 | EB04 | 4 | 2.2 | *Porites* | S | 0 | | |

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|---|---|---|---|---|---|---|---|---|---|
| 965 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | S | 0 | | |
| 966 | 3/9/20 | EB04 | 4 | 2.2 | *Oulophyllia* | XL | 0 | | |
| 967 | 3/9/20 | EB04 | 4 | 2.2 | *Homophyllia* | M | 0 | | |
| 968 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | M | 0 | | |
| 969 | 3/9/20 | EB04 | 4 | 2.2 | *Homophyllia* | M | 0 | | |
| 970 | 3/9/20 | EB04 | 4 | 2.2 | *Acropora* | S | 0 | | 60 |
| 971 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | 100 |
| 972 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | 100 |
| 973 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | 100 |
| 974 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | 100 |
| 975 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | M | 0 | | 100 |
| 976 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | |
| 977 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | |
| 978 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | |
| 979 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | |
| 980 | 3/9/20 | EB04 | 4 | 2.2 | Anemone | S | 0 | | |
| 981 | 3/9/20 | EB05 | 5 | 0.7 | *Homophyllia* | M | 0 | | |
| 982 | 3/9/20 | EB05 | 5 | 0.7 | *Cythastrea* | M | 0 | | |
| 983 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | |
| 984 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | |
| 985 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | 100 |
| 986 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | 100 |
| 987 | 3/9/20 | EB05 | 5 | 0.7 | *Montipora* | L | 10 | edges | |
| 988 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | 0 | | 20 |
| 989 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | |
| 990 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | |
| 991 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | 100 |
| 992 | 3/9/20 | EB05 | 5 | 0.7 | *Pocillopora* | M | 60 | exposed | 60 |
| 993 | 3/9/20 | EB05 | 5 | 0.7 | *Pocillopora* | M | 10 | interior | 10 |
| 994 | 3/9/20 | EB05 | 5 | 0.7 | *Stylophora* | S | 10 | exposed | |
| 995 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | 0 | | |
| 996 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | |
| 997 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | L | 0 | | 10 |
| 998 | 3/9/20 | EB05 | 5 | 0.7 | *Montipora* | L | 15 | exposed | |
| 999 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | 100 |
| 1000 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | 0 | | |
| 1001 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | M | 0 | | 100 |
| 1002 | 3/9/20 | EB05 | 5 | 0.7 | *Pocillopora* | M | 60 | patchy | |
| 1003 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | L | 0 | | |
| 1004 | 3/9/20 | EB05 | 5 | 0.7 | *Pocillopora* | S | 0 | | 10 |
| 1005 | 3/9/20 | EB05 | 5 | 0.7 | *Homophyllia* | M | 10 | patchy | |
| 1006 | 3/9/20 | EB05 | 5 | 0.7 | *Porites* | S | 50 | exposed | 50 |
| 1007 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | |
| 1008 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | |
| 1009 | 3/9/20 | EB05 | 5 | 0.7 | *Pocillopora* | S | 50 | patchy | |
| 1010 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | XL | 0 | | |

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|---|---|---|---|---|---|---|---|---|---|
| 1011 | 3/9/20 | EB05 | 5 | 0.7 | *Acropora* | S | 0 | | |
| 1012 | 3/9/20 | EB05 | 5 | 0.7 | *Porites* | S | 90 | exposed | |
| 1013 | 3/9/20 | EB05 | 5 | 0.7 | *Platygyra* | S | 0 | | |
| 1014 | 3/9/20 | EB05 | 5 | 0.7 | *Homophyllia* | S | 0 | | |
| 1015 | 3/9/20 | EB05 | 5 | 0.7 | Acropora | S | 0 | | |
| 1016 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1017 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1018 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1019 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1020 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1021 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1022 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1023 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1024 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1025 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1026 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | |
| 1027 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | 100 |
| 1028 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | 100 |
| 1029 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | 100 |
| 1030 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | 100 |
| 1031 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | 100 |
| 1032 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | 100 |
| 1033 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | 100 |
| 1034 | 3/9/20 | EB05 | 5 | 0.7 | Anemone | S | 0 | | 100 |
| 1035 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | S | 0 | | |
| 1036 | 3/9/20 | EB06 | 6 | 1.8 | *Goniopora* | S | 0 | | |
| 1037 | 3/9/20 | EB06 | 6 | 1.8 | *Paragoniastrea* | S | 0 | | |
| 1038 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | S | 0 | | |
| 1039 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | M | 20 | patchy | |
| 1040 | 3/9/20 | EB06 | 6 | 1.8 | *Porites* | S | 0 | | |
| 1041 | 3/9/20 | EB06 | 6 | 1.8 | *Porites* | S | 100 | whole_colony | |
| 1042 | 3/9/20 | EB06 | 6 | 1.8 | *Porites* | S | 0 | | |
| 1043 | 3/9/20 | EB06 | 6 | 1.8 | *Goniopora* | S | 0 | | |
| 1044 | 3/9/20 | EB06 | 6 | 1.8 | *Platygyra* | M | 0 | | |
| 1045 | 3/9/20 | EB06 | 6 | 1.8 | *Pectinia* | L | 0 | | |
| 1046 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | XL | 0 | | 100 |
| 1047 | 3/9/20 | EB06 | 6 | 1.8 | *Homophyllia* | M | 0 | | |
| 1048 | 3/9/20 | EB06 | 6 | 1.8 | *Montipora* | L | 10 | edges | |
| 1049 | 3/9/20 | EB06 | 6 | 1.8 | *Montipora* | L | 5 | edges | |
| 1050 | 3/9/20 | EB06 | 6 | 1.8 | *Paragoniastrea* | M | 0 | | 100 |
| 1051 | 3/9/20 | EB06 | 6 | 1.8 | *Astrea* | L | 0 | | |
| 1052 | 3/9/20 | EB06 | 6 | 1.8 | *Acropora* | L | 0 | | 100 |
| 1053 | 3/9/20 | EB06 | 6 | 1.8 | *Acropora* | L | 0 | | |
| 1054 | 3/9/20 | EB06 | 6 | 1.8 | *Pocillopora* | M | 0 | | 100 |
| 1055 | 3/9/20 | EB06 | 6 | 1.8 | *Pocillopora* | M | 10 | tips | 90 |
| 1056 | 3/9/20 | EB06 | 6 | 1.8 | *Pectinia* | S | 0 | | |

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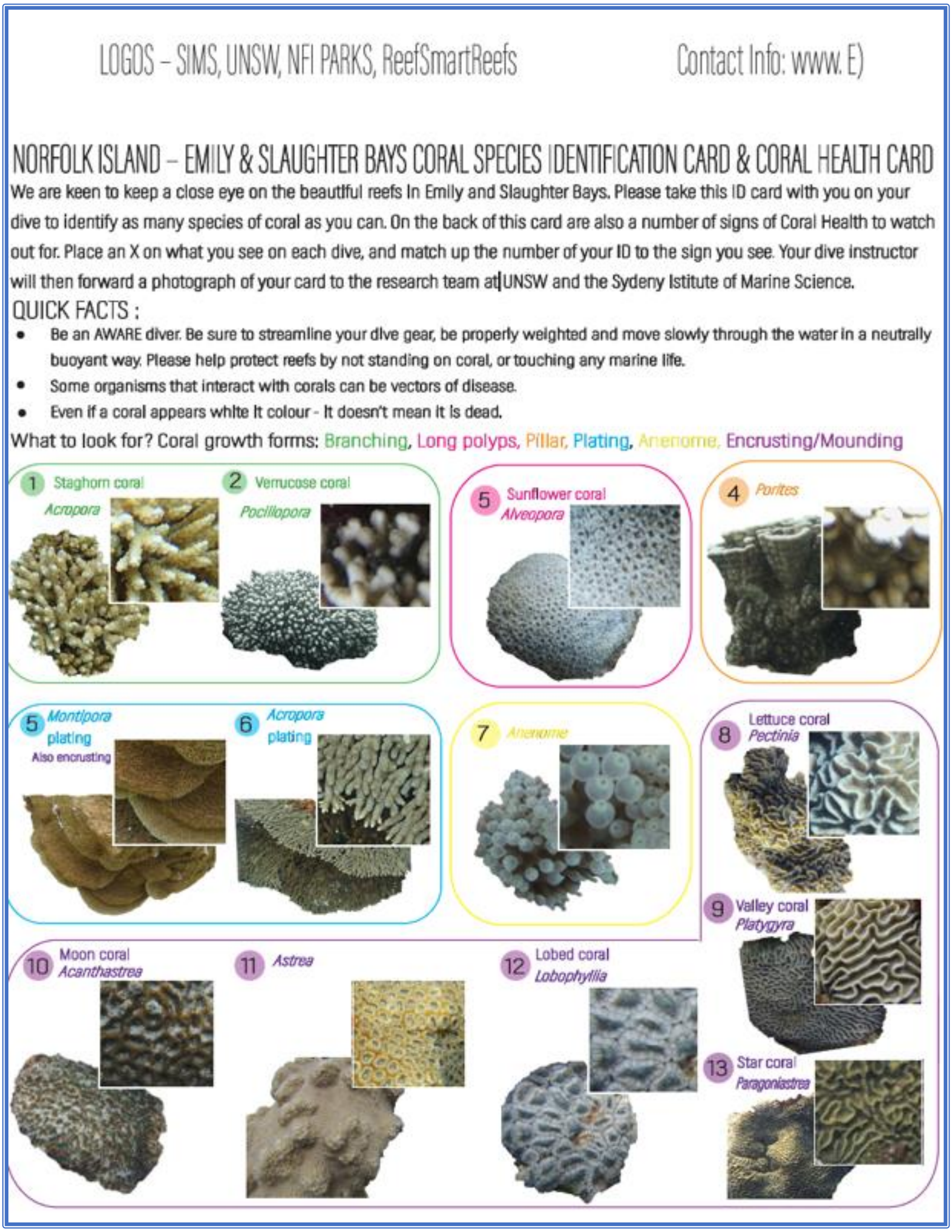
|---|---|---|---|---|---|---|---|---|---|
| 1057 | 3/9/20 | EB06 | 6 | 1.8 | *Acropora* | S | 0 | | |
| 1058 | 3/9/20 | EB06 | 6 | 1.8 | *Acropora* | S | 0 | | 100 |
| 1059 | 3/9/20 | EB06 | 6 | 1.8 | *Pectinia* | S | 10 | patchy | 90 |
| 1060 | 3/9/20 | EB06 | 6 | 1.8 | *Montipora* | S | 20 | exposed | |
| 1061 | 3/9/20 | EB06 | 6 | 1.8 | *Favia* | S | 0 | | |
| 1062 | 3/9/20 | EB06 | 6 | 1.8 | *Montipora* | L | 20 | exposed | |
| 1063 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | S | 0 | | 100 |
| 1064 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | S | 0 | | 100 |
| 1065 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | S | 0 | | 100 |
| 1066 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | S | 0 | | 100 |
| 1067 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | S | 0 | | 100 |
| 1068 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | S | 0 | | 100 |
| 1069 | 3/9/20 | EB06 | 6 | 1.8 | Anemone | S | 0 | | |
| 1070 | 3/9/20 | EB07 | 7 | 1.5 | *Stylophora* | S | 100 | whole_colony | |
| 1071 | 3/9/20 | EB07 | 7 | 1.5 | *Stylophora* | S | 100 | whole_colony | |
| 1072 | 3/9/20 | EB07 | 7 | 1.5 | *Acropora* | M | 0 | | |
| 1073 | 3/9/20 | EB07 | 7 | 1.5 | *Acropora* | S | 0 | | |
| 1074 | 3/9/20 | EB07 | 7 | 1.5 | *Homophyllia* | M | 0 | | |
| 1075 | 3/9/20 | EB07 | 7 | 1.5 | *Montipora* | M | 20 | edges | |
| 1076 | 3/9/20 | EB07 | 7 | 1.5 | *Porites* | L | 100 | whole_colony | |
| 1077 | 3/9/20 | EB07 | 7 | 1.5 | *Porites* | S | 100 | whole_colony | |
| 1078 | 3/9/20 | EB07 | 7 | 1.5 | *Porites* | M | 70 | patchy | 30 |
| 1079 | 3/9/20 | EB07 | 7 | 1.5 | *Homophyllia* | L | 0 | | |
| 1080 | 3/9/20 | EB07 | 7 | 1.5 | *Paragoniastrea* | M | 0 | | 100 |
| 1081 | 3/9/20 | EB07 | 7 | 1.5 | *Stylophora* | L | 60 | patchy | 40 |
| 1082 | 3/9/20 | EB07 | 7 | 1.5 | *Pectinia* | L | 0 | | |
| 1083 | 3/9/20 | EB07 | 7 | 1.5 | *Homophyllia* | XL | 80 | patchy | |
| 1084 | 3/9/20 | EB07 | 7 | 1.5 | *Paragoniastrea* | M | 0 | | |
| 1085 | 3/9/20 | EB07 | 7 | 1.5 | *Homophyllia* | S | 0 | | |
| 1086 | 3/9/20 | EB07 | 7 | 1.5 | *Oulophyllia* | S | 0 | | |
| 1087 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | S | 0 | | 100 |
| 1088 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | S | 0 | | 100 |
| 1089 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | S | 0 | | |
| 1090 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | M | 0 | | |
| 1091 | 3/9/20 | EB07 | 7 | 1.5 | Anemone | M | 0 | | |



LOGOS – SIMS, UNSW, NFI PARKS, ReefSmartReefs Contact Info: www. E)

NORFOLK ISLAND – EMILY & SLAUGHTER BAYS CORAL SPECIES IDENTIFICATION CARD & CORAL HEALTH CARD

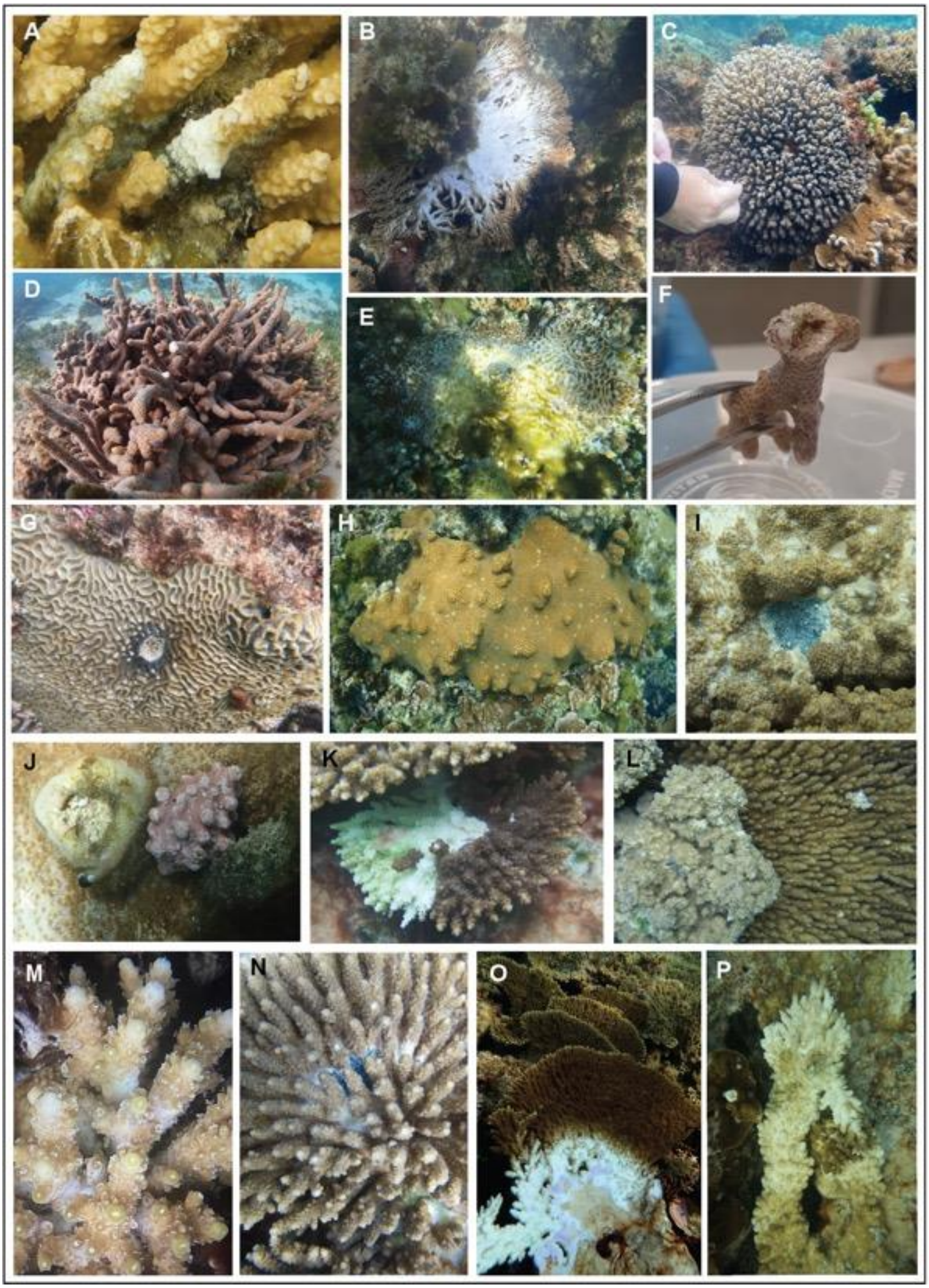
We are keen to keep a close eye on the beautiful reefs in Emily and Slaughter Bays. Please take this ID card with you on your dive to identify as many species of coral as you can. On the back of this card are also a number of signs of Coral Health to watch out for. Place an X on what you see on each dive, and match up the number of your ID to the sign you see. Your dive instructor will then forward a photograph of your card to the research team at UNSW and the Sydeny Istitute of Marine Science.

QUICK FACTS :

- Be an AWARE diver. Be sure to streamline your dive gear, be properly weighted and move slowly through the water in a neutrally buoyant way. Please help protect reefs by not standing on coral, or touching any marine life.
- Some organisms that interact with corals can be vectors of disease.
- Even if a coral appears white it colour - It doesn't mean it is dead.

What to look for? Coral growth forms: Branching, Long polyps, Pillar, Plating, Anenome, Encrusting/Mounding

***<u>CORAL HEALTH IDENTIFICATION IN EMILY AND SLAUGHTER BAY</u>***



***Coral Health Identification in Emily and Slaughter Bay***

A) Tissue loss on branching *Acropora* sp. colonised by a black microalgal or ciliate community *(obs. Nov 20)*.

B) A large colony of plating *Acropora* sp. flipped during storm damage *(obs.Nov 20, April 21).*

C) A *Stylophora* sp. colony showing gradient of tissue colour *(obs, April 21).* Darker fragments on the bottom side of the colony showed signs of colonisation by a brown sponge (see F).

D) Predation and or/breakage on the tips of a branching *Acropora* sp (*obs. Nov 20, April 21*).

E) A white syndrome and heavy turf overgrowth on a mounding *Acanthastra* sp. (*obs. Nov 20*).

F) Colonised *Stylophora sp*. skeleton *(obs. April 21)*.

G) *Pectinia* sp. with a white syndrome lesion (*obs. April 21)*.

H) A mounding *Astrea* sp. colony showing signs of predation damage (*obs. Nov 20, April 21*.).

I) Lesion on plating *Acropora* sp. showing signs of Atrementous Necrosis including black bacterial overgrowth *(obs.April 21).*

J) *Drupella* (corallivorous snail) pictured on a *Montipora* colony (*obs Nov 20*).

K) White syndrome visible in plating Acropora sp. (*obs. April 21*).

L) Growth anomalies in plating *Acropora* sp., (*obs. November 20, April 21*).

M) Tissue loss in basal part of branching *Acropora* sp. colony (*obs April 21*).

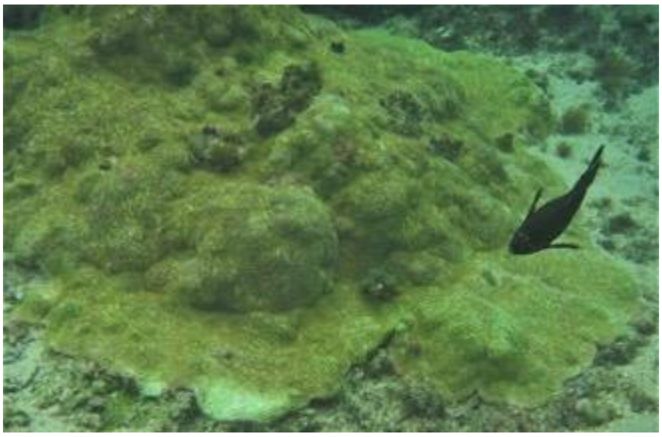
N) White syndrome on a branching *Acropora* sp. colony, also showing signs of Atrementous Necrosis black bacterial overgrowth (*obs. April 21*).

O) White syndrome in plating *Acropora* sp. no overgrowth indicating acute tissue loss.

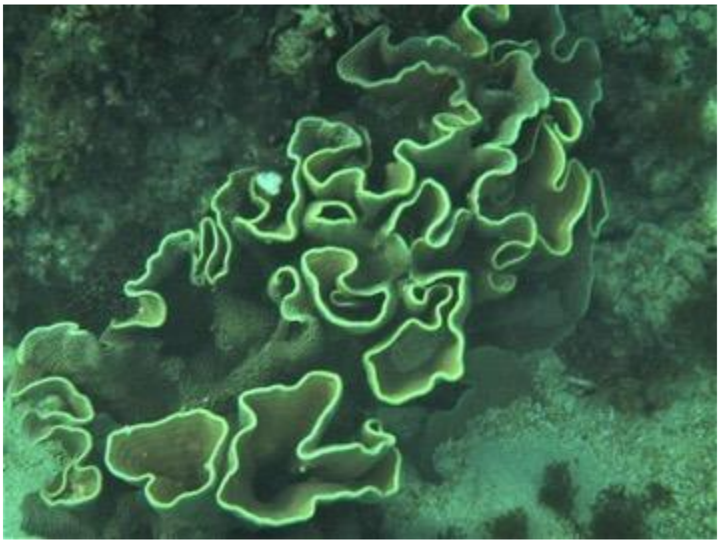
P) Paling and tissue loss in branching *Acropora* sp.

| | |
|---|---|
| **Common name(s):** | Staghorn coral |
| **Family:** | Acroporidae |
| **Genus:** | *Acropora* spp. |
| **Species previously recorded by Veron (1997)** | *A. chesterfieldensis*, *A. clathrata, A. glauca, A. solitariensis* |
| **Morphologies:** | tabular, plating, branching, corymbose, encrusting |
| **Colour morphs:** | light/dark brown, beige/yellow, dark grey |
| **Distinguishing feature(s):** | Differentiated axial polyp |
| **Frequency:** | Very common |

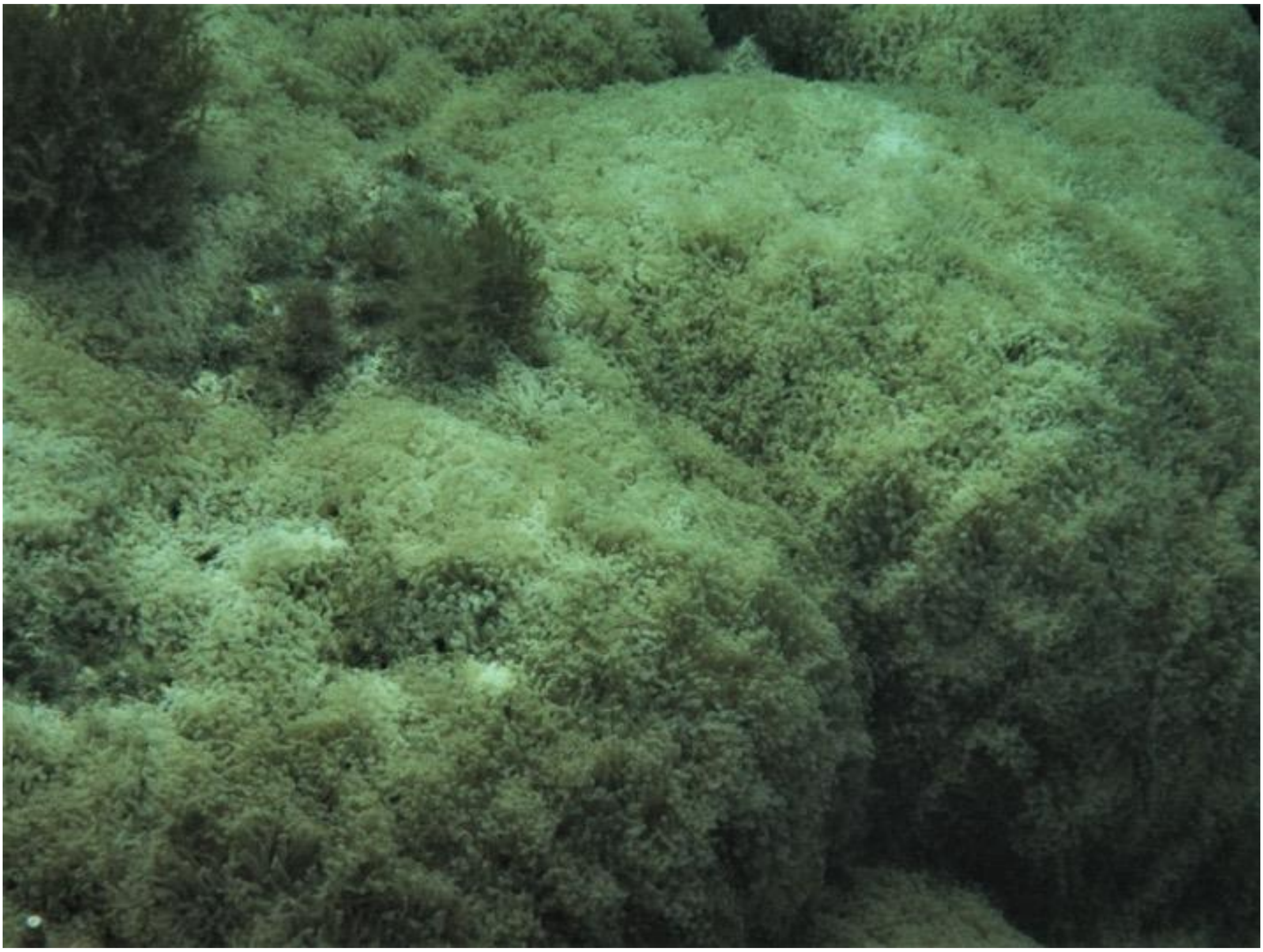
| | |
|---|---|
| **Common name(s):** | Pore coral |
| **Family:** | Acroporidae |
| **Genus:** | *Montipora* spp. |
| **Species previously recorded by Veron (1997)** | *M. aequituberculata, M. danae, M. mollis, M. turgescens, M. turtlensis* |
| **Morphologies:** | Foliose, thin encrusting, columnar |
| **Colour morphs:** | Light brown, blue/purple, green |
| **Distinguishing feature(s):** | Very small polyps extend slightly from the colony surface, evenly spaced apart. Fragile skeleton |
| **Frequency:** | Very common |



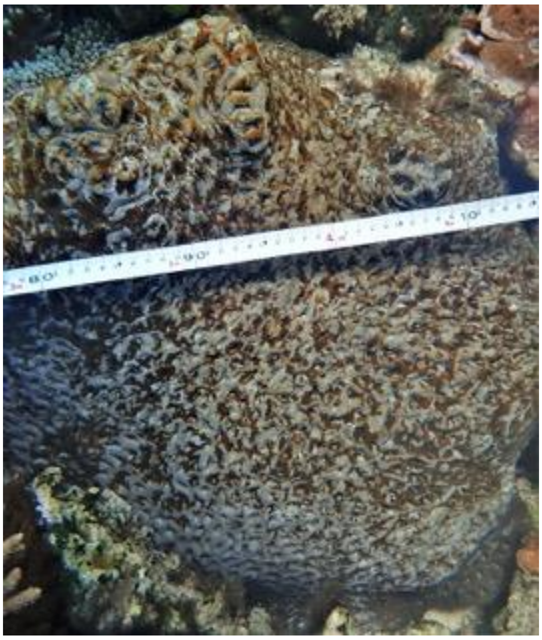
| | |
|---|---|
| **Common names:** | Disc coral |
| **Family:** | Dendrophyllidae |
| **Genus:** | *Turbinaria* spp. |
| **Species previously recorded by Veron (1997)** | *T. frondens, T. patula, T. peltata, T. radicalis* |
| **Morphologies:** | Foliose, thin encrusting |
| **Colour morphs:** | Dark/bright green, purple |
| **Distinguishing feature(s):** | Distinctive "lettuce cup" colony form |
| **Frequency:** | Uncommon |



| | |
|---|---|
| **Common names:** | Anchor coral |
| **Family:** | Euphyllidae |
| **Genus:** | *Euphyllia* spp. |
| **Species previously recorded by Veron (1997)** | *E. ancora* |
| **Morphologies:** | Massive |
| **Colour morphs:** | Cream |
| **Distinguishing feature(s):** | Tubular tentacles on polyps with white tips give ‘bubbly’ appearance to the colony. |
| **Frequency:** | Rare |

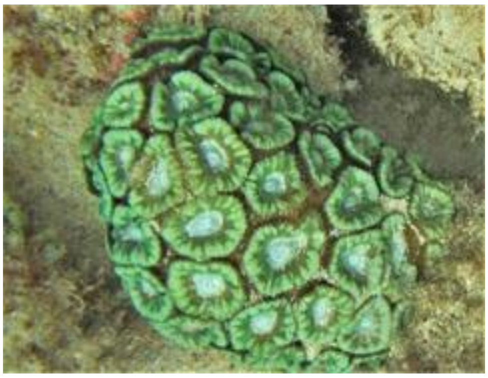


| | |
|---|---|
| **Common name(s):** | Moon coral |
| **Family:** | Lobophyllidae |
| **Genus:** | *Acanthastrea* spp. |
| **Species previously sighted by Veron (1997)** | *A. bowerbanki, A. hillae, A. lordhowensis* |
| **Morphologies:** | Massive, thick encrusting |
| **Colour morphs:** | Light grey, dark brown |
| **Distinguishing feature(s):** | Large fleshy polyps, which share a wall with their neighbours |
| **Frequency:** | Common |



| | |
|---|---|
| **Common names:** | Button coral |
| **Family:** | Lobophyllidae |
| **Genus:** | *Homophyllia* spp. |
| **Species previously sighted by Version (1997)** | *H. australis*. |
| **Morphologies:** | Encrusting |
| **Colour morphs:** | Highly variable across the polyp mantle. |
| **Distinguishing feature(s) -** | Distinctive, solitary saucer shaped, fleshy polyp. Sometimes has multiple centres. |
| **Frequency:** | Uncommon |

| | |
|---|---|
| **Common names:** | Lobed coral |
| **Family:** | Lobophyllidae |
| **Genus:** | Lobophyllia |
| **Species previously sighted by Veron (1997)** | N/A |
| **Morphologies:** | Massive, thick encrusting |
| **Colour morphs:** | Highly variable – light brown/green, orange/cream, blue/grey |
| **Distinguishing feature(s) -** | Large fleshy polyps that do not share walls, with or without gaps between polyps. Individual polyps can be monocentric or in valleys. |
| **Frequency:** | Common |



| | |
|---|---|
| **Common names:** | False knob coral |
| **Family:** | Merulinidae |
| **Genus:** | Astrea spp. |
| **Species previously sighted by Veron (1997):** | *A. curta* |
| **Morphologies:** | Massive, thick encrusting |
| **Colour morphs:** | Pale orange/cream between the polyps, and grey/blue in the corallites centres. |
| **Distinguishing feature(s):** | Corallites are circular and widely spaced |
| **Frequency:** | Very common |

| | |
|---|---|
| **Common names:** | Lesser knob coral |
| **Family:** | Merulinidae |
| **Genus:** | *Cyphastrea* spp. |
| **Species previously sighted by Veron (1997):** | *C. serailia* |
| **Morphologies:** | Massive, thick encrusting |
| **Colour morphs:** | Grey/brown, bright green |
| **Distinguishing feature(s):** | Massive colonies are hillocky or smooth. Corallites are evenly sized, and toothed on their outer edge |
| **Frequency:** | Common |

| | |
|---|---|
| **Common names:** | Lesser star coral |
| **Family:** | Merulinidae |
| **Genus:** | *Paragoniastrea* spp. |
| **Species previously sighted by Veron (1997):** | *P. australensis, P. favulus* |
| **Morphologies:** | Submassive, thick encrusting |
| **Colour morphs:** | Grey/brown, bright green |
| **Distinguishing feature(s):** | Meandering corallites. Compared to *Pectinia* and *Platygyra*, the valleys display very distinctive paliform lobes that aids in identification. |
| **Frequency:** | Common |

| | |
|---|---|
| **Common names:** | Lettuce coral |
| **Family:** | Merulinidae |
| **Genus:** | *Pectinia* spp. |
| **Species previously sighted by Veron (1997):** | N/A |
| **Morphologies:** | Submassive, thick encrusting |
| **Colour morphs:** | Uniform brown, cream |
| **Distinguishing feature(s):** | Meandering corallites. Compared to *Paragoniastrea* and *Platygyra*, corallites have wider and deeper valleys, and relatively thin corallite walls. |
| **Frequency:** | Common |

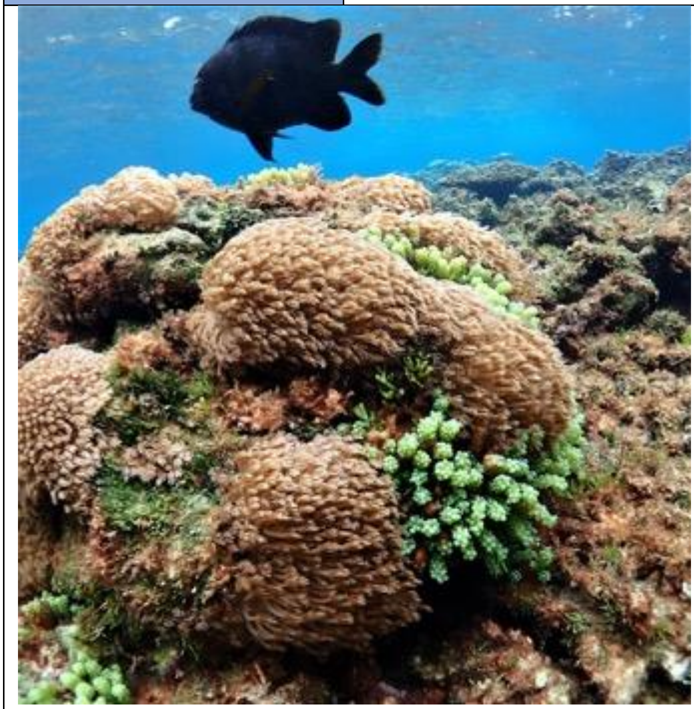
| | |
|---|---|
| **Common names:** | Lettuce coral |
| **Family:** | Merulinidae |
| **Genus:** | *Platygyra* spp. |
| **Species previously sighted by Veron (1997):** | N/A |
| **Morphologies:** | Massive, domed, thick encrusting |
| **Colour morphs:** | Brown, cream and valleys floor may be a different colour |
| **Distinguishing feature(s):** | Long, m eandering corallites. Valley width smaller than *Pectinia* but similar to *Paragoniastrea*. Distinguishing from the latter is aided by an absence of distinct paliform lobes in *Platygyra* |
| **Frequency:** | Common |

| | |
|---|---|
| **Common names:** | Small knob coral |
| **Family:** | Merulinidae |
| **Genus:** | *Plesiastrea* spp. |
| **Species previously sighted by Veron (1997):** | *P. versipora* |
| **Morphologies:** | Massive, thick encrusting |
| **Colour morphs:** | Grey, green |
| **Distinguishing feature(s):** | Corallites round with separate walls, smaller and more regular than *Astrea*. Large colonies in high latitude areas. |
| **Frequency:** | Uncommon |

| | |
|---|---|
| **Common names:** | Cauliflower coral |
| **Family:** | Pocilloporidae |
| **Genus:** | *Pocillopora* spp. |
| **Species previously sighted by Veron (1997):** | *P. damicornis* |
| **Morphologies:** | Stand-alone colonies with tightly packed branches |
| **Colour morphs:** | Pale pink, purple |
| **Distinguishing feature(s):** | The surface is covered in small bumps known as verrucae; corallites grow among or on verrucae. **N. B.** *Pocillopora* is very difficult to distinguish underwater from *Stylophora* at this location. |
| **Frequency:** | Very common |

| | |
|---|---|
| **Common names:** | Smooth cauliflower coral |
| **Family:** | Pocilloporidae |
| **Genus:** | *Pocillopora* spp. |
| **Species previously sighted by Veron (1997):** | *P. damicornis* |
| **Morphologies:** | Stand-alone colonies with tightly packed branches |
| **Colour morphs:** | Pale pink, purple |
| **Distinguishing feature(s):** | The surface is covered in small bumps known as verrucae; corallites grow among or on verrucae. **N. B.** *Pocillopora* is very difficult to distinguish underwater from *Stylophora* at this location. |
| **Frequency:** | Very common |

| | |
|---|---|
| **Common names:** | Flowerpot coral |
| **Family:** | Poritidae |
| **Genus:** | *Goniopora* spp. |
| **Species previously sighted by Veron (1997):** | *G. lobata, G. norfolkensis* |
| **Morphologies:** | Massive, sub-massive |
| **Colour morphs:** | Cream, light brown |
| **Distinguishing feature(s):** | When polyps are extended far beyond the skeleton, they move freely in the water which can make *Goniopora* look similar to a soft coral |
| **Frequency:** | Common |



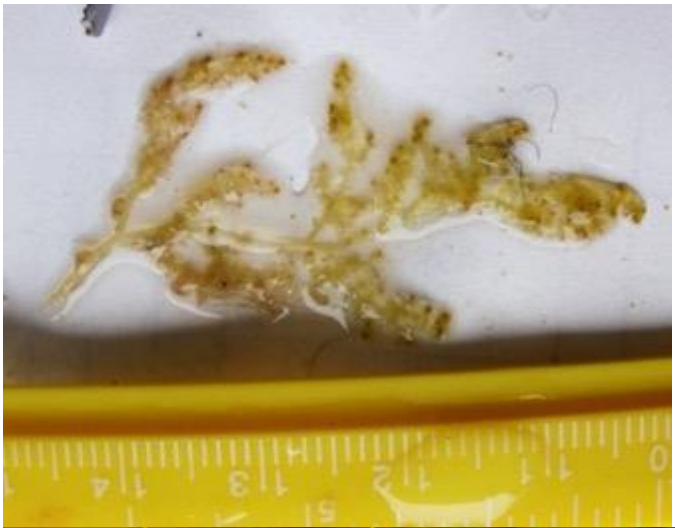
| | |
|---|---|
| **Common names:** | Pillar coral |
| **Family:** | Poritidae |
| **Genus:** | *Porites* spp. |
| **Species previously sighted by Veron (1997):** | *P. heronensis* |
| **Morphologies:** | Encrusting, columnar |
| **Colour morphs:** | Grey |
| **Distinguishing feature(s):** | Pillar-like colonies, with thick skeletons and very small corallites. Uniform dark grey. Compared to *Montipora*, the polyps are sunken. |
| **Frequency:** | Very common |

| | |
|---|---|
| **Common names:** | Pillar coral |
| **Family:** | Psammocoridae |
| **Genus:** | *Psammocora* spp. |
| **Species previously sighted by Veron (1997):** | *P. columna, P. superficialis* |
| **Morphologies:** | Encrusting |
| **Colour morphs:** | Brown |
| **Distinguishing feature(s):** | Small, sunken and indistinct corallites within shallow valleys. Colony has a granulated appearance. |
| **Frequency:** | Rare |

**Supplementary  Examples of algae identification from Norfolk Island**

Phylum – Chlorophyta (Green Algae)

**Hair Algae, *Bryopsis* sp.**

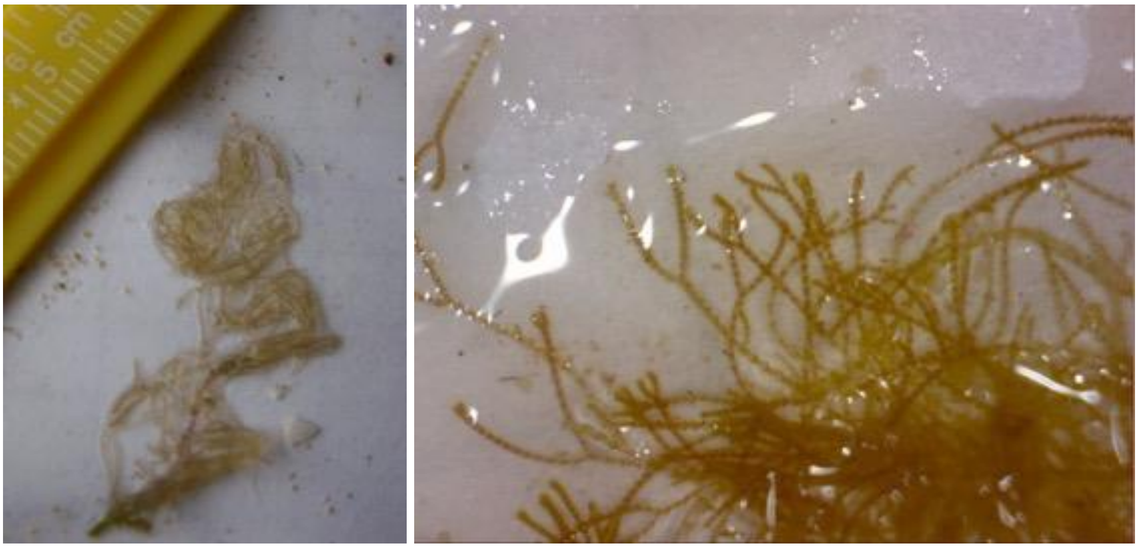


Cactus Tree Algae, *Caulerpa* cf. *cuppressoides*

Sea Grapes, *Caulerpa racemosa* var*. laetivirens* forma. 1 (1) and 2 (2)*.*

(1)

(2)



Sea Emerald, *Chaetomorpha* sp.

Turtle Weed, *Chlorodesmis* sp.

*Cladophora* sp.

Dead Man's Fingers, *Codium cf. fragile*

Green bird dropping, *Codium lucasii*

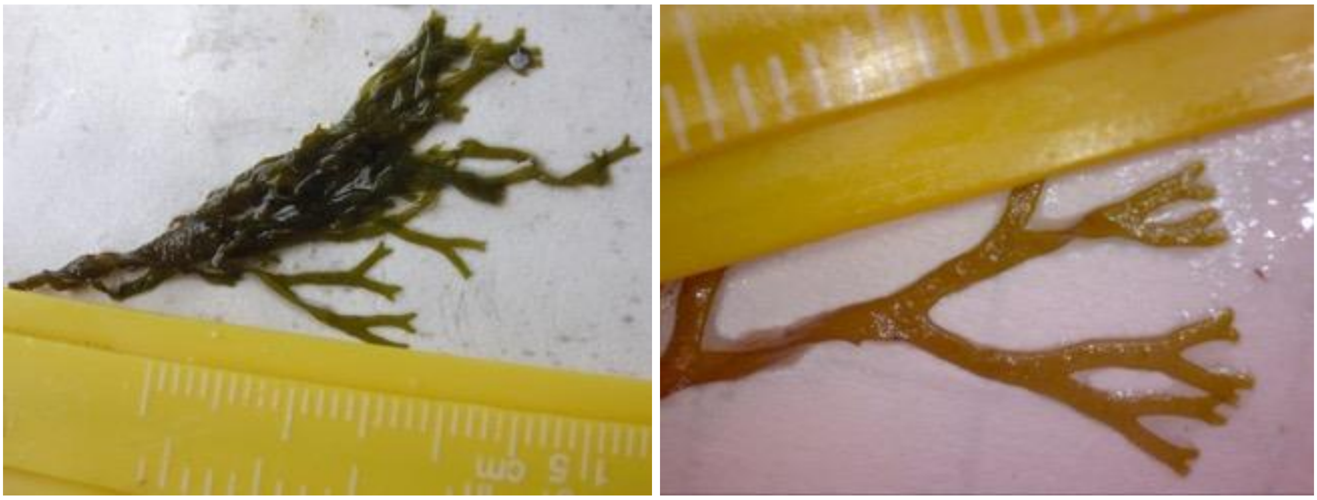

*Dasycladus* sp.

Sea lettuce, *Ulva lactuca*

Sailor’s Eye, *Valonia ventricosa.* Image from Wikimedia Commons.

## *Phylum – Phaeophyta (Brown Algae)*

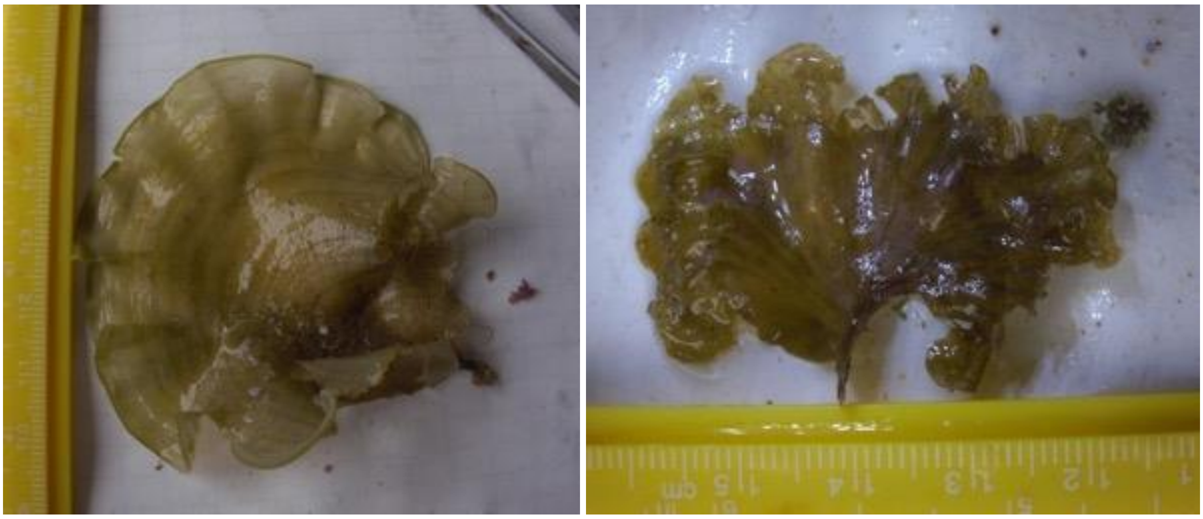
Oyster Thief, *Colpomenia sinuosa.* Image from iNaturalist (https://www.inaturalist.org/guide_taxa/765919).



Divided Net Weed, *Dicytota* cf. *dichotoma*

Netted Wing Weed, *Dicytopteris* cf. *polyploides* (1) and *Dictyopteris* cf. *plagiogramma* (2)

Neptune's Necklace, *Hormosira banksii*. Image from Wikimedia Commons.

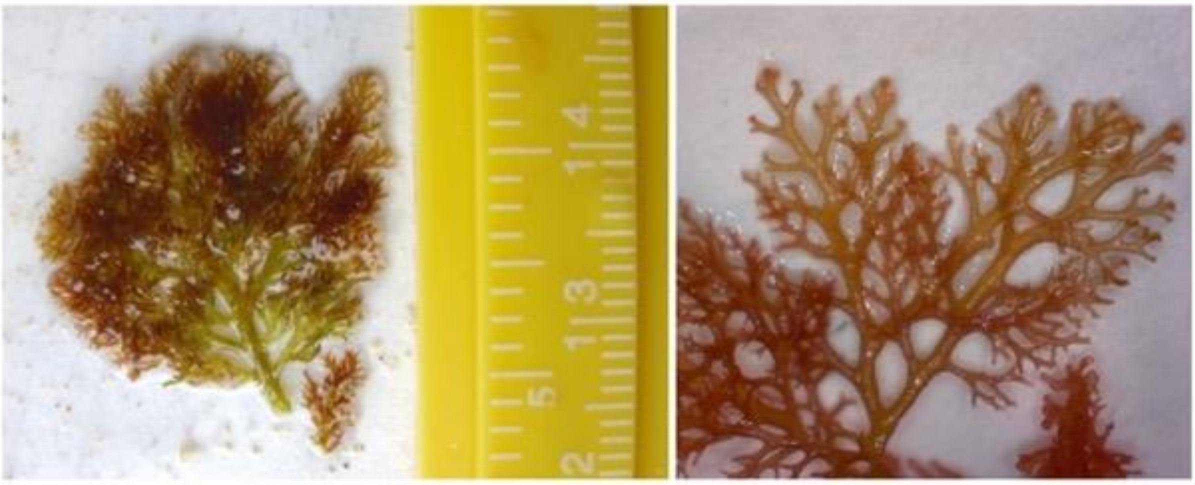


Peacock's Tail, *Padina cf. fraseri* (1) and *P.* cf. *crassa* (2)

Unknown fleshy, corticated algae

*Amansia* sp.

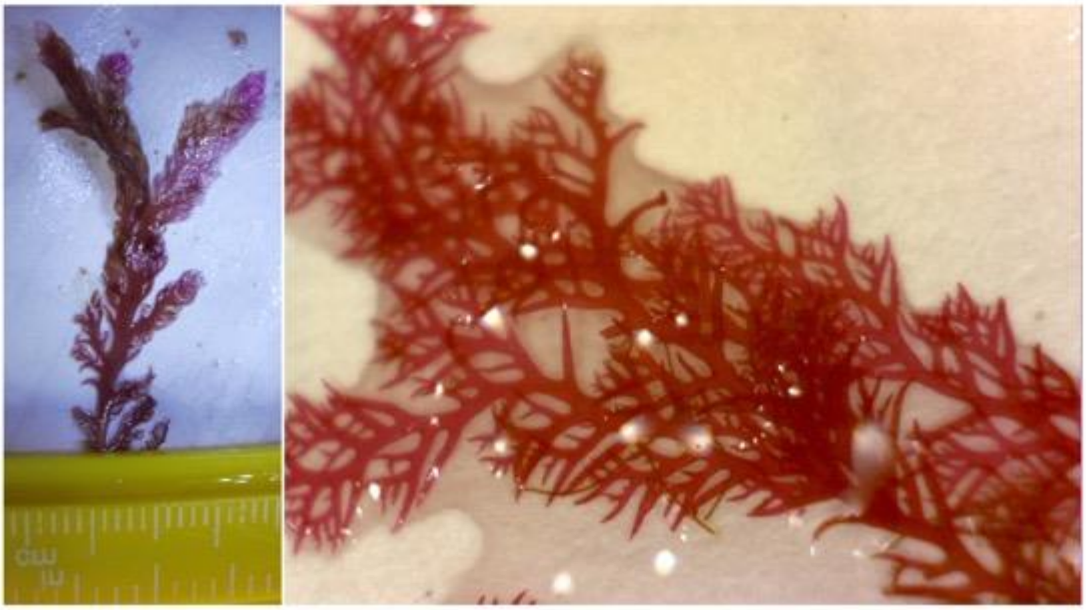
Hooked Seaweed, *Hypnea* sp.



Rounded Brittle Fern Weed, *Laurencia* cf. *obtusa* (1), *L.* cf. *dendroidea* (2) and *Laurencia* sp3

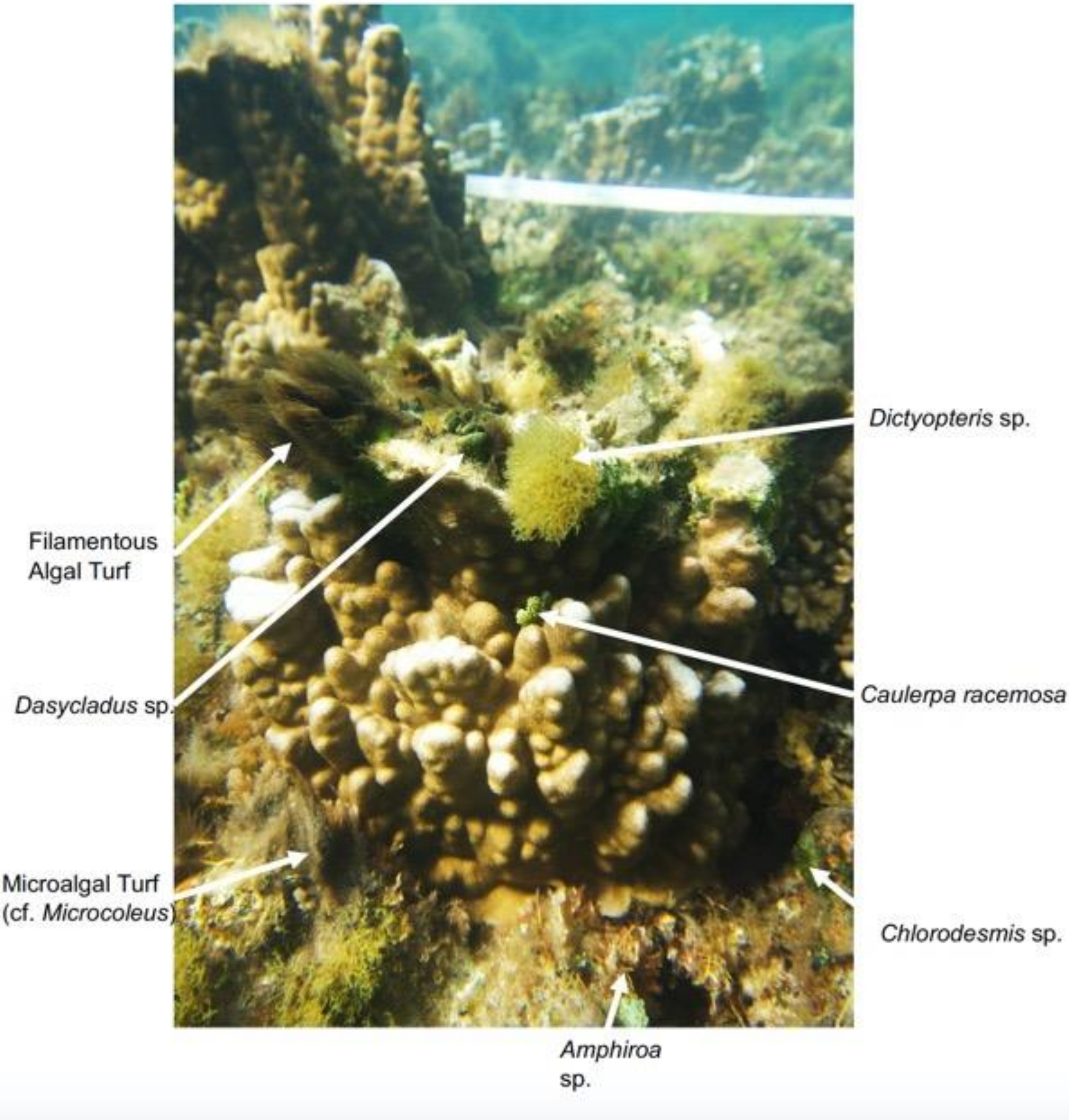
Rhodolith, *Lithophyllum* spp.

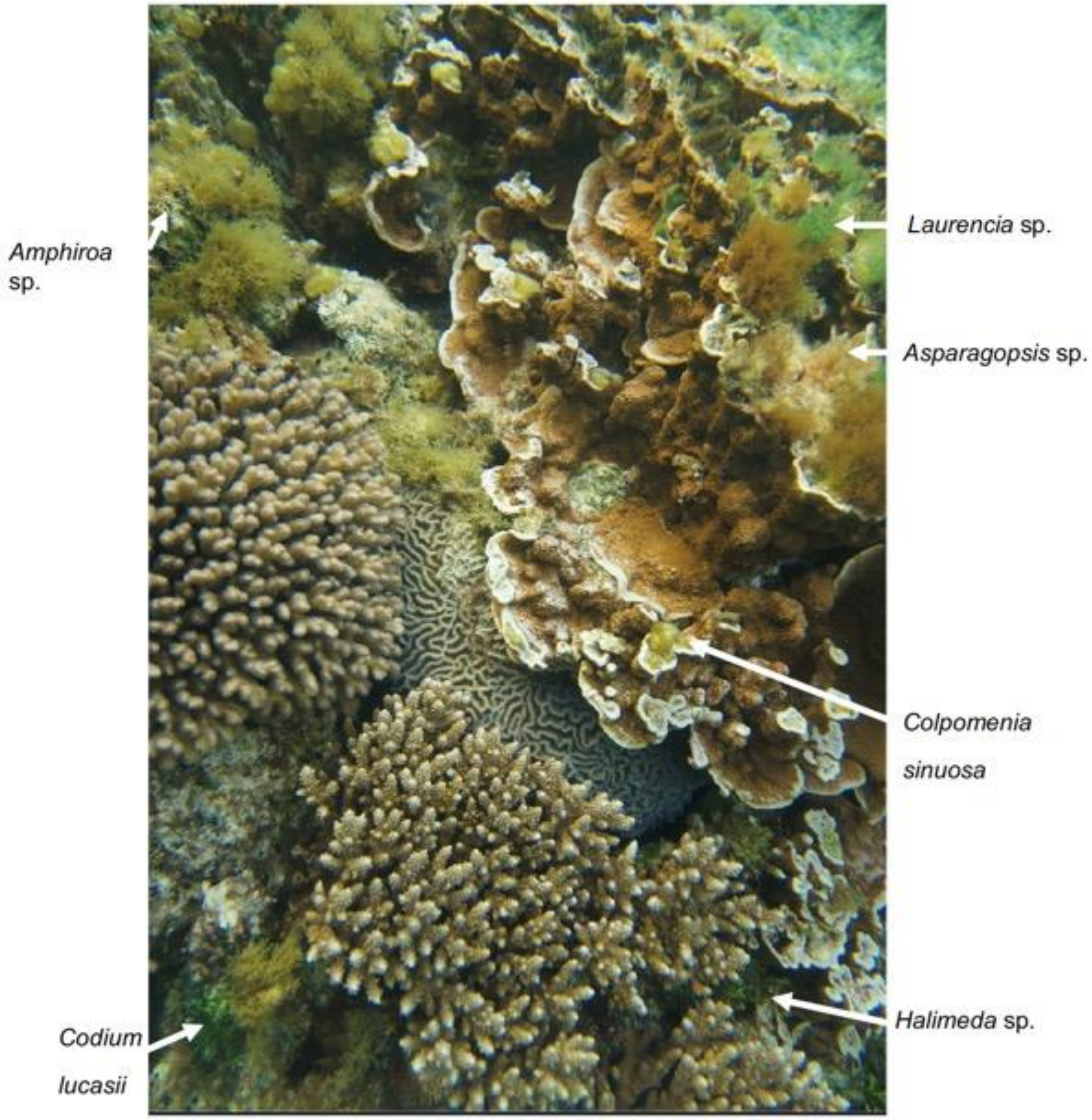
Cock's Comb, *Plocamium* cf. *dilatatum* (1) and *P* cf. *hamatum*.



*Tricleocarpa* cf. *cylindrica*

## ***In situ* photographs**





Amphiroa sp.
Laurencia sp.
Asparagopsis sp.
Colpomenia sinuosa
Codium lucasii
Halimeda sp.